SECTION 18

I/O module descriptions (select I/O modules only)

IN THIS SECTION

18.1 Analog Input module (13-Bit) - (AI-13)

The Ovation Analog Input module with an associated Personality module provides signal conditioning and analog-to-digital conversion for eight galvanically isolated analog inputs. Field inputs are surge protected and routed by the appropriate Personality module and then sent to the Electronics module for conversion.

The Analog Input module (13 bits) is applicable for CE Mark Certified Systems.

Note: *I/O Module General Information contains environmental, installation, wiring, and fuse information for I/O modules.*

18.1.1 Electronics modules (Emod) - (AI-13)

- **1C31113G01** provides voltage input range of ± 20 mV.
- **1C31113G02** provides voltage input range of ± 50 mV.
- **1C31113G03** provides voltage input range of ± 100 mV.
- **1C31113G04** provides voltage input range of ± 1 V.
- **1C31113G05** provides voltage input range of ± 5 V.
- **1C31113G06** provides voltage input range of ± 10 V.

18.1.2 Personality modules and jumper settings (Pmod) - (AI-13)

- **1C31116G01** provides voltage analog inputs.
- **1C31116G02** provides field-powered current analog inputs.
- **1C31116G03** provides locally powered current analog inputs.
- **1C31116G04** provides voltage analog inputs with a temperature sensor for cold junction thermocouple compensation**.**

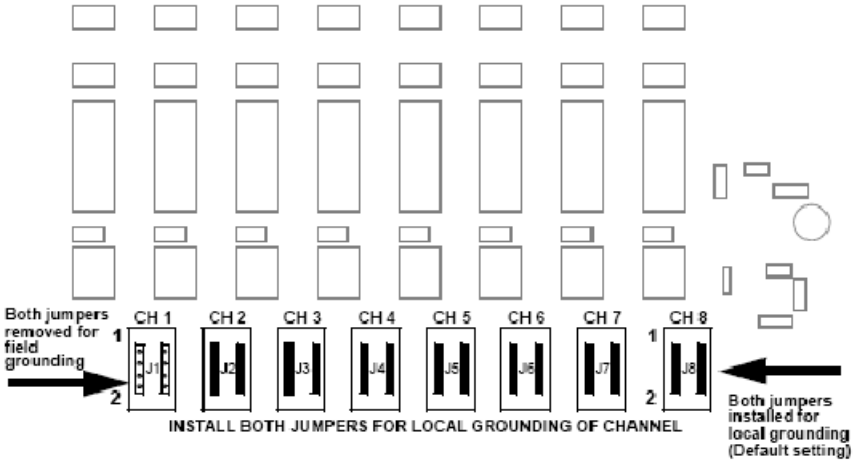


Figure 149: Jumper settings for analog input personality module (1C31116G01 & 04)

Note: *The circuit board must be removed from the module housing to access the jumpers (see page 213).*

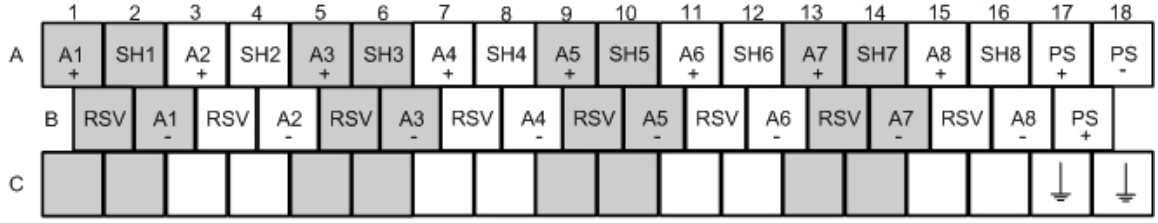
18.1.3 Terminal block wiring information - (AI-13)

Each Personality module has a simplified wiring diagram label on its side, which appears above the terminal block. This diagram indicates how to connect the wiring from the field to the terminal block in the base unit.

Note: *For the Standard I/O Marshalling Base Unit, field terminations are located on the half shells and connected to the base. See* Marshaling Base Unit *(see page 219) for more information.*

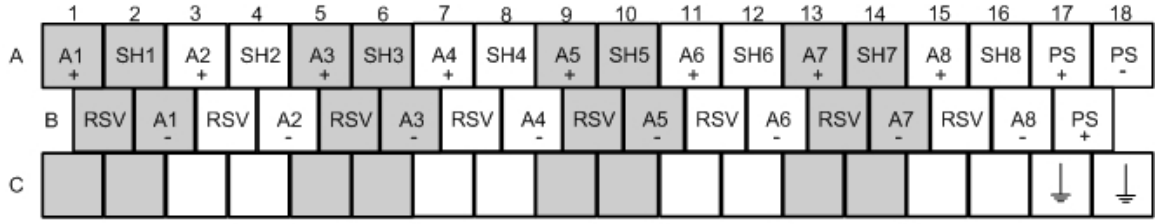
The diagrams for the analog input Personality modules are illustrated in the following figure. The following table lists and defines the abbreviations used in those diagrams.

Voltage Input: (1C31116G01)
Thermocouple Input: (1C31116G04)



Note: Internal jumpers are in this personality module for locally grounding the shield and (-) connections to earth ground.

Field Powered Current Loop: (1C31116G02)



Locally Powered Current Loop: (1C31116G03)

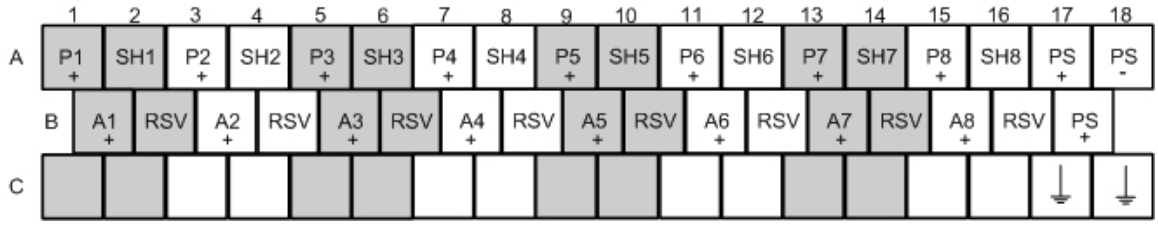
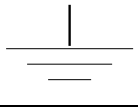


Figure 150: Terminal block connections for the Analog Input Personality modules

Shielded twisted-pair wire should be used for the field interface. For analog input signals; the (-) and shield should be tied together to earth ground either locally at the cabinet or at the field device.

Abbreviations used in diagrams

ABBREVIATION	DEFINITION
	Earth ground terminals
A1 - A8 +	Analog Input positive terminal connection
A1 - A8 -	Analog Input negative terminal connection
P1 - P8 +	Positive terminal connection for current loop power
PS+, PS-	Auxiliary power supply terminals
RSV	Reserved terminal. No connections allowed on these terminals.
SH1 - SH8	Shield terminal connection.

Note: *Do* ***not*** *use unmarked terminal block locations.*

Shield terminals (SH) are ***not*** *connected in CE Mark systems.*

18.1.4 Thermocouple Personality module functionality & coefficients - (AI-13) & (HSAI)

When two dissimilar metals (a thermocouple) are joined together, a voltage (the Seebeck Voltage) is generated between them. This voltage is directly related to the temperature at the junction of the two metals. The relationship between the voltage and the temperature can be best described by a fifth order polynomial, determined by the two types of metals that are joined.

To measure the voltage (Vt) between the two metals, a voltmeter (in this case, an analog input card) must be connected to each wire. Unfortunately, this produces two new junctions and voltages (V1 and V2) between the terminals and the thermocouples. The following formula is used to find Vt: Vt = Vm -V1 -V2.

It is not possible to measure V1 and V2 without inducing more junctions and voltages; therefore, the analog input subsystem has a temperature sensor on the Personality module (1C31116G04) to measure the temperature (Tj) at the terminal block of the base unit.

A conversion formula, determined from the junction metal and thermocouple metals, is used to calculate the combined voltage of V1 and V2. This is called **Cold Junction Compensation**.

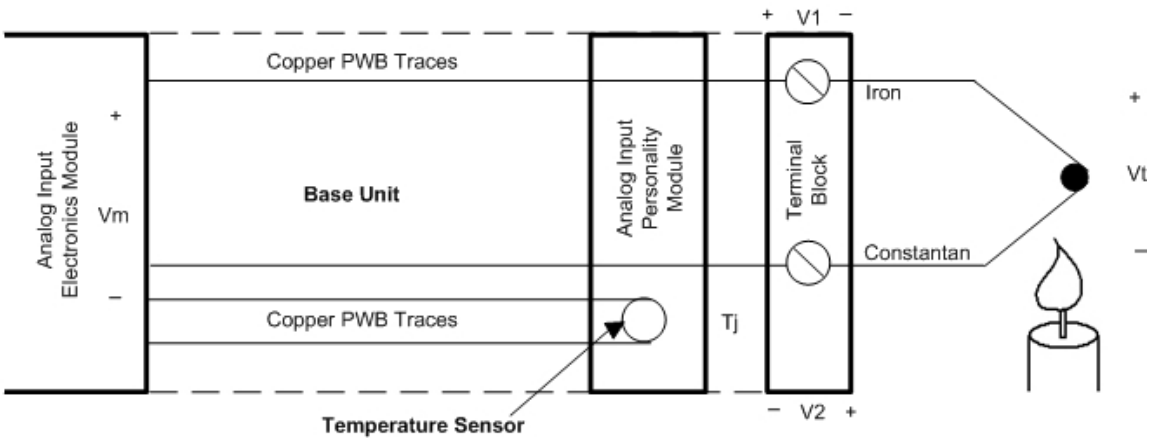


Figure 151: Thermocouple illustration

Select one of the Field Instrumentation Types. The Ovation system assigns the default thermocouple coefficients based on the Thermocouple Type selected.

If you override the default coefficients by entering new values, the new values remain **until** you select another thermocouple type. The values then return to the values for the type just selected.

The following tables list the valid thermocouple types and coefficients:

Thermocouple type B or TB

STANDARD TEMPERATURE RANGE B OR TB	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
400 to 1100 Degrees C 800 to 2000 Degrees F	0.000 to 13.814 0.006 to 13.814	0 to 1820 Degrees C 0 to 3308 Degrees F	20 mv module 20 mv module
Fahrenheit COEF_1 = 3.5164700E+02 COEF_2 = 6.1388490E+05 COEF_3 = – 1.5397740E+08 COEF_4 = 3.3593730E+10 COEF_5 = – 4.0518260E+12 COEF_6 = 2.0039330E+14 COEF_7 = – 5.7368636E-06 COEF_8 = 4.1848114E-08		**Centigrade** COEF_1 = 1.7758167E+02 COEF_2 = 3.4104717E+05 COEF_3 = – 8.5543000E+07 COEF_4 = 1.8663183E+10 COEF_5 = – 2.2510144E+12 COEF_6 = 1.1132961E+14 COEF_7 = – 4.3977239E-06 COEF_8 = 7.5326606E-08	

Thermocouple type E or TE

STANDARD TEMPERATURE RANGE E OR TE	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 18 to 286 Degrees C 0 to 550 Degrees F	– 9.835 to 19.945 – 9.835 to 19.945	– 270 to 286 Degrees C – 450 to 548 Degrees F	20 mv module 20 mv module
– 18 to 661 Degrees C 0 to 1200 Degrees F	– 9.835 to 49.992 – 9.835 to 49.956	– 270 to 661 Degrees C – 450 to 1221 Degrees F	50 mv module 50 mv module
– 18 to 1000 Degrees C 0 to 1832 Degrees F	– 9.835 to 76.358 – 9.835 to 76.358	– 270 to 1000 Degrees C – 450 to 1832 Degrees F	100 mv module 100 mv module
Fahrenheit COEF_1 = 3.1672830E+01 COEF_2 = 3.0306280E+04 COEF_3 = – 3.3449490E+05 COEF_4 = 6.8495880E+06 COEF_5 = – 6.9753490E+07 COEF_6 = 2.9236530E+08 COEF_7 = – 1.0939E-03 COEF_8 = 3.365E-05		**Centigrade** COEF_1 = – 1.8176111E-01 COEF_2 = 1.6836822E+04 COEF_3 = – 1.8583050E+05 COEF_4 = 3.8053267E+06 COEF_5 = – 3.8751939E+07 COEF_6 = 1.6242517E+08 COEF_7 = – 1.71E-05 COEF_8 = 6.057E-05	

Thermocouple type J or TJ

STANDARD TEMPERATURE RANGE J OR TJ	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 18 to 365 Degrees C – 140 to 700 Degrees F	– 8.096 to 19.971 – 8.137 to 19.977	– 210 to 366 Degrees C – 350 to 691 Degrees F	20 mv card 20 mv card
– 18 to 760 Degrees C – 140 to 1400 Degrees F	– 8.096 to 42.922 – 8.137 to 42.922	– 210 to 760 Degrees C – 350 to 1400 Degrees F	50 mv card 50 mv card
Fahrenheit COEF_1 = 3.112531E+01 COEF_2 = 3.6070270E+04 COEF_3 = – 4.2886170E+05 COEF_4 = 2.2613820E+07 COEF_5 = – 5.1743790E+08 COEF_6 = 3.9727830E+09 COEF_7 = – 9.256E-04 COEF_8 = 2.862E-05		**Centigrade** COEF_1 = – 4.8593889E-01 COEF_2 = 2.0039039E+04 COEF_3 = – 2.3825650E+05 COEF_4 = 1.2563233E+07 COEF_5 = – 2.8746550E+08 COEF_6 = 2.2071017E+09 COEF_7 = – 9.76E-06 COEF_8 = 5.1516E-05	

Thermocouple type K or TK

STANDARD TEMPERATURE RANGE K OR TK	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 18 to 480 Degrees C 0 to 900 Degrees F	– 6.458 to 19.959 – 6.456 to 19.978	– 270 to 484 Degrees C – 450 to 904 Degrees F	20 mv card 20 mv card
– 18 to 1230 Degrees C 0 to 2250 Degrees F	– 6.458 to 49.988 – 6.456 to 49.996	– 270 to 1232 Degrees C – 450 to 2250 Degrees F	50 mv card 50 mv card
– 18 to 1370 Degrees C 0 to 2500 Degrees F	– 6.458 to 54.875 – 6.456 to 54.845	– 270 to 1372 Degrees C – 450 to 2500 Degrees F	100 mv card 100 mv card
Fahrenheit COEF_1 = 3.0344730E+01 COEF_2 = 4.4031910E+04 COEF_3 = 1.615839E+05 COEF_4 = – 1.616257E+07 COEF_5 = 4.4011090E+08 COEF_6 = – 3.599650E+09 COEF_7 = – 7.259E-04 COEF_8 = 2.243E-05		**Centigrade** COEF_1 = – 9.1959444E-01 COEF_2 = 2.4462172E+04 COEF_3 = 8.9768833E+04 COEF_4 = – 8.9792056E+06 COEF_5 = 2.4450606E+08 COEF_6 = – 1.9998056E+09 COEF_7 = – 8.14E-06 COEF_8 = 4.0374E-05	

Thermocouple type N or TN

STANDARD TEMPERATURE RANGE N OR TN	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 270 to 584 Degrees C – 454 to 1083 Degrees F	– 4.345 to 19.990 – 4.345 to 19.990	– 270 to 584 Degrees C – 454 to 1083 Degrees F	20 mv card 20 mv card
– 270 to 1300 Degrees C – 454 to 2372 Degrees F	– 4.345 to 47.514 – 4.345 to 47.514	– 270 to 1300 Degrees C – 454 to 2372 Degrees F	50 mv card 50 mv card
Fahrenheit COEF_1 = 2.7795251549E+01 COEF_2 = 7.6249124464E+04 COEF_3 = – 2.8626852972E+06 COEF_4 = 1.3017695115E+08 COEF_5 = – 2.7644988772E+09 COEF_6 = 2.1988892938E+10 COEF_7 = – 4.8744444444E-04 COEF_8 = 1.4888888888E-05		**Centigrade** COEF_1 = – 2.3359713617E+00 COEF_2 = 4.2360624702E+04 COEF_3 = – 1.5903807207E+06 COEF_4 = 7.2320528414E+07 COEF_5 = – 1.5358327096E+09 COEF_6 = 1.2216051632E+10 COEF_7 = – 1.1000000000E-05 COEF_8 = 2.6800000000E-05	

Thermocouple type R or TR

STANDARD TEMPERATURE RANGE R OR TR	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
260 to 1100 Degrees C 500 to 2000 Degrees F	0.000 to 19.998 0.089 to 19.997	0 to 1684 Degrees C 0 to 3063 Degrees F	20 mv card 20 mv card
Fahrenheit COEF_1 = 8.3628480E+01 COEF_2 = 2.2737160E+05 COEF_3 = – 1.2482860E+07 COEF_4 = 1.2062540E+09 COEF_5 = – 7.4221280E+10 COEF_6 = 1.89930000E+12 COEF_7 = – 1.084E-04 COEF_8 = 3.24E-06		**Centigrade** COEF_1 = 2.8682489E+01 COEF_2 = 1.2631756E+05 COEF_3 = – 6.9349222E+06 COEF_4 = 6.7014111E+08 COEF_5 = – 4.1234044E+10 COEF_6 = 1.0551667E+12 COEF_7 = – 4.72E-06 COEF_8 = 5.832E-06	

Thermocouple type S or TS

STANDARD TEMPERATURE RANGE S OR TS	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
400 to 1100 Degrees C 750 to 2000 Degrees F	0.000 to 18.698 -0.092 to 18.696	0 to 1768 Degrees C 0 to 3214 Degrees F	20 mv card 20 mv card

STANDARD TEMPERATURE RANGE S OR TS	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
Fahrenheit COEF_1 = 1.1803440E+02 COEF_2 = 1.9859180E+05 COEF_3 = – 1.9730960E+04 COEF_4 = – 5.0093290E+08 COEF_5 = 4.1104880E+10 COEF_6 = – 1.1557940E+12 COEF_7 = – 1.0847E-04 COEF_8 = 3.26E-06		**Centigrade** COEF_1 = 4.7796889E+01 COEF_2 = 1.1032878E+05 COEF_3 = – 1.0961644E+04 COEF_4 = – 2.7829606E+08 COEF_5 = 2.2836044E+10 COEF_6 = – 6.4210778E+11 COEF_7 = – 4.15E-06 COEF_8 = 5.868E-06	

Thermocouple type T or TT

STANDARD TEMPERATURE RANGE T OR TT	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
-46 to 400 Degrees C -50 to 750 Degrees F	-6.258 to 19.945 -6.254 to 19.979	-270 to 385 Degrees C -450 to 726 Degrees F	20 mv card 20 mv card
Fahrenheit COEF_1 = 3.1892240E+01 COEF_2 = 4.6693280E+04 COEF_3 = – 1.3257390E+06 COEF_4 = 6.9620670E+07 COEF_5 = – 2.3278080E+09 COEF_6 = 3.3306460E+10 COEF_7 = – 7.3333E-04 COEF_8 = 2.243E-05		**Centigrade** COEF_1 = – 5.9866667E-02 COEF_2 = 2.5940711E+04 COEF_3 = – 7.3652167E+05 COEF_4 = 3.8678150E+07 COEF_5 = – 1.2932267E+09 COEF_6 = 1.8503589E+10 COEF_7 = – 1.55700E-05 COEF_8 = 4.0374E-05	

18.1.5 Register configuration/address information - (AI-13)

Word address 13 (D in Hex) is used to configure the module and provide status information to the Controller. The status register can be read by using the Point Information window at an Operator Station (see the Bit Pattern field on the Hardware tab). (See the *Ovation Operator Station User Guide*.)

Analog Input configuration/status register (address 13 or D in Hex)

BIT	DATA DESCRIPTION - CONFIGURATION REGISTER (WRITE)	DATA DESCRIPTION - STATUS REGISTER (READ)
0	Configure module	Module Configured (1 = configured; 0 = unconfigured)
1	Force Error	Internal or forced error (1 = forced error; 0 = no forced error)
2 - 6	Not Used	Not Used (0)
7	Not Used	EEPROM Checksum Error - Module Uncalibrated (1 = error; 0 = no error)
8	50/60 Hz Selection (0 = 60Hz, 1 = 50Hz)	50 Hz/60 Hz System (0 = 60Hz; 1 = 50Hz)

BIT	DATA DESCRIPTION - CONFIGURATION REGISTER (WRITE)	DATA DESCRIPTION - STATUS REGISTER (READ)
9	Use Line Sync if Present (1 = use)	Using Line Sync
10	Not Used	Line Frequency Tracking Active
11	Not Used	EE PROM Program Enabled
12	Not Used	PSD Generator Malfunction
13	Not Used	Internal Memory Error (EPROM Checksum or Static RAM Error)
14	Not Used	Temperature Sensor Failure
15	Not Used	Point Fault [1]
[1] Refer to Point Quality registers for descriptions of the Point Faults.		

Bit 0: This bit configures the module (write) or indicates the configuration state of the module (read). A “1” indicates that the module is configured. Note that until the module is configured, accessing addresses 0 through 11 (B in Hex) produces an attention status.

Bit 1: This bit (write “1”) forces the module into its error state, resulting in the error LED being lit. The read of bit 1 indicates the error state of the module, with “1” indicating that there is an internal error in the module or the Controller has forced the module into an error state. The state of this bit is always reflected by the module's Internal Error LED. Whenever this bit is set, an attention status is returned to the Controller when the point data is read (that is, accessing addresses 0 through 11).

Bits 2 - 6: These bits are “not used” values and are read as “0” under normal operation.

Bit 7: This bit is the result of a checksum test of the EEPROM. A failure of this test can indicate a bad EEPROM, but typically indicates that the module has not been calibrated. A “0” indicates that there is no error condition. If this error is present, the error is indicated by the module error LED being lit and the module does not process the point information. The point fault bit is also set as all the point data is uncalibrated. When this error is present, no other processing takes place. The “1” state of this bit indicates an unrecoverable error condition in the field.

Bit 8: This bit indicates if the on-board integrating timebase is 80 msec (4 line cycles of a 50 Hz system) or 83.3 msec (5 line cycles of a 60 Hz system). A “0” indicates that the timebase is 83.3 msec (60 Hz line frequency) and is the default setting.

Bit 9: This bit indicates whether to use the line frequency tracking if it is present. A write of “1” indicates to use the tracking input. A read of “1” indicates that the module is using the tracking input. The default state is a “0.”

Note: *Line frequency tracking is presently* ***NOT*** *supported by the Ovation I/O system.*

Bit 10: This bit indicates whether the line frequency tracking signal is present and active for greater normal and common mode rejection. A “0” indicates that the line frequency tracking signal is NOT present.

Bit 11: This bit indicates whether the hardware EEPROM PE signal is active. A “0” indicates that the module is in normal operating mode and calibration and ID programming commands are not processed.

Bit 12: This bit reflects the detection of the internal 625 KHz PSD signal at module initialization. This verifies that the multifunction FPGA and the microcontroller's timer 0 are functioning. A “0” indicates that there is no error condition. A “1” indicates an unrecoverable error condition in the field.

Bit 13: This bit is a basic check of program and data memory, along with the microcontroller's data, address, and control buses. A “0” indicates that there is no error condition. A “1” indicates an unrecoverable error condition in the field.

Bit 14: This bit indicates the fault status of the digital temperature sensor. A “0” indicates the sensor is present and communicating properly with the microcontroller. A “1” indicates a fault exists; either there is no sensor present, or problems exist in communicating with the sensor. On an uncalibrated module, a sensor failure is always reported because the uncalibrated status prevents the sensor from being checked.

Bit 15: This bit indicates the point fault status of the module. It is the logical “OR” of the eight individual point quality statuses plus bits 1, 7, 12, and 13 of this register. A “0” indicates that all eight points have good quality and no module errors exist. A “1” indicates that at least one of the points has bad quality and is therefore in fault.

A subsequent read of the Point Quality status register at Address 12 (C in Hex) reveals which of the eight points has bad quality and the cause of the bad quality condition. The Address 12 (C in Hex) Point Quality Status Register contains data only when the module fault is due to a bad point quality; that is, bits 7, 12, and 13 of this register or the forced error bit are not set. Note that the Temperature Sensor (Address 8) status is treated separately and is not included in this module point fault bit.

Word address 12 (C in Hex) serves the purpose of reporting the point quality of the eight channel inputs. The bit definitions for this register are encoded as shown in the following table.

Point Quality register (address 12 or C in Hex)

POINT	BIT	DESCRIPTION
1 - 8	0, 2, 4, 6, 8, 10, 12, 14	Auto Calibration Reasonability Check Failed
1 - 8	1, 3, 5, 7, 9, 11, 13, 15	Overrange Input/Blown Fuse/Open Loop/Open Thermocouple

Auto Calibration Reasonability Check Failed - This bit is set when the auto calibration zero or reference reading is out of tolerance (±6% of the nominal reading).

Overrange Input/Blown Fuse/Open Loop/Open Thermocouple - This bit is set under the following conditions:

- **Voltage Input Configuration** (all groups) - when an overrange input of ±125% of the full scale value is read on the input.
- **Current Input Configuration** (Group 5) - when an input less than 2.5mA (a blown fuse or open loop condition) is detected or an overrange of greater than 25mA of full scale is present.

Secondary configuration/status register (address 14 or E in Hex)

BIT	DATA DESCRIPTION - CURRENT/VOLTAGE CONFIGURATION (WRITE)	DATA DESCRIPTION - CURRENT/VOLTAGE STATUS (READ)
0 - 7	Select Point 1 - 8 Current/Voltage (1 = Current)	Select Point 1 - 8 Current/Voltage (1 = Current)
8 - 15	Not Used	Point 1 - 8 Current Blown Fuse (1 = Blown)

Word address 14 (E in Hex) serves the purpose of the Current/Voltage Configuration/Status Register. The bit definitions for this register are encoded as shown in the following table.

The default state of the register under normal operation is “0” for voltage inputs. The lower 8 bits are configuration bits which are written to and read from the module. The upper 8 bits are read-only status bits indicating the blown fuse status only for those channels which have been configured as current inputs.

18.1.6 Diagnostic Logic card LEDs - (AI-13, AI-14 & HSAI)

LED	DESCRIPTION
P (green)	Power OK LED. Lit when the +5V power is OK.
C (green)	Communication OK LED. Lit when the Ovation Controller is communicating with the module.
E	No LED.
I (Red)	Internal Error LED. Lit whenever there is any type of error with the module **except** for a loss of power. Possible causes are: ▪ Module initialization is in progress. ▪ I/O Bus timeout has occurred. ▪ Internal hardware error. ▪ Module reset ▪ Module is uncalibrated. ▪ Forced error has been received from the Controller. ▪ Communication between the Field and Logic boards failed.
1 - 8 (Red)	Channel error. Lit whenever there is an error associated with a channel or channels. Possible causes are: ▪ Positive overrange: Input voltage greater than +121% of full scale value (for modules configured as voltage input). ▪ Negative overrange: Input voltage less than -121% of full scale value (for modules configured as voltage input). ▪ Current loop out of range ▪ Calibration readings out of range.
9 - 16	No LED.

18.1.7 Specifications - (AI-13)

Electronics module (1C31113)
Personality module (1C31116)

DESCRIPTION	VALUE
Number of channels	8
Input range [1]	G01: ±20 mv G02: ±50 mv G03: ±100 mv G04: ±1 V G05: ±5 V [2] G06: ±10 V
Resolution	13-Bit (including polarity)
Data format	13-bit, two's complement, and error indicator bits
Conversion type	Sigma Delta
Operating mode	Self-scan
Monotonicity	Yes
Non-linearity	0.003% of full scale
Repeatability	Within guaranteed accuracy
Guaranteed accuracy (@25°C)	Accuracy over -25% to 100% range of full scale input level: ▪ ±0.10% of upper range value ±10μV ±1/2LSB @99.7% confidence. ▪ Accuracy over -100% to -25% range of full scale input level: ▪ ±0.15% of upper range value ±10μV ±1/2LSB @99.7% confidence.
Temperature coefficient	±0.24% of the upper range value ±24μV over 0 to 60°C.
Input impedance: [3] Groups G01 through G05 Group G06 (± 10V input only)	 10 M-ohms 2 M-ohms
Maximum overload	G01 - G03: ±10 Vdc or Vrms G04 - G06: ±120 Vdc or Vrms
Sample duration time (msec)	50 Hz configuration : 80 60 Hz configuration: 83.33
Sample repetition (msec)	50 Hz configuration : 80 60 Hz configuration: 83.33
Filtering	Digital, Sinc, 3dB cutoff: 13.1 Hz for 50 Hz, 15.7 Hz for 60 Hz
Offset and gain temperature drift compensation	Automatic
Diagnostics	Internal module operating faults. ▪ Out of range detection. ▪ Open thermocouple detection for thermocouple inputs. ▪ Open loop/blown fuse detection for current inputs.
Dielectric isolation: Channel to channel Channel to logic	 1000 V AC/DC 1000 V AC/DC

DESCRIPTION	VALUE
Normal mode rejection	60 dB at 50 Hz ± 1/2% or 60 Hz ± 1/2% 30 dB (typical) at 50 Hz ± 5% or 60 Hz ± 5%
Common mode rejection and channel to channel crosstalk	120 dB at DC, power line frequency and its harmonics ± 1/2% tracking. 100 dB (typical) for nominal line frequency ± 5% and harmonics.
Module power	Main: 2.5 W typical; 3.38 W Maximum Aux: When used (1C31116G03) Aux power supply voltage = 24 V DC 3.84 W typical (8 inputs @ 20mA each)
Operating temperature range	0 to 60°C (32°F to 140°F)
Storage temperature range	-40°C to 85°C (-40°F to 185°F)
Humidity (non-condensing)	0 to 95%

[1] Ranges are available through separate modules.

[2] Current inputs when using Personality module 1C31116G02 or 1C31116G03 with ± 5V Electronics module.

The input range 0 to 20 mA is also available, but if selected, blown fuse detection will be disabled. If you select 0 to 20 mA, the software adds a suffix “A” to the Personality module identification. This “A” is not displayed, it is only used by the database to differentiate between 0 to 20 mA and 4 to 20 mA, in order to generate correct coefficients.

[3] Only for modules used with voltage input Personality modules (1C1116G01 and 1C1116G04).

18.2 High Speed Analog Input module (14-Bit) - (HSAI)

The combined Personality and Electronics modules form the High Speed Analog Input module. Eight sets of galvanically isolated input channels provide 14-bit resolution with 50 or 60 samples per second conversion rates. The input signals are conditioned and routed through the appropriate Personality module to the Electronics module. The Personality module also provides surge protection to protect the input circuits of the Electronics module. The Electronics module performs the analog to digital conversions and provides interfacing to the Ovation Serial I/O Bus.

The 14-Bit High Speed Analog Input is applicable for CE Mark certified systems.

Note: *I/O Module General Information contains information on for environmental, installation, wiring, and fuse information for I/O modules.*

18.2.1 Electronics modules (Emod) - (HSAI)

- **5X00070G01** interfaces to current signals with an input range of 4 to 20 mA.
- **5X00070G02** interfaces to voltage signals with an input range of ±1V, ±250mV, ±100mV.
- **5X00070G03** interfaces to voltage signals with an input range of ±5V, ±10V.
- **5X00070G04** interfaces to thermocouple inputs ± 20mV, ± 50Vm, ± 100mV.
- **5X00070G05** interfaces to thermocouple inputs ± 20mV, ± 50Vm, ± 100mV, (Non-EMC Cabinet).

18.2.2 Personality modules (Pmod) - (HSAI)

- **1C31227G01** interfaces to current input with an input range of 4 - 20 mA.
- **1C31227G02** voltage input.
- **1C31116G02** field powered current input ± 1mA.
- **1C31116G03** local powered ± 1mA current only.
- **1C31116G04** voltage inputs to temperature sensor.

18.2.3 Thermocouple Personality module functionality & coefficients - (AI-13) & (HSAI)

When two dissimilar metals (a thermocouple) are joined together, a voltage (the Seebeck Voltage) is generated between them. This voltage is directly related to the temperature at the junction of the two metals. The relationship between the voltage and the temperature can be best described by a fifth order polynomial, determined by the two types of metals that are joined.

To measure the voltage (Vt) between the two metals, a voltmeter (in this case, an analog input card) must be connected to each wire. Unfortunately, this produces two new junctions and voltages (V1 and V2) between the terminals and the thermocouples. The following formula is used to find Vt: Vt = Vm -V1 -V2.

It is not possible to measure V1 and V2 without inducing more junctions and voltages; therefore, the analog input subsystem has a temperature sensor on the Personality module (1C31116G04) to measure the temperature (Tj) at the terminal block of the base unit.

A conversion formula, determined from the junction metal and thermocouple metals, is used to calculate the combined voltage of V1 and V2. This is called **Cold Junction Compensation**.

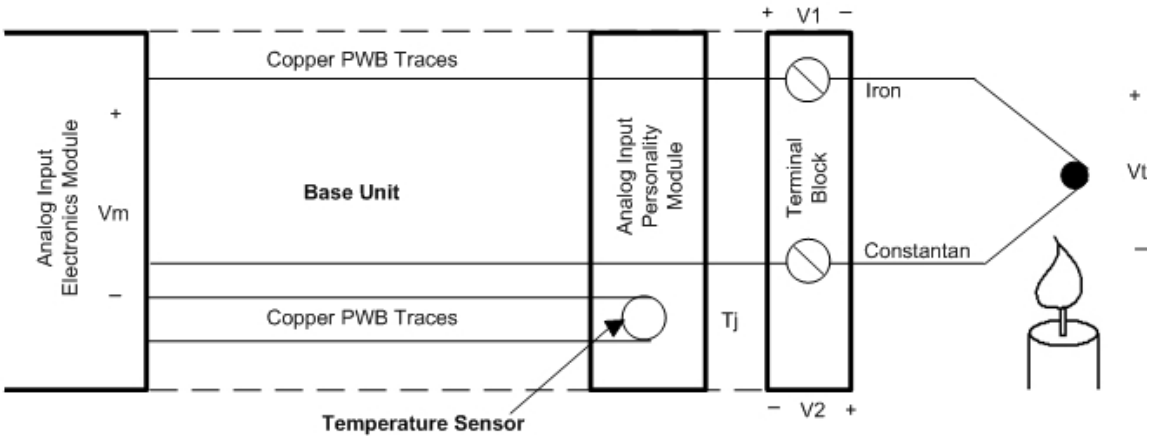


Figure 152: Thermocouple illustration

Select one of the Field Instrumentation Types. The Ovation system assigns the default thermocouple coefficients based on the Thermocouple Type selected.

If you override the default coefficients by entering new values, the new values remain **until** you select another thermocouple type. The values then return to the values for the type just selected.

The following tables list the valid thermocouple types and coefficients:

Thermocouple type B or TB

STANDARD TEMPERATURE RANGE B OR TB	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
400 to 1100 Degrees C 800 to 2000 Degrees F	0.000 to 13.814 0.006 to 13.814	0 to 1820 Degrees C 0 to 3308 Degrees F	20 mv module 20 mv module
Fahrenheit COEF_1 = 3.5164700E+02 COEF_2 = 6.1388490E+05 COEF_3 = – 1.5397740E+08 COEF_4 = 3.3593730E+10 COEF_5 = – 4.0518260E+12 COEF_6 = 2.0039330E+14 COEF_7 = – 5.7368636E-06 COEF_8 = 4.1848114E-08		**Centigrade** COEF_1 = 1.7758167E+02 COEF_2 = 3.4104717E+05 COEF_3 = – 8.5543000E+07 COEF_4 = 1.8663183E+10 COEF_5 = – 2.2510144E+12 COEF_6 = 1.1132961E+14 COEF_7 = – 4.3977239E-06 COEF_8 = 7.5326606E-08	

Thermocouple type E or TE

STANDARD TEMPERATURE RANGE E OR TE	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 18 to 286 Degrees C 0 to 550 Degrees F	– 9.835 to 19.945 – 9.835 to 19.945	– 270 to 286 Degrees C – 450 to 548 Degrees F	20 mv module 20 mv module
– 18 to 661 Degrees C 0 to 1200 Degrees F	– 9.835 to 49.992 – 9.835 to 49.956	– 270 to 661 Degrees C – 450 to 1221 Degrees F	50 mv module 50 mv module
– 18 to 1000 Degrees C 0 to 1832 Degrees F	– 9.835 to 76.358 – 9.835 to 76.358	– 270 to 1000 Degrees C – 450 to 1832 Degrees F	100 mv module 100 mv module
Fahrenheit COEF_1 = 3.1672830E+01 COEF_2 = 3.0306280E+04 COEF_3 = – 3.3449490E+05 COEF_4 = 6.8495880E+06 COEF_5 = – 6.9753490E+07 COEF_6 = 2.9236530E+08 COEF_7 = – 1.0939E-03 COEF_8 = 3.365E-05		**Centigrade** COEF_1 = – 1.8176111E-01 COEF_2 = 1.6836822E+04 COEF_3 = – 1.8583050E+05 COEF_4 = 3.8053267E+06 COEF_5 = – 3.8751939E+07 COEF_6 = 1.6242517E+08 COEF_7 = – 1.71E-05 COEF_8 = 6.057E-05	

Thermocouple type J or TJ

STANDARD TEMPERATURE RANGE J OR TJ	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 18 to 365 Degrees C – 140 to 700 Degrees F	– 8.096 to 19.971 – 8.137 to 19.977	– 210 to 366 Degrees C – 350 to 691 Degrees F	20 mv card 20 mv card
– 18 to 760 Degrees C – 140 to 1400 Degrees F	– 8.096 to 42.922 – 8.137 to 42.922	– 210 to 760 Degrees C – 350 to 1400 Degrees F	50 mv card 50 mv card
Fahrenheit COEF_1 = 3.112531E+01 COEF_2 = 3.6070270E+04 COEF_3 = – 4.2886170E+05 COEF_4 = 2.2613820E+07 COEF_5 = – 5.1743790E+08 COEF_6 = 3.9727830E+09 COEF_7 = – 9.256E-04 COEF_8 = 2.862E-05		**Centigrade** COEF_1 = – 4.8593889E-01 COEF_2 = 2.0039039E+04 COEF_3 = – 2.3825650E+05 COEF_4 = 1.2563233E+07 COEF_5 = – 2.8746550E+08 COEF_6 = 2.2071017E+09 COEF_7 = – 9.76E-06 COEF_8 = 5.1516E-05	

Thermocouple type K or TK

STANDARD TEMPERATURE RANGE K OR TK	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 18 to 480 Degrees C 0 to 900 Degrees F	– 6.458 to 19.959 – 6.456 to 19.978	– 270 to 484 Degrees C – 450 to 904 Degrees F	20 mv card 20 mv card
– 18 to 1230 Degrees C 0 to 2250 Degrees F	– 6.458 to 49.988 – 6.456 to 49.996	– 270 to 1232 Degrees C – 450 to 2250 Degrees F	50 mv card 50 mv card
– 18 to 1370 Degrees C 0 to 2500 Degrees F	– 6.458 to 54.875 – 6.456 to 54.845	– 270 to 1372 Degrees C – 450 to 2500 Degrees F	100 mv card 100 mv card
Fahrenheit COEF_1 = 3.0344730E+01 COEF_2 = 4.4031910E+04 COEF_3 = 1.615839E+05 COEF_4 = – 1.616257E+07 COEF_5 = 4.4011090E+08 COEF_6 = – 3.599650E+09 COEF_7 = – 7.259E-04 COEF_8 = 2.243E-05		**Centigrade** COEF_1 = – 9.1959444E-01 COEF_2 = 2.4462172E+04 COEF_3 = 8.9768833E+04 COEF_4 = – 8.9792056E+06 COEF_5 = 2.4450606E+08 COEF_6 = – 1.9998056E+09 COEF_7 = – 8.14E-06 COEF_8 = 4.0374E-05	

Thermocouple type N or TN

STANDARD TEMPERATURE RANGE N OR TN	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
– 270 to 584 Degrees C – 454 to 1083 Degrees F	– 4.345 to 19.990 – 4.345 to 19.990	– 270 to 584 Degrees C – 454 to 1083 Degrees F	20 mv card 20 mv card
– 270 to 1300 Degrees C – 454 to 2372 Degrees F	– 4.345 to 47.514 – 4.345 to 47.514	– 270 to 1300 Degrees C – 454 to 2372 Degrees F	50 mv card 50 mv card

STANDARD TEMPERATURE RANGE N OR TN	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
Fahrenheit COEF_1 = 2.7795251549E+01 COEF_2 = 7.6249124464E+04 COEF_3 = – 2.8626852972E+06 COEF_4 = 1.3017695115E+08 COEF_5 = – 2.7644988772E+09 COEF_6 = 2.1988892938E+10 COEF_7 = – 4.8744444444E-04 COEF_8 = 1.4888888888E-05		**Centigrade** COEF_1 = – 2.3359713617E+00 COEF_2 = 4.2360624702E+04 COEF_3 = – 1.5903807207E+06 COEF_4 = 7.2320528414E+07 COEF_5 = – 1.5358327096E+09 COEF_6 = 1.2216051632E+10 COEF_7 = – 1.1000000000E-05 COEF_8 = 2.6800000000E-05	

Thermocouple type R or TR

STANDARD TEMPERATURE RANGE R OR TR	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
260 to 1100 Degrees C 500 to 2000 Degrees F	0.000 to 19.998 0.089 to 19.997	0 to 1684 Degrees C 0 to 3063 Degrees F	20 mv card 20 mv card
Fahrenheit COEF_1 = 8.3628480E+01 COEF_2 = 2.2737160E+05 COEF_3 = – 1.2482860E+07 COEF_4 = 1.2062540E+09 COEF_5 = – 7.4221280E+10 COEF_6 = 1.89930000E+12 COEF_7 = – 1.084E-04 COEF_8 = 3.24E-06		**Centigrade** COEF_1 = 2.8682489E+01 COEF_2 = 1.2631756E+05 COEF_3 = – 6.9349222E+06 COEF_4 = 6.7014111E+08 COEF_5 = – 4.1234044E+10 COEF_6 = 1.0551667E+12 COEF_7 = – 4.72E-06 COEF_8 = 5.832E-06	

Thermocouple type S or TS

STANDARD TEMPERATURE RANGE S OR TS	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
400 to 1100 Degrees C 750 to 2000 Degrees F	0.000 to 18.698 -0.092 to 18.696	0 to 1768 Degrees C 0 to 3214 Degrees F	20 mv card 20 mv card
Fahrenheit COEF_1 = 1.1803440E+02 COEF_2 = 1.9859180E+05 COEF_3 = – 1.9730960E+04 COEF_4 = – 5.0093290E+08 COEF_5 = 4.1104880E+10 COEF_6 = – 1.1557940E+12 COEF_7 = – 1.0847E-04 COEF_8 = 3.26E-06		**Centigrade** COEF_1 = 4.7796889E+01 COEF_2 = 1.1032878E+05 COEF_3 = – 1.0961644E+04 COEF_4 = – 2.7829606E+08 COEF_5 = 2.2836044E+10 COEF_6 = – 6.4210778E+11 COEF_7 = – 4.15E-06 COEF_8 = 5.868E-06	

Thermocouple type T or TT

STANDARD TEMPERATURE RANGE T OR TT	MILLIVOLT RANGE	TEMPERATURE RANGE	BEST FIT
-46 to 400 Degrees C -50 to 750 Degrees F	-6.258 to 19.945 -6.254 to 19.979	-270 to 385 Degrees C -450 to 726 Degrees F	20 mv card 20 mv card
Fahrenheit COEF_1 = 3.1892240E+01 COEF_2 = 4.6693280E+04 COEF_3 = – 1.3257390E+06 COEF_4 = 6.9620670E+07 COEF_5 = – 2.3278080E+09 COEF_6 = 3.3306460E+10 COEF_7 = – 7.3333E-04 COEF_8 = 2.243E-05		**Centigrade** COEF_1 = – 5.9866667E-02 COEF_2 = 2.5940711E+04 COEF_3 = – 7.3652167E+05 COEF_4 = 3.8678150E+07 COEF_5 = – 1.2932267E+09 COEF_6 = 1.8503589E+10 COEF_7 = – 1.55700E-05 COEF_8 = 4.0374E-05	

18.2.4 Terminal block wiring information - (HSAI)

Each Personality module has a simplified wiring diagram label on its side, which appears above the terminal block. This diagram indicates how to connect the wiring from the field to the terminal block in the base unit.

Note: *For the Standard I/O Marshalling Base Unit, field terminations are located on the half shells and connected to the base. See* Marshaling Base Unit *(see page 219) for more information.*

The diagrams for the analog input Personality modules are illustrated in the field connections diagrams. The following table lists and defines the abbreviations used in those diagrams.

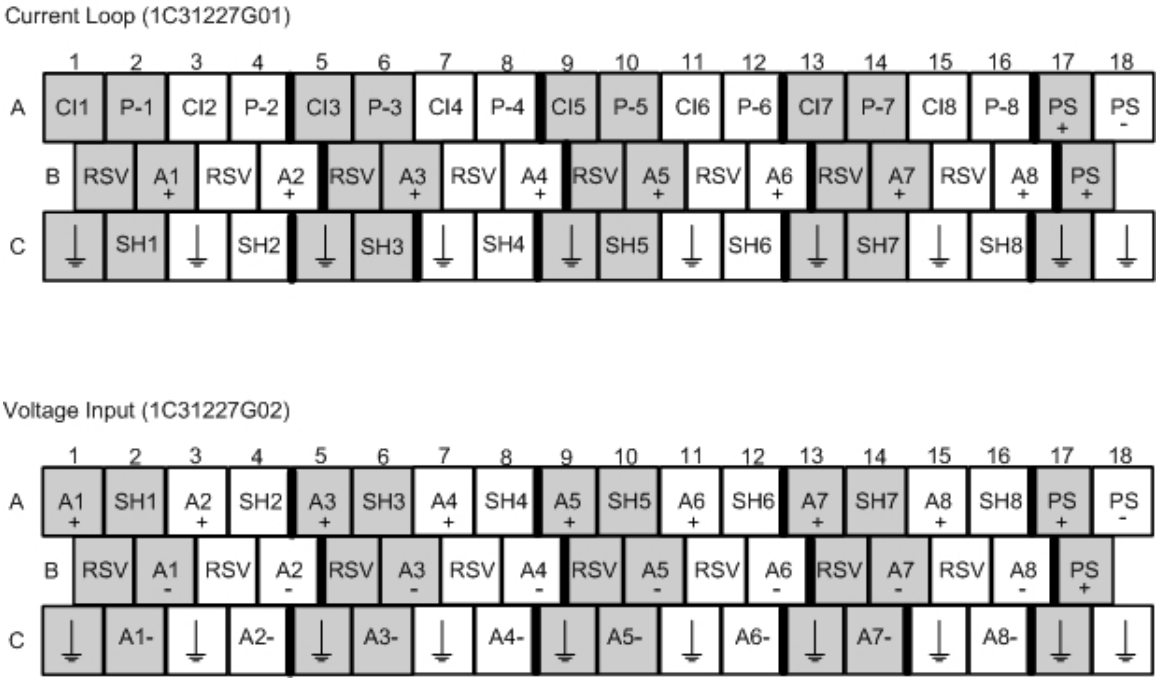
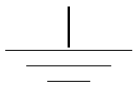


Figure 153: Terminal Block Connections for the Analog Input 1C31227 Pmods

Abbreviations used in diagrams

ABBREVIATION	DEFINITION
	Earth ground terminals.
A1 - A8 +	Analog Input positive terminal connection (connected to the positive terminal of the field device).
A1 - A8 -	Analog Input negative terminal connection (voltage input group only).
CI1 - CI8	Current input terminals.
P-1 - P-8	Loop power output terminals (for locally powered loops).
PS+, PS-	Auxiliary power supply terminals.

ABBREVIATION	DEFINITION
RSV	Reserved terminal. No connections allowed on these terminals.
SH1 - SH8	Shield terminal connection.

Use shielded twisted pair wire for the field wiring. Tie the Analog Input negative terminal and shield together and to earth ground, either locally at the cabinet or at the field device. Voltage inputs use the 1C31227G02 Personality modules. Grounding the shield and the analog input negative terminal at the cabinet or at the field device is arranged by the proper Terminal Block connections.

Similarly, current inputs using the 1C31227G01 Personality modules can accommodate field or locally powered devices by using the correct terminal block connections.

The Personality modules have a field connection diagram label on top of each module to facilitate field wiring. The following figures show the implementations of the field connections for the various Personality module and field device combinations.

18.2.5 Input address locations (Group 4) - (HSAI)

Word address 13 (D in Hex) is used to configure the module and provide status information to the Controller. It varies slightly with the different groups (1-4), primarily in module calibration and range selection. The bit information contained within these words is shown in the following tables.

These status words are only updated once per input channel sampling period; therefore, any Controller action based on changing the configuration (writing to address 13) must take this delay into account.

Data Format for the configuration/module status register for group 4
definitions for the configuration/module status register bits

BIT	DESCRIPTION - CONFIGURATION REGISTER (WRITE)	DESCRIPTION - MODULE STATUS REGISTER (READ)
0	Configure Module	Module Configured (1 = configured)
1	Force Error	Internal or forced error (1 = forced error)
2	0, (ADD4 bit During Diagnostics)	SYS_CAL In Progress (During Diagnostics)
3	0, (ADD5 bit During Diagnostics)	Module In Diagnostic Mode (During Diagnostics)
4	0, (ADD6 bit During Diagnostics)	Warming
5	0, (ADD7 bit During Diagnostics)	(Not Used)
6	0, (ADD8 bit During Diagnostics)	(Not Used)
7	0, (DIAG_SET, Initiates Diagnostics)	Module is Not Calibrated
8	50/60 Hz Selection (1 = 50Hz)	50 Hz/60 Hz System (1 = 50Hz)
9	50mv select (14 bit)/Don't care (13-Bit)	50mv select (14 bit)/ 0 (13-Bit)
10	100mv select (14 bit)/Don't care(13-Bit)	100mv select (14 bit)/0 (13-Bit)
11	SELF_CAL (Initiates Self Calibration)	SYS_CAL Completed (During Diagnostics)
12	0, (Initiates system calibration during Diagnostics)	SYS_CAL Failed (During Diagnostics)

BIT	DESCRIPTION - CONFIGURATION REGISTER (WRITE)	DESCRIPTION - MODULE STATUS REGISTER (READ)
13	0, Lock Calibration Gain (concurrent with the initiation of calibration during diagnostics)	Internal Memory Error
14	0, Clear Calibration (concurrent with the initiation of calibration during diagnostics)	Temperature Sensor Failure
15	Not Defined	Point Fault [1]
[1] Refer to the Point Quality Register for the descriptions of the Point Faults		

Bits defined for Diagnostics are only used during factory testing.

The bit definitions for this register are encoded as shown in the above table and described below:

Bit 0: This bit configures the module (write) or indicates the configuration state of the module (read). A “1” indicates that the module is configured. Note that until the module is configured, reading from addresses 0 through 11 (B in Hex) produces an attention status.

Bit 1: This bit (write “1”) forces the module into the error state, resulting in the error LED being lit. The read of bit “1” indicates that there is an internal module error, or the Controller has forced the module into the error state. The state of this bit is always reflected by the module’s Internal Error LED. Whenever this bit is set, an attention status is returned to the Controller when addresses 0 through 11 (B in Hex) are read.

Bits 2-3: These bits are not used and are read as “0” under normal operation.

Bit 4: This bit (read) indicates that the module is in the “Warming” state. This state exists after power up and terminates after 8.16 seconds. The module is in the error condition during the warm up period.

Bits 5-6: These bits are not used and are read as “0” under normal operation.

Bit 7: This bit (read) is the result of a checksum test of the EEPROM. A failure of this test can indicate a bad EEPROM, but it typically indicates that the module has not been calibrated. A “0” indicates that there is no error condition. If an error is present, the module error LED is lit. The point fault bit is also set as all the point data is not calibrated. The “1” state of this bit indicates an unrecoverable error condition in the field.

Bit 8: The status of this bit (read) indicates the conversion rate of the input module, write to this bit configures the conversion rate of A/D converters as shown in the following table.

CONVERSION RATE (1/SEC.)	BIT 8
60 (for 60Hz systems)	0
50 (for 50Hz systems)	1

Bits 9-10: These bits are used to configure the ranges as follows

FULL SCALE	Bit 9	Bit 10
20 mv	0	0
50 mv	1	0
100 mv	0	1
invalid	1	1

Bit 11: This bit (write) is used to initiate self-calibration. The sampling rate during self-calibration is 2 per second. The status (read) bit is not used and is read as “0” under normal operation

Bit 12: This bit is not used and is read as “0” under normal operation.

Bit 13: This bit (read) indicates that the module has internal memory error (FLASH checksum, Register or Static RAM error). If this error is present, the module error LED is lit, the point fault bit is also set as the condition of the module is undetermined.

Bit 14: This bit, if set, indicates that the temperature sensor has failed.

Bit 15: This bit indicates the point fault status of the module. It is the logical “OR” of the eight individual point-quality status bits, plus the bits 1, 4, 7, and 13 of this register. A “0” indicates that all eight points have good quality and no module error exists. When bits 1, 4, 7 or 13 of the Status Register are not set, this bit (when set to “1”) indicates that at least one of the points has bad quality. A subsequent read of the Point Quality Register (Address 12, C in Hex) reveals the point(s) that have bad quality. The Address 12 (C in Hex) Point Quality Register contains data only when the module fault is due to a bad point quality.

18.2.6 Diagnostic Logic card LEDs - (AI-13, AI-14 & HSAI)

LED	DESCRIPTION
P (green)	Power OK LED. Lit when the +5V power is OK.
C (green)	Communication OK LED. Lit when the Ovation Controller is communicating with the module.
E	No LED.
I (Red)	Internal Error LED. Lit whenever there is any type of error with the module **except** for a loss of power. Possible causes are: ▪ Module initialization is in progress. ▪ I/O Bus timeout has occurred. ▪ Internal hardware error. ▪ Module reset ▪ Module is uncalibrated. ▪ Forced error has been received from the Controller. ▪ Communication between the Field and Logic boards failed.
1 - 8 (Red)	Channel error. Lit whenever there is an error associated with a channel or channels. Possible causes are: ▪ Positive overrange: Input voltage greater than +121% of full scale value (for modules configured as voltage input). ▪ Negative overrange: Input voltage less than -121% of full scale value (for modules configured as voltage input). ▪ Current loop out of range ▪ Calibration readings out of range.
9 - 16	No LED.

18.3 HART High Performance Analog Input module - (HHPAI)

The HART (Highway Addressable Remote Transducer) High Performance Analog Input module is a standard Ovation I/O Module that provides eight galvanically isolated 4-20 mA analog inputs with HART transceivers. Each transceivers provides optically isolated communication to a dedicated UART (Universal Addressable Remote Transducer), thereby Maximizing HART communication throughout. Each channel may be individually configured for field powered or local powered transmitters via user accessible jumpers on the Personality module.

HART is a digital communication protocol designed for industrial process measurement applications. Field measurement devices (transmitters) interface for a process control system via an analog 4-to-20 mA current loop. HART uses a low-level frequency-shift-keyed sine wave signal that is superimposed on the standard 4-to-20 mA process measurement current loop. Since the HART sine wave signal is small and its average value is zero, the current loop analog 4-to-20 mA signal is not significantly affected by the presence of the HART signal. Using HART allows a field device to provide more than one measurement, which is a feature not available when using only the 4-to-20mA analog current signal.

“Smart” field devices may be described as field devices in which the analog 4-to-20 mA signal, digital communication, and sometimes power, co-exist on the same pair of wires. The Ovation HART Fast Analog Input (IAH) module is a standard form factor Ovation I/O module, which permits Ovation to communicate with HART devices.

Note: *I/O Module General Information contains environmental, installation, wiring, and fuse information for I/O modules.*

18.3.1 Electronics modules (Emod) - (HHPAI)

- **5X00106G01** interfaces to eight current loop signals with an input range of 4-20 mA.
- **5X00106G02** interfaces to eight current loop signals with an input range of 4-20 mA, (Reduced radiated emissions).

18.3.2 Personality modules (Pmod) - (HHPAI)

- **5X00109G01** contains eight fused input and user accessible jumpers that configure the channels for field powered or local powered transmitters on an individual basis.
- **5X00109G02** contains eight fused input and user accessible jumpers that configure the channels for field powered or local powered transmitters on an individual basis. Has the addition of active current limiting in the two-wire mode. Note that this module is available only in the following releases:
  - ☐ Ovation 3.4.0 and later.
  - ☐ Ovation 3.3.1 with patch OVA331063 installed.

18.3.3 Subsystems - (HHPAI)

HART High Performance Analog Input subsystems (14-bit)

RANGE	CHANNELS	ELECTRONICS MODULE	PERSONALITY MODULE
4-20 mA [1]	8	5X00106G01	5X00109G01 or 5X00109G02 (Note that this module is available only in the following releases: ▪ Ovation 3.4.0 and later. ▪ Ovation 3.3.1 with patch OVA331063 installed.
4-20 mA[2] (Reduced radiated emissions).	8	5X00106G02	5X00109G01 or 5X00109G02 (Note that this module is available only in the following releases: ▪ Ovation 3.4.0 and later. ▪ Ovation 3.3.1 with patch OVA331063 installed.
[1] This module configuration is CE Mark Certified. [2] This module configuration is CE Mark Certified (Non-EMC Cabinet).			