V380

8-CHANNEL VME

STRAIN GAUGE/WEIGHING

MODULE

Technical Manual

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1. Introduction

This is the technical manual for the Highland Model V380 eight-channel strain gauge/weighing module.

The V380 is a single-width, 6U-height VME module which implements eight channels of precision load-cell-based measurement. The module incorporates excitation for up to eight 350-ohm full-bridge load cells, and provides a precision low-noise differential amplifier and 24-bit analog-to-digital converter for each input channel. The module implements a fast, simple dual-port-memory interface to the VME bus, allowing the implementation of weighing systems with minimal programming effort.

Features of the V380 include:

- Excites and measures up to eight strain gauge load cells
- Includes smart tare, calibration, and weigh functions
- 24-bit ADC per channel Onboard 32-bit processor supports digital filtering, triggered weighing, and custom computations
- Onboard 32-bit processor supports digital filtering, triggered weighing, and custom computations
- 16-bit (65536 count) resolution after tare compensation
- Clean, logical VME bus interface is well suited to PLC-based weighing applications

Although the V380 includes features specific to high-precision weighing, it is suited to nearly any application which acquires data from a strain gauge or other DC bridge-type sensor.

For custom applications, the V380 may be expanded to up to thirty-two weighing channels, and the onboard processor can be programmed to perform application-specific data filtering, linearization, threshold decision logic, partial-portion search algorithms, etc.

2. Specifications

FUNCTION	8-channel load cell module
DEVICE TYPE	Register-based slave: A16:D16:D08(EO) 512-byte data block in bus A16 address range (VME short I/O space) Bus address is set by onboard dipswitch
CHANNELS	8 load cells
EXCITATION	Onboard remote-sensed bridge excitation source, 10-volt standard; 40mA max per-channel load
INPUTS	Eight differential inputs CMRR better than 100 dB Input impedance is 60 MΩ typical Maximum input ±50 mV (equivalent to 5 mV/V excitation)
RESOLUTION	16 bits (65536 counts) MAX after tare and calibration One 24-bit ADC per channel, 32-bit after filtering, 92.132 pV per LSB
TARE	On-demand, per-channel subtraction of reference weight up to full-scale signal range
FILTERING	Programmable digital filtering (Bessel in 0.1 sec, 0.2 sec, and 0.4 sec risetime) and averaging (last N samples)
OPERATING TEMPERATURE	0 to 60°C; extended MIL/COTS ranges available
CALIBRATION INTERVAL	No factory calibration required
POWER	Standard VME supplies: +5 V: 1.5 A max +12 V: 0.6 A -12 V: 0.2 A

CONNECTORS	One front-panel 25-pin D-sub female
INDICATORS	Three LEDs indicate microprocessor heartbeat, VME access, and pass/fail status
PACKAGING	6U single-wide VME module
CONFORMANCE	ANSI/VITA 1-1994 (R2002) VMEbus spec

3. Theory of Operation

3.1 LOAD CELL BASICS

A load cell is a specialized bridge-type strain gauge used for weighing applications. A strain bridge consists of four metal foil or semiconductor resistive elements bonded to a mechanical substrate such that stress applied to the substrate results in the application of tension to two of the resistors and compression to the other two resistors. If the four resistors are arranged in a diamond configuration (Wheatstone bridge) and an excitation voltage is applied between the 'top' and 'bottom' corners of the bridge, the voltage seen across the 'sides' of the bridge will be small, due to the symmetry of the opposite legs of the bridge. If the substrate is strained by the application of a load to the cell, the four resistors will change in value (two will increase and two will decrease), causing a change in the bridge output voltage that is nearly proportional to the applied force.

Actual load cells are very sophisticated and precise devices. They are available for use in tension (hook-on-both-ends), compression, and off-center configurations. An off-center cell is compensated to be insensitive to applied torque, so that such a cell may weigh the load applied to a platform without regard for the position of the load on that platform. Modern load cells are extremely linear and are precisely compensated for the effects of temperature change.

A typical load cell appears electrically as a 4-wire bridge, having about 350 ohms resistance per leg and 350 ohms resistance between any two opposite bridge corners. Two of the leadwires are called the 'excitation' leads, to which an excitation voltage is applied, typically 5 or 10 volts DC. The other two leads are the signal wires, called the positive (or high) and negative (or low) signal outputs. Load cell full-scale capacities range from grams to thousands of kilograms full scale. A typical cell might be excited with 10 volts DC, and demonstrate a 'zero load' bridge imbalance of a few millivolts. This cell, loaded to its maximum specified weight, might output only 30 millivolts or so; such a cell would have a specified sensitivity of 3 mV/V full scale.

Some cells are supplied with six wires, having two wires for each of the excitation leads. The extra excitation wires are called 'sense leads' and may be run back to the excitation power source to permit that supply to observe the excitation voltage at the bridge itself, and adjust for any errors associated with the wire resistance between the source and the load cell.

Load cells are stable and linear, but are not very accurate "as delivered." This means that a given load cell may have an unpredictable zero-load offset signal and have a load sensitivity only within a few percent of the datasheet specification. It is common practice to install a load cell and then perform TARE and CALIBRATION operations to compensate for each cell's zero offset and calibration sensitivity. TARE is performed by removing the weighing load (but leaving any platform, rigging, or other 'overhead' loads in place) and measuring the cell output; this value is the 'tare voltage', and is saved for reference and subtracted from the bridge output in all future weighing operations. After TARE, a known standard weight may be applied to the weighing system and the resulting cell signal measured and saved; this 'cal value' is used to scale all future weight measurements to correct engineering units.

A specification sheet for a typical weighing cell follows.

3.2 V380 Hardware Architecture

The V380 module consists of the following elements :

1. A VME-standard, 6U (double-height) printed circuit board with front panel and load-cell wiring connector.

2. Eight load cell channels, each consisting of an antialiasing filter, a precision differential amplifier, and a 24-bit analog-to-digital converter. Shielding and filtering are such as to minimize thermal effects and EMI sensitivity.

3. A precision +10 volt load cell excitation power supply, with capability for single-point remote sensing.

4. A Motorola MC68332 32-bit (68020-class) microprocessor with EPROM program memory and battery-backed static RAM data memory.

5. A dual-port memory interface to the VME bus.

6. A digital-to-analog converter and maintenance connector port.

7. An optional RS-232 serial port.

The signal measurement path is fully ratiometric, using the same precision voltage source to drive the load cell excitation and to provide the references to the analog-to-digital converters. All critical resistors are packaged thinfilm networks to ensure temperature tracking.

The 16-bit digital-to-analog converter provides an accurate analog output signal which may be driven from any of several internal measured quantities, including channel ADC outputs, filtered ADC signals, and final reported weights. The signal may be observed on an oscilloscope or other recording device to assist in analyzing weighing dynamics, vibration, etc.

The RS-232 port may be used to communicate with other instruments. The V380 may also be used in a stand-alone mode (e.g., without a VME host system) with all input/output via the serial port. In this case, the module can be packaged with its own power supply in a freestanding enclosure.

The V380 may be expanded to up to 32 weighing channels by the addition of up to three slave modules, each conditioning eight additional load cell inputs.

3.3 SIGNAL PROCESSING

Each of the load cell signals is amplified and applied to an individual 24-bit analog-to-digital converter which provides a numerical signal measurement 60 times per second. The on-board processor continuously scans all ADCs, reading each converter and acquiring new measurement values. Each raw bridge voltage measurement is filtered to smooth out electrical noise and physical vibration artifacts, then adjusted for tare and calibration factors. The final filtered and scaled weight value is written to the VME-visible dual-port memory 32 times per second, in the form of a 16-bit scaled integer. The module may also be configured for running-average calculations, discrete weigh-on-demand, or other application-specific computations.

The power of the on-board processor can also be used to implement special signal processing applications, such as channel sum/difference calculations, redundant transducer logic, nonlinearity or tilt corrections, or complex multi-sensor algorithms such as multibucket partial-portion combinational searches.

3.4 SIGNAL FILTERING CONSIDERATIONS

The standard V380 implements DSP-based lowpass filtering to smooth the raw load cell measurements and reduce noise. A number of filter choices are provided, as noted in section 4.3.4.

Nearly all precision weighing systems include some sort of deliberate filtering, including all-mechanical scales whose response time and damping are controlled by design. Filtering is necessary to smooth out inevitable vibration and noise, and to damp any oscillations which tend to increase settling times. Filtering consists of removing high-frequency signals--noise and vibration--from the weight signal, so filtering will itself increase system response time. For a given combination of noise and required weighing accuracy, there is an optimum filter which will result in minimum settling time before an accurate weight can be measured, and there is an inevitable compromise between weighing accuracy and measurement speed.

Special techniques (including LaPlace and Fourier-based notch filter schemes) can reduce sensitivity to specific-frequency vibrations, but tend to disturb high-accuracy settling dynamics and are not effective against transient or variable-frequency noise and vibration.

If precision, high-speed weighing is critical to process performance, the load cell should not be exposed to low-frequency acceleration caused by low-frequency structural and mounting resonances, and the filtering should be optimized to the actual machine situation.

4. Connectors and Installation

WARNING: BEFORE INSTALLING THE V380 CARD IN A VME CAGE SLOT, TURN THE CAGE POWER OFF TO AVOID DAMAGE TO THE V380

Before Installing the V380 module, remove the transparent blue battery protector from the battery mounted on the V380 printed circuit board.

4.1 VME Compatibility

The V380 may be installed in any 6U high, VME-compatible card cage. It uses the mandatory +5V (1.5 Amp max.), -12V (0.2 Amp max.), and +12V (0.6 Amp max.) VME power supply voltages, and derives the load cell excitation voltage from the VME +12 volt supply.

The module occupies 512 bytes of the VME 'short' 16-bit (A16) addressing space, and supports both 16-bit (D16) and 8-bit (D08/EO) data transfers. The module does not use interrupts and passes all interrupt and bus grant signals.

4.2 Address Selection

Prior to installing the V380, the on-board address DIPswitch should be set to select the address range occupied by the module. Modules are factory-set to C000 hex, but may be positioned anywhere in the A16 address space.

To relocate it, pick an unused block, note its hex address, and set the address switch S3 as follows:

SECTION	BIT	HEX VALUE ON	NOTES
1	15	8000	factory ON
2	14	4000	factory ON
3	13	2000	
4	12	1000	
5	11	800	

6	10	400	
7	9	200	
8	-	-	unused

4.3 Load Cell Wiring

The V380 is furnished with a front-panel-mounted DB25 female connector for connection to up to eight load cells. The connector pinout is as follows:

```
  PIN     NAME        FUNCTION
================================================

    1     IN 0+       LOAD CELL 0 POSITIVE SIGNAL   INPUT
    2     IN 1+       LOAD CELL 1 POSITIVE SIGNAL   INPUT
    3     IN 2+       LOAD CELL 2 POSITIVE SIGNAL   INPUT
    4     IN 3+       LOAD CELL 3 POSITIVE SIGNAL   INPUT

    5     IN 4+       LOAD CELL 4 POSITIVE SIGNAL   INPUT
    6     IN 5+       LOAD CELL 5 POSITIVE SIGNAL   INPUT
    7     IN 6+       LOAD CELL 6 POSITIVE SIGNAL   INPUT
    8     IN 7+       LOAD CELL 7 POSITIVE SIGNAL   INPUT

    9     COM         VME COMMON
    10    SENSE +     POSITIVE REMOTE SENSE   INPUT
    11    EXC +       +10 VOLT EXCITATION     OUTPUT

    12    COM         VME COMMON
    13    COM         VME COMMON

    14    IN 0 -      LOAD CELL 0 NEGATIVE SIGNAL   INPUT

    15    IN 1 -      LOAD CELL 1 NEGATIVE SIGNAL   INPUT
    16    IN 2 -      LOAD CELL 2 NEGATIVE SIGNAL   INPUT
    17    IN 3 -      LOAD CELL 3 NEGATIVE SIGNAL   INPUT

    18    IN 4 -      LOAD CELL 4 NEGATIVE SIGNAL   INPUT
    19    IN 5 -      LOAD CELL 5 NEGATIVE SIGNAL   INPUT
    20    IN 6 -      LOAD CELL 6 NEGATIVE SIGNAL   INPUT
    21    IN 7 -      LOAD CELL 7 NEGATIVE SIGNAL   INPUT

    22    COM         VME COMMON
    23    SENSE-      LOWSIDE REMOTE SENSE    INPUT
    24    EXC +       +10 VOLT EXCITATION     OUTPUT

    25    COM         VME COMMON
```

It is suggested that a shielded cable be used to connect to the front-panel connector, with the shield bonded to the mating connector shell. The cable can be run to a convenient junction area where the cable is terminated and wired to load cell signals. It is convenient to use a standard RS-232 cable assembly (wired 1:1 for all 25 pins) to connect the V380 to a termination strip; the Highland model V780 termination panel is recommended for use in interfacing the V380 to field wiring.

Note that the high sides of the load cell excitation is furnished by the EXC+ signals, and the low sides return to the COM signals. EXC+ is derived from the VME +12 volt supply, and COM is connected to the VME bus power return signal. The module front panel is fastened to the VME rack by its mounting screws and is thus connected to the VME system FRAME ground, which may or may not be connected to the VME backplane COMMON signal. It is recommended that the V380 connector COM pins be regarded as signals (namely the equivalent of EXC- and not be otherwise used or grounded.

The V380 provides for remote sensing of the load cell excitation voltage AT THE TERMINATION STRIP ONLY; that is, a single, common remote sense is available to allow the module to automatically compensate for the voltage drop in the module-to-termination-panel wiring run, but remote sensing is not available for each individual load cell.

Wiring from the termination site to the individual load cells should be by means of a suitable 4- or 6-wire shielded cable, with the shields earth grounded at both ends if possible. If a six-wire load cell is used, the sense leads may be ignored, or may be used in parallel with the excitation leads to reduce excitation voltage drop.

There will be some voltage drop in the transducer excitation leads. The 'constant' component of this voltage drop will reduce the excitation voltage and thus reduce load cell sensitivity; this is usually a small effect and is eliminated as an error component when the load cell is processed through the usual TARE and CALIBRATE operations. There will be a residual, non-compensated error component due to the change in lead wire resistance with temperature. For example, a 400-ohm load cell might be connected with 100 feet of 20 AWG copper wire. The excitation wire would have a total of about 2 ohms resistance (0.01 ohms/foot times 200 feet round trip), reducing the load cell sensitivity by about 0.5 percent (2 ohms / 400 ohms). The 2-ohm resistance of the wire run will change by about 4000 PPM (0.4 %) per degree centigrade, or about 0.008 ohms/°C. This temperature change will alter the effective cell sensitivity by about 20 PPM (0.002 %) per °C. This is generally not a severe calibration error but, if the useful weighing range of the cell is a small fraction of the cell's full-scale rating and the cell is tared far from its natural zero point, this 20 PPM/ °C will be 'magnified' and may produce a substantial shift in the tare zero point of the system. Unless this system is tared often enough to cancel wire-run temperature changes, the wire size might need to be increased or the system wiring might be rearranged to move the load cell electrically closer to the excitation sense point.

4.4 Turnon and Checkout

After installing the card in the VME cage (with the power OFF), and upon turning the power ON the V380 SCAN LED will double-flash three times. The first double-flash indicates that the internal processor is alive, the second that the ROM checksum is successful, and the third that the dual-port memory is good. After the third double-flash the pass/fail LED will turn from red to green, meaning that the card is ready for use. If this does not happen, contact Highland Technology on (415) 551-1700 to report the problem. Please have the serial number of the V380 at hand.

Subsequently, the SCAN LED will continue to flash once a second while the V380 remains in operation.

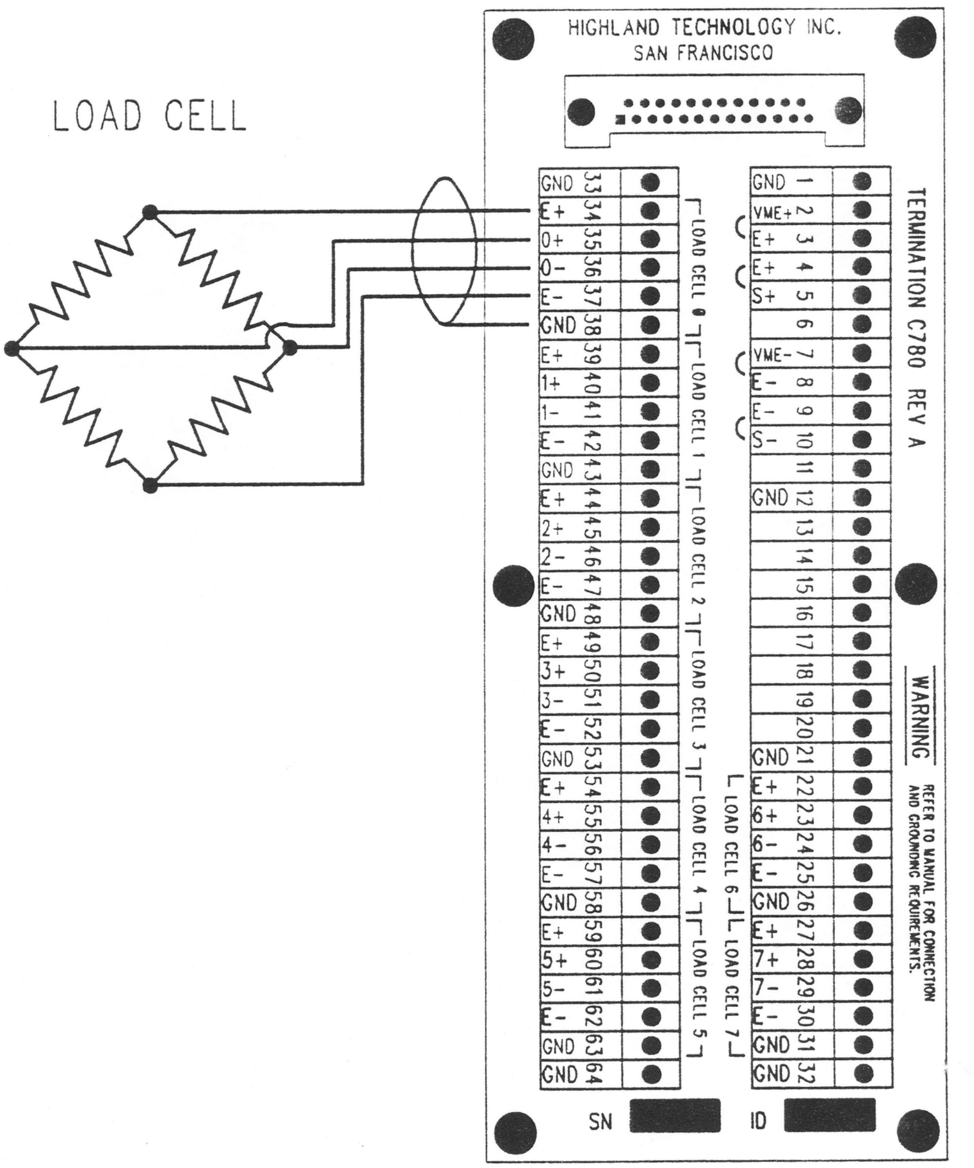

FIG 1-1 TYPICAL LOAD CELL WIRING

The figure above illustrates a typical wiring arrangement. This hookup uses common remote sensing at the cable breakout point.

5. Programming

5.1 V380 VME Register

The V380 module presents its data as a block of 512 bytes (256 words) of addressable registers in the VME short (A16) addressing space. The base address is selectable using the onboard DIPswitch S3 (see section 3.2).

The following table summarizes the functions of the 256 registers. Unless noted otherwise, all registers are 'read only' from the VME bus. Users should not attempt to alter the contents of any registers unless they are specifically documented as writable items. Registers which are writable are identified by the ** tag below. HEX OFFSET refers to the register address as a byte adder to the module base address.

OVERHEAD REGISTERS

HEX OFFSET	REGISTER NAME	FUNCTION
0	VXID	VXI manufacturers ID
2	VTYPE	VXI device type
4	VCSR	VXI status/control register
6	PGID	Firmware program version number
8	PREV	Firmware program revision letter
A	OPTS	Module option flags
C	SN	Module serial number
E	SCAN	Firmware scan counter

MODULE GLOBAL REGISTERS

HEX OFFSET	REGISTER NAME	FUNCTION
10	STS	Global status register
12	DAC	** Selects one channel to route to D/A converter
20	CMD	** Global command register
22	CP1	** Command parameter 1
24	CP2	** (additional command parameters)
26	CP3	** .
28	CP4	** .

TOTALIZER 0 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
080	TWT0	Total weight
082	TST0	Status register
084	TCM0	** Command register
086	TPH0	** Command parameter 0
088	TPL0	** Command parameter 0
08A	TRH0	Raw total weight, MS word
08C	TRL0	Raw total weight, LS word
08E	TTH0	Tare value, MS word
090	TTL0	Tare value, LS word
092	TCH0	Cal value, MS word
094	TCL0	Cal value, LS word
096	TRTH0	Reference tare, MS word
098	TRTL0	Reference tare, LS word
09A	TCS0	Channel select
09C	----	
09E	----	

TOTALIZER 1 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
0A0	TWT1	Total weight
0A2	TST1	Status register
0A4	TCM1	** Command register
0A6	TPH1	** Command parameter 0
0A8	TPL1	** Command parameter 0
0AA	TRH1	Raw total weight, MS word
0AC	TRL1	Raw total weight, LS word
0AE	TTH1	Tare value, MS word
0B0	TTL1	Tare value, LS word
0B2	TCH1	Cal value, MS word
0B4	TCL1	Cal value, LS word
0B6	TRTH1	Reference tare, MS word
0B8	TRTL1	Reference tare, LS word
0BA	TCS1	Channel select
0BC	----	
0BE	----	

TOTALIZER 2 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
0C0	TWT2	Total weight
0C2	TST2	Status register
0C4	TCM2	** Command register
0C6	TPH2	** Command parameter 0
0C8	TPL2	** Command parameter 0
0CA	TRH2	Raw total weight, MS word
0CC	TRL2	Raw total weight, LS word
0CE	TTH2	Tare value, MS word
0D0	TTL2	Tare value, LS word
0D2	TCH2	Cal value, MS word
0D4	TCL2	Cal value, LS word
0D6	TRTH2	Reference tare, MS word
0D8	TRTL2	Reference tare, LS word
0DA	TCS2	Channel select
0DC	----	
0DE	----	

TOTALIZER 3 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
0E0	TWT3	Total weight
0E2	TST3	Status register
0E4	TCM3	** Command register
0E6	TPH3	** Command parameter 0
0E8	TPL3	** Command parameter 0
0EA	TRH3	Raw total weight, MS word
0EC	TRL3	Raw total weight, LS word
0EE	TTH3	Tare value, MS word
0F0	TTL3	Tare value, LS word
0F2	TCH3	Cal value, MS word
0F4	TCL3	Cal value, LS word
0F6	TRTH3	Reference tare, MS word
0F8	TRTL3	Reference tare, LS word
0FA	TCS3	Channel select
0FC	----	
0FE	----	

LOAD CELL 0 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
100	WT0	Measured weight
102	ST0	Status register
104	CM0	** Command register
106	PH0	** MS command parameter
108	PL0	** LS command parameter
10A	RH0	Raw data, MS word
10C	RL0	Raw data, LS word
10E	TH0	Tare value, MS word
110	TL0	Tare value, LS word
112	CH0	Cal value, MS word
114	CL0	Cal value, LS word
116	FF0	Current filter factor
118	RTH0	Reference tare, MS word
11A	RTL0	Reference tare, LS word
11C	---	
11E	---	

LOAD CELL 1 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
120	WT1	Measured weight
122	ST1	Status register
124	CM1	** Command register
126	PH1	** MS command parameter
128	PL1	** LS command parameter
12A	RH1	Raw data, MS word
12C	RL1	Raw data, LS word
12E	TH1	Tare value, MS word
130	TL1	Tare value, LS word
132	CH1	Cal value, MS word
134	CL1	Cal value, LS word
136	FF1	Current filter factor
138	RTH1	Reference tare, MS word
13A	RTL1	Reference tare, LS word
13C	---	
13E	---	

LOAD CELL 2 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
140	WT2	Measured weight
142	ST2	Status register
144	CM2	** Command register
146	PH2	** MS command parameter
148	PL2	** LS command parameter
14A	RH2	Raw data, MS word
14C	RL2	Raw data, LS word
14E	TH2	Tare value, MS word
150	TL2	Tare value, LS word
152	CH2	Cal value, MS word
154	CL2	Cal value, LS word
156	FF2	Current filter factor
158	RTH2	Reference tare, MS word
15A	RTL2	Reference tare, LS word
15C	---	
15E	---	

LOAD CELL 3 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
160	WT3	Measured weight
162	ST3	Status register
164	CM3	** Command register
166	PH3	** MS command parameter
168	PL3	** LS command parameter
16A	RH3	Raw data, MS word
16C	RL3	Raw data, LS word
16E	TH3	Tare value, MS word
170	TL3	Tare value, LS word
172	CH3	Cal value, MS word
174	CL3	Cal value, LS word
176	FF3	Current filter factor
178	RTH3	Reference tare, MS word
17A	RTL3	Reference tare, LS word
17C	---	
17E	---	

LOAD CELL 4 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
180	WT4	Measured weight
182	ST4	Status register
184	CM4	** Command register
186	PH4	** MS command parameter
188	PL4	** LS command parameter
18A	RH4	Raw data, MS word
18C	RL4	Raw data, LS word
18E	TH4	Tare value, MS word
190	TL4	Tare value, LS word
192	CH4	Cal value, MS word
194	CL4	Cal value, LS word
196	FF4	Current filter factor
198	RTH4	Reference tare, MS word
19A	RTL4	Reference tare, LS word
19C	---	
19E	---	

LOAD CELL 5 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
1A0	WT5	Measured weight
1A2	ST5	Status register
1A4	CM5	** Command register
1A6	PH5	** MS command parameter
1A8	PL5	** LS command parameter
1AA	RH5	Raw data, MS word
1AC	RL5	Raw data, LS word
1AE	TH5	Tare value, MS word
1B0	TL5	Tare value, LS word
1B2	CH5	Cal value, MS word
1B4	CL5	Cal value, LS word
1B6	FF5	Current filter factor
1B8	RTH5	Reference tare, MS word
1BA	RTL5	Reference tare, LS word
1BC	---	
1BE	---	

LOAD CELL 6 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
1C0	WT6	Measured weight
1C2	ST6	Status register
1C4	CM6	** Command register
1C6	PH6	** MS command parameter
1C8	PL6	** LS command parameter
1CA	RH6	Raw data, MS word
1CC	RL6	Raw data, LS word
1CE	TH6	Tare value, MS word
1D0	TL6	Tare value, LS word
1D2	CH6	Cal value, MS word
1D4	CL6	Cal value, LS word
1D6	FF6	Current filter factor
1D8	RTH6	Reference tare, MS word
1DA	RTL6	Reference tare, LS word
1DC	---	
1DE	---	

LOAD CELL 7 DATA BLOCK

HEX OFFSET	REGISTER NAME	FUNCTION
1E0	WT7	Measured weight
1E2	ST7	Status register
1E4	CM7	** Command register
1E6	PH7	** MS command parameter
1E8	PL7	** LS command parameter
1EA	RH7	Raw data, MS word
1EC	RL7	Raw data, LS word
1EE	TH7	Tare value, MS word
1F0	TL7	Tare value, LS word
1F2	CH7	Cal value, MS word
1F4	CL7	Cal value, LS word
1F6	FF7	Current filter factor
1F8	RTH7	Reference tare, MS word
1FA	RTL7	Reference tare, LS word
1FC	---	
1FE	---	

VXID REGISTER. This 16-bit register always contains hex value FEEE, Highland Technology's VXI identification code.

VTYPE REGISTER. This register displays decimal value 22380, indicating that this is a V380 module.

VCSR REGISTER. This register will display hex code 400C (VXI flags for PASSED and READY) when the module has completed its powerup self-tests and is operating normally.

PGID REGISTER. This register displays a number which indicates the program ID of the firmware EPROM installed in the module. The standard program is 22380 decimal, equivalent to hex value 576C.

PREV REGISTER. This register displays a value that indicates the revision level of the firmware program. It represents an ASCII code, typically 65 decimal (41 hex), corresponding to the letter "A."

SCAN REGISTER. This 16-bit register 'counts up' constantly, incrementing each time a new set of weight values are posted; this happens 32 times per second in the standard firmware.

GLOBAL STATUS REGISTER. This 16-bit register displays a number of flag bits which indicate various conditions. Bits are...

BIT	HEX VALUE	FUNCTION
0	0001	POWER FAIL: indicates power has failed/recovered
1	0002	REINITIALIZE: flags cold powerup or powerfail/restart with loss of backup memory; indicates that TARE and CAL values have been lost.

Global status flags may be cleared with the CLEAR STATUS global command.

DAC REGISTER. This 16-bit register may be written by the user at any time. The register contents selects one internal value to be routed to the module's 16-bit DAC for external observation. Numerical selection values are, in decimal,...

0 ... 31	Channels 0 to 31, raw ADC data
32 ... 63	Channels 0 to 31, filtered data
64 ... 95	Channels 0 to 31, final reported weight

The raw and filtered ADC data is scaled to +/-3 volts for ADC +/- full scale (+/-50 mV input for the standard module). The final weight value is scaled to 0 volts at zero weight (tare point) and +3 volts at full-scale positive weight.

GLOBAL COMMAND REGISTER. Users may issue global (module-wide) commands to the V380 by writing a command code into this register. Some commands may require additional parameters, conveyed through the GLOBAL PARAMETER registers. See section 4.2 for details.

TOTALIZER DATA BLOCKS. Each totalizer has an associated data block in the module register space. Each block includes the following items :

TWTn: TOTAL WEIGHT. When a totalizer is calibrated as a unipolar weight, TWTn is a 16-bit unsigned integer (decimal value 0 to 65535, hex 0000 to FFFF) that is proportional to the measured weight AFTER the tare and calibration factors have been applied. If the channel has been programmed for bipolar weighing, this value must be interpreted as a signed, two's complement value ranging from +32767 to -32768 decimal (7FFF through 8000 hex).

TSTn: TOTALIZER STATUS. This register indicates the state of the associated load cell totalizer. Individual binary bits flag specific conditions. Bits are...

BIT	HEX VALUE	FUNCTION
0	0001	bit set indicates that TARE has been done
1	0002	bit set indicates that CAL has been done
8	0100	bit set indicates that total weight is bipolar
15	8000	bit set indicates a totalizer error

TCMn: TOTALIZER COMMAND. This register is written to execute a command for the associated totalizer. To execute a command, a numeric command code is written into this register; see section 4.4 for details.

TPHn, TPLn: The COMMAND PARAMETERS are associated with totalizer command execution; see section 4.4.

TRHn, TRLn: The TRH:TRL pair constitutes a 32-bit value that reflects the raw total weigh value for the associated totalizer. This number is directly proportional to the average differential output voltage of the selected load cells, and is unadjusted by any tare and calibration factors. The value should be treated as an offset binary 32-bit integer, where TRH is the most significant 16 bits and TRL is the least significant. For the standard V380 module, the scaling is 93.132 pV per LSB, with hex values ranging from 00000000 at -50 mV to 3FFFFFFF at +50 mV. This value is intended for maintenance and setup purposes only.

TTHn, TTLn: This 32-bit register pair represents the tare value for this totalizer. It is essentially a snapshot of the TRH:TRL register pair, taken at the instant that the TARE command is executed. This value is intended for maintenance and setup purposes only.

TCHn, TCLn: This 32-bit value represents the totalizer calibration factor; it is computed during the CALIBRATE command, and may be interpreted as an unsigned 32-bit fractional value with TCH being the most significant 16 bits. This value can also be downloaded to the card by using the LOAD TOTALIZER CAL FACTOR command (see section 4.4.5).

TRTHn, TRTLn: This 32-bit register pair represents a reference tare value for this totalizer. It is essentially a copy of the TRH:TRL register pair, taken at the instant that the SAVE REFERENCE TARE command is executed. This value is intended for load cell diagnostic, maintenance, and setup purposes only. This data can be used to evaluate the stability of the performance of a load cell array over extended periods of time. Discrepancies between current tare readings and the original reference tare readings stored in these registers, both having been taken under the same conditions, may indicate damage to the load cells.

TCSn: This 16-bit register displays, in its less significant byte, a bit map of the load cell channels selected for this totalizer.

BIT	HEX VALUE	LOAD CELL CHANNEL
0	01	CHANNEL 0
1	02	CHANNEL 1
2	04	CHANNEL 2
3	08	CHANNEL 3
4	10	CHANNEL 4
5	20	CHANNEL 5
6	40	CHANNEL 6
7	80	CHANNEL 7

Setting a channel bit to 1 selects that channel to be summed into the totalizer.

CHANNEL DATA BLOCKS. Each load cell channel has an associated data block in the module register space. Each block includes the following items:

WTn: MEASURED WEIGHT. When a weighing channel has been calibrated as a unipolar weight, WTn is a 16-bit unsigned integer (decimal value 0 to 65535, hex 0000 to FFFF) that is proportional to the measured weight AFTER the tare and calibration factors have been applied. If the channel has been programmed for bipolar weighing, this value must be interpreted as a signed, two's complement value ranging from +32767 to -32768 decimal (7FFF through 8000 hex).

STn: CHANNEL STATUS. This register indicates the state of the associated load cell channel. Individual binary bits flag specific conditions. Bits are...

BIT	HEX VALUE	FUNCTION
0	0001	bit set indicates that TARE has been done
1	0002	bit set indicates that CAL has been done
8	0100	bit set indicates that weight is bipolar
15	8000	bit set indicates a channel error

CMn: CHANNEL COMMAND. This register is written to execute a command for the associated channel. To execute a command, a numeric command code is written into this register; see section 4.3 for details.

PHn, PLn: The COMMAND PARAMETERS are associated with channel command execution; see section 4.3.

RHn, RLn: The RH:RL pair constitutes a 32-bit value that reflects the filtered ADC value for the associated channel. This number is directly proportional to the load cell differential output voltage as reported to the analog-to-digital converter, and is unadjusted by any tare and calibration factors. The value should be treated as an offset binary 32-bit integer, where RH is the most significant 16 bits and RL is the least significant. For the standard V380 module, the scaling is 93.132 pV per LSB, with hex values ranging from 00000000 at -50 mV to 3FFFFFFF at +50 mV. This value is intended for maintenance and setup purposes only.

THn, TLn: This 32-bit register pair represents the tare reference value for this channel. It is essentially a snapshot of the RH:RL register pair, taken at the instant that the TARE command is executed. This value is intended for maintenance and setup purposes only.

CHn, CLn: This 32-bit value represents the channel calibration factor; it is computed during the CALIBRATE command, and may be interpreted as an unsigned 32-bit fractional value with CH being the most significant 16 bits. This value is intended for maintenance and setup purposes only.

TRTHn, TRTLn: This 32-bit register pair represents a reference tare value for this totalizer. It is essentially a copy of the TRH:TRL register pair, taken at the instant that the SAVE REFERENCE TARE command is executed. This value is intended for load cell diagnostic, maintenance, and setup purposes only. This data can be used to evaluate the stability of the performance of a load cell array over extended periods of time. Discrepancies between current tare readings and the original reference tare readings stored in these registers, when the readings have been taken under the same conditions, may indicate damage to the load cells.

5.2 GLOBAL COMMANDS

A number of global commands may be executed, namely operations which affect all measurement channels and totalizers. Some global commands may require additional parameters. To execute a global command,

1. Write parameters, if required,

2. Write a command code value (described below) to the global command register CMD,

3. Wait for the command register to change value; it will change to zero when the command is successfully executed, and will change to hex value 8000 if the command terminates in an error condition.

Global commands are :

CMD CODE hex	CMD CODE decimal	FUNCTION
1	1	REINITIALIZE ALL CHANNELS/TOTALIZERS
2	2	TARE ALL CHANNELS/TOTALIZERS
3	3	CALIBRATE ALL CHANNELS/TOTALIZERS UNIPOLAR
4	4	CALIBRATE ALL CHANNELS/TOTALIZERS BIPOLAR
5	5	SET ALL CHANNEL FILTER FACTORS
6	6	SAVE CHANNELS/TOTALIZERS REFERENCE TARE
7	7	LOAD CHANNELS/TOTALIZERS CAL FACTORS
8	8	LOAD CHANNEL-SELECT MAP FOR TOTALIZERS
A	10	CLEAR GLOBAL STATUS WORD

The REINITIALIZE command clears all channel/totalizer status registers, and initializes all tare and cal factors to their cold-start values; see section 4.3.1.

Executing the TARE ALL command is equivalent to executing tare commands onto all weighing channels/totalizers.

The CALIBRATE ALL commands are identical to the corre-sponding channel/totalizer commands listed below, but simultaneously calibrate all channels/totalizers. The global parameters CP1 and CP2 are used as the calibration targets for all channels/totalizers.

The SET ALL FILTER FACTORS command sets the filter factors for all weighing channels, using the CP1 global parameter as the filter factor. Totalizers are not affected by this command.

The SAVE CHANNELS/TOTALIZERS REFERENCE TARE command makes copies of all the current tare values and stores them in the reference tare registers: TRTHn, TRTn for totalizers and RTHn, RTLn for channels.

The LOAD CHANNELS/TOTALIZERS CAL FACTORS command downloads a common calibration factor to all totalizers and channels. CP1 will contain the MS word of the CAL FACTOR and CP2, the LS word.

The LOAD CHANNEL-SELECT MAP FOR TOTALIZERS command downloads a common channel select map to all totalizers. CP1 will contain in its low byte the channel-select bit map. See section 4.1.

The CLEAR GLOBAL STATUS WORD command clears the global status register, which clears the POWER FAIL and REINITIALIZE flags.

5.3 Channel Commands

It is possible to execute operations onto individual load cell channels. Each channel has a channel command register CMn. To execute a command,

1. Write to one or both of the command parameter registers, as appropriate,

2. Write a command code value (described below) to the channel command register,
3. Wait for the command register to change value; it will change to zero when the command is successfully executed, and will change to hex value 8000 if the command terminates in an error condition.

Channel commands are:

CMD CODE hex	PARAMETERS PH	PL	FUNCTION
1	--	--	REINITIALIZE CHANNEL
2	--	--	TARE
3	WT TARGET	--	CALIBRATE UNIPOLAR
4	WT TARGET	--	CALIBRATE BIPOLAR
5	FILT FCTR	--	SET FILTER FACTOR
6	--	--	SAVE REF TARE
7	CAL FCTR MS	CAL FCTR LS	LOAD CAL FACTOR

5.3.1 Reinitialize

The REINITIALIZE command clears the channel status register and essentially declares the channel to be inactive. To activate the channel, perform the TARE and CALIBRATE commands, as detailed below.

REINITIALIZE will install a set of default tare and calibration values which will result in the reported weight value being an indication of the electrical input to the channel, with integer values ranging from -32768 to +32767 for inputs of -32.768 to +32.767 mV respectively. Absolute accuracy is undefined under these conditions, and the selected filtering remains active.

5.3.2 Tare

A load cell is a bridge-type strain gauge whose electrical output changes when a weight is applied to the cell. The output of the cell is generally NOT exactly zero millivolts with no applied load, and the cell 'zero weight' output may be further altered by the empty weight of weighing platforms, buckets, or linkages.

A TARE operation is used to declare that the current load cell output should henceforth be considered the 'zero weight' level. To TARE a channel, ensure that the load cell is loaded at the 'zero' weight level, then execute the
channel TARE command by writing hex value 0002 into the channel CM register. The TH:TL 32-bit register will then be updated to be equal to the current 'raw' ADC value RH:RL, and this value will be used as the reference for all subsequent weighing operations.

The TARE operation will result in an error condition if the ADC input is overloaded at the instant the command is invoked.

5.3.3 Calibration

Load cell outputs are generally not scaled to any precise relationship between millivolt output and engineering units, so they are generally calibrated in-place. Two CALIBRATE commands are provided to correctly span input signals to engineering units. The CALIBRATE UNIPOLAR calibrates a channel for unipolar (positive weight only) measurement, and the CALIBRATE BIPOLAR command cals a channel for positive/negative weighing.

To calibrate a load cell channel for unipolar weighing, proceed as follows:

1. Perform the TARE operation described in section 4.6.

2. Apply a standard reference weight to the load cell.

3. Write the desired weight target value to the channel's PH command parameter register.

4. Perform the CALIBRATE channel command, by writing hex value 0003 into the channel CM register.

The V380 will then compute the proper calibration factor and present it in the CH:CL register pair.

For example, suppose we wish to use a 500 gram calibration weight, and would like the channel's reported weight value WTn to be equal to 50,000 decimal when 500 grams is applied, giving an LSB resolution of 0.01 grams. After TARE, we would load the cell with the 500 gram weight, write the number 50,000 (C350 hex) to the PH register and, and then execute the CALIBRATE command. The V380 will then compute and update the CH:CL value. Now, the WTn register value will be proportional to applied weight, with decimal value 0 corresponding to zero weight, 50,000 will indicate 500 grams, and the maximum value of 65,535 (FFFF hex) will correspond to a weight of 655.35 grams. This procedure allows ANY arbitrary scaling to be established between load cell output and the reported 16-bit weight value.

The CALIBRATE BIPOLAR operation is identical, except that the weight value and calibration targets are considered to be signed, two's complement 16-bit values which can range in value from -32768 to +32767, corresponding to hex values 8000 to 7FFF respectively. The applied calibration weight must still be positive, and the target value must be positive at CAL time.

Either CALIBRATE operation can result in an error if...

A. The ADC is overloaded at CAL time, or

B. The load cell output is insufficiently greater than the TARE value (less than about 1 part in 10,000 of full scale), or

C. The channel has not been correctly tared.

If such an error is detected, the channel status register will assert its ERROR bit, and the CAL channel status bit will be cleared.

5.3.4 Filtering Options

The V380 can use a number of lowpass filtering algorithms to reduce noise and vibration in reported channel data. To select a filtering option for a single channel, write the desired filter factor into a PHn channel parameter register and write the command code 5 into the channel command register.

To set the filter factors for all weighing channels, write the factor to the CP1 global parameter register and write command code 5 to the global command register; this selection will then be in effect for all measurement channels.

Filtering factor codes are...

```
0 : no filtering. Raw ADC data is used for weight calculations.

1 : 4 Hz, 0.3 s. settling time, 4th order Bessel filter

2 : 2 Hz, 0.6 s. settling time, 4th order Bessel filter

3 : 1 Hz, 1.2 s. settling time, 4th order Bessel filter

4 : 0.5 Hz, 2.4 s. settling time, 4th order Bessel filter
```

NOTE: Settling times are specified to 0.1 percent of final value.

'Running average' filtering may also be requested. In this mode, a new load cell measurement is acquired every 1/60 of a second, and the channel weight is reported as the average of the latest N samples, where N may range from 1 to 180 samples (averaging over corresponding time intervals from 1/60 second to 3.00 seconds). To select averaging mode, load a filter factor value from 257 to 436 decimal, in the form...

```
FF = 256 + N        (or 100 + N in hex)
```

When a channel is tared or calibrated, any uncertainty in the associated measurements will be 'frozen' into all subsequent working measurements. Users may wish to select relatively slow filtering factors during TARE and CAL to reduce measurement noise, then switch to faster filtering
for normal system operation.

For high speed strain gauge instrumentation applications, special versions of the V380 are available with higher measurement rates and faster filtering algorithms.

5.3.5 Save Channel Reference Tare

SAVE CHANNEL REFERENCE TARE command makes a copy of the current tare value and stores it in the reference tare register: RTHn, RTLn.

5.3.6 Load Channel Cal Factor

The LOAD CHANNEL CAL FACTOR command downloads a new cal factor to the channel. PHn will contain the MS word of the CAL FACTOR and PLn, the LS word.

5.4 Totalizer Commands

It is possible to execute operations onto totalizers. Each totalizer has a totalizer command register TCMn. To execute a command,

1. Write to one or both of the command parameter registers (TPHn and TPLn), as appropriate.

2. Write a command code value (described below) to the totalizer command register.

3. Wait for the command register to change value; it will change to zero when the command is successfully executed, and will change to hex value 8000 if the command terminates in an error condition.

Totalizer commands are:

CMD CODE hex	PARAMETERS TPH	TPL	FUNCTION
1	--	--	REINITIALIZE TOTALIZER
2	--	--	TARE
3	WT TARGET	--	CALIBRATE UNIPOLAR
4	WT TARGET	--	CALIBRATE BIPOLAR
6	--	--	SAVE REFERENCE TARE
7	CAL MS	CAL LS	LOAD CAL FACTOR
8	SELECT MAP		LOAD SELECT MAP

5.4.1 Reinitialize Totalizer

The REINITIALIZE command clears the totalizer status register and essentially declares the totalizer to be inactive. To activate the totalizer, perform the TARE and CALIBRATE commands, as detailed below.

REINITIALIZE will install a set of default tare and calibration values which will result in the reported average value of the electrical inputs to the selected channels, with integer values ranging from -32768 to +32767 for inputs of -32.768 to +32.767 mV respectively. Absolute accuracy is undefined under these conditions.

5.4.2 Tare Totalizers

A TARE operation is used to declare that the current total should henceforth be considered the 'zero weight' level. To TARE a totalizer, ensure that the load cell array being totalized is loaded at the 'zero' weight level, then execute the TARE command by writing hex value 0002 into the totalizer TCM register. The TTH:TTL 32-bit register will then be updated to be equal to the current 'raw' total value TRH:TRL, and this value will be used as the reference for all subsequent totalizing operations for the load cell array.

The TARE operation will result in an error condition if the raw total is above 49mV.

5.4.3 Calibration of Totalizers

Different totalizer calibration procedures are followed for arrays of standardized and non-standardized load cells. The commands, CAL TOTALIZER UNIPOLAR and CAL TOTALIZER BIPOLAR, can only be used for standardized load-cell arrays. Consult Highland Technology for the procedure for totalizing non-standard load-cell arrays. Either the UNIPOLAR or BIPOLAR calibration procedures do not have to be preceded by calibration of the individual load cells in the selected array; but individual calibration is still possible. Doing individual calibrations could be used to check the assumption that load cells are indeed standardized.

To calibrate an array of standardized (matched to 0.1% or better) load cells for unipolar weighing, proceed as follows:

1. Perform the TARE operation described in section 4.4.2.

2. Apply a standard reference weight to the load cell.

3. Write the desired weight target value to the channel's TPH command parameter register.

4. Perform the CALIBRATE totalizer command, by writing hex value 0003 into the totalizer TCM register.

The V380 will then compute the proper calibration factor and present it in the TCH:TCL register pair.

The CALIBRATE BIPOLAR operation is identical, except that the total weight value and calibration targets are considered to be signed, two's complement 16-bit values which can range in value from -32768 to +32767, corresponding to hex values 8000 to 7FFF respectively. The applied calibration weight total must still be positive, and the total target value must be positive at CAL time.

Either CALIBRATE operation can result in an error if...

A. The raw total exceeds 49mV at CAL time, or

B. The raw total is insufficiently greater than the TARE value (less than about 1 part in 10,000 of full scale), or

C. The totalizer has not been correctly tared.

If such an error is detected, the totalizer status register, TSTn, will assert its ERROR bit, and the CAL totalizer status bit will be cleared.

5.4.4 Totalizer Reference Tare

The SAVE TOTALIZERS REFERENCE TARE command makes copies of all the current tare values and stores them in the reference tare registers: TRTHn, TRTn.

5.4.5 Load Totalizer Cal Factor

The LOAD TOTALIZER CAL FACTOR command downloads a new cal factor to the totalizer. TPHn will contain the MS word of the CAL FACTOR and TPLn, the LS word.

5.4.6 Load Channel-Select Map For Totalizers

The LOAD CHANNEL-SELECT MAP FOR TOTALIZERS command downloads a channel select map to a totalizer. TPHn will contain in its low byte the channel-select bit map. See section 5.1.

6. Versions

V380-1: 8-channel VME strain gauge/weighing module

7. Customization

Consult factory for information about additional custom versions.

8. Revision History

8.1 Hardware Revision History

Revision B	June 1995
Revision A	March 1995 Initial Release

8.2 Firmware Revision History

Revision E	September 1996
Revision D	July 1995 Fixes bug that updated status registers of totalizers after calibration
Revision C	July 1995
Revision B	February 1995 Initial Release

9. Accessories

V780-1: Field wiring termination panel w/ 6' cable