Reference Notes:

o Chapter 2 includes pinouts for P1, P2, P3, and P4. Refer to pinouts applicable to your system, as needed.

o In regard to calculating system power requirements, refer to *DBK Basics* located near the front of this manual.
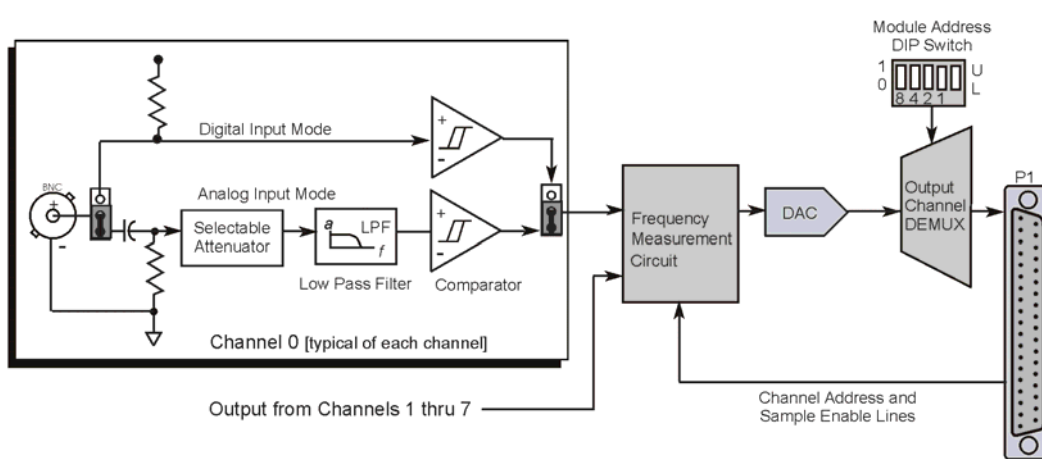

DBK55 Module

Overview

Features of the DBK55

The DBK55 can be used for diverse frequency-monitoring applications. Typical uses include measuring the flow of liquids with a flowmeter and measuring rotation (rpm) with a shaft encoder. The monitored process must generate a series of electrical pulses whose frequency is related to the desired variable.

Features of the DBK55 include:
- Inputs can be analog (high or low level) or digital.
- Each channel has a programmable frequency range.
- Noise effects can be minimized by debounce, attenuation, and low-pass filtering.
- Up to 32 DBK55s can be used with a single LogBook or Daq device for a maximum of 256 channels.

The digital-to-analog converter (DAC) outputs a voltage from -5 V to +5 V to correspond with the selected frequency range. The DaqBook directs the DBK55 module's DAC to convert the data from the proper input channel.


DBK55 Block Diagram

As indicated in the next figure, the DBK55 module completes the following functions for each channel:
- Conditions an input signal
- Selects the signal's rising or falling edge
- Debounces the edge
- Measures the signal's frequency.
- Sends a voltage (V_{out}) analog signal [which corresponds to the measured frequency] from the DAC to the primary data acquisition device.

These functions are discussed in the upcoming text.
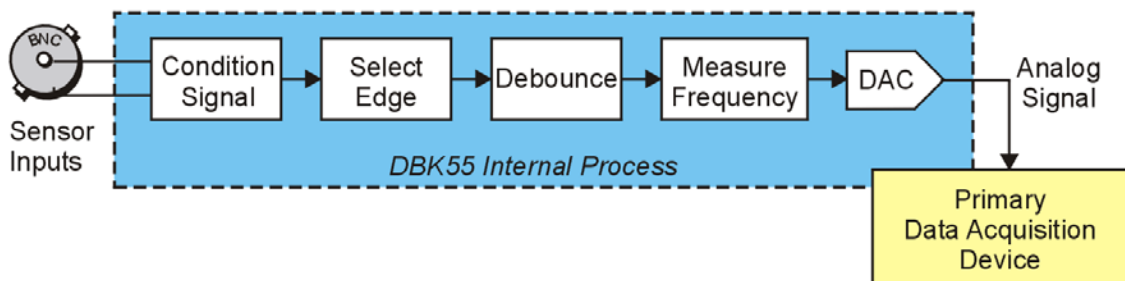

DBK55 System Functionality

Input Signal Conditioning

The DBK55 conditions the input signal in several ways to provide the best output accuracy. Reducing noise and limiting the bandwidth are the first steps in the conditioning process and are done in hardware. Software can further clean up the signal by selecting the cleanest edge to read and by setting a debounce delay to ignore spurious signals. The debounce concept is discussed on page 4.

Analog Input Signal Conditioning

<table>
<tr><td colspan="2" align="center">WARNING</td></tr>
<tr><td>⚠️</td><td>Input voltages should be at least 50 mV peak-to-peak. The maximum analog input signal is 30 Vrms (42 Vpeak, 84 Vp-p). Stronger signals may damage the DBK55 or present an electrical shock hazard.</td></tr>
</table>
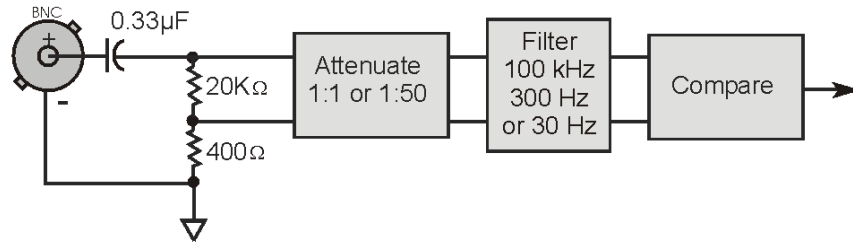
When a channel's two "input circuit jumpers" are set for analog, the center conductor of the BNC connector is AC-coupled through a 0.33 µF capacitor to the attenuator. The outside conductor connects to ground. With the attenuator disabled [full sensitivity] input-protection diodes limit the signal to about 1.5 Vp-p. Larger signals will see an impedance of 6.7 KΩ (rather than 20 KΩ) in series with 0.33 µF. With the attenuator enabled, the input impedance remains 20 KΩ regardless of the input level.

After AC-coupling, attenuation and filtering, a comparator converts the input signal into a clean digital signal. The comparator output is high when the center-pin signal is higher than the outside-conductor signal and low when the center-pin is lower than the outside-conductor signal. The comparator has hysteresis to reduce the effects of noise by ignoring small signals.

The following graph shows typical sine-wave sensitivity in peak-to-peak voltage vs frequency. Six combinations of attenuation (on/off) and low-pass filtering (30 Hz, 300 Hz, and 100 kHz) are graphed.
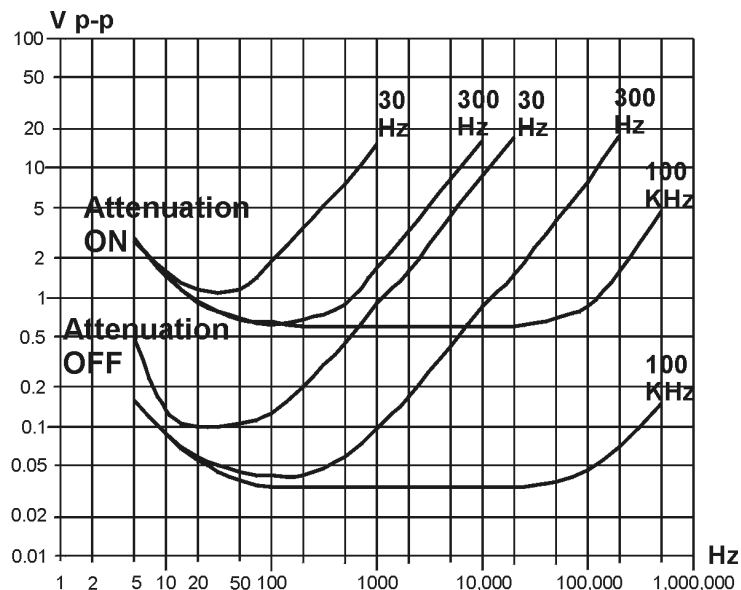


Digital Input Signal Conditioning

CAUTION
⚠️ **The input signal may range from -15 to +15 V. Higher voltages may damage the DBK55.**

The digital input circuit is represented in the left-hand figure, below. When both of a channel's "input circuit jumpers" are set for digital, the outside (shield) conductor of the BNC connector connects to ground. The center conductor is pulled up with 27 KΩ to +5 V and then passes through a 2.7 KΩ protection resistor before being detected by a Schmitt-trigger buffer with input-protection diodes.

The input thresholds are fixed TTL levels. Below 0.5 V (0.8 V typical), the Schmitt-trigger buffer output is low. Above 2.1 V (1.6 V typical), the buffer output is high. The 27 KΩ pull-up resistor allows the digital inputs to sense switches or relays connected directly to the DBK55 as shown in the figure. The debounce circuit can remove noise effects of switching. Debouncing is discussed later on this page.

V (volts)	I (mA)
-15	-6.3
0	-0.2
5	0
15	4.1
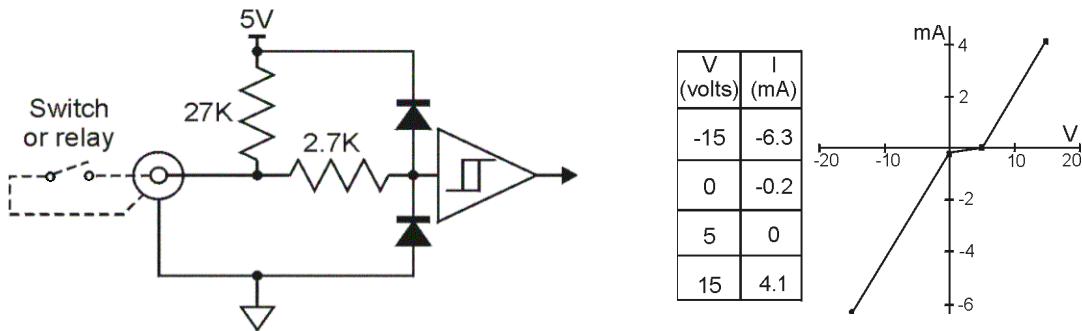
The input impedance for digital signals depends on the signal level. For signals between 0 and 5 V, the input-protection diodes do not conduct, and the digital input impedance is just the 27 KΩ pull-up resistance. For signals less than 0 V or greater than 5 V, the input-protection diodes conduct and the impedance drops to about 2.4 KΩ. The figure (upper right) shows the approximate digital-input current/voltage relationship.

Edge Selection

The DBK55 determines the frequency by measuring the time between successive rising or falling edges of the input signal. Which edge is electrically cleaner depends on the application and related components. If rising edges are used, the edge-selection circuit does not modify the signal. If falling edges are used, the circuit inverts the signal so falling edges appear as rising edges to the subsequent circuits. Through software, each channel can be independently set for rising- or falling-edge.

Debouncing

Debouncing is a process of ignoring signals too short to be real events. When a relay or switch closes, the electrical contacts may not initially make good contact. Mechanical vibrations can occur, and contact is made and broken several times before stabilizing. Counting all these signals would yield too high a frequency. The debounce circuit solves this problem by ignoring rising edges not preceded by a sustained low signal. The sustain interval can be set in software to 0, 0.6, 2.5, or 10 ms for each channel. Debouncing may be disabled (0 ms) for clean, high-frequency signals. Long debounce times will limit high-frequency response (e.g., a 10 ms debounce will limit the frequency to about 100 Hz). In general, use "0" (debounce disabled) for clean, high-frequency signals; increase the debounce as needed for noisy, low-frequency signals from switches and relays.

The figure shows the effect of 10 ms debouncing on a noisy signal. To be counted, a rising edge must be preceded by a low sustained for at least 10 ms without any other edges. Rising edges **a** and **f** are counted because they are preceded by low signal levels sustained for at least 10 ms (the debounce time). All other rising edges (**b**, **c**, **d**, and **e**) are ignored. Any falling edge makes (or keeps) the debounced output low, regardless of preceding edges. Thus, the DBK55 can detect short pulses even with debouncing.
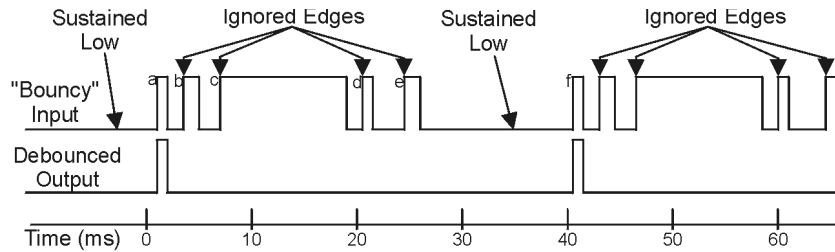
Frequency Measurement

After debouncing, the signal's frequency is ready to be measured. Frequencies are measured to 12-bit accuracy between a minimum frequency (F_{min}) and maximum frequency (F_{max}). This frequency range can be programmed individually for each channel. The limitations on F_{min} and F_{max} are:

- The frequency range must be within 0 to 1 MHz.
- F_{max} - F_{min} must be at least 1 Hz.
- F_{max} / F_{min} must be at least 100/99 (1.010101).

Based on F_{min} and F_{max}, the DBK55 measures the frequency by counting input cycles during a variable time interval. The length of the interval depends on the difference between F_{min} and F_{max}.

- For a wide range (when F_{min} and F_{max} are far apart), each bit of the 12-bit result represents a large frequency change and can be measured quickly.
- For a narrow range (when F_{min} and F_{max} are close together), each bit of the 12-bit result represents a small frequency change and takes longer to measure.

The following equation determines the time interval needed to measure a frequency:

$$\textbf{Minimum Measurement Period (sec)} = (4096 \times 0.5\ \mu s)\ [F_{max}/(F_{max} - F_{min})]$$

In this equation: 4096 derives from 12-bit precision; 0.5 µs is the resolution of the DBK55's timing circuits; and F_{max} / (F_{max} - F_{min}) is the ratio the measurement time must be increased to achieve 12-bit accuracy over the selected range.

To see how the measurement period varies, consider two examples:

- To measure frequencies from 59 to 61 Hz, the measurement period is at least
  4096 x 0.5 µs x 61/2 = 62.5 ms, or about 16 measurements per second.
- To measure frequencies from 1 to 61 Hz, the measurement period is at least
  4096 x 0.5 µs x 61/60 = 2.1 ms. Note that as the DBK55 only measures frequency once per cycle, it would take from 1 to 61 measurements per second.

Thus, measuring frequencies over a narrow range takes longer than over a wide range as the ratio of $F_{max}/(F_{max} - F_{min})$. The actual measurement time is the sum of several items: the minimum measurement period (from the equation above), the actual input period, and a variable processing time of 0 to 4 ms.

Note: **If the Sequence Rep Rate is set faster than the measurement rate, multiple readings of the same measurement will occur.**

After the frequency (F) is measured to the required accuracy, it is scaled to a 12-bit number (D) for use by the Digital to Analog Converter (DAC). This 12-bit number is determined by the formula:

$$D = 4096\ [(F - F_{min}) / (F_{max} - F_{min})];\ \text{where: } 0 < DAC < 4096$$

If the measured frequency is F_{min}, then the scaled result is 0. If the measured frequency were F_{max}, then the scaled result would be 4096 but is limited to 4095. Measured frequencies below F_{min} are scaled as 0; frequencies above F_{max} are scaled as 4095. The highest frequency that produces an accurate result is the one that converts to a DAC value of 4095; that is, $F_{min} + 4095/4096$ ($F_{max} - F_{min}$) which is the same as $F_{max} - 1/4096$ ($F_{max} - F_{min}$).

Digital-to-Analog Conversion

The 12-bit scaled result of the frequency measurement is stored in a DAC to be read by the data acquisition system. The DBK55 makes use of two DACs. The first DAC is shared by channels 0 through 3 and the second by channels 4 through 7. Each time the LogBook or Daq device addresses a different DBK55 channel, the associated DAC supplies the corresponding voltage (V_{out}) according to the formula:

$$V_{out} = 10.0 \ (D/4096) - 5.0 \ V$$

Since DAC values (D) range from 0 to 4095, DBK55 output voltages range from -5.0000 to +4.9976 V.

Calibration for the DBK55 is automatic. When the DBK55 is initialized through software, its gain and offset errors are measured. The output circuits are then adjusted so the LogBook or Daq device measurements correspond to the DAC settings. The DBK55's software-adjustable gain and offset can correct for small errors in the DBK55 or the LogBook or Daq device. This automatic calibration eliminates the periodic need for manual calibration.

Hardware Setup

CAUTION
DBK55 modules must be configured before connecting them to inputs and outputs. Failure to do so could result in damage to equipment.

Hardware-related steps for setting up DBK55 include:

- Configuring the DBK55 for the application
- Configuring the Daq device to which the DBK55 is being connected to
- Connecting the input cables to sensors
- Connecting the module's output cable to a Daq device or LogBook.

Configuring the DBK55 Module

Unless the factory default settings are going to be used, several jumpers and one switch must be set on the DBK55 module to match both the system setup and the signal-conditioning requirements. Each channel can have its own individual hardware and software settings.

The default settings are:

- **Input Circuit – set to Analog**
- **Attenuation – set to Enabled (less sensitive)**
- **Low Pass Filter – set to 100 kHz**

The following table indicates the possible settings of each jumper and includes an illustration to facilitate the location of jumpers. More detailed information concerning jumper settings immediately follows the table.

DBK55 On-board Jumper Configurations

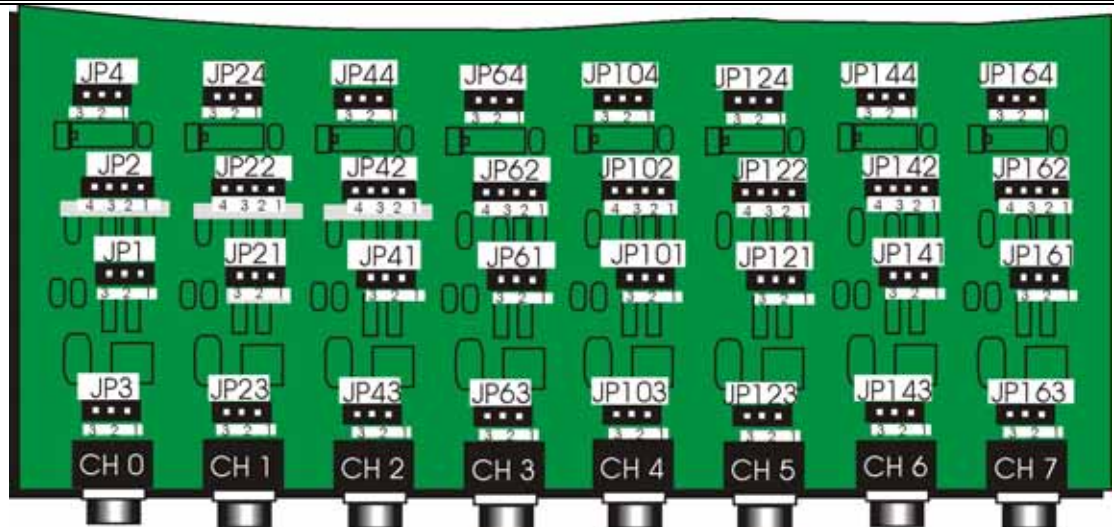| Configuration	Jumpers	Channel	Selected Functions
Input Circuit Selection, pg. 8 • The default is Analog Input; Pins 1 and 2 connected for two associated jumpers. • For Digital Input mode; pins 2 and 3 are connected for the two associated jumpers.	JP3 and JP4	CH 0	**Analog** (Default) **Digital** * Two jumpers are required to set Analog or Digital. For example, JP3 and JP4, which are at the input and output ends of the circuit, respectively.
	JP23 and JP24	CH 1	
	JP43 and JP44	CH 2	
	JP63 and JP64	CH 3	
	JP103 and JP104	CH 4	
	JP123 and JP124	CH 5	
	JP143 and JP144	CH 6	
	JP163 and JP164	CH 7	
Attenuation Selection, pg. 8 • The default is Attenuation Enabled (reduced sensitivity). Pins 1 and 2 are connected. • For Full Sensitivity (Attenuation Disabled) pins 2 and 3 are connected.	JP1	CH 0	**Attenuation Enabled** (Default) **Full Sensitivity**
	JP21	CH 1	
	JP41	CH 2	
	JP61	CH 3	
	JP101	CH 4	
	JP121	CH 5	
	JP141	CH 6	
	JP161	CH 7	
Low Pass Filter Selection, pg. 8 • The default LPF is 100 kHz. Pins 1 and 2 are connected. • For an LPF of 300 Hz, pins 2 and 3 are connected. • For an LPF of 30 Hz, pins 3 and 4 are connected.	JP2	CH 0	100 kHz (Default) 300 Hz 30 Hz
	JP22	CH 1	
	JP42	CH 2	
	JP62	CH 3	
	JP102	CH 4	
	JP122	CH 5	
	JP142	CH 6	
	JP162	CH 7	

Jumper Locations   Partial Board, Not Drawn to Scale

Input Circuit Selection: Analog or Digital

Each input channel can be set for the analog (default) or digital circuit. Two jumpers must be set for each channel. These are listed in the preceding table, along with the associated channels.

Refer to the previous figure and table; then select the input circuit for each input channel as follows:

1. Determine the best circuit type for each channel.
   - The digital input circuit works best for DC-coupled signals where the low level is less than 0.5 V and the high level is above 2.5 V and the voltage does not exceed ±15 V. By using a pull-up resistor, switches and relays can create the signal. Frequencies can be as high as 960 kHz. The digital input circuit does not attenuate or filter the input signal.
   - The analog input circuit is AC-coupled and is sensitive to signals from 100 mV to 84 V p-p. It also provides attenuation and low-pass filtering to reduce the effects of noise.

2. Position each channel's circuit jumpers (2 jumpers per channel) for analog or digital.

3. Verify that both jumpers for a channel are set the same, i.e., both set to pins 1 and 2 for Analog, or both set to pins 2 and 3 for Digital.

Attenuation Selection (Analog Input Circuit Only)

When measuring strong analog signals, the attenuator can reduce the input sensitivity and the effects of noise. If enabled, the attenuator reduces the input sensitivity by a factor of 50.

Refer to the previous figure and table; then set the attenuation for each channel as follows:

1. Decide whether or not you want attenuation for a given channel. Attenuation enabled, which reduces sensitivity, is the default setting.
   - Use attenuation (reduced sensitivity) if the input signal's peak level exceeds 1 V.
   - Disable attenuation (full sensitivity) if the input signal's peak level is less than 1 V.

2. For attenuation, position the associated jumper across pins 1 and 2. To disable attenuation (full sensitivity), position the jumper across pins 2 and 3.

3. Verify the jumper position for each input channel.

Low-Pass Filter Selection (Analog Input Circuit Only)

The low-pass filter removes high-frequency noise that would otherwise have the DBK55 detecting a higher frequency than desired. To set the low-pass filter:

1. Determine the highest frequency you expect to measure on each input channel.

2. Select the next higher cutoff frequency (30 Hz, 300 Hz, or 100 kHz) for each corresponding channel. Verify that the DBK55's sensitivity will accommodate the expected input signal strength. Page 3 includes a graph of typical sine-wave sensitivity (peak-to-peak voltage) verses frequency (Hz).

3. *Refer to the previous figure and table*; then set the associated jumpers for the desired low-pass filter selection.

Address Configuration via Rear Panel DIP Switch

You can connect 1 or 2 DBK55 modules to a single main channel on the primary data acquisition device. Thus, a 16-channel LogBook or Daq device can support up to 32 DBK55 modules. Since each module has 8 input channels, a fully populated system can use 256 input sensors (32 modules x 8 channels per module).

To keep the large number of inputs organized, each DBK55 module is given a unique address via its DIP switch, S1[located on the rear panel].

CAUTION

Each DBK55 must be configured before connecting the module to inputs and outputs. In addition, adjustment of the channel address must only be performed when the system's power is OFF. Failure to do so may result in equipment damage.

S1's four leftmost micro-switches are used to set the module's channel address in binary. Set the micro-switches to the desired address only after ensuring that the system power is OFF. Several example address settings are provided below. Other settings can be easily derived.

Each DBK55 module in the system must have a unique channel address for the primary data acquisition device. Valid addresses are 0 to 15. Note that two modules can have a setting for the same primary channel, for example, two modules could be set to channel 0; as long as one module is set to "L" to indicate the lower sub-channels 0-7 and the other is set to "U" to indicate the upper sub-channels of 8-15.   Examples of various settings follow.

Channel 0 / Lower

Primary Acquisition Device Channel 0
DBK55 Lower Sub-Channels 0-7

The four leftmost micro-switches are set to "0" (Open). This sets the unit to **primary acquisition device Channel 0**. The rightmost switch is at "**L**," setting the module to the **"lower" DBK55 sub-channels (0 through 7)**.

Note: If connecting a second module to primary device Channel 0, the U/L switch for that module would be set to "U" for sub-channels 8 thru 15.

Channel 5 / Lower

Primary Acquisition Device Channel 5
DBK55 Lower Sub-Channels 0-7

The micro-switches for binary 4 and binary 1 are closed. This sets the unit to **primary acquisition device Channel5**. The rightmost switch is at "**L**," setting the module to the **"lower" DBK55 sub-channels (0 through 7)**.

Channel 15 / Lower

Primary Acquisition Device Channel 15
DBK55 Lower Sub-Channels 0-7

The micro-switches for binary 8, 4, 2, and 1 are closed, thus setting the **channel to "15"** (8 + 4 + 2 + 1) for the primary acquisition device. The rightmost switch is at "**L**," setting the module to the **"lower" DBK55 sub-channels (0 through 7)**.

Channel 2 / Upper

Primary Acquisition Device Channel 2
DBK55 Upper Sub-Channels 8-15

The micro-switch for binary 2 is closed, thus setting the **channel to "2"** for the primary acquisition device. The rightmost switch is at "**U**," setting the module to the **"upper" DBK55 sub-channels (8 through 15)**.


Configuring the Primary Data Acquisition Device

DaqBook/100 Series & /200 Series and DaqBoard [ISA type] Configuration

Several setup steps of DaqBook/100 Series & /200 Series devices and DaqBoards [ISA type] are required to use DBK55 modules in a system.

1. If not using auxiliary power, place the JP1 jumper in the expanded analog mode.

Note: This default position is necessary to power the interface circuitry of the DBK42 via the internal ±15 VDC power supply. If using auxiliary power (DBK32A/33), you must remove both JP1 jumpers (refer to the Section *Power Requirements* in the document module *DBK Basics*, in regard to calculating system power requirements).
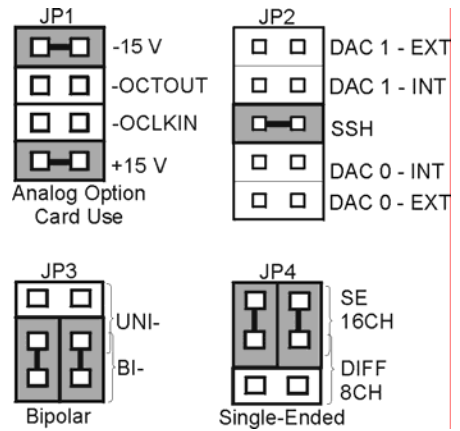
CAUTION

⚠️ **When using the SSH output, do not use an external voltage reference for DAC1. Applying an external voltage reference for DAC1, when using the SSH output, will result in equipment damage due to a conflict on P1, pin #26.**

2. **Place the JP2 jumper in the SSH position (See previous CAUTION).**
3. **For DaqBook/100, /112 and /120 *only***, place JP3 jumpers in *bipolar mode*.
4. **For DaqBook/100, /112 and /120 *only***, place JP4 jumpers in *single-ended mode*.

DaqBook/2000 Series & DaqBoard/2000 Series

No jumper configurations are required on the DaqBook/2000 series and DaqBoard/2000 series devices in regard to connecting a DBK55.

LogBooks

No jumper configurations are required on LogBook devices in regard to connecting a DBK55.

CE Compliance

If your data acquisition system needs to comply with CE standards, the DBK55 must be connected to the LogBook or Daq device by a CA-143-x cable.

Note that in the presence of 3 V/m RF fields, the following conditions must exist in order to meet CE requirements:

- 500 mVpp signals are required to maintain 0.1% accuracy.
- Metal shells of the BNC connectors must be directly connected to the chassis ground in order to maintain 100 mV sensitivity and 0.1% accuracy.
- The host computer must be properly grounded.
- The host computer and peripheral equipment must be CE compliant.

Reference Notes: If your data acquisition system needs to comply with CE standards, refer to the *CE Compliance* section of *Signal Management* chapter.

Connecting the DBK55 to Signals and to the Primary Data Acquisition Device

You can connect the DBK55 module to your primary data acquisition device and to its signal inputs after you have completed the following:

- set the DBK55 module's address
- configured the DBK55 on a channel-by-channel basis for the application
- configured the primary data acquisition device, if applicable

You can connect up to eight sensors to one DBK55, i.e., one per BNC. A CA-37-x (or CA-131-x) cable is used to connect the module to a LogBook or Daq device via the module's DB37 connector (P1).

WARNING

Electric shock hazard! Do not exceed a sensor input of 30 Vrms (42 Vpeak, 84 Vp-p) for analog or ±15 Volts for digital. Exceeding these values may present an electric shock hazard that could possibly result in injury or death, in addition to DBK55 damage.

Connect the DBK55 module as follows. If your system needs to be CE Compliant, be sure to read the preceding *CE Compliance* section prior to connecting the DBK55.

1. Connect each sensor's BNC connector to a mating connector on the DBK55 module

   Label each sensor with its associated channel/sub-channel information.

2. For a single DBK55 module, connect one end of the P1 cable to the module's male DB37 output connector.

   - For DaqBook applications - use a CA-37-1 cable.
   - For DaqBoard/2000 Series or /2000c Series boards - use a CA-37-1 with a DBK200 Series adapter.
   - For DaqBoard [ISA type] boards - use a CA-131-1 cable.

3. Connect the free end of the cable to the P1 port of the LogBook or Daq device. For multiple DBK55 modules, use a CA-37-x (or CA-131-x) cable to daisy-chain several modules or an expansion module. For example, three DBK55s could be connected to a LogBook or a Daq device with via a CA-37-3 cable.

   Note: For longer cable runs, use a CA-113 to add 6 ft of cable length where needed.

Software Setup

LogView does not include the means to directly select DBK55. However, since a single DBK55 has the functionality of two DBK7 cards we can still use a DBK55 with LogBook. To do this, select DBK7 in LogView. This will recognize the DBK55, but will identify it as a DBK7. Next do one of the following, as applicable:

(a) If the DBK55 is set to the L sub-address, Select DBK7 (0) and DBK7 (1)
(b) If the DBK55 is set to the H sub-address, Select DBK7 (2) and DBK7 (3)

Reference Notes:
- o **DaqView users** - Refer to Chapter 3, *DBK Setup in DaqView*.
- o **LogView users** - Refer to Chapter 4, *DBK Setup in LogView*. See above note.

Specifications - DBK55

Name/Function: 8-Channel Frequency-to-Voltage Input Card

Input Channels per Module: 8

Maximum Modules per System: 32

Maximum Channels per System: 256

Input Connector: 1 BNC connector per channel

Connector: DB37 male, mates with P1

Frequency Ranges: (programmable) 0 Hz to 960 kHz

Output Voltage Range: -5 V to +5 V

Debounce Delays: (software selectable) 0, 0.6, 2.5, 10 ms

Measurement Rate: up to 500 per second per channel, 1000 per second total

Accuracy: 0.1%

Power Required: 840 mW

Analog Input

Low-level:

 50 mV typical (100 mV max) p-p sine wave @ 10 Hz to 100 kHz

 Any edge of 50 (100 max) mV amplitude and 5 V/s rate.

 Input impedance: AC-coupled (0.33 µF), in series w/ 20 KΩ to ground.

 15 mV hysteresis.

High-level:

 0.75 V typical (1.25 V max) p-p sine wave @ 10 Hz to 100 kHz

 Any edge of 0.75 V (1.25 V max) amplitude and 50 V/s rate.

 Input impedance: AC-coupled (0.33 µF), in series w/ 20 KΩ to ground.

 250 mV hysteresis.

Maximum Input Voltage: 30 Vrms (84 Vp-p)

Low-Pass Filters: (hardware selectable) 30 Hz, 300 Hz, 100 kHz, single pole

Digital Input

TTL-Level: 0.001 to 960 kHz.

Input Impedance: 27 KΩ pull-up to +5 V || 50 pF

V Low ("0"): 0.8 V typ, 0.5 V min

V High ("1"): 1.6 V typ, 2.1 V max

Hysteresis: 400 mV min

Pulse Width (high or low): 520 nsec min.

Maximum Input Voltage: -15 V to +15 V