

WBK Options

Requires a version of Windows ®



Windows 7 (32 or 64-bit)**
Windows Vista (32 or 64-bit)**
Windows XP SP2 (32-bit)
Windows 2000 SP4



** Neither Windows Vista nor Windows 7 support WaveBook/512A, /516, or /516A.
Windows Vista and Windows 7 both support WaveBook/516E.



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This symbol indicates the message is important, but is not of a Warning or Caution category. These notes can be of great benefit to the user, and should be read.



In this manual, the book symbol always precedes the words “Reference Note.” This type of note identifies the location of additional information that may prove helpful. References may be made to other chapters or other documentation.



Tips provide advice that may save time during a procedure, or help to clarify an issue. Tips may include additional reference.

Specifications and Calibration

Specifications are subject to change without notice. Significant changes will be addressed in an addendum or revision to the manual. As applicable, MCC calibrates its hardware to published specifications. Periodic hardware calibration is not covered under the warranty and must be performed by qualified personnel as specified in this manual. Improper calibration procedures may void the warranty.

CAUTION



Using this equipment in ways other than described in this manual can cause personal injury or equipment damage. Before setting up and using your equipment, you should read *all* documentation that covers your system. Pay special attention to Warnings and Cautions.

Note: During software installation, Adobe® PDF versions of user manuals will automatically install onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. You can also access the PDF documents directly from the CD vis the <View PDFs> button on the CD's opening screen. Refer to the PDF documentation for details regarding both hardware and software.

A copy of the Adobe Acrobat Reader® is included on your CD. The Reader provides a means of reading and printing the PDF documents. Note that hardcopy versions of the manuals can be ordered from the factory.



PDF
489-0902

WBK Option Cards and Modules User's Manual

The WBK Option Cards and Modules Manual discusses each of the WBK products available at the time of print. The following documents are related.



PDF
489-0901

WaveBook User's Manual, for WaveBook/512A, /516, /516A, & /516E

Explains how to make signal and power connections and how to install software and product support for the WaveBook/512A, /516, /516A, & /516E.



PDF
481-0901

WaveBook User's Manual, for WaveBook/512 and /512H

Explains how to make signal and power connections and how to install software and product support for the WaveBook/512 and WaveBook/512H.



PDF

WaveView

Discusses how to install and use this “out-of-the-box” data acquisition program that was designed for use with WaveBook systems.



PDF

Post Acquisition Data Analysis User's Guide



PDF
1008-0901

Programmer's Manual

The programmer's manual pertains to developing custom programs using Applications Program Interface (API) commands.

Note that the install CD-ROM includes WaveBook program examples.

Table of Contents

- [An Introduction to WBKs](#)
- [WBK10A – Analog Expansion Module](#)
- [WBK11A – Simultaneous Sample and Hold \(SSH\) Card](#)
- [WBK12A and WBK13A – Programmable Filter Cards](#)
- [WBK14 – Dynamic Signal Conditioning Module](#)
- [WBK15 – 5B Isolated Signal Conditioning Module](#)
- [WBK16 – Strain Gage Module](#)
- [WBK17 – Counter-Input Module with Quadrature Encoder Support](#)
- [WBK18 – Dynamic Signal Conditioning Module](#)
- [WBK20A – PCMCIA/EPP Interface Card and Cable](#)
- [WBK21 – ISA/EPP Interface Plug-In Board](#)
- [WBK23 – PCI/EPP Interface Plug-In Board](#)
- [WBK25 – Ethernet Interface Module User's Guide \(p/n 1087-0901\)](#)
- [WBK30 – WaveBook Memory Options](#)
- [WBK40 and WBK41 – Thermocouple and Multi-Function I/O Modules](#)
- [WBK61 and WBK62 – High Voltage Adapters](#)
- [Glossary](#)

CAUTION



Using the equipment in ways other than described in this manual can cause personal injury or equipment damage. Pay special attention to all cautions and warnings.



Reference Notes:

- Information (not available at the time of publication), will be made available in **ReadMe** files, or in supplemental documentation.
- For programming-related information refer to the separate *Programmer's Manual*, p/n 1008-0901. (See PDF Note, below).
- WaveBook/512A, WaveBook/516, and WaveBook/516A are covered in the *WaveBook User's Manual*, p/n 489-0901.
- WaveBook/512 and WaveBook/512H are covered in *WaveBook User's Manual*, p/n 481-0901.

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A copy of the Adobe Acrobat Reader® is included on your CD. The Reader provides a means of reading and printing the PDF documents. Note that hardcopy versions of the manuals can be ordered from the factory.

An Introduction to WBKs

[What are WBKs?..... 1](#)

[How do WaveBooks and WBKs Interrelate?4](#)

[How are WaveBook Systems Powered? 5](#)

[How are WBK Modules Mounted to other Modules or to WaveBooks? 5](#)

What are WBKs?

WBKs are WaveBook system options that exist in the form of cards or modules. The WBK options can be used to enhance and/or expand your WaveBook system.

Internally, WaveBook has room for one signal-conditioning card. Externally, one or more expansion modules can be used with a WaveBook.

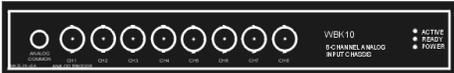
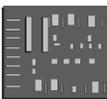
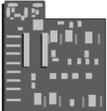
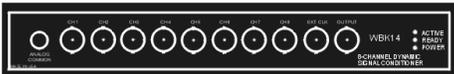


Reference Note:

The WBK option cards and modules that follow are detailed immediately after this introduction. The information is presented in alpha-numerical order and includes product specifications.

WBK Options

Note: The items represented in the table are not shown to the same scale.

 <p>WBK10A Analog Expansion Module 8 Channels via BNC Connectors</p>	<p>Each WBK10A module can be used to provide WaveBook with 8 additional differential-analog-inputs. The modules are equipped with a programmable gain instrumentation amplifier (PGA) and, like the WaveBook, each has a built-in expansion bus.</p> <p>Up to eight WBK10A modules can be cascaded together for a system capacity of 72 differential channels. Each module is capable of supporting a WBK11A, WBK12A, or WBK13A option card.</p>
 <p>WBK11A Simultaneous Sample & Hold Card (8 channels)</p>	<p>The WBK11A card can simultaneously sample 8 channels and can be installed inside a WaveBook or in a WBK10A module. The cards allow for concurrent (<150 ns) capture of multiple input channels and virtually eliminate channel-to-channel time skewing.</p> <p>The WBK11A option is factory install only.</p>
 <p>WBK12A Programmable Low-Pass Filter Card (8 channels)</p> <p>WBK13A Programmable Low-Pass Filter Card with SSH (8 channels)</p>	<p>WBK12A and WBK13A are 8-channel programmable low-pass filter cards for use with WaveBook data acquisition systems. These cards install directly into a WaveBook or WBK10A module and provide programmable low-pass filtering over all channels. Multiple WBK12A and WBK13A cards can be installed in one system for up to 72 channels. All of the cards' low-pass filters and cutoff frequencies are configured via software.</p> <p>WBK13A cards have the additional capability of sampling all channels at the same time.</p> <p>The WBK12A and WBK13A options are factory install only.</p>
 <p>WBK14 Dynamic Signal Conditioning Module 8 Channels via BNC Connectors</p>	<p>The WBK14 is a dynamic analog signal input module. It enables WaveBooks to interface with piezoelectric transducers that include accelerometers, microphones, and force/pressure transducers. Each WBK14 channel has a:</p> <ul style="list-style-type: none"> • current source for transducer biasing • high-pass filter • programmable gain amplifier • anti-aliasing low-pass filter • simultaneous sample-and-hold (SSH) amplifiers



WBK15
8-Slot 5B Signal Conditioning Module
8 channels via 5B Modules

The WBK15 module provides for a diverse range of signals available through optional 5B modules. Measurement types include: LVDT, potentiometer, isolated current loop, $\pm 10\text{mV}$ to $\pm 40\text{V}$ inputs, linearized RTD, thermocouple, frequency-to-voltage, and strain gage.

See latest catalog or contact your sales representative in regard to the types of 5B Modules available for your application.



WBK16
Strain-Gage Module
8 channels via Standard Female DB9

WBK16 is an 8-channel strain-gage signal-conditioning module. Up to eight WBK16 modules (64 channels) can be accommodated by the WaveBook and scanned at $1 \mu\text{s}/\text{channel}$. Almost all bridge configurations are supported via a bridge-completion network and software. High-gain differential-amplifier applications are also supported. Software controls bridge configuration, gain, offset, excitation voltage, polarity, filtering, and the calibration process.



WBK17
Counter-Input Module with Quadrature Encoder Support
8 channels via Removable Screw Terminal Blocks

The WBK17 is an 8-channel multi-function counter/encoder module for use with Wavebook/512A, /516, /516A, and /516E. Each of the high-speed, 32-bit counter channels can be configured for counter, period, pulse width, time between edges, or encoder modes. All channels are capable of measuring analog inputs that are digitized by the WaveBook.



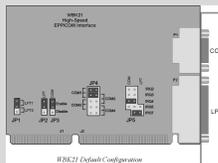
WBK18
Dynamic Signal Conditioning Module with Transducer Electronic Data Sheet support (T.E.D.S).
8 channels via BNC Connectors

WBK18 provides 8 channels of dynamic signal input for WaveBook systems. Each channel on the WBK18 has independent, software control for AC or DC coupling, ICP biasing (0 or 4 mA), and low-pass filter cut-off frequency. The 8-pole Butterworth filter on each channel is programmable from 5 Hz to 50 kHz, in a 1-2-5 progression. The filter can also be bypassed, resulting in a bandwidth of greater than 200 kHz.

WBK20A, WBK21, and WBK23 – Three Interface options that can be used to obtain an Enhanced Parallel Port.



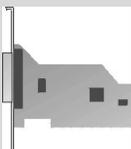
WBK20A
PC-Card /EPP Interface & Cable



WBK21
ISA/EPP Interface Plug-in Board

WBK20A – PCMCIA/EPP Interface Card and Cable
For linking WaveBook to a Notebook PC. This interface provides an Enhanced Parallel Port via a PC-Card Slot.

WBK21 – ISA/EPP Interface Plug-in Board
For linking WaveBook to a desktop PC. This interface provides an Enhanced Parallel Port via an ISA Bus-slot.



WBK23
PCI/EPP Interface Plug-In Board

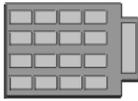
WBK23 – PCI/EPP Interface Plug-In Board
(For linking WaveBook to a desktop PC)
Provides an Enhanced Parallel Port from a PCI Bus-slot.

These three interfaces are shipped with separate documentation and are not detailed in this manual.



WBK25
10/100BaseT Ethernet Interface Module

The WBK25 provides high-speed Ethernet connectivity for WaveBook, DaqBook and WBK40 series products. The WBK25 contains one 10/100BaseT Ethernet port for connection to a PC, and three expansion ports that can attach to any model of WaveBook, DaqBook, WBK40 Series option, or any combination of these devices.



WBK30
WaveBook Memory Options

WBK30 is a DRAM-based memory board that installs inside a WaveBook. There are three models of WBK30 available; each significantly increases the capacity of a WaveBook's standard data buffer of 64 K samples. Capacities are as follows:

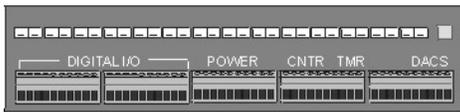
WBK30/16 — 16 MB
WBK30/64 — 64 MB
WBK30/128 — 128 MB

Note: For WaveBook/516E the WBK30 option, if selected, must be factory installed.



WBK40
Thermocouple Input Module
14 channels via Mini-T/C Connectors

The WBK40 attaches to any one of the three expansion ports on the WaveBook/516E or the WBK25, and provides 14 thermocouple input channels. The 14 built-in TC channels accept any type of thermocouple, including types J, K, S, T, E, B, R, and N. Mini-TC connections make it quick and easy to attach thermocouples. The WBK40 can be expanded in 14 channel increments using the DBK84 TC expansion module. A total of 15 DBK84s can be attached to one WBK40, for a total TC channel capacity of 224 channels.



WBK41
Multi-Function I/O Module
14 Thermocouple channels via Mini-T/C Connectors
40 Digital I/O Lines
4 Counter Inputs
2 Timer Outputs
(Optional) 4 Analog Channel Outputs

The WBK41 attaches to any one of the three expansion ports on the WaveBook/516E or WBK25 and provides 14 thermocouple inputs, 40 digital I/O lines, 4 counter inputs, and 2 timer outputs. The WBK41 can also be supplied with an internal, 4-channel, 16-bit, 100-kHz analog output option.

The built-in TC channels on the WBK41 are accessed via mini-TC connectors on the front panel. The counter/timer functions and 16 bits of digital I/O are accessed via removable front panel screw-terminal connectors. Additional digital I/O and expansion connectors are located at the rear of the WBK41.

The WBK41 can be easily expanded beyond its built-in channel capacity. A maximum WBK41 system can include up to 224 TC input channels, 272 digital I/O channels, 4 analog output channels, 4 counter input channels and 2 timer output channels.



WBK61 and WBK62

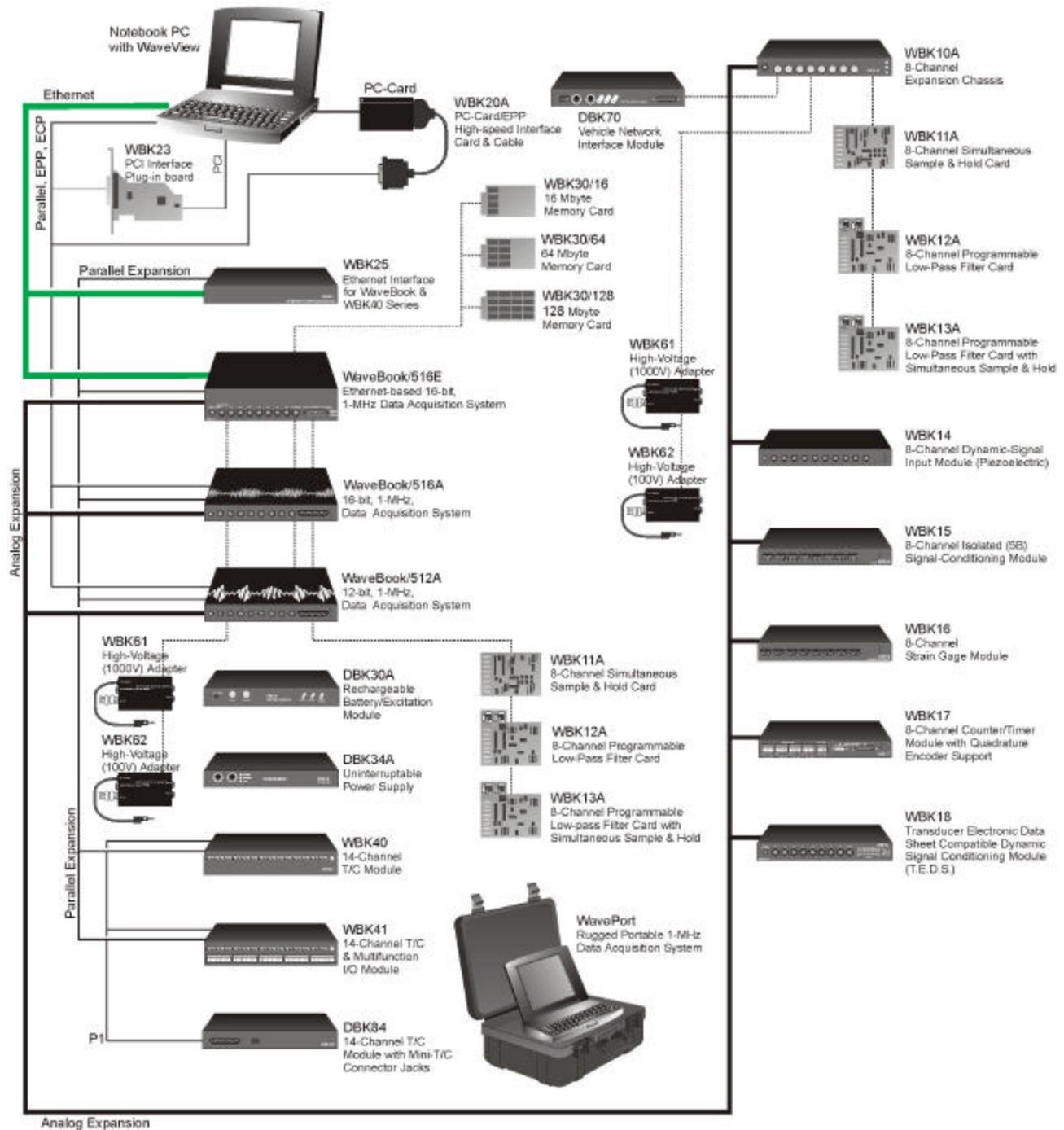
WBK61: High-Voltage Adapter with 200:1 Voltage Divider (1 channel)
WBK62: High-Voltage Adapter with 20:1 Voltage Divider (1 channel)

WBK61 and WBK62 are single-channel high-voltage adapters that can be used with the WaveBook or with a WBK10A expansion module. In addition, WBK61 and WBK62 can be used in conjunction with WBK11A, WBK12A, and WBK13A cards.

WBK61 and WBK62 include safety-style banana-jacks for the high and low inputs, and 60-inch (152 cm) cables with probe tips and alligator clips for easy input connection.

How do WaveBooks and WBKs Interrelate?

WaveBooks and WBKs interrelate when they become part of the same data-acquisition system. The relationship can be broken down into *enhancement*, *expansion*, or both. The following illustrates the relationship of various system components.



WaveBook System Components

How are WaveBook Systems Powered?

Power supply input voltage to the WaveBook and to the system modules, e.g., WBK10A, WBK14, WBK15, WBK16, WBK17, WBK18, WBK40, and WBK41 must be in the range of 10 VDC to 30 VDC and can come from an appropriate AC-to-DC adapter or a battery option. The latter includes DBK power modules and batteries in the range of 10 VDC to 30 VDC.

Note: Power supply input to the WBK25 Ethernet Module must be in the range of 10 VDC to 20 VDC.

Available AC-to-DC adapters include the TR-40U (supplied), which has an input of 90-264 VAC and a output rating of 2.2 amps @ 15 VDC.

Battery options include the DBK30A, DBK34A, and other 10 to 30 VDC sources, such as car batteries. The DBK30A provides 14 VDC and when fully charged has a storage capacity of 3.4 A·hr; car batteries have much higher capacities. The basic formula for battery life is:

$$\text{Runtime (hr)} = \text{Battery capacity (A·hr)} / \text{Current load (A)}$$

System cards, e.g., WBK11A, WBK12A, and WBK13A, get power from their host WaveBook or their host WBK10A expansion module.

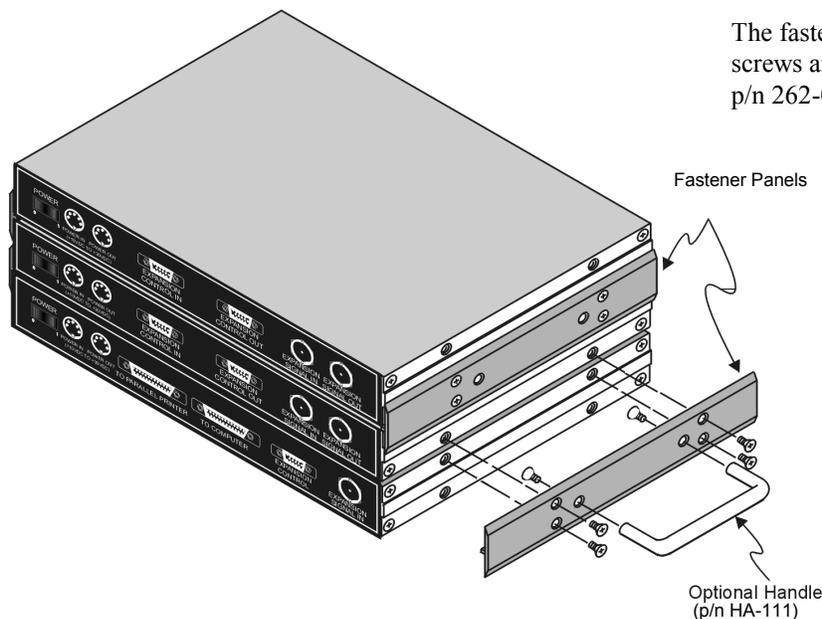
Before connecting your system to power, you need to know the power requirements of your specific system. A calculation method that incorporates the use of worktables is presented in Chapter 2 of *the WaveBook User's Manual* (p/n 489-0901).



Reference Notes:

- In the *WaveBook User's Manual* (p/n 489-0901), the *System Setup and Power Options* chapter includes examples of power connections for different WaveBook system scenarios. In these examples the included TR-40U power adapters are used.
- In the *WaveBook User's Manual* (p/n 489-0901), the *WaveBook Operation Reference* chapter includes discussions of power supplies other than the TR-40U.

How are WBK Modules Mounted to other Modules or to WaveBooks?



The fastener panels and associated screws are from fastener-panel kit, p/n 262-0801.

Using Fastener Panels to Stack a WaveBook and two WBK Modules (use of the handle is optional)

WBK modules can be stacked using fastener panels, sometimes referred to as splice plates. The panels provide a means of stacking modules to create one rigid assembly. The Fastener Panel Kit, p/n 262-0801, is available from the factory and consists of two metal plates and the necessary mounting screws. A Fastener-Panel Handle (p/n HA-111) is also available from the factory. HA-111 consists of 1 handle and two mounting screws.

The previous figure illustrates the simplicity of the mounting process.

Note: When used with a WBK16, WaveBook/516, WaveBook/516A, or WaveBook/512A, fastener panels will partially block the vents on the side of the module. This partial blocking of vents does not jeopardize the cooling process.

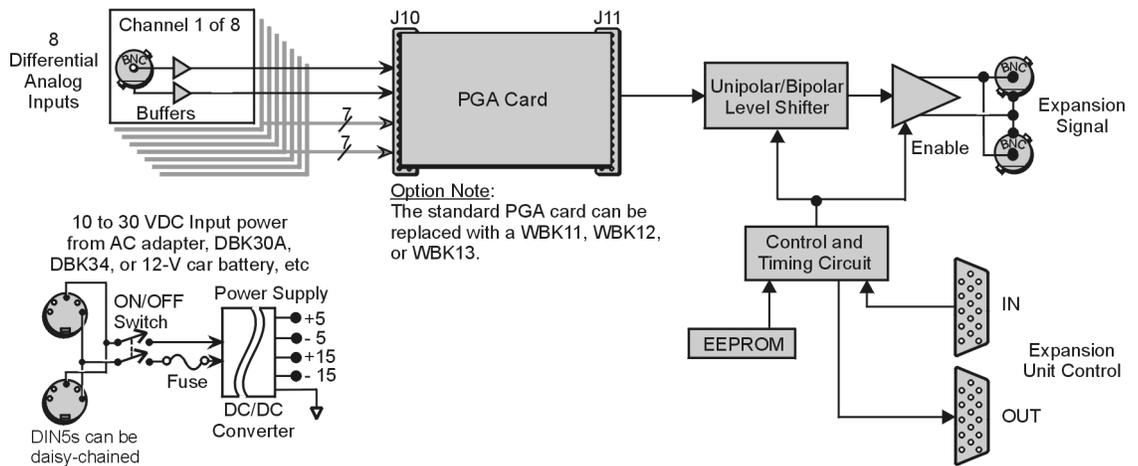
Note! **Important Notice! WaveBook/516E Users**
 WBK option cards for WaveBook/516E are installed at the factory per customer order. Users are not to remove or install cards for these products as the cards are not “plug-and-play” for these devices and erroneous signal values could result. If you desire to remove or add a card to WaveBook/516E contact the factory or your service representative.

Note! **Important Notice! WaveBook/516, /516A, /512A, and WBK10A Users**
 With exception of the WBK30 option, WBK option cards for WaveBook/516, /516A, /512A, and WBK10A are installed at the factory per customer order. Users are not to remove or install cards for these products [other than WBK30 series cards] as the cards are not “plug-and-play” for these devices and erroneous signal values could result. If you desire to remove or add a card to these products, contact the factory or your service representative.

The WBK10A Analog Expansion Module can be used to provide WaveBook with 8 additional differential-analog-inputs. The WBK10A is equipped with a programmable gain instrumentation amplifier (PGA) and, like the WaveBook, has a built-in expansion bus.

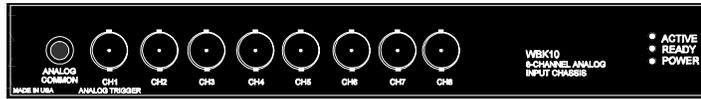
Up to eight WBK10A modules can be cascaded together for a system capacity of 72 differential channels. Each module is capable of supporting a WBK11A, WBK12A, or WBK13A option card.

Note: WBK10A can be ordered with a PGA, WBK11A, WBK12A, or a WBK13A card installed.



WBK10A Block Diagram

The **front panel** has the following connectors and indicators:



WBK10A Front Panel

- 1 Analog Common binding post for reference.
- 8 BNC connectors for analog inputs. Channels are labeled 1 through 8.
- 3 Status LEDs (Active, Ready, Power).

The **rear panel** has a power switch and the following connectors:



WBK10A Rear Panel

- 2 DIN5 connectors [one for Power In, one for Power Out]
- 1 HD-15M Expansion Control In
- 1 HD-15F Expansion Control Out
- 2 BNC connectors [one for analog Expansion Signal In, one for analog Expansion Signal Out]



Reference Notes:

- Setup information pertaining to power, expansion control, and expansion signal connections is contained in the *System Setup and Power Options* chapter of the *WaveBook User's Manual* (p/n 489-0901).
- For detailed WaveView information, refer to the *WaveView Document PDF* that is included on the data acquisition CD. The document can be accessed using the <View PDFs> button on the CD's opening screen.

Specifications - WaveBook/516, /516A, /516E, and WBK10A

Analog Specifications

For either a stand alone WaveBook, or for a WBK10A with a WaveBook

Channel Capacity:

WaveBook/516E: 8 built-in voltage channels, expandable up to 72 channels via WBK options. In addition, WaveBook/516E can accommodate up to 3 WaveBook/516A, /512A, or WBK40 options, in any combination. Each added on WaveBook can be expanded up to 72 channels. The maximum WBK41 capacity is 224 T/C channels, 4 analog output channels, 272 digital I/O channels, and 6 counter/timer channels.

WaveBook/516 and /516A: 8 differential, expandable up to 72 differential

BNC Input Connectors: Center conductor is Channel Hi, outer conductor is Channel Low

Input Voltage Ranges (DC Specifications)

Voltage Range	Standard Unit		With WBK11A (Note 3)			With WBK12A/13A (Note 3)				
	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms DC-500KHz (typical)	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms DC-500KHz (typical)	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms (typical)	
	± % reading	± % range		± % reading	± % range		± % reading	± % range	1KHz Filter	Filter Bypass
0 to +10V	.012%	.008%	2	.012%	.008%	2	.012%	.008%	2.2	2.2
0 to +5V (10A) 0 to +4V (516)	.012%	.009%	2	.012%	.009%	2	.012%	.009%	2.2	2.2
0 to +2V	.012%	.012%	3	.012%	.012%	3	.012%	.012%	2.2	3
0 to +1V (10A only)	.012%	.018%	3	.012%	.018%	3	.012%	.018%	2.2	3
0 to +.5V				.018%	.033%	6	.018%	.033%	2.2	6
0 to +.2V				.018%	.08%	8	.018%	.08%	2.2	12
0 to +.1V				.018%	.16%	15	.018%	.16%	2.2	20
-10 to +10V	.012%	.008%	2	.012%	.008%	2	.012%	.008%	2.2	2.2
-5 to +5V	.012%	.008%	2	.012%	.008%	2	.012%	.008%	2.2	2.2
-2 to +2V	.012%	.009%	2	.012%	.009%	2	.012%	.009%	2.2	3
-1 to +1V	.018%	.012%	3	.018%	.012%	3	.018%	.012%	2.2	3.3
-.5 to +.5V (10A only)	.018%	.018%	5	.018%	.018%	6	.018%	.018%	2.2	6
-.2 to +.2V				.018%	.033%	8	.018%	.033%	2.2	12
-.1 to +.1V				.018%	.08%	15	.018%	.08%	2.2	20
-.05 to +.05V (10A only)				.018%	.16%	26	.018%	.16%	4	40

Notes: 1. Specifications assume differential input scan, unfiltered.

2. Accuracy specification is exclusive of noise.

3. Unipolar ranges are not available for WaveBook/516, /516A, or /516E when a WBK11A, WBK12A, or WBK13A option is installed. Unipolar ranges are available with WBK10A and any option.

System Performance: one year, 18-28°C unless otherwise noted

Differential Nonlinearity: ±2 LSB max

Total Harmonic Distortion (10Hz-20KHz): -84dB typical

Signal to Noise and Distortion (SINAD, 10Hz-20KHz): -74dB typical

Temperature Coefficient of Accuracy (0-18 and 28-50°C):

With PGA and WBK11A: ± (.002% + 0.6 LSB)/°C typical, -10 to +10V range

With WBK12A/13A: ± (.002% + 1 LSB)/°C typical, -10 to +10V range

Input Resistance: 5MΩ (single ended); 10MΩ (differential), in parallel with 30pF

Bias Current: <400 nA (0 to 35°C)

Common Mode Rejection: >70dB minimum; >80dB typical; DC-20KHz

Input Bandwidth: DC to 500KHz

Hostile Channel-to-channel Crosstalk (5Vrms input signal, DC-100KHz): -88dB typical

Over-Voltage Protection: ±35 V relative to analog common

Note: Specifications are subject to change without notice.

PGA Filter

Filter Type: 20KHz low pass, Butterworth, 5-pole filter

WBK11A Functions

Input Voltage Ranges: Software programmable prior to a scan sequence

Aperture Uncertainty (SSH): 75ps max

Voltage Droop (SSH): 0.01mV/ms typ

WBK12A, WBK13A Functions

Input Voltage Ranges: Software programmable prior to a scan sequence

Low Pass Filter Type: Software selectable, 8-Pole elliptic or linear phase

Anti-Aliasing Filters: Single-pole pre and post filters, automatically set depending on filter frequency selected

Low-Pass Filter Frequency Cutoff Range: 100KHz, 75KHz, 60KHz...400Hz, bypass ($f_c=300\text{KHz}/N$ where $N=3$ to 750)

Filter Grouping: 4 Channels each in two programmable banks

Aperture Uncertainty (SSH): 75ps max

Voltage Droop (SSH): 0.01mV/ms typ

Triggering

Channel 1 Analog Trigger

Input Signal Range: -10 to +10V

Input Characteristics and Protection: Same as channel inputs

Latency: 300ns

Multi-Channel Analog Trigger (up to 72 channels):

Range: Selectable per channel to input range

Latency: 2us/channel, plus 4us maximum

TTL Trigger:

Input Signal Range: 0-5V

Input Characteristics: TTL-compatible with 10K ohm pull-up resistor

Input Protection: Zener clamped -0.7 to +5V

Latency: 300ns

Software Trigger

Latency: 100us typical

Pulse Trigger

Input Signal Range: 0-5V

Input Characteristics: 75 ohms

Input Protection: $\pm 10\text{V}$ maximum

Minimum Pulse Width: 100ns

Latency: 300ns

External Clock

Connector: Available on DB25 digital input

Input Signal Range: 5V TTL compatible

Input Characteristics: 50K ohms pull up (to +5V) in parallel with 50pF

Input Protection: Zener clamped -0.7 to +5V

Delay: 200ns

Signal Slew Rate Requirement: 20V/us minimum

Rate: Up to 1MHz

Divisor ratio: Divide by 1 through 255, selectable

Clock Counter Accuracy: <0.02% error

Clock Counter Range: 0.01Hz to 100KHz

Sequencer

Operation: Programmable for channel, gain, and for unipolar/bipolar range in random order

Depth: 128 location

Channel-to-Channel Rate: 1.0-1.1us/channel, all channels equal

Maximum Repeat Rate: 1MHz

Minimum Repeat Rate: 100 seconds per scan

Expansion Channel Sample Rate: Same as on-board channels

High-Speed Digital Inputs/General-Purpose Outputs

Connector: DB25 Female

Configuration: 16 TTL-compatible pins, selectable for input or output

Input Characteristics: TTL-compatible

Output Characteristics: ALS TTL output in series with 33 ohms

Output Updates: Outputs may be changed via program control

Input/Output Protection: Diode clamped to ground and +5V

Period Counter

Operation: Internal counter calculates and reports the external clock's period; counter can be read with each scan

Clock Counter Accuracy: <0.02% error

Clock Counter Range: 0.01 Hz to 100 kHz

General Specifications

Warm-up: 30 minutes to rated specifications

Environment:

Operating: 0-50°C, 0-95% RH (non-condensing)

Storage: -20 to 70°C

Power Consumption:

/516E: 1.8A max @ 15 VDC

/516, /516A & /512A: 1.4A max @ 15VDC

Input Power Range: 10 VDC to 30 VDC

Input Power Fuse F201: 4A MINI ATO; See chapter 9 for fuse replacement instructions.

Vibration: MIL STD 810E, Category 1 and 10

PC Communication:

/516E: 10/100BaseT Ethernet

/516, /516A & /512A: Enhanced Parallel Port (EPP)

Channel Capacity:

/516E: 8 built-in voltage channels, expandable up to 72 channels via WBK options. In addition, WaveBook/516E can accommodate up to 3 WaveBook/516A, /512A, or WBK40 options, in any combination. Each added on WaveBook can be expanded up to 72 channels. The maximum WBK41 capacity is 224 T/C channels, 4 analog output channels, 272 digital I/O channels, and 6 counter/timer channels.

/516, /516A & /512A: 8 built-in voltage channels, expandable up to 72 channels via WBK options

Dimensions:

/516E: 285 mm wide x 220 mm deep x 70 mm high (11 x 8.5 x 2.70 inches)

/516, /516A & /512A: 285 mm wide x 220 mm deep x 45 mm high (11 x 8.5 x 1.75 inches)

Weight:

/516E: 1.9 kg (4.2 lbs)

/516, /516A & /512A: 1.5 kg (3.3 lbs)



Important Notice! WaveBook/516E Users

WBK option cards for WaveBook/516E are installed at the factory per customer order. Users are not to remove or install cards for these products as the cards are not “plug-and-play” for these devices and erroneous signal values could result. If you desire to remove or add a card to WaveBook/516E contact the factory or your service representative.



Important Notice! WaveBook/516, /516A, /512A, and WBK10A Users

With exception of the WBK30 option, WBK option cards for WaveBook/516, /516A, /512A, and WBK10A are installed at the factory per customer order. Users are not to remove or install cards for these products [other than WBK30 series cards] as the cards are not “plug-and-play” for these devices and erroneous signal values could result. If you desire to remove or add a card to these products, contact the factory or your service representative.

Description

The WBK11A is a simultaneous sample-and-hold card (SSH) that provide a means of obtaining concurrent (<150 ns) capture from up to 8 input channels. The card virtually eliminates channel-to-channel time skewing. The card is controlled by the acquisition system’s base WaveBook.

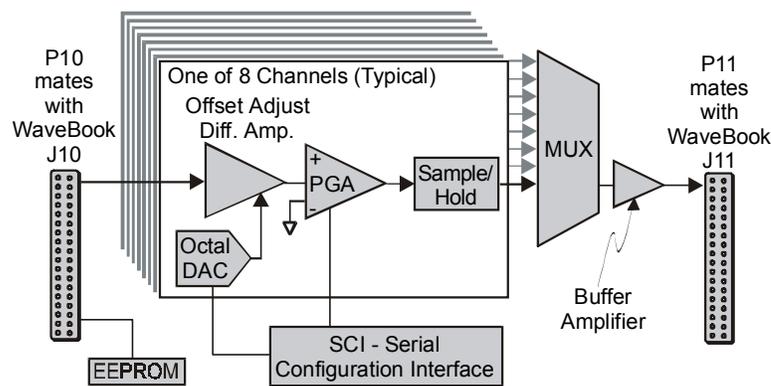
The WBK11A can be installed inside a WaveBook or in a WBK10A series module; however, it must be installed by a qualified service representative (see the important notice above).



When using a WaveBook with an SSH channel enabled, the per-channel sample rates are reduced. The rate reduction is the same as that which would occur if another channel were added. The per-channel rate (with SSH enabled) is:

$$1 \text{ MHz} / (n+1), \text{ where } n \text{ is the number of active channels.}$$

The WBK11A SSH card can accommodate higher gains than the main unit because its gains are fixed for each channel prior to the acquisition. You can use WaveView to set each channel to the ranges listed in the specifications on page 2. All channels equipped with SSH circuitry are sampled simultaneously as a system.



WBK11A Block Diagram

Hardware Setup

Configuration

All WBK11A configurations are controlled by software. There are no hardware settings.



Reference Note:

For detailed *WaveView* information refer to the *WaveView Document*. A PDF version of the document can be accessed from the data acquisition CD via the <View PDFs> button on the CD's opening screen.

Installation

There is no user installation permitted. See notes on page 1.

WBK11A – Specifications

Name/Function: WBK11A; 8-Channel Simultaneous Sample-and-Hold Card

Number of Channels: 8

Connectors: Internal to the WaveBook/512 series, or WaveBook/516 series device;
a 36 pin-socket connector mates with a 36-pin connector

Accuracy: $\pm 0.025\%$ FS for WaveBook/512A applications.

For WaveBook/516 Series applications, see the table on page 3 of this WBK11A document module.

Offset: ± 1 LSB max

Aperture Uncertainty: 75 ps max

Voltage Droop: 0.1 mV/ms max

Maximum Signal Voltage: ± 5.00 VDC ($\times 1$)

Input Voltage Ranges:
Before a scan sequence begins, the input voltage ranges can be programmed via software. The ranges can be expanded as follows:
Unipolar: Unipolar applies to WBK 10A only. 0 to +10 V 0 to +5 V 0 to +2 V 0 to +1 V 0 to +0.5 V 0 to +0.2 V 0 to +0.1 V
Bipolar: Bipolar applies to WaveBook/516, /516A, /516E, /512A, and WBK10A -10 to +10 V -5 to +5 V -2 to +2 V -1 to +1 V -0.5 to +0.5 V -0.2 to +0.2 V -0.1 to +0.1 V
-0.05 to +0.05 V This range applies to WBK 10A only.

Programmable Gain Amplifier Gain Ranges: $\times 1, 2, 5, 10, 20, 50, 100$

Weight: 0.14 kg (0.3 lb)

Accuracy and Noise Specifications

Voltage Range	WaveBook/516 Series (Alone)			WaveBook/516 Series with a WBK11A (Note 3)		
	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms DC-500KHz (typical) (Note 4)	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms DC-500KHz (typical)
	± % reading	± % range		± % reading	± % range	
0 to +10V	.012%	.008%	2	.012%	.008%	2
0 to +5V (10A) 0 to +4V (516)	.012%	.009%	2	.012%	.009%	2
0 to +2V	.012%	.012%	3	.012%	.012%	3
0 to +1V (10A only)	.012%	.018%	3	.012%	.018%	3
0 to +.5V				.018%	.033%	6
0 to +.2V				.018%	.08%	8
0 to +.1V				.018%	.16%	15
-10 to +10V	.012%	.008%	2	.012%	.008%	2
-5 to +5V	.012%	.008%	2	.012%	.008%	2
-2 to +2V	.012%	.009%	2	.012%	.009%	2
-1 to +1V	.018%	.012%	3	.018%	.012%	3
-.5 to +.5V (10A only)	.018%	.018%	5	.018%	.018%	6
-.2 to +.2V				.018%	.033%	8
-.1 to +.1V				.018%	.08%	15
-.05 to +.05V (10A only)				.018%	.16%	26

- Notes:**
1. Specifications assume differential input scan, unfiltered.
 2. Accuracy specification is exclusive of noise.
 3. Unipolar ranges unavailable for a WaveBook/516, /516A, or /516E that has a WBK11A, WBK12A, or WBK13A option installed. Unipolar mode is available with WBK10A and any option.
 4. **Maximum limit is 1.3X typical.**

WBK12A and WBK13A Programmable Low-Pass Filter Cards



Important Notice! WaveBook/516E Users

WBK option cards for WaveBook/516E are installed at the factory per customer order. Users are not to remove or install cards for these products as the cards are not “plug-and-play” for these devices and erroneous signal values could result. If you desire to remove or add a card to WaveBook/516E contact the factory or your service representative.



Important Notice! WaveBook/516, /516A, /512A, and WBK10A Users

With exception of the WBK30 option, WBK option cards for WaveBook/516, /516A, /512A, and WBK10A are installed at the factory per customer order. Users are not to remove or install cards for these products [other than WBK30 series cards] as the cards are not “plug-and-play” for these devices and erroneous signal values could result. If you desire to remove or add a card to these products, contact the factory or your service representative.

Description

The WBK12A and WBK13A are 8-channel programmable low-pass filter cards for use with 1-MHz WaveBook data acquisition systems. These cards install directly into a WaveBook or WBK10A module and provide programmable low-pass filtering over all channels. Multiple WBK12A and WBK13A cards can be installed in one system for up to 72 channels. All of the cards' low-pass filters and cutoff frequencies are configured via software.

The WBK13A card has the additional capability of sampling all channels at the same time. If more than one WBK13A card is installed [within one system] all channels will be sampled within 100 ns of each other.

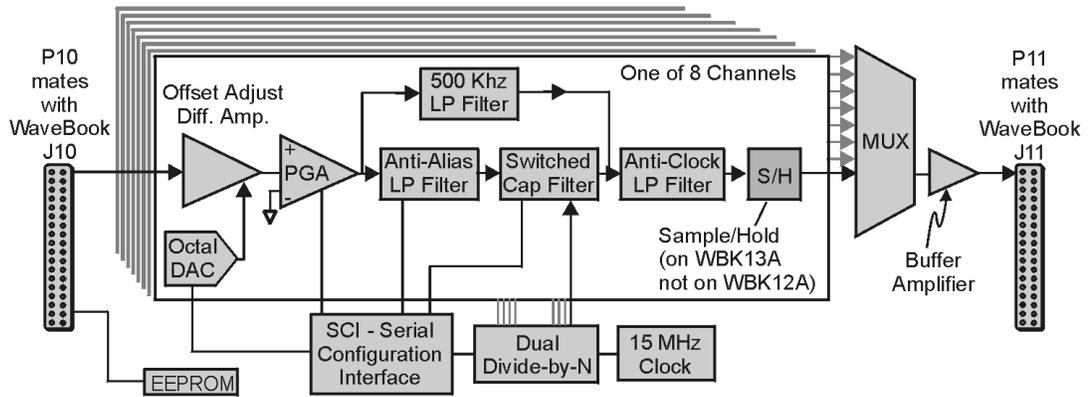
Features of the WBK12A and WBK13A include:

- **Anti-Alias Low-Pass Filters.** Each card provides 8 input channels, arranged in two 4-channel banks; the filter and cutoff frequency configurations are applied per bank. The cards' filters can be configured as either an 8-pole elliptic filter with cutoff frequencies of 400 Hz to 100 kHz, or an 8-pole linear-phase filter with 400 Hz to 50 kHz cutoff frequencies.
- **500 Khz Low Pass Filter.** You can individually configure channels to bypass the programmable filter. The bypass option results in a 1-pole low-pass filter at approximately 500 kHz.
- **Cutoff Frequencies.** The WBK12A and WBK13A provide 748 discrete cutoff frequencies that can be determined exactly by the formula $F_c = 300 \text{ kHz}/N$; where the integer $N = 3 \text{ to } 750$. Alternatively, you can configure any channel to bypass the programmable filter entirely, resulting in a 1-pole low-pass filter at about 500 kHz.
- **Programmable-Gain Amplifiers.** The cards' programmable-gain instrumentation amplifiers can be software selected to various gains on a per channel basis. The gains are set prior to the beginning of an acquisition sequence and cannot be changed during an acquisition.
- **Simultaneous Sample-and-Hold (SSH) (WBK13 only).** In addition to the filtering capability of the WBK12A, the WBK13A provides per channel SSH. Simultaneous sampling of all channels occurs at the start of a scan sequence.



When using a WaveBook with an SSH channel enabled, the per-channel sample rates are reduced. The rate reduction is the same as that which would occur if another channel were added. The per-channel rate (with SSH enabled) is:

$1 \text{ MHz} / (n+1)$, where n is the number of active channels.



WBK12A and WBK13A Block Diagram

Hardware Setup

Configuration

All WBK12A and WBK13A series configurations are controlled by software. There are no hardware settings.

Installation

There is no user installation permitted. See notes on page 1.

Software Setup



Reference Notes:

- Setup information pertaining to power, expansion control, and expansion signal connections is contained in the *System Setup and Power Options* chapter of the *WaveBook User's Manual* (p/n 489-0901).
- For detailed WaveView information, refer to the *WaveView Document PDF* that is included on the data acquisition CD. The document can be accessed using the <View PDFs> button on the CD's opening screen.

WBK12A and WBK13A – Specifications

Name/Function:

WBK12A, Programmable Low-Pass Filter Card
WBK13A, Programmable Low-Pass Filter Card With SSH

Number of Channels: 8

Connector: Internal to WaveBook/512A, /516, /516A, /516E, and WBK10A
 (two 36-pin sockets mate with 36-pin connectors)

Programmable Gain Amplifier Ranges:

×1, 2, 5, 10, 20, 50, and 100

Switched Capacitor Filter Cutoff Frequencies Range:
 400 Hz to 100 kHz

Number of Cutoff Frequencies: 1024

Filter Grouping: 4 channels each in 2 programmable banks

Low-Pass Filter: Software selectable, 8-pole elliptic filter

Low-Pass Filter Type: Software selectable, elliptic or linear phase

Low-Pass Filter Frequency Cutoff Range:

100 kHz, 75 kHz, 60 kHz...400 Hz,

bypass defined as $F_c = 300 \text{ kHz}/N$ where $N = 3$ to 750

Anti-Alias Frequencies: determined by software control

Accuracy: ±0.03% FS DC, for WaveBook/512A

For WaveBook/516 Series see the table on page 4 of this document module.

Offset: ±1 LSB max (for WaveBook/512A)

Aperture Uncertainty: 75 ps max

Voltage Droop: 1 mV/ms max (0.01 mV/ms typ)

Maximum Signal Voltage: ±5.00 VDC (×1)

THD: -65 dB (-70 dB typ) (for WaveBook/512A)

Number of Cutoff Frequencies Simultaneously Set:

two, one for each 4-channel bank of inputs

Weight: 0.14 kg (0.3 lb)

Software Selectable Cutoff Frequencies	
Octave (kHz)	Number of Cutoff Frequencies
0.400 to 0.780	512
0.780 to 1.570	256
1.57 to 3.15	128
3.15 to 6.3	64
6.3 to 12.5	32
12.5 to 25	16
25 to 50	8
50 to 100	5

Input Voltage Ranges:

Before a scan sequence begins, the input voltage ranges can be programmed via software.

The ranges can be expanded as follows:

Unipolar: Unipolar applies to WBK 10A only.

0 to +10 V
 0 to +5 V
 0 to +2 V
 0 to +1 V
 0 to +0.5 V
 0 to +0.2 V
 0 to +0.1 V

Bipolar: Bipolar applies to WaveBook/516, /516A, /516E, /512A, and WBK10A

-10 to +10 V
 -5 to +5 V
 -2 to +2 V
 -1 to +1 V
 -0.5 to +0.5 V
 -0.2 to +0.2 V
 -0.1 to +0.1 V

-0.05 to +0.05 V **This range applies to WBK 10A only.**

Programmable Gain Amplifier Gain Ranges: ×1, 2, 5, 10, 20, 50, 100

Accuracy and Noise Specifications

Voltage Range	WaveBook/516 Series (Alone)			WaveBook/516 Series with a WBK12A or a WBK13A (Note 3)			
	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms DC-500KHz (typical) (Note 4)	Accuracy (Note 2) One Year, 18-28°C		Input Noise LSB rms (typical)	
	± % reading	± % range		± % reading	± % range	1KHz Filter	Filter Bypass
0 to +10V	.012%	.008%	2	.012%	.008%	2.2	2.2
0 to +5V (10A) 0 to +4V (516)	.012%	.009%	2	.012%	.009%	2.2	2.2
0 to +2V	.012%	.012%	3	.012%	.012%	2.2	3
0 to +1V (10A only)	.012%	.018%	3	.012%	.018%	2.2	3
0 to +.5V				.018%	.033%	2.2	6
0 to +.2V				.018%	.08%	2.2	12
0 to +.1V				.018%	.16%	2.2	20
-10 to +10V	.012%	.008%	2	.012%	.008%	2.2	2.2
-5 to +5V	.012%	.008%	2	.012%	.008%	2.2	2.2
-2 to +2V	.012%	.009%	2	.012%	.009%	2.2	3
-1 to +1V	.018%	.012%	3	.018%	.012%	2.2	3.3
-.5 to +.5V (10A only)	.018%	.018%	5	.018%	.018%	2.2	6
-.2 to +.2V				.018%	.033%	2.2	12
-.1 to +.1V				.018%	.08%	2.2	20
-.05 to +.05V (10A only)				.018%	.16%	4	40

- Notes:**
1. Specifications assume differential input scan, unfiltered
 2. Accuracy specification is exclusive of noise.
 3. Unipolar ranges are unavailable for a WaveBook/516 Series with a WBK11A, WBK12A, or WBK13A option installed. Unipolar mode is available with WBK10A and any option.
 4. **Maximum limit is 1.3X typical.**

Predicting Amplitude Loss

The following equations can be used to predict the amplitude loss when passing a signal through either the anti-alias or clock suppression filter.

Definition of equation terms:

Fin is the signal to be measured.

Falias is the cutoff frequency of the anti-alias filter.

Fclock is the cutoff frequency of the clock suppression filter.

$$\text{Err} = 20 \cdot \log \left(\frac{1}{\sqrt{1 + \frac{\text{Fin}}{\text{Falias}}}} \right)$$

$$\text{Err} = 20 \cdot \log \left(\frac{1}{\sqrt{1 + \frac{\text{Fin}}{\text{Fclock}}}} \right)$$

Total error, in dB, due to both filters is :

$$\text{Etot} = 20 \cdot \log \left[\left(\frac{1}{\sqrt{1 + \frac{\text{Fin}}{\text{Falias}}}} \right) \cdot \left(\frac{1}{\sqrt{1 + \frac{\text{Fin}}{\text{Fclock}}}} \right) \right]$$

As an example, with the switched capacitor filter set to 10,000 Hz. and the input frequency set to 6000 Hz.

$$\text{Fin} = 6000$$

$$\text{Falias} = 33554$$

$$\text{Fclock} = 14848$$

$$\text{Total amplitude loss} = \text{sum of both errors} = -2.188 \text{ dB.}$$

$$\text{E1} := 20 \cdot \log \left(\frac{1}{\sqrt{1 + \frac{6000}{33554}}} \right)$$

$$\text{E1} = -0.71446$$

$$\text{E2} := 20 \cdot \log \left(\frac{1}{\sqrt{1 + \frac{6000}{14848}}} \right)$$

$$\text{E2} = -1.47396$$

$$\text{E1} + \text{E2} = -2.18843$$

$$\text{Etot} := 20 \cdot \log \left[\left(\frac{1}{\sqrt{1 + \frac{6000}{33554}}} \right) \cdot \left(\frac{1}{\sqrt{1 + \frac{6000}{14848}}} \right) \right]$$

$$\text{Etot} = -2.18843$$

$$\text{Fx} := 1, 2.. 8000$$

$$\text{Fp} := 33554$$

$$\text{Fc} := 14848$$

$$\text{E}(\text{Fx}) := 20 \cdot \log \left[\left(\frac{1}{\sqrt{1 + \frac{\text{Fx}}{\text{Fp}}}} \right) \cdot \left(\frac{1}{\sqrt{1 + \frac{\text{Fx}}{\text{Fc}}}} \right) \right]$$



WBK12A & WBK13A, Amplitude Loss in dB due to Anti-alias and Clock Filters

Input signal is swept from 1 to 8000 Hz
switched capacitor filter frequency = 8,000 Hz
anti-alias filter cutoff = 33.554 Hz
clock filter = 14,848 Hz

Description..... 1

Current Source	2
High-Pass Filter (HPF)	2
Programmable Gain Amplifier (PGA)	2
Programmable Low-Pass Filter Phase Equalizer	3
Programmable Low-Pass Anti-Aliasing Filter.....	2
Simultaneous Sample and Hold.....	3
Excitation Source	3
Calibration	3

Hardware Setup 4

Configuration.....	4
Power.....	4
Assembly.....	4

Software Setup 5**Using Accelerometers with WBK14 6**

Overview	6
Accelerometer Specification Parameters	6
Electrical Grounding.....	8
Cable Driving.....	8

WBK14 – Specifications 9

Description

The WBK14 is a dynamic analog signal input module for the WaveBook data acquisition system. The WBK14 provides a complete system to interface to piezoelectric transducers that include accelerometers, microphones, force/pressure transducers, and others.

**Reference Note:**

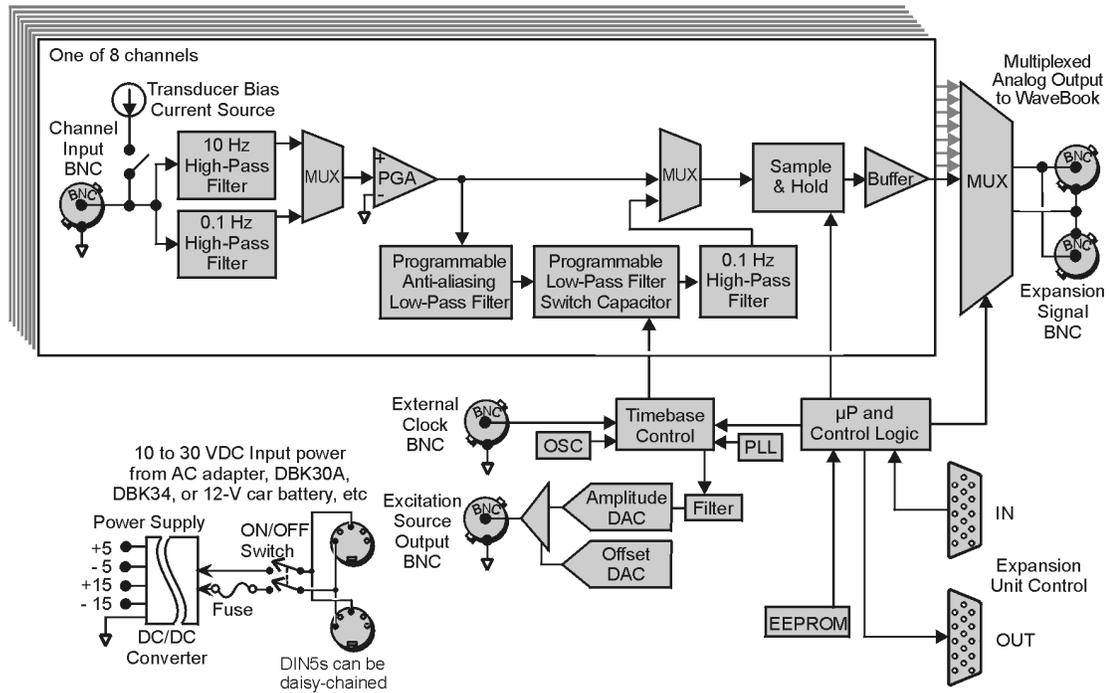
Information regarding [accelerometers](#) begins on page 6 of this document module.

Each WBK14 channel has a:

- current source for transducer biasing
- high-pass filter
- programmable gain amplifier
- anti-aliasing low-pass filter
- simultaneous sample-and-hold (SSH) amplifiers

The gain, filter cut-off frequencies and current biasing levels are software programmable.

WBK14 includes a built-in programmable excitation source. This source stimulates dynamic systems for transfer function measurements, and serves as a reference signal for calibration.



WBK14 Block Diagram

Current Source

WBK14 provides constant current to bias ICP transducers. Two current levels (2 mA or 4 mA) with voltage compliance of 27 V can be selected via software. The bias current is sourced through the center conductor of a coaxial lead and returns to the WBK14 by the outer conductor. The output impedance is larger than 1 MΩ and presents virtually no loading effect on the transducer's output. For applications that do not require bias, the current source can be removed from the BNC input by opening a relay contact. The current sources are applied to (or removed from) the input in channel groups of two; i.e., channels 1-2, 3-4, 5-6, 7-8.

High-Pass Filters (HPF)

Each WBK14 channel has three High-Pass Filters (HPFs) with a 3-dB cut-off frequency (F_c). Two filters are at 0.1 Hz and the other is 10 Hz. The 0.1-Hz HPF filters are single-pole RC filters. They are primarily used to couple vibration signals. The 10-Hz HPF is a 2-pole Butterworth type that can be used to couple acoustic signals or attenuate setup-induced low-frequency signals; since these can reduce the dynamic range of the measurement (for example when using tape recorders as signal sources).

Programmable Gain Amplifier (PGA)

The HPF removes the DC voltage from the input signal. A PGA amplifies the AC voltage with flat response up to 500 kHz. Each channel has a PGA with programmable gains (1, 2, 5, 10, 20, 50, and 100) and a software-controlled DAC for offset nulling. The WBK14 measures only bipolar signals up to 5 V peak.

Programmable Low-Pass Anti-Aliasing Filter

The first filter stage is a programmable 2-pole continuous-time low-pass filter. The filter provides more than 65 dB alias protection to the next filter stage. In addition, it fine-tunes the phase shift of the channel to optimize the phase-matching between channels. At calibration, the phase shift of each channel is measured and stored in an EEPROM that is read at configuration.

Programmable Low-Pass Filter, Switch-Capacitor

Most of the signal alias rejection is performed by an 8-pole Butterworth filter. This filter is implemented with a switch-capacitor network driven by a programmable clock (timebase control). Each channel has an independent clock whose frequency determines the 3-dB cut-off frequency of the filter. The switch-capacitor filter provides no attenuation at the clock frequency—hence, the need for the continuous-time low-pass filter.

Note: The Low-Pass Anti-Aliasing Filter can be bypassed to process signals with a bandwidth higher than 100 kHz.

The External Clock input provides a path to externally control the cut-off frequency of the Low-Pass Anti-Aliasing Filter. The input waveform can be TTL or sinusoidal, with an amplitude peak of at least 500 mV. In this mode, the cut-off frequency is set to the input frequency divided by 50.

Simultaneous Sample and Hold

All WBK14 channels are sampled simultaneously, after which the WaveBook measures each output at 1 μ s/channel until all channels are digitized. The time-skew between sampling on all channels (up to 72) is 150 ns, regardless of the number of WBK14s attached to the WaveBook.



When using WaveBook with an SSH channel enabled, the per-channel sample rates are reduced. The rate reduction is the same as that which would occur if another channel were added. The per-channel rate (with SSH enabled) is:

$1 \text{ MHz} / (n+1)$, where n is the number of active channels.

Excitation Source

The excitation source includes a sine/random waveform generator, a programmable gain amplifier (PGA), a DC-level DAC, and a phase-lock loop (PLL). The PLL is used to synthesize the frequency of a fixed-amplitude sine wave and control the bandwidth of the random signals. The PGA conditions the signal amplitude to a value between 0 V to 5 V peak. The DC level of the signal is varied independently of signal amplitude by a software-controlled DAC from -5 V to +5 V. The DC level of the excitation signal can be used to balance static loads, while the AC signal provides the dynamic excitation.

Calibration

WBK14 is calibrated digitally, eliminating the need for all potentiometers and manual adjustments. *WaveCal*, a provided Windows-based program, simplifies the calibration process.



Reference Note:

The calibration program is detailed in the [WaveCal Document Module](#).

Hardware Setup

CAUTION



If the following two conditions exist *simultaneously*:

- operating WBK14s in a configuration of 4 or more modules
- ambient temperature $\geq 40^{\circ}\text{C}$;

then you must mount the modules on their side (vertically) to facilitate air flow through the side plates. Failure to do so could result in thermal-related problems.

Configuration

All WBK14 configurations are controlled by software. The WBK14 requires no hardware settings.



Reference Notes:

- Setup information pertaining to power, expansion control, and expansion signal connections is contained in the chapter *System Setup and Power Options*, in the *WaveBook User's Manual* (p/n 489-0901).
- For detailed WaveView information, refer to the *WaveView* document PDF. The document can be accessed from the data acquisition CD via the <View PDFs> button on the opening screen.

Power

Like the WaveBook, the WBK14 contains an internal power supply. The unit can be powered by an included AC power adapter or from any 10 to 30 VDC source, such as a 12 V car battery. For portable or field applications, the WBK14 and the WaveBook can be powered by the DBK30A rechargeable battery module or the DBK34 uninterruptible power supply (UPS) / battery module.



You must compute power consumption for your entire system and (if necessary) use auxiliary or high-current power supplies.



Reference Note:

For details regarding power, refer to the chapter, *System Setup and Power Options*, in the *WaveBook User's Manual* (p/n 489-0901).

Assembly

The WBK14 shares the same footprint as other WBK modules and WaveBooks, allowing for convenient mounting. A fastener panel allows multiple units to be stacked vertically. Screw-on handles are available for portable applications. For more assembly information refer to this manual's introduction.

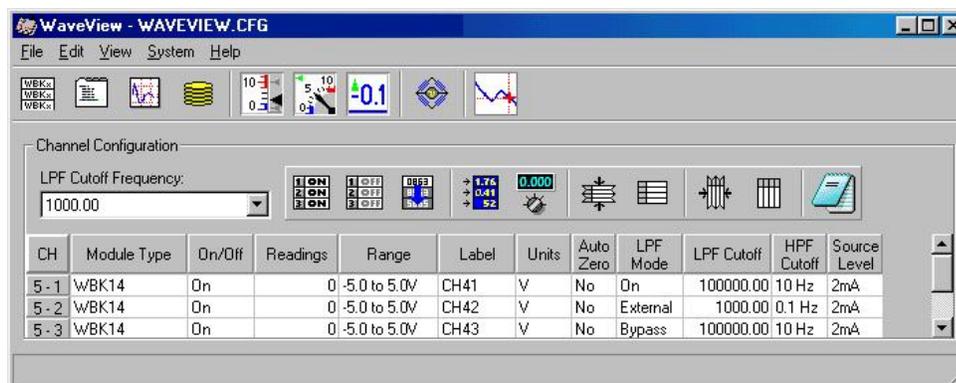
Software Setup

Depending on your application, you will need to set several software parameters. Proper settings will allow *WaveView* to organize data to meet your requirements. Some items of importance to the WBK14 are the **low-pass** and **high-pass filter options** that can be selected from the *WaveView Configuration* main window and the **excitation source** parameters that can be chosen from the *Module Configuration* window. The *Module Configuration* window can be accessed from the View pull-down menu or by use of the first toolbar button (located just below the File pull-down menu).



Reference Note:

For detailed *WaveView* information, refer to the *WaveView Document PDF*. The document can be accessed directly from the data acquisition CD via the <View PDFs> button on the opening screen.



WaveView Configuration Window

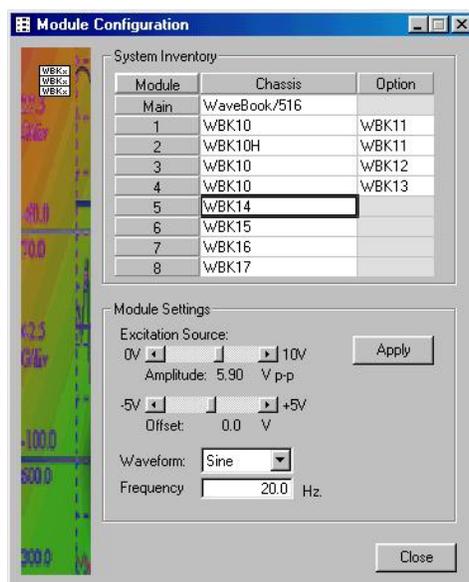
In the *WaveView Configuration* main window (see figure) the following columns are important in regard to filters.

LPF Mode – You can click on a cell in the LPF Mode column to make the cell “active,” and then change its setting. Options for WBK14’s LPF Mode are:

- (a) **On** – turns the Low-Pass Filter on
- (b) **External** – selects an external filter
- (c) **Bypass** – bypasses the low-pass filter

LPF Cutoff – the cells in this column are used to set the Low-Pass Filter cutoff frequency.

HPF Cutoff – the cells in this column are used to set the High-Pass Filter cutoff frequency.



Module Configuration Window

For WBK14 applications, the *Module Configuration* window allows you to set the **excitation source** in regard to:

- amplitude
- offset
- waveform (Sine, or Random)
- frequency

The *Module Configuration* window can be accessed from the View pull-down menu or by use of the first toolbar button (located just below the File pull-down menu).

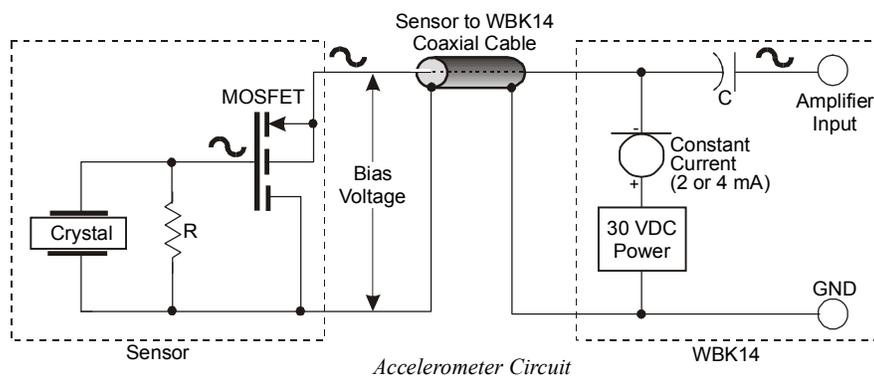
Using Accelerometers with WBK14

Overview

A low-impedance piezoelectric accelerometer consists of a piezoelectric crystal and an electronic amplifier. When stretched or compressed, the two crystal surfaces develop a charge variation that is related to the amount of stress, shock, or vibration on the crystal. The amplifier outputs a corresponding signal and transforms the sensor's high impedance to a lower output impedance of a few hundred ohms. Note that, in addition to acceleration, these sensors can also measure pressure and force.

The circuit requires only two wires (coax or twisted pair) to transmit both power and signal. At low impedance, the system is insensitive to external or "triboelectric" cable noise. Cable length does not affect sensitivity.

The following figure shows a simple sensor-WBK14 connection. The voltage developed across R is applied to the gate of the MOSFET. The MOSFET is powered from a constant current source of 2 or 4 mA and 27 volts.



The MOSFET circuit will bias off at approximately 12 V in the quiet state. As the system is excited, voltage is developed across the crystal and applied to the gate of the MOSFET. This voltage will cause linear variation in the impedance of the MOSFET and a proportional change in bias voltage. This voltage change will be coupled to the WBK14 input amplifier through the capacitor C. The value of R and the internal capacitance of the piezoelectric crystal control the low frequency corner. Units weighing only a few grams can provide high level outputs up to 1 V/g with response to frequencies below 1 Hz.

Accelerometer Specification Parameters

Noise in Accelerometers

The noise floor or resolution specifies lowest discernible amplitude (minimum "g") that can be measured. There are two main sources of noise as follows:

- **Noise from the crystal and microcircuit inside the accelerometer.** Some types of crystals, such as quartz, are inherently more noisy than others. A good noise floor is 10 to 20 μ V.
- **Noise from electrical activity on the mounting surface.** Since the signal from the accelerometer is a voltage, 60 Hz or other voltages (ground loop, etc) can interfere with the signal. The best protection is to electrically isolate the accelerometer.

Sensitivity

The sensitivity of an accelerometer is defined as its output voltage per unit input of motion. The unit of motion used is "g." One "g" is equal to the gravitational acceleration at the Earth's surface, which is 32.2 ft/(sec)(sec) or 981 cm/(sec)(sec). The output is usually specified in millivolts per "g" (mV/g).

Sensitivity is usually specified under defined conditions such as frequency, testing levels, and temperature. An example: 100 mV/g at a frequency of 100 Hz, level +1 g, at 72°F. Note that, although a sensor may have a "typical" sensitivity of 100 mV/g, its actual sensitivity could range from 95 to 105 mV/g (when checked under stated conditions). Manufacturers usually provide sensor calibration values.

Transverse Sensitivity - An accelerometer is designed to have one major axis of sensitivity, usually perpendicular to the base and co-linear with its major cylindrical axis. The output caused by the motion perpendicular to the sensing axis is called *transverse sensitivity*. This value varies with angle and frequency and typically is less than 5% of the basic sensitivity.

Base-Strain Sensitivity - An accelerometer's *base-strain sensitivity* is the output caused by a deformation of the base, due to bending in the mounting structure. In measurements on large structures with low natural frequencies, significant bending may occur. Units with low *base-strain sensitivity* should be selected. Inserting a washer (smaller in diameter than the accelerometer base) under the base reduces contact surface area; and can substantially reduce the effects of base-strain. Note that this technique lowers the usable upper frequency range.

Acoustic Sensitivity - High-level acoustic noise can induce outputs unrelated to vibration input. In general, the effect diminishes as the accelerometer mass increases. Use of a light, foam-rubber boot may reduce this effect.

Frequency Response

An accelerometer's frequency response is the ratio of the sensitivity measured at frequency (f) to the basic sensitivity measured at 100 Hz. This response is usually obtained at a constant acceleration level, typically 1 g or 10 g. Convention defines the usable range of an accelerometer as the frequency band in which the sensitivity remains within 5% of the basic sensitivity. Measurements can be made outside these limits if corrections are applied. Care should be taken at higher frequencies because mounting conditions greatly affect the frequency range (see *Mounting Effects*, in upcoming text).

Dynamic Range

The dynamic measurement range is the ratio of the maximum signal (for a given distortion level) to the minimum detectable signal (for a given signal-to-noise ratio). The dynamic range is determined by several factors such as sensitivity, bias voltage level, power supply voltage, and noise floor.

Bias Level

Under normal operation, a bias voltage appears from the output signal lead to ground. There are two basic MOSFET configurations commonly used. One exhibits a 7-8 V bias and the second a 9-12 V bias. Operation of the two circuits is identical except for the available signal swing. The low-voltage version typically exhibits 5-10 μV_{rms} versus 10-20 μV_{rms} for the high voltage.

Thermal Shock - Temperature Transients

Piezoelectric accelerometers exhibit a transient output that is a function of a temperature's "rate-of-change." This "thermal shock" is usually expressed in $\text{g}/^\circ\text{C}$ and is related to:

- Non-uniform mechanical stresses set up in the accelerometer structure.
- A pyroelectric effect in piezoelectric materials—an electrical charge is produced by the temperature gradient across the crystal.

This quasi-static effect produces a low-frequency voltage input to the MOSFET amplifier. This voltage is usually well below the low-frequency corner, but the effect can reduce the peak clipping level and cause loss of data. This effect does not affect the accelerometer's basic sensitivity or the data unless the thermal shift in the operation bias level results in clipping. Where drastic thermal shifts are expected, use 12 V bias models. The effect's severity is related to the mass of the accelerometer. In 100 mV/g industrial units, the effect is usually negligible. Using rubber thermal boots can reduce the effect significantly.

Overload Recovery

Recovery time from clipping due to over-ranging is typically less than 1 ms. Recoveries from quasi-static overloads that generate high DC bias shifts are controlled by the accelerometer input RC time constant that is fixed during manufacture.

Power Supply Effects

The nominal power supply voltage recommended by most manufacturers is 15 to 24 V. Units may be used with voltages up to 28 volts. Sensitivity variations caused by voltage change is typically 0.05%/volt. Power supply ripple should be less than 1 mV_{rms}.

Connector

This parameter specifies the connector type and size (4-48, 6-40, 10-32 coaxial etc) and the location on the sensor, that is, top or side (usually on the hex base). Where there is no connector on the sensor, an integral cable is specified with the length and the connector, that is, integral 6-ft to 10-32.

Electrical Grounding

Case-Grounded Design

In case-grounded designs, the common lead on the internal impedance matching electronics is tied to the accelerometer case. The accelerometer base/stud assembly forms the signal common and electrically connects to the shell of the output connector. Case-grounded accelerometers are connected electrically to any conductive surface on which they are mounted. When these units are used, take care to avoid errors due to ground noise.

Isolated-Base Design

To prevent ground noise error many accelerometers have base-isolated design. The outer case/base of the accelerometer is isolated electrically off ground by means of an isolation stud insert. The proprietary material used to form the isolation provides strength and stiffness to preserve high-frequency performance.

Cable Driving

Operation over long cables is a concern with all types of sensors. Concerns involve cost, frequency response, noise, ground loops, and distortion caused by insufficient current available to drive the cable capacitance.

The cost of long cables can be reduced by coupling a short (1 m) adapter cable from the accelerometer to a long low-cost cable like RG-58U or RG-62U with BNC connectors. Since cable failure tends to occur at the accelerometer connection where the vibration is the greatest, only the short adapter cable would need replacement.

Capacitive loading in long cables acts like a low-pass, second-order filter and can attenuate or amplify high-frequency signals depending on the output impedance of the accelerometer electronics. Generally this is not a problem with low-frequency vibration (10 Hz to 2000 Hz). For measurements above 2000 Hz and cables longer than 100 ft, the possibility of high-frequency amplification or attenuation should be considered.

The WBK14 constant-current source provides 2 or 4 mA to integral electronics. Use the higher current setting for long cables, high peak voltages, and high signal frequencies.

The maximum frequency that can be transmitted over a given length of cable is a function of both the cable capacitance and the ratio of the maximum peak signal voltage to the current available from the constant current source:

Drive Current (mA)	Cable Length @30 pF/ft (Ft)	Frequency Response to 5% of Maximum Output Signal Amplitude	
		± 1 V	± 5 V
2	10	185 kHz	37 kHz
2	100	18.5 kHz	3.7 kHz
2	1000	1.85 kHz	370 Hz
4	10	550 kHz	110 kHz
4	100	55 kHz	11 kHz
4	1000	5.5 kHz	1.1 kHz

Where:

f = Maximum frequency in Hz

$K = 3.45 \times 10^9$. K is the scale factor to convert Farads to picoFarads and Amperes to milliAmperes and a factor to allow cable capacitance to charge to 95% of the final charge.

C = Cable capacitance in picoFarads

V = Maximum peak measured voltage from sensor in volts

I_{cc} = Constant current from current source in mA

I_b = Current required to bias the internal electronics, typically 1 mA

$$f = \frac{K}{2\pi C \left(\frac{V}{I_{cc} - I_b} \right)}$$

WBK14 – Specifications

Name/Function: WBK14, 8-Channel Dynamic Signal Conditioning Module

Connectors: BNC connector, mates with expansion signal input on the WaveBook/512, /512A, /516, /516A, or /516E.

Two 15-pin connectors, mate with expansion signal control on the WaveBook; signals via 1 BNC per channel

Channels: 8

Gain Ranges: ×1, 2, 5, 10, 20, 50, 100

Power Consumption: 15 Watts typical

Input Power Range: 10 to 30 VDC

Operating Temperature: 0°C to 50°C

Storage Temperature: 0°C to 70°C

Dimensions: 216 mm wide × 279 mm long × 35 mm high (8.5" × 11" × 1.375")

Weight: 1.32 kg (2.9 lb)

ICP Current Source:

Output Impedance: > 1.0 MΩ @ 20 kHz

Compliance: 27 V

Current Levels: 2 & 4 mA

Coupling : AC

10 Hz High-Pass Filter - Input Impedance: 590K

0.1 Hz High-Pass Filter - Input Impedance: 10 MΩ

Input Ranges:

±5.0 V, ±2.5 V, ±1.0 V, ±500 mV, ±250 mV, ±100 mV, ±50 mV

Anti-Aliasing Low-Pass Filter:

Accuracy: ±0.5 dB at the pass-band center

Frequency Span: 30 Hz to 100 kHz

Frequency Settings: 300 kHz / N; N = 3,4,...10000

Dynamic Range @ 1 kHz: 69 dB

THD @ 1 kHz: 70 dB

Amplitude Matching: ± 0.1 dB

Phase Matching: ± 2°

Excitation Source:

Max. Output Voltage: ± 10 V

Max. Output Current: 10 mA

DC Output: ± 5 V

Sine:

Frequency: 20 Hz to 100 kHz

Distortion: < 0.1%

Amplitude: ± 5 V

Steps: 256

Random:

Spectral Distribution: White, Band-limited

Amplitude Distribution: Gaussian

Bandwidth: 20 Hz to 100 kHz

RMS level: Adjustable in binary steps

External Clock:

Digital: TTL levels

Sine: > 500 mV peak

Description 1**Hardware Setup 2**

Configuration 2

Connection 3

Power 4

Safety Concerns 4

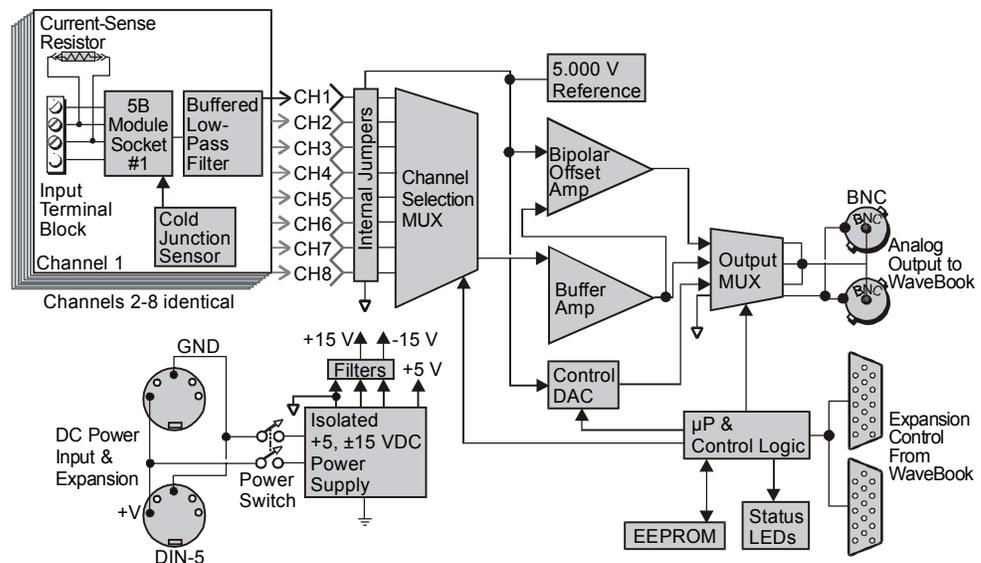
Using Fastener Panels to Stack Modules 4

Software Setup 5**WBK15 – Specifications 7****Description**

The WBK15 module can accommodate eight 5B isolated-input signal-conditioning modules for use with the WaveBook. The WaveBook can accommodate 8 WBK15s for a maximum of 64 expansion channels. The WaveBook scans WBK15's channels at the same 1 μ s/channel rate that it scans all WBK analog inputs, allowing it to measure all channels of a fully configured 72-channel system in 72 μ s.

Other features of WBK15 include:

- Built-in power supply that operates from 10 to 30 VDC and can power a full complement of 5B modules (even with bridge excitation).
- Removable, plug-in screw-terminal blocks for convenient connection of 5B modules.
- On-board cold-junction sensing for thermocouple 5B modules.
- For each 5B module, 1500 V isolation from the system and from other channels.



WBK15 Block Diagram

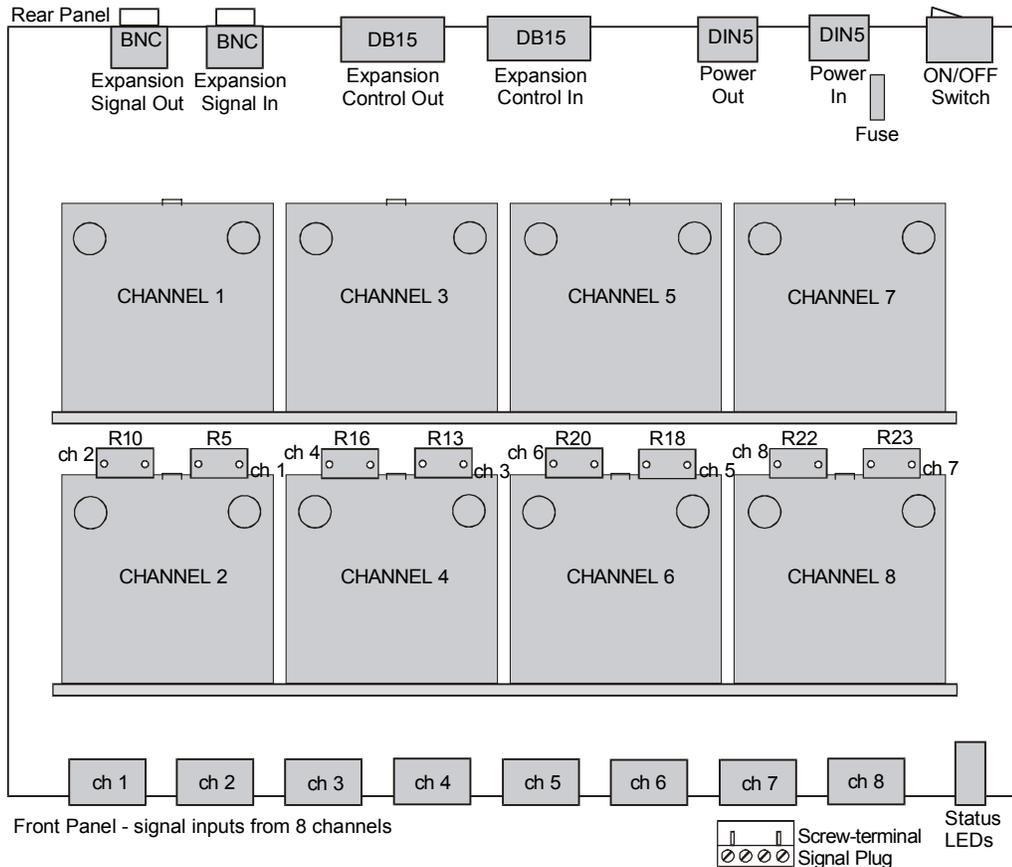
Hardware Setup

Configuration

The next figure shows the board layout within a WBK15. Note the channel-number layout for the 5B modules and the location for plug-in current-sense resistors.



**Only current-input type modules require the plug-in resistors.
The plug-in resistors must be removed for all other module types.**



WBK15 Board Layout

Installation of 5B Modules

WARNING



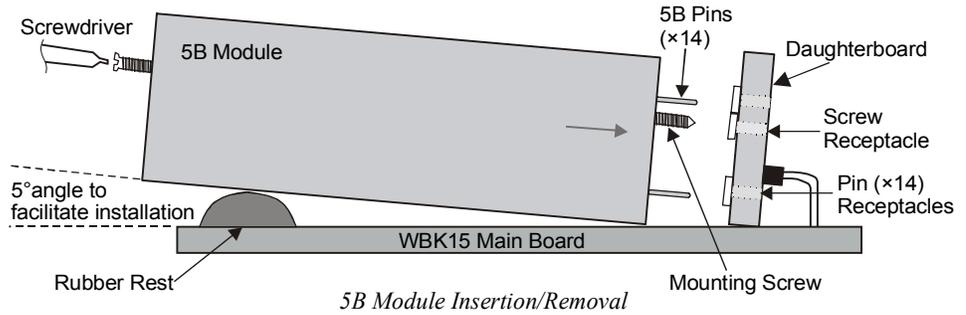
Electric shock hazard! Turn off power to WBK15 and all connected modules and devices before inserting or removing modules. Failure to do so could lead to injury or death due to electric shock.

CAUTION



Handle the 5B module carefully while inserting pins into the daughterboard. Do not over-tighten mounting screw.

The 5B modules plug into a daughterboard (×2) on WBK15's motherboard. Rubber bumpers on one side and a tilted daughterboard allow the module to rest at a 5° angle to facilitate insertion and removal. The adjacent daughterboard has a cut-a-way to allow room for a screwdriver (see figure).



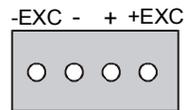
Connection

WARNING



Electric shock hazard! De-energize circuits connected to WBK15 before changing the wiring or configuration. Failure to do so could lead to injury or death due to electric shock.

Signals are connected by screw-terminal signal plugs that plug into the 4-pin jacks on WBK15's front panel (see figure).

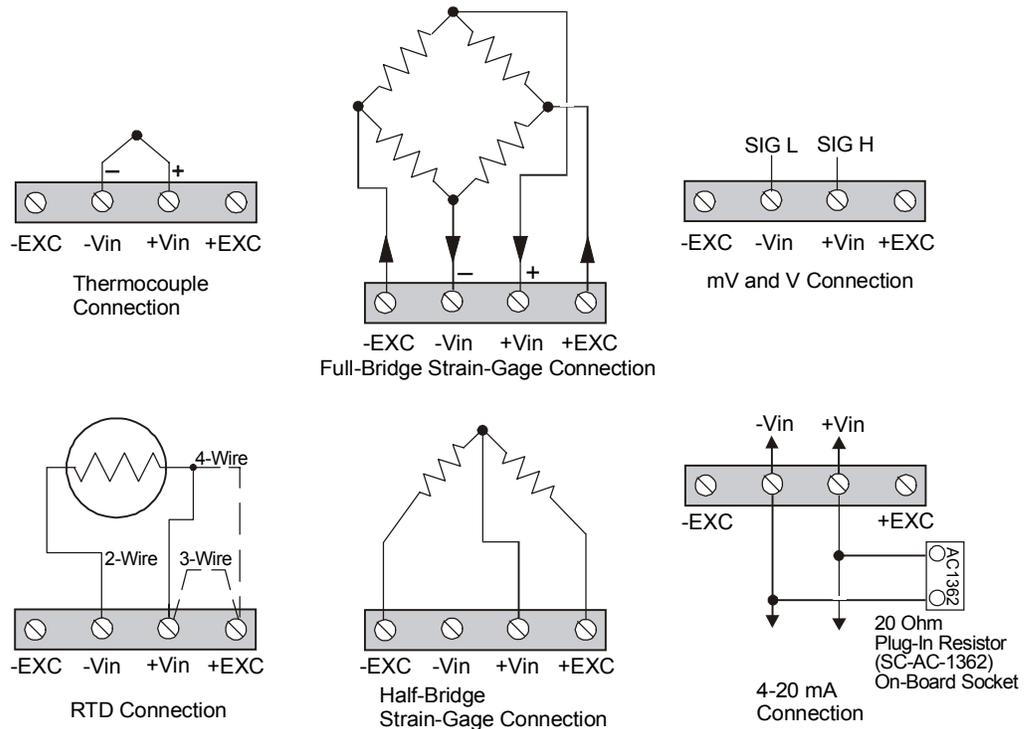


- EXC Negative excitation output - only used on strain-gage type modules
- Negative signal input
- + Positive signal input
- +EXC Positive excitation output - only used on strain-gage type modules

Signal Connection Jacks (per channel)

Input signals (and excitation leads) must be wired to the plug-in terminal blocks. Eight 4-terminal blocks accept up to 8 inputs.

Terminal blocks are connected internally to their corresponding signal conditioning module. The terminal blocks accept up to 14-gage wire into quick-connect screw terminals. Each type of input signal or transducer (such as a thermocouple or strain gage) should be wired to its terminal block as shown in the figure below. Wiring is shown for RTDs, thermocouples, 20mA circuits, mV/V connections, and for full- and half-bridge strain gages.



Typical Signal Connections

Power

Like the WaveBook, WBK15 contains an internal power supply. The unit can be powered by the included AC power adapter or any 10 to 30 VDC source, such as a 12 V car battery. For portable or field applications, WBK15 and the WaveBook can be powered by the DBK30A rechargeable battery module or DBK34 vehicle UPS module. The supply input is fully isolated from the measurement system. If the fuse requires replacement, it is a 2 A fuse (Littelfuse #251002).



Prior to daisy-chaining from one module's power connector to another, be sure to compute the power consumption for the entire system. Some modules may need independent power adapters. The WaveBook manual's chapter entitled, *System Setup and Power Options* contains detailed information regarding power supply issues.

Safety Concerns

WARNING



Shock Hazard! Voltages above 50 Vrms AC and voltages above 100 VDC are considered hazardous. Safety precautions are required when 5B modules are used in situations that require high-voltage isolation from the rest of the system. Failure to practice electrical safety precautions could lead to injury or death.

WBK15 is specified for 1500 VDC isolation in a normal environment free from conductive pollutants and condensation. The 1500 VDC rating requires a proper earth ground connection to the chassis and treatment of adjacent inputs as potentially hazardous. CE-marked units used in the European community are rated at 600 VDC isolation. The 600 VDC CE isolation specification is based on a double insulation requirement, and no earth ground is required.

Input cables must be rated for the isolation potential in use. Line voltage ratings are much lower than the DC isolation values specified due to transients that occur on power lines. Never open the lid unless all inputs with potentially hazardous voltages are removed. The lid must be securely screwed on during use.

Some things to remember:

- Before closing up an open WBK15, ensure no foreign objects are inside.
- Properly tighten all chassis screws before system use.
- Properly tighten the screw that retains the 5B module.
- Never plug in or unplug potentially hazardous connections with power applied to any connected equipment.
- Never attempt to change 5B modules or open the lid with power applied to the WBK15. You could short out internally exposed circuits and cause personal injury or equipment damage.



Reference Note:

Refer to the *System Setup and Power Options* chapter of the *WaveBook User's Manual* for detailed information regarding the power aspects of WaveBook systems.

Using Fastener Panels to Stack Modules

For convenient mounting, the WBK15 has the same footprint as other WBK modules and WaveBooks. Fastener panels (splice plates) provide a means for stacking WaveBooks and modules. Screw-on handles are available for portable applications.



Reference Note:

For an illustration pertaining to mounting modules with fastener panels refer to the introduction of this manual.



When using WBK17 modules in conjunction with other WBK modules, the WBK17 modules must be located closest to the WaveBook/516 (or /516A), due to the CA-217 cable length. The order of the other WBK modules does not matter.



Fastener panels will partially block the vents on WBK16, WaveBook/516, and WaveBook/516A when stacked. This partial blocking of vents does not jeopardize the cooling process.

Software Setup

You will need to set several parameters so WaveView can best meet your application requirements. For detailed WaveView information, refer to the *WaveView Document PDF*.

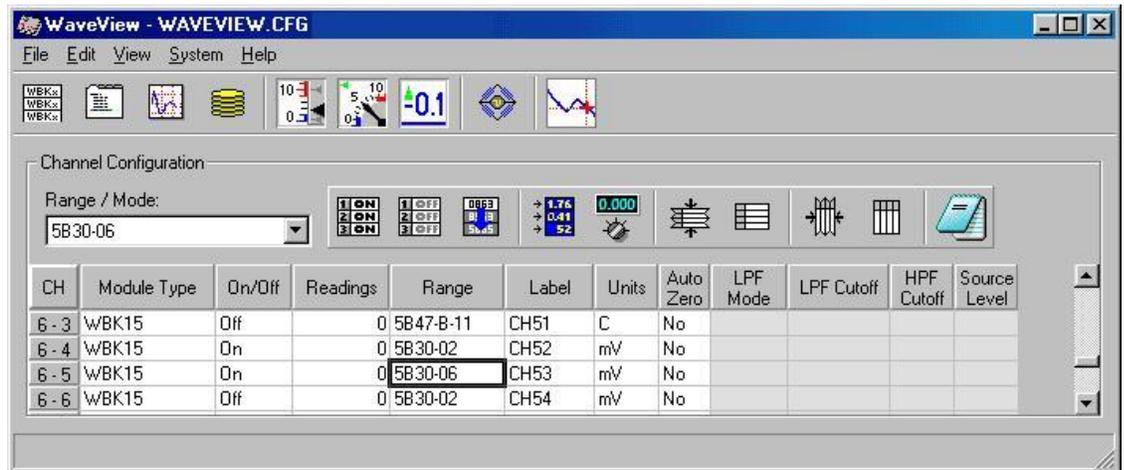
After the 5B module type is identified, WaveView figures out the m and b (of the $mx+b$ equation) for proper engineering units scaling. An example of the $mx + b$ equation follows shortly.



Reference Note:

- For detailed WaveView information, refer to the *WaveView Document PDF*.
- The API does not contain functions specific to WBK15. Refer to related material in the *Programmer's Manual* (p/n 1008-0901) as needed.

PDF Note: During software installation, Adobe® PDF versions of user manuals automatically install onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. Refer to the PDF documentation for details regarding both hardware and software. Note that you can also access PDF documents directly from the data acquisition CD via the <View PDFs> button on the CD's opening screen.



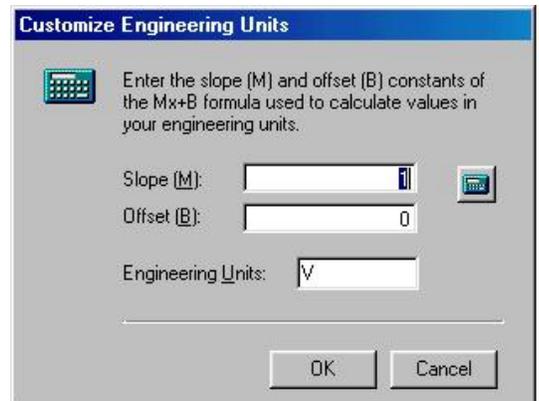
WaveView Configuration Main Window

$mX + b$, an Example

The *Customize Engineering Units* dialog box can be accessed via the *WaveView Configuration main window* by activating the **Units** cell [for the desired channel], then clicking to select $mX+b$.

From the *Customize Engineering Units* dialog box (see figure at right), you can enter values for m and b components of the equation that will be applied to the data. There is also an entry field that allows you to enter a label for the new units that may result from the $mX+b$ calculation.

An example of $mX + b$ equation use follows.



Engineering Units Conversion Using $mx + b$

Most of our data acquisition products allow the user to convert a raw signal input (for example, one that is in volts) to a value that is in engineering units (for example, pressure in psi). The products accomplish this by allowing the user to enter *scale* and *offset* numbers for each input channel, using the software associated with the product. Then the software uses these numbers to convert the raw signals into engineering units using the following “ $mx + b$ ” equation:

$$\text{Engineering Units} = m(\text{Raw Signal}) + b \quad (1)$$

The user must, however, determine the proper values of *scale* (m) and *offset* (b) for the application in question. To do the calculation, the user needs to identify two known values: (1) the raw signal values, and (2) the engineering units that correspond to the raw signal values. After this, the scale and offset parameters can be calculated by solving two equations for the two unknowns. This method is made clear by the following example.

Example

An engineer has a pressure transducer that produces a voltage output of 10.5 volts when the measured pressure is 3200 psi. The same transducer produces an output of 0.5 volt when the pressure is 0 psi. Knowing these facts, m and b are calculated as follows.

A - Write a pair of equations, representing the two *known* points:

$$3200 = m(10.5) + b \quad (2)$$

$$0 = m(0.5) + b \quad (3)$$

B - Solve for m by first subtracting each element in equation (3) from equation (2):

$$3200 - 0 = m(10.5 - 0.5) + (b - b) \quad (4)$$

Simplifying gives you: $3200 = m(10) \quad (5)$

This means: $m = 320 \quad (6)$

C - Substitute the value for m into equation (3) to determine the value for b :

$$0 = 320(0.5) + b \quad (7)$$

So: $b = -160 \quad (8)$

Now it is possible to rewrite the general equation (1) using the specific values for m and b that we just determined:

$$\text{Engineering Units} = 320(\text{Raw Signal}) - 160 \quad (9)$$

The user can then enter the values of m and b into the appropriate location using the facilities provided by compatible data acquisition software, for example: WaveView, DaqView, Personal DaqView, LogView, and TempView. The software uses equation (9) to calculate signal values in engineering units from that point on.

WBK15 – Specifications

Name/Function: WBK15 Multi-Purpose Isolated Signal Conditioning Module

Connectors: 2 BNC connectors, mate with expansion signal input on the WaveBook/512, /512A, /516, /516A, /516E; two 15-pin connectors, mate with the WaveBook's Expansion Signal Control

Module Capacity: Eight 5B modules (optional) *See latest catalog or contact your sales representative in regard to the types of 5B Modules available for your application.*

Input Connections: Removable 4-terminal plugs (Weidmuller type BL4, PN 12593.6, or type BLTOP4, PN 13360.6)

Power Requirements: 10 to 30 VDC, or 120 VAC with included adapter

With 8 thermocouple-type modules: 12 VDC @ 0.25 A, 15 VDC @ 0.20 A, 18 VDC @ 0.2 A

With 8 strain-gage-type modules: 12 VDC @ 0.95 A, 15 VDC @ 0.75 A, 18 VDC @ 0.65 A

Cold-Junction Sensor: Standard per channel

Shunt-Resistor Socket: One per channel for current loop inputs

Isolation

Signal Inputs to System: 1500 VDC (600 VDC for CE compliance)

Input Channel-to-Channel: 1500 VDC (600 VDC for CE compliance)

Power Supply to System: 50 VDC

Dimensions: 221 mm × 285 mm × 36 mm (8.5" × 11" × 1.375")

Weight: 1.8 kg (4 lb) [with no modules installed]

Description 1

Excitation Connection..... 6

Low-Pass Filter Customization 7

Configuration Diagrams..... 8

Connecting to the DB9 Channel Input Connector 12

 CA-177 Strain-Gage Cable 12

 CN-189, DB9 Adapter Option 13

Using the WBK16/LC Load Cell Shunt Cal Option..... 15

Using the CN-115-1 User-Configurable Plug-In Card Option..... 19

Software Setup 22

Sensor Calibration..... 22

 The Five Methods of Sensor Calibration..... 29

 2 Point Manual Calibration 30

 2 Point Auto Calibration 30

 Shunt (Internal Shunt) Calibration 31

 External Shunt Calibration (2 Pt Shunt) 32

 Name Plate Calibration 33

Changing Low-Pass Filter Displays 35

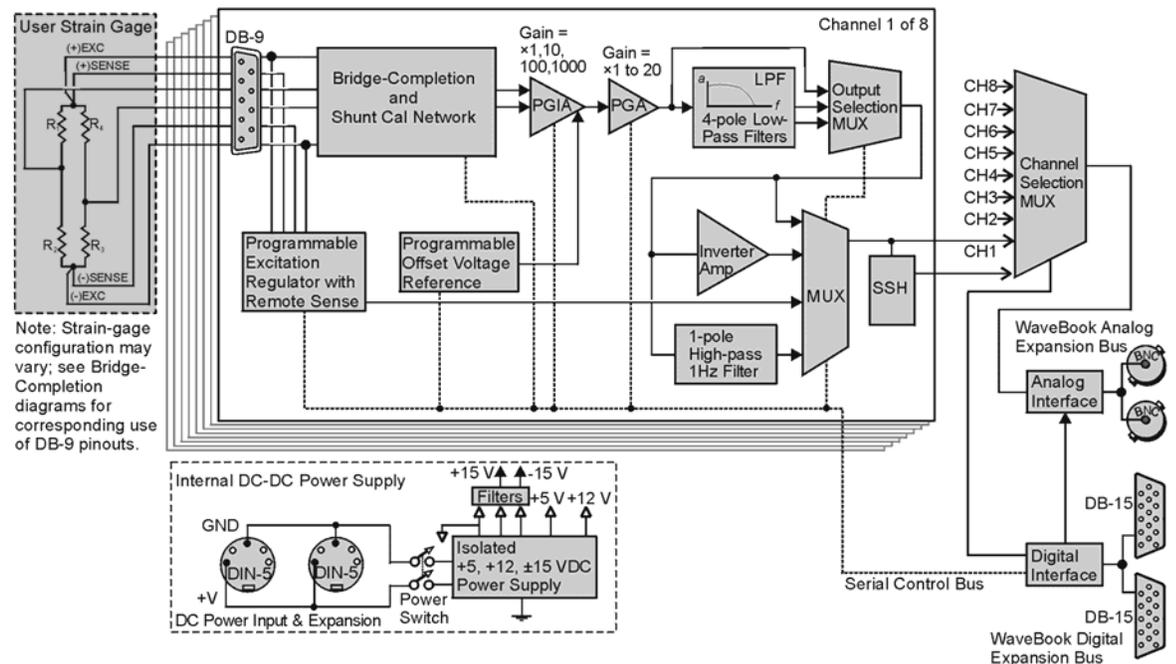
WBK16 – User Tips..... 36

WBK16 – Specifications..... 38

Description

The WBK16 is an 8-channel strain-gage signal-conditioning module for the WaveBook system. Up to eight of these modules (64 channels) can be accommodated by a WaveBook and scanned at 1 μ s/channel. Almost all bridge configurations are supported via a bridge-completion network and software. High-gain differential-amplifier applications are also supported. Software controls bridge configuration, gain, offset, excitation voltage, polarity, filtering, and the calibration process.

Refer to the following block diagram as needed while reading this section.



WBK16 Block Diagram

Channel Selection

The eight independent channels are routed to the Channel Selection MUX (multiplexer) for output to the WaveBook through the Analog Interface. The Digital Interface controls the channel-scanning process and allows digital configuration of all channels through the WaveBook's Serial Control Bus.

Excitation Source

Excitation power is programmable from a dual source—channels 1 to 4 from one source and channels 5 to 8 from another source. Each channel has a separate regulator with a fold-back current limiter. Up to 85 mA is provided at 10 V out, decreasing to 30 mA when shorted. This is sufficient current to operate 120 Ω gages at any voltage. Programmable output voltages of 0, 0.5, 1, 2, 5, and 10 volts are available. Remote-sense inputs are provided and should be connected at the strain gage for best accuracy. If they are not used, they need to be jumpered to the excitation output at the connector. The remote-sense inputs are fully differential, and may even be connected across the completion resistor to form a constant-current linearized quarter-bridge configuration.

Bridge Configuration

The strain gage is connected to the amplifiers through the Bridge Completion and Shunt Cal Network. This network consists of user installed resistors for bridge completion. Several combinations of resistors and three different shunt values may be installed simultaneously. External connector tie points and the programmable Input Configuration & Cal MUX determine the actual configuration in use. Once the network is fully configured, most bridge configurations and resistances can be accommodated without re-opening the box. The shunt resistors allow each bridge to be put into a known imbalance condition for setting or verifying channel calibration. Shunt calibration allows a full-scale gain to be set without physically loading the bridge.

Amplifiers

Each channel has an amplifier consisting of two series-connected stages. The instrumentation amplifier (PGIA) has programmable gains of x1, x10, x100, and x1000. A programmable gain amplifier (PGA) follows, with a gain range of 1 to 20 in 28% steps. This results in a combined programmable gain range of 1 to 20,000 in 28% steps. The optimal gain is automatically determined during the gage calibration process.

Offset Source

A low-drift, programmable offset voltage source with a range of ± 3.0 V is used to balance the bridge during the gage calibration process. This offset source will correct for mismatched bridge resistors and quiescent loads of the strain gage and still retain the full dynamic range.

Auto-zero removes the static portion of the strain load and zeros the input to compensate for any input drift. Because this is done electronically, zeroing is independent of the user. Simply select the channels that are to be auto-zeroed and the WBK16 will complete the task automatically.

Filters

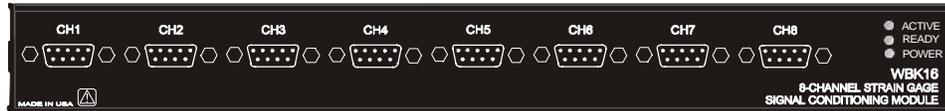
Two different 4-pole Butterworth low-pass noise rejection filters are selectable through software by the Output Selection MUX. The filters have a nominal cutoff frequency of 10 Hz and 1 kHz. Four SIP resistor networks allow you to determine two cutoff frequencies. See the *Hardware Configuration* section for details. If full bandwidth is required, a filter bypass mode is software selectable.

Output Selection

An AC coupling circuit with a 1-Hz cutoff frequency can be software selected by the MUX. This MUX can also select an Inverting Amplifier for proper output signal polarity. The Inverter avoids having to rewire the gage if the polarity is reversed. Note that the Inverter option is not available for AC-coupling modes.

Front & Rear Panels

WBK16's **front panel** has the following connectors and indicators as shown:



- 8 DB-9 connectors for bridge input
- 3 LEDs to indicate system status (Active, Ready, Power)

The **rear panel** has the power switch and the following connectors as shown:

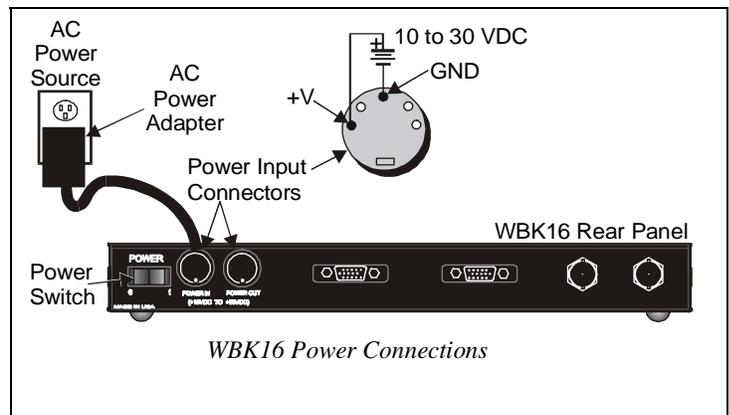


- 2 5-pin DIN5 connectors for power input and power pass-through
- 1 DB-15M expansion control input connector
- 1 DB-15F expansion control output connector
- 2 BNC connectors for analog expansion in and out

Power

WBK16 requires an input voltage between +10 and +30 VDC. The DC source should be filtered but not necessarily regulated. The TR-40U AC power adapter is recommended for AC line applications. WBK16 may be powered with the supplied AC adapter that plugs into any standard AC wall outlet or from any isolated 10-30 VDC source of at least 25 W (see figure). Before plugging unit in, make sure the power switch is in the "0" (OFF) position.

If you are using an AC power adapter, plug it into an AC outlet and attach the low voltage end to WBK16's DIN5 jack. If you are using another source of power, make sure leads are connected to the proper DIN5 terminals as shown in the figure.



CAUTION



Do not exceed the 5 amp maximum DC current limit of the POWER IN and POWER OUT DIN connectors.

Internal DC to DC converters provide properly isolated and regulated +15V, +12V, and +5V from the single 10 to 30 VDC external source. Excitation power is derived from these internal converters. An internal replaceable fuse rated at 4 A provides overload protection. For replacement, use a Littelfuse #251004. Reversed input polarity is the usual cause of a blown fuse.



Reference Note:

The WBK16 fuse (Littelfuse #251004, rated at 4A) is located on the board, between the Power Switch and the Power In connector.



Reference Note:

For details on powering WaveBook systems, refer to the WaveBook manual chapter entitled *System Setup and Power Options*.

Stacking Modules

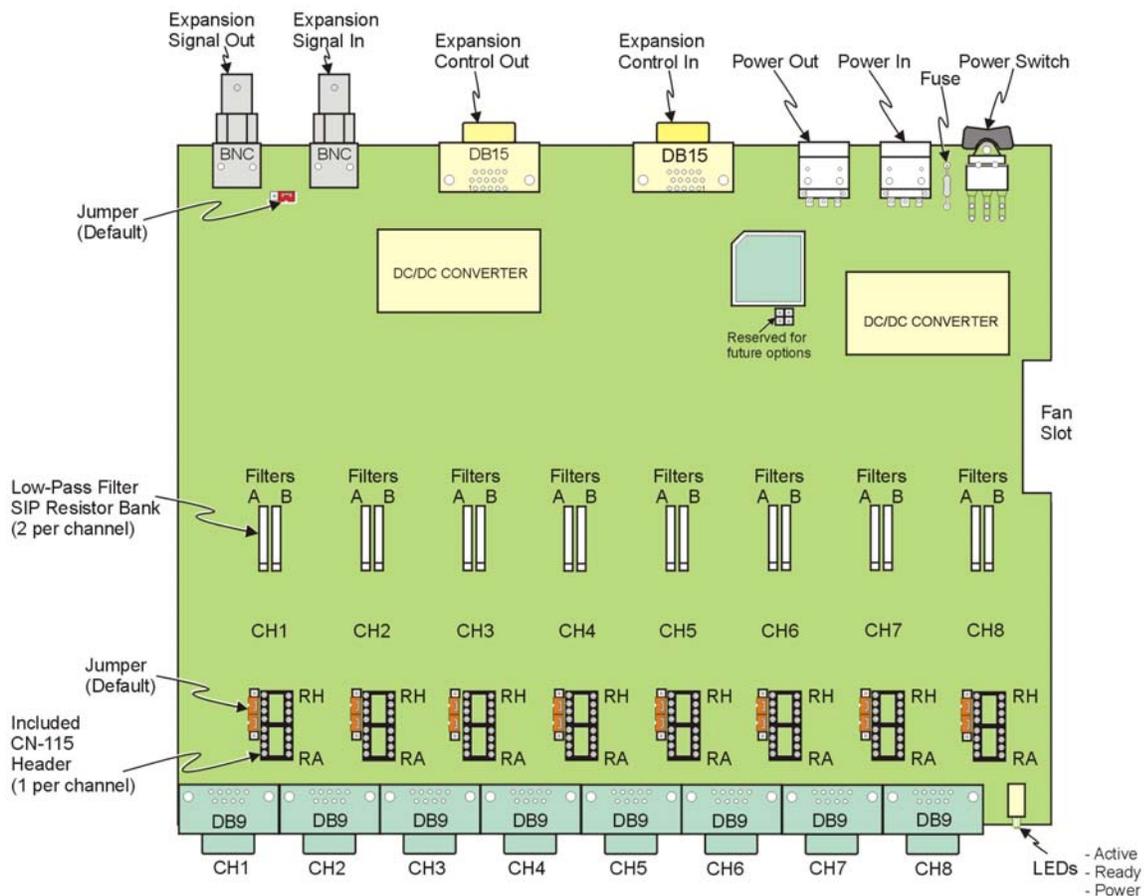
For convenient mounting, the WBK16 has the same footprint as other WBK modules and WaveBooks. Corner brackets (protective ears) provide a means for stacking WaveBooks and modules. Screw-on handles are available for portable applications.



When using WBK17 modules in conjunction with other WBK modules, the WBK17 modules must be located closest to the WaveBook/516 (or /516A), due to the CA-217 cable length. The order of the other WBK modules does not matter.

Board Layout

The following figure shows the WBK16 board layout for locating user-accessible components. You may need to refer to this figure to locate components referenced in the text. The jumper positions are not user functions, and are only shown for reference in case they are dislodged.



WBK16 Board Layout

Configuration options on WBK16 include:

- Customization of low-pass filter frequencies using resistor networks
- Bridge completion resistor installation
- Shunt calibration resistor installation

CAUTION



Be careful to avoid component damage while WBK16 enclosure is open. Always remove bridge completion headers (CN-115) from the unit before soldering resistors in the headers.



A fan draws and exhausts air through vents in the WBK16 enclosure. To maintain sufficient cooling it is important to keep the fan and vents free of obstruction.

Bridge Applications

WBK16 can accommodate many different strain-gage configurations. All strain-gage bridge configurations consist of a 4-element network of resistors. The *quarter*, *half* or *full* designation of a strain gage refers to how many elements in the bridge are strain-variable. A quarter-bridge has 1 strain-variable element; a half-bridge has 2 strain-variable elements; and a full-bridge has 4 strain-variable elements.

Full-bridges generally have the highest output and best performance. Output signal polarity is determined by whether the strain-variable resistance increases or decreases with load, where it is located in the bridge, and how the amplifier inputs connect to it. Configuration polarity is not important in WBK16, due to an internal software-selected inversion stage. This simplifies bridge configuration.

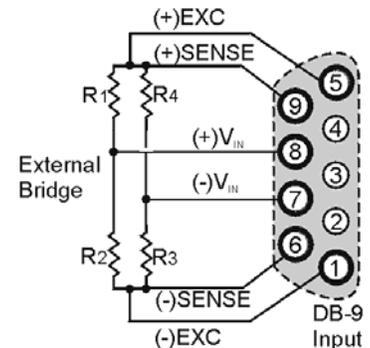
Each WBK16 channel has locations for five bridge-completion resistors. These BCR's are for use with *quarter* and *half-bridge* strain gages. The resistors make up the fixed values necessary to complete the 4-element bridge design.

A full-bridge gage requires no internal completion resistors, but they may still be installed for other configurations in use. The additional resistors will be ignored when the software has selected full-bridge mode. Both quarter- and half-bridge gages require an internal half-bridge consisting of header positions Rg and Rh. The recommended minimum values are 0.1%, <5 PPM/°C drift, 1 KΩ, and 0.25-watt resistors. Lower values will dissipate more power and add heat. Values >1KΩ will increase the amount of drift and noise. The same value half-bridge resistors can be used for any resistance strain gage. This internal half-bridge will be automatically selected by the software when needed.



Internal 1 MΩ shunt resistors are used to avoid open circuits. These resistors are not suitable for high-accuracy/low-noise applications.

A quarter-bridge gage additionally requires a resistor of equal value to itself. Up to 3 different values may be installed simultaneously in header positions Ra, Rc, Re. All of these resistors are connected to the (-) excitation terminal. An external jumper at the input connector determines which resistor is utilized. Therefore, 3 different quarter-bridge values can be supported without opening the enclosure. Each different value bridge would simply have the jumper in a different location; when the gage is plugged in, the proper resistor is then already selected. Configurations with the completion resistor on the (+) excitation are redundant, due to the internal inversion stage, and not used.



Kelvin-Type Excitation Leads

The bridge-configuration figures in the following text show various strain-gage configurations divided into 4 groups: Full-bridge, half-bridge, quarter-bridge, and high-gain voltmeter. Many of these configurations can coexist but are shown individually for clarity.

Excitation Connection

Remote sense inputs are provided for the excitation regulators. The excitation voltage will be most accurate at points where remote sense lines are connected, preferably at the bridge (this is often referred to as a 6-wire connection). Long cables will reduce the voltage at the bridge, due to current flow and wire resistance, if remote sense is not used.

If the 6-wire approach is not used, the remote sense inputs must be jumpered to the excitation outputs at the input connector. Internal 1 M Ω resistors are also connected where the jumpers would be located to prevent circuit discontinuities. These 1 M Ω resistors are not suitable for high-accuracy excitation-voltage regulation.

3-wire quarter-bridge configurations do not benefit from external remote sense connections. The lead resistance is actually a balanced part of the bridge. If the + remote sense input is connected to the + input on a quarter-bridge, the voltage is regulated across the bridge completion resistor. This results in a constant-current linearized quarter-bridge; otherwise quarter-bridges are not perfectly linear.

Shunt-Calibration Resistors. StrainBooks and WBK16s each provide three physical locations for internal shunt-calibration resistors for each channel. Each shunt resistor is switched in from the EXCITATION (-) to the IN (+) of the Instrumentation Amp by a FET switch to create a repeatable bridge imbalance. Internal resistance of the circuit is about 1 k Ω ; the exact amount is automatically accounted for in the software. The software also allows selection of the three shunt resistors (B, D, F). An internal inversion stage insures correct polarity during the shunt calibration process; which arm is shunted is therefore irrelevant. Header positions Rb, Rd, Rf correspond to the software shunt resistor selections of B, D, F.

For any balanced bridge, a resistance value can be placed in parallel with one element to create a predictable imbalance and output voltage. This shunt-resistance value can be calculated by the following equation, where V_{out} is the differential output voltage of the gage.

Example:

$$R_{Shunt} = R_{Bridge\ Arm} [(V_{Excitation} / 4 (V_{out})) - 0.5]$$

$$R_{Shunt} = 350 [(10 / 4(0.020)) - 0.5] = 43,575\Omega$$

CAUTION

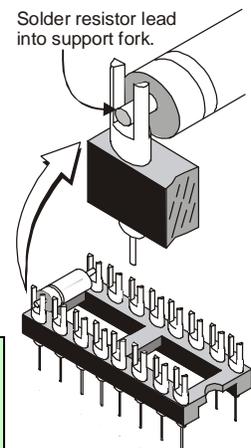


Be careful to avoid component damage while the WBK16 enclosure is open. Always remove bridge completion headers (adapter plugs) from the unit before soldering resistors in the headers.

Configuring the Bridge Completion Resistor Modules. For each channel, the board has a 2x8 resistor socket with rows designated A through H. The removable adapter plugs are included for soldering in the resistors. Additional adapter plugs are available for convenient changeover of alternate configurations. Resistor Ra is located nearest the front panel.

- Half-bridge completion resistors consist of Rg and Rh.
- Quarter-bridge completion resistors consist of Ra, Rc, and Re.
- Shunt resistors consist of Rb, Rd, and Rf.

Inserting resistors directly into the socket makes an unreliable connection and is not recommended. Remove the plug from the main board; then solder resistors to the adapter plug as indicated. To avoid damaging the pin alignment on the plug, solder with minimal heat. After soldering, the resistor leads should be snipped off close to the support.



Soldering Resistors to Adapter Plug



Reference Notes:

- ⊕ **Schematics of various bridge configurations** begin on page 8.
- ⊕ **DB9 connector information**, including use of the optional **CN-189 adapter**, is located on page 12.
- ⊕ The **WBK16/LC Load Cell Shunt Cal Internal Option** is discussed on page 15.
- ⊕ The **CN-115-1 User-Configurable Plug-In Card** performs the same function as the CN-115 Header Plug-in Option. CN-115-1 is discussed on page 19.

Low-Pass Filter Customization

Each StrainBook and WBK16 module has 68 kΩ 4-resistor SIP networks installed at the factory. These networks result in a 10.9 Hz cutoff for filter A and a 1092 Hz cutoff for filter B. The 4-resistor SIP networks are socketed and can be altered to the range of values in the table below. Individual resistors may also be used but should be matched within 2%. Cutoff frequency accuracy is about ±5%.



If you change the filter nominal values, be sure to update the filter cutoff frequencies in the WaveView software. This is discussed in the Chapter 4 section entitled *Changing Low-Pass Filter Displays*.

Filter A			
Resistance in kΩ	Frequency in Hz	Resistance in kΩ	Frequency in Hz
470	1.58	33	22.5
330	2.25	22	33.8
220	3.38	15	49.5
150	4.95	10	74.3
100	7.43	8.2	90.5
82	9.05	6.8	109
68	10.9	4.7	158
47	15.8	3.3	225

Filter B			
Resistance in kΩ	Frequency in Hz	Resistance in kΩ	Frequency in Hz
470	158	33	2250
330	225	22	3375
220	338	15	4950
150	495	10	7425
100	743	8.2	9055
82	905	6.8	10919
68	1092	4.7	15798
47	1580	3.3	22500

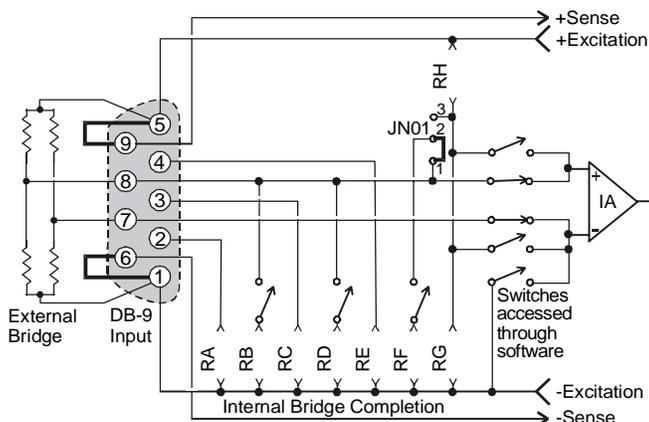
Lower frequency filters, such as the 10-Hz filter provided, are generally used to reduce higher frequency noise. Some common sources of noise are: 50/60 Hz power line pickup on long cables, electromagnetic interference (EMI) from nearby equipment, unwanted vibrations in the strain gage system itself, or at higher gains the intrinsic thermal noise of the amplifiers. All information above the cutoff will also be lost due to the filter’s function.

The 1-kHz filter provided is typically used as an anti-aliasing filter, or for slight noise reduction while still maintaining moderate bandwidth.

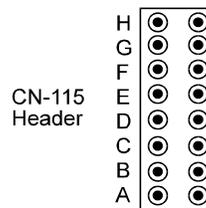
Configuration Diagrams

Full-Bridge Configurations

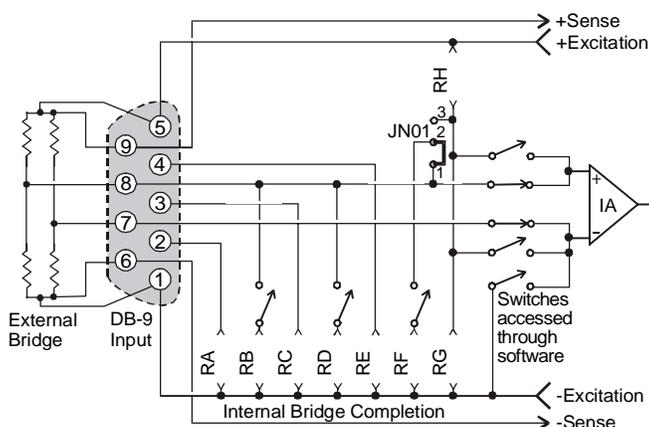
The full-bridge has four strain-variable elements and requires no bridge completion components. Quarter and half-bridge resistors may be left installed. Any bridge resistance from 60 to 1000 ohms can be accommodated.



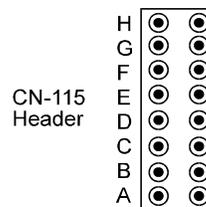
Full-Bridge (+), Any Resistance from 60 to 1000 Ohms



In this connection, excitation voltage is regulated at the connector. **This configuration should only be used for short cable lengths.** Output polarity may be altered by interchanging the (+) and (-) input or by selecting the software invert function.

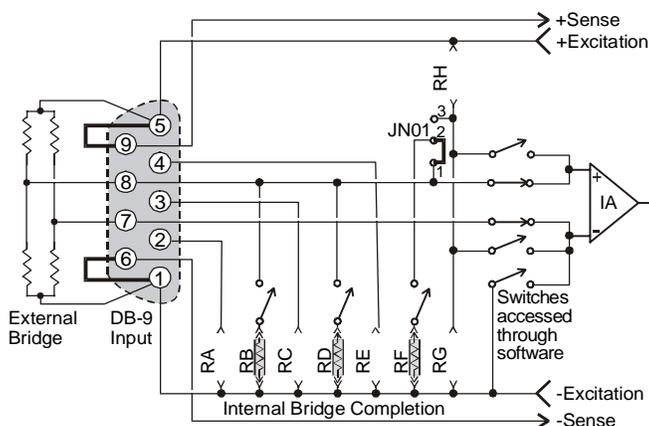


Full-Bridge (+), with Remote Sense

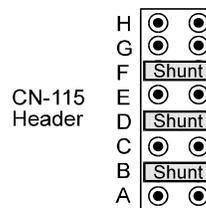


In this connection, excitation voltage is regulated at the strain gage.

This eliminates errors due to cable losses and is the preferred connection for longer cables.



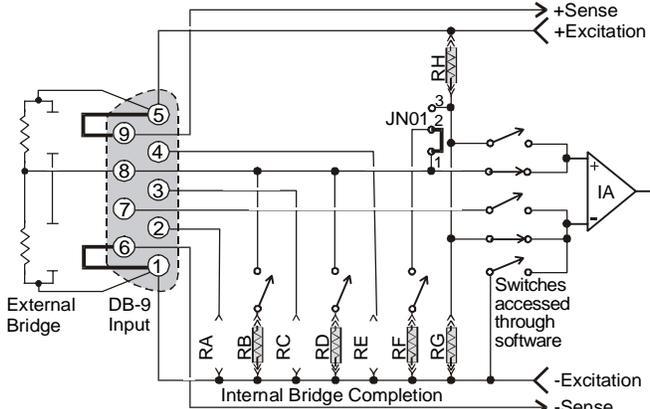
Full-Bridge (+), with B, D, or F Shunt



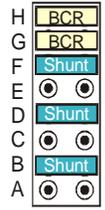
The B, D, or F shunt resistor may be software selected when installed as shown. Output polarity during shunt calibration will be automatically corrected by software. The shunt resistor value will typically be different for each value of bridge resistance.

Half-Bridge Configurations

The half-bridge has two strain-variable elements and requires two internal bridge completion resistors (BCRs). Any bridge resistance from 60 to 1000 ohms can be accommodated for either the internal or external bridge.



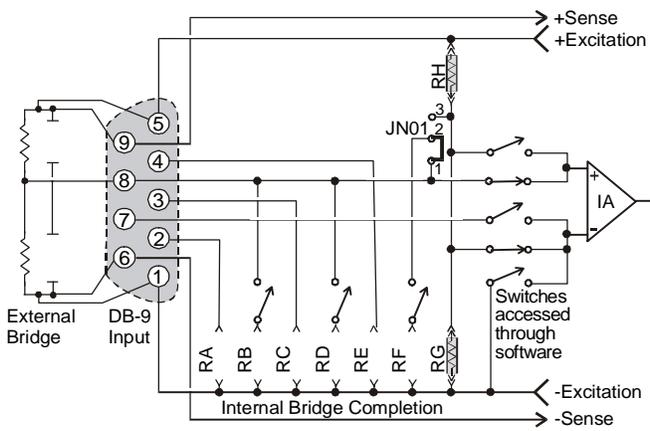
Half-Bridge (+), Any Resistance from 60 to 1000 Ohms, B,D, or F Shunt



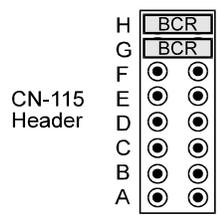
In this connection, excitation voltage is regulated at the connector.

This configuration should only be used for short cable lengths.

Output polarity can be altered by selecting the software invert function. The B, D, or F shunt resistor may be software selected. Output polarity during shunt calibration will be automatically corrected by software.

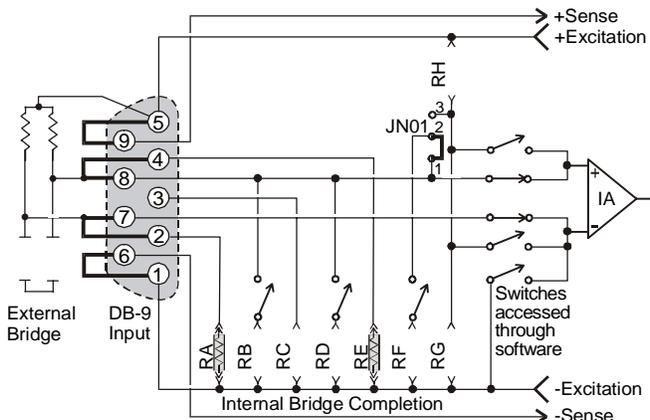


Half-Bridge (+), with Remote Sense

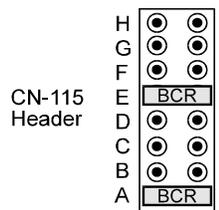


In this connection, excitation voltage is regulated at the strain gage.

This is the preferred connection for longer cables.



3-Wire TC Half-Bridge, Software Invert & B, D, F Shunt Available

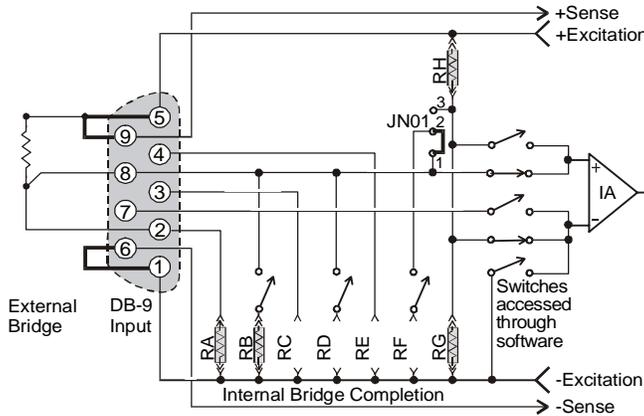


This occasionally utilized connection can be made as shown. Two resistors normally reserved for quarter-bridge completion must be used.

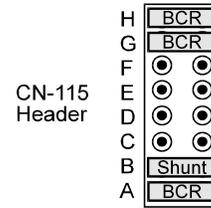
For compatibility with other configurations, use of one of the above two configurations is preferred over this one.

Three-Wire Quarter-Bridge Configurations

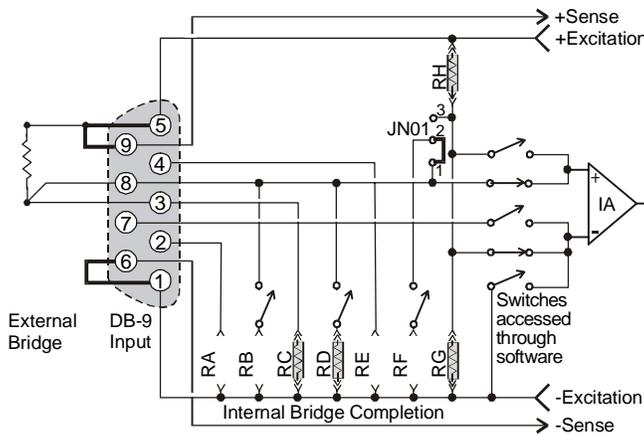
The three-wire quarter-bridge has only one strain-variable element and requires three bridge completion resistors (BCRs). The internal half-bridge may be any two matched values, but the remaining resistor must match the external quarter-bridge value precisely. Three of these values may be installed simultaneously when connected as shown below; the connector pins determine which resistor is used. With all three values installed, WBK16 can accommodate all three quarter-bridge values without changing the internal resistors.



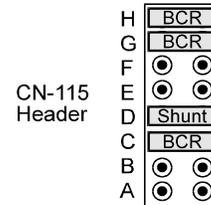
*Three-Wire Quarter-Bridge (+),
Using RA (120-Ohm nominal), B Shunt Resistor*



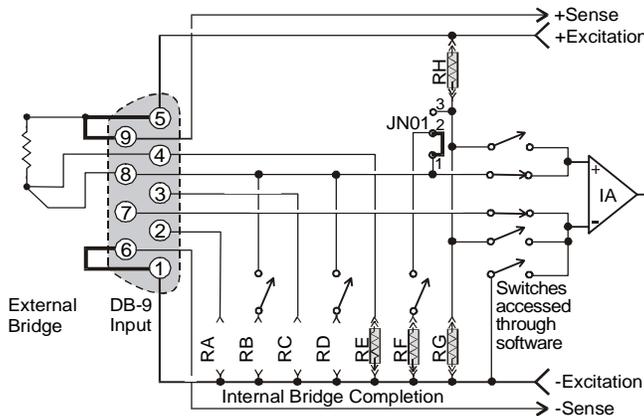
A 120-ohm resistor and its corresponding shunt value may be installed as shown.



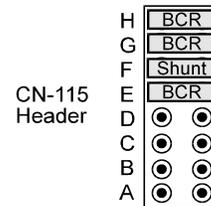
*Three-Wire Quarter-Bridge (+),
Using RC (350-Ohm nominal), D Shunt Resistor*



A 350-ohm resistor and its corresponding shunt value may be installed as shown.



*Three-Wire Quarter-Bridge (+),
Using RE (1-KOhm nominal), F Shunt Resistor*

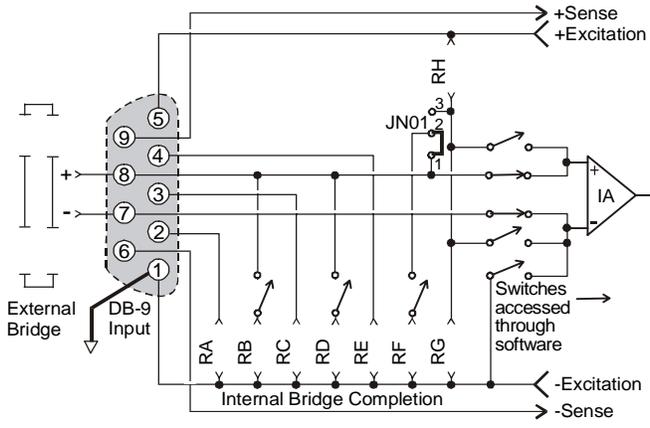


A 1000-ohm (or other value) resistor and its corresponding shunt value may be installed as shown.

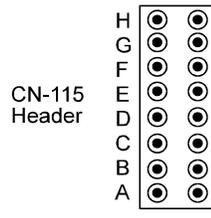
High-Gain Amplifier Configurations

WBK16s are useful as a programmable high-gain amplifier. No external bridge is used in these cases. The inputs are fully differential.

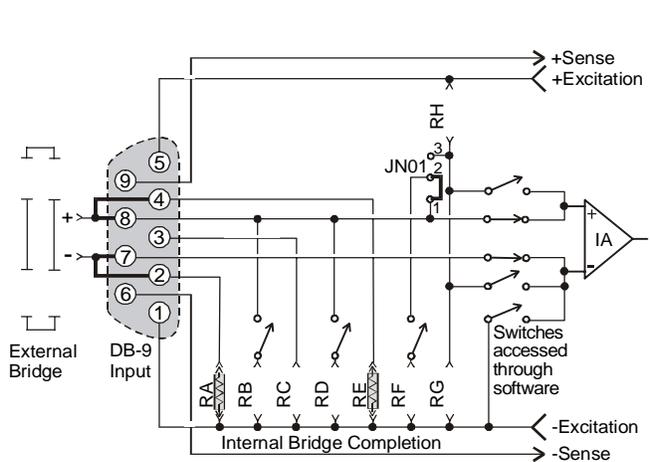
Note: The differential inputs are not isolated inputs. Common mode voltage should not exceed ± 10 V.



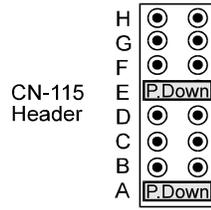
Universal High-Gain Amplifier Input, Differential



No pull-down resistors are required if the input signal ground is connected to Pin 1 as shown.

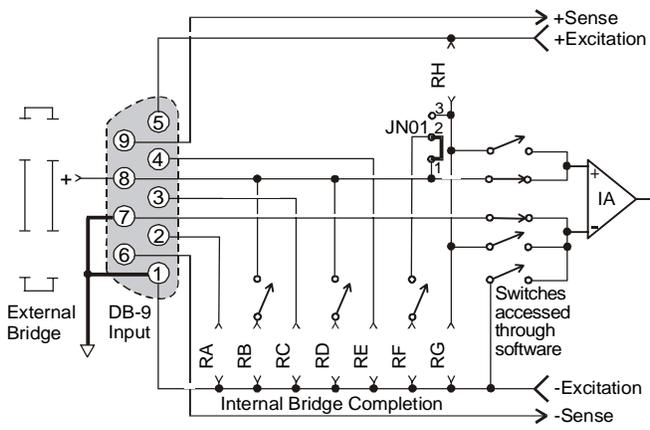


Universal High-Gain Amplifier Input, Differential with Pull Downs

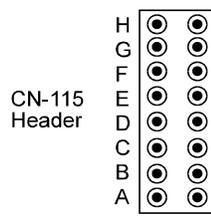


A floating input without a ground reference, such as a battery, requires a path for input bias currents. Pull-down resistors of 1k to 10M Ω may be installed as shown to provide this function. A 10M Ω resistor would be suitable in most cases.

These resistors are not compatible with other bridge configurations.



Universal High-Gain Amplifier Input, Single-Ended



If the (-) input is ground referenced, the input is non-differential and pull-down resistors are not required. A floating source would still result in a truly differential input.

Connecting to the DB9 Channel Input Connector

CAUTION

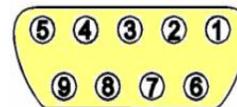


Remove the module from power and disconnect the unit from all externally connected equipment prior to connecting cables, signal lines, and/or removing the cover to install or remove components. Electric shock or damage to equipment can result even under low-voltage conditions.



Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.) Use care to avoid touching board surfaces and onboard components. Only handle boards by their edges (or ORBs, if applicable). Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.

The figure shows the pinout of the DB-9 connector used for channels 1 through 8 located on the front panel. The strain gage will connect directly to these pin sockets, unless the CN-189, DB9 Adapter option is used. The CN-189 option is discussed in the following sub-section.



WBK16's DB9 Pinout

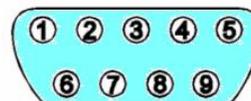
A quality cable (such as the CA-177 strain-gage cable) can improve performance of the system, especially with long cable runs. Use cable with an overall shield connected to the DB9 metal shell. Twisted pair cable with paired leads for signal input, excitation output, and remote sense input is also beneficial.

The wires should be soldered to the DB9 to eliminate noise created by contact resistance variations. The protective hoods should be installed over the 9-pin connectors during use to avoid draft-induced thermal-electric noise in the connector solder joints. Molded cables wider than 1.23 inches will not fit WBK16's connector spacing.

CA-177 Strain-Gage Cable

Use cable with an overall shield connected to the DB9 metal shell. Twisted pair cable with paired leads for signal input, excitation output, and remote sense input are also beneficial.

The wires should be soldered to the cable's DB9 connector to eliminate noise created by contact resistance variations. The protective hoods should be installed over the 9-pin connectors during use to avoid draft-induced thermal-electric noise in the connector solder joints.



Cable Pinout*

Molded cables wider than 1.23 inches will not fit the DB9 connectors due to available space between the unit's connectors.

CA-177 Strain-Gage Cable Pinout*			Cable CA-177 Specifications
DB9 Male End (P1)	Unterminated End (P2)		
Pin 1	Brown wire		P1 Cable End: DB9 male, assembled metal hood with thumbscrews (solder cup DB9). P2 Cable End: Unterminated, blunt cut. Cable Type: Belden 9614 or equivalent. Wire Gauge: 24 AWG. Outer Shield: Foil and 65% braid. Number of Conductors: Nine (9) plus drain. Dimensions: Length: 72" ± 4", Connector width: 1.220" maximum P1-to-P2 Pinout Specifications: As indicated at left.
Pin 2	Red wire		
Pin 3	Orange wire		
Pin 4	Yellow wire		
Pin 5	Green wire		
Pin 6	Blue wire		
Pin 7	Purple wire		
Pin 8	Black wire		
Pin 9	White wire		
Shell	Drain wire	---	

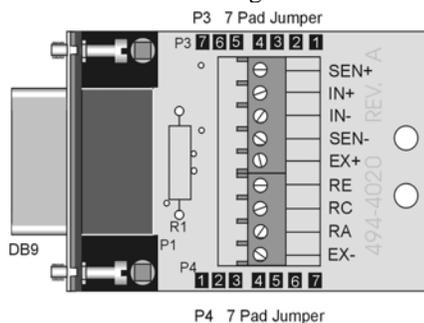
*Cable DB9 numbering is opposite of that found on the WBK16 to allow for correct pin mating.

CN-189, DB9 Adapter Option

CAUTION	
	Remove the WBK16 from power and disconnect the unit from all externally connected equipment prior to connecting cables, signal lines, and/or removing the cover to install or remove components. Electric shock or damage to equipment can result even under low-voltage conditions.
	Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.) Use care to avoid touching board surfaces and onboard components. Only handle boards by their edges (or ORBs, if applicable). Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.
	Be careful to avoid component damage while the WBK16 module is open. Always remove bridge completion headers (CN-115) from the unit before soldering resistors in the headers.

The CN-189 option consists of two 7-pad jumpers (P3 and P4), a DB9 connector, and a 9-slot screw-terminal block. The adapter plugs into channel input DB9 connectors on StrainBooks and WBK16 expansion modules.

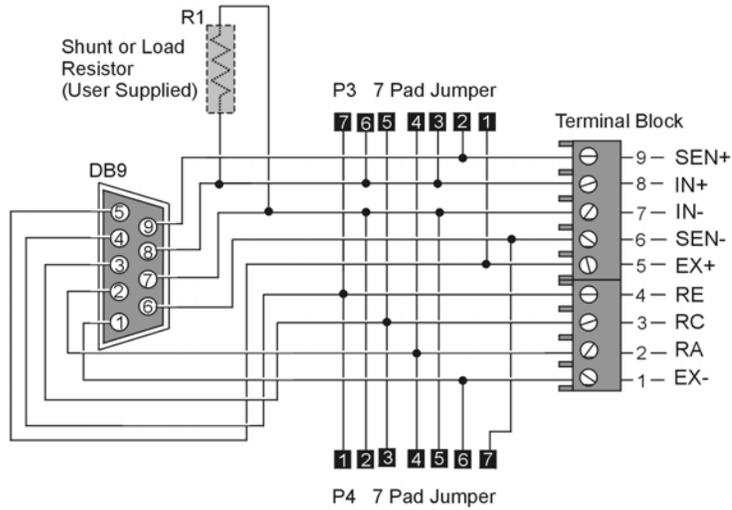
With use of the terminal block and appropriate shorting of jumper pads, the user can easily set up the desired bridge configuration. A table indicating bridge types and the respective CN-189 jumper pad shorts follows shortly. In some cases, the user may want to install a resistor at location R1. The electrical relation of CN-189 components is shown in the following schematic.



CN-189 DB-9 Adapter Option



The CN-189 is intended for convenience and is not shielded. Higher signal quality will be obtained with the use of shielded cables, such as the CA-177 strain gage cable.



CN-189 Schematic

CN-189 DB9 Adapter for WBK16, Configuration Table				
Function	P3	P4	Resistor Used in R1	
1 Internal Excitation Sense	Short 1 and 2	Short 6 and 7		
2 ¼ Bridge Using (RA) 2-Wire	Short 3 and 4			
3 ¼ Bridge Using (RC) 2-Wire	Short 5 and 6			
4 ¼ Bridge Using (RE) 2-Wire	Short 6 and 7			
5 High Gain Amp Ground Path (Short)		Short 5 and 6		
6 High Gain Amp (Resistive) Ground Path (EXT)		Resistor between 5 and 6		
7 High Gain Amp (RE) Ground Path (INT)		Short 1 and 2		
8 High Gain Amp (RC) Ground Path (INT)		Short 2 and 3		
9 High Gain Amp (RA) Ground Path (INT)		Short 4 and 5		
10 Current Measurement (Differential)			Shunt resistor in R1	
11 Differential Load Resistor			Load resistor in R1	

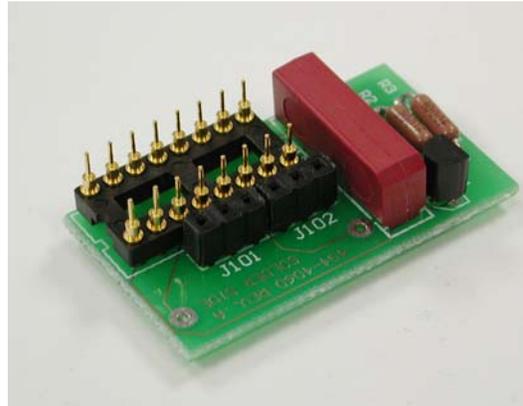


For the functions listed in the preceding table, internal WBK16 configurations still apply as indicated on pages 8 through 12 .

Using the WBK16/LC Load Cell Shunt Cal Option

Purpose of the WBK16/LC

The WBK16/LC provides a non-committed dry contact on two pins of a single StrainBook or WBK16 channel connector. The WBK16/LC can be used for virtually all single value shunt calibration requirements, some of which are not possible with the internal FET/analog switch provisions in the standard channel configurations.



WBK16/LC

Shunt calibrations of load cells and pressure transducers, while conceptually equivalent to shunt calibration of strain gages, do exhibit a few differences.

- Varying physical locations of the shunt cal resistor
- The shunt resistors are often expressed in engineering units instead of ohms
- A shunt switch contact with nominally zero-ohms is required

Any of the following situations can be accommodated by the uncommitted shunt contact of the WBK16/LC:

- A shunt calibration resistor may be provided internal to a load cell or transducer, with an extra connector pin or additional wire in the cable with the requirement that the line be connected to one of the excitation lines to produce a signal equivalent to a specific physical stimulus applied to the transducer.
- A shunt calibration resistor with a defined physical equivalence may be supplied with a transducer giving specific instructions for connections to provide a signal output from the device.
- A user may, empirically, or by electrical calculation, determine the physical equivalence of an available resistance connected to accessible transducer lines to produce an output signal.

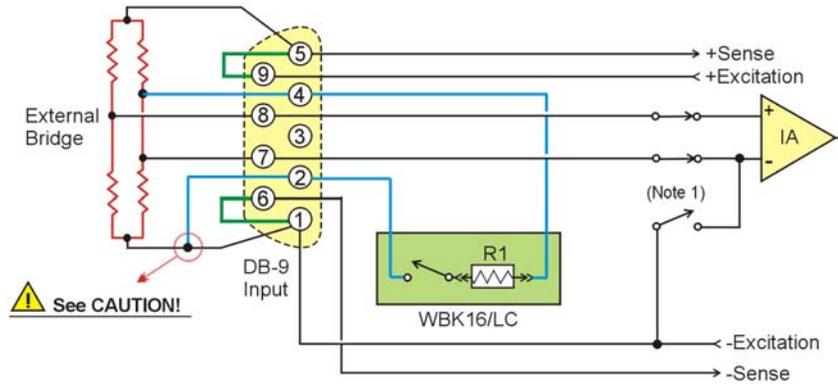
The shunt calibration resistor can be located internal (soldered onto the WBK16/LC in the provided “R1” location) or external to the host StrainBook or WBK16 at a wiring transition location. Four schematics which include an External Full Bridge follow.

CAUTION



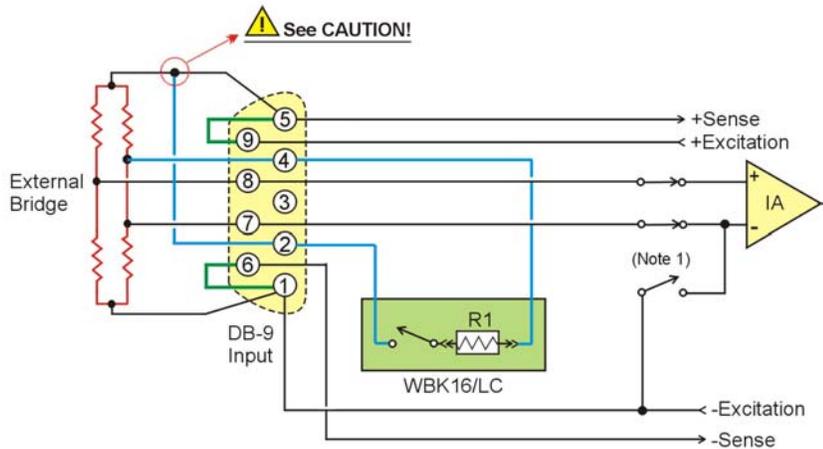
Make the DB9 pin # 2 connection to the “low-side” or the “high-side” of the circuit. **BUT NEVER TO BOTH!** Doing so will create a short circuit that could damage equipment.

Internal Shunt Resistor, Low-Side Connection



*Full Bridge (+) with Internal Shunt Resistor Installed at R1 on the WBK16/LC
DB9 Pin 2 Connected to the Low-Side*

Internal Shunt Resistor, High-Side Connection



*Full Bridge (+) with Internal Shunt Resistor Installed at R1 on the WBK16/LC
DB9 Pin 2 Connected to the High-Side*

CAUTION



Make the DB9 pin # 2 connection to the “low-side” or the “high-side” of the circuit. **BUT NEVER TO BOTH!** Doing so will create a short circuit that could damage equipment.

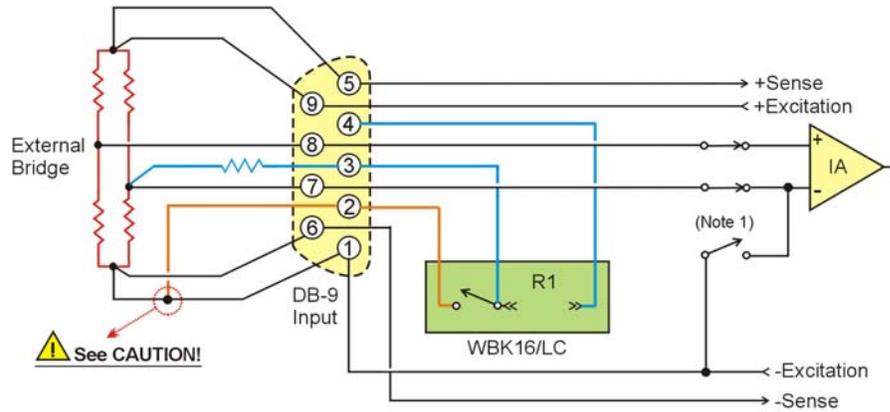
Note 1: The switches represented in the schematics are controlled by software.

CAUTION



Make the DB9 pin # 2 connection to the “low-side” or the “high-side” of the circuit. **BUT NEVER TO BOTH!** Doing so will create a short circuit that could damage equipment.

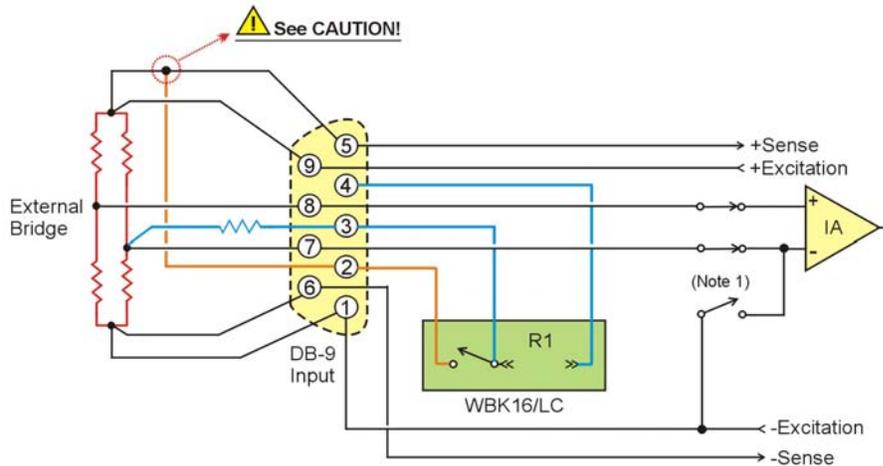
External Shunt Resistor, Low-Side Connection



Full Bridge (+) with External Shunt Resistor

DB9 Pin 2 Connected to the Low-Side

External Shunt Resistor, High-Side Connection



Full Bridge (+) with External Shunt Resistor

DB9 Pin 2 Connected to the High-Side

CAUTION



Make the DB9 pin # 2 connection to the “low-side” or the “high-side” of the circuit. **BUT NEVER TO BOTH!** Doing so will create a short circuit that could damage equipment.

Note 1: The switches represented in the schematics are controlled by software.

Caveats

Transducers and load cells, most often employ full bridges with four active strain gages to benefit from inherent temperature compensation and maximum output signal levels.

The mV/V sensitivities vary from unit to unit, but series resistors may be placed in the excitation lines to adjust them into a particular range window. This technique makes externally connected shunt calibration a little less exacting if the shunt resistor is not connected directly across the desired bridge arm. A shunt calibration resistor provided internally by the transducer manufacturer will usually require connection to an externally accessible node to activate the shunt. The variations in connection requirements require the flexibility of a non-committed dry contact as provided by the WBK16/LC module.

Shunt calibration generally is done by shunting one arm of a bridge with four active arms. For this reason, it is recommended that simulated signal levels be limited to about 20% of the full-scale output of the transducer. Attempting to achieve a high level output with a single resistor will introduce non-linearity errors into the picture. For example, a 5000 pound load cell should be shunt calibrated with a resistance that will introduce about a 1000 pound output signal. Attempting to produce a 4000 pound signal by shunting one of the bridge legs will generally not produce the same quality result.

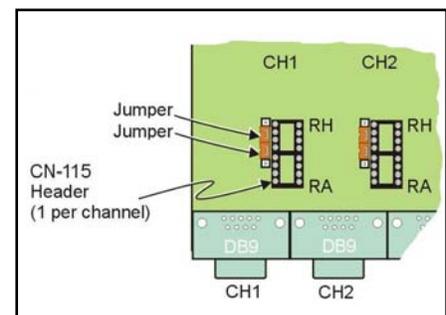
Installation

CAUTION	
	Remove the WBK16 module from power and disconnect the unit from all externally connected equipment prior to connecting cables, signal lines, and/or removing the cover to install or remove components. Electric shock or damage to equipment can result even under low-voltage conditions.
	Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.) Use care to avoid touching board surfaces and onboard components. Only handle boards by their edges (or ORBs, if applicable). Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.
	Be careful to avoid component damage while the WBK16 is open. Always remove the WBK16/LC from the unit before soldering resistors.

You can easily install a WBK16/LC as follows:

Note: If a shunt calibration resistor is to be mounted on the WBK16/LC it should be done prior to the installing the WBK16/LC. Shunt calibration resistors should be soldered in location R1 on the WBK16/LC.

1. Review the preceding CAUTIONS.
2. Remove the StrainBook [or WBK16] from power and disconnect the unit from all external devices and signals.
3. Observe proper ESD precautions.
4. Remove the cover from the StrainBook [or WBK16].
5. Locate the CN-115 channel header(s) in which the WBK16/LC modules are to be installed.
6. Remove one shunt jumper from each of the two 3-pin headers. The 3-pin headers are located beside the CN-115 16-pin header sockets (see figure).
7. Remove the CN-115-1 (or CN-115) to expose the header socket.
8. Carefully plug the module into the header socket.
9. Re-install the cover to the StrainBook [or WBK16].



CN-115 Headers for CH1 and CH2

Calibration Using WaveView



Reference Note:

The Calibration Parameters Tab Selected section of Chapter 4 includes screen shots and text related to the following steps.

1. Select 'load cell' or 'transducer' from the pull-down 'Sensor Type' menu.
2. Select 'shunt' from the pull-down 'Calibration Method' menu.
3. Enter a maximum intended value in the 'Maximum Applied Load' cell in engineering units.
4. Enter a value slightly below zero engineering units in the Quiescent/Tare cell in engineering units. [Note: if the transducer must measure bi-directionally, for example, pressure and vacuum, enter the maximum anticipated negative engineering units.]
5. Enter the physical equivalence in engineering units in the 'Point 2' cell of the shunt calibration resistance.
6. This method assumes the 0.00 engineering units already in the 'Point 1' cell is the intended physical equivalence of the non-shunted transducer or load cell. [Possible exceptions are atmospheric pressure transducers and load cells installed under load in which the relative change is not the measurement of interest.]
7. Push the channel calibrate button and wait for the window verifying successful calibration.

Using the CN-115-1 User-Configurable Plug-In Card Option

CAUTION	
	Remove the WBK16 module from power and disconnect the unit from all externally connected equipment prior to connecting cables, signal lines, and/or removing the cover to install or remove components. Electric shock or damage to equipment can result even under low-voltage conditions.
	Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.) Use care to avoid touching board surfaces and onboard components. Only handle boards by their edges (or ORBs, if applicable). Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.
	Be careful to avoid component damage while the WBK16 module is open. Always remove bridge completion headers (CN-115) from the unit before soldering resistors in the headers.

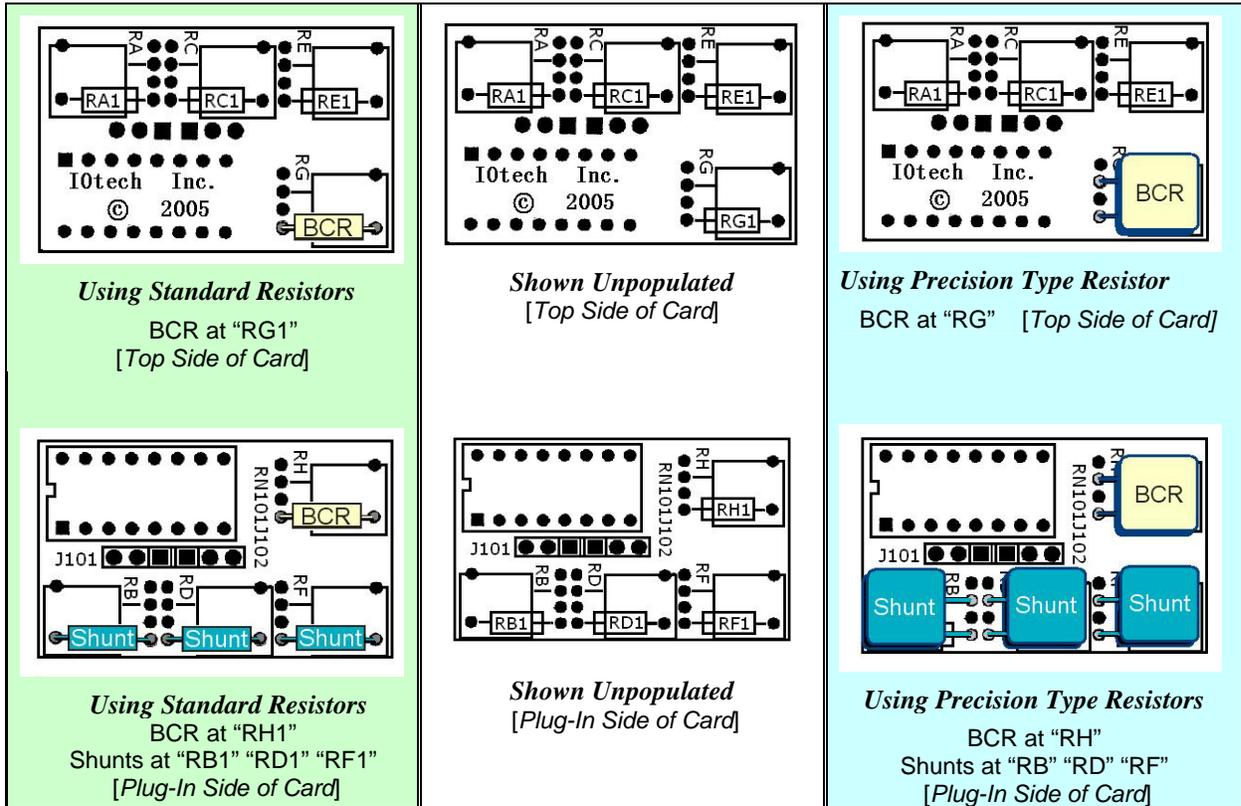
The CN-115-1 serves the same function as the CN-115 adapter plug and can be used for all of the same bridge configurations detailed in the *Configuration Diagrams* section of this chapter. The CN-115-1 can be populated with either standard axial lead resistors or square precision resistors.

Each StrainBook (and WBK16) channel has a on-board 2×8 resistor socket with rows designated A through H. CN-115-1 is a removable plug-in board that can be pre-configured for various bridge options.

It will often be the case that both the top and bottom (plug-in) sides of the CN-115-1 card will need to have resistors installed to create the desired bridge configuration. The configurations are illustrated earlier in the chapter. In general, note that:

- **Half-bridge completion resistors consist of RG and RH (or RG1 and RH1).**
- **Quarter-bridge completion resistors consist of RA, RC, and RE (or RA1, RC1, and RE1).**
- **Shunt resistors consist of RB, RD, and RF (or RB1, RD1, and RF1).**

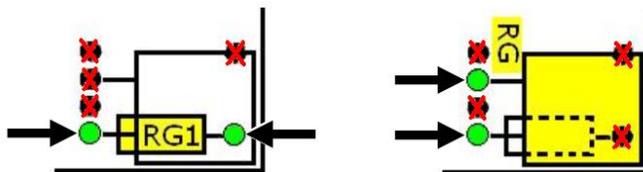
In the example below CN-115-1 is being used to create a half-bridge configuration with two Bridge Completion Resistors (BCRs) and three Shunt resistors. The half-bridge to the left (using standard resistors) is functionally the same as the half-bridge on the right (using “precision” resistors). The center illustration represents an unpopulated card to permit reading of the silk-screen.



For the functions listed in the preceding table, internal WBK16 configurations still apply as indicated on pages 8 through 12.

How to Interpret Resistor Connection Points

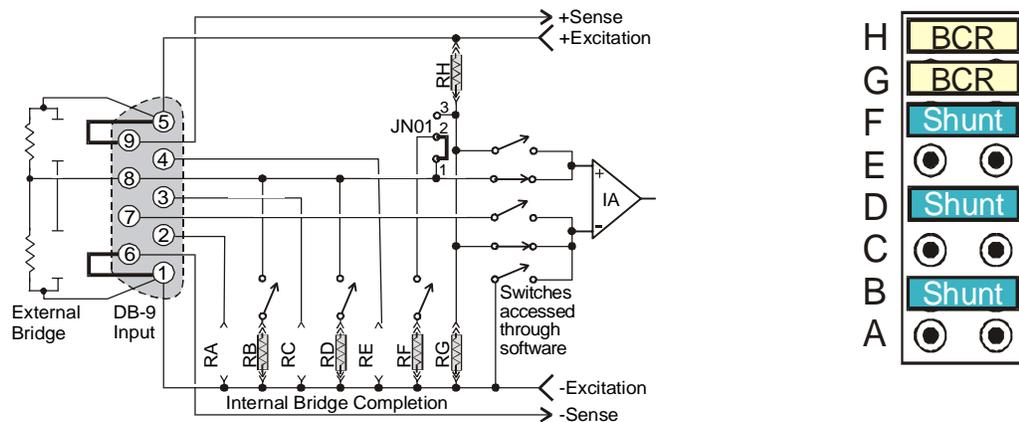
The CN-115-1 plug-in card’s silk-screen makes use of dual templates. For example, if we look at the RG / RG1 section [on the top side of the card] we will see a small resistor image “RG1” with lines connecting to two solder points. Thus we know the connection points for standard resistors. If we are using a flat, relatively square precision-type resistor we would look at the square “RG” portion of the template (right image in the following figure) and ignore the RG1 image. We can see that the lower left solder point remains, however, the second point has changed.



Determining Solder Points for Resistor Leads

Note that the two half-bridges previously described are identical [circuit wise] to the one illustrated below, which is being repeated from page 6.

The A thru H bridge-completion relations are the same, regardless of whether or not you choose to use a CN-115-1 plug-in option. Refer to the configuration diagrams to set up your desired circuit(s).



*Half-Bridge (+), Any Resistance from 60 to 1000 Ohms,
B,D, or F Shunt*

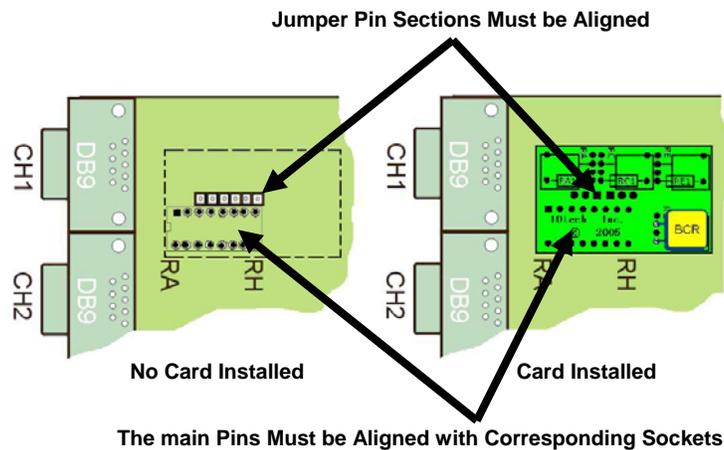
Half-Bridge Circuit Created by using the CN-115 Header Only, i.e., no plug-in card



If present, read the manufacturer's data that applies to your resistors. Important soldering and lead-bending information may be present.

CN-115-1 Mounting Orientation

When installing a CN-115-1 be careful to avoid bending the pins and ensure that the card is oriented in relation to the DB9 connector as indicated below.



CN-115-1 Orientation, Shown for Channel 1

Software Setup

WaveView contains special software features for WBK16. The WBK Sensor Configuration aspect of WaveView is discussed in the following pages.



WBK16 support is only available with the 32-bit driver and 32-bit version of WaveView.



Reference Note:

For detailed information regarding non-WBK16 specific aspects of *WaveView*, refer to the *WaveView document*. A PDF version of the document can be accessed from the data acquisition CD via the <View PDFs> button on the CD's opening screen.

Sensor Calibration

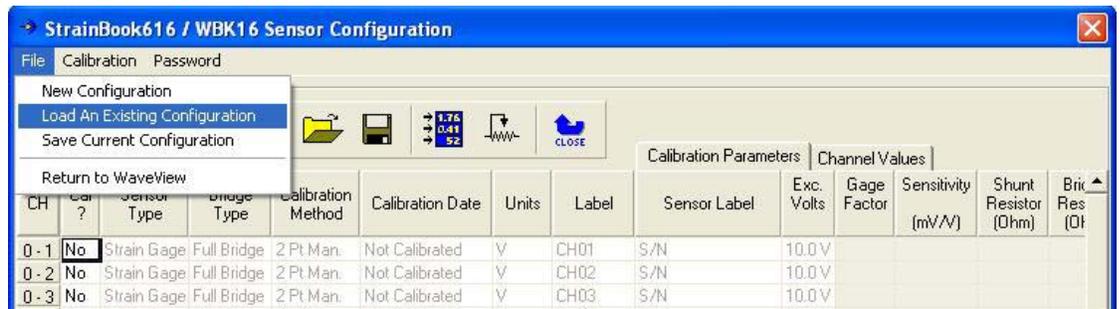
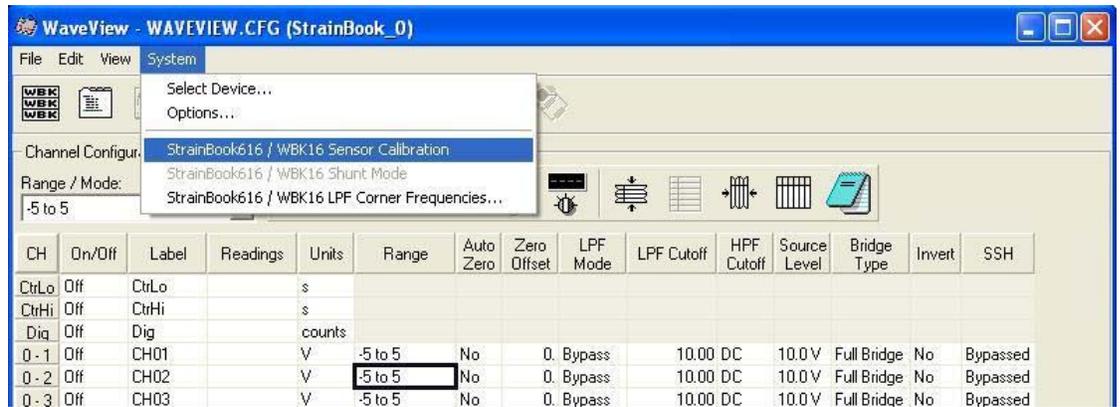
To use the Sensor Calibration Program you must first launch WaveView. This can be done from a shortcut on the desktop, or by selecting WaveView from the Programs group, accessed from the desktop Start menu.

WaveView holds user-configured parameters that can be saved to disk. The default configuration filename is **WAVEVIEW.CFG**. When WaveView starts up, it proceeds to search the working directory for this file. WaveView also holds a default sensor calibration file. The **WAVEVIEW.CFG** file holds the name of this calibration file so that all sensor calibration information from the last WaveView session is also loaded into WaveView during initial boot-up. If the default configuration file is found, all the required setup information will be extracted from it, and the application's main window will open. When connection is established, the application's main window will open with the default setting. If these options fail, a dialog box will ask if you want to open a different setup file.



Reference Notes:

- For detailed WaveView startup information, refer to the *WaveView* PDF. The document can be accessed from the data acquisition CD via the <View PDFs> button on the CD's opening screen.
- The WBK16/LC Load Cell Shunt Cal internal option board may be required to calibrate load cells and transducers that have internal shunt cal resistors. See the WBK16/LC section of chapter 6 for details.



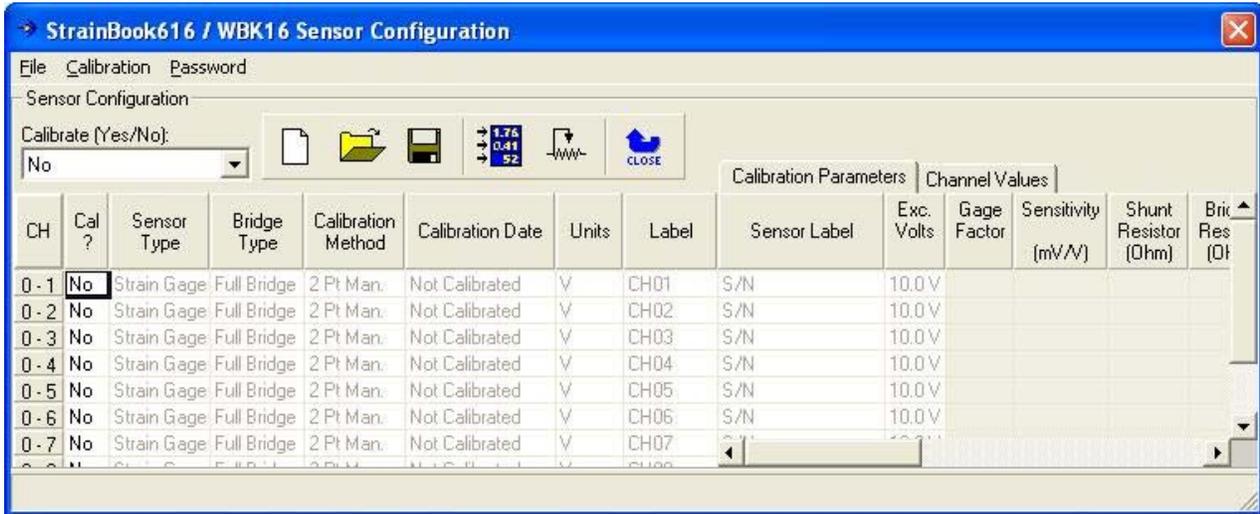
WaveView Configuration Main Window(Top) and Sensor Configuration [Calibration] Window (Bottom)



To open the Sensor Configuration [Calibration] window, click on WaveView's **Sensor Calibration button**. The button is depicted at the left and pointed out in the upper portion of the previous figure. You can also open the window from WaveView's **System pull-down menu**.

You can use the Sensor Configuration window's File pull-down menu to **Load an Existing Configuration**. This option opens a standard dialog box that allows you to select and open the desired file.

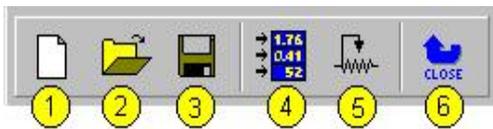
Sensor Configuration Main Components



Sensor Configuration [Calibration] Window

Sensor Configuration Toolbar and Pull-Down Menus

Control functions in the sensor configuration window are available through the pull-down menus or the toolbar. For descriptions of button functions, see the related menu selections. Note that some menu selections have no corresponding button.

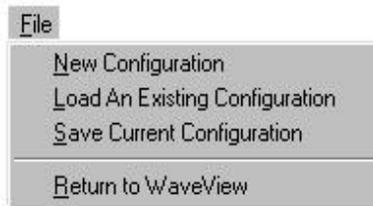


Sensor Configuration Window Toolbar

- 1 – New Configuration; 2 – Load an Existing Configuration; 3 – Save Current Configuration
4 – Take a Single Reading; 5 – Calibrate Enabled Channels; 6 – Return to WaveView

File

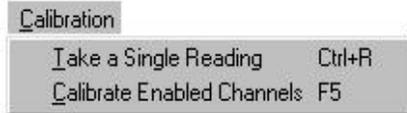
The *File* menu provides four functions:



New Configuration	Set all parameters to their default startup setting.
Load an Existing Configuration	Load a saved sensor calibration configuration.
Save Current Configuration	Save the current sensor calibration configuration for later recall.
Return to WaveView	Exit the <i>Sensor Configuration</i> window and return to WaveView.

Calibration

The *Calibration* menu provides two functions:



Take a Single Reading	This command allows the user to take a single reading and display the values in the <i>Sensor Configuration</i> window.
Calibrate Enabled Channels	This command will calibrate all enabled channels.

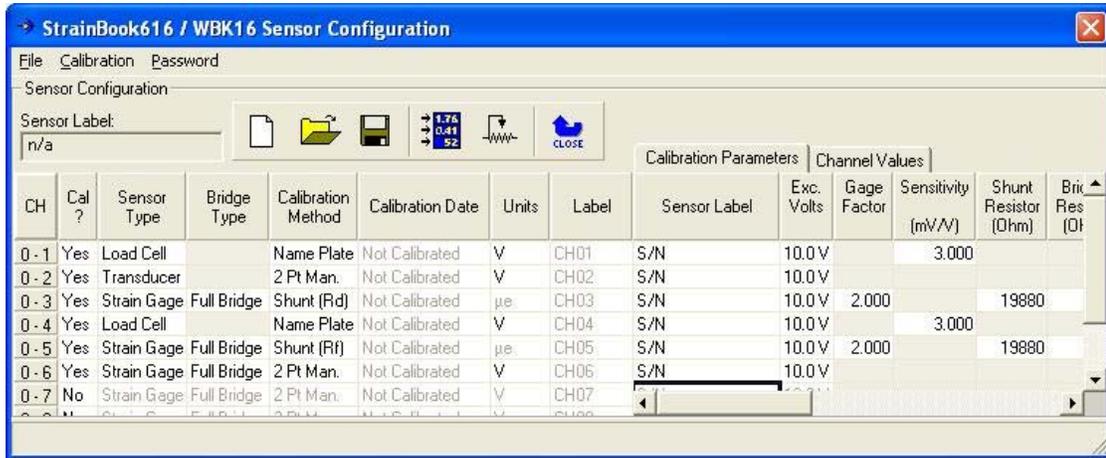
Password

The sensor calibration application provides password protection. If you calibrate any StrainBook channels [or WBK16 expansion channels] and then choose the password protection option WaveView will prevent other users from making changes to your calibration file. The *Password* menu provides three functions:



Enter Password	Use this command to enter a previously selected password, enabling you to change parameters.
Set a New Password	This command allows the user to select a 4-7 character password. A message box will prompt you to enter a new password. Type a password and press "enter", or click on the "OK" button.
Clear Password	This command clears the password protection. A message box will prompt you to enter the current password. Type the current password and press "enter", or click on the "OK" button.

Calibration Parameters Tab Selected



Sensor Configuration Window

Column	Description
Calibrate?	“Yes” enables the selected channel to be calibrated with the “calibrate enabled channels” option. “No” prevents the channel from being calibrated. All other columns for that channel will be disabled if “no” is selected. The channel can still be turned on in WaveView.
Sensor Type	Provides a means of selecting the sensor type. The three available sensor types are: Strain Gage, Load Cell, and Transducer.
Bridge Type	Provides a means of selecting the bridge type. Choices are full-bridge, half-bridge, and quarter-bridge. This option is only available for a strain gage sensor in the calibration program. The bridge type for any sensor can be changed from the <i>Sensor Configuration</i> window.
Calibration Method	Allows the calibration method to be selected. Possible selections are indicated in the figure to the right. These calibration methods are explained later in the document. <div style="text-align: right;"> </div>
Calibration Date	Displays the time and date that the channel was calibrated. If the channel has not been calibrated, “Not Calibrated” appears in the box.
Units	To change the units: highlight the desired box, type-in the new parameters, and then press <Enter> on the keyboard or select another box with the mouse. Up to 5 characters can be entered into this column. To fill the entire column with the value of channel one, make sure “yes” is selected in the “Calibrate” column. Then click on the column label with the mouse. A message box will appear. Click on “yes”. All channels with the “calibrate” function enabled will be filled. Changing the units here will also change the units column in the <i>WaveView Configuration</i> main window.
Label	Used to label channels.
Sensor Label	A serial number or other identifying label for the sensor can be entered here. Up to 39 characters may be entered and 16 will be displayed. The fill option is available for this column (see Units).

Calibration Parameters Section of Window
Two Views Obtained by Scroll Bar Movement

Column	Description
Exc. Volts	Used to change the excitation voltage. Choose between 10.0, 5.0, 2.0, 1.0, .5, and "Off." Changing the excitation voltage on any channel between one and four will change the value on all four lower channels. Likewise, changing the excitation voltage on any channel five through eight will change the value on all four upper channels. Changing the Excitation Voltage here will also change the Source Level column in the <i>WaveView Configuration</i> main window.
Gage Factor	Used for calibrating strain gages with the Name Plate calibration method. To change this value, select the box and enter a number greater than 0 and less than 1000. The fill option is available for this column (see Units).
Sensitivity (mV/V)	This column is used for calibrating a load cell or transducer using the Name Plate calibration method. To change this value, select the box and enter a number greater than 0 and less than 1000. The fill option is available for this column (see Units).
Shunt Resistor (Ohm)	This column is used for calibrating any sensor using the Shunt calibration method. The value must equal the value of the shunt resistor in ohms. To change the value, select the box and enter a number greater than 0 and less than 1000000. The shunt value must not exceed the value entered as the maximum load. The fill option is available for this column (see Units).
Bridge Resistor (Ohm)	Used for calibrating any sensor using the Shunt calibration method. The value refers to the bridge arm that is shunted during shunt calibration. To change the value, select the box and enter a number from 60 to 1000. The fill option is available for this column (see Units).
Full Rated Load (Units)	This column is used for calibrating a load cell or transducer using the Name Plate calibration method. To change this value, select the box and enter a number greater than 0 and less than 100000. The full-rated load must be greater than the value entered for the maximum applied load. The fill option is available for this column (see Units).
Max Applied Load (Units)	Used for calibrating any sensor using any calibration method . To change the value, select the box and enter a number greater than 0 and less than 1000000. This value must be greater than the quiescent/tare value. The fill option is available for this column (see Units).
Quiescent/Tare (Units)	This column is used for calibrating any sensor using any calibration method. The value entered is the value of the quiescent load on the sensor. To change the value, select the box and enter a number between -1000000 and 1000000. This value must be less than the maximum applied load value. The fill option is available for this column (see Units).
Point 1 (mV)	This column is used for calibrating any sensor using the Shunt, or 2-Point Automatic calibration method. The number must equal the input value, in mV, of the first point in the calibration. To change the value, select the box and enter a number between -10000 and 10000. The fill option is available for this column (see Units).
Point 1 (Units)	This column is used for calibrating any sensor using the Shunt, 2-Point Automatic, or 2-Point Manual calibration method. The number must equal the value, in the selected units, of the first point in the calibration. To change the value, select the box and enter a number between -1000000 and 1000000. The fill option is available for this column (see Units).
Point 2 (mV)	Used for calibrating any sensor using the 2-Point Automatic calibration method . The number must equal the input value, in mV, of the second point in the calibration. To change the value, select the box and enter a number between -10000 and 10000. The fill option is available for this column (see Units).
Point 2 (Units)	This column is used for calibrating any sensor using the 2-Point Automatic, or 2-Point Manual calibration method . The number must equal the value, in the selected units, of the second point in the calibration. To change the value, select the box and enter a number between -1000000 and 1000000. The fill option is available for this column (see Units).

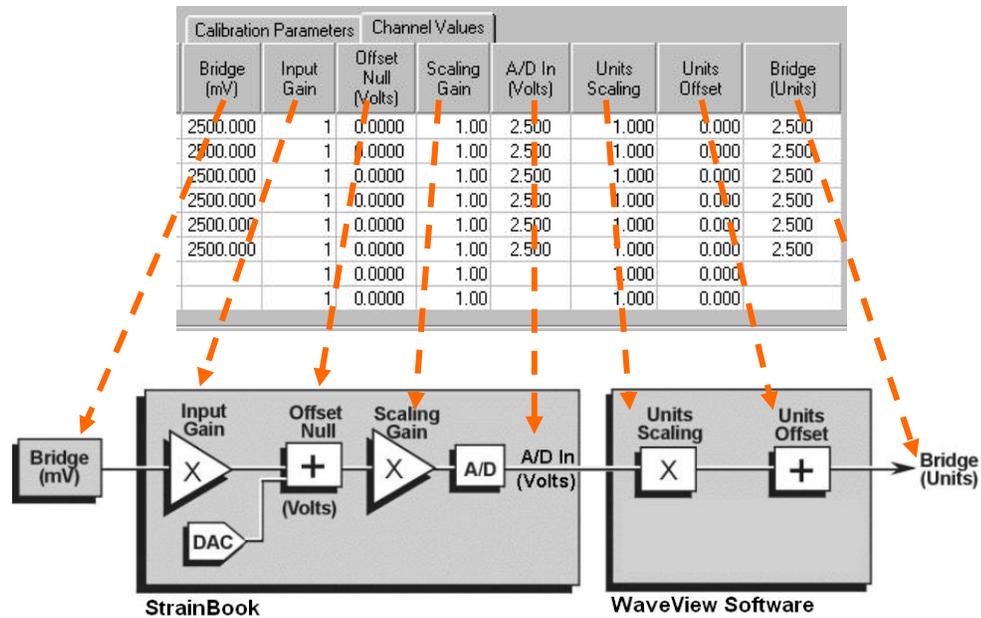


Displaying a Single Reading. In the sensor calibration program, it is possible to take a single reading and display it in the *Sensor Configuration [Calibration]* window. First, click on the *Channel Values* tab. Then click on the *Take a Single Reading* button on the tool bar, or choose *Take a Single Reading* from the *Calibration* menu item.



Displayed readings are based on the most recent calibration. Changing the calibration parameters, without calibrating the system, will not affect the channel values.

Channel Values Tab Selected



Channel Values, Simplified Block Diagram

The simplified block diagram (above) can be used to better understand the relationship of channel amplifiers and their corresponding user interface columns (visible in the Channel Values Tab). These columns are represented in the tab figure, and in the following table.

Column	Display Description
Bridge (mV)	The input value from the bridge. The value is in millivolts.
Input Gain	The Gain setting of WBK16's Input Amplifier. Any one of the following four settings is possible: x1, x10, x100, or x1000.
Offset Null (Volts)	The Voltage summed into WBK16s Scaling Amplifier. The voltage is to compensate for any offset that is present in the sensor's output. The Offset Null voltage is in the range of -3 to +3 volts.
Scaling Gain	The Gain setting of WBK16's Scaling Amplifier. Any one of the following 13 gain settings can be used: 1.0, 1.28, 1.65, 2.11, 2.71, 3.48, 4.47, 5.47, 7.37, 9.46, 12.14, 15.58, or 20.0.
A/D In (Volts)	The digital voltage value that is received as input by WaveView software. This value is also referred to as sensor output voltage.
Units Scaling	The Multiplier value [used by the software] for converting sensor output voltage into User Units.
Units Offset	The Offset value that is added to "Units Scaling" for fine adjustment of what will be the final reading (Bridge Units).
Bridge (Units)	The Reading (in User Units, for example: lbs, psi, kg) that results from converting the initial sensor reading (Bridge mV).

The Five Methods of Sensor Calibration



Before proceeding with calibration, remember to enter your password. The password must be entered before channel parameters can be changed.

Unless all of the parameters (for each channel to be calibrated) are accurately entered into the spreadsheet, the calibration will produce incorrect results.

The sensor calibration program uses five methods of calibration:

- **2-Point Manual**
- **2-Point Automatic**
- **Shunt** (Internal)
- **2-Point Shunt** (External)
- **Name Plate** (for load cell or transducer)

Table of Calibration Methods and Required Parameters

	Excitation	Gage Factor	Sensitivity	Shunt Ohms	Bridge Ohms	Full Load	Max. Load	Quiescent	Pt-1 (mV)	Pt-1 (Units)	Pt-2 (mV)	Pt-2 (Units)
2 Point Manual	✓						✓	✓		✓		✓
2 Point Auto	✓						✓	✓	✓	✓	✓	✓
Shunt (Internal)	✓	✓		✓	✓		✓	✓		✓		
2 Point Shunt (External)	✓						✓	✓		✓	✓	✓
Nameplate	✓		✓			✓	✓	✓				

To use any of these calibration methods, enter the appropriate values into the required spreadsheet columns of the *Sensor Calibration* window, as listed above, and click on the *Calibrate Enabled Channels* button on the toolbar.



In 2-Point Manual calibration, a message box prompts you to apply the first load. When prompted, apply the load and click the OK button. A second message box will prompt you to apply the second load. When prompted, apply the second load and click <OK>.

Saving a Calibration File. After calibrating the enabled channels, a message box asks if you want to save the changes. Click on the *Yes* button to save the calibration and a dialog box will appear. If you choose not to save the changes at this time, another message will appear asking if you want to save the changes when you click on the *Return to WaveView* button on the tool bar. Click on the *Yes* button to save these changes and a dialog box will appear. The most recently saved calibration file will be recorded in the **WAVEVIEW.CFG** default configuration file and will be loaded into WaveView whenever a new session is started. The current configuration can also be saved from the toolbar or *File* menu item.

2 Point Manual Calibration

In the 2 Point Manual Calibration method two readings are taken from the gage with different loads applied for each reading. For this method, the user must enter the following 5 parameters:

Excitation - The value of the constant voltage source used to excite the gage.

Max Load - The maximum load value the gage is expected to measure. This value could be less than the max rated load of the gage.

Quiescent Load - The minimum load value the gage is expected to measure. This value could be greater than the min rated load of the gage.

Point 1 Units - The load that will be placed on the gage for the first calibration measurement.

Point 2 Units - The load that will be placed on the gage for the second calibration measurement.

Example: Excitation voltage is set to 10 volts. A strain gage with a full load rating of +/- 1000 μe is connected to a StrainBook [or WBK16] channel. However, the gage will be used in an environment where the expected range of measurement is limited to 0 to 600 μe . Two certified loads of 50 μe and 500 μe are available for calibration. In the Calibration Parameters spreadsheet, the user would enter the values as follows:

Excitation = 10V

Max Load = 600

Quiescent Load = 0

Point 1 Units = 50

Point 2 Units = 500

1. When the <Calibrate Enabled Channels> toolbar button is pressed, the user is prompted to load the gage with 50 μe .
2. After the load is applied, and the <Ok> button pressed, WaveView takes several voltage readings in an attempt to find the best gain setting for the first load value.
3. When finished, the user is prompted to load the gage with 500 μe .
4. After the load is applied, and the <Ok> button pressed, WaveView again takes several measurements to find the best gain settings for the second load value.
5. After both voltage measurements are obtained, WaveView configures the input channel to provide the optimum settings for the two amplifier gain stages, and the Offset DAC. WaveView also sets the channels $mX+b$ parameters for proper conversion of the input voltage measurements to units of μe (or whatever units have been specified by the user).

Note: The greatest accuracy is obtained from 2 Point Manual calibration when the two calibration points are at the min and max load range of the gage. In the above example, the greatest possible accuracy would be obtained if Point1 was equal to the Quiescent load, and Point 2 was equal to the Max load.

2 Point Auto Calibration

For 2 Point Auto Calibration the user must enter the following 7 parameters:

Excitation - This is the value of the constant voltage source used to excite the gage.

Max Load - Is the maximum load value that the gage will be expected to measure. This value could be less than the max rated load of the gage.

Quiescent Load - Is the minimum load value that the gage will be expected to measure. This value could be greater than the min rated load of the gage.

Point 1 mV - This is the output voltage generated by the gage at the Point 1 Units load.

Point 1 Units - This is the load that is associated with the Point 1 millivolt value.

Point 2 mV - This is the output voltage generated by the gage at the Point 2 Units load.

Point 2 Units - This is the load that is associated with the Point 2 millivolt value.

No actual readings are taken when a 2 Point Auto Calibration is performed. Calibration constants are calculated from the values entered by the user.

Shunt (Internal Shunt) Calibration

The Shunt calibration method pertains to an internal shunt. For this method two readings are acquired from a bridge. The first reading is obtained with the bridge in its quiescent state; the second is taken with one leg of the bridge shunted by one of three selectable resistors. The resistors are located on a plug-in header inside the StrainBook or WBK16 module. Shunt calibration appears as "*Shunt (RB)*", "*Shunt (RD)*", and "*Shunt (RF)*" in the list of calibration methods.

The Internal Shunt Calibration requires that the user enter the following 7 parameters:

Excitation - The value of the constant voltage source used to excite the gage.

Gage Factor - The Gage Factor value of the gage used in the bridge. A Gage Factor of 2 is typical.

Shunt Ohms - The value in Ohms of the shunt resistor mounted on the header inside the StrainBook or WBK16 module.

Bridge Ohms - The resistance value of the gage. Typically 120 or 350 Ohms.

Max Load - The maximum load value the gage is expected to measure. This value could be less than the max rated load of the gage.

Quiescent Load - The *at rest* value of the load applied to the gage. If no load will be applied to the gage in its quiescent state, enter "0" zero.

Point 1 Units - The minimum load value the gage is expected to measure. This value could be greater than the minimum rated load of the gage.

Example: Excitation voltage is set to 2 volts. A Quarter Bridge circuit employing a 350 Ohm strain gage with a Gage Factor of 2 and a full load rating of +/- 1500 μe is connected to a StrainBook [or WBK16 channel]. The gage will be used in an environment where the expected range of measurement is limited to -200 to +1000 μe . This gage [in its quiescent state] has a 500 μe load. A 349,650 Ohm precision resistor is available that will be mounted on the plug-in header in Shunt location R(B). Instructions for installing shunt resistors are provided elsewhere in the document. In this example the user would enter the following values in the Calibration Parameters spreadsheet:

Cal Method Shunt R(B)

Excitation = 2V.

Gage Factor = 2

Shunt Ohms = 349,650

Bridge Ohms = 350

Max Load = 1000

Quiescent Load = 500

Point 1 Units = -200

The accuracy of Shunt Calibration is directly related to the tolerances of the Shunt resistor, Gage(s), and Bridge Completion resistors used in the circuit. In the event that a precision shunt resistor is unavailable, WaveView provides an alternate way of calculating Shunt calibration constants. This method is as follows:

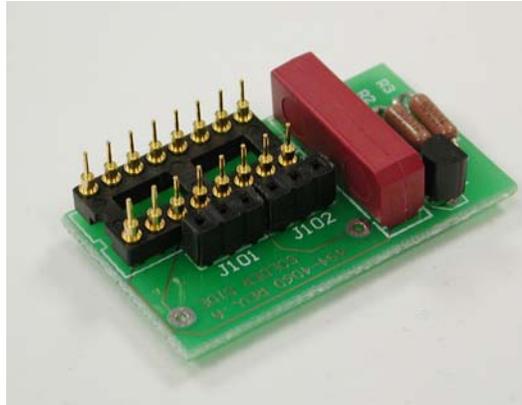
- (a) Install an appropriate non-precision shunt resistor of a value that creates the degree of bridge imbalance desired.
- (b) Press and hold the <Alt> key on the computer's keyboard; then start the calibration process.
- (c) Once the calibration process has started you release the <Alt> key.

This *alternate* Shunt Calibration method calculates the shunted load value from shunted and un-shunted bridge voltage measurements; and then performs the equivalent of a 2 Point Manual calibration.

External Shunt Calibration (2 Pt Shunt)

This calibration method requires the use of a WBK16/LC option, which is discussed elsewhere in the document. The method supports the use of an external shunt resistor. The resistor is shunted across the gage using the (RF) switch in the StrainBook or WBK16. The method appears simply as "Shunt" in the list of calibration methods when either "Load Cell" or "Transducer" is selected as the sensor type.

Note: The WBK16/LC provides a non-committed dry contact on two pins of a single StrainBook or WBK16 channel connector. The WBK16/LC can be used for virtually all single value shunt calibration requirements, some of which are not possible with the internal FET/analog switch provisions in the standard channel configurations.



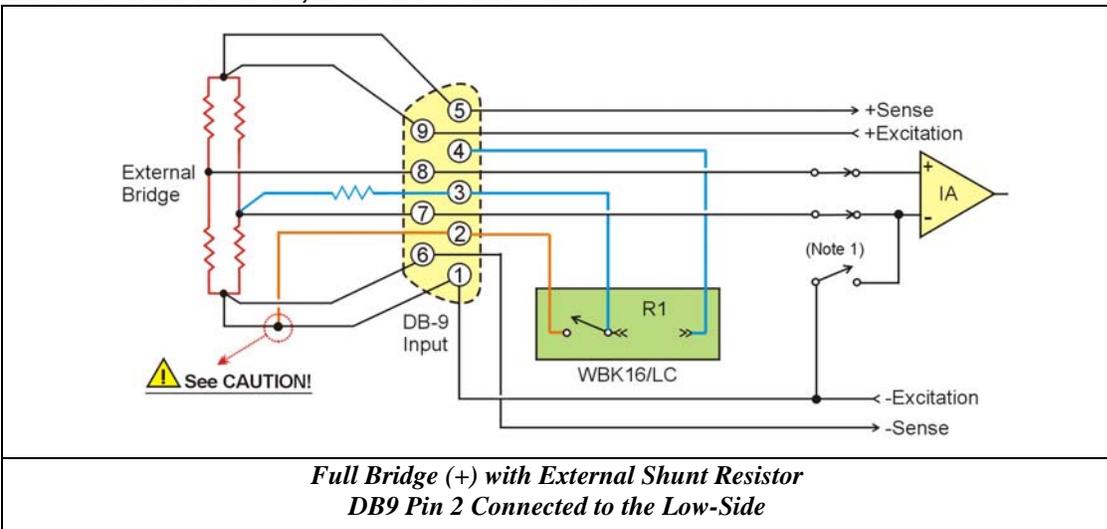
WBK16/LC

CAUTION



Make the DB9 pin # 2 connection to the "low-side" or the "high-side" of the circuit. **BUT NEVER TO BOTH!** Doing so will create a short circuit that could damage equipment.

External Shunt Resistor, Low-Side Connection



Reference Note:

The WBK16/LC Load Cell Shunt Cal internal option board is detailed in an early section. That section includes an alternate schematic for connecting Pin 2 to the High-side.

The External Shunt Calibration method requires that the user enter the following 5 parameters:

Excitation - The value of the constant voltage source used to excite the gage.

Max Load - The maximum load value that the gage is expected to measure. This value could be less than the max rated load of the gage.

Quiescent Load - The minimum load value that the gage is expected to measure. This value could be greater than the minimum rated load of the gage.

Point 1 Units - The user-supplied, *at rest* value of the load applied to the gage. If no load is applied to the gage in its quiescent state, enter "0"zero.

Point 2 Units - The user-supplied *effective load* value that will appear at the gage when the external shunt resistor is switched into place. This load value must be calculated based on the value of the external shunt resistor.

As with the Internal Shunt method, calibration accuracy is directly tied to the accuracy and stability of the shunt resistor used.

Name Plate Calibration

Name Plate Calibration is similar to the 2 Point Auto Calibration method. No actual measurements are taken during the calibration process. The calibration constants are calculated from information provided by the user. The method is called "Name Plate" because the calibration information is obtained from the Name Plate or Label that is attached to the gage or load cell.

The Name Plate Calibration method requires that the user enter the following 5 parameters:

Excitation - The value of the constant voltage source used to excite the gage.

Sensitivity - The output of the gage measured in millivolts per volt.

Full Rated Load - The maximum rated load of the gage.

Max Load - The maximum load value that the gage will be expected to measure. This value could be less than the max rated load of the gage.

Quiescent Load - The minimum or at rest value of the load applied to the gage. If no load is applied to the gage in its quiescent state, enter zero. WaveView assumes the Min Load value is equal to the quiescent load value.

Calibration Example using the Name Plate Method and a Load Cell

The following example uses Name Plate calibration with a load cell.

Load cells come with a mV/V specification (frequently referred to as sensitivity) which means for each volt of excitation at maximum load, the load cell will output a specific millivolt level.

Consider a 3000-pound load cell rated at 3 mV/V using 10 V of excitation. When the load cell is used, a 10-pound platform will be placed on it. Although the load cell is rated at 3000 pounds, 1500 pounds is the maximum load that will ever be applied for this example.

From the above data we know the following parameters:

- Excitation Voltage = 10 volts
- Maximum Applied Load = 1500 pounds
- Quiescent Tare = 10 pounds
- Sensitivity = 3 mV/V
- Full Rated Load = 3000 pounds

Note: These 5 values are used in the following figure.

To calibrate this load cell using the sensor calibration program:

1. Enter the 5 necessary parameters (see preceding bulleted list) into the calibration spreadsheet. These values are used in the following figure, in which a load cell is connected to channel 7-1.
2. Once the parameters are entered into the spreadsheet, select *Calibrated Enabled Channels* either from the menu bar or from the tool bar.
3. After the calibration is complete, the sensor calibration program will ask you if you want to save the calibration data.
4. The calibration is now complete. To use the load cell, exit the *Sensor Calibration* window and return to the main *WaveView Configuration* main window.

StrainBook616 / WBK16 Sensor Configuration														
Sensor Configuration														
Calibration Date: n/a														
Calibration Parameters							Channel Values							
CH	Cal ?	Sensor Type	Bridge Type	Calibration Method	Calibration Date	Units	Label	Sensor Label	Exc. Volts	Gage Factor	Sensitivity (mV/V)	Shunt Resistor (Ohm)	Bridge Resistor (Ohm)	Full Rated Load (Units)
0-1	Yes	Load Cell		Name Plate	Not Calibrated	lbs	CH01	Example Load Cell	10.0 V		3.000			3000.0
0-2	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH02	S/N	10.0 V					
0-3	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH03	S/N	10.0 V					
0-4	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH04	S/N	10.0 V					
0-5	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH05	S/N	10.0 V					
0-6	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH06	S/N	10.0 V					
0-7	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH07	S/N	10.0 V					

Calibration (View of window with scrollbar to the left)

StrainBook616 / WBK16 Sensor Configuration														
Sensor Configuration														
Calibration Date: n/a														
Calibration Parameters							Channel Values							
CH	Cal ?	Sensor Type	Bridge Type	Calibration Method	Calibration Date	Units	Label	Full Rated Load (Units)	Max Appl. Load (Units)	Quiescent / Tare (Units)	Point 1 (mV)	Point 1 (Units)	Point 2 (mV)	Point 2 (Units)
0-1	Yes	Load Cell		Name Plate	Not Calibrated	lbs	CH01	3000.0	3000.0	0.0				
0-2	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH02		3000.0	0.0		0.0		3000.0
0-3	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH03		3000.0	0.0		0.0		3000.0
0-4	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH04		3000.0	0.0		0.0		3000.0
0-5	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH05		3000.0	0.0		0.0		3000.0
0-6	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH06		3000.0	0.0		0.0		3000.0
0-7	No	Strain Gage	Full Bridge	2 Pt Man.	Not Calibrated	V	CH07		3000.0	0.0		0.0		3000.0

Calibration (View of window with scrollbar to the right)

Changing Low-Pass Filter Displays

To change the LPF display, choose *Advanced Features* from the *System* menu item. Enter desired values in the *LPF Corner Frequencies Settings* dialog box. The frequency range for the first LPF setting is 2Hz to 200Hz. The frequency range for the second LPF setting is 200 Hz to 20000 Hz.

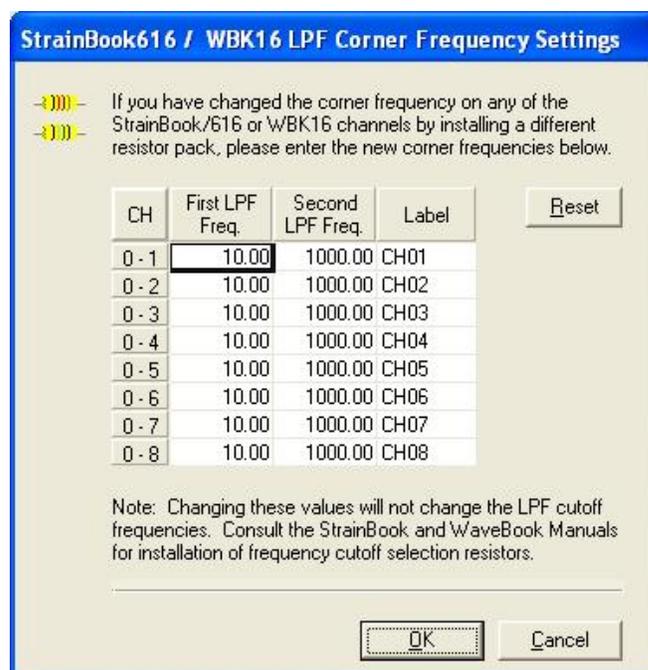
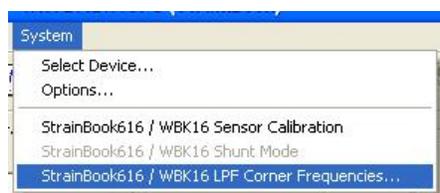


Making changes to the “LPF Settings” or the “LPF Cutoff Column”(of WaveView’s Main Window) will not result in any change to the actual filter. You must physically change frequency cutoff selection resistors so they correspond with the values indicated by the software (or visa versa).



Reference Note:

For information on customizing the Low-Pass Filters refer to *Low-Pass Filter Customization* in Chapter 6, Bridge Configurations.



Accessing the LPF Corner Frequencies Dialog Box

Note: The *LPF Corner Frequencies Dialog Box* is accessed from WaveView’s main window by selecting **Advanced Features** from the **System** pull-down menu.



Reference Note:

If creating your own programs, refer to the Programmer’s Manual, p/n 1008-0901, as needed.

PDF Note: During software installation, Adobe® PDF versions of user manuals automatically install onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. Refer to the PDF documentation for details regarding both hardware and software.

WBK16 – User Tips

There are some aspects of the WBK16 that can cause user difficulties if misunderstood. The following tips should increase your level of understanding and help you get the most out of your WBK16.

(1) Keep things cool.

Operating 120 ohm bridges on 10 volts of excitation is possible with the WBK16 but the strain gages and bridge completion resistors must both be rated for this voltage or there will be excessive drift as the gages and resistors heat up. The 120 ohm bridge completion resistors we offer (part number R-17-120) are of insufficient power rating for 10 volt bridges. If the excitation level is set to 5 volts, drift is not a problem with our 120 ohm resistors. An alternative is to purchase higher quality, higher power and higher cost bridge completion resistors (part number S-120-01) from the Measurement Group.

(2) Understand the difference between calibration and set-up.

Calibration requires measurements of channels with external wiring and gages connected to establish computational data on which to base gain and offset settings. The *two-point manual* and *shunt cal* menu choices provide *calibration*. Set-up uses manually entered parameters to computationally choose gain and offset settings. The two-point automatic and nameplate menu choices provide channel *set-up*.

The *nameplate* menu selection for strain gages cannot effectively calibrate field configured strain gage bridges which have not been externally hardware nulled because the software algorithm assumes the zero point and computes the other settings based on the excitation voltage, gage factor and full scale value entered by the user. Nameplate “calibration” is intended for packaged and pre-calibrated devices, such as load cells and pressure transducers with *nameplates* listing their output sensitivity in mV/V and full-scale output in engineering units.

(3) Do not attempt to “calibrate” all the channels simultaneously.

Although desirable, it is not possible, to globally calibrate all the channels without making any actual measurements. It is possible to apply global auto-zero to previously calibrated channels that have auto-zero enabled. However, the original requirement for the channel to have been externally nulled, prior to performing *nameplate* calibration remains. The overall settings for all of the channels can be stored as a configuration for re-use, but assuming the overall calibration and external system are unchanged between chronologically separated tests is risky and not recommended.

(4) Know an unbalanced bridge when you configure one.

Theoretically, a strain gage bridge is balanced with zero output until strain is applied producing an output voltage linearly proportional to the strain. In the real world, the bridge is slightly unbalanced due to component tolerances. There are two approaches to allow accurate strain measurements with the slightly unbalanced bridge, (1) balance the bridge, or (2) compensate for the error with correction factors. Understand that if you do neither, the bridge will provide erroneous results.

(5) Take it easy on the excitation regulators.

The excitation outputs of the WBK16 will deliver up to 90 mA without any degradation in output voltage. If this level of current is exceeded, the voltage is reduced to protect the regulator. It is important to consider the current drawn by the internal reference node resistors. These resistors are never switched off, they continue to load the excitation regulator no matter what bridge configuration is chosen. If these resistors are 120 ohm resistors, which they never really need to be, they draw 41.7 milliamps at 10 volts. An external full bridge of 120 ohm resistors, and requiring an additional 83.3 milliamps will definitely overload the regulator and result in a reduced excitation level and an incorrect signal level. For two reasons, the best choice for the reference node resistors is 1000 ohms. The parts will draw less excitation current, helping the regulators and the lower degree of self-heating will result in less drift.

(6) Provide adequate input power to each WBK16 in a system.

Providing the proper level of input supply voltage is very important. Insufficient input voltage can cause the WBK16 to exhibit channel-to-channel excitation interaction. All individual channels can be set properly and then begin to lose voltage as additional channels are connected. It is imperative that the WBK16 not be “starved” for input voltage. This can very easily happen if more than one WBK16 is powered from the supplied TR-40U power adapter or some other smaller and inadequate source. A WBK16 can require as much as 25 watts of input power if configured for eight channels of 120 ohm bridges at 10 volts of excitation. The 15V, 2.4A (36 watts) output of the TR-40U is not sufficient for *two* WBK16’s. A variation of this problem can occur if a group of WBK16’s is daisy-chained together with an insufficient wire size feeding the group. Voltage drop in the wiring can also starve the WBK16’s to a greater degree as distance from the source increases. It is strongly recommended that individual WBK16 units each operate from the TR-40U provided or from an individual power lead from an adequately sized source such as a large battery or power supply.

(7) Handle channel configuration headers carefully.

The 16-position, machined-pin IC sockets [into which the bridge completion headers are inserted] have demonstrated a tendency to become unreliable if the headers are rocked sideways to remove them or if resistors with larger leads than those we supply are plugged directly into them. The unreliability manifests itself with widely fluctuating readings, especially if touched, or if the WBK16 enclosure is subjected to shock or vibration. Cold solder joints on the headers have similar symptoms.

(8) Install internal reference node resistors if you plan to use half or quarter bridges

There are internal 1 Meg ohm bias resistors [located between the excitation rails] that create a very high impedance “reference node voltage” in the WBK16 without installing the recommended resistors. Do not attempt measurements using these default resistors, even though it *seems* to work. Install the previously recommended 1000 ohm components and use a calibration method which compensates for the slight bridge imbalance.

(9) Do not neglect the excitation regulator remote sense leads.

The remote sensing feature of the WBK16 will compensate for voltage drop in long lead wires to provide accurate excitation levels at the terminals of full-bridge and half-bridge configurations. If the remote sense lines are not used, be sure to tie them to their respective output lines to minimize excitation noise.

(10) Spend your resistor dollars wisely.

For the widely used 3-wire quarter bridge configuration, purchase the lower bridge completion resistor (R_A) with the best available temperature coefficient and sufficient power rating as to minimize self-heating. The tolerance of the resistance is not as critical, but it should be 0.1% or better. The internal bridge completion locations for the reference node (R_G and R_H) have about 50 milli-ohms resistance between their midpoint connection pads and the tap to the amplifier is at the lower end of this resistance. This resistance nullifies the benefit of using bridge completion resistors with better than 0.1% resistance tolerance because offset nulling will still be necessary. If using shunt calibration, purchase high-precision shunt calibration resistors with micro-strain values appropriate to your application. These are the closest to “standards,” short of a very high precision strain calibrator.

WBK16 – Specifications

Name/Function: Strain-Gage Module

Number of Channels: 8

Input Connector: Standard female DB9 per channel

Input Type: Differential

Input Impedance: 100 M Ω

Coupling: AC and DC, software selectable

Accuracy:

Offset Drift: 1 μ V RTI/ $^{\circ}$ C

CMMR @ DC to 60 Hz: 100 dB at gains > 100

Cross-Talk Rejection: > 90 dB @ less than 1 kHz

Bandwidth:

 50 kHz @ gains < 1 to 100

 10 kHz @ gains > 100 to 2000

 1 kHz @ gains > 2000

Bridge Configuration:

 Full-bridge (4- and 6-wire)

 Half-bridge

 Quarter-bridge (2- and 3-wire)

Bridge Completion: User supplied resistors on removable headers (included)

Bridge Resistance: 60 to 1000 Ω

Overall Gain: 1 to 20000, software selectable in 86 steps

Shunt Calibration: software selection of 3 user-supplied resistors

Auto-Balance: Selected per channel

Auto-Calibration: Either by actual measurement or by calculated load

Offset Adjustment:

\pm 3 V RTI @ gains 1 to 10

\pm 300 mV RTI @ gains 10 to 100

\pm 30 mV RTI @ gains 100 to 2000

\pm 3 mV RTI @ gains 2000 to 20000

Excitation Source: Two independent banks can be set to 0.5, 1.0, 2.0, 5.0, 10.0 volts or off

Excitation Accuracy: \pm 5 mV

Excitation Capacity: 85 mA per channel with fold-back current limiting

Filtering: 4-pole Butterworth, software-selectable and factory-set to 10 Hz, 1 kHz, or bypass;
 field-changeable

Input Power Voltage Range: 10-30 VDC

Power Consumption: 1.0A @ 15V (min);
 1.7A @ 15V (max)

Operating Temperature: 0 $^{\circ}$ to 50 $^{\circ}$ C

Storage Temperature: 0 $^{\circ}$ to 70 $^{\circ}$ C

Humidity: 0 to 95% RH, non-condensing

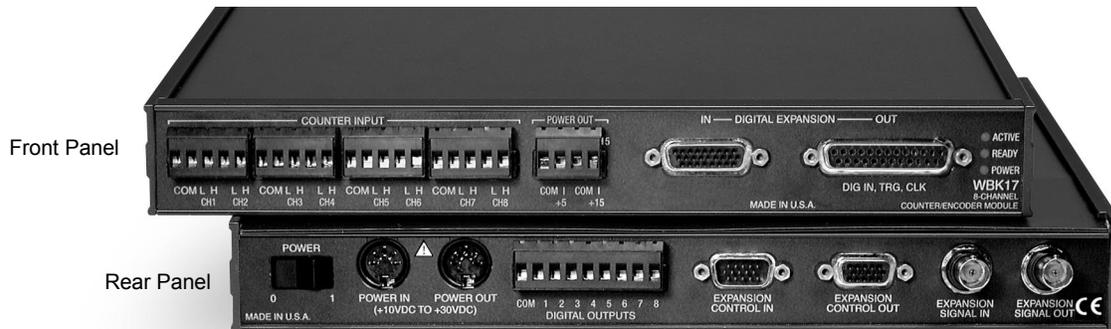
Dimensions: 221mm x 285mm x 35mm (8.5" x 11" x 1.375")

Weight: 1.32 kg (2.9 lb)

For use with WaveBook/516, /512A, /516A, and /516E

- [Description1](#)
- [Hardware Setup3](#)
 - Configuration3
 - Power 3
 - Using Fastener Panels to Stack Modules 4
- [Functional Concepts4](#)
 - Input Coupling4
 - Analog Filtering5
 - Comparator6
 - Debounce Module7
 - Terms Applicable to Counter Modes.....11
 - Counter Options 11
 - Counter/Totalize Mode12
 - Period Mode14
 - Pulsewidth Mode17
 - Timing Mode19
 - Encoder Mode20
 - Digital Inputs29
 - Digital Outputs..... 30
 - Pattern Detection and Data Markers31
- [Software Support31](#)
- [Fuse Replacement36](#)
- [WBK17 - Specifications 37](#)

Description



WBK17 Modules – Showing Front and Rear Panels

Front Panel

- Counter Input** - snap-in terminal blocks. Includes connections for Common, Low, & High for each of 8 channels.
- Power Out [for Encoders]** snap-in terminal block. Includes connections for Common, +5 VDC, and +15 VDC.
- Digital Expansion In** (HD26 Female) & **Digital Expansion Out / Digital In, Trigger, Clock** (DB25 Female)
- LED Indicators** - Active, Ready, and Power

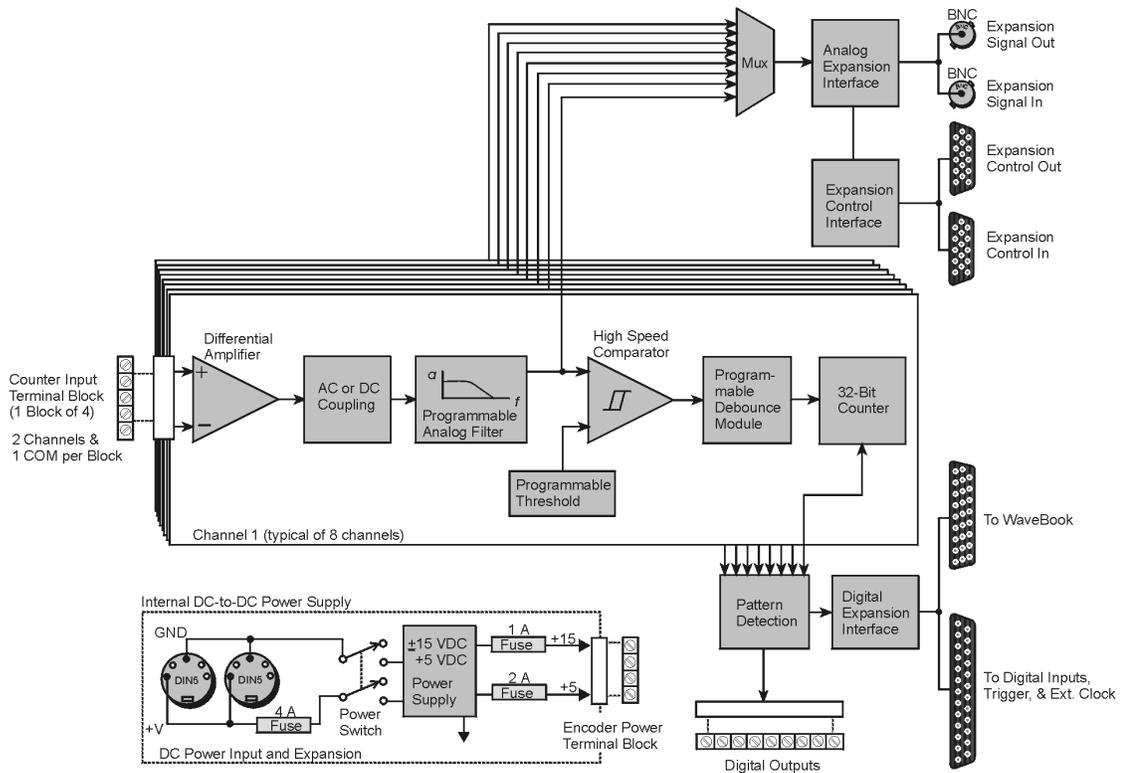
Rear Panel

- Power Switch**
- Power In and Out** (DIN5 connectors) for +10 VDC to +30 VDC
- Digital Outputs** - snap-in terminal block with connection for Common and 8 Channels
- Expansion Control In** (DB15 Male) & **Expansion Control Out** (DB15 Female)
- Expansion Signal In** (BNC) & **Expansion Signal Out** (BNC)

The WBK17 is an 8-channel multi-function counter/encoder module that can be used with WaveBook/516, /512A, /516A, and /516E systems. The WBK17 module can not be used with earlier WaveBook models such as WaveBook/512 and WaveBook/512H.

Each of the high-speed, 32-bit counter channels can be configured for counter, period, pulse width, time between edges, or encoder modes.

All channels are capable of measuring analog inputs that are digitized by the WaveBook at up to 1 MHz. The Analog Waveform Input Mode can be used to measure waveforms from 0 to 100 V peak-to-peak (± 50 V). The maximum analog over-range is 150 V peak-to-peak (± 75 V). The resolution is: 0.002307 V/bit.



WBK17 Block Diagram

The WBK17 can be used with any combination of up to 7 additional WBK signal-conditioning modules. Together these modules can measure a broad range of signal types and address a broad range of applications.

A discussion of the following items is presented in *Functional Concepts*, which immediately follows *Hardware Setup*.

- **AC/DC Coupling**
- **Analog Filtering**
- **Comparator**
- **Debounce Circuit**
- **Counter Options**
- **Digital Inputs**
- **Digital Outputs with Pattern Detection**

Hardware Setup

Configuration

All WBK17 configurations are controlled by software. The WBK17 requires no hardware settings.



Reference Notes:

- Encoder setups for WBK17 applications begin on page 22 of this document module.
- Refer to the *WaveBook User's Manual* (p/n 489-0901) in regard to power, expansion control, and expansion signal connections.
- When using WaveView you will need to set several parameters so WaveView can best meet your application requirements. For software information, refer to the *WaveBook User's Manual* (p/n 489-0901).

Power

Power In [to the WBK17]

The WBK17 can be powered by an included AC power adapter or from any +10 to +30 VDC source, such as a car battery. Check the WBK17 specifications for current requirements. For portable or field applications, the WBK17 and the WaveBook can be powered by the DBK30A Battery Module or the DBK34 UPS/Battery Module. Both devices contain rechargeable battery packs. The *WaveBook User's Manual* (p/n 489-0901) includes details.

Power Out [to the Encoders]

The WBK17 provides output power of +5V at 1A, and +15V at 500 mA to supply power to encoders. Power connections from the WBK17 to [up to 4] encoders are made on the snap-in screw terminal block located on the WBK17's front panel. Example wiring diagrams for encoders begin on page 23.



You must compute power consumption for your entire system. You may need to use auxiliary or high-current power supplies. The *WaveBook User's Manual* (p/n 489-0901) includes tables for calculating system power requirements and discusses power supply options.



Reference Notes:

- The *WaveBook User's Manual* (p/n 489-0901) provides tables for calculating system power requirements and discusses power supply options.
- Encoder wiring diagrams are included in the Encoder section of functional concepts. These drawings begin on page 23.

CE Kit



If your WBK17 is to be part of a CE compliant system, you will need to use part number WBK17-CE KIT. The kit includes the terminal block headers and cable housings that are needed to cover exposed sections of connectors and wiring, thus bringing your WBK17 up to meet or exceed CE standards.

For a list of applicable CE Safety and EMC standards, as well as the CE Compliant Operating Conditions that have been specified for WBK17, refer to the WBK17 Declaration of Conformity, p/n 1064-0740.

Using Fastener Panels to Stack Modules

For convenient mounting, the WBK17 has the same footprint as other WBK modules and WaveBooks. Fastener Panels, sometimes referred to as “splice plates,” provide a means of stacking WaveBooks and modules. Optional screw-on handles are available for portable applications. Refer to this manual’s introduction for assembly information.



When using WBK17 modules in conjunction with other WBK modules, the WBK17 modules must be located closest to the WaveBook due to the CA-217 cable length. The order of the other WBK modules does not matter.



Fastener panels will partially block the vents on WBK16s and the vents on WaveBook/512A, /516, /516A, and /516E when the units are stacked. This partial blocking of vents does not jeopardize the cooling process.

Functional Concepts

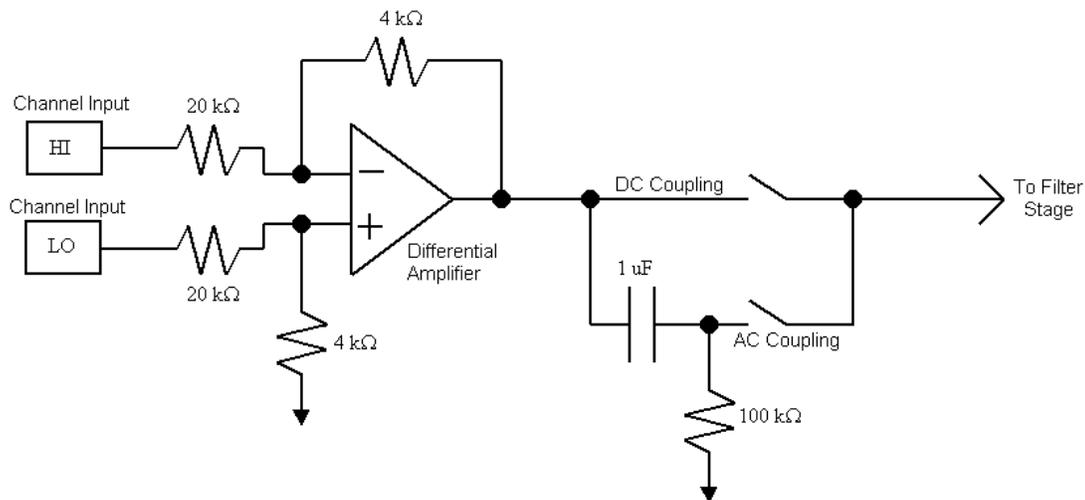
Input Coupling

Each WBK17 channel has a *programmable input coupling* feature. Input coupling can be turned off, or be selected for AC or DC coupling. The type of coupling is determined after the input differential amplifier. DC coupling makes use of the path going straight to the filter stage (of the programmable analog filter), where as AC coupling makes use of the path with the 1 μF capacitor.

The inclusion [or exclusion] of DC offsets is important when calculating the appropriate comparator threshold for the input waveform.

Use AC coupling to reject unwanted DC offsets. In other words, to prevent DC offsets from reaching the comparator. AC coupling works well when the input is constantly changing. If the input stops for longer than one second, it will appear as DC and may cause the comparator to switch on the decaying DC input.

Use DC coupling when both AC and DC components are to be presented as input to the comparator. DC coupling does not reject anything. If the input can have periods of stability longer than one second, use DC coupling so the comparator does not switch on a decaying DC input.



Input Coupling

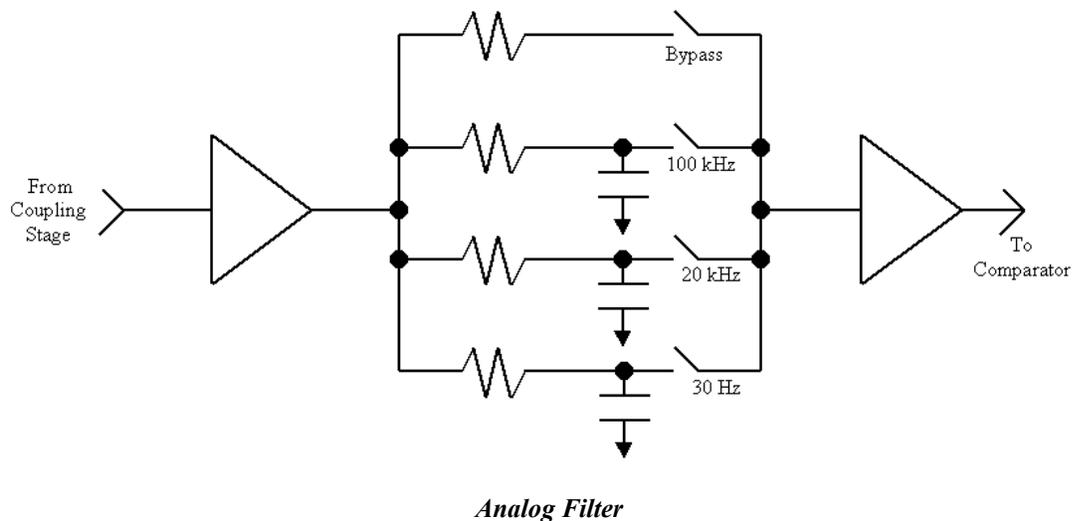
The input coupling stage, shown in the figure above, is compatible with encoder outputs that have balanced outputs (driving both high and low.) The high and low voltages are required to be within the maximum input voltage range of -75V to $+75\text{V}$. A wide range of input waveforms can be accommodated since the WBK17’s comparator threshold can be set anywhere from -12.5V to $+12.5\text{V}$. Many encoders offer line driver outputs, using 4469 or 8830 driver circuits. The 8830 is a dual differential line driver with balanced TTL outputs capable of directly driving long lengths of coax or twisted pair cable. The 4469 is a

CMOS output driver with high current outputs used with voltages of up to 15 V. Balanced line drivers that are used at higher voltages (e.g., +15 V and +24 V) and used in differential mode are particularly immune to external noise sources.

Some encoder outputs will be open-collector type. These require a pullup resistor in order to operate. In many cases, the pullup resistor is already incorporated inside the encoder, other times it must be supplied externally. Since the “open-collector with pullup resistor” output is inherently unbalanced (drives strongly in the low direction, weakly in the high direction) the input differential amplifier will distort the input waveform. This distortion can be easily viewed when the input channel is scanned by the WaveBook. This distortion may have to be taken into account when setting the comparator threshold. Many times the best way to accommodate unbalanced inputs is to AC couple and set the threshold at 0.00V. This forces the comparator to trigger on the center of the waveform, where the input has high slew and little noise. An option is to DC couple and set the comparator threshold at the mid-point of the transition.

If external pullup resistors are required, they can be connected at the WBK17’s input terminal blocks. A pullup resistor can be placed between any input channel and one of the two power supplies offered on the output power connector (+5V and +15V.) Choose a pullup resistor value based on the encoder’s output drive capability and the input impedance of the WBK17. Lower values of pullup resistors will cause less distortion but also cause the encoder’s output driver to pull down with more current. Although the WBK17 has a wide input dynamic range and good common-mode rejection, you should connect the encoder GND to the COM input, when possible.

Analog Filtering



Each channel has a single-pole, low-pass filter with three programmable cut-off frequencies. These are: 100 kHz, 20 kHz, and 30 Hz.

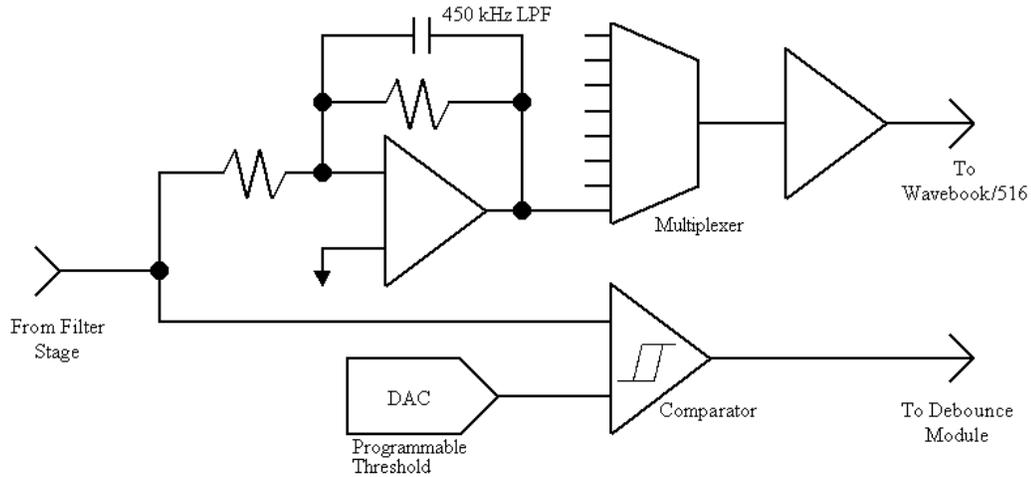
Use analog filtering to reject low-level noise that may otherwise interfere with the comparator. The analog filters are most beneficial when the unwanted noise is far outside the desired bandwidth. For example, if the desired input bandwidth is only 0 to 10 kHz, then the 20 kHz low pass filter will reduce unwanted noise components of 20 kHz by 3dB. Unwanted noise of 200 kHz will be reduced by 23dB; and noise components of 2 MHz will be reduced by 43dB.

Since the analog filters come before the comparator circuit and the expansion analog output path, their effects will be observed at the comparator and in the analog waveform scanned by the WaveBook.

The analog expansion path going back to the WaveBook has a 450 kHz single pole filter.

Comparator

Each channel has its own individually programmable comparator as shown in the figure below. The output of the filter stage feeds the comparator circuit. The analog waveform that is present at the comparator is gain adjusted and then multiplexed onto the WaveBook's analog expansion port. This allows the analog input waveform (as it appears at the comparator, post coupling, post filter) to be scanned like any other analog waveform. The analog path going to the WaveBook is bandwidth-limited to 450 kHz. The analog path between the input and the comparator is not bandwidth-limited unless a low-pass filter is used.



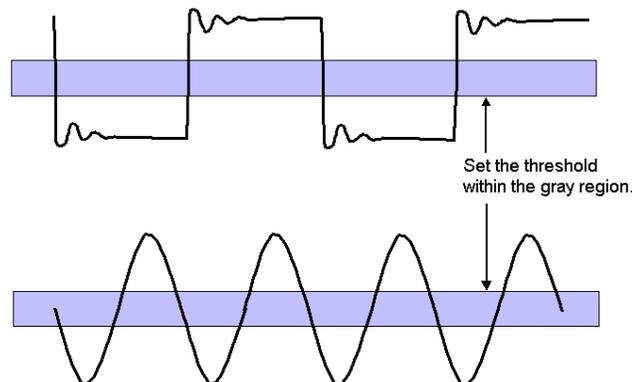
Comparator

The comparator has a programmable threshold, set by the DAC. The threshold can be set anywhere from -12.5V to $+12.5\text{V}$ in 100mV steps, referred to input. Since the counter output and analog waveform can be scanned together, the effects of different comparator switching thresholds can be easily observed. This allows easy adjustment of the comparator-switching threshold based on input waveform characteristics such as noise and ringing.

The following diagram shows two common input waveforms: a square wave that has some ringing and a sine wave. The comparator threshold should be set so that the ringing on the square wave does not cause extraneous switching of the comparator, causing false counts to be measured. Ideally, the comparator threshold should be set so that the comparator switches at the point of fastest slew rate on the input waveform. This occurs in the grayed regions of the waveforms.

Amplitude modulated noise may also cause false switching of the comparator. The effects of amplitude modulated noise can be minimized by setting the threshold at the point of fastest slew rate on the input waveform. The sine wave shown below has its fastest slew rate within the gray region.

Set the comparator threshold within the gray regions to avoid the effects of ringing and noise.



Setting the Comparator Threshold

Debounce Module

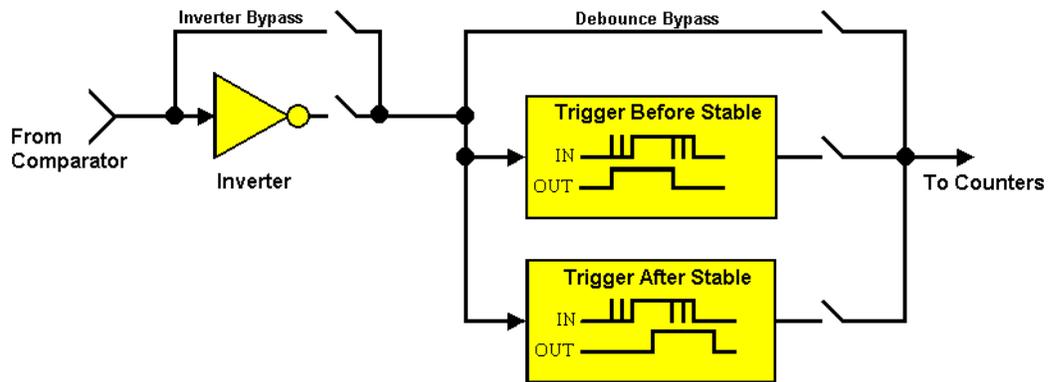
Each channel's comparator output can be debounced with 16 programmable debounce times from 500 ns to 25.5 ms. The debounce module eliminates switch-induced transients typically associated with electro-mechanical devices including relays, proximity switches, and encoders.

From the following illustration we can see that there are two debounce modes, as well as a debounce bypass. In addition, the signal from the comparator can be inverted before it enters the debounce circuitry. The inverter is used to make the input rising-edge or falling-edge sensitive.

Edge selection is available with or without debounce. In this case the debounce time setting is ignored and the input signal goes straight from the inverter [or inverter bypass] to the counter module.

There are 16 different debounce times. In either debounce mode, the debounce time selected determines how fast the signal can change and still be recognized.

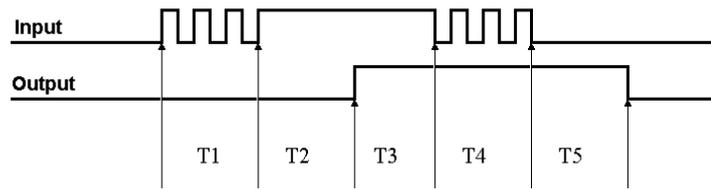
The two debounce modes are "trigger after stable" and "trigger before stable." A discussion of the two modes follows.



Debounce Model

Trigger After Stable Mode

In the “Trigger After Stable” mode, the output of the debounce module will not change state until a period of stability has been achieved. This means that the input has an edge and then must be stable for a period of time equal to the debounce time.



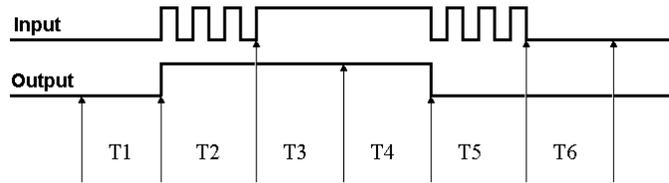
Debounce Module – Trigger After Stable Mode

The following time periods (T1 through T5) pertain to the above drawing. In Trigger After Stable mode, the input signal to the debounce module is required to have a period of stability after an incoming edge, in order for that edge to be accepted (passed through to the counter module.) The debounce time for this example is equal to T2 and T5.

- T1** – In the example above, the input signal goes high at the beginning of time period T1 but never stays high for a period of time equal to the debounce time setting (equal to T2 for this example.)
- T2** – At the end of time period T2, the input signal has transitioned high and stayed there for the required amount of time, therefore the output transitions high. If the Input signal never stabilized in the high state long enough, no transition would have appeared on the output and the entire disturbance on the input would have been rejected.
- T3** – During time period T3 the input signal remained steady. No change in output is seen.
- T4** – During time period T4, the input signal has more disturbances and does not stabilize in any state long enough. No change in the output is seen.
- T5** – At the end of time period T5, the input signal has transitioned low and stayed there for the required amount of time, therefore the output goes low.

Trigger Before Stable Mode

In the “Trigger Before Stable” mode, the output of the debounce module immediately changes state, but will not change state again until a period of stability has passed. For this reason the mode can be used to detect glitches.



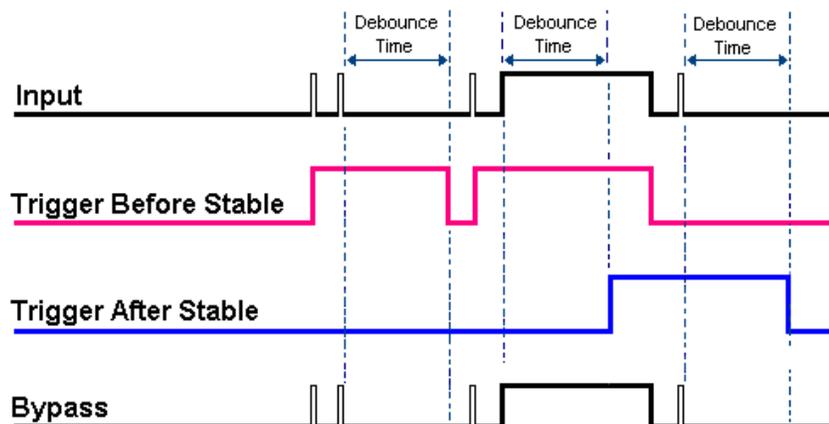
Debounce Module – Trigger Before Stable Mode

The following time periods (T1 through T6) pertain to the above drawing.

- T1** – In the illustrated example, the **Input** signal is low for the debounce time (equal to T1); therefore when the input edge arrives at the end of time period T1 it is accepted and the **Output** (of the debounce module) goes high. Note that a period of stability must precede the edge in order for the edge to be accepted.
- T2** – During time period T2, the input signal is not stable for a length of time equal to T1 (the debounce time setting for this example.) Therefore, the output stays “high” and does not change state during time period T2.
- T3** – During time period T3, the input signal is stable for a time period equal to T1, meeting the debounce requirement. The output is held at the high state. This is the same state as the input.
- T4** – At anytime during time period T4, the input can change state. When this happens, the output will also change state. At the end of time period T4, the input changes state, going low, and the output follows this action [by going low].
- T5** – During time period T5, the input signal again has disturbances that cause the input to not meet the debounce time requirement. The output does not change state.
- T6** – After time period T6, the input signal has been stable for the debounce time and therefore any edge on the input after time period T6 will be immediately reflected in the output of the debounce module.

Mode Comparison

The following example shows how the two modes interpret the same input signal (which exhibits glitches). Notice that the *Trigger Before Stable* mode will recognize more glitches than the *Trigger After Stable* mode. Use the *bypass* option to achieve maximum glitch recognition.

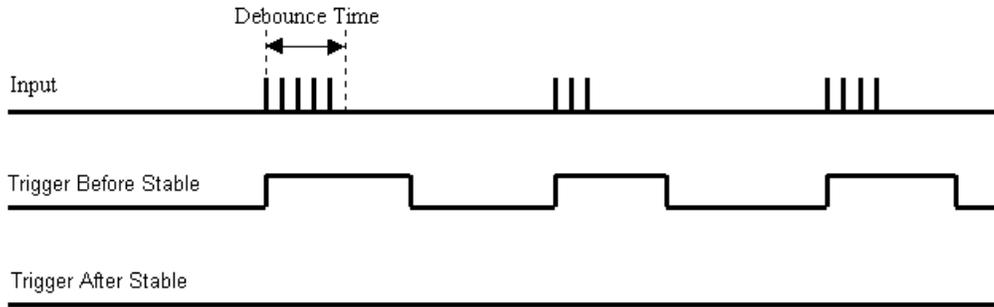


Example of Two Debounce Modes Interpreting the Same Signal

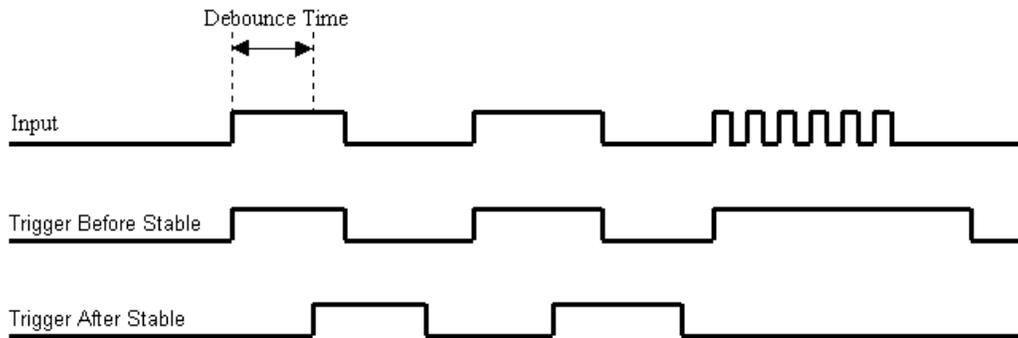
Debounce times should be set according to the amount of instability expected in the input signal. Setting a debounce time that is too short may result in unwanted glitches clocking the counter. Setting a debounce time too long may result in an input signal being rejected entirely. Some experimentation may be required to find the appropriate debounce time for a particular application.

To see the effects of different debounce time settings, simply view the analog waveform along with the counter output.

Use trigger before stable mode when the input signal has groups of glitches and each group is to be counted as one. The trigger before stable mode will recognize and count the first glitch within a group but reject the subsequent glitches within the group if the debounce time is set accordingly. The debounce time should be set to encompass one entire group of glitches as shown in the following diagram.



Trigger after stable mode behaves more like a traditional debounce function: rejecting glitches and only passing state transitions after a required period of stability. Trigger after stable mode is used with electro-mechanical devices like encoders and mechanical switches to reject switch bounce and disturbances due to a vibrating encoder that is not otherwise moving. The debounce time should be set short enough to accept the desired input pulse but longer than the period of the undesired disturbance as shown in the diagram below.



Terms Applicable to Counter Modes

The following terms and definitions are provided as an aid to understanding counter modes.

Detection Signal: A detection signal is one of 8 outputs of the pattern detection module. Each input channel has an associated detection signal (Detect 1 for Channel 1, Detect 2 for Channel 2, etc.) A channel's detection signal will go active high when that channel's counter value meets the setpoint criteria programmed into the pattern detection module. Detection signals can be scanned along with any other channel in the scan group.

Gating: Any counter can be gated by the mapped channel. When the mapped channel is high, the counter will be allowed to count, when the mapped channel is low, the counter will not count but hold its value.

Mapped Channel: A mapped channel is one of 16 signals that can get multiplexed into a channel's counter module. The mapped channel can participate with the channel's input signal by gating the counter, clearing the counter, etc. The 16 possible choices for the mapped channel are the 8 input signals (post debounce) and the 8 detection signals.

Start of Scan: The start of scan is a signal that is internal to the WBK17. It signals the start of a scan group and therefore pulses once every scan period. It can be used to clear the counters and latch the counter value into the acquisition stream.

Terminal Count: This signal is generated by the counter value. There are only two possible values for the terminal count: 65,535 for a 16-bit counter (Counter Low); and 4,294,967,295 for a 32-bit counter (Counter High). The terminal count can be used to stop the counter from rolling over to zero.

Ticksize: The ticksize is a fundamental unit of time and has four possible settings: 20ns, 200ns, 2000ns, 20000ns. For measurements that require a timebase reference like period or pulsewidth, the ticksize is the basic unit of time. The count value returned in the scan is the number of ticks that make up the time measurement.

Counter Options

The following mode options are available with the WBK17 and are detailed in the upcoming pages. A separate block diagram has been created for each mode. Note that the **OPT** numbers relate to sections of the block diagrams.

Counter/Totalize Mode (see page 12):

- OPT0:** Selects *totalize* or *clear on read* mode.
- OPT1:** Determines if the counter is to *rollover* or "*stop at the top.*"
- OPT2:** Determines whether the counter is 16-bits (Counter Low); or 32-bits (Counter High).
- OPT3:** Determines which signal latches the counter outputs into the data stream back to the WaveBook. Start of scan or mapped channel.
- OPT4:** Allows the mapped channel to gate the counter.
- OPT5:** Allows the mapped channel to decrement the counter.
- OPT6:** Allows the mapped channel to increment the counter.

Period Mode (see page 14):

- OPT[1:0]:** Determines the number of periods to time, per measurement (1, 10, 100, 1000).
- OPT2:** Determines whether the period is to be measured with a 16-bit (Counter Low); or 32-bit (Counter High).
- OPT4:** Allows the mapped channel to gate the counter.
- OPT6:** Allows the mapped channel to be measured for periods.

Pulsewidth Mode (see page 17):

- OPT2:** Determines whether the pulsewidth is to be measured with a 16-bit counter (Counter Low); or a 32-bit counter (Counter High).
- OPT4:** Allows the mapped channel to gate the counter.
- OPT6:** Allows the mapped channel to be measured for pulsewidth.

COUNTER: OPT0: This selects *totalize* or *clear on read* mode.

Totalize Mode – The counter counts up and rolls over on the 16-bit (Low Counter) boundary, or on the 32-bit (High Counter) boundary. See OPT2 in regard to choosing 16-bit or 32-bit counters.

Clear On Read Mode – In WaveView, the “Clear On Read Mode” is referred to as the “Counter” mode. The counter is cleared at the beginning of every scan; and the final value of the counter [the value just before it was cleared] is latched and returned to the WaveBook.



When using either an EXT CLK input, or one or both SYNC ports, the *clear on read mode* is not available. In these instances, the *totalize mode* should be used.

COUNTER: OPT1: This determines if the counter is to *rollover* or “*stop at the top.*”

Rollover Mode - The counter continues to count upward, rolling over on the 16-bit (Counter Low) boundary, or on the 32-bit (Counter High) boundary. See OPT2 in regard to choosing 16-bit or 32-bit counters.

Stop at the Top Mode - The counter will stop at the top of its count. The top of the count is FFFF for the 16-bit option (Counter Low), and FFFFFFFF for the 32-bit option (Counter High).

COUNTER: OPT2: Determines whether the counter is **16-bits** or **32-bits** (Counter Low, or Counter High, respectively). This only matters when the counter is using the “stop at the top” option, otherwise this option is inconsequential.

COUNTER: OPT3: Determines which signal latches the counter outputs into the data stream back to the WaveBook. Normally, the start of scan signal latches the counter outputs at the beginning of every scan; but an option is to have the mapped signal latch the counter outputs. This mapped-signal option allows a second signal to control the latching of the count data. This allows the user to know the exact counter value when an edge is present on another channel.

COUNTER: OPT4: Allows the **mapped channel to gate the counter** if desired. When the mapped channel is **high**, the counter is enabled. When the mapped channel is **low**, the counter is disabled (but holds the count value). The mapped channel can be any other input channel, or one of the detection signals.

COUNTER: OPT5: Allows the **mapped channel to decrement the counter**. With this option the input channel [for the counter] will increment the counter. The mapped channel can be used to decrement the counter.

COUNTER: OPT6: Allows the **mapped channel to increment the counter** instead of the main channel. This option allows the counter to be used with any other input channel (post-debounce), or with one of the detection signals. If the channel’s input is used elsewhere, for example, gating another counter, the counter for this channel does not need to go unused.

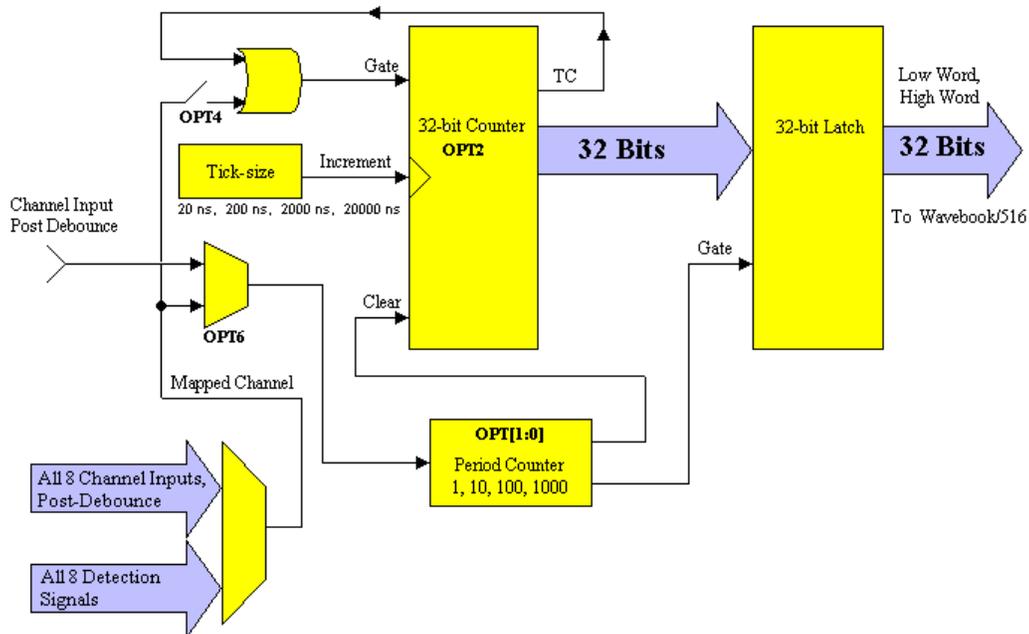


Reference Notes:

For information on implementing [Up/Down Counters](#) of any size, refer to Application Example #2 on page 26 of this document module.

Period Mode

This mode allows for period measurement of the channel input. The measurement period is the time from edge-to-edge, either both rising or both falling. Period data is latched as it becomes available and the data is sent to the WaveBook at the scan rate. Therefore, if the scan period is much faster than the input waveform, there will be a great deal of repetition in the period values. This repetition is due to the fact that updates take place only when another full period becomes available.



Period Mode

An example: One channel's acquired data might be: 0,0,0,0,80,80,80,80,79,79,79,79,81,81,81,81,..... This data represents the number of ticksize intervals counted during the period measurement. The first value(s) returned will be zero since the counters are cleared at the beginning of the acquisition. The data comes in sets of four since the scan period is about one-fourth as long as the input channel's period. Every time the period measurement is latched from the counter, the counter is immediately cleared and begins to count the time for the subsequent period.

If the scan period is a lot slower than the input period, the acquired data will be missing some periods. To obtain greater resolution, you can increase the scan period, or use an averaging option (see OPT[1:0]).

The data returned is interpreted as time measured in ticks. There are four timebase settings: 20 ns, 200 ns, 2 μ s, and 20 μ s. These are often referred to as tick-sizes. The WBK17 uses a 50 MHz, 10 ppm oscillator as a timing source.

PERIOD: OPT[1:0]: Determines the **number of periods to time, per measurement**. This makes it possible to *average out jitter* in the input waveform, sampling error, noise, etc. There are four options:

- (1) The channel's measurement is latched every time one complete period has been observed.
- (2) The channel's measurement is latched every time that 10 complete periods have been observed, the value that gets returned is equal to 10 consecutive periods of the input channel.
- (3) The number returned is 100 consecutive periods.
- (4) The number returned is 1000 consecutive periods.

PERIOD: OPT2: Determines whether the period is to be measured with a **16-bit** (Counter Low), or **32-bit** (Counter High) counter. Since period measurements always have the "stop at the top" option enabled, this option dictates whether the measurement has a range of 0 to 65535 ticks or 0 to 4,294,967,295 ticks.

PERIOD: OPT4: Allows the **mapped channel to gate the counter** if desired. When the mapped channel is **high**, the counter is enabled. When the mapped channel is **low**, the counter is disabled, but still holds the count value. The mapped channel can be any other input channel or a detection signal.

PERIOD: OPT6: This allows a mapped channel's period to be measured, instead of the input channel. The mapped channel can be any other input channel (post debounce) or one of the detection signals (on any channel). This option allows the counter to be used with any other input channel (post-debounce), or with one of the detection signals. If the channel's input is used elsewhere, for example, gating another counter, the counter for this channel does not need to go unused.

Period and Frequency Accuracy

The WBK17 can measure the period of any input waveform. It does this by counting the integral number of “ticks” that make up the period, the data returned will always be time measured in “ticks.” The error in each data sample will come from two sources: the sampling error caused by not being able to count a partial “tick”; and the WBK17's internal timebase inaccuracy. The WBK17's internal timebase has an absolute accuracy of 10ppm. The sampling error will vary with input frequency, selected ticksize, and selected averaging mode. The absolute error is the “root-sum-of-squares” of the two independent error sources. For example, if the sampling error is 10ppm and the timebase accuracy is 10ppm, the absolute accuracy is 14.1 ppm.

Many times the desired accuracy is much less than what the internal timebase is capable of. Other applications will require a more accurate period measurement and the effects of sampling error will have to be averaged out leaving only the inaccuracy associated with the internal timebase. Inaccuracy due to the internal timebase cannot be averaged out.

For period and frequency measurements, percent sampling error is equal to $100\%/(n+1)$ where $n=0$ to 65,535 for a 16-bit counter and $n=0$ to 4,294,967,295 for a 32-bit counter. For small count values, the sampling error is large and for large count values, the sampling error is small. If sampling error is to be less than 0.2%, n must be greater than 499 regardless of counter size. If sampling error is to be less than 0.001% (10 ppm), n must be greater than 99,999 which requires use of a 32-bit counter. These values of n were used to derive the frequency range tables below.

Sampling error can also be reduced by averaging many samples together. Assuming the input signal is asynchronous to the WBK17's internal timebase, sampling error can be divided by the square-root of the number of samples taken. The averaging can be done with PC-based software.

The WBK17 has the ability to measure 1, 10, 100 or 1000 periods, dividing the sampling error by 1, 10, 100, or 1000. This is done inside the WBK17 and may eliminate the need for any averaging to be done in the PC. For high accuracy on high frequency inputs, multiple period measurement and PC-based averaging can be done.

The WBK17 has the ability to provide various frequency ranges that are based upon different ticksizes, averaging options, and counter size (16 bit or 32 bit values.) The frequency ranges are designed to fit a wide array of possible applications. Within each range, the sampling error decreases dramatically as the input period increases. The ranges will get smaller as required accuracy increases.

Upper 16-bits of the 32-bit counter		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 1500u	20000	1
150u – 15m	2000	1
1500u – 150m	200	1
15m – 1500m	20	1
150m – 15	20	10
1500m – 150	20	100
15 – 1500	20	1000

Lower 16-bits of the 32-bit counter		
Range (Hz)	Ticksize (nS)	Averaging Option
1 – 100	20000	1
10 – 1k	2000	1
100 – 10k	200	1
1k – 100k	20	1
10k – 1M	20	10
100k – 5M	20	100
1M – 5M	20	1000

Frequency Ranges for a 16-bit value, sampling error is less than 0.2%

Each frequency range given in the previous table-set can be exceeded. If the input waveform goes under-range by too much, the counter value will top out at 65535 indicating you have reached the lowest possible frequency that can be measured on that range. If the input waveform goes over range by too much, the counter will return values that are very coarse and have a lot of sampling error. The values returned will have a small number of counts for the period duration. If an input waveform cannot fit within one of the 16-bit ranges shown above or requires much higher accuracy, then a 32-bit range should be considered.

Full 32-bit Counter		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 100	20000	1
150u – 1k	2000	1
1.5m – 10k	200	1
15m – 100k	20	1
150m – 1M	20	10
1.5 – 5M	20	100
15 – 5M	20	1000

***Frequency Ranges for a 32-bit Value,
Sampling Error is Less than 0.2%***

The 32-bit ranges shown above are much wider than the 16-bit ranges but also require the full 32-bit value to be returned, this requires two sample periods within each scan group. The 32-bit frequency ranges can also be exceeded with a loss of accuracy or topping out at 4,294,967,295 counts.

Some measurements will require the accuracy of an input waveform to be free of sampling error, having only the absolute accuracy of the internal timebase as the source of error. Sampling error can be averaged out to give the required result. In most cases, the WBK17 can perform the required averaging on the values before they are returned to the PC. The frequency ranges shown below will give a sampling error that is less than 10ppm or 1ppm.

Full 32-bit Counter <10 ppm		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 500m	20000	1
150u – 5	2000	1
1.5m – 50	200	1
15m – 500	20	1
150m – 5k	20	10
1.5 – 50k	20	100
15 – 500k	20	1000

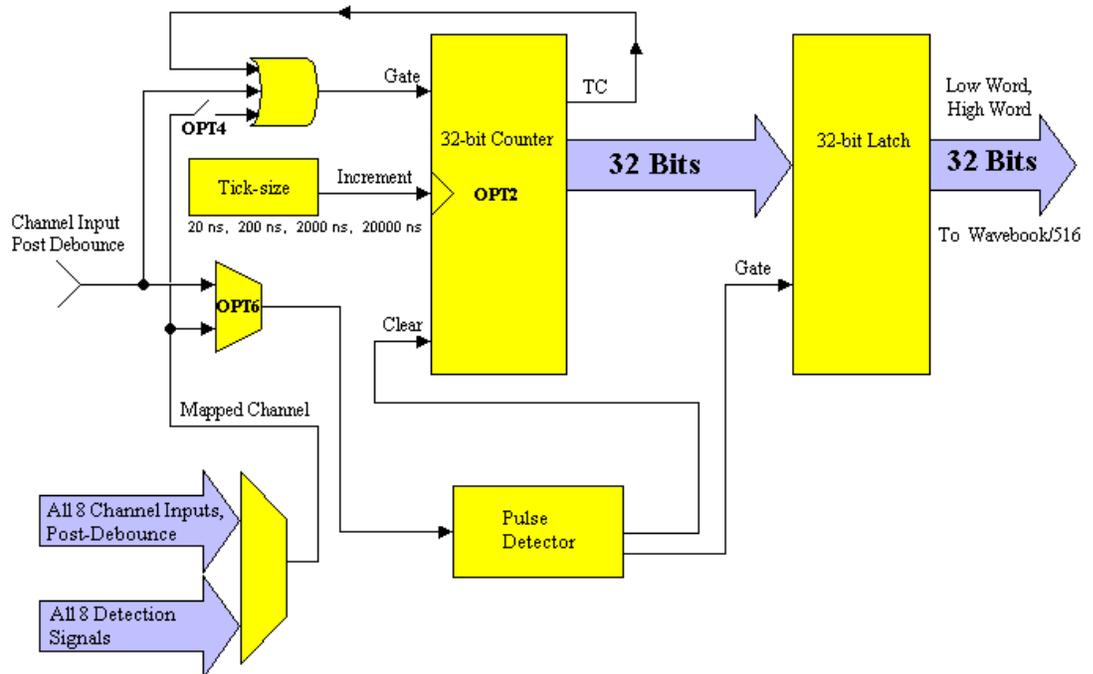
Full 32-bit Counter <1 ppm		
Range (Hz)	Ticksize (nS)	Averaging Option
15u – 50m	20000	1
150u – 500m	2000	1
1.5m – 5	200	1
15m – 50	20	1
150m – 500	20	10
1.5 – 5k	20	100
15 – 50k	20	1000

***High Accuracy Frequency Ranges for a 32-bit Value
that has little sampling error (<10ppm, <1ppm)***

If the input frequency is required to have less than 1 ppm sampling error and is greater than 50kHz, use the 15-50kHz, 1ppm range. The values returned will have sampling error that is greater than 1ppm but they can be averaged by the PC software to further reduce the sampling error.

Pulsewidth Mode

This mode provides a means to measure a channel's pulsewidth. The measurement is the time from the rising edge to the falling edge, or visa versa. The measurement will be either pulsewidth low, or pulsewidth high, depending upon the edge polarity set in the debounce module. Every time the pulsewidth measurement is latched from the counter, the counter is immediately cleared and enabled to count the time for the next pulsewidth. The pulsewidth measurements are latched as they become available.



Pulsewidth Mode

An example: one channel's acquired data might be: 0,0,0,0,80,80,80,80,79,79,79,79,81,81,81,81,... This data represents the number of ticksize intervals counted during the pulsewidth measurement. The first value(s) returned will be zero since the counters are cleared at the beginning of the acquisition. In this example the data comes in sets of four because the scan period is about one-fourth as long as the input channel's period. Every time the pulsewidth measurement is latched from the counter, the counter is immediately cleared and enabled to count time for the next pulsewidth.

If the scan period is much slower than the input period, then the acquisitions will miss some pulsewidths. Decreasing the scan period will increase the number of different pulsewidths received.

The data returned is interpreted as time measured in ticks. There are four timebase settings: 20 ns, 200 ns, 2 μ s, and 20 μ s. These are often referred to as tick-sizes. The WBK17 uses a 50 MHz, 10 ppm oscillator as a timing source.



If the input signal has a poor slew rate the pulsewidth mode will provide variant results, dependant upon the comparator threshold..

PULSEWIDTH: OPT2: Determines whether the pulsewidth is to be measured with a **16-bit** (Counter Low), or **32-bit** (counter High) counter. Since pulsewidth measurements always have the "stop at the top" option enabled, this option dictates whether the measurement has a range of 0 to 65535 ticks, or 0 to 4,294,967,295 ticks.

PULSEWIDTH: OPT4: Allows the **mapped channel to gate the counter**. When the mapped channel is **high**, the counter is enabled to count. When the mapped channel is **low**, the counter is disabled, but holds the count value. The mapped channel can be any other input channel, or one of the detection signals.

PULSEWIDTH: OPT6: This allows the mapped channel's pulsewidth to be measured instead of the input channel. The mapped channel can be any other input channel (post debounce) or one of the detection signals (on any channel). This option allows the counter to be used with any other input channel (post-debounce), or with one of the detection signals. If the channel's input is used elsewhere, for example, gating another counter, the counter for this channel does not need to go unused.

Pulsewidth and Timing mode Accuracy

The WBK17 has the ability to measure the pulsewidth of an input and the time between any two edges on any two inputs. The time ranges are similar to those shown for period mode except that averaging is not available. The ranges given below reflect this.

Upper 16-bits of the 32-bit Counter		
Range (S)	Ticksize (nS)	Averaging Option
800 – 80000	20000	1
80 – 8000	2000	1
8 – 800	200	1
800m – 80	20	1

Lower 16-bits of the 32-bit Counter		
Range (S)	Ticksize (nS)	Averaging Option
10m – 1	20000	1
1m – 100m	2000	1
100u – 10m	200	1
10u – 1m	20	1

*Pulsewidth and Time Ranges for a 16-bit Value
Sampling error is less than 0.2%*

Full 32-bit Counter		
Range (S)	Ticksize (nS)	Averaging Option
10m – 80000	20000	1
1m – 8000	2000	1
100u – 800	200	1
10u - 80	20	1

*Pulsewidth and Time Ranges for a 32-bit Value
Sampling error is less than 0.2%*

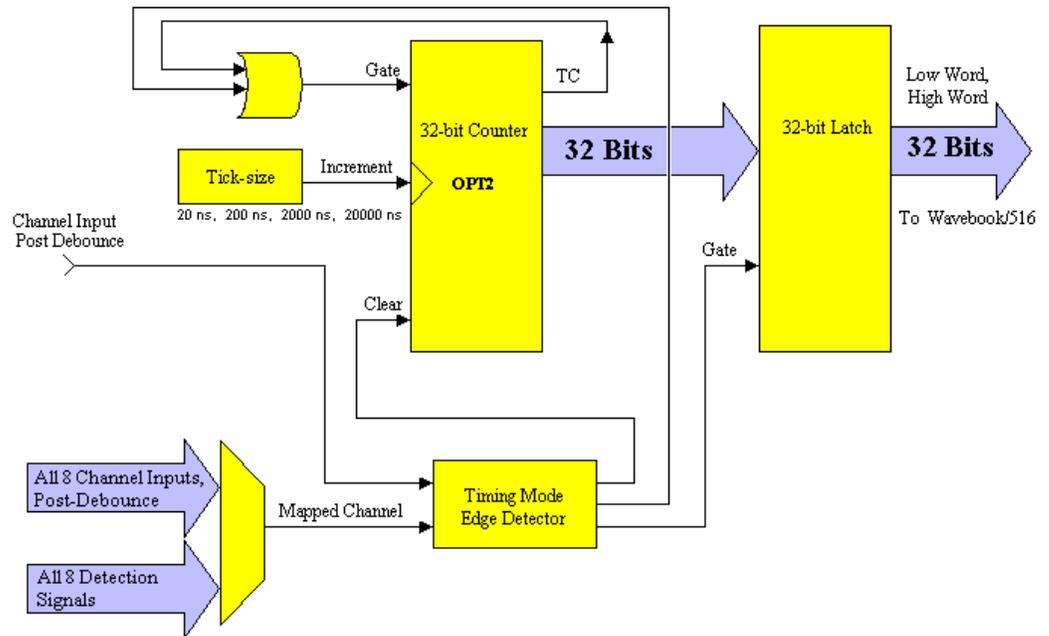
Full 32-bit Counter <10 ppm		
Range (S)	Ticksize (nS)	Averaging Option
2 – 80000	20000	1
200m – 8000	2000	1
20m – 800	200	1
2m – 80	20	1

Full 32-bit Counter <1 ppm		
Range (S)	Ticksize (nS)	Averaging Option
20 – 80000	20000	1
2 – 8000	2000	1
200m – 800	200	1
20m – 80	20	1

*High Accuracy Pulsewidth and Time Ranges for a 32-bit Value
that has little sampling error (<10ppm, <1ppm)*

Timing Mode

This mode provides a means of measuring time between two subsequent events, i.e., the edge of one channel with respect to the edge of another channel. The edge selection is done in each channel's debounce setup. Whenever the time measurement is latched from the counter, the counter is immediately cleared and enabled for accepting the subsequent time period, which starts with the next edge on the main channel.



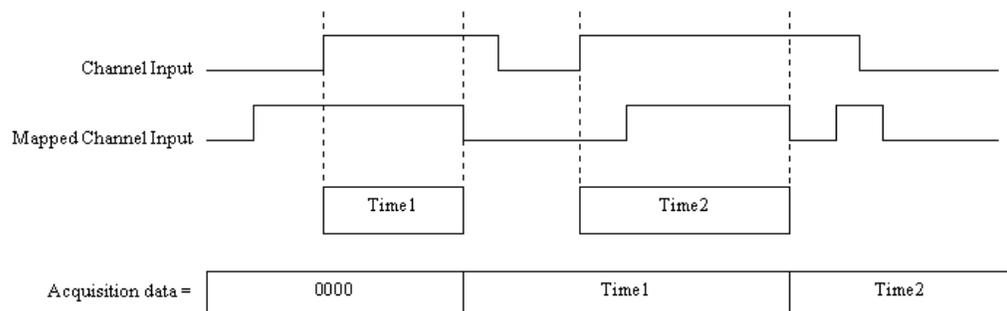
Timing Mode

An Example of Timing Mode

The following example represents one channel in timing mode. The time desired is between the *rising edge* on the **input channel** and the *falling edge* on the **mapped channel**. Zeroes are returned, in the scan, until one complete time measurement has been taken. At that point, the value (time in ticks) is latched and output to the WaveBook until the next time measurement has been completed. Rising edges on the input channel will clear the counter and falling edges on the mapped channel will latch the output of the counter at that time. If the scan period is much slower than the rate of time-frames coming [available on the two channels] then the data will miss some time-frames. The scan period can be decreased to capture more time-frames.

The data returned is interpreted as time measured in ticks. This data represents the number of ticksize intervals counted during the timing measurement. There are four timebase settings: 20 ns, 200 ns, 2 μ s, and 20 μ s. These are often referred to as tick-sizes. The WBK17 uses a 50 MHz, 10 ppm oscillator as a timing source.

Note! If the input signal has a poor slew rate the timing mode will provide variant results, dependant upon the comparator threshold.



Example of One Channel in Timing Mode

TIMING: OPT2: This determines whether the time is to be measured with a **16-bit** (Counter Low), or **32-bit** (Counter High) counter. Since time measurements always have the “stop at the top” option enabled, this option dictates whether the measurement has a range of 0 to 65535 ticks or 0 to 4,294,967,295 ticks.

Encoder Mode

Introduction

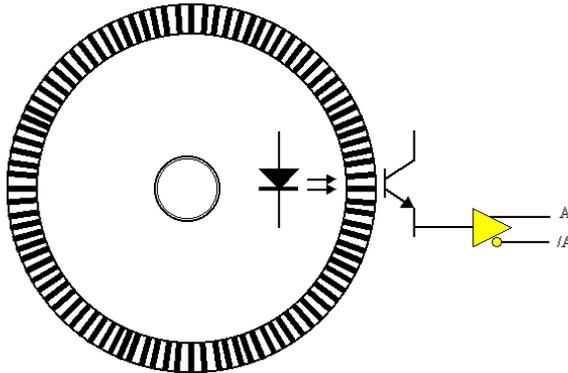
Rotary shaft encoders are frequently used with CNC equipment, metal-working machines, packaging equipment, elevators, valve control systems, and in a multitude of other applications in which rotary shafts are involved.

The *encoder mode* allows the WBK17 to make use of data from optical incremental quadrature encoders. When in the *encoder mode*, the WBK17 accepts either *differential* or *single-ended* inputs and provides power for up to four encoders. When reading phase A, phase B, and index Z signals, the WBK17 provides positioning, direction, and velocity data.



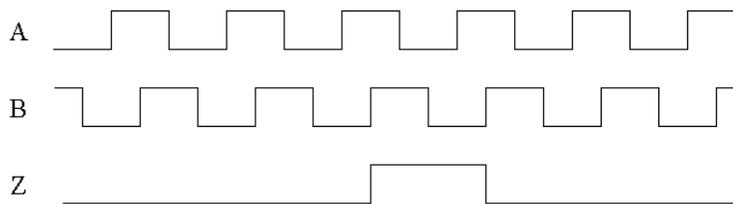
The WBK17 can receive input from up to four encoders; however, the WaveView data acquisition program can accept input from only one or two encoders. To receive input from three or four encoders [with one WBK17] refer to the Programmer’s Manual (p/n 1008-0901).

The WBK17 supports quadrature encoders with a 16-bit (Counter Low), or a 32-bit (Counter High) counter, 5 MHz frequency, and x1, x2, and x4 count modes. With only phase A and phase B signals, 4 channels are supported; with phase A, phase B, and index Z signals, 2 channels are supported.



Quadrature encoders generally have 3 outputs: A, B, and Z. The A and B signals are pulse trains driven by an optical sensor inside the encoder. As the encoder shaft rotates, a laminated optical shield rotates inside the encoder. The shield has three concentric circular patterns of alternating opaque and transparent windows through which an LED will shine. There is one LED for each of the concentric circular patterns and likewise, one phototransistor. One phototransistor produces the A signal, another phototransistor produces the B signal and the last phototransistor produces the Z signal. The concentric pattern for A has 512 window pairs (or 1024, 4096, etc.) The concentric pattern for B has the same number of window pairs as A except that the entire pattern is rotated by 1/4 of a window-pair. Thus the B signal will always be 90 degrees out of phase from the A signal. The A and B signals will pulse 512 times (or 1024, 4096, etc.) per complete rotation of the encoder.

The concentric pattern for the Z signal has only one transparent window and therefore pulses only once per complete rotation. Representative signals are shown in the figure below.

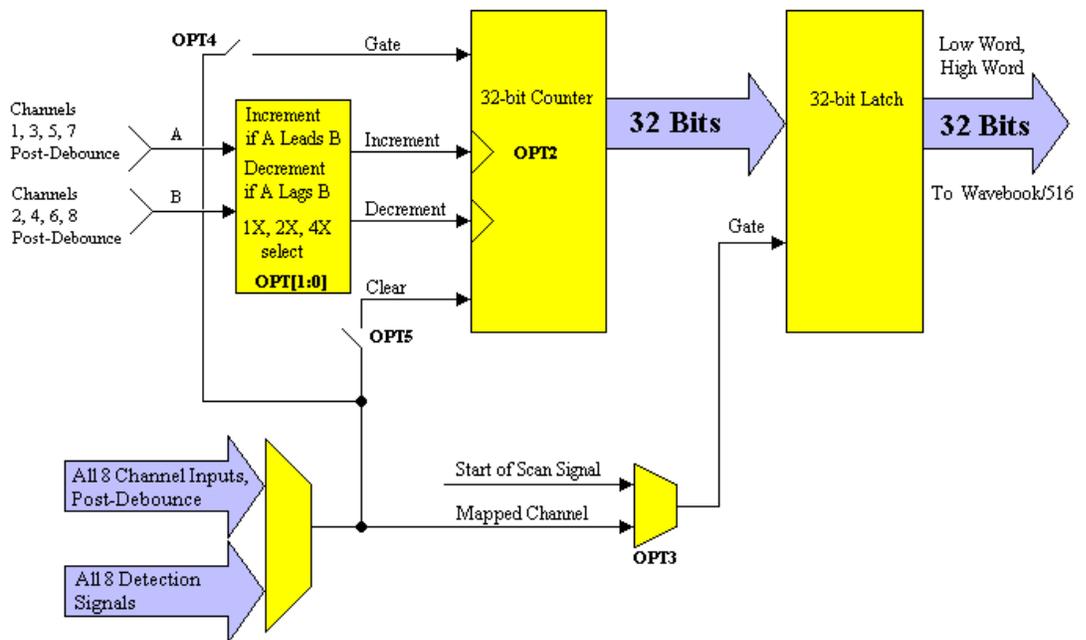


Representation of Quadrature Encoder Outputs: A, B, and Z

As the encoder rotates, the A (or B) signal is indicative of the distance the encoder has traveled. The frequency of A (or B) indicates the velocity of rotation of the encoder. If the Z signal is used to zero a counter (that is clocked by A) then that counter will give the number of pulses the encoder has rotated from its reference. The Z signal is a reference marker for the encoder. It should be noted that when the encoder is rotating clockwise (as viewed from the back), A will lead B and when the encoder is rotating counter-clockwise, A will lag B. If the counter direction control logic is such that the counter counts upward when A leads B and counts downward when A lags B, then the counter will give direction control as well as distance from the reference.

An Example of Encoder Accuracy

If there are 512 pulses on A, then the encoder position is accurate to within 360 degrees/512. Even greater accuracy can be obtained by counting not only rising edges on A but also falling edges on A, giving position accuracy to 360 degrees/1024. The ultimate accuracy is obtained by counting rising and falling edges on A and on B (since B also has 512 pulses.) This gives a position accuracy of 360 degrees/2048. These 3 different modes are known as 1X, 2X, and 4X. The WBK17 implements all of these modes and functions, as described in the following options.



Encoder Mode

ENCODER: OPT[1:0]: This determines the encoder measurement mode: 1X, 2X, or 4X.

ENCODER: OPT3: This determines which signal latches the counter outputs into the data stream going back to the WaveBook. Normally, the start of scan signal latches the counter outputs at the beginning of every scan. The other option is to have the mapped signal latch the counter outputs. This allows the user to have another signal control the latching of the count data, so the exact value of the counter is known when an edge is present on another channel.

ENCODER: OPT4: This allows the mapped channel to gate the counter if desired. When the mapped channel is high, the counter is enabled to count, when the mapped channel is low, the counter is disabled (but holds the count value.) The mapped channel can be any other input channel or one of the detection signals.

ENCODER: OPT5: This allows the mapped channel to clear the counter if desired. OPT5 implements the Z-function [described above], allowing the encoder reference to clear the counter. The counter is cleared on the rising edge of the mapped channel.

Encoder Wiring Diagrams

You can use up to four encoders with each WBK17 module in your WaveBook system. Each A and B signal can be made as a single-ended connection with respect to common ground, or as a differential connection.

Encoder wiring diagrams and example setup tables are included in the following pages; refer to them as needed.

For Single-ended Connections:

For single-ended applications, the connections made from the encoder to WBK17's front panel are as follows:

- Signals A, B, and Z connect to the "H" (channel high) connectors on WBK17's Counter Input Terminal Blocks. A, B, and Z "highs" must be connected to separate channels.
- The input channel lows must be jumpered to COM.
- Each encoder ground connects to COM.
- Up to four encoders can be powered from the Encoder Power (Power Out) terminal block. Refer to your encoder specification sheet for actual power requirements. Each encoder power wire connects to the Encoder Power (Power Out) terminal block's +15 VDC or +5 VDC connector, as applicable.

For Differential Connections:

For differential applications, connections made from the encoder to the WBK17's front panel are as follows:

- Signals A, B, and Z connect to the "H" (channel high) connections on WBK17's Counter Input Terminal Blocks. A, B, and Z "highs" must be connected to separate channels.
- Signals /A, /B, and /Z connect to the respective "L" (channel low) connections on WBK17's Counter Input Terminal Blocks.
- Each encoder ground connects to COM.
- Up to four encoders can be powered from the Encoder Power (Power Out) terminal block. Refer to your encoder specification sheet for actual power requirement. Each encoder power wire connects to the Encoder Power (Power Out) terminal block's +15 VDC or +5 VDC connector, as applicable.



For Open-Collector Outputs: External *pullup resistors* can be connected to the WBK17's counter input terminal blocks. A pullup resistor can be placed between any input channel and *one of the two* power supplies (+5V, or +15V) provided by the Encoder Power (Power Out) terminal block. Choose a pullup resistor value based on the encoder's output drive capability and the input impedance of the WBK17. Lower values of pullup resistors will cause less distortion but also cause the encoder's output driver to pull down with more current. If the inputs are connected differentially, then each channel will need two pullup resistors, i.e., one on the low signal input and one on the high signal input.

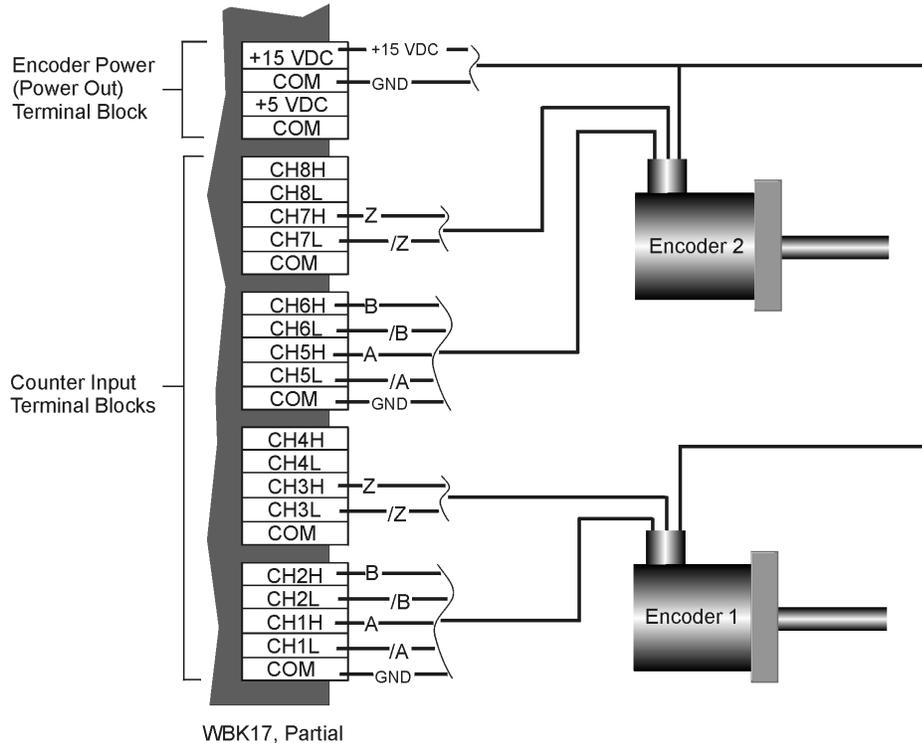
Wiring for 1 or 2 Encoders

The following figure illustrates *differential* connections for two encoders. For *single-ended* connections, remove the /A, /B, and /Z signal connections and short the Low inputs of these channels to COM.



The “A” signals must be connected to odd numbered channels and the associated “B” signals must be connected to the next [higher] even numbered channels. For example, for “A” connected to channel 1H, “B” is connected to channel 2H.

A wiring diagram for one encoder is not shown as it would be identical to the following diagram, except one of the encoders and its associated wiring would be removed.



Two Encoders with Differential Connections to WBK17

In addition to the previous figure, the following table indicates how to connect two encoders to a WBK17 module. Each signal (A, B, Z) can be connected as a single-ended connection with respect to the common ground or as a true differential input. Both encoders can draw their power from the WBK17’s power output connector. Connect the encoder’s power input to the +5V or +15V power, connect the return to common ground (COM) on the same connector. The programming setup given below is just a representative of possible options.

Two Encoders – Example Setup		
Channel	Connection	Example Programming Setup
1	Encoder1 – A	Encoder Mode, 4X option, 16-bit counter, Latch on SOS, Map channel Clears the counter, set Map channel to 3
2	Encoder1 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksiz to 200ns
3	Encoder1 – Z	Counter in Totalize mode, stop-at-the-top, 16-bit counter
4	No connection	--
5	Encoder2 – A	Encoder Mode, 4X option, 16-bit counter, Latch on SOS, Map channel Clears the counter, set Map channel to 7
6	Encoder2 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksiz to 200ns
7	Encoder2 – Z	Counter in Totalize mode, stop-at-the-top, 16-bit counter
8	No connection	--

There are other useful encoder options; for example, *analog filtering*. If the encoders are known to run in a noisy environment then some analog filtering may be in order. A low-pass filter [with 20kHz or 100kHz cutoff frequency] can be used to reduce extraneous high-frequency [normal mode] noise that may come in on the encoder lines. In addition, if the encoder is connected in differential mode any common-mode noise will be reduced by the common-mode rejection of the WBK17's front-end differential amplifier, typically -70dB .

If the encoder stops rotating, but is vibrating [due to the machine it is mounted to], the debounce feature can be used to eliminate false edges. An appropriate debounce time can be chosen and applied to each encoder channel. Refer to the [Debounce Module](#) section on page 7 for additional information regarding debounce times.

Relative position and *velocity* can be obtained from each of the encoders. However, during an acquisition, data that is relative to the Z-position can not be obtained until the encoder locates the Z-reference.



During an acquisition, data that is relative to the Z-position can not be obtained until the encoder locates the Z-reference.

Note that the number of Z-reference crossings can be tabulated. If the encoder was turning in only one direction, then the Z-reference crossings will equal the number of complete revolutions. This means that the data streaming to the PC will be *relative position*, $period = 1/velocity$, and *revolutions*.



You can set detection setpoints on any or all channels. Detection setpoints can be used as data markers, digital port updates, and as mapped channels.

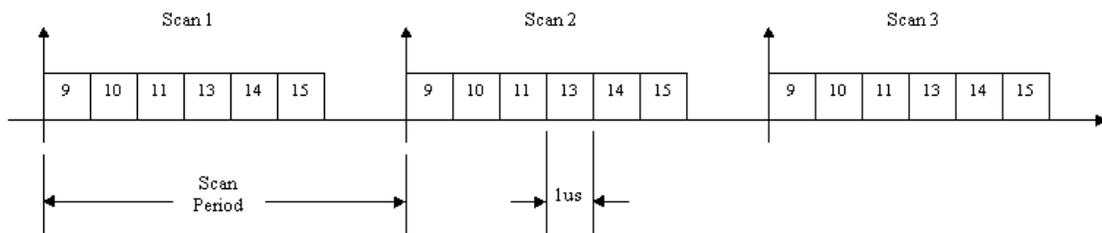
Each of the WBK17's eight channels has one detection signal. For measurement purposes, the detection signals can be routed to an unused counter. The number of times a certain detection setpoint has been met can be the output data for this counter channel.



Reference Note:

For a complete discussion of setpoints see the section, [Pattern Detection and Data Markers](#), beginning on page 31 of this document module.

A typical acquisition might take 6 readings off of the WBK17 module as illustrated below. The user determines the scan rate and the number of scans to take. Note that the channel numbers shown assume that the WBK17 is the first expansion module.



WBK17 Acquisition of Six Readings per Scan

In general, the output of each channel's counter is latched at the beginning of each scan period (called the *start-of-scan*.) Every time the WBK17 receives a *start-of-scan* signal from the WaveBook, the counter values are latched and are available to be sourced-down to the WaveBook as each WBK17 channel is selected [during the scan period].

The WBK17 clears all counter channels at the beginning of the acquisition. This means that the values returned during scan period 1 will always be zero. The values returned during scan period 2 reflect what happened during scan period 1.



The scan period defines the timing resolution for the WaveBook and the WBK17. If you need a higher timing resolution, shorten the scan period.

If more timing resolution is needed, the scan period must be shortened. This has an impact when setting a detection setpoint because the values coming back from the acquisition have the timing granularity defined by the scan period, not the actual counter. The counter may be counting very fast but the scan period could be much slower, so the acquired data may only show every 10th count or every 100th count or whatever. If the counter input is sufficiently fast and the scan period much slower, a detection setpoint could be completely “stepped over” and go unrecognized, even though the counter clearly ran through the setpoint.

Application Example #1

Determining how many times an encoder goes beyond a certain position.

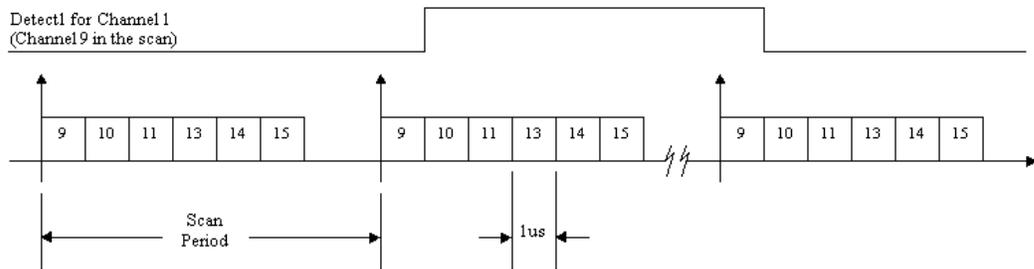
A user wants to know the number of times an encoder goes beyond a certain position. We will refer to the position to be exceeded as “**Low Limit.**” To find the answer he completes the following steps.

1. Sets a detection setpoint on Channel 1 of the WBK17 (channel 9 in the scan). The detection setpoint will be **CH1 data > Low Limit**, where Low Limit is a 16-bit value.
2. Sets channel 9 in the scan to be in Encoder Mode. Note that channel 9 is A, channel 10 is B, and channel 11 is Z.
3. Sets channel 12 to count the mapped channel.
4. Sets the mapped channel to Detect1.
5. Starts the acquisition.

In this example the setpoint criteria is simple, **Ch1 data > Low Limit**. Because of the criteria, whenever the data on channel 1 goes beyond the value of Low Limit, Detect1 will go high.

Note: Detection setpoints are evaluated on a per-sample basis, for every scan. Since each channel can have up to 16 different setpoints, the WBK17 must cycle through 16 setpoints, searching for a match, every microsecond. The first match that is found terminates the search for that channel’s current sample. Once the match has been found the digital output port can be updated (or NOT) and the Detect1 signal (for channel 1) will be taken high.

The following timing diagram represents detection setpoints being used to drive a Detection signal for channel 1.



Timing Diagram with Channel Detection Signal

As shown in the diagram, Detect1 for Channel 1 (Channel 9) will go high for those samples that meet the setpoint criteria (**Ch1 data > Low Limit**). Note that the Detect signal can get routed to another counter channel and be used at that channel to clock a counter. This allows the user to count the number of times an encoder crosses a specified boundary. As an alternative, the Detect signal’s pulsewidth could be measured, giving the amount of time that the encoder spent beyond the setpoint criteria.

The channel’s data stream will return data indicative of the time that Detect was active high and, more importantly, the time that the encoder’s position was within the setpoint window. Keep in mind that the timing resolution of the Detect signal is directly related to the Scan period, not to the actual counter. Therefore smaller scan periods result in better timing resolution for the Detect signal and for measurements based on the Detect signal.



Having your Detect signal as a part of the scan group allows for real-time data analysis.

Application Example #2

Using Encoder mode to implement Up/Down Counters of any size.

The encoder mode does not have to be used exclusively with quadrature encoders. The encoder mode can be used to implement a 16 or 32 bit counter that has direction control. The encoder mode can also be used to force the counter to rollover on any value.

When an odd-numbered channel (1, 3, 5, 7) is put in encoder mode, the next higher channel (2, 4, 6, 8) is automatically selected to be the direction control. Therefore, if channel 1 is in encoder mode, channel 2 is the direction control. Channel 1's counter will count up (at the edge rate coming in on channel 1) if channel 2 is low and channel 1 will count down if channel 2 is high. If channel 1's counter is required to decrement only, then channel 2 can be forced high by software (set the coupling mode to OFF and the comparator threshold to negative 12V.) Any input channel can be forced to a low or high simply by setting the coupling mode to OFF and setting the appropriate threshold level. When a channel is turned OFF, the input settles to 0.0V, setting a positive threshold will force a low and setting a negative threshold will force a high.

Encoder mode allows the mapped channel to clear the counter. If the mapped channel is programmed to be the detection signal for the counter, then the counter will rollover to zero when the setpoint criteria is met. The setpoint criteria could be a simple "greater-than" limit, forcing the counter to rollover on 1000, for example.

The following steps show how to set up a counter so that it will rollover on the count value of 1000.

1. Configure Channel 1 as Encoder mode, 1X option, 16-bit counter, Map channel clears the counter option, set the Map channel to Detect 1. Select desired coupling, low pass filtering, comparator threshold and debounce.
2. Configure Channel 2 as:
 - Analog mode
 - Coupling = OFF
 - LPF = 30Hz
 - Comparator threshold = 12.0V



If you want to observe the terminal count on pulsing high, scan the Detect signals.

3. Program a setpoint on channel 1 to be "greater than 1000." This will take Detect 1 high whenever channel 1's acquired counter data is greater than 1000.
4. Take 10,000 scans at a scan rate of 2 kHz.
5. Connect a 1kHz signal to channel 1's input. Make sure it meets the comparator threshold setting.
6. Take the acquisition.

The counter on channel 1 will count up and rollover on the count of 1000. Since the pattern detection circuit works on data that is latched into the data stream, the scan rate must be greater than the input edge rate. If the scan rate is less than the input edge rate, then the counter will actually count up beyond 1000 before the count value is sampled, detected, and then cleared back to zero.



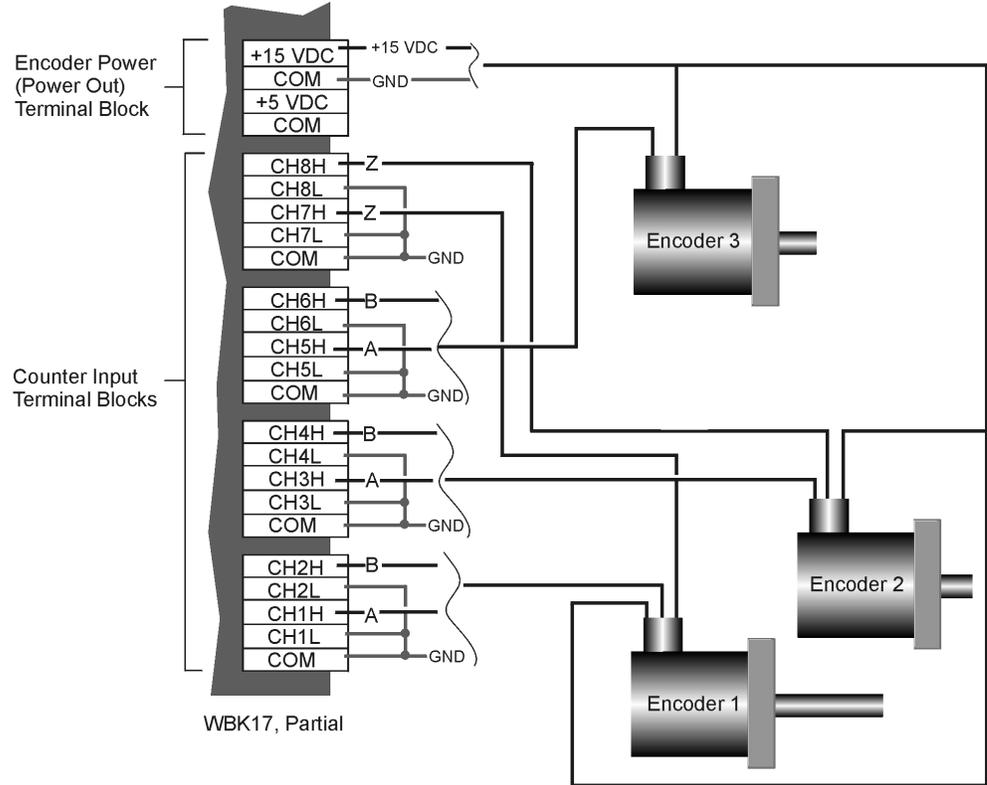
It is important to realize that the Detect signals have the timing resolution of the scan period and that the pattern detection module only looks at acquired data, not the actual counter value.

Wiring for 3 Encoders

The following figure illustrates single-ended connections for three encoders. For differential connections we would simply make /A, /B, and /Z signal connections to the respective channel slots. With three encoders it should be noted that there is no separate channel for a third set of Z, /Z signals; thus, in the following figure Encoder 3 has no Z signal.



The WBK17 can receive input from up to four encoders; however, the WaveView data acquisition program can accept input from only one or two encoders. To receive input from three or four encoders [with one WBK17] refer to the Programmer's Manual (p/n 1008-0901).



Three Encoders with Single-Ended Connections to WBK17

Connect three encoders to the WBK17 as shown in the table below. Each signal (A, B) can be connected as a single-ended connection with respect to the common ground or as a true differential input. All three encoders can draw their power from the power output connector. Connect the encoder's power input to the +5V or +15V power, connect the return to COM on the same connector. Make sure that the current output spec is not violated or a fuse may blow. The programming setup given below is just a representative of possible options.

Three Encoders – Example Setup		
Channel	Connection	Programming Setup
1	Encoder1 – A	Encoder Mode, 1X option, 16-bit counter, Latch on SOS
2	Encoder1 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksizeto 20000ns
3	Encoder2 – A	Encoder Mode, 2X option, 16-bit counter, Latch on SOS
4	Encoder2 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksizeto 2000ns
5	Encoder3 – A	Encoder Mode, 4X option, 16-bit counter, Latch on SOS
6	Encoder3 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksizeto 200ns
7	Encoder1 – Z	Counter in Totalize mode, stop-at-the-top, 16-bit counter
8	Encoder2 – Z	Counter in Totalize mode, stop-at-the-top, 16-bit counter

With the encoders connected in this manner there is relative positioning information available on two of the encoders (Encoder 1 and 2) but not on the third encoder since there is no Z signal connection for it. Therefore only distance traveled can be measured (along with velocity) for the third encoder.

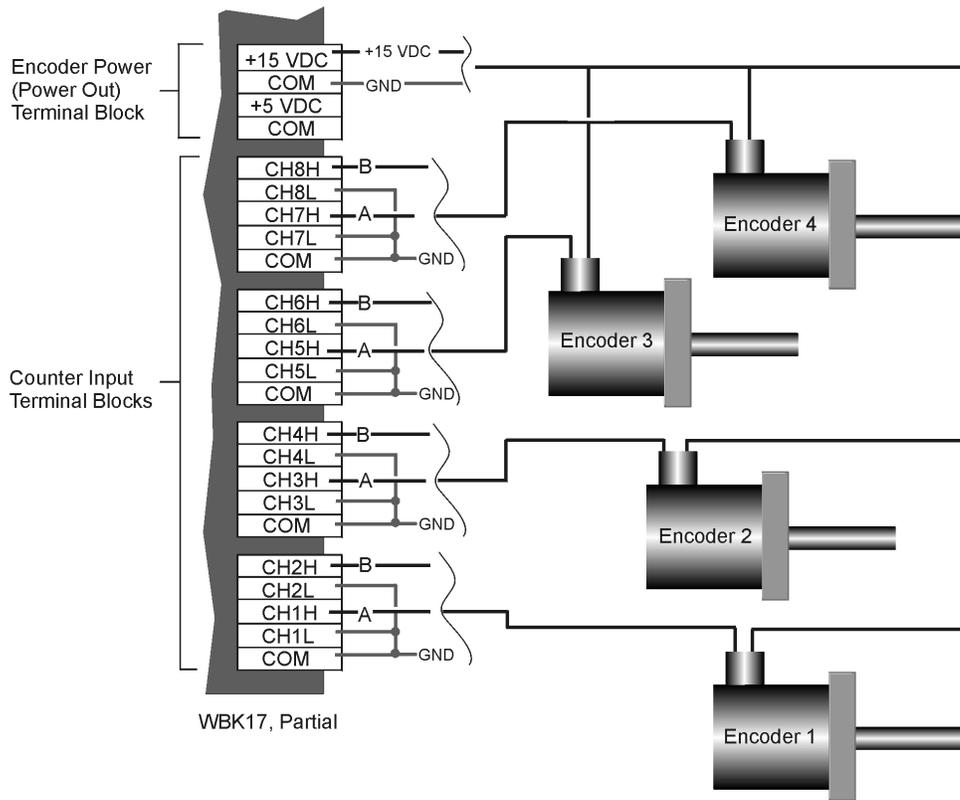
Setpoints can be done just like in the previous example. The digital output port can be updated by any individual channel, a set of selected channels, or by all channels.

Wiring for 4 Encoders

The following figure illustrates single-ended connections for four encoders. For differential connections we would simply make /A, /B, and /Z signal connections to the respective channel low inputs. With four encoders it should be noted that there are no channels available for Z, /Z signals. In this scenario no encoder has a Z signal connection.



The WBK17 can receive input from up to four encoders; however, the WaveView data acquisition program can accept input from only one or two encoders. To receive input from three or four encoders [with one WBK17] refer to the Programmer's Manual (p/n 1008-0901).



Four Encoders with Single-Ended Connections to WBK17

Connect four encoders to the WBK17. Refer to the above diagram and following table, *Four Encoders – Example Setup*, as needed. Each signal (A, B) can be connected as a single-ended connection with respect to the common ground or as a true differential input. All four encoders can draw their power from the power output connector, connect the encoder's power input to the +5V or +15V power, connect the return to COM on the same connector. Make sure that the current output spec is not violated or a fuse may blow. The programming setup given below is just a representative of possible options.

Four Encoders – Example Setup		
Channel	Connection	Programming Setup
1	Encoder1 – A	Encoder Mode, 1X option, 16-bit counter, Latch on SOS
2	Encoder1 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksiz to 20000ns
3	Encoder2 – A	Encoder Mode, 2X option, 16-bit counter, Latch on SOS
4	Encoder2 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksiz to 2000ns
5	Encoder3 – A	Encoder Mode, 4X option, 16-bit counter, Latch on SOS
6	Encoder3 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksiz to 200ns
7	Encoder4 – A	Encoder Mode, 4X option, 16-bit counter, Latch on SOS
8	Encoder4 – B	Period Mode, 1Xperiod option, 16-bit counter, Map channel doesn't gate, Ticksiz to 200ns

With the encoders connected in this manner there is no relative positioning information available since there is no Z signal connection. Therefore only distance traveled can be measured on the A channels. This means that for each encoder we can only know distance traveled and velocity of travel.

Setpoints can be done just like in the previous example. The digital output port can be updated by any individual channel, a set of selected channels, or by all channels.

Digital Inputs

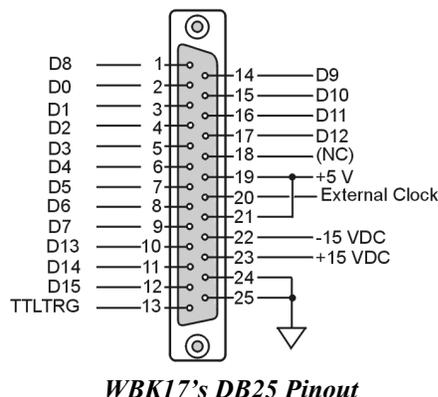
The WBK17 has 16 general-purpose digital inputs that can be scanned into an acquisition along with any other channel on the WaveBook system. These are available on the 25 pin DSUB connector [Digital Inputs, Trigger, External Clock connector] located on the WBK17 front panel, as shown in the figure on page 1 of this document module.

The following signals are present on the DB25F high-speed digital I/O connector.

- 16 High-Speed Digital Input Lines (D0 through D15)
- TTL Trigger Input (TTLTRG)
- +15 V (pin 23), -15 V (pin 22), 50 mA max. (each)
- two +5 V (pin 19 and pin 21), 250 mA max. (total)
- External Clock (pin 20)
- two Digital Grounds (pins 24 and 25)

To sample just 16 digital input signals, connect them directly to the digital Input data lines. D15 is the most significant bit, and D0 is the least.

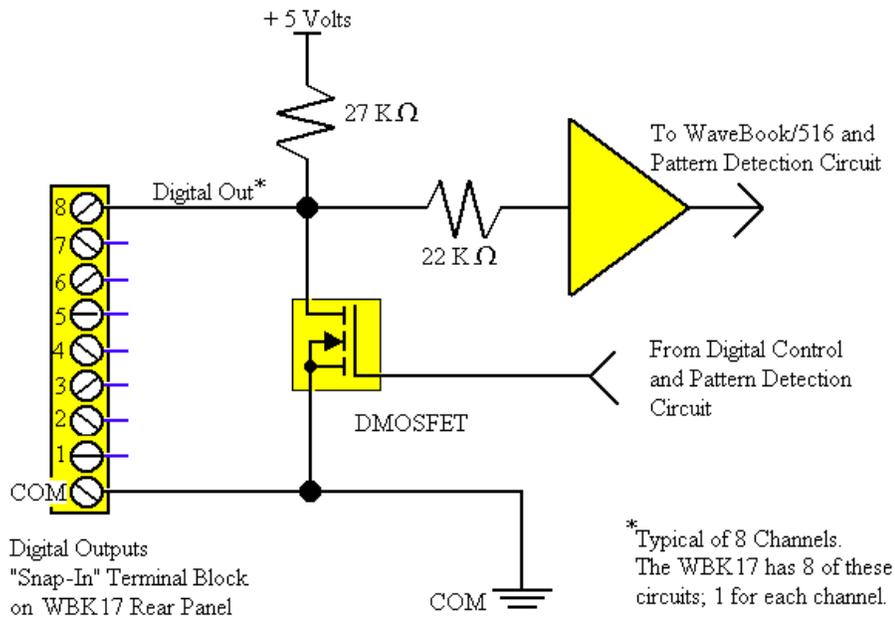
The following figure depicts WBK17's DB25 connector, rotated 90 degrees counter-clockwise for convenience of labeling. Note that an optional *Clock and External Trigger cable* (CA-178) is available for use with the WBK17. The cable connects to the DB25 connector and terminates in two BNC connectors, one for an external clock (via pin 20) and the other to TTL external trigger (via pin 13).



Digital I/O Connections for WBK17	
D0 – D15	High Speed Digital Input data lines
TTLTRG	TTL trigger input
External Clock	16 bit mode, read/write strobe
+5 VDC	250 mA maximum
+15,-15 VDC	50 mA maximum (each)
Digital Grounds	Pins 24 and 25

Digital Outputs

The WBK17 has 8 fully programmable digital outputs. Each output has an open-drain DMOS FET (Double-diffused Metal Oxide Semiconductor Field Effect Transistor) that can sink up to 150 mA and is capable of directly driving relays.



Digital Output Port

The digital output port can be read back as part of the scan group of an acquisition. If the DMOSFET is never turned on by the WBK17, then the digital output port can be used as an input port. An external driver can drive any of the digital output bits high or low, as long as the WBK17's DMOSFET is not turned on.

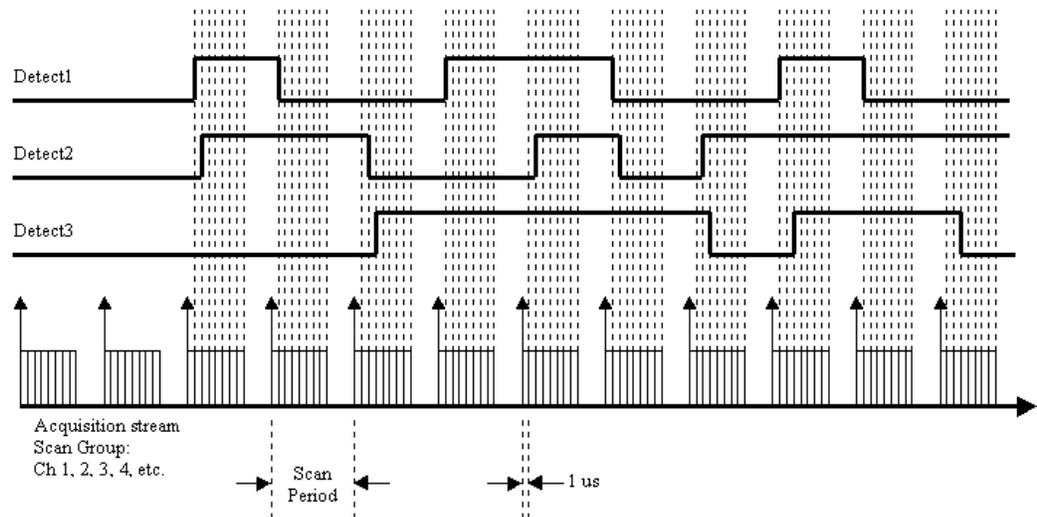
The digital outputs can be directly updated by application software at any time. The digital output port has an 8-bit Mask byte associated with the digital update byte. The output port will be updated if the corresponding bit in the Mask byte is a 1. Otherwise the output port bit will be left unchanged.

The digital outputs can be updated based on the condition of any input channel value(s). Up to 16 set points (each with two 16-bit compare values, an 8-bit digital output port byte, an 8-bit mask byte, and a control byte) can be assigned to a channel. When a set point has been programmed (count value, period, pulsewidth, position, or velocity) the two 16-bit values are compared, in real-time, to the measured value for that channel. When the comparison condition is met, the output port is updated instantaneously. Valid conditions include greater than value, less than value, inside the window, and outside the window. Since each set point has an 8-bit mask byte, any or all of the digital output bits can be updated. With 16 setpoints per channel complex updating schemes can be defined to meet the most demanding application requirements.

Pattern Detection and Data Markers

The WBK17 has a pattern detection feature that can be individually programmed for any of the 8 input channels. The pattern detection feature allows up to 16 detection setpoints to be set on each channel. Each detection setpoint can be programmed in several ways: inside the window, outside the window, above setpoint, below setpoint. When a channel's setpoint criteria has been met, a digital marker signal called the detect signal will go high. The detect signals can also be part of the scan group and measured just like any other input channel, allowing real time data analysis during an acquisition. Each setpoint can also update the digital output port with a data byte and mask byte allowing real time control based on acquisition data.

The WBK17 pattern detection module looks at the 16-bit data being returned on a given channel and generates another signal for each channel, Detect1 for Channel 1, Detect2 for Channel 2, etc. These signals act like data markers for each channel's data, whether that data is counts, period, pulsewidth, timing, or encoder position. A channel's detect signal will be high when the channel's data meets any one of 16 pre-programmed setpoint windows, the detect signal will be low when the channel's data does not meet any of the setpoint windows. The detect signal has the timing resolution of the scan period as seen in the diagram below. The detect signal can change no faster than the scan frequency ($1/\text{scan period}$.)



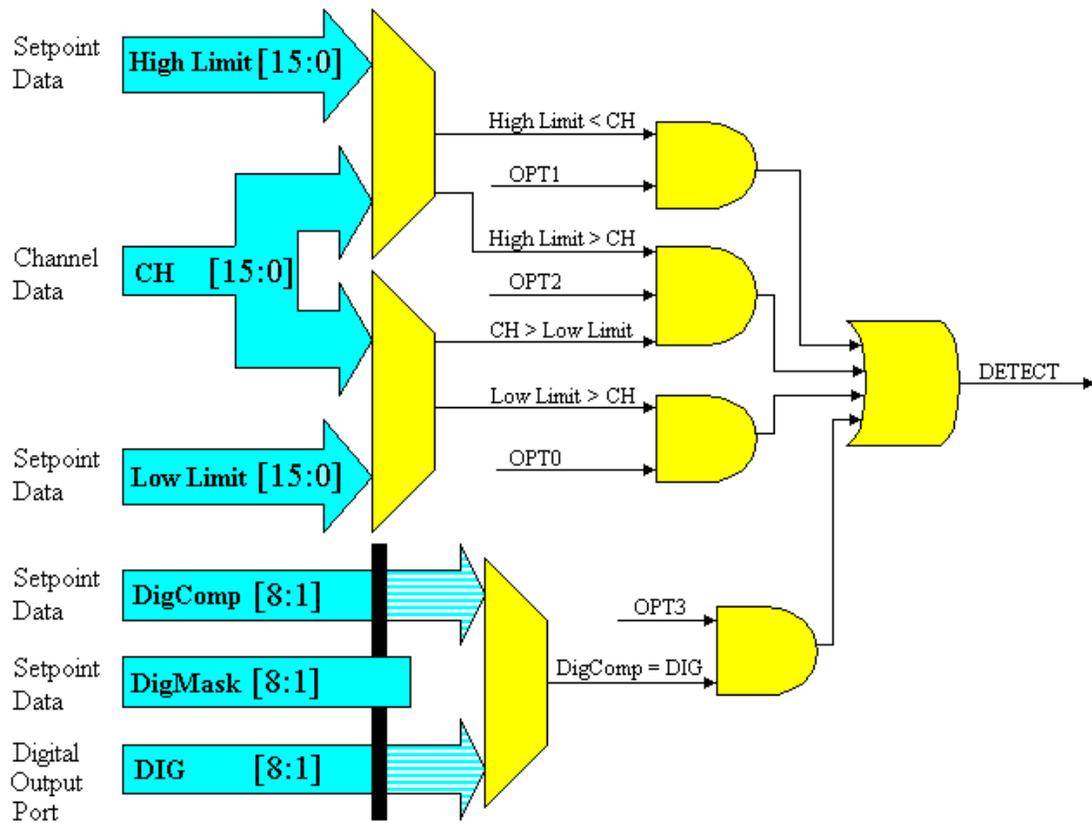
Example Diagram of Detection Signals for Channels 1, 2, and 3

Each channel can have 16 detection setpoints. Detection setpoints act on 16-bit data only. Since the WBK17 has 32-bit counters for each channel, data is returned 16-bits at a time. The lower word, the higher word or both lower and higher words can be part of the scan group. Each channel has 16 detection setpoints for the counter's lower 16-bit value and 16 detection setpoints for the counter's higher 16-bit value. Any mix of setpoints can be programmed to drive the detect signal. If all lower word setpoints and higher word setpoints were programmed for a channel, that channel would have 32 programmed setpoints driving the detect signal during the acquisition.

All setpoints are programmed as part of the pre-acquisition setup, similar to setting up the analog path, debounce mode, or counter mode setup. As stated above, each setpoint acts on 16-bit data. Therefore each setpoint has two 16-bit compare values: **High Limit** and **Low Limit**. The High Limit and Low Limit values define the setpoint window. Each setpoint has four comparison types: (1) inside the window, (2) outside the window, (3) greater than value, and (4) less than value. The programmed comparison type tells the detection module how to compare the channel's data value to the values of High Limit and Low Limit.

Each setpoint can also be programmed with an 8-bit digital output byte (**DigOut**) and corresponding 8-bit mask byte (**DigMask**). When the setpoint criteria has been met, the digital output port can be updated with the given byte and mask.

The digital output port can also be part of the setpoint comparison. Any setpoint can be programmed to take the detect signal high when the digital output port is equal to the 8-bit digital byte **DigComp** qualified by the 8-bit **DigMask**. If any of the digital output port bits are not going to be driven as outputs, they can act as inputs that drive the detection signals via setpoints. The diagram below summarizes the comparisons that are possible.

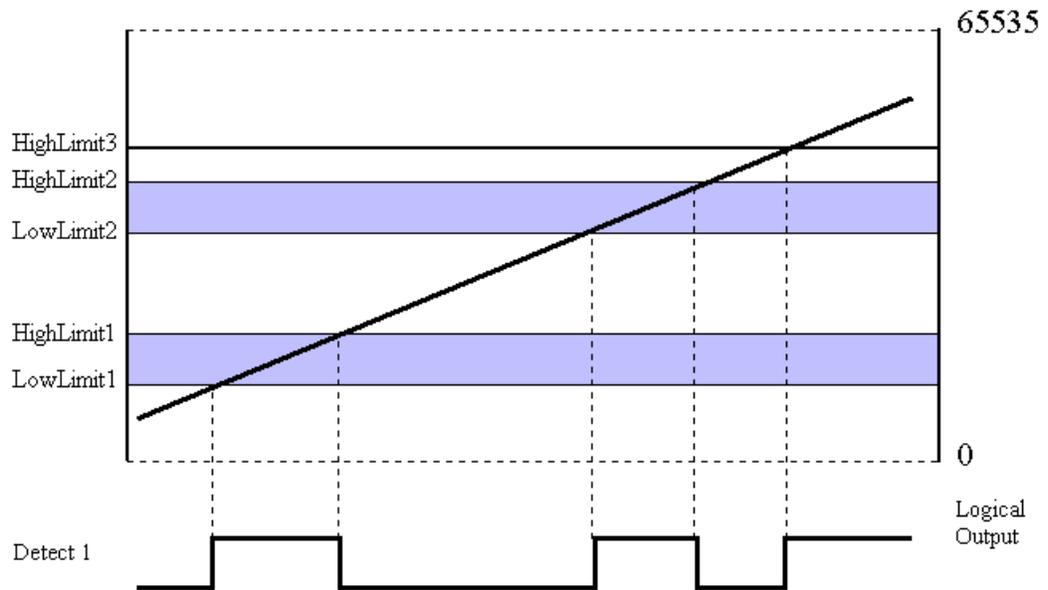


Pattern Detection Module

Note: OPT bits (see figure) are set by software options.

Example: Setpoint Detection on a Totalizing Counter

The figure below shows how 3 setpoints could be defined for channel 1. Channel 1 is shown in totalize mode, the counter is simply counting upward. The setpoints define points of change for Detect 1 as the counter counts upward. The first setpoint (**High Limit1, Low Limit1**) dictates channel 1's detect output to be high when greater than Low Limit1 but less than High Limit1. In this case, the channel 1 setpoint is defined for the 16 lower bits of channel 1's value. Channel 1 could be in 16 or 32-bit mode, the detect pattern would just repeat every time the lower 16-bit counter rolled over. There is another setpoint set by (High Limit2, Low Limit2), and then another set by (High Limit3, Low Limit3). The last setpoint (High Limit3, Low Limit3) dictates that channel 1's detect output be high whenever Channel 1's value is greater than HighLimit3. LowLimit3 is ignored. The digital output port could be updated on each rising edge of Detect 1.



Example Detection: Channel 1 in Totalizing Counter Mode

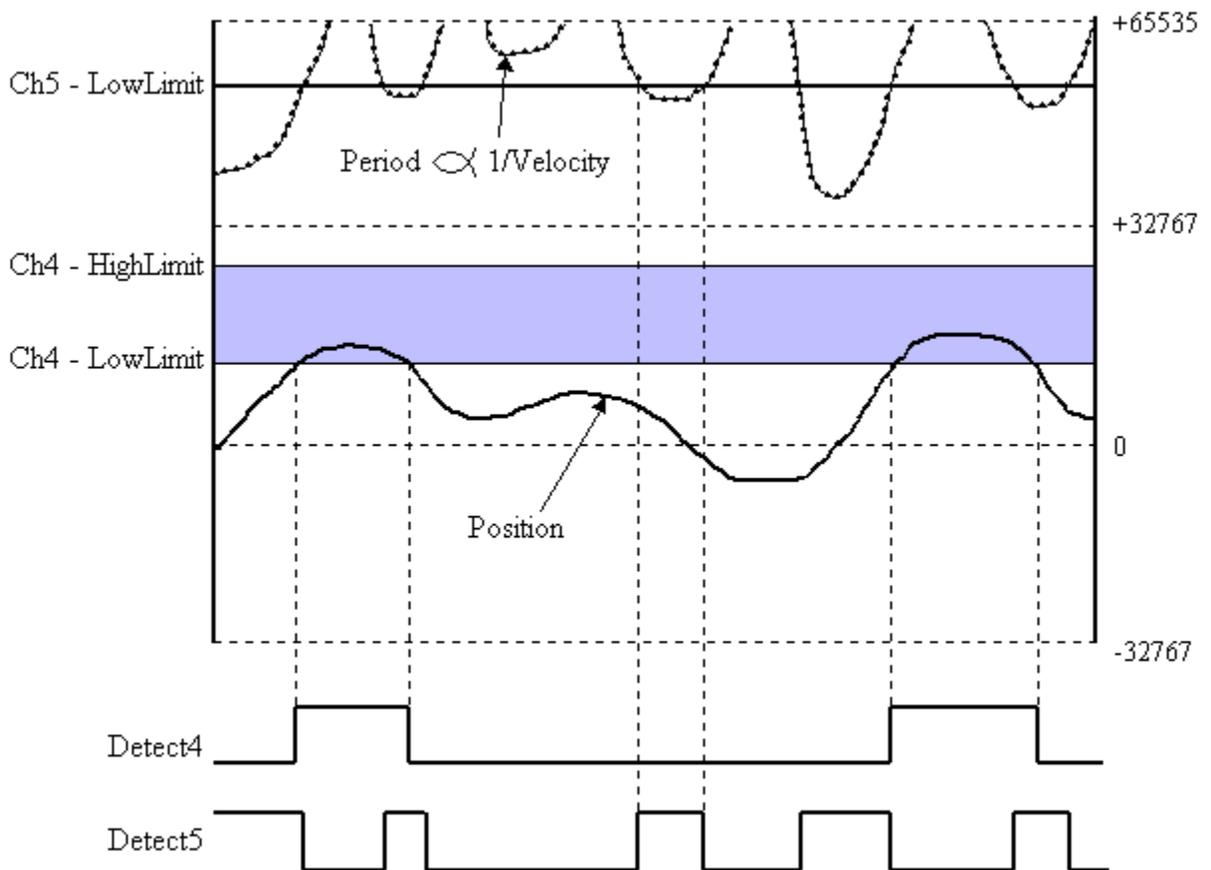
The detection circuit works on data that is latched out of the counters and put into the acquisition stream at the scan rate. This data is acquired according to the pre-acquisition setup (scan group, scan period, etc.) and returned to the PC. The actual counters may be counting much faster than the scan rate and therefore only every 10th, 100th, or nth count will show up in the acquisition data. Therefore it is possible to set a small detection window on a totalizing counter channel and have the detection setpoint “stepped over” since the scan period was too long. Even though the counter value stepped into and out of the detection window, the actual values going back to the PC may not. This is true no matter what mode the counter channel is in. The setting of a detection window must be done with a scan period in mind.

Two possible solutions for overcoming this problem. The scan period could be shortened to give more timing resolution on the counter values or the setpoint window (High Limit and Low Limit) could be widened. Perhaps a combination of both solutions is the best compromise.

Example: Setpoint Detection on Encoder Position and Velocity.

The figure below shows how setpoints can be used on two channels. Channel 4 is in encoder mode using channel 1 as the Z-index, therefore relative to Z position information will be acquired on channel 4. Channel 5 is the encoder’s B signal input. Channel 5 is in period mode, the data being acquired will be inversely proportional to the encoder’s velocity.

Two setpoints have been programmed, one on channel 4 and the other on channel 5. Channel 4’s setpoint is a window setpoint, Detect 4 will go high whenever the encoder’s relative position is within the setpoint window. Channel 5’s setpoint is a “less than value” setpoint, Detect 5 will go high whenever the encoder’s velocity is greater than the setpoint.



Detection Example: Channel 4 in Encoder Position Mode, Channel 5 in Period Mode

Detect 4 can be routed to the counter input of another channel that would otherwise be unused. If Detect 4 was measured for pulsewidth, the data returned in the acquisition would be the amount of time that the encoder position was within the setpoint window. If Detect 4 was measured for period, the data returned in the acquisition would be the periodicity of the encoder entering the setpoint window. If Detect 4 simply clocked a totalizing counter, the data returned in the acquisition would be the number of times the encoder entered the setpoint window. Any or all of these measurements could be made in the acquisition along with the channel 4 position data and channel 5 period data. It should be noted that the timing resolution of the Detect signals is the scan period. Reduce the scan period if more resolution is needed.

Detect 5 can also be routed to a counter input of another channel that would otherwise go unused. If Detect 5 was measured for pulsewidth, the data returned in the acquisition would be the amount of time that the encoder velocity was greater than the setpoint. If Detect 5 was measured for period, the data returned in the acquisition would be the periodicity of the encoder velocity going beyond the setpoint. If Detect 5 simply clocked a totalizing counter, the data returned in the acquisition would be the number of times the encoder went beyond the setpoint velocity.

Software Support

WaveView contains special software features for WBK17. These features are discussed in the WaveView document module.

You can use WaveView's spreadsheet-style GUI to select a specific counter mode, AC/DC coupling, low-pass filter cut-off frequency, and other WBK17-specific configuration parameters. The WBK17 can be configured to make several different types of measurements at the same time, but on different channels; for example: frequency, period, and quadrature encoder measurements. A wide variety of setups is possible.

In addition to the *Out-of-the-Box™ WaveView* software, the WBK17 is supported by a complete set of language drivers and documentation for developing custom applications using high-level languages such as: Visual Basic®, C++, and Delphi™ for Windows® 95/98/2000/Me/NT and LabVIEW®. For applications that require sophisticated graphical analysis and control that go beyond the scope of WaveView™, icon-based DASYLab® software can be used. The *WaveBook User's Manual* (p/n 489-0901) discusses software options.



WBK17 support is only available with the 32-bit driver and 32-bit version of WaveView.



Reference Notes:

- For information regarding software installation, refer to the *WaveBook User's Manual* (p/n 489-0901).
- For detailed information regarding *WaveView*, refer to the WaveView document module, included as a part of the *WaveBook User's Manual*.
- If creating custom programs, refer to the *Programmer's Manual*, p/n 1008-0901.

Fuse Replacement

The WBK17 has three user-replaceable fuses as follows:

- **F1 - Power Output Fuse (for +15V Encoder Power).** 1.0 A, Mini ATO. Located near the center of the front panel (see figure).
- **F2 - Power Output Fuse (for +5V Encoder Power).** 2.0 A, Mini ATO. Located near the center of the front panel (see figure).
- **F201 – Input Power Fuse.** 4.0 A, Mini ATO. Located between the 5DIN Power In connector and the DC/DC Converter (see figure).

WARNING

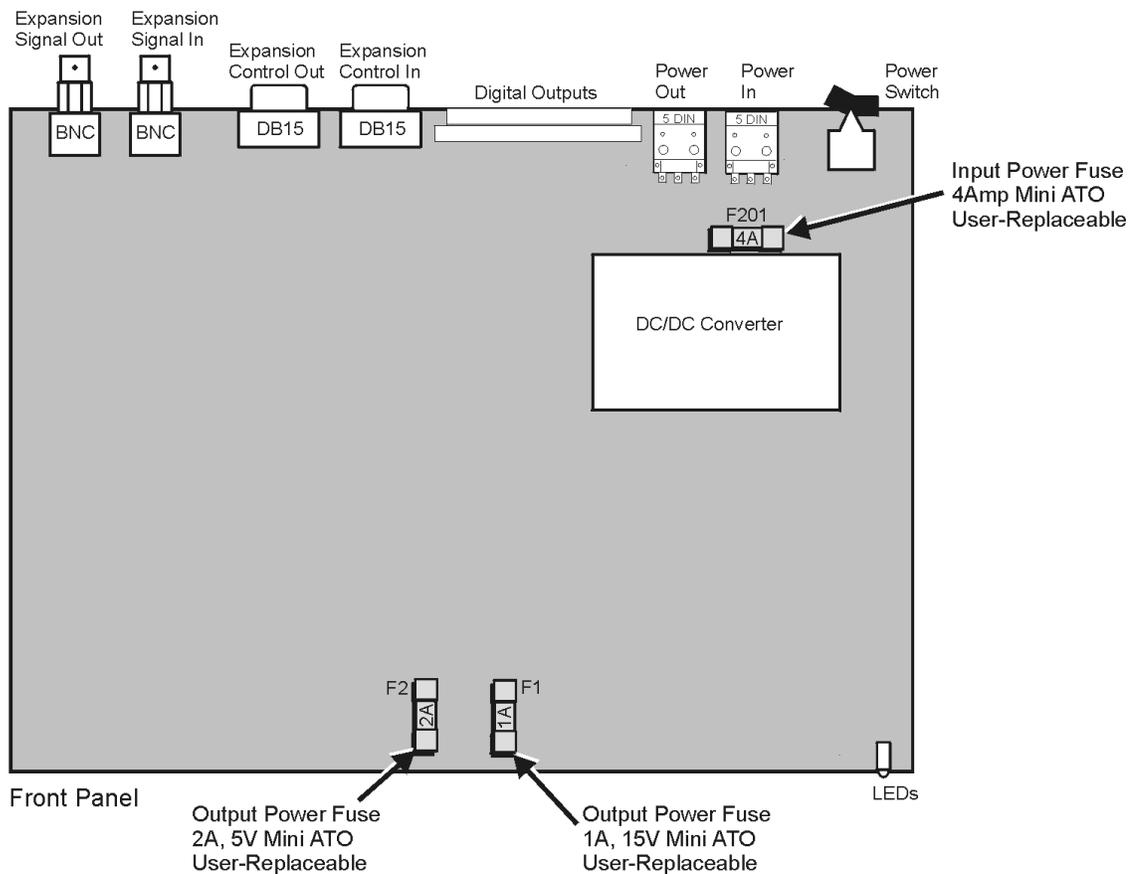


Electric shock hazard! Remove the WBK17, and all devices connected to it, from power before removing the WBK17's cover plate. Failure to do so could result in electric shock and possible death.

CAUTION



Be careful to avoid component damage while WBK17 enclosure is open.



Locations of WBK17's User-Replaceable Fuses

WBK17 - Specifications

General

Power Consumption: 520 mA @ 15V input, 310 mA @ 25V input (assuming no load on power output)
Input Power Range: 10 to 30 VDC
Input Power Fuse (F201): 4A Mini ATO, user-replaceable
Power Output, to Quadrature Encoder: 5V \pm 10% @ 1000 mA and 15V \pm 10% @ 500 mA
Output Power Connector: Removable screw terminal block
15V Output Power, to Encoder, Fuse (F1): 1A, Mini ATO, user-replaceable
5V Output Power, to Encoder, Fuse (F2): 2A, Mini ATO, user-replaceable
Operating Temperature: 0° to 50°C
Storage Temperature: 0° to 70°C
Vibration: MIL STD 810E, Category 1
Humidity: 0 to 95% RH, non-condensing
Dimensions: 285 mm W x 220 mm D x 35 mm H (11" x 8.5" x 1.375")
Weight: 1.5 kg (3.1 lbs)

Analog Inputs

Channels: 8 differential
Input Connections: COM, CH high, CH low
Input Connectors: Removable screw-terminal blocks (2 channels per block)
Input Impedance: 20K Ohm single-ended; 40K Ohm, double-ended
Input Voltage ranges: -50V to +50Volts specified; -75 Volts to + 75 Volts maximum
Resolution: 0.002307 V/bit
DC Accuracy: 0.25% of reading + 200 mV offset
Noise: 5 mVrms (typical); 10 mVrms (maximum)
Common Mode Rejection: -70 dB typical (0 to 60 Hz); -40 dB guaranteed (0 to 60 Hz)
Coupling: AC or DC, programmable
Analog Sampling Bandwidth: DC to 1 MHz
Filtering: Programmable 30 Hz, 20 kHz, 100 kHz, Single pole low-pass filter

Comparator

Input Threshold: -12.5V to +12.5V referred to input, programmable in 100 mV steps
Threshold Accuracy: 2% of setting, plus 125 mV offset
Input Hysteresis: 50 mV minimum, 100 mV maximum
Input Frequency: DC to 5 MHz
Sensitivity: 500 mVpp DC to 1 MHz
5 Vpp 1 MHz to 5 MHz

Debounce Module

Debounce Times: 16 selections from 500 ns to 25.5 ms, Positive or negative edge sensitive, Glitch detect mode or debounce mode.

Counter Module

Time Base Accuracy: 10 ppm (0° to 50°C)
Five Programmable Modes: Counter, Period, Pulsewidth, Timing, Encoder
Counter Mode Options: Totalize, Clear on Read, Rollover, Stop at all Fs, 16-bit or 32-bit, any other channel can decrement the counter
Period Mode Options: Measure x1, x10, x100, or x1000 periods, 16-bit or 32-bit, 4 time bases to choose from (20 ns, 200 ns, 2 μ s, 20 μ s), any other channel can gate the period measurement
Pulsewidth Mode Options: 16-bit or 32-bit values, 4 time bases to choose from (20 ns, 200 ns, 2 μ s, 20 μ s), any other channel can gate the pulsewidth measurement
Timing Mode Options: 16-bit or 32-bit values, 4 time bases to choose from (20 ns, 200 ns, 2 μ s, 20 μ s)
Encoder Mode Options: x1, x2, x4 options, 16-bit or 32-bit values, Z-channel clearing of the counter, any other channel can gate the counter

Digital Inputs

Inputs: 8 Digital Inputs
Connector: DB25 female
Configuration: 16TTL-compatible pins
Input Characteristics: TTL-compatible
Input/Output Protection: Diode clamped to ground and to +5V.

Digital Outputs

Outputs: 8 Digital Outputs
Connector: Removable screw-terminal block
Output Type: Open-drain DMOSFET
Output Pullup Resistor: 27k Ohm to +5V
Output Sink Current: 150 mA/output continuous, 500 mA output peak (<100 μ s), 150 total continuous (per bank of 8 outputs)
Output Voltage Range: 0 to +5V, no external pullup required; 0 to +30V, with external pullup resistor
Output Resistance: 10 Ohms maximum
Note: All digital outputs are fully programmable with masking.

Detection Circuit

Digital Pattern Detection Choices: Greater than value, less than value, inside the window, outside the window.
Detection Setpoints Per Channel: 16. Note that each detection setpoint can be associated with a digital output port update (with mask).

CE Compliance

In regard to CE Compliance, refer to the WBK17 *Declaration of Conformity* (p/n 1064-0740). As stated in that document, one of the several requirements for CE compliance is the use of a WBK17 CE kit (p/n WBK17-CE-Kit). Contact the factory or your service representative should you desire detailed information.

The *Declaration of Conformity* is shipped with the WBK17 module.

Description..... 1

- Current Source with Transducer Fault Detection..... 2
- Input Coupling 2
- Programmable Gain Amplifier (PGA) 2
- Low-Pass Anti-Aliasing Filter 3
- Overrange Detection 3
- Simultaneous Sample and Hold 3
- TEDS Support 4
- Excitation Source 4
- LEDs 4

Hardware Setup 5

- Configuration..... 5
- Power..... 5
- Assembly..... 6
- Input Connections6

Software Setup 7

- General7
- Maximizing Alias Protection9
- Using the 2-Pole Filter and Bypass.....11
- Module Configuration 13

Using Accelerometers 18

- Overview 18
- Accelerometer Specification Parameters 18
- Electrical Grounding..... 20
- Cable Driving..... 20

Fuse Replacement 22

Specifications 24

Description

The WBK18 is a dynamic analog signal input module for the WaveBook data acquisition system. The WBK18 provides a complete system to interface to piezoelectric transducers that include accelerometers, microphones, force/pressure transducers, and others.



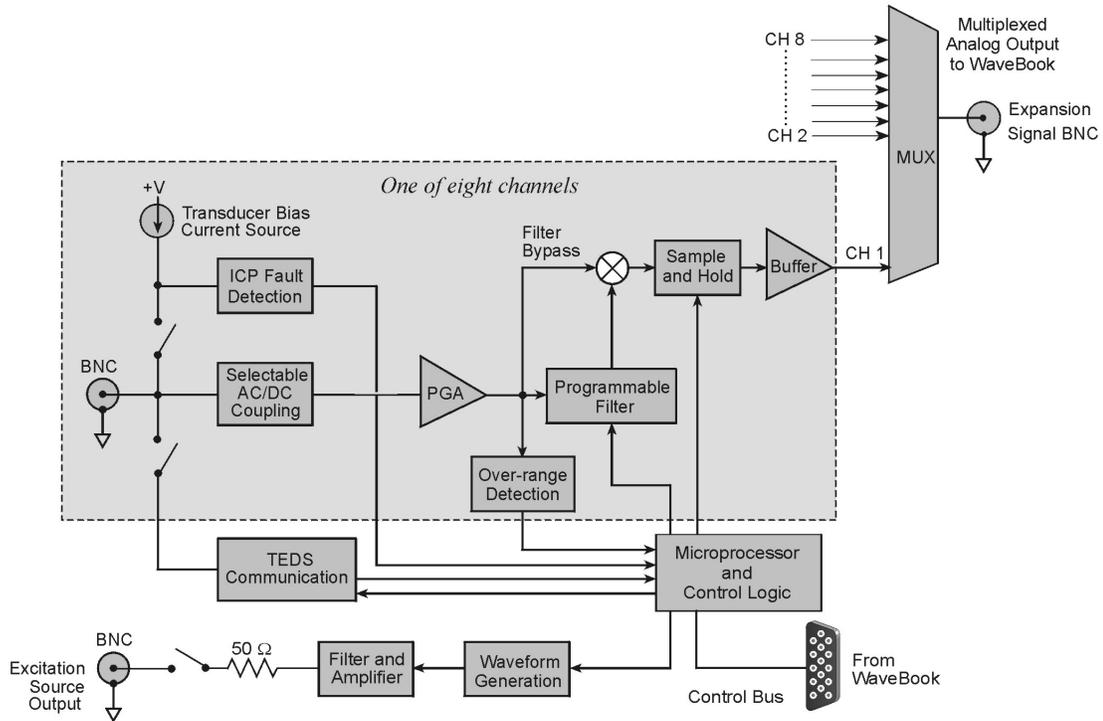
WBK18, Front and Rear Panel Views

Each WBK18 channel features:

- a 4 mA current source for transducer biasing
- hardware detection of a transducer fault
- AC (0.1 Hz or 10 Hz) or DC coupling
- a programmable gain amplifier (range selection)
- hardware overrange detection
- an anti-aliasing low-pass filter
- a simultaneous sample-and-hold (SSH) amplifier
- support for optional TEDS (Transducer Electronic Data Sheet), if purchased

All of these parameters are independently controlled in software on a per channel basis except for overrange detection level, which is set on a per module basis.

The WBK18 module includes a built-in programmable voltage excitation source. This source can be used to stimulate dynamic systems for transfer function measurements, and also serves as a test signal for the input channels.



WBK18 Block Diagram

Current Source with Transducer Fault Detection

The WBK18 module provides constant current of 4mA to bias ICP transducers. The bias current is sourced through the center conductor of the input channel BNC connector and returns to the WBK18 by the outer conductor. The current source features an operating compliance of 24V and is short-circuit and overvoltage protected. Operating compliance refers to the highest voltage that can be applied without change of the current source value. In the absence of a transducer, the current source will output an open circuit voltage of 30V. For applications that do not require bias, the current source can be disconnected from the input via software control on a per channel basis.

When the current source is enabled, the input voltage is continuously monitored with level detection circuitry. Recognition of a voltage greater than 25V (transducer open) or less than 1V (transducer short) triggers a transducer fault condition for the affected channel. This error is communicated to the user via a front panel LED and is also available through a software status request at the end of an acquisition. When recognized, an error is latched until the commencement of a new acquisition. Consequently, even intermittent faults are detected and communicated. Detection of a fault does not, however, alter the acquisition process or its data.

Input Coupling

Each WBK18 channel offers the selection of three coupling modes: 0.1 Hz, 10 Hz, or DC. The 0.1 Hz path is a 1-pole high-pass filter with a -3dB point at 0.1 Hz. The 10 Hz path is a 2-pole high-pass filter with a -3dB point at 10 Hz. The DC path provides a direct signal connection.

Programmable Gain Amplifier (PGA)

The WBK18 provides programmable gains of 1, 2, 5, 10, 20, 50, 100, and 200. These correspond to bipolar input ranges of 5V, 2.5V, 1V, 500mV, 250mV, 100mV, 50mV, and 25mV. Additionally, there is a 25V DC-coupled only range that is suitable for proximity sensor measurements. Range selection is programmable on a per channel basis.

Low-Pass Anti-Aliasing Filter

Each channel features a programmable low-pass filter to provide alias protection and to allow for the removal of undesired frequencies from the measured response. This filter is configurable within 3 modes: 8-pole, 2-pole, and Bypass. The 8-pole Butterworth *switched capacitor filter* offers the greatest alias protection and is most commonly used in vibration measurements. Its -3dB cutoff frequency is settable from 10 Hz to 50 kHz in a 1-2-5 progression. Application information regarding the proper setting of this filter is provided in *Maximizing Alias Protection*.

2-pole mode utilizes two RC filters in series. Its -3dB cutoff frequency is settable as well from 10 Hz to 50 kHz in a 1-2-5 progression. It provides tighter amplitude and offset accuracy than 8-pole mode at the expense of reduced alias protection (due to its more gradual roll-off). It is most commonly used in proximity sensor measurements, where the DC component of the input signal is critical. Additionally, the filter can be bypassed altogether, resulting in a signal bandwidth of up to 200 kHz.

When the LPF (Low Pass Filter) is in the Bypass mode, the bandwidth of the system depends on the coupling mode selected. For the 0.1 Hz and 10 Hz selections, the bandwidth is approximately 190 kHz. For the DC selection, the bandwidth is approximately 130 kHz. For the 25 V range, the bandwidth is approximately 120 kHz.



Reference Note:

Application information regarding the 2-pole and Bypass settings of the filter is provided in the section entitled, [Using the 2-Pole Filter and Bypass](#) (page 11).

Overrange Detection

Each WBK18 channel is equipped with overrange detection circuitry. Use of this feature insures that all data collected during an acquisition did not exceed a user-specified level, set as a percentage of range. In its most common use, with the level set to 100%, the user is notified if the input signal exceeded the input full-scale range, even momentarily. This protection is critical, for overrange signals result in clipped data that significantly corrupts FFT analysis. This error is communicated to the user via a front panel LED and is also available through a software status request at the end of an acquisition. When recognized, an error is latched until the commencement of a new acquisition. Consequently, even intermittent faults are detected and communicated. However, an overrange event does not stop the acquisition process or change the data, providing the user with full control over the disposition of data.

An extension of the overrange capability could involve its integration into a process monitor application, whereby the fault condition is used to monitor the stability of a previously characterized dynamic signal. The overrange level is programmable from 1 to 100% of range on a *per WBK18* basis. Overrange detection can be enabled or disabled on a per channel basis.

Simultaneous Sample and Hold

All WBK18 channels are sampled simultaneously, after which the WaveBook measures each output until all channels are digitized. The time-skew between sampling on all channels is 100ns, regardless of the number of WBK18s connected to the WaveBook. This maximizes channel-to-channel phase matching.



When using WaveBook with an SSH channel enabled, the per-channel sample rates are reduced. The rate reduction is the same as that which would occur if another channel were added. The per-channel rate (with SSH enabled) is:

$1\text{ MHz} / (n+1)$, where n is the number of active channels.

TEDS Support

TEDS, Transducer Electronic Data Sheet, is a purchased option. The TEDS feature enables a WBK18 module to access the calibration information that is stored within TEDS-compatible sensors. The WBK18 can read calibration information from sensors and automatically scale the readings from each sensor, using the acquired calibration information. TEDS support is a software option that can easily be added after the initial purchase of the WBK18.



Reference Note:

Information regarding [TEDS](#) in relation to the *WaveView* software application begins on page 8.

Excitation Source

The WBK18's AC excitation source is a sine wave-based voltage source that is programmable in frequency from 1 Hz to 5 kHz and in discrete amplitudes from 100 mVp-p to 10 Vp-p. Continuous sine, sweep sine, and custom sine modes are available. It can be used as a test source for the input channels or as excitation for other system elements, such as the amplifier for a shaker table. All of its parameters are software controlled, and its output is conveniently provided on a front panel BNC connection. Detailed information on the excitation source and its operation can be found in the Software Setup section.

Do not confuse excitation source with the *Source Level* column in WaveView's main window, as source level refers to transducer bias current (see [Source Level](#), page 8) and not to the excitation source.

LEDs

The right-hand side of the WBK18 front panel includes 19 indicator LEDs. There are eight Transducer Fault LEDs (1 for each channel), eight Overrange LEDs (1 for each channel), an Active LED, Ready LED and a Power LED. The indicators have the following meanings.

Transducer Fault (1 LED per Channel)	When lit, a Transducer Fault LED indicates that the transducer for the associated channel has either an open circuit or a short circuit. In addition to LED indication, transducer fault information is available through a software status request at the end of an acquisition. Transducer fault errors are latched until the commencement of a new acquisition. Consequently, even intermittent faults are detected and communicated. Detection of a transducer fault does not stop an acquisition or alter data. For related information refer to Current Source with Transducer Fault Detection on page 2.
Overrange (1 LED per Channel)	When lit, an Overrange LED indicates that the associated channel's input signal has exceeded the input full-scale range, which was programmed for that specific WBK18 module. Even a momentary exceeding of the range will cause the LED to light. This indication is critical, for overrange signals result in clipped data that significantly corrupts FFT analysis. In addition to LED indication, the overrange condition is available through a software status request at the end of an acquisition. Overrange errors are latched until the commencement of a new acquisition. Consequently, even intermittent faults are detected and communicated. Overrange events do not stop an acquisition or alter data. For related information refer to Overrange Detection on page 3.
Active	Lights when data is being converted.
Ready	Lights when the WBK18 has established communication via its Expansion Control In connector.
Power	Lights when power to the unit is turned on and present.

Hardware Setup

Configuration

The WBK18 requires no physical hardware settings. All WBK18 configurations are controlled by software.



Reference Note:

Setup information pertaining to power, expansion control, and expansion signal connections is contained in the chapter *System Setup and Power Options*, in the *WaveBook User's Manual*.



It is possible to connect a WaveBook to the host computer's parallel port with either a 2-foot (CA-35-2) or 6-foot (CA-35-6) communication cable. To minimize the amount of noise that is introduced to the WBK18, use of the 2-foot (CA-35-2) cable with the WaveBook is recommended.

Power

The WBK18 module can be powered by an AC power adapter or directly from any 10 to 30 VDC source, such as a 12 V car battery. For portable or field applications, the WBK18 and the WaveBook can be powered by the DBK30A rechargeable battery module.



Reference Note:

For details regarding power, refer to the chapter, *System Setup and Power Options*, in the *WaveBook User's Manual*.

As described in this referenced chapter, it is possible to power the WBK18 from the POWER OUT DIN5 connector on the WaveBook and to power other WBK expansion modules from the POWER OUT DIN5 connector on the WBK18. The following notes apply to those types of power connections.



Tables for determining amp load are provided in the *WaveBook User's Manual* chapter entitled *System Setup and Power Options*. The following factors are very important.

- Calculate system amp load prior to creating a system daisy-chain. Although WaveBook device connectors and CA-115 power cables have 5 amp limits, TR-40Us are limited to 2.2 amps. If necessary use auxiliary or high-current power supplies.
- If using an AC power adapter for the system power, use separate adapters for the WaveBook and the WBK18.
- The WBK18 has a 5 amp current limit. TR-40U power supplies are limited to 2.2 amps. Power consumption calculations must be done to ensure that a particular daisy-chain scheme does not exceed either of these current limits.



To ensure that the software recognizes all system components, when powering up an Ethernet connected WaveBook system, it is important that the WaveBook/516E (or WBK25) is powered last, and that the most remote system components are powered first. Other power-up sequences will result in software's failure to recognize all components.*

- First, power-on the WBK expansion modules.
- Second, power-on WaveBooks or WBK modules that are connected to the expansion ports of the WaveBook/516E or WBK25.
- Finally, power-on the WaveBook/516E and/or WBK25 devices.

*An exception to this power-up scheme is to power-on the entire system at once.

Assembly

The WBK18 has the same footprint as the WaveBook and other modules, allowing for convenient mounting. A fastener panel allows multiple units to be stacked vertically. Screw-on handles are available for portable applications. For more assembly information, see chapter 3 of the *WaveBook User's Manual* (p/n 489-0901).

Input Connections

All input connections are made into the front panel BNCs, in which the BNC center conductor is the signal HI and the BNC shell is the signal LO. The BNC shell is common among all eight input channels and is not isolated from earth ground. Consequently, the shell is not meant to be driven with respect to earth ground. An additional consideration exists regarding the setup of the input transducer. If the transducer case is effectively earth grounded through its connection to a device under test, there exists the possibility for added measurement noise due to the ground loop that is created. This issue is minimized by electrically isolating the transducer from the device.

CAUTION



The BNC shell is not to be driven with respect to earth ground. Attempting to do so could result in equipment damage.



Additional measurement noise may be present when using earth grounded transducers. For best results, electrically isolate the input transducers from earth ground.

Software Setup

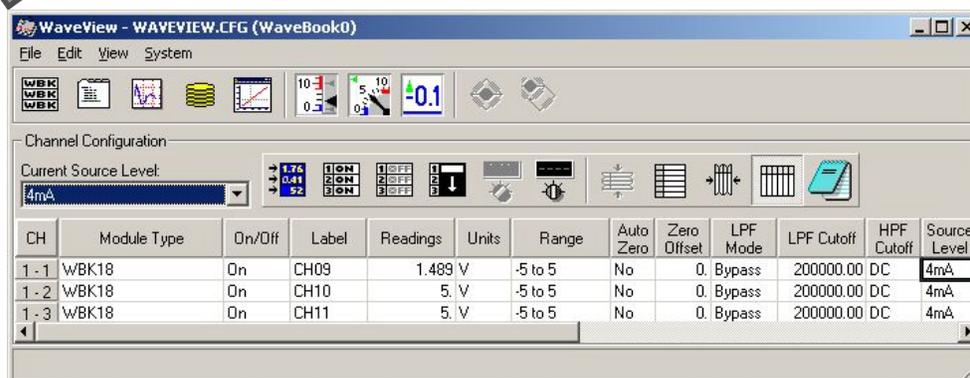
General

Depending on your application, you will need to set several software parameters. Proper settings will allow *WaveView* to organize data to meet your requirements. Some items of importance to the WBK18 are the **low-pass** and **high-pass filter options** that can be selected from the *WaveView Configuration* main window and the **excitation source** and **overrange detection** parameters that can be chosen from the *Module Configuration* window. The *Module Configuration* window can be accessed from the View pull-down menu or by use of the first toolbar button (located just below the File pull-down menu).



Reference Note:

For detailed *WaveView* information, refer to the *WaveView Document PDF*.



WaveView Configuration Window

In the *WaveView Configuration* main window (see figure) the following columns are applicable to the WBK18.

LPF Mode – Click on a cell in the LPF Mode column to make the cell active, and then change its setting. Options for WBK18’s LPF Mode are:

- 8-Pole**: selects the 8-pole low-pass filter
- 2-Pole**: selects the 2-pole low-pass filter
- Bypass** – bypasses the low-pass filter

LPF Cutoff - Click on a cell in the LPF Cutoff column to make the cell active, and then change its setting. Options for LPF Cutoff (in Hz) are: 10, 20, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, and 50000. Note that when the LPF Mode is “Bypass,” this parameter is fixed at 200000 Hz.



Reference Note:

Application information regarding the proper setting of LPF Mode and LPF Cutoff is provided in the sections entitled [Maximizing Alias Protection](#) (page 9) and [Using the 2-Pole Filter and Bypass](#) (page 11).

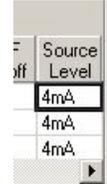
HPF Cutoff - This is used to select input coupling. Click on a cell in the HPF Cutoff column to make the cell active, and then change its setting. Options for HPF Cutoff are:

- 0.1 Hz**: selects the 0.1 Hz, 1-pole high-pass filter
- 10 Hz**: selects the 10 Hz, 2-pole high-pass filter
- DC**: selects DC coupling

Note that when the Range is “ $\pm 25V$,” the HPF Cutoff is fixed at DC.

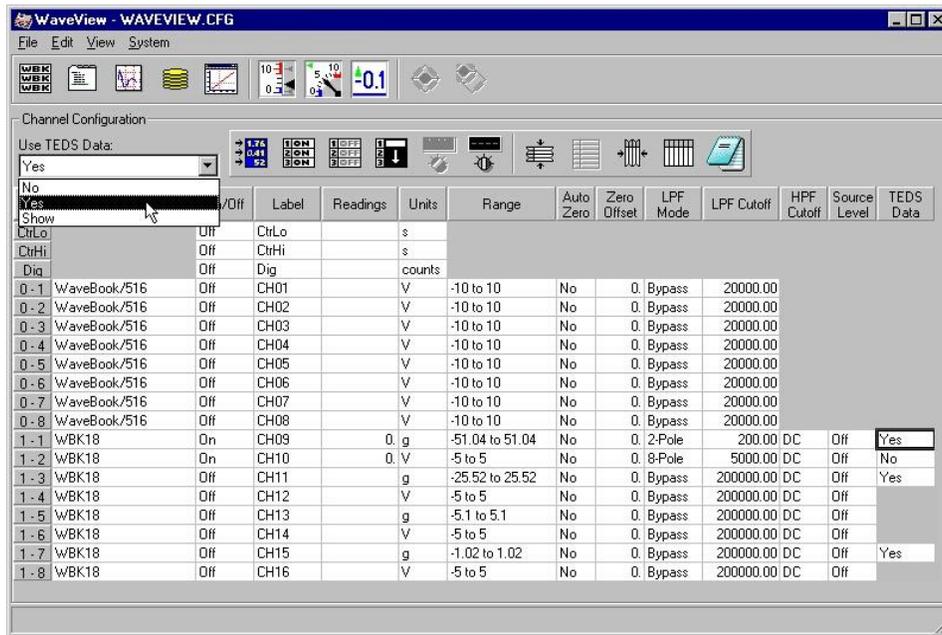
Range - This is used to select the input range. Click on a cell in the Range column to make the cell active, and then change its setting. Options for Range are: $\pm 25V$, $\pm 5V$, $\pm 2.5V$, $\pm 1V$, $\pm 500mV$, $\pm 250mV$, $\pm 100mV$, $\pm 50mV$, and $\pm 25mV$. Note that when the Range is “ $\pm 25V$,” the HPF Cutoff is fixed at DC.

Source Level – Source Level refers to the transducer bias current and is not to be confused with the excitation source that is discussed on pages 4 and 14. The current *Source Level* column of WaveView’s main window is used to turn the transducer bias current on at a current value of 4 mA, or to turn the transducer bias current off. Click on a cell in the *Source Level* column to make the cell active, and then change its setting to 4 mA or to off, according to the application. If a channel is connected to a transducer that requires a current source, set the source level to 4 mA; otherwise set the source level to off.



TEDS (Transducer Electronic Data Sheet)

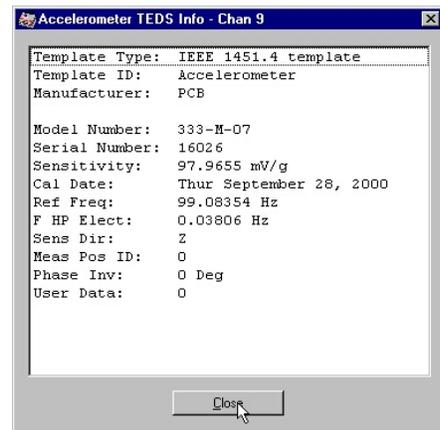
TEDS is a purchased option that enables WBK18 modules to access calibration information from TEDS-compatible sensors. The WBK18 automatically scales the readings and sets the range according to the information stored on the sensor. This is done independently for each TEDS associated channel, providing that “Yes” appears in the TEDS Data cell (right-hand column, following figure).



WaveView Configuration Window

If no WBK18 channels are connected to a TEDS sensor, the entire TEDS Data column, including the heading, will be grayed-out. When a channel does have a TEDS sensor it will have an associated cell. You can click on the cell to access the “Use TEDS Data” pull-down list, which offers 3 choices: *No*, *Yes*, and *Show*.

- “No” instructs *WaveView* not to use TEDS. When TEDS is not used the associated channel will use the default range and units of volts (V).
- “Yes” instructs *WaveView* to use TEDS. The channel’s ranges will be automatically scaled according to the TEDS sensor’s calibration data and the units will appear as “g.”
- “Show” accesses an *Accelerometer TEDS Information* box for the associated channel. An example is provided to the right. The channel, in this case channel 9, is identified in the title bar. When the information box is closed the TEDS Data cell will indicate its previous status of Yes or No.



Accelerometer TEDS Information Box



If you add, remove, or relocate a TEDS sensor at the WBK18 channel inputs, the TEDS information, and WaveView’s range and units will not reflect the change until either (a) the WaveBook is reselected as a device, or (b) WaveView is closed and then reopened.

Maximizing Alias Protection

What is Aliasing?

Aliasing is a phenomenon of sampled data systems wherein a high frequency signal is misrepresented as a low frequency signal when the A/D converter sampling rate being used is too slow. This misrepresentation can result in severe data corruption and incorrect FFT results. Aliasing is a well-documented data acquisition effect, and interested users are encouraged to research detailed information that is available on-line from companies such as Analog Devices and Texas Instruments. This text aims to not supplant those resources, but to provide most users with sufficient knowledge to avoid most alias problems through proper filter and sampling rate configuration.

For a given sampling rate, F_s , input signals of frequency up to $F_s/2$ will be processed correctly. However, input signals above $F_s/2$ are subject to aliasing. For example, a sampling rate of 100 kHz can process signals up to 50 kHz without aliasing. An input signal of 90 kHz, however, will be aliased. Specifically, it will appear in the sampled data as a signal of frequency $F_s - F_{IN}$, which in this case is $100 \text{ kHz} - 90 \text{ kHz} = 10 \text{ kHz}$.

Aliasing, and its prevention, should be a consideration in all sampled data systems. This is especially important in mechanical vibration measurements, because most mechanical systems exhibit a resonance apart from their fundamental frequency. That is, there may be signal energy present that has the potential to be aliased that is unknown to the user. And the worst part of aliasing is that its effects are indistinguishable from real input signals. That is, in the given example, it is not apparent to the user whether the 10 kHz energy is real or an alias.

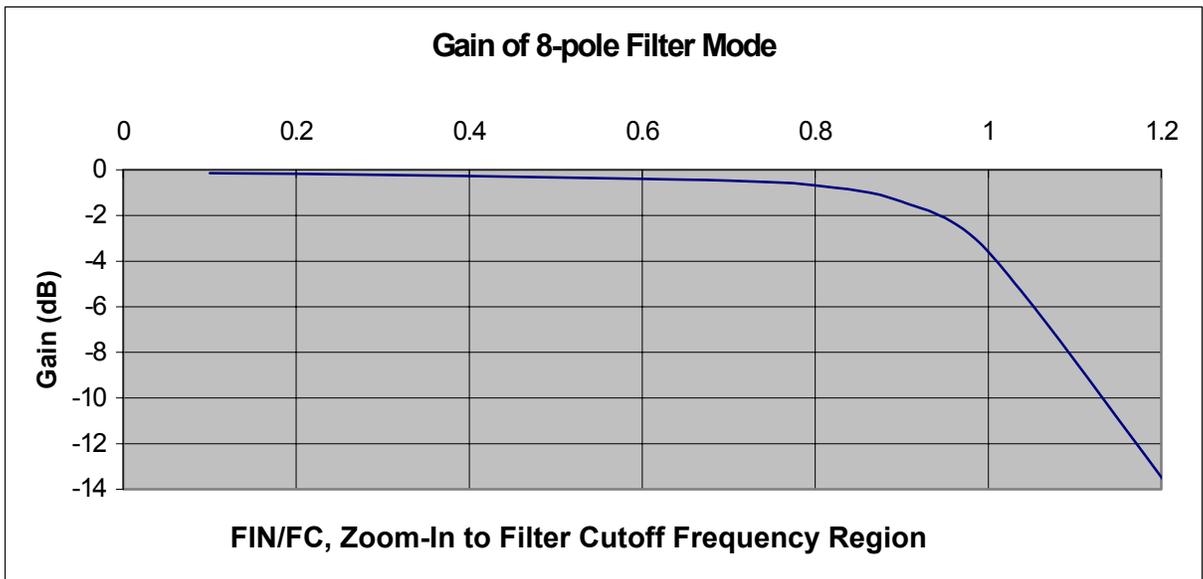
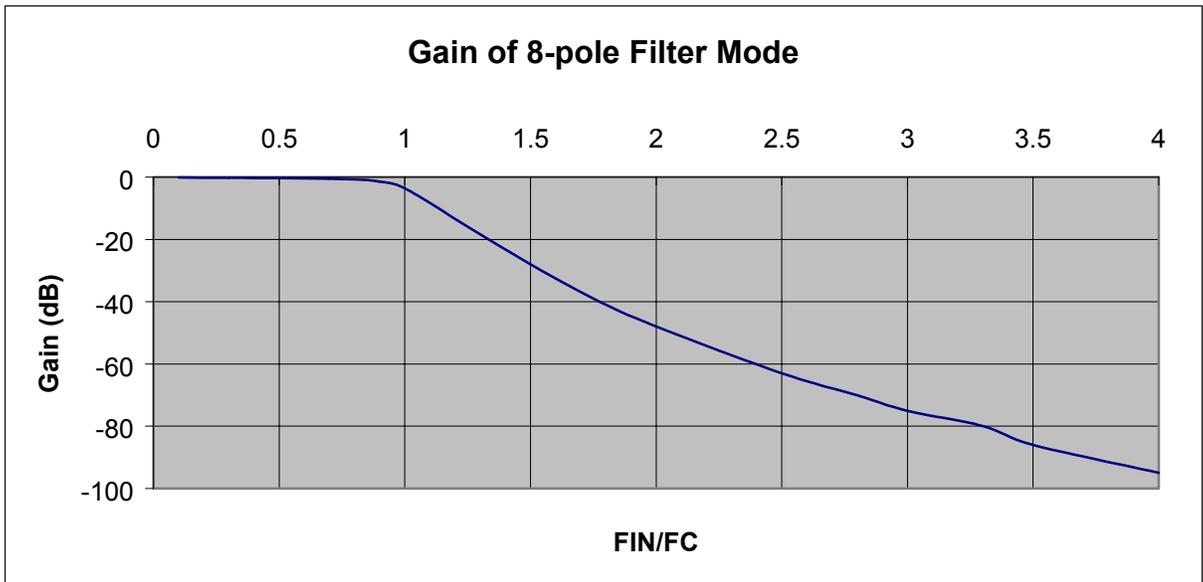
Aliasing Protection using the WBK18

The WBK18 provides alias rejection via its 8-pole filter. This filter has an extremely steep roll-off characteristic, very closely achieving an ideal “brick-wall” response. It consequently passes frequencies of interest without significant attenuation, but significantly attenuates frequencies just above. Its attenuation is so high that most alias frequency energy is reduced to a level below the noise floor of the measurement system. However, it must be configured correctly to achieve these results. In general, the cutoff frequency (F_C) of the filter should be set as close to, but above, the highest input frequency of interest. This will maximize the alias rejection it provides.

The 8-pole filter provides excellent filter response. However, no filter is perfect, meaning that some signal attenuation occurs for frequencies just below F_C and maximum attenuation is not exhibited for frequencies just above F_C .

For reference, the typical response of the 8-pole filter is provided in the table at the right and the graphs that follow.

F_{IN}/F_C	Gain (dB)
<0.1	-0.15
0.1	-0.15
0.2	-0.18
0.3	-0.22
0.4	-0.27
0.5	-0.33
0.6	-0.39
0.7	-0.47
0.8	-0.68
0.9	-1.4
1.0	-3.6
1.25	-16
1.5	-28
1.75	-39
2.0	-48
2.5	-63
2.8	-70
3.0	-75
3.3	-80
3.5	-86
4.0	-95



As described above, aliasing results from the relationship between input frequency and sampling frequency. Configuring the filter correctly serves to attenuate undesired frequencies. However, thought must also be given to the sampling rate of the A/D converter. In general, for alias considerations, the sampling rate should be set as high as possible, given the number of active channels being used. Recall that the maximum sampling rate is $1 \text{ MHz}/(n + 1)$ where n is the number of active channels. Because the sampling rate determines the frequency at which aliasing occurs, it determines the input signal bandwidth, for a given level of alias rejection. This relationship is shown in the following example.

Example

of channels: 4

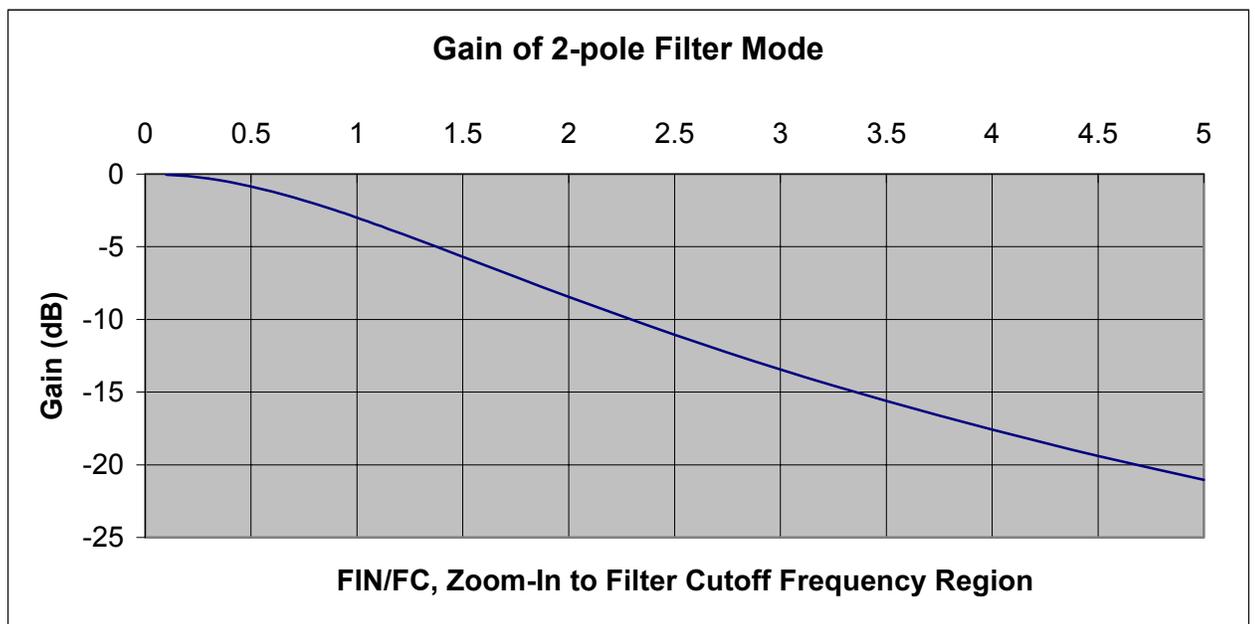
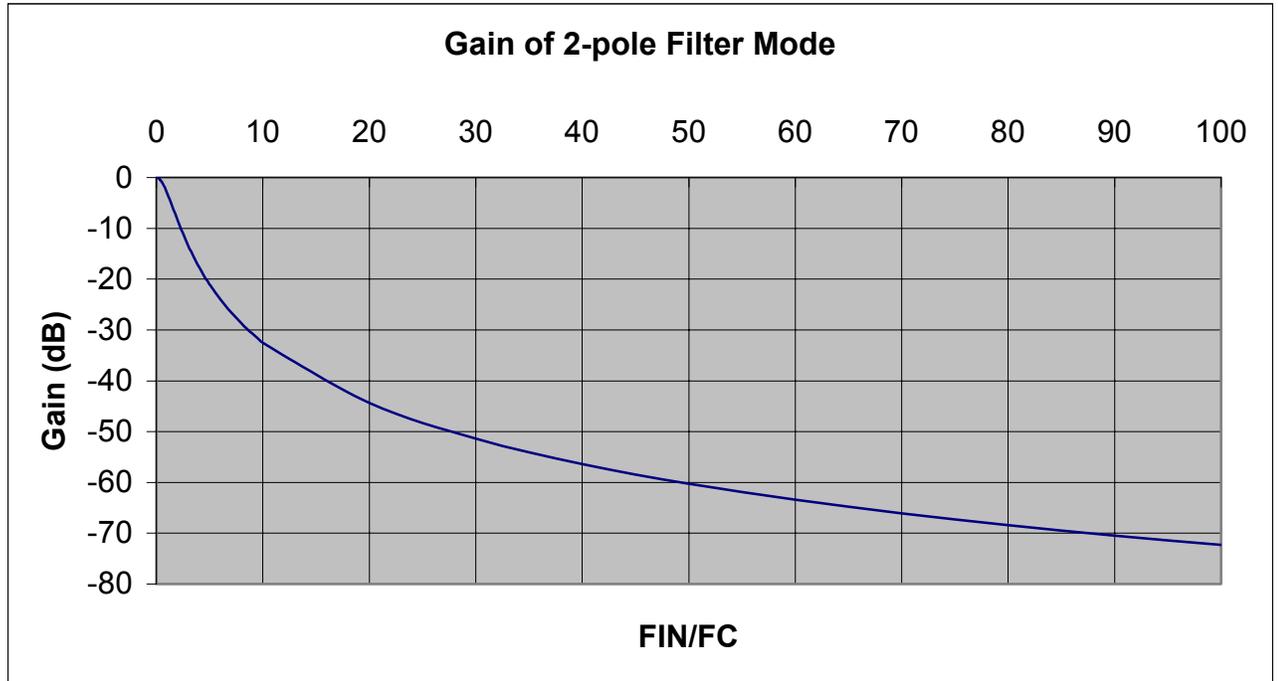
Alias rejection: -70dB min

The sampling rate (F_S) is chosen to be the maximum of $1 \text{ MHz}/(4 + 1) = 200 \text{ kHz}$. The alias frequency is $F_S/2$, or 100 kHz. Referring to the attenuation table, to achieve a minimum of -70dB of alias rejection, there must be at least a 2.8 ratio between F_{IN} and F_C . For the F_{IN} value of 100 kHz, this translates into a maximum value of F_C of $100 \text{ kHz} / 2.8 = 35.7 \text{ kHz}$. The largest available F_C value that satisfies this condition is 20 kHz. The input signal bandwidth for this case is then 20 kHz.

Using the 2-pole Filter and Bypass

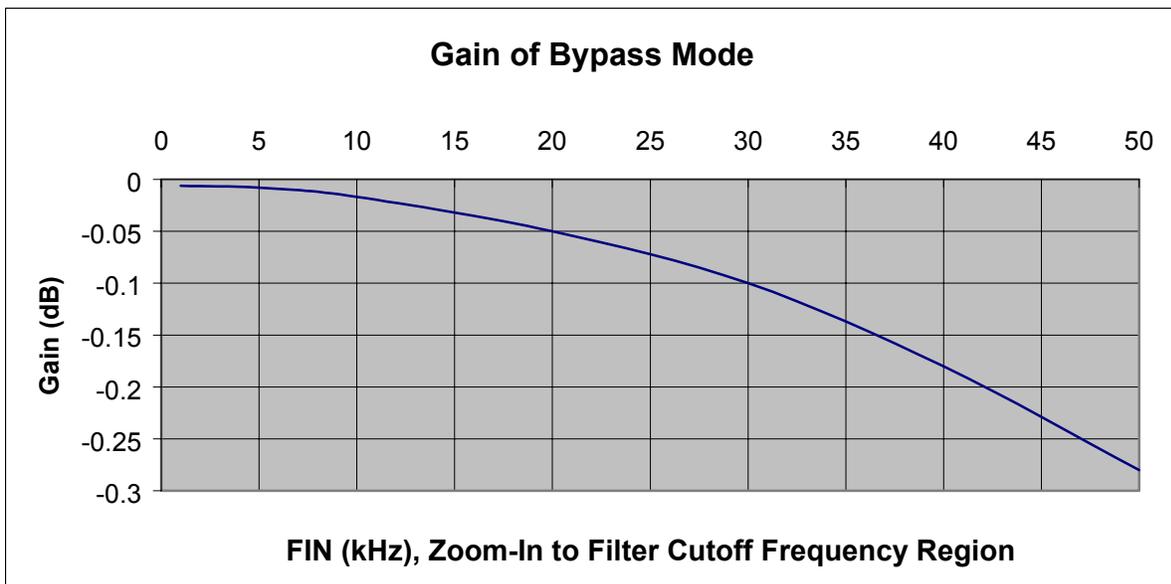
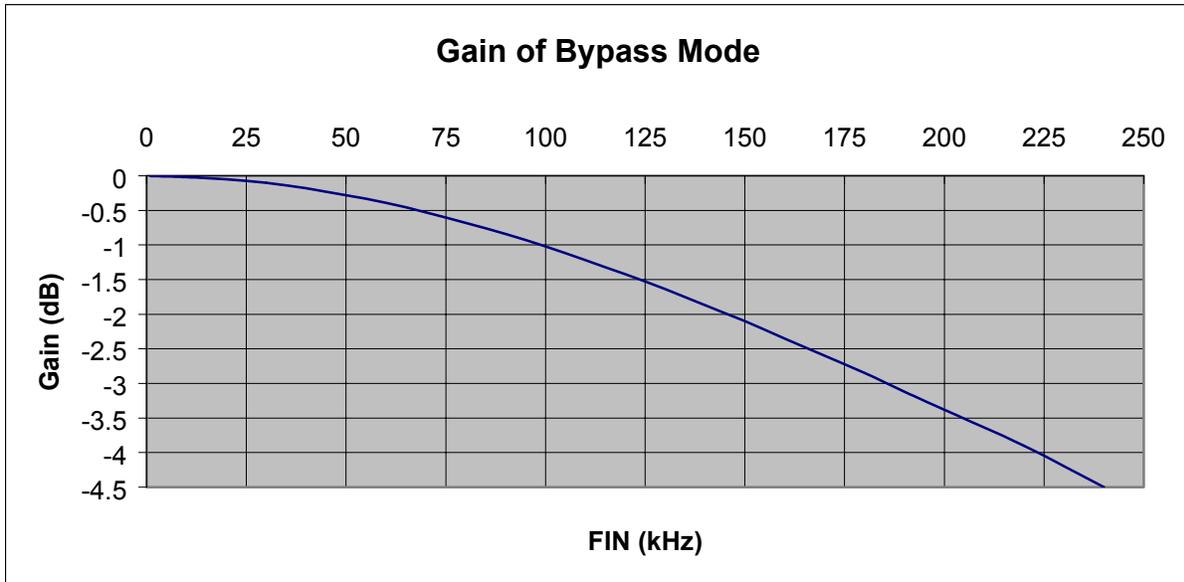
2-pole Filter Mode

For applications where the signal of interest is entirely AC in nature, the low-pass filter mode of 8-pole is the best choice. Vibration signals coupled through an ICP accelerometer are an example of this. However, for applications where the DC component of the input signal is also of importance, 2-pole mode may provide better results. Proximity sensor measurements are an example of this. This is because the 8-pole switched capacitor filter, while providing excellent attenuation characteristics, does not process DC signals with a high level of accuracy. For accelerometer applications this is not a limitation, as there is no information in the DC component of the input signal. The 2-pole filter, in contrast, is formed by two 1-pole RC filters in series. This filter provides excellent passband accuracy, at the expense of a more gradual roll-off characteristic, as detailed below.



Bypass Mode

Bypass mode also provides excellent passband accuracy and provides minimal signal attenuation up to very high frequencies for those applications that need to measure signals of frequency exceeding 20 kHz. For reference, the typical roll-off characteristic of Bypass mode is the following:



DC Accuracy

As previously mentioned, the 2-pole and Bypass filter modes are most commonly used in applications where DC signal information is important. The AC response of each of these modes is described above. The DC accuracy, excluding noise, for both modes is:

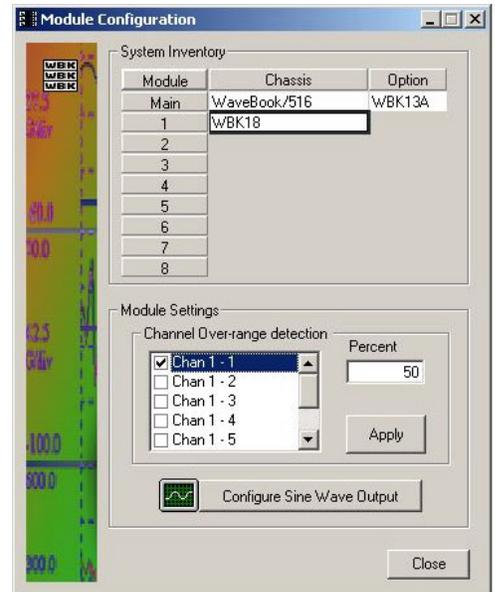
Range	Accuracy at 0° to 50°C (32° to 122°F)		Offset
	± % of Reading		
	Typical	Maximum	
±25V	0.5	1	±15mV
±5V	0.15	0.3	±3mV
±2.5V	0.15	0.3	±2mV
±1V	0.15	0.3	±1mV
±500mV	0.15	0.3	±900μV
±250mV	0.15	0.3	±800μV
±100mV	0.15	0.3	±800μV
±50mV	0.15	0.3	±800μV
±25mV	0.2	0.4	±800μV

These numbers are valid for 1 year after calibration and over the entire operating temperature range of the unit.

Module Configuration

Overrange Detection

The configuration of overrange detection is done through the *Module Configuration* window. The *Module Configuration* window can be accessed from the View pull-down menu or by use of the first toolbar button (located just below the File pull-down menu). In this window, the user enables/disables overrange detection on a per channel basis. A checkmark next to the channel number indicates that overrange detection is enabled for that channel. The overrange detection level is also set in this screen. It is set as a percentage of range that applies to all channels of the WBK18 unit being configured. After channel enable and level selections are made, the “Apply” button must be clicked to accept the changes.



Module Configuration Window



When configuring overrange detection, after channel enable and level selections are made, the <Apply> button must be clicked to accept the changes.

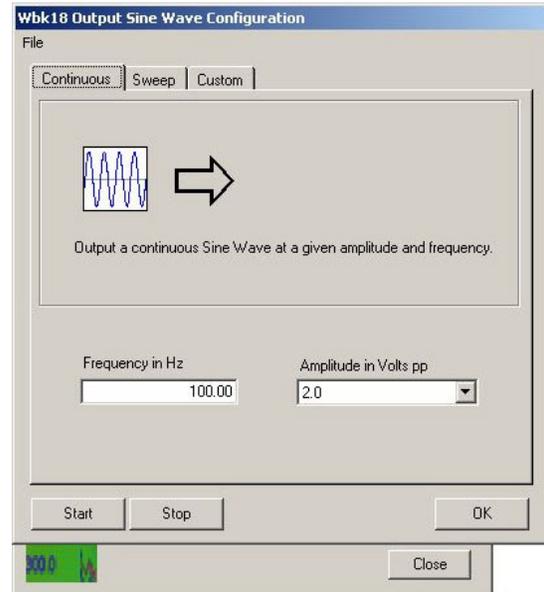
Excitation Source

In order to configure the excitation source, click on the *Configure Sine Wave Output* button in the *Module Configuration* window. This brings up a secondary window in which the excitation source is configured. Do not confuse excitation source with the Source Level column in WaveView's main window.

Continuous Mode

Continuous mode refers to a continuously running sine wave of the selected amplitude and frequency. To configure, select a frequency and amplitude, and then click "Start." The selected output will begin and continue running until the <Stop> button is clicked or WaveView is terminated.

Note: You can save output sine wave configuration files and open pre-saved files as discussed in the upcoming section, *How to Save or Open Output Sine Wave Configuration Files*, page 17.



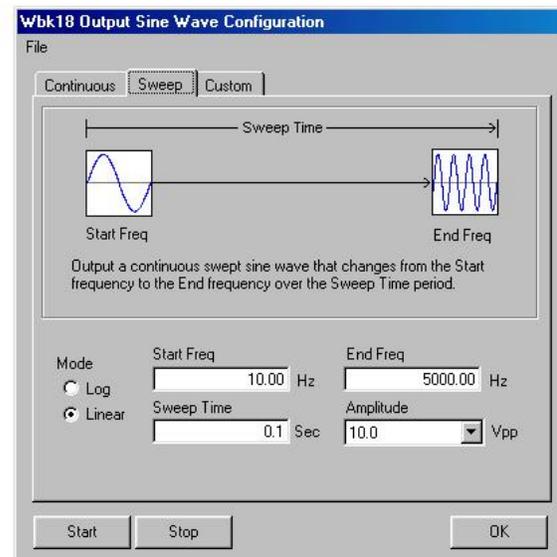
Continuous Tab Selected

Sweep Mode

Sweep mode refers to a constant amplitude sine wave that is being swept in frequency from a selected start frequency to a selected stop frequency over a selected sweep time duration. The frequency sweep characteristic can be chosen to be linear or logarithmic, and is distributed among 1280 discrete steps. The transitions between steps are continuous in phase and in amplitude.

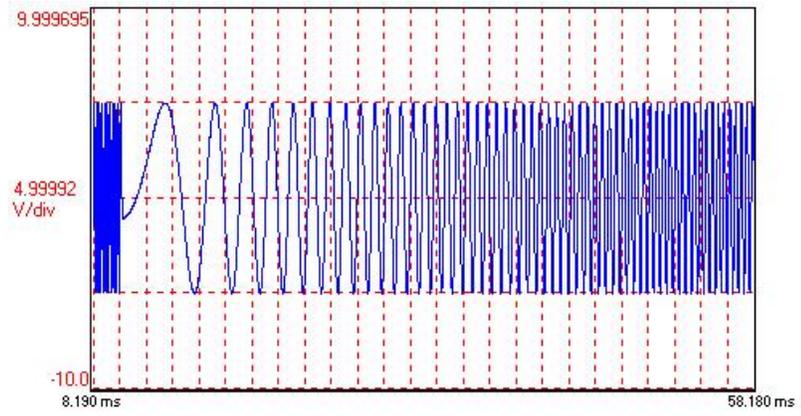
To configure, make selections for the available parameters, and then click the <Start> button. Once a sweep is completed, the waveform returns to its start frequency and is swept again and again until stopped by the user or WaveView is terminated.

Note: You can save output sine wave configuration files and open pre-saved files as discussed in the upcoming section, *How to Save or Open Output Sine Wave Configuration Files*, page 17.

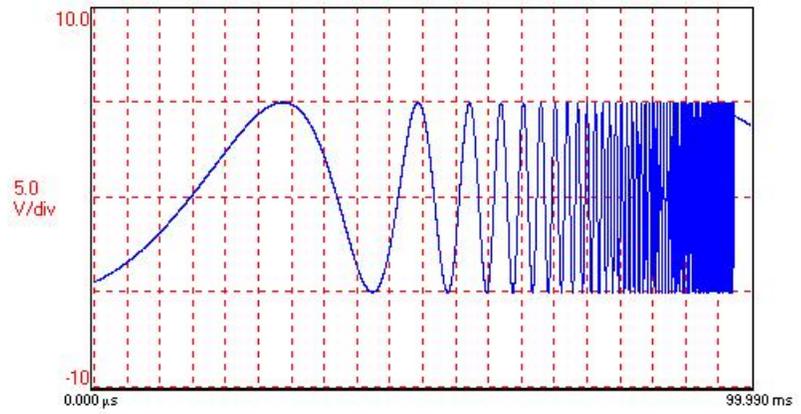


Sweep Tab Selected

Sweep Mode (continued)



Example of a Linear Sweep Waveform

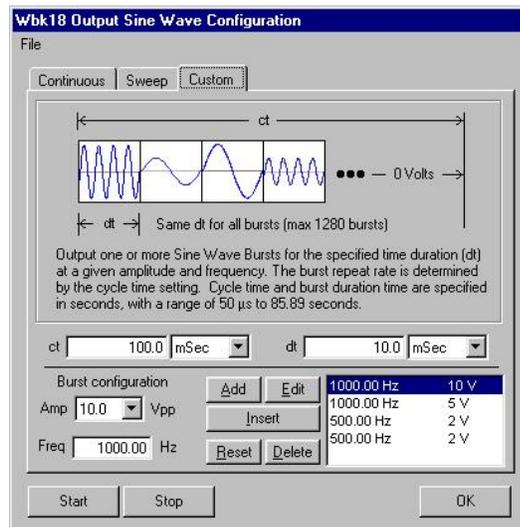


Example of a Log Sweep Waveform

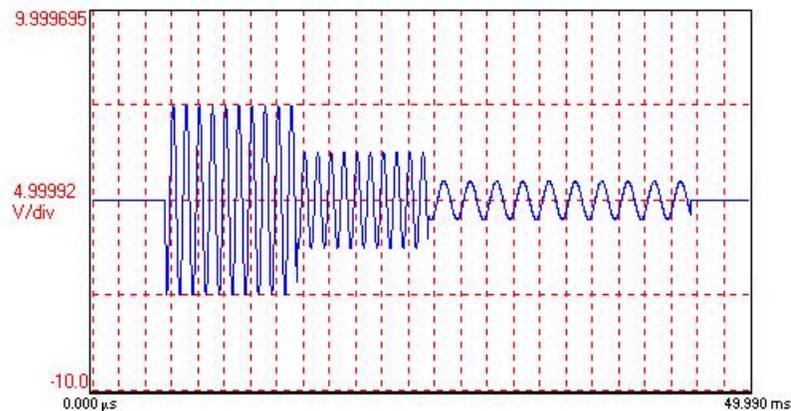
Custom Mode

In this mode, the user can create customized waveforms built out of specified sine wave-based components. For example, a waveform could be 1V, 1 kHz for 2 seconds, followed by 5V, 100 Hz for 5 seconds, and then 2V, 500 Hz for 1 second. Up to 1280 distinct points can be entered, providing the capability to create a virtually unlimited waveform set. Within this mode, there is also an amplitude selection of 0 mV. This corresponds to an active zero voltage and is used to create off time in a voltage waveform. Programming of this mode is done by creating/editing a list of output amplitude/frequency points. After the desired list is entered, the waveform output is begun by clicking “Start.” Once the waveform sequence completes, it returns to the first entry in the list and cycles through again and again until stopped by the user.

Note: You can save output sine wave configuration files and open pre-saved files as discussed in the following section, [How to Save or Open Output Sine Wave Configuration Files](#).



Setting Up Custom Waveforms from the Custom Tab



Example of Waveforms Created in the Custom Mode

How to Save or Open Output Sine Wave Configuration Files

Within all modes, there is the ability to save and recall waveform configurations, which is very beneficial for complex custom configurations. Within WaveView, this feature is accessed through *File* in the WBK18 Output Sine Wave Configuration Window.

To Save a Configuration

1. Click on “File” in the upper left corner of the screen.
2. Click on the option labeled “Save Waveform Configuration As...”
3. Name the file. Note that it will have a .dds extension.
4. Save the file to the desired drive.

To Open a Configuration

1. Click on “File” in the upper left corner of the screen.
2. Click on the option labeled “Open Waveform Configuration...”
3. Open the desired file.

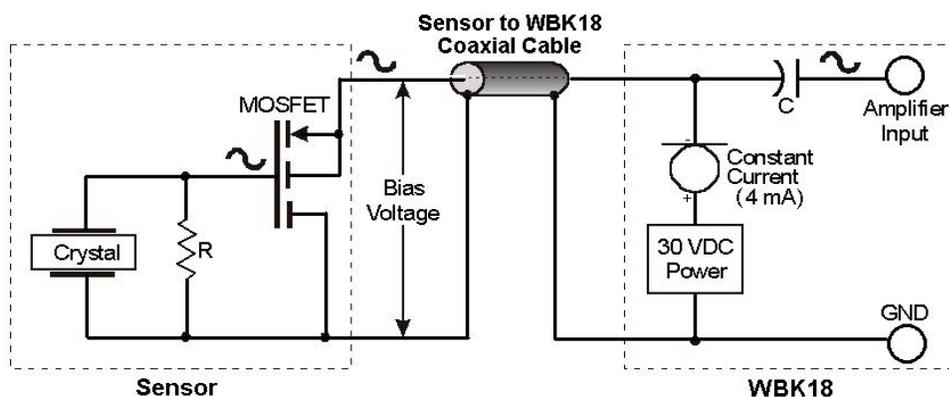
Using Accelerometers

Overview

A low-impedance piezoelectric accelerometer consists of a piezoelectric crystal and an electronic amplifier. When stretched or compressed, the two crystal surfaces develop a charge variation that is related to the amount of stress, shock, or vibration on the crystal. The amplifier outputs a corresponding signal and transforms the sensor's high impedance to a lower output impedance of a few hundred ohms. Note that, in addition to acceleration, these sensors can also measure pressure and force.

The circuit requires only two wires (coax or twisted pair) to transmit both power and signal. At low impedance, the system is insensitive to external or "triboelectric" cable noise. Cable length does not affect sensitivity.

The following figure shows a simple sensor-WBK18 connection. The voltage developed across R is applied to the gate of the MOSFET. The MOSFET is powered from a constant current source of 4 mA and 30 volts.



The MOSFET circuit will bias at approximately 12 V in the quiet state. As the system is excited, voltage is developed across the crystal and applied to the gate of the MOSFET. This voltage will cause linear variation in the impedance of the MOSFET and a proportional change in bias voltage. This voltage change will be coupled to the WBK18 input amplifier through the capacitor C. The value of R and the internal capacitance of the piezoelectric crystal control the low frequency corner. Units weighing only a few grams can provide high-level outputs up to 1 V/g with response to frequencies below 1 Hz.

Accelerometer Specification Parameters

Noise in Accelerometers

The noise floor or resolution specifies the lowest discernible amplitude (minimum "g") that can be measured. There are two main sources of noise as follows:

- **Noise from the crystal and microcircuit inside the accelerometer.** Some types of crystals, such as quartz, are inherently noisier than others. A good noise floor is 10 to 20 μV .
- **Noise from electrical activity on the mounting surface.** Since the signal from the accelerometer is a voltage, 60 Hz or other voltages (ground loop, etc) can interfere with the signal. The best protection is to electrically isolate the accelerometer.

Sensitivity

The sensitivity of an accelerometer is defined as its output voltage per unit input of motion. The unit of motion used is “g.” One “g” is equal to the gravitational acceleration at the Earth’s surface, which is 32.2 ft/(sec)(sec) or 981 cm/(sec)(sec). The output is usually specified in millivolts per “g” (mV/g).

Sensitivity is usually specified under defined conditions such as frequency, testing levels, and temperature. An example: 100 mV/g at a frequency of 100 Hz, level +1 g, at 72°F. Note that, although a sensor may have a “typical” sensitivity of 100 mV/g, its actual sensitivity could range from 95 to 105 mV/g (when checked under stated conditions). Manufacturers usually provide sensor calibration values.

Transverse Sensitivity - An accelerometer is designed to have one major axis of sensitivity, usually perpendicular to the base and co-linear with its major cylindrical axis. The output caused by the motion perpendicular to the sensing axis is called *transverse sensitivity*. This value varies with angle and frequency and typically is less than 5% of the basic sensitivity.

Base-Strain Sensitivity - An accelerometer’s *base-strain sensitivity* is the output caused by a deformation of the base, due to bending in the mounting structure. In measurements on large structures with low natural frequencies, significant bending may occur. Units with low *base-strain sensitivity* should be selected. Inserting a washer (smaller in diameter than the accelerometer base) under the base reduces contact surface area; and can substantially reduce the effects of base-strain. Note that this technique lowers the usable upper frequency range.

Acoustic Sensitivity - High-level acoustic noise can induce outputs unrelated to vibration input. In general, the effect diminishes as the accelerometer mass increases. Use of a light, foam-rubber boot may reduce this effect.

Frequency Response

An accelerometer’s frequency response is the ratio of the sensitivity measured at frequency (f) to the basic sensitivity measured at 100 Hz. This response is usually obtained at a constant acceleration level, typically 1 g or 10 g. Convention defines the usable range of an accelerometer as the frequency band in which the sensitivity remains within 5% of the basic sensitivity. Measurements can be made outside these limits if corrections are applied. Care should be taken at higher frequencies because mounting conditions greatly affect the frequency range (see *Mounting Effects*, in upcoming text).

Dynamic Range

The dynamic measurement range is the ratio of the maximum signal (for a given distortion level) to the minimum detectable signal (for a given signal-to-noise ratio). The dynamic range is determined by several factors such as sensitivity, bias voltage level, power supply voltage, and noise floor.

Bias Level

Under normal operation, a bias voltage appears from the output signal lead to ground. There are two basic MOSFET configurations commonly used. One exhibits a 7-8 V bias and the second a 9-12 V bias. Operation of the two circuits is identical except for the available signal swing.

Thermal Shock - Temperature Transients

Piezoelectric accelerometers exhibit a transient output that is a function of a temperature’s “rate-of-change.” This “thermal shock” is usually expressed in g/°C and is related to:

- Non-uniform mechanical stresses set up in the accelerometer structure.
- A pyroelectric effect in piezoelectric materials—an electrical charge is produced by the temperature gradient across the crystal.

This quasi-static effect produces a low-frequency voltage input to the MOSFET amplifier. This voltage is usually well below the low-frequency corner, but the effect can reduce the peak clipping level and cause loss of data. This effect does not affect the accelerometer’s basic sensitivity or the data unless the thermal shift in the operation bias level results in clipping. Where drastic thermal shifts are expected, use 12 V bias models. The effect’s severity is related to the mass of the accelerometer. In 100 mV/g industrial units, the effect is usually negligible. Using rubber thermal boots can reduce the effect significantly.

Overload Recovery

Recovery time from clipping due to over-ranging is typically less than 1 ms. Recoveries from quasi-static overloads that generate high DC bias shifts are controlled by the accelerometer input RC time constant that is fixed during manufacture.

Connector

This parameter specifies the connector type and size (4-48, 6-40, 10-32 coaxial etc) and the location on the sensor, that is, top or side (usually on the hex base). Where there is no connector on the sensor, an integral cable is specified with the length and the connector, that is, integral 6-ft to 10-32.

Electrical Grounding

Case-Grounded Design

In case-grounded designs, the common lead on the internal impedance matching electronics is tied to the accelerometer case. The accelerometer base/stud assembly forms the signal common and electrically connects to the shell of the output connector. Case-grounded accelerometers are connected electrically to any conductive surface on which they are mounted. When these units are used, take care to avoid errors due to ground noise.

Isolated-Base Design

To prevent ground noise error many accelerometers have base-isolated design. The outer case/base of the accelerometer is isolated electrically off ground by means of an isolation stud insert. The proprietary material used to form the isolation provides strength and stiffness to preserve high-frequency performance.

Cable Driving

Operation over long cables is a concern with all types of sensors. Concerns involve cost, frequency response, noise, ground loops, and distortion caused by insufficient current available to drive the cable capacitance.

The cost of long cables can be reduced by coupling a short (1 m) adapter cable from the accelerometer to a long low-cost cable like RG-58U or RG-62U with BNC connectors. Since cable failure tends to occur at the accelerometer connection where the vibration is the greatest, only the short adapter cable would need replacement.

Capacitive loading in long cables acts like a low-pass, second-order filter and can attenuate or amplify high-frequency signals depending on the output impedance of the accelerometer electronics. Generally this is not a problem with low-frequency vibration (10 Hz to 2000 Hz). For measurements above 2000 Hz and cables longer than 100 ft, the possibility of high-frequency amplification or attenuation should be considered.

The maximum frequency that can be transmitted over a given length of cable is a function of both the cable capacitance and the ratio of the maximum peak signal voltage to the current available from the constant current source:

Drive Current (mA)	Cable Length @30 pF/ft (Ft)	Frequency Response to 5% of Maximum Output Signal Amplitude	
		± 1 V	± 5 V
4	10	550 kHz	110 kHz
4	100	55 kHz	11 kHz
4	1000	5.5 kHz	1.1 kHz

Where:

f = Maximum frequency in Hz

$K = 3.45 \times 10^9$. K is the scale factor to convert Farads to picoFarads and Amperes to milliAmperes and a factor to allow cable capacitance to charge to 95% of the final charge.

C = Cable capacitance in picoFarads

V = Maximum peak measured voltage from sensor in volts

I_{cc} = Constant current from current source in mA

I_b = Current required to bias the internal electronics, typically 1 mA

$$f = \frac{K}{2\pi C \left(\frac{V}{I_{cc} - I_b} \right)}$$

Fuse Replacement – for WBK18

CAUTION



Turn OFF the power to, and UNPLUG the WBK18 module and all connected equipment. Remove all signal I/O lines from the unit. Electric shock or damage to equipment can result even under low-voltage conditions.



Take ESD precautions, to include using a grounded wrist strap.

Use care to avoid touching board surfaces and onboard components. Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.



You should only replace a fuse if your device shows no sign of damage. If your device appears damaged such as evidenced by a “smoked” component, contact the factory as soon as possible.

If the replacement fuse blows, contact the factory as this indicates a problem may exist with your WBK18 module.

Each WBK18 has one user-replaceable fuse designated as F900.

F900 Input Power Fuse. 4.0 A, MINI ATO.

This 4-amp fuse is located near the rear panel’s 5DIN POWER IN connector. If this fuse has blown the WBK18 module will not power up.

Factory Part Number: **FU-8-4**

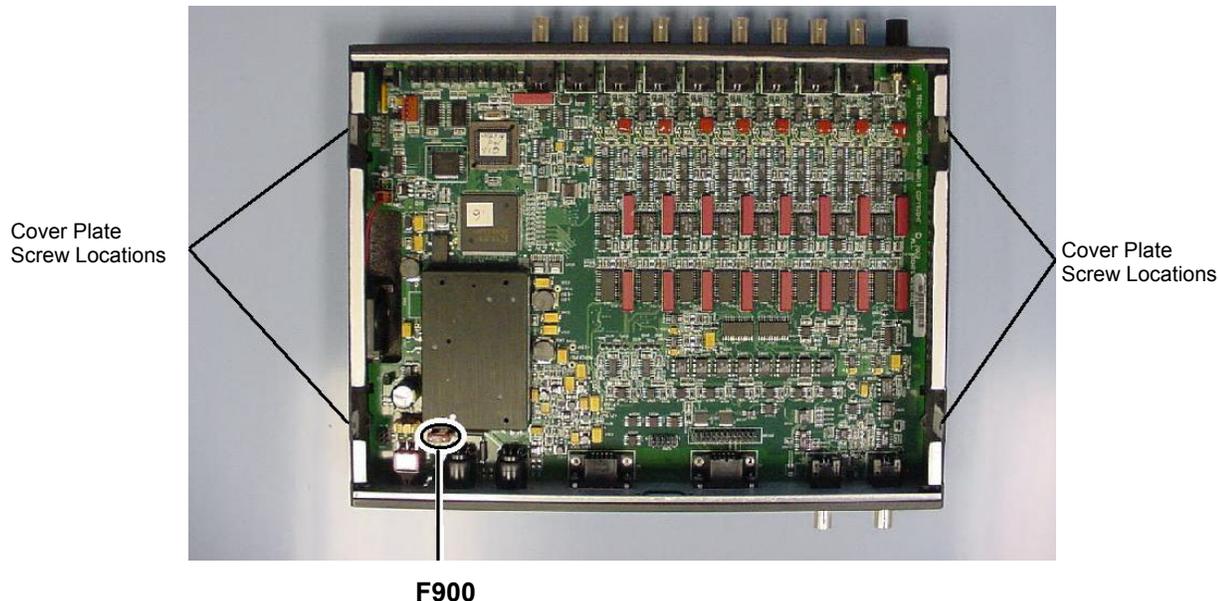
Littelfuse Part Number: **297-004**, Littelfuse Body Color Code: **Pink**

You will need the following:

- Phillips Screwdriver
- 3AG Fuse Puller, or needle-nose pliers*
- Grounding wrist strap and associated anti-static pad
- Replacement fuse F900

* Needle-nose pliers can be used to pull MINI ATO fuses; but should not be used to insert fuses.

1. If you have not already done so, turn OFF the power to, and UNPLUG the WBK18 module and all connected equipment. Remove all signal I/O lines from the unit.
2. Using a Phillips screwdriver, remove the four Cover Plate Screws from the left and right sides of the unit. The following figure points out the screw locations.
3. Remove the Cover Plate [not shown].



F900
F900 Fuse Location in a WBK18 Module

4. Locate the F900 fuse. It is located near the rear panel edge, close to the DIN5 POWER IN connector.
5. While wearing a grounded wrist strap, remove and replace the bad fuse. Ensure that the new fuse is fully seated.
6. Replace the Cover Plate and secure it to the chassis with the 4 screws that were removed in step 2.
7. Return the WBK18 module to normal service. Should any problems be noted, consult the factory.

General

System Connectors: BNC connector, mates with expansion signal input on the WaveBook; female DB15 connector, mates with expansion control signal on the WaveBook.

Input Power Range: 10 to 30 VDC

Input Power Fuse F900: 4A MINI ATO, user replaceable; refer to page 21 for details.

Power Consumption

@ 12V: 1.6A

@ 15V: 1.3A

@ 24V: 0.8A

Environment

Operating: 0° to 50°C; 0 to 95% RH, non-condensing

Storage: 0° to 70°C

Vibration: MIL STD 810E, category 1

Dimensions: 280 mm W x 216 mm D x 42 mm H (11" x 8.5" x 1.65")

Weight: 1.3 kg (2.9 lbs)

Analog Inputs

Channels: 8

Signal Connection: 1 BNC per channel

Input Impedance: 200k Ohm (single-ended)

Input Coupling: AC, DC (software programmable per channel)

High-Pass Filter: 0.1 Hz or 10 Hz (software programmable per channel)

Input Ranges: ±25V (DC coupled only), ±5V, ±2.5V, ±1V, ±500mV, ±250mV, ±100mV, ±50mV, ±25mV (software programmable per channel)

Overrange Detection: Programmable from 1% to 100% of range

Overrange Indication: Front panel LED per channel, software status

Low-Pass Filter (software programmable per channel)

Type: 8-pole Butterworth with simultaneous sample-and-hold (SSH)

Cutoff Frequency (Fc): 10 Hz to 50 kHz in 1-2-5 progression

Alias Rejection: 75dB min

Channel-to-Channel Phase Matching*: 1° typ, 2° max

Unit-to-Unit Phase Matching*: 1° typ, 2° max

SSH latency: 100ns max

Amplitude Accuracy:** ±0.5dB ($F_{in} \leq F_c/2$)

Total Harmonic Distortion: -70dB typ

ICP Bias Source: 4mA, 24V compliance (on/off software programmable per channel)

ICP Fault Detection Thresholds: <1V (short), >25V (open)

ICP Fault Indication: Front panel LED per channel, software status

*** Conditions for Low-Pass Filter Phase-Matching**

8-pole LPF mode, 0.1 Hz or DC HPF mode

$1 \text{ Hz} \leq F_{in} \leq F_c/2$

$200 \text{ Hz} \leq F_c \leq 20 \text{ kHz}$

All WBK18 units connected to same WaveBook

**** Condition for Amplitude Accuracy**

For $F_{in} \leq 20 \text{ kHz}$

Excitation Source

Channels: 1

Signal Connection: BNC

Frequency Range: 1 Hz to 5 kHz

Frequency Resolution: 0.01 Hz

Amplitude Settings (p-p): 10V, 5V, 2V, 1V, 500mV, 200mV, 100mV, 0mV

Waveform Modes: Continuous sine, Sweep sine, Custom sine

Output Impedance: 50 Ohm

Accuracy: ± 0.1 dB

DC Accuracy, Excluding Noise

Applies to 2-Pole and Bypass Filter Modes

Accuracy at 0° to 50°C (32° to 122°F)			
Range	\pm % of Reading		Offset
	Typical	Maximum	
± 25 V	0.5	1	± 15 mV
± 5 V	0.15	0.3	± 3 mV
± 2.5 V	0.15	0.3	± 2 mV
± 1 V	0.15	0.3	± 1 mV
± 500 mV	0.15	0.3	± 1 mV
± 250 mV	0.15	0.3	± 1 mV
± 100 mV	0.15	0.4	± 1 mV
± 50 mV	0.15	0.4	± 1 mV
± 25 mV	0.2	0.4	± 1 mV

These numbers are valid for 1 year after calibration and over the entire operating temperature range of the unit.

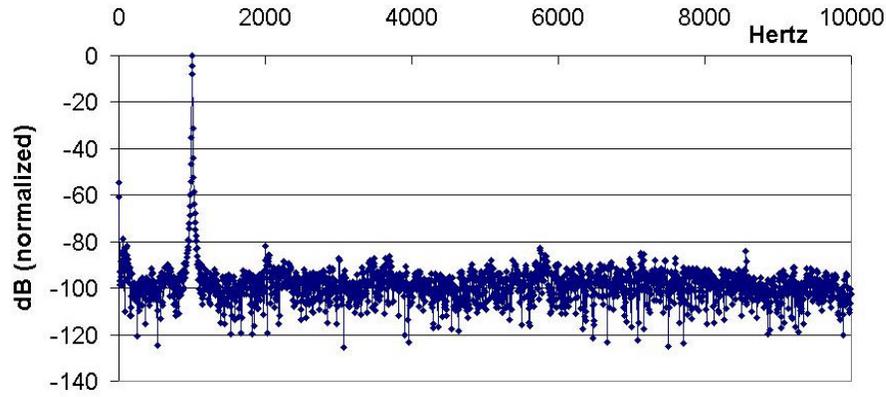
Specifications are continued on following page.

Typical Performance Characteristics

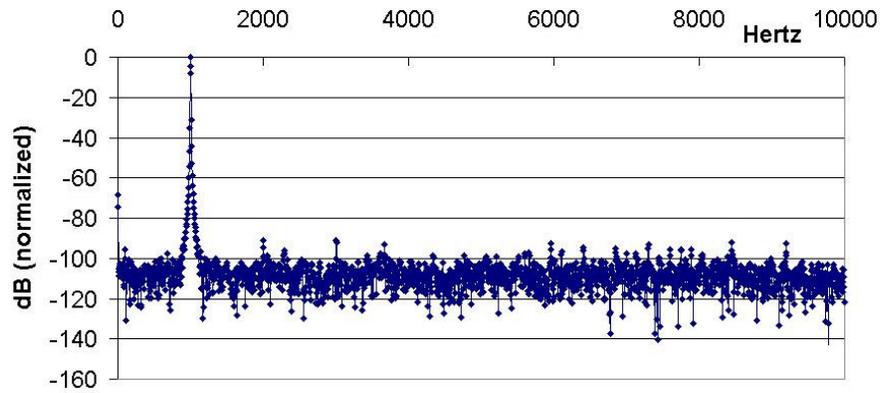
WBK18 Frequency Spectrums (typical)

Each spectrum was taken from a WaveBook/516A that was sampling at 20kSamples/sec, 4096-point FFT, B-H Window.

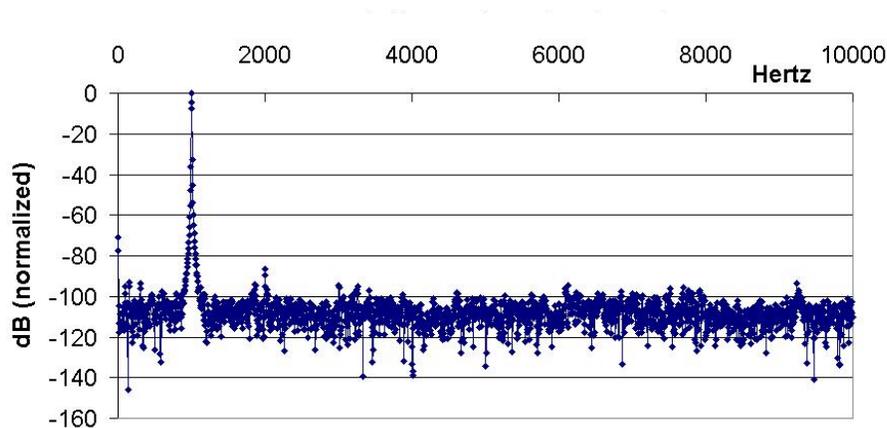
3 Vpp, 1000Hz Sine wave input; $\pm 5V$ range, 10Hz High pass filter, 10 kHz 8-pole Low pass filter.



8 Vpp, 1000Hz Sine wave input; $\pm 5V$ range, 10Hz High pass filter, 10 kHz 2-pole Low pass filter.



8 Vpp, 1000Hz Sine wave input; $\pm 5V$ range, 10Hz High pass filter, 200 kHz Low pass filter (Bypass mode).



For Linking a WaveBook or DaqBook to a Notebook PC



WBK20A Interface Card and Cable



Reference Note:

The WBK20A is shipped with a *WBK20A User's Guide* (p/n 274-0901). Refer to that document for product information and installation instructions.

For Linking a WaveBook to a Desktop PC

WARNING

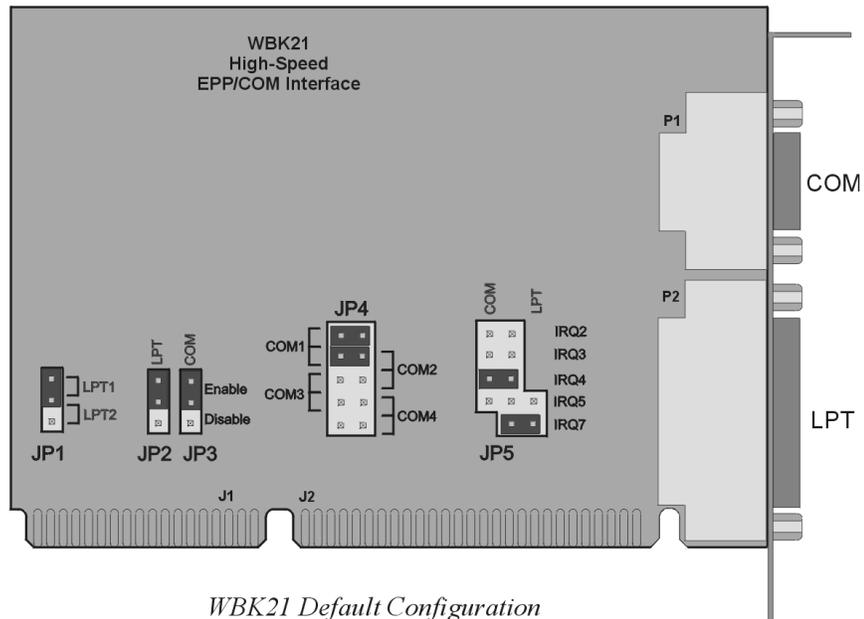


Electrical Shock Hazard! Perform all hardware setups with all power off to the device serviced and to all connected equipment; otherwise, personal injury may result.

WBK21 is used to link WaveBook to a desktop PC. WBK21 contains the following two ports:

- 2.5 Mbyte/second (enhanced parallel port), often referred to as an LPT printer port.
- 16550 type buffered, high-speed, serial port. Often referred to as serial communication, or COM port.

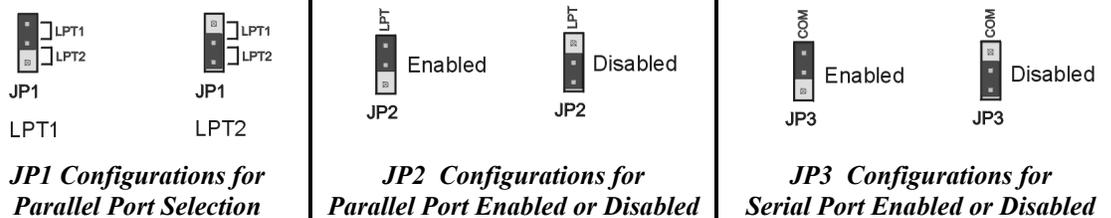
WBK21 installs into an IBM compatible computer using any available 16-bit ISA bus backplane slot. Prior to installing the card, make sure it is configured for your preferences. A discussion of card configuration now follows.



WBK21 Jumper Settings

JP1 WBK21 occupies the I/O address space of one parallel printer port (LPT1, LPT2, or LPT3). The factory default setting (via JP1) is LPT1 (&h378).

If an IBM Monochrome board is not installed, then WBK21 would be designated as LPT1 or LPT2.

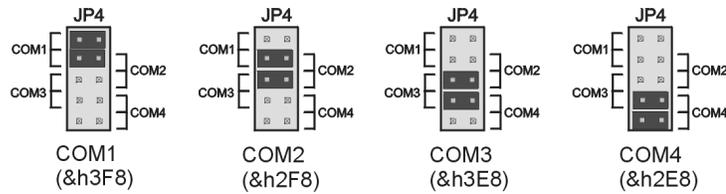


If an IBM Monochrome display board (with an on-board parallel printer port) is installed in your PC, the Monochrome printer port will always be designated LPT1 and have an address designation of &h03BC. Other parallel printer ports (or WBK21s) are then designated as LPT2, or LPT3.

JP2 The JP2 configuration enables (or disables) the parallel port. Enabled is the default.

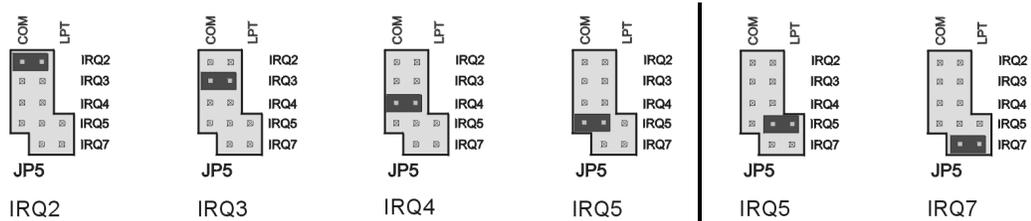
JP3 The JP3 configuration enables (or disables) the serial port. Enabled is the default.

JP4 JP4's configuration determines the serial port (COM port) used. COM1 is the default. The COM port that designates WBK21 depends on two factors: (1) WBK21 configuration, and (2) other installed devices making use of COM ports.



JP4 Configurations for Serial Port Selection

JP5 In reference to the following figure, the top four jumper positions on JP5 select the serial port IRQ level. IRQ4 is the default setting. The bottom two jumper rows select the parallel port IRQ level. IRQ7 is the default parallel port setting. Note that COM and LPT ports cannot both be configured for IRQ5 at the same time.



JP5 Configurations for Serial Port IRQ Level

JP5 Configurations for Parallel Port IRQ Level

After WBK21 is properly configured, power-off your computer and install WBK21 into an available 16-bit ISA bus. Consult your PC user's manual as needed.

After WBK21 has been physically installed, power up your PC.

WBK21 - Specifications

Name/Function: WBK21 ISA/EPP Interface Plug-in Board

Bus Interface: 16-bit ISA-bus interface

Transfer Rate: > 2.5 Mbytes/s

LPT Address: 378 or 278

LPT Interrupts: 5 or 7

Connector: DB25F

Serial-Port: high-speed 16C550 via DB9

Serial-Port Address: 3F8, 2F8, 3E8, or 2E8

Serial-Port Interrupt: 2, 3, 4, or 5

Connector: DB9M

For Linking a WaveBook or DaqBook to a PC

WARNING



Electrical Shock Hazard! Your computer must be unplugged prior to installing a WBK23. Refer to the WBK23 installation instructions, shipped with the device, prior to installation.



Reference Note:

The WBK23 is shipped with separate installation instructions. Refer to that documentation prior to installing a WBK23 plug-in board.



The WBK23 PCI/EPP Interface Plug-In Board

Features

- Provides high-speed data transfer between desktop PCs and WaveBook or DaqBook systems
- Easy jumperless plug-and-play installation
- 100% PCI 2.1 compliant

The WBK23 is a PCI/EPP (Enhanced Parallel Port) interface that enables high-speed data transfer between a WaveBook or DaqBook system and a desktop PC with an available PCI slot. With typical transfer rates of up to 550 Ksamples/s [with a sample size equal to 2 bytes] the WBK23 is up to five times faster than the standard parallel port.

WBK23 is plug-and-play compatible with all versions of Windows[®] operating systems to automatically configure I/O addresses and IRQ's. Because the WBK23 is 100% PCI 2.1 compliant it can share IRQ's with other PCI devices.

The WBK23 is backward compatible with standard 4- and 8-bit (bi-directional) parallel ports. The board can be used with other parallel port devices, including scanners and tape backup systems.

Specifications

Bus Interface: PCI, 2.1 Compliant

Connector: DB25 female

Transfer Rates: 1 Mbyte/s (typical)

LPT Address: Plug-and-play, any PCI I/O address

LPT Interrupts: Plug-and-play

Compliance: FCC & CE marked

Port Standard: IEEE 1284

Operating Temp: 0 to 70°C (32 to 158°F)

Max Humidity: 90% at STP

For Connecting a WaveBook, DaqBook, WBK40, or WBK41 to the Ethernet

- [Features 1](#)
- [Description 2](#)
- [Operational Aspects 3](#)
- [Connecting a WBK25 to the Ethernet 4](#)
- [Fuse Replacement 16](#)
- [Specifications 17](#)
- [Ethernet CE Kit Installation Instructions \(p/n 1077-0901\)](#)



The WBK25 Ethernet-to-Parallel Port Interface

Features

- Provides 10/100BaseT Ethernet connection for up to three WaveBook/512A, /516, /516A, DaqBook/2000A, DaqBook/2000X, WBK40, or WBK41 devices, in any combination
- High-speed performance guarantees continuous data transfer to the PC without data loss

The WBK25 is an Ethernet-to-parallel port interface, which provides high-speed Ethernet connectivity for WaveBook, DaqBook, WBK40, and WBK41 systems. Connection to the Ethernet is made via an Ethernet patch cable, which links the WBK25's 10/100BaseT Ethernet port to a PC's Ethernet jack or an Ethernet network hub.

The WBK25 includes three parallel ports, labeled as expansion ports 1 through 3. Each of these parallel ports can be attached to one of the designated acquisition devices via a parallel cable. The ports cannot be used for auxiliary devices such as printers and scanners.



WBK25's three parallel ports are labeled as expansion ports 1 through 3. They are used to connect to WaveBook, DaqBook, WBK40, and WBK41 systems via parallel cables. The ports cannot be used for other parallel devices, such as printers and scanners.

Description

Front Panel

The left side of the WBK25 front panel will include a **MAC (Media Access Control) Address Label**. The label displays the device serial number in both barcode and base 10 formats. The label also provides the Ethernet address (MAC Address) which is derived from the serial number in hexadecimal. If prompted to enter a serial number in software, use the base 10 number. After doing so, conversion to a hexadecimal number for use in addressing will be automatic.

Note: If your network administrator asks you for a MAC number or a MAC Address, provide him [or her] with the hexadecimal number that is located at the bottom of the label.

Rear Panel

The WBK25 rear panel includes a power switch, DIN5 power in connector, Ethernet port, 5 LEDs (2 of which are on the Ethernet port), and three parallel ports. These items are described below, in order as they appear from left to right.



WBK25, Rear Panel

POWER Switch: A rocker-type switch with a “0” label for Power Off, and a “1” for Power On.

DIN5 POWER IN: +10 to +30 VDC, through a socket type DIN5 connector on the chassis. Power is typically supplied from a TR-40U power adapter.

ETHERNET: The 10/100BaseT Ethernet port can connect to the Ethernet port of the host PC, or to an Ethernet network. Either of two Ethernet patch cables may be used to make the connection. CA-242 is a 1.5-foot long cable. CA-242-7 is a 7-foot long cable. Note that the Ethernet connector has two built in LEDs (Tx and Rx) that indicate traffic flow. These are discussed with the three other Ethernet-related LEDs.



To be CE compliant, the length of the Ethernet cable can not exceed 10m.

LEDs: There are 5 ETHERNET Status LEDs. Two rectangular LEDs (Tx and Rx) are built into the frame of the Ethernet port. The other three LEDs, located just to the right of the Ethernet port, are round and are labeled L, T, and D for Link, BaseT, and Duplex, respectively.

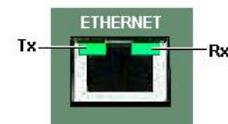
Tx – “ON” indicates traffic is being transmitted (see following figure).

Rx – “ON” indicates that the port is receiving traffic.

L (Link) “ON” indicates a link exists. “OFF” indicates no link.

T (BaseT) “ON” indicates 100BaseTx; “OFF” indicates 10BaseT.

D (Duplex) “ON” indicates full duplex, which allows simultaneous two-way data traffic. “OFF” indicates half-duplex, which only allows one-way data traffic at any given time.



Tx and Rx LEDs

EXPANSION PORTS 1, 2, and 3: The three parallel ports are used to expand the system with up to three additional devices. Each of these ports can be connected to the parallel port of a WaveBook/512A, /516, /516A, DaqBook/2000A, DaqBook/2000X, WBK40, or a WBK41 via a CA-35-2 (2-foot) or a CA-35-12 (1-foot) cable.

Operational Aspects

The WBK25 provides an interface for high-speed Ethernet connectivity. The module contains one 10/100BaseT Ethernet port for connection to a PC's Ethernet jack or to an Ethernet network hub. The WBK25 also includes three parallel ports, which are designated as "expansion ports." Each port can be attached to a to one device, such as a: WaveBook/512A, /516, /516A, DaqBook/2000A, DaqBook/2000X, WBK40, or a WBK41.



WBK25's three parallel ports are labeled as expansion ports 1 through 3. They are used to connect to WaveBook, DaqBook, WBK40, and WBK41 systems via parallel cables. The ports cannot be used for other parallel devices, such as printers and scanners.

Data transfer rates with the WBK25 depend on the network to which it is attached. If the WBK25 is used in a point-to-point configuration, where the WBK25 and the PC are the only devices on the network, then data transfers that exceed 2 Mbytes per second can be expected. The point-to-point scenario is recommended for WaveBook applications where data transfer speeds may be critical.

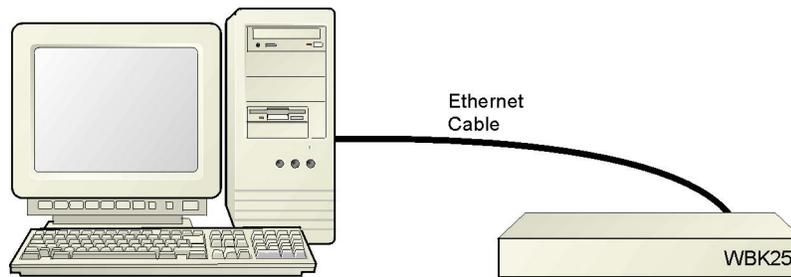
A single WaveBook, attached to a WBK25, can operate at its maximum 1 Msamples/s sampling rate while transferring data continuously to the PC. If the application requires that more than one WaveBook be attached to one WBK25, with each operating at its maximum 1 Mreading/s sampling rate, contact the factory for the latest information on data transfer rates. We will continue to improve the WBK25's data transfer rates as PCs and networks themselves increase in speed. Users will be able to perform the upgrades in the field.

If the WBK25 is used with DaqBook/2000A, DaqBook/2000X, and/or WBK40 series options, then up to three of these devices can be attached to one WBK25 and will be capable of simultaneously transferring data at their maximum sampling rate.

If the WBK25 is attached to a shared Ethernet network the data transfer rates will be dependent on the network traffic at the time. It is not possible to guarantee maximum data transfer rates in this mode. However, the WaveBook offers internal memory option cards (WBK30 series) for applications such as this, so that the acquired data can be locally stored in the event that the shared network traffic prohibits the WaveBook from transferring data at the same rate at which it was acquired.

Note: It is possible to attach multiple WBK25 units to a single PC that has more than one Ethernet port. It is also possible to attach several WBK25 units to a multi-port Ethernet hub. Performance under these conditions will be dependent on the PC's ability to handle multiple networks.

Connecting a WBK25 to the Ethernet



Connecting a WBK25 to the Ethernet

Introduction

The WBK25 connects directly to an Ethernet port on a PC or network hub via the unit's built-in 10/100BaseT Ethernet interface. An Ethernet patch cable CA-242 (1.5 foot) or CA-242-7 (7 foot) cable is used to make the connection.

CAUTION



Turn off power to the system devices and externally connected equipment before connecting cables. Electric shock or damage to equipment can result even under low-voltage conditions.



Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.)



Reference Note: Adobe PDF versions of user manuals will automatically install onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. You can also access documents directly from the data acquisition CD via the <View PDFs> button located on the CD's opening screen.

Minimum System Requirements

PC system with Pentium® Processor
Windows Operating System

RAM, as follows:

- 32 Mbytes of RAM for Windows NT
- 64 Mbytes of RAM for Windows 2000
- 64 Mbytes of RAM for Windows XP



Contact the factory or your service representative in regard to Ethernet connectivity if your operating system is other than Windows NT, Windows 2000, or Windows XP.

STEP 1 – Install the Software

1. Remove previous version Daq drivers, if present. You can do this through Microsoft's *Add/Remove Programs* feature.
2. Place the Data Acquisition CD into the CD-ROM drive. Wait for PC to auto-run the CD. This may take a few moments, depending on your PC. If the CD does not auto-run, use the Desktop's *Start/Run/Browse* feature to locate and run the CD's **setup.exe** file.
3. After the intro-screen appears, follow the screen prompts.

STEP 2 – Determine the type of Network Connection

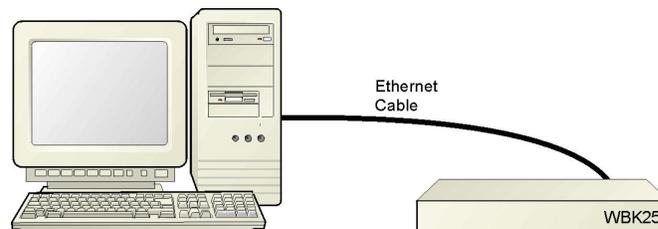
To properly connect a WBK25 you must determine the type of network that it will become part of. This is because the type of network used has a direct bearing on the IP address that will be assigned.

Briefly, the four network types are as follows:

- **Dedicated Network - with a direct cable connection from the PC to the device**
- **Dedicated Network - making use of a network hub or switch**
- **LAN with a DHCP Server**
(Local Area Network with a Dynamic Host Configuration Protocol)
- **LAN with no DHCP Server**
(Local Area Network with no Dynamic Host Configuration Protocol)

Dedicated Network - with a direct cable connection from the PC to the device

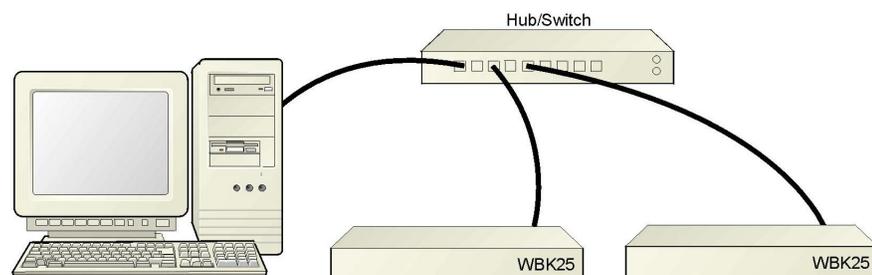
In this scenario the WBK25 is connected directly to an Ethernet jack on a host computer.



Dedicated Network using a Direct Cable Connection

Dedicated Network - making use of a network hub or switch

In this scenario the WBK25 is connected to the Ethernet through a network hub or switch. At least one computer is also connected to the hub.



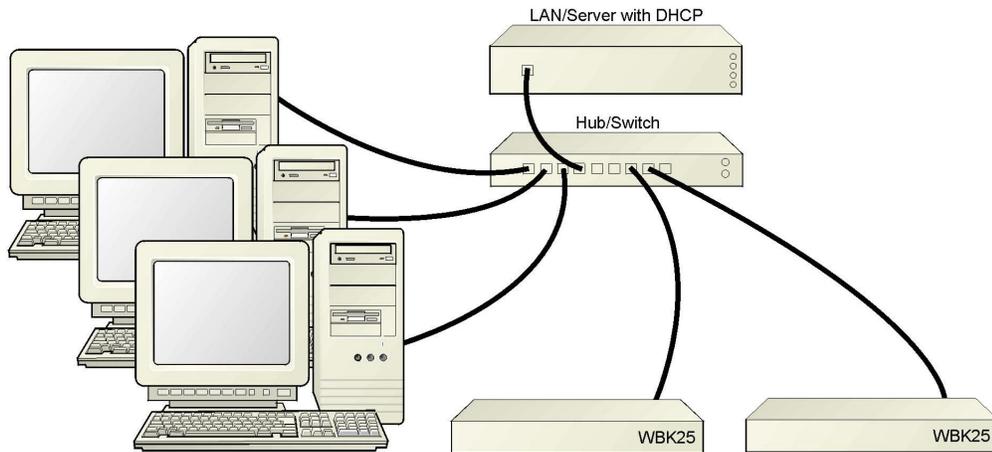
Dedicated Network using a Hub/Switch



Some network devices such as a *wireless access point* may act as a DHCP server. If this is the case, follow the instructions for the LAN with DHCP server. For detailed information consult the documentation that is specific to your network device.

LAN with a DHCP Server (Local Area Network with a Dynamic Host Configuration Protocol)

Many corporations use the LAN/Server with DHCP arrangement for their networks. In this type of setup several computers are typically connected to a network that makes use of a DHCP server. In addition, one or more WBK25 modules are connected to the network hub/switch.



LAN with a DHCP Server

Notes:

- Using the WBK25 on a typical LAN may affect the speed of the network and internet data transfer. Because of this we recommend adding a network card to the computer and using one of the two dedicated network configurations.
- Contact your network administrator before connecting a WBK25 to a corporate network.

LAN with no DHCP Server

(Local Area Network with no Dynamic Host Configuration Protocol)

This scenario looks the same as that shown in the previous illustration, except there is no Dynamic Host Configuration Protocol (DHCP). In this type of setup one or more computers are connected to a network and each computer has a static IP address.

STEP 3 – Connect the WBK25 to the Ethernet



Reference Note:

For examples of system connections, including cable use, refer to the following documents, as applicable:

- For DaqBook/2000 Series systems refer to the section entitled *Examples of System Expansion* in the *DaqBook/2000 Series Installation Guide* (p/n 1103-0940) or the *DaqBook/2000 Series User's Manual* (p/n 1103-0901).
- For WaveBook systems refer to the *System Enhancement and Expansion* section of the *WaveBook User's Manual* (p/n 489-0901).

What you will need to connect a WBK25 to the Ethernet:

- An available connection to the Ethernet. The connection can be either
 - an Ethernet jack on a computer or
 - an Ethernet jack on a hub that is connected to the Ethernet.
- An Ethernet patch cable, e.g., a CA-242 (1.5 foot cable) or a CA-242-7 (7-foot cable).

1. Connect the Ethernet cable to the Ethernet jack on the WBK25.
2. Connect the other end of the Ethernet cable to the Ethernet jack on the host computer or network hub.

STEP 4 – Power-up the WBK25

What you will need:

A power supply with a range of +10 VDC to +30 VDC.
The power supply needs to have a male DIN5 connector.

Note: The switching-mode power supply that is commonly used with these systems has an input range of 100 VAC to 240 VAC at 50 Hz to 60 Hz. The power supply's output [to the device] is typically 15 VDC @ 2.7 amps via a DIN5 connector.

Note: Various AC adapter models support power grids of USA, Europe, Japan, and Asia.

How to make the connection:

1. Place the WBK25's power switch in the "OFF" (0) position, if it is not already OFF.
2. Connect the DIN5 end of the adapter's cable to the power in connector on the WBK25.
3. Connect the adapter's plug to a standard AC outlet.
4. If your adapter has a power switch, position it to "ON."
5. Turn ON the WBK25 by placing the power switch to the "1" position.
The power led will light up.



The power management and power requirements sections of the associated user's manual(s) should be reviewed prior to powering up a system.

- For DaqBook/2000 Series systems refer the *DaqBook/2000 Series User's Manual* (p/n 1103-0901).
- For WaveBook systems refer to the *WaveBook User's Manual* (p/n 489-0901).

The PDF versions of these documents can be accessed from the data acquisition CD via the <View PDFs> button on the CD's opening screen.

STEP 5 - Configure the Computer's Network Settings [Applies to "dedicated networks" only]



If using a LAN (Local Area Network), which has a DHCP server, skip this section and continue with [STEP 7 - Configure and Test the System using the Daq*Configuration Applet](#) (page 12).



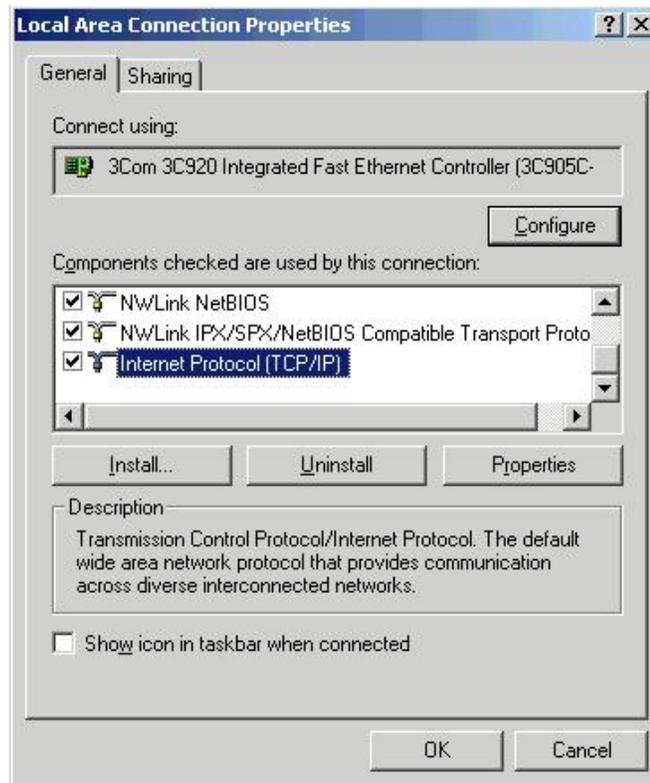
If using a LAN (Local Area Network), which has no DHCP server, skip this section and continue with [STEP 6 - Configure Device Network Settings using DaqIPConfig](#) (page 10).

1. Open the Control Panel by navigating from the Windows Desktop as follows:
Start Menu ⇒ **Settings** ⇒ **Control Panel**.
2. Double-click the "Network and Dial-up Connections" icon.
3. Double-click the "Network Connection" icon for the network that the WBK25 is connected to.



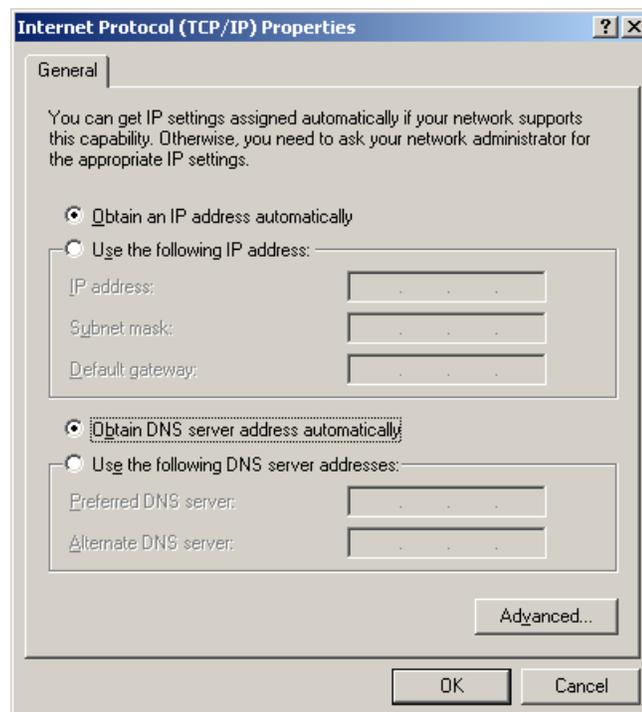
Local Area Connection Status

4. In the "Local Area Connection Status" box (previous figure), click on the <**Properties**> button. The "Local Area Connection Properties" box will appear (following figure).



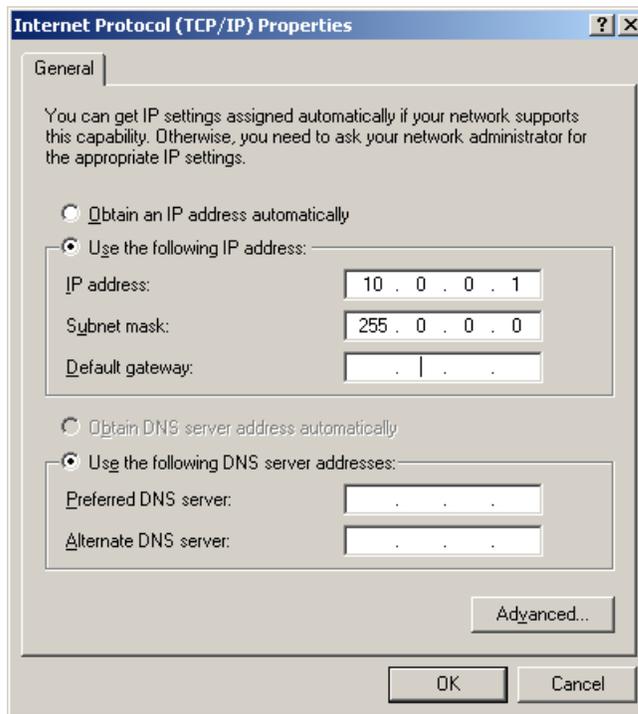
Local Area Connection Properties

5. Double-click the “Internet Protocol (TCP/IP)” component (previous figure). The “Internet Protocol (TCP/IP) Properties” box will appear (following figure).



Internet Protocol (TCP/IP) Properties

Configure the Computer's TCP/IP settings as follows.



Internet Protocol (TCP/IP) Properties

6. Select the “Use the following IP Address” radio button.
7. Set the IP address field to 10.0.0.x where x is some number from 1 to 255.
Make sure that each computer on the dedicated network has a unique IP address.
8. Set the Subnet mask to 255.0.0.0. Note that the remaining fields can be left unchanged.

STEP 6 - Configure Device Network Settings using DaqIPConfig

Applies only to a LAN (Local Area Network), which has a no DHCP server.



If using a LAN (Local Area Network), which has a DHCP server, skip this section and continue with [STEP 7 - Configure and Test the System using the Daq*Configuration Applet](#) (page 12).

The *DaqIPConfig* applet, designed for 32-bit Windows /NT/2000/XP systems. *DaqIPConfig* allows you to change the IP address of a device to match the address of a host computer. The applet is located in the program group for the associated device and can be accessed from the Windows Desktop via the start menu.

1. Locate the DaqIPConfig Applet.

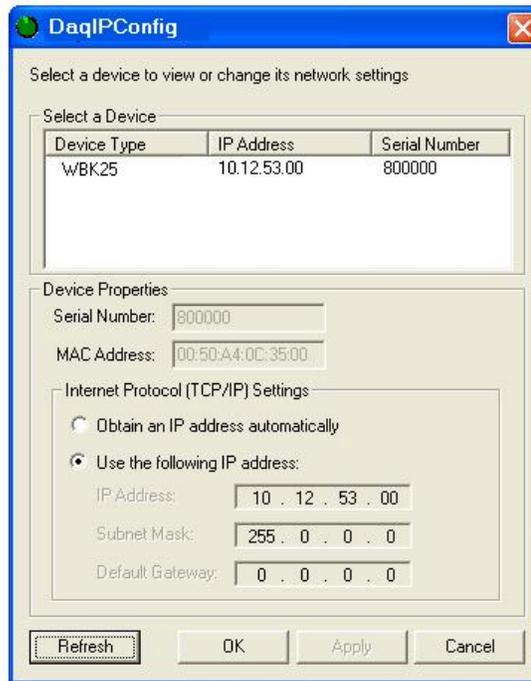
Locate the DaqIPConfig applet by navigating from the Windows' Desktop as follows:

DaqBook Users: Start Menu ⇒ Programs ⇒ IOtech DaqX Software ⇒ DaqIPConfig

WaveBook Users: Start Menu ⇒ Programs ⇒ IOtech WaveBook Software ⇒ DaqIPConfig

2. Open the DaqIPConfig Applet.

Click on the DaqIPConfig selection to open the applet.



DaqIPConfig

3. Select the device that is to have the address change.

Note: In the above figure there is only one device to select, i.e., WBK25.

4. Set the internet protocol (TCP/IP) settings to be compatible with host computer.

- a. Select the radio button labeled “Use the following IP address.”
- b. Enter the new internet protocol settings. If needed, consult your network administrator for acceptable numbers.
- c. Click the <OK> button.

5. Reboot the device.

The new IP address will not take affect until the device has been powered-off, then powered back on.

6. Repeat steps 3, 4, and 5 for other devices in the system.

After configuring the network settings for all devices, proceed to Step 7.

STEP 7 - Configure the System using the Daq* Configuration Applet

The *Daq* Configuration* applet, designed for 32-bit Windows 95/98/Me/NT/2000/XP systems, is located in the *Windows Control Panel*. It allows you to add or remove a device and change configuration settings.

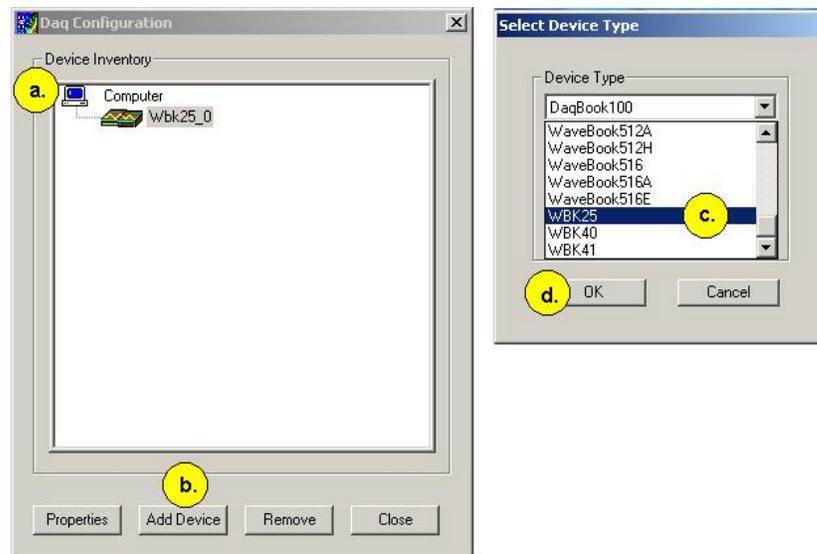
1. Open the *Daq* Configuration Applet*.

- a. Open the Control Panel by navigating from the Windows' Desktop as follows:
Start Menu ⇒ Settings ⇒ Control Panel
- b. From the Control Panel, double-click the *Daq* Configuration* icon.

2. Add the *WBK25* to the list of installed devices.

The first-level device is the device that will be connected directly to the Ethernet, via a host computer's Ethernet jack or a jack on a network hub. The WBK25 is a first-level device.

- a. Select the Computer image in the Device Inventory configuration tree (following figure).
- b. Click the <Add Device> button. The "Select Device Type" box will appear.
- c. Select the WBK25 from the list of devices, as applicable.
- d. Click the <OK> button. The "Properties" box will appear for the selected device.



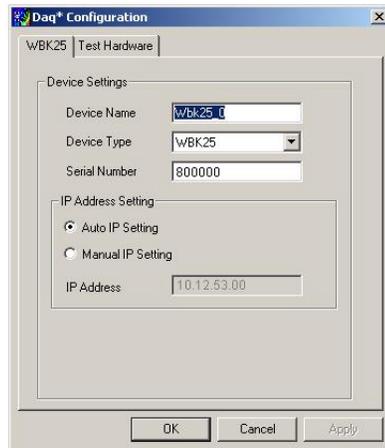
Using Daq Configuration Device Inventory & Select Device Type to Add a Device*

3. Set the properties of the WBK25.

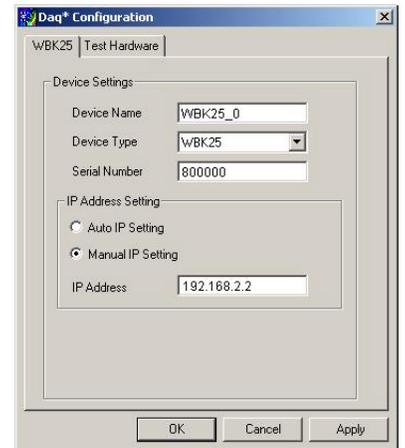
In this step you will set the device properties according to one of the following two methods, depending on whether you have a “Dedicated Network” or a “LAN with DHCP Server Network.” Illustrations of the network types are provided on page 5.

Users of Dedicated Networks follow these 3 steps.

- Enter the **Serial Number** of the first-level device (WBK25). In the following screen shots the Serial Number is 800000.
- Select the “**Auto IP Setting**” radio button. Note that the IP Address of the WBK25 will automatically be calculated and displayed in the IP Address field as indicated in the following left-hand figure.
- Click the <OK> button.



For DEDICATED Networks



For LAN with DHCP Server Networks

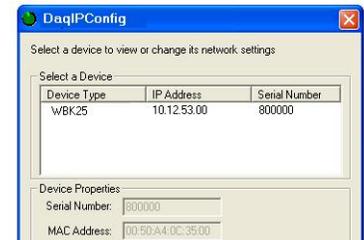
Daq Configuration, Properties Dialog Boxes*

Users of LAN with DHCP Server Networks follow these 4 steps.

The *DaqIPConfig* applet provides the Serial Number and the IP Address of the device. Users of LAN with DHCP Server Networks will need to enter both numbers in the *Daq* Configuration, Properties* dialog boxes (previous right-hand figure). Page 10 includes instructions for accessing *DaqIPConfig*.

If needed, refer to the upper right-hand figure in regard to radio-button and data entry locations.

- Enter the base 10 version of the **Serial Number** of the WBK25.
- Select the “**Manual IP Setting**” radio button.
- In the **IP Address** field, enter the IP address.
- Click the <OK> button.



Partial View of DaqIP Config
Showing IP Addresses & Serial Numbers



Provide your network administrator with the information on the device’s MAC label. Also, find out from the administrator if the IP Address will be changing. If so, see if you can obtain a permanent IP Address dedicated specifically to your device.

4. Test the system connections.

Before testing the system, make sure the device has been properly installed and powered-on. Make sure all cables are properly and securely connected.



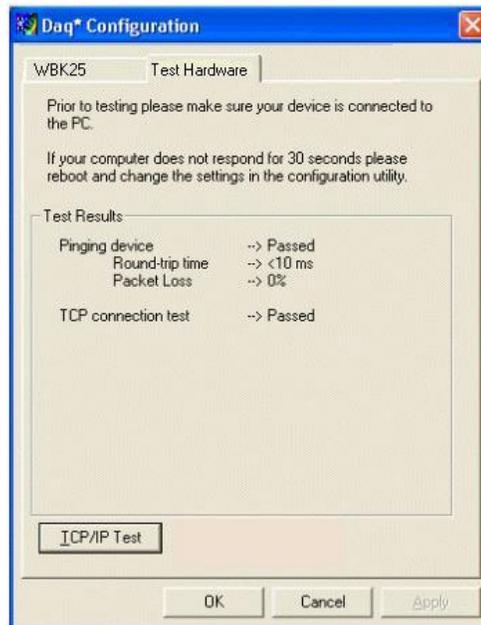
If the unit does not respond within 30 seconds perform the following steps:

- 1) **reboot the system**
- 2) **upon power-up, re-open the *Daq* Configuration* applet**
- 3) **select another configuration setting**
- 4) **reinitiate the test**

How to run the TCP/IP Test (The TCP/IP test is for Ethernet devices only)

The TCP/IP (Transmission Control Protocol/Internet Protocol) test is for Ethernet devices only. The test is accessed and initiated as follows.

- a. Open the Control Panel by navigating from the Windows' Desktop as follows:
Start Menu ⇒ Settings ⇒ Control Panel
- b. From the Control Panel, double-click the *Daq* Configuration* icon.
- c. Select the device that you want to test from the Device Inventory configuration tree.
- d. Click the <**Properties**> button. The Properties dialog box will open.
- e. Click the “**Test Hardware**” tab.
- f. Click the <**TCP/IP Test**> button.



Results of a TCP/IP Test

What does the TCP/IP test tell me?

The TCP/IP test provides test results for “Pinging Device” and “TCP Connection Test.”

Pinging Device. The Pinging Device test is an ICMP (Internet Control Message Protocol) ping test. In addition to indicating either “Passed” or “Failed,” the test displays;

- (a) The round-trip time of the ping, for example, <10 ms.
- (b) Packet Loss expressed as a percent of data lost.

A long ping round trip time, for example, >50 ms and/or any packet loss indicates a slow network that is not optimized.

If the Pinging Device Test *fails* a <Details> button will appear just above the <Resource Test> button. If this is the case, click the <Details> button to obtain possible causes and possible solutions.

TCP (Transmission Control Protocol) Connection Test. The result of the TCP test will be either *passed* or *failed*. If the TCP test *failed* a <Details> button will appear. If this is the case, click the <Details> button to obtain possible causes and possible solutions.

This completes the procedure for connecting a WBK25 to the Ethernet. At this point you should refer to the more detailed user documentation that applies to the other devices that are included in your data acquisition system, e.g., WaveBooks, WBK options, DaqBooks, and DBK options. User manuals typically include pinouts, information on system explanation, data acquisition, and links to software and programming documents (in PDF format).



Reference Notes:

For additional device and system information:

- DaqBook/2000 Series users should refer to the *DaqBook/2000 Series User's Manual*, (p/n 1103-0901) and the *DBK Options Manual* (p/n 457-0905).
- WaveBook and WBK option users should refer to both the *WaveBook User's Manual*, (p/n 489-0901) and the *WBK Options Manual* (p/n 489-0902).
- Programming information is contained in the *Programmer's Manual*, (p/n 1008-0901).

Note: You can access PDF documents directly from the opening screen of the data acquisition CD via the <View PDFs> button.

Fuse Replacement

CAUTION



Turn OFF the power to, and UNPLUG the WBK25 Ethernet Interface Module and all connected equipment. Electric shock or damage to equipment can result even under low-voltage conditions.



Take ESD precautions, to include using a grounded wrist strap.

Use care to avoid touching board surfaces and onboard components. Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.



You should only replace a fuse if your device shows no sign of damage. If your device appears damaged, such as evidenced by a “smoked” component, contact the factory as soon as possible.

If the replacement fuse blows contact the factory as this indicates a problem may exist with your WBK25 module.

Each WBK25 Ethernet Interface Module has one user-replaceable fuse designated as F201.

F201 Input Power Fuse. 4.0 A, MINI ATO.

This 4-amp fuse is located near the rear panel’s 5DIN POWER IN connector.

If this fuse has blown, the WBK25 module will not power up.

Factory Part Number: **FU-8-4**

Littelfuse Part Number: **297-004**, Littelfuse Body Color Code: **Pink**

You will need the following:

- Phillips Screwdriver
- 3AG Fuse Puller, or needle-nose pliers*
- Grounding wrist strap and associated anti-static pad
- Replacement fuse F201

* Needle-nose pliers can be used to pull MINI ATO fuses; but should not be used to insert fuses.

1. If you have not already done so, turn OFF the power to, and UNPLUG the WBK25 module and all connected equipment. Remove all lines from the unit.
2. Using a Phillips screwdriver, remove the 4 cover plate screws and the cover plate (not shown).



WBK25, Fuse and Cover Plate Screw Locations

3. Locate fuse F201 near the Power In DIN 5 Connector (left edge of the rear panel, see figure).
4. While wearing a grounded wrist strap, remove and replace the bad fuse. Ensure that the new fuse is fully seated.
5. Replace the cover plate and secure it to the chassis with the 4 screws that were removed in step 2.
6. Return the WBK25 Ethernet Interface Module to normal service. Should any problems be noted consult the factory.

Specifications

Environment

Operating: 0 to 50°C (32° to 122°F); 0 to 95% humidity, non-condensing

Storage: -20° to 70°C (-4° to 158°F)

Power: 0.75A @ 15V

Fuse: F201 Input Power Fuse. 4.0 A, MINI ATO. Factory Part Number: FU-8-4

Littelfuse Part Number: 297-004, Littelfuse Body Color Code: Pink

Dimensions: 285 mm W x 220 mm D x 35 mm H (11" x 8.5" x 1.375")

Ethernet Interface: 10/100BaseT

Ethernet Connector: RJ45

Parallel Interface: Three EPP (Enhanced Parallel Ports)

Parallel Connectors: DB25, female

Accessories & Cables

	Part No.
Fastener-panel kit for WBK series	262-0801
Fastener-panel kit for DBK series	232-0810
Fastener-panel handle	HA-111
DB25 male to DB25 female parallel cable, 2 ft.	CA-35-2
DB25 male to DB25 female parallel cable, 1 ft.	CA-35-12
Ethernet patch cable, 1.5 ft.	CA-242
Ethernet patch cable, 7 ft.	CA-242-7

Note: WBK25 is supported in the 32-bit driver only.

Introduction

The Ethernet CE Kit includes three ferrite clamp-on inductive collars to reduce EMI. It also includes a ground-line for safety. The kit is simple to install and consists of the following components.

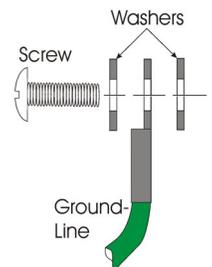
- **3 Ferrite Inductive Collars with Tie-wrap**, p/n L-8-1
- **1 Ground-Line**, p/n CA-250
- **4 Washers**, #8 External Tooth, p/n WA-5 – used to lock screws (2 washers per screw)
- **1 Screw, #8-32x1/4** Phillips Pan-head, p/n HA-154-4 – used to secure the ground-line to a threaded splice-plate hole on the data acquisition device
- **1 Screw, #6-32x5/16** Phillips Pan-head, p/n HA-2-5 – used to secure the ground-line to the PC

Connect the Ground Line

1. *If using a desktop or tower PC*, (a) remove a screw that secures the computer casing to the chassis. The first photo shows a good connection point for the PC ground. (b) Use the #6-32x5/16 screw and two #8 tooth washers, orientated as illustrated, to secure one end of the ground line to the PC chassis.

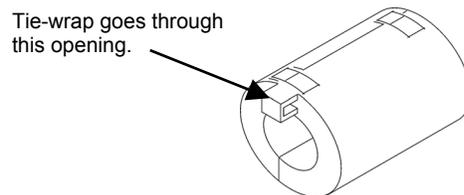
If using a notebook (laptop) PC, connect one end of the ground-line to a known earth ground. Depending on the ground chosen, you may need to use a screw other than the one supplied.

2. On the data acquisition device, locate an available threaded splice-plate hole. This will be used for attaching the ground line to the device, as indicated in the second photo.
3. Use the #8-32x1/4 screw and two #8 tooth washers, orientated as illustrated, to secure the free end of the ground line to the chassis of the data acquisition device. The second photo shows such a connection.



Install the Ferrite Inductive Collars

1. Place one ferrite collar at each end of the Ethernet cable. Snap the two collars shut. See photos.
2. Place the remaining ferrite collar next to the DIN5 connector on the power cable. Snap the collar shut.
3. Use a tie-wrap (one per ferrite collar) to secure each collar to its respective cable.



4. (Optional) Trim the excess tie-wrap material. While trimming use care to avoid cutting into the cables.

This completes the installation.



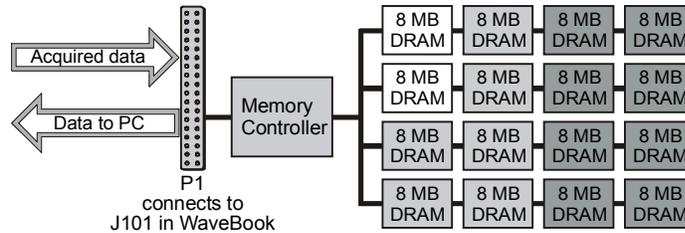
This partial view of the host PC shows the Ethernet cable with a ferrite collar. The PC's connection to the ground-line is also visible.



This partial view of the data acquisition device shows its connection to the ground-line. It also shows two ferrite collars, the foremost of which is clamped to the power cable. The background collar is clamped onto the Ethernet cable.

Note! **Important Notice for WaveBook/516E Users!**
 For the WaveBook/516E, WBK30 option cards are only to be installed or removed at the factory. If you desire to remove or add a card to WaveBook/516E, contact the factory or your service representative.

Description



WBK30 Block Diagram

The WBK30 is a DRAM-based memory board that installs inside a WaveBook. There are three models of WBK30 available; each significantly increases the capacity of WaveBook's standard data buffer of 64 K samples. Capacities are as follows:

- WBK30/16—16 MB
- WBK30/64—64 MB
- WBK30/128—128 MB

Benefits of using the larger and enhanced data buffer include:

- The WBK30 Pre-Trigger Mode compensates for a slow connection, slow disk-drive, or limited memory in the host PC. In addition, there is a reduction of the host computer's CPU load during pre-trigger acquisition. This reduction is obtained by internal buffer management.
- The WBK30 Overflow Protection mode prevents data loss when an acquisition is stopped (deliberately, or due to buffer overflow). On disarm, data in WBK30 is preserved and transferred to the PC.



Data acquired from a WaveBook flows as fast as possible from the WaveBook to the host PC. When a WBK30 is installed, and you have selected high acquisition rates (relative to the transfer rate), then some delay in "real-time" viewing may occur.

Hardware Setup

CAUTION



Turn power off to all connected devices before performing the setup.
 To avoid pin damage, make sure the WBK30 card is aligned correctly with the mating connector (J101) prior to pressing in place.

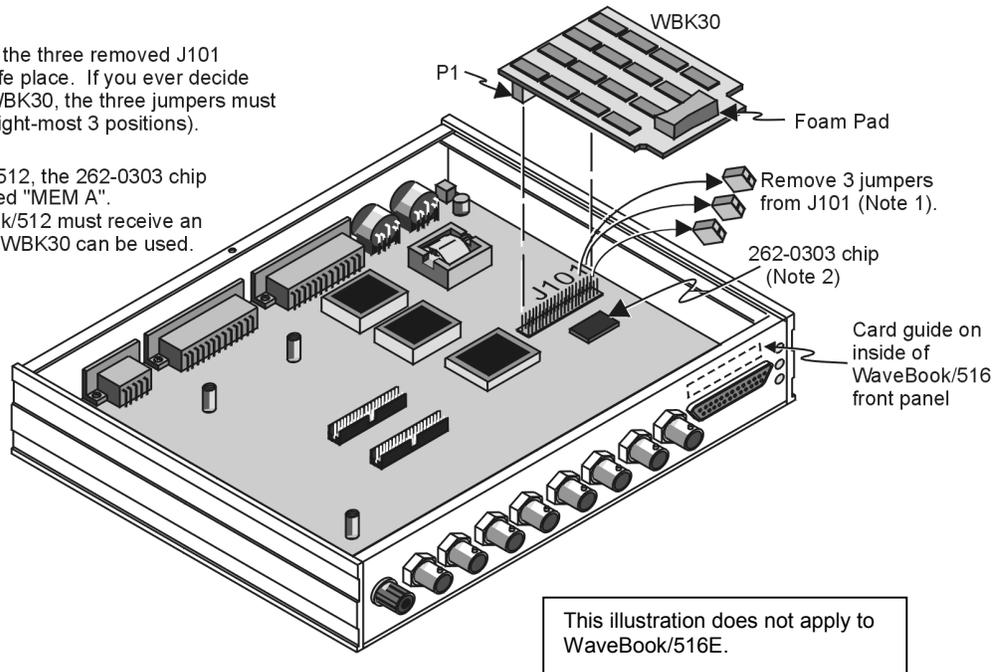
CAUTION



Components are sensitive to damage from electrostatic discharge. Perform the setup in a static-free work area using tools, wrist strap, containers, and procedures that are ESD-safe.

Note 1: Be sure to keep the three removed J101 jumpers in a safe place. If you ever decide to remove the WBK30, the three jumpers must be installed (in right-most 3 positions).

Note 2: For WaveBook/512, the 262-0303 chip must be stamped "MEM A". If not, WaveBook/512 must receive an upgrade before WBK30 can be used.



With exception of the WaveBook/516E, for which the WBK30 option must be factory installed if the option is selected, use the following steps to install WBK30 into a WaveBook. WaveBook/516E users will need to consult the factory should a WBK30 need added or removed.

1. Turn off all system power, and unplug the power adapter from the WaveBook.
2. Remove the WaveBook's top cover plate.
3. **WaveBook/512 users only.** Verify compatibility. WBK30 is compatible with all *upgraded* WaveBook/512s. To determine WaveBook/512 compatibility, locate p/n 262-0303 (the FPGA IC) on the WaveBook's motherboard (see figure).



For WaveBook/512 users only, if the 262-0303 chip lacks a "MEM A" stamp, then the WaveBook/512 is not compatible with the WBK30 memory option.

WaveBook/512s with the following serial numbers are not compatible:
148010 and below, 148253, 149322, 150411-150413, 150415, 150418, 151597, 153335.

If a compatibility issue exists, you can contact the factory to arrange upgrading your WaveBook/512.

Note that **after a WaveBook/512 is modified for WBK30, it must have a WBK30 to work properly,** as the internal FIFO is no longer available.

4. Remove the three jumpers from the WaveBook's 40-pin connector (J101).
5. Align WBK30 so its P1 connector is directly over J101. [*In a WaveBook/516*, before pressing the connectors together, slip the opposite end of WBK30 into the plastic card guide above the D-sub connector on the front panel.] Gently press the connectors together, while being careful to avoid pin damage.

Note: In WaveBook/512, the foam pad braces the WBK30 against the top cover plate.

6. Replace and secure the cover plate.
7. Power up the system.

Software Setup

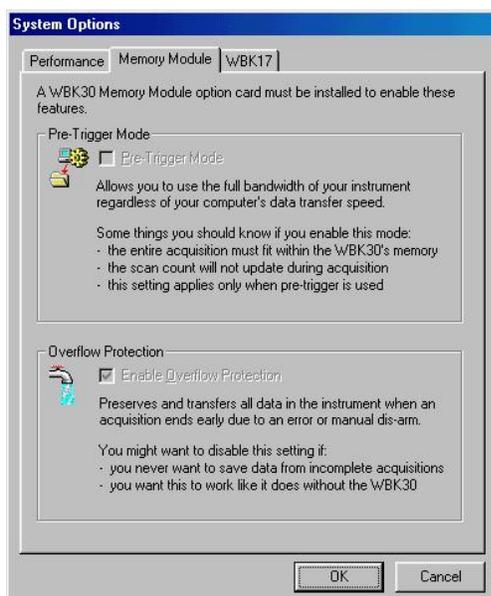


Reference Note:

Refer to the *WaveView Document Module* for detailed information regarding WaveBook's *out-of-the-box* data acquisition software. If you intend to write your own applications programs refer to the *WaveBook Programmer's Manual* (1008-0901). Both documents can be viewed directly from your data acquisition CD by using the <View PDFs> button located on the CD's opening screen.

WaveView

WBK30 is supported by WaveView versions 7.2 and higher. Check-boxes in WaveView's *Memory Module Tab* allow you to enable or disable the Pre-Trigger and/or Overflow Protection modes. You can access the Memory Module Tab as described below. Note that both modes will be enabled by default when WaveView first detects the presence of a WBK30.



Memory Module Tab

To access the Memory Module Tab from WaveView's main window, make the following selections:

- 1) System pull-down menu
- 2) Options
- 3) Memory Module

Enable WBK30 Pre-Trigger Mode— causes WaveView to use the Pre-Trigger Mode for high-speed pre-trigger acquisitions. *Pre-trigger Mode* allows local buffering of pre-trigger acquisitions. WBK30 manages finite-length acquisitions entirely within its own buffer (instead of using the host PC's resources). During the acquisition, the WaveBook begins acquiring data in advance of the trigger. When the trigger occurs, a specified amount of the most recent "pre-trigger" data is preserved. The "post-trigger" data is then collected as specified. Together, pre-trigger data and post-trigger data comprise the entire acquisition.

Without a WBK30, pre-trigger sample rates are limited by the transfer rate and pre-trigger data (including any to be discarded) must be transferred into the PC's memory.

With WBK30, you can choose to buffer all data in the WBK30, until the acquisition is complete. Then, the PC (at its own speed) reads the entire, correct acquisition. When in the pre-trigger mode, WBK30 must have the capacity to hold all pre-trigger *and* post-trigger data.

Note: When using WBK30's pre-trigger mode, the actual number of pre-trigger scans acquired may be up to three scans less than the pre-trigger scan count programmed in the acquisition configuration dialog box.

Enable Overflow Protection Mode— causes WaveView to use Overflow Protection for all acquisitions. Usually, when buffer overflow occurs, the acquisition stops and all data in the FIFO is purged. *Overflow Protection* forces WaveBook to transfer all data that existed up to the time of the overflow. Note that data is preserved if you cancel a transfer by selecting the STOP button in either the Scope or Direct-to-Disk window.

Note: Disable the Overflow Protection Mode if you do not want data from a stopped acquisition.

DaqX Programming of WBK30

Programmers wanting to create their own programs should refer to the separate *Programmer's Manual* (p/n 1008-0901). Note that only DaqX version API (versions 2.4 and higher) supports WBK30. The older *wbk-prefixed* commands cannot address the WBK30.

WBK30 – Specifications

Name/Function: WaveBook Memory Option / expands internal data FIFO from 64 Ksamples to 8-64 Msamples

Memory Capacity (M = 1,000,000)			
Part Number	WBK30/16	WBK30/64	WBK30/128
Bytes	16.7 M	67.1 M	134.2 M
Samples	8.3 M	33.5 M	67.1 M
Packed Samples	11.1 M	44.7 M	89.4 M

Maximum Acquisition Length:

Pre-Trigger Acquisitions: Same as memory capacity

Post-Trigger Acquisitions: Depends on PC transfer rate, acquisition rate (both in samples per second), and capacity as follows:

Maximum Acquisition Length = $T \times \text{acquisition rate}$

Where: $T = \text{Time-to-overflow} = \text{Capacity} / (\text{acquisition rate} - \text{transfer rate})$

Example:

Acquiring 500 K unpacked samples per second with a WBK30/16 and a PC capable of transferring 200 Ksamples/second, overflow will occur in: $T = 8.3M / (500K - 200K) = 27.6$ seconds, thus: Acquisition Length = 27.6 seconds \times 500K = 13.8 million samples

Pre-Trigger Mode: Allows indefinite pre-trigger duration, regardless of PC resources and transfer rate.

Environmental: 0°C to 70°C (compatible with WaveBook internal environment).

User Installation: Requires main board modification for Wavebook/512 shipped before July 1998. Plug-in compatible with Wavebook/512 shipped after July 1998.

Mechanical Mounting: Friction fit with 40-pin header. Fit with foam rubber spacers in Wavebook/512.

Power: 300 mA maximum (200 mA typical) at 5 V

Dimensions: 2.6 x 4.1 inches.

WBK30 – Frequently Asked Questions

Question: How does the addition of the WBK30 memory module affect the operation of a WaveBook?

Answer: The WBK30 memory option plugs into the WaveBook and expands the standard 64K of FIFO memory up to 128 megabytes of RAM. By increasing the FIFO size, a user can sample at higher speeds for a longer period of time before encountering a buffer overflow due to limitations in computer resources such as parallel port speed, memory allocation, hard disk size, or processor speed. Otherwise, the operation of the WaveBook is unaffected.

Question: Do I need to upgrade my WaveBook before installing a WBK30 memory option?

Answer: It depends. WaveBooks shipped before June 1998 do require a hardware upgrade before a WBK30 can be installed. Any unit shipped after the June 1988 date is WBK30-ready. WaveBooks with the following serial numbers will need an upgrade before a WBK30 can be properly installed: 148010 and under, and 148253, 149322, 150411, 150412, 150413, 150415, 150418, 151597, 153335

Question: Is there any down side to the upgrade for the WBK30 install?

Answer: Once the unit has been upgraded it can not be returned to using the internal 64K FIFO; i.e., a WBK30 card must remain in the unit. Note that this is not true for units that did not need an upgrade. In the later case, the user can remove the WBK30 and revert back to the internal FIFO.

Question: Do either the 16-bit driver or the 16-bit versions of WaveView support the WBK30 memory option?

Answer: No. The WBK30 is not available through the 16 bit driver or the 16 bit version of WaveView. The 32-bit driver, version 2.4 or high supports the WBK30, along with WaveView versions 7.2 and higher. Like other enhancements, the latest WaveView version is available from our web site.

Question: What is the WBK30's impact on existing software?

Answer: For many applications, adding a WBK30 to the system will not require any changes to existing software. The WBK30 is essentially a deeper FIFO. When it is added to a WaveBook, the software will function identically to the standard FIFO, *except* that the time to buffer overflow will be greater. Refer to program examples if detailed information is needed.

Question: When using a WBK30, how do I calculate the length of the acquisition?

Answer: Before we answer, consider the following analogy: the WBK30 can be thought of as a water bucket with a hole in it. You fill the bucket at one rate and empty it at another. The time to fill the bucket is determined by the size of the bucket and difference between these two rates.

Calculating the maximum acquisition length.

This calculation can be broken down into three steps:

Step 1: Determine how long it will take to fill the memory. The following equation is used.

$$T = \text{Capacity} / (\text{RateA} - \text{RateB})$$

Where: T = Time to fill the memory
Capacity = Memory Capacity
RateA = acquisition rate
RateB = transfer rate

The time-to-full memory is simply the memory capacity divided by the difference in rate of filling and emptying. This value (T) is used in step 2.

Step 2: Determine how much data transfers before the memory is full.

$$\text{Data Transferred} = T * \text{Transfer Speed}$$

The “Data Transferred” value will be used in step three.

Step 3: Determine the acquisition length. This is a combination of the data transferred plus the data still in the full memory that is waiting to be transferred. The equation is:

$$\text{Maximum Acquisition Length} = \text{Data transferred} + \text{Memory Capacity.}$$

Example: You need to acquire 10 Msamples of data at 500K samples / second and are considering a WBK30/16 because your PC is only capable of transferring 200Ksamples / sec. How much data could you stream to disk before the memory is full and data collection stops? Is the WBK30/16 adequate?

WBK30/16 holds approximately 8.3 Msamples of data so

[Step 1] Determine how long it will take to fill the memory. In this example:

$$T = \text{Capacity} / (\text{RateA} - \text{RateB})$$
$$T = 8.3\text{M} / (500\text{K} - 200\text{K}) = 27.6 \text{ seconds}$$

[Step 2] Determine how much data will be transferred before the memory is full.

$$\text{Data Transferred} = T * \text{Transfer Speed}$$
$$\text{Data Transferred} = 27.6 \text{ secs} * 200\text{K} = 5.52\text{M}$$

[Step 3] Determine the acquisition length.

$$\text{Maximum Acquisition Length} = \text{Data transferred} + \text{Memory Capacity.}$$
$$\text{Maximum Acquisition Length} = 5.52\text{M} + 8.3\text{M} = 13.82 \text{ Msamples}$$

Since you needed to acquire 10 Msamples and our Maximum Acquisition Length with the WBK30/16 calculated out to be 13.82 Msamples the WBK30/16 is seen to be sufficient.

Note that this example does not take into account the data packing capabilities of the WaveBook/512. With data packing, acquisition lengths would be 25% greater.

For use with WaveBook/516E and WBK25

Overview 1

- What are WBK40 and WBK41? 1
- Front Panel Connectors 2
- Rear Panel Connectors 4

Setup 5

- Hardware Setup 5
- Software Setup 14

Operational Aspects 14

- Block Diagrams 14
- Thermocouple Measurements 15
- Digital I/O, *WBK41 Only* 16
- Synchronous Input Operations 16
- Output Channel Configuration 17
- Asynchronous I/O Operations 18
- Analog Outputs, *WBK41 Only (DBK46 Required)* 19

Using a Temperature Calibrator 20

CE Compliance 21

Fuse Replacement 23

P1 - DB37 Connector Pinout 26

P2 - DB37 Connector Pinout (*WBK41 Only*) 27

Specifications 28

[WBK40 & WBK41 Installation Guide](#) (p/n 1066-0901)



WBK40
14 Channel Thermocouple Input Module,
Front & Rear Views



WBK41
Multi-Function Thermocouple I/O Module,
Front & Rear Views

Overview

What are WBK40 and WBK41?

The WBK40 is a 14-Channel Thermocouple Input Module. The WBK41 is a Multi-Functional I/O Module. The latter includes the thermocouple functionality of the WBK40 and additional features, as will be discussed shortly. Both the WBK40 and WBK41 attach to any one of the three DB25 parallel expansion ports on a WaveBook/516E or WBK25. Because the modules each have a built-in 16 bit, 200-kHz A/D converter, measurements do not consume valuable sampling time from the host WaveBook's 1-MHz A/D converter. For this reason, there are no speed implications to WaveBook [or other WBK] measurements when a WBK40 or a WBK41 is attached. Measurements can be made synchronous with the WaveBook/516E, providing precise time correlation between readings from both measurement devices.

Features common to WBK40 and WBK41

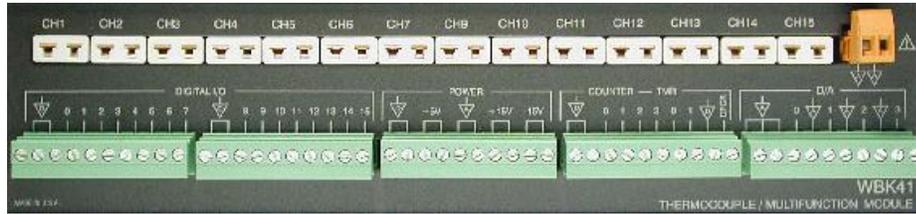
- Provides a means of adding from 14 to 224 thermocouple inputs to the WaveBook/516E or WBK25
- Provides linearized and cold-junction compensated readings for all thermocouple types
- Exhibits 1.0°C [or better] accuracy for most ranges and TC types
- Consumes no measurement bandwidth from the WaveBook/516E
- Detects open thermocouples

Additional features of the WBK41

- 16 Digital I/O Lines (via front panel screw-terminal blocks)
- 24 Digital I/O Lines (via a rear panel 37-pin connector, P2)
- 4 Counter Inputs (via front panel screw-terminal blocks)
- 2 Timer Outputs (via front panel screw-terminal blocks)
- 4 Channel, 16-bit, 100 kHz Analog Output (via front panel screw-terminal blocks; but *only* when a factory-installed DBK46 option is in place)

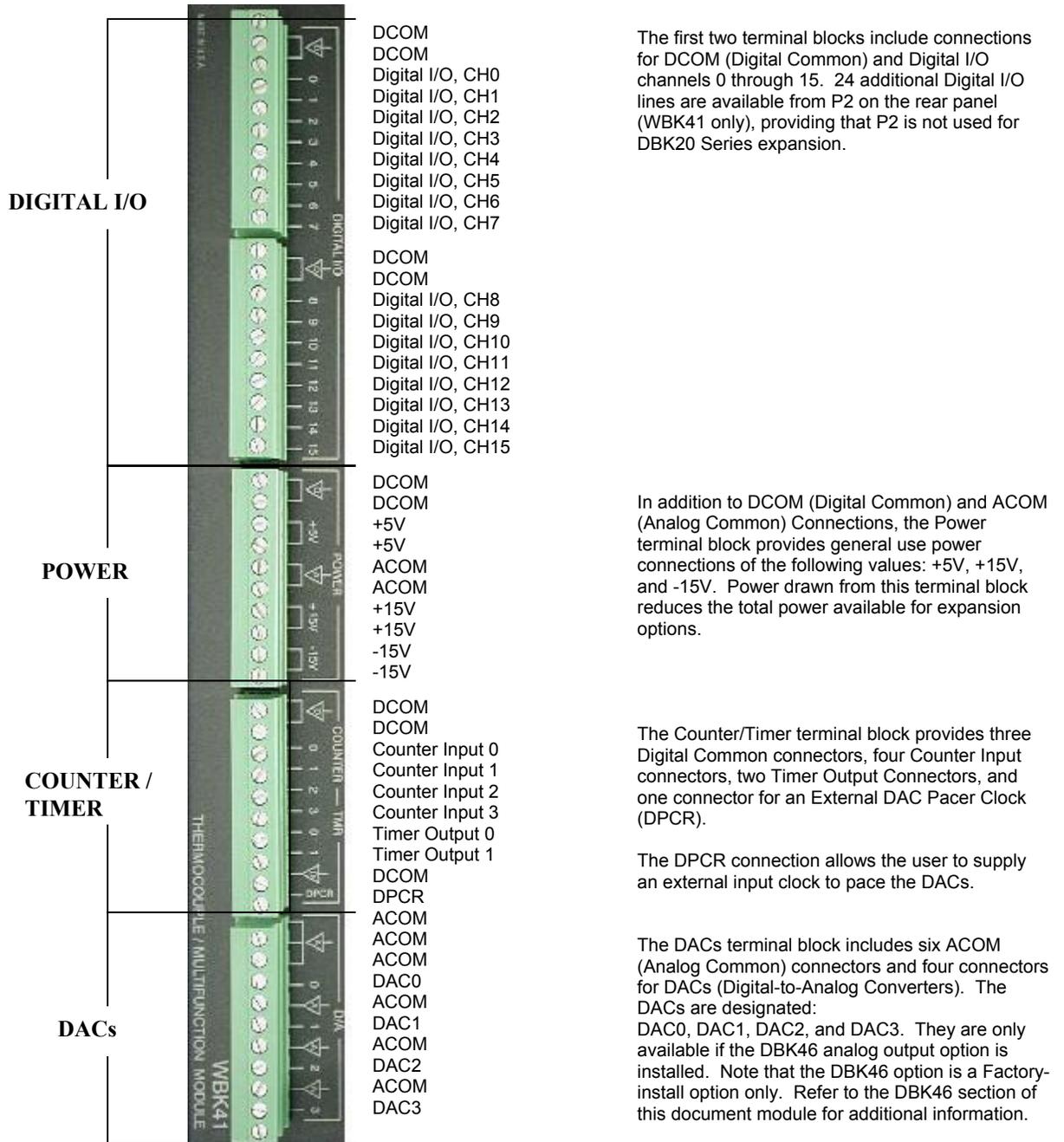
Front Panel Connectors

WBK41 Front Panel



WBK41, Front Panel Connectors

Note that the WBK40's Front Panel is identical, except it has no Screw-Terminal Blocks (see pg. 3).



WBK40 Front Panel



WBK40 Front Panel Connectors

The Mini-TC and Analog Common Connectors exist on both the WBK40 and WBK41 Modules.

Item	Description (Applies to both WBK40 and WBK41)
CH1 through CH15 Mini-TC Connectors	This row contains 14 mini-TC connectors. These are for connecting thermocouples to channels 1 through 7 and to channels 9 through 15. Channels 0 and 8 have no mini-TC connectors, as these two channels are used for cold-junction compensation (CJC).
Analog Common 	Analog Common. This is a dual-pin receptacle located next to the Channel 15 TC connector. A typical use of the ACOM connection would be to attach the shield of a shielded thermocouple. If a thermocouple shield is connected to a WBK40 [or WBK41] module, leave the shield unconnected at the other end of the thermocouple to avoid a ground loop.

The modules' built-in TC channels are accessed via mini-TC connectors on the front panel. This is true for both the WBK40 and the WBK41. The 14 built-in TC channels can accept any type of thermocouple, including types J, K, S, T, E, B, R, and N. The units can be expanded in 14-channel increments using DBK84 TC expansion modules. A total of 15 DBK84s can be attached to one WBK40 [or WBK41], for a total TC channel capacity of 224 channels.



If more than eight DBK84 modules are to be connected to one WBK40 [or WBK41], additional power must be supplied. The power can be obtained from DBK32A or DBK33 Auxiliary Power Supply Cards, housed within a DBK10 expansion chassis.

WBK41's Counter/Timer functions and 16 bits of Digital I/O are accessed via removable front panel screw-terminal connectors (see previous figure). Additional Digital I/O and expansion connectors are located at the rear of the WBK41, as indicated in the following figure.

The WBK41 can be easily expanded beyond its built-in channel capacity. WBK41 systems can include:

- up to 224 TC Input Channels by connecting to 15 DBK84 modules
- up to 208 Digital I/O Channels by connecting to 4 DBK20 Series cards or up to 272 Digital I/O channels by connecting to 8 DBK208 expansion boards
- 4 Analog Output channels when a DBK46 DAC option card is installed
- 4 Counter Input channels and 2 Timer Output channels

Rear Panel Connectors

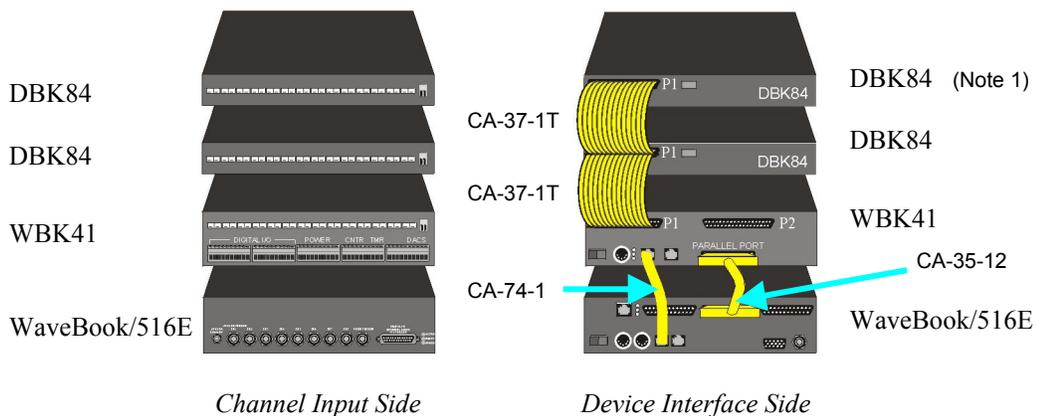


Note:
The P2 Connector does not apply to WBK40.

WBK41, Rear Panel Connectors

Note that WBK40's Rear Panel is identical, except it has no P2 connector. Page 1 includes a photo of the WBK40 rear panel.

Item	Description
P1 (see page 26 for pinout)	P1 is an Analog Expansion Port. This DB37 connector is used to connect the WBK40 or WBK41 to an optional DBK84, 14-Channel Thermocouple Module. The connection is typically made via a CA-37-x ribbon cable, where "x" equals the number of analog expansion devices.
P2 (WBK41 Only) (see page 27 for pinout)	P2 is a Digital Expansion Port, which is available on the WBK41, but not on the WBK40. This DB37 connector can be used to connect the WBK41 to an optional DBK20 Series device. The connection is typically made via a CA-37-x ribbon cable, where "x" equals the number of digital expansion devices. If P2 is not used for DBK20 Series expansion, it allows for 24 bits of Digital I/O, which is in addition to the 16 bits of Digital I/O that are provided by front panel terminal blocks.
POWER [switch]	Two-position rocker switch with labels "0" for "Power OFF" and "1" for "Power ON."
POWER IN	A DIN5 connector which accepts power of +10 to +30 VDC. Power is typically supplied via a TR-40U power adapter.
LEDs	ACTIVE – Lights when a sample is being converted by the Analog-to-Digital Converter (ADC) that resides inside the WBK40 or WBK41. ONLINE – Lights when software is communicating with the WBK40 or WBK41. POWER – Lights when power is available to the WBK40 or WBK41, and the Power switch is in the "1" (Power ON) position.
SYNC Ports (2)	Two SYNC Ports are available to synchronize sampling with other connected devices that have SYNC ports, for example, the WaveBook/516E. Cable CA-74-1 or CA-74-5 is typically used to provide a synchronization link from a WBK40 [or WBK41] module to another device.
PARALLEL PORT	The Parallel Port is a DB25 connector that is used to connect the WBK40 [or WBK41] to a WaveBook/516E or WBK25 Ethernet Interface Module.



One of Many Possible WBK41-Based Systems

Note 1: Each DBK84 module requires a unique address setting as explained on page 13.

Setup



Reference Note

For a quick set up involving connecting a WBK40 or a WBK41 to a WaveBook/516E or to a WBK25, refer to the [WBK40 & WBK41 Installation Guide](#) (p/n 1066-0901). For convenience, a copy has been placed after the specifications section of this document.

Hardware Setup, for WBK40 and WBK41

WARNING



Electrical Shock Hazard! To avoid possible injury and equipment damage, turn off power to devices and connected equipment prior to setup.

Connecting to the Channel Input Side

WBK40 and WBK41 each have a row of 14 mini-TC connectors. These are for connecting thermocouples to channels 1 through 7 and to channels 9 through 15. Channels 0 and 8 have no mini-TC connectors, as these two channels are used for cold-junction compensation (CJC). The connection information regarding thermocouples is included in the upcoming sub-sections, [Thermocouple Connections](#) (page 6) and [Open Thermocouple Detection](#) (page 7).

In addition to thermocouple connections, the WBK41 can accept signal lines for the following:

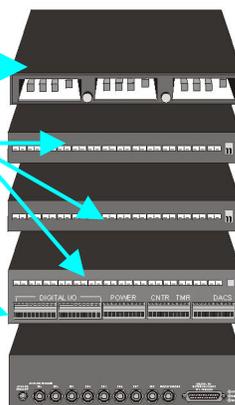
- 16 Digital I/O Lines (via front panel screw-terminal blocks)
- 24 Digital I/O Lines (via a rear panel 37-pin connector, P2)
- 4 Counter Inputs (via front panel screw-terminal blocks)
- 2 Timer Outputs (via front panel screw-terminal blocks)
- 4 Channel, 16-bit, 100 kHz Analog Output (via front panel screw-terminal blocks; but *only* when a factory-installed DBK46 option is in place)

System Example

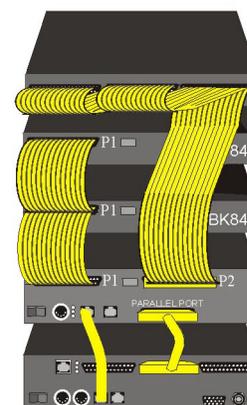
144 Digital I/O
(via 3 DBK21 Cards in a DBK10 Chassis)

14 Thermocouples can be connected to each DBK84 and to the WBK41 (or WBK40).

For WBK41: Digital I/O, Counter Input (CNTR), Timer Output (TMR), and Analog Output (DACS) lines can be connected to the associated terminal block screw connectors. (See following photo.)



Channel Input Side

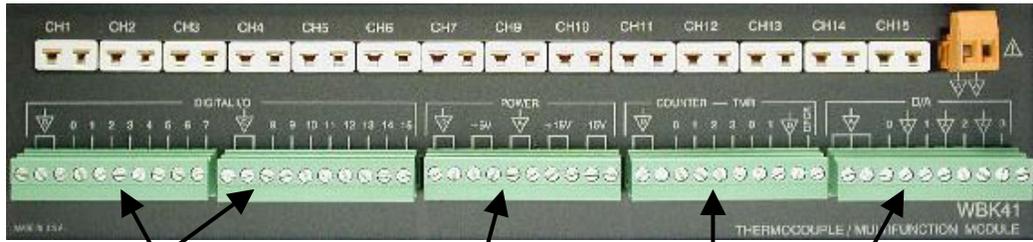


DBK10 with
3 DBK21 Cards
DBK84 (Note 1)
DBK84
WBK41
WaveBook/516E

Device Interface Side

One of Many Possible WBK41-Based Systems

Note 1: Each DBK84 module requires a unique address setting as explained on page 13.



Note:
The row of terminal blocks does not apply to WBK40.

DIGITAL I/O (2 Terminal Blocks) POWER [Out] COUNTER - TMR D/A (DAC0, DAC1, DAC2, DAC3)

WBK41, Front Panel Connectors

Note that WBK40's Front Panel is identical, except it has no screw-terminal blocks. Page 1 includes a photo of WBK40. Page 2 includes a table that describes each item found on the front panel.

Thermocouple Connections

The WBK40 and WBK41 each accept up to 14 thermocouples [with mini-TC plugs] via channels 1 through 7 and 9 through 15. All channels have the same level of functionality.

Thermocouple wire is standardized, color-coded, and polarized, as noted in the following table.

Mini-TC plugs are type-specific, and for best measurement operation the plug TC type should match the wire TC type. If necessary, copper/copper (Type U) plugs may be used, but measurement stability will be slightly degraded. Mini-TC plugs are polarized as well, and it is critical for proper measurement operation that this polarity be followed when connecting the thermocouple wire. Once wired, the TC plugs will only mate into the unit's TC connectors in one orientation, thus ensuring a correct connection.

Thermocouple Standards			
T/C Type	(+) Lead to Channel High	(-) Lead to Channel Low	
J	White	Red	
K	Yellow	Red	
T	Blue	Red	
E	Violet	Red	
N28	Orange	Red	
N14	Orange	Red	
S	Black	Red	
R	Black	Red	
B	Gray	Red	

It should be noted that thermocouples output very small voltages and that long thermocouple leads can pickup a large amount of noise. However, both the WBK40 and WBK41 inherently provide a high level of noise immunity via their 4 Hz signal bandwidth and input filtering. If desired, further noise reduction can be achieved through the use of shielded thermocouples and/or averaging.



You can minimize the effect of noise by:

- (1) using shielded thermocouples**
- (2) averaging readings**
- (3) employing both of the above practices**

To accommodate shielding, grounded connections, labeled "Analog Common," are provided. A typical use of the connection would be to attach the shield of a shielded thermocouple. Note that the Analog Common connector is removable to facilitate wiring.



If a thermocouple shield is connected to a WBK40, or WBK41 module, leave the shield unconnected at the other end of the thermocouple.

Open Thermocouple Detection

The WBK40, WBK41, and DBK84 modules are equipped with open thermocouple detection for each channel. This means that a broken thermocouple wire [or otherwise unconnected input] that is measured will result in an off-scale reading. This is accomplished by applying a small bias current to each of the channel inputs. Whenever a valid input is absent, the bias current saturates the input amplifier, resulting in the off-scale reading. When in this “off-scale” state, however, the input amplifier draws more current from the power supply. Specifically, the power draw of the module from ± 15 V will increase by 0.75 mA for each open channel.



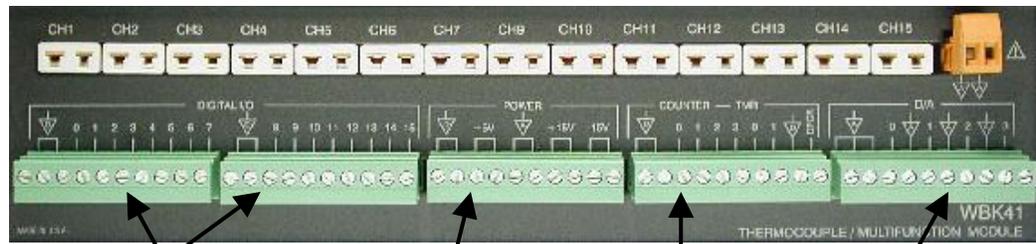
If available power is limited, insert shorted TC plugs into unused channels. This will minimize power consumption. Note that it is not enough to simply avoid scanning unused channels; to minimize power consumption the channels must be physically shorted in the hardware.



The power requirements, detailed in the product specification, assume worst case connection conditions.

Digital I/O, Power, Counter/Timer, and DAC Connections (WBK41 Only)

The front panel of the WBK41 includes removable plug-in screw-terminal blocks for Digital I/O, Power, Counter/Timer, and DAC (see following picture). Note that the DACs are only available if the DBK46 option is installed. Signal assignments are provided on page 2.



DIGITAL I/O (2 Terminal Blocks)

POWER [Out]

COUNTER - TMR

D/A (DAC0, DAC1, DAC2, DAC3)

WBK41, Front Panel Connectors

CAUTION



Signal mix-up will result in erroneous readings and can damage equipment. Be sure to connect signal lines to the proper screw-terminal connections.

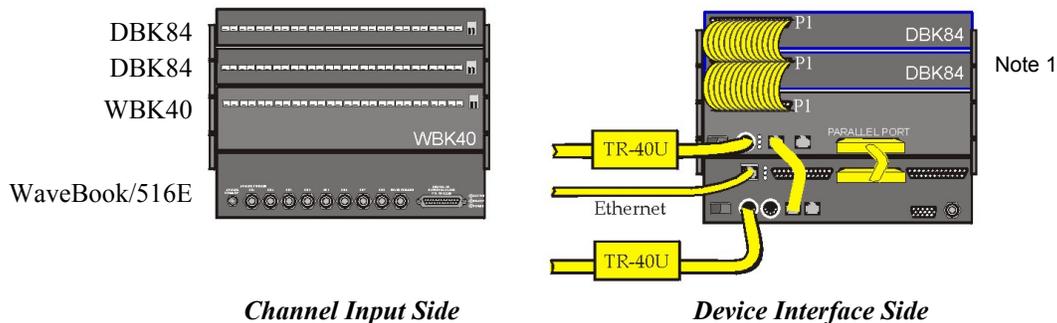
Never move a wired terminal block from its intended terminal block socket to another. The improperly routed signals, which result, can cause equipment damage.

Connecting to the Device Interface Side – WBK40 System Examples

WARNING



Electrical Shock Hazard! To avoid possible injury and equipment damage, turn off power to devices and connected equipment prior to setup.



Channel Input Side

Device Interface Side

A WaveBook/516E with a WBK40 and two DBK84 Modules

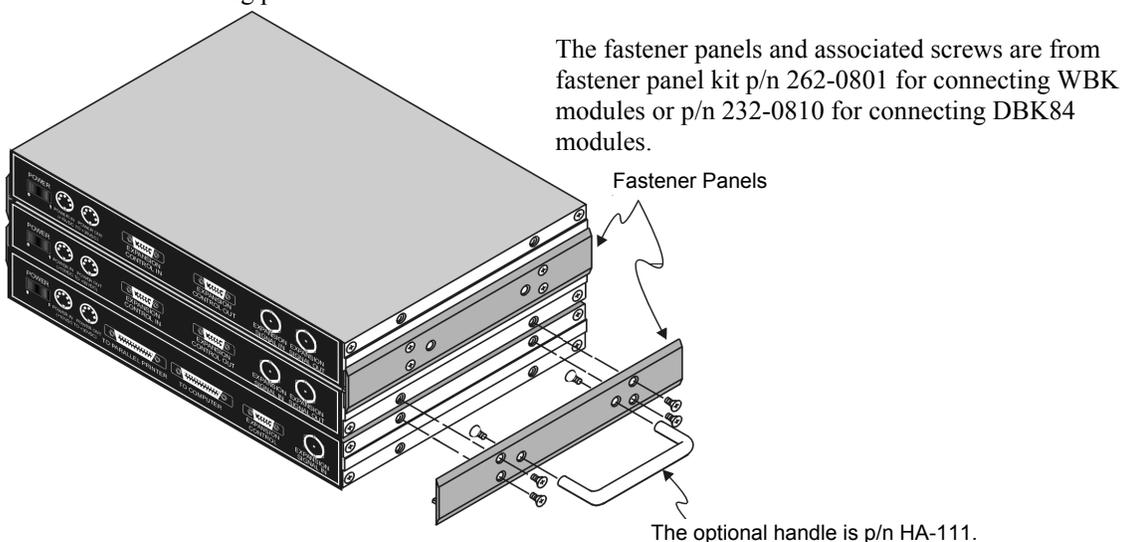
Note 1: Each DBK84 module requires a unique address setting as explained on page 13.

Device Interface Connections (seen in the above example):

1. From the WBK40 P1 connector to two DBK84 Modules via two CA-37-1T cables. (Page 10 discusses T-Cables)
2. From a WBK40 SYNC port to a WaveBook/516E SYNC Port via a CA-74-1 cable.
3. From a WaveBook/516E EXPANSION PORT to the WBK40 PARALLEL PORT via a CA-35-12 cable.
4. From the WaveBook/516E ETHERNET port to the Ethernet via a CA-242 cable.
5. Power Supply – a TR-40U was connected to the POWER IN [DIN 5] connector to supply power at +10 VDC to +30 VDC for the WBK40 and for the WaveBook/516E.

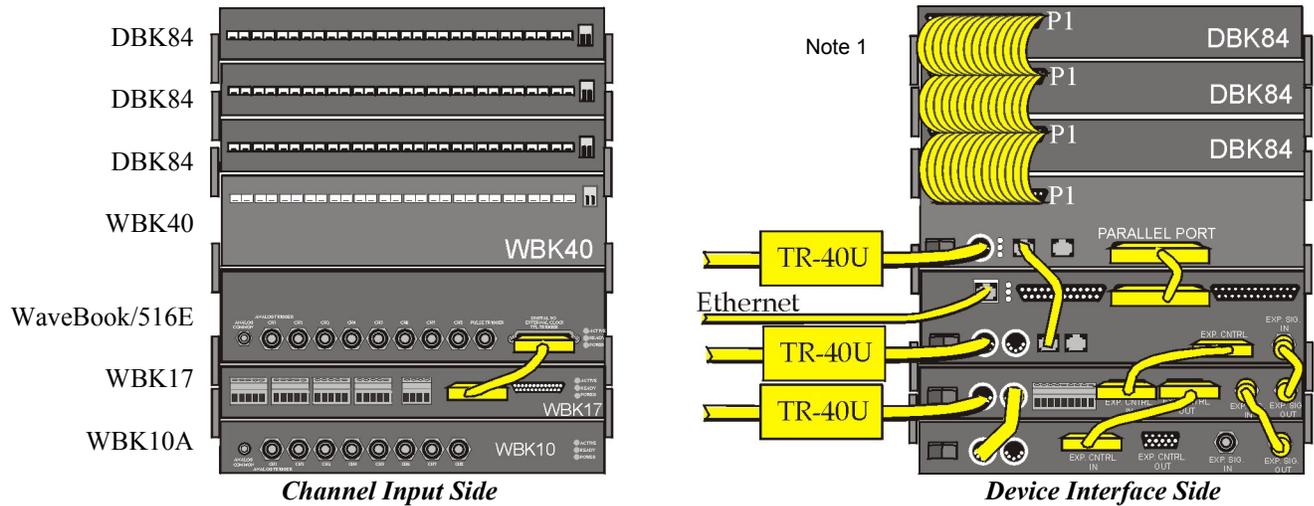
Using Fastener Panels to Stack Modules:

Fastener Panels, sometimes referred to as “splice plates” (p/n 262-0801 and p/n 232-0810) are typically used to stack modules to WaveBooks, and/or other modules. Optional handles (p/n HA-111) may also be attached to a system. The following figure illustrates the simplicity of the mounting process.



Using Fastener Panels to Stack a WaveBook and two WBK Modules (use of the handle is optional)

Note: When used with a WBK16, WaveBook/516, WaveBook/516A, or WaveBook/512A, fastener panels will partially block the vents on the side of the module. This partial blocking of vents does not jeopardize the cooling process.



A WaveBook/516E with a WBK17, WBK10A, WBK40, and three DBK84 Modules

Device Interface Connections (seen in the above example):

1. From the WBK40 P1 connector to three DBK84 Modules via three CA-37-1T cables.*
2. From the WBK40 SYNC port to WaveBook/516E SYNC Port via a CA-74-1 cable.
3. From the WBK40 PARALLEL PORT to the WaveBook/516E Expansion Port via a CA-35-12 cable.
4. From the WaveBook/516E's ETHERNET port to the Ethernet via a CA-242 cable.
5. From the WaveBook/516E EXTERNAL CONTROL connector to the WBK17's EXPANSION CONTROL IN connector, via a CA-129 cable.
6. From the WaveBook/516E EXTERNAL SIGNAL IN connector to the WBK17 EXTERNAL SIGNAL OUT connector via a CA-150 cable.
7. From the WaveBook/516E Channel Input Side's DIGITAL I/O AND TRIGGER connector to the WBK17 DIGITAL EXPANSION IN connector via a CA-217 cable.
8. From the WBK17 EXPANSION CONTROL OUT connector to the WBK10A EXPANSION CONTROL IN connector via a CA-129 cable.
9. From the WBK17's EXPANSION SIGNAL IN connector to the WBK10A's EXPANSION SIGNAL OUT connector via a CA-150 cable.
10. Power Supply – a TR-40U was connected to the POWER IN [DIN 5] connector to supply power at +10 VDC to +30 VDC for the WBK40, WaveBook/516E, and WBK17.
11. Power Supply – From the WBK17 POWER OUT [DIN 5] +10 VDC to +30 VDC connector to the WBK10A POWER IN [DIN 5] connector via a CA-115 power cable. The CA-115 is a 6-inch long cable which has a 5-pin DIN male connector at each end.

CAUTION



An incorrect use of power can damage equipment or degrade performance. Prior to connecting your devices to power, calculate your system's power requirements.



Reference Note

Information pertaining to connecting the system to power and calculating the amount of power needed can be found in the *WaveBook User's Manual*. A PDF version is included on the data acquisition CD and can be accessed from the CD's intro-screen by using the <View PDFs> button.

* Information regarding the use of CA-37-T cables is provided on page 10.

Using Fastener Panels to Stack Modules:

Fastener panels are illustrated and discussed on page 8.

Note 1: Each DBK84 module requires a unique address setting as explained on page 13.

What are “T-Cables” and how are they used?

CAUTION



Turn power **OFF** to the acquisition devices and to externally connected equipment prior to connecting cables. Electrical shock or damage to equipment can result even under low-voltage conditions.

A T-Cable is a ribbon cable that extends the connections of one of the ports it plugs into, thus allowing a second cable to plug into that port. The following figure clarifies the concept.

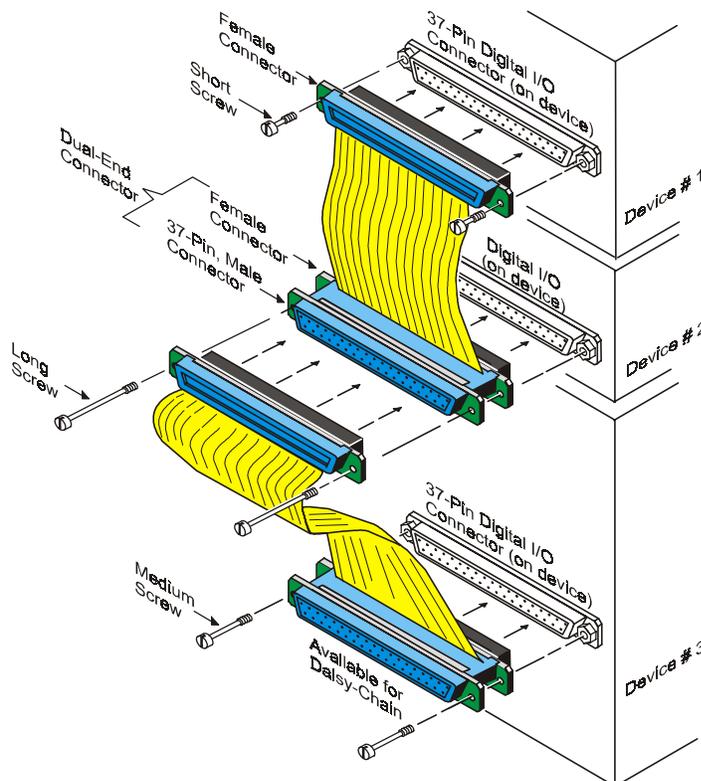
T-Cables are available in different lengths and can be used for linking two or more compatible devices together via the device’s 37-pin connectors.

The bottom-end of the T-Cable is a dual-connector, consisting of both a female connector, and a 37-pin (male) connector. As seen in the following illustration, the T-Cable’s 37-pin (male) connector can be used for “Daisy-Chain” applications.

Each T-Cable comes with three sets of screws. These are designated (in the diagram) as: short, medium, and long. Use the short screws to secure the single, female-end of the cable to the device; and use the medium length screws to secure a cable’s “dual-end” connector. Use the long screws for daisy-chain applications (when you are connecting one T-Cable to another T-Cable).



Tighten screws snug only; do not over-tighten!

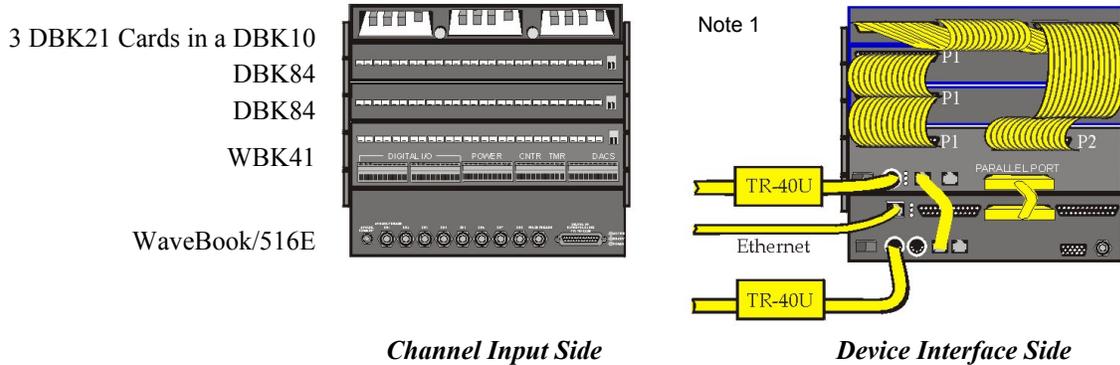


Connecting to the Device Interface Side – WBK41 System Examples

WARNING



Electrical Shock Hazard! To avoid possible injury and equipment damage, turn off power to devices and connected equipment prior to setup.



A WaveBook/516E with a WBK41, two DBK84 Modules, & three DBK21 Cards (in a DBK10)

Device Interface Connections (seen in the above example):

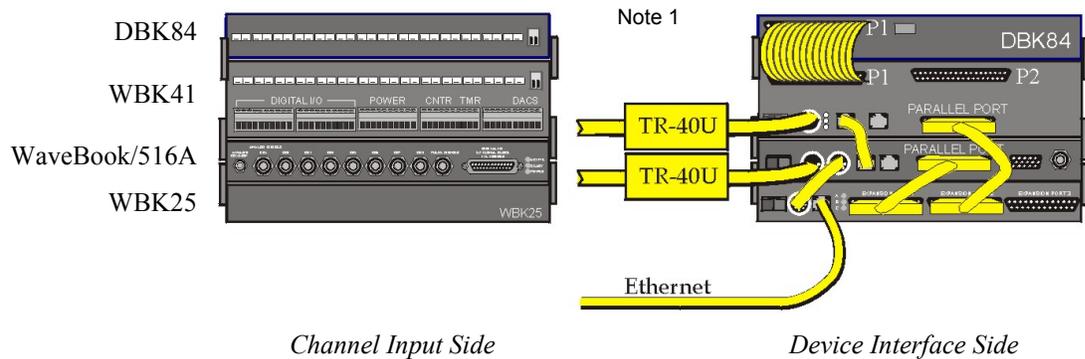
1. From the WBK41 P1 connector to two DBK84 Modules via two CA-37-1T Cables.*
2. From a WBK41 SYNC port to a WaveBook/516E SYNC Port via CA-74-1 Cable.
3. From the WaveBook/516E EXPANSION port to the WBK41 PARALLEL PORT via a CA-35-12 cable.
4. From the WaveBook/516E ETHERNET port to the Ethernet via a CA-242 cable.
5. From the WBK41 P2 connector to three DBK21 Cards (in a DBK10 Chassis) via a CA-37-3 cable.
6. Power Supply – a TR-40U was connected to the POWER IN [DIN 5] connector to supply power at +10 VDC to +30 VDC for each of the following devices:
 - WBK41
 - WaveBook/516E

* Information regarding the use of CA-37-T cables is provided on page 10.

Using Fastener Panels to Stack Modules:

Fastener Panels are discussed on page 7.

Note 1: Each DBK84 module requires a unique address setting as explained on page 13 of this document module and in the *DBK Options User's Manual* (p/n 457-0905). Each DBK21 card also requires a unique address as discussed in the *DBK Options User's Manual*.



A WaveBook/516A with a WBK25, WBK41, and DBK84

Device Interface Connections (seen in the above example):

1. From the WBK41 P1 connector to the DBK84 Module via one CA-37-1T Cable.*
2. From a WBK41 SYNC port to a WaveBook/516A SYNC Port via CA-74-1 Cable.
3. From the WBK41 PARALLEL PORT connector to the WBK25 EXPANSION PORT 2 connector via a CA-35-12 cable.
4. From the WaveBook/516A PARALLEL PORT to the WBK25 EXPANSION PORT 1 connector via a CA-35-12 cable.
5. From the WBK25 ETHERNET port to the Ethernet via a CA-242 cable.
6. Power Supply – a TR-40U was connected to the POWER IN [DIN 5] connector to supply power at +10 VDC to +30 VDC for the WBK41 and the WaveBook/516A.
7. Power Supply – From the WaveBook/516A’s POWER OUT [DIN 5] +10 VDC to +30 VDC connector to the WBK25’s POWER IN [DIN 5] connector via a CA-115 power cable. The CA-115 is a 6-inch long cable which has a 5-pin DIN male connector at each end.

CAUTION

An incorrect use of power can damage equipment or degrade performance. Prior to connecting your devices to power, calculate your system’s power requirements.

Reference Note
 Information pertaining to connecting the system to power and calculating the amount of power needed can be found in the *WaveBook User’s Manual*. A PDF version is included on the data acquisition CD and can be accessed from the CD’s intro-screen by using the <View PDFs> button.

* Information regarding the use of CA-37-T cables is provided on page 10.

Using Fastener Panels to Stack Modules:
 Fastener Panels are discussed on page 7.

Note 1: Each DBK84 module requires a unique address setting as explained on page 13.

Setting “Unique” Channel Addresses for DBK84 Modules

All DBK84 modules that are connected to WBK40 or WBK41 systems must have unique channel address settings. Unlike the WBK40 and WBK41, which are internally pre-set with an address of “0,” each DBK84 module requires that the address be set via DIP switches located on the front panel of that module.

CAUTION



Adjustment of the channel address must only be performed when the system power is OFF. Failure to do so may result in equipment damage.

DBK84 modules that are connected to a WBK40 or WBK41 must have their addresses physically set to a value between 1 and 15, inclusive. Four micro-switches [on a DIP switch] are used to set the module’s channel address in binary.

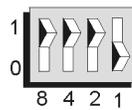
Set a DBK84 address as follows:

1. Locate the DIP switch. It is just to the right of the P1 connector.
2. Ensure system power is OFF.
3. Adjust the micro-switches to set the desired address. Refer to the following figure.

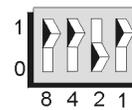


Address “0” is used by WBK40 and WBK41 and is not to be assigned to a DBK84 that is part of a WBK40 or WBK41 system. Each connected DBK84 must have a unique address. The following figure shows the complete range of switch settings.

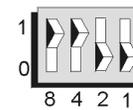
See Note regarding Address “0”



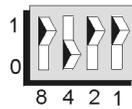
1



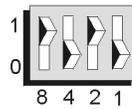
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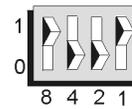
3



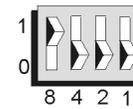
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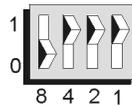
5



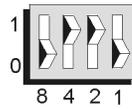
6



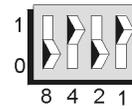
7



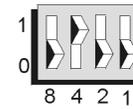
8



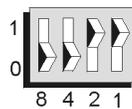
9



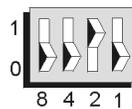
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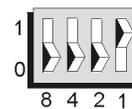
11



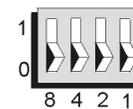
12



13



14



15

Possible Address Settings for a DBK84

Software Setup



You will need to use the *Daq* Configuration* control panel applet to add the WBK40 or WBK41 device to the parent (first level) device, i.e., a WaveBook/516E or a WBK25 module. Refer to the [WBK40 & WBK41 Installation Guide](#) (p/n 1066-0901). For convenience, a copy has been placed after the specifications section of this document.

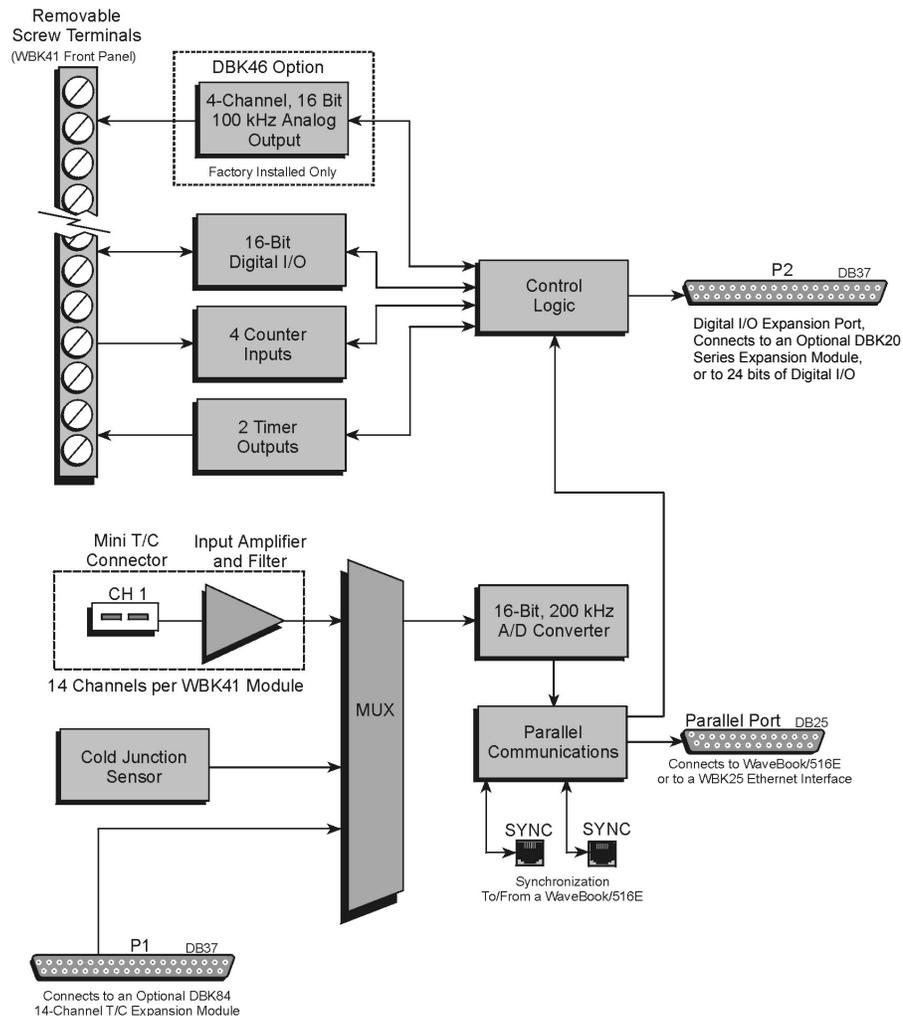


As this document goes to print there is no *out-of-the-box* software support for WBK40 and WBK41 systems. At this early stage of the product cycle users must create their own custom programs using API commands. These are covered in the *Programmer's Manual* (p/n 1008-0901).

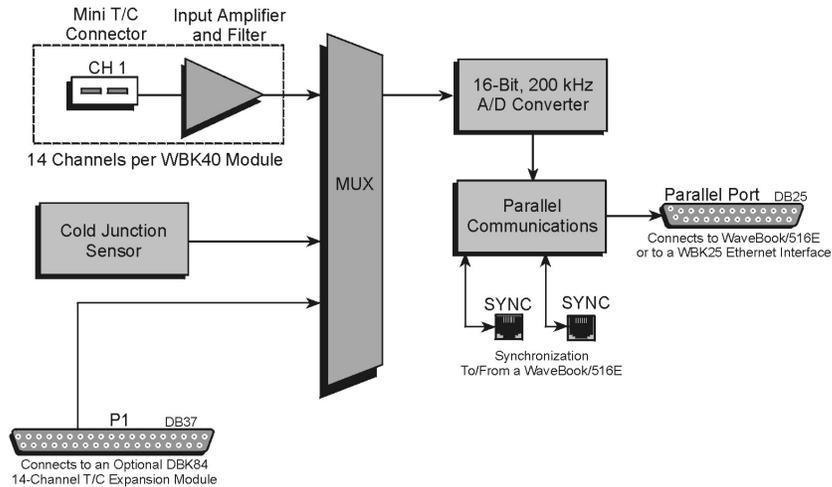
Refer to the [ProgrammersManual.pdf](#) regarding API. The document is included on the Data Acquisition CD and can be accessed via the <View PDF> button that appears on the CD's opening screen.

Operational Aspects

Block Diagrams



WBK41 Block Diagram



WBK40 Block Diagram

Thermocouple Measurements

Each WBK40 and WBK41 module's internal circuitry includes cold junction compensation (CJC) for direct measurement of type J, K, T, E, N28, N14, S, R, and B thermocouples. The following table provides the temperature range for each of these thermocouple types.

Thermocouple Temperature Ranges									
T/C Type	J	K	T	E	N28	N14	S	R	B
Temperature Range °C	-200 to 760	-200 to 1200	-200 to 400	-270 to 650	-270 to 400	0 to 1300	-50 to 1768	-50 to 1768	50 to 1780
Temperature Range °F	-328 to 1400	-328 to 2192	-328 to 752	-454 to 1202	-454 to 752	32 to 2372	-58 to 3214	-58 to 3214	122 to 3236

The modules automatically convert TC measurements into temperature readings, including cold-junction compensation and linearization. Open TC detection and overload protection up to $\pm 40V$ is also included on every channel. To expand beyond the built-in 14 TC input channels, up to fifteen DBK84 expansion modules can be attached to one WBK40 or WBK41, providing an additional 14 TC input channels per module.

Fifteen DBK84 Thermocouple Modules connected (via daisy-chain) to a single WBK40 or WBK41 module provide up to 210 additional temperature channels, for a total system capability of 224 channels; i.e., 14 channels per device x 16 devices.



If more than eight DBK84 modules are to be connected to one WBK40 [or WBK41] module, additional power must be supplied. The power can be obtained from DBK32A or DBK33 Auxiliary Power Supply Cards, housed within a DBK10 expansion chassis.

In comparison to typical DBK options, the DBK84 modules demand significant power from the system's $\pm 15V$ power supplies. It is important that you calculate your system's power demand, as you may need to add auxiliary power supplies. Refer to the *Power Management* section of the *DBK Option Cards and Modules User's Manual*, in regard to calculating system power requirements.

Note that WBK40 and WBK41 can each provide up to 15000 mW of power to DBK84 modules that are added to the system. (See previous note regarding auxiliary power).

In regard to adding thermocouples to WBK40, WBK41, or DBK84 modules, Channels 1 through 7 are used for the first seven thermocouples, and channels 9 through 15 are used for the second set of seven. Channels “0” and “8” are not used for thermocouple input, but instead measure the two CJs.

In addition to thermocouple measurements, each input channel can be configured for a fixed voltage gain of 100. When in this mode, voltage can be measured in the range of ± 100 mV.

Built into the WBK40 and WBK41 is a 16 bit, 200-kHz A/D converter that samples all of the TC inputs, including inputs attached to the DBK84 expansion modules. The SYNC connection between the WBK40 or WBK41 module and the WaveBook/516E ensures that thermocouple measurements on the module are synchronized with higher-speed measurements on the WaveBook. WaveBook software automatically compensates for the difference in sampling rates between the WaveBook and WBK40 [or WBK41], ensuring that there is exact time correlation between readings from both devices.

The WBK40 and WBK41 automatically perform thermocouple linearization and cold-junction compensation, providing accurate and stable temperature readings in either $^{\circ}\text{C}$, $^{\circ}\text{F}$, or $^{\circ}\text{K}$. Typical TC accuracy is better than 1.0°C , with channel-to-channel variation and noise typically better than 0.2°C .

Digital I/O, WBK41 Only

Forty Digital I/O lines are built-into the WBK41. Sixteen are accessible via front-panel removable screw terminal connectors, and can be defined under program control as either all inputs or all outputs. As inputs, these channels can be scanned synchronously during an acquisition, or asynchronously under program control. As outputs, these lines can be set prior to an acquisition, or changed during an acquisition if used with a programming environment such as Visual Basic®, C, or LabVIEW®.

In addition to the 16 front-panel Digital I/O lines, 24 lines are provided on the rear panel 37-pin D connector, designated as P2. These lines are logically divided into three 8-bit ports, with each port programmable as input or output. As with the front-panel Digital I/O, these lines can be scanned as inputs along with other channels in a scan group, or read during an acquisition when a programming environment is being used.

Note that P2 can be used as a Digital I/O expansion port. In this role it can be expanded up to 256 digital I/O lines using our DBK20 Series options. DBK20 Series devices provide additional signal I/O, including optical isolation and relay closure. The *DBK Option Cards and Modules User's Manual* (457-0905), which is included in PDF format on your data acquisition CD, contains details regarding each DBK20 Series device.

Synchronous Input Operations

The WBK40 and the WBK41 allow synchronous scanning and acquisition of Thermocouple Inputs. This type of data can be from either the WBK40, the WBK41, or from DBK84 expansion modules. In addition to Thermocouple Input, the WBK41 can receive Digital Input and Counter Input Data at up to 200kHz aggregate scanning rates. The WBK41 can input Digital Data through its Digital I/O terminal blocks [on the front panel], or via its DB37 P2 connector, which can be used to expand to a DBK20 Series card or module.

Digital Input Channels

The WBK41 allows for either synchronous scanning of digital input channels or asynchronous I/O operations for all configured digital channels.

Counter Input Channels

The devices allow synchronous scanning of the 4 16-bit counter input channels. The four 16-bit counter channels can also be cascaded into two 32-bit counter channels. For either cascaded or non-cascaded counter channels each channel can be configured for:

- **Clear on Read Mode** – specifies that each counter should be reset to zero upon being read and placed into the input scan.
- **Continuous Totalize Mode** – specifies that each counter is to free-run and not be cleared during the input acquisition.



Reference Note

Information pertaining to *Synchronization* and *Scanning* can be found in the *WaveBook User's Manual*. A PDF version is included on the data acquisition CD and can be accessed from the CD's intro-screen by using the <View PDFs> button.

Synchronous Output Operations - DBK46 Required

With the optional DBK46 Analog Output card installed, the WBK41 will allow synchronous output of D/A channels at up to 100kHz, for each channel. The channels may have output streamed to them and be clocked-out synchronously.

All waveform data is downloaded to a 256k sample buffer on the DBK46. The waveform can then be started and DAC updates made synchronous to the acquisition pacer clock.

Output Channel Configuration - DBK46 Required

Analog Output Channels

Each D/A channel of a DBK46 can be configured for waveform output individually. If the D/A channel is not configured for waveform output it then is available for asynchronous output operations.

Synchronous Output Clocking

The devices allow clocking of the synchronized output by the acquisition clock source, an internal, programmable pacer clock or by an external clock source. When the clock source generates a new clock signal all outputs are updated concurrently. Regardless of the clock source, the clock may not exceed the maximum update rate of 100kHz.

Synchronous Output Data Source

Each device [that has a DBK46 installed] allows the data source for synchronized DAC output operations to be that of a memory based buffer on the DBK46. The output data, for all the channels, is contained in the buffer.

Asynchronous I/O Operations - WBK41

The WBK41 allows asynchronous input of any counter or digital channel that is not currently configured for synchronous acquisition. The unit also allows for asynchronous output to any DBK46 D/A channels that are not currently configured for waveform output. Note that the DBK46 is an option that must be installed for this to be true.

Likewise, all 40 Digital I/O channels (16 from front panel terminal blocks and 24 from the rear panel P2 connector) can be used for both asynchronous input and output operations. In addition, the Timer Outputs (from a front panel terminal block) can be programmed at any time, regardless of the current state of synchronous or asynchronous operations on other channels.

Digital I/O Channels

Rear Panel P2 Connector, 24 Bit Digital I/O

The devices have an implemented Intel 8255 core in the digital I/O logic on the P2 port. With the Intel 8255 there are three 8-bit wide ports available for I/O and one 8-bit wide port for configuration purposes. The configuration port is used to configure the other three 8-bit ports for either input or output operations.

Front Panel, Terminal Blocks, 16 Bit Digital I/O

The WBK41's front panel terminal blocks include a 16-bit Digital I/O port. With this port, no configuration is required; the port simply outputs when written to and inputs when read.

Expansion Digital I/O

The WBK41 has the ability to expand its Digital I/O capabilities via the rear panel P2 port via the connection of applicable Digital I/O expansion modules, i.e., a DBK20 Series card or module. These modules are discussed in the *DBK Option Cards & Modules User's Manual*. When using Digital I/O expansion modules the local P2 Intel 8255 Digital I/O becomes inaccessible in lieu of the expansion modules. The expansion modules provide additional Intel 8255 ports, as well as input isolation for applications that require the expanded capabilities.

Pulse Stream Output Using Timers

The WBK41 allows for the generation of output pulses based upon a programmable setting. These output timers can be set at any time regardless of the state of any synchronous or asynchronous operations which are currently taking place on other channels. Connections for the two Timer Outputs, designated as "TMR 0" and "TMR 1," are located on the front panel terminal blocks.

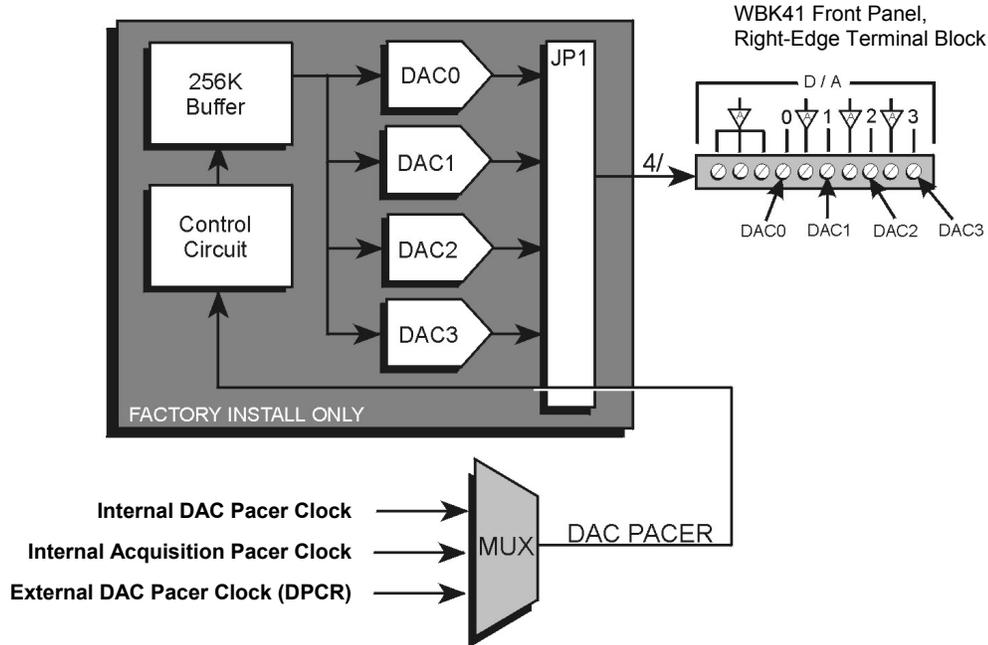
Counter Input Channels

WBK41 modules have Counter Input capabilities for four channels (CNTR0, CNTR1, CNTR2, and CNTR3). Connection points are provided on a front panel terminal block. Providing that a counter channel is not configured for synchronous acquisition, it can be used to read counter input. As in the case of synchronous operations, the four 16-bit counter input channels can be used individually, or can be cascaded into two 32-bit counter channels. For either cascaded or non-cascaded counter channels, each channel can be configured for:

- ***Clear on Read Mode*** – specifies that each counter should be reset to zero upon being read.
- ***Continuous Totalize Mode*** – specifies that each counter is to free-run and not be cleared during the read operation.

Analog Output Channels (The DBK46 Factory Install Option is Required)

When a WBK41 has a DBK46 option installed, the module has the ability to output analog data to any of the four D/A channels (DAC0, DAC1, DAC2, and DAC3). Connection points are on a front panel terminal block. If a D/A channel is not being used for waveform output operations, it can be asynchronously updated by an application.



DBK46 Block Diagram, WBK41 Application

The DBK46 has a 256K sample buffer that can be used for one to four DACs. If only one DAC is enabled for waveform output, then the entire 256K sample memory can be used to store a waveform for that DAC. If two DACs are enabled for waveform output, then 128K of sample memory is available for each of the two DACs. Use of all four DACs drops the available memory down to 64K per DAC.

Software loads the waveform(s) into the 256K sample buffer. The waveform data drives the DACs at the rate of the specified DAC Pacer Clock. The waveforms will repeat until the DACs are disabled by software.

The DBK46 provides an output range of -10V to +10V. The card's 256 Kbyte of sample buffer memory can store waveforms from the PC. When used to generate waveforms, the DACs can be clocked in one of three modes. These are:

- **Internal DAC Pacer Clock** - The WBK41 programmable clock can generate updates ranging from 1.5 Hz to 100 kHz, independent of any acquisition rate.
- **Internal Acquisition Pacer Clock** – By using the WBK41 programmable clock, the analog output *rate of update* can be synchronized to the acquisition rate derived from 100 kHz to once every 5.96 hours.
- **External DAC Pacer Clock (DPCR)** - A user-supplied external input clock can be used to pace the DAC, entirely independent of other analog inputs. This external clock input connects to the DPCR connector, located on the Counter/Timer Terminal Block.

DBK46 is installed at the factory. To verify that a DBK46 is installed, simply check the acquisition software's Analog Output Window for the presence of DAC0, DAC1, DAC2, and DAC3.

Note that the DBK46 does not require any setup in software.



Reference Note:

In regard to the *out-of-the-box* software and analog output channels, refer to the *WaveView* Document PDF. **However, as of this document date, the WaveView graphical user interface (GUI) does not specifically address WBK40 or WBK41.**

Using a Temperature Calibrator

The thermocouple modules provide accurate and repeatable temperature measurements across a wide range of operating conditions. However, all instrumentation is subject to drift with time and with ambient temperature change. If the ambient temperature of the operating environment is below 18°C or above 28°C, or if the product is near or outside its one-year calibration interval, then the absolute accuracy may be improved through the use of an external temperature calibrator.

A temperature calibrator is a temperature simulation instrument that allows selection of thermocouple type and temperature. For proper operation, it must be connected to the WBK40, WBK41, or DBK84 with the same type thermocouple wire and connector that is used in normal testing. The calibrator then generates and supplies a voltage to the module. The supplied voltage corresponds to that which would be generated by the chosen thermocouple type at the selected temperature.

The temperature selected on the calibrator will be dictated by the nature of normal testing. 0°C is usually the best choice. Calibrators are the most accurate at this setting, and the connecting thermocouple wire will contribute very little error at this temperature. However, if the dynamic range of the normal testing is, for example, 100°C to 300°C, a selection of 200°C may give better results. In either case, the level of adjustment is determined by comparing the unit reading to the selected calibrator temperature. For example, if the calibrator is set to 0°C output, and the unit reads 0.3°C, then an adjustment of -0.3°C is required. That is, the adjustment value is determined by subtracting the device reading from the calibrator setting.

To implement the adjustment in DaqView:

1. Ensure that the acquisition process is turned off.
2. Click on the cell in the Units column for the channel that is connected to the calibrator. The engineering units pull-down menu above the grid becomes active.
3. Click on the down arrow and select the “mx+b” option. This option allows post-acquisition mathematical manipulation.
4. For the example adjustment, enter -0.3 for “b.” The channel under calibration will now read 0°C.

Note that this adjustment is a mathematical operation only, and in no way alters the hardware calibration of the product. Moreover, it operates on a per channel basis, with the settings for a given channel having no influence on any other channels.



Reference Notes:

For Additional mx+b information, refer to the *mx_plus_b.pdf* document, which is included on the data acquisition CD.

CE Compliance

Overview



CE-compliant products bear the “CE” mark and include a *Declaration of Conformity* stating the particular specifications and conditions that apply. The test records and supporting documentation that validate the compliance are kept on file at the factory.

The European Union established CE standards in 1985. The standards include specifications for safety, EMI emissions, and immunity from electromagnetic interference. Products that are intended for placement in the European Union must meet or exceed the standards and bear the "CE" mark.

Although not required in the USA, meeting or exceeding the CE standards is considered good engineering practice, since doing so enhances safety while reducing noise and ESD problems.

In contracted and in-house testing, most Daq products met the required specifications. In many cases, products that were not originally in compliance were redesigned accordingly. In noted instances, alternate product versions, shield plates, edge guards, special connectors, or add-on kits are required to meet CE compliance.

CE Standards and Directives

The electromagnetic compatibility (EMC) directives specify two basic requirements:

1. The device must not interfere with radio or telecommunications.
2. The device must be immune from electromagnetic interference from RF transmitters, etc.

The standards are published in the *Official Journal of European Union* under direction of CENELEC (European Committee for Electrotechnical Standardization). The specific standards relevant to Daq equipment are listed on the product's Declaration of Conformity and include: CISPR22:1985; EN55022:1988 (Information Technology Equipment, Class A for commercial/industrial use); and EN50082-1:1992 for various categories of EMI immunity.

The safety standard that applies to Daq products is EN 61010-1 : 1993 (*Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements*).

Environmental conditions include the following:

- indoor use
- altitude up to 2000 m
- temperature 5°C to 40°C (41°F to 104°F)
- maximum relative humidity 80% for temperatures up to 31°C (87.8°F) decreasing linearly to 50% relative humidity at 40°C (104°F)
- mains supply voltage fluctuations not to exceed $\pm 10\%$ of the nominal voltage
- other supply voltage fluctuations as stated by the manufacturer
- transient overvoltage according to installation categories (overvoltage categories) I, II and III
For mains supply, the minimum and normal category is II
- pollution degree I or II in accordance with IEC 664

For clarification, terms used in some Declarations of Conformity include:

- **pollution degree:** any addition of foreign matter, solid, liquid or gaseous (ionized gases) that may produce a reduction of dielectric strength or surface resistivity. **Pollution Degree I** has no influence on safety and implies: the equipment is at operating temperature with non-condensing humidity conditions; no conductive particles are permitted in the atmosphere; warm-up time is sufficient to avert any condensation or frost; no hazardous voltages are applied until completion of the warm-up period. **Pollution Degree II** implies the expectation of occasional condensation.
- **overvoltage (installation) category:** classification with limits for transient overvoltage, dependent on the nominal line voltage to earth. **Category I** implies signals without high transient values. **Category II** applies to typical mains power lines with some transients.

Safety Conditions

Users must comply with all relevant safety conditions in the user's manual and the Declarations of Conformity. This manual and Daq hardware make use of the following Warning and Caution symbols: If you see either of these symbols on a product, carefully read the related information and be alert to the possibility of personal injury.



This warning symbol is used in this manual or on the equipment to warn of possible injury or death from electrical shock under noted conditions.



This warning/caution symbol is used to warn of possible personal injury or equipment damage under noted conditions.

Daq products contain no user-serviceable parts; refer all service to qualified personnel. The specific safety conditions for CE compliance vary by product; but general safety conditions include:

- The operator must observe all safety cautions and operating conditions specified in the documentation for all hardware used.
- The host computer and all connected equipment must be CE compliant.
- All power must be off to the device and externally connected equipment before internal access to the device is permitted.
- Isolation voltage ratings: do not exceed documented voltage limits for power and signal inputs. All wire insulation and terminal blocks in the system must be rated for the isolation voltage in use. Voltages above 30 Vrms or ± 60 VDC must not be applied if any condensation has formed on the device.
- Current and power use must not exceed specifications. Do not defeat fuses or other over-current protection.

Emissions/Immunity Conditions

The specific immunity conditions for CE compliance vary by product; but general immunity conditions include:

- Cables must be shielded, braid-type with metal-shelled connectors. Input terminal connections are to be made with shielded wire. The shield should be connected to the chassis ground with the hardware provided.
- The host computer must be properly grounded.
- In low-level analog applications, some inaccuracy is to be expected when I/O leads are exposed to RF fields or transients over 3 or 10 V/m as noted on the Declaration of Conformity.

CE Enhancements for DBKs

The following CE enhancements are described in the individual document modules of the *DBK Cards and Modules User's Manual* (p/n 457-0905).

- DBK41/CE
- Edge Guard (for DBK5, DBK8, and DBK44)
- Applicable cables and connectors

CE Compliance for WaveBook System Expansion

WaveBooks, WBK40, WBK41, and other CE-designated WBK and DBK boards and modules are CE Compliant at the time they leave the factory, and will remain in compliance providing that the required conditions, as stated on the associated product's *Declaration of Conformity*, continue to be met.

Note that connecting a *non-CE Compliant* DBK or WBK module or card to your system will make the system non-compliant.

You may want to expand your WaveBook system while having it retain its status of "CE Compliant." If so, refer to the most recent *Declaration of Conformity* for each device, prior to making any efforts to expand the system.

Fuse Replacement

CAUTION



Turn OFF the power to, and UNPLUG the WBK40 or WBK41 module and all connected equipment. Remove all signal I/O lines from the unit. Electric shock or damage to equipment can result even under low-voltage conditions.



Take ESD precautions, to include using a grounded wrist strap.

Use care to avoid touching board surfaces and onboard components. Ensure boards do not come into contact with foreign elements such as oils, water, and industrial particulate.



You should only replace a fuse if your device shows no sign of damage. If your device appears damaged, such as evidenced by a "smoked" component, contact the factory as soon as possible.

If the replacement fuse blows, contact the factory, as this indicates a problem may exist with your WBK40 or WBK41 module.

Each WBK40 and WBK41 module has one user-replaceable fuse designated as F201.

F201 Input Power Fuse. 4.0 A, MINI ATO.

This 4-amp fuse is located near the rear panel's 5DIN POWER IN connector. If this fuse has blown, the WBK40 or WBK41 module will not power up.

Factory Part Number: **FU-8-4**

Littelfuse Part Number: **297-004**, Littelfuse Body Color Code: **Pink**

You will need the following:

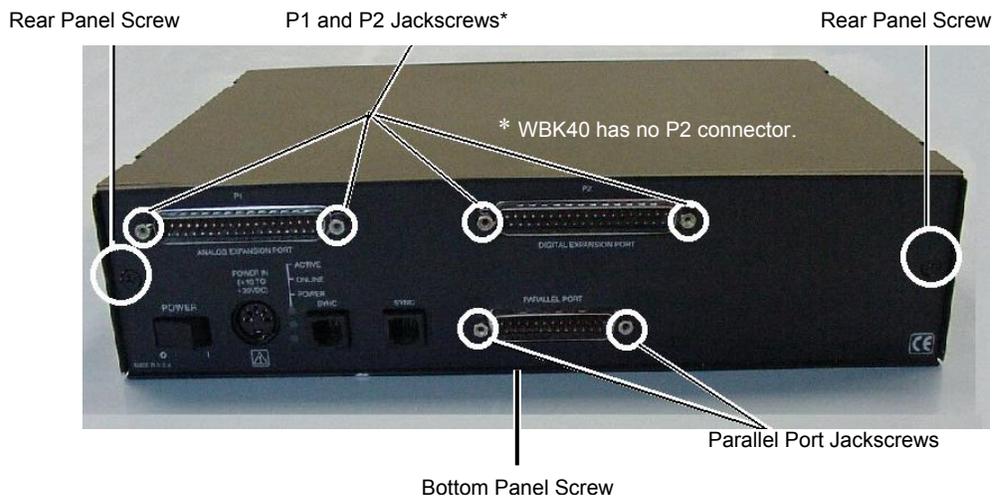
- Phillips Screwdriver
- 3AG Fuse Puller, or needle-nose pliers*
- 3/16-inch hex-nut driver
- Grounding wrist strap and associated anti-static pad
- Replacement fuse F201

* Needle-nose pliers can be used to pull MINI ATO fuses; but should not be used to insert fuses.



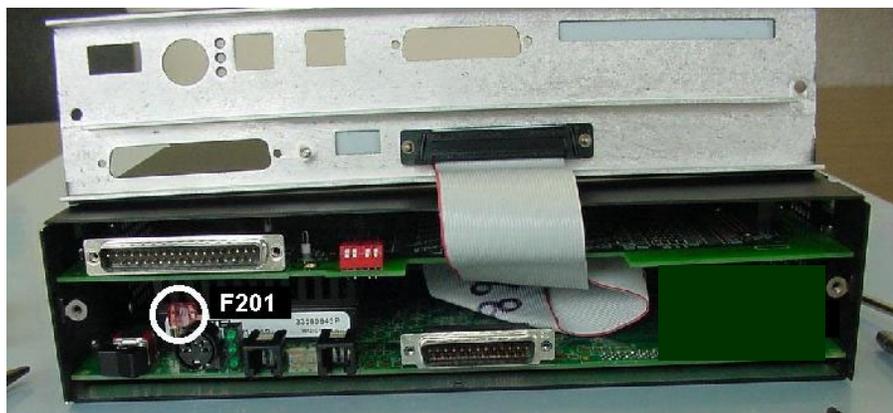
Observe the Caution and the important note on page 23 of this document module prior to beginning this fuse replacement procedure.

1. If you have not already done so, turn OFF the power to, and UNPLUG the WBK40 or WBK41 module and all connected equipment. Remove all signal I/O lines from the unit.
2. Remove the Jackscrews from the P1 and PARALLEL PORT connectors. In addition, WBK41 users must remove Jackscrews from the P2 connector. The following figure shows the screw locations.
3. Using a Phillips screwdriver, remove the two Rear Panel Screws and the Bottom Panel Screw.



WBK41 Rear Panel, Screw Removal

4. Remove the Rear Panel from the rest of the chassis.

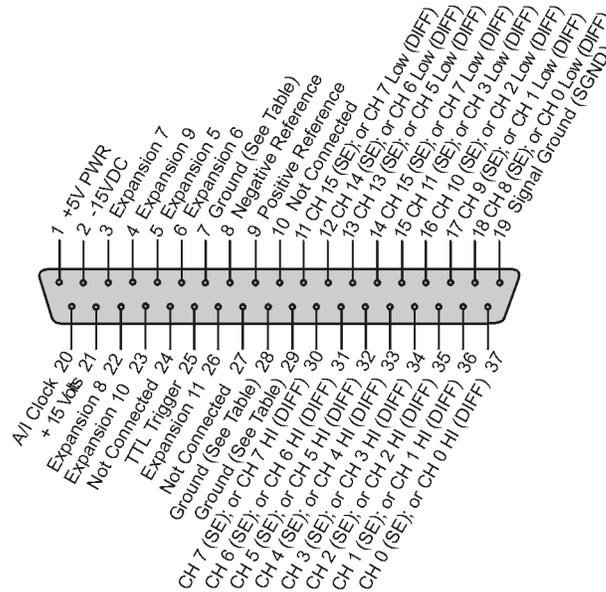


F201 Fuse Location

5. Locate fuse F201 (see the preceding figure).
6. While wearing a grounded wrist strap, remove and replace the bad fuse. Ensure that the new fuse is fully seated.
7. Replace the Rear Panel and secure it to the chassis with the 2 Rear Panel Screws, the Bottom Panel Screw, and the connector Jackscrews that were removed in step 2.
8. Return the WBK40 [or WBK41] to normal service. Should any problems be noted, consult the factory.

P1 DB37 Connector Pinout

Analog I/O

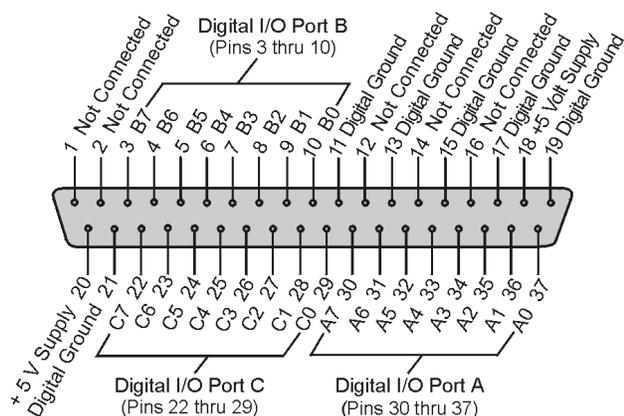


Pin	Signal Name	Description for P1 Pin Use
1	+5 VDC	Expansion +5 V power
2	-15 VDC	Expansion -15 V power
3	Expansion 7	Digital OUT, external ADDRESS select bit 3
4	Expansion 9	Digital OUT, external ADDRESS select bit 1
5	Expansion 5	Digital OUT, external GAIN select bit 1
6	Expansion 6	Digital OUT, external GAIN select bit 0
7	DGND	Digital Ground
8	Negative Reference	Analog -5 V reference
9	Positive Reference	Analog +5V reference
10	Not Connected	N/A
11	CH 15 (SE), or CH 7 LO DIFF	Ch 15 HI IN (single-ended mode) / Ch 7 LO IN (differential mode)
12	CH 14 (SE), or CH 6 LO DIFF	Ch 14 HI IN (single-ended mode) / Ch 6 LO IN (differential mode)
13	CH 13 (SE), or CH 5 LO DIFF	Ch 13 HI IN (single-ended mode) / Ch 5 LO IN (differential mode)
14	CH 12 (SE), or CH 4 LO DIFF	Ch 12 HI IN (single-ended mode) / Ch 4 LO IN (differential mode)
15	CH 11 (SE), or CH 3 LO DIFF	Ch 11 HI IN (single-ended mode) / Ch 3 LO IN (differential mode)
16	CH 10 (SE), or CH 2 LO DIFF	Ch 10 HI IN (single-ended mode) / Ch 2 LO IN (differential mode)
17	CH 9 (SE), or CH 1 LO DIFF	Ch 9 HI IN (single-ended mode) / Ch 1 LO IN (differential mode)
18	CH 8 (SE), or CH 0 LO DIFF	Ch 8 HI IN (single-ended mode) / Ch 0 LO IN (differential mode)
19	Signal Ground (SGND)	Sense Common (SGND)
20	A/I Clock	External ADC Pacer Clock Input / Internal ADC Pacer Clock Output
21	+15 VDC	Expansion +15 V power
22	Expansion 8	Digital OUT, external ADDRESS select bit 2
23	Expansion 10	Digital OUT, external ADDRESS select bit 0
24	Not Connected	N/A
25	TTL Trigger	Digital IN, External TTL Trigger Input
26	Expansion 11	Digital OUT, Simultaneous sample and hold (SSH)
27	Not Connected	N/A
28	AGND	Analog Ground
29	AGND	Analog Ground
30	CH 7 (SE), or CH 7 HI DIFF	Ch 7 IN (single-ended mode) / Ch 7 HI IN (differential mode)
31	CH 6 (SE), or CH 6 HI DIFF	Ch 6 IN (single-ended mode) / Ch 6 HI IN (differential mode)
32	CH 5 (SE), or CH 5 HI DIFF	Ch 5 IN (single-ended mode) / Ch 5 HI IN (differential mode)
33	CH 4 (SE), or CH 4 HI DIFF	Ch 4 IN (single-ended mode) / Ch 4 HI IN (differential mode)
34	CH 3 (SE), or CH 3 HI DIFF	Ch 3 IN (single-ended mode) / Ch 3 HI IN (differential mode)
35	CH 2 (SE), or CH 2 HI DIFF	Ch 2 IN (single-ended mode) / Ch 2 HI IN (differential mode)
36	CH 1 (SE), or CH 1 HI DIFF	Ch 1 IN (single-ended mode) / Ch 1 HI IN (differential mode)
37	CH 0 (SE), or CH 0 HI DIFF	Ch 0 IN (single-ended mode) / Ch 0 HI IN (differential mode)

P2 DB37 Connector Pinout (WBK41 Only)

Digital I/O

P2 does not apply to WBK40.



Pin	Signal Name	Description for P2 Pin Use
1	Not Connected	N/A
2	Not Connected	N/A
3	Port B - B7	Digital I/O: P2 Digital Port B, Bit 7; or, P2 Expansion Address Bit 0 Out
4	Port B - B6	Digital I/O: P2 Digital Port B, Bit 6; or, P2 Expansion Address Bit 1 Out
5	Port B - B5	Digital I/O: P2 Digital Port B, Bit 5; or, P2 Expansion Address Bit 2 Out
6	Port B - B4	Digital I/O: P2 Digital Port B, Bit 4; or, P2 Expansion Address Bit 3 Out
7	Port B - B3	Digital I/O: P2 Digital Port B, Bit 3; or, P2 Expansion Address Bit 4 Out
8	Port B - B2	Digital I/O: P2 Digital Port B, Bit 2; or, P2 Expansion RESET Output
9	Port B - B1	Digital I/O: P2 Digital Port B, Bit 1; or, P2 Expansion WRITE Output
10	Port B - B0	Digital I/O: P2 Digital Port B, Bit 0; or, P2 Expansion READ Output
11	DGND	Digital Ground
12	Not Connected	N/A
13	DGND	Digital Ground
14	Not Connected	N/A
15	DGND	Digital Ground
16	Not Connected	N/A
17	DGND	Digital Ground
18	+ 5 Volt Supply	Expansion +5 Volt Power
19	DGND	Digital Ground
20	+ 5 Volt Supply	Expansion +5 Volt Power
21	DGND	Digital Ground
22	Port C - C7	Digital I/O: P2 Digital Port C, Bit 7; or, P2 Expansion Data Bit 7
23	Port C - C6	Digital I/O: P2 Digital Port C, Bit 6; or, P2 Expansion Data Bit 6
24	Port C - C5	Digital I/O: P2 Digital Port C, Bit 5; or, P2 Expansion Data Bit 5
25	Port C - C4	Digital I/O: P2 Digital Port C, Bit 4; or, P2 Expansion Data Bit 4
26	Port C - C3	Digital I/O: P2 Digital Port C, Bit 3; or, P2 Expansion Data Bit 3
27	Port C - C2	Digital I/O: P2 Digital Port C, Bit 2; or, P2 Expansion Data Bit 2
28	Port C - C1	Digital I/O: P2 Digital Port C, Bit 1; or, P2 Expansion Data Bit 1
29	Port C - C0	Digital I/O: P2 Digital Port C, Bit 0; or, P2 Expansion Data Bit 0
30	Port A - A7	Digital I/O: P2 Digital Port A, Bit 7
31	Port A - A6	Digital I/O: P2 Digital Port A, Bit 6
32	Port A - A5	Digital I/O: P2 Digital Port A, Bit 5
33	Port A - A4	Digital I/O: P2 Digital Port A, Bit 4
34	Port A - A3	Digital I/O: P2 Digital Port A, Bit 3
35	Port A - A2	Digital I/O: P2 Digital Port A, Bit 2
36	Port A - A1	Digital I/O: P2 Digital Port A, Bit 1
37	Port A - A0	Digital I/O: P2 Digital Port A, Bit 0

Specifications – WBK40 and WBK41

Power

Supply Voltage Range: 10 to 30 VDC

Power Out, from P1:

+15 VDC @ 500 mA (via pin 21)

-15 VDC @ 500 mA (via pin 2)

+5 VDC @ 1000 mA (via pin 1)

- Up to eight DBK84 options can be powered from the DB37 P1 connector.
- For applications with 9 to 15 DBK84 options, a DBK32A must be added to the system.
- The WBK41 includes a Power Terminal Block on the front panel. When used, it draws from the total power available to P1.

Fuses:

Input Power Fuse (F201): 4A MINI ATO, user replaceable; refer to page 23 for details.

5V Power Output Fuse (F1): 2.5A resettable; not user replaceable.

General

Operating Temperature: 0° to 50°C (32° to 122°F)

Storage Temperature: -40° to 70°C (-40° to 158°F)

Relative Humidity: 0 to 95%, non-condensing

Vibration: MIL STD 810E

System Connectors:

Analog Expansion: P1, DB37 male connector on rear panel.

Digital Expansion: P2, DB37 male connector on WBK41 rear panel. P2 does not apply to WBK40.

TC/mV Connector: Mini-TC connectors (WBK40 & WBK41)

Digital I/O, Power [out], Counter/Timer, DAC: Removable Screw-Terminal Blocks on front panel, WBK41 only.

A factory installed DBK46 option is required for DAC outputs (see page 17).

Dimensions: 285 mm W x 220 mm D x 70 mm H (11" x 8.5" x 2.70")

Weight: 1.6 kg (3.5 lbs)

A/D Specifications

Type: Successive approximation

Resolution: 16 bit

Conversion Time: 5 μ s

Maximum Sample Rate: 200 kHz

Nonlinearity (Integral): ± 1 LSB

Nonlinearity (Differential): No missing codes

Thermocouple Inputs

Functions: TC types J, K, S, T, E, B, R, N; x100 (voltage)

Inputs: 14 differential TC/mV inputs

Input Voltage Range: ± 100 mV

Input Impedance: 40M Ohm (differential); 20M Ohm (single-ended)

Input Bandwidth: 4 Hz

Input Bias Current: 10 nA typical

CMRR: 100dB typical

Maximum Working Voltage (signal + common mode): ± 10 V

Over-Voltage Protection: ± 40 V

Voltage Accuracy: $\pm(0.2\%$ of reading + 50 μ V)

TC Accuracy: See the following table. Valid for one year, 18 to 28°C

Minimum Resolution: 0.1°C for all TC types

Note: Specifications are subject to change without notice.

TC Accuracy at Measurement Temperature in °C (±°C)											
Type	Min	Max	-100	0	100	300	500	700	900	1100	1400
J	-200	760	0.6	0.5	0.5	0.6	0.7	0.7	—	—	—
K	-200	1200	0.7	0.6	0.6	0.7	0.8	0.8	0.9	1.0	—
T	-200	400	0.7	0.6	0.6	0.6	—	—	—	—	—
E	-270	650	0.6	0.5	0.5	0.5	0.6	—	—	—	—
S	-50	1768	—	2.3	1.8	1.5	1.5	1.4	1.5	1.6	1.6
R	-50	1768	—	2.3	1.6	1.5	1.4	1.4	1.3	1.4	1.5
B	50	1780	—	—	—	3.7	2.4	2.1	1.8	1.7	1.5
N28	-270	400	0.9	0.7	0.7	0.7	—	—	—	—	—
N14	0	1300	—	0.7	0.7	0.7	0.8	0.8	0.9	1.0	—

Input Sequencer

Scan Clock Sources: 2

1. Internal, programmable from 5 μ s to 5.96 hours in 5 μ s steps
2. External, TTL level input up to 200 kHz max; pin 20 on P1.

Depth: 512 locations

Channel-to-Channel Scan Rate: 5 μ s per channel, programmable

Data Buffer: 64 Ksample FIFO

Note for WBK41 Only: Analog, digital and frequency inputs can be scanned synchronously, based on either an internal programmable timer, or an external clock source.

External Acquisition Scan Clock Input

Maximum Rate: 200 kHz

Clock Signal Range: 0V to +5V

Minimum Pulse Width: 50 ns high, 50 ns low

External SYNC Port: Available on rear panel, allows the modules to be synchronized with a WaveBook/516E

Note: Specifications are subject to change without notice.

Triggering

WBK40, Trigger Sources

Four, individually selectable for starting and stopping an acquisition. Stop acquisition can occur on a different channel than start acquisition; stop acquisition can be triggered via modes 2 or 4 described below. Pre-trigger is supported with fixed or variable pre-trigger periods.

WBK41, Trigger Sources

Six, individually selectable for starting and stopping an acquisition. Stop acquisition can occur on a different channel than start acquisition; stop acquisition can be triggered via modes 2, 4, 5, or 6 described below. Pre-trigger is supported with fixed or variable pre-trigger periods.

1. Single-Channel Analog Hardware Trigger

Any analog input channel can be software programmed as the analog trigger channel, including any of the 224 TC expansion channels.

Input Signal Range: -10 V to +10 V max

Trigger Level: Programmable (11-bit resolution)

Hysteresis: Programmable (11-bit resolution)

Latency: 5 μ s max

2. Single-Channel Analog Software Trigger

Any TC input channel, including any of the 224 TC expansion channels, can be selected as the software trigger channel

Input Signal Range: Anywhere within range of the selected trigger channel

Trigger Level: Programmable (16-bit resolution), including "window triggering"

Latency: One scan period max

3. Single-Channel Digital Trigger

A separate digital input is provided for digital triggering.

Input Signal Range: -15V to +15V

Trigger Level: TTL

Minimum Pulse Width: 50 ns high, 50 ns low

Latency: 5 μ s max

4. Software Triggering

Trigger can be initiated under program control.

5. Digital Pattern Triggering

8- or 16-bit pattern triggering on any of the digital input ports. Programmable for trigger on equal, above, below, or within/outside of a window. Individual bits can be masked for "don't care" condition.

Latency: One scan period max

6. Counter/Totalizer Triggering

Counter/totalizer inputs can trigger an acquisition. User can select to trigger on a frequency or on total counts that are equal, above, below, or within/outside of a window.

Latency: One scan period, max.

Note: Specifications are subject to change without notice.

Additional Specifications for WBK41

In addition to the preceding specifications, the following apply to WBK41. They do not apply to WBK40.

Power Out (accessed from front panel Terminal Block connectors):
+15V @ 500 mA; -15 VDC @ 500 mA; +5VDC @ 1000 mA

WBK41 includes a Power Terminal Block on the front panel. When used, it draws from the total power available to P1. The terminal block is not used to power DBK84 modules, but is for general use. Note that the P1 connector, located on the rear panel, supplies power to up to eight DBK84 modules. For applications with 9 to 15 DBK84 options, a DBK32A must be added to the system.

Analog Output (accessed from Terminal Block Connectors, if the optional DBK46 is installed)

Providing that the DBK46 factory-install has been made, four analog output channels can be updated synchronously relative to scanned inputs, or clocked from either an internal onboard clock, or an external clock source. Analog outputs can also be updated asynchronously, independent of any other scanning in the system.

Channels: 4 (DAC0, DAC1, DAC2, and DAC3)

Resolution: 16 bits

Data Buffer: 256 Ksample

Output Voltage Range: $\pm 10V$

Output Current: ± 10 mA

Offset Error: $\pm 0.0045V$ max

Gain Error: $\pm 0.01\%$

Update Rate: 100 kHz max, 1.5 Hz min (no minimum with external clock)

Settling Time: 10 μ sec max to 1 LSB for full-scale step

Digital Feed-thru: a spike of up to 50 mV may occur on the DAC output each time that the DAC output is updated.

Clock Sources: 4, programmable

1. Onboard D/A clock, independent of scanning input clock
2. Onboard scanning input clock
3. External D/A input clock, independent of external scanning input clock

Digital I/O (16 Channels accessed from front panel Terminal Block Connectors, 24 channels accessed from the DB37 P2 connector on the on rear panel):

Channels: 40, expandable up to 272 with external digital DBK options

Input Scanning Modes: 2

1. Asynchronous, under program control at anytime relative to input scanning
2. Synchronous with input scanning

Ports: 3 x 8-bit from the rear panel DB37 (P2) connector; and 1 x 16-bit (front panel screw terminal); each port is programmable as input or output

I/O Levels: TTL

Sampling/Update Rate: 200 kHz max

P2 – Digital I/O Characteristics:

Output Driver:

Resistor & Pull-up: 33 Ω series resistor with a 680 Ω pull-up to 5 V
Current: can only sink current, source-current from pull-up resistor

Output Voltage:

High Level: 2.0 V min @ 4 mA; 4.0 V min @ 1 mA

Low Level: 0.5 V min @ 4 mA

Input Voltage: valid range of - 0.3 V to + 5.0 V

Note: Specifications are subject to change without notice.

Front Panel – Digital I/O Characteristics:

Note: The following characteristics apply to the 16 Digital I/O lines that connect to the front panel's removable screw-terminal blocks.

Output Driver:

Resistor & Pull-up: 100 Ω series resistor with a 10 K Ω pull-up to 5 V

Current: source 12 mA; sink 12 mA

Output Voltage:

High Level: 2.5 V min @ 12 mA

Low Level: 0.5 V min @ 4 mA

Input Voltage: valid range of - 0.3 V to + 5.0 V

Frequency/Pulse Counters

Counter inputs can be scanned synchronously along with analog and digital scanned inputs, based either on internal programmable timer, or an external clock source. Counters can be configured to clear when read, or to totalize and clear under program control.

Channels: 4 x 16-bit; cascadable as 2 x 32-bit

Frequency Measurement Rate: 10 MHz max

Input Signal Range: -15V to +15V

Trigger Level: TTL

Minimum Pulse Width: 50 ns high, 50 ns low

Frequency/Pulse Generators

Channels: 2 x 16-bit

Output Waveform: Square wave

Output Rate: 1 MHz base rate divided by 1 to 65535 (programmable)

High-Level Output Voltage: 2.0V min @ -3.75 mA; 3.0V min @ -2.5 mA

Low-Level Output Voltage: 0.4V max @ 2.5 mA

Ordering Information

Modules

14-channel thermocouple input module for the WaveBook/516E and WBK25	WBK40
Multi-function I/O module for the WaveBook/516E and WBK25	WBK41
14-channel expansion module for the WBK40 and WBK41	DBK84

Accessories & Cables*

Fastener-panel kit for WBK Series Modules	262-0801
Fastener-panel kit for DBK Series Modules	232-0810
Fastener-panel handle	HA-111
DB25M to DB25F, 12 inch parallel cable	CA-35-12
Expansion cable for connecting DBK84 options; specify number of DBK84 options (x) to be connected	CA-37-x
Expansion cable for connecting to DBK expansion products,	
2.5 inch expansion cable	CA-37-1T
4.5 inch expansion cable	CA-37-3T
5.5 inch expansion cable	CA-37-4T
11.5 inch expansion cable	CA-37-8T
SYNC cable for multi-unit synchronization; 1 ft.	CA-74-1
SYNC cable for multiunit synchronization; 5 ft.	CA-74-5
5-pin male DIN to 5-pin male DIN provides convenient connection between WBK40 power input connectors and battery packs	CA-115
5-pin DIN to automobile cigarette lighter power cable, 8 ft.	CA-116
Male Connectors for Subminiature TC Jacks	
Type B male connector	CN-144-BM
Type E male connector	CN-144-EM
Type J male connector	CN-144-JM
Type K male connector	CN-144-KM
Type N male connector	CN-144-NM
Type R male connector	CN-144-RM
Type S male connector	CN-144-SM
Type T male connector	CN-144-TM
Copper to copper male connector	CN-144-UM

Related Products

DBK20 - 48-Line General Purpose Digital I/O Card with two DB37 male connectors for signal outputs
DBK21 - 48-Line General Purpose Digital I/O Card with screw-terminals for signal outputs
DBK23 - 24-Line Optically Isolated Digital-Input Module
DBK24 - 24-Line Optically Isolated Digital-Output Module
DBK25 - 8-Channel Relay-Output Card
DBK32A - Auxiliary Power Supply Card
DBK46 - Analog Output, 4 DACs. *This option, if selected, must be installed at the factory.*
DBK84 - 14-Channel Thermocouple/mV expansion module
WaveBook/516E - 16-bit, 1-MHz sampling, with built in 10/100BaseT Ethernet Interface
WBK25 - Ethernet Interface Module for WaveBook, DaqBook, WBK40, and WBK41

* Additional cables and/or accessories may apply, depending on the WaveBook model and the WBK module(s) that are being used in the WBK40-based [or WBK41-based] data acquisition system.

Note: Ordering information is subject to change without notice.

For connecting to a WaveBook/516E or to a WBK25



WBK40
14 Channel Thermocouple Input Module,
Front & Rear Views



WBK41
Multi-Function Thermocouple I/O Module,
Front & Rear Views

The following instructions pertain to both physical hardware connections and to setting up the WBK40 or WBK41 in the *Daq*Configuration* control panel applet. Setup information regarding complex systems is included in the *WBK Options Manual* (p/n 489-0902) and in the *WaveBook User's Manual* (489-0901). PDF versions of both documents can be accessed from the data acquisition CD from the <View PDFs> button on the CD's opening screen.

CAUTION



Turn off power to the system devices and externally connected equipment before connecting cables. Electric shock or damage to equipment can result even under low-voltage conditions.



Take ESD precautions (packaging, proper handling, grounded wrist strap, etc.)



Reference Note: Adobe PDF versions of user manuals will automatically install onto your hard drive as a part of product support. The default location is in the **Programs** group, which can be accessed from the *Windows Desktop*. You can also access documents directly from the data acquisition CD via the <View PDFs> button located on the CD's opening screen.

Minimum System Requirements

- PC system with Pentium® Processor
- Windows 2000 or Windows XP (Note 1)
- 64 Mbytes of RAM

Note 1: Consult the factory in regard to using other Windows operating systems.



Power-up Notice for WaveBook/516E and WBK25 Applications:

When powering up the data acquisition system it is important that the WaveBook/516E or WBK25 is powered last, and that the most remote system components are powered first. Other power-up sequences will result in software's failure to recognize all components.*

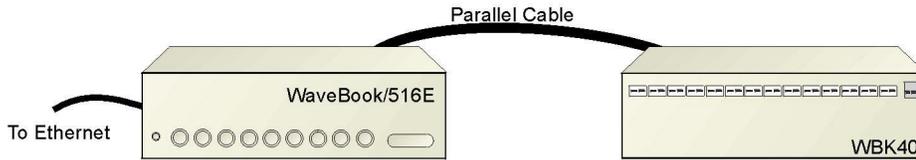
- First, power-on the WBK expansion modules.
- Second, power-on the WBK40 or WBK41, or DBK modules that are connected to the expansion ports of the WaveBook/516E or WBK25.
- Finally, power-on the WaveBook/516E or WBK25.

* An exception to this power-up scheme is to power-on the entire system at once.



These instructions begin with the assumption that the following two conditions are satisfied: (1) the WaveBook/516E or WBK25 is already connected to the Ethernet, and (2) the associated software from the data acquisition CD is installed. If needed, refer to the documents associated with those devices.

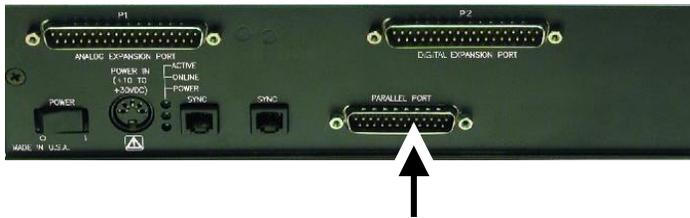
STEP 1 – Connect the WBK40 or WBK41 to an Expansion Port on the WaveBook/516E or on the WBK25



Connecting a WBK40 to a WaveBook/516E

What you will need:

One parallel port cable, e.g. a CA-35-2 (2-foot) or a CA-35-12 (1-foot) cable.

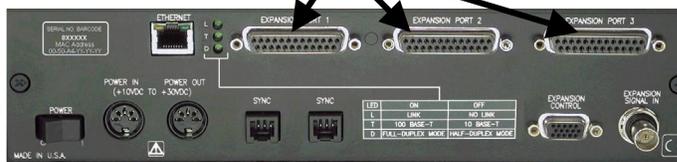


DB25 Parallel Port Connector

How to make the connection:

1. Place the WaveBook/516E or WBK25 power switch in the “OFF” (0) position, if it is not already OFF.
2. Connect the parallel port cable to the parallel port connector on the rear panel of the WBK40 or WBK41. See the preceding picture.
3. Connect the other end of the cable to one of three expansion ports on the WaveBook/516E or WBK25.

Parallel (Expansion) Ports



Parallel Ports (Expansion Ports) on a WaveBook/516E



Parallel Ports (Expansion Ports) as they appear on a WBK25

STEP 2 – Connect the WBK40 or WBK41 to Power

What you will need:

A power supply with a range of +10 VDC to +30 VDC.
The power supply needs to have a male DIN5 connector.

Note: The switching-mode power supply that is commonly used has an input range of 100 VAC to 240 VAC at 50 Hz to 60 Hz. The power supply's output [to the device] is 15 VDC @ 2.7 amps via a DIN5 connector.

Note: Various AC adapter models support power grids of USA, Europe, Japan, and Asia.



Reference Note: It is possible to use a VDC power source other than the commonly used switching-mode power supply, often referred to as an adapter. However, you should consult the *Power Management Section* of your *WaveBook User's Manual* (p/n 489-0901) before doing so.



DIN5 POWER IN Connector (+10 to +30 VDC)

How to make the connection:

1. Place the WBK40 or WBK41 power switch in the “OFF” (0) position, if it is not already OFF.
2. Connect the DIN5 end of the adapter's cable to the power in connector on the WBK40 or WBK41 (see preceding figure).

If using a power source other than the adapter, consult the *Power Management Section* of your *WaveBook User's Manual* (p/n 489-0901) before doing so.

3. Connect the adapter's plug to a standard AC outlet.
4. If your adapter has a power switch, position it to “ON.”
5. Turn ON the WBK40 or WBK41 by placing the unit's power switch to the “1” position. The power led will light up.
6. Turn the WaveBook/516E or WBK25 “ON” by placing the unit's power switch to the “1” position. The power led will light up.

STEP 3 – Configure and Test the Hardware

The *Daq* Configuration* applet, designed for 32-bit Windows 95/98/Me/NT/2000/XP systems, is located in the Windows *Control Panel*. It allows you to add or remove a device and change configuration settings. The included test utility provides feedback on the validity of current configuration settings, as well as performance summaries.

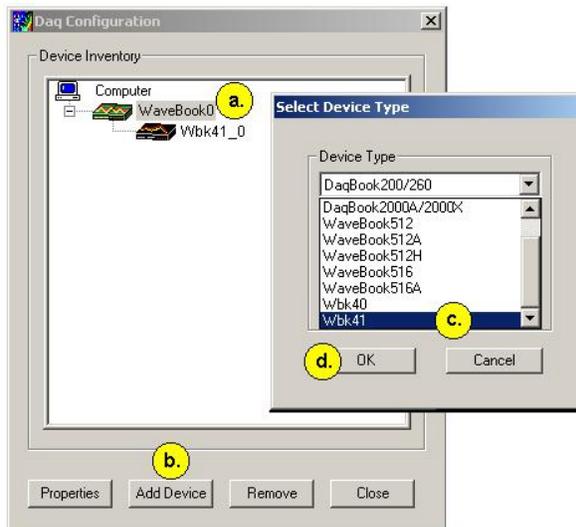
1. Open the *Daq* Configuration* Applet.

- a. Open the Control Panel by navigating from the Windows' Desktop as follows:
Start Menu ⇒ Settings ⇒ Control Panel
- b. From the Control Panel, double-click the *Daq* Configuration* icon.

2. Add the *WBK40* or *WBK41*.

In the *Daq Configuration* applet, add the *WBK40* or *WBK41* to one of the three expansion ports of the *WaveBook/516E* or *WBK25*.

- a. Select the *WaveBook/516E* or *WBK25* in the *Device Inventory* configuration tree (see following figure).
- b. Click the **<Add Device>** button. The “*Select Device Type*” box will appear.
- c. Select “*WBK40*” or “*WBK41*” from the device list, as applicable.
- d. Click the **<OK>** button. The “*Properties*” box for the device will appear.



*Adding a **WBK40** or **WBK41** to a **WaveBook/516E** or **WBK25***

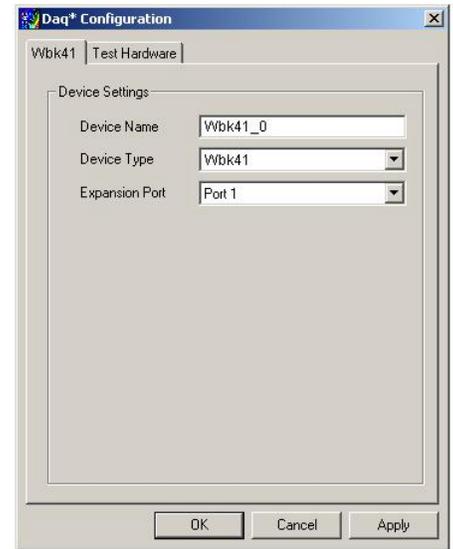
Note: Devices have default names, for example, *WBK40_0*. If desired, you can change the device name.

3. Set the Expansion Port number.

In our current setup, the WBK40 or WBK41 is a second-level device. This is because it is connected to an expansion port of a first-level device, i.e., the WaveBook/516E or WBK25.

For this step select the expansion port number to which the WBK40 or WBK41 is connected, i.e., Port 1, Port 2, or Port 3.

Note: The WBK40 or WBK41 make use of the same IP address as the WaveBook/516E or WBK25 to which they are connected. For this reason no configuration of the IP address is called for in the second-level device's properties box.



Setting the Expansion Port Number

4. Test the system connections.

- Make sure the device has been properly installed and is powered-on.
- Make sure all cables are properly and securely connected.
- Click the "Test Hardware" tab.
- Click the <Resource Test> button.

Note: The test results have two components: *Resource Tests* and *Performance Tests*. Each is described briefly.



**Daq* Configuration
Test Hardware Tab**

Resource Tests. The resource tests are intended to test system capability for the current device configuration. Resource tests are *pass/fail*. Test failure may indicate a lack of availability of the resource, or a possible resource conflict.

Base Address Test. This resource test checks the base address for the selected port. Failure of this test may indicate that the port is not properly configured within the system. See relevant operating system and computer manufacturer's documentation to correct the problem.

Interrupt Level Test – Tests the ability of a parallel port to generate interrupts. Failure of this test may indicate that the parallel port may be currently unable to generate the necessary hardware interrupt, while other parallel port devices may work OK in this mode. Some parallel port devices (such as printers) do not require interrupts to work properly. See relevant operating system and computer manufacturer's documentation to correct the problem.

Performance Tests. These types of tests are intended to check various device functions, using the current device configuration. Performance tests provide quantitative results for each supported functional group.

Test results represent maximum rates the various operations can be performed. The rates depend on the selected parallel port protocol, and vary according to port hardware capabilities.



Testing the WBK40 or WBK41 may, in some cases, cause the system to hang. If test results are not displayed in 30 seconds or the system does not seem to be responding, reboot the system. Upon power-up, re-enter the Daq Configuration and change the device configuration settings to those that work properly.

This completes the instructions for connecting a WBK40 or WBK41 to a WaveBook/516E or WBK25. At this point you should refer to the *WaveBook User's Manual* (p/n 489-0901) and to the WBK40 & WBK41 section of the *WBK Options Manual* (p/n 489-0902) for additional system information. The document includes pinouts, information on system expansion, data acquisition, and links to software and programming documents (in PDF format).

You can access the documents directly from the opening screen of the data acquisition CD via the <View PDFs> button.



Reference Notes:

- If you experience difficulties, please consult the additional user documentation before calling technical support. User documentation is included on your data acquisition CD, and is installed automatically as a part of product support, when your software is installed. The default location is the Programs Group. The documentation includes API information, pinouts, troubleshooting, and a great deal of material regarding specific DBK cards and modules.
- Documents can be read directly from the data acquisition CD via the <View PDFs> button located on the opening screen.
- Hardcopy versions of the manuals can be ordered from the factory.

Description

The WBK61 and WBK62 are single-channel high-voltage adapters that can be used with WaveBooks, or with WBK10A expansion modules. In addition, WBK61 and WBK62 can be used with WBK11A, WBK12A and WBK13A signal conditioning cards.

WBK61 and WBK62, Product Comparison		
	WBK61	WBK62
Voltage Divider	200:1 fixed	20:1 fixed
Maximum Voltage	1000 V_{peak} (on either input reference to earth ground)	100 V_{peak} (on either input reference to earth ground)
Maximum Differential Voltage	2000 V_{peak} (if neither input exceeds 1000 V _p rating to earth ground)	200 V_{peak} (if neither input exceeds 100 V _p rating to earth ground)

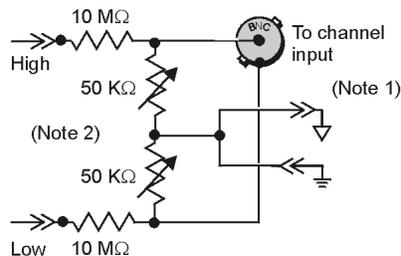
The channel output connection [for both the WBK61 and WBK62 voltage adapters] is made through a BNC-to-BNC coupler. Each model has two signal input-connections, one for low-signal input, and the other for high-signal input. The input channels are resistively isolated from ground, providing for safe connection of the test device. Series resistors, for both high and low channels, serve as attenuators and provide a maximum current limit of 100 μ A.

The WBK61 and WBK62 include:

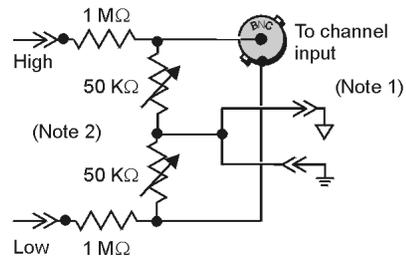
- Input HI, safety-style banana-jack
- Input LO, safety-style banana-jack
- 60-inch (152 cm) cables with probe tips and alligator clips
- Green stacking banana plug (for analog common)
- CN-110 BNC-to-BNC Coupler
- CN-111 Banana Plug/Alligator-clip earth-ground cable

The following figure provides a simplified schematic for each model.

WBK61, with 200:1 Divider Ratio



WBK62, with 20:1 Divider Ratio



WBK61 and WBK62 Schematics

Note 1: Channel input connections are made from the WBK61/62 BNC to a Channel BNC on the WaveBook data acquisition system or to the WBK10A analog expansion module. A CN-110 BNC-to-BNC Coupler is used to make the connection. Refer to the [Hardware Setup](#) section of this document module for information regarding channel and ground connections.

Note 2: The variable resistors are factory set at 50 K Ω and are not user-adjustable.

Hardware Setup

Refer to the following steps and figures to connect the high voltage adapter. Note that we will use the term “WBK61/62” to refer to both WBK61 and WBK62 since the installation of these models is identical.

WARNING



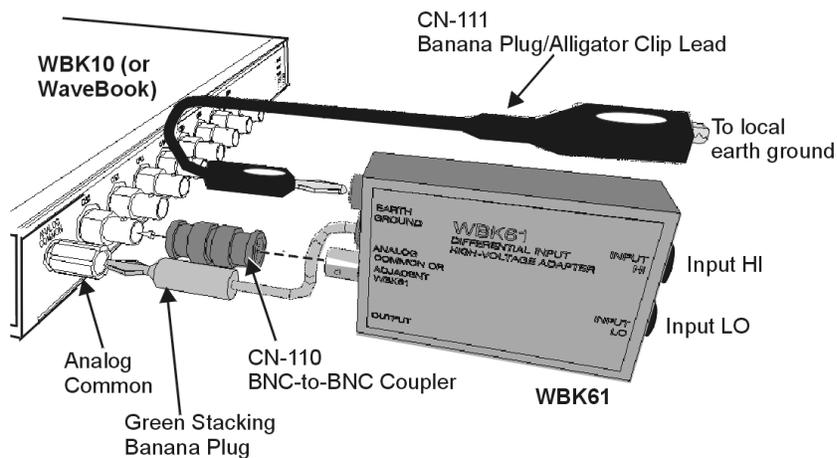
High voltages can cause death or severe injury. Do not connect or disconnect the probes from WBK61 or WBK62 when the leads are connected to a voltage source.

WARNING



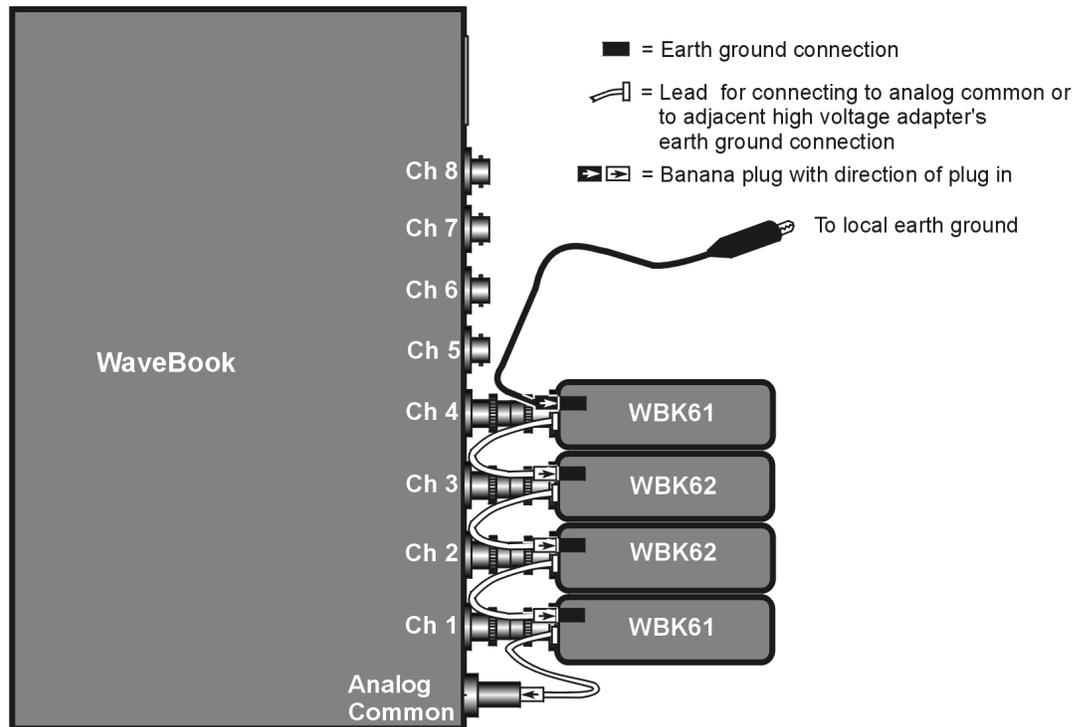
Failure to properly connect a WBK61 or WBK62 to the acquisition device (WaveBook or WBK10A) and to ground will result in unsafe operation.

1. Connect WBK61/62 to any input channel(s) of the WaveBook or WBK10A module using the supplied BNC-to-BNC coupler (CN-110). Refer to the following figures.
2. *If connecting only one WBK61/62*, connect the green stacking banana plug to analog common (J12) on the WaveBook or WBK10A module.



A WBK61 Being Connected to a Channel 1 BNC

If connecting two or more WBK61/62s, connect the green stacking banana plug of the first WBK61/62 to analog common (J12) on the WaveBook or WBK10A module. Connect the other WBK61/62 stacking banana plugs to the adjacent WBK61/62 earth ground connections (see following figure).



Example: Two WBK61 and two WBK62 High Voltage Adapters Connected to a WaveBook/512

3. **If connecting only one WBK61/62**, connect the green *banana plug/alligator clip* lead (CN-111) from the WBK61/62 earth ground connector to the local earth ground.

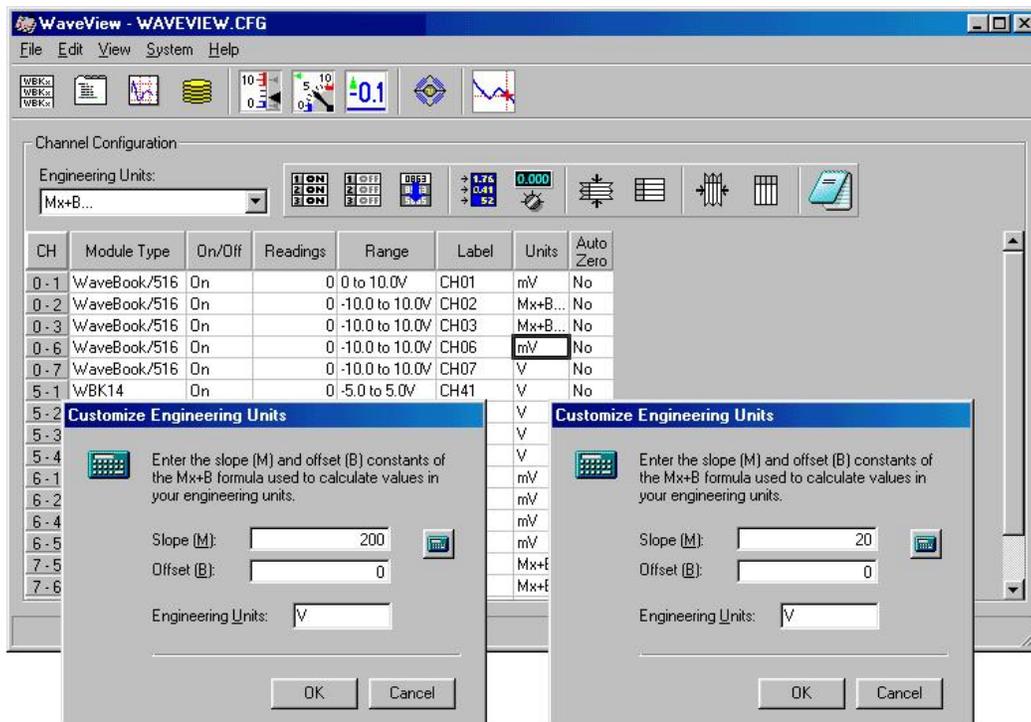
If connecting two or more WBK61/62s, connect the green *banana plug/alligator clip* lead (CN-111) from the *last* WBK61/62 earth ground connector to the local earth ground. Refer also to step 2 and the above figure.

4. Connect the input leads (CA-152) to the WBK61/62 *Input HI* and *Input LO* jacks.
5. Connect the test leads (CA-152) to the circuit under test. You may use alligator clips (CN-109) to connect test leads.

If desired, set the applicable WaveBook channel(s) to the appropriate scale by setting the $mx+b$ function in the WaveView program as discussed in the following section, *Software Setup*.

Software Setup

Depending on your application, you will need to set several software parameters so that *WaveView* will organize data to meet your requirements. Of special importance is the correct setting of the scaling factor. This is done using the $mx + b$ equation.



For WBK61 Applications, set "m" to 200.

For WBK62 Applications, set "m" to 20.

WaveView Configuration Main Window

with "*Customize Engineering Units*" dialog boxes for setting $Mx + B$ and *Engineering Units**

***Note:** In actual applications only one *Customize Engineering Units* box is displayed.

To configure units for WBK61 and WBK62, you must use the *Customize Engineering Units* dialog box to ensure the units are correctly scaled. This is done as follows:

1. Right-click on the *Units* column (in *WaveView*'s main window).
2. Select $mx + b$ in the *Units* box. The *Configure Engineering Units* dialog box will appear.
3. For WBK61: set m to 200 (see previous figure)
For WBK62: set m to 20 (see previous figure)



Reference Notes:

- For detailed *WaveView* information, refer to the *WaveView Document Module*. The document can be accessed directly from the data acquisition CD via the <View PDFs> button located on the CD's opening screen.
- If you intend to write your own computer programs refer to the *Programmer's Manual* (p/n 1008-0901) as needed. Note that the API does not contain functions that are specific to WBK61 or WBK62. The document can be accessed directly from the data acquisition CD via the <View PDFs> button located on the CD's opening screen.

WBK61 and WBK62 - Specifications

Name/Function:

WBK61, High-Voltage Adapter with Probes, 200:1 Voltage Divider

WBK62, High-Voltage Adapter with Probes, 20:1 Voltage Divider

Number of Channels: 1

Dimensions: 83 mm × 61 mm × 19.5 mm (3.25" × 2.375" × 0.77")

Cables: 60" leads with detachable probe tips and alligator clips

Output Connector: BNC female

Voltage Divider:

WBK61: 200:1 fixed

WBK62: 20:1 fixed

Maximum Voltage

WBK61: 1000 V_{peak} (on either input reference to earth ground)

WBK62: 100 V_{peak} (on either input reference to earth ground)

Maximum Differential Voltage:

WBK61: 2000 V_{peak} (if neither input exceeds 1000 V_p rating to earth ground)

WBK62: 200 V_{peak} (if neither input exceeds 100 V_p rating to earth ground)

Frequency Characteristics: approximates a single-pole frequency response

-3 dB Bandwidth: 200 kHz minimum

WBK61, Effective Voltage Ranges		
Range	WaveBook	WBK10A
Bipolar	±2000V	±2000V
	±1000V	±1000V
	±400V	±400V
	±200V	±200V
	±100V*	±100V*
	±40V*	±40V*
	±20V*	±20V*
Unipolar	Not Available	0 to 2000V
		0 to 1000V
		0 to 400V
		0 to 200V
		0 to 100V*
		0 to 40V*
		0 to 20V*

WBK62, Effective Voltage Ranges		
Range	WaveBook	WBK10A
Bipolar	±200V	±200V
	±100V	±100V
	±40V	±40V
	±20V	±20V
	±10V*	±10V*
	±4V*	±4V*
	±2V*	±2V*
Unipolar	Not Available	0 to 200V
		0 to 100V
		0 to 40V
		0 to 20V
		0 to 10V*
		0 to 4V*
		0 to 2V*

*Available through the WBK11A, WBK12A, or WBK13A option cards.

Measurement Errors:

The following values include total system error, i.e., they include errors from WaveBook, WBK10A, WBK11A, WBK12A, and WBK13A. The value for gain error does not include offset error.

Gain Error:

0.1% FS (unipolar)

0.2% FS (bipolar)

Offset Error:

0.1% FS (unipolar)

0.2% FS (bipolar)

Glossary

Acquisition	A collection of scans acquired at a specified rate as controlled by the sequencer.
Analog	A signal of varying voltage or current that communicates data.
Analog-to-Digital Converter (ADC)	A circuit or device that converts analog values into digital values, such as binary bits, for use in digital computer processing.
API	Application Program Interface. The interface program within the data acquisition system's driver that includes function calls specific to the acquisition hardware and can be used with user-written programs. Several languages are supported.
Bipolar	A range of analog signals with positive and negative values (e.g., -5 to +5 V); see <i>unipolar</i> .
Buffer	<p><i>Buffer</i> refers to a circuit or device that allows a signal to pass through it, while providing isolation, or another function, without altering the signal. <i>Buffer</i> usually refers to:</p> <ul style="list-style-type: none">(a) A device or circuit that allows for the temporary storage of data during data transfers. Such storage can compensate for differences in data flow rates. In a FIFO (First In - First Out) buffer, the data that is stored first is also the first data to leave the buffer.(b) A follower stage used to drive a number of gates without overloading the preceding stage.(c) An amplifier which accepts high source impedance input and results in low source impedance output (effectively, an impedance buffer).
Buffer Amplifier	An amplifier used primarily to match two different impedance points, and isolate one stage from a succeeding stage in order to prevent an undesirable interaction between the two stages. (Also see, <i>Buffer</i>).
Channel	<p>In reference to data acquisition, <i>channel</i> simply refers to a single <i>input</i>, or <i>output</i> entity.</p> <p>In a broader sense, an <i>input channel</i> is a signal path between the transducer at the point of measurement and the data acquisition system. A channel can go through various stages (buffers, multiplexers, or signal conditioning amplifiers and filters). Input channels are periodically sampled for readings.</p> <p>An <i>output channel</i> from a device can be digital or analog. Outputs can vary in a programmed way in response to an input channel signal.</p>
Common mode	Common mode pertains to signals that are identical in amplitude and duration; also can be used in reference to signal components.
Common mode voltage	Common mode voltage refers to a voltage magnitude (referenced to a common point) that is shared by 2 or more signals. Example: referenced to common, Signal 1 is +5 VDC and Signal 2 is +6 VDC. The common mode voltage for the two signals is +5.5 VDC $[(5 + 6)/2]$.
Crosstalk	An undesired transfer of signals between systems or system components. Crosstalk causes signal interference, more commonly referred to as <i>noise</i> .
Detection Signal	In relation to WBK17, a detection signal is one of 8 outputs of the pattern detection module. Each input channel has an associated detection signal (Detect 1 for Channel 1, Detect 2 for Channel 2, etc.) A channel's detection signal will go active high when that channel's counter value meets the setpoint criteria programmed into the pattern detection module. Detection signals can be scanned along with any other channel in the scan group.

Digital	A digital signal is one of discrete value, in contrast to a varying signal. Combinations of binary digits (0s and 1s) represent digital data.
Digital-to-Analog Converter (DAC)	A circuit or device that converts digital values (binary bits), into analog signals.
DIP switch	A DIP switch is a group of miniature switches in a small <i>Dual In-line Package</i> (DIP). Typically, users set these switches to configure their particular application.
Differential mode	The differential mode measures a voltage between 2 signal lines for a single channel. (Also see <i>single-ended mode</i>).
Differential mode voltage	Differential mode voltage refers to a voltage difference between two signals that are referenced to a common point. Example: Signal 1 is +5 VDC referenced to common. Signal 2 is +6 VDC referenced to common. If the +5 VDC signal is used as the reference, the differential mode voltage is +1 VDC (+ 6 VDC - +5 VDC = +1 VDC). If the +6 VDC signal is used as the reference, the differential mode voltage is -1 VDC (+ 5 VDC - +6 VDC = -1 VDC).
Encoder Mode	The <i>encoder mode</i> allows the WBK17 to make use of data from optical incremental quadrature encoders. When in the <i>encoder mode</i> , the WBK17 accepts either <i>differential</i> or <i>single-ended</i> inputs and provides power for up to four encoders. When reading phase A, phase B, and index Z signals, the WBK17 provides positioning, direction, and velocity data.
ESD	Electrostatic discharge (ESD) is the transfer of an electrostatic charge between bodies having different electrostatic potentials. This transfer occurs during direct contact of the bodies, or when induced by an electrostatic field. ESD energy can damage an integrated circuit (IC); so safe handling is required.
Excitation	Some transducers [e.g. strain gages, thermistors, and resistance temperature detectors (RTDs)] require a known voltage or current. Typically, the variation of this signal through the transducer corresponds to the condition measured.
Gain	The degree to which an input signal is amplified (or attenuated) to allow greater accuracy and resolution; can be expressed as $\times n$ or $\pm dB$.
Gating	In relation to the WBK17, any counter can be gated by the mapped channel. When the mapped channel is high, the counter will be allowed to count, when the mapped channel is low, the counter will not count but hold its value.
Isolation	The arrangement or operation of a circuit so that signals from another circuit or device do not affect the <i>isolated</i> circuit. In reference to data acquisition, <i>isolation</i> usually refers to a separation of the direct link between the signal source and the analog-to-digital converter (ADC). Isolation is necessary when measuring high common-mode voltage.
Linearization	Some transducers produce a voltage in linear proportion to the condition measured. Other transducers (e.g., thermocouples) have a nonlinear response. To convert nonlinear signals into accurate readings requires software to calibrate several points in the range used and then interpolate values between these points.

Mapped Channel	In relation to the WBK17, a mapped channel is one of 16 signals that can get multiplexed into a channel's counter module. The mapped channel can participate with the channel's input signal by gating the counter, clearing the counter, etc. The 16 possible choices for the mapped channel are the 8 input signals (post debounce) and the 8 detection signals.
Multiplexer (MUX)	A device that collects signals from several inputs and outputs them on a single channel.
Sample (reading)	The value of a signal on a channel at an instant in time. When triggered, the ADC reads the channel and converts the sampled value into a 12- or 16-bit value.
Scan	The channels that are selected for sampling.
Sequencer	A programmable device that manages channels and channel-specific settings.
Simultaneous Sample-and-Hold	An operation that gathers samples from multiple channels at the same instant and holds these values until all are sequentially converted to digital values.
Single-ended mode	The single-ended mode measures a voltage between a signal line and a common reference that may be shared with other channels. (Also see <i>differential mode</i>).
Start of Scan	In relation to the WBK17, "start of scan" is a signal that is internal to the WBK17. It signals the start of a scan group and therefore pulses once every scan period. It can be used to clear the counters and latch the counter value into the acquisition stream.
Terminal Count	In relation to theWBK17, this signal is generated by the counter value. There are only two possible values for the terminal count: 65,535 (for a 16-bit counter) and 4,294,967,295 (for a 32-bit counter.) The terminal count can be used to stop the counter from rolling over to zero.
Ticksize	In relation to theWBK17, the ticksize is a fundamental unit of time and has four possible settings: 20ns, 200ns, 2000ns, 20000ns. For measurements that require a timebase reference like period or pulsewidth, the ticksize is the basic unit of time. The count value returned in the scan is the number of ticks that make up the time measurement.
Trigger	An event to start a scan or mark an instant during an acquisition. The event can be defined in various ways; e.g., a TTL signal, a specified voltage level in a monitored channel, a button manually or mechanically engaged, a software command, etc. Some applications may use pre- and post-triggers to gather data around an instant or based on signal counts.
TTL	Transistor-Transistor Logic (TTL) is a circuit in which a multiple-emitter transistor has replaced the multiple diode cluster (of the diode-transistor logic circuit); typically used to communicate logic signals at 5 V.
Unipolar	A range of analog signals that is always zero or positive (e.g., 0 to 10 V). Evaluating a signal in the right range (unipolar or bipolar) allows greater resolution by using the full-range of the corresponding digital value. See <i>bipolar</i> .