ENGINEERING, INC.

SignalPro™

Signal Conditioning System

Users Manual

CUSTOM CONFIGURABLE SIGNAL CONDITIONING MODULES

OMEGA ENGINEERING, INC.
One Omega Drive
P.O. Box 4047
Stamford, CT 06907-4047

Tel: (203) 359-1660
Fax: (203) 359-7700
Toll free:1-800-826-6342
E-mail:das@omega.com

http://www.dasieee.com

WARRANTY WARRANTY/DISCLAIMER

OMEGA ENGINEERING, INC., warrants this unit to be free of defects in materials and workmanship for a period of **13 months** from the date of purchase. OMEGA warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover shipping and handling time. This ensures that OMEGA's customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. OMEGA's Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. OMEGA's warranty does not apply to defects resulting from any action of the purchaser, including but not limited to mishandling, improper interfacing, operation outside design limits, improper repair or unauthorized modification. This WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear are not warranted, including but not limited to contact points, fuses and triacs.

OMEGA is pleased to offer suggestions on the use of its various products. However, OMEGA neither assumes responsibility for any omissions or errors nor assumes liability for any damages that result from the use of its products in accordance with information provided from OMEGA, either verbal or written. OMEGA warrants only that the parts manufactured by it will be as specified and free of defects. OMEGA MAKES NO OTHER WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE, AND ALL IMPLIED WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED. LIMITATION OF LIABILITY: The remedies of purchaser set forth herein are exclusive and the total liability of OMEGA with respect to this order, whether based on contract, warranty, negligence, indemnification, strict liability or otherwise, shall not exceed the purchase price of the component upon which liability is based. In no event shall OMEGA be liable for consequential, incidental or special damages.

CONDITIONS: Equipment sold by OMEGA is not intended to be used**,** nor shall it be used: (1) as a "Basic Component" under 10 CFR 21 (NRC), used in or with any nuclear installation or activity, medical application or used on humans. Should any Product(s) be used in or with any nuclear installation or activity, medical application, used on humans or misused in any way, OMEGA assumes no responsibility as set forth in our basic WARRANTY / DISCLAIMER language, and additionally, the purchaser will indemnify OMEGA and hold OMEGA harmless from any liability or damage whatsoever arising out of the use of the Product(s) in such a manner.

RETURN REQUESTS/INQUIRIES

Direct all warranty and repair requests / inquiries to the OMEGA Customer Service Department. BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, THE PURCHASER MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OMEGA'S CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). THE ASSIGNED NUMBER SHOULD THEN BE MARKED ON THE OUTSIDE OF THE RETURN PACKAGE AND ON ANY CORRESPONDENCE. THE PURCHASER IS RESPONSIBLE FOR SHIPPING CHARGES, FREIGHT, INSURANCE AND PROPER PACKAGING TO PREVENT BREAKAGE IN TRANSIT.

FOR **WARRANTY** RETURNS, please have the following information available BEFORE contacting OMEGA:
(1) P.O. Number under which the product was purchased,
(2) Model and serial number of the product under warranty, and
(3) Repair instructions and / or specific problems relative to the product.

FOR **NON-WARRANTY** REPAIRS, consult OMEGA for current repair charges. Have the following information available BEFORE contacting OMEGA:
(1) P.O. Number to cover the cost of the repair,
(2) Model and serial number of the product, and
(3) Repair instructions relative to the product.

OMEGA's policy is to make running changes, not model changes, whenever an improvement is possible. This affords our customers the latest in technology and engineering. OMEGA is a registered trademark of OMEGA ENGINEERING, INC.

OMEGAnet® On-line Service: http://www.omega.com

Internet e-mail: info@omega.com

Servicing North America:

USA:
ISO 9001 Certified

One Omega Drive, Box 4047
Stamford, CT 06907-0047
Tel: (203) 359-1660
E-mail: info@omega.com
FAX: (203) 359-7700

Canada:

976 Bergar
Laval (Quebec) H7L 5A1
Tel: (514) 856-6928
E-mail: info@omega.com
FAX: (514) 856-6886

For immediate technical or application assistance:

USA and Canada:

Sales Service: 1-800-826-6342 / 1-800-TC-OMEGA[SM]
Customer Service: 1-800-622-2378 / 1-800-622-BEST[SM]
Engineering Service: 1-800-872-9436 / 1-800-USA-WHEN[SM]
TELEX: 996404 EASYLINK: 62968934 CABLE: OMEGA

Mexico and Latin America:

Tel: (001) 800-826-6342 FAX: (001) 203-359-7807
En Espanol: (001) 203-359-7803
E-mail: espanol@omega.com

Servicing Europe:

Benelux:

Postbus 8034, 1180 LA Amstelveen, The Netherlands
Tel: (31) 20 6418405
Toll Free in Benelux: 0800 0993344
E-mail: nl@omega.com

Czech Republic:

ul.Rude armady 1868, 733 01 Karvina-Hraniee
Tel: 42 (69) 6311899
FAX: 42 (69) 6311114
Toll Free: 0800-1-66342
E-mail: czech@omega.com

France:

9, rue Denis Papin, 78190 Trappes
Tel: (33) 130-621-400
Toll Free in France: 0800-4-06342
E-mail: france@omega.com

Germany/Austria:

Daimlerstrasse 26, D-75392 Deckenpfronn, Germany
Tel: 49 (07056) 3017
Toll Free in Germany: 0130 11 21 66
E-mail: germany@omega.com

United Kingdom: One Omega Drive, River Bend Technology Drive
<u>ISO 9002 Certified</u> Northbank, Irlam, Manchester
M44 5EX, England
Tel: 44 (161) 777-6611
FAX: 44 (161) 777-6622
Toll Free in England: 0800-488-488
E-mail: info@omega.co.uk

It is the policy of OMEGA to comply with all worldwide safety and EMC/EMI regulations that apply. OMEGA is constantly pursuing certification of it's products to the European New Approach Directives. OMEGA will add the CE mark to every appropriate device upon certification.

The information contained in this document is believed to be correct but OMEGA Engineering, Inc. accepts no liability for any errors it contains, and reserves the right to alter specifications without notice. **WARNING**: These products are not designed for use in, and should not be used for, patient connected applications.

Table of Contents

List of Figures

List of Tables

1 SignalPro™ Series Overview

Electrical measurement of physical quantities is often performed using a “transducer”. Transducers, in the context of this discussion, are devices that convert physical quantities such as acceleration, strain or temperature to an electrical output signal. An example of a transducer is the thermocouple, which is used to measure temperature. Transducers are available in a wide variety of shapes, sizes and specifications for most applications.

The Omega SignalPro signal conditioning system provides a complete solution for data acquisition using transducers. The SignalPro system provides the transducer with excitation or biasing when required and then performs the necessary “conditioning” of the electrical output signal from the transducer prior to measurement by an analog-to-digital converter (ADC).

1.1 Functional Description

The SignalPro signal conditioning system covers a wide range of transducers and applications, yet most of the modules share some common elements. Figure 1-1 shows a block diagram of a typical data acquisition system using SignalPro series signal conditioning modules.

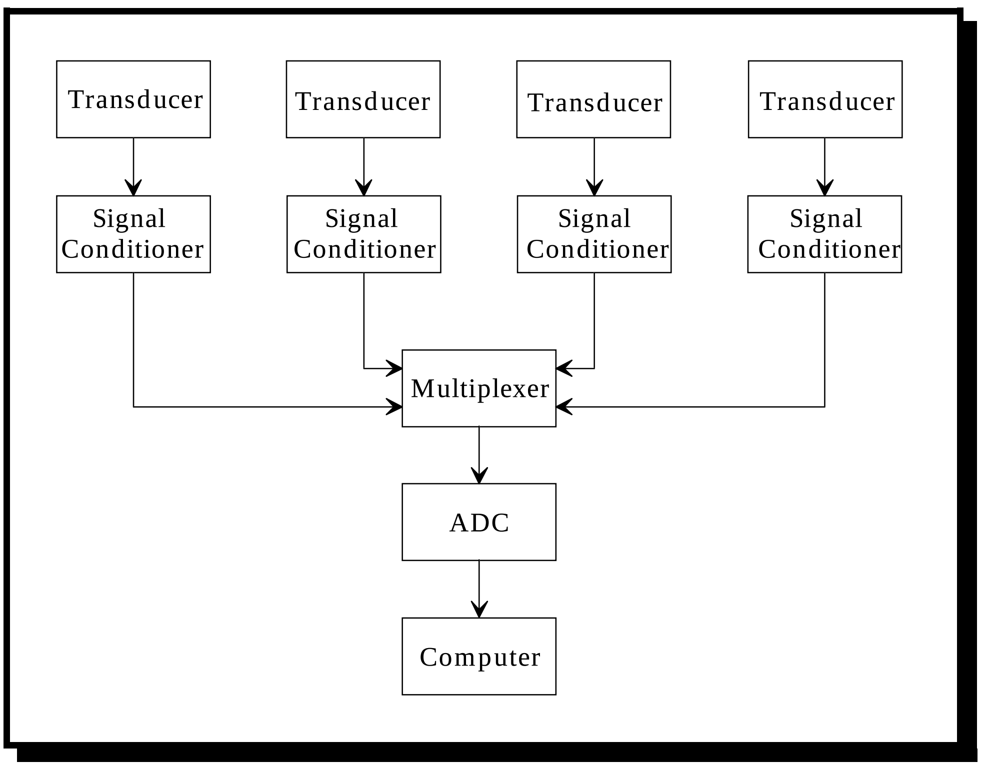

Figure 1-1. SignalPro Data Acquisition System Block Diagram

1.1.1 Transducers

The SignalPro series includes signal conditioning modules that enable the user to create data acquisition systems for transducers such as thermocouples, resistance temperature detectors (RTDs), strain gages and accelerometers. Multiple transducers can be attached to a single module, the number of which depends on the specific module selected.

1.1.2 Signal Conditioner

The electrical output signal generated by a transducer often needs "conditioning" before it can be measured by an ADC. The signal may require amplification, filtering, linearization and more before the ADC can accurately read it. Additionally, some transducers require an excitation source or proper biasing to complete measurements. The SignalPro system provides the transducer with any required excitation or biasing and performs all necessary conditioning of the electrical output signal.

1.1.3 Multiplexer

SignalPro series modules can provide up to 16 channels of transducer input by multiplexing a single main analog-to-digital (A/D) channel off the data acquisition adapter in the host computer. The multiplexers on a SignalPro series module work like a switch, scanning each transducer input channel and connecting the input to the selected main A/D channel.

The multiplexed input channels on the SignalPro module may be mapped back to any main A/D channel on the data acquisition adapter in the host computer via jumper configuration. Some modules provide less than 16 input channels, yet allow multiple modules to share a single main A/D channel. For example, the QTC-250 RTD signal conditioning module has eight input channels. Two QTC-250 modules may share one main A/D input channel to provide 16 transducer input channels per main A/D channel. Multiplexing of all 16 main A/D channels, (provided the A/D adapter type supports 16 channels), from the host computer data acquisition adapter results in a maximum of 256 A/D transducer input channels (16 x 16) per adapter.

1.1.4 Analog-to-Digital Converter (ADC)

The analog output signal from the transducer is converted to digital information by the ADC in the data acquisition adapter in the host computer. Omega offers a complete line of data acquisition adapters with both 12 and 16 bit resolution.

1.2 Hardware Description

SignalPro series modules come in several configurations. The QTC-100 is a self-contained power adapter module. The QTC-350 and QTC-450 are self contained interface boards with BNC connectors. The remaining modules consist of two circuit boards: an interface board and a removable terminal board. The interface boards are standard 3U size and easily mount in the QTE-7 (seven modules), QTE-14 (fourteen modules) or QTC-xxx-PCS (one module) data acquisition enclosures. The SignalPro terminal boards contain the transducer input screw terminal blocks and most of the user configurable switches and jumper blocks. Figure 1-2 depicts a two board configuration with a single module data acquisition enclosure.

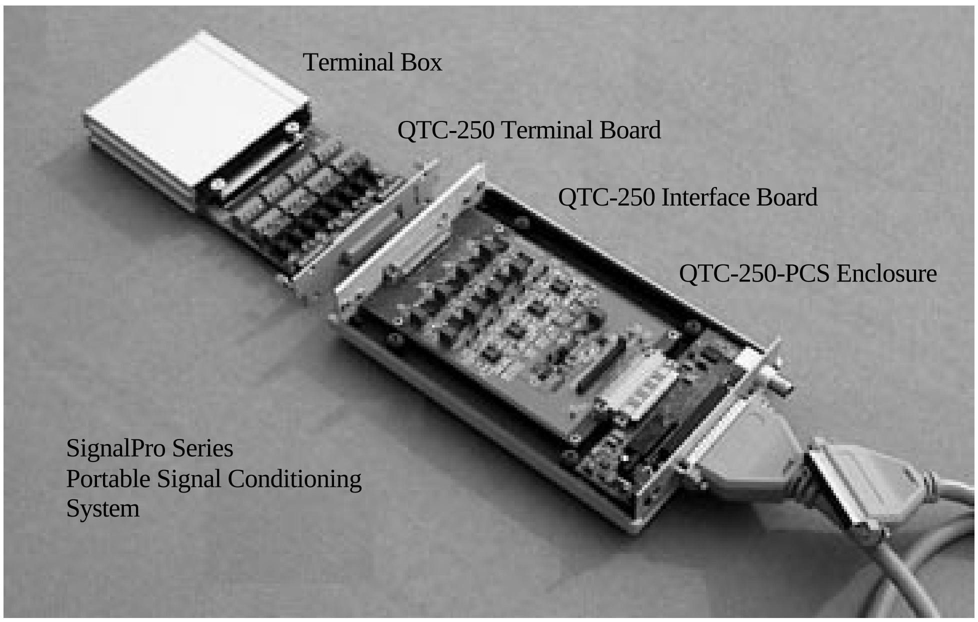

Figure 1-2. SignalPro Portable Signal Conditioning System (QTC-250-PCS)

1.2.1 Interface Board Description

SignalPro interface boards operate with the following transducers and sensors: thermocouple (QTC-200/200T), RTD (QTC-250/250T), strain gage (QTC-300/300T), accelerometer (QTC-350), voltage/current (QTC-400/400T) and analog signal filter (QTC-450). The QTC-500/500T is a multipurpose interface board that provides isolated input signals utilizing 5B modules. The SignalPro DC voltage adapter module, QTC-100, provides a versatile means to power signal conditioning modules mounted in the QTE-7 half rack housing unit using automobile battery power. After the initial configuration and mounting of an interface circuit board, it rarely requires removal from the QTE-7, QTE-14 or QTC-xxx-PCS enclosure. For information on interface board data acquisition enclosures, see Chapter 2: SignalPro Series Racks and Enclosures.

1.2.2 Terminal Board Description

SignalPro series modules QTC-200, 250, 300, 400 and 500 use the removable terminal board to facilitate the quick connection of transducer lead wires. Lead wires easily attach to the screw blocks on the portable terminal board. SignalPro series terminal boards slide into their own protective enclosure which connects externally to the interface board and is secured with two thumb screws.

1.3 Hardware Configuration

For the purpose of this discussion, it is presumed the user is configuring the SignalPro signal conditioning system using an Omega sixteen channel data acquisition adapter, product number: DAQP-12 or DAQP-16 (PCMCIA) or DAQ-1201/02 (ISA).

1.3.1 Main A/D Channel Selection and Jumper Configuration

There are sixteen analog input channels on the main connector of a Omega data acquisition adapter. Each analog input channel of the adapter can connect to either one signal conditioning module or multiple modules of the same type and thus be expanded up to 16 signal conditioning channels. The number of modules that can be connected to a single analog input channel varies depending on the number of expansion channels the specific module supports. For example, the QTC-300 supports four expansion channels, so four modules can be connected to one analog input channel (4 x 4 = 16). The QTC-250 supports eight expansion channels, so two modules can be connected to one analog input channel (8 x 2 = 16). Table 1-1 lists available expansion channels.

Signal Conditioning Module	Number of Expansion Channels Supported
QTC-200	14
QTC-250	8
QTC-300	4
QTC-350	4
QTC-400	16
QTC-450	4
QTC-500	8

Table 1-1. Expansion Channel Availability

SignalPro series modules can occupy any analog input channel on the data acquisition adapter. Which channel the module(s) will occupy is dependent on the configuration of the main A/D channel selection jumper. Note that if multiple modules occupy the same main A/D channel, then each module must have the same jumper setting. Figure 1-3 depicts the main A/D channel selection jumper. The factory default setting is channel zero (CH0) for all SignalPro series modules installed in the QTC-xxx-PCS portable data acquisition enclosure. For modules installed in the QTE-7 and QTE-14 rack enclosures, the factory default setting for the main A/D channel jumper will vary depending on the number of modules in each system. See section 1.3.3 for a system configuration example.

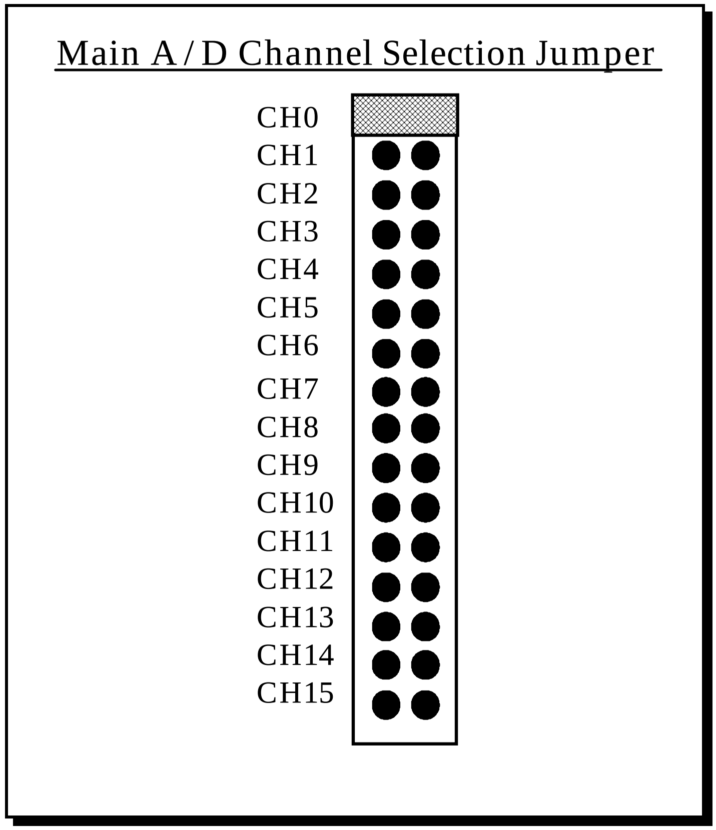

Figure 1-3. SignalPro Series Main A/D Channel Selection Jumpers

The numerical designator for the main A/D channel jumper block varies from module to module. Table 1-2 lists the designator for each specific module.

Signal Conditioning Module	Main A/D Channel Jumper Designation
QTC-200	J1
QTC-250	J10
QTC-300	J5
QTC-350	J15
QTC-400	J1
QTC-450	J11
QTC-500	J1

Table 1-2. Main A/D Channel Jumper Block Designators

1.3.2 Board Selection Jumper Configuration

Board selection jumper configuration options vary from module to module depending on the number of expansion channels the module will support. Figure 1-4 depicts the board selection jumpers with factory default settings and the numerical designator for each jumper block. Note the factory default for all board selection jumpers is the lowest board number.

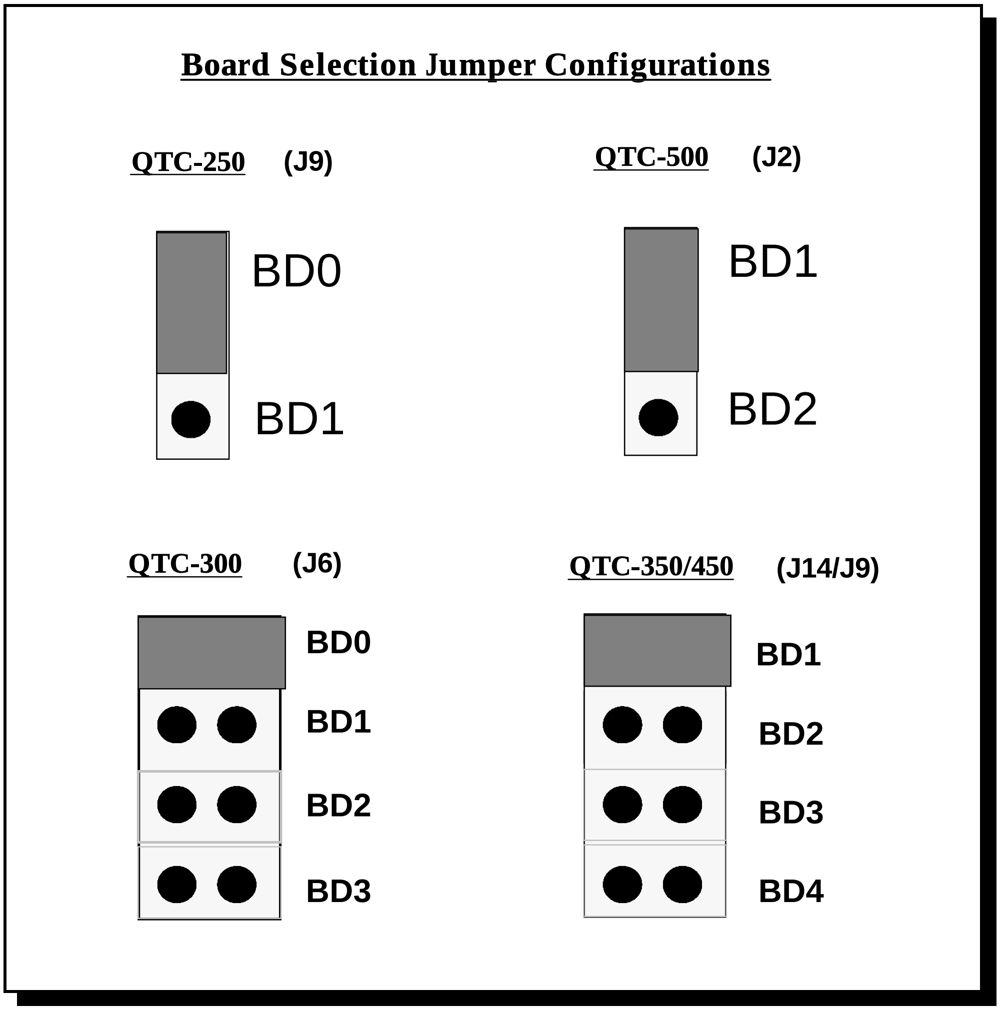

Figure 1-4. SignalPro Series Board Selection Jumpers

When configuring multiple SignalPro modules to one main A/D channel, the position of the board selection jumper will determine which module is connected to a specific numerical section of the sixteen available expansion channels. For example, if two QTC-250 modules were connected to one main A/D channel, the first QTC-250 module would use the "BD0" configuration and would occupy expansion channels 0 - 7. The second QTC-250 module would use the "BD1" configuration and would occupy expansion channels 8 - 15.

1.3.3 Expansion Channel Numbering

Figure 1-5 depicts the logical channel numbering for a signal conditioning system in which four main A/D channels from the host computer data acquisition adapter are expanded. (The QTC-200 module actually only has fourteen data acquisition channels. Channels one and two are utilized for cold junction and offset information).

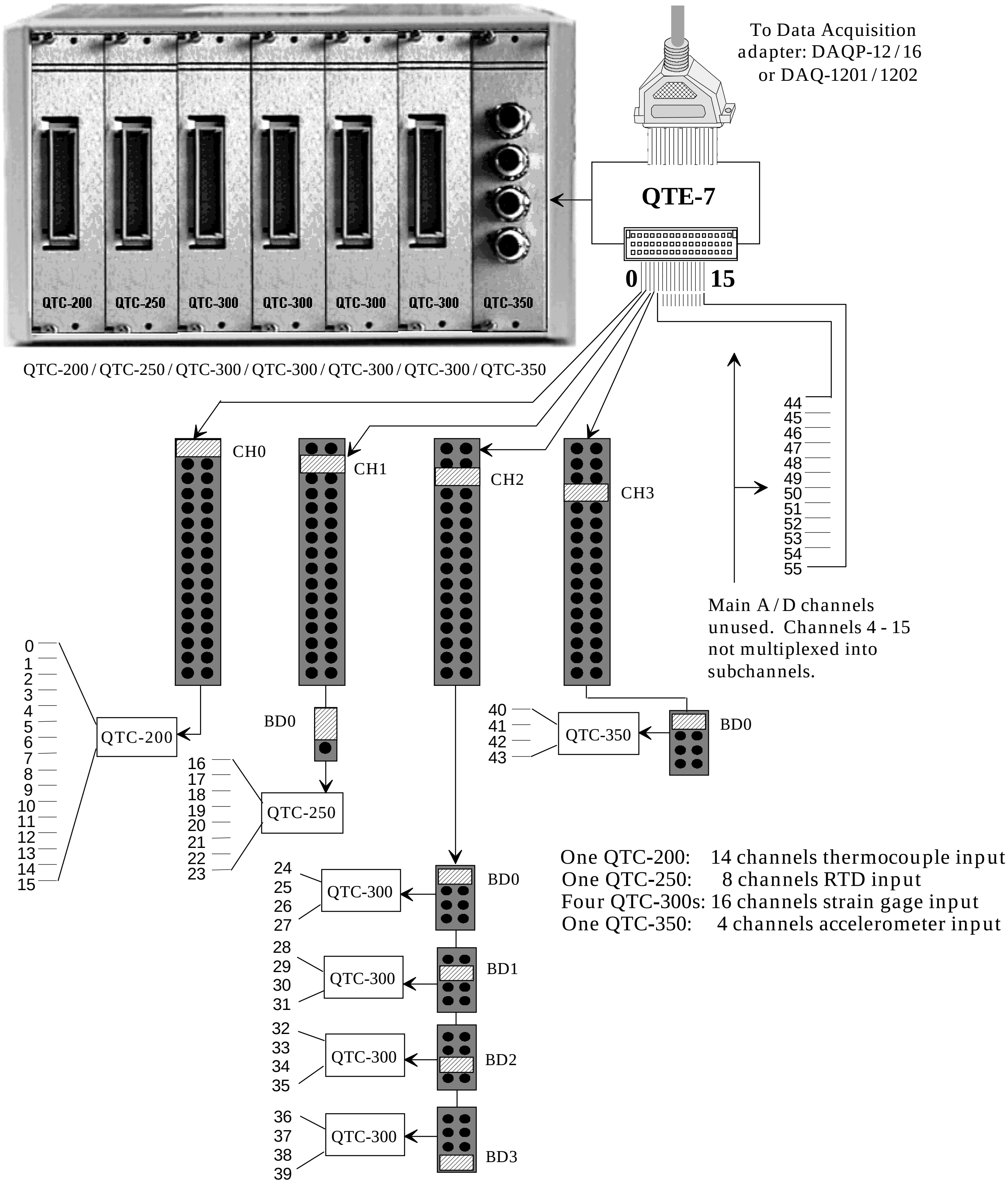

Figure 1-5. Expansion Channel Numbering in a Multiple Module System

2 SignalPro™ Series Racks and Enclosures

Enclosure Features

- Flexibility to combine multiple types of modules in a single unit
- Ruggedized aluminum, metal, and plastic enclosures
- External trigger source input with BNC connector
- Compatible with all SignalPro Series modules
- Multiple enclosures can be linked together using only one data acquisition adapter for up to 256 channels in a system.
- Power can be supplied by a flexible range of either AC or DC voltage with appropriate options installed

The SignalPro series interface boards are a standard 3U size and mount easily into the QTE-7, QTE-14 or QTC-xxx-PCS data acquisition enclosures. Each of these enclosures is equipped with a DIN-48 female connector(s) to mate with the interface boards and a standard Omega D-37 data acquisition connector which mates with the data acquisition adapter in the host computer.

There are three housing options available for SignalPro modules: (1) the QTE-14 rack mount enclosure which holds up to 14 modules, (2) the QTE-7 half rack enclosure which holds up to 7 modules and (3) the QTC-xxx-PCS portable unit which accommodates a single module. (See Figure 2-1).

Figure 2-1. SignalPro Series Data Acquisition Racks and Enclosures

2.1 Multiple Module Enclosures

Figure 2-2 shows the block diagrams for the QTE-7 and QTE-14 data acquisition enclosures.

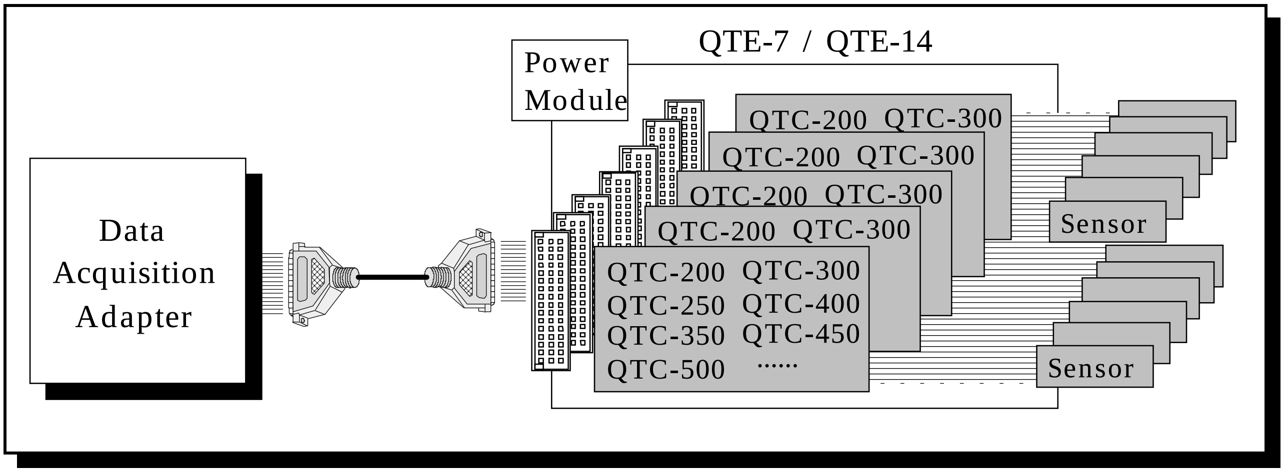

Figure 2-2. Multiple Module Enclosure Block Diagram

SignalPro modules may be mounted into any slot in the data acquisition enclosures. (The QTC-100 power adapter module will only mount in the first slot of the QTE-7 and are not available for the QTE-14).

2.2 External Connections

2.2.1 Data Acquisition Adapter Connection

Each of the SignalPro series enclosures is equipped with a D-37 female connector that is pin compatible with Omega data acquisition adapters. Omega data acquisition adapters are available with 12 and 16 bit resolution.

2.2.2 External TTL Trigger Connector

The data acquisition adapter in the host computer requires an initial signal to start A/D conversions. Depending on the software configuration, A/D conversions will be initiated by either a software trigger or an external hardware trigger. Each of the SignalPro series data acquisition enclosures provides a BNC connector for a hardware TTL trigger input. The TTL trigger starts A/D conversions on either the rising or falling edge of a TTL signal. The BNC connector maps the TTL input back to pin 25, (digital input channel 0), on the Omega D-37 data acquisition adapter.

2.2.3 Multiple Enclosures

Multiple SignalPro series enclosures can be linked together using only one data acquisition adapter to expand a signal conditioning system from sixteen up to 256 channels. An Omega D-37 adapter cable, product number: CP-DAQ, is required to link multiple enclosures in your system.

2.3 Power Requirements

The QTE-7 and QTE-14 enclosures require an AC input voltage from 90 to 260 VAC @ 60 Hz. With the QTE-7, the user has the option of using an Omega QTC-100 power module. The power module allows the user to power a remote data acquisition system with automobile battery power. The QTC-xxx-PCS requires a DC input voltage from 9 to 25 VDC and is shipped with a 12v, 2.92A power supply module included.

All three enclosure models have a +5V and +/-15V DC power supply mounted inside the enclosure to provide power for SignalPro series modules. The QTC-xxx-PCS internal power supply automatically corrects the polarity of the input voltage to provide maximum flexibility in choosing a power source for the portable enclosure.

2.4 Physical Dimensions

Table 2-1 lists the physical dimensions of each enclosure in the SignalPro series.

SignalPro Enclosure	Width	Depth	Height
QTC-xxx-PCS	5.57” (141.5mm)	8.78” (233.0mm)	1.56” (39.62mm)
QTE-7	9.28” (235.7mm)	9.39” (238.7mm)	5.22” (132.7mm)
QTE-14	17.68” (449.1mm)	9.39” (238.7mm)	5.22” (132.7mm)

Table 2-1. Data Acquisition Enclosure Physical Dimensions

3 QTC-100 DC Voltage Power Adapter Module

QTC-100 Features

- Standard 3U interface board for use with the QTE-7 half-rack housing unit
- Supplies 25 watts of total power to the QTE-7
- No polarity required on the DC input voltage - Center pin can be positive or negative
- Power LED to indicate slot status
- Optional power cord allows system to be powered from a standard automobile cigarette lighter

The QTC-100 is a DC voltage power adapter module which provides a convenient way to power SignalPro series modules using an automobile battery. For use with the QTE-7 half-rack housing unit, the QTC-100 accepts DC input voltage from 10 to 28vdc and generates the +5 and ±15vdc output required to power a remote data acquisition system. An optional six foot cord, (product number: QTC-PWR-DC), is available to allow the user to generate system power using a standard automobile cigarette lighter. (See Figure 3-1).

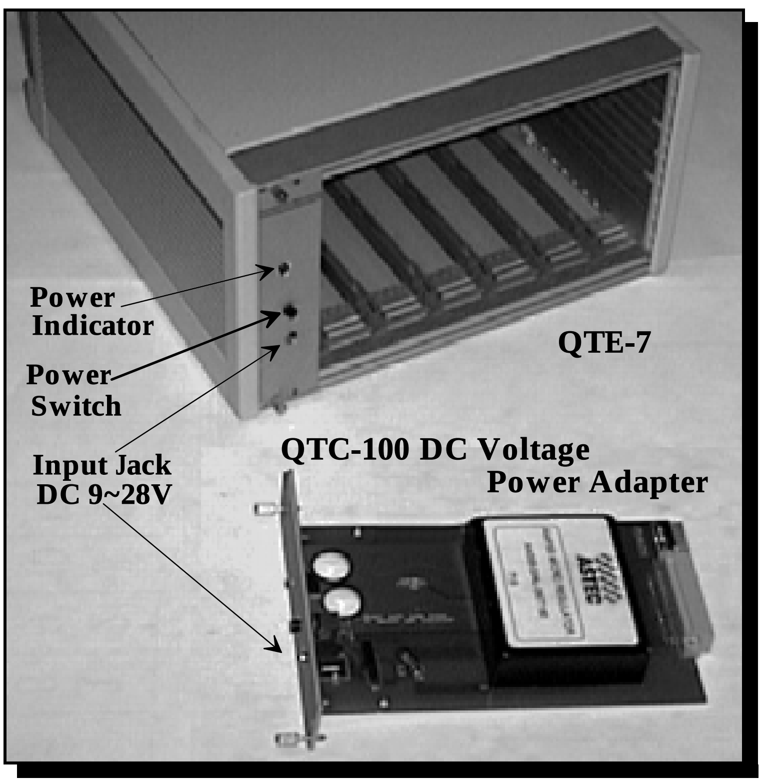

Figure 3-1. QTC-100 DC Voltage Power Adapter Module

3.1 Circuit Board Description

The QTC-100 is a standard 3U size board designed for use with the QTE-7 half rack data acquisition enclosure. A block diagram of QTC-100 is shown in Figure 3-2. The DC to DC converter accepts input voltage from 10 to 28vdc and in turn generates +5, +15 and -15vdc. The 14-pin male power connector and the DIN-48 male connector on the QTC-100 interface board will only connect to the first slot of the QTE-7.

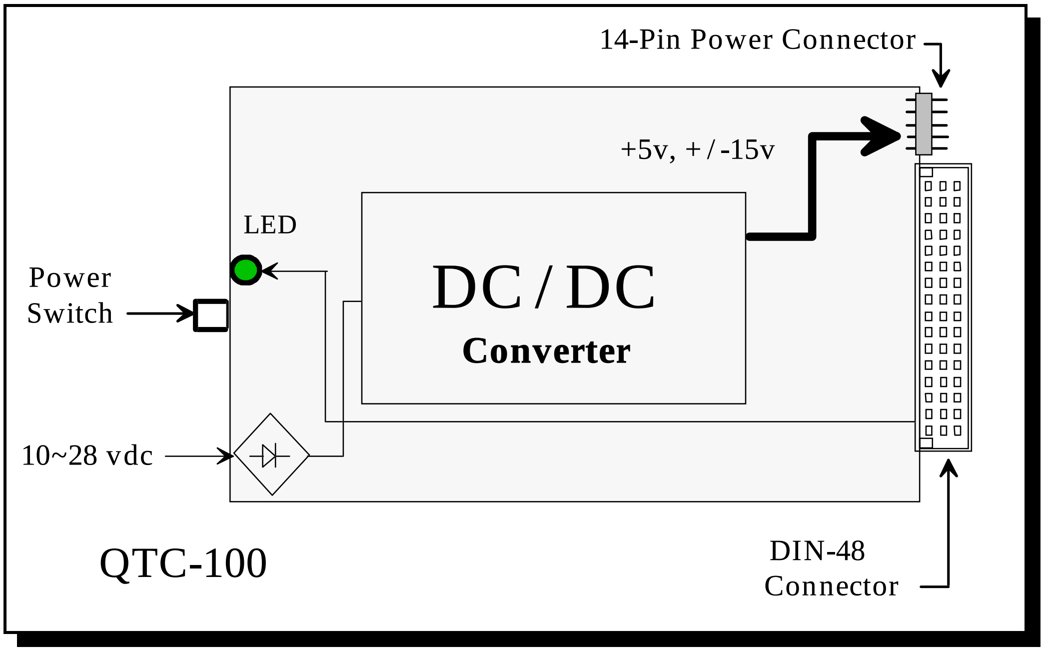

Figure 3-2. QTC-100 Block Diagram

3.1.1 AC/DC Power Supply Priority

With the QTC-100 DC Voltage Power Adapter Module, the QTE-7 half rack enclosure can accept either AC power (90~260 vac) or DC power (9~28 vdc). If both power supplies are available simultaneously, the QTE-7 will use AC power to generate the +5, +15 and -15VDC power required for all SignalPro series modules in the QTE-7 system. If the AC power supply is unavailable or failed, the QTE-7 will automatically switch to DC power from QTC-100 power module.

3.1.2 Power Jack and Switch

The QTC-100 power jack accepts 9~28vdc through a 2.5 x 5.5mm DC plug in which the center pin can be either positive or negative. A push button switch on the front panel is used to control power to the QTE-7 and a green LED indicates the power status. (Refer to Figure 3-1 for locations of the power jack, switch and indicator).

3.2 QTC-100 Specifications

Connectors:	DIN-48 male and 14-pin right angle male, mates with first slot of QTE-7
Power Jack:	Suitable for 2.5 x 5.5mm DC plug
Input Polarity:	No Polarity required (Center pin can be either positive or negative)
Input Ripple Current:	<100 mA p-p 80-85% typical
Total Power:	25 Watts
Output Voltage:	+5V+/-1%@3.50A, +15V+/-3%@0.50A, -15V+/-3%@0.50A
Line Regulation:	0.25% for +5V, 2% for +/-15V
Load Regulation:	0.25% (+5V), 3% (+/-15V)
Noise/Ripple:	50mV p-p (+5V), 100mV p-p (+/-15V)
Isolation:	500 VDC
Dimension:	100mm X 166.4mm
Weight:	0.3 Kg

4 QTC-200 Thermocouple Input Module

QTC-200 Features

- Fourteen Thermocouple input channels
- Up to 224 Analog Input Channels can be configured in a system
- Thermocouple types J, K, T, E, S or R, N & B supported
- On board Low Pass Filter for each channel (-80dB @ 50Hz)
- Isolated Cold Junction Compensation
- Terminal block for quick, easy signal connections

The QTC-200 is a fourteen channel thermocouple input module. Each channel is equipped with a separate instrument amplifier, offset adjustment and low pass filter. Up to sixteen QTC-200 modules can be configured in an Omega signal conditioning and data acquisition system for a total of 224 analog input channels. The QTC-200 can also be coupled with other modules in Quatech's SignalPro™ series to provide a versatile data acquisition system.

The QTC-200 module consists of two circuit boards: the QTC-200 interface board and the QTC-200T terminal board. The interface board is a standard 3U size board which can be mounted in the QTE-7, QTE-14 or QTC-200-PCS data acquisition enclosures. The QTC-200T terminal board contains the thermocouple input screw blocks, Cold Junction Compensation (CJC) sensor and the mode selection switches. This two board configuration allows quick and easy connection of the thermocouple lead wires. After the initial configuration of the interface board, it can be mounted in a data acquisition enclosure and will rarely require removal. All connections are completed on the screw terminals of the portable QTC-200T, which is then plugged into the interface board and secured using two thumb screws. (See Figure 4-1).

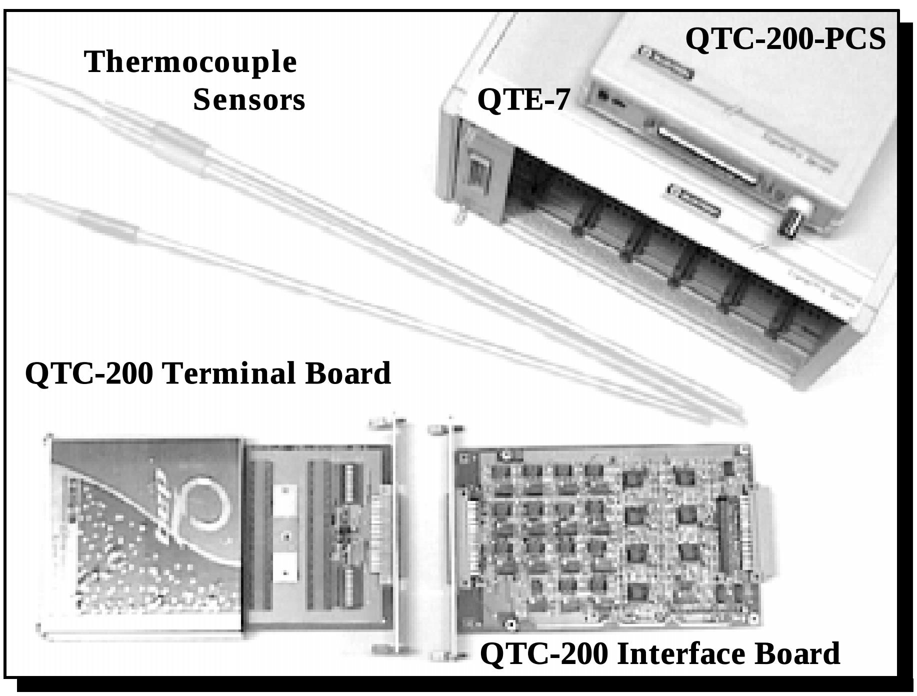

Figure 4-1. QTC-200 Thermocouple Input Module

4.1 Circuit Board Description

4.1.1 QTC-200 Interface Board Description

The QTC-200 interface board shown in Figure 4-1 can be mounted in SignalPro series data acquisition racks and enclosures. (See Chapter 2 for information on SignalPro series racks). Each rack enclosure is equipped with a DIN-48 female connector which mates to the QTC-200 and other SignalPro series signal conditioners. The rack also contains a standard Omega D37 connector which attaches to the host computer data acquisition adapter.

The QTC-200 provides sixteen channels; one channel for CJC input, one channel for zero offset input and fourteen channels for thermocouple input; by multiplexing a single main A/D channel off the host computer data acquisition adapter. The multiplexer on the QTC-200 scans the sixteen input channels sequentially and connects each input to the single main A/D channel. The sixteen multiplexed input channels may be mapped back to any main A/D channel on the data acquisition adapter depending on the configuration of jumper J1. Multiplexing of all 16 main A/D channels from the host computer results in a maximum of 256 channels consisting of 224 A/D input channels (14 x 16) and 32 CJC/zero offset input channels (2 x 16) per data acquisition adapter.

4.1.2 QTC-200T Terminal Board Description

The QTC-200T terminal board contains the thermocouple input screw blocks and the mode selection switches which configure either differential or single ended input for each channel. The terminal board DIN-48 female connector plugs into the QTC-200 interface board and is equipped with a strain relief bracket to secure external thermocouple wiring.

4.2 Hardware Configuration

For system configuration options see Chapter 1: SignalPro Series Overview, section 1.3: Hardware Configuration.

4.2.1 QTC-200 Interface Board Configuration

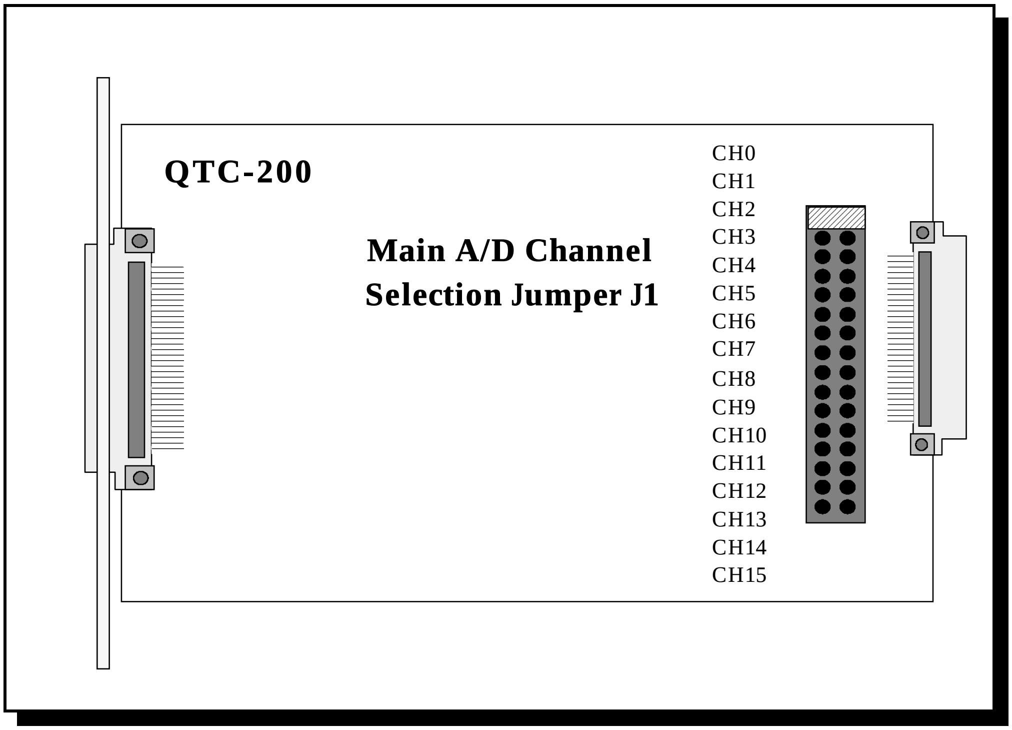

Figure 4-2. QTC-200 Main A / D Channel Jumper Block Location

Figure 4-2 shows the location of the main A / D channel selection jumper block J1. System configuration options for J1 are discussed extensively in Chapter 1, section 1.3

4.2.2 QTC-200T Terminal Board Configuration

Figure 4-3 depicts the location of the thermocouple input screw blocks, differential or single-ended mode selection switches (SW1 and SW2), CJC sensor and the thermocouple lead wire strain relief bracket.

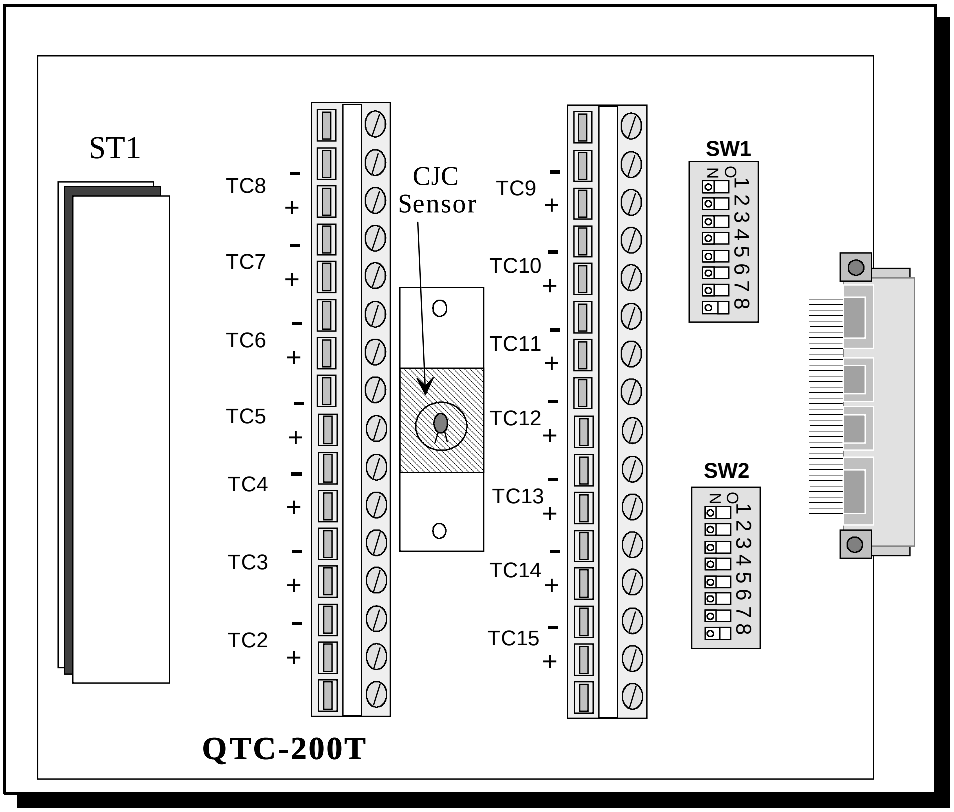

Figure 4-3. QTC-200T Terminal Board

4.2.2.1 Thermocouple Input Mode Selection Switches

Figure 4-4 depicts the mode selection switches for thermocouple input channels 2 through 15.

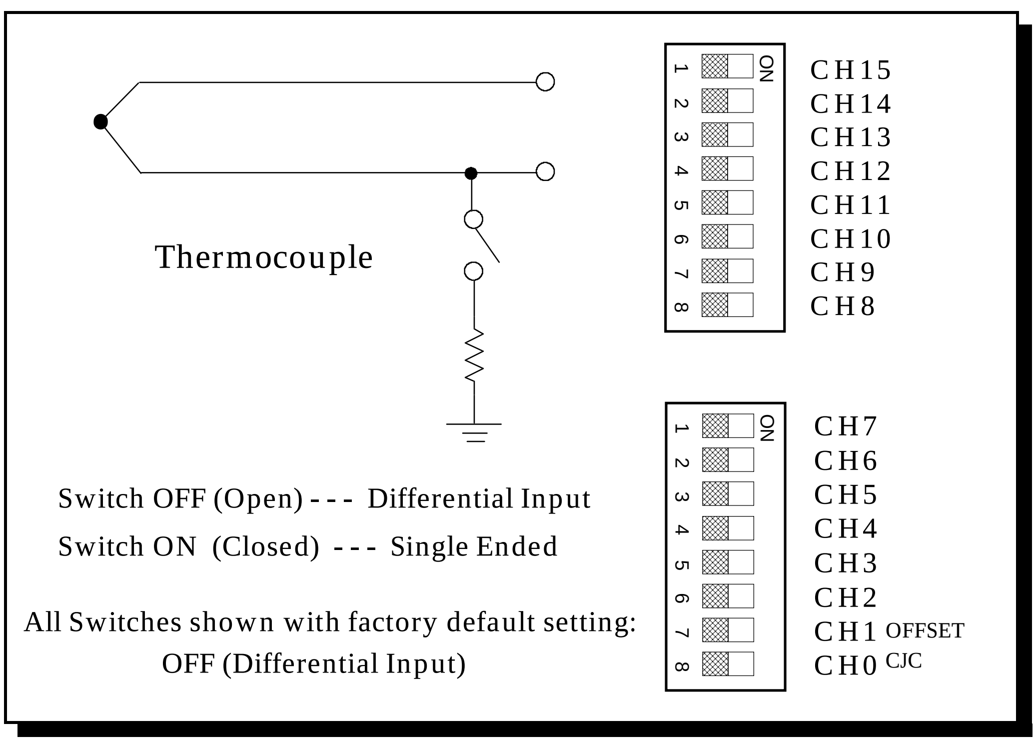

Figure 4-4. Thermocouple Input Mode Selection Switches

4.3 Basic Principles

Thermocouples measure temperature using the Seebeck Effect which occurs at the junction connection of two dissimilar metals. A voltage difference is generated at the junction that changes with temperature over a given range. This voltage is not a linear function of temperature and therefore cannot be related directly to temperature. Linearization tables and polynomial approximation are two methods used to transform thermocouple input into real temperature measurement.

One problem experienced with thermocouple temperature measurement is when the junction between thermocouple lead wires and terminal blocks creates, in essence, another thermocouple. The QTC-200 signal conditioning module provides a practical solution to this problem by using a built in cold junction compensation circuit to neutralize the voltage created at the terminal block junction.

Damaged thermocouples can introduce another significant source of measurement error by becoming open or extremely resistive. The QTC-200 signal conditioning module uses an open thermocouple detection circuit on each thermocouple input to guard against this possibility. The detection circuit drives a low level current through the thermocouple causing the input amplifiers to be driven to rails whenever an open or highly resistive thermocouple is present.

4.3.1 Cold Junction Compensation (CJC) Sensor

The QTC-200T uses an isolated CJC sensor to detect temperature at the thermocouple terminals with high accuracy and minimize any temperature difference between the CJC sensor and thermocouple terminal junctions.

The first channel (CH0) is used to measure temperature at the CJC sensor.
Temperature in °C : TC and in °F : TF is calculated as follows:

$$TC = \frac{1}{(A+B*\ln(R)+C*(\ln(R))^3)} - 273$$

$$R = VCH0 * 5000 \ / \ (10 - VCH0)$$

$$TF = Tc * 9 \ / \ 5 + 32$$

where A=0.00128974451631 VCH0: Voltage reading at CH0 in volts

B=0.00023530184288 R: Resistance of the sensor in ohms

C=0.00000009729702

4.3.2 Software Zero Correction

Since most thermocouple signals are within the 100mV range, offset voltage between the QTC-200T and the data acquisition adapter must be monitored. QTC-200 channel 1 (CH1) is used to check the zero reference of the QTC-200T, then the data acquisition system software subtracts this offset.

4.3.3 Single Ended Thermocouple Measurements

A single ended thermocouple measurement is shown in Figure 4-5. The thermocouple input channel must be configured for single ended operation as discussed in section 4.2.2.1 of this chapter.

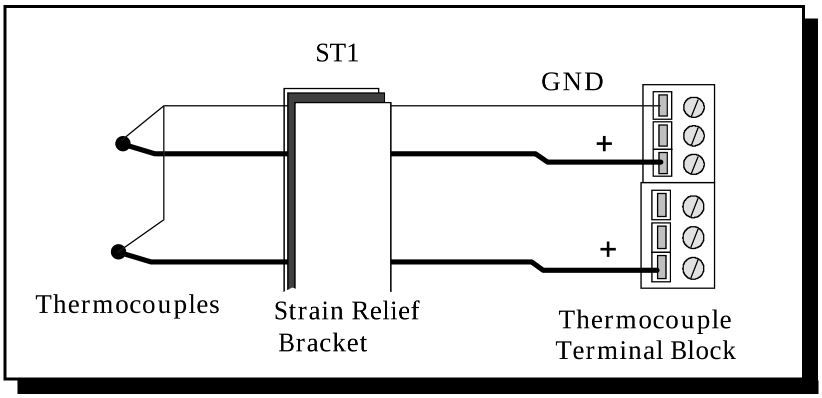

Figure 4-5 Single Ended Thermocouple Measurement

4.3.4 Differential Thermocouple Measurements

A differential thermocouple measurement is shown in Figure 4-6. The thermocouple input channel must be configured for differential operation as discussed in section 4.2.2.1 of this chapter.

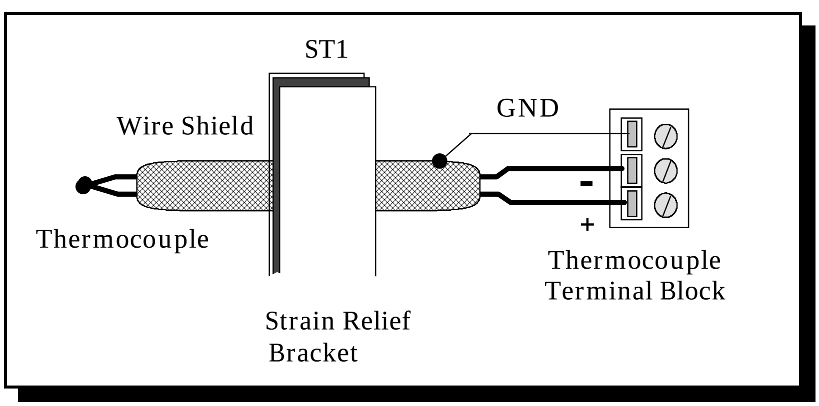

Figure 4-6. Differential Thermocouple Measurement

4.4 QTC-200/QTC-200T Specifications

Connector:	DIN-48 male, mates with QTE-7, QTE-14 and QTC-200-PCS
Signal Connection:	DIN-48 female, mates with terminal block
Number of TC Channels:	14 (CH0: CJC; CH1: Zero offset; CH2-15: Thermocouple inputs)
Input Type:	Differential / Single-ended (DIP Switch Select-able)
Precision Thermistor:	5000 Ohm @ 25 °C

Supported Thermocouple Type, Temperature Range

Type	Range
J Thermocouple:	-200°C to 760°C
K Thermocouple:	-100°C to 1350°C
T Thermocouple:	-200°C to 400°C
E Thermocouple:	-200°C to 1000°C
S or R Thermocouple:	0°C to 1760°C
N Thermocouple:	0°C to 1300°C
B Thermocouple:	0°C to 1800°C

Voltage Input Range:	±100 mVDC
Maximum Input Voltage:	-20V to +15V DC
Input Bias Current:	6 nA typ
Input Offset Voltage:	± 0.07 mV typ, ± 0.25 mV max (Adjustable to zero)
Input Offset Drift:	± 0.4 lV / °C typ, ± 2.0 lV / °C max
Gain Range:	100 fixed
Gain Error:	X100
Input Impedance:	12 GW
Gain Nonlinearity :	X100
Gain Error Drift:	X100
Common Mode Rejection:	X100
Cutoff Frequency (-3dB):	5 Hz (4 Poles Butterworth, -3dB@5Hz, -80dB@50Hz)

Dimension:	160mm X 100 mm for QTC-200;
	100mm X 100mm for QTC-200T
Weight:	QTC-200 0.29Kg;
	QTC-200T (with enclosure): 0.36Kg
Power Consumption:	+5V / 20mA typ; +15V / 40mA typ; -15V / 40mA typ
Temperature Range:	0 ~ +70°C

5 QTC-250 RTD Signal Conditioning Module

QTC-250 Features

- Eight channel Resistor Temperature Detector (RTD)
- On board low-pass filter for each channel (-80dB @ 50Hz)
- Per channel jumper selectable excitation current source of 1mA, 0.5mA or 0.25mA
- Supports 2, 3 and 4 wire RTD configurations
- Up to 256 channels can be configured in a system
- Terminal block for quick, easy signal connections

The QTC-250 is an eight channel Resistance Temperature Detector (RTD) input signal conditioning module. Each channel is equipped with separate instrument amplifiers, three excitation current source options and a fourth order low pass filter. Up to thirty-two QTC-250 modules can be configured in an Omega signal conditioning and data acquisition system for a total of 256 analog input channels. The QTC-250 can also be coupled with other modules in Omega's SignalPro™ series to provide a versatile data acquisition system.

The QTC-250 module consists of two circuit boards: the QTC-250 interface board and the QTC-250T terminal board. The interface board is a standard 3U size board which can be mounted in the QTE-7, QTE-14 or QTC-250-PCS data acquisition enclosures. The QTC-250T terminal board contains the RTD input screw blocks, channel gain select switches and channel excitation current sources. This two board configuration allows quick and easy connection of the RTD lead wires. After the initial configuration of the interface board, it can be mounted in a data acquisition enclosure and will rarely require removal. All connections are completed on the screw terminals of the portable QTC-250T, which is then plugged into the QTC-250 interface board and secured using two thumb screws. (See Figure 5-1).

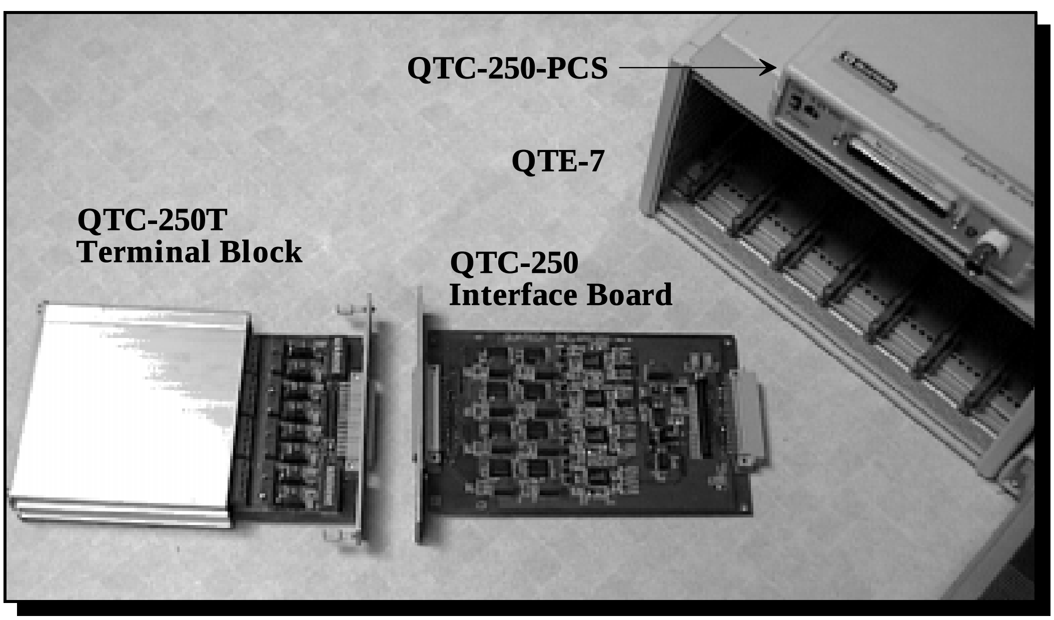

Figure 5-1. RTD Signal Conditioning Module

5.1 Circuit Board Description

5.1.1 QTC-250 Interface Board Description

The QTC-250 interface board shown in Figure 5-1 can be mounted in SignalPro series data acquisition racks and enclosures. (See Chapter 2 for information on SignalPro series racks). Each rack enclosure is equipped with a DIN-48 female connector which mates to the QTC-250 and other SignalPro series signal conditioners. The rack also contains a standard D37 connector which attaches to the host computer data acquisition adapter.

Eight RTD input channels are provided by multiplexing a single main A/D channel off the host computer data acquisition adapter. The multiplexer on the QTC-250 scans the eight RTD input channels sequentially and connects each input to the single main A/D channel. The eight multiplexed input channels may be mapped back to any main A/D channel on the data acquisition adapter depending on the configuration of jumper J10. Two interface boards may share one single ended A/D input from the host computer to provide a maximum of 16 multiplexed channels per main A/D channel. Multiplexing of all 16 main A/D channels from the host computer results in a maximum of 256 A/D input channels, (16 x 16), per data acquisition adapter.

5.1.2 QTC-250T Terminal Board Description

The QTC-250T terminal board shown in Figure 5-2 contains the input terminal blocks, excitation current sources and input gain amplifiers for each of the eight RTD inputs. The terminal board DIN-48 female connector plugs into the QTC-250 interface board and is equipped with a strain relief bracket to secure external RTD wiring.

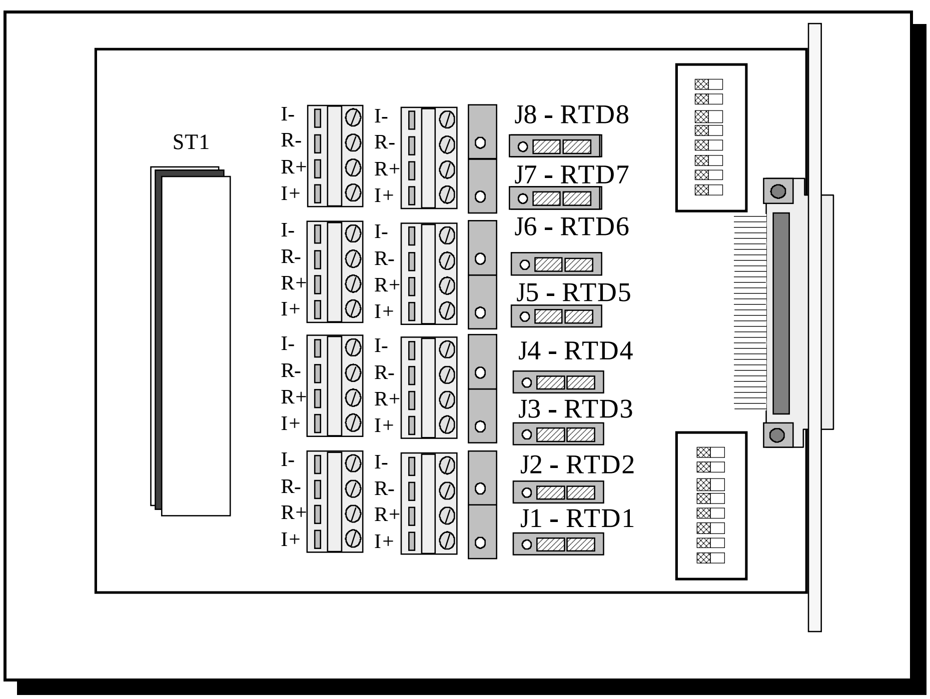

Figure 5-2. QTC-250T Terminal Board

5.2 Hardware Configuration

For system configuration options see Chapter 1: SignalPro Series Overview, section 1.3: Hardware Configuration.

5.2.1 QTC-250 Interface Board Configuration

Figure 5-3 depicts the location of the main A/D channel and board selection jumpers (J9/J10). System configuration options for J9 and J10 are discussed extensively in Chapter 1, section 1.3.

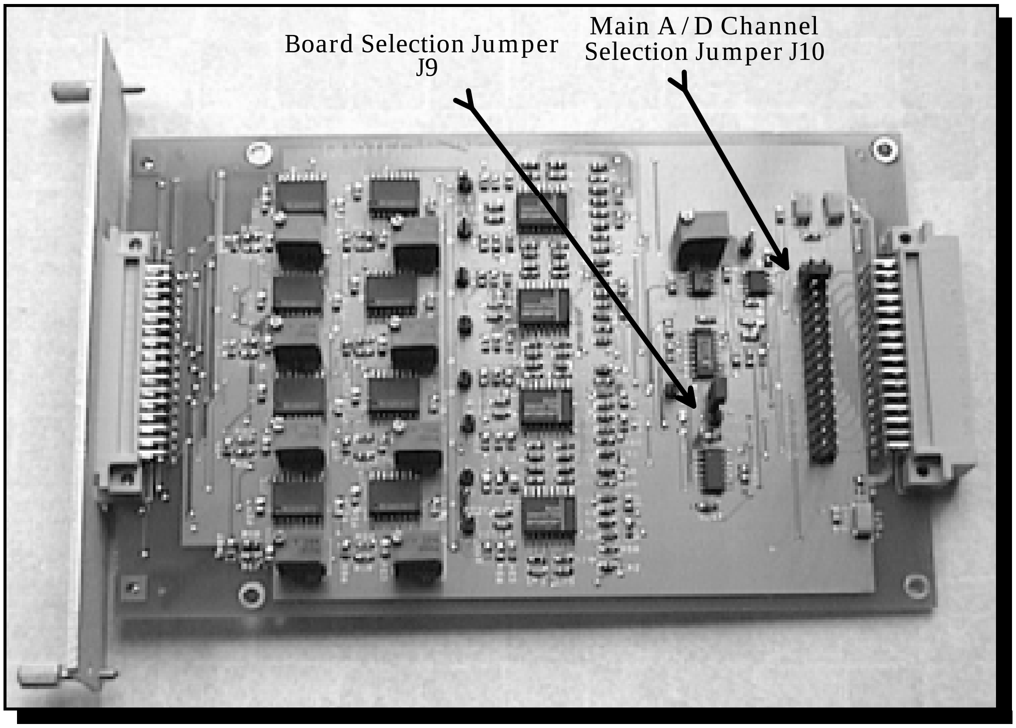

Figure 5-3. QTC-250 Interface Board Jumper Locations

5.2.2 QTC-250T Terminal Board Configuration

The QTC-250T terminal board contains the excitation current selection jumpers and the input gain selection switches for each of the eight RTD inputs. The user must configure two settings: Input gain (GAIN) and excitation current source (I). The gain and current source settings are determined according to the following two considerations:

I * RRTDMAX * GAIN should be as close as possible to, but not exceed, the full scale value of 10 Volts, where RRTDMAX is the maximum RTD resistance in the specific measuring range. The excitation current "I" should be the smallest possible value, (0.25mA, 0.5mA or 1.0mA), that will satisfy the first consideration.

Note that resistive heating must be considered when determining the excitation current source amplitude. The RTD dissipates power at the rate of Power = I^2 x R, where I is the excitation current and R is the RTD resistance. The heat generated by the excitation current through the RTD is a source of error in temperature measurements. Since lower current options will generate less heat, a combination of low current with a high A/D input gain is desirable.

Table 5-1 lists the suggested gain and excitation current values for all supported RTD types.

RTD Types W @0°C(a) **1**	Temperature Range (°C)	Resistance Range (W)	Excitation Current mA	Gain Setting **2**	Full Scale Output (Volts) **3**
Platinum					
25.5 (0.00392)	-200 to 630	4.334 / 83.575	1.0 mA	100	8.36
100 (0.00385)	-200 to 800	18.52 / 375.704	0.25 mA	100	9.39
200 (0.00385)	-200 to 600	37.04 / 627.416	1.0 mA	10	6.27
470 (0.00392)	-200 to 600	79.881 / 1494.393	0.5 mA	10	7.47
500 (0.00385)	-200 to 600	92.6 / 1568.54	0.5 mA	10	7.84
1,000 (0.00385)	-200 to 600	185.201 / 3137.08	0.25 mA	10	7.84
Copper					
9.035 (0.00427)	-100 to 260	5.128 / 19.116	1.0 mA	100	1.91
Nickel					
100 (0.00618)	-60 to 180	69.528 / 223.221	0.25 mA	100	5.58
120 (0.00672)	-80 to 260	66.6 / 380.31	0.25 mA	100	9.51
Nickel-Iron					
604 (0.00518)	-100 to 200	372.789 / 1301.86	0.5 mA	10	6.51
908.4 (0.00527)	-100 to 200	566.576 / 1961.381	0.5 mA	10	9.81
1,816.81(0.00527)	-100 to 200	1133.158 / 3922.784	0.25 mA	10	9.81

Table 5-1. Suggested Gain and Excitation Current Values for Supported RTD Types

Notes:

1. (a) is the temperature coefficient in W / W / º C .

2. The gain setting listed in Table 5-1 is the hardware setting for each supported RTD sensor. If using DaqEZ, the QTC-250 module gain should be set to 1. The hardware configuration, (gain and current settings), for each RTD channel will be determined by the DaqEZ signal conditioner database.

3. The full scale output is from the QTC-250 to the data acquisition card.

5.2.2.1 A/D Gain Selection Switches

The A/D input gain for each of the RTD inputs is individually selectable using SW1 and SW2 as shown in Figure 5-4. Each of the input amplifiers can be configured for gains of x1, x10 or x100. Configuring the gain setting on the QTC-250T terminal board input amplifiers will result in less signal noise than using the A/D configuration options available on the data acquisition adapter in the host computer.

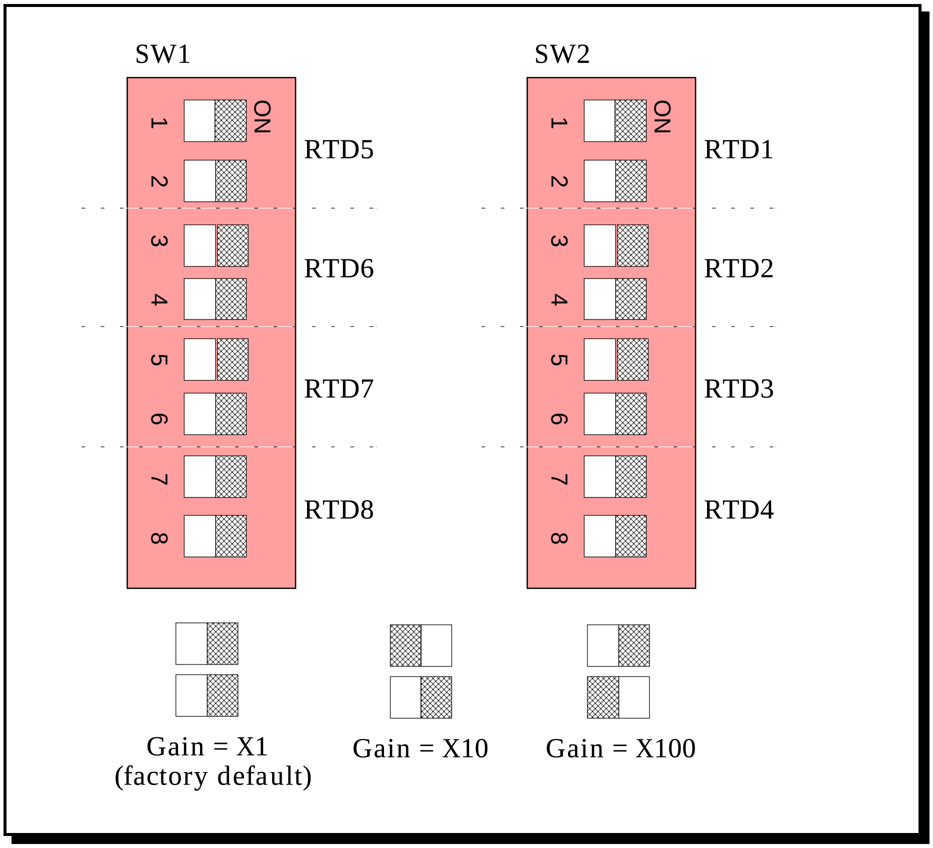

Figure 5-4. A/D Gain Selection Switches

5.2.2.2 Excitation Current Selection Jumpers

The QTC-250T provides a stable, constant current source for each of the eight RTD input channels. The excitation current value of 1.0mA, 0.5mA or 0.25mA for each channel can be selected using jumper blocks J1 through J8 as shown in Figure 5-5.

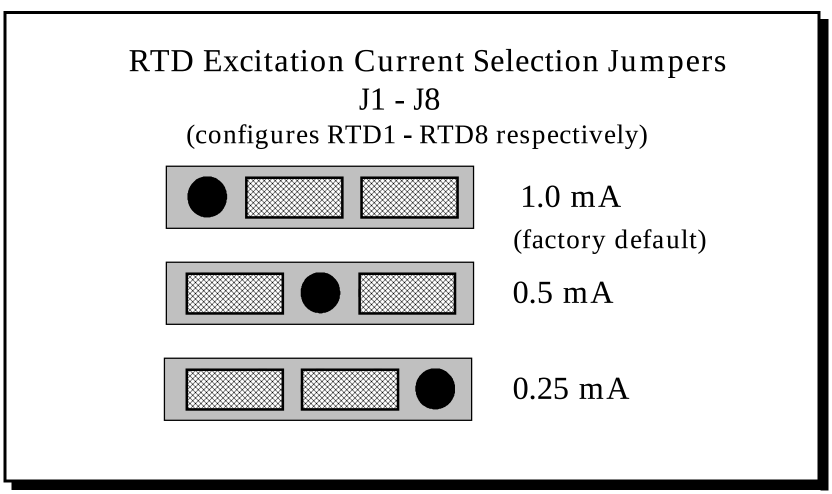

Figure 5-5. Excitation Current Selection Jumpers

5.3 RTD Measurements

5.4 Basic Principles

The basic principle behind RTD measurements is that resistance of an RTD increases with temperature. By supplying the RTD with a constant current source and measuring the voltage drop across the RTD, the change in resistance can be monitored. The relationship between the change in temperature and the change in RTD resistance can be defined as follows:

$$\Delta T \rightarrow \Delta R_{RTD} = \Delta V_{RTD} \div I$$

where:

ΔT	=	the change in temperature
ΔR_{RTD}	=	the change in RTD resistance
ΔV_{RTD}	=	the voltage drop across the RTD
I	=	the RTD excitation current source value

Note: RTD resistance is measured in units of voltage or current where the current amplitude from the QTC-250 is constant.

5.4.1 Two-Wire RTD Measurements

The configuration of a two-wire measurement circuit is shown in Figure 5-6. The RTD resistance in this circuit is read at the current source. If the lines connected to the RTD are short, this method may be acceptable. However, this method is generally inaccurate since the resistance and thermal heating characteristics of long lead wires (R_{line}) connected to the RTD introduce some measurement error.

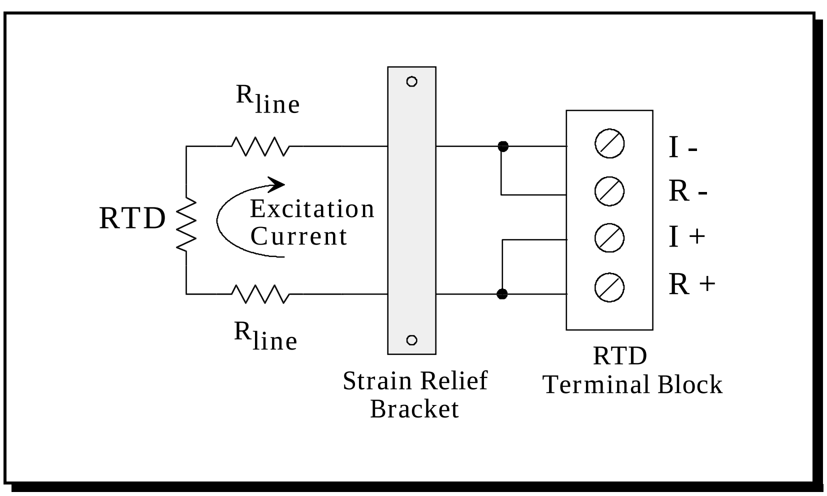

Figure 5-6. Two-Wire RTD Measurement

5.4.2 Three-Wire RTD Measurements

The configuration of a three-wire measurement circuit is shown in Figure 5-7. The advantage of this circuit over the two-wire method is the elimination of one current carrying lead wire. However, the resistance and thermal heating characteristics of the remaining lead wire (R_{line}) to the RTD may still introduce some measurement error.

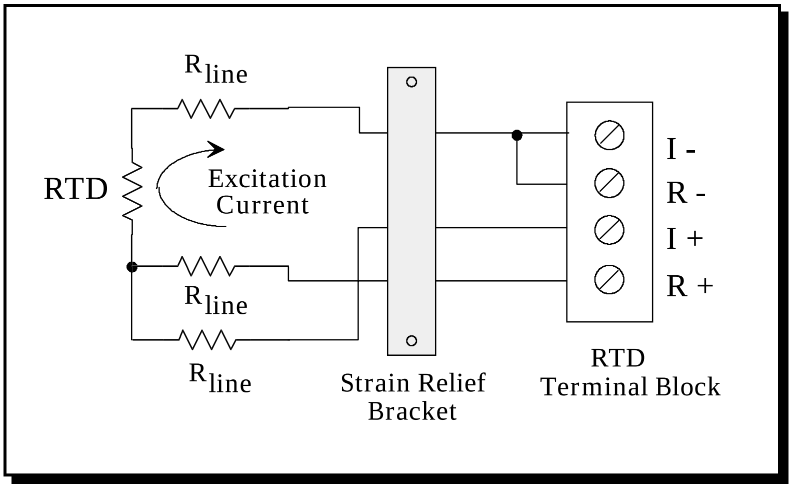

Figure 5-7. Three-Wire RTD Measurement

5.4.3 Four-Wire RTD Measurements

The configuration of a four-wire measurement circuit is shown in Figure 5-8. The advantage of this circuit over the previous two and three-wire methods is that greater accuracy is obtained. By measuring the change in the RTD voltage drop directly at the RTD resistor, the error introduced from the lead wires (R_{line}) to the RTD is removed. The measurement error introduced due to resistance of the A/D lead wires (R_{lead}) is insignificant. The input impedance of the A/D is very high and thus minimizes current flow through the lead wires.

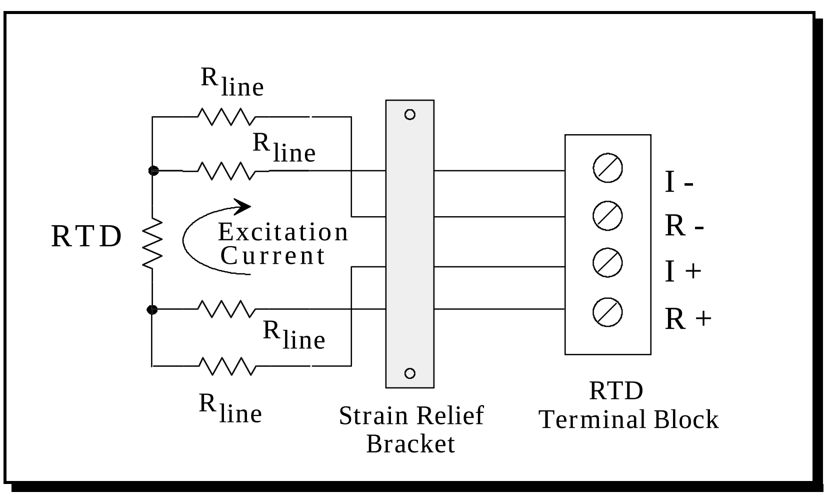

Figure 5-8. Four-Wire RTD Measurement

5.5 QTC-250/QTC-250T Specifications

Connector: DIN-48 male, mates with QTE-7, QTE-14, and QTC-250-PCS

Signal Connection: DIN-48 female, mates screw terminal block for easy connection

Number of Channels: 8

RTD type: Platinum 25.5W, 100W, 200W, 470W, 500W, 1000W

Copper 10W

Nickel 100W, 120W

Nickel-Iron 604W, 908.4W, 1816.81W

Accuracy and Resolution:

Type	Range	Accuracy	Resolution(12-bit / 16-bit)
100 W Platinum	-100°C to +600°C	0.4 °C	0.3 °C / 0.1 °C
120 W Nickel	0°C to 260°C	0.15 °C 0.	3 °C / 0.1 °C

Excitation Current: 1.0 mA, 0.5mA, 0.25 mA

Output Impedance: 1990K Compliance: 10V

RTD Configuration: 2-wire, 3-wire, 4-wire

Input Type: Differential

Voltage Input Range: ±10 V

Input Bias Current: ±0.5 pA typ; ±2 pA max

Input Offset Voltage: ± (0.01+0.02 / G) mV typ, ± (0.05+0.1 / G) mV max

(Adjustable to zero)

Input Offset Drift: ± (0.1+0.5 / G) lV / °C typ, ± (0.25+100 / G) lV / °C max

Gain Range: 1, 10, 100

Gain Error: X1 0.005% typ, 0.024% max

X10, X100 0.01% typ, 0.024% max

Input Impedance: 10 GW

Gain Non linearity : X1,X10, X100 ± 0.0004% of FS typ, ± 0.001% of FS max

Gain Temp. Coefficient: X1, X10, X100 ± 2.5 ppm / °C typ, ± 10 ppm / °C max,

Common Mode Rejection:	X1	80 dB min	99 dB typ
	X10	96 dB min	114 dB typ
	X100	110 dB min	123 dB typ
Cutoff Frequency:	5 Hz (4 Poles Butterworth, -3dB@5Hz, -80dB@50Hz)		
Power Requirement:	+ 5V ±5%	70mA typ	
	+15V ±5%	50~70mA typ	
	-15V ±5%	50mA typ	
Dimension:	160mm X 100mm for QTC-250; 100mm X 100mm for QTC-250T		
Weight:	0.13Kg for QTC-250; 0.35Kg for QTC-250T.		

6 QTC-300 Strain Gage Input Signal Conditioning Module

QTC-300 Features

- Four Strain Gage input channels (Up to 256 channels can be configured in system)
- Custom configurable excitation current source which readily converts to vendor specified Strain Gage Excitation Voltage
- Supports full, half and quarter bridge gage configurations
- On board low-pass filter for each channel (10Hz, 100Hz or 1KHz cut off frequency)
- Easy zero and shunt calibration
- Terminal block for quick, easy signal connections

The QTC-300 is a four channel strain gage input signal conditioning module. Each channel is equipped with separate instrument amplifiers, multiple excitation current source options and a fourth order low pass filter. Up to 64 QTC-300 modules can be configured in an Omega signal conditioning and data acquisition system for a total of 256 analog input channels. Each channel has selectable gain of 1, 10, 100, 200 or 500. The QTC-300 can also be coupled with other modules in Omega's SignalPro series to provide a versatile data acquisition system.

The QTC-300 module consists of two circuit boards: the QTC-300 interface board and the QTC-300T terminal board. The interface board is a standard 3U size board which can be mounted in the QTE-7, QTE-14 or QTC-300-PCS data acquisition enclosures. The QTC-300T terminal board contains the strain gage input screw blocks, bridge completion circuits and the calibration switch. This two board configuration allows quick and easy connection of the strain gage lead wires. After the initial configuration of the interface board, it can be mounted in a data acquisition enclosure and will rarely require removal. All connections are completed on the screw terminals of the portable QTC-300T, which is then plugged into the QTC-300 interface board and secured using two thumb screws. (See Figure 6-1).

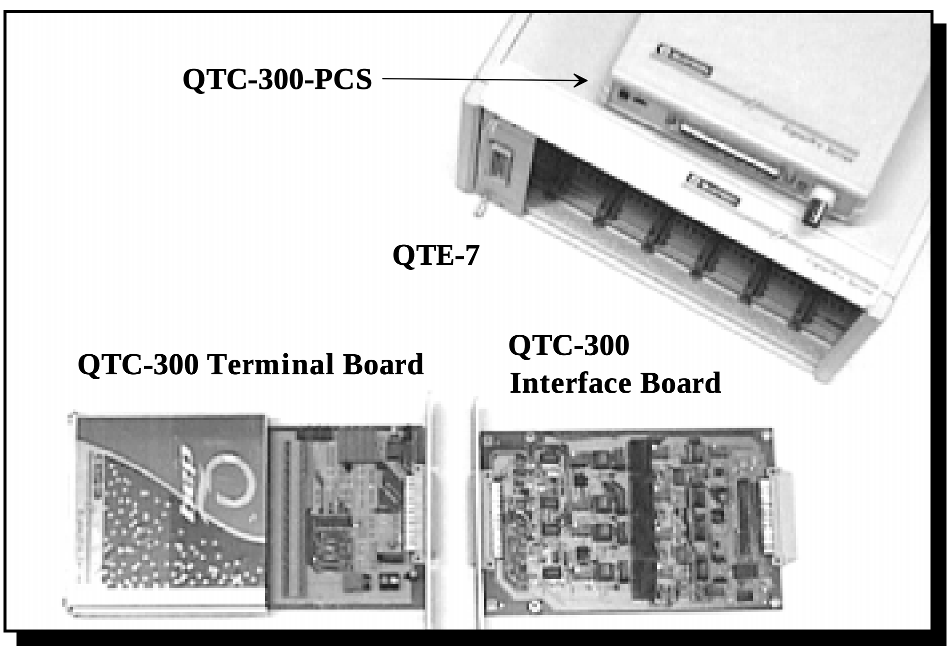

Figure 6-1. QTC-300 Strain Gage Input Module

6.1 Circuit Board Description

6.1.1 QTC-300 Interface Board Description

The QTC-300 interface board shown in Figure 6-1 can be mounted in SignalPro series data acquisition racks and enclosures. (See Chapter 2 for information on SignalPro series racks). Each rack enclosure is equipped with a DIN-48 female connector which mates to the QTC-300 and other SignalPro series signal conditioners. The rack also contains a standard D37 connector which attaches to the host computer data acquisition adapter.

Four strain gage input channels are provided by multiplexing a single main A/D channel off the host computer data acquisition adapter. The multiplexer on the QTC-300 scans the four strain gage input channels sequentially and connects each input to the single main A/D channel. The four multiplexed input channels may be mapped back to any main A/D channel on the data acquisition adapter depending on the configuration of jumper J5. Four interface boards may share one single ended A/D input from the host computer to provide a maximum of 16 multiplexed channels per main A/D channel. Multiplexing of all 16 main A/D channels from the host computer results in a maximum of 256 A/D input channels, (16 x 16), per data acquisition adapter.

6.1.2 QTC-300T Terminal Board Description

The QTC-300T terminal board shown in Figure 6-1 contains the strain gage input terminal blocks, bridge connection LEDs, calibration switch, offset null potentiometers, excitation current selection resistor sockets, external excitation power supply connector and the bridge completion circuits. The terminal board DIN-48 female connector plugs into the QTC-300 interface board and is equipped with a strain relief bracket to secure external strain gage wiring.

6.2 Hardware Configuration

For system configuration options see Chapter 1: SignalPro Series Overview, section 1.3: Hardware Configuration.

6.2.1 QTC-300 Interface Board Configuration

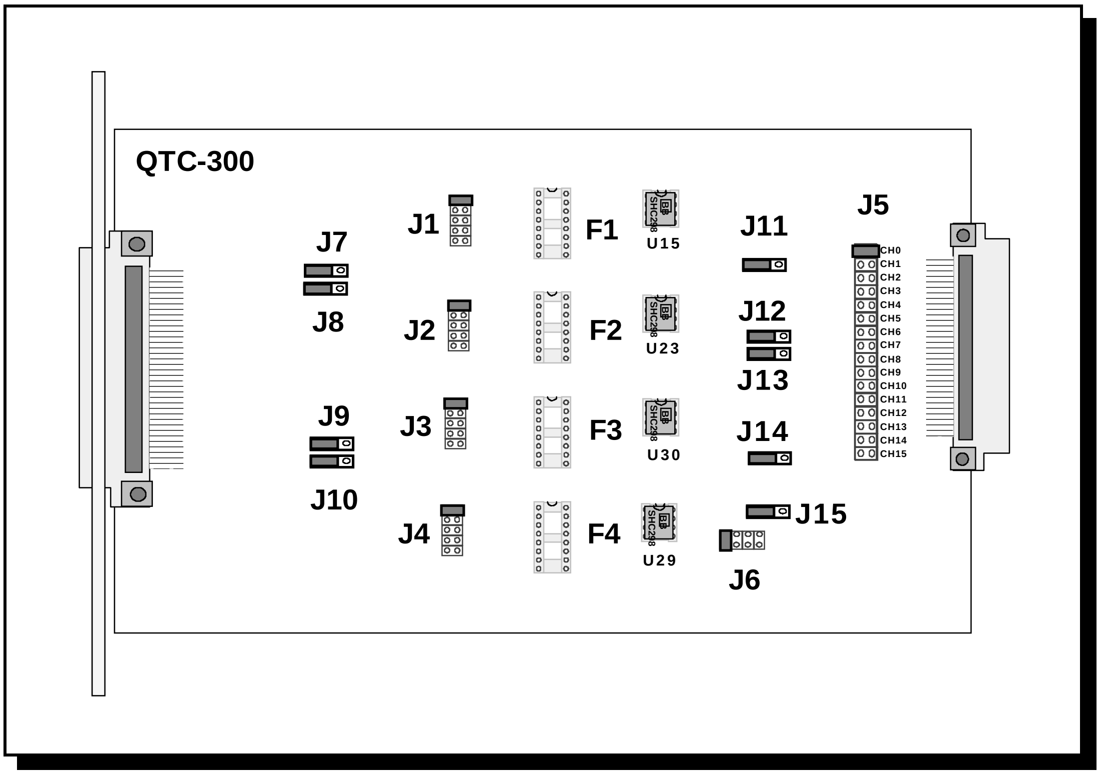

Figure 6-2. QTC-300 Jumper and Filter Block Locations

Figure 6-2 depicts the location of the main A/D channel and board selection jumper blocks (J5/J6), SSH option jumper block (J11), A/D gain selection jumper blocks (J1 through J4), filter selection jumper blocks (J12 through J15), filter blocks (F1 through F4) and the AC/DC coupling selection jumpers (J7 through J10). System configuration options for J5 and J6 are discussed extensively in Chapter 1, section 1.3.

6.2.1.1 Simultaneous and Sample Hold Jumper (QTC-300S only)

The simultaneous sample and hold feature on the QTC-300S eliminates time skew across the four analog input channels. At the beginning of an A/D channel scan, the SSH device simultaneously samples all four of the QTC-300S input channels and holds the input signals. The A/D multiplexer then scans each of the channels in sequence and performs the A/D conversions one at a time. The default setting for the QTC-300S is SSH disabled. The customer must enable SSH by changing the jumper position. The QTC-300 does not support SSH and is also shipped with the jumper set for SSH disabled. (See Figure 6-3).

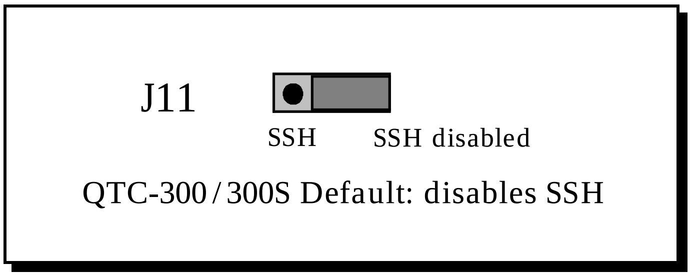

Figure 6-3. QTC-300/QTC-300S SSH Selection Jumper

6.2.1.2 A/D Gain Selection Jumpers

The A/D input gain for each strain gage channel of the QTC-300 is individually selectable using jumper blocks J1 through J4 for input channels 0 through 3 respectively. Each of the input amplifiers is configurable for gains of 1, 10, 100, 200 or 500. Using the A/D gain selection option provided on the QTC-300 interface board will result in less signal noise than using the A/D gain selection options available on the data acquisition adapter in the host computer. Figure 6-4 depicts the configuration options and factory default setting for jumper blocks J1 through J4.

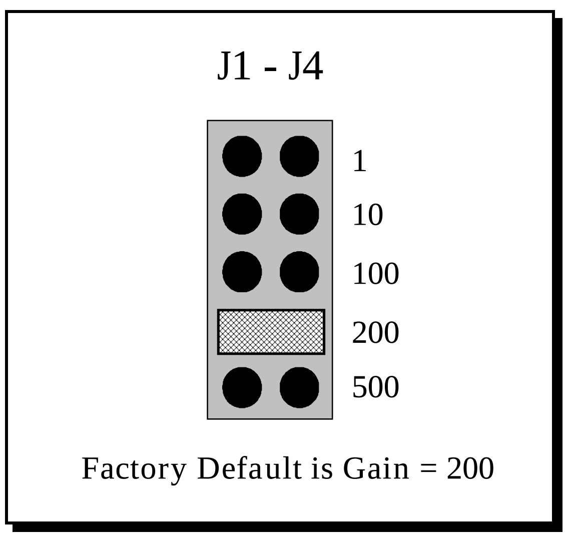

Figure 6-4. A/D Gain Selection Jumpers

6.2.1.3 Filter Selection Jumpers

Jumper blocks J12 through J15 determine whether the low-pass filter options for channels 0 through 3 are used. The factory default is "AP" (All Pass) for all four channels with the corresponding filter blocks (F1 through F4) empty. When the low-pass filter option is desired, that channel's filter module should be installed into the corresponding filter block and the low pass filter selection jumper should be moved to "LP" (Low Pass). Note that if a filter module is installed and the selection jumper is set to "AP", the filter will still have a partial effect on that channel. Figure 6-5 shows the factory default setting and lists the selection jumper and filter block that correspond to each channel.

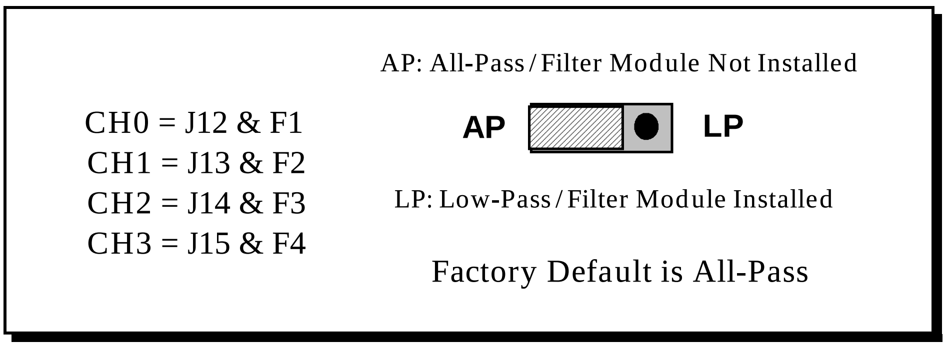

Figure 6-5. Filter Selection Jumper

6.2.1.4 Filter Block Description

The active filters of QTC-300 / QTC-300S employ a unity-gain Sallen-Key complex pole-pair to implement Butterworth filters. The module provides four 16-pin filter block sockets (F1 through F4) to facilitate easy configuration of different filter types. Each socket has eight positions to hold resistors or capacitors. The positions are designated as shown in Figure 6-6.

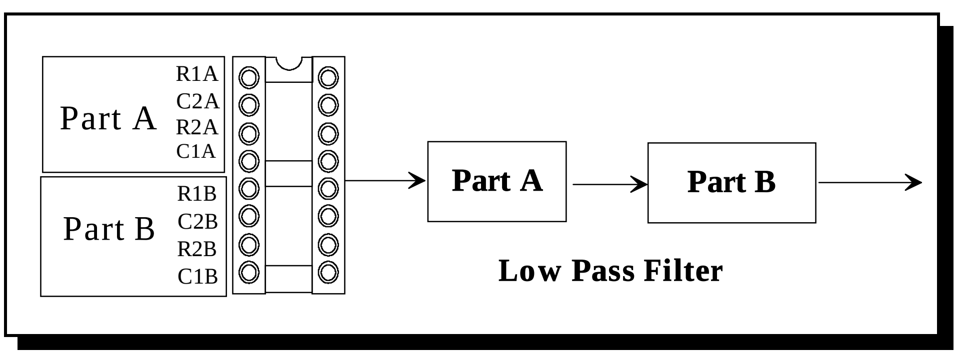

Figure 6-6. Low-Pass Filter Block

Filter cut off frequency is determined by a RC circuit that is configured on the filter block socket. Omega offers pre-configured 4th order Butterworth low-pass filter blocks for ease in pre-selecting cut off frequencies. Omega also offers a pre-configured filter block that is custom built to customer specifications. (See Table 6-1).

Product Number	**Cut off Frequency**
FTR-10	10 Hz
FTR-100	100 Hz
FTR-1k	1 kHz
FTR-C	Customer Specified

Table 6-1. Omega Pre-configured RC Filter Blocks

Table 6-2 shows Butterworth low-pass filter design examples for four different cutoff frequencies. The filter block positions in Table 6-2 correspond to the locations previously depicted in Figure 6-6. To configure different cutoff frequencies and filter types, the user is advised to follow the instructions in the Burr-Brown® FilterPro™ software package supplied on the customer CD-ROM.

Filter Block Position	**5Hz**	**10Hz**	**100Hz**	**500 Hz**	**1kHz**
R1A	20.50K	10.20K	1.02K	205	102
C2A	1.0uF	1.0uF	1.0uF	1.0uF	1.0uF
R2A	105.0K	52.3K	5.23K	1.05K	523
C1A	0.47uF	0.47uF	0.47uF	0.47uF	0.47uF
R1B	53.6K	26.7K	2.67K	536	267
C2B	1.0uF	1.0uF	1.0uF	1.0uF	1.0uF
R2B	191.0K	95.3K	9.53K	1.91K	953
C1B	0.1uF	0.1uF	0.1uF	0.1uF	0.1uF

Notes: 0.1uF=100n; 0.01u=10n; 1000P=1n

Table 6-2. Butterworth Low-Pass Filter Design Examples

6.2.1.5 AC / DC Coupling Jumper

Jumpers J7 through J10 select the option of AC or DC coupling for channels 0 through 3 respectively. DC coupling should be used when measuring static signals. Note that sensor offset is usually not zero in DC coupling mode. AC coupling provides auto zero balanced voltage reading and drift-free dynamic operation. The default setting is DC coupling as shown in Figure 6-7.

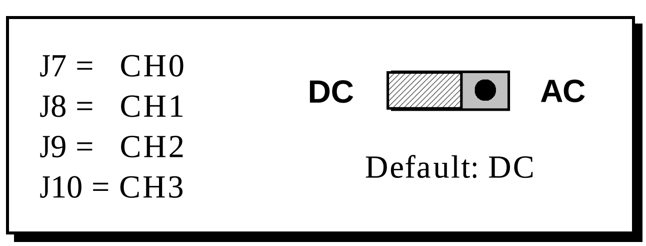

Figure 6-7. AC / DC Coupling Jumper

6.2.2 QTC-300T Terminal Board Configuration

The QTC-300T terminal board shown in Figure 6-8 contains the strain gage input terminal blocks, bridge connection LEDs, calibration switch, offset null potentiometers, excitation current selection resistor sockets, external excitation power supply connector and the bridge completion circuits. The terminal board DIN-48 female connector plugs into the QTC-300 interface board and is equipped with a strain relief bracket to secure external strain gage wiring.

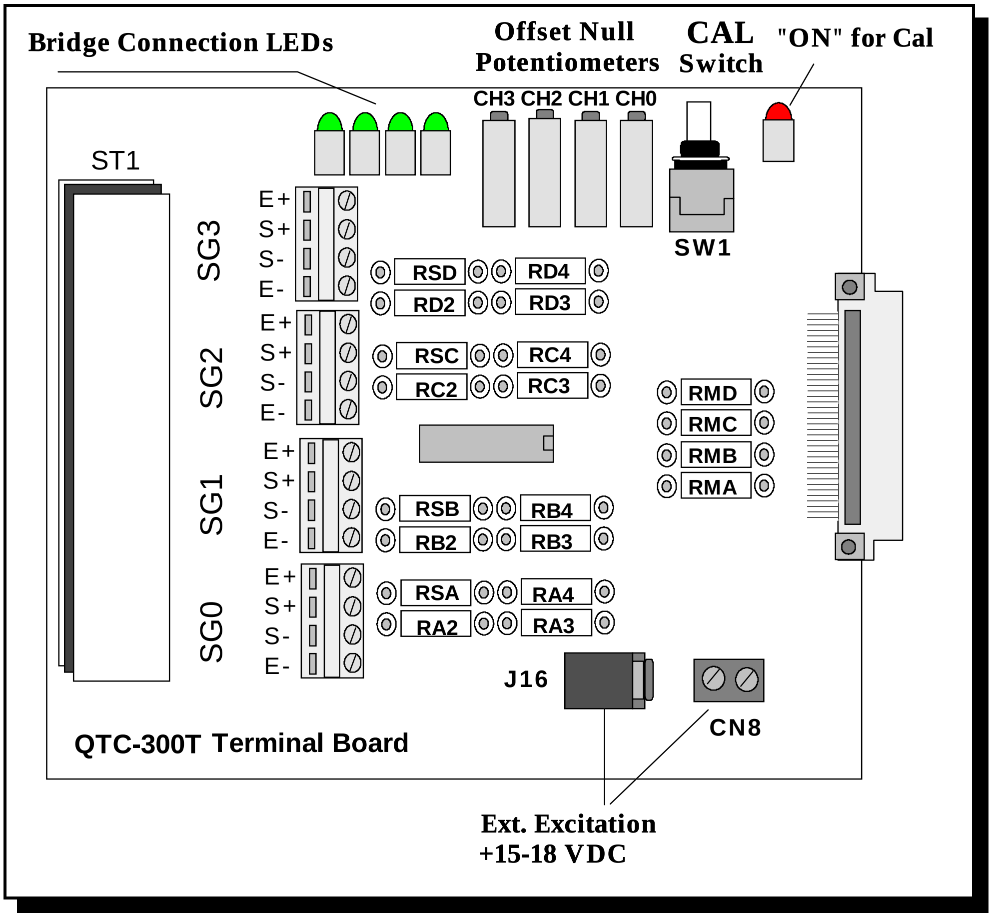

Figure 6-8. QTC-300T Terminal Board

6.2.2.1 Input Terminal Blocks and Bridge Connection LEDs

The input terminal screw blocks provide for quick and easy connection of the strain gage lead wires. Blocks are designated SG0 through SG3 for channels 0 through 3 respectively. Note that E+/E- beside the blocks refers to Excitation positive and negative inputs and S+/S- refers to Signal positive and negative inputs. Each bridge connection LED illuminates when there is a strain gage signal connection to it's respective channel.

6.2.2.2 Calibration Switch

The QTC-300T utilizes a push button switch (SW1) to select either calibration mode or normal mode as shown in Figure 6-8. A red LED is used to indicate calibration mode status. The LED turns OFF in normal mode.

6.2.2.3 Offset Null Potentiometers

The QTC-300T terminal board has an offset null potentiometer for each channel. (See Figure 6-8 for potentiometer locations). With offset null circuitry for each individual channel, the offset voltage of the strain gage transducer can be easily adjusted for null.

6.2.2.4 Excitation Current Selection Resistor Sockets

The QTC-300T provides a stable, constant current source* for each of the four strain gage input channels. The excitation current value of 2.0 ~ 20.0mA for each channel can be configured by using selected resistor values in the resistor sockets RMA, RMB, RMC or RMD. Use the equation shown in Figure 6-9 to determine the appropriate resistor value for the desired excitation current.

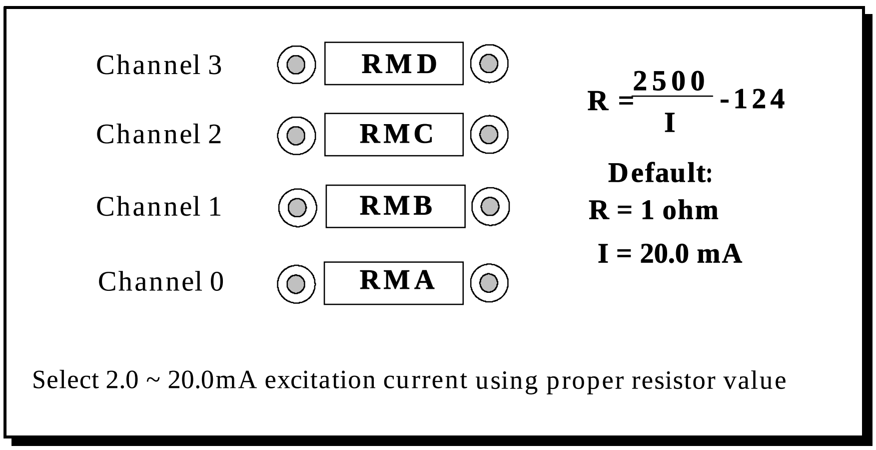

Figure 6-9. Excitation Current Selection

*Note: Excitation Voltage = (Excitation Current) x (Vendor Specified Input Impedance)

6.2.2.5 External Excitation Power Supply Connections

Two connectors are provided for an external excitation power supply connection as shown in Figure 6-10. Both connectors accept a power input of +15 ~ 18VDC @ 200mA. No polarity is required for power connection.

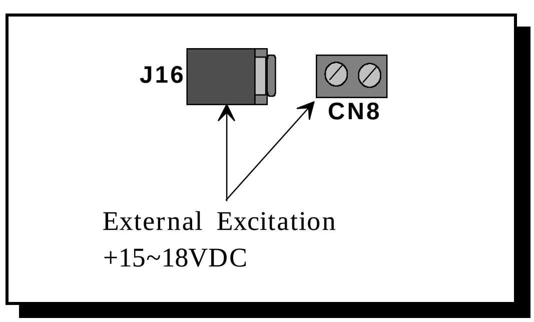

Figure 6-10. External Excitation Power Supply Connections

6.3 Calibration Modes

In order for the QTC-300 module to accurately measure strain, it must first be calibrated using the DAQCAL utility. Calibration must be completed each time a new sensor is attached to the QTC-300 module or each time an existing sensor is remounted. Once a sensor is attached and mounted in a fixed location, it is recommended that calibration of the system be completed every 30 days to ensure the utmost accuracy of the measurements obtained. (Note that the DAQCAL utility does not currently support mode (3), shunt calibration, but the hardware is capable of performing this function).

Two external gain lines (G1 and G0) are used to select one of the four modes depicted in Figure 6-11. The values of G1 and G0 are software selectable.

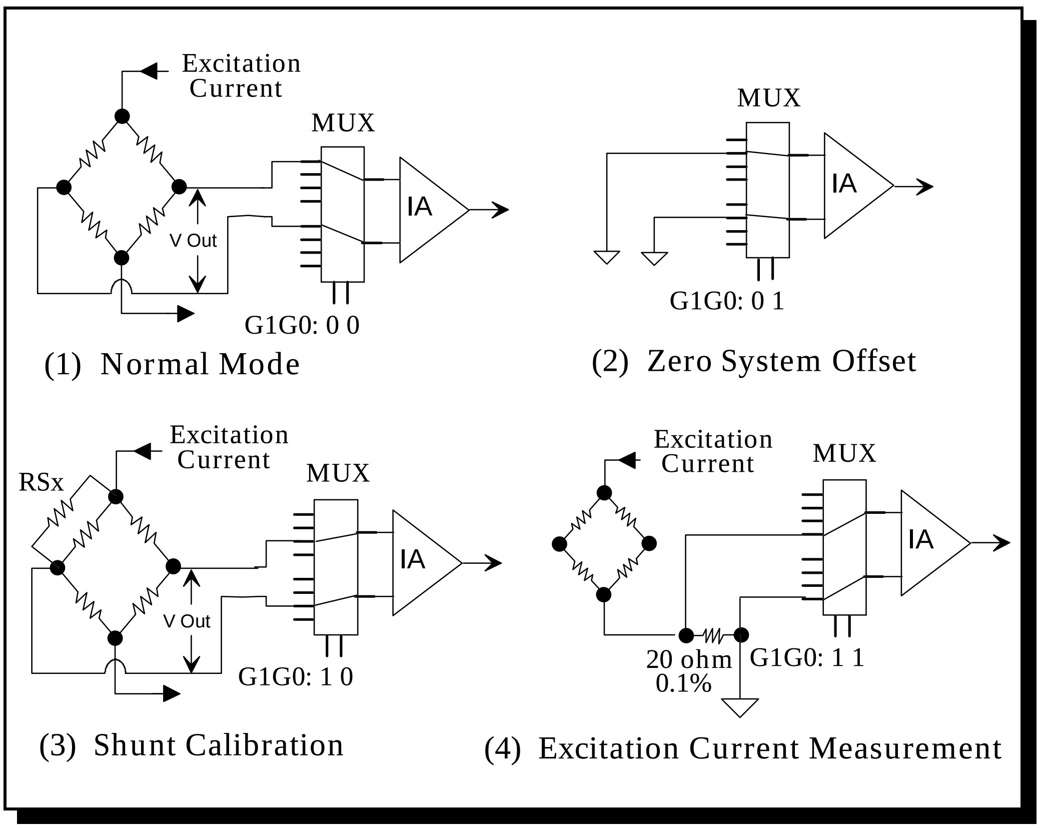

Figure 6-11. Calibration Modes

6.3.1 Normal Mode

With the calibration switch SW1 set for normal mode, the strain gage signal is connected to the instrument amplifier (IA) through the multiplexer (MUX) as shown in Figure 6-11 (1). The input channel multiplexer stays in normal mode for all combinations of the external gain lines G1 and G0. (The red LED should not be illuminated in this mode).

6.3.2 Calibration Mode

With the calibration switch SW1 set for calibration mode there are three modes of strain gage calibration:

1. Zero System Offset

As shown in Figure 6-11 (2), both of the IA inputs are grounded and the IA output should be very close to zero. If the output is not zero, then the value represents the offset of the data acquisition system. The total system offset can be adjusted to a zero base line through the corresponding channel offset null potentiometer. (See Figure 6-8 for offset potentiometer locations).

2. Shunt Calibration (currently not supported by the DAQCAL utility)

An additional resistor (RSX) is shunted in parallel with one arm of the Wheatstone Bridge as shown in Figure 6-11(3). The variable “X” corresponds to A, B, C or D for channels 0, 1, 2 or 3 respectively. Thus the additional resistor is installed into resistor sockets RSA, RSB, RSC or RSD depending on which channel the user is configuring. (See Figure 6-8 for the location of resistor sockets RSA through RSD).

3. Excitation Current Measurement

The circuit diagram for this mode is shown in Figure 6-11 (4). The excitation current can be measured through the voltage drop across the 20 ohm .1 % precision resistor.

The four calibration modes are summarized as shown in Table 6-3.

G1:G0	Calibration mode	Input of IA	Figure
0 0	Normal	Signal from strain gage	Figure 7-9 (1)
0 1	Zero Offset Calibration	Both inputs shorted to ground	Figure 7-9 (2)
1 0	Shunt Calibration	Bridge with one arm shunt to RSX	Figure 7-9 (3)
1 1	Current Measurement	Across 20 ohm 0.1% precision resistor	Figure 7-9 (4)

Table 6-3. QTC-300 Calibration Modes

6.4 Strain Gage Measurements

6.4.1 Basic Principles

Strain can be defined as the physical deformation, deflection or change in length of a solid material that results from stress. Strain may be either tensile (positive) causing elongation of a solid material or compressive (negative) causing contraction of a solid material. The strain in a material cannot be measured directly. It must be computed from other measurable parameters, one of which is electrical resistance which varies in proportion to strain. A frequently used circuit for measuring an electrical resistance change is the Wheatstone Bridge shown in Figure 6-12. The QTC-300 supports full, half and quarter bridge configurations.

6.4.2 Full Bridge Strain Gage Measurements

The full bridge configuration employs four strain gages wired into a bridge. Two of the gages are subject to tensile strain and the other two are subject to compressive strain. An excitation current is applied by the QTC-300 and as the material being measured changes shape, the tensile gages increase resistance and the compressive gages decrease resistance. The total strain is the accumulation of all four strains and is represented by a change in voltage: “Vout”. (See Figure 6-12).

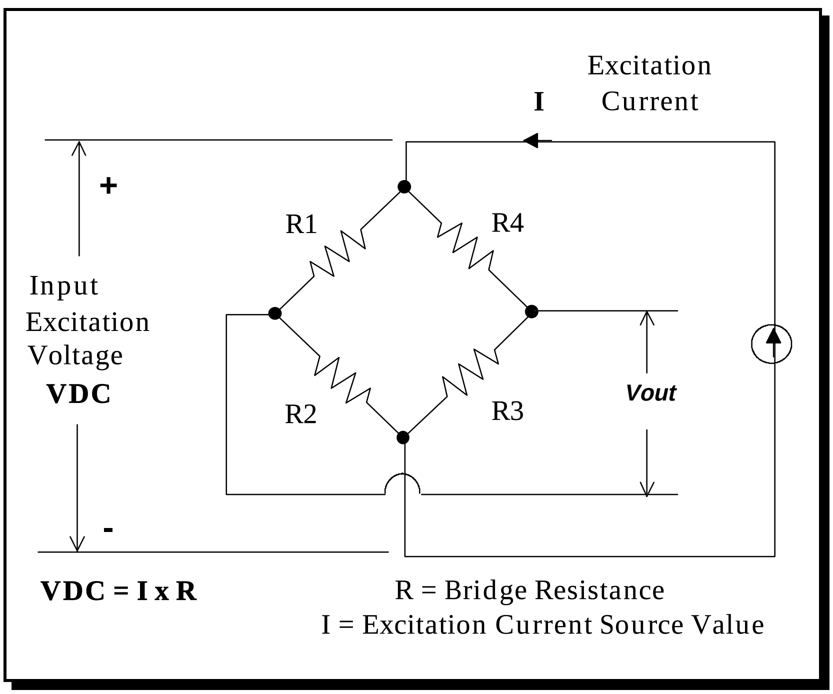

Figure 6-12. Full Wheatstone Bridge Strain Gage Measurement

Because it employs active strain gages at all four measurement points, a full bridge configuration is the best choice for strain measurements. It provides the highest sensitivity and the greatest output, making noise less of a factor in measurements.

A full bridge strain gage wiring configuration is shown in Figure 6-13. This configuration uses channel zero (SG0) as an example.

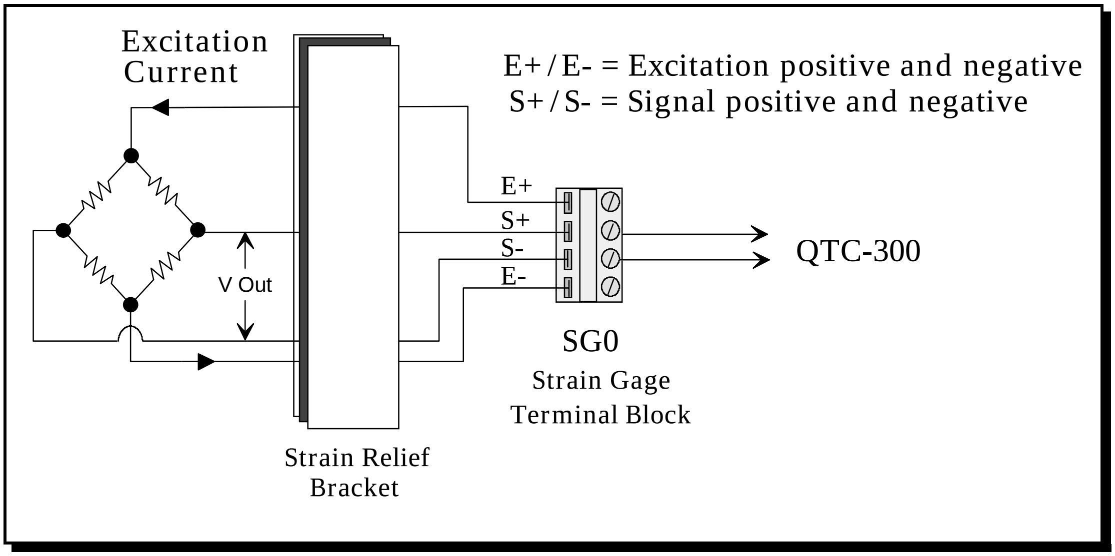

Figure 6-13. Full Bridge Wiring Configuration

6.4.3 Half Bridge Strain Gage Measurements

The configuration of a half bridge measurement circuit is shown in Figure 6-14. The user must insert resistors into the correct sockets to build a Wheatstone Bridge for the strain gage measurement. The channel zero (SG0) connection depicted in Figure 6-14 uses resistor sockets RA3 and RA4. The values of RA3 and RA4 will depend on the half bridge strain gage chosen. Subsequent channels 1 through 3 use resistor sockets RB3/4, RC3/4 and RD3/4 respectively. (See Figure 6-8 for resistor socket locations).

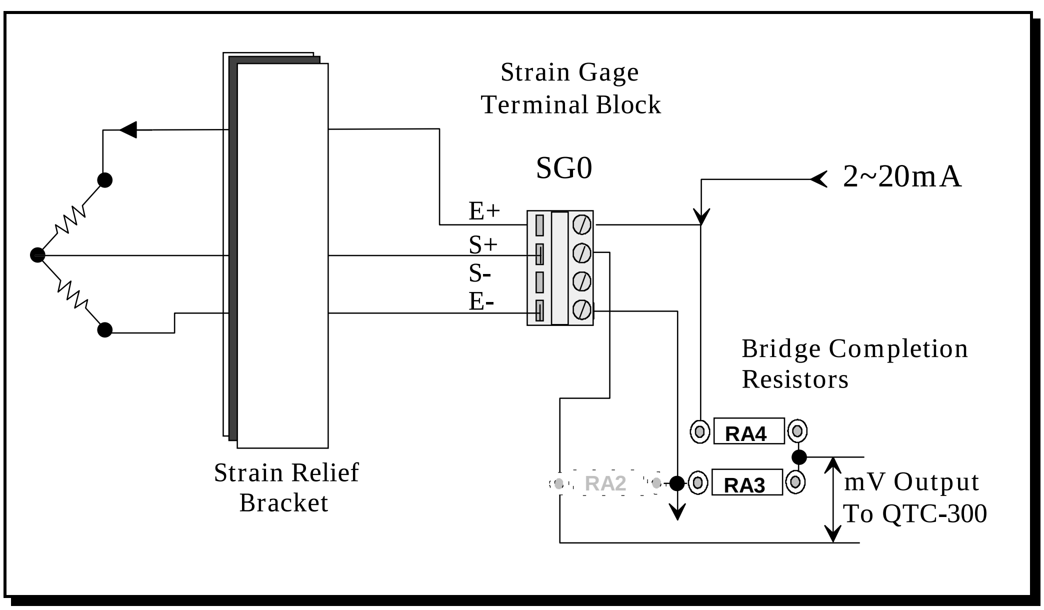

Figure 6-14. Half Bridge Wiring Configuration

6.4.4 Quarter Bridge Strain Gage Measurements

The configuration of a Quarter Bridge measurement circuit is shown in Figure 6-15. The user must insert resistors into sockets RA2, RA3 and RA4 to build a Wheatstone Bridge for the strain gage measurement. The values of RA2, RA3 and RA4 will depend on the quarter bridge strain gage chosen. Subsequent channels 1 through 3 use resistor sockets RB2/3/4, RC2/3/4 and RD2/3/4 respectively. (See Figure 6-8 for resistor socket locations).

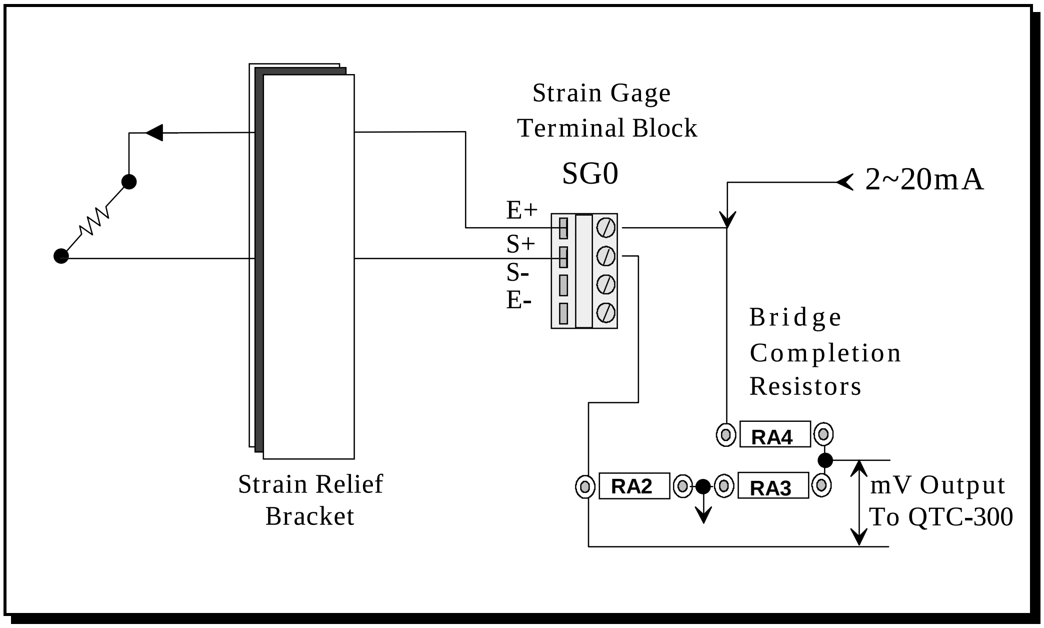

Figure 6-15. Quarter Bridge Wiring Configuration

6.5 Configuration Examples

The strain gage vendor will provide specifications for input pressure range, input impedance, rated excitation voltage and full scale output. The following three examples illustrate how to compute the sensitivity of the strain gage, how to compute the excitation voltage for the selected excitation current and how to select the appropriate gain so the strain gage output voltage stays within the allowable input range of the data acquisition system.

Example 1. A transducer has the following specifications:

input pressure range = 100 psi
input impedance = 800 ohms
rated excitation = 10 VDC
full scale output = 100 mV

1) The sensitivity of the transducer is computed:

$$\text{Sensitivity} = \frac{\text{Full Scale Output}}{\text{Rated Excitation}} = \frac{100\text{mV}}{10\text{V}} = 10\text{mV/V}$$

2) If an excitation current of 10mA is chosen by the user, the excitation voltage is then computed:

Input Impedance x Excitation Current = Excitation Voltage
800W x 10mA = 8V

3) The transducer output is calculated using the excitation voltage and sensitivity:

Excitation Voltage x Sensitivity = Transducer Output
8V x 10mV / V = 80mV

4) The 0 ~ 80mV transducer output then corresponds to 0 ~ 100 psi input pressure.

5) The gain setting must be chosen so that when transducer output (computed in step 3) is multiplied by the gain, the result is within the allowable -10V ~ +10 V input range of the data acquisition system. In this example, a gain of 100 multiplied by the 80mV transducer output would result in an input of 8V to the data acquisition system, (well within the allowable ±10V range).

Example 2. A transducer has the following specifications:

input pressure range = 200 psi
input impedance = 280 ohms
rated excitation = 5 VDC
full scale output = 100 mV

1) The sensitivity of the transducer is computed:

$$\text{Sensitivity} = \frac{\text{Full Scale Output}}{\text{Rated Excitation}} = \frac{100\text{mV}}{5\text{V}} = 20\text{mV/V}$$

2) If an excitation current of 6mA is chosen by the user, the excitation voltage is then computed:

Input Impedance x Excitation Current = Excitation Voltage
280W x 6mA = 1.68V

3) The transducer output is calculated using the excitation voltage and sensitivity:

Excitation Voltage x Sensitivity = Transducer Output
1.68V x 20mV / V = 33.6mV

4) The 0 ~ 33.6mV transducer output then corresponds to 0 ~ 200 psi input pressure.

5) The gain setting must be chosen so that when transducer output (computed in step 3) is multiplied by the gain, the result is within the allowable -10V ~ +10 V input range of the data acquisition system. In this example, a gain of 200 multiplied by the 33.6mV transducer output would result in an input of 6.72V to the data acquisition system, (well within the allowable ±10V range).

Example 3. A transducer has the following specifications:

input pressure range = 300 psi
input impedance = 4500 ohms
rated excitation = 10 VDC
full scale output = 30 mV

1) The sensitivity of the transducer is computed:

$$\text{Sensitivity} = \frac{\text{Full Scale Output}}{\text{Rated Excitation}} = \frac{30\text{mV}}{10\text{V}} = 3 \text{ mV/V}$$

2) If an excitation current of 2mA is chosen by the user, the excitation voltage is then computed:

Input Impedance x Excitation Current = Excitation Voltage
4500W x 2mA = 9V

3) The transducer output is calculated using the excitation voltage and sensitivity:

Excitation Voltage x Sensitivity = Transducer Output
9V x 3mV / V = 27mV

4) The 0 ~ 27mV transducer output then corresponds to 0 ~ 300 psi input pressure.

5) The gain setting must be chosen so that when transducer output (computed in step 3) is multiplied by the gain, the result is within the allowable -10V ~ +10 V input range of the data acquisition system. In this example, a gain of 200 multiplied by the 27mV transducer output would result in an input of 5.4V to the data acquisition system, (well within the allowable ±10V range).

6.6 QTC-300S/QTC-300T Specifications

Connector:	DIN-48 male; mates with QTE-7, QTE-14 and QTC-300-PCS		
Signal Connection:	DIN-48 female, mates screw terminal block for easy connection.		
Number of Channels:	4		
Excitation Current:	10 mA, 20 mA, Rx: 0 - 1126 ohm	2-20 mA (2.5 / (124+Rx))	
Output Impedance:	1900K	Compliance: 12V	
Power Requirement:	+5V ±5%	300mA typ,	
	+15V ±5%	50 ~ 150mA typ (depends on excitation current)	
	-15V ±5%	50mA typ	
External Excitation Power:	+15V ~ +18V @ 200mA		
Bridge Types:	Full bridge (4-wire), half bridge (3-wire), quarter bridge (2-wire)		
Bridge Resistors:	On board resistor socket for each arm on each channel		
Input Type:	Differential		
Over Voltage Input:	±30 VDC		
Calibration:	Zero System Offset, Shunt and Excitation Current Measurement.		
Voltage Input Range:	±10 VDC, ±1VDC, ±100 mVDC, ±50 mVDC, ±20 mVDC		
Input Bias Current:	20 pA typ,	100 pA max	
Input Offset Voltage:	± (0.1+1 / G) mV typ, ± (0.5+5 / G) mV max (Adjustable to zero)		
Input Offset Drift:	± (2+20 / G) lV / °C typ, ± (5+100 / G) lV / °C max		
Gain Range:	1, 10, 100, 200, 500		
Gain Accuracy:	X1	0.002% typ,	0.04% max
	X10	0.01% typ,	0.1% max
	X100	0.02% typ,	0.2% max
	X200	0.04% typ,	0.4% max
	X500	0.1% typ,	1% max
Input Impedance:	200 GW		

Gain Nonlinearity :	X1	± 0.001% of FS typ,	± 0.01% of FS max
	X10	± 0.002% of FS typ,	± 0.01% of FS max
	X100	± 0.004% of FS typ,	± 0.02% of FS max
	X200	± 0.006% of FS typ,	± 0.02% of FS max
	X500	± 0.01% of FS typ,	± 0.04% of FS max
Gain Temp. Coefficient:	X1	± 3 ppm/°C typ,	± 20 ppm/°C max
	X10	± 4 ppm/°C typ,	± 20 ppm/°C max
	X100	± 6 ppm/°C typ,	± 40 ppm/°C max
	X200	± 10 ppm/°C typ,	± 60 ppm/°C max
	X500	± 25 ppm/°C typ,	± 100 ppm/°C max
Common Mode Rejection:	X1	70 dB typ,	90 dB max
	X10	87 dB typ,	104 dB max
	X100	100 dB typ,	110 dB max
	X200	100 dB typ,	110 dB max
	X500	100 dB typ,	110 dB max
Low Pass Filter (-3dB):	QTC-300-10: 10Hz, QTC-300-100: 100Hz, QTC-300-1K:1Khz		
(also user by-passable)			
High Pass Filter:	0.28Hz (for AC Coupling)		
Simultaneous Sample Hold			
Acquisition Time:	10V Step to 0.1% 4ls typ,	6ls to 0.01%	
Aperture Time:	200 ns		
Hold Settling Time:	1ls to 1mV		
Hold Droop Rate:	0.03lV/ls		
Input Voltage Offset:	±1 mV typ (adjust to zero)		
SSH Accuracy:	±0.01% FS Gain Error		
Dimension:	160mm X 100mm for QTC-300 or QTC-300S		
	100mm X 100mm for QTC-300T		
Weight:	0.13Kg for QTC-300 or QTC-300S/0.36Kg for QTC-300T		

7 QTC-350 Accelerometer/Dynamic Signal Input Module

QTC-350 Features

- Four Accelerometer / Dynamic Signal input channels with BNC connections
- Up to 256 channels can be configured in a system
- Custom configurable excitation current source of 4mA or 2-10mA
- DIP switch selectable gain of 1, 2, 4 or 8
- On board low-pass or by-pass filter for each channel
- (10Hz, 100Hz or 1KHz cut off frequency)
- Jumper selectable AC or DC coupling
- Supports PCB® ICP® type and Analog Devices® Monolithic type accelerometers
- Simultaneous Sample and Hold Option (QTC-350S)

The QTC-350 is a four channel accelerometer / dynamic signal input module. Each channel is equipped with a separate instrument amplifier, low pass filter and a custom configurable current source. Up to sixty-four QTC-350 modules can be configured in an Omega signal conditioning and data acquisition system for a total of 256 analog input channels. The QTC-350 can also be coupled with other modules in Omega's SignalPro series to provide a versatile data acquisition system.

The QTC-350 signal conditioning module shown in Figure 7-1 consists of a single standard 3U size interface board which mounts in the QTE-7, QTE-14 or QTC-350-PCS data acquisition enclosures. The QTC-350 is equipped with four standard BNC connectors each with a jumper selectable option of either ICP® or dynamic sensor input. The QTC-350 can also be specially equipped with a Simultaneous Sample and Hold feature for each channel, (QTC-350S).

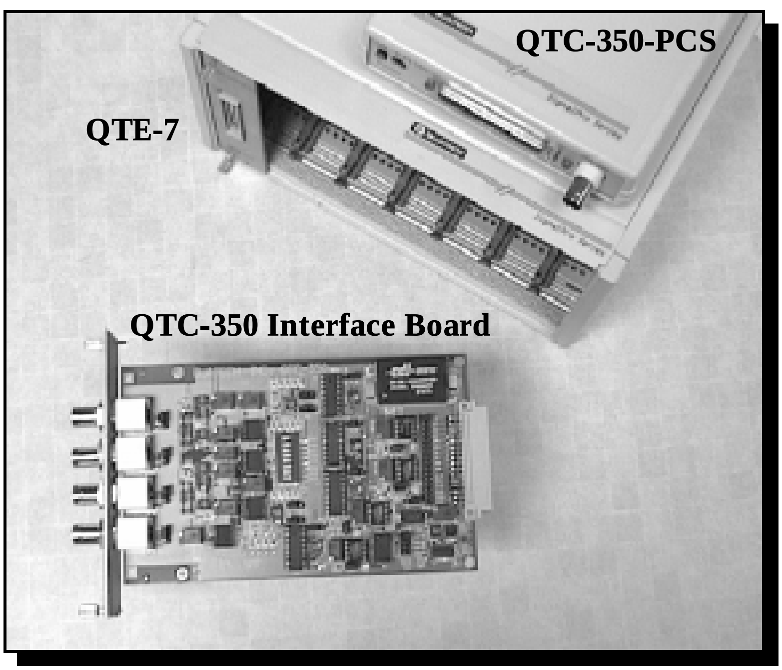

Figure 7-1. QTC-350 Accelerometer / Dynamic Signal Input Module

7.1 Circuit Board Description

The QTC-350 interface board shown in Figure 7-1 can be mounted in SignalPro series data acquisition racks and enclosures. (See Chapter 2 for information on SignalPro series racks). Each rack enclosure is equipped with a DIN-48 female connector which mates to the QTC-350 and other SignalPro series modules. The rack also contains a standard Omega D37 connector which attaches to the host computer data acquisition adapter.

Four accelerometer or dynamic signal input channels are provided by multiplexing a single main A/D channel off the host computer data acquisition adapter. The multiplexer on the QTC-350 scans the four accelerometer input channels sequentially and connects each input to the single main A/D channel. The four multiplexed input channels may be mapped back to any main A/D channel on the data acquisition adapter depending on the configuration of jumper J15. Four interface boards may share one single ended A/D input from the host computer to provide a maximum of 16 multiplexed channels per main A/D channel. Multiplexing of all 16 main A/D channels from the host computer results in a maximum of 256 A/D input channels, (16 x 16), per data acquisition adapter.

7.2 Hardware Configuration

For system configuration options see Chapter 1: SignalPro Series Overview, Section 1.3: Hardware Configuration.

7.2.1 QTC-350 Interface Board Configuration

Figure 7-2 depicts the location of the main A/D channel and board selection jumper blocks (J14 and J15), SSH option jumper block (J13), filter selection jumpers (J9 through J12), filter blocks (F1 through F4), coupling selection jumper blocks (J5 through J8), sensor type selection jumper blocks (J1 through J4), input gain selection switch (SW1) and the excitation current selection resistor sockets (R6, R8, R9 and R10).

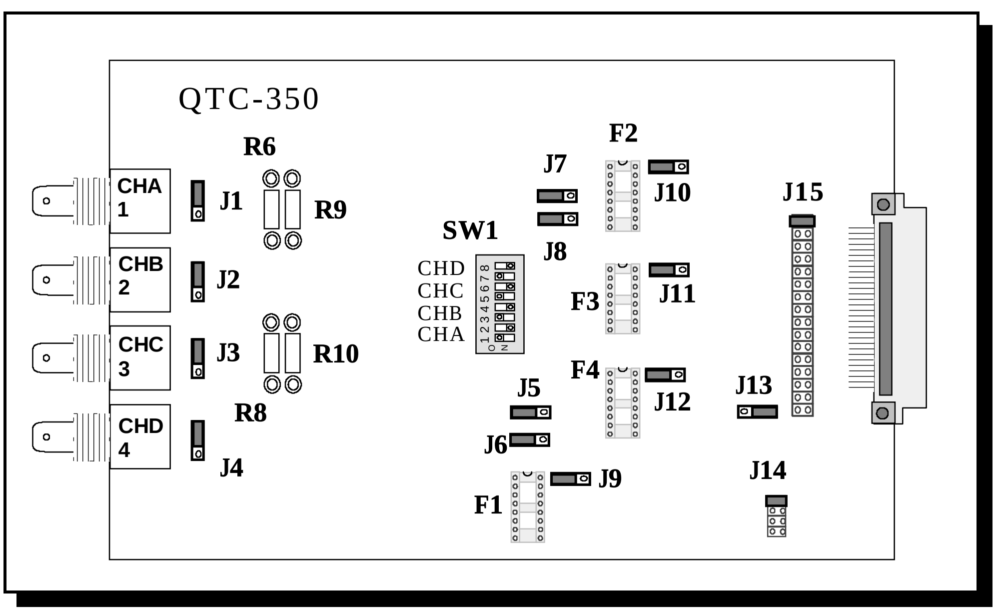

Figure 7-2. QTC-350 Interface Board Jumper and Switch Locations

7.2.1.1 Simultaneous Sample and Hold Jumper (QTC-350S only)

The simultaneous sample and hold feature eliminates time skew errors across the four analog input channels. At the beginning of an A/D channel scan, the SSH device simultaneously samples all four of the QTC-350S input channels and holds the input signals. The A/D multiplexer then scans each of the channels in sequence and performs the A/D conversions one at a time.

The default setting for the QTC-350S is SSH disabled. The customer must enable SSH by changing the jumper position. The QTC-350 does not support SSH and is also shipped with SSH disabled. (See Figure 7-3).

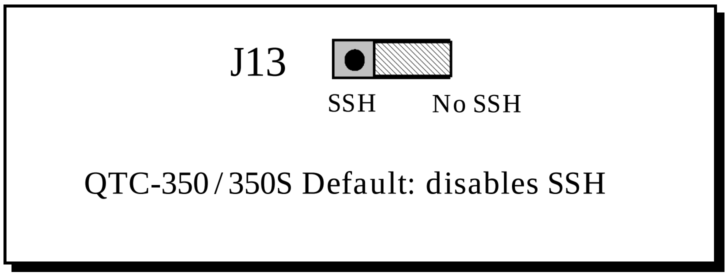

Figure 7-3. QTC-350/QTC-350S SSH Selection Jumper

7.2.1.2 Filter Selection Jumpers

Jumper blocks J9 through J12 determine whether the low-pass filter options for channels A through D are used. The factory default is “AP” (All Pass) for all four channels with the corresponding filter blocks (F1 through F4) empty. When the low-pass filter option is desired, that channel’s filter module should be installed into the corresponding filter block and the low pass filter selection jumper should be moved to “LP” (Low Pass). Note that if a filter module is installed and the selection jumper is set to “AP”, the filter will still have a partial effect on that channel. Figure 7-4 shows the factory default setting and lists the selection jumper and filter block that corresponds to each channel. (See Figure 7-2 for channel locations).

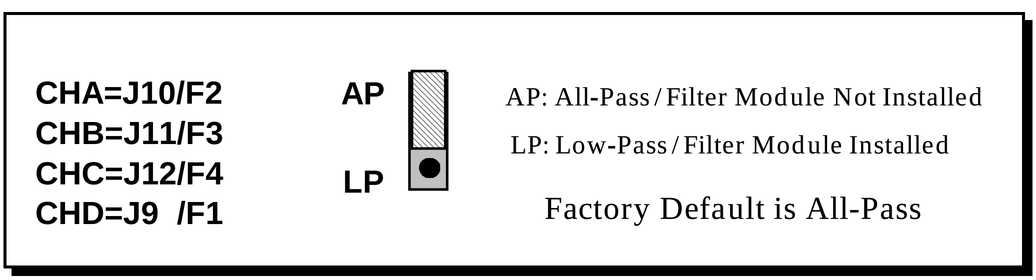

Figure 7-4. Filter Selection Jumpers

7.2.1.3 Filter Block Description

The active filters of QTC-350/350S employ a unity-gain Sallen-Key complex pole-pair to implement Butterworth filters. Four 16-pin filter block sockets (F1 through F4) are provided to facilitate easy configuration of different filter types. Each socket has eight positions to hold resistors or capacitors. The positions are designated as shown in Figure 7-5.

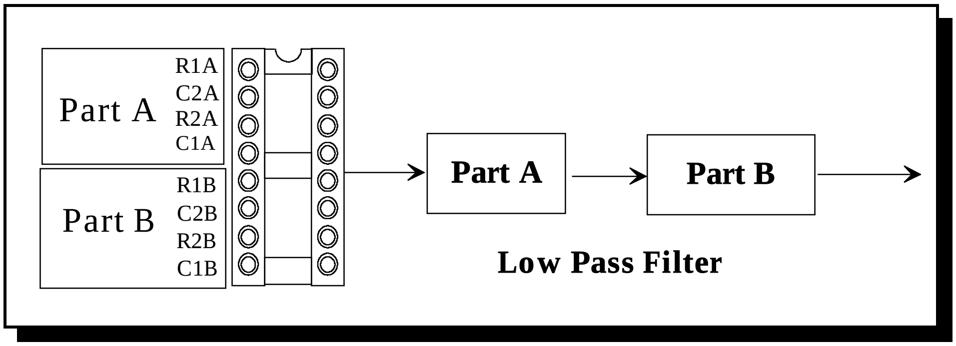

Figure 7-5. Filter Block Socket Designations

Filter cut off frequency is determined by a RC circuit that is configured on the filter block socket. Omega offers pre-configured 3rd order Butterworth low-pass filter blocks for ease in pre-selecting cut off frequencies. Omega also offers a pre-configured filter block that is custom built to customer specifications. (See Table 7-1).

Product Number	**Cut off Frequency**
FTR-10	10 Hz
FTR-100	100 Hz
FTR-1k	1 kHz
FTR-C	Customer specified

Table 7-1. Omega Pre-configured RC Filter Blocks

Table 7-2 shows Butterworth low-pass filter design examples for five different cutoff frequencies. To configure different cutoff frequencies and filter types, the user is advised to follow the instructions in the Burr-Brown® FilterPro™ software package supplied with the customer CD-ROM.

Filter Block Position	**5Hz**	**10Hz**	**100Hz**	**500Hz**	**1kHz**
R1A	20.50K	10.20K	1.02K	205	102
C2A	1.0uF	1.0uF	1.0uF	1.0uF	1.0uF
R2A	105.0K	52.3K	5.23K	1.05K	523
C1A	0.47uF	0.47uF	0.47uF	0.47uF	0.47uF
R1B	53.6K	26.7K	2.67K	536	267
C2B	1.0uF	1.0uF	1.0uF	1.0uF	1.0uF
R2B	191.0K	95.3K	9.53K	1.91K	953
C1B	0.1uF	0.1uF	0.1uF	0.1uF	0.1uF

Notes: 0.1uF=100n; 0.01u=10n; 1000P=1n

Table7-2. Butterworth Low-Pass Filter Design Examples

7.2.1.4 Sensor Type Selection and AC/DC Coupling Jumpers

The QTC-350 is equipped with four BNC connectors for differential signal input. Each input can be connected to either ICP® type or Dynamic (DYN) type sensors depending on the configuration of jumpers J1 through J4. Figure7-6 shows channel versus jumper assignment and the factory default setting.

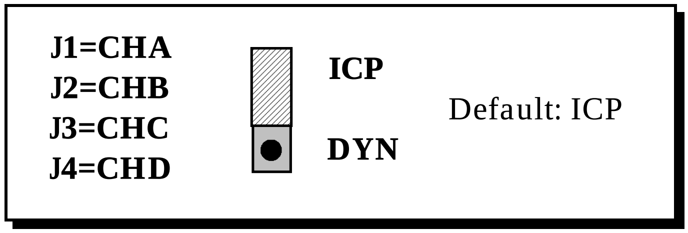

Figure 7-6. Sensor Type Selection Jumper

Each QTC-350 channel is also equipped with a jumper selectable option of either DC or AC coupling. Figure 7-7 shows channel versus jumper assignment and the factory default setting.

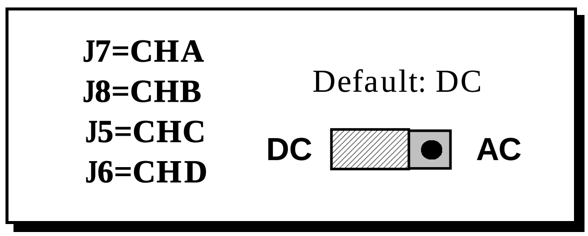

Figure 7-7. AC/DC Coupling Selection Jumper

7.2.1.5 A/D Gain Selection Switch

The A/D input gain for each of the accelerometer or dynamic inputs is individually selectable using SW1 as shown in Figure 7-8. Each of the input amplifiers can be configured for gains of x1, x2, x4 or x8.

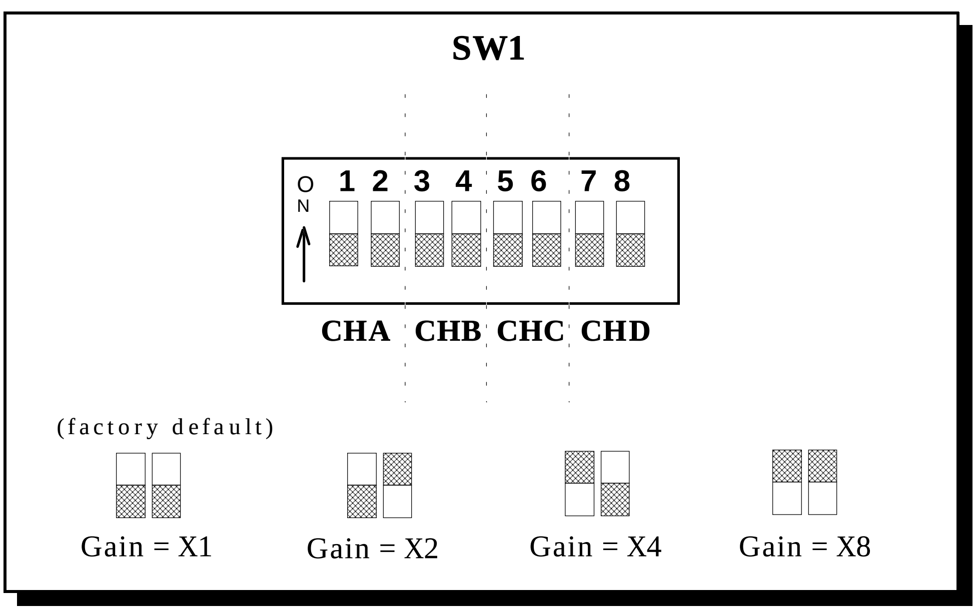

Figure 7-8. A/D Gain Selection Switch

Up to four QTC-350 interface boards may share one single ended A/D input from the host computer to provide a maximum of sixteen multiplexed channels per main A/D channel. Table7-3 shows which logical channels will be affected by SW1 gain settings. For example, in a four board configuration, setting SW1 positions 3 and 4 (CHB) for a gain of x2 will cause logical channels 1, 5, 9 and 13 to all have a gain of x2.

QTC-350	CHA	CHB	CHC	CHD
Board 1	0	1	2	3
Board 2	4	5	6	7
Board 3	8	9	10	11
Board 4	12	13	14	15

Table 7-3. Expansion Channels versus A/D Gain Selection

7.2.1.6 Excitation Current Selection Resistors

The QTC-350 provides a stable, constant current source for each of the four accelerometer input channels. The excitation current value of 2.0 - 10.0mA for each channel can be configured by using selected resistor values in the resistor sockets R6, R8, R9 or R10. (See Figure 7-2 for specific location of resistor sockets). Use the equation shown in Figure 7-9 to determine the appropriate resistor value for the desired excitation current.

$$\mathbf{R} = \frac{2500}{I} - 250$$

Default: R = 375 ohms

I = 4.0 mA

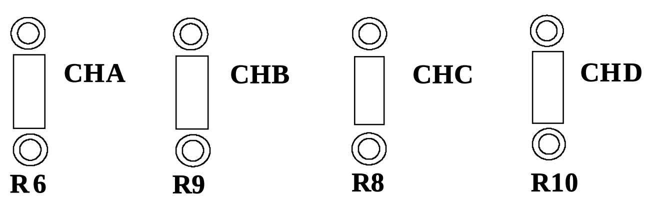

Figure 7-9. Excitation Current Selection

7.3 Field Wiring

An ICP® sensor configuration is shown in Figure 7-10 and a dynamic sensor configuration is shown in Figure 7-11.

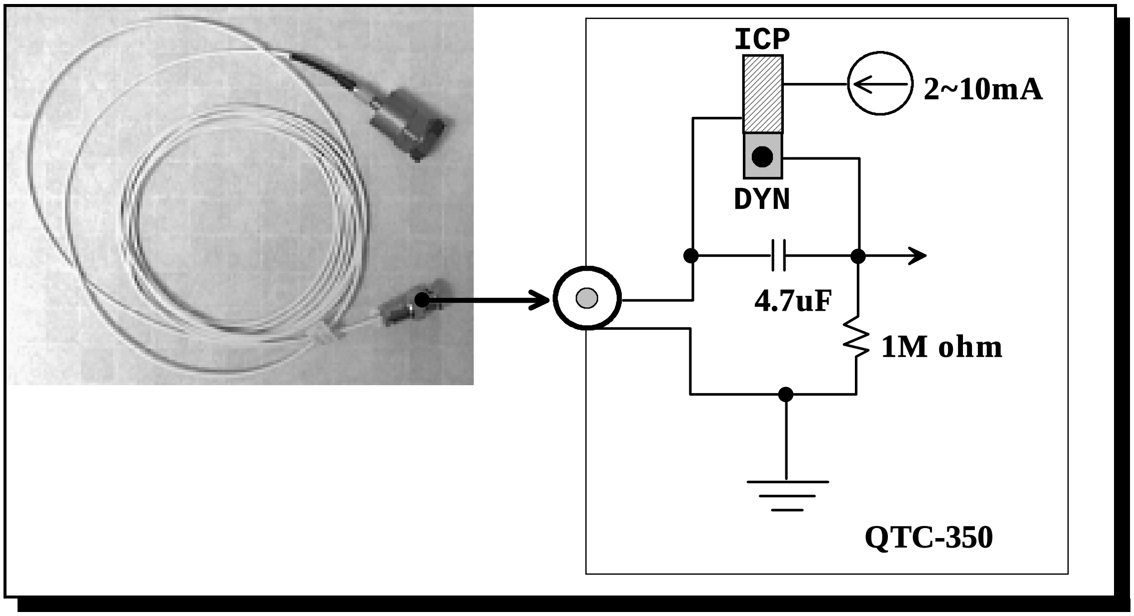

Figure 7-10. ICP Sensor Configuration

Note that for a dynamic sensor configuration, the user needs to provide an external +5V power supply as shown in Figure 7-11.

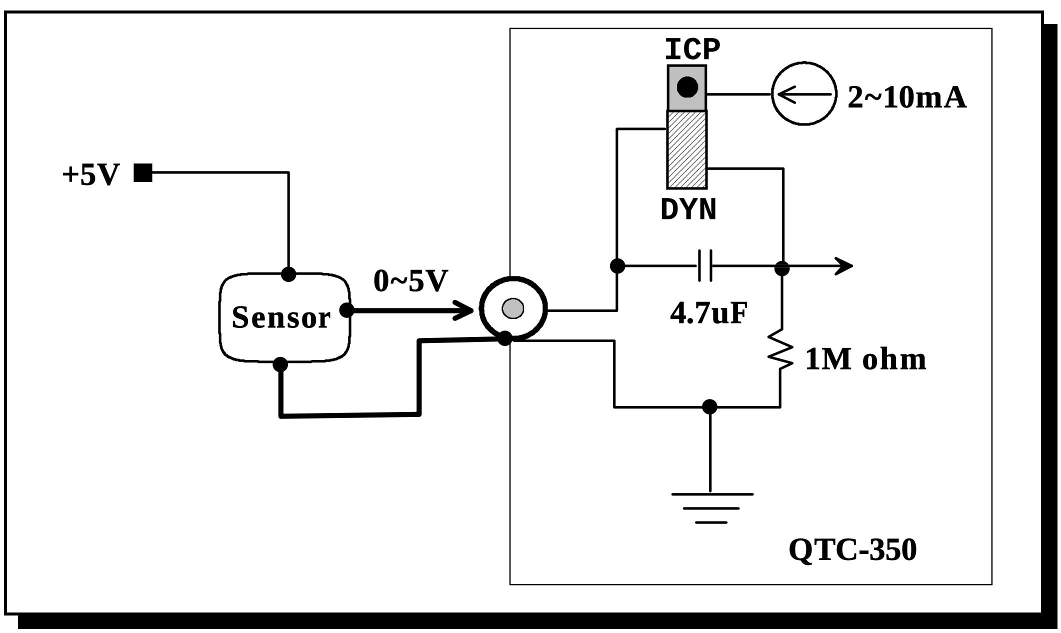

Figure 7-11. Dynamic Sensor Configuration

When configuring sensors, a long cable length may affect frequency response and introduce noise or distortion when insufficient current is available to drive cable capacitance. The cable length driving capability is dependent on the excitation current value and the frequency of the signal. Table 7-4 shows the maximum driving capability of a coaxial cable with a capacitance of 30pf/ft. at various input frequencies.

Input Frequency	Excitation Current = 4 mA	Excitation Current = 10 mA
1.0 kHz	3400 ft	8500 ft
5.0 kHz	680 ft	1700 ft
10.0 kHz	340 ft	850 ft

Table 7-4. Maximum Driving Capability of Coaxial Cable with 30pf/ft. Capacitance

7.4 QTC-350/QTC-350S Specifications

Connector:	DIN-48 male; mates with QTE-7, QTE-14 and QTC-350-PCS	
Signal Connection:	BNC connector	
Number of Channels:	4	
Power Requirements:	+5V ±5% @400mA, +15V±5% @50mA, -15V ±5% @50mA	
Excitation Current:	4 mA,	2-10 mA
	2500/(250.0+Rx) where Rx: 0 - 1000 ohm	
Output Impedance:	1900K	
Compliance:	25V	
Simultaneous Sample Hold	(QTC-350S only):	
Acquisition Time:	10V Step to 0.1% 4ls typ,	6ls to 0.01%
Aperture Time:	200 ns	
Hold Settling Time:	1ls to 1mV	
Hold Droop Rate:	0.03lV/ls	
Input Voltage Offset:	±1 mV typ (adjust to zero)	
SSH Acuracy:	±0.01% FS Gain Error	
AC Coupling Frequency:	0.28Hz (-3dB)	
Accelerometer input:	Two wire BNC connection	
Maximum Voltage Input:	±30 V	
Voltage Input Range:	±10 V, ±5 V, ±2.5 V, ±1.25 V	
Input Bias Current:	±0.5 pA typ;	±5 pA max
Input Offset Voltage:	± (0.025+0.03/G) mV typ,	± (0.125+0.5/G) mV max
(Adjustable to zero)		
Input Offset Drift:	± (0.1+0.5/G) lV/°C typ,	± (0.25+100/G) lV/°C max
Gain Range:	1, 2, 4, 8	
Gain Error: X1	0.005% typ,	0.024% max
X2, X4, X8	0.01% typ,	0.024% max
Input Impedance:	10 GW	

Gain Nonlinearity :	± 0.00024% of FS typ,		± 0.004% of FS max
Gain Temp. Coefficient:	± 2.5 ppm / °C typ,		± 10 ppm / °C max,
Common Mode Rejection:	X1	75 dB min,	88 dB typ
	X2	80 dB min ,	94 dB typ
	X4	85 dB min ,	100 dB typ
	X8	89 dB min ,	106 dB typ
Low-pass Filter:	Optional (10Hz, 100Hz, or 1KHz)		
Dimension:	160mm X 100mm		
Weight:	0.17Kg		
Temperature Range:	0 ~ +70°C		

8 QTC-400 Universal Current/Voltage Input Module

QTC-400 Features

- Sixteen Differential or Single-ended input channels
- User configurable for either Current or Voltage input
- Programmable Gain Selection of 1, 2, 4 or 8
- 4-20 mA or 0-20 mA current measurement
- Voltage input range of ±1.25, 2.5, 5 or 10 VDC
- Terminal block for quick, easy signal connections

The QTC-400 is a sixteen channel universal current and voltage input module that provides either single-ended or differential inputs to the data acquisition system. Up to sixteen QTC-400 modules can be configured in an Omega signal conditioning and data acquisition system for a total of 256 analog input channels. The QTC-400 can also be coupled with other modules in Omega's SignalPro series to provide a versatile data acquisition system.

The QTC-400 universal current/voltage input module consists of two circuit boards: the QTC-400 interface board and the QTC-400T terminal board. The interface board is a standard 3U size board which can be mounted in the QTE-7, QTE-14 or QTC-400-PCS data acquisition enclosures. The terminal board contains the input screw blocks for the sixteen voltage or current inputs. This two board configuration allows quick and easy connection of the input lead wires. After the initial configuration of the interface board, it can be mounted in a data acquisition enclosure and will rarely require removal. All connections are completed on the screw terminals of the portable QTC-400T, which is then plugged in to the interface board and secured using two thumb screws. (See Figure 8-1).

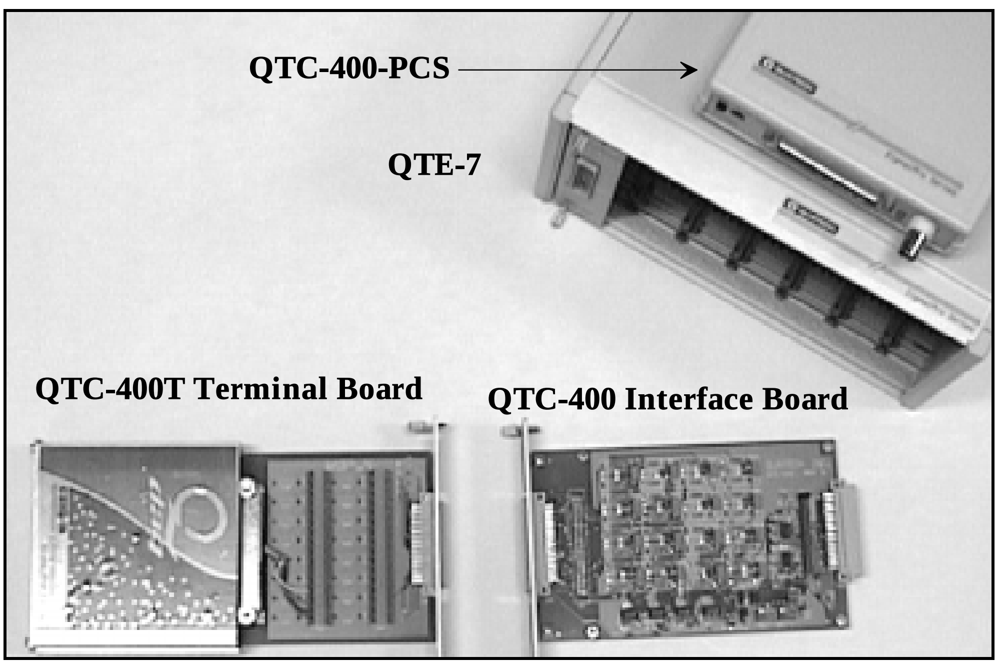

Figure 8-1. QTC-400 Universal Voltage/Current Module

8.1 Circuit Board Description

8.1.1 QTC-400 Interface Board Description

The QTC-400 interface board shown in Figure 8-1 can be mounted in SignalPro Series data acquisition racks and enclosures. (See Chapter 2 for information on SignalPro Series racks). Each rack enclosure is equipped with a DIN-48 female connector which mates to the QTC-400 and other SignalPro series signal conditioners. The rack also contains a standard Omega D37 connector which attaches to the host computer data acquisition adapter.

Sixteen voltage or current input channels are provided by multiplexing a single main A/D channel off the host computer data acquisition adapter. The multiplexer on the QTC-400 scans the sixteen analog input channels sequentially and connects each input to the single main A/D channel. The sixteen multiplexed input channels may be mapped back to any main A/D channel on the data acquisition adapter depending on the configuration of jumper J1. Multiplexing of all 16 main A/D channels from the host computer results in a maximum of 256 A/D input channels, (16 x 16), per data acquisition adapter.

8.1.2 QTC-400T Terminal Board Description

The QTC-400T terminal board contains the input terminal blocks for each of the sixteen voltage/current inputs. The terminal board DIN-48 female connector plugs into the interface board and is equipped with a strain relief bracket to secure external input wiring.

8.2 Hardware Configuration

8.2.1 QTC-400 Interface Board Configuration

<u>8.2.1.1 Current Measurement Resistors/Channel Input Terminals</u>

The QTC-400 is shipped with 20 ohm ±0.1% precision resistors which can be used to measure current in the range of 0 to 20mA. Insert a resistor into the socket by each channel input terminal block as shown in Figure 8-2.

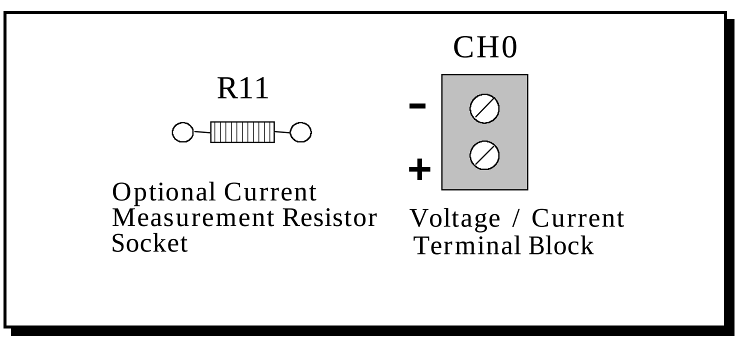

Figure 8-2. Current Measurement Resistor Sockets

8.2.1.2 Analog Ground Option Jumper

The QTC-400 differential input signals can be connected to analog ground for reference purposes using jumper blocks J2 and J3. The positive and negative side of each differential signal optionally connects to analog ground as shown in Figure 8-3.

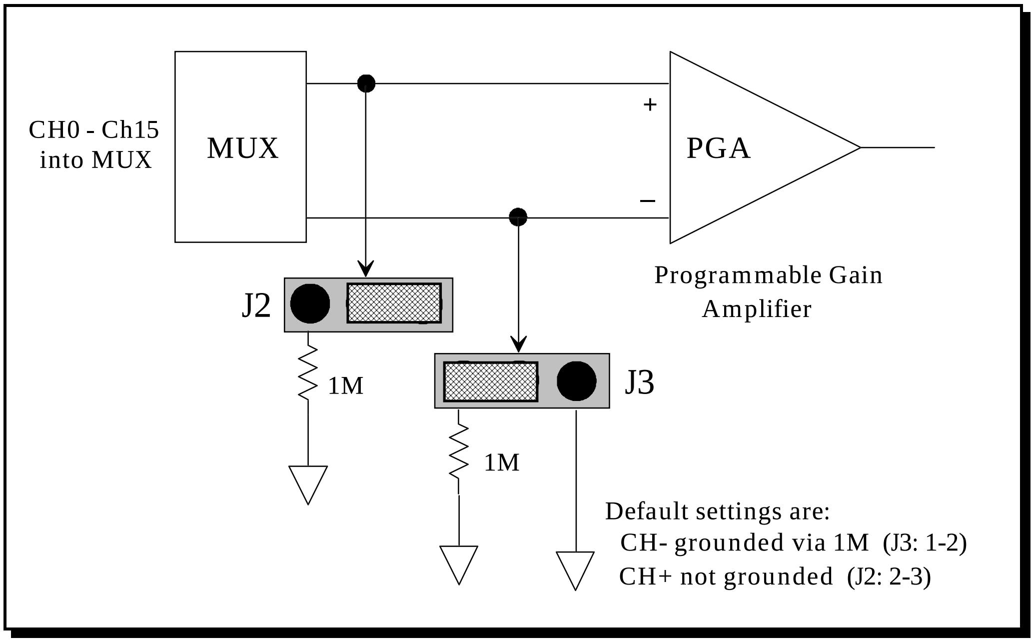

Figure 8-3. Analog Ground Option Jumper

8.3 QTC-400/400T Specifications

Connector:	DIN-48 male, mates with QTE-7, QTE-14, and QTC-400-PCS
Signal Connection:	DIN-48 female, mates screw terminal block for easy connection
Number of Channels:	16 differential or 16 single-ended
Gain Range:	1, 2, 4, 8
Voltage Input Range:	±10 VDC, ±5 VDC, ±2.5 VDC, ±1.25 VDC
Over Voltage Protection:	±30 VDC
Gain Accuracy:	± 0.05% typ, ± 0.25% max
Gain Non linearity:	± 0.002% typ,± 0.015% max
Slew Rate:	10 V/ls min, 20 V/ls typ
Settling Time (0.01%)	2 ls
Overload Recovery time:	5 ls
CMMR:	80 db min
Offset Voltage @ 25°C:	± (0.5+5/G) mV typ,± (2+24/G) mV max
Offset Drift:	± (3+50/G) lV/°C typ, ± (24+240/G) lV/°C max
Power Requirements:	+5V ±5% @20mA +15V ±5% @17mA -15V ±5% @17mA
Dimension:	160mm x 100mm for QTC-400 100mm x 100mm for QTC-400T
Weight:	0.13 Kg for QTC-400 0.36 Kg for QTC-400T
Temperature Range:	0 ~ +70 °C

9 QTC-450 Low/High Bandpass Filter Input Module

QTC-450 Features

- Four channel Active Filter module with Simultaneous Sample and Hold (SSH)
- Low-pass, high-pass, band-pass or by-pass filter option for each channel
- Differential signal inputs on each channel via BNC connectors
- Jumper selectable gain of 0.5, 5, 50, 100 or 250
- Software included for active filter design and RC selection
- Up to 256 channels can be configured in a system

The QTC-450 is a four channel active filter module with a simultaneous sample and hold option. Each channel has an independent instrumentation amplifier with jumper selectable gain of 0.5, 5, 50, 100 or 250 and a filter option of low-pass, high-pass, band-pass or by-pass. Up to sixty-four QTC-450 boards can be configured in a SignalPro signal conditioning and data acquisition system to provide 256 channels of analog input. The QTC-450 can also be coupled with other modules in Quatech's SignalPro series to provide a flexible data acquisition system. (See Figure 9-1).

The QTC-450 signal conditioning module consists of a single standard 3U size interface board which mounts in the QTE-7, QTE-14 or QTC-450-PCS data acquisition enclosures. The QTC-450 is equipped with four standard BNC connectors for differential signal inputs to each of the filtered channels.

Two variations of the QTC-450 are also available. The QTC-450F has the same signal filtering options as the QTC-450, but does not include the SSH feature. The QTC-450S offers four channel SSH signal input, but does not include the active filtering capabilities of the QTC-450.

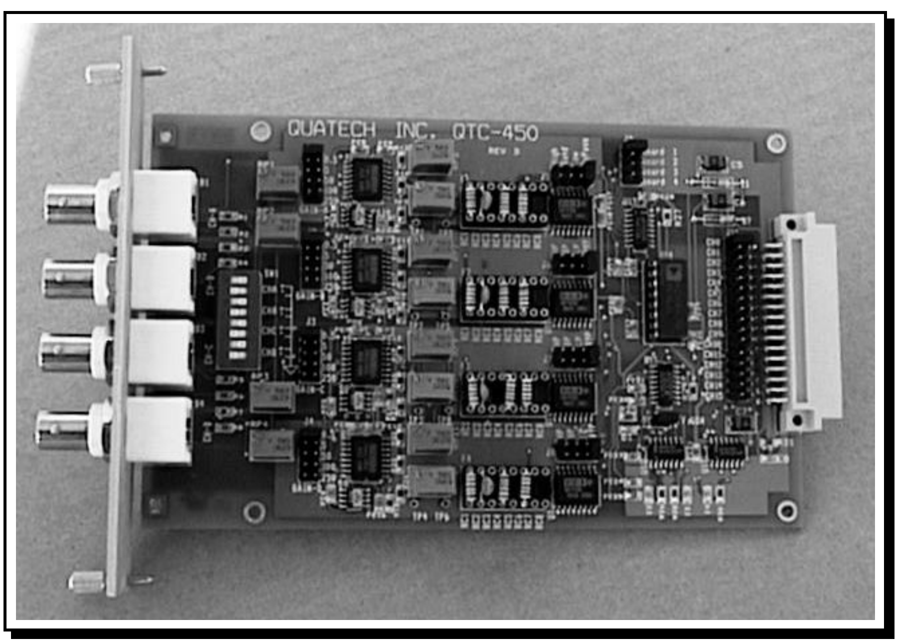

Figure 9-1. QTC-450 Low / High Bandpass Filter Input Module

9.1 Circuit Board Description

The QTC-450 interface board shown in Figure 9-1 can be mounted in SignalPro series data acquisition racks and enclosures. (See Chapter 2 for information on SignalPro Series racks). Each rack enclosure is equipped with a DIN-48 female connector which mates to the QTC-450 and other SignalPro series signal conditioners. The rack also contains a standard Omega D37 connector which attaches to the host computer data acquisition adapter.

Four filtered input channels are provided by multiplexing a single main A/D channel off the host computer data acquisition adapter. The multiplexer on the QTC-450 scans the four filtered input channels sequentially and connects each input to the single main A/D channel. The four multiplexed input channels may be mapped back to any main A/D channel on the data acquisition adapter depending on the configuration of jumper J11. Four interface boards may share one single ended A/D input from the host computer to provide a maximum of 16 multiplexed channels per main A/D channel. Multiplexing of all 16 main A/D channels from the host computer results in a maximum of 256 A/D input channels, (16 x 16), per data acquisition adapter.

9.2 Hardware Configuration

For system configuration options see Chapter 1: SignalPro Series Overview, Section 1.3: Hardware Configuration.

9.2.1 QTC-450 Interface Board Configuration

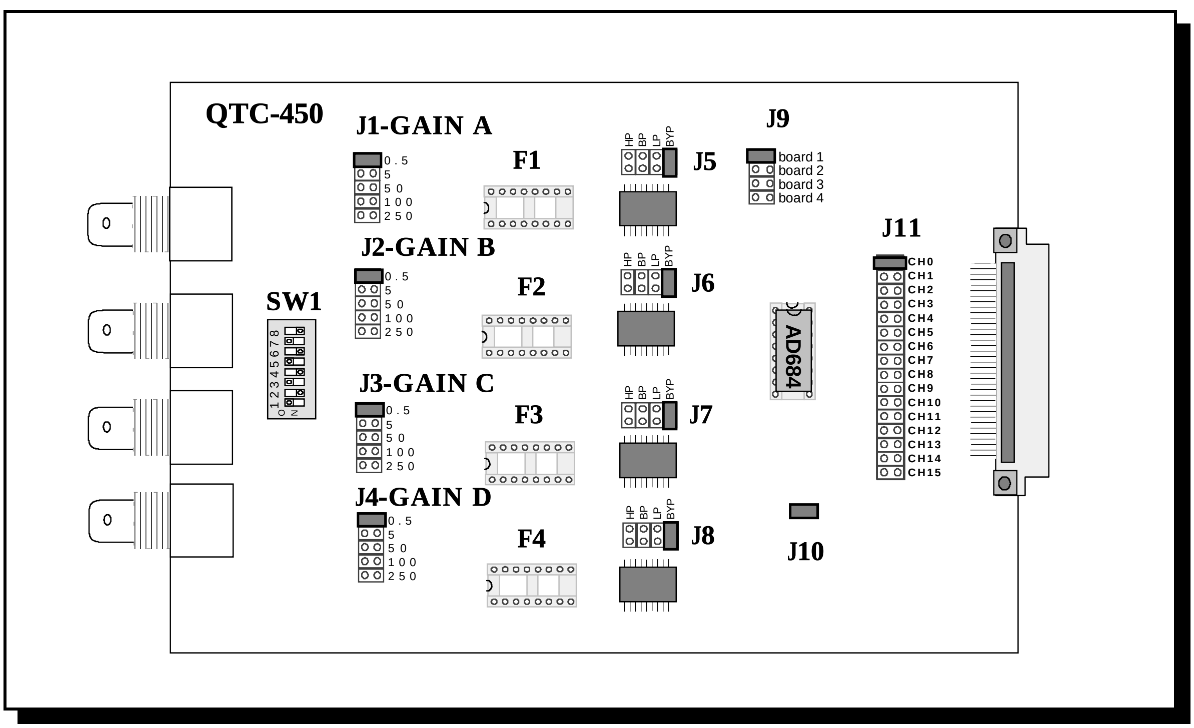

Figure 9-2. QTC-450 Jumper Block, Filter Block and Switch Locations

Figure 9-2 depicts the location of the main A/D channel and board selection jumper blocks (J9 and J11), A/D gain selection jumper blocks (J1 through J4), filter selection jumper blocks (J5 through J8), SSH option jumper block (J10), filter blocks (F1 through F4) and the analog ground option switch (SW1). System configuration options for J9 and J11 are discussed extensively in Chapter 1, section 1.3.

9.2.1.1 A/D Gain Selection Jumpers

The A/D input gain for each of the four QTC-450 input channels is individually selectable using J1 through J4 for input channels A through D respectively, (see Figure 12-2 for the location of channels A through D). Each of the input instrument amplifiers is configurable for gains of 0.5, 5, 10, 100 or 250. Using the A/D gain selection option provided on the QTC-450 interface board will result in less signal noise than using the A/D gain selection options available on the data acquisition adapter in the host computer. Figure 9-3 depicts the configuration options and factory default setting for jumper blocks J1 through J4.

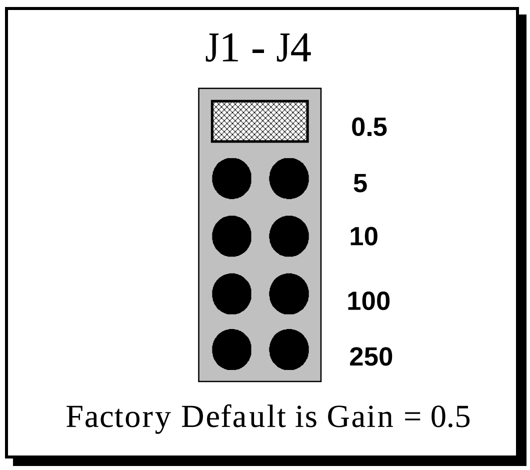

Figure 9-3. A/D Channel Gain Selection Jumpers

9.2.1.2 Filter Selection Jumpers

Jumper blocks J5 through J8 select the filter type for input channels 1 through 4 respectively. This jumper configuration is dependent on the filter block design installed in sockets F1 through F4. (See section 9.3 for discussion on filter block design). Figure 9-4 depicts the configuration options and factory default setting for jumper blocks J5 through J8.

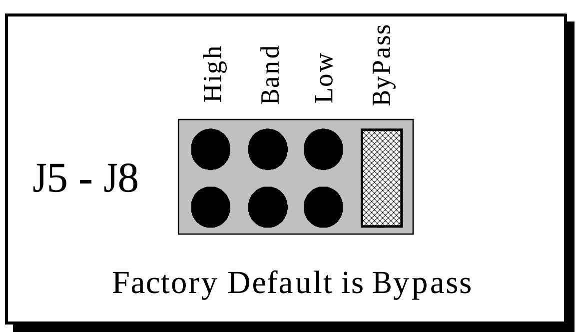

Figure 9-4. Filter Selection Jumpers

9.2.1.3 Simultaneous Sample and Hold Jumper

The simultaneous sample and hold feature on the QTC-450 and QTC-450S eliminates time skew errors across the four analog input channels. At the beginning of an A/D channel scan, the SSH device simultaneously samples all four of the QTC-450 input channels and holds the input signals. The A/D multiplexer then scans each of the channels in sequence and performs the A/D conversions one at a time. The default setting for signal conditioning system modules with the SSH feature is J10 open, (SSH enabled), as shown in Figure 9-5. The QTC-450F does not support SSH and is shipped with J10 shorted (SSH disabled).

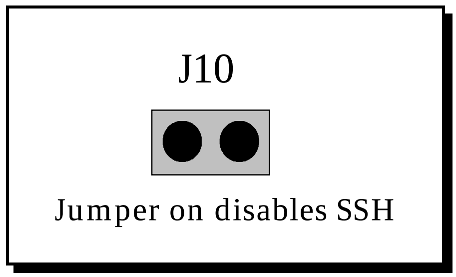

Figure 9-5. SSH Selection Jumper

9.2.1.4 Filter Blocks

The QTC-450 filter module provides four 16-pin filter block sockets to facilitate easy configuration of different filter types. Filter block sockets F1 through F4 are assigned to channels 1 through 4 respectively and each socket has eight positions to hold resistors or capacitors. The positions are designated as shown in Figure 9-6.

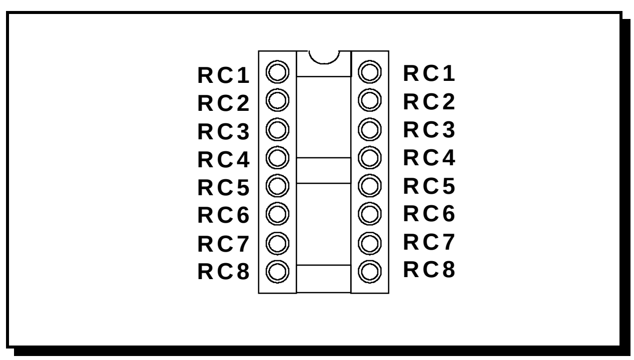

Figure 9-6. Filter Block Socket Designations

Filter cut off frequency is determined by a RC circuit that is configured on the filter block socket. Omega offers pre-configured RC blocks for ease in pre-selecting low-pass filter cut off frequencies. (All pre-configured filter blocks are 3rd order Butterworth low-pass filters). Omega also offers a pre-configured filter block that is custom built to customer specifications. (See Table 9-1).

Product Number	**Cut off Frequency**
FTRB-1	5 Hz
FTRB-2	10 Hz
FTRB-3	100 Hz
FTRB-4	500 Hz
FTRB-5	1 Khz
FTRB-C	Customer Specified

Table 9-1. Omega Pre-configured Filter Blocks

9.2.1.5 Analog Ground Option Switch

The QTC-450 interface board is equipped with four BNC connectors for differential input signals. Each input (A through D respectively) can be connected to analog ground for reference purposes via switch block SW1. The positive and negative side of each differential signal optionally connects to analog ground as shown in Figure 9-7.

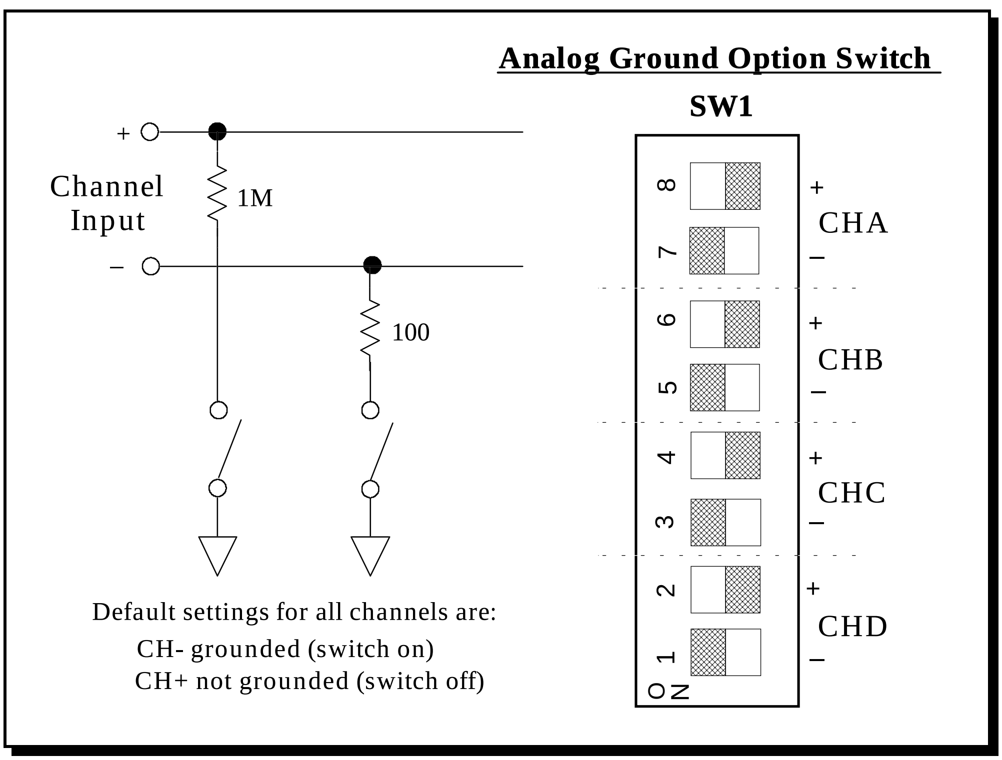

Figure 9-7. Analog Ground Option Switch

9.3 Field Wiring

Figure 9-8 shows a basic wiring diagram for inputs to the QTC-450 filter module. The positive side of each input signal connects to the BNC center connector, and the negative side of the signal connects to the BNC outer shell.

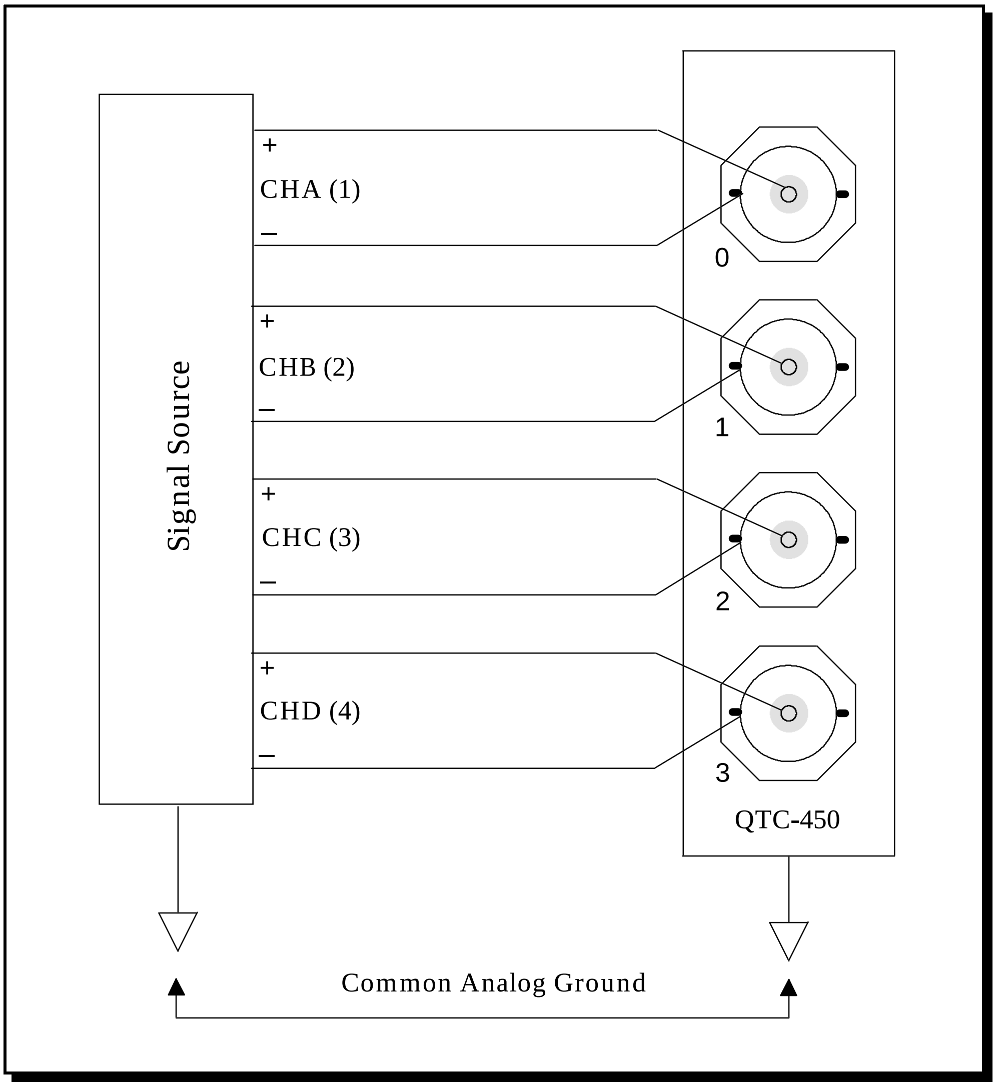

Figure 9-8. QTC-450 Wiring Diagram

9.4 Filter Design Program

The QTC-450 filter module is designed around the Burr-Brown® UAF42 universal active filter. To aid in the design of active filters, Burr-Brown® provides a series of FilterPro™ computer aided design programs. Using the FILTER42 program and the UAF42, it is simple to design and implement all kinds of active filters. The DOS-compatible program guides the user through the design process and automatically calculates component values. FILTER42 supports the following all pole filter types: Butterworth, Bessel, Chebyshev, Inverse Chebyshev and Tuned Circuit. Burr-Brown® Application Bulletin AB-035C discusses in depth the operation and configuration options for the UAF42 and is included with the QTC-450 filter module (on the customer CD-ROM) to ensure ease of operation.

9.4.1 Filter Parameter Selection

To configure the desired filter type, initiate the FilterPro™ design program and select the UAF42 option. The program will prompt the user to enter the following parameters:

(1) the desired response:
- low-pass, high-pass or band-pass

(2) the filter type:
- Butterworth, Chebyshev or Bessel filter for low-pass or high-pass response
- Tuned Circuit for band-pass response

(3) the filter order:
- [n=2] for band-pass
- [n=3] for low-pass & high-pass

(4) the -3 dB cutoff frequency

(5) the reference frequency (where a reference line will be drawn in the frequency response plot to show the magnitude and the phase angle of the response)

Once these parameters are entered, the user can view the frequency response (magnitude and phase) plot and see the component values computed by the program in order to determine which filter values met the above specifications.

9.4.2 Filter Block Configuration

The components of a low-pass, high-pass and band-pass filter are presented as two blocks in Figure 9-9.

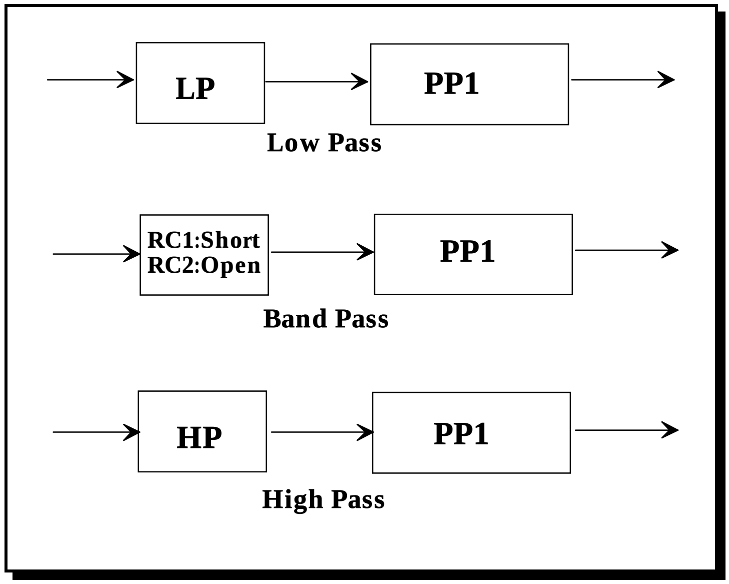

Figure 9-9. Low-pass, Band-pass and High-pass Filter Block Diagram

The FilterPro™ program will determine component values for the following variables: Rp, Cp, Rq, RF1, C1A RF2, C2A and R2A. Figure 12-10 matches the blocks from the previous diagram to corresponding locations on the QTC-450 filter blocks. The FilterPro™ component values should be inserted into the filter block positions of RC1 through RC8 as depicted in Figure 9-10.

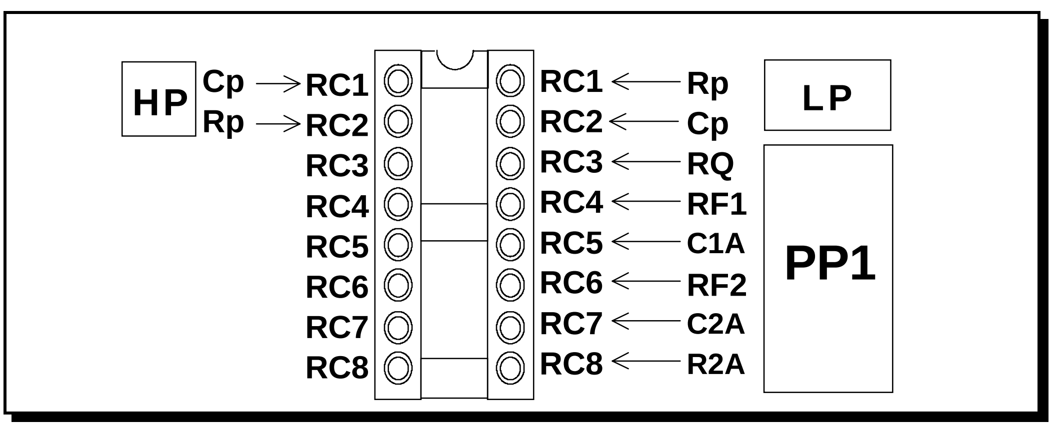

Figure 9-10. Corresponding Component Values of LP, HP and PP1

For example, if the component values of LP are Rp=316kW and Cp=0.1lF, then a 316kW resistor should be inserted in the RC1 position of the filter block and 0.1 lF capacitor should be inserted in RC2 position. As shown in Figure 9-9, for a bandpass filter the RC1 position would be shorted and the RC2 position would be open.

9.4.3 Low Pass Filter Design Examples

Table 9-2 lists the component values for third order Butterworth low-pass filters at various theoretical cutoff frequencies. The last two rows show the actual -3dB cutoff frequency and the associated phase angles.

Filter	5Hz	10Hz	50Hz	100Hz	500Hz	1kHz	
RC1 RC2	316K 0.1uF	158K 0.1uF	316K 0.01uF	158K 0.01uF	316K 1000PF	158K 1000PF	LP
RC3 RC4	 2.87M	 1.43M	 3.16M	 1,58M	 316K	 158K	
RC5 RC6	 2.87M	 1.43M	 3.16M	 1,58M	 316K	 158K	PP1
RC7 RC8							
-3dB Freq.	5.03	10.07	50.2	100.4	502	1.004K	
Phase	-134.06	-134.06	-134.06	-134.06	-134.06	-134.06	

Table 9-2. Butterworth Low Pass Filter Design Examples

9.5 QTC-450 Specifications

Connector:	DIN-48 male, mates with QTE-7, QTE-14, and QTC-450-PCS		
Signal Connection:	BNC Connector		
Signal Type:	Differential		
Number of Channels:	4		
Voltage Input Range:	±10 VDC, ±1 VDC, ±100 mVDC, ±50 mVDC, ±20 mVDC		
Input Bias Current:	20 pA typ, 100 pA max		
Input Offset Voltage:	± (0.1+0.5 / G) mV typ, ± (0.5+2.5 / G) mV max (Adjustable to zero)		
Input Offset Drift:	± (2+10 / G) lV / °C typ, ± (5+50 / G) lV / °C max		
Input Impedance:	500 GW		
Slew Rate:	12 V / ls min, 17 V / ls typ		
Gain Range:	0.5, 5, 50, 100, 250		
Gain Error:	X0.5	0.002% typ,	0.04% max
	X5	0.01% typ,	0.1% max
	X50	0.02% typ,	0.2% max
	X100	0.04% typ,	0.4% max
	X250	0.1% typ,	1% max
Gain Non linearity:	X0.5	± 0.001% of FS typ,	± 0.01% of FS max
	X5	± 0.002% of FS typ,	± 0.01% of FS max
	X50	± 0.004% of FS typ,	± 0.02% of FS max
	X100	± 0.006% of FS typ,	± 0.02% of FS max
	X250	± 0.01% of FS typ,	± 0.04% of FS max
Gain Temp. Coefficient:	X0.5	± 3 ppm / °C typ,	± 20 ppm / °C max
	X5	± 4 ppm / °C typ,	± 20 ppm / °C max
	X50	± 6 ppm / °C typ,	± 40 ppm / °C max
	X100	± 10 ppm / °C typ,	± 60 ppm / °C max
	X250	± 25 ppm / °C typ,	± 100 ppm / °C max

Common Mode Rejection:	X0.5	70 dB typ,	90 dB max
	X5	87 dB typ,	104 dB max
	X50	100 dB typ,	110 dB max
	X100	100 dB typ,	110 dB max
	X250	100 dB typ,	110 dB max
Active Filter Device:		Burr-Brown UAF42	
Filter Frequency Range:	0.1 Hz to 50 KHz		
Filter Option:	Low pass, high pass, band pass (jumper selectable)		
Types of Filters:	Bessel, Butterworth, Chebyshev, Inverse Chebyshev, Tuned Circuit		
Number of Poles:	3 for low-pass and high-pass / 2 for band-pass		
Power Requirements:	+5V ±5% @80mA		
	+15V ±5% @70mA		
	-15V ±5% @70mA		
Dimension:	160mm x 100mm		
Weight:	0.17 Kg		
Temperature Range:	0 - 70° C		

Simultaneous Sample Hold -

Acquisition Time:	10V Step to 0.01%	0.75ls typ
	10V Step to 0.1%	0.5ls typ
Bandwidth:	1MHz	
Aperture Jitter:	50 ps	
Hold Settling Time:	250ns to 1mV	
Hold Droop Rate:	0.01 lV/ls	
Hold Mode Offset:	-1mV typ	
SSH Accuracy:	±0.002% FS	
SSH Nonlinearity:	±0.03% FS Gain Error	

10 QTC-500 5B Module Multipurpose Isolated Signal Input Card

QTC-500 Features

- Eight channel Multipurpose Input
- Industry Standard 5B series compatible (easy socket and screw connections)
- Up to 256 5B modules can be configured in a system
- Optional cold junction sensor for thermocouple calibration
- Mix and Match 5B Modules: Thermocouple, RTD, Strain, Frequency, mV, V & mA
- Terminal block for quick, easy signal connections

The QTC-500 is a multipurpose input card which provides isolated input signals by utilizing 5B modules. Each installed 5B module offers 1500V isolation both from the system and other channels. Up to thirty-two QTC-500 cards can be configured in an Omega signal conditioning and data acquisition system for a total of 256 analog input channels. The QTC-500 can also be coupled with other modules in Omega's SignalPro series to provide a versatile data acquisition system.

The QTC-500 module consists of two circuit boards: the QTC-500 interface board and the QTC-500T terminal board. The interface board is a standard 3U size board which can be mounted in the QTE-7 or QTE-14 data acquisition enclosures. The QTC-500T terminal board contains the 5B module input terminal blocks. This two board configuration allows quick and easy connection of sensor lead wires. After the initial configuration of the interface board, it can be mounted in a data acquisition enclosure and will rarely require removal. All connections are completed on the screw terminals of the portable QTC-500T, which is then plugged into the interface board and secured using two thumb screws. (See Figure 10-1).

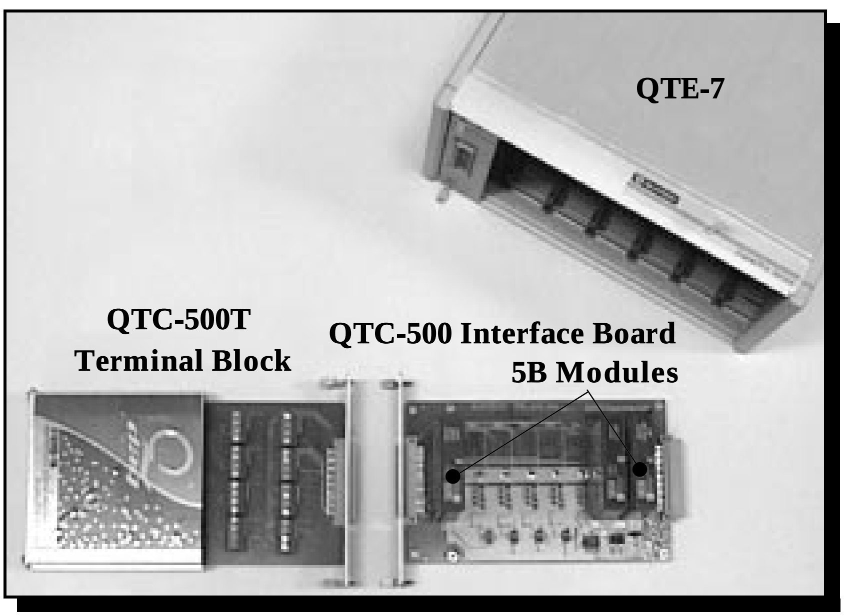

Figure 10-1. QTC-500 5B Module Multipurpose Isolated Input Card

10.1 Circuit Board Description

10.1.1 QTC-500 Interface Board Description

The QTC-500 interface board shown in Figure 10-1 can be mounted in either the QTE-7 or QTE-14 data acquisition rack enclosures. Each QTC-500 board will occupy three rack enclosure slots due to the height of the 5B modules. (See Chapter 2 for information on SignalPro series racks). Each rack enclosure is equipped with DIN-48 female connector which mates to the QTC-500 and other SignalPro series signal conditioners. The rack also contains a standard Omega D37 connector which attaches to the host computer data acquisition adapter.

10.1.2 QTC-500T/QTC-500TC Terminal Board Description

The QTC-500T terminal board shown in Figure 10-1 contains the 5B module input terminal blocks and optional current measurement resistor sockets. An optional cold junction compensation circuit is available for thermocouple calibration on terminal board model QTC-500TC. The terminal board DIN-48 male connector plugs into the QTC-500 interface board and is equipped with a strain relief bracket to secure external transducer wiring.

10.2 Hardware Configuration

For system configuration options see Chapter 1: SignalPro Series Overview, section 1.3: Hardware Configuration.

10.2.1 QTC-500 Interface Board Configuration

Figure 10-2 depicts the location of the main A/D channel and board selection jumper blocks (J1 and J2) and the eight 5B module sockets. System configuration options for J1 and J2 are discussed extensively in Chapter 1, section 1.3.

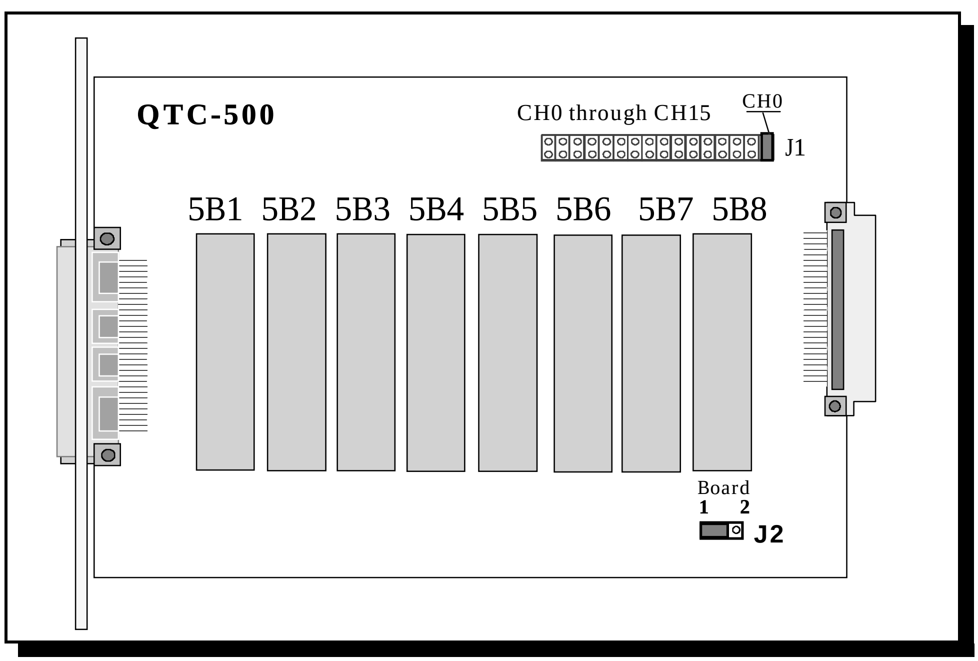

Figure 10-2. QTC-500 Jumper Block Locations

10.2.2 QTC-500T / QTC-500TC Terminal Board Configuration

The QTC-500T/500TC terminal board shown in Figure 13-3 shows the location of the 5B module terminal blocks, optional current measurement resistor sockets and the Cold Junction Compensation (CJC) temperature sensor (QTC-500TC only). The terminal board DIN-48 male connector plugs into the QTC-500 interface board and is equipped with a strain relief bracket to secure external sensor wiring.

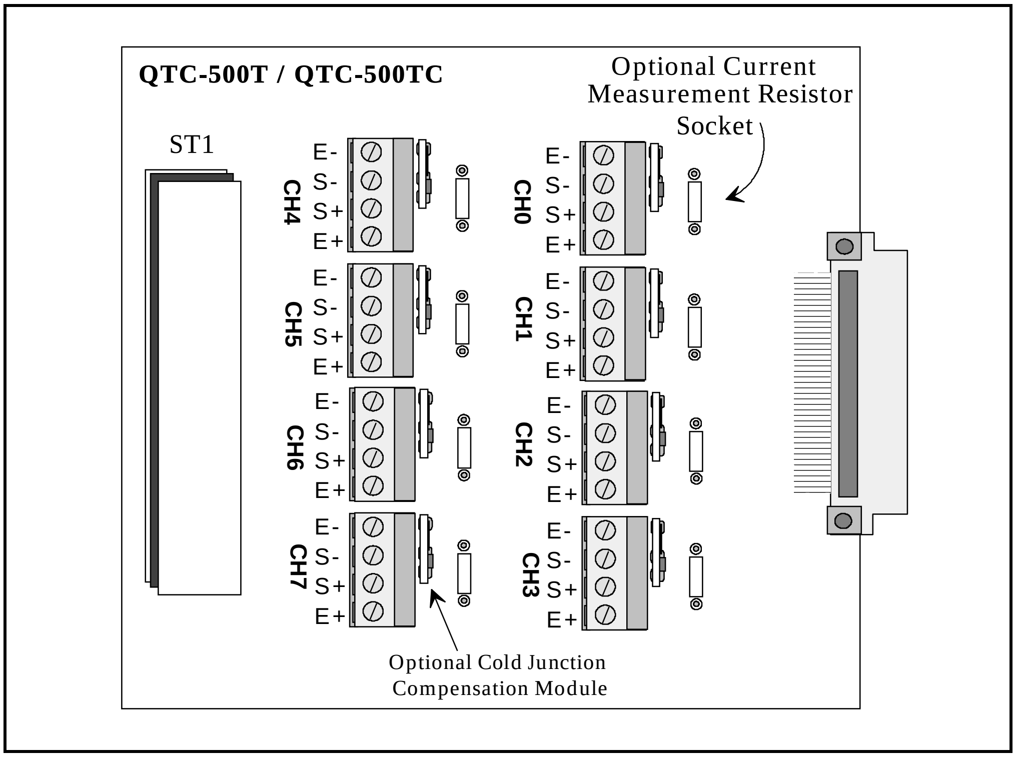

Figure 10-3. QTC-500T / QTC-500TC Terminal Board

The QTC-500TC CJC temperature sensor (AC1361) is only required by thermocouple modules such as 5B37 and 5B47. Figure 10-3 depicts the location of the optional current measurement resistor sockets provided for use with current modules of 4~20mA or 0~20mA. Eight 20 ohm ±0.1% precision resistors are included with QTC-500T/QTC-500TC for current measurement configuration. Insert the resistors into the socket by each terminal block for the specific channel(s) where current measurement configuration is desired.

10.3 Field Wiring

Each QTC-500 interface board can accommodate up to eight different 5B modules, accepting a wide variety of transducer signals such as thermocouple, RTD, mV, V, mA, frequency and strain. The transducer connections to the QTC-500T are made via four position screw terminal blocks associated with each channel. Figure 10-4 illustrates the field wiring for various 5B series modules.

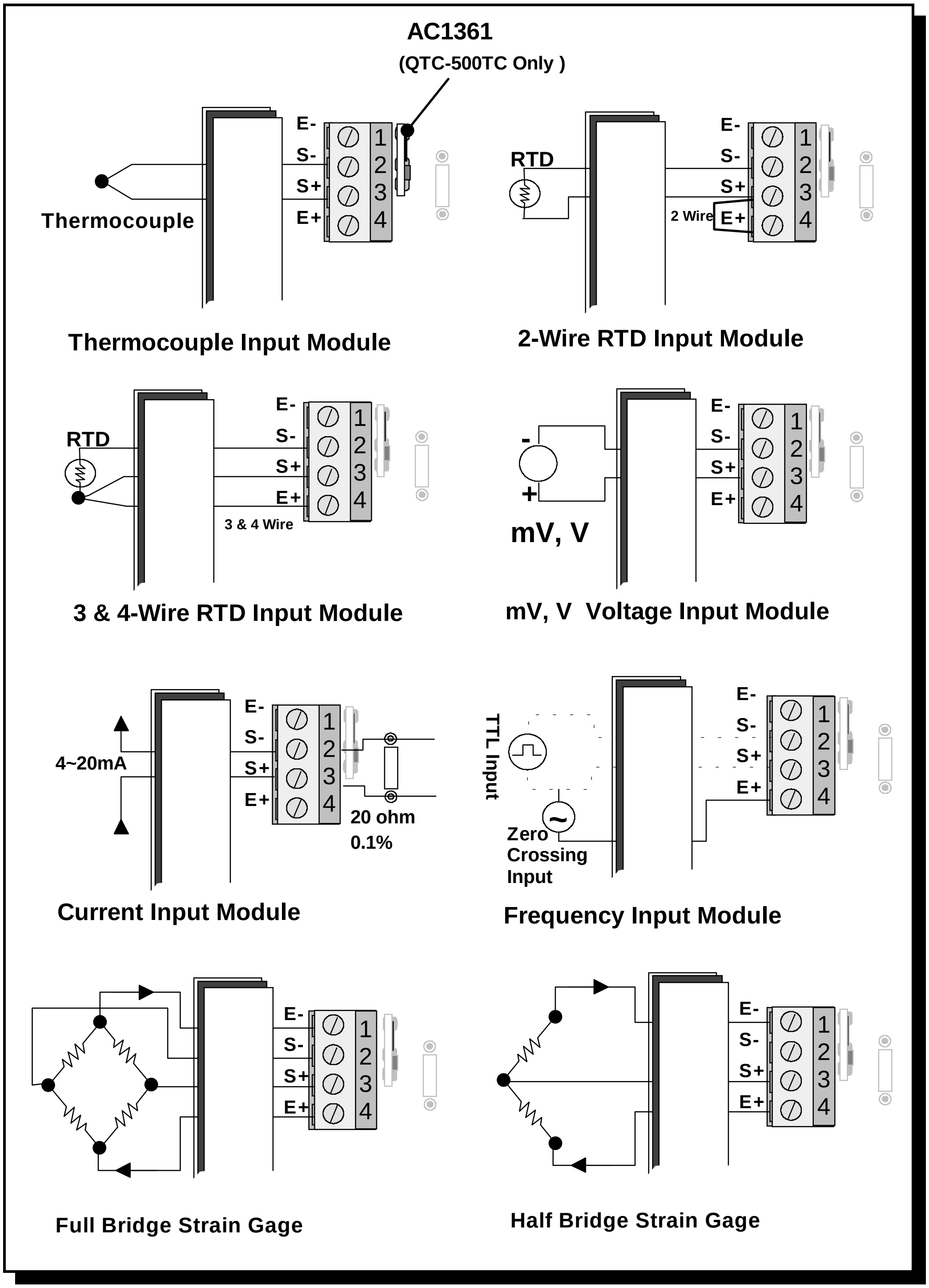

Figure 10-4. Field Wiring of 5B Series Modules

10.4 QTC-500/QTC-500T/QTC-500TC Specifications

Connector:	DIN-48 male, mates with QTC-7 and QTC-14
Signal Connection:	DIN-48 female, mates with screw terminal block for easy connection
Number of Channels:	Eight 5B module inputs
CJC Sensor	Model AC1361
CJC Accuracy:	± 0.25 °C @ +25°C,
	± 0.5 °C Over +5 °C to +45°C
Isolation:	1500 VDC (Signal inputs to system, channel-to-channel)
Power Requirements:	+5V ±5% @15mA + current requirment of 5B modules
	+15V±5% @7mA typical
	-15V±5% @7mA typical
Dimension:	160mm x 100mm x 71mm for QTC-500 100mm x 100mm x 30mm for QTC-500T / 500TC
Weight:	0.12 Kg excluding 5B modules for QTC-500 0.35 Kg for QTC-500T / 500TC
Temperature Range:	0 ~ +70 °C

SignalPro Series Users Manual
Version 1.80
January 15, 1999
Part No. 940-0135-180