Precision VME High Voltage Power Supply
VHS Multi Channel Series

Operator's Manual

Contents:

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Attention!

-It is not allowed to use the unit if the covers have been removed.

-We decline all responsibility for damages and injuries caused by an improper use of the module. It is highly recommended to read the operators manual before any kind of operation.

Note

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1. General Information

The VHS modules are High Voltage power supplies in 6U VME format, 164 mm deep, the 4 channel (VHS 40x) in single width (up to 4 kV), the 12 channel (VHS C0x) in double width. The units are controlled exclusively via the VME bus system.
The high voltage supplies provide a high precision output voltage with very low ripple and noise, even under full load. A separate hardware setting for voltage and current limits protects connected sensitive devices. Additionally, the maximal output current per channel is programmable via the interface.
The maximum output voltage for the channels 0 to 3 is defined through the position of the potentiometer V_{max} .
The maximum output current for the channels 0 to 3 is defined through the position of the potentiometer I_{max} .
It is possible to measure the hardware voltage and current limit, which have been set with reference to the maximum possible value at the socket below. 100 % V_{max} and I_{max} corresponds to 2,5 V.
The output voltage and current will be limited to the setting value (when KillEnable is not active) or will be shut off (KillEnable is active)

The green LED on the front panel is an over-all indicator for the status of all channels and the module. When Module is in good state, the LED is ON. If there is an abnormal state (e.g. any limit or bounds is exceeded or any output is shut off in KillEnable active mode) this LED is 'OFF'.
When a VME cycle addresses the module, the LED flashes one time per second. The duty cycle gives the information about the LED status: 90% ON, 10% OFF means the module is in good state, otherwise the duty cyle is 10% ON, 90% OFF.

The high voltage outputs are protected against overload and short circuit. The HV-GND is connected to the chassis and the GND.

The socket for the safety loop (global interlock signal) is at the bottom of the front panel. If the safety loop is active, output voltage is only present if a current in a range of 4 to 20 mA of any polarity is flowing at the safety loop connection point (i.e. safety loop is closed). If the safety loop is opened during operation then the output voltages are shut off without ramp and the corresponding bit in the 'ModuleStatus' will be cancelled respectively the corresponding bit in the ModuleEventStatus will be set. When loop is closed again the ModuleEventStatus bits have to be reset before channels can be switched 'ON' .
The pins of the loop are potential free, the internal voltage drop is ca. 3 V.
Coming from the factory the safety loop is not active (the corresponding bit is always set). Removing of an internal jumper activates the loop. The removing jumper "ILK" can be found on the topside of the board.

Coming from the factory the VME base address is set to 0x4000 (byte-wise, respective 0x2000 word-wise) with help of setting the internal jumper "ADR" on the topside of the board (see 4.4.1 Setting of Base Address).

OPTIONS:

Interlock Output Signal on SL-connector (instead safety loop input)
An Interlock Output Signal will be static active while:

- Kill is disable (ModuleControl bit SetKilEnable=0)
- and
  - o Voltage or Current limit has been exceeded
    Channel status flag IsVLIM=1 or IsCLIM=1
  - or
  - o unit works in current control mode
    Channel status flag IsCC=1
  - or
  - o Output Voltage exceeded Voltage Bounds
    Channel status flag IsVBNDS=1

Single-channel switch off via individual TTL-inputs

- INHIBIT input open or at high level: channel works normal
- INHIBIT input connected to ground or at low level: channel is switched off

2. Technical Data

4 channel VHS	40 05p	40 05n	40 10p	40 10n	40 20p	40 20n	40 30p	40 30n	40 40p	40 40n	40 60p	40 60n
Output voltage V_{nom}	+ 500 V	– 500 V	+ 1 kV	– 1 kV	+ 2 kV	– 2 kV	+ 3 kV	– 3 kV	+ 4 kV	– 4 kV	+ 6 kV	– 6 kV
Output per channel I_{nom}	15 mA		8 mA		4 mA		3 mA		2 mA		1 mA	
Setting resolution voltage)*	20 mV		40 mV		80 mV		120 mV		160 mV		240 mV	
Setting resolution current)*	600 nA		320 nA		160 nA		120 nA		80 nA		40 nA	
Measurement resolution voltage)*	10 mV		20 mV		40 mV		60 mV		80 mV		120 mV	
Measurement resolution current)*	300 nA		160 nA		80 nA		60 nA		40 nA		20 nA	
Ripple & noise (f > 10 Hz)	< 10 mV										< 50 mV	
)* with standard sample rate	**500/s, digital filter 64 and only guarantied in the setting range**											
Accuracy voltage measurement	± (0,01% ∗ V_O + 0,02% ∗ $V_{O\,nom}$ + 1 digit) (for one year) only guarantied in the setting range **1% ∗ $V_{O\,nom}$** < $V_O \leq V_{O\,nom}$											
Accuracy current measurement	± (0,01% ∗ I_O + 0,02% ∗ $I_{O\,nom}$ + 1 digit) (for one year) only guarantied in the setting range **1% ∗ $V_{O\,nom}$** < $V_O \leq V_{O\,nom}$											
Stability V_O	< 0,01% ∗ V_{nom} (no load/load and Δ V_{IN})											
Temperature coefficient V_O	< 5 ∗ 10^{-5} /K											
Hardware limits V_{max} / I_{max}	potentiometer per module (V_{max} / I_{max} is the same for all channels)											
Interface	VME-Interface											
Rate of change of output voltage	via software: 0,0004* V_{nom} /s to 0,2 * V_{nom} /s											
Module status	green LED at channels 0-11 will work with status ready											
Protection loop (I_s) potential free (2 pin Lemo-socket)	5 mA < I_s < 20 mA ⇒ module on I_s < 0,5 mA ⇒ module off											
Power requirements V_{INPUT}	± 12 V (< 1,8 A) and + 5 V (< 0,2 A)											
Packing	6U VME cassette (single width and 164 mm deep)											
Connector on the rear	96-pin connector according to DIN 41612											
HV connector	SHV connector or REDEL Multipin HV connector											
Environment conditions	Operating temperature: 0 up to 40 °C Humidity: up to 80 %, no condensation											
Storage temperature	-20 ... +60 °C											

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12 channel VHS	**C0 05p**	**C0 05n**	**C0 10p**	**C0 10n**	**C0 20p**	**C0 20n**	**C0 30p**	**C0 30n**	**C0 40p**	**C0 40n**
Output voltage V_{nom}	+ 500 V	– 500 V	+ 1 kV	– 1 kV	+ 2 kV	– 2 kV	+ 3 kV	– 3 kV	+ 4 kV	– 4 kV
Output per channel I_{nom}	15 mA		8 mA		4 mA		3 mA		2 mA	
Resolution of voltage setting)*	20 mV		40 mV		80 mV		120 mV		160 mV	
Resolution of current setting)*	600 nA		320 nA		160 nA		120 nA		80 nA	
Resolution of voltage setting)*	10 mV		20 mV		40 mV		60 mV		80 mV	
Resolution of current setting)*	300 nA		160 nA		80 nA		60 nA		40 nA	
)* with standard sample rate 500/s, digital filter 64 and only guarantied in the setting range										
Accuracy voltage measurement	$\pm$ (0,01% $*$ V_O + 0,02% $*$ $V_{O\,nom}$ + 1 digit) (for one year) only guarantied in the setting range **1% $*$ $V_{O\,nom}$** < $V_O \leq V_{O\,nom}$									
Accuracy current measurement	$\pm$ (0,01% $*$ I_O + 0,02% $*$ $I_{O\,nom}$ + 1 digit) (for one year) only guarantied in the setting range **1% $*$ $V_{O\,nom}$** < $V_O \leq V_{O\,nom}$									
Ripple and noise (f > 10 Hz)	< 10 mV									
Stability V_O	< 0,01% $*$ V_{nom} (no load/load and Δ V_{IN})									
Temperature coefficient V_O	< 5 $*$ 10^{-5} /K									
Hardware limits V_{max} / I_{max}	potentiometer per module (V_{max} / I_{max} is the same for all channels)									
Interface	VME-Interface									
Rate of change of output voltage	via software: 0,0004* V_{nom} /s to 0,2 * V_{nom} /s									
Module status	green LED at channels 0-11 will work with status ready									
Protection loop (I_s) potential free (2 pin Lemo-socket)	5 mA < I_s < 20 mA $\Rightarrow$ module on I_s < 0,5 mA $\Rightarrow$ module off									
Power requirements V_{INPUT}	$\pm$ 12 V (< 5 A) and + 5 V (< 0,2 A)									
Packing	6U VME cassette (double width and 164 mm deep)									
Connector on the rear	96-pin connector according to DIN 41612									
HV connector	SHV connector or REDEL Multipin HV connector									
Environment conditions	Operating temperature: 0 up to 40 °C Humidity: up to 80 %, no condensation									
Storage temperature	-20 ... +60 °C									

Precision VME High Voltage Power Supply

Operator's Manual VME Interface

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1. Operating principle

The functionality of the module is achieved by hard and software in narrow interaction. Pure hardware functions are used there where none or only low temporal delays are authorized. All further functions are executed by firmware algorithms under control.

1.1 Hardware functions

1.1.1 Front panel indicators

1.1.2 Interlock input

The Interlock signal is an external signal. It can be used for fast switching the high voltage off e.g. in critical system states. At activation of the signal the high tension production is immediately switched off.

- global Interlock signal for switching off the whole module,
  - is made as a current loop (safety loop),
  - can be de-activated by a jumper;
- optional: single-channel switch off via individual TTL-inputs ;
  - input open or at high level: channel works normal
  - input connected to ground or at low level: channel is switched off

With the option INTERLOCK OUTPUT (see point 3.3.1) this function is not available

1.1.3 KillEnable / Kill / ClearKill

The signal SetKillEnable is a global control signal of the module. It defines how the module shall react in the case of an exceeding of the predefined voltage limit (Vmax) and the predefined current (Imax/Iset/Itrip). If KillEnable is active, then in the case of exceeding of Imax/Iset in the correlative channel a signal Kill is generated. This signal leads switches off the channel immediately without ramp. The signal Kill refers to the respective channel. An active signal Kill prevents distributing the high tension in the appropriate channel.
Is KillEnable inactive, so is changed in the case of reaching of Imax/Iset from the voltage control mode into the current control mode.
The signal ClearKill is also a module-wide acting signal. The signals Kill stored in the channels are set back with activation of ClearKill. Without this reset a new switch on isn't possible for the high voltage.

1.1.4 Modus: Voltage regulation / Current regulation / Current trip

Into dependence of the signal SetKillEnable just described and of the operating point of the channel output 3 work modes can be established:

Voltage regulation (CV)
In the mode Voltage regulation the module works as a constant voltage source. It has to be made sure that the predefined current value Iset or Itrip is greater than the output current adapting.

Current regulation (CC)
In the mode Current regulation the module works as a constant current source. It has to be made sure that the predefined voltage value Vset is greater than the output voltage adapting.

Current trip
This is a special case of the voltage regulation. The module usually provides a constant output voltage. With the help of Itrip a maximum current limit is provided. If this value is reached or exceeded (e.g. by arcs), a switching the channel off immediately is carried out.

1.2 Software functions

The qualities and functions described below are determined by the internal control of the module substantially. Main item is a microcontroller, which can measure or provide the analogous condition quantities over analogous I/O assemblies (ADC or DAC) and which determines the switching states of the hardware over digital I/O ports. The microcontroller controls and supervises the function of the voltage generation in the channels, the compliance with the limiting values, the occurence of certain events. Furthermore the communication on the interface is incumbent the microprozessor. Details to this are described in section 0.
Single module and channel characteristics are described in the following

1.2.1 Analogous values

Control items as well as status items come under this category
Analogous control items of the module

- voltage ramp speed
- current ramp speed
- restart time after recall set values
- voltage maximum set
- current maximum set
- ADC samples per second
- digital filter set

Analogous control items of a channel

- voltage set
- current set
- voltage bounds
- voltage interlock maximum set
- voltage interlock minimum set
- current bounds
- current interlock maximum set
- current interlock minimum set

Analogous status items of the module

- power supply voltages
- temperature
- maximum voltage
- maximum current

Analogous status items of a channel

- voltage out
- current out
- voltage nominal
- current nominal

1.2.1.1 Voltage bounds / Voltage interlock maximum set / Voltage interlock minimum set Current bounds / Current interlock maximum set / Current interlock minimum set

This function of the module can be used for a largely autonomous business. With the help of the control variables VoltageBounds, Voltage interlock maximum set, Voltage interlock minimum set and CurrentBounds, Current interlock maximum set, Current interlock minimum set tubes are formed around the specification values VoltageSet and CurrentSet. If the measured condition sizes output voltage or output current is within these tubes, the condition is as interpreted well. If the condition values leave the specification area, a corresponding fault event is registered.

1.2.2 Digital values

The digital control and state variables serve the setting or re-registration of single module or channel functions.

1.2.2.1 Status and event

You distinguish at the condition items in status and event. In status words the current status of the item is given. Depending on current condition the bits are set or reset by the controller. Unlike this a event is registered in event words without resetting it when the event has finished. A reset of stored events is made by a specific write on the event word.

status Summary of actual condition of module, channel or group
event Event, that characterizes a former or actual special condition of module, channel or group

1.2.2.2 Event status and event mask

So that all event sources don't always have to be checked by events on arriving, the module has a hierarchical chain for the combination of the events to a single status bit which represents the short-term condition of the event hierarchy.
This structure for the event processing is built up uniformly for events from the module status, the status of the channels and the group status. An event status register and an event mask register exists respectively.

Event status Combination of the events arrived till now
Event mask Filter which checks the combination of individual events to sum events

A bit in the event mask is assigned to every event bit in the event status register. If the mask bit is set, the occurring of the accompanying event leads sum event to the activation. In turn these sum events are collected in an event status register and connected with an event mask register at this higher level.

A check of EventStatus and EventMask is made before the HV will be switched on. When bits are set in the EventStatus and the corresponding bits are set in the EventMask the HV cannot be switched on again before the EventStatus bits are reset by writing “1” on the corresponding bit positions.

The individual event in the channels sources are starting point of the event logic. Every appearing event (status = 1) is stored in a bit of the event status register of the channel. Bits in a mask register are assigned to these event bits in the channel event status register. A logical AND condition (bit wise) between the event bit and the accompanying mask bit is achieved that a result arises only there where the mask bit is set. A following logical OR of all these result bits yields the event status of the channel.

```
EventChannelStatus[n] =   (Channel[n].EventVoltageLimit AND Channel[n].MaskEventVoltageLimit) OR
                          (Channel[n].EventCurrentLimit AND Channel[n].MaskEventCurrentLimit) OR
                          (Channel[n].EventCurrentTrip AND Channel[n].MaskEventCurrentTrip) OR
                          (Channel[n].EventExtInhibit AND Channel[n].MaskEventExtInhibit) OR
                          (Channel[n].EventVoltageBounds AND Channel[n].MaskEventVoltageBounds) OR
                          (Channel[n].EventCurrentBounds AND Channel[n].MaskEventCurrentBounds) OR
                          (Channel[n].EventControlledVoltage AND Channel[n].MaskEventControlledVoltage) OR
                          (Channel[n].EventControlledCurrent AND Channel[n].MaskEventControlledCurrent) OR
                          (Channel[n].EventEmergency AND Channel[n].MaskEventEmergency) OR
                          (Channel[n].EventEndOfRamp AND Channel[n].MaskEventEndOfRamp) OR
                          (Channel[n].EventOnToOff AND Channel[n].MaskEventOnToOff ) OR
                          (Channel[n].EventInputError AND Channel[n].MaskEventInputError)
```

The condition of all event statuses of the channels is summarized in the register EventChannelStatus. For the choice or filtration of the channel events a mask register is also assigned (EventChannelMask) here. By means of the AND or ODER combination described in the channel the global signal AnyChannelEventActive of the channels is caused.

```
EventChannelActive =      (EventChannelStatus[0] AND EventChannelMask[0]) OR
                          (EventChannelStatus[1] AND EventChannelMask[1]) OR
                          ...
                          (EventChannelStatus[n] AND EventChannelMask[n])
```

Besides the channel based events special conditions can be registered of qualities of the complete module as an event. The following scheme applies to these module events:

EventModuleActive = (EventTemperatureNotGood AND MaskEventTemperatureNotGood) OR
(EventSupplyNotGood AND MaskEventSupplyNotGood) OR
(EventSafetyLoopNotGood AND MaskEventSafetyLoopNotGood)

Parallel to these evaluation structures, events of the groups are supervised. Are described how later, different groups (monitor group, time out group) also can cause events. These stored group events are summarized in the status word EventGroupStatus. With the help of the mask register EventGroupMask the event-collecting signal of the groups EventGroupActive is formed from these group events.

EventGroupActive = (EventGroupStatus[0] AND EventGroupMask[0]) OR
(EventGroupStatus[1] AND EventGroupMask[1]) OR
...
(EventGroupStatus[32] AND EventGroupMask[32])

All summarized events are summarized to the bit IsEventActive of the register ModuleStatus:
IsEventActive = EventChannelActive OR EventModuleActive OR EventGroupActive

1.2.3 Summarizing of channel characteristics into groups

The module shows a flexible group function. With the first one there is the possibility to set single specification values in all channels of the module with the help of Fix Groups. Furthermore Variable Groups can be defined. They allow to customize the logical structure of the module to the logical structure of the application. For these Variable Groups group types were pre-defined for whose application there isn't any restriction apart from the maximum number of groups (32). In particular got predefined:

- Set Group:
  - puts the condition of a channel characteristic for selected channels
  - no event generation
- Status Group:
  - represents the status (condition) of a channel characteristic for all channels
  - no event generation
- Monitor Group
  - monitors the condition of a channel characteristic for selected channels
  - event generation in condition change
  - reaction selectable (e.g.switch off)
- Timeout Group:
  - monitors the current trip in selected channels
  - It is prerequisite that the signal KillEnable is turned off
  - Event generation only after expiry of a predefined time within which the trip condition must be active
  - reaction selectable (e.g.switch off)

1.2.4 Reactions after events (Soft-Kill features)

In the event generating groups there is a choice between 4 reactions that have to be executed after the event is generated:

- switch off of the whole module, without ramp
  - high voltage of all channels of the module is switched off
- switch off of all members of the group, without ramp
  - high voltage of all channels of the group is switched off
- switch off of all members of the group, with ramp
  - high voltage of all channels of the group is ramped down
- no reaction
  - no change
  -

1.2.5 Autostart

The Autostart is a functionality which allows a recall/reload of stored values to the corresponding set values. A delayed switch On of the high voltages can be configured. The delay time for a delayed switch ON will configured in RestartTimeAfterRecallSetValues.

The following set values can be stored permanently for

the channels:	ChannelControl
	ChannelEventMask
	VoltageSet
	CurrentSet/CurrentTrip
	VoltageBounds/VoltageIlkMaxSet
	CurrentBounds/CurrentIlkMaxSet
	VoltageIlkMinSet
	CurrentIlkMinSet
	VoltageMaxSet
	CurrentMaxSet
the module:	ModuleControl
	ModuleEventMask
	ModuleEventChannelMask
	ModuleEventGroupMask
	VoltageRampSpeed
	CurrentRampSpeed
	RestartTimeAfterRecallSetValues
	ADCSamplesPerSecond
	DigitalFilter

Once a configuration of set values has been stored permanently, it can be “recalled/reloaded” anytime. For this purpose control and status bits are available in the ModulControl, ModulStatus and ModulEventStatus. The detailed explanation is made in chapter 4.2.1. Module registers, ModulStatus, ModulControl, ModuleEventStatus and RestartTimeAfterRecallSetValues.

2. VME-Interface

Access Mode:

Short supervisory access (AM=0x2D)
Short non privileged access (AM=0x29)

Command execution time:

The command execution times are 1 µs typically.

Memory space:

The control of the module is working via a data exchange in the RAM memory of the VME module. This is working with a space of 1024 bytes or 512 words of 16-bit each.

The description of RAM addressing in this document is done both in a word addressing type and in a byte addressing type. The word addressing (addressing of a 2 byte = 1 word of 16 bit) is chosen because the access mode of the VME bus is word-wise. The byte addressing is for simple memory count.
The RAM memory space begins at the base address (BA). This is a 16bit address, where the 10 LSB bits are 0. The 6 MSB bits can be set by the customer to insert the module's RAM into the VME space.

in words:				
binary:	BA	=	0bbbbbb0 00000000	(with b={0|1})
hexadezimal:	BA	=	xy00	(with x={0..7}, y={0,2,4,6,8,A,C,E}.
in bytes:				
binary:	BA	=	bbbbbb00 00000000	(with b={0|1})
hexadezimal:	BA	=	xy00	(with x={0..F}, y={0,4,8,C}.

The MSB byte of the base address is stored in the non-volatile memory. It can be changed with help of a special write command (see special commands).

The factory setting is BA=0x2000 (addressing words in VME short access) resp. BA=0x4000 in Bytes

Partition of the memory (given in words (in respect to VME short access)):

BA+0x0000 .. BA+0x001f :	module data . 32 words	32 Words
BA+0x0030 .. BA+0x014f :	12 channel data blocks ea. 24 words	288 Words
BA+0x0150 .. BA+0x0153 :	2 fixed groups ea. 2 words	4 Words
BA+0x0160 .. BA+0x019f :	32 variable groups (set, status, monitoring or timeout groups) data block ea. 2 words	64 Words
BA+0x01d0 .. BA+0x01ff :	control registers for special use	

Partition of the memory (given in bytes):

BA+0x0000 .. BA+0x003f :	module data . 64 bytes	64 Bytes
BA+0x0060 .. BA+0x029f :	12 channel data blocks ea. 48 bytes	576 Bytes
BA+0x02a0 .. BA+0x02a7 :	2 fixed groups ea. 4 bytes	8 Bytes
BA+0x02c0 .. BA+0x033f :	32 variable groups (set, status, monitoring or timeout groups) data block ea. 4 bytes	128 Bytes
BA+0x03a0 .. BA+0x03ff :	control registers for special use	

The data exchange is working in standard formats ‘Unsigned Long‘ (uint32), ‘Unsigned Integer‘ (uint16) and Float, single precision (float). The access is with 16Bit words. There is no hardware check regarding non-valid data conditions (e.g. between writing of the first and second words of a floating value), also if an access conflict occurs in the dual ported RAM. Therefore it is necessary to find reasonable measures to save the correct data transfer. (e.g. read or write repetition).

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2.1 Memory space

Module data

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0000	0x0000	ModuleStatus	uint16	r
0x0001	0x0002	ModuleControl	uint16	r/w
0x0002	0x0004	ModuleEventStatus	uint16	r/w
0x0003	0x0006	ModuleEventMask	uint16	r/w
0x0004	0x0008	ModulEventChannelStatus	uint16	r/w
0x0005	0x000A	ModulEventChannelMask	uint16	r/w
0x0006	0x000C	ModuleEventGroupStatus	uint32	r/w
0x0008	0x0010	ModuleEventGroupMask	uint32	r/w
0x000A	0x0014	VoltageRampSpeed	float	r/w
0x000C	0x0018	CurrentRampSpeed	float	r/w
0x000E	0x001C	VoltageMax	float	r
0x0010	0x0020	CurrentMax	float	r
0x0012	0x0024	SupplyP5	float	r
0x0014	0x0028	SupplyP12	float	r
0x0016	0x002C	SupplyN12	float	r
0x0018	0x0030	Temperature	float	r
0x001A	0x0034	SerialNumber	uint32	r
0x001C	0x0038	FirmwareRelease	uint8[4]	r
0x001E	0x003C	PlacedChannels	uint16	r
0x001F	0x003E	DeviceClass	uint16	r
0x0020	0x0040	ModuleInterlockOut Registers		
...0x0025	...0x004A	(look at chapter 2.5.1)		
0x28	0x0050	RestartTimeAfterRecallSetValues	uint16	r/w
0x2C	0x0058	ADCSamplesPerSecond	uint16	r/w
0x2D	0x005a	DigitalFilter	uint16	r/w
0x002e	0x005C	VendorId: const ‘i’,’s’,’e’,’g’ = 0x69736567	uint8[4]	r

Channels

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	
0x0030	0x0060	ChAddr[0]	begin of channel 0
0x0048	0x0090	ChAddr[1]	begin of channel 1
0x0060	0x00C0	ChAddr[2]	begin of channel 2
0x0078	0x00F0	ChAddr[3]	begin of channel 3
0x0090	0x0120	ChAddr[4] [1]	begin of channel 4
0x00A8	0x0150	ChAddr[5] [1]	begin of channel 5
0x00C0	0x0180	ChAddr[6] [1]	begin of channel 6
0x00D8	0x01B0	ChAddr[7] [1]	begin of channel 7
0x00F0	0x01E0	ChAddr[8] [1]	begin of channel 8
0x0108	0x0210	ChAddr[9] [1]	begin of channel 9
0x0120	0x0240	ChAddr[10] [1]	begin of channel 10
0x0138	0x0270	ChAddr[11] [1]	begin of channel 11

[1] only in module type VHS Cxx

Channel data

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name	Data type	Access
0	0	ChannelStatus	uint16	r
1	2	ChannelControl	uint16	r/w
2	4	ChannelEventStatus	uint16	r/w
3	6	ChannelEventMask	uint16	r/w
4	8	VoltageSet	float	r/w
6	12	CurrentSet / CurrentTrip [2]	float	r/w
8	16	VoltageMeasure	float	r
10	20	CurrentMeasure	float	r
12	24	VoltageBounds / VoltageIlkMaxSet [3]	float	r/w
14	28	CurrentBounds / CurrentIlkMaxSet [4]	float	r/w
16	32	VoltageNominal / VoltageMaxSet [5]	float	r/(w)
18	36	CurrentNominal / CurrentMaxSet [5]	float	r/(w)
19	40	VoltageIlkMinSet	float	r/w
20	44	CurrentIlkMinSet	float	r/w

2 when KilEnable=active
3 the addressed item are multiplexed by the ModuleControl bit setAVBND(0) – VoltageBounds, setAVBND(1) - VoltageIlkMaxSet
4 the addressed item are multiplexed by the ModuleControl bit setACBND(0) – CurrentBounds, setACBND(1) – CurrentIlkMaxSet
5 can be written in mode ModuleStatus IsStop = 1

Group data

Fixed Groups

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0150	0x02A0	SetVoltageAllChannels	float	r/w
0x0152	0x02A4	SetCurrentAllChannels	float	r/w
0x0154	0x02A8	SetVoltageBoundsAllChannels	float	r/w
0x0156	0x02AC	SetCurrentBoundsAllChannels	float	r/w
0x0158	0x02B0	SetEmergencyAllChannels	uint32	r/w
0x015A	0x02B4	SetOnOffAllChannels	uint32	r/w
0x015C	0x02B8	SetVoltageIlkMinSetAllChannels	float	r/w
0x015E	0x02BA	SetCurrentIlkMinSetAllChannels	float	r/w

Variable Groups

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	
0x0160	0x02C0	GrAddr[0]	begin of group 0
0x0162	0x02C4	GrAddr[1]	begin of group 1
0x0164	0x02C8	GrAddr[2]	begin of group 2
0x0166	0x02CC	GrAddr[3]	begin of group 3
0x0168	0x02D0	GrAddr[4]	begin of group 4
0x016A	0x02D4	GrAddr[5]	begin of group 5
0x016C	0x02D8	GrAddr[6]	begin of group 6
0x016E	0x02DC	GrAddr[7]	begin of group 7
0x0170	0x02E0	GrAddr[8]	begin of group 8
...	...	...	...
0x019E	0x033C	GrAddr[31]	begin of group 31

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User defined nominal values (ModuleStatus IsStop(0))

Offset Words (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x01A0	0x0340	VoltageMaxSet channel 0	float	r
0x01A2	0x0344	CurrentMaxSet channel 0	float	r
0x01A4	0x0348	VoltageMaxSet channel 1	float	r
0x01A8	0x034C	CurrentMaxSet channel 1	float	r
0x01CC	0x0398	VoltageMaxSet channel 11	float	r
0x01CE	0x039C	CurrentMaxSet channel 11	float	r

If the module is not in mode STOP the values of VoltageMaxSet and CurrentMaxSet appear.

Hardware defined nominal values (ModuleControl SetStop(1), ModuleStatus IsStop(1))

Offset Words (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x01A0	0x0340	VoltageNominal channel 0	float	r
0x01A2	0x0344	CurrentNominal channel 0	float	r
0x01A4	0x0348	VoltageNominal channel 1	float	r
0x01A8	0x034C	CurrentNominal channel 1	float	r
0x01CC	0x0398	VoltageNominal channel 11	float	r
0x01CE	0x039C	CurrentNominal channel 11	float	r

If the module is in mode STOP the values of VoltageNominal and CurrentNominal appear.

Special Registers

Offset Words (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x01D0	0x03A0	NewBaseAddress	uint16	r/w
0x01D1	0x03A2	NewBaseAddressXor	uint16	r/w
0x01D2	0x03A4	OldBaseAddress	uint16	R
0x01D3	0x03A6	NewBaseAddressAccepted	uint16	R
0x01D8	0x03B0	SpecialControlStatus	uint16	R
0x01D9	0x03B2	SpecialControlCommand	uint16	r/w

2.2 Details to the memory space

2.2.1 Module registers

ModuleStatus

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0000	0x0000	ModuleStatus	uint16	r

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
isKILE	isTMPG	isSPLYG	isMODG	isEVNTA	isSFLPG	isnRMP	isnSERR	isCCMPL	isSPMD	isIERR	ndSRVC	res	isSTOP	isILKO	isADJ

isKILE	IsKillEnable	Kill enable (1); Kill disable (0)
isTMPG	IsTemperatureGood	Module temperature good
isSPLYG	IsSupplyGood	Power supply good
isMODG	IsModuleGood	Module in state good
isEVNTA	IsEventActive	Any event is active and mask is set
isSFLPG	IsSafetyLoopGood	Safety loop closed
isnRMP	IsNoRamp	All channels stable, no ramp active .
isnSERR	IsNoSumError	Module without failure
isCCMPL	IsCommandComplete	All commands complete
isSPMD	IsSpecialMode	Module is in SpecialMode
isIERR	IsInputError	Input error in connection with a module access
ndSRVC	IsServiceNeeded	Module shows that a factory service is needed
isSTOP	IsStop	Modules is in state STOP, all high voltages are off
isILKO	IsInterlockOutput	InterlockOutput is active
isADJ	IsAdjustment	Activation of fine adjustment
Res	Reserved	

The status bits as there are IsTemperatureGood, IsSupplyGood, IsModuleGood, IsEventActive, IsSafetyLoopGood, IsNoRamp, IsNoSumError and IsServiceNeeded indicate the single status for the complete module.

The status bit IsCommandComplete indicates that all VME commands given to the module have been executed.

The condition bit IsEventActive is set, if at least one event is active in the channel, groups or module area and the corresponding masking bits are set.

The signal IsStop(1) shows that module is in mode STOP. In mode STOP it is possible to change the user defined nominal values VoltageMaxSet, CurrentMaxSet to a value lower or equal to the nominal values of hardware - VoltageNominal, CurrentNominal. When a user defined nominal value has been set, the module firmware will operate with it instead of the nominal value of hardware. In addition the Autostart function can be configured in this mode.

The signal IsAdjustment(1) shows that the high voltage is locked under fine adjustment. That means after a switch ON the high voltage will ramp to the value of set voltage followed by steps of adjustment until the measured value fits the set value and only bit wise correction of temperature drifts are necessary.

ModuleControl

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0001	0x0002	ModuleControl	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
doSVSV	setKILE	res	setADJ	res	ILVL2	ILVL1	ILVL0	res	doCLEAR	res	res	setAON	setSTOP	doRCSV	setSPMD
0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0

doSVSV	DoSaveSetValues	DoSaveSetValues(1); no action (0)
setKILE	SetKillEnable	Kill enable SetKillEnable(1); Kill disable SetKillEnable(0)
setADJ	SetAdjustment	Activation of fine adjustment
ILVL[2..0]	IntLevel[2..0]	Code for VME-Interrupt-Level (1 to 7); Level 0 means: no VME Interrupt
doCLEAR	DoClear	Clears Kill (hardware) signals and all event signals of module and channels
setAON	SetActionOn	SetActionOn(1) activate a time delayed switch ON of the high voltages after a recall of the stored values when ChannelControl SetON(1)
setSTOP	SetStop	SetStop(1);
doRCSV	DoRecallSetValues	DoRecallSetValues(1); no action (0)
setSPMD	SetSpecialMode	Set into SpecialMode, for special tasks only Attention: Return from SpecialMode only with SpecialControlCommands e.g. EndSpecial
res	Reserved	

The signal SetAdjustment is used to enable an adjustment of the HV precisely in case of temperature drifts.

The signal SetKillEnable controls the reaction of the channels to extraordinary events, e.g. overcurrent. The signal is set module-wide, while the reaction (e.g. turn off the high voltage) is done in the correlating channel.

The signals SetStop, SetActionOn, DoSaveSetValues and DoRecallSetValues will be used to realize the Autostart functionality which allows a store and recall/reload of stored values. A time delay of switch ON high voltages is configurable.

SetStop(1) The high voltage of all channels will be decreased with the VoltageRamp and switched OFF. The module firmware goes in the state IsStop(1),ModuleStatus when all channels are OFF.

doSaveSetValues(1) –when setStop(1) only
will start a task to store the set values permanently, listed in chapter 3.2.5 Autostart, when the module is in state IsStop(1). When the task is finished the bit is reset to zero.

SetStop(0) A software restart will be executed whereas the stored set values are reloaded from flash memory. Depending from the bit SetActionOn a delayed switch ON of high voltage will realized.

DoRecallSetValues(1)
execute a recall of the stored set values. The high voltages will be switched on after the value RestartTimeAfterRecallSetValues when a delayed switch ON has been configured SetActionOn(1).

SetActionOn(1)
A recall of the stored values with time delayed switch ON of the high voltages will cause the bit set ERSTA of ModuleEventStatus.

Short overview about reaction in dependency of KillEnable:

	Vout >= Voltage limit	Iout >= Current limit	Iout >= Iset
SetKillEnable=1 (ON)	Kill =1;Vout -> 0; Vset=0;	Kill=1; Vout -> 0; Vset=0;	Vout -> 0, Vset=0
SetKillEnable=0 (OFF)	Vout = Voltage limit	Iout = Current limit	Iout = Iset

The signal SetAdjustment switches on the fine justification of the high voltage, around temperature drifts compensate by the DAC. It is activated after reset.

ModuleEventStatus

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0002	0x0004	ModuleEventStatus	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	ETMPngd	ESPLYngd	res	res	ESFLPngd	res	res	res	res	EIERR	ESRVC	res	res	ERSTA	res

ETMPngd	EventTemperatureNotGood	Event: Temperature is above 55°C
ESPLYngd	EventSupplyNotGood	Event: at least one of the supplies is not good
ESFLPngd	EventSafetyLoopNotGood	Event: Safety loop is open
EIERR	EventInputError	Event: Input error in connection with a module access
ESRVC	EventServiceNeeded	Event: Module needs a factory service
ERSTA	EventRestart	Event: Restart of HV after the RestartTimerAfterRecallSetValues
res	Reserved	

These bits are set when the condition occurs. They can be reset individually by writing ones. If the triggering event is still active, a reset isn't possible.

ModuleEventMask

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0003	0x0006	ModuleEventMask	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	METMPngd	MESPLYngd	res	res	MESFLPngd	res	res	res	res	MEIERR	res	res	res	MERSTA	res

METMPngd	MaskEventTemperatureNotGood	MEventMask: Temperature is above 55°C
MESPLYngd	MaskEventSupplyNotGood	MEventMask: at least one of the supplies is not good
MESFLPngd	MaskEventSafetyLoopNotGood	MEventMask: Safety loop (SL) is open
MEIERR	MaskEventInputError	MEventMask: Input error in connection with a module access
MERSTA	MaskEventRestart	MEventMask: Restart of HV after the RestartTimeAfterRecallSetValues
res	Reserved	

This register decides whether a pending event leads to the sum event flag of the module or not. If the a bit of the mask is set and the corresponding event in the ModuleEventStatus is active the bit IsEventActive in the ModuleStatus register is set.

ModuleEventChannelStatus

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0004	0x0008	ModuleEventChannelStatus	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	res	res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

The n-th bit of the register is set, if an event is active in the n-th channel and the associated bit in the EventMask register of the n-th channel is set too.

CHn = EventStatus[n] & EventMask[n]

The bits can be reset individually by writing ones. If the triggering event is still active, a reset isn't possible.

ModuleEventChannelMask

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0005	0x000A	ModuleEventChannelMask	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	res	res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

This register decides whether a pending event leads to the sum event flag of the module or not. If the n-th bit of the mask is set and the n-th channel has an active event in the ModuleEventChannelStatus the bit isEventActive in the ModuleStatus register is set.

ModuleEventGroupStatus

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0006	0x000C	ModuleEventGroupStatus	uint32	r/w

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24	Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
GR31	GR30	GR29	GR28	GR27	GR26	GR25	GR24	GR23	GR22	GR21	GR20	GR19	GR18	GR17	GR16

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
GR15	GR14	GR13	GR12	GR11	GR10	GR9	GR8	GR7	GR6	GR5	GR4	GR3	GR2	GR1	GR0

The n-th bit of this double word register is set, if an event is active in the n-th group.

ModuleEventGroupMask

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0008	0x0010	ModuleEventGroupMask	uint32	r/w

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24	Bit23	Bit22	Bit21	Bit20	Bit19	Bit18	Bit17	Bit16
GR31	GR30	GR29	GR28	GR27	GR26	GR25	GR24	GR23	GR22	GR21	GR20	GR19	GR18	GR17	GR16

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
GR15	GR14	GR13	GR12	GR11	GR10	GR9	GR8	GR7	GR6	GR5	GR4	GR3	GR2	GR1	GR0

This register decides whether a pending event leads to the sum event flag of the module or not. If the n-th bit of the mask is set and the n-th group has an active event in the ModuleEventGroupStatus the bit isEventActive in the ModuleStatus register is set.

VoltageRampSpeed

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x000A	0x0014	VoltageRampSpeed	float	r/w

The speed of the voltage ramp in percent of the nominal voltage of the channel. The upper limit is 20%. The lower limit is equivalent to 1mV/s.

CurrentRampSpeed (option)

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x000C	0x0018	CurrentRampSpeed	float	r/w

not realized in VHS x0x

VoltageMax

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x000E	0x001C	VoltageMax	float	r

VoltageMax is the actual value of the trim potentiometer of the front panel, given in per cent. In conjunction with the nominal voltage VoltageNominal of a channel one can calculate the actual maximal output voltage of the channel.

VoltageLimit = VoltageNomial * VoltageMax

This voltage value VoltageLimit is the reference for setting the status bit IsVoltageLimitExceeded.

CurrentMax

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0010	0x0020	CurrentMax	float	r

CurrentMax is the current value of the trim potentiometer of the front panel, given in per cent. In conjunction with the nominal current CurrNom of a channel one can calculate the actual maximal output current of the channel.

CurrentLimit = CurrentNomial * CurrentMax

This current value CurrentLimit is the reference for setting the status bit IsCurrentLimitExceeded.

SupplyP5

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0012	0x0024	SupplyP5	float	r

The actual value of the +5 line of the power supply, given in V.

SupplyP12

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0014	0x0028	SupplyP12	float	r

The actual value of the +12 line of the power supply, given in V.

SupplyN12

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0016	0x002C	SupplyN12	float	r

The actual value of the -12 line of the power supply, given in V.

Temperature

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0018	0x0030	Temperature	float	r

The actual temperature of the board, given in °C.

SerialNumber

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x001A	0x0034	SerialNumber	uint32	r

The Serial number of the module as long integer value.

FirmwareRelease

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x001C	0x0038	FirmwareRelease	uint8[4]	r

The firmware release as a sequence of four unsigned short integer values.

PlacedChannels

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x001E	0x003C	PlacedChannels	uint16	r

For each existent channel the corresponding bit is set in this word.
For example, a fully equipped 4 channel module VHS 40x has PlacedChannels = 0x000f, a fully equipped 12 channel module VHS C0x has PlacedChannels = 0x0fff .

DeviceClass

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x001F	0x003E	DeviceClass	uint16	r

This is a constant value to divide device families in iseg firmware and applications.
For VHS x0x this value is 20 (0x14).

RestartTimeAfterReloadSetValues

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0028	0x0050	RestartTimeAfterRecallSetValues	uint16	r/w

This is value for a delay until restart the HV - activation of the stored setON of the corresponding channels – after the control command doRecallSetValues has been sent.
RestartTimeAfterRecallSetValues unit [ms]

ADC SamplesPerSecond SPS

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x002C	0x0058	ADCSamplesPerSecond	uint16	r/w

Adjusts the number of averages of the programmable ADC filter of the HV module. Possible values are 500, 100, 60 and 50 SPS. Notch should be set with 60 SPS using a 110V line with 60Hz and 50 SPS using a 230V line with 50Hz in order to improve the common-mode rejection of these frequencies. However a SPS value of the ADC will increase the main loop time by 4*1/SPS multiplied with the number of channels for device.
Factory settings: 500 SPS

DigitalFilter

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x002D	0x005A	**DigitalFilter**	uint16	r/w

The digital filter in the firmware of the processor reduces the white noise of the analog values of channel VoltageMeasure, channel CurrentMeasure. The digital filtering gives the possibility to get a higher precision and to react fast on changes of the measured values. The filter is not used during a voltage ramp. The filter is restarted after a significant change of the signal. The value DigitalFilter represents the number of filter steps.
Factory settings: 64

VendorId

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x002E	0x005C	VendorId	Uint8[4]	r

This is a constant value to identify the vendor / manufacturer. The value is {0x69;0x73;0x65;0x67}, or in ASCII {“i”;”s”;”e”;”g”}.

2.2.2 Channel registers

The channel Status and Control information will allow to monitor and control output voltage, output current, control and status information of each channel. These detailed information can be collected in groups and several channel can be set and/ or controlled with help of group commands).

ChannelStatus

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name	Data type	Access
0	0	ChannelStatus	uint16	R

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
isVLIM	isCLIM	isTRIP	isEINH	isVBNDs	isCBNDs	res	res	isCV	isCC	isEMCY	isRAMP	isON	isIERR	res	res

isVLIM	IsVoltageLimitExceeded	Hardware- voltage limit has been exceeded (when KillEnable=0)
isCLIM	IsCurrentLimitExceeded	Hardware- current limit has been exceeded (when KillEnable=0)
isTRIP	IsTripSet	Trip is set when Iset has been exceeded (when KillEnable=1)
isEINH	IsExtInhibit	External Inhibit
isVBNDs	IsVoltageBoundsExceeded	Voltage out of bounds
isCBNDs	IsCurrentBoundsExceeded	Current out of bounds
isCV	IsControlledVoltage	Voltage control active
isCC	IsControlledCurrent	Current control active
isEMCY	IsEmergency	Emergency off without ramp
isON	IsOn	On
isRAMP	IsRamping	Ramp is running
isIERR	IsInputError	Input error
res	Reserved	

The channel status register describes the actual status. Depending on the status of the module the bits will be set or reset.
The bit IsInputError is set if the given parameter isn't plausible or it exceeds the module parameters (e.g. if the command Vset=4000V is given to a module with NomianalVoltage=3000V). The bit IsInputError isn't set if the given values are temporarily not possible (e.g. Vset=2800 at a module with NominalVoltage=3000V, but HardwareLimitVoltage=2500V). A certain signature which kind of input error it is does not yet happen.

The status bits isVoltageBoundsExceeded resp. isCurrentBoundsExceeded are set:

if (| Vmeas – Vset | > Vbounds) isVoltageBoundsExceeded =1;
if (| Imeas – Iset | > Ibounds) isCurrentBoundsExceeded =1;

ChannelControl

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name	Data type	Access
1	2	ChannelControl	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	res	res	res	setAVBND	setACBND	res	res	res	res	setEMCY	res	setON	res	res	res

setEMCY	SetEmergency	Set "Emergency": shut off the channel without ramp, clear the Vset value
setON	SetOn	Set On, if 1; set Off if 0: ramp the output to Vset or to Zero
setAVBND	SetAsymmetricVoltageBounds	Set setAVBND, if 1 - set asymmetric voltage bounds; if 0 - set symmetric voltage bounds
setACBND	SetAsymmetricCurrentBounds	Set setACBND, if 1 - set asymmetric current bounds; if 0 - set symmetric current bounds
res	Reserved	

The signals SetOn and SetEmergency control basic functions of the channel. The signal SetOn is switching ON the HV of the channel and is a precondition for giving voltage to the output. As far as a VoltageSet has been set and no event has occurred and is not registered yet (in minimum, bit 5 and bit 10 to 15 of ChannelEventStatus register must be 0), a start of a HV ramp will be synchronized (a ramp is a software controlled, time proportionally increase / decrease of the output voltage).

There are methods to observe the high voltage via the measured values of voltage and current in stable state outside of a ramp. For this purpose the set values VoltageBounds, VoltageMinIlkSet, CurrentBounds and CurrentMinIlkSet are used to define a tolerance bounds for the measurement values. When the measured values crossing the defined bounds an event will be generated.
The ChannelControl bits setAVBND and setACBND define whether the tolerance bounds are asymmetric setA[V/C]BND(1) to the set value as an absolute value or symmetric setA[V/C]BND(0) as a relative value to the set value.

setAVBND(1)

VoltageIlkMaxSet ≤ VoltageMeasure ≤ VoltageIlkMaxSet	No event!
VoltageIlkMaxSet > VoltageMeasure or VoltageMeasure > VoltageIlkMaxSet	IsVoltageBoundsExceeded(1), ModuleStatus EventVoltageBounds(1), ModuleEventStatus

setAVBND(0)

VoltageSet-VoltageBounds ≤ VoltageMeasure ≤ VoltageSet+VoltageBounds	No event!
VoltageSet-VoltageBounds > VoltageMeasure or VoltageMeasure > VoltageSet+VoltageBounds	IsVoltageBoundsExceeded(1), ModuleStatus EventVoltageBounds(1), ModuleEventStatus

setACBND(1)

CurrentIlkMaxSet ≤ CurrentMeasure ≤ CurrentIlkMaxSet	No event!
CurrentIlkMaxSet > CurrentMeasure or CurrentMeasure > CurrentIlkMaxSet	IsCurrentBoundsExceeded(1), ModuleStatus EventCurrentBounds(1), ModuleEventStatus

setACBND(0)

CurrentSet-CurrentBounds ≤ CurrentMeasure ≤ CurrentSet+CurrentBounds	No event!
CurrentSet-CurrentBounds > CurrentMeasure or CurrentMeasure > CurrentSet+CurrentBounds	IsCurrentBoundsExceeded(1), ModuleStatus EventCurrentBounds(1), ModuleEventStatus

A special feature is the correct changeover from symmetric to asymmetric bounds or from asymmetric to symmetric bounds:

setA[V/C]BND(0) to setA[V/C]BND(1)

Voltage:	VoltageIlkMaxSet=VoltageSet+VoltageBounds VoltageIlkMinSet=VoltageSet-VoltageBounds
Current:	when ChannelStatus isCC(1) CurrentIlkMaxSet=CurrentSet+CurrentBounds CurrentIlkMinSet=CurrentSet-CurrentBounds ChannelStatus isCC(0), ChannelStatus isON(1), ChannelStatus isRAMP(0) CurrentIlkMaxSet=CurrentMeasure+CurrentBounds CurrentIlkMinSet=CurrentMeasure-CurrentBounds

setA[V/C]BND(1) to setA[V/C]BND(0)

Voltage:	VoltageBounds=(VoltageIlkMaxSet- VoltageIlkMinSet)/2
Current:	CurrentBounds=(CurrentIlkMaxSet-CurrentIlkMinSet)/2

ChannelEventStatus

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name	Data type	Access
2	4	ChannelEventStatus	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
EVLIM	ECLIM	ECTRP	EEINH	EVBNDs	ECBNDs	res	res	ECV	ECC	EEMCY	EEOR	Eon2Off	EIER	res	res

EVLIM	EventVoltageLimit	Event: Hardware- voltage limit has been exceeded
ECLIM	EventCurrentLimit	Event: Hardware- current limit has been exceeded
ETRIP	EventTrip	Event: Trip is set when Iset has been exceeded (when KillEnable=1)
EEINH	EventExtInhibit	Event external Inhibit
EVBNDs	EventVoltageBounds	Event: Voltage out of bounds
ECBNDs	EventCurrentBounds	Event: Current out of bounds
ECV	EventControlledVoltage	Event: Voltage control
ECC	EventControlledCurrent	Event: Current control
EEMCY	EventEmergency	Event: Emergency
EEOR	EventEndOfRamp	Event: End of ramp
EOn2Off	EventOnToOff	Event: Change from state "On" to "Off" without ramp [1]
EIER	EventInputError	Event: Input Error
res	Reserved	

An event bit is permanently set if the status bit is 1 or changes to 1. Different to the status bit an event bit isn't reset automatically. A reset has to be done by customer by writing an 1 to this event bit.

ChannelEventMask

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name	Data type	Access
3	6	ChannelEventMask	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
MEVLIM	MECLIM	MECTRP	MEEINH	MEVBNDs	MECBNDs	res	res	MECV	MECC	MEEMCY	MEEOR	MEOn2Off	MEIERR	res	res

MEVLIM	MaskEventVoltageLimit	EventMask: Hardware- voltage limit has been exceeded
MECLIM	MaskEventCurrentLimit	EventMask: Hardware- current limit has been exceeded
METRIP	MaskEventTrip	EventMask: Voltage limit or Current limit or Iset has been exceeded (when KillEnable=1)
MEEINH	MaskEventExtInhibit	EventMask: External Inhibit
MEVBNDs	MaskEventVoltageBounds	EventMask: Voltage out of bounds
MECBNDs	MaskEventCurrentBounds	EventMask: Current out of bounds
MECV	MaskEventControlledVoltage	EventMask: Voltage control
MECC	MaskEventControlledCurrent	EventMask: Current control
MEEMCY	MaskEventEmergency	EventMask: Emergency off
MEEOR	MaskEventEndOfRamp	EventMask: End of ramp
MEOn2Off	MaskEventOnToOff	EventMask: Change from state on to off without ramp
MEIER	MaskEventInputError	EventMask: Input Error
res	Reserved	

VoltageSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
4	8	VoltageSet	Vset	float	r/w

The value of VoltageSet (Vset) is the preset for voltage regulation. Valid values are between 0 and the actual hardware limit value. This actual hardware limit value computes as follows:

voltage limit = VoltageNominal * VoltageMax

When writing values between the actual hardware limit and the nominal value, then the module reduces these values to the value of the actual hardware limit. When writing values above the nominal data or smaller than 0 an input error is indicated by setting the bit IsInputError.

CurrentSet /
CurrentTrip

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
6	12	CurrentSet / CurrentTrip	Iset/Itrip	float	r/w

The value of CurrentSet is the preset for current regulation. Valid values are between 0 and the actual hardware limit value. This actual hardware limit value computes as follows:

current limit of channel x = CurrentNominal * CurrentMax

When writing values between the actual hardware limit and the nominal value, then the module reduces these values to the value of the actual hardware limit. When writing values above the nominal data or smaller than 0 an input error is indicated by setting the bit IsInputError.
In case of KillEnable=1 there no current regulation in the module active. Then the item CurrentSet (Iset) is replaced by CurrentTrip (Itrip). When exceeding this value a current trip event is registered ad the voltage output is set to 0V.

VoltageMeasure

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
8	16	VoltageMeasure	Vmeas	float	r/w

VoltageMeasure (Vmeas) is the actual measured value of voltage, in V.

CurrentMeasure

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
10	20	CurrentMeasure	Imeas	float	r/w

CurrentMeasure (Imeas) is the actual measured value of current, in A.

VoltageBounds
VoltageIlkMaxSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
12	24	VoltageBounds	Vbounds	float	r/w
12	24	VoltageIlkMaxSet	VIlkMaxSet	float	r/w

VoltageBounds:
By the help of VoltageBounds (Vbounds) there is defined a region around VoltageSet (Vset), where the actual values are interpreted as good. This region is defined as follows:

| Vmeas – Vset | ≤ Vbounds

If this area is left, a corresponding event is registered.

VoltageIlkMaxSet:
By the help of VoltageIlkMaxSet (VIlkMaxSet) and VoltageIlkMinSet (VIlkMinSet) there is defined a region around VoltageSet (Vset), where the actual values are interpreted as good. This region is defined as follows:

VIlkMinSet ≤ Vmeas ≤ VIlkMaxSet

If this area is left, a corresponding event is registered.

CurrentBounds
CurrentIlkMaxSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
14	28	CurrentBounds	Ibounds	float	r/w
14	28	CurrentIlkMaxSet	IIlkMaxSet	float	r/w

CurrentBounds:
By the help of CurrentBounds (Ibounds) there is defined a region around CurrentSet (Iset), where the actual values are interpreted as good. This regions is defined as follows:

| Imeas – Iset | ≤ Ibounds

If this area is left, a corresponding event is registered.

CurrentIlkMaxSet:
By the help of CurrentIlkMaxSet (IIlkMaxSet) and CurrentIlkMinSet (IIlkMinSet) there is defined a region around CurrentSet (Iset), where the actual current are interpreted as good. This region is defined as follows:

IIlkMinSet ≤ Imeas ≤ IIlkMaxSet

If this area is left, a corresponding event is registered.

VoltageNominal / VoltageMaxSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
16	32	VoltageNominal / VoltageMaxSet	Vnom	float	r/(w)

This is the maximal possible output voltage of the channel. Normally this is the fixed value of the HV channel hardware (given by the technical specifications of the module). If the user writes a lower VoltageMaxSet, this value appears here. VoltageMaxSet is writeable in mode ModuleStatus IsStop = 1
in the range (0 < VoltageMaxSet ≤ VoltageNominal)

CurrentNominal / CurrentMaxSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
18	36	CurrentNominal / CurrentMaxSet	Inom	float	r/(w)

This is the maximal possible output current of the channel. Normally this is the fixed value of the HV channel hardware (given by the technical specifications of the module). If the user writes a lower CurrentMaxSet, this value appears here. CurrentMaxSet is writeable in mode ModuleStatus IsStop = 1
in the range (0 < CurrentMaxSet ≤ CurrentNominal)

VoltageIlkMinSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
20	40	VoltageIlkMinSet	VIlkMinSet	float	r/w

see VoltageIlkMaxSet above

CurrentIlkMinSet

Offset Words (rel to ChAddr)	Offset Bytes (rel. to ChAddr)	Name		Data type	Access
22	44	CurrentIlkMinSet	IIlkMinSet	float	r/w

see CurrentIlkMaxSet above

2.2.3 Groups

The Multi Channel VME module offers an extended and flexible range of group functions. There are both well defined Fix Groups and free configurable variable groups.
Each definition of a group consists of 2 words (4 bytes).
In the Fix Groups these 2 words hold the value of a floating point value or a logical information. In Variable Groups is one word an identifier for the group. The other word holds the information about the group members (which channel is a member of the group) or it gives an overview over a characteristic in all channels.

Caution!
In order to avoid a malfunction both words of a group have to be written, even in case just one has been changed.

Four different groups have been established:
- Set group
- Status group
- Monitoring group
- Timeout group

2.2.3.1 Fix Groups

The functions and characteristics of the groups are fix defined.

SetVoltageAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0150	0x02A0	SetVoltageAllChannels	float	r/w

The value of the set voltage in V for all channels will be submitted to the group as a floating point number in the 4 bytes. This value is accepted, if the corresponding channel characteristics permit it. Otherwise it's ignored.

SetCurrentAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0152	0x02A4	SetCurrentAllChannels	float	r/w

The value of the set current in A for all channels will be submitted to the group as a floating point number in the 4 bytes. This value is accepted, if the corresponding channel characteristics permit it. Otherwise it's ignored.

SetVoltageBoundsAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0154	0x02A8	SetVoltageBoundsAllChannels	float	r/w

The value of the voltage bounds in V for all channels will be submitted to the group as a floating point number in the 4 bytes. This value is accepted, if the corresponding channel characteristics permit it. Otherwise it's ignored.

SetCurrentBoundsAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0156	0x02AC	SetCurrentBoundsAllChannels	float	r/w

The value of the current bounds in A for all channels will be submitted to the group as a floating point number in the 4 bytes. This value is accepted, if the corresponding channel characteristics permit it. Otherwise it's ignored.

SetEmergencyAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0158	0x02B0	SetEmergencyAllChannels	uint32	r/w

Is worth without coding. Writing any information to this group triggers an alarm switching off in all channels of the module.

SetOnOffAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x015A	0x02B4	SetOnOffAllChannels	uint32	r/w

The data word holds the function of the command:

data = 1: Switch on all channels of the module
data = 0: Switch off all channels of the module

SetVoltageIlkMinSetAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x015C	0x02B8	SetVoltageIlkMinSetAllChannels	float	r/w

The value of the SetVoltageIlkMaxSetAllChannels in V for all channels will be submitted to the group as a floating point number in the 4 bytes. This value is accepted, if the corresponding channel characteristics permit it. Otherwise it's ignored.

SetCurrentIlkMinSetAllChannels

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x015E	0x02BC	SetCurrentIlkMinSetAllChannels	float	r/w

The value of the SetCurrentIlkMinSetAllChannels in A for all channels will be submitted to the group as a floating point number in the 4 bytes. This value is accepted, if the corresponding channel characteristics permit it. Otherwise it's ignored.

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2.2.3.2 Variable Groups

2.2.3.2.1 Set group

Set groups will be used in order to set channels to a same value, which happen to carry the identical channel value. Therefore within the group will be defined:

- Member of the group
  - Each member will be activated in the member list
- Type of the group
  - constant: SetGroupType
- Channel characteristics
  - Coding of characteristics , which are to be set commonly
- Control mode
  - Divides between a one-time setting of the slave channel property and a permanently copying of the Master channel's property to the slave channels
- Master channel
  - Number of the channel, which characteristics will be transferred to the other channels.
  - Is just necessary for Set groups which set a value.
    If functions have to be initialized e.g. start of ramp then there is no Master channel

SetGroup

Offset Words (rel to GrAddr)	Offset Bytes (rel. to GrAddr)	Name	Data type	Access
0	0	MemberList	uint16	r/w
1	2	TypeSet	uint16	r/w

MemberList:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	res	Res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

TypeSet:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TYPE1	TYPE0	Res	res	res	res	res	MOD0	SET3	SET2	SET1	SET0	MCH3	MCH2	MCH1	MCH0

TYPE1	TYPE0	Value	
0	0	SetGroupType	Group is defined as Set group

MOD0	Value	
0	0	The group function is done one time
1	1	The group function is done permanently

SET3	SET2	SET1	SET0	Value	
0	0	0	1	SetVset	Copy Vset from MCH to all members
0	0	1	0	SetIset	Copy Iset from MCH to all members
0	1	0	0	SetVbnds	Copy Vbounds from MCH to all members
0	1	0	1	SetIbnds	Copy Ibounds from MCH to all members
0	1	1	0	SetVIlkMinSet	Copy VIlkMinSet from MCH to all members
0	1	1	1	SetIIlkMinSet	Copy IIlkMinSet from MCH to all members
1	0	1	0	SetOn	Switch ON/OFF all members depending on setON in MCH
1	0	1	1	SetEmrgCutOff	Switch OFF all members (Emergeny OFF)
1	1	1	1	Cloning	Set all properties of members like MCH properties *(in preparation)*

MCH3	MCH2	MCH1	MCH0	Value	
0	0	0	0	0	1: Channel 0 is MasterChannel MCH
0	0	0	1	1	1: Channel 1 is MasterChannel MCH
...	...	...	...	...	...
0	0	1	1	3	1: Channel 3 ist MasterChannel MCH

2.2.3.2.2 Status group

Status groups are used to report the status of a single characteristic of all channels simultaneously. No action is foreseen. Therefore within the group has to be defined :

- type of the group
  - constant: StatusGroupType
- channel characteristics
  - coding of characteristics , which is to be reported

StatusGroup

Offset Words (rel to GrAddr)	Offset Bytes (rel. to GrAddr)	Name	Data type	Access
0	0	ChannelStatusList	uint16	r/w
1	2	TypeStatus	uint16	r/w

ChannelStatusList:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Res	res	res	res	CHST11	CHST10	CHST9	CHST 8	CHST 7	CHST 6	CHST 5	CHST 4	CHST3	CHST 2	CHST 1	CHST0

TypeStatus:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TYPE1	TYPE0	res	res	res	res	res	res	STAT3	STAT2	STAT1	STAT0	Res	res	res	Res

TYPE1	TYPE0	Value	
0	1	StatusGroupType	Group will be defined as Status group

STAT3	STAT2	STAT1	STAT0	Value	
0	0	1	1	ChkIsOn	check channel Status.isON (is on)
0	1	0	0	ChkIsRamping	check channel Status.isRAMP (is ramping)
0	1	1	0	ChkIsControlledCurrent	check channel Status.isCC (is current control)
0	1	1	1	ChkIsControlledVoltage	check channel Status.isCV (is voltage control)
1	0	1	0	ChkIsCurrentBounds	check channel Status.isCBNDs (is current bounds)
1	0	1	1	ChkIsVoltageBounds	check channel Status.isVBNDs (is voltage bounds)
1	1	0	0	ChkIsExternalInhibit	check channel Status.isEINH (is external inhibit)
1	1	0	1	ChkIsTrip	check channel Status.isTRIP(is trip)
1	1	1	0	ChkIsCurrentLimit	check channel Status.isCLIM (is current limit exceeded)
1	1	1	1	ChkIsVoltageLimit	check channel Status.isVLIM (is voltage limit exceeded)

2.2.3.2.3 Monitoring group

Monitoring groups are used to observe a single characteristic of selected channels simultaneously and in case of need take action. Therefore the group has to be defined :

- members of the group
  - each member will be activated in the member list
- type of the group
  - constant: MonitoringGroupType
- channel characteristics
  - coding of characteristics , which is to be monitored
- control mode
  - coding of the control function, i.e. which kind of change in the group-image shall cause a signal.
- activity
  - define , which activity has to happen after the event

MonitoringGroup

Offset Words (rel to GrAddr)	Offset Bytes (rel. to GrAddr)	Name	Data type	Access
0	0	MemberList	uint16	r/w
1	2	TypeMonitoring	uint16	r/w

MemberList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	Res	res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

TypeMonitoring:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TYPE1	TYPE0	ACT1	ACT0	res	res	res	MOD0	MON3	MON2	MON1	MON0	res	res	Res	res

TYPE1	TYPE0	Value	
1	0	MonitoringGroupType	Group will be defined as Monitoring group

MON3	MON2	MON1	MON0	Value	
0	0	1	1	MonitorIsOn	monitor channel Status.isON (is on)
0	1	0	0	MonitorIsRamping	monitor channel Status.isRAMP (is ramping)
0	1	1	0	MonitorIsControlledCurrent	monitor channel Status.isCC (is current control)
0	1	1	1	MonitorIsControlledVoltage	monitor channel Status.isCV (is voltage control)
1	0	1	0	MonitorIsCurrentBounds	monitor channel Status.isCBNDs (is current bounds)
1	0	1	1	MonitorIsVoltageBounds	monitor channel Status.isVBNDs (is voltage bounds)
1	1	0	0	MonitorIsExternalInhibit	monitor channel Status.isEINH (is external inhibit)
1	1	0	1	MonitorIsTrip	monitor channel Status.isTRIP (is trip)
1	1	1	0	MonitorIsCurrentLimit	monitor channel Status.isCLIM (is current limit exceeded)
1	1	1	1	MonitorIsVoltageLimit	monitor channel Status.isVLIM (is voltage limit exceeded)

MOD0	Value	
0	0	event will happen if at least one Channel == 0
1	1	event will happen if at least one Channel == 1

ACT1	ACT0	Value	
0	0	0	No special action ; EventGroupStatus[grp] will be set
0	1	1	Ramp down of group; EventGroupStatus[grp] will be set
1	0	2	Switch OFF of group without ramp; EventGroupStatus[grp] will be set
1	1	3	Switch OFF of module without ramp; EventGroupStatus[grp] will be set

2.2.3.2.4 Timeout group

Timeout groups are necessary to keep the timing for the time controlled Trip function and to define the action which has to happen after a Trip.

Therefore in the group will be defined:

- members of group
  - each member will be activated in a word MemberList
- type of the group
  - constant: TimeOutGroupType
- activity
  - define , which activity has to happen after time controlled Trip
- timeout
  - coding of Timeout-time as 12 Bit Integer

TimeOutGroup:

Offset Words (rel to GrAddr)	Offset Bytes (rel. to GrAddr)	Name	Data type	Access
0	0	MemberList	uint16	r/w
1	2	TypeTimeOut	uint16	r/w

MemberList:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	res	res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

TypeTimeOut:

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
TYPE1	TYPE0	ACT1	ACT0	TOT11	TOT10	TOT9	TOT8	TOT7	TOT6	TOT5	TOT4	TOT3	TOT2	TOT1	TOT0

TYPE1	TYPE0	Value	
1	1	TimeOutGroupType	Group will be defined as Timeout group .

ACT1	ACT0	Value	
0	0	0	No special action ; EventGroupStatus[grp] will be set
0	1	1	Ramp down of group EventGroupStatus[grp] will be set
1	0	2	Switch OFF of group without ramp; EventGroupStatus[grp] will be set
1	1	3	Switch OFF of module without ramp; EventGroupStatus[grp] will be set

TOT[11..0]: Binary coded Timeout-time in ms (0..4096ms)

2.3 Events and interrupts

Remark: The activation of interrupts at the VME bus is not realized yet. The event handling is realized

The module provides an extended event collecting and interrupt logic. This is necessary to monitor extraordinary events and forward them to the host.

Events can be generated by:

- occurrence of special conditions in the module status (e.g. safety loop open, temperature too high)
- occurrence of special conditions in a channel (e.g. over-voltage, over-current, current-trip)
- occurrence of events in channel status (e.g. end of a ramp)
- occurrence of events in a monitoring group
- occurence of events in a timeout group

The occurence of such single events will be stored in the EventStatus registers:

- ModuleEventStatus
- ChannelEventStatus
- ModuleEventGroupStatus

Since every appearing event doesn't have inevitably to lead to a report to the host, the EventMask registers exist parallel to the EventStatus registers. These decide whether an occurred event leads to a report to the host or not. If the event shall be reported, the responsible bit must be set in the mask register.

A check of EventStatus and EventMask is made before the HV will be switched on. When bits are set in the EventStatus and the corresponding bits are set in the EventMask the HV cannot be switched on again before the EventStatus bits are reset by writing “1” on the corresponding bit positions.

The report to the host can be made by queries of the bit "IsEventActive" in the ModuleStatus register. This bit is set if an event has occurred and the setting of the event mask enables the passing.
Independent of the being of the reason for an event, these remain stored further in the accompanying event status register.

The reset of the individual events is done by a re-write of a 1 to the event bit in the accompanying EventStatus register. It's possible to reset more then one event at the same time. If there is still the reason for the event, the reset is prevented or a new set of an event is immediately carried out.

2.3.1 Events in channels

Main origin of the event logic are the single event sources in the channels. The occurrence of an event is stored in the register ChannelEventStatus of the channel. The accompanying register ChannelEventMask decides if the event is to be reported. An event is reported if the accompanying bit in the mask register is set. To generate a global information about the existence of any event to be reported a sum signal is made. All these sum signals of all channels are stored in the status register ModuleEventChannelStatus

ModuleEventChannelStatus [n] =
(EventVoltageLimit[n] AND MaskEventVoltageLimit[n]) OR
(EventCurrentLimit[n] AND MaskEventCurrentLimit[n]) OR
(EventTrip[n] AND MaskEventTrip[n]) OR
(EventExtInhibit[n] AND MaskEventExtInhibit[n]) OR
(EventVoltageBounds[n] AND MaskEventVoltageBounds[n]) OR
(EventCurrentBounds[n] AND MaskEventCurrentBounds[n]) OR
(EventControlledVoltage[n] AND MaskEventControlledVoltage[n]) OR
(EventControlledCurrent[n] AND MaskEventControlledCurrent[n]) OR
(EventEmergency[n] AND MaskEventEmergency[n]) OR
(EventEndOfRamp[n] AND MaskEventEndOfRamp[n]) OR
(EventOnToOff[n] AND MaskEventOnToOff [n]) OR
(EventInputError[n] AND MaskEventInputError[n])

where is:
ModuleEventChannelStatus[n]: ch-th bitof the register ModuleEventChannelStatus
EventVoltageLimit[n]: bit EventVoltageLimit of register ChannelEventStatus of thr ch-th channel
MaskEventVoltageLimit[n]: bit MaskEventVoltageLimit of register ChannelEventMask of thr ch-th channel

The selection of channels is done by the register ModuleEventChannelMask. Only those channels can report an event that have a set bit in this mask register. The sum event of all channel events is the (internal) signal EventChannelActive:

EventChannelActive = (ModuleEventChannelStatus[0] AND ModuleEventChannelMask[0]) OR
(ModuleEventChannelStatus[1] AND ModuleEventChannelMask[1]) OR
...
(ModuleEventChannelStatus[n] AND ModuleEventChannelMask[n])

2.3.2 Events in groups

Like written before groups are also able to generate Events. These events will be collected in the status word ModuleEventGroupStatus. This status word is 32 bits wide. It consists of the status registers ModuleEventGroupStatusHigh and ModuleEventGroupStatusLow, each 16bit wide. With help of the accompanying mask register ModuleEventGroupMask the events are filtered and the (internal) signal of the groups EventGroupActive will be generated.

EventGroupActive = (ModuleEventGroupStatus[0] AND ModuleEventGroupMask[0]) OR
(ModuleEventGroupStatus[1] AND ModuleEventGroupMask[1]) OR
...
(ModuleEventGroupStatus[23] AND ModuleEventGroupMask[24])

2.3.3 Events in characteristics of the whole module

These events are events of single characteristics of the module. An event is stored in the register EventModuleStatus. This register also has a mask register for filtering. The sum signal of this type of events is the (internal) signal EventModuleActive.

EventModuleActive = (EventTemperatureNotGood AND MaskEventTemperatureNotGood) OR
(EventSupplyNotGood AND MaskEventSupplyNotGood) OR
(EventSafetyLoopNotGood AND MaskEventSafetyLoopNotGood) OR
(EventRestart AND MaskEventResart) OR

2.3.4 Event status of the module

The event status of the module is summarized out of the event status of the channels, of the groups and of the module single characteristics. This sum signal IsEventActive is part of the register ModuleStatus:

IsEventActive = EventChannelActive OR
EventGroupActive OR
EventModuleActive

2.4 Special registers

2.4.1 Setting of Basis Address

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x01D0	0x03A0	NewBaseAddress	uint16	r/w
0x01D1	0x03A2	NewBaseAddressXor	uint16	r/w
0x01D2	0x03A4	OldBaseAddress	uint16	r
0x01D3	0x03A6	NewBaseAddressAccepted	uint16	r

As shown in the preliminary remarks to section 4, the module is bound into the VME address room by defining the Basis Address BA. This address is the begin of a 1kByte wide memory segment. the address BA is free in the bits A15 to A10, the bits A9 to A1 are fixed to 0.

in words:
binary: BA = 0bbbbbb0 00000000 (with b={0|1})
hexadezimal: BA = xy00 (with x={0..7}, y={0,2,4,6,8,A,C,E}.

in bytes:
binary: BA = bbbbbb00 00000000 (with b={0|1})
hexadezimal: BA = xy00 (with x={0..F}, y={0,4,8,C}.

The default value (factory setting and setting when started with jumper “ADR” on the topside of the board has been set) is BA=0x4000 (in bytes) resp. BA=0x2000 in words.

New address setting is done using four registers:
In register "NewBaseAddress" the new base address (byte counting) is to write. In register "NewBaseAddressXor" the complementary value of "NewBaseAddress" is to write.

NewBaseAddressXor = NewBaseAddress XOR 0xFFFF

When both values are written, and the condition is fulfilled, the new address is accepted. If the new address doesn't point to the beginning of a 1kByte segment, it is corrected to the beginning of the next smaller segment.
After that, the value is stored into EEPROM.
This new Base Address is used after the next reset (e.g. after PowerOn, SYSRESET or a special command). Until this the old address is valid.

When the jumper "ADR" is set the Base Address of the module will reset to the default address 0x4000 after a power up. This function can be used when there is no communication for instance the Base Address is unknown.
When the jumper is not set the stored address inside of the module will be used as Base Address.

2.4.2 Special Control Register

Offset Worte (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x01D8	0x03B0	SpecialControlStatus	uint16	r
0x01D9	0x03B2	SpecialControlCommand	uint16	r/w

Both these registers "SpecialControlStatus" and "SpecialControlCommand" are used for maintenance and service purposes. Their usage is explained in a separate manual.

2.5 Options

2.5.1 Interlock Output

The Interlock Output is a static TTL signal which is active at Low level on the safety loop connector on the front panel. The function Interlock input (see position 3.1.1) is not available in this option.
The Interlock Output signal can be generated when the control signal SetKilEenable of the ModuleControl register (see 4.2.1) is not set. This status is to be observed by the bit IsKilEnable of the ModuleStatus register.

Interlock Output is active in 2 cases:

A: After Power On reset
After Power On reset the Interlock Output system waits for handling all channels. The Interlock Output is active. This state is indicated by ModuleInterlockOutStatus.IsILKStandBy ==1.

This state is ended by one of the following actions:

1. Each channel must be switched on one times in minimum. The channels should be initialized by setting the demand voltage Vset and switching the channel on. If one channel isn't used in the system, it must be switched on also. After that it can be switched off.
2. The Interlock Output system is reset. Therefore the bit ModuleInterlockOutControl.SetILKEnable must be cleared and after that set.

B: When any of the following conditions in any channel of the module is true:

1. CurrentMeasure is equal or greater than CurrentSet
   The channel will switch to current control; this is shown by active bit "isCC" in ChannelStatus register
2. CurrentMeasure is equal or greater than the actual maximal Current (CurrentLimit) of the channel.
   This is shown by active bit "isCLIM" of the ChannelStatus register. The CurrentLimit is calculated by channel's CurrentNominal multiplied by CurrentMax of the front panel potentiometer.
3. VoltageMeasure is equal or greater than the actual maximal Voltage (VoltageLimit) of the channel.
   This is shown by active bit "isVLIM" of the ChannelStatus register. The VoltageLimit is calculated by channel's VoltageNominal multiplied by VoltageMax of the front panel potentiometer.
4. VoltageMeasure exceeds the VoltageBounds
   This is shown by active bit "isVBNDS" of the ChannelStatus register

For monitoring and control of the Interlock Output function, some auxiliary bits and registers are defined in the module.

2.5.1.1 Overview of the Interlock Output Registers

Special Registers

Offset Words (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0020	0x0040	ModuleInterlockOutStatus	uint16	r
0x0021	0x0042	ModuleInterlockOutControl	uint16	r/w
0x0022	0x0044	ModuleInterlockCount	uint16	r
0x0023	0x0046	ModuleInterlockLastTrigger	uint16	r
0x0024	0x0048	ModuleInterlockChnActualActive	uint16	r
0x0025	0x004a	ModuleInterlockChnEverTriggered	uint16	r

2.5.1.2 ModuleInterlockOutStatus

ModuleInterlockOutStatus

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0020	0x0040	ModuleInterlockOutStatus	uint16	r

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
isILKena	isILKact	res	res	res	res	res	res	res	res	res	res	isILKTL3	isILKTL2	isILKTL1	isILKTL0

isILKena	IsIlkEnabled	Interlock Output enabled (1) or disabled (0)
isILKact	IsIlkActive	Interlock Output signal active (any condition is true)
isILKstby	IsILKStandBy	Interlock Output signal active because of PowerOn reset and channels are not handled yet
isILKTL0..3	IsIlkTestLoops[0;1;2;3]	Counter for Stretching of the Interlock Test Pulse
Res	reserverd	reserved

2.5.1.3 ModuleInterlockOutControl

ModuleInterlockOutControl

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0021	0x0042	ModuleInterlockOutCommand	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
setILKena	clrILKregs	res	res	res	res	res	setILKCb	setILKVl	setILKVb	setILKCl	setILKIs	doILKTL3	doILKTL2	doILKTL1	doILKTL0

setILKena	SetIlkEnable	enable (1) or disable (0) Interlock Output
clrILKregs	ClearIlkRegisters	clear Interlock Out part registers
setILKCb	SetIlkCBnds	simulate Interlock Out triggered by Current Bounds
setILKVl	SetIlkVlim	simulate Interlock Out triggered by Vlimit
setILKVb	SetIlkVBnds	simulate Interlock Out triggered by Voltage Bounds
setILKCl	SetIlkClim	simulate Interlock Out triggered by Climit
setILKIs	SetIlkIset	simulate Interlock Out triggered by Iset
doILKTL	DoIlkTestLoops[0;1;2;3]	simulate an Interlock Out pulse of n * 40ms length; n= 1..15; n=0 => no test pulse
Res	reserverd	reserved

The register ModuleInterlockOutControl controls all work with the Interlock output part. The bit setIlkEnable enables or disables the output.
The output signal is generated when at least one of the interlock conditions (see chapter 2.5.1) is true. For test purposes, the generation of a test pulse can be initiated. To have a possibility to check the handler of the external control software, the generation of different trigger sources and pulse lengths is possible.

2.5.1.4 ModuleInterlockCount

ModuleInterlockCount

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0022	0x0044	ModuleInterlockCount	uint16	r

Counter of 16 bit unsigned integer to count different states of Interlock condition is true.
A true Interlock condition of a channel is counted only in case no other Interlock condition is active on the same channel (means, the corresponding channel bit in register ModuleInterlockChnActualActive is not set).

2.5.1.5 ModuleInterlockLastTrigger

ModuleInterlockLastTrigger

Offset Words (rel. to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0023	0x0046	ModuleInterlockLastTrigger	uint16	r/w

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	res	res	res	Chn3	Chn2	Chn1	Chn0	isILKVl	isILKVb	isILKCl	isILKIs	isILKCb	res	res	isIlkTst

Chn0..3	IlkChn [0;1;2;3]	number of the channel that initiated last trigger ; for testing: IlkChn = 15
isILKVl	IsIlkVlim	Interlock Out triggered by Vlimit
isILKVb	IsIlkVBnds	Interlock Out triggered by Voltage Bounds
isILKCl	IsIlkClim	Interlock Out triggered by Climit
isILKIs	IsIlkIset	Interlock Out triggered by Iset
IsILKCb	IsILKCBnds	Interlock Out triggered by Current Bounds
isILKTst	IsIlkTest	Last Interlock signal was simulated
res	reserverd	reserved

The register ModuleInterlockLastTrigger catches the information of the channel that triggered at last.
Such information are the channel number and the trigger source.
If an Interlock condition on this channel becomes active after the channel was registered as the last triggered channel, this new condition is added to the stored ones.
A new interlock condition at another channel (the corresponding channel bit in register ModuleInterlockChnActualActive was not active) overwrites the whole register.

2.5.1.6 ModuleInterlockChnActualActive

ModuleInterlockChnActualActive

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0024	0x0048	ModuleInterlockChnActualActive	uint16	r/w

ChannelList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	Res	res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

If a channel has an active Interlock condition at the moment, the corresponding channel bit is set. If the condition is resolved the corresponding bit is cleared.

2.5.1.7 ModuleInterlockChnEverTriggered

ModuleInterlockChnEverTriggered

Offset Words (rel to BA)	Offset Bytes (rel. to BA)	Name	Data type	Access
0x0025	0x004A	ModuleInterlockChnEverTriggered	uint16	r/w

ChannelList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
res	Res	res	res	CH11	CH10	CH9	CH8	CH7	CH6	CH5	CH4	CH3	CH2	CH1	CH0

If a channel has an active Interlock condition, the corresponding channel bit is set. If the condition is resolved the corresponding bit remains set.