IMKO
MICROMODULTECHNIK GMBH

PRECISE MOISTURE MEASUREMENT

TRIME®-PICO 64/32

User Manual

Silver Medal Innovation Award of the DLG (German Agricultural Society)

Innovation Award of the State of Baden-Württemberg

IMKO
MICROMODULTECHNIK GMBH

Thank you for buying IMKO.

Should you have any queries please
don't hesitate to contact your local
distributor or address directly to IMKO:

IMKO Micromodultechnik GmbH

Im Stoeck 2
D-76275 Ettlingen
Germany

Phone: +49-7243-5921-0
Fax: +49-7243-90856
E-mail: info@imko.de
Internet: http://www.imko.de

Operating instructions for TRIME®-PICO 64/32

status June 2009

List of contents

1 Functional Description

The intelligent and compact TRIME-PICO64/32 sensors are measurement devices for continuous and non-destructive determination of volumetric soil moisture and soil temperature. They are designed for stationary subterranean field use. A variety of installation options (greater depth, vertical or horizontal orientation) offer a wide range of applications.

TRIME-PICO64/32 systems require an external 7-24V/AC power supply. They are designed for connection to a data logger or a PC for monitoring and data logging purposes.

Your sensor is supplied ready for use and works in a wide range of standard soils. For further information please check the details under Section 6!

1.1 Operation modes

TRIME-PICO64/32 systems are supplied with an IMP-Bus interface **and** analogue output of 0..1V for soil moisture and temperature.

TRIME-PICO64/32 sensors can be easily connected to an IMKO GlobeLogger (Operation mode A) **and** conventional analogue data loggers (operation modes B and C).

A detailed description of how to select a specific operation mode for your application can be found below.

***PLEASE NOTE:* Analogue dataloggers require differential inputs!**

1.1.1 Operation mode A (Bus communication)

TRIME-PICO64/32 systems can be connected directly to the IMP-Bus (4-wire bus system), either via IMKO's GlobeLog datalogger or via the SM-23U level converter module for use in conjunction with the EnvisLog data-logging software.

If multiple sensors are to be wired as a network, IMKO offers 3-port, 6-port and 12-port distribution modules. Please note that the IMP-Bus cable length and cable diameter must be properly matched as otherwise the energy consumption of the TRIME sensors (100mA @ 12V/DC for 2..3s) may cause a drop in voltage. *More information is available in Section 5.*

- Benefits:
  - Extremely low power consumption in field installations (with GlobeLogger)
  - Straightforward installation and simple wiring by virtue of pre-configured standard components (e.g. lightning protection, distribution modules…)
  - Attachment of any other analogue sensors to IMP-Bus (via SM-Modules)
  - Systems are supplied ready for use
  - Cable length >1000m (with only 4 wires for all sensors)
- For use with:
  - GlobeLogger
  - EnvisLog (PC-Software for Microsoft Windows) only with converter module
  - IMKO calibration and test software TrimeTool (see www.imko.de) only with converter module

1.1.2 Operation mode B (Single measurement)

TRIME-PICO64/32 will perform a single measurement when the power is switched on. Once the measurement has been taken (2..3s) the readings are supplied as analogue output signals until the power is switched off. The probe switches to the energy-saving mode (>1mA) and takes no more measurements until the power has been switched off.

- Benefits:
  - Low power consumption in field installations
  - Easy control of the measurement rate from an external source
  - No implementation of commands necessary
- For use with:
  - Switched power supply
  - Analogue data loggers with relay
  - PC A/D converter boards with relay

1.1.3 Operation mode C (Cyclic measurement)

TRIME-PICO64/32 takes measurements at a freely configurable measurement rate (from 8s..24h). Once the measurements have been taken (2..3s) the measured values are supplied as analogue output signals. Until the next measurement is finished, the values of the previous measurement are available as analogue signal. In standby until the next measurement is executed the probe consumes 8..10mA @ 12V/DC.

- Benefits:
  - Probe can be supplied with mains power
  - Measurement rate can be specified as required (even independent from logging rate of analogue logger)
  - No implementation of commands necessary
  - Non-intelligent logger can be used (without power management)
- For use with:
  - Mains power
  - Analogue data loggers with mains power
  - PC A/D converter boards

The operation mode is preset to customer specifications prior to despatch. Reconfiguration is possible using the complementary software TrimeTool (download under http://www.imko.de).

1.1.4 PC connection

The TRIME-PICO64/32 can be connected to a PC via:

- SM-23U IMP-Bus → RS232 converter module
- BT-Module IMP-Bus → Bluetooth converter module (available from Quarter 4 2008)
- SM-USB IMP-Bus → USB converter module (available from Quarter 1 2009)

1.2 External power supply

In the IMP-Bus the power to sensors can be supplied by battery, a complete solar system or mains power. For serial connection of a large number of sensors or long IMP232-bus cables it is advisable to use a power amplifier module (SM-23LV) or decentralised power supply.

1.3 Installation hints

Please assure careful installation of the probes with close contact between rod and soil. It is important to avoid air pockets around the rods as the highest measuring sensitivity is directly around them.

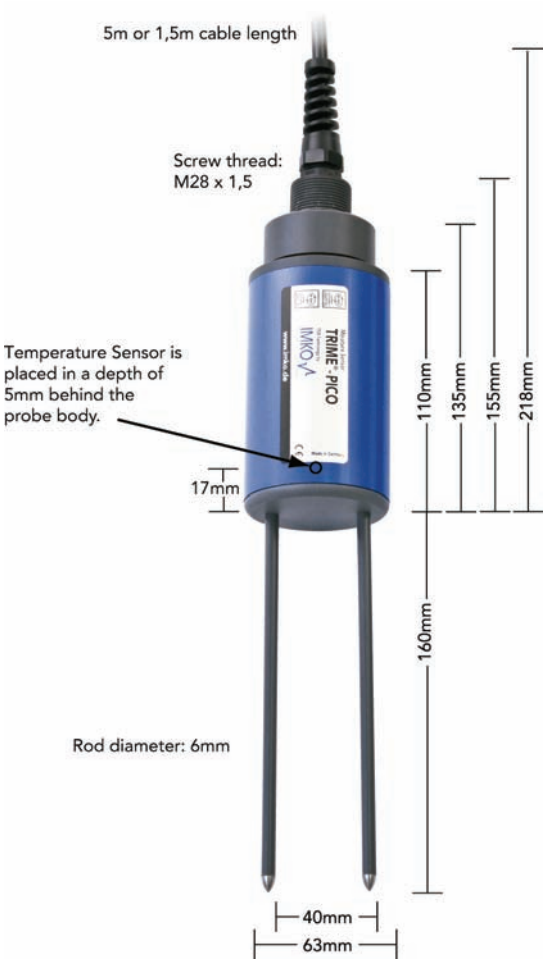
Air pockets around the probe rods can reduce the measured moisture reading. Where saturated soils are involved, water-filled air pockets will result in an exaggerated reading.

IMKO supplies pre-drilling sets for an optimal preparation of the installation point avoiding compaction of soil otherwise caused by the insertion of the rods.

2 Technical Data

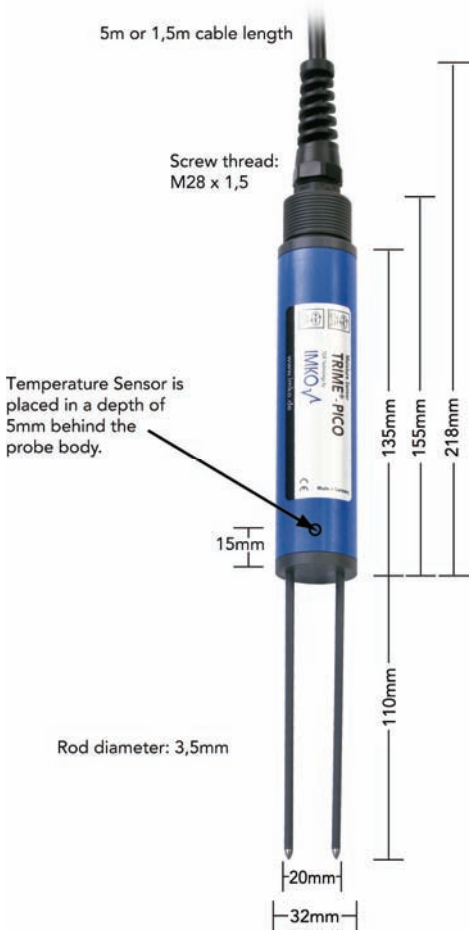
2.1 TRIME-PICO64

For in situ monitoring of volumetric moisture in soils. The large measuring volume is particularly suitable for applications in heterogeneous and skeletal media. Burying capability for both horizontal and vertical orientation.



2.2 TRIME-PICO32

For in situ monitoring of volumetric moisture in soils. The small measuring volume permits high spatial resolution. Burying capability for both horizontal and vertical orientation.



	TRIME®-PICO64			TRIME®-PICO32		
Power supply:	7V..24V-DC					
Power consumption:	100mA @ 12V/DC during 2..3sec. of measuring					
Moisture measuring range:	0..100% volumetric water content					
Accuracy (in % volumetric water content):						
conductivity range:	0..6dS/m	6..12dS/m	12..50dS/m	0..6dS/m	6..12dS/m	12..50dS/m
Moisture range 0..40%:	±1%	±2%	with material specific calibration	±1%	±2%	with material specific calibration
Moisture range 40..70%:	±2%	±3%		±2%	±3%	
Repeating accuracy:	±0.2%	±0.3%		±0.2%	±0.3%	
Temperature caused drift of electronics (full range):	±0.3%					
Soil temperature measuring range:	-15°C...50°C					
Soil temperature measuring accuracy:	±0,2°C					
Measurement volume:	1,25L ≙ 160x100mm diameter			0,25L ≙ 110x50mm diameter		
Operating Temperature:	-15°C...50°C (extended temperature range on request)					
Calibration:	Calibration for a wide range of standard soil types (in accordance with Topp (equation))					
	standard calibration for most soils, customizable material specific calibration, storage of up to 15 user defined calibration curves, calibration of dielectric permittivity is *possible*			standard calibration for most soils, customizable material specific calibration, storage of up to 15 user defined calibration curves, calibration of dielectric permittivity is *available*		
Probe body:	waterproof sealed PVC (IP68)					
Size:	155 x Ø63mm			155 x Ø32mm		
Rod lenght:	standard: 160mm			standard: 110mm		
Rod diameter:	6mm			3,5mm		
Interfaces:	IMP-BUS RS485 Analogue output: 2x 0..1V, 0(4)..20mA[1] 0..100% vol. water content -40..+70°C soil temperature					
Option 1 (RS485 & analogue):	1,5m cable with 7-pin female connector					
Option 2 (IMP-BUS):	5m cable with 4-pin female connector					
Option 3 (all interfaces):	5m cable with end splices (all interfaces)					

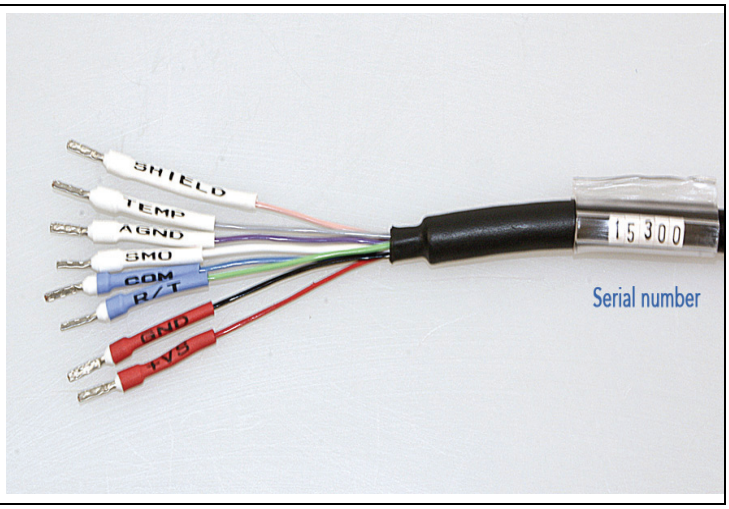
Optional available for cable extension: E-BOX (cable extension box)

[1]Optional available for cable extension and current output: C-BOX (0..1V to 0(4)..20 mA converter box)

3 TRIME-PICO64/32 Versions:

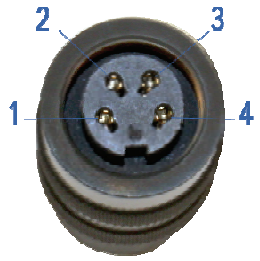
3.1 PICO DataLogger cable 5m with end splices (Item no.: 300082)

Wiring:	
Pink:	Shield
Grey:	0..1V = -40..+70°C soil temperature
Violet:	AGND
White:	0..1V = 0..100% vol. water content
Blue:	COM (IMP-Bus)
Green:	R/T (IMP-Bus)
Black:	GND
Red:	+Vs



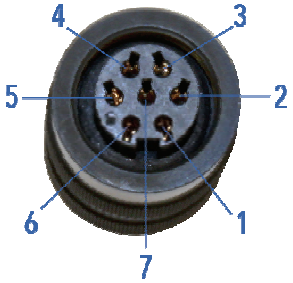
3.2 PICO IMP-Bus cable 5m, 4-pin female connector (Item no.: 300080)

Pin layout:	
Pin 1:	+Vs
Pin 2:	R/T (IMP-Bus)
Pin 3:	GND
Pin 4:	COM (IMP-Bus)



3.3 PICO TRIME-HD cable 1.5m, 7-pin female connector (Item no.:300081)

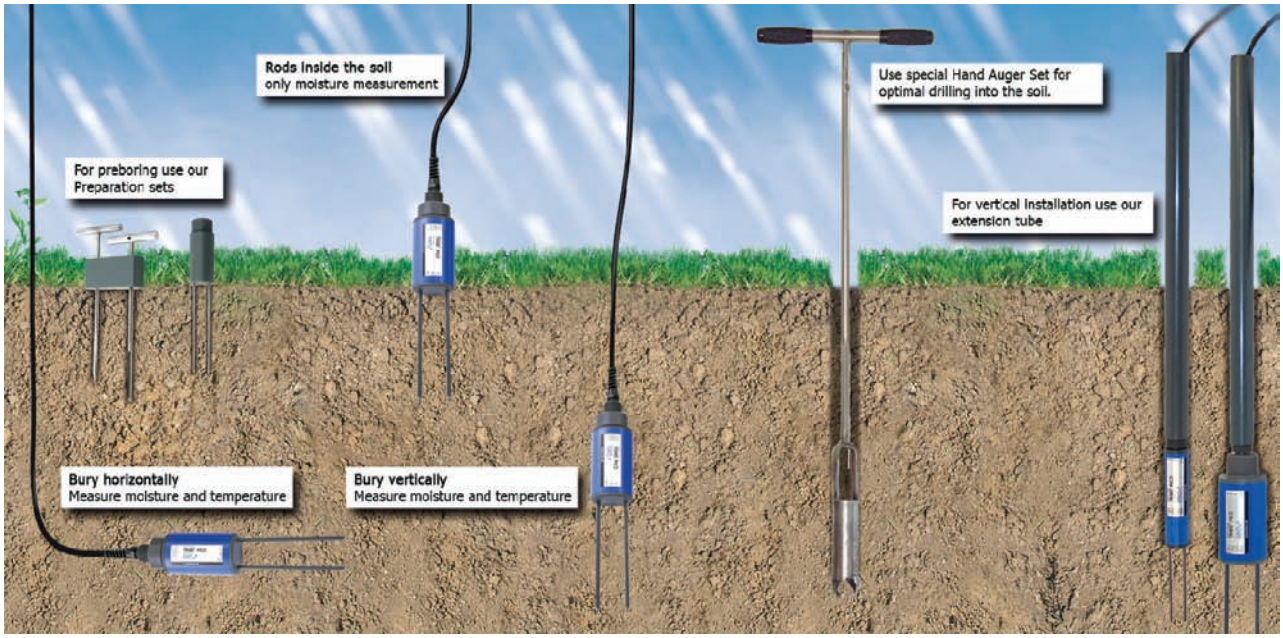
Pin layout:	
Pin 1:	+Vs
Pin 2:	R/T (IMP-Bus)
Pin 3:	GND
Pin 4:	COM (IMP-Bus)
Pin 5:	0..1V = 0..100% vol. soil water content
Pin 6:	AGND
Pin 7:	0..1V = -40..+70°C soil temperature



List of abbreviations:	
+Vs: + Voltage supply (7..24V/DC)	COM: Common (ground for IMP-Bus)
GND: Ground (for voltage supply)	AGND: Analogue ground
R/T: Receive/Transmit (on IMP-Bus)	

4 Installation details:

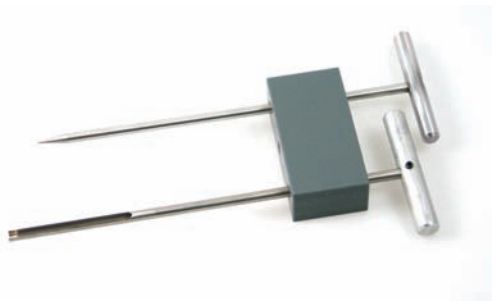
4.1 Temperature measurement:



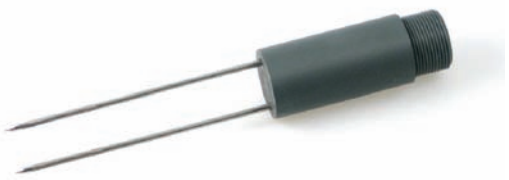
Conclusion: the probes should be permanently buried in the soil for optimum temperature measurement!

4.2 Installation equipment:

4.2.1 Preparation set for TRIME-PICO64

For preboring the soil prior to probe insertion. 1 x spike 1 x core drill 1 x PVC block Item no.: 302035	

4.2.2 Preparation set for TRIME-PICO32

For preboring the soil prior to probe insertion. Rod length: 110mm. Item no.: 302023	

For compacted, coarse or stony soil use the preparation set to bore a pilot hole!

Preboring using the preparation rods for PICO32 and PICO64 avoids

- compaction of soil (which would impair measurement accuracy)
- damaging the probe's rods or rod tips. A defective PVC rod coating or a blank rod is sensitive to electromagnetic charge and may destroy the electronics of sensor.

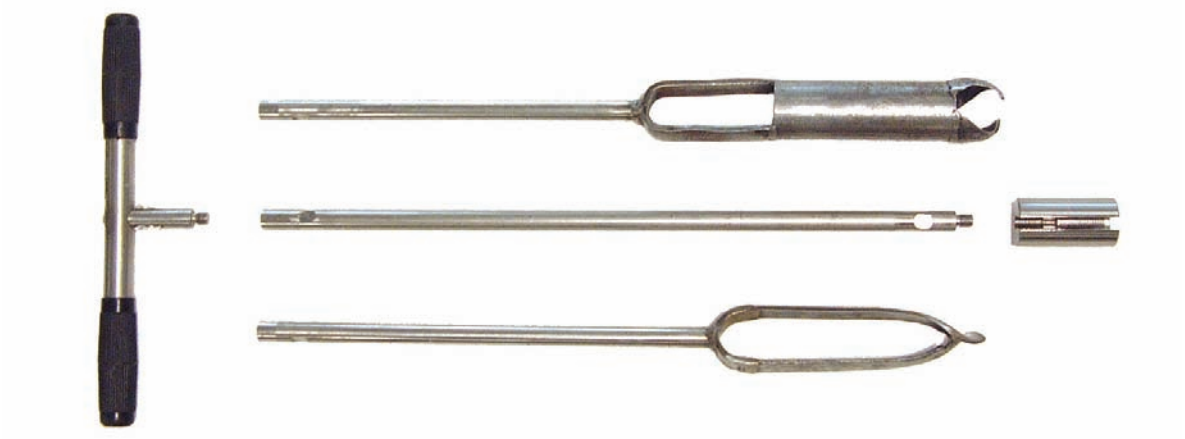
4.2.3 Extension tubes for TRIME-PICO64 & TRIME-PICO32

Length 0.5m: Item no.: 302014

Length 1.0m: Item no.: 302015

4.2.4 Hand Auger Set for TRIME-PICO64 & TRIME-PICO32

Please contact us for further details.



5 Remote Power Supply to TRIME-PICO

The operation of TRIME sensors may cause problems when power has to be supplied via long cables. There are limitations to the maximum cable length depending on the cable diameter.

When power is supplied over long distance the maximum cable length depends on the cable cross section ***A***, the supply voltage V_s and the number ***n*** of the sensors measuring simultaneously. Device-specific data also be applied to the formula:

Power consumption during measurements:	I_{norm}	=	100mA @ 12V/DC
Power consumption at min. voltage:	I_{max}	=	175mA @ 7V/DC
Supply voltage:	V_s	=	12V
Minimum sensor voltage at circuit end:	V_{min}	=	7V
Wire cross section:	A	=	0,34mm²
Specific electrical resistance of copper:	ρ	=	0.0178Ω x mm² / m
Number of sensors:	n	=	1…

The maximum possible circuit length I_{max} can then be calculated in the following manner:

$$l_{\max} = \frac{A \cdot (V_s - V_{\min})}{2 \cdot \rho \cdot n \cdot I_{\max}}$$

Please see the following the following example:
In the IMP232 environmental measurement system a bus cable with a wire cross section of A = 0.34 mm^2 is normally used. We further assume that the power supply voltage is V_s =12 V and only one sensor is designated to measure. Thus n = 1.

$$l_{\max} = \frac{0.34mm^2 \cdot (12V - 7V)}{0.0356\Omega \frac{mm^2}{m} \cdot 1 \cdot 0.175A} = 270m$$

In the above calculation, no tolerance is included; for security reasons the calculated cable length should be reduced by 10% to obtain a realistic value.

In order to increase the maximum possible cable length several solutions are feasible.

1. Using cables with larger conductor diameters
   By using 6-core conductor cables instead of 4-core, the cable length can be doubled as two extra cores can be used for power supply. Cables with conductors of larger diameters will further increase the maximum cable length possible.
2. Increasing the power supply voltage
   Power supply voltage can be increased up to 17V, thereby raising the maximum length from 270m to 540m in the example calculation above.
3. Installation of buffer batteries in the distributor
   Additional storage batteries close to the TRIME sensors, e.g. in the distributor, allow cable lengths up to 1km and enable simultaneous measurement of several sensors. However, this method requires an additional charging circuit for the buffer storage battery.
4. Installation of a voltage regulator at the distributor
   Voltage loss in the cable can be reduced with a 30V power supply and an installation of a voltage regulator directly in front of the TRIME sensor, thus allowing circuit lengths of up to 1km.

Which solution is best suited mainly depends on the nature of the power supply of the measurement system:

- **Battery supply**: solution 1 and possibly solution 3 should be considered, the latter being relatively expensive.
- **Mains supply**: solutions 1 and 2 could be combined, or, more expensive, solutions 2 or 4 could be chosen.

6 Basic Calibration with the Calibration Set

6.1 What is a basic calibration?

Basic calibration serves to compensate the cable length and tolerances of the probe mechanics (thickness of the rod coating, rod length, etc.). After two measurements, one in dry and one in water- saturated glass beads, the calibration data is calculated and stored in the TRIME sensor.

Every TRIME-PICO64/32sensor must be calibrated before it can supply proper measurement results. **Basic calibration is carried out by IMKO in the factory prior to shipment.**

6.2 What are the benefits of the calibration set for the user?

With the calibration set you can easily carry out basic calibration of your TRIME sensor yourself.

- If defective probe rods must be changed, you can perform the required basic calibration yourself.

The calibration set **cannot** be used for establishing a material (soil) specific calibration. For this purpose a measurement dataset must be created for the specific material. The complementary calibration program ***TRIME-Tool*** is required to calculate the calibration data for this dataset and to download it to the TRIME-PICO-Probe.

6.2.1 Calibration set for TRIME probes

For basic calibration of TRIME probes.

- 2 x boxes (7 litres.)

- 22kg glass beads

Item no.: 305017

6.3 How to perform basic calibration?

6.3.1 Preparation of the glass beads

The glass beads, supplied with the calibration set, have to be prepared first:

Fill up one bucket until the rods of the probe can be immersed completely. To obtain a consistent density, knock the bucket on the ground several times.

- The density of the glass beads increases with frequent insertion of probes. Therefore the glass beads should be poured out into another bucket and poured back to achieve the original density.

Now the second bucket has to be filled with water in order to be able to fill in the glass beads without leaving air-bubbles. An additional precaution against air-bubbles is to stir slightly while filling in the glass beads. The container must now be knocked on the ground several times to obtain a consistent density. The surplus water must be poured out until the depth of the water film above the glass beads is less than 2mm.

The water-saturated glass beads should be in a temperature range between 20°C and 25°.

- **Attention:** Water dissolves Na_2O and K_2O from glass which causes a rising pH-value and higher electrical conductivity. **New glass beads have to be washed intensively with tap water!!!**

  1. Fill a bucket with water
  2. Stir the beads under water to drive out all air bubbles
  3. Pour out the water. This procedure should be done with new glass beads at least five times, each time with fresh water. If the glass beads have been in use for a prolonged period, three times is sufficient.

Please note that the electrical conductivity of the water-saturated glass beads medium increases already after a few days storage. Therefore the glass beads must be washed again before the next calibration.

6.3.2 Basic calibration procedure

Basic calibration must be performed using the calibration program ***TRIME-Tool*** . Please read the information about basic calibration with ***TRIME-Tool*** in the Help function of the ***TRIME-Tool*** software.

7 Material-Specific Calibration

Your TRIME measuring system operates with a universal calibration for mineral soils as a standard.

The following parameters limit the application range of the universal calibration:

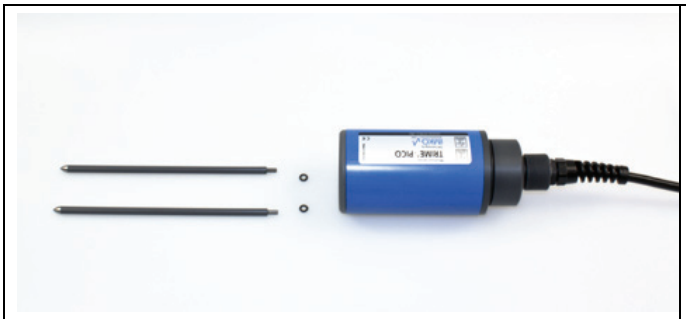
- *Clay content:* *>50%*
- *Organic content:* *>10%*
- *Bulk density:* *<1.1kg/dm³ or >1.7kg/dm³*

Exceeding these limits may cause the tolerances given on page 5 to be overstepped.

Material-specific calibration is advisable if your soil is listed above or if you require accuracy down to the last digit. The ***TRIME-Tool*** software is required for setting up a material-specific calibration (*download under* ***www.imko.de***).

A test series with reference values is necessary for performing material-specific calibration (e.*g. Oven drying at 105°C until weight is constant*). The test series –and consequently the calibration– should include minimum and maximum moisture values. TRIME readings and reference values are compared in a table. The calibration coefficients must then be calculated and uploaded to the TRIME-device.

8 Mounting Spare Rods with O-ring Seals

	
1) Prepare probe body, seals, rods	2) Insert the seals into the bore holes
	
3) Push the seals to the base of the bore holes where the threads begin	4) Screw the rods into the probe body

NOTE!

Basic calibration must be performed after exchanging the rods.

Failure to do so will cause a deviation of +2% or more!

9 EMV/EMI protection

EMV/EMI protection using ferrite filters ensures better interference suppression and therefore improves measurement accuracy. Ferrite filters are integrated into the TRIME sensor and at the connector end of the sensor cable.

10 Information on Lightning Protection of the ENVIS Environmental Measurement System

(IMP-Bus, GlobeLog Logger and integrated Sensors)

10.1 Introduction

Lightning strikes can cause considerable and costly damage to unprotected electronics. The equipment is often totally destroyed. A good number of users are not or only partially insured. Customers who have lightning protection insurance must comply with defined clauses regarding lightning and excess voltage. Insurance companies only cover the damage when compliance with the defined clauses has been proven. IMKO strongly recommends adequate lightning / excess voltage protection equipment for ENVIS environmental measurement systems.

10.2 Excess voltage protection on 110/220V mains supply

Lightning strikes in proximity to high-voltage transmission lines can cause excess voltage in the mains power supply which may result in damage of electronic components. Environmental measurement systems with 110/220V mains supply are at risk from this excess voltage. It may affect the whole system through the power supply unit and the central station (GlobeLog Logger or SM-23U). Excess voltage can even enter the measuring system through the data acquisition computer's mains power supply. An excess voltage protection is highly recommended for all 110/220V devices connected to the ENVIS system

10.3 Protection of modem and telephone lines

Telephone lines are at risk from excess voltage. If a modem is connected to the measurement system the telephone line should also be protected by a lightning protection module.

10.4 Excess voltage protection for network modules by "SM-Blitz"

Excess voltage caused by lightning strokes in close proximity to the environmental measurement test system may enter the IMP-Bus transmission lines. Longer lines increase the risk of lightning strikes. Theoretically maximum protection is achieved by installation of a lightning protection module (SM-Blitz) in front of each SM-Module. Lightning protection is not cheap but it is certainly worthwhile. A compromise should be found between costs and the maximum-affordable protection, i.e. interconnection of adjacent SM-Modules to lightning protected groups.

10.5 Lightning protection on meteorological towers

SM-Modules installed on meteorological towers cannot be protected from lightning strikes. The field strength resulting from the electromagnetic fields and the associated accumulated energy will cause damage to the electronics. Two solutions to the problem:

- Erect a higher lightning conductor close to the meteorological tower serving as a lightning conductor.
- Install the measuring modules a number of metres away. Then all lines coming from the tower have to be protected by lightning protection modules.

10.6 Installation instructions for SM BLITZ lightning protection modules

Basically, there are two potential sources of risk in the field of environmental measurement technology: transmission lines and sensors or network devices. Lightning protection modules should always be installed at the beginning and at the end of a circuit in order to protect the electronics from excess voltage (Attention: SM-Blitz modules have a protected and an unprotected side).

The SM-BLITZ lightning protection module has to be grounded using a ground conductor with a wire cross- section of at least 6 mm^2 screwed to the long side of the module. A 2-metre long grounding rod may serve as a ground conductor. Grounding is optimal when the grounding rod is in direct contact with ground water.

10.7 Conclusion

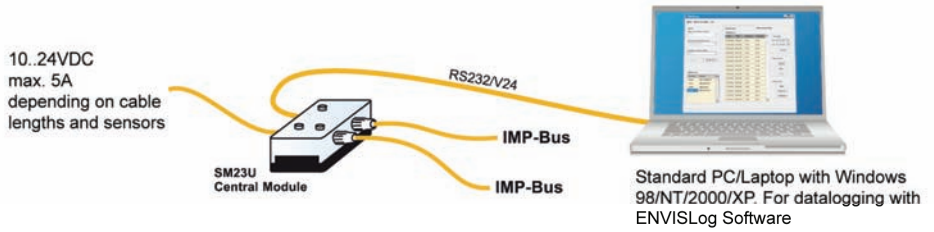
Only limited protection against excess voltage is possible where natural phenomenon such as lightning strikes are concerned. Direct lightning strikes may cause damage nevertheless.

If you have any questions regarding lightning protection please do not hesitate to contact us.

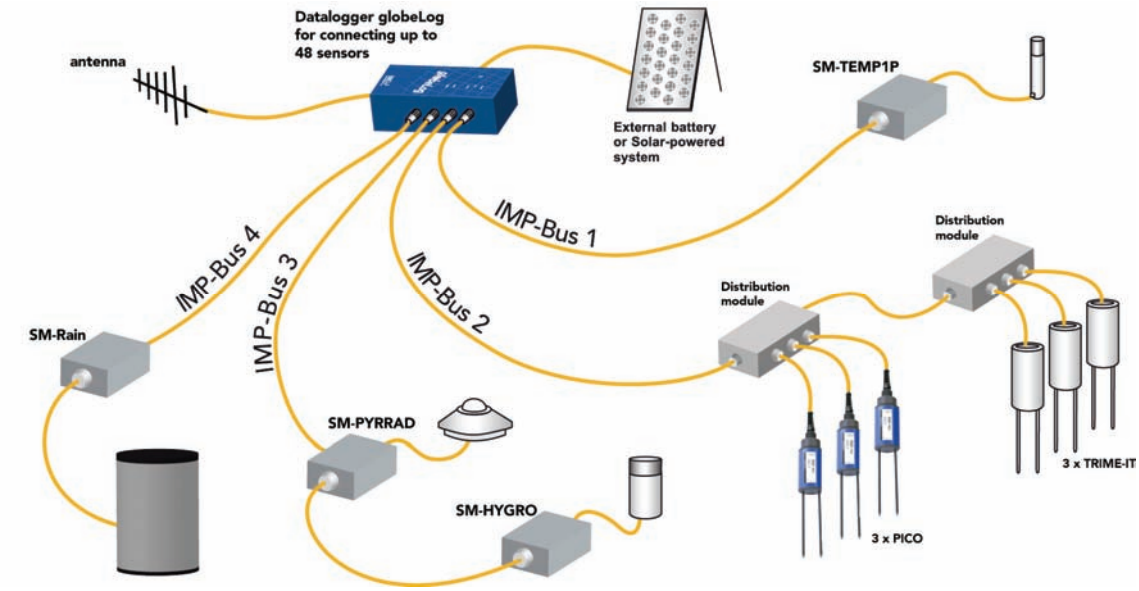
11 Configuration example

11.1 PICO 64/32 connected to the GlobeLog logger

Large ENVIS System for connecting up to 200 Sensors



External battery-, Solar-powered system or 220V power supply



12 Error codes

12.1 TRIMETOOL Errors (Software errors),which will be coded with 4 digits.

Code	Explanation	Measurement
0101-0108, 0301	Serial Port errors	Check port's setting or if the port has been opened. Then close and restart the program.
0201	No answer	Check the power of Pico, the serial port of PC and the connection between PC and PICO.
0202-0212	Protocol errors	Check if TrimeTool's version passes PICO's version.
0302-0307	Protocol error, Parameter setting false	Check if parameters are correct and if TrimeTool's version passes PICO's version.
0401	Can not find config file TrimeTool.con	Look for the file in the exe path. If not found, copy the file to the path.
0501-0508	Errors in Event & MeasureMode	Restart PICO and TrimeTool
0601,0602,0604, 0605,0606,0607, 0609	Operation errors in Basic Balancing	Operate correctly and try it again.
0603,0608,0610, 0611	Communication or protocol errors in Basic Balancing	Restart PICO and TrimeTool.
0701,0702	Read file errors in Material Property Calibration	Check if the files are in the required path. If not, copy the files to the path or redefine the path under the menu Bus/Configuration/Material Property Calibration.
0703	Operation errors in Material Property Calibration	Operate correctly and try it again.
0704, 0705,0706	Communication or protocol errors in Material Property Calibration	Restart PICO and TrimeTool.
0801-0805,0901	Operation errors in Calibration IDs and Names	Operate correctly and try it again.
1001,1101,1102	Read file errors in Calibration IDs and Names	Check if the files are in the required path. If not, copy

		the files to the path or redefine the path under the menu Bus/Configuration/Material Property Calibration.
1201, 1203	Operation errors in Test	Operate correctly and try it again.
1202	Communication or protocol errors in Test	Restart PICO and TrimeTool.
1301	Write file error in Test	Check file path and try it again. If failed, restart TrimeTool.
4001-4002, 4101-4106,4201	Read file or write file errors	Check the files and try again.
4301-4303	Intenal calculating errors	Restart TrimeTool and try again.Otherwise contact IMKO.

12.2 PICO Errors (Firmware errors). The errors come from the firmware, from 1 to 255.

Code	Explanation	Measurement
1-19	The serial communication errors due to incorrect telegram, baud rate, timing etc.	Power off, power on PICO and try it again. Otherwise contact IMKO.
20-39	incorrect command number, command right or command parameters.	Power off, power on PICO and try it again. Otherwise contact IMKO.
40-49	EEPROM is defect	Power off, power on PICO and try it again. Otherwise contact IMKO.
50-59	ASIC is defect	Power off, power on PICO and try it again. Otherwise contact IMKO.
60	Power voltage is too low	Check power voltage of PICO, it is minimal 6V.
100	TDR measurement parameter is incorrectly set or the material conductivity is too high.	Adjust the TDR measurement parameters or contact IMKO
101	TDR measurement parameter is incorrectly set	Adjust the TDR measurement parameters or contact IMKO
102	ASIC is defect	Power off, power on PICO and try it again. Otherwise contact IMKO.
103	EC parameter is incorrectly set.	Power off, power on PICO and try it again. Otherwise contact IMKO.
105	Tp is out of range for the standard calibration polynomial.	Check if PICO is inserted in the measured material correctly.
108	TDR measurement parameter is incorrectly set or the material conductivity is too high.	Adjust the TDR measurement parameters or contact IMKO
120-129	Internal chip problem	Power off, power on PICO and try it again. Otherwise contact IMKO.
130-199	Internal errors	Contact IMKO
200-254	Reserved	
255	The data transmission is not finished.	

PRECISE MOISTURE MEASUREMENT

in hydrology, forestry, agriculture, environmental and earth science,
civil engineering, as well as individual applications!

www.imko.de

IMKO GmbH ■ Im Stöck 2 ■ Germany-76275 Ettlingen ■ Phone +49-(0)72 43-59 210 ■ Fax +49-(0)72 43-9 08 56 ■ e-mail INFO@IMKO.de ■ www.IMKO.de