Interface Manual

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. Please read the interface manual carefully before using the product.

Note

The information in this manual is subject to change without notice. We take no responsibility whatsoever for any error in the document. We reserve the right to make changes in the product design without reservation and without notification to the users.

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1 Operation principals

1.1 Remote interface control

The Multi-Channel HV modules are controlled via a remote interface. The communication between an application and the module is performed by the transmission of data items. A data item is a unit 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 event's
- 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

1.2 Operation modes

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

1.2.1 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 (Iset) or current trip (Itrip) is greater than the resulting output current.

1.2.2 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 current set value Iset is smaller than the current that would result from set voltage and the load at the HV output.

1.2.3 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 Itrip 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.

1.3 Function KillEnable

KillEnable is a global control signal that defines the behaviour of the module if a given voltage (Vmax) or current limit (Imax/Iset/Itrip) 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 Imax/Iset or Itrip is exceeded the following will happen:

HV hardware with current control - switch the channel from voltage control into 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.

2 Control and Status items

2.1 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 (**ModuleControl**) 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).

2.2 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

2.3 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.

If an event bit in the EventStatus is active and the corresponding bit in the EventMask is set, it is not possible to ramp up the voltage or to activate the HV generation if it has been switched off. To unblock this the EventStatus bits must be reset 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
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(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 (monitor group, timeout group, see chapter 3) 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 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:

3.1 Set Group

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

3.2 Status Group

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

3.3 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 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)

3.5 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

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4 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 ModuleControl, ModuleStatus and ModuleEventStatus. The detailed explanation is given in chapter 4.2.1. Module registers, ModuleStatus, ModuleControl, ModuleEventStatus and RestartTimeAfterRecallSetValues.