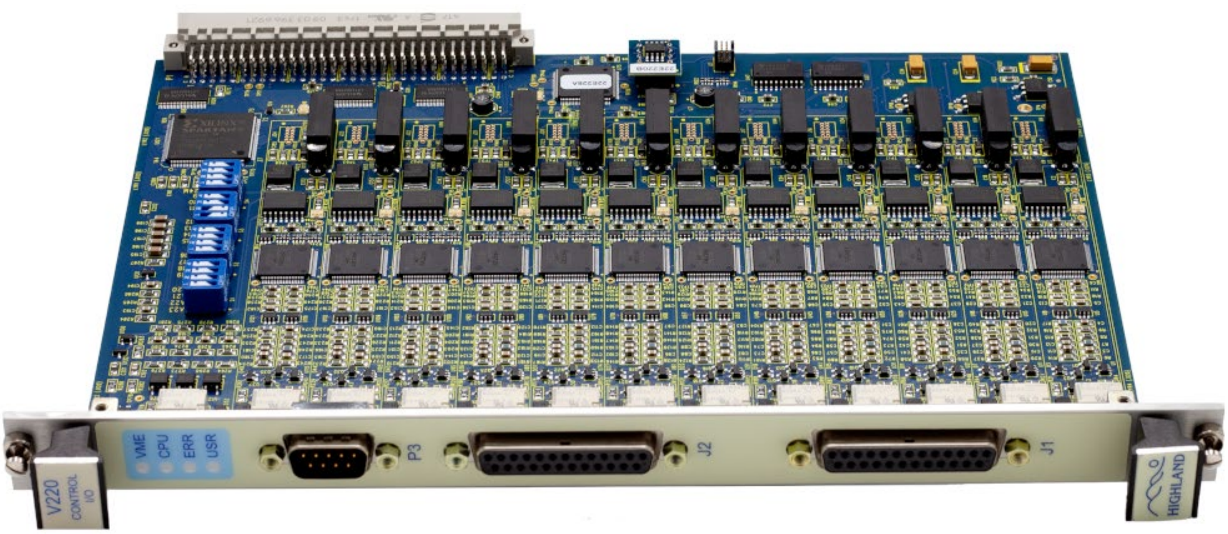
HIGHLAND TECHNOLOGY

V220 VME

4-20 mA ANALOG CONTROL I/O

MODULE



Technical Manual

November 1, 2023

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1 Introduction

This is the manual for the V220, a VME module intended for use in 4-20 mA industrial current loop applications.

Module features include:
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- 12 independently isolated, independently programmable channels
- Capable of simulating both controllers and transducers, measuring loop voltages and currents, and simulating faults
- Channel functions include:
    - 0 to 24 mA output using internal power source
    - 0 to 32 mA current control with external loop power
    - 0 to 32 mA loop current measurement
    - 0 to 18 V voltage output with current measurement
    - -5 to +32 volts voltage measurement
    - Open circuit
    - Short circuit
- Voltage and current measurement in all modes
- Operates up to 18 volts with internal power, 48 volts with external loop power
- Protected to ± 50 volts in all modes
- 0.1% basic accuracy
- Separate test connector supports in-crate calibration check
- Clearly labeled dipswitches set VME address; no jumpers, headers, or trimpots
- Optional built-in self-test (BIST)

2 Specifications

FUNCTION	12-channel current-loop analog I/O module
DEVICE TYPE	16-bit VME register-based slave: A24:A16:D16 Implements 256 16 bit registers at switch selectable addresses in the VME 16 or 24 bit addressing spaces
CHANNELS	12, electrically isolated, independently programmable
CHANNEL MODES	0. Open circuit/voltmeter, -5 to +32 volts range 1. CV/CC out, internal power, 0 to 18 volts, 0 to 24 mA 2. Loop current control, external power, 0 to 32 mA, 48 volts max 3. 0 to 32 mA current measurement, 2 volts max drop 4. Short circuit, 20 Ω nominal, 200 mA max
RESPONSE TIME	1 ms typical; 100 ms in SLOW mode
PROTECTION	± 50 volts differential, ± 250 volts common-mode
RESOLUTION	16 bits
ACCURACY	± 0.1 % of range
OPERATING TEMPERATURE	0 to 60°C; extended MIL/COTS version available
CALIBRATION INTERVAL	One year
POWER	Standard VME supplies: +5 volts, 0.5 amp max +12 volts, 750 mA max -12 volts, 750 mA max
CONNECTORS	Two D25 female, each 6 channels One D9 male, test/calibration check
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

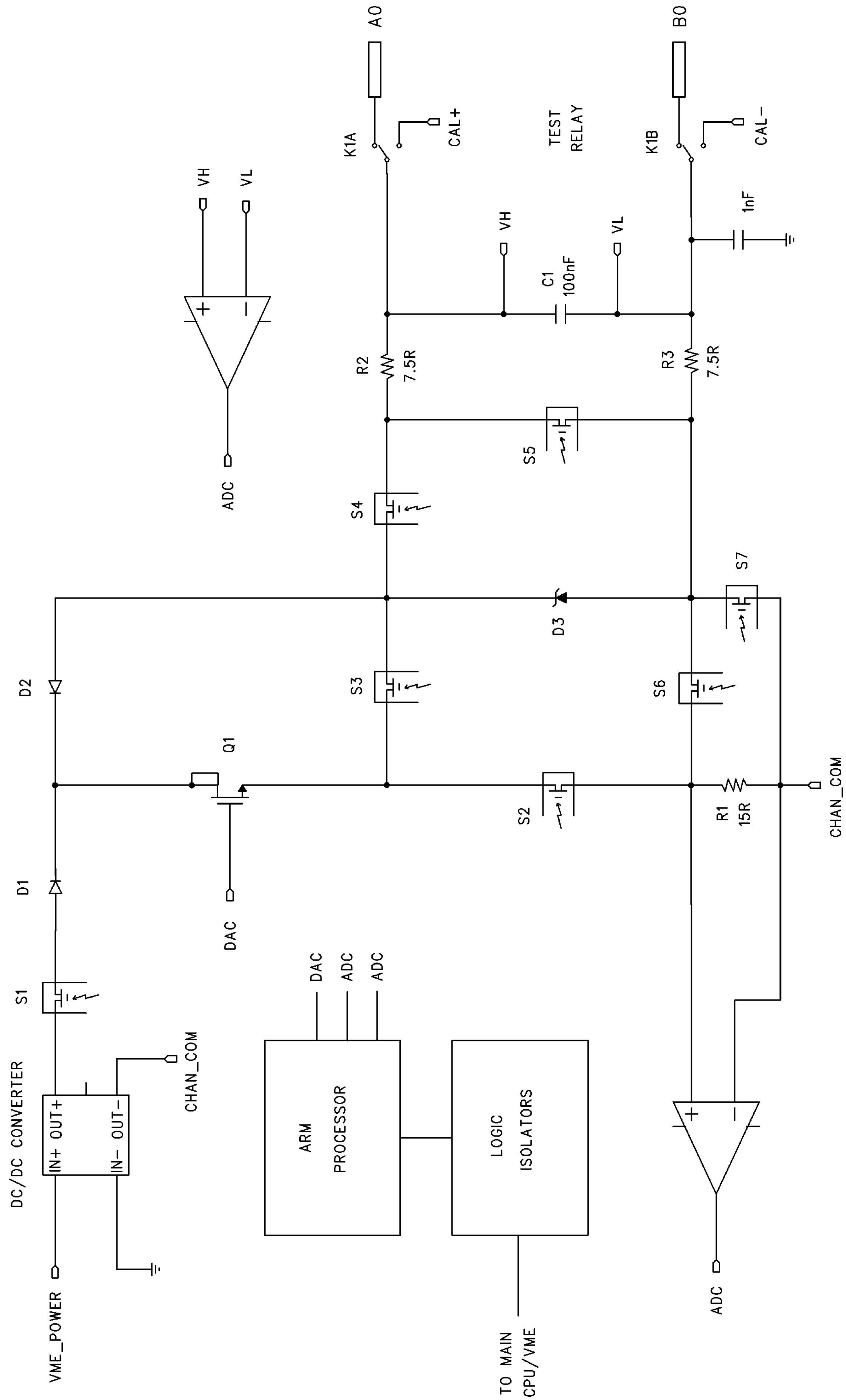
3 Overview

The V220 includes:

- A supervisory microprocessor with dual-port-memory interface to the VME bus
- 12 independent, isolated channels, each with its own control microprocessor
- Relay switching to route any channel to the D9 test connector
- Associated power supplies and indicators
- Optional BIST, built-in self-test

3.1 Channel Circuits

The figure below depicts channel signal flow:


A0
B0
CAL+
CAL-
TEST
RELAY
K1A
K1B
VH
VL
1nF
C1
100nF
R2
7.5R
R3
7.5R
S1
S2
S3
S4
S5
S6
S7
D1
D2
D3
Q1
R1
15R
CHAN_COM
ADC
DAC
DC/DC CONVERTER
IN+ OUT+
IN- OUT-
VME_POWER
ARM
PROCESSOR
LOGIC
ISOLATORS
TO MAIN
CPU/VME

Each channel is powered by an isolated DC/DC converter and supervised by a 100 MHz ARM microprocessor with integral ADC, DAC, and SPI controllers.

Shunt resistor R1 measures loop current. A differential amplifier senses resistor voltage drop and scales it for an ARM internal ADC channel. A second differential amplifier senses terminal voltage and applies it to another ADC channel.

S1 through S7 are solid-state relays.

D3 is a 50-volt transzorb zener diode. K1 is the channel test relay, which can switch the channel to the internal calibration bus.

The ARM DAC channel controls series regulator Q1. Loop control algorithms and channel protections are executed in firmware.

The available channel modes are:

Mode 0: open circuit/voltmeter

In mode 0, all switches are open. The processor measures and reports the A:B terminal voltage. Measurement range is -5 to +32.767 volts. Input impedance is 1 megohm shunted by 100 nF.

Mode 1: CV/CC output, internal power

In Mode 1, users specify a target current and a maximum output voltage, similar to the programming of a constant-voltage, current-limited power supply. This mode is used to drive devices which do not themselves furnish loop power.

To drive an external current-operated actuator or indicator, voltage may be set to its maximum value, 18 volts, and the current programmed from 0 to 24 mA as desired to drive the device.

To read an unpowered 4-20 mA sensor-type transducer, voltage and current may both be programmed to their maximum values, 18 volts and 24 mA. The external transducer then regulates the actual loop current, and the module reports the realtime transducer voltage and current.

Voltage-operated devices may be driven by programming output current to any desired limiting value up to 24 mA, and then setting the desired voltage.

The external device is always connected between pins A (positive) and B (negative.)

In mode 1, S1 and D1 apply +30 volt isolated power to current regulator transistor Q1. Current then flows through S3, S4, R2, and K1A to positive output pin A, into the external load. Return current enters pin B and flows through K1B, S6, and the current sense resistor R1. The microprocessor digitizes the loop current and the terminal voltage and adjusts the DAC to servo the current and voltage to the setpoint values.

Mode 2: current control, external loop power

Mode 2 allows simulation of a 2-wire, 4-20 mA transducer to an external loop or instrument that furnishes its own loop excitation power. The external loop power supply may be up to 48 volts. A minimum voltage drop of 5 volts is required across the V220 terminals to ensure current regulation.

In mode 2, an external power supply, in series with any associated loop load devices, is connected between pins A (positive) and B. Users set a target loop current up to 32 mA. The processor digitizes the current and manipulates the DAC to servo loop current to the setpoint value. Actual current and terminal voltage are reported. A channel error will be flagged if the current setpoint is not achieved, or if the channel enters protective shutdown mode.

Current enters pin A and passes through K1A, R2, S4, and D2 to the current regulator Q1. Current from Q1 passes through S2, sense resistor R1, S7, R3, K1B, and back out pin B.

Mode 3: current measurement/ammeter mode

In mode 3, a current to be measured enters pin A and flows through the path K1A, R2, S4, S3, S2, R1, S7, R3, K1B, and back out pin B. The processor digitizes the voltage drop across R1, and reports loop current. The full-scale current range is 32.767 mA, and the resulting voltage drop will be less than 2 volts.

Mode 4: short

Mode 4 provides a low-resistance short circuit for transducer fault simulation. S5 is closed and all other switches are opened. The effective resistance is nominally 20 ohms, and the voltage drop is digitized and reported. Actual current is reported in the channel's "IM" measured-current register, with LSB value of 1 mA and accuracy of ± 2%.

In Mode 4, the V220 will not attempt to close a short if the applied voltage is above +35 or below -2. If the on-state current exceeds 200 mA for 1 millisecond, the switch will be opened to prevent circuit damage, and will retry the shorting operation once a second.

Notes

Pin A of each channel is always positive relative to pin B.

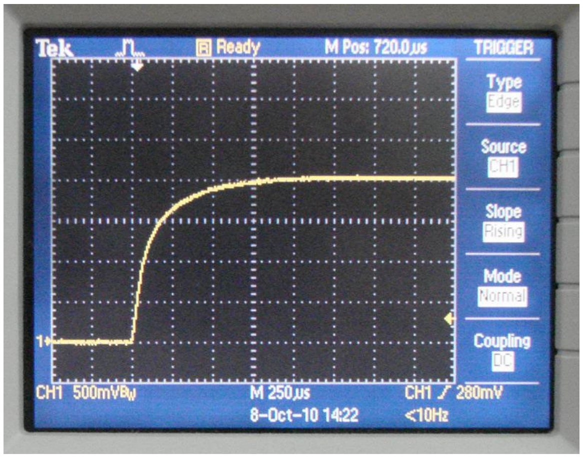
In mode 1, internal loop power mode, current exits pin A, passes through an external load, and returns via pin B.

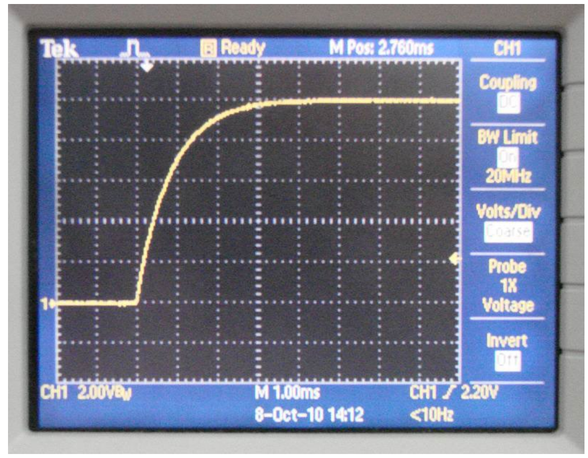
In modes 2 and 3, current from an external source enters A and returns via B.

The processor provides error checking and overload protection in all modes, opening switches as required to prevent damage. If excessive voltage or current are applied, or if reverse potential is sensed, the channel will enter a protective shutdown state with all switches off. An error flag will be posted, the red ERR led will blink, and the channel will periodically retry/recover when the fault condition is removed.

3.2 Time Response

In normal mode (channel SLOW bit off) the output step responses are...

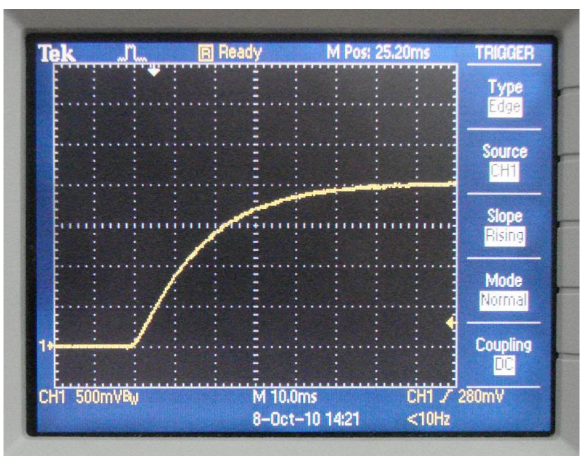


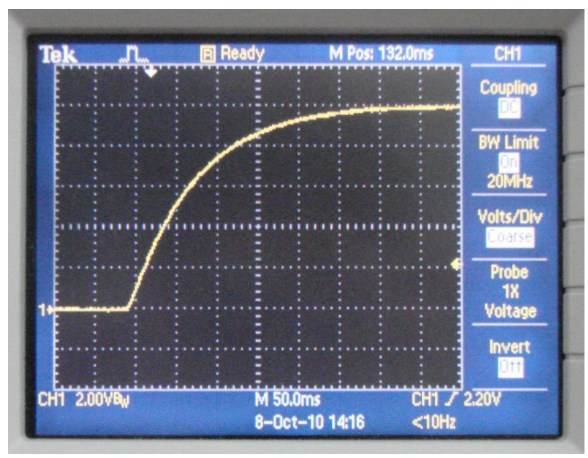


Current, 0 to 20 mA step   250 us/cm

Voltage, 0 to +10 v   1 ms/cm

In Slow mode, step responses are...





Current, 0 to 20 mA step   10 ms/cm

Voltage, 0 to +10 v 50 ms/cm

Measurements are filtered with a time constant of 1 millisecond. In SLOW mode, the measurement filter time constant is 100 milliseconds.

Data is transferred between VME registers and any channel about every 700 microseconds.

3.3 Front-Panel LEDs

There are four front-panel LEDs.

The green CPU led will blink about once a second to indicate normal operation of the CPU. It will double-blink during BIST.

The blue VME led will flash on any VME access.

The red ERR led will flash in various patterns to indicate error conditions:

One blink if any channels are improperly programmed.

Two blinks if any channel has a loop error, or is in the safety shutdown state.

Four blinks indicates that the calibration table is incorrect. The default cal table is used, but accuracy is degraded.

Five blinks indicates a serious hardware problem, an FPGA or channel error.

One long blink if any BIST errors were detected. Users may clear the BERN register to inhibit the long blinks.

The red led comes on at powerup and will remain on if the internal CPU does not initialize properly.

The orange USR led is user-programmable. See section 6.4.

4 Connectors and Installation

4.1 Address DIP Switches

The V220 occupies 256 16-bit registers in the VME A16 or A24 address spaces.

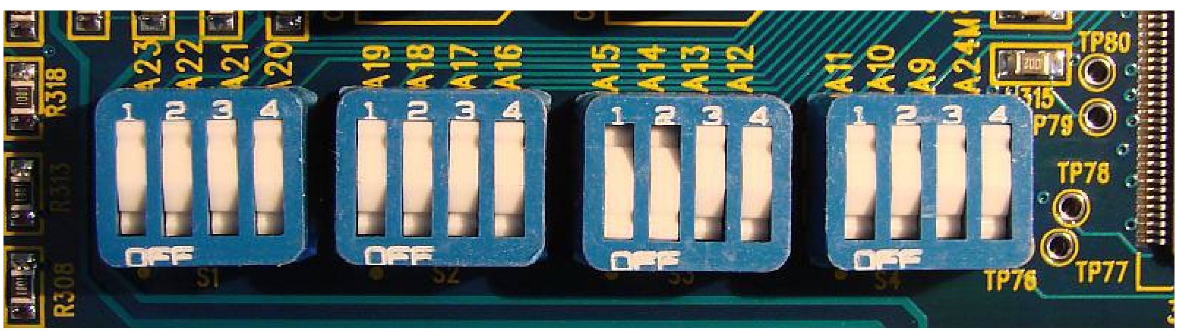
Four 4-position rocker-type dipswitches are provided near the top edge of the board to set the module base address. They are labeled, left to right, "A23" through "A9" and finally "A24M".

To set a switch to the logical "1" or "ON" position, press the side of the switch nearest its "Axx" 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 codes 0x39 and 0x3D.

If the A24M switch is off, the module resides in the A16 space and responds to address modifiers 0x29 and 0x2D. In this case, only address switches A15 through A9 are active.

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



4.2 Installation

The V220 may be installed in any VME (IEEE 1014) crate, including VME64 variants. It supports 16-bit data transfers using the P1 connector.

The V220 passes all interrupt and bus grant signals, so may be used with backplane grant jumpers installed or not installed.

⚠ **CAUTION: Do not install or remove the V220 with crate power on. VME modules are not hot-pluggable. The V220 will be damaged if hot-plugged.**

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

⚠ **CAUTION: Handle the V220 with proper ESD precautions to avoid static damage.**

4.3 D25 Input Connectors

Two front-panel female D-25 connectors are provided.

The pinout of the D25 connectors is as follows:

J1 Pin	Function	J2 Pin	Function
J1-1	ch 0A	J2-1	ch 6A
J1-14	ch 0B	J2-14	ch 6B
J1-2	ch 1A	J2-2	ch 7A
J1-15	ch 1B	J2-15	ch 7B
J1-3	ch 2A	J2-3	ch 8A
J1-16	ch 2B	J2-16	ch 8B
J1-4	ch 3A	J2-4	ch 9A
J1-17	ch 3B	J2-17	ch 9B
J1-5	ch 4A	J2-5	ch 10A
J1-18	ch 4B	J2-18	ch 10B
J1-6	ch 5A	J2-6	ch 11A
J1-19	ch 5B	J2-19	ch 11B
J1-22	VME Ground	J2-22	VME Ground
J1-24	VME Ground	J2-24	VME Ground

Pin A of each channel is positive relative to pin B. In mode 1, current exits pin A, passes through an external load, and returns via pin B.

In modes 2 and 3, current from an external source enters A and returns via B.

Connector shells are bonded to the VME front panel, which connects to the crate frame through the module securing screws.

4.4 D9 Calibration Connector

A male D9 connector is provided for connection to an external DVM or precision voltage source. Each input channel incorporates a relay which allows it to be switched, under software control, to this test connector.

Pinout of the D9 is:

P3-7	CAL+	to external DVM or source
P3-6	CAL-	
P3-5	VME Ground	

An external DVM or voltage/current source may be connected to Pins 7 and 6, and a channel relay activated to allow the channel to be connected to test equipment instead of its normal input.

The RELAYS register is used to control the channel test relays. The MODE register controls switching of the internal cal bus to the D9 test connector.

5 VME Registers

The V220 implements 256 16-bit VME registers. REG# below is the ordinal register number in decimal; OFFSET is the hex VMEbus offset from the module base address.

Registers identified as "RO" should be treated as read-only and should not be written from VME; these registers are periodically refreshed by the microprocessor.

Read-write (RW) registers are written by VME and are not altered by the internal microprocessor.

Read-write + macro registers (RWM) can be written by the user, but may also be changed by the V220 in response to a user executed MACRO command. A macro handshake protocol is defined in Section 5.7.

5.1 VME Register Map

REG Name	REG#	Offset	R/W	Function
VXI MFR	0	0x00	RO	VXI mfr ID: reads 65262 (0xFEEE)
VXITYPE	1	0x02	RO	module type, always 22220 decimal
SERIAL	3	0x06	RO	unit serial number
ROM ID	4	0x08	RO	CPU firmware ID
ROM REV	5	0x0A	RO	firmware revision
MCOUNT	6	0x0C	RO	microprocessor IRQ update counter
DASH	7	0x0E	RO	module dash (version) number
RELAYS	11	0x16	RW	controls calibration-bus relays
ULED	12	0x18	RW	user LED control
MODE	13	0x1A	RW	module operating mode
CALID	14	0x1C	RO	calibration table status
BISS	15	0x1E	RO	BIST status register
MACRO	16	0x20	RWM	macro command register
PARAM0	17	0x22	RWM	macro parameter
PARAM1	18	0x24	RWM	macro parameter
PARAM2	19	0x26	RWM	macro parameter

REG Name	REG#	Offset	R/W	Function
YCAL	20	0x28	RO	calibration date, year
DCAL	21	0x2A	RO	calibration date, month/day
BERN	22	0x2C	RW	BIST error counter
C0	32	0x40	RW	channel 0 control
S0	33	0x42	RO	channel 0 status
IR0	34	0x44	RW	channel 0 requested loop current
VR0	35	0x46	RW	channel 0 requested terminal voltage
IM0	36	0x48	RO	channel 0 measured loop current
VM0	37	0x4A	RO	channel 0 measured terminal voltage
C1	40	0x50	RW	channel 1 control
S1	41	0x52	RO	channel 1 status
IR1	42	0x54	RW	channel 1 requested loop current
VR1	43	0x56	RW	channel 1 requested terminal voltage
IM1	44	0x58	RO	channel 1 measured loop current
VM1	45	0x5A	RO	channel 1 measured terminal voltage
C2	48	0x60	RW	channel 2 control
S2	49	0x62	RO	channel 2 status
IR2	50	0x64	RW	channel 2 requested loop current
VR2	51	0x66	RW	channel 2 requested terminal voltage
IM2	52	0x68	RO	channel 2 measured loop current
VM2	53	0x6A	RO	channel 2 measured terminal voltage
C3	56	0x70	RW	channel 3 control
S3	57	0x72	RO	channel 3 status
IR3	58	0x74	RW	channel 3 requested loop current
VR3	59	0x76	RW	channel 3 requested terminal voltage
IM3	60	0x78	RO	channel 3 measured loop current
VM3	61	0x7A	RO	channel 3 measured terminal voltage

REG Name	REG#	Offset	R/W	Function
C4	64	0x80	RW	channel 4 control
S4	65	0x82	RO	channel 4 status
IR4	66	0x84	RW	channel 4 requested loop current
VR4	67	0x86	RW	channel 4 requested terminal voltage
IM4	68	0x88	RO	channel 4 measured loop current
VM4	69	0x8A	RO	channel 4 measured terminal voltage
C5	72	0x90	RW	channel 5 control
S5	73	0x92	RO	channel 5 status
IR5	74	0x94	RW	channel 5 requested loop current
VR5	75	0x96	RW	channel 5 requested terminal voltage
IM5	76	0x98	RO	channel 5 measured loop current
VM5	77	0x9A	RO	channel 5 measured terminal voltage
C6	80	0xA0	RW	channel 6 control
S6	81	0xA2	RO	channel 6 status
IR6	82	0xA4	RW	channel 6 requested loop current
VR6	83	0xA6	RW	channel 6 requested terminal voltage
IM6	84	0xA8	RO	channel 6 measured loop current
VM6	85	0xAA	RO	channel 6 measured terminal voltage
C7	88	0xB0	RW	channel 7 control
S7	89	0xB2	RO	channel 7 status
IR7	90	0xB4	RW	channel 7 requested loop current
VR7	91	0xB6	RW	channel 7 requested terminal voltage
IM7	92	0xB8	RO	channel 7 measured loop current
VM7	93	0xBA	RO	channel 7 measured terminal voltage
C8	96	0xB0	RW	channel 8 control
S8	97	0xB2	RO	channel 8 status
IR8	98	0xB4	RW	channel 8 requested loop current
VR8	99	0xB6	RW	channel 8 requested terminal voltage
IM8	100	0xB8	RO	channel 8 measured loop current

REG Name	REG#	Offset	R/W	Function
VM8	101	0xBA	RO	channel 8 measured terminal voltage
C9	104	0xD0	RW	channel 9 control
S9	105	0xD2	RO	channel 9 status
IR9	106	0xD4	RW	channel 9 requested loop current
VR9	107	0xD6	RW	channel 9 requested terminal voltage
IM9	108	0xD8	RO	channel 9 measured loop current
VM9	109	0xDA	RO	channel 9 measured terminal voltage
C10	112	0xE0	RW	channel 10 control
S10	113	0xE2	RO	channel 10 status
IR10	114	0xE4	RW	channel 10 requested loop current
VR10	115	0xE6	RW	channel 10 requested terminal voltage
IM10	116	0xE8	RO	channel 10 measured loop current
VM10	117	0xEA	RO	channel 10 measured terminal voltage
C11	120	0xF0	RW	channel 11 control
S11	121	0xF2	RO	channel 11 status
IR11	122	0xF4	RW	channel 11 requested loop current
VR11	123	0xF6	RW	channel 11 requested terminal voltage
IM11	124	0xF8	RO	channel 11 measured loop current
VM11	125	0xFA	RO	channel 11 measured terminal voltage
BFLAG0	128	0x100	RO	channel 0 BIST flags
BFLAG1	129	0x102	RO	channel 1 BIST flags
BFLAG2	130	0x104	RO	channel 2 BIST flags
BFLAG3	131	0x106	RO	channel 3 BIST flags
BFLAG4	132	0x108	RO	channel 4 BIST flags
BFLAG5	133	0x10A	RO	channel 5 BIST flags
BFLAG6	134	0x10C	RO	channel 6 BIST flags
BFLAG7	135	0x10E	RO	channel 7 BIST flags
BFLAG8	136	0x110	RO	channel 8 BIST flags
BFLAG9	137	0x112	RO	channel 9 BIST flags

REG Name	REG#	Offset	R/W	Function
BFLAG10	138	0x114	RO	channel 10 BIST flags
BFLAG11	139	0x116	RO	channel 11 BIST flags
BFLAGX	140	0x118	RO	miscellaneous BIST flags
BDATA	144-255	120-1FE	RO	BIST measurement data

5.2 Module Overhead Registers

A number of read-only overhead registers are provided.

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

VXITYPE: always reads 22220 decimal.

SERIAL: module serial number.

DASH: module dash (version) number.

ROM ID: firmware version, typically 22220 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 microprocessor every channel scan, about every 700 microseconds

5.3 RELAYS and MODE Registers

The RELAYS register controls actuation of the 12 channel test relays.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
				K11	K10	K9	K8	K7	K6	K5	K4	K3	K2	K1	K0

If the user sets a bit on, the corresponding channel test relay will be actuated. The analog i/o of the associated channel will then be disconnected from the front-panel D25 connector and connected to the internal cal bus, which will in turn be routed to the CAL+ and CAL- pins (pins 7 and 6) of the D9 test connector.

To prevent possible overloads, only one or two bits may be set simultaneously. If more than two bits are set, no relays will be actuated. It is possible to connect two channels using this facility.

Upon altering the RELAYS register it may take up to 20 milliseconds before all relay contact changes have settled.

Set the MODE register to 1 to route the cal bus out the front-panel D9 test connector.

5.4 ULED - User LED Control

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. Pattern 0xF000 would result in a blink pattern, 0.5 seconds on and 1.5 seconds off.

5.5 CALID, YCAL, DCAL - Calibration Status Registers

The CALID register displays a value which reflects the currently installed calibration table. The normal value is 22220 decimal. If the default table is installed, the register value will be 0xDEFC and the red ERR led will blink, indicating that calibration is degraded.

YCAL and DCAL display the last date of module calibration. YCAL is the year, as an integer, such as 2006 decimal. The high byte of DCAL is month 1-12, and the low byte is day 1-31. The recommended factory recalibration interval for the V220 is one year.

5.6 BERN - BIST Error Count

The BERN register provides the error count for a just-completed BIST operation. For the V220-1, lacking BIST, this register will always read zero. Users may clear this register to inhibit red LED blinks following BIST errors. See section 7.

5.7 MACRO, PARAMx - Macro Controls

The macro control register allows the execution of microprocessor functions macros which perform automatic tasks. The PARAM registers convey any required macro parameters to/from macro calls.

To execute a macro, verify that the MS bit (bit 15) of the MACRO register is clear, write any required parameters, then write a macro code to the MACRO register. Wait until the MSB of MACRO self-clears.

The MACRO codes are...

```
0x8400    no-op dummy macro

0x8401    run full BIST; see section 7

0x8407    Reboot. The module will disappear from
          the VME bus for about 5 seconds.

0x8411    Run single-channel BIST. Param 0
          specifies channel number 0..11

0x8412    Run multi-channel BIST. Param 0
          specifies channel bit map.
```

The MACRO register will go to zero after the macro is successfully executed. If an illegal macro is requested, MACRO will return 0x0100.

5.8 *Channel Registers*

Each of the 12 channels has a block of 6 associated registers.

5.8.1 Channel Control Register

Each of the 12 input channels has an associated read/write channel control register, registers C0 through C11 for the respective 12 channels. Users must initialize the control registers of any channels which will be used. The control register arrangement is:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							SLOW						CC2	CC1	CC0

The CC bits select the operating mode for this channel, with the three bits encoded 0 through 4 decimal. Powerup default is mode 0, open circuit/voltmeter.

The available modes are:

0. Open circuit/voltmeter
1. CV/CC out, internal power
2. Loop current control, external power
3. 0-32 mA current measurement
4. Short circuit

If the user sets the SLOW bit, channel voltage and current measurements are lowpass filtered with a nominal 100 millisecond time constant, which will reduce measured process noise. The current/voltage regulation control loop is slowed down to reduce slew rate and increase stability, as might be required with, for example, inductive loads.

The powerup default is zero, which places all channels into voltmeter mode.

Future versions of the V220 may include a programmable circuit-breaker mode. To ensure forward compatibility, it is recommended that users load zero into the Requested Current and Requested Voltage registers of channels operated in the Short mode, mode 4.

5.8.2 Channel Status Register

Each of the 12 channels has an associated read-only status register, S0 through S11.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CF	CX							SD	ER	PE				CV	CC

SD is set if the channel detects a hazardous overload and shuts off all of its solid-state relays to avoid damage. The channel microprocessor will check terminal voltage and, if conditions permit, retry normal operation once per second.

In closed-loop channel modes 1 and 2, the ER bit is set if the channel senses an internal loop error, indicating that that the programmed setpoints are not being correctly achieved. This is usually caused by an external open, short, or other condition that prevents the channel from regulating to a target setpoint.

The PE bit will be true if any channel programmed settings are incorrect, for example an out-of-range setpoint, or an undefined channel operating mode.

CC will be set if the channel is operating in mode 1 in constant-current mode, namely if the programmed current is being properly delivered by the module. CV will be set if load current is low enough that the output is at the programmed voltage, namely if the channel is acting as a constant-voltage power supply.

The CF bit flags a channel communications or microprocessor failure. CX indicates a channel calibration error. The red front-panel LED will flash if any channels have their hard-error PE or CF bits set.

5.8.3 Channel Requested Current

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

Users may load this register to set the requested loop current in modes 1 and 2.

The format is unsigned integer with LSB value of 1 microampere; for example, integer value 24000 decimal corresponds to 24 mA. When internal excitation is used (mode 1) values over 24000 are internally clipped to 24000. With external excitation (mode 2) the current setpoint can be up to 32 mA, integer value 32000.

5.8.4 Channel Requested Voltage

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

Users may load this register to set the requested output voltage in mode 1. This is the maximum no-load voltage; actual voltage will be less if the external device, receiving the requested current, exhibits a voltage drop below this setting.

The format is unsigned integer with LSB value of 1 millivolt, so integer value 18000 decimal corresponds to 18 volts. Values over 18000 are internally clipped to 18000.

Future versions of the V220 may include a programmable circuit-breaker mode. To ensure forward compatibility, it is recommended that users load zero into the Requested Current and Requested Voltage registers of channels operated in the Short mode, mode 4.

5.8.5 Channel Measured Current

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

This register reports actual loop current in modes 1, 2, and 3. Format is signed integer with LSB value of 1 microampere, so integer value 32000 decimal corresponds to 32 mA. The maximum measurable value is 32.767 mA.

This value can go slightly negative due to internal offsets. This allows users to perform external calibrations at 0 mA actual current, and to determine the actual magnitude of any zero offsets.

In Short mode, mode 4, the short-circuit current is reported in this register, with LSB value of 1 mA. Accuracy is ± 2%.

5.8.6 Channel Measured Voltage

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MSB															LSB

This register reports actual A-B terminal voltage in all modes. Format is signed integer with LSB of one millivolt, with +20000 corresponding to +20.000 volts. The actual measurement range is -5 volts to +32.767 volts.

6 BIST

The V220-2 version includes built-in self-test. Note that BIST performs a basic functional check of the module logic, power supplies, and channel functions. BIST verifies all channel modes, switch paths, and ADC/DAC channels, but it cannot verify module calibration, which requires the use of external test equipment that is traceable to NIST standards.

To invoke full BIST, verify that the MS bit of the MACRO register is clear, then write 0x8401 to MACRO. This will begin the self-test, which will take about 10 seconds. The BIST request will report a macro error if the BIST option is not available.

At the end of BIST, the MACRO register will clear. The number of errors will be reported in the BERN register. BIST reporting registers BFLAG0 through BFLAG11 will report channel errors for channels 0 through 11 respectively. The BFLAGX register will report power supply and BIST self-check errors.

After BIST, if the BERN error register is nonzero, the red front-panel ERR LED will make a long flash about every 2 seconds. Users may clear BERN to clear this blink state.

The format of the BFLAG0 through BFLAG11 registers is...

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CK					IR	VS	IS	IL	SZ	IZ	I1	I0	VZ	V1	V0

Error flag bits are...

V0	excessive zero offset in voltage measurement mode
V1	gain error in voltage measurement mode
VZ	voltmeter input impedance error
I0	excessive zero offset in current measurement mode
I1	gain error in current measurement mode
IZ	ammeter input impedance error
SZ	short-mode impedance error
IL	isolation error
IS	current out (sourcing) error
VS	voltage out (sourcing) error
IR	current regulation (external source) error
CK	flags a checksum error in the SPI communications to a channel processor

The format of the BFLAGX register is...

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							I30	F3	F2	F1	F0		PS12	PS3	PS1

PS1 flags an error on the 1.2 volt power supply.

PS3 flags an error on the 3.3 volt power supply.

PS12 flags an error on the 12 volt power supply
.
F0, F1, F2, and F3 flag errors on the calibration bus

I30 flags an error in the internal 30 mA test current source.

To test a single channel, write the channel number to the PARAM0 register, then write 0x8411 to the MACRO register. The test will take about one second. BERN will indicate the number of errors found, and the appropriate channel BFLAG register will be updated.

Multiple channels can similarly be tested, with PARAM0 being a channel selection mask in bits 0..11, and the MACRO command is 0x8412.

7 Versions

V220-1: 12-channel VME current loop/process control I/O module

V220-2: 12-channel VME current loop/process control I/O module with BIST

8 Customization

Consult factory for information on additional custom versions.

9 Revision History

Revision E
Minor artwork adjustment for better manufacturing yield
Shipped with firmware 22E220 revision B

Revision D
Minor artwork adjustment for better manufacturing yield
Shipped with firmware 22E220 revision B

Revision C
Improved hardware control loop performance.
Shipped with firmware 22E220 revision B
Fixed incorrect margins on 1.2V power supply.

Revision B
First production version of the V220, introduced in December 2010
Shipped with firmware 22E220 revision A