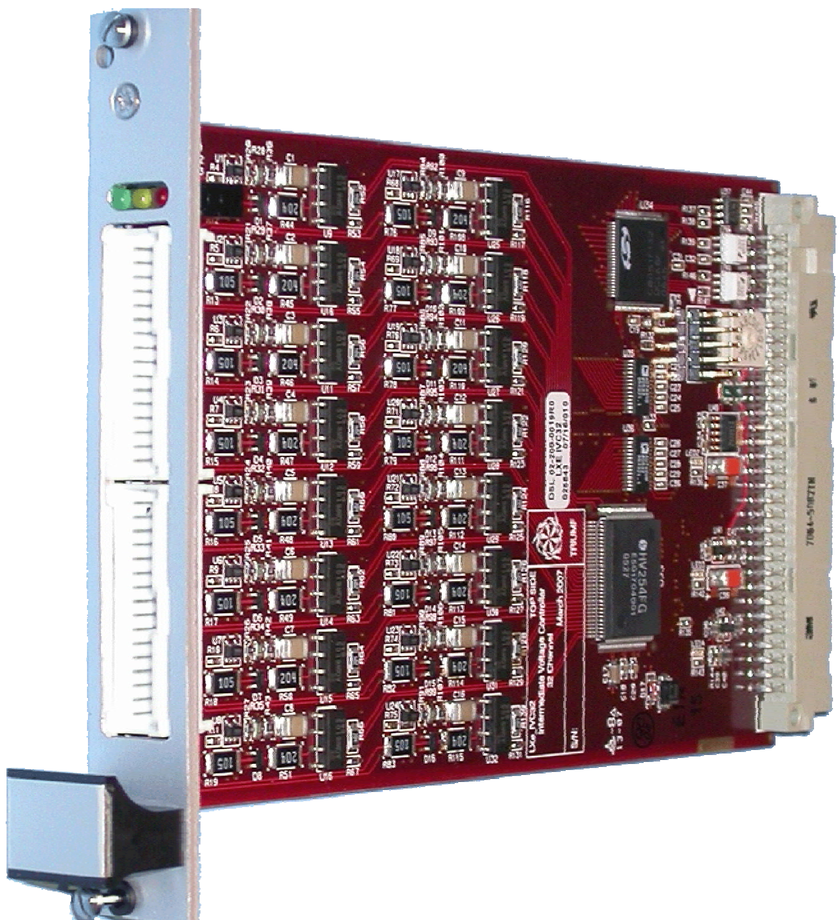
LXe_IVC32

32-Channel Intermediate Voltage Control Module
User's Manual



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Introduction

LXe_IVC32 is a 32-channel intermediate voltage control module. It was designed to be used as an APD bias controller for the Liquid Xenon project. Each of the 32 outputs can deliver 0-238V and are intended to supply 0 – 500nA, however, all channels may simultaneously draw up to 80uA if current monitoring is not required. The outputs may be set with a resolution of 61mV and is regulated to ±1 LSB over the full 0-238V range. Output current is monitored with a 0.61nA resolution. The module is compliant with the Midas Slow Control Bus (MSCB).

The LXe_IVC32 modules are based on a standard single height (3U x 160mm) eurocard and may be housed in a variety of standard crates. A 21-slot custom backplane has been developed which distributes the various power supplies and MSCB signals.

Electrical Specifications

PARAMETER		CONDITION	MIN	TYP	MAX	UNIT
Vs	LV Supply Voltage Range		5.225		10	V
		Backplane J22, J23 placed (Vs powering MSCB)	5.225		5.5	V
Is	LV Supply Current			150		mA
V_{HV}	HV Supply Voltage Range			250	275	V
V_{out}	Output Voltage Range	V_{HV} = 250V, No Load	0		238	V
$V_{out\ LSB}$	Output Voltage Resolution			61		mV
ΔV_{out}	Output Voltage Accuracy			±1		LSB
I_{OUT}	Output Current	* sum of all channels *			2.5	mA
I_{CHmon}	HV Output Monitoring Leakage Current (per channel)	V_{HV} = 250V, No Load		30	55	uA
		V_{HV} = 250V, 100MΩ Load		275	350	uA

Table 1: LXe_IVC32 Electrical Specifications

MSCB Interface

The LXe_IVC32 is compliant with the MSCB specification. For more information concerning MSCB please refer to http://midas.psi.ch/mscb

Module Addressing

The 16-bit address of a specific LXe_IVC32 module is set using a combination of the MSCB soft addressing and the hexadecimal rotary switch, S1, as follows:

Soft Addr.				Hard Addr.							Channel Addr.				
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Table 2: 16-bit Module Address Definition

Bits	Description
4..0	Channel sub-address – 0x0 to 0x1F (32 channels)
7..5	Not Used – Available for future use (defaults to 000)
11..8	Hard Address • Set using rotary switch S1 • Read once at power-up / reset
15..12	MSCB Soft Address • Set using MSCB 'sa' command • Soft address is persistent through reset or power cycle • Defaults to 0xF on first use

NOTE: Using the MSCB 'sa' command, bits 11..5 will be overwritten in effect creating an 11-bit soft address. The next time the power is cycled or a reset is issued the hard address (S1) and '000' of the unused bits take precedence and only bits 15..12 of the soft address are retained.

Node Variables

Each individually addressable channel of the LXe_IVC32 module has the following set of node variables that are used for control and monitoring of that output channel.

Table 3: Summary of MSCB Node Variables

Index	Variable	Description	Type
0	Control	Control Register	Read / Write
1	Status	Status Register	Read Only
2	Vset	Desired Output Voltage	Read / Write
3	Vmeas	Monitored Output Voltage	Read Only
4	Imeas	Monitored Output Current	Read Only
5	Ilimit	Trip Threshold – Output Current Limit	Read / Write
6	TripTime	Time Over-Current for Trip	Read / Write

7	RampStep	Voltage Step for Ramping	Read / Write
8	StepTime	Time per Step for Ramping	Read / Write
9	Vsuppy	Monitored HV Supply Voltage	Read Only
10	T_CPU	Monitored CPU Temperature	Read Only
11	Vgain	Calibration – Voltage Monitor Gain	Hidden / Read / Write
12	Voffset	Calibration – Voltage Monitor Offset	Hidden / Read / Write
13	Igain	Calibration – Current Monitor Gain	Hidden / Read / Write
14	Ioffset	Calibration – Current Monitor Offset	Hidden / Read / Write

0 - Control Register

The control register contains various parameters that define the operation for the associated channel.

						REG	EN
7	6	5	4	3	2	1	0

Table 4: Control Register Definition

Bits	Description
0	EN – Output Enable Bit 0 : Disabled 1 : Enabled
1	REG – Output Regulation Enable Bit 0 : Disabled 1 : Enabled
7..2	Not Used – Available for future use

EN

When the EN bit is asserted, the addressed channel is active and the output is tied to the set voltage, driven from DAC and HV amplifier.

When the EN bit is cleared, the channel is disabled and the output is tied to ground.

NOTE: The EN bit may be cleared automatically, disabling the channel, if an over-current condition is detected as defined by Ilimit and TripTime parameters.

REG

When the REG bit is asserted, the output of the addressed channel is regulated by comparing the measured voltage (Vmeas) and the desired voltage (Vset) and adjusting the DAC set point as required.

When the REG bit is cleared, the channel output is set based on a calculated optimal DAC setting.

1 - Status Register

The status register is a read only register that contains the current operational status of the LXe_IVC32 module.

ILIM	VLIM				RAMP	UP	DN
7	6	5	4	3	2	1	0

Table 5: Status Register Definition

Bits	Description
0	DN – Ramping Down Status Flag
1	UP – Ramping Up Status Flag
2	RAMP – Ramping to New Set Point Status Flag 0 : Ramping complete… Regulating channel if REG is set in Control Reg. 1 : Ramping to new value
5..3	Not Used – Available for future use
6	VLIM – Voltage Limit Flag 0 : Normal Operation 1 : Output is voltage limited… Desired set point is not attainable
7	ILIM – Over-current Condition Flag 0 : Normal Operation 1 : Output is over the current limit set by Ilimit

2 - Vset

Vset parameter contains the desired output voltage for the associated channel. Writing a new value to Vset will set the RAMP bit in the status register and begin ramping the output voltage up or down to the desired set voltage.

Actual voltage seen at the output is limited by the supplied voltage on HV supply. Due to current leakage through the voltage and current monitoring circuits and the associated voltage drops through the current limiting protection resistors, the maximum attainable output voltage is actually less than the HV supply voltage. Typically no load voltage drops are about 10V, but this value is load dependent.

3 - Vmeas

Vmeas is a read-only variable that contains the monitored voltage at the output for the associated channel. The voltage is monitored with a resolution of 61mV over the full range of 0 – 250V.

4 - Imeas

Imeas is a read-only variable that contains the monitored current (in nA) at the output for the associated channel. The current is monitored with a resolution of 0.61nA over the full range 0 – 500nA.

5 - Ilimit

Ilimit parameter sets the maximum allowed output current (in nA) for the associated channel. If the measured current (Imeas) exceeds this threshold then the ILIM flag is raised in the status register signaling an over-current condition. If the over-current condition persists for the time, specified in the TripTime parameter, then the channel will trip and be automatically disabled.

NOTE: To disable the over-current trip feature write 0xFFFF to the TripTime parameter.

6 - TripTime

TripTime defines the output current time-over-threshold (in ms) before the channel will trip and is automatically disabled. If 0xFFFF is written to TripTime then the over-current trip feature is disabled.

7 - RampStep

RampStep defines the amplitude (in V) of a single step while ramping the output voltage after a new value is written to Vset or the channel is enabled.

8 - StepTime

StepTime defines the time (in ms) taken for a single step while ramping the output voltage after a new value is written to Vset or the channel is enabled.

9 - Vsupply

Vsupply is a read-only variable that contains the voltage of the HV supply. The voltage is monitored with a resolution of 244mV over the full range of 0 – 250V.

10 - T_CPU

T_CPU is a read-only variable that contains the temperature (in °C) measured inside the microcontroller.

11 - Vgain HIDDEN

Vgain is a calibration parameter that defines the gain in the voltage monitoring circuit for the associated channel. The default value is 50.8.

12 - Voffset HIDDEN

Voffset is a calibration parameter that defines the offset in the voltage monitoring circuit for the associated channel. The default value is 0.

13 - Igain HIDDEN

Igain is a calibration parameter that defines the gain in the current monitoring circuit for the associated channel. The default value is 1000 (for current in nA).

14 - Ioffset HIDDEN

Ioffset is a calibration parameter that defines the offset in the current monitoring circuit for the associated channel. The default value is 0.

Operating Features

On-board Power LEDs

There are three orange surface mount power LEDs, LED2 – LED4, located near the backplane connector of the each LXe_IVC32 module. They serve as a quick verification that the power supplies necessary for correct operation are functioning: +3.3V, +5V and -5V (from top to bottom respectively).

Front Panel Status LEDs

There are three LEDs on the front panel associated with each port of the VPC6 module. Their functionality is as follows:

MSCB Primary – Green LED

BLINK	The module is fully operational.
OFF	The module is not operational. Reset the module.

Ramp Status – Yellow LED

ON	
OFF	

HV Warning – Red LED

ON	A high voltage supply greater than 24V is present. Caution should be exercised as higher voltages may be present on the outputs. By design, no injury should be caused through human contact, but damage to the electronics may result. DO NOT remove an LXe_IVC32 module from the crate while this LED is on. Turn off the HV supply then remove the module.
OFF	HV Supply is not present or less than 24V

Front Panel HV Output Ports

On the front panel, two 32-pin Molex MicroClasp locking connectors, P1 and P2, provide the output of the LXe_IVC32 voltage control module. The mating wire-to-board receptacle (Molex 51353-3200) and crimp terminals (Molex 56134-9000) should be used. Alternating signal-ground pin configurations make for easy termination using coaxial cable.

Pin	Function	Pin	Function
1	AGND – Analog GND	2	V_{OUT0} – Ch. 0 Output
3	AGND – Analog GND	4	V_{OUT1} – Ch. 1 Output
5	AGND – Analog GND	6	V_{OUT2} – Ch. 2 Output
7	AGND – Analog GND	8	V_{OUT3} – Ch. 3 Output
9	AGND – Analog GND	10	V_{OUT4} – Ch. 4 Output
11	AGND – Analog GND	12	V_{OUT5} – Ch. 5 Output
13	AGND – Analog GND	14	V_{OUT6} – Ch. 6 Output
15	AGND – Analog GND	16	V_{OUT7} – Ch. 7 Output
17	AGND – Analog GND	18	V_{OUT8} – Ch. 8 Output
19	AGND – Analog GND	20	V_{OUT9} – Ch. 9 Output
21	AGND – Analog GND	22	V_{OUT10} – Ch. 10 Output
23	AGND – Analog GND	24	V_{OUT11} – Ch. 11 Output
25	AGND – Analog GND	26	V_{OUT12} – Ch. 12 Output
27	AGND – Analog GND	28	V_{OUT13} – Ch. 13 Output
29	AGND – Analog GND	30	V_{OUT14} – Ch. 14 Output
31	AGND – Analog GND	32	V_{OUT15} – Ch. 15 Output

Table 6: P2 Connector Pin-Out

Pin	Function	Pin	Function
1	AGND – Analog GND	2	V_{OUT16} – Ch. 16 Output
3	AGND – Analog GND	4	V_{OUT17} – Ch. 17 Output
5	AGND – Analog GND	6	V_{OUT18} – Ch. 18 Output
7	AGND – Analog GND	8	V_{OUT19} – Ch. 19 Output
9	AGND – Analog GND	10	V_{OUT20} – Ch. 20 Output
11	AGND – Analog GND	12	V_{OUT21} – Ch. 21 Output
13	AGND – Analog GND	14	V_{OUT22} – Ch. 22 Output
15	AGND – Analog GND	16	V_{OUT23} – Ch. 23 Output
17	AGND – Analog GND	18	V_{OUT24} – Ch. 24 Output
19	AGND – Analog GND	20	V_{OUT25} – Ch. 25 Output
21	AGND – Analog GND	22	V_{OUT26} – Ch. 26 Output
23	AGND – Analog GND	24	V_{OUT27} – Ch. 27 Output
25	AGND – Analog GND	26	V_{OUT28} – Ch. 28 Output
27	AGND – Analog GND	28	V_{OUT29} – Ch. 29 Output
29	AGND – Analog GND	30	V_{OUT30} – Ch. 30 Output
31	AGND – Analog GND	32	V_{OUT31} – Ch. 31 Output

Table 7: P1 Connector Pin-Out

Backplane Connector

A backplane connector, P3, is used to deliver all required power and module level control for the operation of the LXe_IVC32. A standard DIN 41612, 64-position, 2 row, type B connector is used. All power for the board, including low voltage and high voltage (~250V), and the MSCB control signals are supplied through this connector.

The interface was designed for use with a custom 21-slot 3U backplane called LXe_IVC32_Backplane. If a backplane is not desired, the pinout was designed such that an MSCB connector may be plugged directly into the back of the module. In this case, power may be supplied to the board through a standard 0.1" pitch connector.

Pin	Function	Pin	Function
A1	MSCB – RS485-	B1	MSCB – RS485+
A2		B2	
A3	MSCB – GND	B3	MSCB – +5V supply
A4		B4	
A5		B5	
A6	Vs – LV Supply	B6	Vs – LV Supply
A7	Vs – LV Supply	B7	Vs – LV Supply
A8	Vs – LV Supply	B8	Vs – LV Supply
A9	Vs – LV Supply	B9	Vs – LV Supply
A10	Vs – LV Supply	B10	Vs – LV Supply
A11	DGND – Digital GND	B11	DGND – Digital GND
A12	DGND – Digital GND	B12	DGND – Digital GND
A13	DGND – Digital GND	B13	DGND – Digital GND
A14	DGND – Digital GND	B14	DGND – Digital GND
A15	DGND – Digital GND	B15	DGND – Digital GND
A16	DGND – Digital GND	B16	DGND – Digital GND
A17	DGND – Digital GND	B17	DGND – Digital GND
A18	DGND – Digital GND	B18	DGND – Digital GND
A19	DGND – Digital GND	B19	DGND – Digital GND
A20	AGND – Analog GND	B20	AGND – Analog GND
A21	AGND – Analog GND	B21	AGND – Analog GND
A22	AGND – Analog GND	B22	AGND – Analog GND
A23	AGND – Analog GND	B23	AGND – Analog GND
A24	AGND – Analog GND	B24	AGND – Analog GND
A25	AGND – Analog GND	B25	AGND – Analog GND
A26	AGND – Analog GND	B26	AGND – Analog GND
A27	AGND – Analog GND	B27	AGND – Analog GND
A28	AGND – Analog GND	B28	AGND – Analog GND
A29	V_{HV} – HV Supply	B29	V_{HV} – HV Supply
A30	V_{HV} – HV Supply	B30	V_{HV} – HV Supply
A31	V_{HV} – HV Supply	B31	V_{HV} – HV Supply
A32	V_{HV} – HV Supply	B32	V_{HV} – HV Supply

Table 8: P3 Connector Pin-Out