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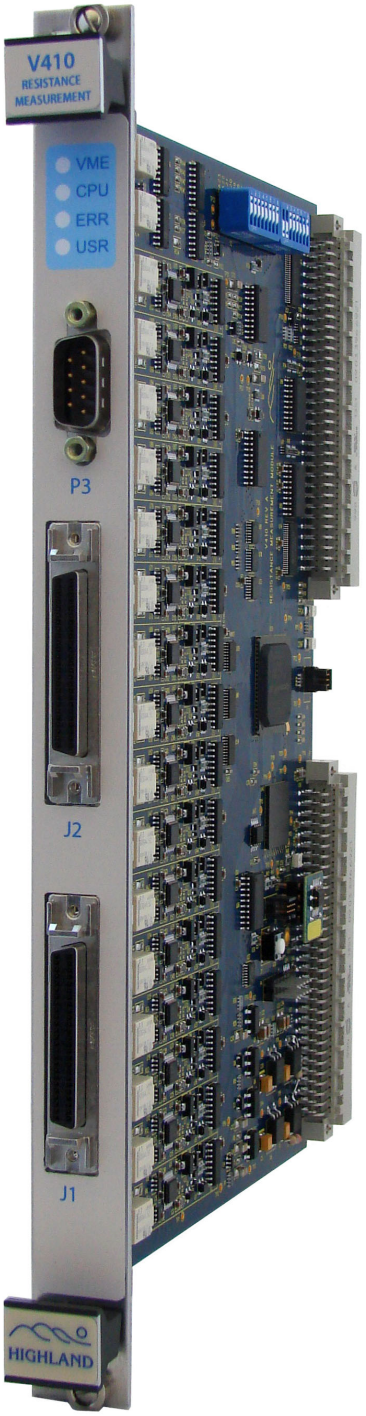

V410 16-CHANNEL RTD/RESISTANCE INPUT MODULE

Technical Manual

October 2, 2023

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Table of Contents

1 Introduction

This is the manual for the V410, a 16 channel VME module capable of reading RTDs, thermistors, and similar resistive sensors. It can also read cryogenic diodes.

Features of the V410 include:

- 16 independent, non-isolated input channels
- 4-wire, 3-wire, and 2-wire sensor compatibility
- Measures 1 ohm to 3 Megohms
- 0.3% accuracy, equivalent to 0.75°C for a 100 ohm RTD at 0°C
- Includes RTD linearization; readout in ohms or °C
- Fault protected to ± 30 volts DC
- Readout at full VMEbus speed without handshaking
- Clearly labeled dipswitches set VME address; no jumpers, headers, or trimpots
- Multiple built-in self-test modes (BIST): Online BIST runs continuously and transparently, while full BIST can be called as needed to perform more comprehensive tests

2 Specifications: V410 RTD/Resistance Input Module

FUNCTION	16-channel resistor/RTD input VME module
DEVICE TYPE	16-bit VME register-based slave: A24:A16:D16; Implements 128 16-bit registers at switch selectable addresses in the VME 16 or 24 bit addressing spaces
INPUTS	Sixteen 4-wire resistive sensors Usable in 3-wire and 2-wire modes using external jumpers
RANGES	Voltage range: -0.5 – 3 V Five current source ranges: Off, 1 µA, 10 µA, 200 µA, and 2 mA Four resistance ranges: 3 MΩ, 300 KΩ, 15 KΩ, and 1500 Ω Four pre-programmed RTD temperature conversions: 100 and 1000 Ω 0.00385 platinum RTD; 100 and 1000 Ω 0.00392 platinum RTD
SAMPLE RATE	15 samples per second
FILTERING	Analog, 16 Hz 1st order pre-ADC lowpass
PROTECTION	± 30 volts any input to ground
OPERATING TEMPERATURE	-40 to 85°C operating; -50 to 85°C storage
CALIBRATION INTERVAL	One year
POWER	VME supplies: + 5 volts, 0.4 amp max ± 12 volts, 0.05 amp max
CONNECTORS	Two VME connectors Two 50-pin SCSI females, each 8 channels One D9 male for testing through the BIST bus
INDICATORS	LEDs indicate VME access, CPU activity, error conditions; additional LED is user programmable
PACKAGING	6U single-wide VME module
CONFORMANCE	ANSI/VITA 1-1994 (R2002) VMEbus spec Resistance to temperature conversion of 0.00385 RTDs based on DIN/IEC 60751

4-Wire Measurement Accuracy:

Measurement	RANGE	TYPICAL	LIMIT 15-35°C*	LIMIT 0-70°C*
100 ohm RTD	-200 – 660°C	±0.1°C ±0.05%†	±0.5°C ±0.1%†	±0.5°C ±0.2%†
1000 ohm RTD	-200 – 660°C	±0.03°C ±0.1%†	±0.08°C ±0.1%†	±0.08°C ±0.2%†
Resistance	1500 ohms	±0.04Ω ±0.05%	±0.2Ω ±0.1%	±0.2Ω ±0.2%
Resistance	15K ohms	±0.1Ω ±0.1%	±0.3Ω ±0.1%	±0.3Ω ±0.2%
Resistance	300K ohms	±1Ω ±0.1%	±4Ω ±0.1%	±4Ω ±0.2%
Resistance	3M ohms	±30Ω ±0.05%	±40Ω ±0.15%	±40Ω ±0.4%
Voltage	-0.5 – 3 Volts	±20µV ±0.02%	±100µV ±0.1%	±100µV ±0.2%

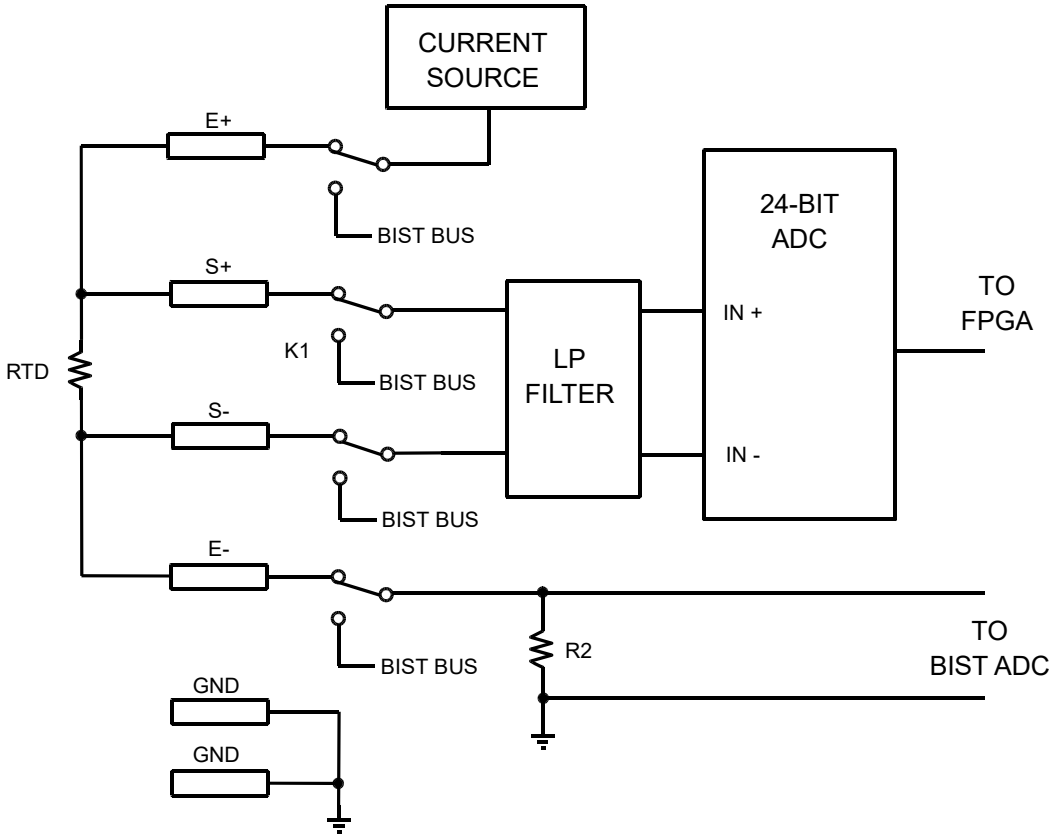
* V410 module temperature
† For RTD accuracy, percentage is of RTD temperature in kelvins. For 100ohm RTDs at 0°C, the 15-35°C error is ±(0.5 + 0.273)°C.

The V410 is calibrated based on resistance accuracy. For non-resistive sensors, the user may want a precise figure for the source current. The 10uA source will be within 0.1% of its intended value with module temperature of 15-35°C. This is stable enough to be used reading cryogenic diodes. The other sources may be as much as 0.5% off, or 5% in the case of the 1uA source. If high accuracy is needed, we recommend that the user measure the current directly. Note that any differences in current from the stated value are compensated by factory calibration when reporting resistance. The tolerances listed above are uncorrelated to current source discrepancies.

Maximum lead resistance to maintain accuracy for 4-wire measurements is 150Ω per lead.

3 Overview

The V410 provides 16 independent resistance measurement channels. The equivalent circuit of each input channel is:



In normal operation, current flows from the upper source, through the external RTD, and then through R2 to ground. The ADC measures the S+/S- sense voltage to compute resistance. The lowpass filter has a 1st order response and a 16 Hz cutoff frequency.

The ADC inputs are 3 volts full-scale.

The available current ranges are:

CURRENT	TYPICAL USE
2mA	10, 100 ohm RTDs
200uA	1K RTDs
10uA	cryogenic diodes
1uA	thermistors
0	voltage measurement

Intrinsically the module measures voltage. To compute resistance it internally converts the voltage using ohms law and correcting for any non-linearity of the circuit. To compute temperature it then converts from resistance using standard resistance to temperature values for 0.00385 and 0.00392 platinum RTDs.

The module is capable of measuring 4, 3, and 2-wire resistive sensors, including RTDs. For 3-wire sensors, an internal switch is connected to make the appropriate corrections for lead resistance. For 3 and 2-wire sensors, external jumpers are required. See section 5.3.

There are two self-test modes. Online BIST runs continuously. In normal operation, the voltage drop across R2 is continuously digitized by the BIST ADC, and its value is cross-checked against the selected current source value measurements. S+ and S- are gently pulled down and up, respectively, so that if either is left floating, the channel ADC will read negative. The voltage reference and power supplies are connected to the BIST ADC which continuously monitors their values. This non-intrusive test can catch most internal failure modes and external wiring errors.

Full BIST is performed by actuating the K1 test relay, thereby disconnecting the external sensor and connecting the channel to the BIST bus. The BIST mux applies precision resistors to the selected channel. This test is much more comprehensive and checks many of the less likely board failure modes.

The user can also manually route the BIST bus to the front-panel D9 test connector to allow verification against external, traceable standards.

4 Connectors and Installation

4.1 Address DIP Switches

The V410 appears as 256 16-bit registers in the VME 16 or 24-bit addressing spaces. The base address of the 256 registers is set by dip switches.

Two rocker-type dipswitches are provided near the top edge of the board. They are labeled, left to right, "A23" through "A11", “X”, “Y”, and finally "A24M".

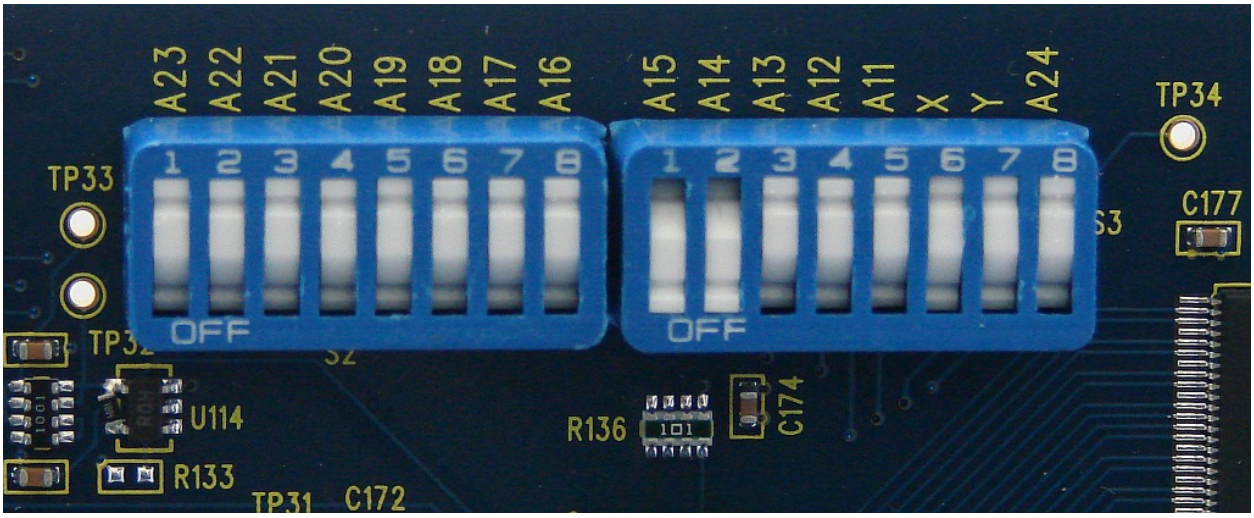
To set a switch to the logical "1" or "ON" position, press the side of the switch nearest its "Ann" lettering. Use a toothpick or paper clip, not a pen or pencil.

The A24M switch, when set, allows the board to operate in the VME 24-bit (A24) address space; in this case, all address switches are active and the board responds to VME address modifier code 0x3D.

If the A24M switch is off, the module resides in the A16 space and responds to address modifier 0x2D. In this case, only address switches A15 through A11 are active.

The X and Y switches are currently unused.

Units are shipped with switches A15 and A14 on, all others off, locating the register base at 0xC000 in the A16 space, as shown below.



Address DIP Switch

4.2 Installation

The V410 may be installed in any standard 6U VME crate, including VME64 variants. It supports 16-bit data transfers using the P1 connector.

The V410 passes all interrupt and bus grant signals, and may be used with backplane grant jumpers installed or not installed.

CAUTION: Do not install or remove the V410 with crate power on. VME modules are not hot-pluggable. The module will be damaged if hot-plugged.

CAUTION: Fully seat the module and secure front-panel screws before applying power.

CAUTION: Handle the V410 with proper ESD precautions to avoid static damage.

4.3 Input Connectors

Two front-panel female 50-pin SCSI connectors are provided. The connectors used are TYCO AMP part number 787171-5 or equivalent.

A suitable 2-meter, double-ended, 25-pair shielded cable is Highland model J52, TRIPPLITE part number S366-006.

Pinout is as follows:

Channel	Connector	E+ Pin	E- PIN	S+ PIN	S- PIN	GND	GND
0	J1	1	26	2	27	3	28
1	J1	4	29	5	30	6	31
2	J1	7	32	8	33	9	34
3	J1	10	35	11	36	12	37
4	J1	13	38	14	39	15	40
5	J1	16	41	17	42	18	43
6	J1	19	44	20	45	21	46
7	J1	22	47	23	48	24	49
						25	50
8	J2	1	26	2	27	3	28
9	J2	4	29	5	30	6	31
10	J2	7	32	8	33	9	34
11	J2	10	35	11	36	12	37
12	J2	13	38	14	39	15	40
13	J2	16	41	17	42	18	43
14	J2	19	44	20	45	21	46
15	J2	22	47	23	48	24	49
						25	50

The GND pins listed above are PCB/VME backplane grounds. Connector shells are bonded to the VME front panel, which connects to the crate frame through the module securing screws.

4.4 D9 Test Connector

One front-panel male 9-pin DSUB connectors is provided.

Pinout is as follows:

E+ Pin	S+ Pin	S- Pin	E- Pin	GND
7	9	8	6	1

The GND pin listed above is PCB/VME backplane ground. Connector shells are bonded to the VME front panel, which connects to the crate frame through the module securing screws.

5 Operation

5.1 LEDs

There are four front-panel LED indicators.

The blue VME led flashes whenever the module is accessed from the VME bus.

The green CPU led flashes about once a second to indicate FPGA activity. Double blinks indicate full BIST in progress.

The orange USR led displays a user-defined blink pattern.

The red ERR led will blink to indicate a module error. The blinking pattern indicates a category of error:

1 blink	Indicates a flag in one of the channel status registers
2 blinks	Indicates a flag in the PERR register
3 blinks	Indicates an error in the factory calibration data flash

There is an additional LED on the PCB surface, labeled “CONF”, which illuminates green when the FPGA is properly configured.

5.2 Powerup Defaults

At powerup, the module setup will be:

Current source off, no reading

ULED led control register clear

The red ERR LED will be on at powerup, and will go off when the FPGA is properly initialized and operating.

The powerup sequence takes about 1 second.

5.3 3, 2-wire Modes

The V410 is capable of measuring resistive sensors in both 3-wire and 2-wire modes.

For 3-wire mode, the user must externally jumper the E+ and S+ pins. The closer this jumper is to the module, the better. Any resistance between the SCSI connector and the

jumper will show as an error. The 3W bit in the Channel Control register must also be set. In this mode the module will internally correct for the line resistance to the sensor under the assumption that the resistance of the E+/S+ and E- lines are identical.

For 2-wire mode, the user must externally jumper E+ to S+ and E- to S-. In this case it's better for the jumper to be close to the resistance sensor. Any resistance between the jumper and the sensor will show as an error. All internal settings should be set the same as for 4-wire mode.

5.4 Quick Start Procedure

Basic operation of the V410 can be demonstrated by the following steps:

A 6U VME crate and computer interface are required. The crate must be compliant with the IEEE 1014 VME specification, or the equivalent ANSI/VITA 1-1994 (R2002) VMEbus spec. Any crate with the standard power supplies (+12, +5, -12) and the 16-bit "P1" bus is adequate.

The computer interface must allow, as a minimum, reading and writing 16-bit registers in the A16 or A24 address spaces.

Pick an address space and module base address and set the V410 dip switches accordingly. See section 4.1. The as-shipped default is address 0xC000 in the 16-bit supervisory address space.

With crate power off, insert the V410 into any crate slot and firmly secure its mounting screws. **Do not hot-plug VME modules.**

Power up. The green "CPU" LED should blink, and the other LEDs should be off.

Now run software that can display the contents of VME registers.

Read the manufacturer ID register, the 16-bit VME register at the module base address. The default address would be 0xC000 in the A16 supervisory space. The blue "VME" LED should flash, and the register value should be 0xFEEE, identifying this as a Highland VME module.

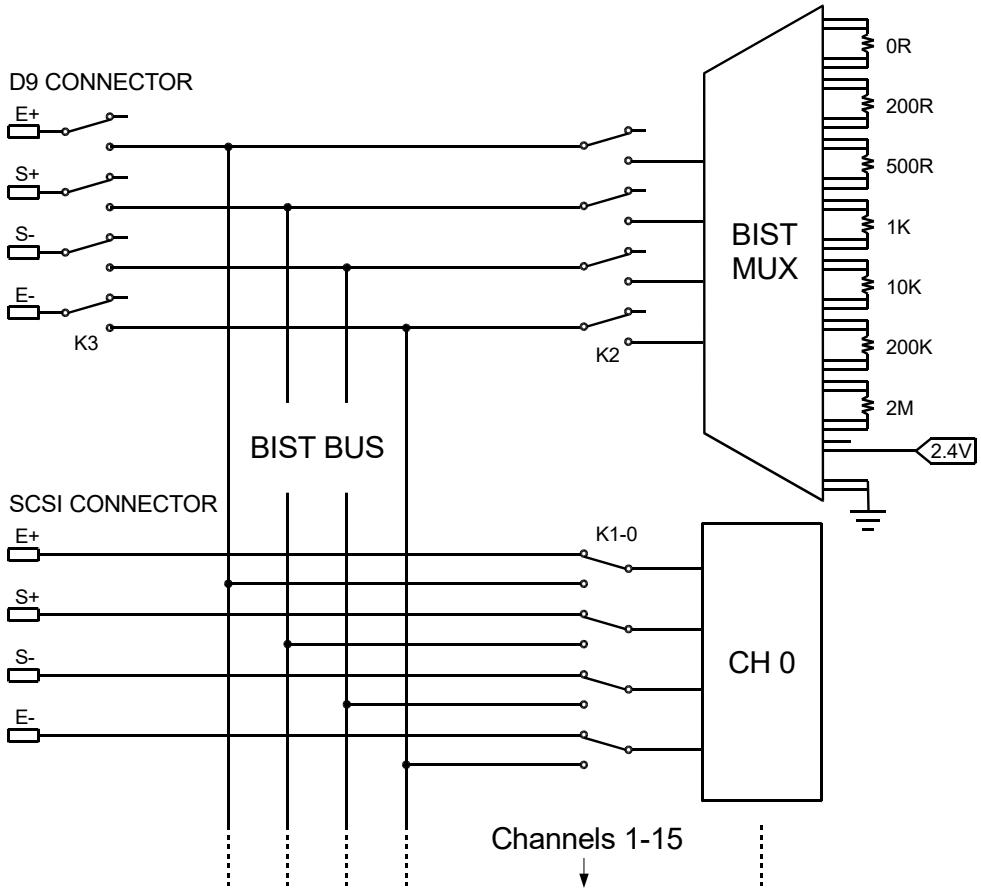
Read the next register, offset address 0x02, default 0xC002. It should read 22410 decimal, 0x578A, identifying the module as a V410.

By default, every channel is set so the current source is off and no measurement is taken. Write 0x000A to the CC registers, offset addresses 0x40 through 0x5E, default 0xC040 through 0xC05E. This sets them to read 100 ohm RTDs (0.00385).

If RTDs are connected, read temperatures in the RD registers, offset addresses 0x60 through 0x9E, default 0xC060 through 0xC09E. Values are reported as 32-bit floats.

6 Full BIST

The V410 has a built-in self test (BIST) bus that connects channels to the D9 connector and BIST mux through relays K1, K2, and K3:



Users may access full BIST through the MACRO register. When running full BIST, the module will apply a given channel and the BIST mux to the BIST bus. It will then cycle the channel through different ranges and apply different resistive/voltage elements through the BIST mux. It checks the measured values against what is expected and will throw an error if any measurement is significantly off. For a single channel, this takes about 12 seconds.

Manual control of K1, K2, and K3 is available through the CHREL and BREL registers.

The BIST mux connects the BIST bus to one of seven resistors or to a voltage reference. The resistors are high accuracy but are not suitable for confirming calibration. Rather, the BIST is designed to confirm general function of the module. For example it will test whether any major components of the module are malfunctioning or have drifted significantly. Control of the BIST mux is available through the BMUX register.

Users may also connect the BIST bus to the D9 connector to, for example, check calibration against a known resistance or voltage reference.

7 VME Registers

The V410 implements 256 16-bit VME registers. OFFSET is the hex VMEbus offset from the module base address.

Read-only (RO) registers cannot be written from VME; these registers are periodically refreshed by the internal microprocessor. Read-write (RW) registers are written and read back by VME.

7.1 VME Register Map

Reg Name	Offset	R/W	Function
VXI MFR	0x00	RO	Highland ID: reads 65262, 0xFEEE
VXI TYPE	0x02	RO	V410 module ID, 22410, 0x578A
MOD REV	0x04	RO	hardware revision
SERIAL	0x06	RO	unit serial number
ROM ID	0x08	RO	firmware ID
ROM REV	0x0A	RO	firmware revision
MCOUNT	0x0C	RO	1 KHz realtime counter
DASH	0x0E	RO	module version (dash) number
STATE	0x10	RO	module boot state
ULED	0x12	RW	user LED control
ERR	0x14	RO	module errors
CALID	0x18	RO	calibration table status
YCAL	0x1A	RO	calibration date: year
DCAL	0x1C	RO	calibration date: month/day
BREL	0x1E	RW	BIST relay control
CHREL	0x20	RW	channel cal-bus relay control
BMUX	0x22	RW	BIST mux control
BERN	0x24	RO	BIST error count
PERR	0x26	RO	power supply error flags
MACRO	0x30	RW	macro command register
MP0-3	0x32	RW	4 macro parameter registers

Reg Name	Offset	R/W	Function
CC0-15	0x40	RW	16 channel control registers
RD0-15	0x60	RO	16 channel value registers (voltage/resistance/temperature), 32-bit float
STATUS0-15	0xA0	RO	16 channel status registers
BUFFER0-127	0x100	RW	128 buffer registers

7.2 Detailed Register Descriptions

7.2.1 Module ID Registers (RO)

A number of read-only overhead registers are provided.

VXI MFR always reads 0xFEEE, Highland's registered VXI module ID code

VXI TYPE always reads 22410 decimal to identify a V410 module

MOD REV ASCII code identifying the revision letter of the hardware, typically 0x0042, ASCII "B"

SERIAL module serial number

ROM ID firmware ID, typically 22411 decimal

ROM REV ASCII code identifying the revision letter of the firmware, typically 0x0041, ASCII "A"

MCOUNT a 16-bit counter that is incremented by the internal logic at 1 KHz

DASH module version (dash) number

7.2.2 STATE - Module State Register (RO)

15	14	13	12	11	10	9	8
						RF	FF
7	6	5	4	3	2	1	0
			K			Y	X

X and Y bits show the state of the corresponding X and Y switches on the address DIP switches.

The onboard flash memory contains a boot loader, a factory-installed firmware image, and storage for a field-reflashed upgrade firmware image. The encoded K bit indicates which code is currently running:

0 factory- installed firmware

1 upgrade firmware

If the FF bit is set, a valid factory code image is available in flash memory. If RF is set, an upgrade image is available.

7.2.3 ULED - User LED Control Register (RW)

An orange LED is provided on the front panel for user application. The ULED register allows user flash patterns to be loaded. An internal shift register is periodically loaded from the contents of the ULED register, and the MS bit of this register operates the orange LED. The shift register is left-shifted every 125 milliseconds, and the register is reloaded every 16 shifts, namely every 2 seconds.

ULED pattern 0x0000 turns the user LED off. Pattern 0xFFFF turns it steady on.

7.2.4 ERR – Module Error Status Register (RO)

15	14	13	12	11	10	9	8
7	6	5	4	3	2	1	0
				CALTBL		CH	PERR

PERR Indicates an error flag in the PERR registry

CH Indicates an error flag in one of the STATUS registers

CALTBL Indicates an error in the factory calibration data flash

The ERR register provides a convenient single location to indicate the occurrence of an error anywhere in the module. 0x0000 indicates no errors.

7.2.5 CALID, YCAL, DCAL - Calibration Status Registers (RO)

The CALID register displays a value which reflects the currently installed calibration table. The normal value is 22411 decimal. If the factory calibration table is corrupted, the firmware will install the default calibration table, the CALID register will display value 0xDEFC and the red LED will flash three times every few seconds.

YCAL and DCAL display the last date of module calibration. YCAL is the year, as an integer, such as 2012 decimal. The high byte of DCAL (bits 15-8) is month 1-12, and the low byte (bits 7-0) is day 1-31.

7.2.6 BREL, CHREL, BMUX, BERN – Full BIST Control Registers (RW except BERN, RO)

BREL

Register Value	BIST bus connection
0	NONE
1	D9
2	BIST mux
3	D9 and BIST mux

The BREL register controls the BIST relays. It can connect the BIST bus to the BIST mux, the D9 connecter, both, or neither. Do not load any values not shown on the table.

CHREL

15	14	13	12	11	10	9	8
CH15	CH14	CH13	CH12	CH11	CH10	CH9	CH8
7	6	5	4	3	2	1	0
CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

Setting any bit in the CHREL register disconnects the corresponding channel from the SCSI connector and connects it to the BIST bus.

BMUX

Register Value	BIST mux connection
0	SHORT
1	200 ohms
2	500 ohms
3	1K ohms
4	10K ohms
5	200K ohms
6	2M ohms
7	2.4V reference

The BMUX register controls the BIST mux. The mux is connected to a variety of resistors as well as a voltage reference.

Users may manipulate these registers directly or use one of the BIST macro commands to execute full BIST. The BERN register displays the number of times full BIST has failed. It is reset upon module reboot.

7.2.7 PERR - Power Supply Error Register (RO)

15	14	13	12	11	10	9	8
7	6	5	4	3	2	1	0
	AVSS	AVDD		3.3	2.5	1.25	REFP

REFP	Channel ADC Vref
1.25	+1.25V supply
2.5	+2.5V supply
3.3	+3.3V supply
AVDD	ADC –supply (-0.6V)
AVSS	ADC +supply (4V)

The PERR register indicates live status of the onboard power supplies. Errors are raised if any supply drifts significantly from its intended value.

7.2.8 Macro Registers (RW)

The MACRO register is used to invoke special module operations. See Sec. 8, Macros and Program Management, for details on how to use macros.

7.2.9 Channel Control Registers (RW)

15	14	13	12	11	10	9	8
						3W	ERR_IG
7	6	5	4	3	2	1	0
RNG							

RNG Channel range

ERR_IG Online BIST current check error ignore

3W 3-Wire measurement mode

These registers control the range setting of each channel. The range determines what current source is applied to the DUT. It also determines what value gets reported in the channel value registers. The module can report the calibrated voltage directly from the ADC or convert it to resistance or temperature.

RNG Value	Current Source	Output Range, Units	Typical DUT
0	Current Source Off	N/A, 0x0000	
1	Current Source Off	-0.5 – 3 Volts	
2	1uA Current Source	-0.5 – 3 Volts	
3	10uA Current Source	-0.5 – 3 Volts	cryogenic diode
4	200uA Current Source	-0.5 – 3 Volts	
5	2mA Current Source	-0.5 – 3 Volts	
6	1uA Current Source	0 – 3M ohms	<3M ohms resistor
7	10uA Current Source	0 – 300K ohms	<300K ohms resistor
8	200uA Current Source	0 – 15K ohms	<15K ohms resistor
9	2mA Current Source	0 – 1500 ohms	<1500 ohms resistor
10	2mA Current Source	-200 – 800°C	100 ohm RTD (0.00385) only
11	200uA Current Source	-200 – 800°C	1000 ohm RTD (0.00385) only

12	2mA Current Source	-200 – 660°C	100 ohm RTD (0.00392) only
13	200uA Current Source	-200 – 660°C	1000 ohm RTD (0.00392) only

Setting ERR_IG ignores online BIST current check errors in the channel value register (See Sec. 7.2.10). Errors are still reported in STATUS registers but calculated data will show in the Channel Value registers instead of -Infinity.

Setting 3W enables 3-wire resistance measurement mode. An internal switch is connected in the channel and the wire resistance is automatically compensated.

To maintain accuracy, if a channel is not in use its RNG setting should be set to 0.

7.2.10 Channel Value (Voltage/Resistance/Temperature) Registers (RO)

These registers show the current measured value of each channel. Units are determined by the corresponding Channel Control Register.

Measured values are provided in 32-bit IEEE floating-point format. Since VME is big-endian, the first 16-bit word (at the lowest bus address) is the sign plus exponent half of the float. When reading floats from the register, the even address must be read first, followed by the odd address. If using the Highland Technology V120 Crate Controller, this is managed automatically.

Certain reported values indicate channel errors:

Error	Reported Value
RTD temperature out of defined limits (HI/LO)	(+/-)Infinity
Module ADC out of range (HI/LO)	(+/-)Infinity
Online BIST current check error	-Infinity

In most cases these errors can be fixed by changing the range in the Channel Control Register or by fixing a problem with test cabling. For more detail on the error see the channel status registers.

7.2.11 Channel Status Registers (RO)

15	14	13	12	11	10	9	8
B_3W	B_PULL	B_VOLT	B_2M	B_200U	B_10U	B_1U	B_OFF
7	6	5	4	3	2	1	0
		HI_RANG	LO_RANG	OVFL	LO_VOLT	HI_CURR	LO_CURR

LO_CURR	Online BIST reports lower current than expected
HI_CURR	Online BIST reports higher current than expected
LO_VOLT	ADC voltage lower than -0.5V
OVFL	ADC positive overflow
LO_RANG	RTD value lower than defined RTD limits
HI_RANG	RTD value higher than defined RTD limits
B_OFF	Full BIST failed for Isource OFF
B_1U	Full BIST failed for Isource 1uA
B_10U	Full BIST failed for Isource 10uA
B_200U	Full BIST failed for Isource 200uA
B_2M	Full BIST failed for Isource 2mA
B_VOLT	Full BIST failed for ADC
B_PULL	Full BIST failed for pull-up/down resistors
B_3W	Full BIST failed for 3-wire mode

The lower byte of this register shows live error status for each channel.

The upper byte shows results from the last full BIST performed on the channel.

7.2.12 Buffer Registers (RW)

The 128 16-bit buffer registers are used by factory macros. Users may treat them as general-purpose RAM. A read-write data pattern test of this RAM, plus a read of the first two ID registers, is a complete test of the module's VME address and data paths.

Results of a single-channel full BIST are reported in the buffer. See section 8.3.

8 Macros and Program Management

The macro control register allows invocation of microprocessor service routines. Some macros take or return data in the MP0 through MP3 registers. Macro codes not listed in the sections below are reserved for Highland Technology calibration/maintenance and should not be used.

To execute a macro:

Verify that the MS bit (bit 15) of the MACRO register is clear, indicating that the microprocessor is ready to accept a command.

Write any required macro parameters.

Write the 16-bit macro code to the MACRO register. All valid macro codes set bit 15.

Wait for MACRO bit 15 to clear. Once it clears, if any other bits are set in MACRO then an error has occurred.

Read any returned parameters.

If the MS bit of the MACRO register clears but the MACRO register does not equal zero, an error has occurred.

Error Code	Error
0x0000	No Error
0x0100	Illegal macro (does not exist or called out of order)
0x0200	Macro param error
0x0300	BIST failure

8.1 NOOP Macro – 0x8400

This will clear the MACRO registers.

8.2 Module Full BIST Macro – 0x8401

During full BIST, the entire module is taken temporarily offline. It is therefore impossible to run the BIST operation while normal data acquisition is active.

To initiate the BIST sequence,

Verify that the MS bit, bit 15, of the MACRO register is clear. This is the "macro busy" bit.

Write the module full BIST command, 0x8401, to the MACRO register

While the macro is running, PARAM0 shows which channel is currently being tested.

Wait for MACRO bit 15 to clear. This will take about 180 seconds. If there was an error, the MACRO register will show 0x0300 and the upper bytes of the STATUS0-15 registers will flag the failed channel.

8.3 Single Channel Full BIST Macro – 0x8402

During full BIST, the entire module is taken temporarily offline. It is therefore impossible to run the BIST operation while normal data acquisition is active.

To initiate the BIST sequence,

Verify that the MS bit, bit 15, of the MACRO register is clear. This is the "macro busy" bit.

Write the number of the channel to be tested to PARAM0. Write the single channel full BIST command, 0x8402, to the MACRO register

Wait for MACRO bit 15 to clear. This will take about 12 seconds. If there was a failure, the MACRO register will show 0x0300 and the upper bytes of the STATUS0-15 registers will flag the failed channel.

Results for each test performed as part of the BIST appear in the BUFFER registers as floats. BUFFER0 shows the channel number and the rest of the data appears as follows:

Register	BIST mux connection	Current Source	Value
BUFFER2-3	SHORT	2mA	Vadc
BUFFER4-5	SHORT	2mA	Isens

Register	BIST mux connection	Current Source	Value
BUFFER6-7	SHORT	2mA	Resistance
BUFFER8-9	200Ω	2mA	Vadc
BUFFER10-11	200Ω	2mA	Isens
BUFFER12-13	200Ω	2mA	Resistance
BUFFER14-15	500Ω	2mA	Vadc
BUFFER16-17	500Ω	2mA	Isens
BUFFER18-19	500Ω	2mA	Resistance
BUFFER20-21	1kΩ	2mA	Vadc
BUFFER22-23	1kΩ	2mA	Isens
BUFFER24-25	1kΩ	2mA	Resistance
BUFFER26-27	SHORT	200uA	Vadc
BUFFER28-29	SHORT	200uA	Isens
BUFFER30-31	SHORT	200uA	Resistance
BUFFER32-33	1kΩ	200uA	Vadc
BUFFER34-35	1kΩ	200uA	Isens
BUFFER36-37	1kΩ	200uA	Resistance
BUFFER38-39	10kΩ	200uA	Vadc
BUFFER40-41	10kΩ	200uA	Isens
BUFFER42-43	10kΩ	200uA	Resistance
BUFFER44-45	SHORT	10uA	Vadc
BUFFER46-47	SHORT	10uA	Isens
BUFFER48-49	SHORT	10uA	Resistance
BUFFER50-51	10kΩ	10uA	Vadc
BUFFER52-53	10kΩ	10uA	Isens
BUFFER54-55	10kΩ	10uA	Resistance
BUFFER56-57	200kΩ	10uA	Vadc

Register	BIST mux connection	Current Source	Value
BUFFER58-59	200kΩ	10uA	Isens
BUFFER60-61	200kΩ	10uA	Resistance
BUFFER62-63	SHORT	1uA	Vadc
BUFFER64-65	SHORT	1uA	Isens
BUFFER66-67	SHORT	1uA	Resistance
BUFFER68-69	200kΩ	1uA	Vadc
BUFFER70-71	200kΩ	1uA	Isens
BUFFER72-73	200kΩ	1uA	Resistance
BUFFER74-75	2MΩ	1uA	Vadc
BUFFER76-77	2MΩ	1uA	Isens
BUFFER78-79	2MΩ	1uA	Resistance
BUFFER80-81	CALREF	OFF	Vadc
BUFFER82-83	CALREF	OFF	Isens
BUFFER86-87	10kΩ	OFF	Vadc
BUFFER88-89	10kΩ	OFF	Isens
BUFFER92-93	SHORT	OFF	Vadc
BUFFER94-95	SHORT	OFF	Isens
BUFFER98-99	2M	OFF	Vadc
BUFFER100-101	2M	OFF	Isens
BUFFER104-105	1kΩ	2mA	V 3-wire, channel
BUFFER106-107	1kΩ	2mA	V 3-wire, BIST

8.4 Flash Checksum Macro – 0x8404

This macro runs a checksum on the images stored in the flash. The results are stored in the PARAM0 and PARAM1 registers:

PARAM0 result:

15	14	13	12	11	10	9	8
						FP1	FP0
7	6	5	4	3	2	1	0
						FF1	FF0

PARAM1 result:

15	14	13	12	11	10	9	8
						UP1	UP0
7	6	5	4	3	2	1	0
						UF1	UF0

Bit fields are:

FP	Factory FPGA
FF	Factory Firmware
UP	Upgrade FPGA
UF	Upgrade Firmware

The field values for all fields are:

00	Image not present
01	Checksum okay
10	Checksum fail
11	Undefined

This macro is useful for determining the success of a re-flash operation before resetting the V410. See section 9 about upgrading the firmware.

This macro should be processed within five seconds.

8.5 Flash Unlock Macro – 0x8405

This macro enables write accesses to the flash memory. It exists as a redundant measure to prevent accidental/unintended flash accesses.

This must be executed before any flash programming operations. It remains active until a reboot.

8.6 Flash Erase Macro – 0x8406

This macro erases the user-upgrade region of the flash memory. The Flash Unlock macro must have been executed first.

This takes up to 25 seconds. While the flash is erasing, PARAM0 will be updated with the sector number (16 to 31) of the flash that is being erased.

8.7 Flash Write Macro – 0x8407

This macro copies data from the buffers to the user-upgrade region of the flash memory. The Flash Unlock macro must have been executed first.

PARAM0 should contain the number of the 128-byte page, indexed from zero.

Registers BUFFER0-127 should contain the data to write, in *little endian format*. For example, if the first six bytes to write into a page of the flash are {0x01, 0x02, 0x03, 0x04, 0x05, 0x06}, then BUFFER0 should be 0x0201, BUFFER1 should be 0x0403, and BUFFER2 should be 0x0605.

See section 9 about upgrading the firmware.

8.8 Reboot Macro – 0x8408

This macro reboots the module. The V410 will disappear from the VME bus for about 1 second. The V410 will not retain any settings from before the reboot.

8.9 Flash Read Macro – 0x8409

Read 256 bytes out of the upgrade portion of the flash.

PARAM0 should hold the 256-byte page number. (This is the same parameter value that would be used for the Flash Write macro.)

The results will be printed to registers BUFFER0-127, in little-endian format. For example, if BUFFER0 is 0x0102, then the first byte of the requested flash page is 0x02 and the second byte of the page is 0x01.

This macro is useful for verifying that a page was correctly written with the Flash Write macro. See section 9 about updating the firmware.

8.10 Report Channel Current Macro – 0x840A

This macro reports the most recent online BIST current check measurement of the selected channel. This is only meant to debug, not to check calibration.

Write the channel number to be reported to PARAM0.

Results are returned in PARAM1 and PARAM2 as a floating point value in amperes.

8.11 Report Power Supply Voltage Macro – 0x840B

This macro reports the most recent online BIST voltage measurement of the selected power supply or voltage reference. This is only meant to debug, not to check calibration.

Write the value corresponding to the device to be reported to PARAM0:

PARAM0 Value	Device
0	Channel ADC Vref
1	+1.25V
2	+2.5V
3	+3.3V
4	ADC –supply (-0.6V)
5	ADC +supply (4V)
6	BIST S-
7	BIST E-

Results are returned in PARAM1 and PARAM2 as a floating point value in volts.

9 Upgrade Procedure

V410 modules can be field-re-flashed using the MACRO and PARAM registers and the register file BUFFERR0-127. Highland will furnish a file named in the style of "22E410B_upgrade.bin" for field program upgrades.

See section 8 for a detailed description of the macros discussed below. The upgrade is performed using the MACRO and PARAM registers, and the BUFFER0-127 register file. Throughout the following procedure, the MACRO register should be checked for an error (non-zero) value each time its MS bit clears after executing a macro.

To perform an upgrade:

Execute the Flash Unlock macro (0x8405) and wait for the MS bit of the MACRO register to clear.

Execute the Flash Erase macro (0x8406) and wait for the MS bit of the MACRO register to clear. This may take up to 25 seconds.

Once the upgrade region is erased, perform the following loop:

Read a 256-byte page from the binary file and write it sequentially into the BUFFER0-127 registers, in little-endian format (see section 8.7).

Write the page number to the PARAM0 register. Write zero for the first page of the file, incrementing by one for each pass of this loop.

Write the Flash Write macro (0x8407) to the MACRO register and wait for the MS bit to clear.

Optional: Verify that the page was correctly written. With the same page number in the PARAM0 register, execute the Flash Read macro (0x8409) and wait for the MS bit of the MACRO register to clear. BUFFER0-127 now hold data read back out of the flash, in little endian format (see section 8.9). Compare this data to the data that you intended to write.

Repeat this loop for each page of the binary file, incrementing PARAM0 for each 256-byte page, until the end of the binary file is reached. It is okay if the final page does not equal 256 bytes; write it anyway.

Optional: Execute the Checksum Flash macro (0x8404) to determine if the re-flash procedure was successful. The UP and UF fields of the PARAM1 register (see section 8.5) should both be 01 binary, "checksum okay". If not, the re-flash procedure has failed and a reset will result in the factory image being loaded. If you choose to restart this procedure, the flash must be erased again with the Flash Erase macro before writing to it.

Execute the Reboot macro (0x8408) for the upgrade to be complete. After rebooting, the STATE register (see section 7.2.2) will show upgrade status.

10 Versions

V410-2: 16-channel VME RTD/resistance input module with BIST

V410-12: 16-channel VME RTD/resistance input module with BIST and conformal coating

11 Customization

Consult factory for information about additional custom versions.

12 Hardware and Firmware Revision History

12.1 Hardware Revision History

Revision A	Jul 2014 Initial PCB release (22A410A)
Revision B	February 2015 Added 3-wire capability, increased range for 2mA setting

12.2 Firmware Revision History

The firmware is provided as a plug-in EEPROM chip which can be field upgraded.

22C410 Revision A	Aug 2014 Initial FPGA release Used on revision A hardware only
22E410 Revision A	Aug 2014 Initial serial flash image
22C411 Revision A	Feb 2015 Added 3-wire support for rev B
22E411 Revision A	Feb 2015 Added 3-wire support for rev B
22E411 Revision B	Jul 2018 The background BIST no longer scans MUX_E and MUX_S if the cal bus is connected to the D9 on the front panel. Install on Rev B hardware only.

13 Accessories

J51-1: 3' shielded-pair 50 pin male SCSI cable

J52-1: 6' shielded-pair 50 pin male SCSI cable

J280-1: 50-pin SCSI breakout board