Programmer guide
last change on: 2021-09-10

Operator's Manual VME Interface

Document history

Version	Date	Major changes
1.1	2021-09-10	Improved documentation, VHS interface options
1.0	2020-10-13	Relayouted documentation

Disclaimer / Copyright

The information in this manual is subject to change without notice. We take no responsibility for any mistake in the document. We reserve the right to make changes in the product design without reservation and without notification to the users. We decline all responsibility for damages and injuries caused by an improper use of the device.

Safety

This section contains important security information for the installation and operation of the device. Failure to follow safety instructions and warnings can result in serious injury or death and property damage.

Safety and operating instructions must be read carefully before starting any operation.

We decline all responsibility for damages and injuries caused which may arise from improper use of our equipment.

Depiction of the safety instructions

DANGER!

DANGER!

"Danger!" indicates a severe injury hazard. The non-observance of safety instructions marked as "Danger!" will lead to possible injury or death.

WARNING!

WARNING!

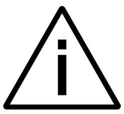
"Warning!" indicates an injury hazard. The non-observance of safety instructions marked as "Warning!" could lead to possible injury or death.

CAUTION!

CAUTION!

Advices marked as "Caution!" describe actions to avoid possible damages to property.

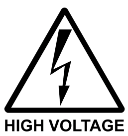
INFORMATION



INFORMATION

Advices marked as "Information" give important information.

Read the manual.



Attention high voltage!

Important information.

Intended Use

The device may only be operated within the limits specified in the data sheet. The permissible ambient conditions (temperature, humidity) must be observed. The device is designed exclusively to control high voltage systems as specified in the data sheet.
It must only be used specified in Technical data. Any other use not specified by the manufacturer is not intended.
The manufacturer is not liable for any damage resulting from improper use.

Qualification of personnel

A qualified person is someone who is able to assess the work assigned to him, recognize possible dangers and take suitable safety measures on the basis of his technical training, his knowledge and experience as well as his knowledge of the relevant regulations.

General safety instructions

- Observe the valid regulations for accident prevention and environmental protection.
- Observe the safety regulations of the country in which the product is used.
- Observe the technical data and environmental conditions specified in the product documentation.
- You may only put the product into operation after it has been established that the high-voltage device complies with the country-specific regulations, safety regulations and standards of the application.
- The high-voltage power supply unit may only be installed by qualified personnel.

Important safety instructions

DANGER!	
DANGER!	This device is part of a high voltage supplying systems. High voltages are dangerous and may be fatal. USE CAUTION WHILE WORKING WITH THIS EQUIPMENT. BE AWARE OF ELECTRICAL HAZARDS. Always follow at the minimum these provisions: • High voltages must always be grounded • Do not touch wiring or connectors without securing • Never remove covers or equipment • Always observe humidity conditions • Service must be done by qualified personnel only

WARNING!	
WARNING!	RAMP DOWN VOLTAGES! Before insertion or removal of crate controller, please make sure, that all voltages are ramped down, modules are switched off and power cord is disconnected.

CAUTION!	
CAUTION!	When controlling, with software, the high voltage systems, make sure that nobody is near the high voltage or can be injured.

INFORMATION	
INFORMATION	Please check the compatibility with the devices used.

Table of Contents

1 General information

This Manual describes for one the VME Interface commands for VME High Voltage Supply.

1.1 Terminology

Syntax	Declaration
V_{nom}	Voltage nominal, the maximum possible output voltage
I_{nom}	Current nominal, the maximum possible output current
V_{set}	Voltage Set, the user-controllable demanded output voltage
V_{meas}	Voltage Measure, the actual measured output voltage
V_{lim}	Voltage Limit. Can be a hardware or a software limit and serves two purposes: 1. It limits the upper value of V_{set} to the given limit value: $\lvert V_{set} \rvert \leq V_{lim}$ 2. It generates the Channel Status is Voltage Limit if V_{meas} exceeds the limit value (the exact threshold value is device dependent)
$I_{set:}$	Current Set, the user-controllable demanded output current
I_{meas}	Current Measure, the actual measured output current
I_{lim}	Current Limit. Can be a hardware or a software limit and serves two purposes: 1. It limits the upper value of I_{set} to the given limit value: $\lvert I_{set} \rvert \leq I_{lim}$ 2. It generates the Channel Status is Current Limit if I_{meas} exceeds the limit value (the exact threshold value is device dependent)
V_{bounds}	Voltage bounds, a tolerance tube $V_{set} \pm V_{bounds}$ around V_{set}. If V_{meas} exceeds this tolerance in either direction, the Channel Status is Voltage Bounds is generated. (condition: no ramping)
I_{bounds}	Current bounds, a tolerance tube $I_{set} \pm I_{bounds}$ around I_{set}. If I_{meas} exceeds this tolerance in either direction, the Channel Status is Current Bounds is generated. (condition: no ramping)

1.2 Channel operation modes

Operation Mode	Description
Off	The channel is off, it does not generate high voltage. If all status conditions are satisfied, the channel can be turned on.
On	The channel is actively generating high voltage.
Ramping	The channel ramps to the V_{set} if turned on or is turns off with the programmed ramp speed.
Emergency Off	The channel is shut down without ramp. Afterwards, it stays in Emergency Off until Emergency Clear is given.
Emergency Clear	The channel leaves the state Emergency Off and goes to state Off. If the channel is not in Emergency Off, nothing happens.
Kill Enable active	The mode Kill Enable provides a higher safety. This mode is module-wide and therefore affects all channels. The channel will got to Trip and shut down without ramp when any of the following conditions occur: • $V_{meas} > V_{lim}$ OR • $V_{meas} > V_{set} + V_{bounds}$ • $I_{meas} > I_{lim}$ OR • $V_{meas} < V_{set} - V_{bounds}$ • $I_{meas} > I_{set}$ OR • $I_{meas} < I_{set} - I_{bounds}$
Kill Enable inactive	If of the limits above will happen: • Switch the channel from operating mode voltage control into current control if there is a HV hardware with current control. • HV hardware without current control – a trip in the channel hardware will switch off the high voltage generation. Then the module automatically starts to restore the HV via a voltage ramp to the set voltage. If the HV is held during the trip, e.g. by an external capacity load, the recovery of the HV starts from the voltage at the output. The auto-recovery of the voltage is performed only once in a time span of 10 minutes. If the channel trips a second time within the 10 minutes the HV will be switched off.
Constant Voltage	The channel operates as constant voltage source, that means $V_{meas} \approx V_{set}$ and $I_{meas} < I_{set}$
Constant Current	The channel operates as constant current source, that meas $V_{meas} < V_{set}$ and $I_{meas} \approx I_{set}$
Delayed Trip	This is a special mode of Constant Current. If this mode is activated, and I_{meas} reaches or exceeds I_{set}, the Channel Status is Current Trip is generated. Depending on the trip configuration, the channel may stay in Constant Current, or turn off with ramp or shut down without ramp. Trip also happens when Kill Enable is active and any of the Kill conditions occur.
Input Error	An input error occurs, if an invalid command or parameter is given, or the parameter of a command exceeds the allowed range. Example: setting a V_{set} of 4000 V for a channel with V_{nom} of 3000 V.

2 Commands for High Voltage Devices

Each single HV channel is independently controllable. The modules are software controlled via VME-Interface through a PC or similar controller.

2.1 General settings and options

Please note that there are additional hardware features for these devices in this manual called **OPTION**. The use of an access without the hardware implementation will be described under **OPTION** in manual.

2.2 Operation principle

The communication between an application and the module is performed by the transmission of data items. A data item contains information to be submitted to and/or received from the module. It can represent a specific quantity or a union of single bits. The majority of the data items are standard for all Multi-Channel HV modules and are described in the interface manual in detail. Data items for optional functions are described in the interface options manual.

A general distinction can be made between data items to control individual HV channels and data items to control the HV modules with the sum of all contained channels.

The former group includes the following data items, which exist for every single HV channel:

- items to handle channel status, control and event's
- items to set the voltage or current, bounds, interlock maximum and minimum
- items to read the measured voltage and current
- items to read the nominal voltage and current

The following data items control the properties of the whole HV module. These items exist only once per module:

- items to handle module status, control and events
- voltage ramp speed (is the same for all HV channels)
- current ramp speed (is the same for all HV channels)
- restart time after recalling set values
- maximum set voltage
- maximum set current
- ADC samples per second
- digital filter setting
- power supply voltages
- temperature
- maximum voltage
- maximum current

2.3 Operation modes

There are three operation modes depending on the HV hardware and the module configuration.

2.3.1 Voltage control (CV)

In the mode Voltage control the module works as a constant voltage source. For this mode it is required that the value for current set (I_{set}) or current trip (I_{trip}) is greater than the resulting output current.

2.3.2 Current control (CC)

In the mode Current control the module works as a constant current source. For this mode it is required that the HV channel has implemented a current control and that the voltage set value V_{set} is greater than the resulting output voltage.

2.3.3 Current trip

This is a special case of the voltage regulation. The module usually provides a constant output voltage, where the value of the parameter I_{trip} defines a current limit. If this value is reached or exceeded (e.g. by arcs), in this mode the channel will be switched off immediately.

2.3.4 Function KillEnable

KillEnable is a global control signal that defines the behaviour of the module if a given voltage (V_{max}) or current limit (I_{max}/I_{set}/I_{trip}) is exceeded.

If KillEnable is active the violation of one of the limits will trigger a Kill-signal in the respective channel. This signal will switch off the channel immediately without ramp.

If KillEnable is inactive and one of the limits I_{max}/I_{set} or I_{trip} is exceeded the following will happen:

HV hardware with current control	HV hardware without current control
Switch the channel from voltage control into current control.	A trip in the channel hardware will switch off the high voltage generation. Then the module automatically starts to restore the HV via a voltage ramp to the set voltage. If the HV is held during the trip, e.g. by an external capacity load, the recovery of the HV starts from the voltage at the output. The auto-recovery of the voltage is performed only once in a time span of 10 minutes. If the channel trips a second time within the 10 minutes the HV will be switched off.

3 Control and Status items

3.1 Controls

Control items encapsulate a number of bits which allow to switch On or Off specific functions. There is a control item for the module (**ModulControl**) and one for each channel (**ChannelControl**). Control bits that are used to switch a function permanently are named "set..." (e.g. "**setON**" to switch a channel On of Off). Bits that initiate the execution of a task just once are named "do..." (e.g. "**doClear**" to clear all events).

3.2 Status and events

Status items contain a register that encapsulates bits that indicate the current status of the module or channel. Status bits are named starting with "is...". The status always displays only present conditions, if a condition has changed corresponding status bits will be updated.

Unlike the status, event items record previous conditions (e.g. exceeded limits, trips etc.). If an event is registered the corresponding event bit is set permanently to "1" and will keep the information until explicitly reset. Event bits are named starting with "E...".

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

3.3 Event status and event mask

To avoid the need for checking all event sources permanently for incoming events, the module provides a hierarchical chain for the combination of the events to a single status bit. The structure for the event processing allows a combination of events coming from the module status, the status of the channels and the group status. For each event status item a corresponding event mask item is provided. The event mask defines which event status bits contribute to the combined event status.

Event status	Events that have been registered so far
Event mask	Filter to define which individual events contribute to the summarized event

Between event status items and the corresponding mask is a bit by bit correspondence. The bits in the mask are named starting with "ME...". If the mask bit is set, the occurring of the respective event will activate the combined event. In turn these sum events are collected in an event status register and connected with an event mask register at this higher level.

CAUTION!

CAUTION!

The "**EventStatus**" and "**EventMask**" is always checked before the HV is switched on.

If an event bit in the "**EventStatus**" is active and the corresponding bit in the "**EventMask**" is set, the HV generation cannot be activated. The "**EventStatus**" bits must be reset first by writing "1" on the corresponding bit positions.

Individual events in the channel event status are starting point of the event combination logic. First each event status bit for the channel is combined with the corresponding bit in the event mask using a logical AND. Then an event status bit for the channel is generated by combining all resulting bits with a logical OR. The full logical operation is given by

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 result of the first step for all channels is stored in the register "**EventChannelStatus**".

In the next step all bits of the "**EventChannelStatus**" are combined to a single status bit, using the corresponding mask ("**EventChannelMask**"). The logical operation is given by

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

A second branch in the event processing logic treats events generated by the status of the module. The following scheme applies to these module events:

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

A third branch combines events generated by groups (3.4.3 Monitor Group, 3.4.4 Timeout Group, see chapter 3.4 Summarizing channel characteristics into groups).

Group events are stored in the status register "**EventGroupStatus**". The mask "**EventGroupMask**" is used to generate the combined bit "**EventGroupActive**" with the following operation:

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

Finally the three branches are combined to the bit "**IsEventActive**" in the register ModuleStatus:

IsEventActive = EventChannelActive OR EventModuleActive OR EventGroupActive

3.4 Summarizing channel characteristics into groups

The module provides a highly flexible group functionality. A group is a combination of all or a selection of channels with the ability to control or monitor a specified quantity or characteristic of all included channels. There are two classes of groups "Fix Groups" and "Variable Groups". The former are predefined groups that allow to set single specification values in all channels. The latter are configurable groups that allow to customize the logical structure of the module to the logical structure of the application. They allow an arbitrary assignment of channels and provide a wide range of functionality, structured in four predefined group types. Up to 32 Variable Groups can be defined. The predefined group types are:

- 3.4.1 Set Group
- 3.4.2 Status Group
- 3.4.3 Monitor Group
- 3.4.4 Timeout Group

3.4.1 Set Group

- sets a specified channel characteristic in all selected channels
- no event generation

3.4.2 Status Group

- represents the status (condition) of a channel characteristic for all channels
- no event generation

3.4.3 Monitor Group

- monitors the condition of a channel characteristic for selected channels
- event generation when the condition changes
- configurable response (e.g. switch off)

3.4.4 Timeout Group

- monitors the current trip in selected channels
- to employ this group the signal KillEnable must be turned off
- Event generation only after expiry of a predefined time within which the trip condition must be active
- configurable response (e.g. switch off)

3.4.5 Responses on events (Soft-Kill features)

Event generating groups can be configured to perform one out of four predefined responses if the event has been generated:

shut down of the whole module without ramp	high voltage in all channels of the module is switched off
switch off all channels that are members of the group without ramp	high voltage in all channels of the group is switched off
switch off all channels that are members of the group with ramp	high voltage in all channels of the group is ramped down
no response	no change

3.5 Autostart

The Autostart functionality allows a recall/reload of stored values to the corresponding set values. A delayed switch-on of the high voltage can be configured. The delay time is configured using the item 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 given in chapter 5.5 Module registers, “**ModulStatus**”, “**ModulControl**”, “**ModuleEventStatus**” and “**RestartTimeAfterRecallSetValues**”.

4 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.

The description of RAM addressing in this document is done in a byte addressing type. 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 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=0x4000 in Bytes

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).

Data formats:

The data format on the VME bus is Big Endian format, i.e. highest byte on lowest address. In contrast, Intel computers store the value byte-wise reversed in memory (Little Endian).

The following formats are used:

uint8	unsigned character (8 bit)
uint16	unsigned word (16 bit)
uint32	unsigned integer (32 bit)
float	floating point according to IEEE-754 single precision format

To convert floating-point values to their hexadecimal representation and vice versa, can be used an online calculator.

Example:

Channel 0 V_{set} = 1000 V:

Data-Bytes on the VME bus:	0x44 0x7A 0x00 0x00
Data-Bytes in little endian memory:	0x00 0x00 0x7A 0x44

Usually, the byte-swapping within a 16 bit word is done by the VME driver. As all VME accesses are 16 bit wide, only the data words have to be swapped, not the bytes.

1. Writing word-wise:
   a) Write the high memory word to the lower VME address: write 0x447A to address 0x4068
   b) Write the low memory word to the higher VME address: write 0x0000 to address 0x406A

2. Reading word-wise:
   a) Read the lower VME address and store the value in the high memory word read from 0x406A, value = 0x0000
   b) Read the higher VME address and store the value in the low memory word read from 0x4068, value = 0x447A

5 Description of control, status, event, and mask registers

5.1 Module data

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0000	5.5.1 ModuleStatus	uint16	r
0x0002	5.5.2 ModuleControl	uint16	r/w
0x0004	5.5.3 ModuleEventStatus	uint16	r/w
0x0006	5.5.4 ModuleEventMask	uint16	r/w
0x0008	5.5.5 ModuleEventChannelStatus	uint16	r/w
0x000A	5.5.6 ModuleEventChannelMask	uint16	r/w
0x000C	5.5.7 ModuleEventGroupStatus	uint32	r/w
0x0010	5.5.7 ModuleEventGroupStatus	uint32	r/w
0x0014	5.5.9 VoltageRampSpeed	float	r/w
0x0018	5.5.10 CurrentRampSpeed (option)	float	r/w
0x001C	5.5.11 VoltageMax	float	r
0x0020	5.5.12 CurrentMax	float	r
0x0024	5.5.13 SupplyP5	float	r
0x0028	5.5.14 SupplyP12	float	r
0x002C	5.5.15 SupplyN12	float	r
0x0030	5.5.16 Temperature	float	r
0x0034	5.5.17 SerialNumber	uint32	r
0x0038	5.5.18 FirmwareRelease	uint8[4]	r
0x003C	5.5.19 PlacedChannels	uint16	r
0x003E	5.5.20 DeviceClass	uint16	r
0x0040	8.2.2 ModuleInterlockOutStatus	uint16	r
0x0042	8.2.3 ModuleInterlockOutControl	uint16	r/w
0x0044	8.2.4 ModuleInterlockCount	uint16	r
0x0046	8.2.5 ModuleInterlockLastTrigger	uint16	r
0x0048	8.2.6 ModuleInterlockChnActualActive	uint16	r
0x004A	8.2.7 ModuleInterlockChnEverTriggered	uint16	r
0x0050	5.5.21 RestartTimeAfterReloadSetValues	uint16	r/w
0x0058	5.5.22 ADC SamplesPerSecond SPS	uint16	r/w
0x005A	5.5.23 DigitalFilter	uint16	r/w
0x005C	5.5.24 VendorId: const ‘i’,’s’,’e’,’g’ = 0x69736567	uint8[4]	r

5.2 Channels

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

Notes:
rel. to BA: relative to Base Address
[1] only in module type VHS Cxx

5.3 Channel data

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
0	5.6.1 ChannelStatus	uint16	r
2	5.6.2 ChannelControl	uint16	r/w
4	5.6.3 ChannelEventStatus	uint16	r/w
6	5.6.4 ChannelEventMask	uint16	r/w
8	5.6.5 VoltageSet	float	r/w
12	5.6.6 CurrentSet / CurrentTrip [2]	float	r/w
16	5.6.7 VoltageMeasure	float	r
20	5.6.8 CurrentMeasure	float	r
24	5.6.9 VoltageBounds / VoltageIlkMaxSet [3]	float	r/w
28	5.6.10 CurrentBounds / CurrentIlkMaxSet [4]	float	r/w
32	5.6.11 VoltageNominal / VoltageMaxSet [5]	float	r/(w)
36	5.6.12 CurrentNominal / CurrentMaxSet [5]	float	r/(w)
40	5.6.13 VoltageIlkMinSet	float	r/w
44	5.6.14 CurrentIlkMinSet	float	r/w

Notes:
rel. to ChAddr: relative to Channel Address
[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

5.4 Group data

5.4.1 Fixed Groups

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02A0	5.8.1 SetVoltageAllChannels	float	r/w
0x02A4	5.8.2 SetCurrentAllChannels	float	r/w
0x02A8	5.8.3 SetVoltageBoundsAllChannels	float	r/w
0x02AC	5.8.4 SetCurrentBoundsAllChannels	float	r/w
0x02B0	5.8.5 SetEmergencyAllChannels	uint32	r/w
0x02B4	5.8.6 SetOnOffAllChannels	uint32	r/w
0x02B8	5.8.7 SetVoltageIlkMinSetAllChannels	float	r/w
0x02BA	5.8.8 SetCurrentIlkMinSetAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

5.4.2 Variable Groups

Offset Bytes (rel. to BA)	Name	
0x02C0	GrAddr[0]	begin of group 0
0x02C4	GrAddr[1]	begin of group 1
0x02C8	GrAddr[2]	begin of group 2
0x02CC	GrAddr[3]	begin of group 3
0x02D0	GrAddr[4]	begin of group 4
0x02D4	GrAddr[5]	begin of group 5
0x02D8	GrAddr[6]	begin of group 6
0x02DC	GrAddr[7]	begin of group 7
0x02E0	GrAddr[8]	begin of group 8
…	…	…
0x033C	GrAddr[31]	begin of group 31
Notes: rel. to BA: relative to Base Address		

User defined nominal values (**ModuleStatusIsStop**(0))

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0340	VoltageMaxSet channel 0	float	r
0x0344	CurrentMaxSet channel 0	float	r
0x0348	VoltageMaxSet channel 1	float	r
0x034C	CurrentMaxSet channel 1	float	r
0x0398	VoltageMaxSet channel 11	float	r
0x039C	CurrentMaxSet channel 11	float	r
Notes: rel. to BA: relative to Base Address			

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

Hardware defined nominal values (**ModuleControlSetStop**(1), **ModuleStatusIsStop**(1))

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0340	VoltageNominal channel 0	float	r
0x0344	CurrentNominal channel 0	float	r
0x0348	VoltageNominal channel 1	float	r
0x034C	CurrentNominal channel 1	float	r
0x0398	VoltageNominal channel 11	float	r
0x039C	CurrentNominal channel 11	float	r
Notes: rel. to BA: relative to Base Address			

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

5.4.3 Special Registers

Offset Bytes (rel. to BA)	Name	Data type	Access
0x03A0	NewBaseAddress	uint16	r/w
0x03A2	NewBaseAddressXor	uint16	r/w
0x03A4	OldBaseAddress	uint16	R
0x03A6	NewBaseAddressAccepted	uint16	R
0x03B0	SpecialControlStatus	uint16	R
0x03B2	SpecialControlCommand	uint16	r/w
Notes: rel. to BA: relative to Base Address			

5.5 Module registers

5.5.1 ModuleStatus

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0000	ModuleStatus	uint16	r
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Is Kill Enable	Is Temperature Good	Is Supply Good	Is Module Good	Is Event Active	Is Safety Loop Good	Is No Ramp	Is No Sum Error
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Is Command Complete	Is Special Mode	Is Input Error	Is Service Needed	Reserved	Is Stop	Is Interlock Output	Is Adjustment

Bit Name	Description
Is Kill Enable	Kill enable (1); Kill disable (0)
Is Temperature Good	Module temperature good
Is Supply Good	Power supply good
Is Module Good	Module in state good
Is Event Active	Any event is active and mask is set
Is Safety Loop Good	Safety loop closed
Is No Ramp	All channels stable, no ramp active
Is No Sum Error	Module without failure
Is Command Complete	All commands complete
Is Special Mode	Module is in Special Mode
Is Input Error	Input error in connection with a module access
Is Service Needed	Module shows that a factory service is needed
Is Stop	Modules is in state STOP, all high voltages are off
Is Interlock Output	Interlock Output is active
Is Adjustment	Activation of fine adjustment
Reserved	Reserved

The status bits as there are **Is Temperature Good**, **Is Supply Good**, **Is Module Good**, **Is Event Active**, **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.

5.5.2 ModuleControl

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

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Do Save Set Values	Set Kill Enable	Reserved	Set Adjustment	Reserved	IntLevel2	IntLevel1	IntLevel0
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Reserved	Do Clear	Reserved	Reserved	Set Action On	Set Stop	Do Recall Set Values	Set Special Mode

Bit Name	Description
Do Save Set Values	Do Save Set Values (1); no action (0)
Set Kill Enable	Kill enable Set Kill Enable(1); Kill disable Set Kill Enable(0)
Set Adjustment	Activation of fine adjustment
IntLevel[2..0]	Code for VME-Interrupt-Level (1 to 7); Level 0 means: no VME Interrupt
Do Clear	Clears Kill (hardware) signals and all event signals of module and channels
Set Action On	Set Action On(1) activate a time delayed switch ON of the high voltages after a recall of the stored values when **Channel Control Set ON**(1)
Set Stop	SetStop(1);
Do Recall Set Values	Do Recall Set Values(1); no action (0)
Set Special Mode	Set into Special Mode, for special tasks only **Attention:** Return from SpecialMode only with SpecialControlCommands e.g. EndSpecial
Reserved	Reserved

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

The signal **Set Kill Enable** 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.

Set Stop(1)	The high voltage of all channels will be decreased with the **Voltage Ramp** and switched OFF. The module firmware goes in the state **Is Stop**(1), **Module Status** when all channels are OFF.
doSaveSetValues(1)	when **set Stop**(1) only will start a task to store the set values permanently, listed in chapter 3.5 Autostart, when the module is in state **Is Stop**(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:

	V_{out} ≥ Voltage limit	Iout ≥ Current limit	Iout ≥ Iset
SetKillEnable=1 (ON)	Kill = 1; V_{out} ➜ 0; V_{set} = 0;	Kill = 1; V_{out} ➜ 0; V_{set} = 0;	V_{out} ➜ 0; V_{set} = 0
SetKillEnable=0 (OFF)	V_{out} = Voltage limit	I_{out} = Current limit	I_{out} = I_{set}

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

5.5.3 ModuleEventStatus

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0004	ModuleEventStatus	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Event Temperature Not Good	Event Supply Not Good	Reserved	Reserved	Event Safety Loop Not Good	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Reserved	Reserved	Event Input Error	Event Service Needed	Reserved	Reserved	Event Restart	Reserved

Bit Name	Description
Event Temperature Not Good	Temperature is above 55°C
Event Supply Not Good	at least one of the supplies is not good
Event Safety Loop Not Good	Safety loop is open
Event Input Error	Input error in connection with a module access
Event Service Needed	Module needs a factory service
Event Restart	Restart of HV after the **RestartTimerAfterRecallSetValues**
Reserved	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.

5.5.4 ModuleEventMask

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0006	ModuleEventMask	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Mask Event Temperature Not Good	Mask Event Supply Not Good	Reserved	Reserved	Mask Event Safety Loop Not Good	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Reserved	Reserved	Mask Event Input Error	Reserved	Reserved	Reserved	Mask Event Restart	Reserved

Bit Name	Description
Mask Event Temperature Not Good	Temperature is above 55°C
Mask Event Supply Not Good	at least one of the supplies is not good
Mask Event Safety Loop Not Good	Safety loop (SL) is open
Mask Event Input Error	Input error in connection with a module access
Mask Event Restart	Restart of HV after the **RestartTimeAfterRecallSetValues**
Reserved	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.

5.5.5 ModuleEventChannelStatus

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0008	ModuleEventChannelStatus	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CH11	CH10	CH09	CH08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00

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.

5.5.6 ModuleEventChannelMask

Offset Bytes (rel. to BA)	Name	Data type	Access
0x000A	ModuleEventChannelMask	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CH11	CH10	CH09	CH08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00

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.

5.5.7 ModuleEventGroupStatus

Offset Bytes (rel. to BA)	Name	Data type	Access
0x000C	ModuleEventGroupStatus	uint32	r/w
Notes: rel. to BA: relative to Base Address			

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
GROUP31	GROUP30	GROUP29	GROUP28	GROUP27	GROUP26	GROUP25	GROUP24
Bit23	**Bit22**	**Bit21**	**Bit20**	**Bit19**	**Bit18**	**Bit17**	**Bit16**
GROUP23	GROUP22	GROUP21	GROUP20	GROUP19	GROUP18	GROUP17	GROUP16
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit09**	**Bit08**
GROUP15	GROUP14	GROUP13	GROUP12	GROUP11	GROUP10	GROUP09	GROUP08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
GROUP07	GROUP06	GROUP05	GROUP04	GROUP03	GROUP02	GROUP01	GROUP00

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

5.5.8 ModuleEventGroupMask

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0010	ModuleEventGroupMask	uint32	r/w
Notes: rel. to BA: relative to Base Address			

Bit31	Bit30	Bit29	Bit28	Bit27	Bit26	Bit25	Bit24
GROUP31	GROUP30	GROUP29	GROUP28	GROUP27	GROUP26	GROUP25	GROUP24
Bit23	**Bit22**	**Bit21**	**Bit20**	**Bit19**	**Bit18**	**Bit17**	**Bit16**
GROUP23	GROUP22	GROUP21	GROUP20	GROUP19	GROUP18	GROUP17	GROUP16
Bit15	**Bit14**	**Bit13**	**Bit12**	**Bit11**	**Bit10**	**Bit09**	**Bit08**
GROUP15	GROUP14	GROUP13	GROUP12	GROUP11	GROUP10	GROUP09	GROUP08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
GROUP07	GROUP06	GROUP05	GROUP04	GROUP03	GROUP02	GROUP01	GROUP00

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.

5.5.9 VoltageRampSpeed

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0014	VoltageRampSpeed	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.5.10 CurrentRampSpeed (option)

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0018	CurrentRampSpeed (1	float	r/w
Notes: rel. to BA: relative to Base Address 1) not realized in VHS x0x			

5.5.11 VoltageMax

Offset Bytes (rel. to BA)	Name	Data type	Access
0x001C	VoltageMax	float	r
Notes: rel. to BA: relative to Base Address			

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**.

5.5.12 CurrentMax

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0020	CurrentMax	float	r
Notes: rel. to BA: relative to Base Address			

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**.

5.5.13 SupplyP5

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0024	SupplyP5	float	r
Notes: rel. to BA: relative to Base Address			

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

5.5.14 SupplyP12

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0028	SupplyP12	float	r
Notes: rel. to BA: relative to Base Address			

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

5.5.15 SupplyN12

Offset Bytes (rel. to BA)	Name	Data type	Access
0x002C	SupplyN12	float	r
Notes: rel. to BA: relative to Base Address			

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

5.5.16 Temperature

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0030	Temperature	float	r
Notes: rel. to BA: relative to Base Address			

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

5.5.17 SerialNumber

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0034	SerialNumber	uint32	r
Notes: rel. to BA: relative to Base Address			

The Serial number of the module as long integer value.

5.5.18 FirmwareRelease

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0038	FirmwareRelease	uint8[4]	r
Notes: rel. to BA: relative to Base Address			

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

5.5.19 PlacedChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x003C	PlacedChannels	uint16	r
Notes: rel. to BA: relative to Base Address			

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.

5.5.20 DeviceClass

Offset Bytes (rel. to BA)	Name	Data type	Access
0x003E	DeviceClass	uint16	r
Notes: rel. to BA: relative to Base Address			

This is a constant value to divide device families in iseg firmware and applications.

For VHS x0x this value is 20 (0x14).

5.5.21 RestartTimeAfterReloadSetValues

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0050	RestartTimeAfterRecallSetValues	uint16	r/w
Notes: rel. to BA: relative to Base Address			

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]

5.5.22 ADC SamplesPerSecond SPS

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0058	ADCSamplesPerSecond	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Adjusts the number of averages of the programmable ADC filter of the HV module. Possible values are 500, 100, 60, 50, 25, 10 and 5 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

5.5.23 DigitalFilter

Offset Bytes (rel. to BA)	Name	Data type	Access
0x005A	DigitalFilter	uint16	r/w
Notes: rel. to BA: relative to Base Address			

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.

Possible steps are: 1, 16, 64, 256, 512 and 1024

Factory settings: 64

5.5.24 VendorId

Offset Bytes (rel. to BA)	Name	Data type	Access
0x005C	VendorId	Uint8[4]	r
Notes: rel. to BA: relative to Base Address			

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

5.6 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).

5.6.1 ChannelStatus

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
0	ChannelStatus	uint16	R
Notes: rel. to ChAddr: relative to Channel Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Is Voltage Limit Exceeded	Is Current Limit Exceeded	Is Trip Set	Is Ext Inhibit	Is Voltage Bounds Exceeded	Is Current Bounds Exceeded	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Is Controlled Voltage	Is Controlled Current	Is Emergency	Is Ramping	Is On	Is Input Error	Reserved	Reserved

Bit Name	Description
Is Voltage Limit Exceeded	Hardware- voltage limit has been exceeded, when KillEnable=0
Is Current Limit Exceeded	Hardware- current limit has been exceeded, when KillEnable=0
Is Trip Set	Trip is set when Iset has been exceeded, when KillEnable=1
Is Ext Inhibit	External Inhibit
Is Voltage Bounds Exceeded	Voltage out of bounds
Is Current Bounds Exceeded	Current out of bounds
Is Controlled Voltage	Voltage control active
Is Controlled Current	Current control active
Is Emergency	Emergency off without ramp
Is Ramping	Ramp is running
Is On	On
Is Input Error	Input error
Reserved	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 V_{set}=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. V_{set} = 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 ($|V_{meas} - V_{set}| > V_{bounds}$) isVoltageBoundsExceeded =1;

if ($|I_{meas} - I_{set}| > I_{bounds}$) isCurrentBoundsExceeded =1;

5.6.2 ChannelControl

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
2	ChannelControl	uint16	r/w
Notes: rel. to ChAddr: relative to Channel Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	Set Asymmetric Voltage Bounds	Set Asymmetric Current Bounds	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Reserved	Reserved	Set Emergency	Reserved	Set On	Reserved	Reserved	Reserved

Bit Name	Description
Set Asymmetric Voltage Bounds	Set **setAVBND**, if 1 – set asymmetric voltage bounds, if 0 – set symmetric voltage bounds
Set Asymmetric Current Bounds	Set **setACBND**, if 1 – set asymmetric current bounds, if 0 – set symmetric current bounds
Set Emergency	Set "Emergency": shut off the channel without ramp, clear the V_{set} value
Set On	Set On if 1; Set Off if 0: ramp the output to V_{set} or to Zero
Reserved	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 Channel Control 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)	Description
VoltageIlkMaxSet ≤ VoltageMeasure ≤ VoltageIlkMaxSet	No event!
VoltageIlkMaxSet > VoltageMeasure or VoltageMeasure > VoltageIlkMaxSet	IsVoltageBoundsExceeded(1), ModuleStatusEventVoltageBounds(1), ModuleEventStatus
setAVBND(0)	
VoltageSet-VoltageBounds ≤ VoltageMeasure ≤ VoltageSet+VoltageBounds	No event!
VoltageSet-VoltageBounds > VoltageMeasure or VoltageMeasure > VoltageSet+VoltageBounds	IsVoltageBoundsExceeded(1), ModuleStatusEventVoltageBounds(1), ModuleEventStatus
setACBND(1)	
CurrentIlkMaxSet ≤ CurrentMeasure ≤ CurrentIlkMaxSet	No event!
CurrentIlkMaxSet > CurrentMeasure or CurrentMeasure > CurrentIlkMaxSet	IsCurrentBoundsExceeded(1), ModuleStatusEventCurrentBounds(1), ModuleEventStatus
setACBND(0)	
CurrentSet-CurrentBounds ≤ CurrentMeasure ≤ CurrentSet+CurrentBounds	No event!
CurrentSet-CurrentBounds > CurrentMeasure or CurrentMeasure > CurrentSet+CurrentBounds	IsCurrentBoundsExceeded(1), ModuleStatusEventCurrentBounds(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)	Description
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

5.6.3 ChannelEventStatus

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
4	ChannelEventStatus	uint16	r/w
Notes: rel. to ChAddr: relative to Channel Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Event Voltage Limit	Event Current Limit	Event Trip	Event Ext Inhibit	Event Voltage Bounds	Event Current Bounds	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Event Controlled Voltage	Event Controlled Current	Event Emergency	Event End Of Ramp	Event On To Off	Event Input Error	Reserved	Reserved

Bit Name	Description
Event Voltage Limit	Event: Hardware- voltage limit has been exceeded
Event Current Limit	Event: Hardware- current limit has been exceeded
Event Trip	Event: Trip is set when I_{set} has been exceeded (when KillEnable=1)
Event Ext Inhibit	Event external Inhibit
Event Voltage Bounds	Event: Voltage out of bounds
Event Current Bounds	Event: Current out of bounds
Event Controlled Voltage	Event: Voltage control
Event Controlled Current	Event: Current control
Event Emergency	Event: Emergency
Event End Of Ramp	Event: End of ramp
Event On To Off	Event: Change from state "On" to "Off" without ramp, see chapter 2.3.4 Function KillEnable
Event Input Error	Event: Input Error
Reserved	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.

5.6.4 ChannelEventMask

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
6	ChannelEventMask	uint16	r/w
Notes: rel. to ChAddr: relative to Channel Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Mask Event Voltage Limit	Mask Event Current Limit	Mask Event Trip	Mask Event Ext Inhibit	Mask Event Voltage Bounds	Mask Event Current Bounds	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Mask Event Controlled Voltage	Mask Event Controlled Current	Mask Event Emergency	Mask Event End Of Ramp	Mask Event On To Off	Mask Event Input Error	Reserved	Reserved

Bit Name	Description
Mask Event Voltage Limit	Hardware- voltage limit has been exceeded
Mask Event Current Limit	Hardware- current limit has been exceeded
Mask Event Trip	Voltage limit or Current limit or I_{set} has been exceeded (when KillEnable=1)
Mask Event Ext Inhibit	External Inhibit
Mask Event Voltage Bounds	Voltage out of bounds
Mask Event Current Bounds	Current out of bounds
Mask Event Controlled Voltage	Voltage control
Mask Event Controlled Current	Current control
Mask Event Emergency	Emergency off
Mask Event End Of Ramp	End of ramp
Mask Event On To Off	Change from state on to off without ramp
Mask Event Input Error	Input Error
Reserved	Reserved

5.6.5 VoltageSet

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
8	VoltageSet	V_{set}	float
Notes: rel. to ChAddr: relative to Channel Address			

The value of **VoltageSet** (V_{set}) 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**.

5.6.6 CurrentSet / CurrentTrip

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
12	CurrentSet / CurrentTrip	I_{set} / I_{trip}	float
Notes: rel. to ChAddr: relative to Channel Address			

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 = Current Nominal • Current Max

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** (I_{set}) is replaced by **CurrentTrip** (I_{trip}). When exceeding this value a current trip event is registered ad the voltage output is set to 0V.

5.6.7 VoltageMeasure

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
16	Voltage Measure	V_{meas}	float
Notes: rel. to ChAddr: relative to Channel Address			

VoltageMeasure (V_{meas}) is the actual measured value of voltage, in V.

5.6.8 CurrentMeasure

Offset Bytes (rel. to ChAddr)	Name	Data type	Access
20	CurrentMeasure	I_{meas}	float
Notes: rel. to ChAddr: relative to Channel Address			

CurrentMeasure (I_{meas}) is the actual measured value of current, in A.

5.6.9 VoltageBounds / VoltageIlkMaxSet

Offset Bytes (rel. to ChAddr)	Name		Data type	Access
24	VoltageBounds	V_{bounds}	float	r/w
24	VoltageIlkMaxSet	VIlkMaxSet	float	r/w
Notes: rel. to ChAddr: relative to Channel Address				

VoltageBounds

By the help of **VoltageBounds** (V_{bounds}) there is defined a region around **VoltageSet** (V_{set}), where the actual values are interpreted as good. This region is defined as follows:

$| V_{meas} – V_{set} | \leq V_{bounds}$

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 $\leq V_{meas} \leq$ VIlkMaxSet

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

5.6.10 CurrentBounds / CurrentIlkMaxSet

Offset Bytes (rel. to ChAddr)	Name		Data type	Access
28	CurrentBounds	Ibounds	float	r/w
28	CurrentIlkMaxSet	IIlkMaxSet	float	r/w
Notes: rel. to ChAddr: relative to Channel Address				

CurrentBounds

By the help of **CurrentBounds** (I_{bounds}) there is defined a region around **CurrentSet** (I_{set}), where the actual values are interpreted as good. This regions is defined as follows:

$$| I_{meas} – I_{set} | \leq I_{bounds}$$

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.

5.6.11 VoltageNominal / VoltageMaxSet

Offset Bytes (rel. to ChAddr)	Name		Data type	Access
32	VoltageNominal / VoltageMaxSet	V_{nom}	float	r/(w)
Notes: rel. to ChAddr: relative to Channel Address				

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).

5.6.12 CurrentNominal / CurrentMaxSet

Offset Bytes (rel. to ChAddr)	Name		Data type	Access
36	CurrentNominal / CurrentMaxSet	I_{nom}	float	r/(w)
Notes: rel. to ChAddr: relative to Channel Address				

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):

5.6.13 VoltageIlkMinSet

Offset Bytes (rel. to ChAddr)	Name		Data type	Access
40	VoltageIlkMinSet	VIlkMinSet	float	r/w
Notes: rel. to ChAddr: relative to Channel Address				

see 5.6.9 VoltageBounds / VoltageIlkMaxSet above.

5.6.14 CurrentIlkMinSet

Offset Bytes (rel. to ChAddr)	Name		Data type	Access
44	CurrentIlkMinSet	IIlkMinSet	float	r/w
Notes: rel. to ChAddr: relative to Channel Address				

see 5.6.10 CurrentBounds / CurrentIlkMaxSet above.

5.7 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!	
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, 3.4.1 Set Group
- Status group, 3.4.2 Status Group
- Monitoring group, 3.4.3 Monitor Group
- Timeout group, 3.4.4 Timeout Group

5.8 Fix Groups

The functions and characteristics of the groups are fix defined.

5.8.1 SetVoltageAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02A0	SetVoltageAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.8.2 SetCurrentAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02A4	SetCurrentAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.8.3 SetVoltageBoundsAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02A8	SetVoltageBoundsAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.8.4 SetCurrentBoundsAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02AC	SetCurrentBoundsAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.8.5 SetEmergencyAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02B0	SetEmergencyAllChannels	uint32	r/w
Notes: rel. to BA: relative to Base Address			

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

5.8.6 SetOnOffAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02B4	SetOnOffAllChannels	uint32	r/w
Notes: rel. to BA: relative to Base Address			

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

5.8.7 SetVoltageIlkMinSetAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02B8	SetVoltageIlkMinSetAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.8.8 SetCurrentIlkMinSetAllChannels

Offset Bytes (rel. to BA)	Name	Data type	Access
0x02BC	SetCurrentIlkMinSetAllChannels	float	r/w
Notes: rel. to BA: relative to Base Address			

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.

5.9 Variable Groups

5.9.1 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 Bytes (rel. to GrAddr)	Name	Data type	Access
0	MemberList	uint16	r/w
2	TypeSet	uint16	r/w
Notes: rel. to GrAddr: relative to Group Address			

MemberList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CH11	CH10	CH09	CH08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00

TypeSet

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
TYPE1	TYPE0	Reserved	Reserved	Reserved	Reserved	Reserved	MOD0
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
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 V_{set} from MCH to all members
0	0	1	0	SetIset	Copy I_{set} from MCH to all members
0	1	0	0	SetVbnds	Copy V_{bounds} from MCH to all members
0	1	0	1	SetIbnds	Copy I_{bounds} 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)

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

5.9.2 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 Bytes (rel. to GrAddr)	Name	Data type	Access
0	ChannelStatusList	uint16	r/w
2	TypeStatus	uint16	r/w
Notes: rel. to GrAddr: relative to Group Address			

ChannelStatusList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CHST11	CHST10	CHST09	CHST08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CHST07	CHST06	CHST05	CHST04	CHST03	CHST02	CHST01	CHST00

TypeStatus

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
TYPE1	TYPE0	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
STAT3	STAT2	STAT1	STAT0	Reserved	Reserved	Reserved	Reserved

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

5.9.3 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 Bytes (rel. to GrAddr)	Name	Data type	Access
0	MemberList	uint16	r/w
2	TypeMonitoring	uint16	r/w
Notes: rel. to GrAddr: relative to Group Address			

MemberList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CH11	CH10	CH09	CH08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00

TypeMonitoring

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
TYPE1	TYPE0	ACT1	ACT0	Reserved	Reserved	Reserved	MOD0
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
MON3	MON2	MON1	MON0	Reserved	Reserved	Reserved	Reserved

TYPE1	TYPE0	Value
1	0	MonitoringGroupType

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

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

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)

5.9.4 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 Bytes (rel. to GrAddr)	Name	Data type	Access
0	MemberList	uint16	r/w
2	TypeTimeOut	uint16	r/w
Notes: rel. to GrAddr: relative to Group Address			

MemberList

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
TYPE1	TYPE0	ACT1	ACT0	TOT11	TOT10	TOT09	TOT08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
TOT07	TOT06	TOT05	TOT04	TOT03	TOT02	TOT01	TOT00
Notes: TOT[11..0]: Binary coded Timeout-time in ms (0..4096ms)							

TYPE1	TYPE0	Value
1	1	TimeOutGroupType

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

6 Events and interrupts

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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:

- 5.5.3 ModuleEventStatus
- 5.6.3 ChannelEventStatus
- 5.5.7 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.

CAUTION!

CAUTION!

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.

6.1 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])

6.2 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])

6.3 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

6.4 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

7 Special registers

7.1 Setting of Basis Address

Offset Bytes (rel. to BA)	Name	Data type	Access
0x03A0	NewBaseAddress	uint16	r/w
0x03A2	NewBaseAddressXor	uint16	r/w
0x03A4	OldBaseAddress	uint16	r
0x03A6	NewBaseAddressAccepted	uint16	r
Notes: rel. to BA: relative to Base Address			

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.

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

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

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.

CAUTION!

CAUTION!

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.

7.2 Special Control Register

Offset Bytes (rel. to BA)	Name	Data type	Access
0x03B0	SpecialControlStatus	uint16	r
0x03B2	SpecialControlCommand	uint16	r/w
Notes: rel. to BA: relative to Base Address			

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

8 Options

8.1 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 1 General information) is not available in this option.

The Interlock Output signal can be generated when the control signal SetKilEenable of the ModuleControl register (see 5.5 Module registers) 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.	VoltageMeasure is equal or greater than the actual maximal Voltage (VoltageLimit) of the channel. This is shown by active bit "EVLIM" of the ChannelEventStatus register. The VoltageLimit is calculated by channel's VoltageNominal multiplied by VoltageMax of the front panel potentiometer.
2.	VoltageMeasure exceeds the VoltageBounds This is shown by active bit "EVBNDS" of the ChannelEventStatus register
3.	CurrentMeasure is equal or greater than the actual maximal Current (CurrentLimit) of the channel. This is shown by active bit "ECLIM" of the ChannelEventStatus register. The CurrentLimit is calculated by channel's CurrentNominal multiplied by CurrentMax of the front panel potentiometer.
4.	CurrentMeasure exceeds the CurrentBounds
5.	CurrentMeasure is equal or greater than CurrentSet - ModuleControl register setKILE=0 The channel will switch to current control; this is shown by active bit "ECC" in ChannelEventStatus register OR CurrentMeasure has been exceeded the CurrentSet - ModuleControl register setKILE=1 The channel has caught an event trip; this is shown by active bit "ETRP" in ChannelEventStatus register

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

8.2 Overview of the Interlock Output Registers

8.2.1 Special Registers

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0040	ModuleInterlockOutStatus	uint16	r
0x0042	ModuleInterlockOutControl	uint16	r/w
0x0044	ModuleInterlockCount	uint16	r
0x0046	ModuleInterlockLastTrigger	uint16	r
0x0048	ModuleInterlockChnActualActive	uint16	r
0x004a	ModuleInterlockChnEverTriggered	uint16	r
Notes: rel. to BA: relative to Base Address			

8.2.2 ModuleInterlockOutStatus

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0040	ModuleInterlockOutStatus	uint16	r
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Is Interlock Enabled	Is Interlock Active	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Reserved	Reserved	Reserved	Reserved	Is Interlock Test Loops 3	Is Interlock Test Loops 2	Is Interlock Test Loops 1	Is Interlock Test Loops 0

Bit Name	Description
Is Interlock Enabled	Interlock Output enabled (1) or disabled (0)
Is Interlock Active	Interlock Output signal active (any condition is true)
Is Interlock StandBy	Interlock Output signal active because of PowerOn reset and channels are not handled yet
Is Interlock Test Loops[0;1;2;3]	Counter for Stretching of the Interlock Test Pulse
Reserved	reserved

8.2.3 ModuleInterlockOutControl

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0042	ModuleInterlockOutCommand	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Set Interlock Enable	Clear Interlock Registers	Reserved	Reserved	Reserved	Reserved	Reserved	Set Interlock Current Bounds
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Set Interlock Vlimit	Set Interlock Voltage Bounds	Set Interlock Climit	Set Interlock Iset	Do Interlock Test Loops 3	Do Interlock Test Loops 2	Do Interlock Test Loops 1	Do Interlock Test Loops 0

Bit Name	Description
Set Interlock Enable	enable (1) or disable (0) Interlock Output
Clear Interlock Registers	clear Interlock Out part registers
Set Interlock Current Bounds	simulate Interlock Out triggered by Current Bounds
Set Interlock Vlimit	simulate Interlock Out triggered by Vlimit
Set Interlock Voltage Bounds	simulate Interlock Out triggered by Voltage Bounds
Set Interlock Climit	simulate Interlock Out triggered by Climit
Set Interlock Iset	simulate Interlock Out triggered by Iset
Do Interlock Test Loops [0;1;2;3]	simulate an Interlock Out pulse of n * 40ms length; n= 1..15; n=0 => no test pulse
Reserved	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 8.1 Interlock Output) 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.

8.2.4 ModuleInterlockCount

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0044	ModuleInterlockCount	uint16	r
Notes: rel. to BA: relative to Base Address			

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).

8.2.5 ModuleInterlockLastTrigger

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0046	ModuleInterlockLastTrigger	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	Interlock Channel 3	Interlock Channel 2	Interlock Channel 1	Interlock Channel 0
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
Interlock Vlimit	Interlock Voltage Bounds	Interlock Climit	Interlock Iset	Interlock Current Bounds	Reserved	Reserved	Interlock Test

Bit Name	Description
Interlock Channel [0;1;2;3]	number of the channel that initiated last trigger; for testing: IlkChn = 15
Interlock Vlimit	Interlock Out triggered by Vlimit
Interlock Voltage Bounds	Interlock Out triggered by Voltage Bounds
Interlock Climit	Interlock Out triggered by Climit
Interlock Iset	Interlock Out triggered by Iset
Interlock Current Bounds	Interlock Out triggered by Current Bounds
Interlock Test	Last Interlock signal was simulated
Reserved	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.

8.2.6 ModuleInterlockChnActualActive

Offset Bytes (rel. to BA)	Name	Data type	Access
0x0048	ModuleInterlockChnActualActive	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CH11	CH10	CH09	CH08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00

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.

8.2.7 ModuleInterlockChnEverTriggered

Offset Bytes (rel. to BA)	Name	Data type	Access
0x004A	ModuleInterlockChnEverTriggered	uint16	r/w
Notes: rel. to BA: relative to Base Address			

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit09	Bit08
Reserved	Reserved	Reserved	Reserved	CH11	CH10	CH09	CH08
Bit07	**Bit06**	**Bit05**	**Bit04**	**Bit03**	**Bit02**	**Bit01**	**Bit00**
CH07	CH06	CH05	CH04	CH03	CH02	CH01	CH00

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

9 Appendix

BCD	binary coded decimal format
CHm	channel m=0 … 15
CH	channel
DATA_ID	data identifier of DCP
fN	first filter notch frequency
HV	High voltage
HW	hardware
Imeas	Actual current
Imax	Hardware current limit
IO max	Nominal current
Iset	Set current
Itrip	Trip current
ISO	International Standard Organization
LSB	least significant bit
MBR	channel members
MSB	most significant bit
NBR	group number
NMT	network management service
OSI	Open System Interconnect
PCB	printed circuit board
p/a	passive / active
SN.	serial number
Vmeas	Actual voltage
Vmax	Hardware voltage limit
VO max	Nominal voltage
Vset	Set voltage
SW	software
BA	Base Address
ChAddr	Channel Address
GrAddr	Group Address

Glossary

SHORTCUT	MEANING
V_{nom}	nominal output voltage
V_{out}	output voltage
V_{set}	set value of output voltage
V_{mon}	monitor voltage of output voltage
V_{meas}	digital measured value of output voltage
V_{p-p}	peak to peak ripple voltage
V_{in}	input / supply voltage
V_{type}	type of output voltage (AC, DC)
V_{ref}	internal reference voltage
V_{max}	limit (max.) value of output voltage
ΔV_{out} – [ΔV_{in}]	deviation of V_{out} depending on variation of supply voltage
ΔV_{out} – [ΔR_{load}]	deviation of V_{out} depending on variation of output load
V_{bounds}	voltage bounds, a tolerance tube $V_{set} \pm V_{bounds}$ around V_{set}
I_{nom}	nominal output current
I_{out}	output current
I_{set}	set value of output current
I_{mon}	monitor voltage of output current
I_{meas}	digital measured value of current
I_{trip}	current limit to shut down the output voltage
I_{in}	input / supply current
I_{max}	limit (max.) value of output current
I_{limit}	current limit
I_{bounds}	current bounds, a tolerance tube $I_{set} \pm I_{bounds}$ around I_{set}
P_{nom}	nominal output power
P_{in}	input power
P_{in_nom}	nominal input power
T	temperature
T_{REF}	reference temperature
ON	HV ON
OFF	HV OFF
CH	channel(s)
HV	high voltage
LV	low voltage
GND	signal ground
INH	Inhibit
POL	Polarity
KILL	KillEnable

10 Appendix

This document
https://iseg-hv.com/download/SYSTEMS/VME/VHS/VHS_interface_options.pdf

11 Manufacturer contact

iseg Spezialelektronik GmbH

Bautzner Landstr. 23

01454 Radeberg / OT Rossendorf

GERMANY

FON: +49 351 26996-0 | FAX: +49 351 26996-21

www.iseg-hv.com | info@iseg-hv.de | sales@iseg-hv.de