Life Science Suite™

ACQ-7700 Amplifiers

Manual Number
MACQ7700AMPS

By Gould Instrument Systems, Inc.

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SAFETY SUMMARY

This general safety information is for both user and service personnel. Specific **WARNINGS** and **CAUTIONS** will be found throughout the manual where applicable.

TERMS IN THIS MANUAL AND ON THE INSTRUMENT

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property if instructions are not followed. They appear in boldfaced capital letters.

WARNING statements identify conditions or practices that could result in personal injury or loss of life if instructions are not followed. They appear in boldfaced capital letters.

SYMBOLS IN THIS MANUAL AND ON THE EQUIPMENT

This symbol indicates paragraphs providing cautionary and detailed information about a specific part of the instrument. That part of the equipment is also marked with this symbol. (See references to this symbol in the manual.)

WARNING, risk of electric shock

AC, Alternating current

DC, Direct Current

Type B Equipment with an F-Type applied part

Type B Equipment

Type CF Equipment

PROTECTIVE CONDUCTOR TERMINAL; Earth (ground) (reference IEC publication 417-5019)

Earth (ground) TERMINAL (reference IEC publication 417-5017)

Equipotentiality (reference IEC publication 417-5021) Chassis (ground)

Fuse

OFF (Power connection from Main)

ON (Power connection to Main)

STANDBY (Power is on, instrument off in standby mode)

WARNING

IF THIS GOULD INSTRUMENT IS OPERATED OR USED IN A MANNER NOT SPECIFIED BY GOULD INSTRUMENTS SYSTEMS INC., THE PROTECTION PROVIDED BY THE SYSTEM MAY BE IMPAIRED.

POWER SOURCE

This instrument is intended to operate from a power source that does not apply more than 250Volts RMS between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential.

GROUNDING THE INSTRUMENT

This instrument is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) may render an electric shock.

USE THE PROPER POWER CORD

Use only the power cord and connector specified for your instrument. Use only a power cord that is in good condition.

TEST LEADS AND INTERCONNECT CABLES

Test leads and/or interconnect cables may carry **HAZARDOUS** live voltages. They must be examined regularly for mechanical and electrical wear and tear. If any wear or break has occurred, the lead or cable should be replaced.

USE THE PROPER FUSE

To avoid fire hazard, use only a fuse of the correct type, voltage rating and current rating as specified in the parts list for your instrument.

DO NOT OPERATE WITHOUT COVERS AND PANELS INSTALLED

To avoid personal injury and equipment damage, the user should disconnect power before removing covers, panels, or any grounding straps. Reinstall covers, panels, and any grounding straps *before* reconnecting power.

WARNINGS FOR AUTHORIZED SERVICE PERSONNEL

Dangerous voltages exist at several points in this instrument. To avoid personal injury, do not touch exposed connections or components while power is on. Disconnect power before removing protective panels, soldering, or replacing components.

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System Overview

Introduction

This manual describes the installation, operation, and specifications for the Gould ACQ-7700 Based amplifiers that operate with the PONEMAH Physiology Platform.

Each ACQ-7700 amplifier module has common user interface elements that are described in a common section of this manual. For specific details of a particular amplifier module, refer to that section of the manual.

All ACQ-7700 Signal Conditioners are user-installable modules which are compatible with Gould instruments that accept the ACQ-7700 series signal conditioning modules, such as the ACQ-7700 products. For more information on where and how this module can be used, contact your local Gould representative.

ACQ-7700 Signal Conditioning System

The Gould ACQ-7700 series of signal conditioning modules are fully programmable. Integrated with the Gould Life Science Suite PONEMAH P3 Plus acquisition and analysis software, they create a powerful yet easy to use data recording system. The Gould P3 Plus software was created to optimize the real-time monitoring, acquisition, review, and analysis of physiology signals. It is a 32-bit application designed for the Microsoft® Windows™ NT and 2000 Operating System environment, delivering very efficient utilization of computer resources.

Signal conditioner setup is performed using an intuitive graphic user interface. All parameters can be programmed directly in your test parameter units, greatly reducing potential data conversion errors. All setup parameters can be saved as a logical test name for later recall, saving valuable protocol set up time.

System Configuration

The Gould 7700 signal conditioners module occupies a single slot of the Gould ACQ-7700 case assembly. The input signals from the amplifiers are conditioned, digitized, and routed, via the 7700 "Broadcast" backplane, to the recording system. The P3 Plus software controls the viewing and acquisition of this data.

Within the P3 Plus software, an integrated software module handles all control and communication with the 7700 signal conditioning modules. You do not have to load any additional software or configure any software systems. When the system is started, the P3 Plus software will automatically interrogate the system and identify the 7700 modules and their slot placement.

For detailed information on the P3 Plus software, please refer to the P3 Plus Installation and Reference Manual.

Contact your local Gould sales representative to discuss your signal conditioning requirements and to obtain a complete listing of available modules and their specific capabilities.

System Requirements

The minimum requirements for the Life Science Suite are:

1. A personal computer configured as follows:
   A. PONEMAH Physiology Platform software, P3 Plus Acquisition and Analysis operation disks
   B. Pentium III 500 MHz processor or better
   C. Windows NT or 2000
   D. Minimum of 128 MB of RAM
   E. Hard disk capable of holding system software and experiment data (500 MB recommended minimum)
   F. AGP/PCI video graphics board capable of at least SVGA (800x600); for best performance it is strongly recommended that a video graphics card capable of 1024x768 resolution be used.
   G. One open PCI slot
2. PCI EPP Interface Card - part number P01926
3. Your choice of instrumentation signal conditioning modules and analysis modules

For information on Gould products and services, check out our website at www.GouldIS.com.

Configuring the System

System Description

The Gould 7700 signal conditioner uses a single slot of the Gould ACQ-7700 case. It includes three sections: the analog conditioning front end, an analog to digital conversion section and a bus communication and data interface section. There are no controls or internal jumpers or settings on any of the 7700 modules; all control is performed by software. The Gould ACQ-7700 chassis accepts up to six Gould 7700 Series Signal Conditioning modules. Modules are inserted into guided slots and secured by the positive threaded latching screws on the module.

Power, data, and communication connections are via a board-mounted connector on the rear of the 7700 module. The only user connections are the individual input signals.

Initial Inspection

Prior to attempting any electrical connections or operation, visually examine the unit for any damage.

Installing ACQ-7700 Modules

1. Turn OFF the power to the ACQ-7700 system (The signal conditioning modules **may be damaged** if inserted or removed under power and the ACQ-7700 system must be initiated with modules inserted for the controlling software to recognize their presence). The power switch is located in the rear of the ACQ-7700 system.
2. Remove a blank panel from the ACQ-7700 chassis. **NOTE: Slots cannot be skipped.** When installing ACQ-7700 modules, slots must be filled from slot A to slot F, starting with slot A. Slot A must be occupied.
3. Slide the signal conditioner into the open slot. The ACQ-7700 module metal side plate fits into plastic guides that align the module with the backplane mating connectors. Turn the latching screw knobs clockwise to secure the signal conditioner in its slot. Tightening the latching screws secures the mating connectors, located on the rear of the signal conditioner, into the backplane connector of the ACQ-7700 case. Be careful not to over tighten these screws.
4. Connect the signal conditioner's input cables and restore power.

Removing ACQ-7700 Modules

1. Turn OFF the power to the ACQ-7700 system. (The signal conditioning modules **may be damaged** if inserted or removed under power). The power switch is located in the rear of the ACQ-7700 system.
2. Disconnect the signal conditioner's input cables.
3. Turn the latching screw knobs counter-clockwise until the signal conditioner is released from the input bay and slide the signal conditioner module out of the ACQ-7700 chassis.
4. Insert a blank panel into the exposed slot. These panels perform more than simply an aesthetic function. They are required for proper system cooling and RFI/EMI shielding.

ACQ-7700 Chassis

An ACQ-7700 chassis or case assembly is used in a number of Gould recording instruments. This assembly is designed to house 7700 signal conditioning modules and supply all power, communications and data transfer to and from the host instrument. A typical ACQ-7700 case is illustrated in *ACQ-7700 Chassis*.

ACQ-7700 Chassis

Getting Started

Introduction

Please reference the ACQ-7700 / Type 3 Installation Manual (PN: MACQ7700) for a detailed description of the ACQ-7700 installation.

Before turning on the Acquisition Interface power, be sure the line voltage is within the power supply specifications.

The power switch for the ACQ-7700 is located on the rear of the unit. A green light located on the **ACQ MODULE** front panel illuminates when power is ON.

Connect the ACQ-7700 to the LPT port selected during installation using a standard parallel cable (Gould part No. P01255). If you have not already installed the P3 Plus-xxxx software on your system, please refer to the **PONEMAH Physiology Platform** reference manual (PN: MWIN-PPP-88W) for installation instructions.

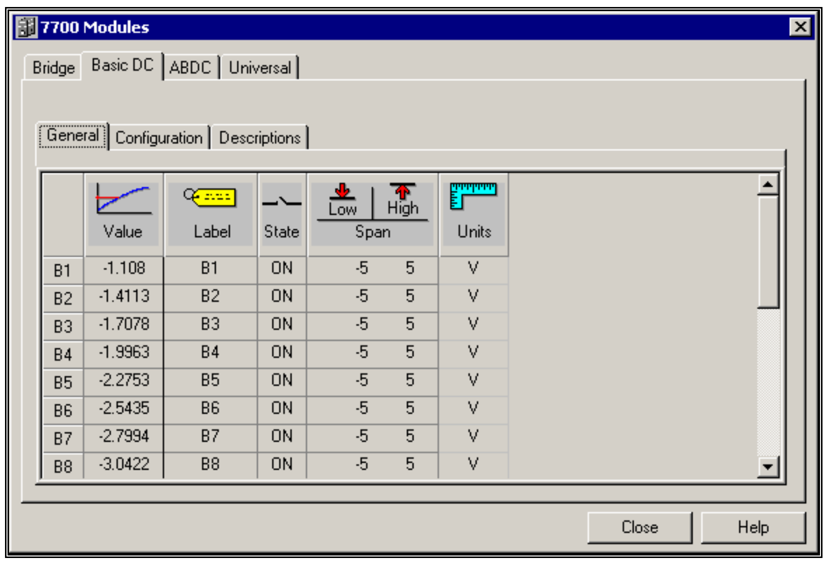
Once the inputs are connected, power up the Acquisition Interface, and start the P3 Plus application. You are now ready to begin recording data.

ACQ-7700 Amplifier User Interface

The amplifier Main Menu may be accessed by selecting the menu item **Calibration**, **7700 Amplifier Setup** from the P3 Plus application as displayed here:

7700 Amplifier Setup

The amplifier Main Menu displays an overview of the amplifiers installed within your recording system. If more than one type of module is installed, each type will display an associated setup configuration menu, which is accessed by selecting the appropriate tab in the Main Menu. In the example in Figure *Amplifier Configuration Dialog*, four types of modules are installed: Bridge, Basic DC, ABDC (Advanced Basic DC), and Universal. You can select any module for setup by clicking your mouse pointer on the tab associated with that module.



Amplifier Configuration Dialog

The General tab displays the setup status of the module. The slots in the ACQ-7700 chassis are labeled **A** through **F**, from left to right. The first slot is **A**. Since the Basic DC module has 16 input channels, there will be 16 set up rows displayed. In this example, B1 through B16 are displayed (accessed by the scroll bar on the right side) since the module is inserted in the second slot. For each channel, all parameters are displayed in the Units selected for that input.

Channel specific parameters may be entered in two ways. Text entry can be performed by selecting a particular cell, clicking your mouse pointer on it, and entering the new value, or double clicking on a particular cell, then a graphic element will appear which prompts you for your input. These are displayed, along with a description of the function, which is below it.

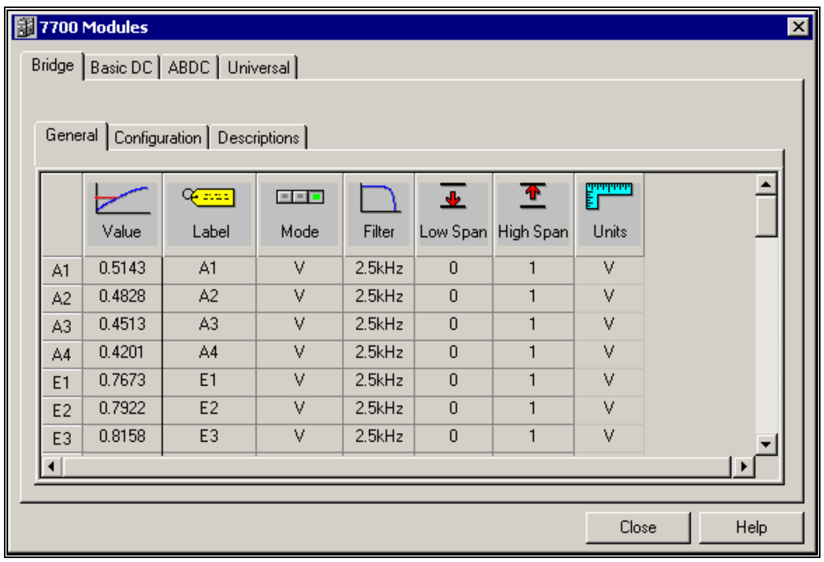
If you click on the icon of a setup function, such as **Label** or **Span**, all channels in that setup column will be selected. A graphic element or dialog box will appear and all channels may be changed, globally, with one entry.

For functions that use a graphical toggle switch, the function is enabled by double clicking your mouse pointer in the desired cell. Once selected, a graphical representation of a toggle switch will briefly appear, the switch position will change, and the selection panel will close. To disable the function, simply follow the same procedure, double clicking your mouse pointer in the desired cell. The switch position will change and the panel will close.

The sections that follow will describe the common functions that are available in all amplifier dialogs for setups and they will not be discussed in the individual sections of the manual. Only columns that are specific to an amplifier will be detailed in the specific amplifier manual.

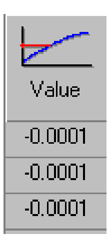
General Tab

All amplifier modules will have a General tab. In this tab, common elements such as **Value**, **Label**, and **Low Span/High Span** will be available for the user to configure the signal conditioner.



General Tab

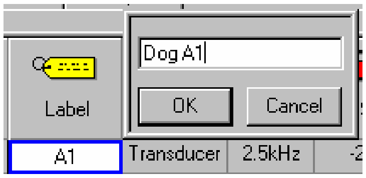
Value



This column continuously displays the current value that is on the input of the amplifier. This column is updated by the system once every second and cannot be updated by the User.

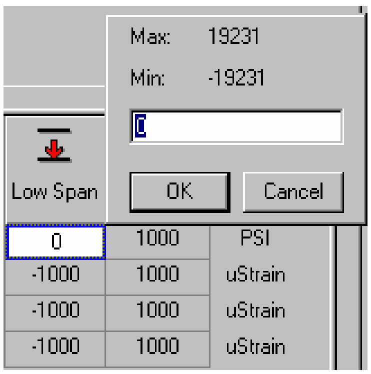
This column is useful in troubleshooting the amplifier input connection.

Label



Label allows you to type in a logical name (10 characters) for this particular input channel. The chosen name will be saved and used to identify the input data throughout the system, such as in the display frame and other dialogs that display input channel information.

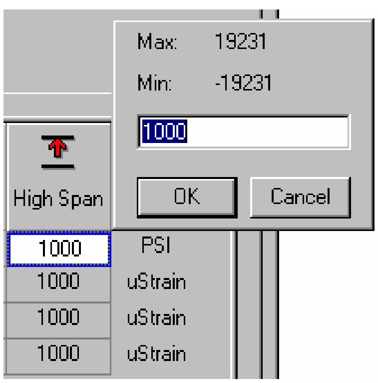
Low Span



The span defines the sensitivity or scale for each channel. The Low Span sets the minimum value, in user units that will be recorded.

The span is dependent upon the mode of operation selected. The Low Span may be chosen to be any value within the valid range for that input. The valid range is shown above the data entry box. When Low Span is selected, a dialog box appears. Simply type in the value desired. If the value entered is outside the acceptable range for this input, an **Invalid** message will flash in the Low Span window. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application.

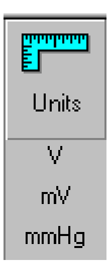
High Span



The high span defines the sensitivity or scale for each channel. The High Span sets the maximum value, in user units that will be recorded.

The span is dependent upon the mode of operation selected. The High Span may be chosen to be any value within the valid range for that input. The valid range is shown above the data entry box. When High Span is selected, a dialog box appears. Simply type in the value desired. If the value entered is outside the acceptable range for this input, an **Invalid** message will flash in the High Span window. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application.

Units

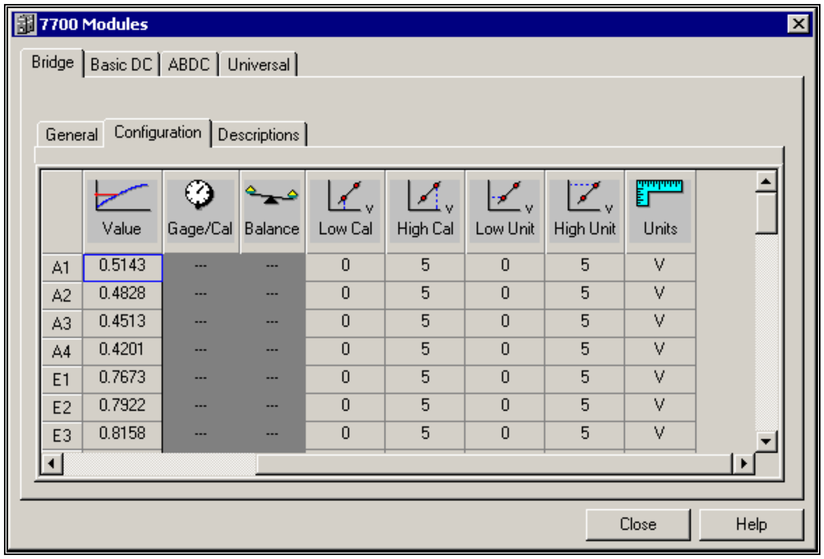


This column displays the Units that have been set in the **Configuration** tab and cannot be changed in this tab.

The Units have no effect on the channel and this is for documenting the Input units.

Configuration Tab

All amplifier modules will have a Configuration tab. In this tab, common elements such as **Low Units**, **High Units**, **Low Cal**, **High Cal**, and **Units** will be available for the user to configure the signal conditioner.

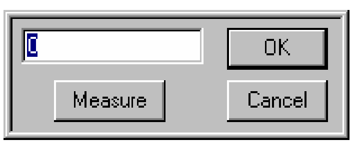


Configuration Tab

Value

This column is the same as the **General** tab Value column.

Low Cal



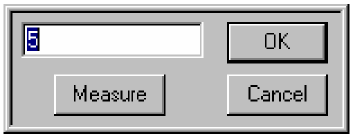
If you have available an input calibration signal (voltage), it can be used to automatically set your calibration and span to be recorded. Double clicking on either the **Low Cal** or **High Cal** cell associated with the channel will open a dialog box as shown. This function allows a specific value to be entered or measured that will be assigned to the Low Cal, or, by clicking the **Measure** button, accept an external signal source value that will set the calibration of the amplifier channel to correspond to the external calibration signal.

In Transducer Mode or in Voltage Mode, additional setup information is needed to correctly scale the particular low signal input. Since the input can be from a vast number of different sources, the specific input Low and High Units of measure should be set up. This calibrates the channel to the actual user units and scaling. The system will display, record, and perform analysis directly in your units of measure.

When the system defaults are: -1.00 Low Cal = -1 Unit. With Low Units set to -1, the ratios are 1:1. Low and High Cal entries are actual voltage values. The opposite defaults are present in the High Cal function. Also see Low and High Units and Measure section.

NOTE: The Low Cal must be performed before the High Cal measure.

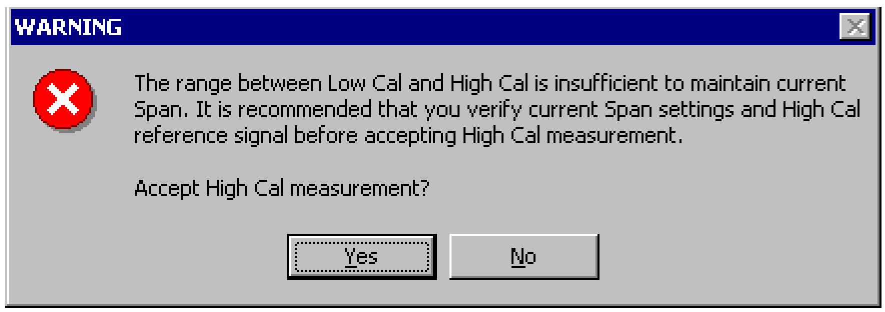
High Cal



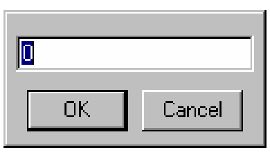
In Transducer Mode or in Voltage Mode, additional setup information is needed to correctly scale the particular high signal input. Since the input can be from a vast number of different sources, the specific input Units, High Unit, and Low Unit of measure should be set up. This calibrates the channel to the actual user units and scaling. The system will now display, record, and perform analysis directly in your units of measure.

For example, assume you are using a pressure transducer that outputs 50.12µV/V/cmHg and have set the channel excitation to 5Volts. Now assume you apply a pressure of 100mmHg to the transducer. In this example, the transducer bridge circuit will output 2.506mV (.05012mV * 5V * 10cmHg). Clicking on the **Measure** button will accept this voltage value 2.506mV (conversion of mV to Volts). Entering 100 in the Low Unit dialog box then sets the low point for the channel calibration. Repeating this process for High Cal and High Unit completes the calibration process.

If the Low Cal and High Cal does not have sufficient span, the following Warning message will be displayed.



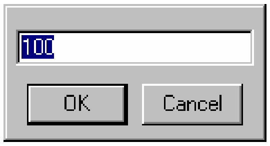
Low Unit



The Low Unit defines the Low Value or scale for a particular channel when operating in External or Voltage Mode. The Low Unit sets the minimum value, in user units that will be recorded.

The Low Unit is dependent upon the type of signal being recorded by this particular channel. The Low Unit may be chosen to be any value within the valid range for that input. When Low Unit is selected, a dialog box appears. Simply type in the value desired. Refer to the example included in the High Unit setup description.

High Unit

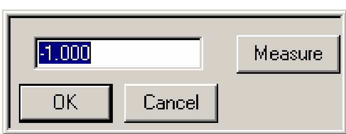


The High Unit defines the High Value or scale for a particular channel when operating in External or Voltage Mode. The High Unit sets the maximum value, in user units that will be recorded.

The High Unit is dependent upon the type of signal being recorded by this particular channel. The High Unit may be chosen to be any value within the valid range for that input. When High Unit is selected, a dialog box appears. Simply type in the value desired. The following example illustrates how Low/High Unit and Low/High Cal may be used to calibrate an individual input channel operating in Voltage Mode.

Example: Calibrate channel 4 to record the range 0 to 15ml/sec of flow. For this example, first set the input A4 to operate in Voltage Mode. This enables the Cal and Unit functions. Double click on the **Low Unit** cell in the A4 row. This will open the text box. Type in the value 0 and click on the **OK** button. Repeat this process for the **High Unit** cell, entering the value 15. For our example, we know that the flow meter we are using outputs 100mV per 1ml/sec of flow. To calibrate this input, double click on the **High Cal** cell. In the **Measure** text box, type in the value 15. This value is calculated by multiplying the desired High Unit (15ml/sec) by the flow meter output (100mV per 1ml/sec), arriving at a value of 1.5Volts. Click on the **OK** button to accept this value and close the window. Similarly, open the Low Cal text box and enter 0 (0mV), which is derived from multiplying the desired Low Unit value by the flow output. Click on the **OK** button. This channel is now calibrated.

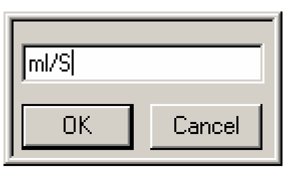
Measure



In instances where there is offset on the input signal, the Measure function can compensate for this offset. The software can measure a Low or High Cal value, and equivocate that value to equal the entry in the Low or High Units cells.

If you have an available input calibration signal (voltage), it can be used to automatically set your calibration and span. Double clicking on either the **Low Cal** or **High Cal** cell associated with the channel will open a **Measure** dialog box as shown here. This function allows you to manually enter a specific value that will be assigned to either the Low or High Cal, or, by clicking the **Measure** button to measure an external voltage that will set the calibration of the amplifier channel to correspond to the external calibration signal.

Units

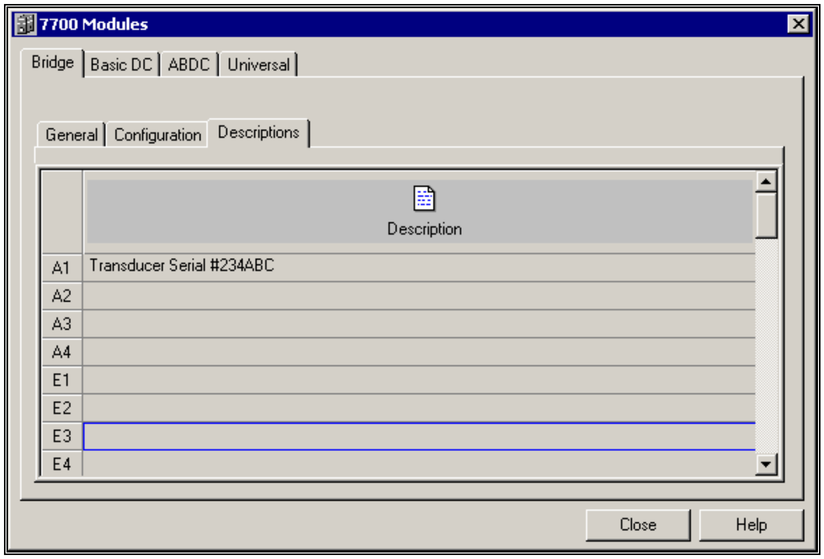


Units allows you to enter the actual physiology units being measured when operating in Voltage Mode. In Voltage Mode the default is Volts, but this may be changed to any applicable units. The User Unit input field is limited to 8 characters.

Example: Suppose channel 4 is connected to a flow meter that outputs a voltage proportional to the blood flow. To record this, input A4 will be configured in Voltage Mode. Double clicking on the A4 Units cell will display a text box, allowing you to enter "ml/S".

Descriptions Tab

The Descriptions Menu allows you to enter text to further describe the parameters being recorded. This may include additional transducer information or test setup information. It is not directly used as part of the amplifier configuration but is available for review or printing whenever desired. It expands upon the descriptions of the transducers being used and the setup for the measurement of blood pressure in this example. The following graphic represents a typical Description tab.



Description Tab

Basic DC (16 ch) & ABDC (32 ch)

Introduction

This section describes the operation and specifications for the Gould 8/16 channel Basic DC Signal Conditioner, Model Number 13-7715-00 and Model Number 13-7715-02, the Advanced Basic DC (ABDC) with 32-channel capability. Both DC Signal Conditioners are user installable modules, compatible with Gould instruments that accept the 7700 series signal conditioning modules, such as the ACQ-7700.

The Gould 7700 Basic DC signal conditioner is an eight to sixteen channel module, depending upon the mode of operation. It incorporates a programmable front end allowing the input circuits to be configured as either single ended or differential. If all channels are configured for single ended operation, the module can record 16 independent inputs. Differential input operation is achieved by combining two channels. In this way, from one to 8 channels can be configured as differential inputs. A unique feature is that inputs can be mixed; therefore, 2 channels (using four input circuits) may be configured as differential while the remaining 12 are configured as single ended. This greatly increases the module flexibility and optimizes system performance. The 7700 ABDC 32 Signal Condition has 32 single ended or 16 differential channels with unipolar / bipolar ranges using two 16 bit A/D converters.

The modules occupy a single slot of the Gould 7700 case assembly. The input signals are conditioned, digitized, and routed, via the 7700 “Broadcast” backplane, to the recording system. The P3 Plus software controls the viewing and acquisition of this data.

Within the P3 Plus software, an integrated software module handles all control and communication with the 7700 signal conditioning modules. The User does not have to load any additional software or configure any software systems. When the system is started, the P3 Plus software will automatically interrogate the system and identify the 7700 modules and their slot placement.

Analog Inputs

The DC signal conditioners are supplied with one 37-pin "D" shell type, male, input mating connector. This connector may be wired for up to 8 differential inputs or up to 16 single ended inputs for the Basic Amplifier. For the ABDC, it can be wired for 32 single ended or 16 differential channels. See *Input Signal Connections*. Also see *Accessories* in this section for optional input connection fixtures.

Caution ⚠

MAXIMUM NON-DESTRUCTIVE VOLTAGE ABOVE EARTH POTENTIAL TO ANY INPUT CONNECTION IS ±20 VDC OR PEAK AC FOR THE BASIC AMPLIFIER AND ±50 VDC OR PEAK AC FOR THE ABDC AMPLIFIER.

Input Signal Connections—BASIC 16 channel

The input channels on the 7700 Basic DC module may be configured as either single ended or differential inputs. To achieve a differential input circuit, two input channels must be combined. These "associated" channels are pre-defined. Channel 1 is associated with Channel 9; Channel 2 is associated with Channel 10 and so on through Channel 8 and Channel 16. Only inputs 1 - 8 may be selected as differential. If an input (Ch 1 - Ch 8) is configured as a differential circuit, its associated input channel (Ch 9 - Ch 16) will not be available as a single ended input channel.

The maximum input voltage is defined by the selected input range. The tables below define the in put connections for the single ended and differential modes.

It is recommended that a shielded cable be used. A selection of optional cables and adapters, pre-wired on one end to a 37 pin "D" shell mating connector are available. See the Accessories section of this manual.

Pin #	Single Ended Input	Pin #	Single Ended Input
1	Ground	20	Signal Channel 1
2	Ground	21	Signal Channel 2
3	Ground	22	Signal Channel 3
4	Ground	23	Signal Channel 4
5	Ground	24	Signal Channel 5
6	Ground	25	Signal Channel 6
7	Ground	26	Signal Channel 7
8	Ground	27	Signal Channel 8
9	Ground	28	Signal Channel 9
10	Ground	29	Signal Channel 10
11	Ground	30	Signal Channel 11
12	Ground	31	Signal Channel 12
13	Ground	32	Signal Channel 13
14	Ground	33	Signal Channel 14
15	Ground	34	Signal Channel 15
16	Ground	35	Signal Channel 16
17	NC	36	NC
18	NC	37	NC
19	NC		

Basic DC Input Connections in Single Ended Input Mode

Pin #	Differential Input	Pin #	Differential Input
1	Ground	20	Signal Channel 1+
2	Ground	21	Signal Channel 2+
3	Ground	22	Signal Channel 3+
4	Ground	23	Signal Channel 4+
5	Ground	24	Signal Channel 5+
6	Ground	25	Signal Channel 6+
7	Ground	26	Signal Channel 7+
8	Ground	27	Signal Channel 8+
9	Ground	28	Signal Channel 1-
10	Ground	29	Signal Channel 2-
11	Ground	30	Signal Channel 3-
12	Ground	31	Signal Channel 4-
13	Ground	32	Signal Channel 5-
14	Ground	33	Signal Channel 6-
15	Ground	34	Signal Channel 7-
16	Ground	35	Signal Channel 8-
17	NC	36	NC
18	NC	37	NC
19	NC		

Basic DC Input Connections in Differential Input Mode

Input Signal Connections—ABDC 32 channel

The input channels on the module may be configured as either single ended or differential inputs. To achieve a differential input circuit, two input channels must be combined. These "associated" channels are pre-defined. Channel 1 is associated with Channel 9; Channel 2 is associated with Channel 10 and so on through Channel 8 and Channel 16. From the menu only inputs 1 - 8 may be selected as differential. If an input (Ch 1 - Ch 8) is configured as a differential circuit, its associated input channel (Ch 9 - Ch 16) will not be available as an input channel. There are similar associations for channels 17 through 32.

The maximum input voltage is defined by the selected input range. The tables below define the in put connections for the single ended and differential modes.

It is recommended that a shielded cable be used. A selection of optional cables and adapters, pre-wired on one end to a 37 pin "D" shell mating connector are available. See the Accessories section of this manual.

Pin #	Single Ended Input	Pin #	Single Ended Input
1	Signal Channel 9	20	Signal Channel 1
2	Signal Channel 10	21	Signal Channel 2
3	Signal Channel 11	22	Signal Channel 3
4	Signal Channel 12	23	Signal Channel 4
5	Signal Channel 13	24	Signal Channel 5
6	Signal Channel 14	25	Signal Channel 6
7	Signal Channel 15	26	Signal Channel 7
8	Signal Channel 16	27	Signal Channel 8
9	Signal Channel 25	28	Signal Channel 17
10	Signal Channel 26	29	Signal Channel 18
11	Signal Channel 27	30	Signal Channel 19
12	Signal Channel 28	31	Signal Channel 20
13	Signal Channel 29	32	Signal Channel 21
14	Signal Channel 30	33	Signal Channel 22
15	Signal Channel 31	34	Signal Channel 23
16	Signal Channel 32	35	Signal Channel 24
17	Ground	36	Ground
18	Ground	37	Ground
19	Ground		

Advanced Basic DC Input Connections in Single Ended Input Mode

Pin #	Differential Input	Pin #	Differential Input
1	Signal Channel 1-	20	Signal Channel 1+
2	Signal Channel 2-	21	Signal Channel 2+
3	Signal Channel 3-	22	Signal Channel 3+
4	Signal Channel 4-	23	Signal Channel 4+
5	Signal Channel 5-	24	Signal Channel 5+
6	Signal Channel 6-	25	Signal Channel 6+
7	Signal Channel 7-	26	Signal Channel 7+
8	Signal Channel 8-	27	Signal Channel 8+
9	Signal Channel 17-	28	Signal Channel 17+
10	Signal Channel 18-	29	Signal Channel 18+
11	Signal Channel 19-	30	Signal Channel 19+
12	Signal Channel 20-	31	Signal Channel 20+
13	Signal Channel 21-	32	Signal Channel 21+
14	Signal Channel 22-	33	Signal Channel 22+
15	Signal Channel 23-	34	Signal Channel 23+
16	Signal Channel 24-	35	Signal Channel 24+
17	Ground	36	Ground
18	Ground	37	Ground
19	Ground		

Advanced Basic DC Input Connections in Differential Input Mode

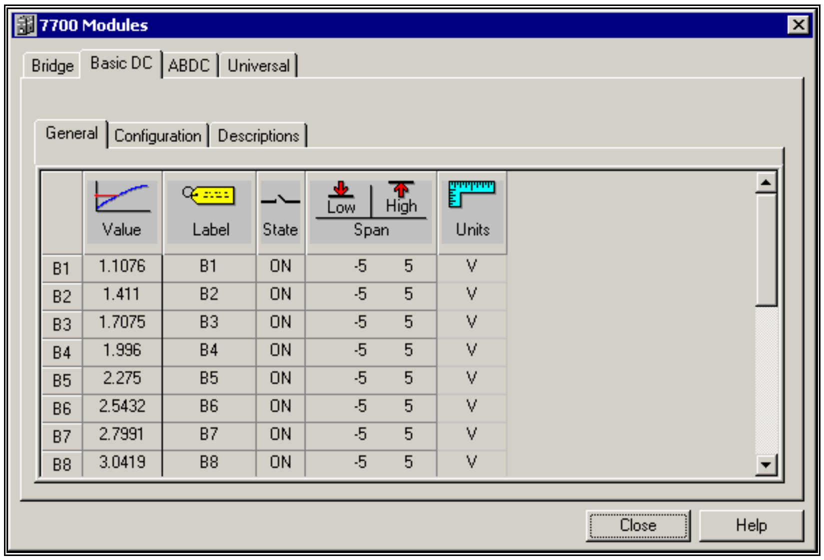
Configuring the Basic DC Amplifier

In the figure below, *Basic DC General Tab*, the Basic DC module has been selected. When a module type is selected, its tab is brought to the foreground and a group of set up menus specific to that module will be displayed. This will include General, Configuration, and Descriptions tabs, which are accessed by their own tabs.

General Tab

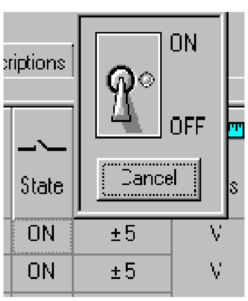
The General tab, as seen in Basic DC Amplifier, allows the user to set up channel specific signal conditioner parameters. This includes the channel Label, State, and Span.

See Getting Started / General Tab for definitions of common menu items.



Basic DC General Tab

State

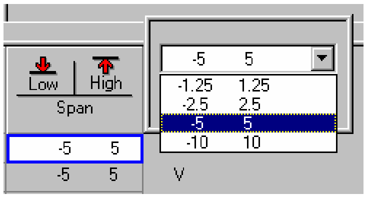


State will turn ON and OFF the electronics of the inputs, and has no effect on whether or not the input is sampled. To include or exclude a channel from being sampled, refer to the **Input Setup** dialog in the **P3 Plus Reference** Manual and set the **Analysis** to DIS to disable that input from being sampled.

For example, if the State is set to OFF, the amplifier will turn the amplifier input off, but if the input has been assigned to an **Analysis** module in the **Input Setup** dialog, the input channel will be saved in the data set.

Inputs that are not going to be sampled should be turned off. This allows the amplifier to have a high aggregate sample rate.

Span



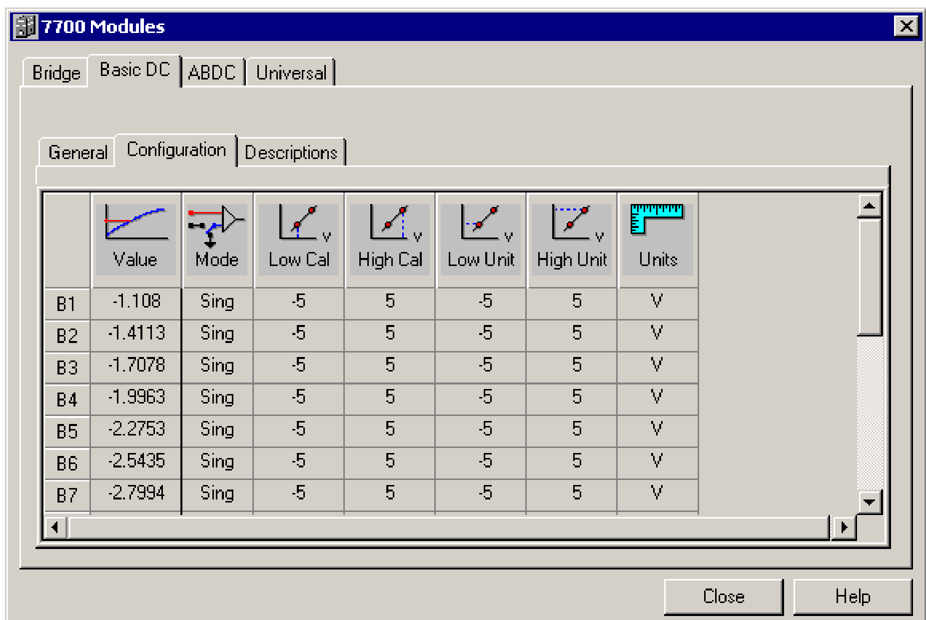
There is only one span selection that sets the maximum input of the amplifier. The Low/High span is symmetrical.

The Span defines the sensitivity or scale for each channel. This function sets the maximum and minimum values, in User units that will be recorded. For the Basic DC module, there are four selectable choices. These ranges are always bi-polar.

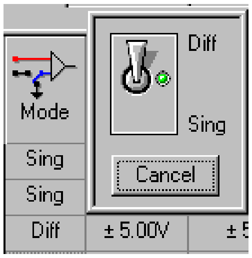
The Span may be chosen to be any of the four selections within the valid range for that input. When Span is selected, a dialog box appears. Simply select the range desired. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application. This will be defined by the calibration and unit set up in the Configuration tab. Refer to High/Low Cal and High/Low Unit setup for a sample setup. In this example, the input is calibrated to measure the input voltage of ±5Volts. The four span ranges allowed will then become a ratio of this calibrated span. Once calibrated, you can record and display any of the four ranges.

Configuration Tab

To set up the actual signal input configuration, select the Configuration tab in the signal conditioner setup panel. The Configuration set up screen, as shown in Figure *Basic DC Configuration Tab*, will be displayed.



Basic DC Configuration Tab



Mode

The Mode function allows you to select the input circuit configuration, either Single Ended or Differential. This is accomplished by a simple toggle switch function.

The Basic DC module is designed such that two input channels may be combined to achieve a single Differential input channel. These "associated" channels are pre-defined. Channel 1 is associated with Channel 9; Channel 2 is associated with Channel 10 and so on through Channel 8 and Channel 16. Due to this, only inputs 1 - 8 may be selected as differential. If an input (Ch 1 - Ch 8) is configured as differential mode, its associated input channel (Ch 9 - Ch 16) will be grayed out in both the General and Configuration menus, as they are no longer available as an input channel.

For the Low Cal, High Cal, Low Unit, High Unit and Units refer to Configuration Tab on page 11, Getting Started / General Tab.

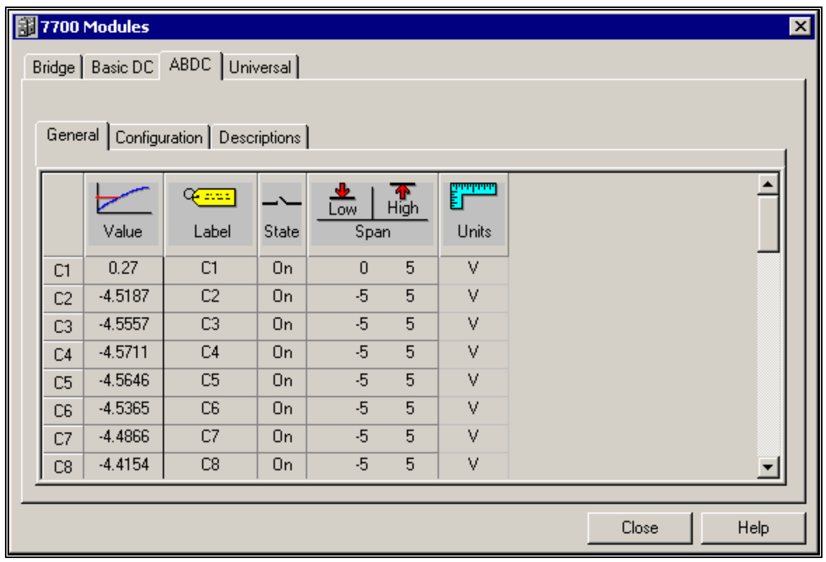
Configuring the ABDC (Advanced Basic) 32 channel

In the figures below, the ABDC module has been selected. When a module type is selected, its tab is brought to the foreground and a group of set up menus specific to that module will be displayed. This will include General, Configuration, and Descriptions tabs, which are accessed by their own tabs.

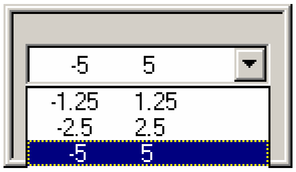
General Tab

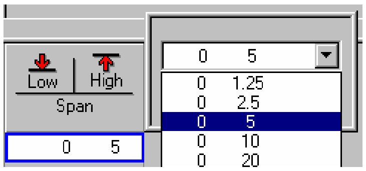
The General tab allows the user to set up channel specific signal conditioner parameters. This includes the channel Label, State, and Span. Dependent on the Polarity selection in the Configuration Tab, Span may be indicated as Bipolar or Unipolar as shown below.

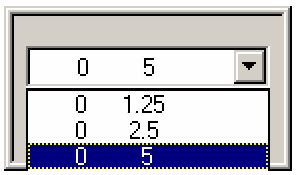
See Getting Started / General Tab for definitions of common menu items.



ABDC General tab







Unipolar Span

Span

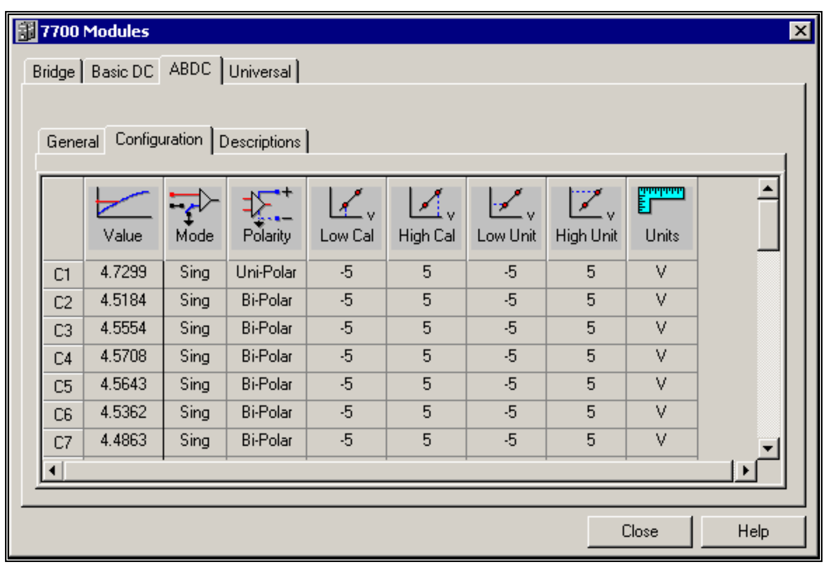
Span selection sets the maximum input of the amplifier. The Low/High Span is symmetrical for Bio-polar polarity and 0V to max span for Unipolar polarity.

The Span defines the sensitivity or scale for each channel. This function sets the maximum and minimum values, in User units that will be recorded. There are five selectable choices: 1.25V, 2.5V, 5V, 10V, and 20V in Bi-polar or Unipolar polarities.

The Span may be chosen to be any of the five selections within the valid range for that input. When Span is selected, a dialog box appears. Simply select the range desired. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application. This will be defined by the calibration and unit set up in the Configuration tab. Refer to Low/High Cal and Low/High Unit setup for a sample setup in the Getting Started / General Tab on page 9.

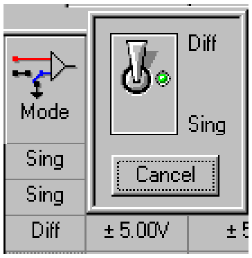
Configuration Tab

To set up the actual signal input configuration, select the Configuration tab in the signal conditioner setup panel. The Configuration set up screen, as shown in Figure *ABDC Configuration Tab*, will be displayed. Bipolar or Unipolar Polarity can be selected. Singular or differential modes can also be selected.



ABDC Configuration tab

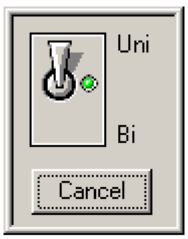
Mode



The Mode function allows you to select the input circuit configuration, either Single Ended or Differential. This is accomplished by a simple toggle switch function.

The ABDC module is designed such that two input channels may be combined to achieve a single Differential input channel. These "associated" channels are pre-defined. Channel 1 is associated with Channel 9; Channel 2 is associated with Channel 10 and so on through Channel 8 and Channel 16. Due to this, only inputs 1 - 8 may be selected as differential. If an input (Ch 1 - Ch 8) is configured as differential mode, its associated input channel (Ch 9 - Ch 16) will be grayed out in both the General and Configuration menus, as they are no longer available as an input channel. Channels 17 through 32 are associated in a similar manner.

Polarity



The Polarity function allows you to select the polarity of the signal to be displayed either in Bi-polar or Unipolar mode. This is accomplished by a simple toggle switch function.

The ABDC module is designed such that a 16-channel group (1 through 16 or 17 through 32) may be either bi-polar (zero centered) or unipolar (Zero at the edge). Double clicking on any one channel 1 through 16, (or 17 through 32), will change the polarity of that 16-channel group. All channels can be changed at once by clicking on the Polarity Icon.

For Low Cal, High Cal, Low Unit, High Unit and Units, refer to Configuration Tab on page 11 Getting Started.

Accessories

This section lists the available accessories that are available for the Basic DC amplifier and the Advanced Basic DC Amplifier:

Part Number	Description
CL-210942-37 (shell) CL-245537-37 (connector)	Shell and connector for both the Basic 16 and ABDC 32
CL-713497	Input cable assembly for Basic 16 for inputs 1 through 8 only
J02867	Input Screw terminal box for Basic 16
J03032	Input Screw terminal box for ABDC 32
J03055	Input BNC terminal box with cable assembly CL-311222-1 for both Basic 16 and ABDC 32

DC/Bridge Amplifier

Introduction

This section describes the installation, operation, and specifications for the Gould 4 channel DC/Bridge/Transducer Signal Conditioner, Model Number 13-7715-30. The DC/Bridge/Transducer Signal Conditioner is a user installable module compatible with Gould instruments that accept the 7700 series signal conditioning modules, such as the ACQ-7700 product.

The Gould 7700 DC/Bridge/Transducer signal conditioner is a four-channel module. Four independent input connectors, each with its own associated excitation source for use with transducers or strain gauge circuits, are employed for ease of use. The module occupies a single slot of the Gould 7700 case assembly. The four input signals are conditioned, digitized, and routed, via the 7700 "Broadcast" backplane, to the recording system. The P3 Plus software controls the viewing and acquisition of this data.

Analog Inputs

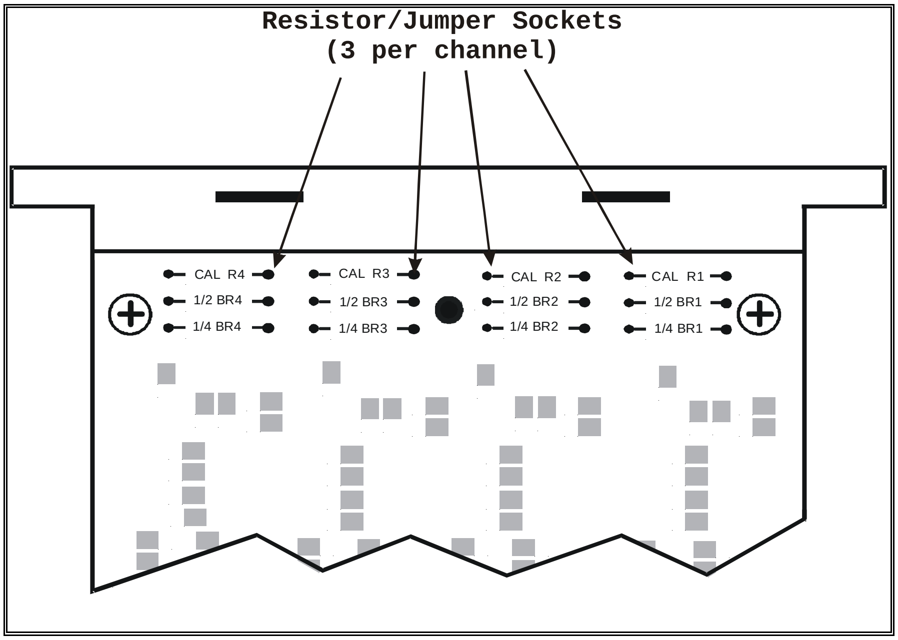
The DC/Bridge/Transducer signal conditioner is supplied with one eight-pin miniature "DIN Style", male input mating connector per channel. Each of the module front panel connectors is labeled with its channel number. See Input Signal Connections.

CAUTION

MAXIMUM VOLTAGE ABOVE EARTH POTENTIAL TO EITHER INPUT TERMINAL IS 30 VDC OR PEAK AC.

Internal Settings

The 7700 DC/Bridge/Transducer signal-conditioning module has three sockets dedicated to each input channel. These allow you to insert resistors and/or jumpers for transducer calibration or bridge completion. Refer to Figure *Resistor Calibration and Completion Sockets*. The accompanying table identifies these sockets.



Resistor Calibration and Completion Sockets

The following table describes the sockets as illustrated in Figure *Resistor Calibration and Completion Sockets*. If you need to utilize these circuits for your application, refer to your transducer supplier's manuals and Appendix A for assistance in calculating values for the plug in resistors.

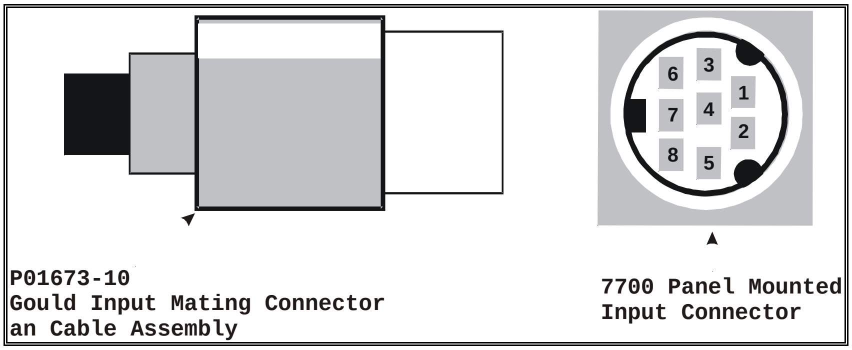
NOTE: If your transducer has a built-in calibration resistor, the CAL Rx socket must remain open. Cal Rx is used only if the transducer manufacturer supplies a separate (unattached) calibration resistor along with the transducer, or if none is supplied and you choose to calculate the appropriate value and add it to the internal amplifier circuit.

Connection (x = 1-4)	Circuit Completion
CAL Rx	Internal Calibration resistor (if required)
½ Bridge	Wire jumper (#22 AWG, 0.025 inch diameter)
¼ Bridge	Completion resistor, typically 120 or 350Ω

Input Signal Connections

The signal input connection is shown in Figure *Bridge Mating Connector and Input Connector*. The table that follows describes the pin connections for this connector. The maximum input voltage is ±5VDC or 10V peak. It is recommended that a shielded eight-conductor cable be used for low-level measurements. Circuit Common (pin 4) may be connected to the negative input terminal (pin 2) for non-inverting measurements or to the positive input terminal (pin 1) for inverting measurements. An optional 3-meter, 8 wire shielded cable, pre-wired on one end to a miniature "DIN Style" mating connector is available. Due to the small, tightly spaced pins on these connectors, it is recommended that the pre-wired cable be used. See the accessories section of this manual.

Note: Pin 4 is reserved for circuit common.



Bridge Mating Connector and Input Connector

Pin	Connection	Input Cable Color
1	+ V In	Brown
2	- V In	Red
3	+ Excitation	Orange
4	Circuit Common	Yellow
5	- Excitation	Green
6	+ Sense	Blue
7	R CAL	Violet
8	- Sense	Gray
Shield (9)	Chassis Ground	Shield

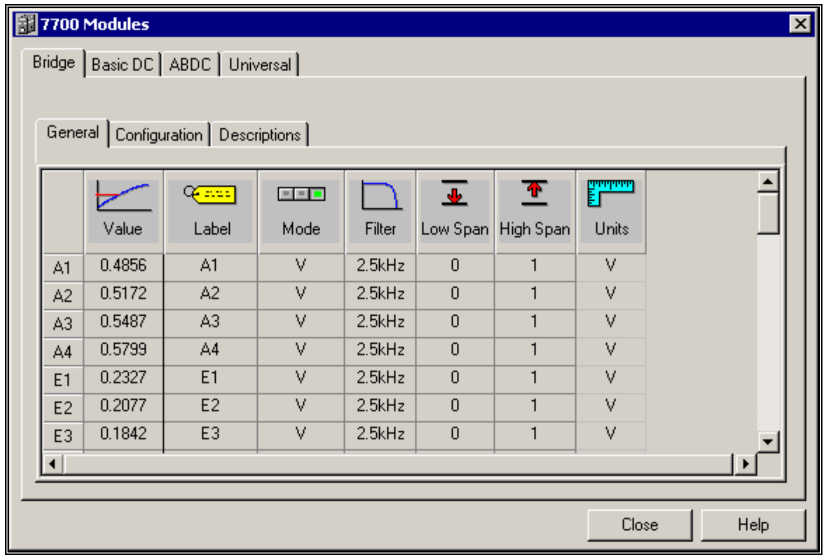
Configuring the DC/Bridge/Transducer Amplifier

In the following figure, *DC/Bridge/Transducer General Tab*, the Bridge Amplifier module has been selected. When a module type is selected, its tab is brought to the foreground and a group of set up menus specific to that module will be displayed. This will include General, Configuration, and Descriptions tabs, which are accessed by their own tabs.

General Tab

The General tab allows the user to set up channel specific signal conditioner parameters. This includes the channel Label, Mode, and Span.

See Getting Started / General Tab for definitions of common menu items.

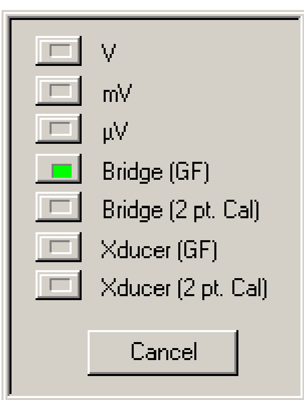


Bridge General Tab

Mode

This selection allows you to choose the mode of operation for a particular channel or module. As with all amplifier functions, double clicking the mouse pointer in the **Mode** cell of a particular channel allows you to set that channel. Double clicking on the **Mode** symbol allows you to set all modules, globally, to the same mode of operation. In both instances a graphic selection panel will appear with the options of: Transducer, Bridge, or DC (Voltage) operating modes.

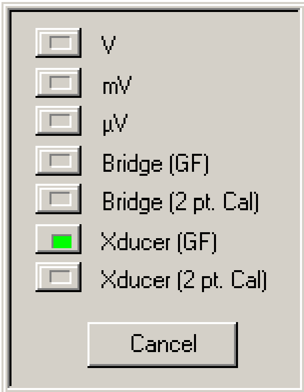
Bridge



This operating mode is chosen when you are using strain gauges to record direct force (tension, compression, etc.). Two options are offered in this mode: Bridge Gauge Factor and Bridge 2 point Cal. In Bridge mode, the amplifier module supplies excitation to the strain gauges and measures the resultant output voltage. Although the 7700 module allows you to add completion resistors and jumpers enabling the use of 1, 2, or 4 arm bridge circuits, it is strongly recommended that 1-arm bridge circuits are not used (see details and descriptions of bridge completion circuits in Appendix A).

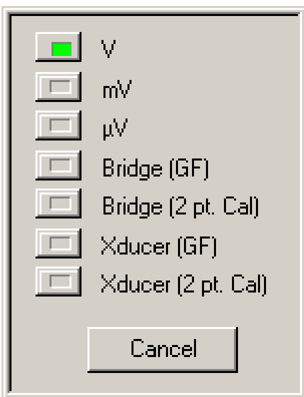
If Bridge Gauge Factor is selected, The Gauge Factor for the particular strain gauge being used must be entered to calibrate the input to the appropriate units (see Gauge/Cal in the Configuration section for proper set up). If Bridge 2 point cal is selected, the amplifier will use the direct input from the bridge circuit to calibrate the input channel in user units (see Unit/Cal setup in the Configuration Tab section).

Xducer



This mode is used when connecting to a strain gauge based transducer, such as a pressure transducer. It is assumed that the transducer will have a complete 4-arm circuit and, therefore, the set up selection for the number of arms is not valid when this mode is chosen. Two options are offered in this mode: Xducer Gauge Factor and Xducer 2 point Cal. In Transducer mode, the amplifier module supplies excitation to the transducer strain gauge circuit and measures the resultant output voltage. If Xducer Gauge Factor is selected, the Cal Factor for the particular transducer being used must be entered to calibrate the input to the appropriate units (see Gauge/Cal in the Configuration Tab section for proper set up). If Transducer External is selected, the amplifier will use the direct input from the transducer to calibrate the input channel in user units (see Unit/Cal setup in the Configuration Tab section).

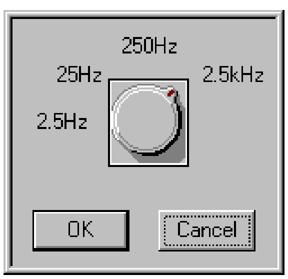
DC (Voltage)



This mode sets the module to operate as a general purpose DC input amplifier. In this mode, Gauge/Cal and Arms are not applicable. In Bridge/Xducer 2 point Cal mode or in Voltage Mode, additional information is needed to correctly set up the particular signal input. Since the input can be from a vast number of different sources, the specific input Units, High Unit, and Low Unit of measure may be input manually. This calibrates the channel to the actual user units and scaling. The system will now display, record, and perform analysis directly in your units of measure.

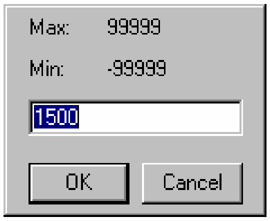
The three selections: **V**, **mV,** or **µV** selects whether the amplifier is measuring volts, millivolts or microvolts. The **Span** will be entered in these units.

Filter



This function allows you to add filtering to your input signal. Due to the bandwidth of the Bridge/Transducer/ Voltage module and the maximum sampling rate of the A/D converter, the default or "open" value is 2.5kHz. This setting performs as an anti-aliasing filter for the module.

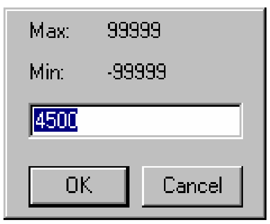
If you desire to enable input filtering, you can select from one of three additional low pass filter settings. This feature is especially useful if you are attempting to record slow changing phenomena, such as flow or pressure, in a noisy environment.



Low Span

The span defines the sensitivity or scale for each channel. The Low Span sets the minimum value, in user units that will be recorded.

The span is dependent upon the mode of operation (Bridge/Xducer/DC) selected. The Low Span may be chosen to be any value within the valid range for that input. The valid range is shown above the data entry box. When Low Span is selected, a dialog box appears. Simply type in the value desired. If the value entered is outside of the acceptable range for this input, an **Invalid** message will flash in the Low Span window. Refer to Input Voltage Range/Suppression/Balance table below for the valid span ranges in volts. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application. This will be defined by either the Cal factor of the transducer or the Gauge factor for the strain gauges used, or by the calibration and unit set up when an input is operated in Bridge/Xducer 2 pt Cal or Voltage mode.



High Span

The span defines the sensitivity or scale for each channel. The High Span sets the maximum value, in user units that will be recorded.

The span is dependent upon the mode of operation (Bridge/Xducer/DC) selected. The High Span may be chosen to be any value within the valid range for that input. The valid range is shown above the data entry box. When High Span is selected, a dialog box appears. Simply type in the value desired. If the value entered is outside of the acceptable range for this input, an **Invalid** message will flash in the High Span window. Refer to Input Voltage Range/Suppression/Balance table for the valid span ranges in volts. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application. This will be defined by either the Cal factor of the transducer or the Gauge factor for the strain gauges used, or by the calibration and unit set up when an input is operated in Bridge/Xducer 2 pt Cal or Voltage mode.

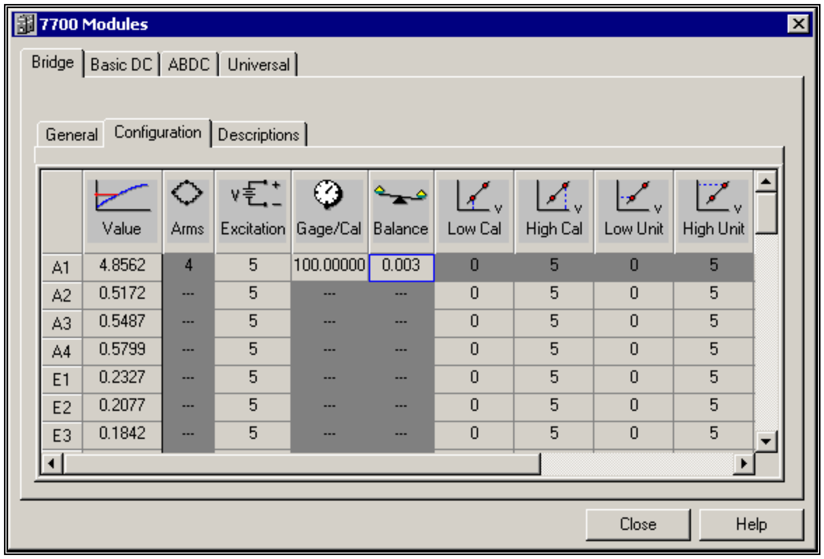
Input Voltage Range	Maximum Suppression/Balance
High Span - Low span ≥ 250µV and < 2.5mV	(High Span + Low Span)/2 ≤ 25mV
High Span - Low span ≥ 2.5mV and < 25mV	(High Span + Low Span)/2 ≤ 250mV
High Span - Low span ≥ 25mV and < 250mV	(High Span + Low Span)/2 ≤ 2.5V
High Span - Low span ≥ 250mV and < 2.5V	(High Span + Low Span)/2 ≤ 2.5V
High Span - Low span ≥ 2.5V and < 10V	(High Span + Low Span)/2 ≤ 10V

Input Voltage Range/Suppression/Balance table

In the General set up window, the Units for each input channel are displayed. The Span is displayed directly in these user units. The actual units of measure are set up in the Configuration section (see Units).

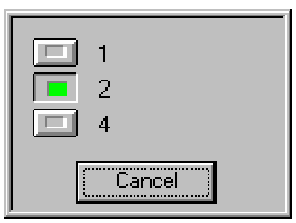
Configuration Tab

To set up the actual signal input configuration, select the Configuration tab in the signal conditioner setup panel. The Configuration set up screen, as shown below will be displayed.



Bridge Configuration Tab

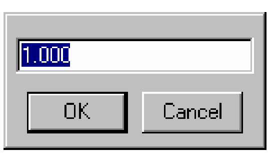
Arms



This function allows you to set the number of strain gauge arms used as a transducer in a bridge circuit. When selected, a graphic display will appear allowing you to choose 1, 2, or 4 arms. If you are using a single strain gauge or two strain gauges to record force or displacement, you must complete the remaining arms by inserting the appropriate resistors and/or jumpers on the 7700 module. Refer to the Internal Settings section and Appendix A for information on how to accomplish this. The 7700 module automatically adjusts the circuit gain to compensate for the number of arms.

NOTE: It is strongly recommended that a minimum of two strain gauges always be used. See Appendix A, Introduction to Strain Recording for a description of the different configurations and their associated advantages/disadvantages.

Excitation



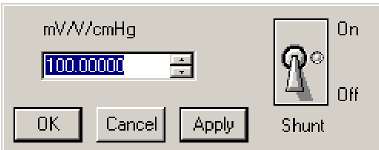
This function displays a text box that allows you to set the excitation voltage that will be applied to the transducer or strain gauge. Although this is commonly set to 5Volts DC, it may be beneficial to change this setting. Any integer value from 1 to 10 (1Volt to 10Volts) may be entered. The output of a transducer is directly proportional to the input excitation. Therefore, by doubling the excitation voltage you can double the output of the transducer.

NOTE: You should be careful not to exceed the rated operational range of your transducer. Also, adding excitation will increase the current and the heat that must be dissipated by the transducer. In some cases, this additional heat may cause the transducer signal to drift unacceptably.

Caution: Excitation current is limited to 20mA. Exceeding this limit will lead to measurement errors!

$$\textbf{Excitation maximum} = (20 * 10^{-3}) *(R_{bridge})$$

Gauge/Cal



The Gauge or Cal factor is usually either printed on the transducer or is included with the strain gauge or transducer documentation. Selecting this function displays a text box that allows you to enter the Gauge/Cal factor. Entering the Gauge/Cal factor for the bridge or transducer allows the input for that channel to be calibrated to the associated units. The Gauge/Cal factor is often stated as a dimensionless number, such as 50.12, but is really a function dependent upon the type of sensor. For example, if you are using a pressure transducer, which outputs a voltage proportional to pressure in cmHg (centimeters of Mercury), entering the cal factor from the transducer will calibrate the amplifier input directly to the transducer's output (cmHg). The cal factor for a transducer is commonly stated as µV/Volt per unit of measure. For a typical pressure transducer this may be µV/Volt/cmHg. The Cal input function is defaulted to a value of 100µV/V. For a typical strain gauge, the Gauge factor will be stated as mV/V/1000µStrain. Selecting Bridge Internal sets the module for use with standard strain gauges and defaults the Gauge factor to a value of 1mV/V/1000µStrain. If you are using a strain gauge that has a gauge factor of 2.11mV/V/1000µStrain the value you enter will be 2.11. If you are using a transducer with a Cal factor other than µV/Volt or a strain gauge with a Gauge factor other than mV/V, you must convert the Gauge/Cal factor into the appropriate units.

Some pressure transducers may not state a Gauge/Cal factor; instead they may state an output in mV/PSIG (Pounds per Square Inch, Gauge). For these transducers, either the Transducer "External" mode or Voltage Mode can be used. In Transducer External mode, calibration is performed by applying a known load and recording the transducer output (see Transducer External Mode operation and Unit/Cal set up). Alternatively, the Voltage Mode may be used. In this case you can simply convert the amplifier calibration from Volts to PSIG by employing the transducer conversion factor (mV/PSIG) in the Cal and Unit input cells (see Figure *Resistor Calibration and Completion Sockets*).

Shunt allows you to electronically place a shunt resistor across the input circuit for system calibration. This shunt may be contained within the transducer or may be a Calibration resistor placed in the internal socket for that particular channel. See Figure *Resistor Calibration and Completion Sockets* and the accompanying table for a description and explanation of this internal calibration resistor.

This function operates as a "toggle" switch; once selected it remains on until turned off. With the shunt resistor in the circuit, the recording system can be calibrated based upon the simulated force, displacement, flow, etc.

Balance

This function displays a push button which, when enabled, automatically nulls the offsets in the bridge circuit. This function is valid for either Transducer or Bridge operation. Balance must be performed prior to calibration and setting of the Span parameters. The auto-balance function is a "momentary" function that is activated by the push button. While the BAL function is in progress, the message **Wait** will be flashed in the input cell. When the bridge circuit balance is completed, the button panel will disappear and the input cell will display **BAL**. If the bridge circuit cannot be balanced, an **Invalid** warning will flash and the circuit status will be returned to the state it was in prior to attempting the balance function. Canceling the balance function also returns the circuit to its prior state.

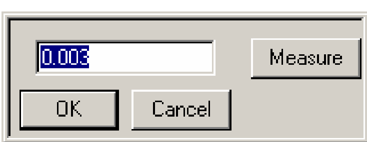
NOTE: Balance must be performed prior to setting the amplifier span and initiating an acquisition. If the amplifier span (gain) is changed, the bridge circuit must be re-balanced or the output will not be calibrated. **WHENEVER THE SPAN IS CHANGED THE BRIDGE CIRCUIT MUST BE BALANCED TO ENSURE ACCURATE MEASUREMENTS.**

Low Cal

In Bridge/Transducer (2 pt. Cal) mode or in Voltage Mode, additional setup information is needed to correctly scale the particular low signal input. Since the input can be from a vast number of different sources, the specific input Units, High Unit, and Low Unit of measure should be set up. This calibrates the channel to the actual user units and scaling. The system will now display, record, and perform analysis directly in your units of measure.

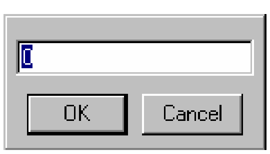
If you have available an input calibration signal (voltage), it can be used to automatically set your calibration and span to be recorded. Double clicking on either the **Low Cal** or **High Cal** cell associated with the channel operating in (2 pt. Cal) or Voltage Mode will open a measure dialog box as shown here. This function allows you to manually enter a specific value that will be assigned to either the Low or High Cal, or, by clicking the **Measure** button accept an external voltage that will set the calibration of the amplifier channel to correspond to the external calibration signal.

High Cal



In Bridge/Transducer (2 pt. Cal) mode or in Voltage Mode, additional setup information is needed to correctly scale the particular high signal input. Since the input can be from a vast number of different sources, the specific input Units, High Unit, and Low Unit of measure should be set up. This calibrates the channel to the actual user units and scaling. The system will now display, record, and perform analysis directly in your units of measure. Refer to Low Cal setup for additional information on the measure function.

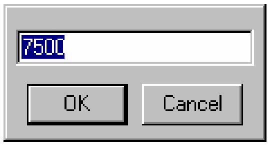
Low Unit



The Low Unit defines the Low Value or scale for a particular channel when operating in (2 pt. Cal) or Voltage Mode. The Low Unit sets the minimum value, in User units that will be recorded.

The Low Unit is dependent upon the type of signal being recorded by this particular channel. The Low Unit may be chosen to be any value within the valid range for that input. When Low Unit is selected, a dialog box appears. Simply type in the value desired. Refer to the example included in the High Unit setup description.

High Unit



The High Unit defines the High Value or scale for a particular channel when operating in (2 pt. Cal) or Voltage Mode. The High Unit sets the maximum value, in user units that will be recorded.

The High Unit is dependent upon the type of signal being recorded by this particular channel. The High Unit may be chosen to be any value within the valid range for that input. When High Unit is selected, a dialog box appears. Simply type in the value desired. The following example illustrates how Low/High Unit and Low/High Cal may be used to calibrate an individual input channel operating in Voltage Mode.

Accessories

This section lists the available accessories that are available for the DC/Bridge/Transducer amplifier.

Part Number	Description
P01490-B	8 pin mating miniature, male, "DIN Style" input connector for customer hook-up. Connector comes with eight male pins and one strain relief. **NOTE: Due to the miniature pins and pin spacing on this connector, it is difficult to wire and we strongly recommend using the pre-wired cable assembly.**
P01673-10	72" long, 8 conductor shielded input cable assembly. This cable is pre-wired on one end to a mating 8-pin miniature, male, "DIN Style" input connector.
242879-121	Bridge completion resistors: 120Ohm; 1Watt, 0.025" diameter wire for board socket. **NOTE: Bridge completion resistors must be low TC metal film or wire wound types of the same resistance value as the active arms of the bridge and should be ±0.1%.**
10-240368-350R0	Bridge completion resistors: 350Ohm; 1Watt, 0.025" diameter wire for board socket. **NOTE: Bridge completion resistors must be low TC metal film or wire wound types of the same resistance value as the active arms of the bridge and should be ±0.1%.**

Calibration Resistors

These resistors, if used, are specific to a particular transducer. The transducer manufacturer may supply a separate (unattached) calibration resistor, the necessary information to select a calibration resistor value, or the transducer may have a resistor embedded within the transducer/connector housing. Typically, the resistance value will be selected such that the simulated load is approximately 75% of full load for the transducer.

If you are using a transducer that has an embedded calibration resistor and wish to use it for calibration, you must leave the "CAL R" socket on the 7700 amplifier board open (the default setup). If the transducer you are using requires an external (separate) calibration resistor, you must place the appropriate resistor in this "CAL R" socket (see Figure *Resistor Calibration and Completion Sockets*).

Refer to Appendix A for these bridge circuit completion diagrams.

Universal Amplifier

Introduction

This section describes the installation, operation, and specifications for the Gould 3 channel Universal Signal Conditioner, Model Number 13-7715-58. The Universal Signal Conditioner is a user installable module compatible with Gould instruments that accept the 7700 series signal conditioning modules, such as the ACQ-7700 products. For more information on where and how this module can be used, contact your local Gould representative.

The Gould 7700 Universal Signal Conditioner is a three-channel module. The three independent input connectors each have their own associated excitation source for use with transducers or strain gages. The module occupies a single slot of the Gould ACQ-7700 case assembly. The three input signals are conditioned, digitized, and routed, via the 7700 "Broadcast" backplane, to the recording system. The system software controls the viewing and acquisition of this data. Ponemah software version 3.303 or higher is required to operate the Universal Amplifier.

The maximum acquisition sampling rate for the Universal Amplifier is 50kHz per channel due to processing time required for the DSP circuitry.

Analog Inputs

The Universal Signal Conditioner is supplied with one 15-pin "D" high-density connector per channel. Each of the modules front panel connectors are labeled with its channel number. See *Input Signal Connections*.

⚠

CAUTION

MAXIMUM VOLTAGE ABOVE EARTH POTENTIAL TO EITHER INPUT TERMINAL IS 30 VDC OR PEAK AC. EXCEEDING THIS VALUE CAN CAUSE DAMAGE. NORMAL CONTINUOUS INPUT VOLTAGE MAXIMUMS WITHOUT DAMAGE ARE ±2.5VDC OR 5V PEAK.

Input Signal Connections

The Universal signal input connection is made with a 15-pin "D" high-density connector. The maximum input voltage is a 5Volt span (±2.5V or 5VDC). It is recommended that a shielded cable be used for low-level measurements.

Pin	Function	Pin	Function
1	+INPUT	9	Chassis Ground
2	AC/DC Coupling (output)	10	Excitation Return
3	-12VDC Power	11	-INPUT
4	+Excitation	12	Reserved for future use
5	+5VDC Power	13	+12VDC Power
6	Signal Common	14	Reserved for future use
7	Reserved for future use	15	POWER Return
8	Baseline Reset (output)		

DESCRIPTION OF FUNCTIONS:

PIN 1. +INPUT - positive input of differential amplifier, 10Meg Ohm input impedance.

PIN 2. AC/DC Coupling - output to the probe; AC Coupling active TTL High; DC Coupling active TTL Low.

PIN 3. -12VDC Power - power for probes.

PIN 4. +Excitation - user selectable, referenced to pin 10 Excitation Return; 30mADC max.

PIN 5. +5VDC Power - power for probes.

PIN 6. Signal Common - Common reference for the differential amplifier.

PIN 8. Baseline Reset (output) - Baseline Reset is an active TTL High pulse of approx. 250ms duration.

PIN 9. Chassis Ground.

PIN 10. Excitation Return - return line for Excitation supply.

PIN 11. -INPUT - negative input of differential amplifier, 10Meg Ohm input impedance.

PIN 13. +12VDC Power - power for probes.

PIN 15. POWER Return - return line for +5VDC, +12VDC, and -12VDC power.

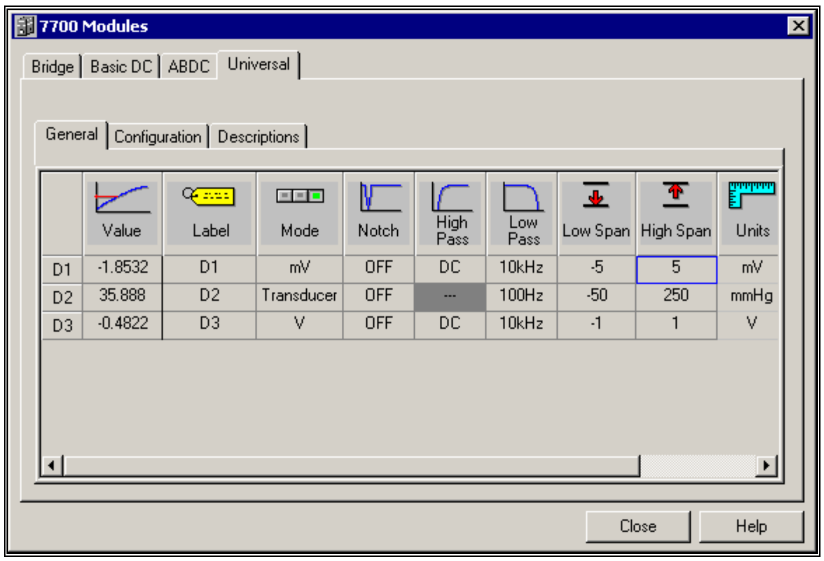
Configuring the Universal Amplifier

In the figure below, *Universal General Tab*, the Universal Amplifier module has been selected. When a module type is selected, its tab is brought to the foreground and a group of set up menus specific to that module will be displayed. This will include General, Configuration, and Descriptions menus, which are accessed by their own tabs.

General Tab

The General tab allows the user to set up channel specific signal conditioner parameters.

See Getting Started / General Tab for definitions of common menu items.

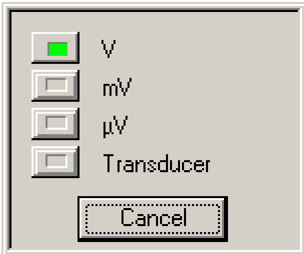


Universal General Tab

Mode

This selection allows you to choose the mode of operation for a particular channel or module. As with all amplifier functions, double clicking the mouse pointer in the Mode cell of a particular channel allows you to set that channel. Double clicking on the Mode symbol allows you to set all modules, globally, to the same mode of operation. In both instances, a graphic selection panel will appear with the options of Transducer or Voltage operating modes.

Transducer

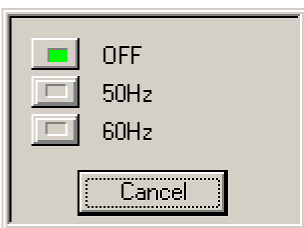


This mode is used when connecting to a strain gauge based transducer, such as a blood pressure transducer. The transducer must have a complete 4-arm circuit. In Transducer mode, the amplifier module supplies excitation to the transducer strain gauge circuit and measures the resultant output voltage. When Transducer is selected, the amplifier will use the direct input from the transducer to calibrate the input channel in user units (see Unit/Cal setup in the Configuration tab section). Units default to mmHg in Transducer mode.

Voltage

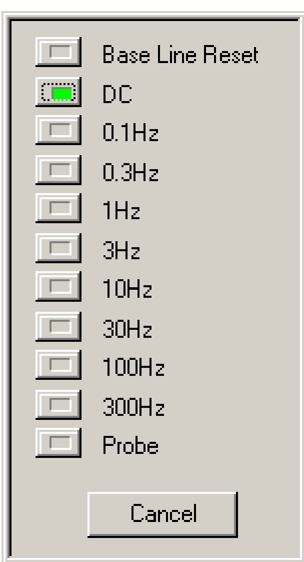
This mode sets the module to operate as a general purpose DC input amplifier with selections of microvolts, millivolts, or volts. In Voltage Mode, additional information is needed to correctly set up the particular signal input. Since the input can be from a vast number of different sources, the specific input Units, High Unit, and Low Unit of measure may be changed manually. This calibrates the channel to the actual user units and scaling. The system will now display, record, and perform analysis directly in your units of measure. Unit defaults match the mode selection, i.e. mV defaults to mV in the units cell.

Notch



This function allows you to remove unwanted line frequency noise from the input signal. This is useful when measuring bio-potentials that have line frequency noise. A 50Hz or 60Hz filter is available. If a notch filter is desired, the selection should match the line frequency in your country.

High Pass



This function allows you to add a high pass filter to your input signal.

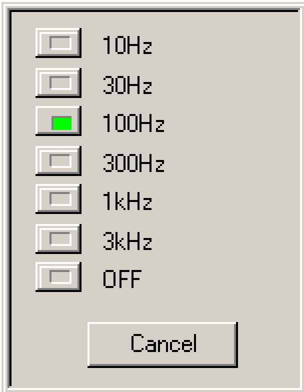
Typically a High Pass filter is needed when using a high sensitivity on the amplifier with the input measuring a bio-potential.

The **Base Line Reset** will discharge the capacitors on the input from a saturation condition. Clicking on **Base Line Reset** will produce ONE reset function. Also see Auto Reset for additional reset functions.

High Pass Selection is not available in the transducer mode.

An additional filter setting may be available by selecting **Probe**, while leaving the amplifier in DC Coupling mode. Please consult the appropriate Probe manual for filter specifications.

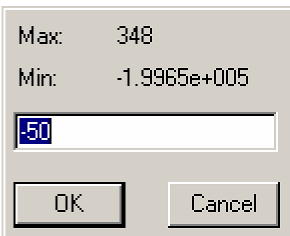
Low Pass



This function allows you to add a low pass filter to your input signal.

Since the Universal module has a large input bandwidth, certain signals require that the signal be bandwidth limited. This performs as an anti-aliasing filter for the module. Selecting **OFF** sets the Low Pass Filter to maximum bandpass of the amplifier, approximately 5kHz at -3db.

Low Span



The span defines the sensitivity or scale for each channel. The Low Span sets the minimum value, in user units that will be recorded. When setting up channel parameters, SPAN should be set last. Assure the setting is appropriate for the anticipated readings. If offset is anticipated, set the low span for a number that will allow the trace to remain on the display.

The span is dependent upon the mode of operation (Transducer / Voltage) selected. The Low Span may be chosen to be any value within the valid range for that input. The valid range is shown above the data entry box. When Low Span is selected, a dialog box appears. Simply type in the value desired. If the value entered is outside of the acceptable range for this input, an **INVALID** message will flash in the Low Span window. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application.

Under certain conditions, the Spans will display the minimum or maximum allowed value in scientific notation as displayed in the dialog on the left.

High Span

The span defines the sensitivity or scale for each channel. The High Span sets the maximum value, in user units that will be recorded. When setting up channel parameters, SPAN should be set last. Assure the setting is appropriate for the anticipated readings. Assure to set the high span for a number that will allow the trace to remain on the display.

The span is dependent upon the mode of operation (Transducer / Voltage) selected. The High Span may be chosen to be any value within the valid range for that input. The valid range is shown above the data entry box. When High Span is selected, a dialog box appears. Simply type in the value desired. If the value entered is outside of the acceptable range for this input, an **INVALID** message will flash in the High Span window. The actual value you enter may be considerably different since it will usually be in the units corresponding to your application.

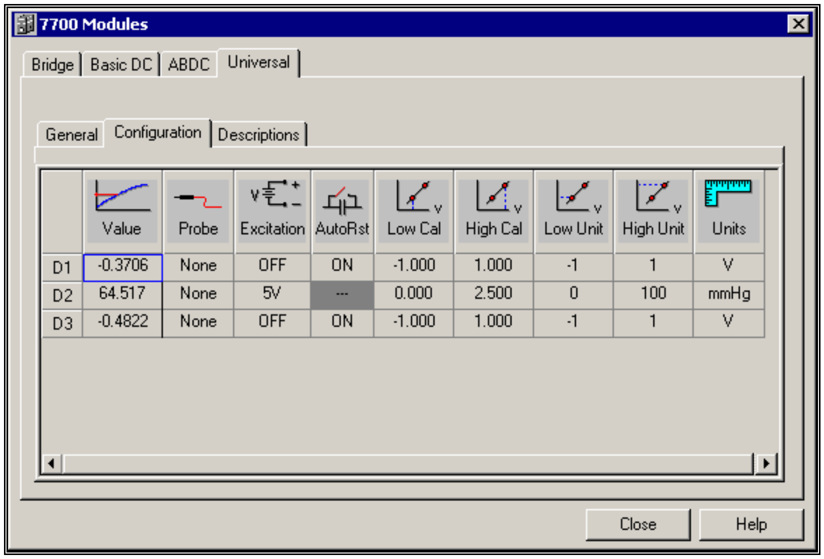
Input Voltage Range	Maximum Suppression
25µV - 249µV	50mV
250µV - 2.49mV	50mV
2.5mV - 24.9mV	500mV

25mV - 249mV	5V
250mV - 2.5V	5V

The above table maximum suppression for the amplifier to remove an offset.

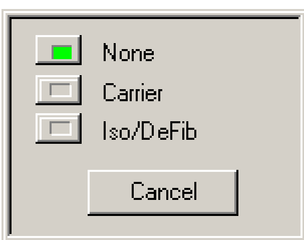
Configuration Tab

To set up the actual signal input configuration, select the Configuration tab in the signal conditioner setup panel. The Configuration set up screen, as shown in *Universal Configuration tab* will be displayed.



Universal Configuration Tab

Probe

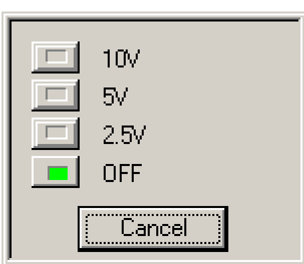


Clicking on the Probe column will detect and display the type of probe that is connected to the input.

The **Carrier** probe allows an AC excited transducer to be used with the Universal amplifier. Please contact Gould Instrument Systems, Inc. for information on supported transducers.

The **Iso/DeFib** probe provides signal isolation and defib protection when the Universal Amplifier measures bio-potentials, specifically ECG.

Excitation



This function displays a text box that allows you to set the excitation voltage that will be applied to the transducer or strain gauge. Although this is commonly set to 5VDC, it may be beneficial to change this setting. The output of a transducer is directly proportional to the input excitation. Therefore, by doubling the excitation voltage, you can double the output of the transducer.

NOTE: You should be careful not to exceed the rated operational range of your transducer. Also, adding excitation will increase the current and the heat that must be dissipated by the transducer. In some cases, this additional heat may cause the transducer signal to drift unacceptably.

Caution: Excitation current is limited to 20mA. Exceeding this limit will lead to measurement errors!

$$\textbf{Excitation maximum} = (20 * 10^{-3}) * (R_{bridge})$$

Auto Reset

The Universal Amplifier can track and detect an over voltage condition on the inputs and the Auto Reset will reset the input capacitors on the High Pass Filter, driving the signal to 0V on the display. This is useful when there is artifact on the input signal and the input signal needs to be restored quickly. If activated, the reset function will continue to operate until the over range condition is corrected. A +TTL pulse of approximately 250ms is generated with each Auto Reset condition. This output is available on Pin 8 of the amplifier connector.

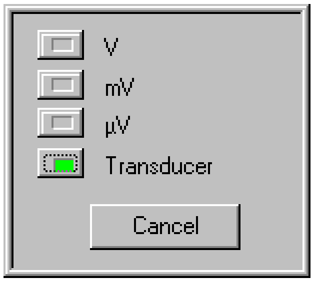
The Auto Reset feature is not available in Transducer mode.

Low Cal / High Cal / Low Unit / High Unit

For the Low Cal, High Cal, Low Unit, High Unit, and Units, refer to **Getting Started / Configuration Tab** on page **11**.

Typical Transducer Setup

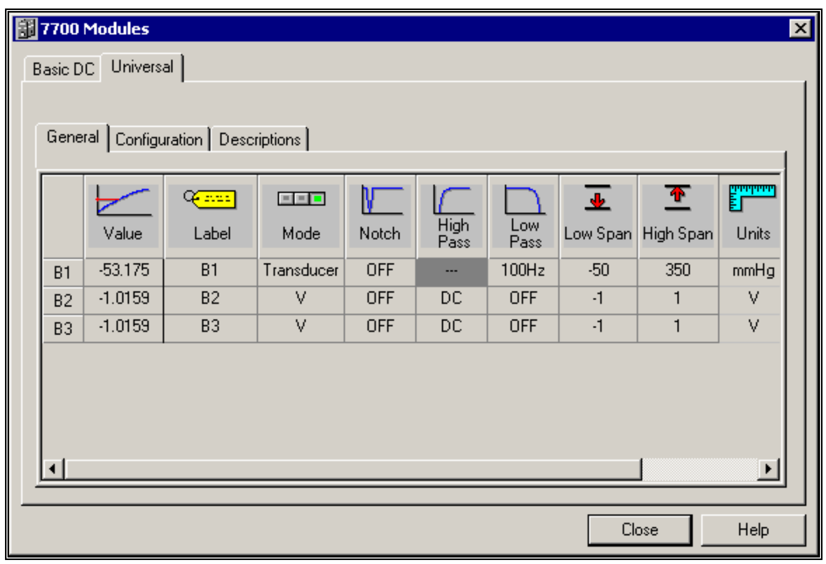
Selection of Mode



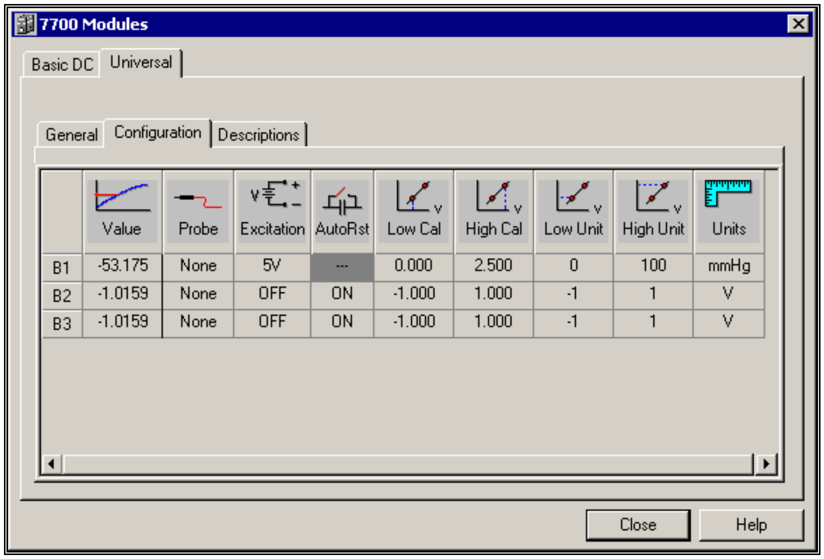
In this example, channel one will be set to the transducer mode. First, select the general menu. Highlight and change channel one to Transducer in the mode column as shown on the left. Channel one will now be in the default transducer mode. Shown below are the General and Configuration setup menus in the transducer default mode with only channel one being selected. In the General menu, note that the High Pass filter is grayed out indicating only the Voltage Mode of coupling can be used for Transducer operation. Other defaults of 100Hz Low Pass filter and Span of -50 to +350 mmHg can be changed by the user if desired. In the Configuration menu, the default is 5V Excitation and Low and High Cal and Low and High units defaulting as follows: 0mVDC = 0mmHg and 2.500mVDC = 100mmHg. Many transducers are typically 50µV/V/cmHg. Thus the calibration factor is 50µV per V (5V Excitation)=250µV x 10(cm) = 2.5mV.

Defaults

The following dialogs display the defaults in Transducer mode.



General tab Transducer defaults

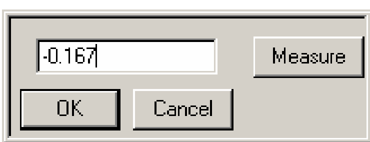


Configuration tab Transducer defaults

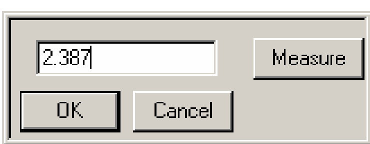
Transducer Calibration

Most transducers are not EXACTLY 50µV/V/cmHg so the amplifier must be calibrated for a particular transducer.

First a zero baseline must be established, and this is typically with no pressure being applied to the transducer. Dependent on the position of the transducer at rest, there is usually some offset due to gravity or any other forces acting on the transducer causing a small amount of zero shift or offset.



Double click on the Low Cal cell for channel one. This opens a dialog box that enables the user to either enter the offset value in mV (if known), or “Measure” the value. By clicking the **Measure** button, the software will accept an external voltage that will set the zero calibration of the channel to correspond to the value read. With the transducer at rest, click on the **Measure** button. The offset value will be read and automatically inserted in the Low Cal menu. The example at the left indicates that there is -0.167mV offset with the transducer at rest.

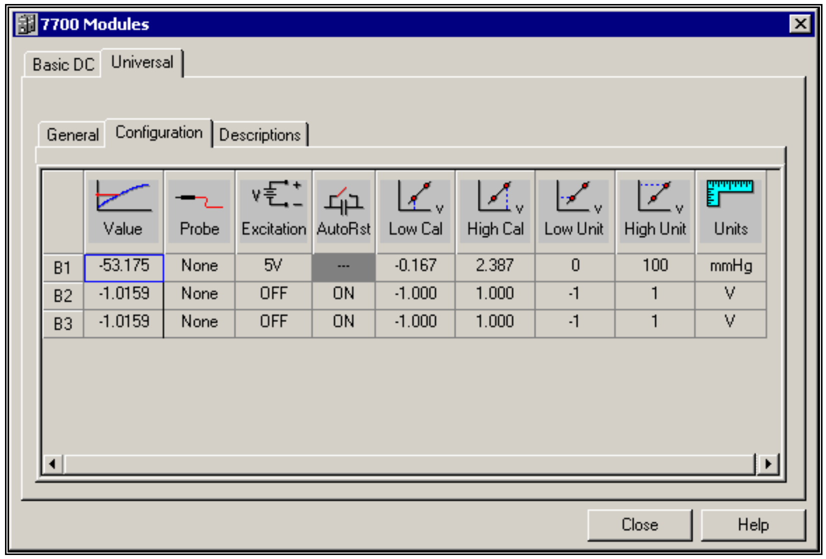


Next, a gain value must be entered in High Cal. If you have an input calibration source available, it can be used to input a value to set the gain. Double click on the High Cal cell for channel one. This opens a dialog box that enables the user to either enter the gain value in mV (if known), or “Measure” the value. By clicking the **Measure** button, the software will accept an external voltage that will set the gain calibration of the channel to correspond to the value read. Apply 100mmHg pressure to the transducer and, click on the **Measure** button. The gain value will be read and automatically inserted in the High Cal menu. The example at the left indicates that the gain calibration value is 2.387mV. This indicates that this transducer is not exactly 50µV/V/cmHg. If so, that value would be read as 2.500mV.

If you have the calibration factor for the transducer, you may enter its value directly. Many manufacturers supply that value with the transducer. Typically, the 50µV sensitivity may vary. Inserting that value into the equation: “__”µV per “__”V (excitation value) x 10 (10cm=100mm) = __mV. The values are typically between 2.300 and 2.600mV for 5Volts excitation.

Calibration is now completed. 0mm pressure will now read 0mmHg and when 100mmHg is applied the reading will be 100mmHg. Shown below is the

Configuration menu after completion of the transducer calibration. Saving this file will save the offsets and the calibration factors.



Transducer Calibrated

Accessories

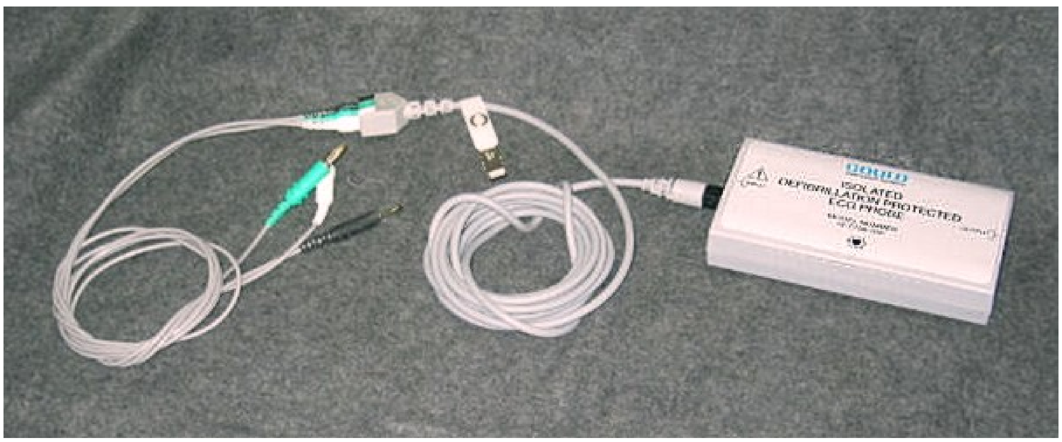
This section lists the accessories that are available for the Universal Amplifier.

Part Number	Description
P02039-12	Input Cable 13-7715-58 BD Transducer / Blood Pressure 12ft
J03174	Input Cable 13-7715-58 to BNC 10ft
P02052	Input Cable 13-7715-58 to 3 Lead ECG 10ft
P02052-25	Input Cable 13-7715-58 to 3 Lead ECG 25ft
P02053	Input Mating connector w/solder pins
CL-210942-9	Cover shield for input mating connector
J03169	Buxco TRD4510 Pressure Transducer
J03170	Buxco TRD5500 Pressure Transducer

Supplied with each amplifier are three each of P02053 and CL-210942-9.

Consult the factory for additional input accessories and cables.

7700 Universal Amplifier Isolated Defibrillation Protected ECG Probe



Introduction

Description

Intended Use: The 7700 Universal Amplifier Isolated Defibrillation Protected ECG Probe (13-7758-IDP) is designed to conduct pre-clinical studies and investigation (clinical research) of human physiological processes. This product may not be used for the purpose of diagnosis, prevention, monitoring, treatment or alleviation of disease, injury, or handicap.

The 7700 Universal Amplifier Isolated Defibrillation Protected ECG Probe is used in conjunction with the Model 13-7715-58, 7700 Universal Amplifier. The probe provides the connected amplifier input channel with galvanic patient isolation. In addition, the probe will protect the amplifier input circuitry from over-voltage conditions caused by defibrillator discharges. The ECG Probe will allow for a 3-lead ECG connection to be implemented while applying a gain of 10 to the input signals.

SAFETY SUMMARY

This general safety information is for both user and service personnel. Specific **WARNINGS** and **CAUTIONS** will be found throughout the manual where applicable.

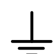
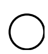
TERMS IN THIS MANUAL AND ON THE INSTRUMENT

CAUTION statements identify conditions or practices that could result in damage to the equipment or other property if instructions are not followed. They appear in boldfaced capital letters.

WARNING statements identify conditions or practices that could result in personal injury or loss of life if instructions are not followed. They appear in boldfaced capital letters.

SYMBOLS IN THIS MANUAL AND ON THE EQUIPMENT

This symbol indicates paragraphs providing cautionary and detailed information about a specific part of the instrument. That part of the equipment is also marked with this symbol (See references to this symbol in the manual).

	WARNING, risk of electric shock		PROTECTIVE CONDUCTOR TERMINAL; Earth (ground) (reference IEC publication 417-5019)
	AC, Alternating current		Earth (ground) TERMINAL (reference IEC publication 417-5017)
	DC, Direct Current		Equipotentiality (reference IEC publication 417-5021) Chassis (ground)
	Type CF Equipment		Fuse
	STANDBY (Power is on, instrument off in standby mode)		OFF (Power connection from Main)
		I	ON (Power connection to Main)

WARNING

IF THE ISOLATED DEFIBRILLATION PROTECTED ECG PROBE (MODEL NO. 13-7758-IDP) IS OPERATED OR USED IN A MANNER NOT SPECIFIED BY GOULD INSTRUMENTS SYSTEMS INC., THE PROTECTION PROVIDED BY THE SYSTEM MAY BE IMPAIRED.

POWER SOURCE

This instrument is intended to operate from a power source that does not apply more than 250 volts RMS between the supply conductors or between either supply conductor and ground. A protective ground connection by way of the grounding conductor in the power cord is essential.

GROUNDING THE INSTRUMENT

This instrument is grounded through the grounding conductor of the power cord. To avoid electrical shock, plug the power cord into a properly wired receptacle. A protective ground connection by way of the grounding conductor in the power cord is essential for safe operation.

Upon loss of the protective-ground connection, all accessible conductive parts (including knobs and controls that may appear to be insulating) may render an electric shock.

USE THE PROPER POWER CORD

Use only the power cord and connector specified for your instrument. Use only a power cord that is in good condition.

TEST LEADS AND INTERCONNECT CABLES

Test leads and/or interconnect cables may carry **HAZARDOUS** live voltages. They must be examined regularly for mechanical and electrical wear and tear. If any wear or break has occurred, the lead or cable should be replaced.

USE THE PROPER FUSE

To avoid fire hazard, use only a fuse of the correct type, voltage rating, and current rating as specified in the parts list for your instrument.

DO NOT OPERATE WITHOUT COVERS AND PANELS INSTALLED

To avoid personal injury and equipment damage, the user should disconnect power before removing covers, panels, or any grounding straps. Reinstall covers, panels, and any grounding straps *before* reconnecting power.

WARNINGS FOR AUTHORIZED SERVICE PERSONNEL

Dangerous voltages exist at several points in this instrument. To avoid personal injury, do not touch exposed connections or components while power is on. Disconnect power before removing protective panels, soldering, or replacing components.

Parts List

The following is a list of the components that are a part of the Isolated Defibrillation Protected ECG Probe.

1. J03196 – ISO/DEFIB/ECG Probe
2. P02144-1 – 15 Pin HD M/F 2.5ft
3. P02141 – ECG Cable Kit
    a. P02173 – 3 Lead Input Cable, 1 each
    b. P02143-1 – Snap Lead Wire, set of 3
    c. P02143-2 – Grabber Lead Wire, set of 3
    d. P02143-3 – Banana Lead Wire, set of 3
    e. P02143-5 – .80 Receptacle Lead Wire, set of 3
    f. P02143-4 – Banana to CLIP Adapter, 3 each

Installation

Hardware Installation

Turn off the ACQ-7700. Connect the ECG input cable (P02173) to the input of the ECG Probe. Use the interconnect 15 pin cable (P02144-1) between the output of the ECG Probe and an input of the 7700 Universal Amplifier. Turn on the ACQ-7700.

ECG Lead Connections

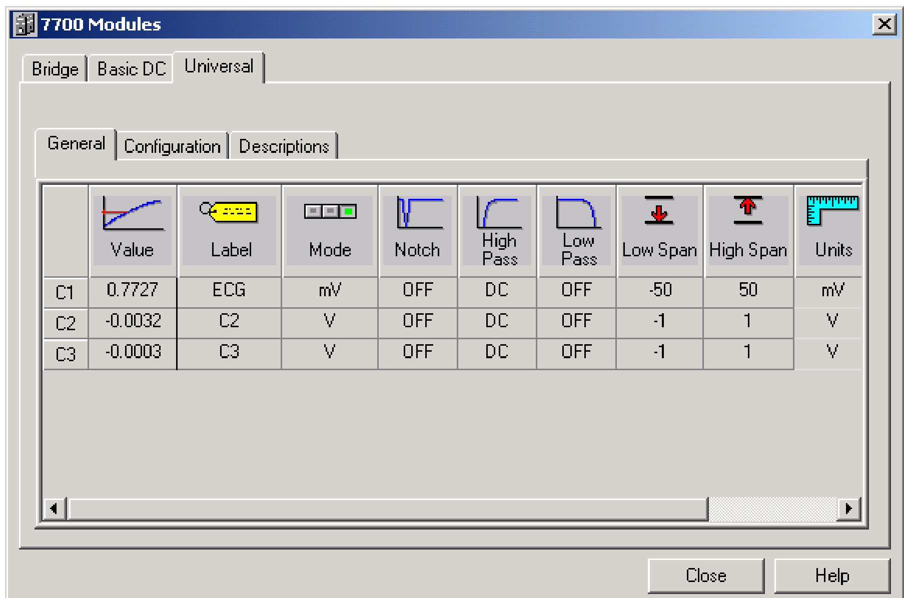
In order for the amplifier to work correctly, the ECG leads must be connected to the subject using intra-cardiac or surface electrodes. Connections are made with the provided ECG input cable (P02173). The ECG inputs are color-coded. The green lead is the ground/reference electrode and is typically connected to the right leg. The white lead is for the low signal. The black lead is for the high signal.

Operation

Power Up

Connect power to the unit and power up the ACQ-7700 by turning on the power switch on the rear panel. The light on the front panel will illuminate. If the light does not illuminate, see the Troubleshooting section of this manual.

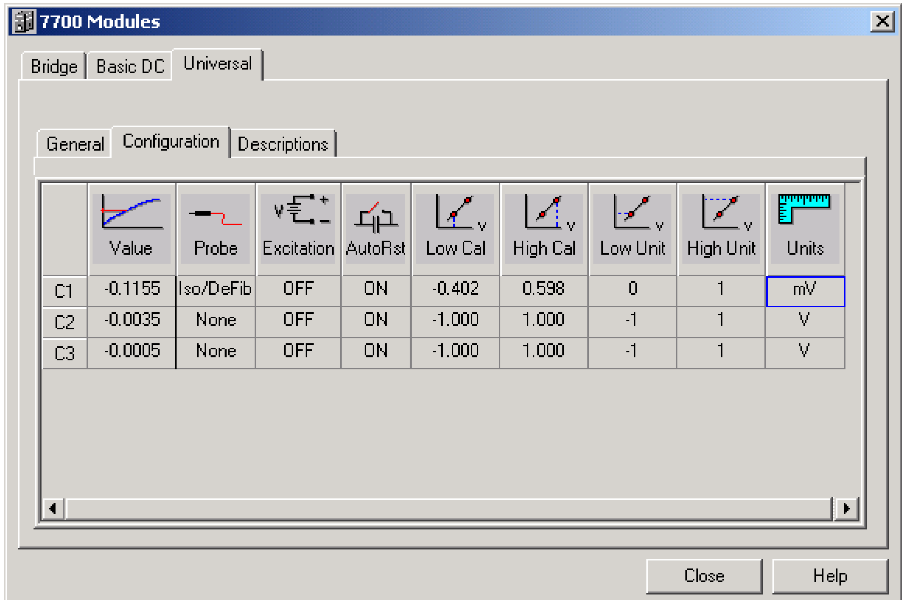
Calibration



General Tab

1. Start up the **P3 Plus** software.
2. Under the **Calibration** menu, select **7700 Amplifier Setup…**
3. In the **7700 Modules** window, select the **Universal** tab. Select the **General** tab.
    a. You may label the relevant channel by clicking within the **Label** column.
    b. Double click the relevant channel in the **Mode** column and select **mV**.
    c. Adjust the **Notch**, **High Pass** and **Low Pass** filter settings as required. For most ECG applications, default settings are adequate. Default filter settings are **OFF** for **Notch**, **DC** for **High Pass** and **OFF** for **Low Pass**.

       Note: A **High Pass** Filter setting of **Probe** sets a 0.05Hz filter. This setting can only be used with the ECG probe. It is the minimum filter setting possible for use with the ECG probe. The lower the **High Pass** filter setting the more accurate the signal displayed.



Configuration Tab

4. Select the **Configuration** tab.
    a. Double click the relevant channel in the **Probe** column and select **Iso/DeFib**.
    b. Leave the channel settings at **OFF** for **Excitation** and **ON** for **AutoRst**.
    c. Remove zero offset:
        i. Disconnect the ECG leads and short them together. If the number in the **Value** column is a steady value that is not around zero mV, perform the following steps to remove the zero offset.
        ii. Enter '0' in the **Low Unit** column.
        iii. Double click on the **Low Cal** column. Click **Measure** to read the zero value. Click **OK** to accept this value.
        iv. Click on the **High Cal** column. Add one to the value seen in the **Low Cal** column and enter the value for the **High Cal** column. This is to keep the difference between the **High Cal** and **Low Cal** equal to 1. Ensure that the **High Unit** column is left at the default value of '1' for this operation.
    d. Enter 'mV' in the **Units** column for the relevant channel.
5. Return to the **General** tab. The **Low Span** column defaults to -50 and the **High Span** column to 50mV. Modify this range to optimally record the signal under consideration.

    Note: For all **High Pass** Filter settings other than **DC** or **Probe**, the **Low Span** settings are disabled. If you have selected a **High Pass** setting of **Probe**, it may be necessary to adjust the **Low Span** to eliminate any offset still noted on the signal.
6. Click **Close** to accept the calibration.

WARNING

The following should be considered to assure safe and effective use of the ECG probe:

- To avoid possible electrical shock, assure that the entire system is always connected to the main using a 3-wire grounding cord. The ECG Probe is a Class 1 device (IEC60601-1:1990) and is designed with double insulation, which is an additional safety precaution that prevents accessible hazards in the event of failure of the basic insulation.
- If the system is to be used with multiple equipment, an equipotentiality chassis grounding access has been provided on the rear panel of the ACQ-7700. This connection may be made to an earth ground along with other equipment to assure a common (equal) earth is provided to all associated equipment.
- The user should verify that any electrodes used, including the neutral electrode, do not contact any conductive parts, including earth.
- The ECG Probe has been designed and tested for protection against the effects of the discharge of a cardiac defibrillator. Provided are an ECG input cable (P02173) and lead kits that have also been tested with the ECG Probe. For continued safe operation, it is recommended that the provided cables and ECG Probe be used together to continue protection against the effects of cardiac defibrillation.
- Whenever a defibrillator is used, verify that the leads are placed at the appropriate locations on the subject. Leads should never be placed on grounded surfaces. Verify that leads are NOT placed directly on the defibrillator electrodes.
- It is imperative that the ECG leads be removed from the subject before using any HF surgical equipment. This equipment DOES NOT provide protective means against burns when used with HF surgical equipment.
- The ECG Probe has been designed and tested to meet safe leakage current specifications when attached to the subject. Any additional equipment added to the subject may increase leakage. The operator should be aware of the possible summation of additional leakage currents when additional equipment is connected to the subject.
- The operator should be aware of any possible interactions or safety hazards when the system is used in conjunction with cardiac pacemakers and other stimulant devices. The manufacturer of these devices should be consulted for additional information.
- The ECG Probe has been tested to comply with electromagnetic (EMC) and safety standards; however, the user should be aware of possible electromagnetic interactions between this device and other devices in the same area and correct the situation as needed.

User Maintenance

User Maintenance is generally limited to cleaning only. Disconnect the ECG Probe and remove the power cord. Loose dust and dirt may be removed with a soft cloth or brush. Any dirt remaining behind can be removed with a soft cloth dampened with a mild detergent and water solution. Do not allow liquid to enter the interior of the ECG Probe as electrical leakage characteristics may change. Never use abrasive cleaners. Do not autoclave the ECG Probe.

The ECG cables may be cleaned by wiping them with a cloth dampened with a solution of warm water and a mild detergent or USP soap tincture. Do not submerge the cables. To disinfect the cables, wipe them with a disinfectant. Do not use organic solvents. Ethylene oxide may be used to sterilize the ECG cables. After cleaning, the cables should be wiped with water and dried with a clean cloth. Do not autoclave the cables. For further information on cleaning the specific ECG cables, refer to literature from the manufacturer that accompanies the cable.

Troubleshooting

The table below lists certain conditions that can occur and the corrective action to take to resolve the problem. If the following actions do not solve the problem, consult the factory prior to returning the unit for service.

Problem	Solution
No Output Signal	1. Verify that the power switch of the ACQ-7700 is on. 2. Calibrate the software for an ECG signal. 3. Bad connection to subject.
Noise on ECG Signal Response Incorrect	1. Verify that all subject connections are correct. 2. Inspect cabling for breaks in shielding.

Re-Certification of Performance

For continued safe operation and verification of specifications, it is recommended that the ECG probe, including the supplied ECG cable and leads, be recertified (calibrated) annually by the factory. For further information please contact Technical Support at 216-328-7000 or e-mail support@gouldis.com.

Specifications

The following table lists the specifications of the amplifier.

Electrical Specifications

Gain	x10
Maximum Output Range	±1VDC
Input Leads	RA, LA, RL (+, -, REF)
Dynamic Range	±100mV
Maximum input DC offset	±300mV
Input Impedance	≥ 30MΩ @ 10Hz when using fully shielded cable (ConMed FSR 397 with patient cable and lead wires).
CMRR	≥ 90dB @ 60Hz with 51kΩ, 0.047uF source imbalance
Input Risk Current	< 10µA @ 265V RMS 60Hz, sink all leads to ground
Defibrillator Protection	360Joules delivered at 5000Volts
Isolation	> 1500V RMS for 1 minute, isolated circuits to chassis
Noise	<30µV_{pp} @ 1kHz
Amplitude Inaccuracy	±5%
Bandwidth	0.05 to 1.6kHz

Physical Specifications

Height	1.2 inches
Width	3.1 inches
Length	5.9 inches
Weight	0.5 pounds

Environmental Specifications

Temperature Operating Storage	 0 to 40° C 20 to 70° C
Humidity RH, non-condensing Operating Storage	 10% to 95% 5% to 95%
Cooling	Convection only
Altitude	2000 meters maximum

Connectors

The following tables list the connectors on the ECG Probe. The table will have the pin number and the function of the pin.

ECG Input Signal Connection

This 3-pin Hypertronics connector allows the connection of the 3 input leads to the amplifier. The table below lists the connections.

Pin	Signal
1	Signal High (Black Lead)
2	Signal Low (White Lead)
3	ISO common (Green Lead)

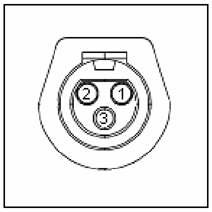


Figure 1: ECG Probe Input 3-pin Hypertronics Connector

Output Signal Connection

The ECG Probe output connection is made with a 15 pin "D-SUB" high density connector. It is recommended that a shielded cable be used for low-level measurements. The table below lists the connections:

Pin	Function	Pin	Function
1	+ Signal (Output)	9	Chassis Ground
2	AC/DC Coupling (Input)	10	Not Connected
3	-12VDC Power	11	- Signal (Output)
4	Not Connected	12	Not Connected
5	+5VDC Power (Input)	13	+12 VDC Power (Input)
6	Not Connected	14	Not Connected
7	Not Connected	15	Power Return
8	Baseline Reset (Input)		

DESCRIPTION OF FUNCTIONS:

PIN 1. +Signal output line to 7700 Universal Amplifier.

PIN 2. AC/DC Coupling: for AC coupling, line is TTL High; for DC coupling line is TTL Low.

PIN 3. –12VDC, power input for probe circuitry.

PIN 5. +5VDC, power input for probe circuitry.

PIN 8. Baseline Reset (Input) – from 7700 Universal Amplifier. An active TTL High pulse resets high pass filter.

PIN 9. Chassis Ground.

PIN 11. -Signal output line to 7700 Universal Amplifier.

PIN 13. +12VDC, Power input for probe circuitry.

PIN 15. Power Return line for +5VDC, +12VDC and -12VDC from 7700 Universal Amplifier.

Appendix

General Amplifier Specifications

The following is a list of amplifier specifications that are common to all amplifiers.

Packaging

The dimensions including input connectors are 6.79" L x 5.06" H x 1.03" W. A simple brushed aluminum I/O plate is the only visible surface once installed in a unit.

Temperature

These temperatures reflect the local ambient of the host unit:

0°C to 40°C Operating

-20°C to 80°C Non-operating

Humidity

20 to 80% Relative Humidity non-condensing.

Installation Category

Category I, designed and tested to withstand limited over-voltages.

Pollution Degree

Pollution degree 2. Equipment shall be stored or operated where no conductive pollution occurs.

Specific Amplifier Specifications

The following section lists specifications for individual amplifiers.

Basic 16

Input Specifications

Circuit: Differential, balanced to ground or single ended.

Impedance: 1 Meg Ohm to each input.

Maximum input voltage: ±20V without damage for 30 seconds.

Common Mode Rejection: ≥-80dB minute.

Input Range: ±1.25V, ±2.5V, ±5V, and ±10V.

Filter

Antialias/noise filter: Fixed, -3dB at 150kHz one pole filter per channel.

A/D Converter

Resolution: 12 bit, reported as 16 bits with the four LSBs being '0'.

Conversion rate: 250k samples/second aggregate.

Output

Accuracy: ±0.3% of full-scale typical, ±0.5% max.

Bandwidth: Flat to ±2% at 10kHz.

Noise: Less than 0.15% F.S. typical, 0.5% max.

Offset: ±0.15% F.S. typical, ±0.25% max. with input shorted.

Power Specifications

+5V @ <300mA.

+12V @ <100mA.

-12V @ <100mA.

ABDC 32

Input Specifications

Circuit: Differential, balanced to ground, or single ended.

Impedance: 100k Ohm to each input.

Maximum input voltage: ±50V without damage for 30 seconds.

Common Mode Rejection: ≥-80 dB minute.

Input Range Bipolar: ±1.25V, ±2.5V, ±5V, ±10V and ±20V.

Input Range Unipolar: 0 to 1.25V, 0 to 2.5V, 0 to 5V, 0 to 10V and 0 to 20V.

A/D Converter

Resolution: 16 bits.

Conversion rate: 250k samples/second aggregate.

Output

Accuracy: ±0.5% of full scale typical, ±0.7% max.

Bandwidth: Flat to ±2% at 10kHz.

Noise: Less than 0.3% F.S. typical, 0.5% max.

Offset: ±0.3% F.S. typical, ±0.5% max. with input shorted.

Power Specifications

+5V @ <600mA.

+12V @ <200mA.

-12V @ <200mA.

Bridge/Transducer

13-7715-30 Bridge/Transducer Amplifier is a four-channel signal conditioner designed specifically to work with signals from bridges and transducers with sensitivities from 250 µV to 10Volts full scale. All channels are identical, but can be independently configured. Each channel has its own programmable voltage excitation supply as well. Programmable four-pole low pass filters for each channel are available for both noise and anti-alias filtering. The total functionality of each channel is controlled through the VME interface.

Input Circuit (typical of each channel)

Differential, non-isolated

Coupling: DC

Impedance: 1 Meg Ohm each input to common

Common mode range: ± 5.0Volts without signal distortion

Maximum input voltage without damage: ± 30Volts DC or peak AC

Common Mode Rejection (with 100 Ω unbalance):

1) 250µV to 2.5V 80dB typical @ 60Hz
2) 2.5V to 10V 60dB typical @ 60Hz

Measurement Range

Linear Range: 250 µV to 10Volts full scale

Bridge Sensitivity (Vex): 250µV/V to 1V/V (4 arm bridge)

Bridge Excitation

Voltage: 1.0 to 10Volts ± 0.5%. Excitation is bipolar (±0.5 to ±5.0Volts) and symmetrical to circuit common (± with respect to circuit common).

Resolution: 12 Bit. 1 Bit = 2.4mV

Maximum current: 20mA

Maximum capacitance: The excitation circuit is capable of driving up to 0.2µF of cable capacitance.

Remote Voltage Sense: Where current is low and the bridge wire resistance is low, the voltage at the bridge terminals is close to the internal excitation voltage. Where the reverse is true, the voltage at the bridge may be several percent lower and can lead to measurement errors. Separate sense lines are available to minimize this problem.

Maximum wire resistance: Dependent upon both the internal excitation voltage and bridge current. The total of the bridge excitation plus wire resistance drop cannot exceed 16Volts (±8.0V). Vex + (Rw)x(Ib) ≤ 16Volts. (Rw = total of + and - excitation wires).

Filter

Antialias/Noise Filter: Four pole Bessel with four fixed settings of 2.5, 25, 250, and 2500Hz ±15%.

Autobalance

Autobalance is accomplished via a 16 Bit D/A converter.

Measurement Span	AutoBalance Limits
250µV - 2.499mV	±25mV
2.5mV - 24.99mV	±250mV
25mV - 249.9mV	±2.5V
250mV - 2.499V	±2.5V
2.5V -10 V	±5.0V

Accuracy: ±0.1% of range

Resolution: 0.003% of range (0.03% in the ±5.0V range)

Zero Stability: 0.002% of range/°C

Zero Suppression

Suppression is accomplished via a 16 Bit D/A Converter.

Measurement Span	Zero Suppression Limits
250µV - 2.499mV	±25mV
2.5mV - 24.99mV	±250mV
25mV - 249.9mV	±2.5V
250mV - 2.499V	±2.5V
2.5V - 10V	±5.0V

Accuracy: ±0.1%

Resolution: 0.003% of range (0.03% in the ±5.0V range)

Stability: 0.002% of range/°C

Signal Conditioner Output

A/D Converter: 12 Bit

Sample Rate: 25kHz per channel maximum.

Gain Inaccuracy: ±0.5% of measured vs. actual value.

Zero Instability: ±2.0 µV/°C RTI after 1 hour warm-up.

Non-linearity: 0.1% of full range.

Noise: Less than 20 µV Peak-to-Peak RTI maximum @ 2.5kHz on the most sensitive range.

Frequency response: Selectable in four decade steps: 2.5, 25, 250, and 2.5kHz, -3dB.

Filter type: 4 pole Bessel.

Attenuation: 24dB/octave (80dB/decade).

Bridge Completion

Half Bridge: Half-bridge completion for each channel is enabled by setting a jumper from the negative input of the channel to the half-bridge network, consisting of two equal 1.5kΩ resistors.

Quarter-Bridge: Each channel also has a provision for quarter-bridge completion. This resistor is User supplied. It is recommended that, as a minimum, 0.1%, low TC metal film or wire wound resistors be used.

Calibration Resistor

The unit is shipped with provision for a plug-in User supplied calibration resistor. The calibration resistor is switched in/out across one arm of the bridge to produce a known simulated load. This is accomplished via a menu command from the User interface. **NOTE: This socket must be left open if the transducer has a built-in calibration resistor.**

Universal

13-7715-58 Universal Amplifier is a three-channel signal conditioner designed specifically to work with signals from low-level input voltage and transducers with sensitivities from 50µV to 5Volts full scale. All channels are identical, but can be independently configured. Each channel has its own programmable voltage excitation supply as well. Programmable four-pole low pass filters for each channel are available for both noise and anti-alias filtering. The total functionality of each channel is controlled through the VME interface.

Input Circuit (typical of each channel)

Differential non-isolated balanced to ground

10 Meg Ohm each input to common

Less than 2nA either input to common

Maximum input ±30VDC or peak AC volts

Measurement Range

Linear Range:	50µV to 5Volts full scale

Transducer Excitation

Type:	Unipolar, with short circuit protection
Voltage:	Off, 2.5, 5.0, and 10Volts ±1.5
Resolution:	16 Bit. 1 Bit = 2.4mV
Maximum current:	30mA

Filters

Low pass five pole Bessel with seven selectable settings of 10, 30, 100, 300, 1000, 3000, and OFF ±5% (OFF =>5kHz).

High pass one pole Bessel with seven selectable settings if 0.1, 0.3, 1.0, 3.0, 10, 30, 100, and 300Hz ±10%.

Notch filter with selection of Off, 50 or 60Hz @ 40dB.

Amplifier Output

A/D Converter:	16 Bits
Sample Rate:	100kHz per channel maximum

DC Mode Gain Accuracy

±25µV to < ±250µV	±10% of reading
(FS=50µV to < 500µV)	
±250µV to < ±2.5mV	±1% of reading
(FS=500µV to < 5mV)	
±2.5mV to ±2.5V	±0.5% of reading
(FS=5mV to 5V)	

DC Mode Zero Error

±25µV to < ±250µV	±3µV or ±0.6% of FS
(FS=50µV to < 500µV)	
±250µV to < ±2.5mV	±5µV or ±0.1% of FS
(FS=500µV to < 5mV)	
±2.5mV to ±2.5V	±250µV or ±0.05% of FS
(FS=5mV to 5V)	

AC Mode Zero

±25µV to < ±250µV	±6% of FS
±250µV to < ±2.5mV	±0.6% of FS
±2.5mV to ±2.5V	±0.05% of FS

Stability

DC mode @ 500µV full scale:	±2% of full scale/ºC
AC mode @ 50µV full scale:	±0.05% of full scale/ºC

Common Mode

-74dB minimum with 1k Ohm unbalance @ 60Hz

Crosstalk

-90dB between adjacent channels on the most sensitive ranges

Linearity

0.03% of full scale

Noise

DC to 10Hz:	Less than 2μV peak-peak
DC to 1kHz:	Less than 6μV peak-peak
DC to 10kHz:	Less than 15μV peak-peak

Signal Sources

An understanding of signal sources and connections in electrical measurement is vital to prevent noise or ambient conditions from overshadowing desired physical or electrical variables. Final data may be useless unless a signal source is properly selected or identified and used with an appropriate signal conditioner.

Selection of transducer or signal source(s) is the first step in most measurement or recording applications. Low impedance devices are preferred to reduce system noise and to minimize the shunting effect (loading), which the measuring instrument imposes on the source.

The signal source must be properly identified so that it can be matched with an appropriate signal conditioner. Signal sources fall into six classes, according to the configuration of the output circuit. These are summarized below.

Single Ended - Grounded

This signal source has two output terminals, one of which is connected to source ground. The AC line powered signal generator with a two terminal grounded output is typical.

Single Ended - Floating

This source has two output terminals that are isolated from ground. A floating output can be grounded or reversed without disturbing the circuit. The dry cell battery, the output from a magnetic head, or a two terminal battery powered signal generator are typical examples.

Single Ended - Driven Off Ground

This source has two output terminals that are driven off ground by a second voltage. A driven off ground signal source can NEVER be grounded. A resistive shunt installed in the hot side of a power line or DC bus for measuring current is a classic example.

Balanced - Grounded

This signal source has two active output terminals, which have equal impedance to a common ground. The output terminals can be reversed without disturbing the circuit. A four-arm Wheatstone bridge output that is excited from a grounded power supply is a good example.

Balanced - Floating

This source is one that has two active output terminals, which have equal impedance to common point that is floating. A four-arm Wheatstone bridge output that is excited from a floating power supply or a center-tapped transformer secondary are typical examples. The output terminals can be reversed or the common terminal can be grounded without disturbing the circuit.

Balanced - Driven Off Ground

This source has two active output terminals, which have equal impedance to a common point, which is driven, off ground by a second voltage. The active output terminals can be grounded without disturbing or destroying the signal source. An example is a differential output amplifier, which produces an output of ±30Volts, but operates at about +60Volts DC off ground.

Identification of Signal Sources

If an electrical schematic is not available, a signal source may be identified by using one channel of a Gould recording instrument plus an ohmmeter. To identify a two-terminal source, the ground or low recorder input terminal is connected to a good solid ground at the signal source. With the source turned ON, the high side of the recorder input is connected to one output terminal of the signal source and then the other. The amplitude and character of these two measurements provide the required information about the source.

A zero signal from one signal source terminal and a usable signal from the other indicate a single ended-grounded source. Equal 60Hz noise signals from both terminals indicate a floating source. If there are only two terminals, a floating source is probably single ended floating. A resistance of several hundred Meg Ohms from each terminal to ground confirms that the source is floating. Usable but unequal signals from the two terminals indicate a driven off ground output. The average of the two signals is the off ground or common mode voltage; the difference is the signal amplitude. If the two-terminal source is turned OFF and the ohmmeter shows unequal resistance from the terminals to ground, the source is probably single ended-driven off ground. For all three-source types, an ohmmeter across the two terminals with the source turned OFF indicates the source resistance.

To identify a three terminal source, the ground, or low recorder input terminal, is again grounded at the signal source. The high recorder terminal is connected to each of the three source output terminals in sequence.

A zero signal from one terminal and equal or similar signals from the other two indicates a balanced-grounded source. With the signal source turned OFF, resistance readings from ground to each terminal identify the ground terminal and the source resistance of each active output terminal to ground. Equal 60Hz noise signals from the three terminals, and a resistance of several hundred Meg Ohms between all three terminals to ground, indicates a balanced-floating source. With the source turned OFF, ohmmeter readings across the three output terminals reveal the common terminal, the source resistance of each leg to common, and the total source resistance.

A usable signal from one terminal to ground and nearly equal signals from the other two, indicates a driven off ground source. The terminal with the minimum signal or a signal different from the other two is probably the common terminal, and the signal from it to ground is the off-ground or common mode voltage. With the source turned OFF, equal resistance readings taken across the three output terminals reveal the common terminal, the output resistance of each leg to common, and the total source resistance.

Elusive Ground Loop

The **GROUND LOOP** is the largest source of electrical noise between electronics modules. More than one ground on a signal circuit or signal cable shield produces a common impedance coupling or ground loop between these two points. This generates large 60Hz electrical noise currents, which are in series and combined with the useful signal. The magnitude of ground loop current is directly proportional to the difference in absolute potential between the two grounds. In most cases, a ground loop through either a cable shield or signal circuit will produce so much 60Hz noise that will obscure millivolt level signals.

Two separate grounds are seldom, if ever, at the same absolute voltage. This potential difference creates unwanted current in series with one of the signal leads. The potential difference between "Earth Ground No. 1" and "Earth Ground No. 2" often produces a ground loop current in the lower signal lead from the signal source to the input of the signal conditioner, causing ground loop noise to be combined with the useful signal. There is also often a second ground loop through the signal cable shield from the signal source to the signal conditioner. The ground loop current in the shield is coupled to the signal pair through the distributed capacity in the signal cable. This current is returned through the output impedance of the signal source and back to Earth Ground No. 1, adding a second source of noise to the useful signal. Either one of these ground loops is capable of generating a noise signal that is at least one hundred times larger than a typical millivolt level signal.

Guidelines on Grounding

The following guidelines should be maintained when grounding signal sources:

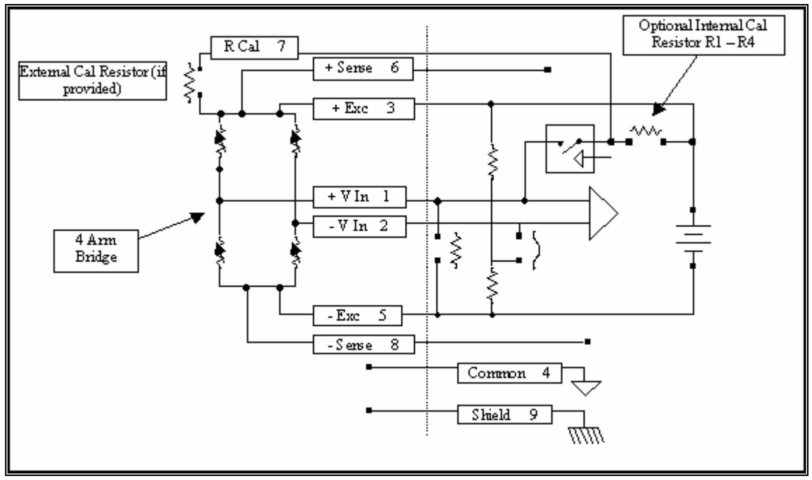
- The recording system should have a stable system ground.
- The signal circuit should never be grounded at more than one point.
- The signal cable shield should not be attached to more than one ground; the 7700 series General Purpose AC/DC module has this shield tied to ground at the amplifier.
- More than one intentional or accidental grounds on the signal circuit or signal cable shield will produce excessive electrical noise in any low level circuit.

In off-ground recording, the signal cable shield should not be grounded; it should be connected to the center tap or the low side of the signal source.

Setting Up Strain Gauge Circuits

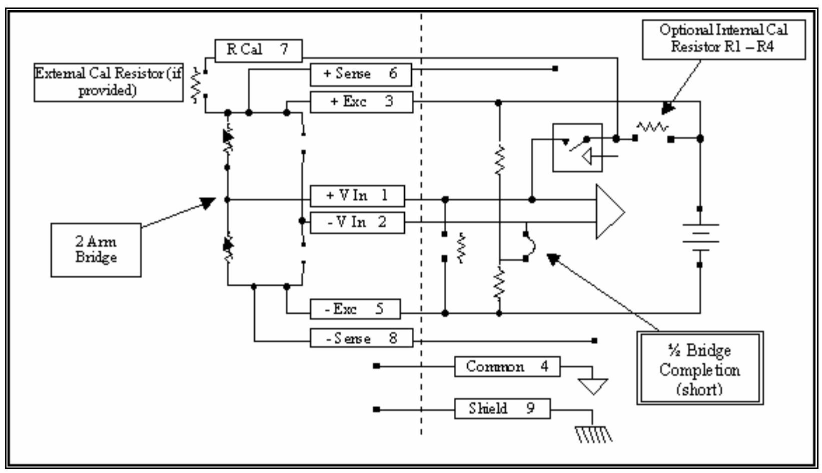
This section explains the different strain gauge configurations that the 7700 DC/Bridge/Transducer amplifier supports.

4 Arm Strain Gauge Circuit



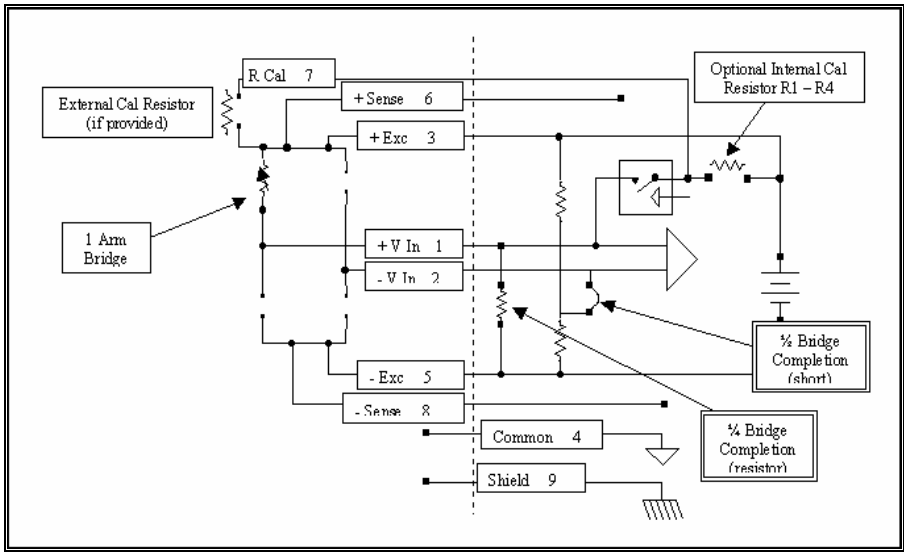
Four Arm Circuit

2 Arm (1/2 Bridge) Strain Gauge Circuit



Two Arm Circuit

1 Arm Strain Gauge Circuit



One Arm Circuit

Calculating Output Of A Strain Gauge Bridge

Use the following formula to calculate the output of the bridge.

$$e_0 = KE\,\varepsilon \text{ where:}$$

e_0 = Output voltage in microvolts

K = Gauge factor

ε = $\varepsilon_1 - \varepsilon_2 + \varepsilon_3 - \varepsilon_4$ = average strain in micro-inches / inch

E = Bridge excitation in volts

Note: Use (+) sign for tension, (-) sign for compression, and (0) for inactive arms. The expression for e_0 is valid for any number of active arms of a bridge as long as zero (0) is substituted for inactive arms in the formula.

Introduction To Strain Recording

Strain is a fundamental physical phenomenon. It exists in solids at all times, due either to loads or to the weight of the material itself. The terms “strain” and “physical deformation” are synonymous. In engineering, strain refers to the change in any linear dimension of a body, which is due to the application of either internal or external forces.

“Strain” as defined above refers to total strain, but we are primarily interested in “unit strain” which has much greater significance. Average unit strain is the total deformation of a body in a given direction divided by the original length in that direction. Unit strain as determined by a strain gauge is expressed in micro inches per inch.

Strain = Change in length/Original Length (micro inches):

$$\varepsilon = \frac{\triangle L}{L}$$

The word “strain” (or “micro-strain”) when used alone normally refers to “unit strain.” Engineers and scientists have attempted for centuries to measure strain accurately, but only the last two decades have seen outstanding advancement in the art of strain measurement, made possible by the development of the bonded resistance strain gauge.

In use, each portion of the strain gauge is intimately bonded to the member being tested and accurately follows its movements in both tension and compression. It measures the average of strains all along the gauge length.

The measurement of strain can be beneficial to almost any product research application. The performance and safety of modern aircraft is directly attributable to extensive use of bonded strain gauges. Today, bonded strain gauges are used to help develop such diverse products as high-speed turbine blades, golf clubs, and pharmaceuticals.

Accuracy

Strain gauges are electromechanical transducers that are typically applied either directly to the surface of the material under test, or on a diaphragm linked to the material under test. The strain gauge exhibits a change of electrical resistance with a change in strain. The change is linear, and may be measured with suitable instrumentation. Using standard equipment, properly applied and operated with reasonable care, you can expect to achieve accuracy within about 1% although measurement accuracy within 0.1% can be achieved by using special equipment.

Sensitivity

The sensitivity of a strain gauge is determined by the electrical conductivity of the sensing element material and its configuration. It is predetermined by the manufacturer. “Gauge factor” is a measure of strain gauge sensitivity. All commercial resistance strain gauges have a positive gauge factor. This means that an increase in strain produces an increase in strain gauge resistance. Strain has been defined as the change in length divided by the original length. The unit change in resistance that the strain produces is defined as the change in resistance divided by the original resistance.

Gauge factor (G_f) is defined as the unit resistance change divided by the unit strain. That is:

$$G_f = \frac{\triangle R/R}{\triangle L/L}$$

The measured gauge factor stated on each strain gauge package should be used in all instrument calibrations.

Temperature Compensation

Temperature compensation is one of the most important and one of the most frequently over-looked factors in the field of strain measurement. It is possible to start out to measure strain and end up measuring ambient temperature changes. Millions of dollars worth of strain data has had to be scrapped because adequate temperature compensation was not achieved by conventional "dummy" gauge compensating techniques. Any strain gauge will respond to all strains in the test material whether the strains are thermally induced or produced by an external force or load. If you wish to record strain and not temperature changes, it is urged that you pay special attention to the temperature compensated bridge circuits, temperature compensated strain gauges and temperature compensated lead wire systems described here.

The terms "self-compensated", "temperature-compensated", or "self-temperature-compensated" are applied to strain gauges intended for use on materials having a related thermal coefficient of expansion. The gauge alloy is so processed that the combined effects of thermal coefficient of resistance in the gauge and thermal coefficient of expansion in the mounting surface result in essentially zero resistance change due to temperature. This results in a very low value of "apparent" or "temperature-induced" strain.

When transient temperature conditions are encountered, best accuracy will be obtained by using temperature-compensated strain gauges, available from several sources.

Self-temperature-compensated strain gauges are designated by an extra letter and digit in their type number, which indicate the expansion coefficient for the material for which the gauge is designed. This might be on the order of 6 parts per million per degree Fahrenheit.

Lead wire resistance and capacitance also change with temperature. Therefore, lead wires from strain gauges to the amplifier must also be temperature compensated.

Each lead wire between the strain gauges and the amplifier should be made exactly the same length and the same size of copper wire so that each lead wire will have exactly the same resistance. Changes in ambient temperature along the lead wire cable will not affect the strain measurements if the temperature is uniform at any cross-section along the cable. For long runs, the size of the copper lead wires should be sufficiently large so that lead wire resistance is small when compared to the resistance of the Wheatstone bridge circuit.

In strain gauge work, never use the shield as a conductor.

Basic Strain Recording

The Wheatstone bridge circuit can be made up with one active strain gauge and three fixed resistors, two active strain gauges and two fixed resistors, or four active strain gauges. A basic Wheatstone bridge circuit includes one active strain gauge and three fixed resistors. A variable resistor is used to balance the bridge with no load applied to the active strain gauge. The variable resistor provides an adjustment of the bridge excitation and thereby adjusts the bridge output.

During normal strain measurements, the change in resistance of the resistance strain gauge is so small in comparison to the unstressed resistance of the strain gauge, that bridge linearity remains excellent. Bridge output can be considered directly proportional to changes in strain gauge resistance as long as the strain gauge receives constant current excitation.

When connecting strain gauges in a bridge circuit it is important to remember that the Wheatstone bridge output will be directly proportional to the difference of resistance changes in any two adjacent arms. Also, in any two opposite arms, the Wheatstone bridge output will be directly proportional to the sum of the resistance changes.

Assumed Circuit Conditions

Performance of the strain recording circuits, as discussed, is based upon the following assumptions:

- Circuits receive constant current strain gauge excitation.
- Minor changes in the modulus of elasticity of the material due to temperature changes are neglected.
- Transverse effects are neglected.

Typical gauge sensitivity is obtained for any 100 to 1000Ohm strain gauge with a gauge factor of 2.0 or higher. If desired, the system may be calibrated for a lower sensitivity.

One Active Strain Gauge

When one active strain gauge is used, a Gould strain recording system is normally calibrated for a sensitivity of approximately five micro-inches per inch of strain per division. This is the simplest but least accurate method of strain measurement. Only one active strain gauge is employed with the inactive arms of the bridge circuit completed using a precision resistor and a jumper placed in the amplifier circuit (see Figure *One Arm Circuit*).

With one active strain gauge mounted and connected in a Wheatstone bridge circuit, the output of the bridge will be:

- Proportional to the change in bending load, or …
- Proportional to the change in axial load, or …
- Proportional to the algebraic sum of the two above loads.

The output of this circuit is also proportional to any temperature change in the active strain gauge. Since this arrangement does not provide temperature compensation, it is not acceptable for accurate static measurements. It is useful only in the laboratory where temperature is controlled, or for dynamic measurements where it is not required to record the static strain or where the static strain is of such short duration that temperature change effects are slight.

One Active Gauge and One Compensating Gauge

One of the more popular techniques for securing temperature-compensation is to use a temperature-compensated strain gauge, which exhibits a very low temperature coefficient when mounted on the proper material. This type of bridge circuit should be completed with three unstressed, temperature-compensated gauges mounted on the proper material. This arrangement performs well for both gradual changes and transient temperature changes.

With one temperature-compensated strain gauge, mounted and connected in a Wheatstone bridge circuit, the output of the bridge will be:

- Directly proportional to the change in bending load, or …
- Directly proportional to the change in axial load, or …

- Directly proportional to the algebraic sum of the two above loads.

The output of this circuit is independent of temperature changes. This arrangement should be used only when axial loading remains constant during the measurement of bending loads or where bending load remains constant during the measurement of axial loads, or where the algebraic sum is desired.

Two Active Gauges

Using two active gauges allows your system to be calibrated to a sensitivity of twice that of a single gauge system, overcomes temperature compensation problems, and allows measurement flexibility. The bridge circuit is completed in the amplifier by a jumper (see Figure *Two Arm Circuit*).

In Adjacent Arms of the Bridge

An excellent strain recording circuit is achieved when two active strain gauges are connected in adjacent arms of the bridge and subjected to strains of equal magnitude but have opposite sign. With two active strain gauges mounted and connected in a Wheatstone bridge circuit, the output of the bridge will be:

- Directly proportional to the change in bending load.
- Independent of axial loads.
- Independent of torsion.
- Independent of temperature changes as long as these take place uniformly throughout the material.
- Twice as large as the output from a single gauge.

This arrangement is an easy method of achieving temperature compensation and determining the bending stresses in a member independent of axial thrust or tension. Temperature compensation in the lead wires is accomplished by using the three wire lead system.

In Opposite Arms of the Bridge

To obtain the sum of two separate strains, install two active temperature-compensated gauges and connect to opposite arms of the bridge. In this case temperature compensation in the lead wires is secured by using a separate three wire lead system for each active gauge.

Four Active Gauges

Recording systems using four active gauges can be calibrated to a sensitivity of four times a single gauge system. Satisfactory temperature compensation in the lead wires will be achieved by connecting all four-strain gauges to a terminal block in close proximity to the gauges. Connection to the amplifier should then be made using four identical leads in a common shielded cable, see Figure *Four Arm Circuit*.

With four active strain gauges mounted and connected in a Wheatstone bridge circuit, the output of the bridge will be:

- Directly proportional to the change in bending load.
- Independent of axial loads.
- Independent of torsion.

- Independent of temperature changes as long as these take place uniformly throughout the material.

This arrangement is often used for the following reasons:

- Temperature compensation is achieved without difficulty.
- Bending stresses can be measured independent of axial thrust or tension.
- The bridge circuit produces maximum output.

Two Active Gauges and Two Compensating Gauges

This Poisson's (P_r) arrangement of strain gauges is frequently used to measure strain produced by axial thrust, load, or tension by mounting four gauges directly on the material under test. Two active gauges are mounted parallel to the centerline (axial), but on opposite sides of the member. The two temperature compensating gauges are mounted at right angles to the two active gauges. The two active gauges are connected in opposite arms of the bridge to add their output and each of the other gauges is connected adjacent to an active gauge which not only provides temperature compensation, but also increases the bridge output in accordance with Poisson's Ratio for the material involved.

When the four gauges are mounted on a member of uniform cross-section and connected in the four arms of a Wheatstone bridge, the output of the bridge, for a change in axial thrust, load, or tension will be:

- Directly proportional to the change in applied load.
- Independent of bending.
- Independent of temperature changes as long as these take place uniformly throughout the material.
- Independent of torsion.

With this arrangement, the output of the bridge circuit will be more than two times as large as the output from a single gauge, dependent upon Poisson's Ratio. In the example, assume the material is cold rolled steel. The Poisson's Ratio for this material is 0.287 and the output of the bridge circuit will then be:

$$\mathbf{2*(1+P_r) = 2*(1+0.287) = 2.574}$$

Temperature compensation in the lead wires is achieved by connecting strain gauges to an adjacent terminal block with identical leads and running a shielded cable containing four identical leads from the terminal block to the amplifier. This arrangement is frequently used in applications where the principal strain occurs in only one direction.

Measuring Torque With Four Active Gauges

When a cylindrical shaft is subject to torsion, the principal axes of strain on the surface will be inclined at 45 degrees to the axis and the magnitude of these strains will be equal but in opposite directions.

Measurement of torsion or torque can be accomplished quite easily by mounting two active gauges on a shaft at right angles to one another. Under these conditions, one gauge is in tension while the other gauge is in compression so they are connected in adjacent arms of the bridge. A similar pair of active gauges is installed on the opposite side of the specimen from the first pair in order to double the bridge output and provide a measurement, which is independent of bending.

When the four strain gauges are mounted on the shaft and connected in a Wheatstone bridge circuit, the output of the bridge will be:

- Directly proportional to the applied torque.
- Independent of bending.
- Independent of temperature changes as long as these take place uniformly throughout the shaft.
- Independent of axial loading.
- The output from this bridge circuit arrangement will be four times as large as the output from a single strain gauge.

Temperature compensation in the lead wires is achieved by connecting strain gauges to an adjacent terminal block with identical leads and running a shielded cable containing four identical leads from the terminal block to the amplifier.

The output from the bridge circuit may be taken off a rotating shaft by an appropriate slip ring device. Both the slip ring and brushes must be of high quality and in good state of repair so that variable resistances are not introduced into the circuit. Torque can also be measured with two active strain gauges mounted at right angles to each other and connected to adjacent arms of the bridge. This is NOT independent of bending and has one half the output of the previous circuit. Temperature compensation in lead wires is automatically accomplished by using the conventional three wire lead system.

Elimination Of Errors In Wheatstone Bridge Circuits

All connections in the Wheatstone bridge circuit must be low resistance joints in order to secure accurate recordings. Difficulties from contact resistance can be avoided by soldering, fusing, welding, or by using good compression type connectors. The common “banana plug” type of connector must be avoided, but a tight screw-down connection on clean, tinned copper wire is acceptable. For DC excited bridge circuits, thermocouple effects can be minimized by placing both strain gauge lead wire junctions close together physically, within the same temperature zone, and encasing them in cement on a common piece of metal or other form of “heat-sink”.

If strain gauge leads are allowed to hang freely the strains produced in the leads by their own weight may change the lead wire resistance and cause strain measurements to vary. The movement of leads can also cause capacity changes in the lead wires, which may produce a measurable capacity unbalance in the bridge circuit. An example would be where lead wires are allowed to flop against a metallic column or pipe and are allowed to hang loosely. If separate lead wires (rather than a shielded cable) are employed, tie the leads together in a single cable and secure the cable firmly so that the strain gauge readings are not modulated by the swinging of the lead wires.

Recording From Strain Gauge Based Transducers

The great versatility of the strain gauge has been realized through its use as the heart of the precision bridge type sensing elements employed in many transducers. Typical of transducers available are the numerous types of load cells, pressure gauges, torque meters, accelerometers, flow meters, and load beams. Each is precision built and calibrated to handle a large range of variables including industrial and medical research applications. These include measuring the flow of fuel to a rocket engine, recording torque from a brake dynamometer, and monitoring blood pressure.

There are two basic types of strain gauge based transducers in wide use: the bonded type and the un-bonded type. The bonded type gauge usually takes the form of a flat grid that is cemented directly to the sensing element or diaphragm of the transducer. Four strain gauges, connected in a conventional Wheatstone bridge are generally used for the sensing circuit. Temperature compensation, linearity, hysteresis, and moisture resistance all receive special consideration during the design and manufacture of the transducer.

The un-bonded strain gauge consists of a stationary frame, which supports a moveable armature through thin cantilever plates. The strain sensitive wire is strung under tension between pins located on the frame of the transducer and pins located on the moveable armature. Four filaments are normally used in each transducer, connected in a conventional Wheatstone bridge, which makes up the sensing circuit. As the armature is moved longitudinally by an external force, the resistance increases in one pair of filaments and decreases in the other. This provides a bridge output that is directly proportional to the longitudinal movement of the force applied. The choice between bonded or un-bonded strain gauge based transducers depends upon the specific application and the personal preference of the User.

Product Issue Report

Report Taken By: ____________________
Assigned To: ____________________
IDENTIFIER ____________________
☐ Call Back Needed ☐ Enter into DCS
☐ Entered into DCS
☐ Already in Database, Add person reporting bug

REPORTED BY

Name
Company
Address
Phone Number
Email Address
Project/Product
Serial number
Found in Release
Other User Info/Notes

Priority
Date

(CHECK ONE)	☐ Unreproduced	☐ Reproduced
	☐ Needs Repair	☐ As Intended

HARDWARE CONFIGURATION

Computer Brand/Model
CPU Type
ROM Type/Version Memory
Graphics Card Monitor
Mouse
Disk Info
Printer
Network
Operating System
Resident Software

Description/Steps to Reproduce

Notes

☐ Change Manual
Form L-408

Feature Request

REQUESTED BY

Name

Company

Address

Phone Number

Email Address

Project/Product

Serial number

Other User Info/Notes

Priority

Date

(CHECK ONE) ☐ Unevaluated ☐ Pending

☐ Implement ☐ Already Exists

Request Taken By: ____________________________

Assigned To: _________________________________

IDENTIFIER __________________________________

☐ Call Back Needed ☐ Enter into DCS

☐ Entered into DCS

☐ Already in Database, Add person requesting change

Description

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