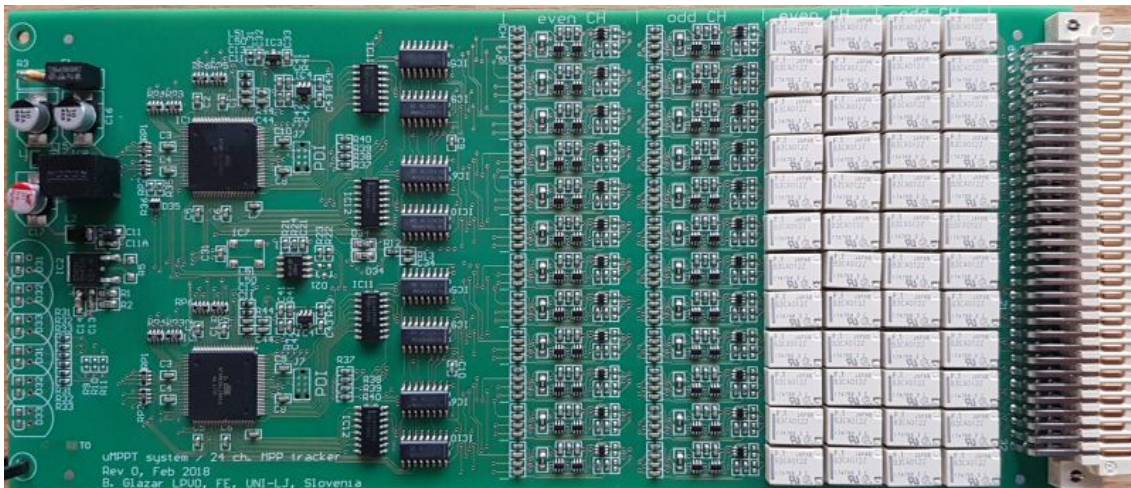




Maximum Power Point Trackers

MP0205M6 and MP0205M24



(in the picture: MP0205M24, not to scale)

User's manual

August 2020

Introduction

The unit is designed for multiple laboratory PV cell monitoring. It tracks maximum power of the cells or maintains a cell at a preset voltage. Energy from the cells is converted to heat. Bypass switches are provided to connect an input directly to bypass output. Four wire connection of the module reduces measurement and tracking errors.

Specifications in this manual are subject to change without prior notice. Values that will be defined in the future are marked as *TBD* – To Be Determined.

Electrostatic precautions

The units can be provided as an evaluation board or board without an enclosure. Although external connections are protected against electrostatic discharge, user should be aware that internal connections are more sensitive to electrostatic discharges. Therefore avoid touching internal circuitry and try to first touch the ground. It is recommended to discharge your static charge to an earthed metallic object.

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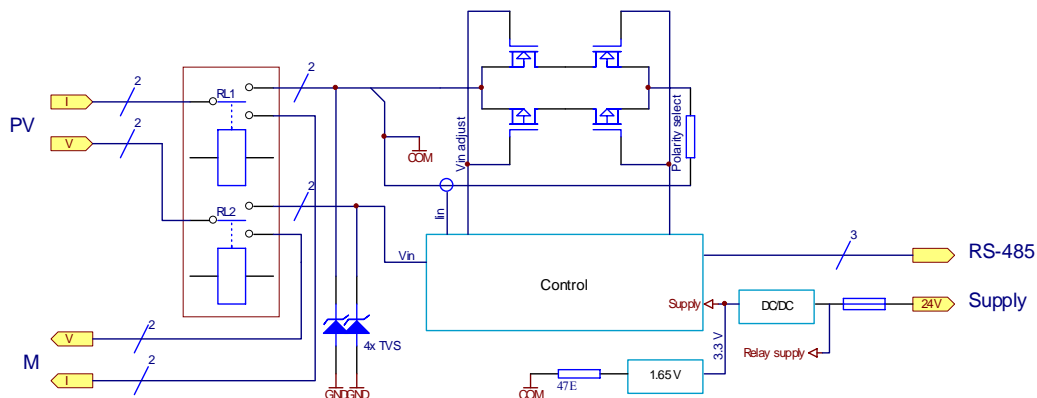
Description

MP0205M6 and MP0205M24 share common design with the biggest differences in form-factor and communication interface. MP0205M6 is a stand-alone 6 channel demo board whereas MP0205M24 is a 24 channel unit designed to be plugged into a 19" rack enclosure. The trackers can be controlled over RS-485 communication bus and in the case of MP0205M6 also over USB.

Block diagram of the internal circuit is shown below. Two two-pole relays per channel are used to connect the PV input to the circuit or to the bypass output. The later can be used for a common I-V curve measurement unit. Normal state is connection to the circuit. When the relays are activated the PV input has no connection with the internal circuitry. Both polarities of input voltage are supported.

Each input channel uses 4 MOSFETs to control load to the cell. Two MOSFETs select input polarity whereas the other two are used as source followers to load the cell. For correct operation proper input polarity should be selected. At wrong polarity input is presented with MOSFET body diode and some series resistance. The circuit is able to operate in between open-circuit and short-circuit without any additional components. Note that the MPPT can only sink power. The negative input is not connected to system ground, but to a potential of nominally 1.65 V to simplify the circuitry.

The trackers can be powered from external voltage and in the case of MP0205M6 also from the USB. In any case, suitable external voltage is required to supply the relays.



Block diagram of MPPT tracker
Control and supply parts are common to multiple channels.

Modes of operation

Mode of operation is changed over RS-485 or USB bus.

Open circuit (OC)

MOSFETs of the channel are closed. The cell is in open circuit.

Maximum Power Point Tracking (MPPT)

MOSFET gate voltage is adjusted so that product of input current and voltage is maximised.

Short Circuit (SC)

MOSFETs of the channel are opened and provide some minimal input resistance.

Constant Voltage (VCST)

MOSFET gate voltage is adjusted so that the voltage is maintained at a specified value. If the target value cannot be maintained, it will equal voltage in SC or OC modes.

Bypass (BYP)

Relay is activated to connect the input directly to measurement output. Readings of input current and voltage are not valid in this mode (current should read zero). Keeping current through measurement terminals low before this mode is exited is advised in order to prolong life of the relay.

MPP tracking algorithm

Maximum power point tracking is performed in firmware of the built-in microcontroller which is upgradeable.

Currently the firmware uses Perturb and Observe (P&O) algorithm. On regular intervals (0.2 s by default) the firmware calculates input power and compares to the power at previous interval. If power increases or stays equal, the voltage on gate of the load transistor is changed in the same direction as before. When a decrease in power is detected the voltage changes direction. Default gate voltage step is currently about 6 mV, which results in voltage slew rate of 32 mV/s. The same or lower step will also be present at input terminals. Gate voltage is further limited to stay below open circuit voltage and such that input current is higher than zero.

If mode is changed from MPPT to BYPass, the gate voltage is stored and used as a starting point when mode change back is made. In other cases tracking starts at the current point.

Constant voltage mode algorithm

The firmware implements a type of integrating regulator to keep input voltage at a specified value. If target voltage cannot be maintained, the operation will equal Open Circuit or Short Circuit modes.

Connections on MP0205M24 (plug-in board)

The 24 channel tracker is designed for plugging into a 3U 19" rack. All of the connections go through the back DIN 41612 connector. PV cells are connected to the back of the backplane using an adapter board or directly using a 160-pole connector. Other connections are normally made on another slot of the backplane.

Central row (b) plus the two ground pins are connected to other slots on the backplane. Other four rows (z, a, c and d) with exception of the two GND connections go through the backplane to DUT interface without any connection on the backplane. The outer two rows are reserved for even numbered channels allowing use of three row connection for half of the channels.

Pinout – looking into the front of the backplane. Connections in the parenthesis are not connected in the current version and might change functionality in future revisions.

	z	a	b	c	d
1			GND		
2			GND		
3	CH2_I+	CH1_I+	(Vout)	CH1_V+	CH2_V+
4	CH2_I-	CH1_I-	(Vout)	CH1_V-	CH2_V-
5	CH4_I+	CH3_I+	VR+	CH3_V+	CH4_V+
6	CH4_I-	CH3_I-	GND	CH3_V-	CH4_V-
7	CH6_I+	CH5_I+	(VCC)	CH5_V+	CH6_V+
8	CH6_I-	CH5_I-	GND	CH5_V-	CH6_V-
9	CH8_I+	CH7_I+		CH7_V+	CH8_V+
10	CH8_I-	CH7_I-		CH7_V-	CH8_V-
11	CH10_I+	CH9_I+	M_V+	CH9_V+	CH10_V+
12	CH10_I-	CH9_I-	M_I+	CH9_V-	CH10_V-
13	CH12_I+	CH11_I+	M_I-	CH11_V+	CH12_V+
14	CH12_I-	CH11_I-	M_V-	CH11_V-	CH12_V-
15		VCC	(RS485V)	COM1	COM2
16		SDA1	RS485B	(OC1)	OC3
17		SCL1	RS485A	(OC2)	(OC4)
18		GND	RS485G		
19	CH14_I+	CH13_I+		CH13_V+	CH14_V+
20	CH14_I-	CH13_I-		CH13_V-	CH14_V-
21	CH16_I+	CH15_I+		CH15_V+	CH16_V+
22	CH16_I-	CH15_I-		CH15_V-	CH16_V-
23	CH18_I+	CH17_I+	GND	CH17_V+	CH18_V+
24	CH18_I-	CH17_I-	GA0	CH17_V-	CH18_V-
25	CH20_I+	CH19_I+	GA1	CH19_V+	CH20_V+
26	CH20_I-	CH19_I-	GA2	CH19_V-	CH20_V-
27	CH22_I+	CH21_I+	GA3	CH21_V+	CH22_V+
28	CH22_I-	CH21_I-	GA4	CH21_V-	CH22_V-
29	CH24_I+	CH23_I+	GAP	CH23_V+	CH24_V+
30	CH24_I-	CH23_I-	CA0	CH23_V-	CH24_V-
31			CA1		
32	GND		GND		GND

CHn

Inputs (24 times) to the tracker. “I” denotes current terminals and “V” denotes voltage terminals. Voltage terminals must be connected for channels used. I– is connected to COM when the input is not bypassed. Therefore all I– terminals of non-bypassed channels of the same half are connected together. For maximum current measurement accuracy avoid current flow between channels, i.e. it is preferable I– and I+ currents of a channel to be oppositely equal.

COM and GND

COM is virtual ground for the circuit and not equal to GND! GND is ground. The difference is nominally 1.65 V. COM1 is virtual ground for the first 12 channels (top), whereas COM2 is virtual ground for the second 12 channels (bottom). Both COM terminals can be connected together if desired.

VR+

Positive terminal of the power supply input. The input is common to multiple cards.

M_V+, M_I+, M_I–, M_V–,

Bypass (measurement) output. This is connected directly to input terminals by a relay in bypass mode. The link is galvanically isolated from the rest of the circuit. The output is common to multiple cards.

RS-485

RS-485 communication bus. G is ground and equals GND. V is reserved for supply and is not connected in the current version. All devices on one RS-485 bus should be daisy-chained and terminating resistors should be connected between A and B on each end. Pull-up and -down resistors are recommended at the master.

GAn, GAP

Geographical addressing. These are open-collector inputs, active low. Connection to GND means the active state. GAP is odd parity. The pins define the slot number as per VME standard, i.e. GA0 is pulled low for the first slot, Slot 1.

CAn

Crate addressing. Similar as GA, without parity. Two pins provide four combinations, allowing use of up to four crates on an RS-485 bus.

GA and CA are used to determine address on the RS-485 bus.

OCn

Open collector output, suitable to drive 24 V relays.

VCC, SDA1, SCL1, GND

SDA and SCL are digital I/O pins with 3.3 V CMOS levels and pull-up resistors. In the current version they have I2C and PWM capability. Supply and ground is also provided.

The board can be hot-plugged into a backplane with 5-row connectors. Communication on the RS-485 bus might be hindered during insertion or extraction. In any other case hot-plugging is not permitted (GND must make contact before VR+).

Connections on MP0205M6 (demo board)

All the connections to the tracker are accomplished with pluggable screw terminals, Sauro CTF series is used with a pitch of 3.5 mm. They support wire of up to 1.5 mm² solid or 1.0 mm² stranded. Many other manufacturers provide compatible connectors.

Top – signal side

PV (J1)

Inputs (six times) to the tracker. “I” denotes current terminals and “V” denotes voltage terminals. Voltage terminals must be connected for channels used. I– is connected to COM when the input is not bypassed. Therefore all I– terminals of non-bypassed channels are connected together. For maximum current measurement accuracy avoid current flow between channels, i.e. it is preferable I– and I+ currents to be oppositely equal.

BYPASS OUT (J3)

Bypass (measurement) output. This is connected directly to input terminals by a relay in bypass mode. The link is galvanically isolated from the rest of the circuit.

COM and GND (J4)

COM is virtual ground for the circuit and not equal to GND! GND is ground. The difference is nominally 1.65 V.

AUX (J5)

VCC is 3.3 V supply. SDA currently serves as data line for 1-wire sensors. SCL is auxiliary digital pin for future use

Bottom – control side

This terminal is used for control supply to the tracker, communication and open drain output for fan control. Multiple trackers are normally connected in parallel with this terminal. GND connections are the same as for the connector on bottom right.

EXT PWR (J2)

Supply for the tracker, required to operate relays with coil voltage higher than 5 V. Voltage shall equal supply voltage for relays. Negative terminal is connected to GND.

RS-485 (J1)

RS-485 communication bus. G is ground and equals GND. All devices on one RS-485 bus should be daisy-chained and terminating resistors should be connected between A and B on each end. Pull-up and -down resistors are recommended at the master.

NC

This pin has no connection.

USB (J6)

USB-B upstream connector. USB can also be used to power the MPPT. The GND equals system ground.

Jumpers

JP1 (POWER)

Selects power source for the control circuit.

1-2 (EXT) EXT PWR connector

2-3 (USB) USB connector

DO NOT connect all three pins together to avoid possible damage to USB host.

JP2 (RLY PWR)

Selects power source for relay coils.

1-2 (EXT) EXT PWR connector. This connection is permanent when the built-in relays require more than 5 V.

2-3 (INT) Same as control circuit (defined by JP1)

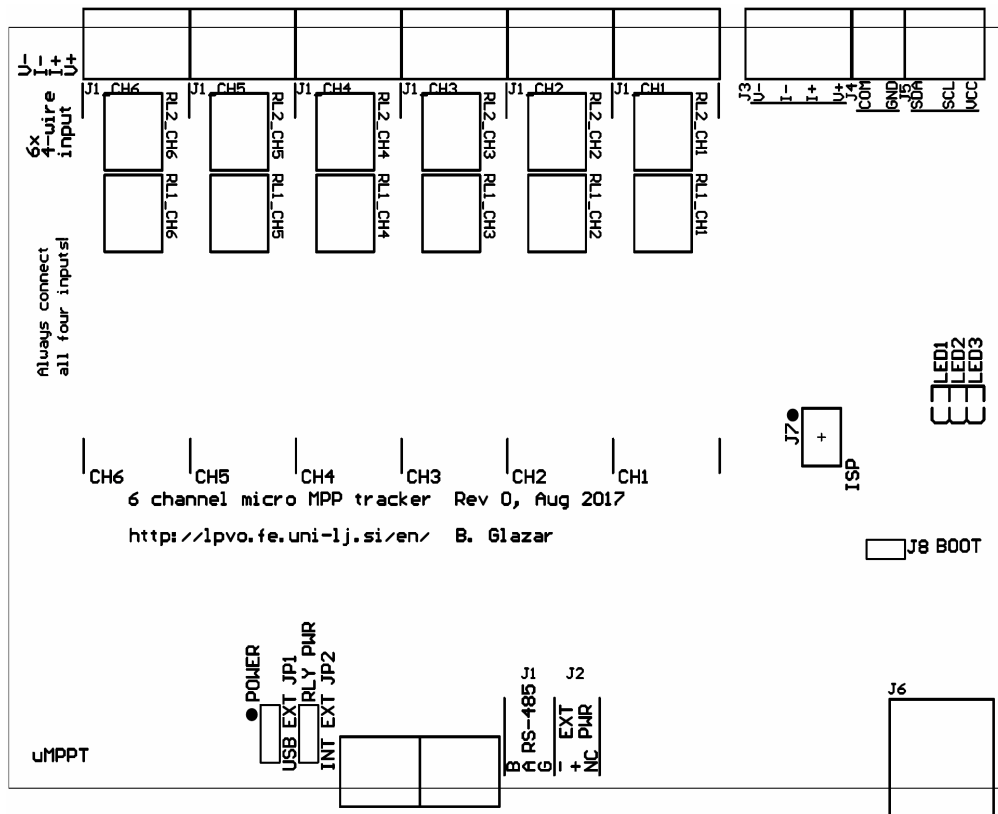
DO NOT connect all three pins together to avoid possible damage to USB host. It is recommended to leave the jumper open when the MPPT is supplied with higher voltage than nominal voltage for relays in order to protect them.

J7 (ISP)

PDI programming interface. Pins 5 and 6 can be used as a reset input. Pins 3 and 4 are not connected and can be used for a spare jumper.

J8 (BOOT)

Enables (DFU) boot-loader after reset. Shorting this during operation will prevent correct voltage measurement on even-numbered channels.



Layout of the demo board displaying connectors, jumpers and relays. (M: 1:1)

Local user interface

Local user interface is the same for both types of trackers. The current 24-channel version has two triples of the LEDs, each for one half of the channels.

LEDs

LED1 (red)	Indicates an abnormal state either: <ul style="list-style-type: none">• Glows when an over-range current was detected. In that case the result is incorrect even if does not seem saturated.• Glows when supply voltage is too low to switch the relays reliably and bypass mode was selected. (At current hardware revision only applicable to plug-in board and currently for the first MCU only.)• Glows when VCOM deviates too much (20 %). See command list for implementation limits.• Glows when bootloader is running (plug-in board only).
LED2 (orange)	Indicates power supply and input current presence: <ul style="list-style-type: none">• Blinking: Currents in all channels are below threshold.• Steady light: Current is flowing.
LED3 (green)	Indicates that at least one channel is bypassed (a relay activated). Note that the LED only indicates active signal for a relay. Adequate supply voltage must also be present to activate the relay.

All the LEDs are fully firmware controlled and therefore programmable for future revisions.

Remote commands

Both interfaces (USB and RS-485) use common command set. The tracker understands all command sent through USB as addressed, whereas RS-485 distinguishes between addressed and broadcast modes. Both interfaces are active at the same time. Response is sent to the interface where the last command was received on. Commands should not be sent to both interfaces at the same moment.

Only one command is allowed in a packet except for *OPC? command. Maximum length of user data in a packet is currently 248 bytes. If the command is not a query, nothing is returned.

Commands for selected channel

These commands act only on one channel. Number (n) appended to the command selects channel. If no number is appended, channel 1 is used. Channels are numbered 1 through 6/24.

MODE[<n>] {OC | MPPT | SC| VCST | BYP | DISC | LNBP}

MODE[<n>]?

Sets or reads mode of operation of the currently selected channel. These modes are possible:

- Open Circuit – The tracker does not take current from the PV input
- Maximum Power Point Tracking – The tracker loads PV input to maximum available power.
- Short Circuit – Input will be shorted.
- ConStanT Voltage – The tracker maintains voltage preset by command MODE:VCST.
- BYPass – PV input will be connected to BYPASS output and disconnected from the tracker by a relay. Input voltage and current measurement are not valid in this mode.
- DISConnected – This is translated to OC for compatibility. This value is never returned on query.
- Last-Not-ByPass – Changes the mode to the last mode prior to BYPass mode. This value is never returned on query. Only this value is accepted on broadcast address.

Default value is OC.

POL[<n>] {POS | NEG | AUTO}

POL[<n>]?

Sets or reads preset polarity of input connection. In AUTOMATIC mode the polarity is selected base on polarity of input voltage and current. In case of low values, polarity selection should be manual. Polarity selection does not affect bypass output. Default value is POS.

POLA?

Read currently active input polarity. The result is either POS or NEG. The polarity affects input stage and all the results. Correct polarity is essential for proper tracking and input voltage regulation.

MPPT[<n>]:

Command in this subsystem set or read parameters of MPPT tracker.

MPPT[<n>]:VCST <voltage>

MPPT[<n>]:VCST?

Sets or reads voltage in volts for constant voltage mode. Valid range is –2.04 to +2.04 V.

Default value is 0.

MPPT:PER <period> (*)**

MPPT:PER? (*)**

Sets or reads period for MPP tracking in seconds. The same period is applied to all channels. If a channel number is supplied it will be applied to all channels on the MCU (as with current firmware). Granularity is currently 0.2 s.

Default value is 0.2.

MPPT[<n>]:STEP <step_size> (*)**

MPPT[<n>]:STEP? (*)**

Sets or reads voltage step size for MPP tracking in volts. The same step is applied to all channels. If a channel number is supplied it will be applied to all channels on the MCU (as with current firmware). The value will be cropped to range 4 – 806 mV.

Default value is 0.006.

MPPT[<n>]:THOC <threshold> ()**

MPPT[<n>]:THOC? ()**

MPPT[<n>]:THSC <threshold> ()**

MPPT[<n>]:THSC? ()**

VIN[<n>]?

Returns input voltage in volts in engineering notation. The result is corrected for polarity, nominally returning only positive values. In BYPass mode the reading is not valid.

IIN[<n>]?

Returns input current in amperes in engineering notation. The result is corrected for polarity, nominally returning only positive values. In BYPass mode should read zero.

FETC[<n>][:{VIN | IIN}]?

Returns buffered value for a measurement. When no variable is given, both are returned, separated by comma. The values are buffered when *TRG is received.

DUTY[<n>]?

Returns duty cycle of the MOSFET controller.

Commands for whole tracker

These commands act on whole tracker and do not feature channel selection.

VCOM? (*)**

Returns voltage in volts on common terminal, that is I– for all channels on the MCU. Add a channel number to select other MCU. It is nominally 1.65 V. Large deviation will degrade input stage voltage span.

VR? (*)**

Return supply voltage in volts. In current hardware revision only plug-in board supports this query.

ONEW:ENUM? (*)**

Searches for 1-wire devices and returns number of devices detected. Sensors IDs will be stored in non-volatile memory. Temperature measurement on all sensors will be triggered after execution of this command and on start-up. The measurement will be repeated every 10 seconds.

ONEW:IDS? (*)**

Returns comma separated list of IDs of devices detected by :ENUM? command. IDs are sent in hexadecimal form.

ONEW:MEAS? (*)**

Reads temperatures from the enumerated 1-wire sensors and returns them in comma separated list in degrees Celsius in engineering notation. The results are listed in the same order as IDs from :IDS? command. If reading from a sensor fails a negative out-of-range temperature will be reported instead.

ONEW:MRH? (*)**

Reads humidity from the enumerated 1-wire sensors and returns them in comma separated list in percents of relative humidity in engineering notation. The results are listed in the same order as IDs. A negative out-of-range value will be returned for sensors that do not support humidity.

TEMP? (*)

Returns internal temperature of the microcontroller in degrees Celsius in engineering notation.

***IDN?**

Return product identification string. The string includes last compile date.

***CLS**

Clears error queue.

CAL:IINZ {RUN | CLR | SAV | RCL} (*)**

CAL:IINZ? Returns RDY | RUN

Calibrates current measurement offset for demo board, as it does not feature auto-offset cancellation. Calibration is performed on all channels at the same time. To calibrate no current should flow through the input channels. Ideally this is achieved by disconnecting all inputs. Calibration should be performed after warm-up period, preferably in the measurement setup (the same temperature). RUN will start calibration. During the calibration returned values for current might be wrong. Calibration runs long enough to reduce noise below output quantisation value using integration. In the current version this is 26 seconds. During the calibration RUN will be returned on query, afterwards RDY will be returned. Once calibration finishes the calibrated value will be used for the results but not automatically saved to non-volatile memory. SAV saves the calibration values to non-volatile memory, whereas RCL recalls the old values and CLR clears the calibration in volatile memory to zero for testing purposes. On start-up the values from non-volatile memory are used.

ADR <address> ()**

***ADR?**

Sets or reads RS-485 device address. Address set will be stored to non-volatile memory and effective immediately. Address must be given and is returned in decimal notation. Default value is 82.

Device address can only be set for the standalone version. Address for the plug-in board will be calculated according to the slot and crate number as:

$RS485_addr = 21 * \langle crate_num \rangle + \langle slot_num \rangle$

Crates are numbered 0 – 3, whereas slots are numbered 1 – 21. If slot number parity is wrong (e.g. when adapter board is connected directly to the tracker card, without the backplane), the default address will be used.

***OPC? (*)**

Returns “1” when after the command is executed. This command can be in the same string after another non-query command. In that case “1” will be returned after the command is executed. Both commands must be separated with a semicolon (;) and a space (e.g. MODE BYP; *OPC?).

When bypass relay is switched, “1” will be returned after the switching phase is over.

***TRG**

Triggers measurement of temperature and stores results for VIN and IIN to buffers to be read by FETC? command. The *TRG command is also accepted on broadcast address.

SYST:ERR?

Retrieve an error from a first-in-first-out (FIFO) queue. If more than 19 errors have occurred, the last error stored in the queue is replaced with -350, “Too many errors”. If no errors have occurred, the tracker responds with +0, “No errors”. Error queue is cleared on power on and after *CLS command.

CAL:TEMP <temp> (*)

Calibrates internal temperature sensor to read given value (degrees Celsius) at current temperature. This should be performed at room temperature.

Commands accepted for compatibility

These commands are implemented only to allow use of the tracker with existing software designed for our other trackers and avoid generation of errors.

BIAS:EN {*any string*}

BIAS:EN?

Returns "OFF".

IB?

Returns zero.

VOUT?

Returns zero.

ONEW:ENSU?

Returns zero.

(*) These commands are not (fully) implemented yet.

(**) These commands are not implemented yet and their formatting is not confirmed.

(***) These commands have different support across different hardware and firmware versions. See table below. This note can be removed when old firmware versions become outdated.

Version support

Minimum hardware and/or software version for specific functionality. Consult this table for commands marked with (***).

Command	MP0205M6	MP0205M24
MPPT:PER	FW 0.9.0	FW 0.9.1
MPPT:STEP		
VCOM?	not yet	FW 0.9.0
VR?	no support in hardware Rev 0	FW 0.9.0
ONEW:*	FW 0.9.1	FW 1.0.2
	no enumeration at start-up	
ONEW:MRH?	FW 0.9.4	not yet
CAL:IINZ	FW 0.9.5	not applicable
*ADR(?)	FW 0.9.5	not applicable

Error codes:

- 0 No error**
Error queue is empty.
- 100 Command error**
Command was not recognized by the tracker.
- 109 Missing parameter**
Fewer parameters were received than required for the header.
- 113 Undefined header**
A command was received that is not valid for the tracker. Check spelling.
- 200 Execution error**
Command cannot be executed. Check that an existing channel is selected.
- 222 Invalid range**
Out of range parameter was received.
- 224 Illegal parameter value**
A discrete parameter was received which was not a valid choice for the command. You may have used an invalid parameter choice.
- 315 Configuration memory lost**
Invalid parameters were read from the EEPROM on start-up. This error will also be generated when not all the required settings are configured.
- 330 Self-test failed**
The tracker experienced an internal failure.
- 340 Calibration failed**
- 350 Queue overflow**
The queue is full because more than 19 errors occurred.
- 370 Input overvoltage**
Input over-voltage was detected.

RS-485 protocol

Protocol on top of RS-485 interface is a multi-drop master-slave protocol. Data is transferred in addressed packets. Address of master must be 0. The tracker will respond to requests and cannot be programmed to continuously send data.

Data rate is 125 kb/s with standard serial formatting, i.e. 8N1.

If more than 1 tracker (or other device) is used in a system, unique address must be set to each of them before they are connected to the same bus.

Byte	Meaning	Description
0	STX	Start delimiter (0x55)
1	destination	Destination address
2	source	Source address
3	length	Length of payload – n
4...n+3	data	Payload, max 240 bytes
n+4	CRC MSB	CRC-16-IBM checksum polynomial: 0x8005
n+5	CRC LSB	
n+6	ETX	End delimiter (0xAA)

Packet example

A packet with identification command sent to address 82 (default) is given below.

0x55 0x52 0x00 0x05 0x2A 0x49 0x44 0x4E 0x3F 0x8F 0xBE 0xAA

USB protocol

The tracker acts as a Communications Device Class and enumerates as a serial port. Serial parameters are not important, however a suggestion is 115,200 kb/s 8N1. Command should be terminated by Carriage Return (CR), Line Feed (LF) or both. Responses are concluded by CRLF.

If Windows does not install the driver automatically, it can be downloaded here:

http://lpvo.fe.uni-lj.si/fileadmin/files/Raziskave/mppt/atmel_devices_cdc.zip

Firmware upgrade

The microcontroller uses memory that can be programmed multiple times either using a programmer or by a built in boot-loader. A PDI programmer can be connected to J7. All microcontrollers on a board must be separately programmed.

USB bootloader (on MP0205M6 (demo board))

To update the firmware using the USB bootloader, short J8 and reset the microcontroller or reconnect power. The tracker will enumerate as DFU (Device Firmware Upgrade). On the Windows PC run Atmel FLIP programming utility and follow screen prompts. A third party command line utility is also available for other platforms. After programming do not forget to remove short on J8 and reset the microcontroller again to enable correct operation.

Atmel FLIP can be downloaded here:

<http://www.atmel.com/tools/FLIP.aspx>

RS-485 bootloader (on MP0205M24 (plug-in board))

Firmware update via the RS-485 bootloader is performed using a special program. The firmware can be upgraded when a board is in complete system or when it is connected just to adapter board. Each microcontroller on the board must be updated by a separate upload. Note that when a compatible firmware is not running on one microcontroller the other one will use default RS-485 address. Please consult the bootloader software manual for further details.

Specifications

Power Input

Voltage	$\pm 1,75$ V in normal conditions (see measurement range)
Current	200 or 50 mA (depending on shunt)
Power	300 mW at room temperature
Input resistance in SC add shunt resistance	2.5 Ω typical for positive inputs 1.5 Ω typical for negative inputs
Connection	4-wire (2-wire available on request)
Number of channels	24 or 6

Measurement (bypass) Output

Voltage	48 V
Current	1 A
Breaking capacity	see data for Fujitsu FTR-B3

Measurements

Input Differential Voltage	range: ± 2.047 V resolution: 1 mV or better Note: ± 1.75 V at nominal VCOM and no voltage drop on negative wire.
Common Mode Voltage (voltage on each input pin against ground)	GND -0.1 V ... Vcc $+0.1$ V (nominally COM ± 1.75 V) Accuracy outside these limits is not guaranteed.
Internal supply voltage – Vcc	3.3 V, 3.6 V can be ordered
Shunt Resistance	2.2 Ω or 24 Ω
Input Current	range: ± 58 mA @ 2.2 Ω or ± 10.5 mA @ 24 Ω (extendable/reducible in steps of factor 2 with firmware upgrade) resolution: approx. 2 μ A or better
Internal Temperature	range: <i>TBD</i> resolution: <i>TBD</i>

Control Interfaces

RS-485

Operation	multi-drop device
Speed	125 kb/s

Ground is shared with other circuitry.

USB

Connector	Standard upstream USB-B
Speed	Full speed (12 Mb/s)
Device Class	Communication Device Class (CDC)

Ground is shared with other circuitry.

Power supply

Voltage range	<u>Plug-in board:</u> 20–28 V 7–28 V (when relays are not used) <u>Demo board:</u> same as relays used 4.4–28 V (when relays are not used)
Consumption	<u>Plug-in board:</u> 330 mW typical +280 mW for each channel bypassed Add consumption of external devices connected to VCC and COM to this value as 6 mW/mA. <u>Demo board:</u> 30 mA typical +19 mA for each 24 V relay pair activated +280 mW for non-24 V relay pairs Add consumption of external devices connected to VCC and COM to this value in 1:1 ratio (linear regulator).
VCC output	3.3 V, 3.6 V can be ordered
COM output	VCC/2 (nominally 1.65 V) Output resistance: 47 Ω

Dimensions MP0205M24 (plug-in board)

Footprint (without connector and extraction handle)	220 x 100 mm ²
Height	approx 15 mm
Weight	148 g

Dimensions MP0205M6 (demo board)

Footprint (without connectors)	101 x 131 mm ²
Height	approx 16 mm
Weight	72 g (without plugged connectors)
Mounting holes	four M3 holes spaced at 119.4 x 50.8 mm ²

Standard orderable combinations

Relay voltage (equals supply voltage)	5, 12 or 24 V for demo board 24 V for plug-in board
Shunt Resistance	2.2 Ω or 24 Ω Higher value will provide better accuracy and higher minimum voltage drop.
VCOM	3.3 V or 3.6 V
Input wiring 2- or 4- wire	4-wire for demo board 2- or 4- wire for plug-in board Optional current to voltage pin resistors on plug-in board for wiring flexibility.
Bypass output	Optionally no relays for bypass output.

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