USER'S GUIDE

Vaisala HUMICAP® Moisture and Temperature Transmitter for Oil MMT162

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CHAPTER 1
GENERAL INFORMATION

This chapter provides general notes for the manual and the product.

About This Manual

This manual provides information for installing, operating, and maintaining Vaisala HUMICAP® Moisture and Temperature Transmitter for Oil MMT162.

Contents of This Manual

This manual consists of the following chapters:

- Chapter 1, General Information, provides general notes for the manual and the product.
- Chapter 2, Product Overview, introduces the features, advantages, and the product nomenclature
- Chapter 3, Installation, provides you with information that is intended to help you install the product.
- Chapter 4, Operation, provides information that is needed in basic maintenance of the product.
- Chapter 5, Maintenance, provides information that is needed in basic maintenance of the product.
- Chapter 6, Calibration and Adjustment, provides information that is needed in calibration and adjustment of the product.
- Chapter 7, Technical data, provides the technical data of the product.

Version Information

Table 1   Manual Revisions

Manual Code	Description
M210934EN-C	April 2013. This manual. Updated descriptions of connection cables and serial line commands. Updated list of spare parts and accessories.
M210934EN-B	March 2009. Previous version. Updated cable specification.

Related Manuals

Table 2   Related Manuals

Manual Code	Manual Name
M210935EN	MMT162 Quick Reference Guide

Documentation Conventions

Throughout the manual, important safety considerations are highlighted as follows:

WARNING	Warning alerts you to a serious hazard. If you do not read and follow instructions very carefully at this point, there is a risk of injury or even death.

CAUTION	Caution warns you of a potential hazard. If you do not read and follow instructions carefully at this point, the product could be damaged or important data could be lost.

NOTE	Note highlights important information on using the product.

Safety

The Vaisala HUMICAP® Moisture and Temperature Transmitter for Oil MMT162 delivered to you has been tested for safety and approved as shipped from the factory. Note the following precautions:

WARNING	Ground the product, and verify outdoor installation grounding periodically to minimize shock hazard.

CAUTION	Do not modify the unit. Improper modification can damage the product or lead to malfunction.

Recycling

	Recycle all applicable material.

	Dispose of batteries and the unit according to statutory regulations. Do not dispose of with regular household refuse.

Regulatory Compliances

Vaisala HUMICAP® Moisture and Temperature Transmitter for Oil MMT162 is in conformity with the following EU directive:

- EMC-Directive

Conformity is shown by compliance with the following standards:

- EN 61326-1: Electrical equipment for measurement, control and laboratory use - EMC requirements - Industrial environment.
- EN 55022 Class B: Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement.

Trademarks

HUMICAP$^®$ is a registered trademark of Vaisala Oyj.

Windows® is a registered trademark of Microsoft Corporation in the United States and/or other countries.

License Agreement

All rights to any software are held by Vaisala or third parties. The customer is allowed to use the software only to the extent that is provided by the applicable supply contract or Software License Agreement.

Warranty

Visit our Internet pages for standard warranty terms and conditions: www.vaisala.com/warranty.

Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or Conditions of Sale for details of the warranty for each product.

CHAPTER 2
PRODUCT OVERVIEW

This chapter introduces the features, advantages, and the product nomenclature of Moisture and Temperature Transmitter for Oil MMT162.

Introduction to MMT162

The MMT162 transmitter is a microprocessor based instrument for the measurement of moisture in terms of water activity, for example in the lubrication of circulation systems or in transformer oil. The probe incorporates a capacitive thin film sensor. The operation of the sensor is based on changes in its capacitance as the thin polymer film absorbs water molecules.

The MMT162 transmitter is available with either metal or plastic housing. The transmitter can be configured in many ways: two analog output signals can be scaled, the measurement ranges can be changed within certain limits and there are two mechanical connection options, ISO and NPT 1/2. The MMT162 probe is supplied with a three or five meter connection cable.

The MMT162 also provides for accurate temperature measurement. It is an easy-to-install on-line probe which can be calibrated against, for example, traceable salt solutions.

Table 3   **Parameters Measured and Calculated by MMT162**

Parameter	Abbreviation	Metric Unit	Non Metric Unit
Water activity	A_w		
Temperature	T	°C	°F
Mass concentration of water in oil	ppm		

NOTE	ppm is only applicable to transformer oil.

Vaisala HUMICAP® Moisture and Temperature Transmitter for Oil MMT162 provides reliable moisture measurement in wide range of applications. Analog outputs can be chosen between current and voltage signals. Alternatively, digital output RS-485 comes as standard.

Basic Features and Options

- Two analog outputs
- Digital output: RS-485
- USB connectivity for service connections via the optional USB M8 cable
- Different cable lengths available
- Available with two different thread options: ISO G1/2" and NPT 1/2"
- Low maintenance requirements due to excellent long term stability
- LED cable option that enables a visual alarm function
- Field calibration possible with MM70
- Two filter types available: stainless steel grid filter and high flow stainless steel grid filter (> 1 m/s)

Transmitter Structure

The structure of the MMT162 is shown in Figure 1 on page 11. The transmitter body does not have user serviceable parts inside, and is not designed to be opened. Opening the transmitter will void the warranty.

When the transmitter is delivered, the filter is protected by a yellow transport protection cap. Remove the transport protection cap before installing the transmitter.
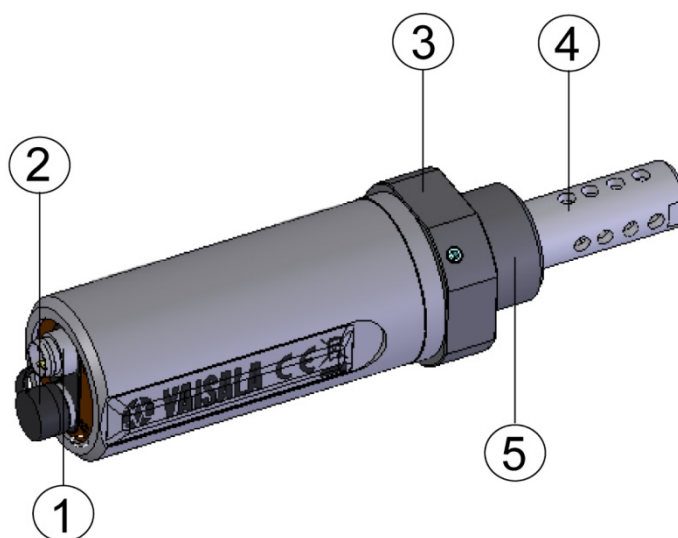
0805-007

Figure 1   Moisture and Temperature Transmitter for Oil MMT162

where

1 = 4-pin M8 connector I: analog output channels and operating power
2 = 4-pin M8 connector II (shown with protective cap): digital output (RS-485) and operating power
3 = 30 mm nut
4 = HUMICAP® sensor protected with stainless steel grid filter
5 = Connection thread: ISO G1/2" or NPT 1/2"

Typical Applications

Method Used for Measuring Moisture in Oil

The MMT162 transmitter measures water in oil in terms of water activity (aw) which can be determined as follows: water activity indicates the amount of water on the scale of 0 - 1 aw. In this scale, 0 aw is an indication of completely water free oil and 1 aw an indication of oil fully saturated with water. Water is present in free form.

The most important feature which distinguishes the measurement of water activity (aw) from the traditional measurement of absolute water content (in ppm) is that the saturation point remains stable regardless of the oil type or the aging of oil, additives used etc. As water activity exceeds 0.9 aw in any system, there is a risk for segregation (especially if the temperature decreases).

The water activity is used for alarming at the point of >0.9 aw that the risk for free water in the system is obvious. The most important advantages of this system are the fact that water activity is immune to the aging of oil and to additives, and that the MMT162 transmitter can be used for continuous on-line measurements. In addition, the MMT162 can be calibrated against salt solutions and no reference oils are needed.

NOTE	To avoid self-heating of the probe and consequential measurement errors, make sure there is some flow in the application process.

Lubrication Oil

In many industrial plants, like paper mills, hydro power plants and off-shore wind turbines, there is a certain amount of free moisture constantly present. This means that there is a high risk of the free moisture becoming into contact with the machine bearings. The most common reasons for the entrance of water are inadequate sealing of the housing or moisture absorption from ambient air. Accidental leakages from oil coolers and other equipment can also cause damage.

Free water in lubrication oil prevents oil from forming a uniform layer on the metal surfaces and thus deteriorating its lubrication properties. This can cause, for example, spot heating, cavitation, corrosion and micro pitting. Free water also ruins additives like AW (antiwear) and EP (extreme pressure). Note that bearings should never be exposed to oils that have high water content; this is also important during standstill because the risk for corrosion increases as the oil temperature decreases.

It is essential to monitor the water content and to keep it on a suitable level, meaning below saturation.

When measuring the water content of oil, it is best to measure the water activity before an oil reservoir and from a pressure line flow. This way the performance of dehumidifiers can be kept under control to ensure that no free water reaches the bearings.

Transformer Oil

The determination of moisture in oil is an essential part of a comprehensive transformer maintenance program. Aging and deterioration increase the capacity of oil to absorb water. The primary interest in transformers is to measure the water not in oil but in the cellulosic insulation around the transformer windings. Heating and cooling have a considerable effect on moisture levels in oil. While temperature rises, the paper insulation of transformers tends to loose moisture which is absorbed by the oil surrounding it. Saturation level is thus a true indicator of moisture present. The MMT162 method provides for a reliable detection of the aging of oil and possible leakages.

Oil immersed transformers rely on the oil for cooling, protection from corrosion and as an important component of their insulation. Excessive moisture content in oil causes accelerated ageing of the insulation materials and reduces their dielectric strength. In extreme cases this can result in arcing and short circuits within the windings. Accurate moisture measurements can also warn about leaks in the oil system, as water is absorbed from the surrounding air.

Heating and cooling of a transformer affect moisture levels in oil. This is due to the fact that the water solubility of oil is temperature dependent. In general, water solubility increases as temperature rises; see Figure 2 on page 14 below. Changes in temperature also have an effect on water desorption of the paper insulation around the transformer windings. Desorption of water from the insulation increases as temperature rises and the surrounded oil absorbs desorbed water. Moisture level in oil is thus a true indicator of moisture present in the paper insulation.

In addition, it must be noted that capacity of oil to absorb water depends both on the chemical structure of the oil and the additives.

WATER SOLUBILITY IN MINERAL TRANSFORMER OIL

0510-029
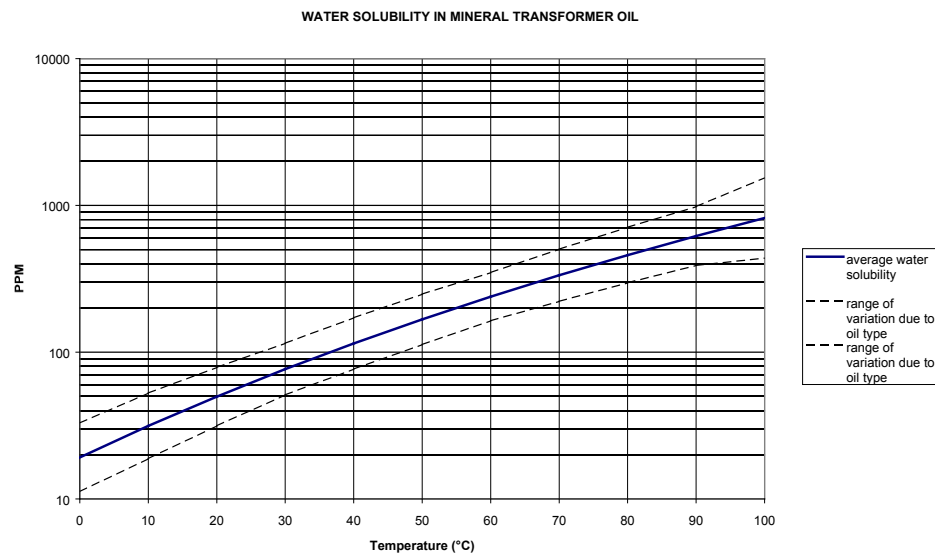
Figure 2   Water Solubility of Transformer Oils versus Temperature

The margins show the range of variation of water solubility found in mineral oils.

CHAPTER 3
INSTALLATION

This chapter provides you with information that is intended to help you install the product.

Installing the Transmitter

After selecting a suitable measurement location, follow the procedure below to install the transmitter:

1. Remove the yellow transport protection cap from the transmitter.
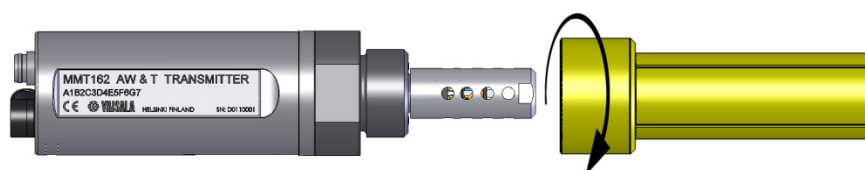
0805-005

Figure 3   Removing the Transportation Protection Cap

2. Prepare the sealing of the connection:
   - If the transmitter has a parallel ISO G1/2" thread, place the sealing ring at the base of the thread. Always use a new sealing ring; do not re-use a previously installed one.
   - If the transmitter has an NPT 1/2" thread, do not use the sealing ring. Instead, apply PTFE tape or suitable paste sealant to the thread. Follow the application instructions of the sealant.

3. Make sure that the threads on the mounting point are of the correct type, and fasten the transmitter to the measurement point. Use your hands to turn the probe until it feels tight. Do not use force at this point, and check that the sealing ring (if used) remains centered.
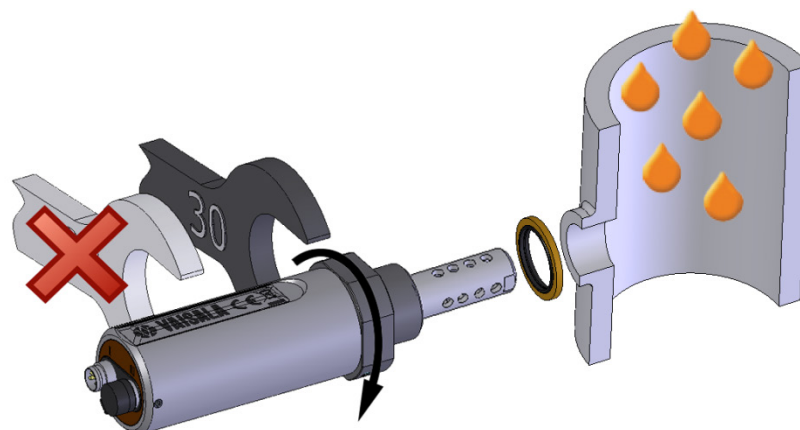
0805-006

Figure 4   Installing the Transmitter

4.   Use a 30 mm wrench to tighten the connection to 25 Nm, as shown
      in Figure 4 above. If you do not have a 30 mm wrench, use a
      1 3/16" wrench or an adjustable wrench instead.

CAUTION	Only tighten the probe from the 30 mm nut. Do NOT apply force to other points in the probe body.

5.   Connect the wires of the connection cable.
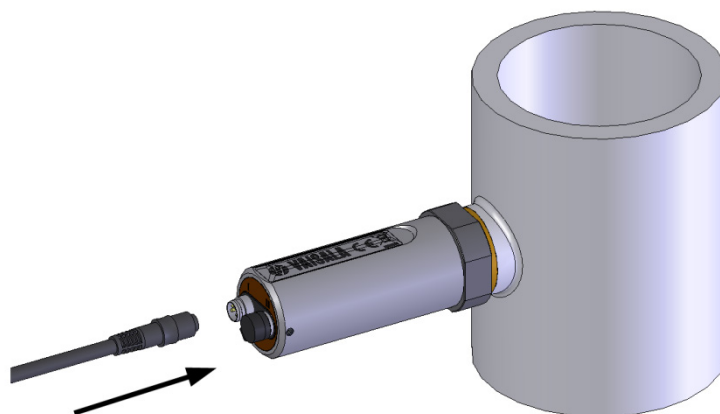
0710-130

Figure 5   Connecting the Cable

6.   Plug in the cable to the transmitter. Be sure to use the correct
      connector; refer to section Wiring on page 17.

7.   Cover the unused connector on the transmitter with the rubber plug
      that is attached to the transmitter.

Wiring

Pin	I	II	Wire Color
1	Vcc	Vcc	Brown
2	Analog output 1	RS-485 B / D-	White
3	GND	GND	Blue
4	Analog output 2 / LED	RS-485 A / D+	Black
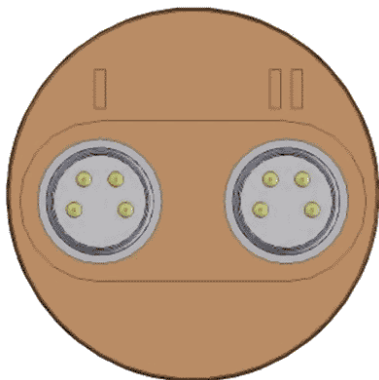
0707-035

Figure 6   Connectors I and II
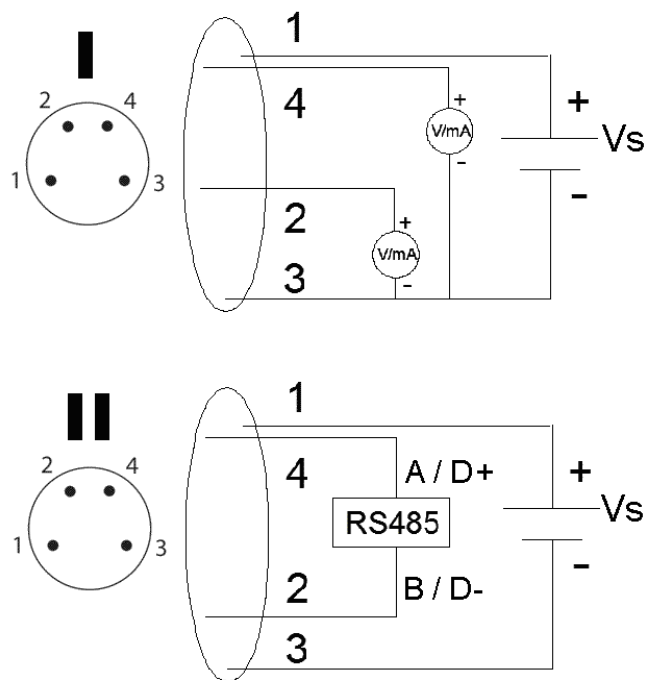
1210-005

Figure 7   Connector Pinout

Connection Cables

The following connection cable options are available for MMT162:

- Shielded cables with M8 female straight threaded connector
- Cables with M8 female 90° angle threaded connector
- LED cable
- USB serial interface cable

The figures below show the different cable options that are available. For order codes, see section Spare Parts and Accessories on page 61.

1210-063

Figure 8   Cable with Threaded Connector

1211-024

Figure 9   Cable with 90° Angle Threaded Connector

1211-025

Figure 10   LED Cable

1210-062

Figure 11   USB Serial Interface Cable

Power Supply Requirements

The MMT162 transmitters are designed to operate with a supply voltage of 14 … 24 VDC.

The power supply should maintain the voltage for all load conditions. Current consumption during normal measurement is 20 mA + load current. For more specific information, see chapter Technical data on page 59.

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CHAPTER 4
OPERATION

This chapter contains information that is needed to operate this product.

Getting Started

MMT162 is ready to be used once it has been connected to a power source.

Analog Output Operation Modes

The MMT162 has two analog output channels. These channels can function in two different modes, which can be set individually for both channels:

1.   Normal operation mode
2.   Limit alarm mode

When the transmitter is ordered from Vaisala, the modes are configured as specified in the order form. You can change the operation settings after delivery by using serial commands and the USB cable accessory.

Normal Operation Mode and Malfunction Alarm

In the normal operation mode, a channel outputs voltage or current that corresponds to the reading of the selected parameter.

If the transmitter is malfunctioning, the channel output is set to a pre-defined level. This level can be changed using the **AERR** command; see page 35.

NOTE	The malfunction alarm overrides the limit alarm mode. If the transmitter is malfunctioning, the analog outputs are set to the levels specified with the **AERR** command, unless the malfunction prevents the outputs from being controlled.

Limit Alarm

The limit alarm is activated when the measured parameter goes below the low limit, or above the high limit. The alarm levels and limits are configurable using the **ALARM** command (see page 35). By default, the alarm levels are set as follows:

- For **current output**, an active alarm is indicated by the current being at the maximum of the scale (20 mA).
- For **voltage output**, an active alarm is indicated by the voltage being at the maximum of the selected scale. For example, if the voltage output scale is 0 … 5 V, an output of 5 V indicates the alarm is active.
- For **LED alarm,** an active alarm is indicated by a lit LED. When the alarm status is low, the LED is not lit. If the transmitter is malfunctioning or it cannot measure for some reason, this causes the LED to blink at 0.5 Hz frequency.

LED alarm indicator is integrated to a LED cable (Vaisala item MP300LEDCBL) that can be ordered and used instead of a regular connection cable.

Serial Communication

Connecting to Serial Interface

The MMT162 can be connected to a PC using the RS-485 line, for example using the USB serial connection cable (Vaisala item 219690). The cable also provides operation power to the transmitter from the USB port. It is OK to connect the USB serial connection cable even if the transmitter is already supplied with operation power from another cable.

To connect to serial interface:

1.   If you have not used the MMT162 USB serial connection cable before, install the driver that came with the cable. Refer to section Installing the Driver for the USB Cable on page 23 for detailed instructions.
2.   Connect the USB serial connection cable between your PC and the RS-485 port of the MMT162 (port II).
3.   Open the terminal program (for example, PuTTY in Microsoft Windows®).
4.   Set the serial settings of the terminal program, and open the connection. See the following table.

Table 4   **Default Serial Interface Settings**

Property	Description / Value
Baud rate	19200
Parity	none
Data bits	8
Stop bits	1

Installing the Driver for the USB Cable

Before taking the USB cable into use, you must install the provided USB driver on your PC.

1. Check that the USB cable is not connected. Disconnect the cable if you have already connected it.

2. Insert the media that came with the cable, or download the driver from www.vaisala.com.

3. Execute the USB driver installation program and accept the installation defaults. The installation of the driver may take several minutes.

4. After the driver has been installed, connect the USB cable to a USB port on your PC. Windows will detect the new device, and use the driver automatically.

5. The installation has reserved a COM port for the cable. Verify the port number, and the status of the cable, using the **Vaisala USB Instrument Finder** program that has been installed in the Windows Start menu.

Windows will recognize each individual cable as a different device, and reserve a new COM port. Remember to use the correct port in the settings of your terminal program.

There is no reason to uninstall the driver for normal use. However, if you wish to remove the driver files and all Vaisala USB cable devices, you can do so by uninstalling the entry for **Vaisala USB Instrument Driver** from the **Programs and Features** menu in the Windows Control Panel. In Windows XP and earlier Windows versions the menu is called **Add or Remove Programs.**

Terminal Program Settings

The default settings of the MMT162 serial interface are presented in Table 4 on page 23. If the settings of your MMT162 have been changed and you do not know what they are, refer to section Unknown Serial Settings on page 49.

The steps below describe how to connect to the MMT162 using the PuTTY terminal application for Windows (available for download at www.vaisala.com) and a USB serial interface cable:

1. Connect the USB serial interface cable between your PC and the RS-485 port of the MMT162 (port II).

2. Start the PuTTY application.

3. Select the **Serial** settings category, and check that the correct COM port is selected in the **Serial line to connect to** field.

   Note: You can check which port the USB cable is using with the **Vaisala USB Instrument Finder program** that has been installed in the Windows Start menu.

4. Check that the other serial settings are correct for your connection, and change if necessary. **Flow control** should be set to **None** unless you have a reason to change it.

5. Click the **Open** button to open the connection window and start using the serial line.

   Note: If PuTTY is unable to open the serial port you selected, it will show you an error message instead. If this happens, restart PuTTY and check the settings.

6. You may need to set the **Local echo** setting to **Force on** in the **Terminal** category to see what you are typing on the serial line. To access the configuration screen while a session is running, click the right mouse button over the session window, and select **Change Settings...** from the pop-up menu.
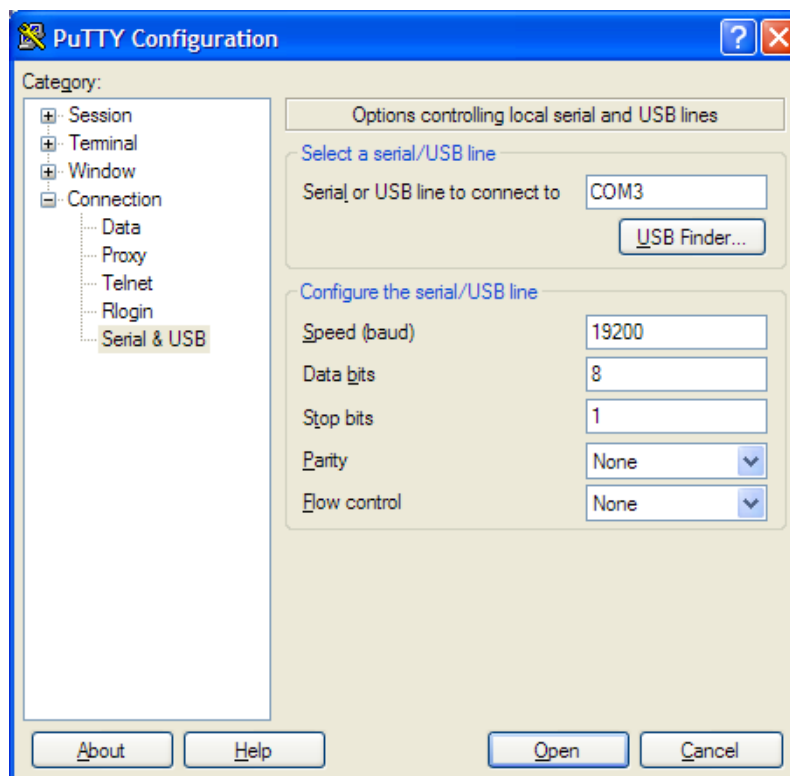
0807-004

Figure 12   PuTTY Terminal Application

List of Serial Commands

All commands can be issued either in uppercase or lowercase. In the command examples, the keyboard input by the user is in **bold** type.

The notation <cr> refers to pressing the carriage return (**Enter**) key on your computer keyboard. Enter a <cr> to clear the command buffer before starting to enter commands.

Table 5   Serial Line Commands

Command	Description
?	Output information about the device
??	Output information about the device in POLL mode
ACAL	Analog output calibration
ADDR **[0 ... 255]**	Set the transmitter address (for POLL mode)
AERR	Change the analog error output values
ALARM	Set analog output limit alarm modes
AMODE	Set analog output modes
AOVER [ON/OFF]	Allow analog outputs to exceed their range 10%
ASEL	Select the parameters for the analog outputs
ATEST	Set and display current output values
CLOSE	Close the temporary connection (Back to POLL mode)
CRH	Relative humidity calibration
CT	Temperature calibration
ERRS	List present transmitter errors
FORM	Set the output format of SEND and R commands
FRESTORE	Restore factory settings
HELP	List the most common commands
INTV **[0** ... 255 **S**/MIN/H]	Set the continuous output interval (for RUN mode)
LED	Set voltage for LED alarm
OIL	Display oil parameters
OILI	Set new oil parameters
OPEN **[0 ... 255]**	Open a temporary connection to a POLL mode device
R	Start the continuous outputting
RESET	Reset the transmitter
S	Stop the continuous outputting
SDELAY	View or set user port (RS-485) answer minimum delay
SEND [0 ... 255]	Output the reading once
SERI [baud p d s]	User Port settings (Default: 4800 E 7 1) baud: 300 ... 115200
SMODE **[STOP**/RUN/POLL]	Set the serial interface mode
UNIT [M/N]	Select the metric or non-metric output units
VERS	Display the software version information

Device Information and Status

Show Device Information

The **?** command outputs a listing of device information. If you wish to display the listing for all devices on the current serial line, issue the command **??**.

?<cr>

??<cr>

Example:

```
?
MMT162 0.92
Serial number  : G0000002
Batch number   : D0720012
Module number  : ????????
Sensor number  : C6010000
Sensor model   : Humicap L2
Cal. date      : YYYYMMDD
Cal. info      : NONE
Time           : 00:21:19
Serial mode    :     STOP
Baud P D S     :     4800 E 7 1
Output interval:        2 S
Serial delay   :        0
Address        :        0
Pressure       :   1.0132 bar
Filter         :    0.800
Ch1 output     : 0 ... 20 mA
Ch2 output     : 0 ... 20 mA
Ch0 error out  :    0.000 mA
Ch1 error out  :    0.000 mA
Ch0 aw   lo    :     0.00
Ch0 aw   hi    :     1.00
Ch1 T    lo    :   -20.00 'C
Ch1 T    hi    :    80.00 'C
```

Show Firmware Version

Use the **VERS** command to display software version information.

Example:

```
vers
MMT162 1.02
```

Configuring Serial Line Operation

Set Serial Line Settings

Use the serial line command **SERI** [*b p d s*] to set communication settings for the user port.

SERI [*b p d s*]<cr>

where

b = Bit rate (110, 150, 300, 600, 1200, 2400, 4800, 9600,19200, 38400)
p = Parity (n = none, e = even, o = odd)
d = Data bits (7 or 8)
s = Stop bits (1 or 2)

Example:

```
seri 600 n 8 1
600 N 8 1
```

You need to reset the transmitter to activate the new communication settings set with the **SERI** command.

The settings can be changed one parameter at a time or all parameters at once:

```
seri o                      changing parity only
4800 O 7 1
```

```
seri 600 n 8 1              changing all parameters
600 N 8 1
```

You can use the **SERI** command to change/view the user port settings even if you are currently connected to the service port.

Set Serial Line Response Time

With the **SDELAY** command you can set delay (response time) of the serial line, or view the currently set delay value.

SDELAY [*delay*]<cr>

where

delay = Serial line delay, range 0 ... 255. Multiply the value by four to get milliseconds (for example, delay value of 10 equals 40 millisecond delay).

Example:

```
sdelay
Serial delay  : 0 ? 10

sdelay
Serial delay  : 10 ?
```

Set Transmitter Address

Addresses are required only for POLL mode (see Set Serial Interface Mode on page 33). Use the **ADDR** command to input the RS-485 transmitter address.

ADDR [*aaa*]<cr>

where

aaa = address (0 ... 255) (default = 0)

Example (configure transmitter to address 99):

```
addr
Address : 2 ?  99
```

Format Measurement Output

Use the serial line command **FORM** to change the format or select certain parameters for the output commands **SEND** and **R**.

FORM [*x*]<cr>

where

x = Formatter string

Formatter string consists of parameters and modifiers. The MMT162 measures the following parameters:

- water activity (aw)
- temperature (T) (metric unit: ºC, non metric unit:ºF)
- ppm for transformer oil only (H_2O)

When selecting the parameter, use its abbreviation (for example, aw). The modifiers are presented in Table 6 on page 31.

Example (configure transmitter to output water activity and temperature):

```
form "aw=" 6.4 aw #t "t=" 6.2 t #r#n
OK
send
aw=      0.2644   t=     25.50
```

Example (configure transmitter to output ppm only):

```
form "Oil ppm= " h2o " " u3 #r#n
OK
send
Oil ppm=     16.6 ppm
```


Example (configure transmitter to default output format):

```
form /
OK
send
aw=   0.087 T= 24.0 'C
```

Table 6   FORM Command Modifiers

Modifier	Description
/	Restores the default output message (depends on the device configuration). Used alone.
x.y	Length modifier (number of digits and decimal places).
parameter	Abbreviation of a measured parameter, for example aw. Outputs the measured value of the parameter, or * characters if measured value is not available.
U1…U7	Unit symbol in the specified number of characters (truncated or space filled as necessary).
"xxx"	String constant (free text).
#a \a	Audible bell character <0x07>.
#b \b	Backspace character <0x08>
#f \f	Form feed character <0x0C>.
#n \n	Line feed character <0x0A>.
#r \r	Carriage return character <0x0D>.
#t \t	Horizontal tabulator character <0x09>.
#v \v	Vertical tabulator character <0x0B>.
#\ \\	Backslash character.
#0…#255 \0…\255	Data byte with the specified decimal value.
ADDR	Device address (left-filled with spaces).
CS2	Modulus-256 checksum of message sent so far, hexadecimal format.
CS4	Modulus-65536 checksum of message sent so far, hexadecimal format.
CSX	NMEA XOR checksum of message sent so far, hexadecimal format
ERR	Currently active transmitter errors in a four bit field. 0 = no error, 1 = error. bit1 = Temperature measurement (T meas error) bit2 = Not used bit3 = Humidity measurement (F meas error) bit4 = Internal error (Program flash check sum error)
SN	Device serial number.
TIME	Time since transmitter startup in format *hh:mm:ss*.

Checksums are calculated as described in the equations below.

$$1 \quad = \quad cs_2 = \sum_{i=1}^{n} b_i \bmod 256$$

$$2 \quad = \quad cs_4 = \sum_{i=1}^{n} b_i \bmod 65536$$

$$3 \quad = \quad cs_x = b'_1 \oplus b'_2 \oplus \ldots \oplus b'_n$$

$$b'_i = b_i \quad if \; b_i \neq 36 \, and \, b_i \neq 42$$

$$b'_i = 0 \quad if \; b_i = 36 \, or \, b_i = 42$$

Table 7   Symbols Used in FORM Checksum Equations

Symbol	Description
cs_2	Value of CS2 checksum in the output message.
cs_4	Value of CS4 checksum in the output message.
cs_x	Value of CSX checksum in the output message.
b_i	Value of the byte at position i (1-based) in the output message.
n	Number of bytes in the output message before the CS2, CS4, or CSX field (including earlier checksum fields, if any).
$\oplus$	Bit-wise exclusive-or operator.
36	Byte value of ASCII $ character.
42	Byte value of ASCII * character.

Select Unit

Use the **UNIT** command to select metric or non-metric output units.

UNIT [*x*]<cr>

where

x   =   M or N

where

M   =   Metric units
N   =   Non-metric units

Set Serial Interface Mode

Use the **SMODE** command to set the default serial interface mode.

SMODE [*xxxx*]<cr>

where

xxxx = STOP, RUN or POLL

In STOP mode: measurements output only by command SEND, all commands can be used

In RUN mode: outputting automatically, only command S can be used to stop.

In POLL mode: measurements output only with command SEND [*addr*].

When several transmitters are connected to the same line, each transmitter must be entered an own address in the initial configuration, and POLL mode must be used.

Configuring Measurement Parameters

Select Analog Output Parameter and Scaling

Select and scale the parameters for the analog outputs with the **ASEL** command. Note that the optional parameters can be selected only if they have been selected when ordering the device.

ASEL [*xxx yyy*]<cr>

where

xxx = Parameter of channel 1
yyy = Parameter of channel 2

Always enter all the parameters for all outputs. The MMT162 measures the following parameters:

- water activity (aw)
- temperature (T) (metric unit: ºC, non metric unit: ºF)
- ppm for transformer oil only (H_2O)

Example:

```
asel
Ch0 aw   lo    :      0.00   ?
Ch0 aw   hi    :      1.00   ?
Ch1 T    lo    :    -20.00  'C ?
Ch1 T    hi    :     80.00  'C ?
```

Set Analog Output Mode (mA/V)

The **AMODE** command can be used to change the analog output mode of channels 1 and 2. When used without parameters it displays the current settings and with parameters new settings can be set. The available parameters are listed in Table 8 below.

Table 8   **Analog Output Modes**

Parameter	Output mode
1	0 … 20 mA
2	4 … 20 mA
4	0 … 5 V
5	0 … 10 V
6	LED alarm
7	Current alarm
8	Voltage alarm

Example:

```
amode 1 2
Ch1 output      : 0 ... 20 mA
Ch2 output      : 4 ... 20 mA
```

Calibrate Analog Output

Use the **ACAL** command to adjust analog output channels.

ACAL [*channel*]<cr>

where

channel = Analog output channel to be adjusted, 1 or 2.

After entering the **ACAL** command, use a calibrated current/voltage meter to measure the output, and enter the values.

Example:

```
acal 1
Ch1    U1 ( V  ) ? 1.001
Ch1    U2 ( V  ) ? 9.011
acal 2
Ch2    U1 ( V  ) ? 0.0988
Ch2    U2 ( V  ) ? 0.8997
```

Set Malfunction Alarm Output for Analog Channels

Use the **AERR** command to set the analog output levels that are output in case of a device malfunction. The default output level is 0.

AERR<cr>

Example:

```
aerr
Ch1 error out  : 10.000V ? 0
Ch2 error out  : 1.000V ? 0
```

NOTE	The error output value must be within a valid range of the output mode.

NOTE	The error output value is displayed only when there are minor electrical faults such as a humidity sensor damage. When there is a severe device malfunction, the error output value is not necessarily shown.

Set Alarm Limits and LED Indication for Analog Outputs

Use the **ALARM** command to set the analog output alarm limits and parameters. For an explanation of the alarm limits, see section Limit Alarm on page 22.

ALARM<cr>

Before setting the alarm limits, verify the currently set analog output modes using the **AMODE** command.

The following example shows that a high limit alarm has been enabled for channel 2. If the measured value rises above the limit (0.90 a_w), an error is reported. If you are using a LED cable, the LED lights up to indicate an error state.

Example:

```
alarm ?
Channel 1:
Low Limit       :       OFF
High Limit      :       OFF
Aerr            :        ON
Quantity        :         T
Limit Lo        :     15.00
Limit Hi        :     30.00
```

```
Hysteresis      :      0.50
Level Lo        :      0.20
Level Hi        :      0.80
Channel 2:
Low Limit       :       OFF
High Limit      :        ON
Aerr            :       OFF
Quantity        :        aw
Limit Lo        :      0.10
Limit Hi        :      0.90
Hysteresis      :      0.01
Level Lo        :      0.20
Level Hi        :      0.80
```

Set Voltage for LED Alarm

With the **LED** command, you can set a different voltage level for each channel.

LED<cr>

Example:

```
led ?
Ch 1 Led Voltage    :     2.80 V
Ch 2 Led Voltage    :     2.80 V
```

Extend Analog Output Range

Use the **AOVER** command to allow the analog output channels to exceed their specified range by 10 %. The scaling of the parameter remains as before; the extra range is used for additional measurement range in the wet end.

AOVER [*ON/OFF*]<cr>

Example:

```
aover on
                : ON
```

Serial Line Output Commands

Start Measurement Output

Use the **R** command to start the continuous outputting of measurement values as an ASCII text string to the serial line. The format of the measurement message is set with the **FORM** command.

R<cr>

Example:

```
r
aw=    0.261 T= 23.8 'C H2O=    15 ppm
```

You can change the format of the output with the following commands:

- Outputting interval can be changed with the **INTV** command.
- Output message format can be changed with the **FORM** command**.**

Stop Measurement Output

Use the **S** command to end the RUN mode. After this command all other commands can be used. You can also press the **Esc** button or reset the transmitter to stop the outputting.

S<cr>

Since the interface is half-duplex, you must enter the command when the transmitter is not outputting. Give the command again if the transmitter continues to output measurement messages.

Set Output Interval

Use the **INTV** command to set or display the output interval.

INTV [*n xxx*]<cr>

where

n   =   time interval = 0 ... 255
xxx   =   time unit = "S", "MIN", or "H"

Example:

```
intv 1 min
Output interval:    1 MIN
```

The shortest output interval (with n = 0) is approximately one second due to the internal measurement cycle.

Output Reading Once

Use the **SEND** command to output the reading once in STOP mode.

The output format depends on which parameters the transmitter can output.

SEND [*aaa*]<cr>

where

aaa = Transmitter address (0 ... 255). Must be specified if the transmitter is in POLL mode, and a line has not been opened using the **OPEN** command.

Example:

```
send
T= 25.2 'C aw=   0.299 H2O=    19 ppm  RS= 29.9 %
```

Troubleshooting Commands

Display the Currently Active Errors

Use the **ERRS** command to display the currently active transmitter error states. Possible errors and their causes are listed in Table 9 on page 49.

ERRS<cr>

Example:

```
errs
No errors
```

Test Analog Outputs

The operation of the analog outputs can be tested with the **ATEST** command by forcing the output to a given value which can then be measured with calibrated multimeter. The command uses the currently selected analog output types for the channels (voltage or current) so you do not have to specify the unit.

Before testing, you can verify the currently set analog output modes using the **AMODE** command. After testing the output, give the **ATEST** command again to exit the test mode.

ATEST [*xxx yyy*]<cr>

where

xxx   =   Channel 1 output value (V or mA)
yyy   =   Channel 2 output value (V or mA)

The output shows the test values of the analog channels, and diagnostic information that may be useful to Vaisala Service if there is a problem with the analog outputs.

Example:

```
atest 1 15
    1.00      2660
   15.00     19425

atest
    0.00        79
    0.00     20110
```

Other Commands

Opening the Transmitter in POLL Mode

Use the **OPEN** command to connect to a transmitter that is in POLL mode.

OPEN [*aaa*]<cr>

where

aaa   =   address (0 ... 255)

Example:

```
open 0
MMT162   0 line opened for operator commands
```

Closing the Connection to a Transmitter in POLL Mode

The **CLOSE** command closes the connection to the transmitter.

CLOSE<cr>

Example:

```
close
line closed
```

Display Command List

Use the **HELP** command to list the available commands.

HELP<cr>

Example:

```
help
?
??
ACAL
ADDR
ADJD
AERR
ALARM
AMODE
AOVER
ASEL
ATEST
CDATE
CLOSE
CRH
CT
CTEXT
ERRS
FILT
FORM
FRESTORE
HELP
INTV
L
LED
OIL
OILI
OPEN
PCOMP
PRES
R
RESET
SDELAY
SEND
SERI
SMODE
UNIT
```

Reset Transmitter

When the **RESET** command is given, the transmitter will restart as if it had just been powered on. All transmitter settings are retained. The serial line mode of the transmitter will be set to the mode that was set using the **SMODE** command.

RESET<cr>

Restore Factory Settings

Use the **FRESTORE** command to restore the factory settings to the transmitter. All user settings will be lost.

FRESTORE<cr>

ppm Conversion

MMT162 ppm Conversion for Transformer Oils

Traditionally, moisture in transformer oil is measured by using ppm units. The ppm output shows the average *mass concentration of water* in oil.

The moisture and temperature transmitter MMT162 has an option for ppm-output provided that this has been notified when placing the order for the transmitter. Vaisala has this conversion readily available for mineral transformer oils.

Conversion Model with Average Coefficients

The conversion model of the MMT162 is based on the average water solubility behaviour of transformer oils. The ppm-output is calculated as follows:

$$\mathbf{ppm = aw \times 10^{(A/(T+273.16)+B)}}$$

where

aw   =   water activity
A,B =   coefficients (average/oil-specific)
T   =   temperature (ºC)

Generally, measurements with MMT162 give accuracy better than 10 % of the reading. If additional accuracy is needed, refer to section Conversion Model with Oil-specific Coefficients below.

Conversion Model with Oil-specific Coefficients

For additional accuracy, oil-specific conversion model can be used both for mineral and silicon based oils. An oil sample has to be sent to Vaisala for modelling. As a result, the specific coefficients (A and B) for the transformer oil are determined by Vaisala. For additional information, please contact Vaisala.

The determined coefficients of the transformer oil can be programmed to the MMT162 by Vaisala or by a user according to the instructions presented in this chapter.

NOTE	Conversion model with oil-specific coefficients is always needed for **silicone based oils.**

Setting Oil Coefficients Using Serial Line

If the ppm conversion and oil-specific coefficients have been programmed at Vaisala, you do not have to set the conversion co-efficients.

If you have defined the coefficients or separately received from Vaisala the oil-specific coefficients A and B, related to your own oil type, the coefficients can be set to the software of MMT162 by using serial line.

OIL

Use the serial line command **OIL** to display oil-specific parameters for ppm conversion. With **OILI** command you can set new oil parameters.

Example:

```
oil
Oil[0]    :   -1.66269994E+03
Oil[1]    :    7.36940002E+00
Oil[2]    :    0.00000000E+00
```

where

Oil [0]   corresponds to parameter A
Oil [1]   corresponds to parameter B
Oil [2]   Corresponds to parameter C

Determination of Oil-Specific Coefficients

The equation of the ppm calculation is:

ppm = aw×10$^{(B+A/T)}$

With the following procedure the coefficients A and B can be defined for the equation:

LOG(PPM$_{sat}$)= B + A/T

Equipment needed:

- Apparatus for determining water content (for example, coulometric titrator and e.g. magnetic stirrer.)
- Oil test station:
    - a temperature test chamber.
    - a suitable container (for example, a conical 1 L flask) sealed by PTFE stopper with an inlet for a moisture probe.
    - a MMT162 transmitter by Vaisala.
    - a magnetic stirrer.

Procedure:

1. Define the water content of the oil sample with the titration. Use the oil moisture level that is close to real conditions in the process.
2. Measure the water activity of this sample with MMT162 at two temperatures that differ at least 20 °C.

NOTE	The sample has to be sealed very carefully. Contact with ambient air will change the water content.

NOTE	If the oil sample is very dry and the temperatures are close to each other, it may cause inaccuracy to the calculation model. In order to get the best possible performance it is recommended to use oil conditions that represent real conditions in application. Recommended values for sample are aw approx. 0.5 at 20 °C.

3.   Define the correlation between aw, T and PPM (w/w) from the measured values. Calculate A and B according to the following example.

$$A = \frac{LOG(PPM_{sat}[T2]) - LOG(PPM_{sat}[T1])}{1/(T2) - 1/(T1)}$$

$$B = LOG(PPM_{sat}[T1]) - A/T1$$

Example (measured water content 213 ppm):

T (°C)	aw	ppm_saturation
24.1	0.478	213/0.478 = 445.6067
57.6	0.188	213/0.188 = 1132.979

A = (LOG(1132.98)-LOG(445.607))/(1/(57.6+273.16)-1/(24.1+273.16)) = -1189.4581

B= LOG(445.607)-(-1189.4581)/(24.1 + 273.16) = 6.6503583

Assumptions:

The isoterm of water activity versus water concentration is linear and the solubility curve has the form of the given equation.

CHAPTER 5
MAINTENANCE

This chapter provides information that is needed in basic maintenance of the product.

Cleaning

Clean the transmitter enclosure with a soft. lint-free cloth moistened with mild detergent.

Clean the sensor before storing the MMT162 probe and before calibration. For cleaning the the probe you need instrument air and heptane (C_7H_{16}) liquid. If heptane is not available, you can also use diesel oil or petrol. Dry with instrument air to prevent oxidation of the oil on the sensor. The oxidation of the oil on the sensor can cause extended response times or drifting.

1. Blow the probe head (with filter) with instrument air to remove the remains of oil.
2. Immerse the probe head into heptane liquid and rinse out the oil (for one minute maximum).
3. Dry the probe head with instrument air. In case you are going to calibrate the probe, remove the filter and dry the sensor with instrument air. Check that the sensor looks clean.

NOTE	Do not immerse the sensor in any polar solvents, for example ketones or alcohols.

Changing the Filter

1.   Remove the filter from the probe.

2.   Install a new filter on the probe. When using the stainless steel filter (for oil and fuel cell), take care to tighten the filter properly (recommended force 130 Ncm).

New filters can be ordered from Vaisala, see section Spare Parts and Accessories on page 61.

Changing the Sensor

If you need to change the sensor on your MMT162, send it to Vaisala where the sensor will be changed for you.

Error States

MMT162 has the following states that indicate a problem with the probe:

-   Analog 4 - 20 mA current output at 0 mA
-   Analog voltage output at 0 V
-   Serial line outputs asterisk characters (*** **)

The asterisk characters on the serial line may also appear during the start-up procedure.

You can also check the error message via the serial interface by using the **ERRS** command. In case of constant error, please contact Vaisala; see section Technical Support on page 50.

Table 9   Error Messages

Error Message	Action
Voltage error	Internal error or invalid supply voltage.
T meas error	Internal error, can be caused by damage to the temperature sensor.
F meas error	Internal error, can be caused by damage to the HUMICAP® sensor.
Voltage too low error	Supplied operating voltage is too low for reliable operation.
Voltage too low for mA output	Supplied operating voltage is too low for reliable operation of the analog current output.
Voltage is too low for V output	Supplied operating voltage is too low for reliable operation of the analog voltage output.
Program flash check sum error	Internal error
Parameter check sum error	Internal error
INFOA check sum error	Internal error
SCOEFS check sum error	Internal error
CURRENT check sum error	Internal error

Unknown Serial Settings

If you are not sure what the current serial settings of your transmitter are, follow the steps below to connect to the transmitter. This procedure assumes you have the USB service cable available.

For more information on the USB service cable and the PuTTY terminal application, see section Serial Communication on page 22.

1. Connect the USB service cable to your PC, but do not connect it to the transmitter yet.
2. Start a terminal application and open a terminal session using the default serial settings of 19200 8 N 1.
3. Plug the USB service cable into the transmitter, and quickly send at least one hash character # to the serial line:

    #

4. The normal startup of the transmitter is now interrupted, and the transmitter is available for commands with the default serial settings. You can now check the transmitter's information by issuing the **?** command:

    ?

    The transmitter's currently stored serial settings are visible on the line marked **Baud P D S**.

Technical Support

For technical questions, contact the Vaisala technical support by e-mail at helpdesk@vaisala.com. Provide at least the following supporting information:

- Name and model of the product in question
- Serial number of the product
- Name and location of the installation site
- Name and contact information of a technically competent person who can provide further information on the problem.

Product Returns

If the product must be returned for service, see www.vaisala.com/returns.

For contact information of Vaisala Service Centers, see www.vaisala.com/servicecenters.

CHAPTER 6
CALIBRATION AND ADJUSTMENT

This chapter provides information that is needed in calibration and adjustment of the product.

The MMT162 is fully calibrated and adjusted as shipped from factory. The calibration interval depends on the application. It is recommended that calibration is done always when there is a reason to believe that the device is not within the accuracy specifications.

You can calibrate the MMT162 yourself or send it to Vaisala for calibration. Calibration and adjustment is usually carried out through serial line. One-point calibrations and adjustments can also be done by using an MI70 indicator and Vaisala humidity calibrator HMK15.

Before the calibration, the used sensor needs to be cleaned with instrument air to blow out existing oil or gently first flush with hepthane (C_7H_{16}) and dry with instrument air to decrease response time, see section Cleaning on page 47.

NOTE	It is important to clean the sensor before calibration as the oily sensor can contaminate the salt bath and change the reference condition.

Vaisala HUMICAP® hand-held moisture and temperature in oil meter MM70 can also be used for calibration.

MM70 in Checking and Adjusting

MMT162 can be checked and adjusted by using the MM70. In the field you can check and adjust the probe's reading against the calibrated reference probe of the MM70.

To check the MMT162 transmitter with MM70:

1. Connect the MMT162 to the MM70 indicator with the appropriate connection cable (Vaisala item 219980).
2. Turn on the MM70.
3. Prepare the probe for adjustment by opening the adjustment menu on the MM70 (**Menu → Functions → Adjustments**)

NOTE	Make sure that both probes are stabilized to same conditions so that the temperature readings are the same.

4. Press the **OK** key to start adjustment.

One-Point Relative Humidity Adjustment

Note that the humidity reference must be at least 50% RH. The MMT162 must be unpowered during stabilization which can take 30 minutes or more.

Using Serial Line

To adjust the relative humidity:

1. Remove the filter from the probe and insert the probe into a measurement hole of the dry end reference chamber (for example, NaCl: 75 % RH in the humidity calibrator HMK15). Use the adapter fitting.
2. Wait at least 30 minutes for the sensor to stabilize.
3. Connect the MMT162 to a PC, see section Serial Communication on page 22. Then open a terminal program.
4. Enter the **CRH** command and press **ENTER.**

CRH

5. Type **C** and press **ENTER** a few times to check if the reading has stabilized.

6.   When the reading is stable, give the reference humidity after the
   question mark and press **ENTER.**

```
crh
 RH  :     25.21  Ref1 ?
 RH  :     25.22  Ref1 ?
 RH  :     25.22  Ref1 ? 30.1
 Press any key when ready ...
 RH  :     25.19  Ref2 ?
OK
```

7.   OK indicates that the adjustment has succeeded and the new
     calibration coefficients are calculated and stored.

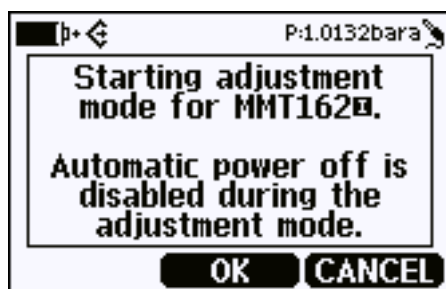8.   Take the probe out of the reference conditions and replace the
     filter.

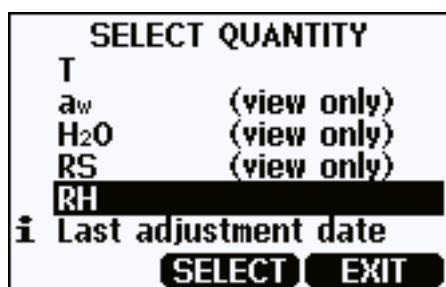# Using MI70

To adjust the relative humidity:

1.   Connect MI70 to MMT162.

2.   Turn MI70 on.

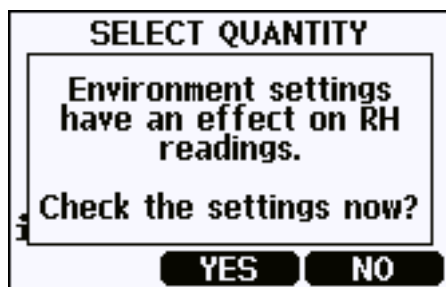3.   On the MI70, go to **Menu → Functions → Adjustments.**
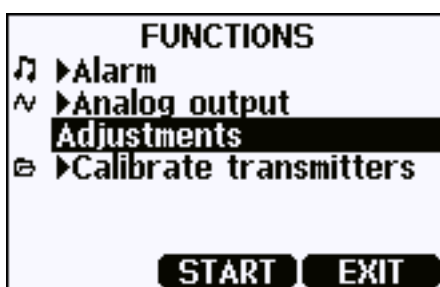
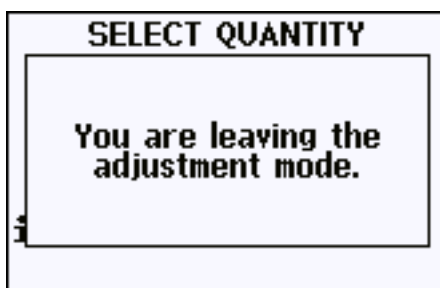4. Follow the instructions given on the display.

5. Select RH from the list and press **Select.**

6. When adjusting relative humidity, you need to check the environment settings before making the adjustment.

7. In adjustment mode, enter the correct reference value and then exit by pressing **Back**.

One-Point Temperature Adjustment

The MMT162 must be unpowered during stabilization which can take 30 minutes or more.

Using Serial Line

1.   Remove the probe filter and insert the probe into the reference temperature.

2.   Enter the command **CT** and press **ENTER**:

   CT<cr>

3.   Type **C** and press **ENTER** a few times to check if the reading is stabilized. Let the reading stabilize, give the reference temperature after the question mark and press **ENTER** three times**.**

   Example:
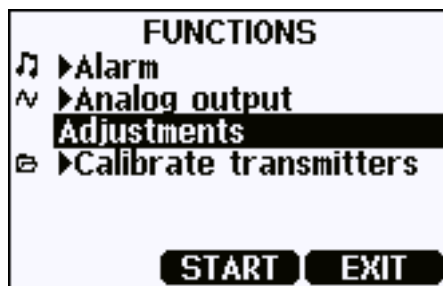
   ```
   ct
    T   :     22.03  Ref1 ?
    T   :     22.03  Ref1 ?
    T   :     22.03  Ref1 ? 25.0
    Press any key when ready ...
    T   :     22.02  Ref2 ?
   OK
   ```

4.   **OK** indicates that the calibration has succeeded.

5.   Take the probe out of the reference conditions and replace the filter.
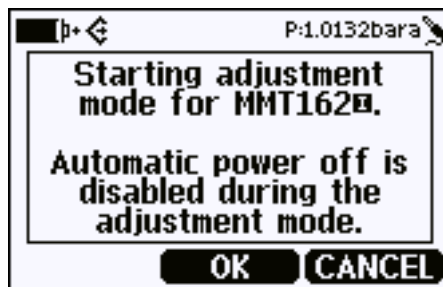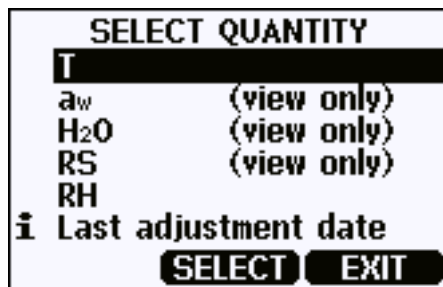
Using MI70

To adjust temperature:

1.   Connect MI70 to MMT162 via connector II.

2.   Turn on MI70.

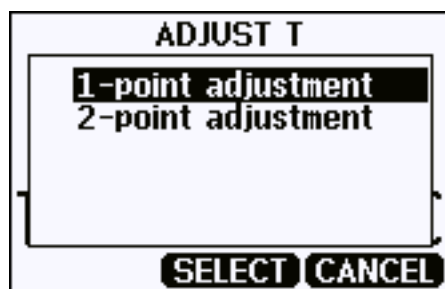3.   On the MI70 display, go to **Menu → Functions → Adjustments**.

4.   Follow the instructions given on the MI70 display.

5.   Select **T** from the list and press **Select.**

6.   Select 1-point adjustment and press **Select**.

        ADJUST T

        1-point adjustment
        2-point adjustment

        SELECT CANCEL

7.   In adjustment mode, enter the correct reference value and then exit by pressing **Back**.

        ADJUSTMENT MODE
        24.1
        T   °C
        GRAPH ADJUST BACK

8.   After you have exited the adjustment mode, MI70 confirms it by displaying the message below.

        SELECT QUANTITY

        You are leaving the
        adjustment mode.
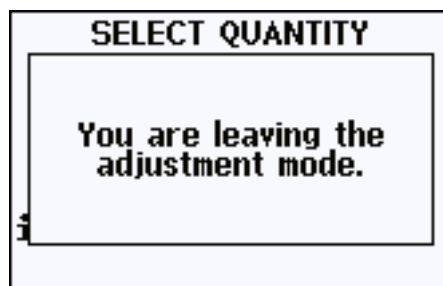
Analog Output Adjustment

In the analog output calibration the analog output is forced to the following values:

- current output: 2 mA and 18 mA

- voltage output: 10 % and 90 % of the range

Connect MMT162 to a calibrated current/voltage meter in order to measure either current or voltage depending on the selected output type.

To calibrate analog output, see section Calibrate Analog Output on page 34.

CHAPTER 7
TECHNICAL DATA

This chapter provides the technical data of the product.

Measured Parameters

Water activity

Measurement range	0 ... 1 (@-40 ... +180 °C/ -40 ... +356 °F)

Accuracy (including non-linearity, hysteresis and repeatability)
When calibrated against salt solutions (ASTM E104-85):

0 ... 0.9	± 0.02
0.9 ... 1.0	± 0.03
Response time in oil flow (typical) with stainless steel filter	< 1 min. (dry-wet)
Sensor	HUMICAP®

Temperature

Measurement range	-40 ... +80 °C (-40 ... +176 °F)
Accuracy at +20 °C (+68 °F)	± 0.2 °C (± 32.36 °F)
Typical temperature dependence of electronics	± 0.005 °C/°C (± 0.003 °F/°F)
Sensor	Pt100 RTD Class F0.1 IEC 60751

Operating Environment

Operating temperature	-40 ... +60 °C (40 ... +140°F)
Pressure range	
metal version	up to 200 bar
plastic version	up to 40 bar
Complies with EMC standard	EN61326-1: Industrial environment
Oil flow	some flow recommended

Inputs and Outputs

|	
Minimum operating voltage	
with current output	22…28 VDC
with voltage output	16…28 VDC
with RS-485	14…28 VDC
Supply current	
normal measurement	20 mA + load current
External load for	
current output	max. 500 Ω
voltage output	min. 10 kΩ
Analog outputs (2 standard)	
current output	0 ... 20 mA, 4 ... 20 mA
voltage output	0 ... 5 V, 0 ... 10 V
Accuracy of analog outputs at 20 °C	± 0.05 % full scale
Temperature dependence of the analog outputs	
current	± 0.005 %/°C full scale
voltage	
Digital output	RS-485

Mechanics

Interface cable connector	M8 series 4-pin (male) with plug (female) with straight or 90° angle connector
Probe cable diameter	5.5 mm
Probe cable lengths	
shielded cables	0.32 m, 3 m, 5 m and 10 m
90° angle cable	2 m and 5 m
LED cable	3 m
Housing material	
metal	AISI 316L
plastic	PPS + 40% GF
Housing classification	IP 65 (NEMA 4)
Mechanical connections	
Option 1	ISO G1/2"
Option 2	NPT 1/2"
Weight	
Metal with ISO thread	200 g
Metal with NPT thread	200 g
Plastic with ISO thread	65 g

# Spare Parts and Accessories

Description	Order code
Connection cable for MM70	219980
USB serial interface cable	219690
CH1 signal + Ch2 LED cable, M8 threaded connector	MP300LEDCBL
Sealing ring set (copper) ISO G1/2, 3 pieces	221524SP
Sealing ring set (U-seal) ISO G1/2, 3 pieces	221525SP
Protection plug for connector	218675
ISO 1/2" plug	218773
NPT 1/2" plug	222507
110 … 240 VAC external power supply	POWER-1
Calibration adapter for HMK15	211302SP
Filters	
Stainless steel grid filter (with 3 mm holes)	225356SP
Stainless steel grid filter for high flow (with 2 mm holes, for > 1 m/s flow)	221494SP
Analog/RS-485 output cables	
0.32 m (1 ft) shielded cable, M8 threaded connector	HMP50Z032
3 m (9.8 ft) shielded cable, M8 threaded connector	HMP50Z300
5 m (16.4 ft) shielded cable, M8 threaded connector	HMP50Z500
10 m (32.8 ft) shielded cable, M8 threaded connector	HMP50Z1000
2 m (9.8 ft) cable, 90° angle connector	221739
5 m (16.4 ft) cable, 90° angle connector	221740
Sampling cells (available only for ISO G1/2")	
Sampling cell	DMT242SC
Sampling cell with 1/4" male Swagelok connectors	DMT242SC2

Dimensions in mm (inches)
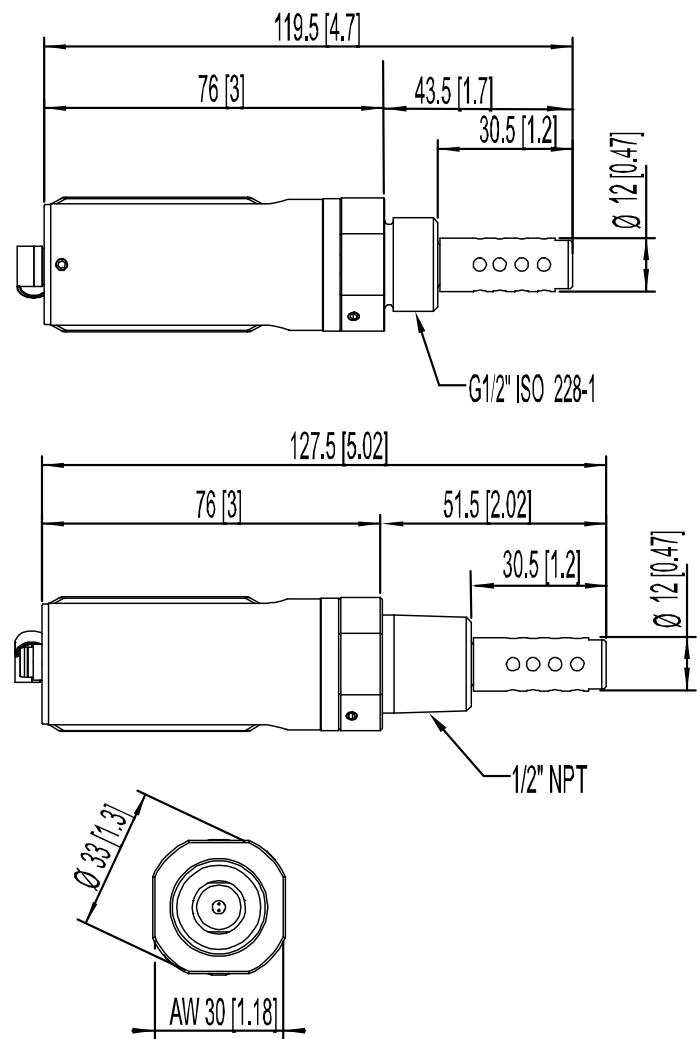
0804-084

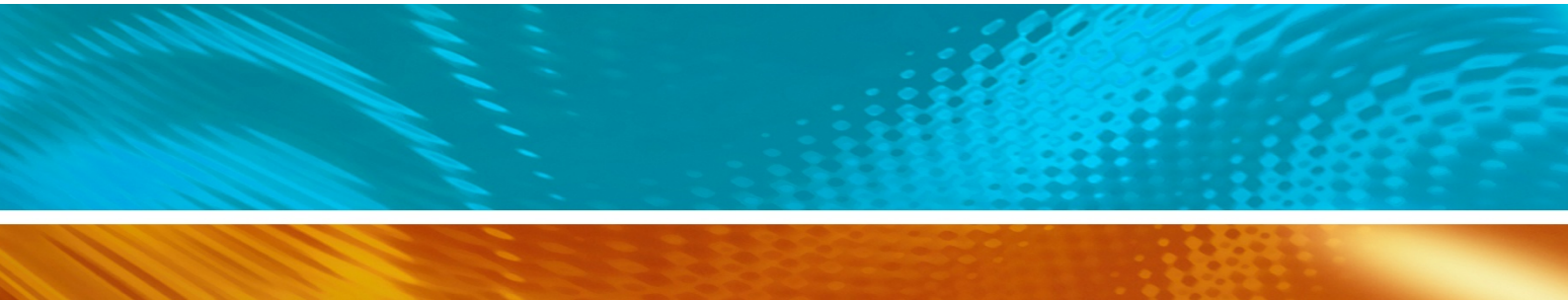**Figure 13   Metal Housing Transmitter Dimensions**
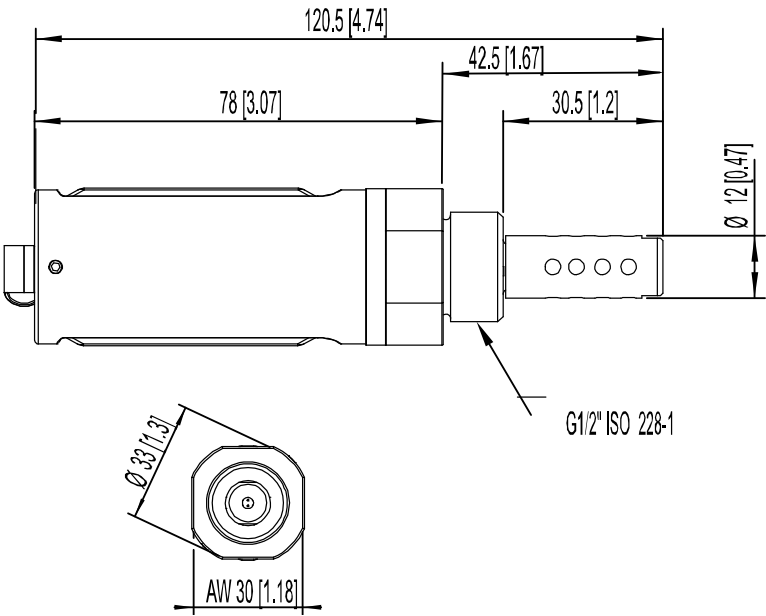
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Figure 14   Plastic Housing Transmitter Dimensions

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