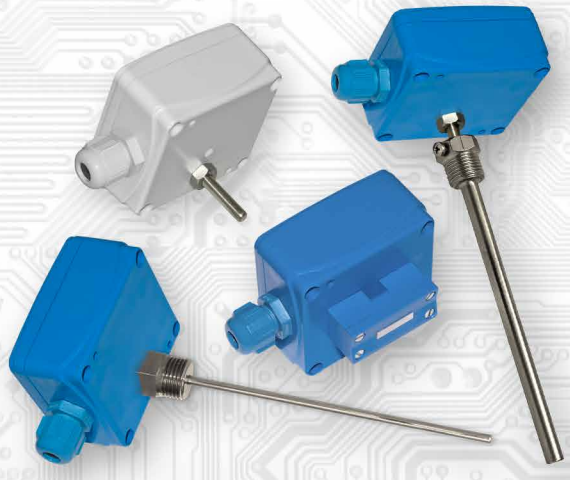
Temperature sensors with Modbus RTU communication



- Modbus RTU communication over RS485 line
- Wide range of power supply
- Hight accuracy
- Configuration via the USB port
- Option to display temperature on LCD (P1xMU-D)

Description

These sensors are intended for general-purpose application in control and regulation systems for the temperature measurement. The communication with superior system is led in the line RS485 by the protocol Modbus RTU and the device always operates in the "slave" mode. The P1xMU-D type also allows for local display of the measured temperature using a display built into the transparent sensor cap. The device configuration is made with sensor connection, using the standard USB cable, to PC with Windows system using the freeware application USB_SET. By standard, the sensors are supplied in pass-through design with two glands. Only sensors ordered as end pieces (type P1xMU/K) are equipped with a single gland. The head of sensor is made of the plastic material, cover is provided with quick-locking screws, the stem is made of stainless steel (DIN1.4301).

Basic technical parameters

Power supply	10 to 30 VDC
Power consumption	max. 0,5W
Temperature resolution	0,1°C
Accuracy	± 0,5°C
Communication	RS485, protokol ModBus RTU, 8bitů, 1 stop bit, optional parity
Baud rate	1200 ÷ 57600 Bd
Input impedance of the RS485 receiver	min. 96 kΩ , typ. 150 kΩ
Max. number of sensors in the line	254
Galvanic separation RS485	no
Working range P11MU P14MU P16MU P12MU, P13MU P18MU with Pt 1000 / 3850ppm	 -30 to 60°C -50 to 120°C -50 to 100°C -50 to 200°C (custom-made to 400°C)
Recommended calibration interval	2 years
Ambient temperature	-30 ÷ 60 °C
Range of recommended storage temp. / RH	10 ÷ 50 °C / 20 ÷ 60 %RH
Protection level	IP65
Type of terminal board	COB (cond. max. 1,5 mm ^{2})
Cable gland / max. Ø	PG9 / 8 mm
Configuration and upgrade program	USBset; freeware; www.regmet.cz

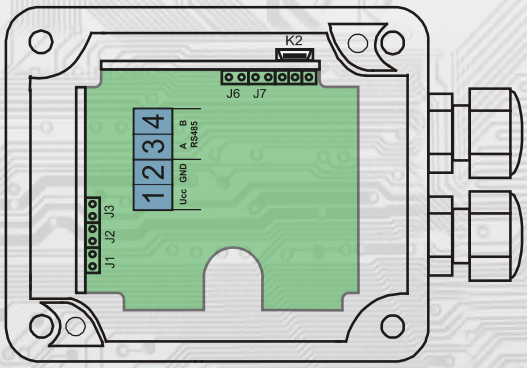
List of available types:

Interior	**P10MU**
Outdoor Air	**P11MU**
Duct probe	**P12MU-L1**
Well insertion probe	**P13MU-L2**
Strap-mount	**P14MU**
Quick-action	**P16MU-L3**
Cable type	**P18MU**

Standard length L1 and L2

L1 (mm)	L2 (mm)	L3 (mm)
120	100	100
180	160	160
240	220	
300	280	
360	340	

Layout of connecting terminals and connectors (fig. 1)



K2...connector USB mini B

J1…terminal resistor 120R
J2…definition of still stand (conductor A)
J3…definition of still stand (conductor B)
J6…device configuration
J7… reset

Terminal 1..... + pole (Ucc)
Terminal 2..... - pole (GND)
Terminal 3..... RS485 - A
Terminal 4..... RS485 - B

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1.1 Properties of communication protocol:

Protocol Modbus RTU with adjustable Baud rate 1200 - 57600 Bd, 8 bits, no parity, 1 stop bit, line RS485, half-duplex operation.
Supported features:
03 (0x03): Read Holding Registers
04 (0x04): Read Input Registers
06 (0x06): Write Single Register
16 (0x10): Write Multiple Registers

2.1 Description of registers of the device:

1Modbus registr = 2 Byte

During the transfer the register addresses are indexed from zero, i.e. register 0x0001 is physically sent through the busbar as 0x0000... (zero based addressing). The Holding registers will be mentioned in the description together with the function code field 4xxxx and the Input registers including 3xxxx. Thus the Holding register 40001 is physically sent through the busbar as register 0000 and the Input register 30001 as 0000.
Examples of communication are shown in Chapter 2.8.

he registers are divided in four basic memory zones:

Operational registers are situated at addresses 40001, 40002 and 40006. To read these registers use command no. 03 “register reading” (0x03 Read Holding Registers)

The configuration registers are situated in the zone of Holding registers at addresses 40041 to 40078. They are used for configuration of the device. The registration in registers is protected and allowed under the configuration mode, i.e. when the jumper shorts out the link J6. In this mode the device communicates at dedicated address 255 of the Baud rate 19200 Bd. The configuration registers can be rewritten only using the communication protocol and under the above stated conditions. The change of setting and at the same time the registration in FLASH is done only after writing 0xC003 (49155 dek) to 40029 – the Register Status

The information registers are situated in the zone of Input registers at addresses 30001 to 30032. They serve for unchanged preservation of device identification data.

The Status Register serves for two-way communication between the device and the superior system. The device notifies the superior system of the internal status and the superior system sends requests for performance of commands.

STATUS Information messages from the device to the superior system:
- Normal Run, 0x0000 (0 dek) the device works in normal operational mode
- Menu Active, 0xB000 (45056 dek) the user has opened the manual menu
- Memory Read, 0xB001 (45057 dek) the device is reading from FLASH
- Memory Write 0xB002 (45058 dek) the device is registering to FLASH

STATUS Error messages from the device to the superior system:

- CRC Error	0xBE01	(48641 dek)	Application program is damaged in the FLASH memory
- LCD Error	0xBE02	(48642 dek)	Error of communication with LCD
- Sensor Error	0xBE02	(48642 dek)	Error of communication with the sensor
- Memory Error	0xBE04	(48644 dek)	Error of communication with FLASH

STATUS Commands for the device issued from the superior system:
- Clear STATUS 0x0000 (0 dek) writes 0 to the register
- Write Area 3 0xC003 (49155 dek) it rewrites the Configuration registers to FLASH

In brackets behind the registers described, abbreviations of possible features may appear:

R	Read for reading
W	Write for writing
WP	Write protect for protected writing
M	Parallel manual access from the device menu

2.2 Description of operational registers:

				Modbus register [dek]
Measured temperature	-	-	-	1 - 4
-	-	-	Measured resistance	5 - 8

40001 (R) – Measured temperature:
is detected with an inbuilt digital sensor that is built in the stainelss steel stem of the sensor. The value is sent in °C in form of 16-bit number with sign (signed integer) multiplied by the constant 10:
0x0136 = 310dek = 31,0°C.

40008 (R) - Measured resistance of the temperature sensor at the ADC input:
Resistance value of the temperature sensor (Pt1000) at the ADC input. Used for control or service purposes only.
The value is sent in Ω as a 16-bit signed integer multiplied by
const. 10: 0x2BC6 = 11206dek = 1120.6Ω = 31.0°C.

2.3 Description of Status register:

				Modbus register [dek]
Status registr				29

40029 (R,W) - Status Register:
It provides the superior system with information on the internal status of the device, for example the current error statuses or information that the manual setting menu is currently activated by the user. At the same time it serves as the receiving register for special commands, for example rewrite/backup of working registers to FLASH.
The number format is 16-bit unsigned integer.
See the detailed description in the Status Register in Chapter 2.1 Description of device registers.

2.4 Description of configuration registers:

Saving to EEPROM is performed only after writing 0xC003 (49155 dec) to 40029 - Register Status.

Text_1	Text_2	Text_3	Text_4	41 - 44
Text_5	Text_6	Text_7	Text_8	45 - 48
Network address	Baud rate + parite	-	-	49 - 52
-	-	-	-	53 - 56
-	-	-	-	57 – 60
-	-	-	-	61 – 64
-	-	-	-	65 – 68
-	-	-	-	69 – 72
-	-	-	-	73 – 76
Measured temp., Offset	-	-	-	77 – 80

40041 ÷ 40048 (R,WP) - Text
The custom text field. It is determined for the client´s identification of the device. The number format is 16-bit unsigned integer. Two ASCII signs can be in one Modbus Register

40049 (R,WP) – Network address
The network address of the sensor. The number format is 16-bit unsigned integer. It acquires the values 0 ÷ 255 dek, whereas the address 0 is reserved for the broadcast and the sensor does not respond to it, the address 255 is reserved for the controller configuration. Thus the range of available addresses is 1 ÷ 254

40050 (R,WP) – Baud rate + parity:
Lower byte: Baud rate

value [dek]	0	1	2	3	4	5	6
Baud rate [Bd]	1200	2400	4800	9600	19200	38400	57600

Upper byte: parity

value [dek]	0	1	2
parity	Bez (none)	Lichá (odd)	Sudá (even)

Example:

0x0004 = 19200Bd, without parity
0x0203 = 9600Bd, even parity

40077 (R,WP) – Measured temperature, Offset
Setting the measured temperature offset.
The value is in °C in form of 16 bit number with a sign (signed integer) multiplied by the constant 10.
For example, when it seems that the device shows a value 1°C higher , value – 10 will be set in this register and the device will display and send the temperature value decreased by 1°C than the actually measured value is.

2.5 Description of information registers:

				Modbus register [dek]
HW_Platform_1	HW_Platform_2	HW_Platform_3	HW_Platform_4	1 - 4
HW_Platform_5	HW_Platform_6	HW_Platform_7	HW_Platform_8	5 - 8
HW_Version_1	HW_Version_2	HW_Version_3	HW_Version_4	9 - 12
FW_Boot_Version_1	FW_Boot_Version_2	FW_Boot_Version_3	FW_Boot_Version_4	13 - 16
ID_Device_1	ID_Device_2	ID_Device_3	ID_Device_4	17 – 20
ID_Device_5	ID_Device_6	ID_Device_7	ID_Device_8	21 – 24
FW_Applic_Version_1	FW_Applic_Version_2	FW_Applic_Version_3	FW_Applic_Version_4	25 – 28
0x0000	0x0000	0x0000	0x0000	29 – 32

Information on HW and SW of the device, commands 04 (Read Input Registers) are counted at the addresses 30001 to 30032 (including the function code field 3xxxx, i.e. register 30001 is sent through the bus bar as register 0000).
The number format is 16 bit unsigned integer. One Modbus register contains two ASCII signs.

Content of Modbus Holding Registers (tab. 2):

Operational registers:

				Modbus register [dek]
Measured temperature	-	-	-	1 - 4
-	-	-	Measured resistance	5 - 8

Status register:

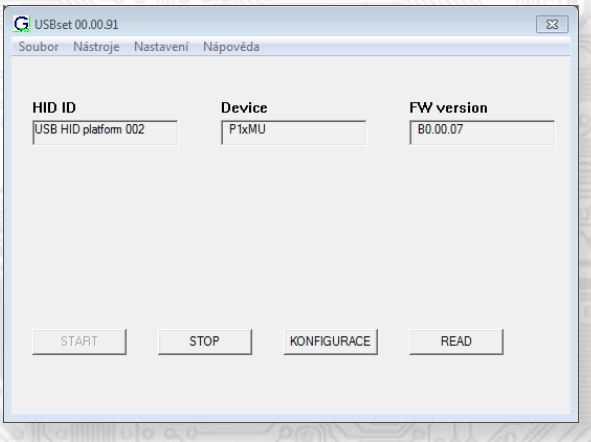
Status register				29

Configuration registers:
Saving into the EEPROM is done only after writing 0xC003 (49155 dec) to 40021 - Registry status!!

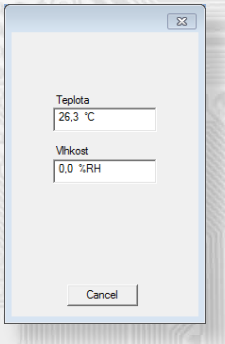
Text_1	Text_2	Text_3	Text_4	41 - 44
Text_5	Text_6	Text_7	Text_8	45 - 48
Network address	Baud rate + parity:	-	-	49 - 52
-	-	-	-	53 - 56
-	-	-	-	57 – 60
-	-	-	-	61 – 64
-	-	-	-	65 – 68
-	-	-	-	69 – 72
-	-	-	-	73 – 76
Measured temp., Offset	-	-	-	77 – 80

3.1 **SW configuration of sensor using the USBset program:**

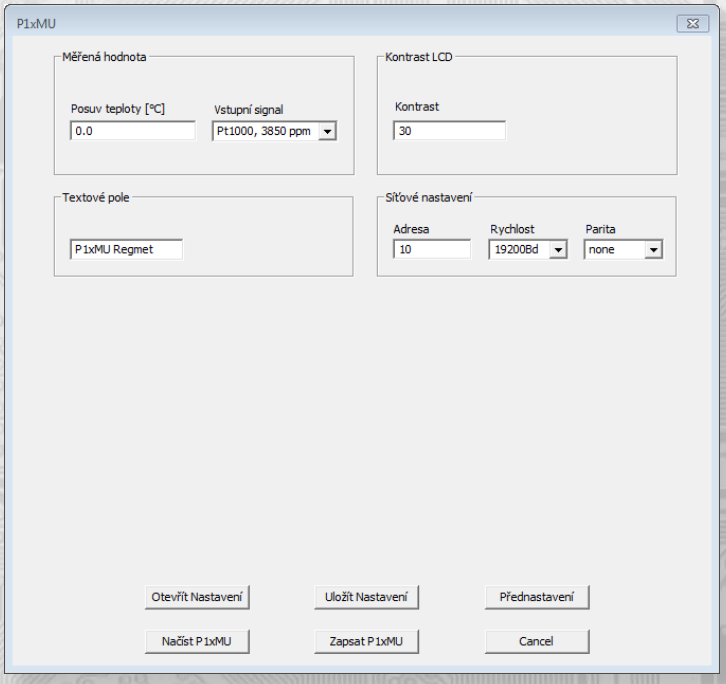
The conguration application USBset is freely available at producer´s web pages. The sensor can be configured only when the jumper J6 is inserted before the connection of supply voltage (reset). The sensor is connected with PC using the cable of USB mini B type. With connected cable the USB communication has the priority over the line RS485.
After the launching of USBset program, the basic window is opened and the connected sensor is automatically connected with the hosting PC.



With clicking on the "READ" button opens the window with the current input values.



With clicking on the button “CONFIGURATION” the configuration window gets opened



With clicking on the button “READ” the conguration values from the ash memory of sensor are read.

Measured value:
- Shift of measured value (T, RH, light intensity)
For example, when it seems the device measures over by 1° C (for example due to the inappropriate location, own heating at often communication with loaded line...), the value – 1,0 is set and the device will display and send the temperature value lower by 1°C than the really measured value is.

- Input signal: selection of the used temperature resistance sensor, usable only for P18MU types with connectable external sensor. For other types, do not change this item! (keep Pt1000, 3850ppm).

Contrast: it serves for setting of LCD contract with inactive display (saving mode) in the range 1 ÷ 100%

Text field: intended for the client´s identification of the controller (title, location...).

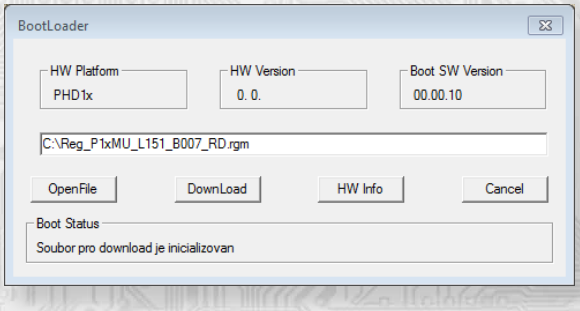
Network setting:
- address (40049): selection of network address in the range 1 ÷ 254 for the operation of sensor in the serial line.

- baud rate (40050): selection of Baud rate in the range 1200 ÷ 57600 Bd for the operation of sensor in the serial line.

- parity (40050): Parity selection
none: without parity
odd: odd parity
even: even parity

After setting of required values and quantities the new configuration values are saved in the flash memory of the device by clicking on the button “Write"
The writing into the flash memory is conditioned by insertion of jumper J6 (authorisation for configuration values recording) before the clicking on the button “Write”
By clicking on the button "Cancel" the configuration windows gets closed.
After USB cable disconnection the jumper J6 is pulled out and the device is ready for operation

3.2 Variation of the application part FW:
After the USBset program launching click on the Tools – BootLoader and the windows gets opened:



The work with application is conditioned by insertion of the jumper J6 (authorisation for configuration values recording).
Using the button “OpenFile“ the new application FW is chosen and using the button “DownLoad“ the FW variation gets started, being automatically controlled by PC and the device.
For the maximum simplicity and safety every device has unambiguous identification of HW platform. This designation describes HW topology and also defines what application FW can be sued for the specific type of HW. This information can be read through the button “HW info“.
The application FW are distributed in data format “.reg “. In case of application variation the information on HW platform and HW version are always read after the connection of PC with the device. At the same time, the HW platforms descriptors and HW versions from the file “.reg “ are read. Provided HW platform and HW version are not compatible, the FW variation cannot be done. Provided the communication failure occurs during the application FW variation, for example due to the supply voltage drop, the application SW will not be functional. In such case the automatic launching of “bootload” process as well as the automatic reading of HW info will not work. The Bootloader in the device gets always activated after the reset, thus it is necessary to reset manually. Using the RESET jumper or the simple disconnection and subsequent connection of supply voltage.
JProvided the automatic sequence of FW variation launching is damaged:
- switch off the device or connect the jumper at RESET pins
- launch the bootload process using the button “DownLoad“
- switch on the supply voltage or release the RESET jumper
- delay between the activation of button “DownLoad“ and the switching on or by the RESET shall be shorter than 2s.
After the USB cable disconnection the jumper J6 is pulled out and the device reset is performed using the short shorting of RST jumper (J7).

The integrity check of content of memory:
The bootloader as well as the application are protected by control total sums. Provided the data integrity is broken, the content of FLASH memory MCU is damaged and the damaged program will not be launched.

4.1 Examples of communication:

Command 03 (0x03): Read Holding Registers:

Master: 02 03 00 04 00 01 Crc Crc
- 02 – Address of device (device with address 2)
- 03 – Command (Read Holding Registers)
- 00 04 – Address of initially read register (0x0005)
- 00 01 – Number of read registers (1 registers)

Slave: 02 03 06 00 FF Crc Crc
- 02 – Address of device (device with address 2)
- 03 – Command (Read Holding Registers)
- 06 – Number of bytes (2)
- 00 FF – Data (x00FF)

The starting register address is 0x0005 **, the number of read registers is 1. Thus: the measured value is 0x00FF = 25,5°C.

Command 16 (0x10) Write Multiple Registers:

Master:
FF 10 00 30 00 02 04 00 02 00 03 Crc Crc
- FF – Address of device (with inserted jumper J6 - address 255)
- 10 – Command (Write Multiple Registers)
- 00 30 – Address of first registered register (0x0031**)
- 00 02 – Number of registered registers (2)
- 04 – Number of bytes (4)
- 00 02 – Registered data 1. Regist. reg. (0x0002)
- 00 03 – Registered data 2. Regist. reg. (0x0003)

Slave:
FF 10 00 30 00 02 Crc Crc
- FF – Address of device (with inserted jumper J6 - address 255)
- 10 – Command (Write Multiple Registers)
- 00 30 – Address of first registered register (0x0031**)
- 00 02 – Number of registered registers (2)

With writing of the value 2dek in register 0x0031* (40049 – Network address) the network communication address 2 is set and with the writing of the value 3dek in register 0x0032** (40050 – Baud rate + parity) the Baud rate 9 600 Bd is set, without parity.

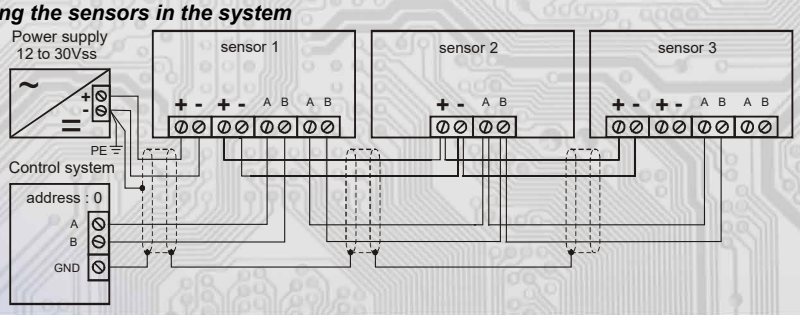
Command 06 (0x06) Write Single Register:

Master:
FF 06 00 1C C0 03 Crc Crc
- FF – Address of device (with inserted jumper J6 - address 255)
- 06 – Command (Write Single Register)
- 00 1C – Address of registered register (0x001D**)
- C0 03 – Registered data (0xC003 = 49155dek)

Slave:
FF 06 00 1C C0 03 Crc Crc
- FF – Address of device (with inserted jumper J6 - address 255)
- 06 – Command (Write Single Register)
- 00 1C – Address of registered register (0x001D**)
- C0 03 – Registered data (0xC003 = 49155dek)

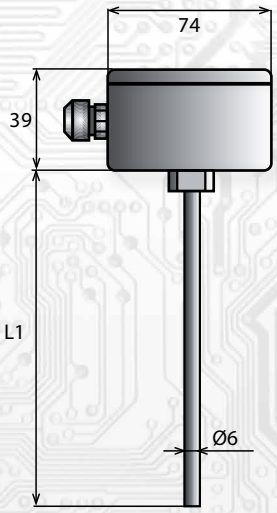
By writing the value 49155dek in register 0x001D** (40029 -Status Register),the configuration registers are saved in the flash memory of the device. If, for example, the communication address and rate pursuant to the previous example are changed through the network, then after this registration in the Status Register this change will be valid even after the device is reset or switched off.**
During the transfer the addresses of registers are indexed from zero, i.e. register 0x0001 is physically sent through the bus bar as 0x0000... (zero based addressing).

Example of wiring the sensors in the system

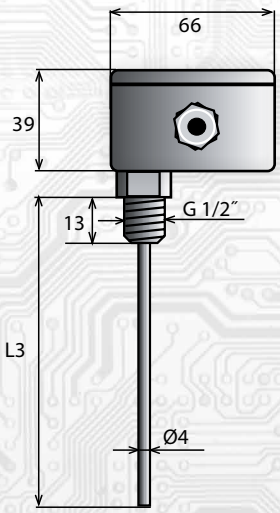


Dimensions and accessories

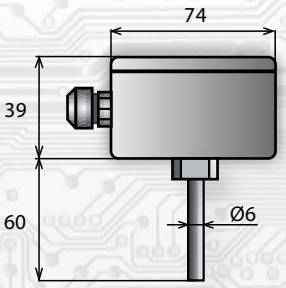
P12MU/K



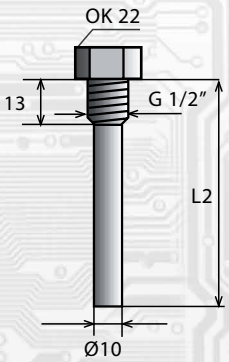
P16MU/K



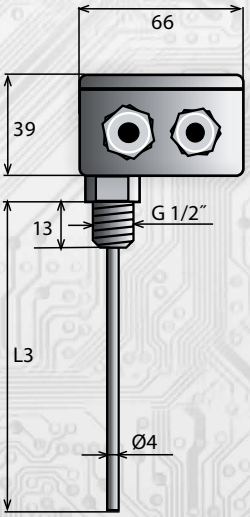
P11MU



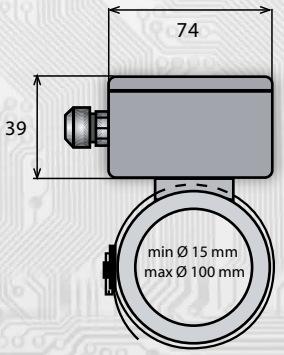
Thermowell



P16MU

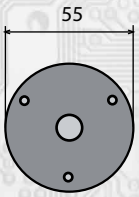


P14MU/K



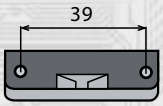
Maximum temperature of the surface measured
tp< 120°C

Central holder A - to P12MU



3 holes of Ø 4,5 mm

Side holder A - to P11MU



2 holes.... Ø 4,5 mm