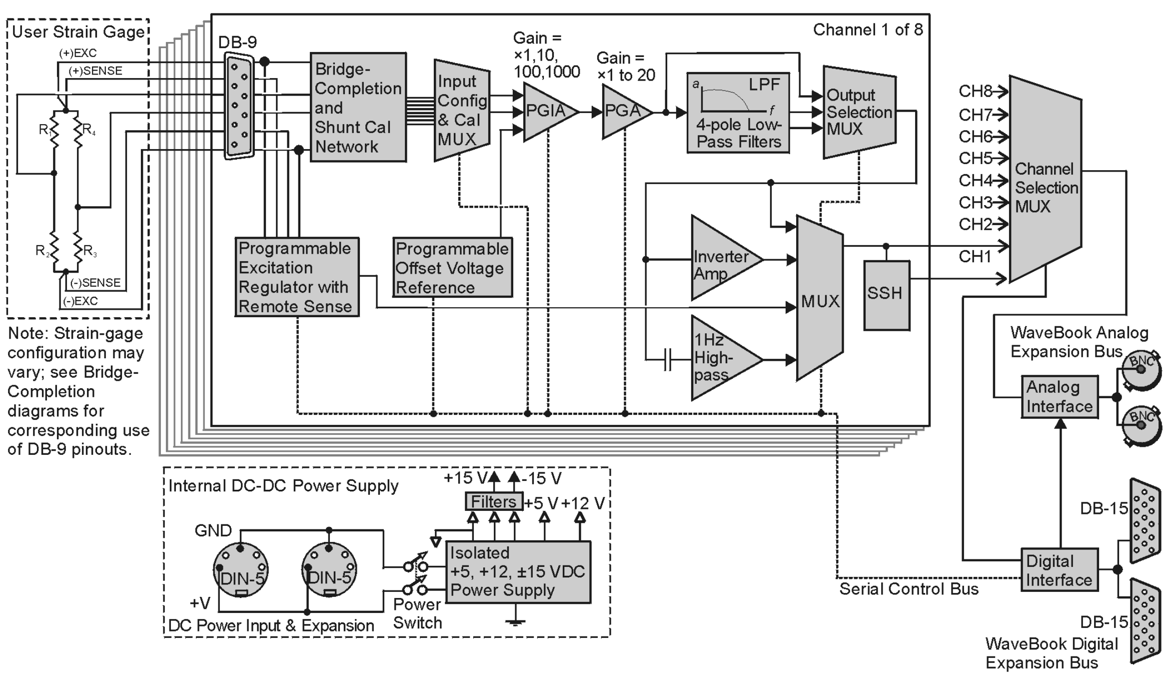
WBK16 - Strain-Gage Module

Description

WBK16 is an 8-channel strain-gage signal-conditioning module for the WaveBook system. Up to eight WBK16 modules (64 channels) can be accommodated by the WaveBook and scanned at 1 μs/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. *Hardware Setup*, beginning on page 3 of this section, contains detailed information. Page 11 of this WBK16 section discusses a DB9 Adapter option that provides a means of easily setting up a bridge configuration.

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

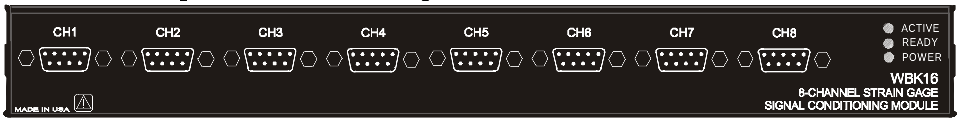
Two different 4-pole Butterworth low-pass noise rejection filters are selectable through software by the Output Selection MUX. The filters have a nominal cutoff frequency of 10 Hz and 1 kHz. Four SIP resistor networks allow you to determine two cutoff frequencies. See the *Hardware Configuration* section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

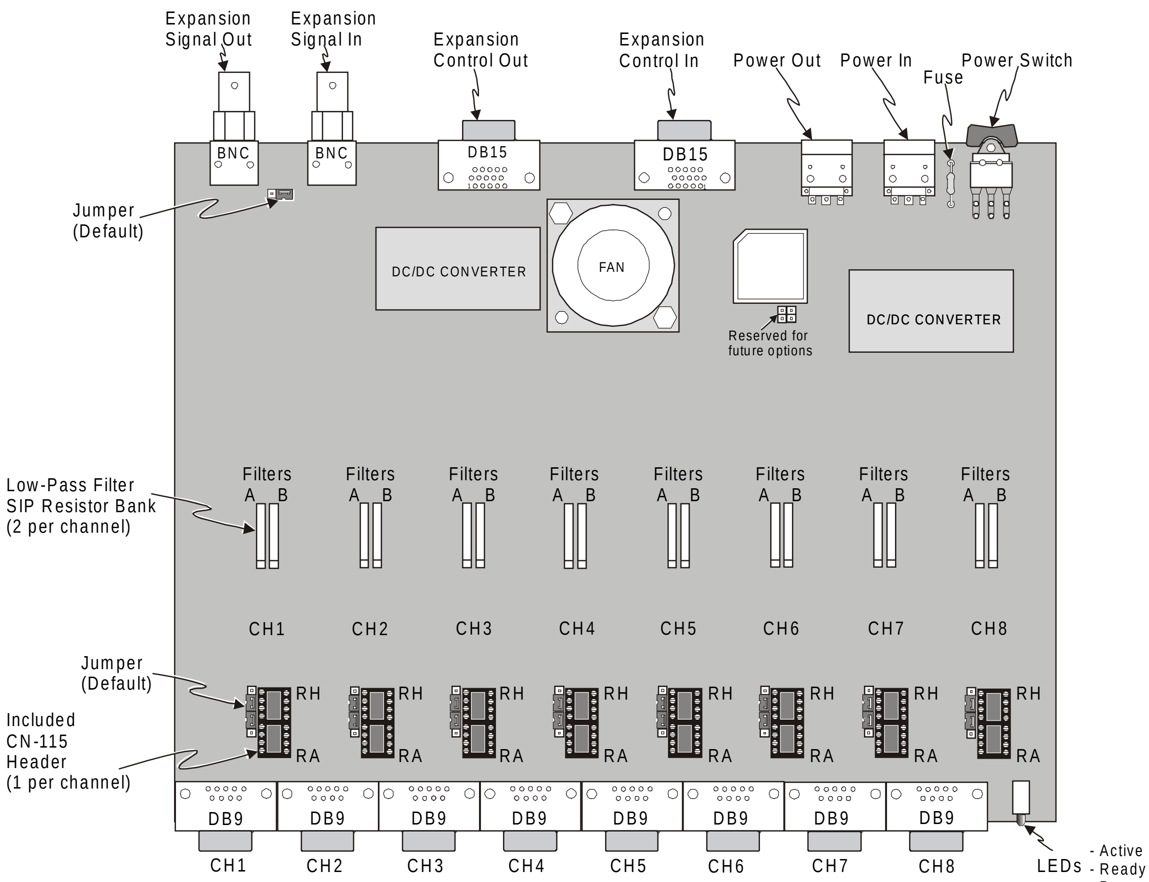
The **rear panel** has the power switch and the following connectors as shown:

- 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

Hardware Setup

Configuration

The 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.



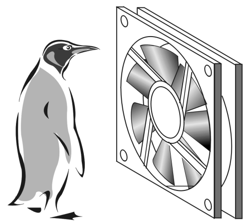
WBK16 Board Layout

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.



Please don't block the fan or the cooling vents.

WBK16 Fan

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

Note: The partial blocking of vents by splice plates (in stacked assemblies) does not jeopardize unit cooling.

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.

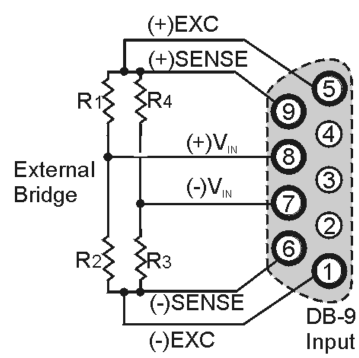
Full-bridges generally have the highest output and best performance. Output signal polarity is determined by whether the strain-variable resistance increases or decreases with load, where it is located in the bridge, and how the amplifier inputs connect to it. Configuration polarity is not important 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 MΩ resistors are also connected where the jumpers would be located to prevent circuit discontinuities. These 1 MΩ 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. WBK16 provides 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 kΩ; 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:

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

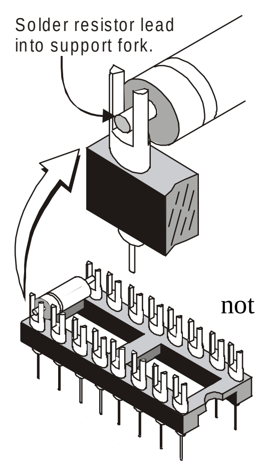
$$R_{Shunt} = 350\ [\ (\ 10 / 4(0.020))\ -\ 0.5\ ]\ =\ 43{,}575\Omega$$

CAUTION
Be careful to avoid component damage while 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 2×8 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. Solder resistors to the adapter plug as shown. Remove the plug from the main board. 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

Low-Pass Filter Customization

WBK16 has 68 kΩ 4-resistor SIP networks installed from the factory. These networks result in a 10.9 Hz cutoff for filter A and a 1.09 kHz 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 section, *WaveBook Advanced Features*, on page 23 of this WBK16 section.

Resistor	Filter A
330 kΩ	2.20 Hz
450 kΩ	4.95 Hz
120 kΩ	3.37 Hz
100 kΩ	7.42 Hz
82 kΩ	9.05 Hz
68 kΩ	10.9 Hz
47 kΩ	15.8 Hz
33 kΩ	22.5 Hz
22 kΩ	33.7 Hz
15 kΩ	49.5 Hz
10 kΩ	74.2 Hz
8.2 kΩ	90.5 Hz
6.8 kΩ	109 Hz
4.7 kΩ	158 Hz
3.3 kΩ	225 Hz
3 to 330 kΩ	$R=742K/f_{cut}$

Resistor	Filter B
330 kΩ	225 Hz
450 kΩ	495 Hz
120 kΩ	337 Hz
100 kΩ	742 Hz
82 kΩ	905 Hz
68 kΩ	1.09 kHz
47 kΩ	1.57 kHz
33 kΩ	2.25 kHz
22 kΩ	3.37 kHz
15 kΩ	4.95 kHz
10 kΩ	7.42 kHz
8.2 kΩ	9.05 kHz
6.8 kΩ	10.9 kHz
4.7 kΩ	15.8 kHz
3.3 kΩ	22.5 kHz
3 to 330 kΩ	$R=74.2M/f_{cut}$

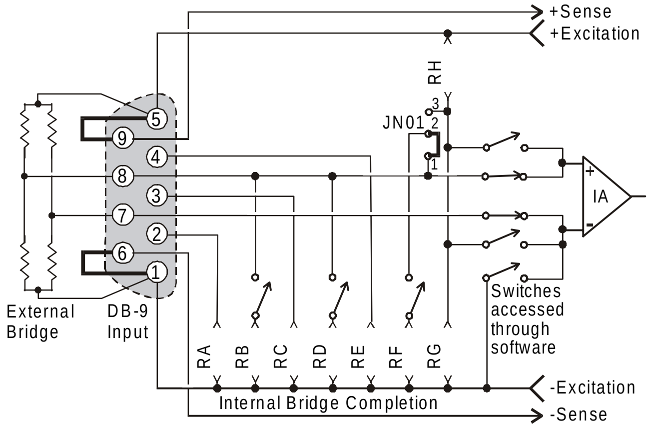
Lower frequency filters, such as the 10-Hz filter provided, are generally used to reduce higher frequency noise. Some common sources of noise are: 50/60 Hz power line pickup on long cables, electromagnetic interference (EMI) from nearby equipment, unwanted vibrations in the strain gage system itself, 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.

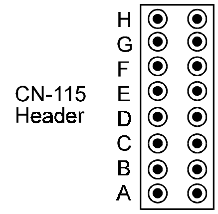
Reference Notes:
(1) Schematics of various bridge configurations can be found on WBK16 pages 7 through 10.
(2) DB9 connector information, including use of the optional CN-189 adapter, is located on page 11 of this WBK16 section.

Full-Bridge Configurations

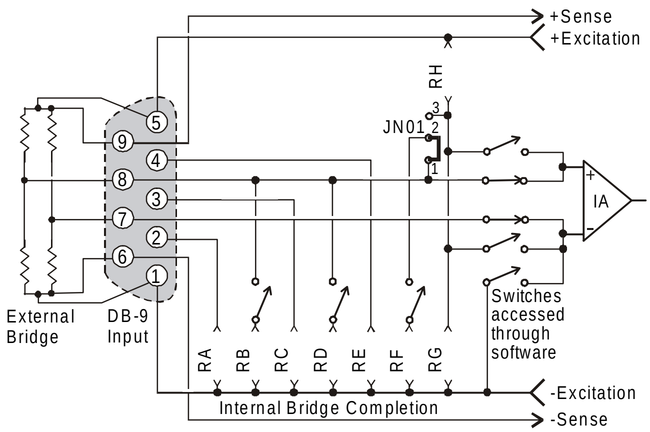
The full-bridge has four strain-variable elements and requires no bridge completion components. Quarter and half-bridge resistors may be left installed. Any bridge resistance from 60 to 1000 ohms can be accommodated.



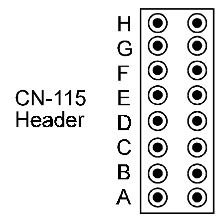
Full-Bridge (+), Any Resistance from 60 to 1000 Ohms



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.

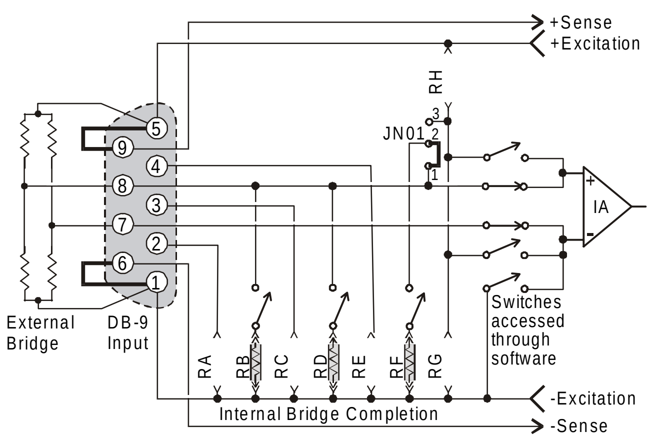


Full-Bridge (+), with Remote Sense

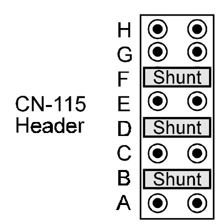


In this connection, excitation voltage is regulated at the strain gage.

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



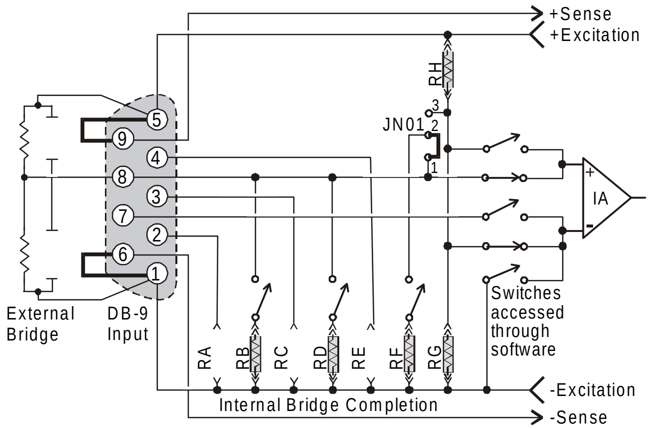
Full-Bridge (+), with B, D, or F Shunt



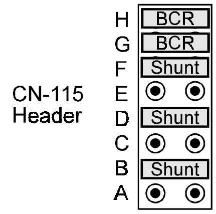
The B, D, or F shunt resistor may be software selected when installed as shown. Output polarity during shunt calibration will be automatically corrected by software. The shunt resistor value will typically be different for each value of bridge resistance.

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.



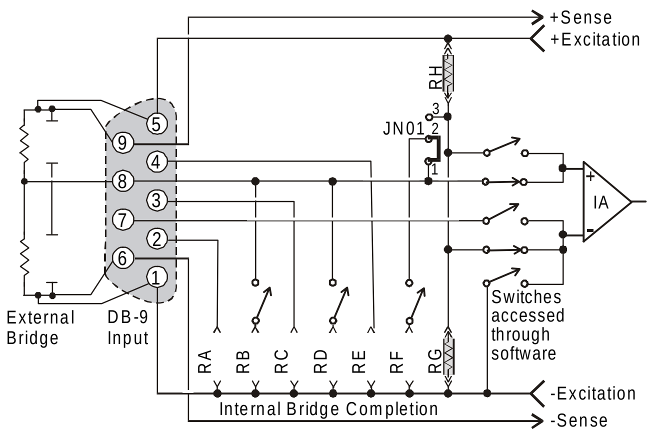
Half-Bridge (+), Any Resistance from 60 to 1000 Ohms, B,D, or F Shunt



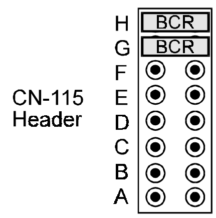
In this connection, excitation voltage is regulated at the connector.

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.

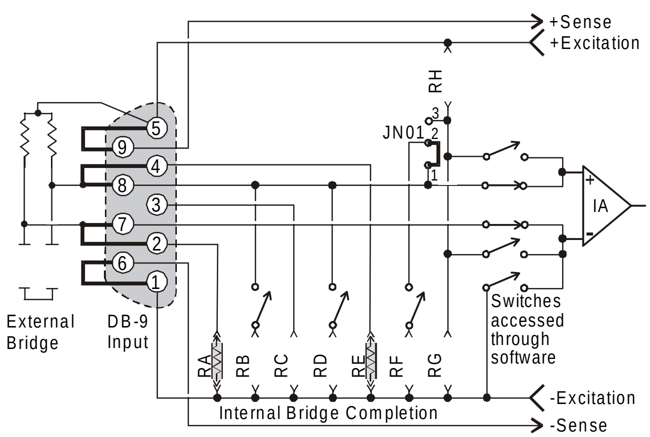


Half-Bridge (+), with Remote Sense

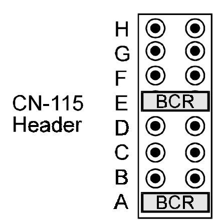


In this connection, excitation voltage is regulated at the strain gage.

This is the preferred connection for longer cables.



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

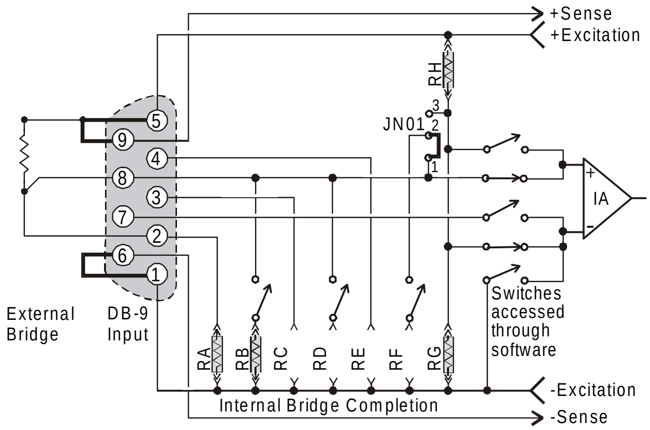


This occasionally utilized connection can be made as shown. Two resistors normally reserved for quarter-bridge completion must be used.

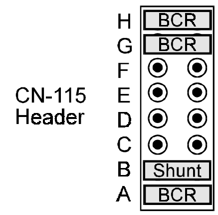
For compatibility with other configurations, use of one of the above two configurations is preferred over this one.

Three-Wire Quarter-Bridge Configurations

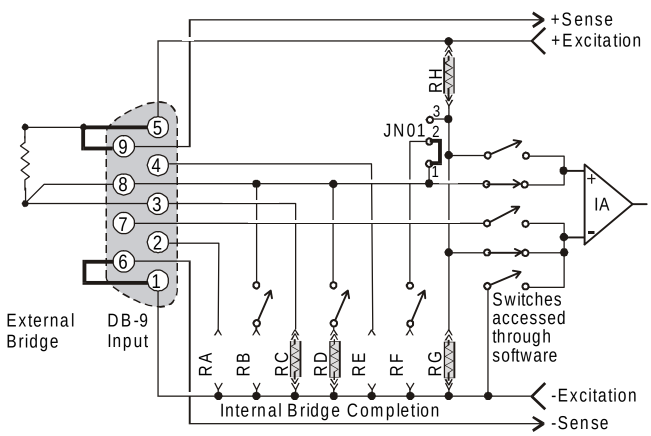
The three-wire quarter-bridge has only one strain-variable element and requires three bridge completion resistors (BCRs). The internal half-bridge may be any two matched values, but the remaining resistor must match the external quarter-bridge value precisely. Three of these values may be installed simultaneously 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.



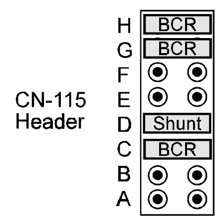
Three-Wire Quarter-Bridge (+),
Using RA (120-Ohm nominal), B Shunt Resistor



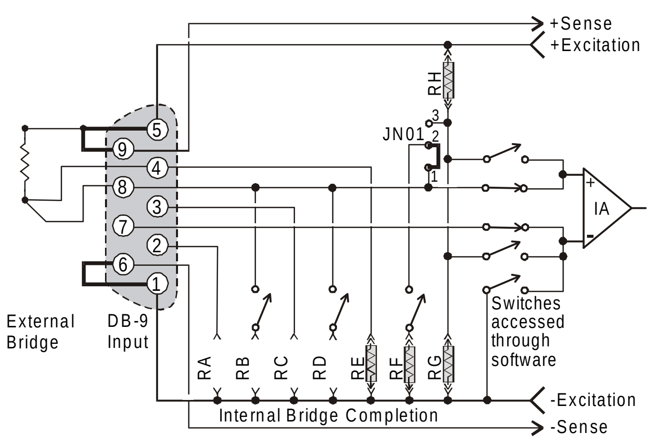
A 120-ohm resistor and its corresponding shunt value may be installed as shown.



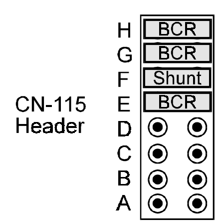
Three-Wire Quarter-Bridge (+),
Using RC (350-Ohm nominal), D Shunt Resistor



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

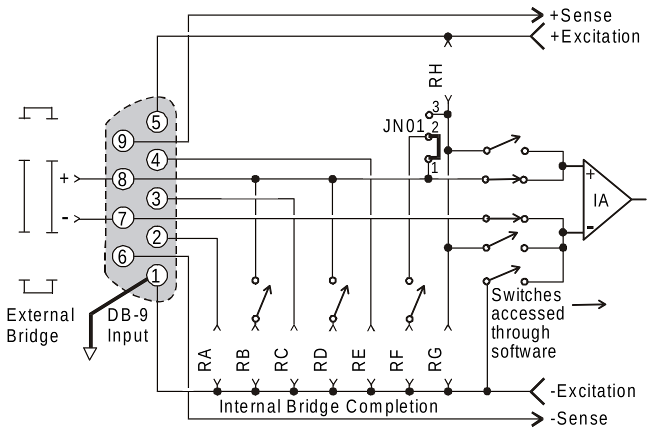


A 1000-ohm (or other value) resistor and its corresponding shunt value may be installed as shown.

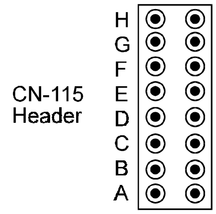
High-Gain Amplifier Configurations

WBK16 is useful as a programmable high-gain amplifier. No external bridge is used in these cases. The inputs are fully differential.

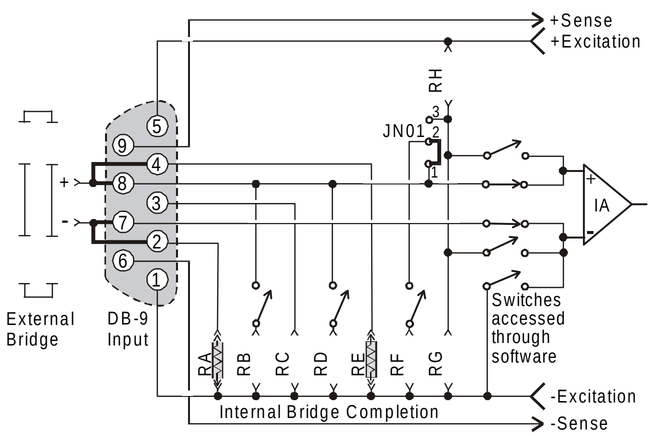
Note: The differential inputs are not isolated inputs. Common mode voltage should not exceed ±10 V.



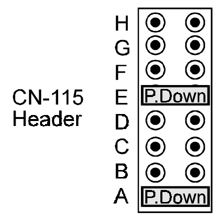
Universal High-Gain Amplifier Input, Differential



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

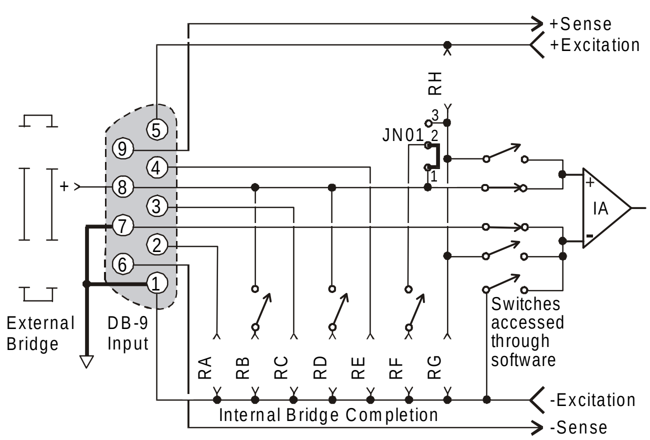


Universal High-Gain Amplifier Input, Differential with Pull Downs

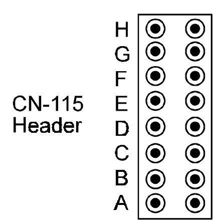


A floating input without a ground reference, such as a battery, requires a path for input bias currents. Pull-down resistors of 1k to 10MΩ may be installed as shown to provide this function.
A 10MΩ resistor would be suitable in most cases.

These resistors are not compatible with other bridge configurations.

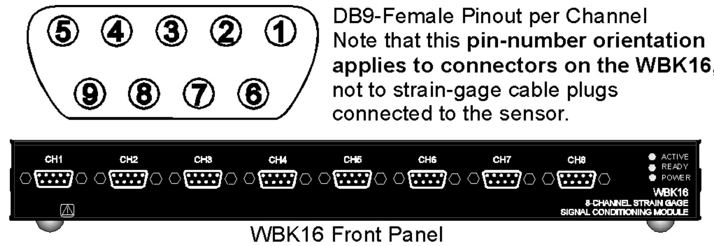


Universal High-Gain Amplifier Input, Single-Ended



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.

Connection



WBK16 Front Panel

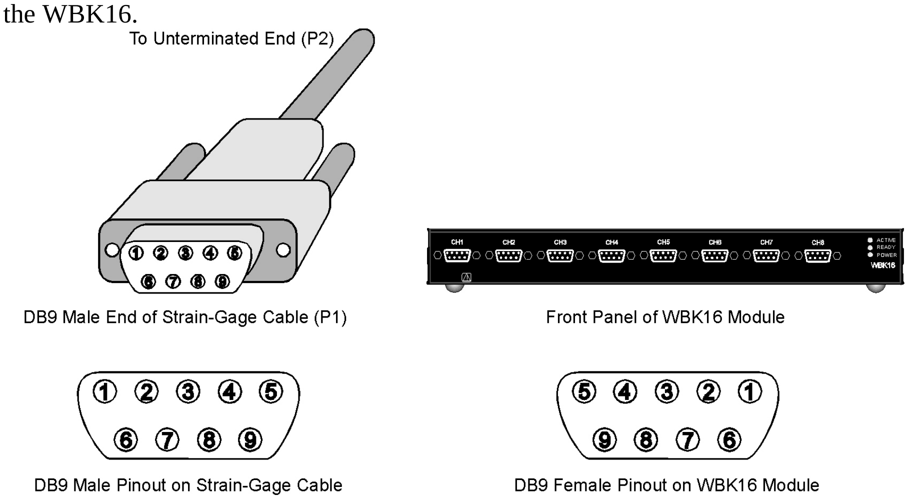
The figure shows the pin numbers of the DB-9 connector (1 of 8) on WBK16’s front panel. The strain gage will connect to these pins, unless the CN-189, DB9 Adapter option is used. The CN-189 option is discussed in the following sub-section.

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

Connections to WBK16

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 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. Some types of molded cables (wider than 1.23 inches) will not fit the compressed connector spacing of the WBK16.



DB9 Connector Pinouts for the Strain-Gage Cable and the WBK16 Module

CA-177 Strain-Gage Cable Pinout			
DB9 Male End (P1)	**Unterminated End (P2)**	**DB9 Male End (P1)**	**Unterminated End (P2)**
Pin 1	Brown wire	Pin 6	Blue wire
Pin 2	Red wire	Pin 7	Purple wire
Pin 3	Orange wire	Pin 8	Black wire
Pin 4	Yellow wire	Pin 9	White wire
Pin 5	Green wire	Shell	Drain wire

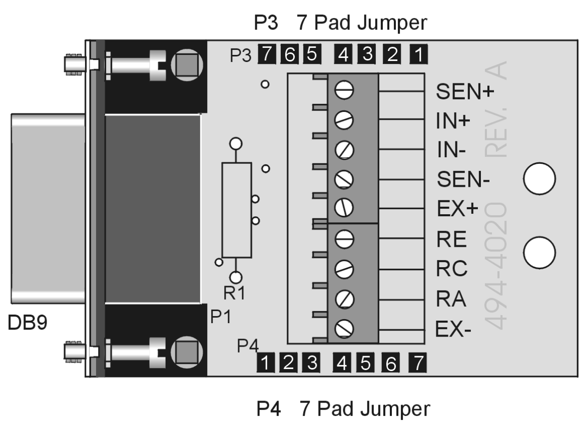
Cable CA-177 Specifications

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 shown in the previous table.

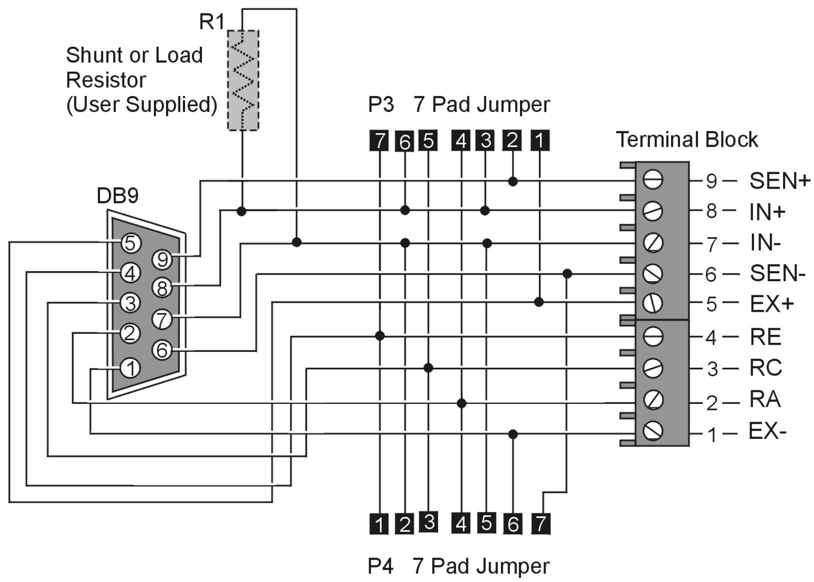
CN-189, DB9 Adapter Option

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 WBK16's Signal Input DB9 connector. 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.

Note: **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, DB9 Adapter Option



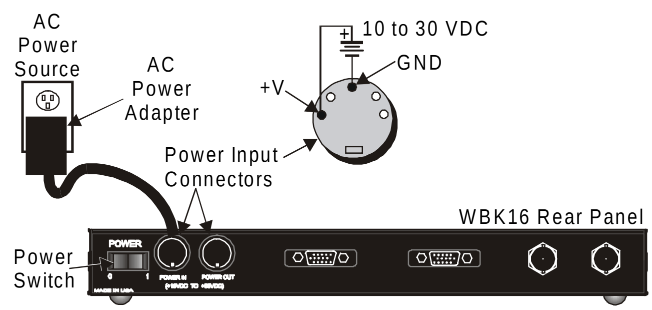
CN-189 Schematic

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

Note! **For the functions listed in the preceding table, internal WBK16 configurations still apply as indicated on WBK16 pages 7 through 10 .**

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.



WBK16 Power Connections

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. Refer to WBK16 page 3 for board layout, if needed.

Reference Note:
Refer to chapter 3 for details on powering WaveBook systems.

Using Splice Plates to Stack Modules

For convenient mounting, the WBK16 has the same footprint as other WBK modules and WaveBooks. Splice plates provide a means for stacking WaveBooks and modules. Screw-on handles are available for portable applications. Refer to chapter 3 for assembly information.

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

Splice plates will partially block the vents on WBK16s and WaveBook/516s when stacked. This partial blocking of vents does not jeopardize the cooling process.

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.

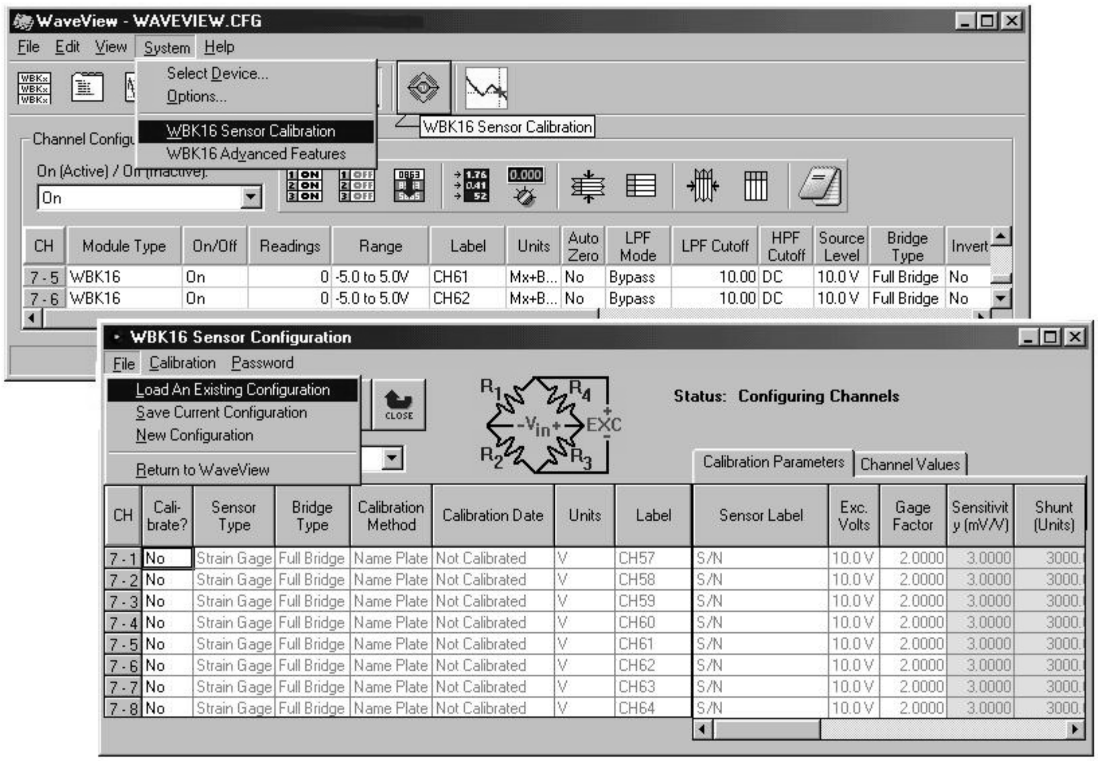
Reference Notes:
For information regarding software setup, refer to the *Software Setup* section in chapter 3.
For detailed information regarding non-WBK16 specific aspects of *WaveView*, refer to the *WaveView Document Module*.

Using the Sensor Calibration Program in WaveView

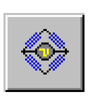
To launch WaveView, double click on the WaveView icon in the WaveView program group. WaveView holds user-configured parameters that can be saved to disk. The default configuration filename is **`WAVEVIEW.CFG`**. When WaveView starts up, it proceeds to search the working directory for this file. WaveView 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.
- If 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. For detailed WaveView startup information, refer to the *WaveView Document Module*.



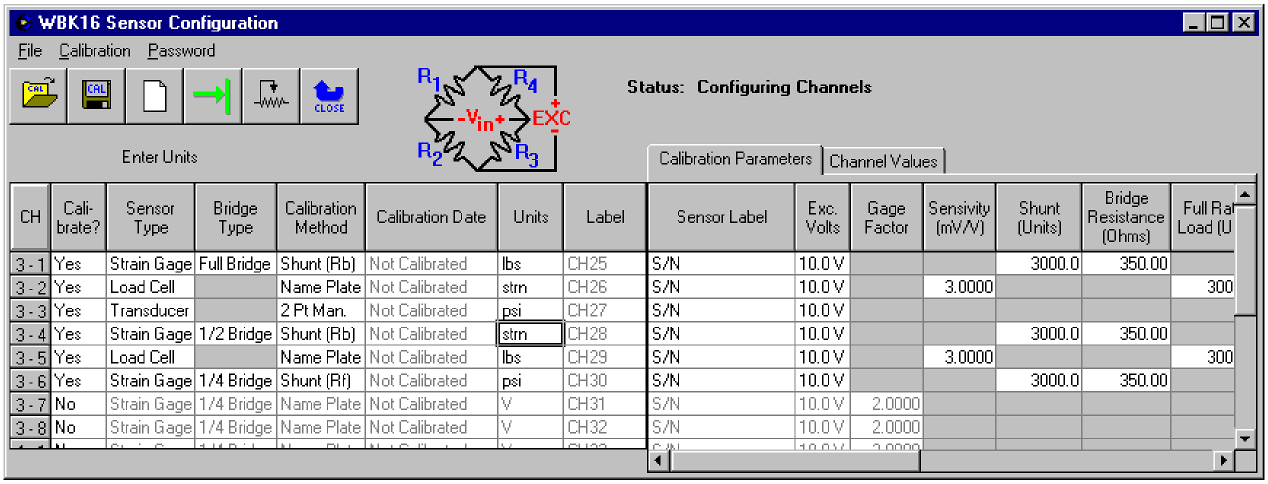
WaveView Configuration Main Window and WBK16 Sensor Configuration Window



You can click on the WaveView's **WBK16 Sensor Calibration button** (depicted at the left and pointed out in the above figure), to open the WBK16 Sensor Configuration window. You can also open the window from WaveView's **System pull-down menu**.

You can use the WBK16 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.

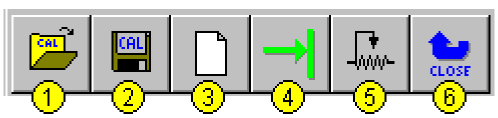
Sensor Configuration Main Components



WBK16 Sensor Configuration 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.

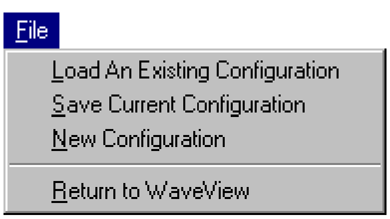


WBK16 Sensor Configuration Window Toolbar

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

File

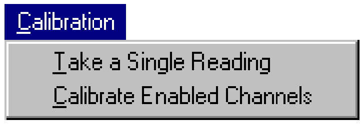
The *File* menu provides four functions:



Load an Existing Configuration	Load a saved sensor calibration configuration.
Save Current Configuration	Save the current sensor calibration configuration for later recall.
New Configuration	Set all parameters to their default startup setting.
Return to WaveView	Exit the *WBK16 Sensor Configuration* 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 *WBK16 Sensor Configuration* window.
Calibrate Enabled Channels	This command will calibrate all enabled channels.

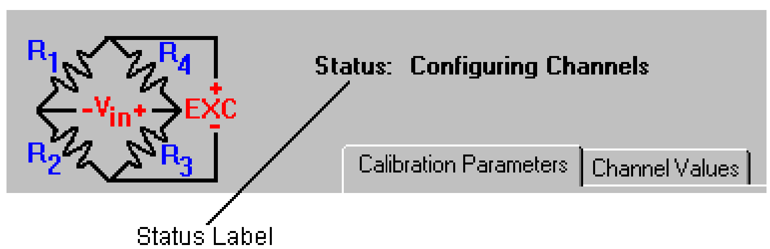
Password

The sensor calibration application provides password protection. If you calibrate any WBK16 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.

The following text pertains to other areas of the configuration window, including the spreadsheet columns.

Status Label

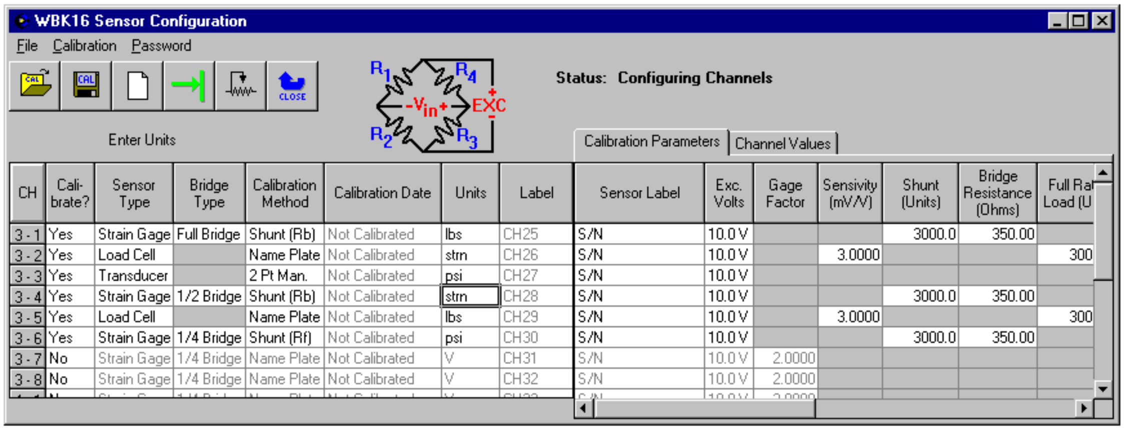


The *Status* label describes the current state of the sensor calibration spreadsheet. This label is located at the top of the *WBK16 Sensor Calibration* window to the right of the strain gage diagram. The 3 possible states of the *Status* label are as follows:

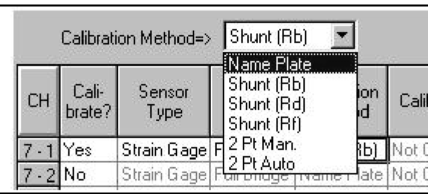
- ***Configuring Channels.*** When the *Status* label displays "**Status: Configuring Channels**," the user can enter parameters for a calibration into the spreadsheet cells.
- ***Calibrating Channel X-Y.*** If the user selects *Calibrate Enabled Channels*, either from the menu bar or the toolbar, the *Status* label will read "**Status: Calibrating Channel X-Y**" where X and Y correspond to the module number (X) and the channel number (Y) being calibrated.
- ***Reading Channel X-Y.*** If the user selects *Take a Single Reading* either from the menu bar or the toolbar, the *Status* label will read "**Status: Reading Channel X-Y**" where X and Y correspond to the module number (X) and the channel number (Y) being read.

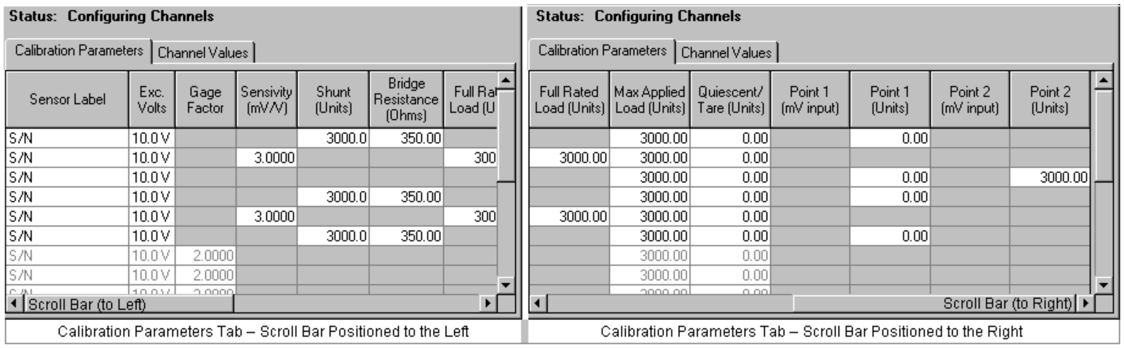
Calibration Parameters Tab Selected

Note: The Calibration Parameters tab has more columns than can be display at once. For this reason, two images are provided. The upper figure was captured with the scroll bar to the left; the lower figure was captured with the scroll bar to the right.



WBK16 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 *WBK16 Sensor Configuration* 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. 
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 *WaveView Configuration* 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).



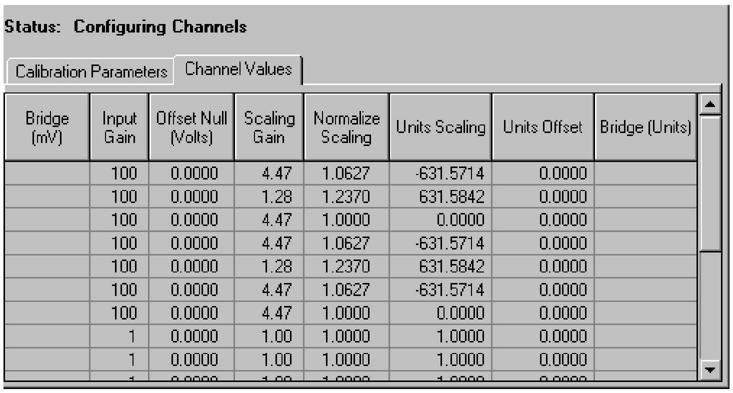
Calibration Parameters Section of Window, Two Views

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 *WaveView Configuration* 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 (Units)	This column is used for calibrating **any sensor** using the **Shunt calibration** method. The value must equal the value of the shunt resistor in desired units. 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 Resistance (Ohms)	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 input)	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 input)	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 WBK16 sensor calibration program, it is possible to take a single reading and display it in the *WBK16 Sensor Configuration* 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.

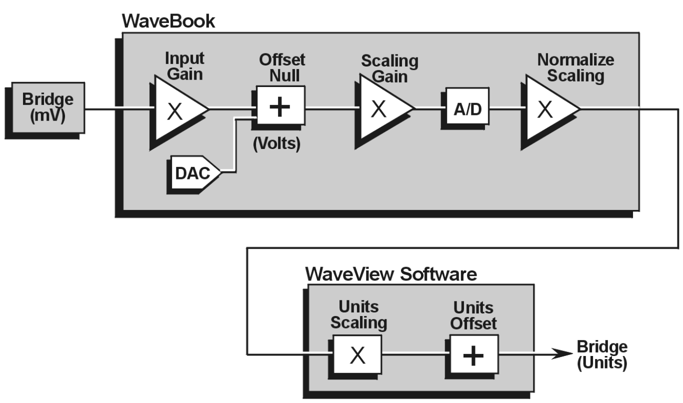
Channel Values Tab Selected


Status: Configuring Channels

Calibration Parameters | Channel Values

Bridge (mV)	Input Gain	Offset Null (Volts)	Scaling Gain	Normalize Scaling	Units Scaling	Units Offset	Bridge (Units)
	100	0.0000	4.47	1.0627	-631.5714	0.0000	
	100	0.0000	1.28	1.2370	631.5842	0.0000	
	100	0.0000	4.47	1.0000	0.0000	0.0000	
	100	0.0000	4.47	1.0627	-631.5714	0.0000	
	100	0.0000	1.28	1.2370	631.5842	0.0000	
	100	0.0000	4.47	1.0627	-631.5714	0.0000	
	100	0.0000	4.47	1.0000	0.0000	0.0000	
	1	0.0000	1.00	1.0000	1.0000	0.0000	
	1	0.0000	1.00	1.0000	1.0000	0.0000	

Channel Values Tab



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.
Normalize Scaling	The Multiplier value applied to the A/D converter output for fine adjustment. The value range for the Multiplier is 1 to 2.
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).

Calibrating a Sensor Using the Sensor Calibration Program

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 WBK16 sensor calibration program uses four basic methods of calibration:

Name Plate
Shunt
2-Point Manual
2-Point Automatic

Each of these four calibration methods requires values for the excitation voltage, maximum applied load, and quiescent/tare for all sensor types.

Required Calibration Parameters	Calibration Methods				
	Name Plate		Shunt	2-Point Manual	2-Point Automatic
	Strain Gage	Load Cell or Transducer			
Excitation Voltage	✓	✓	✓	✓	✓
Max. Applied Load	✓	✓	✓	✓	✓
Quiescent/Tare	✓	✓	✓	✓	✓
Gage Factor	✓				
Sensitivity		✓			
Full Rated Load		✓			
Shunt Load Value			✓		
Bridge Resistance			✓		
Point 1 (mV Input)			✓		✓
Point 1 (Units Input)			✓	✓	✓
Point 2 (mV Input)					✓
Point 2 (Units Input)				✓	✓

To use any of these calibration methods, enter the appropriate values into the required spreadsheet columns of the *WBK16 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.

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.

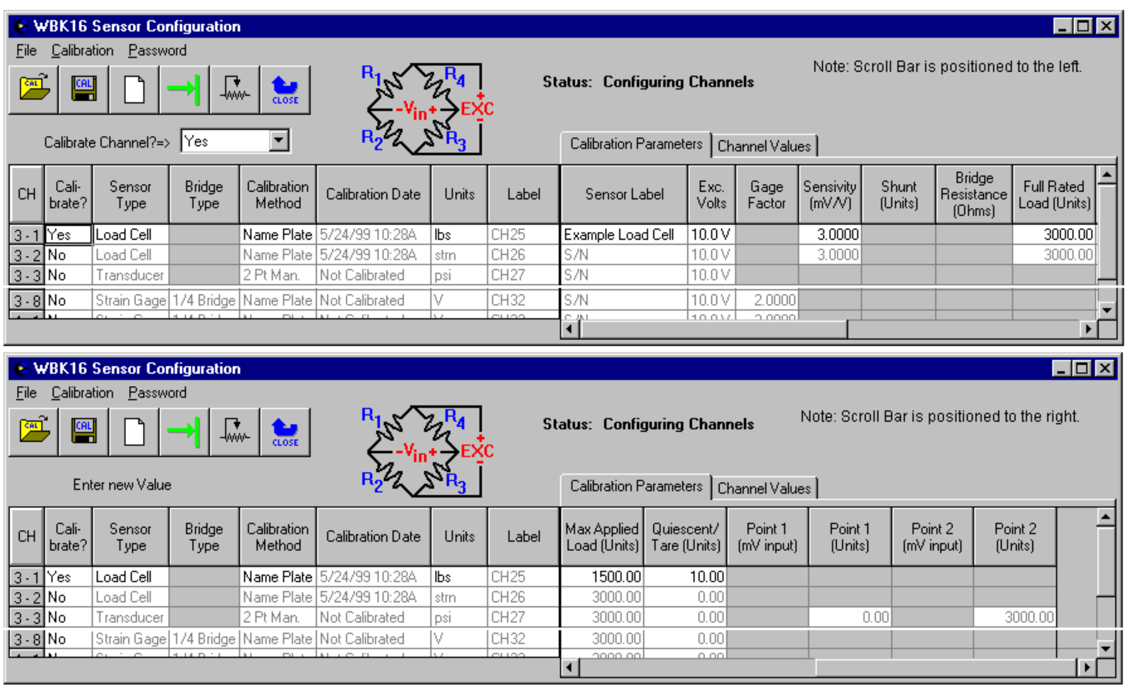
Consider a 3000-pound load cell rated at 3 mV/V using 10 V of excitation. When the load cell is used, a 10-pound platform will be placed on it. Although the load cell is rated at 3000 pounds, 1500 pounds is the maximum load that will ever be applied for this example.

According to the previous table, the required parameters for a Name Plate calibration when a load cell is used are excitation voltage, maximum applied load, quiescent/tare, sensitivity and full rated load. 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

To calibrate this load cell using the sensor calibration program:

1. First, enter the 5 necessary parameters into the calibration spreadsheet (see the figures below where the load cell used in this example is connected to channel 1-1).
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 *WBK16 Sensor Calibration* window and return to the main *WaveView Configuration* main window.

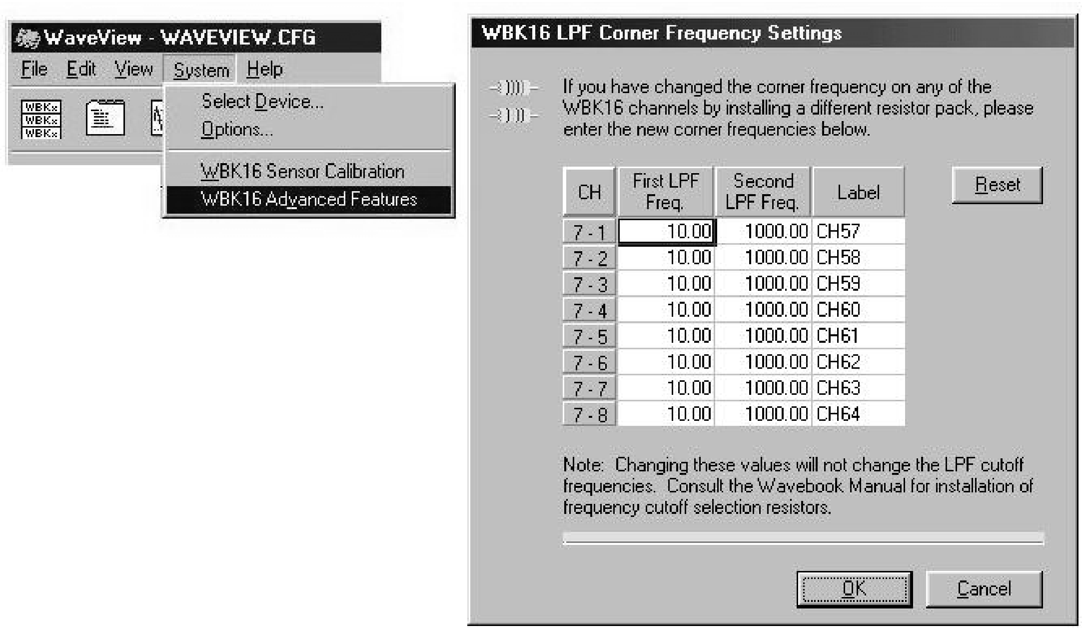


Calibration Example, Two Views

Changing Low-Pass Filter Displays

To change the LPF display, choose *WBK16 Advanced Features* from the *System* menu item. Enter desired values in the *WBK16 LPF Corner Frequencies Settings* dialog box. The frequency range for the first LPF setting is 2Hz-200Hz. The frequency range for the second LPF setting is 200 Hz to 20000 Hz.

Making changes to the "WBK16LPF 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). Refer to the section *Low-Pass Filter Customization*, page 6 in regard to customizing the Low-Pass Filters.



Accessing the WBK16 LPF Corner Frequencies Dialog Box

The *WBK16 LPF Corner Frequencies Dialog Box* is accessed from WaveView's main window by selecting **WBK16 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.

WBK16 – Specifications

Name/Function: Strain-Gage Module
Number of Channels: 8
Input Connector: Standard female DB9 per channel
Input Type: Differential
Input Impedance: 100 MΩ
Coupling: AC and DC, software selectable
Accuracy:
  Offset Drift: 1μV RTI/°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:
  ±3 V RTI @ gains 1 to 10
  ±300 mV RTI @ gains 10 to 100
  ±30 mV RTI @ gains 100 to 2000
  ±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: ±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° to 50°C
Storage Temperature: 0° to 70°C
Humidity: 0 to 95% RH, non-condensing
Dimensions: 221mm x 285mm x 35mm (8.5” × 11” × 1.375”)
Weight: 1.32 kg (2.9 lb)

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 <u>not</u> 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.