USER Manual
IRS31Pro-UMB

Intelligent Road Sensor

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Please read this operating manual completely before commissioning the equipment.

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Contents

1 Please Read Before Use ... 5
1.1 Symbols Used ... 5
1.2 Safety Instructions ... 5
1.3 Designated Use ... 5
1.4 Incorrect Use ... 5
1.5 Guarantee ... 5
1.6 Brand Names ... 5
2 Scope of Delivery ... 6
3 Order Numbers ... 7
3.1 Accessories ... 7
3.2 Additional Documents and Software ... 7
4 Equipment Description ... 8
4.1 IRS31Pro-UMB Sensor ... 8
5 Generation of Measurements ... 9
5.1 Current Measurement (act) ... 9
5.2 Average Value (avg) ... 9
5.3 Sampling Rate ... 9
6 Transmission of Measurements ... 10
6.1 Measurements ... 10
7 Installation ... 14
7.1 Preparation ... 14
7.2 Installation ... 14
7.3 Connecting the Supply Cable ... 16
7.4 Use of Surge Protection (8379.USP) ... 20
7.5 Commissioning and Testing ... 21
8 Maintenance ... 22
8.1 Replacing the Sensor ... 22
9 Connections ... 23
9.1 Supply Cable ... 23
10 Configuration and Testing ... 25
10.1 Factory Settings ... 25
10.2 Configuration with PC Configuration Software UMB Config Tool ... 25
10.3 Function Test with the UMB Config Tool ... 30
11 IRS31-UMB Compatibility mode ... 32
11.1 Important notes for using Sensor in compatibility mode ... 32
11.2 Configuration possibilities ... 32
11.3 Examples for the Creation of Addresses ... 33
11.4 Firmware-Update ... 33
11.5 Overview channel list of an IRS31-UMB (IRS31Pro-UMB in IRS31-UMB compatibility mode) ... 34
12 Coupling with ARS31/ARS31Pro-UMB ... 37
12.1 Configuration of coupling within IRS31Pro-UMB: ... 37
13 Technical Data ... 39
13.1 Measuring Range / Accuracy ... 39
14 Fault Description ... 41
15 Certifications ... 42
15.1 CE ... 42
15.2 FCC ... 42
15.3 IC ... 42
16 Disposal ... 43
16.1 Inside the EU ... 43

16.2 Outside the EU ... 43
17 Repair / Corrective Maintenance ... 43
17.1 Technical Support ... 43
18 Appendix ... 44
18.1 Channel List Summary ... 44
18.2 Channel List Summary per TLS2012 FG3 ... 45
18.3 Communication in Binary Protocol ... 46
18.4 Communication in ASCII Protocol ... 49
18.5 Communication in SDI12 Protocol ... 52
19 List of Figures ... 61
20 Index ... 62

Version history:

Version	Date	Edited by	Comments
V1	11.2013	RR/BR/LA	First version
V2	01.2014	LA/BR	IRS31-UMB compatibility mode, revised channel list for TLS.
V3	02.2014	LA/BR	Coupling of IRS31Pro-UMB with ARS31-UMB
V4	04.2014	GS	SDI12 Protocol
V5	03.2015	BR/LA	Description of channels 900 and 905 improved; with the existing description the calculation of these values in the ASCII protocol was unclear. Experimental implementation of CaCl2 und MgCl2. Freezing temperature and salt concentration output in the IRS31-UMB compatibility mode as in the IRS31-UMB. Configurable freezing temperature and salt concentration output at non-measurable freezing temperature.
V6	12.2015	LA	Supplementary notes on chapter 8 “Maintenance”.
V7	04.2016	BR	Chapter 13, SDI12 interface added
V8	07.2016	RR	Warranty 24 month; CE declaration removed and set up separately
V9	07.2017	BR/LA	All 6 fastening screws of the cover are then tightened with a torque of 2 Nm. Information added for the new 8910.UXXXX-HD.
			Extended range for water film height accuracy.
		BR/LA	10.2.3, 10.2.6 Firmware update only with 19200 BD, 9.1.1.2 SDI12 added
V10	01.2020	NT	Updated regulatory information

1 Please Read Before Use

Please read this Operating Manual completely before commissioning the equipment and keep it handy for future reference. Please note that various components of the sensor and the described software may look somewhat different from those shown in the illustrations in this operating manual.

This manual is valid for the IRS31Pro-UMB from device version 8 (from February 2014). Some functions or features specified in this manual may not be available or may not be valid with older versions of the device. The device version is indicated as the last number of the serial number printed on the type plate, e.g.: the device with serial number: 063.1013.1203.0**14** has the device version 14.

1.1 Symbols Used

⚠ Important indication concerning possible hazards to the user

☛ Important indication for the correct functioning of the equipment

1.2 Safety Instructions

⚠
- Installation and commissioning must only be carried out by suitably qualified specialist personnel.
- Never take measurements on or touch live electrical parts.
- Pay attention to the technical data and storage and operating conditions.

1.3 Designated Use

⚠
- The equipment must only be operated within the range of the specified technical data.
- The safety and operation of the equipment can no longer be guaranteed if it is modified or adapted.
- The Sensor is intended for flush-mounted installation in solid road- or runway surface. It is used to determine the measurements described in chapter 6.1.
- The Sensor can be used as a replacement part for IRS31-UMB. For this purpose the sensor should be appropriate configured. See chapter 11 for details.

1.4 Incorrect Use

If the equipment is installed incorrectly:

⚠
- It may not function or may only function to a limited extent
- It may be permanently damaged

If the equipment is not connected correctly

⚠
- It may not function
- It may be permanently damaged
- There may be a possibility of an electrical shock

When connecting the power supply to the sensor, ensure the correct supply voltage (12VDC).

Under no circumstances is it allowed to connect the negative supply voltage (GND1) with the cable shield (connected to earth) of the sensor.

1.5 Guarantee

The guarantee period is 24 months from the date of delivery. The guarantee is forfeited if the designated use is violated.

1.6 Brand Names

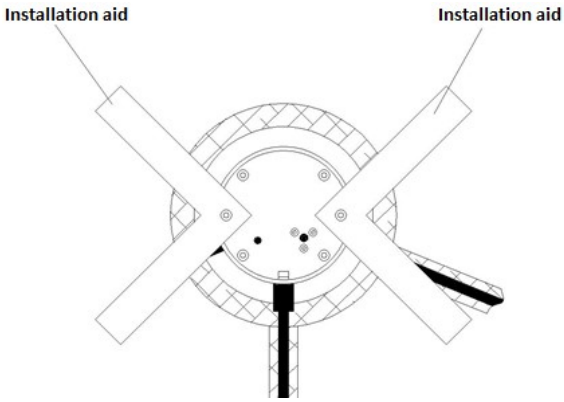
All brand names referred to are subject without limitation to the valid trademark and ownership rights of the respective owner.

2 Scope of Delivery

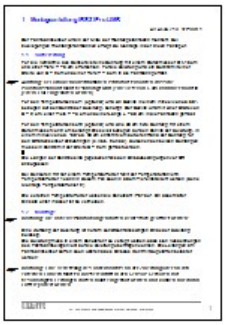
The content of the delivery consists of the following components:

- Sensor IRS31Pro-UMB

- Installation aid



- Installation instructions



- Transport packaging

3 Order Numbers

Standard version

IRS31Pro-UMB ..... 50 m cable length **8910.U050**
IRS31Pro-UMB ..... 50 m cable length, 1 below-ground temperature sensor **8910.U051**
IRS31Pro-UMB ..... 50 m cable length, 2 below-ground temperature sensors **8910.U052**
IRS31Pro-UMB ..... 100 m cable length **8910.U100**
IRS31Pro-UMB ..... 100 m cable length, 1 below-ground temperature sensor **8910.U101**
IRS31Pro-UMB ..... 100 m cable length, 2 below-ground temperature sensors **8910.U102**

Version with reinforced floor

IRS31Pro-UMB ..... 50 m cable length **8910.U050-HD**
IRS31Pro-UMB ..... 50 m cable length, 1 below-ground temperature sensor **8910.U051-HD**
IRS31Pro-UMB ..... 50 m cable length, 2 below-ground temperature sensors ... **8910.U052-HD**
IRS31Pro-UMB ..... 100 m cable length **8910.U100-HD**
IRS31Pro-UMB ..... 100 m cable length, 1 below-ground temperature sensor **8910.U101-HD**
IRS31Pro-UMB ..... 100 m cable length, 2 below-ground temperature sensors ... **8910.U102-HD**

- Intelligent passive road sensor including integrated road surface temperature sensor

3.1 Accessories

Power supply unit 24V/100VA 8366.USV1
ISOCON-UMB 8160.UISO
Surge protection 8379.USP
DACON8-UMB 8160.UDAC

3.2 Additional Documents and Software

You can download the following documents and software via the Internet at www.lufft.de:

- Operating Manual — This document
- UMB Config Tool — Windows® software for testing, firmware updates and configuration of UMB devices
- UMB Protocol — Communication protocol for UMB devices
- Firmware — The current equipment firmware

4 Equipment Description

Depending on the requirements of the road traffic meteorological monitoring network, sensors are installed in the roadways and / or "overhead". The Lufft IRS31Pro-UMB is intended for installation in the roadway. The passive measuring instrument IRS31Pro-UMB is used to determine the road surface temperature, the height of the water film above the sensor and the saline concentration on the sensor (from which the freezing temperature is derived). The built-in road condition models use these variables to determine the corresponding road conditions.

The sensor provides the following established and commonly used decision-making data for winter maintenance services: water film height, road condition, road surface temperature and freezing temperature. In addition, the sensor delivers an ice percentage reading. As the ice percentage increases on the surface, the friction coefficient falls and this can then be used to support preventive gritting decisions.

Depending on the sensor type, up to 2 below-ground temperatures can be measured, preferably at depths of 5 cm and 30 cm.

The equipment is connected by way of a 4-pin connection cable (with a length of 50 m or 100 m, depending on the type).

The measured values can be requested over the RS485 interface in accordance with the UMB protocol.

During commissioning, configuration and verification takes place using the UMB Config Tool (Windows®PC software).

4.1 IRS31Pro-UMB Sensor

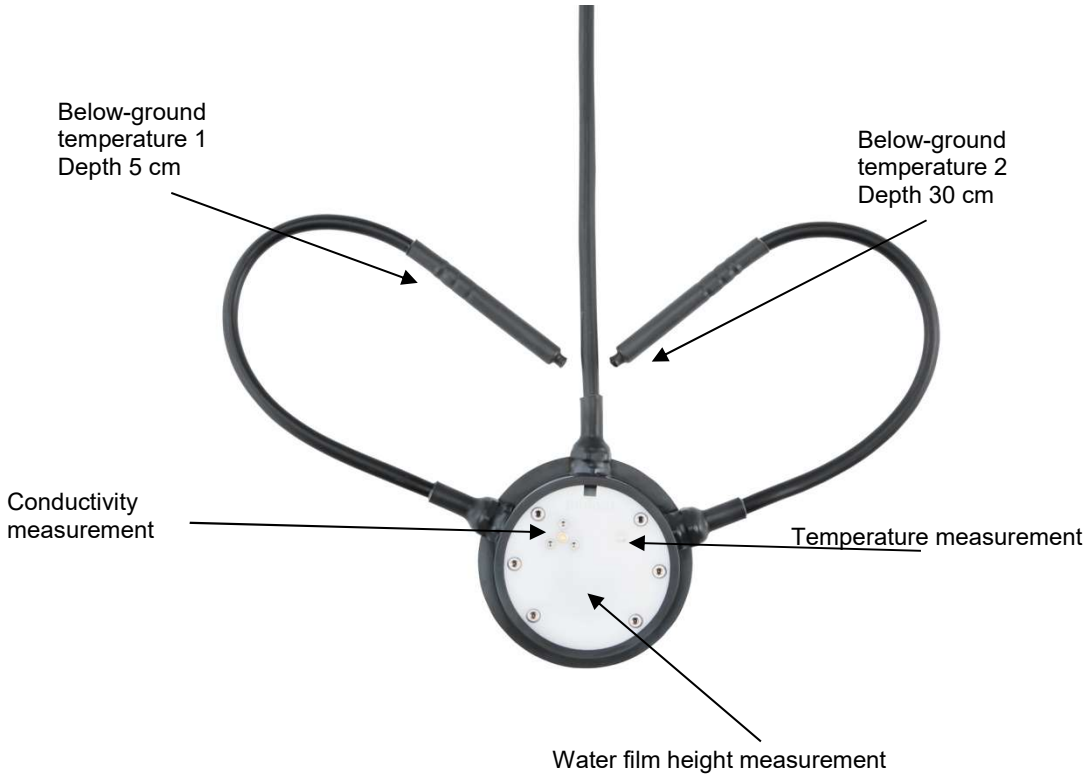


Figure 1: Sensor

5 Generation of Measurements

It is recommended to query the average channels. The measured values of the TLS-channels are based on the configured averaging.

5.1 Current Measurement (act)

The value of the last measurement is transmitted when the current measurement value is requested.

5.2 Average Value (avg)

The number of measurements that are included in the moving average can be configured between 1 and 20. In the factory setting, the sampling rate is 10 s and the moving average is generated from 6 measurements.

The "average" road condition is calculated from the average values of the underlying channels.

The average freezing temperature is calculated from the average saline concentration.

5.3 Sampling Rate

The sampling rate in the sensor is configurable and can be set at 10, 20, 30 or 60 seconds. Typically, measurement values are polled at intervals of 1, 2, 5 or 10 minutes. An average value is recommended if the measurement and sampling rates are different.

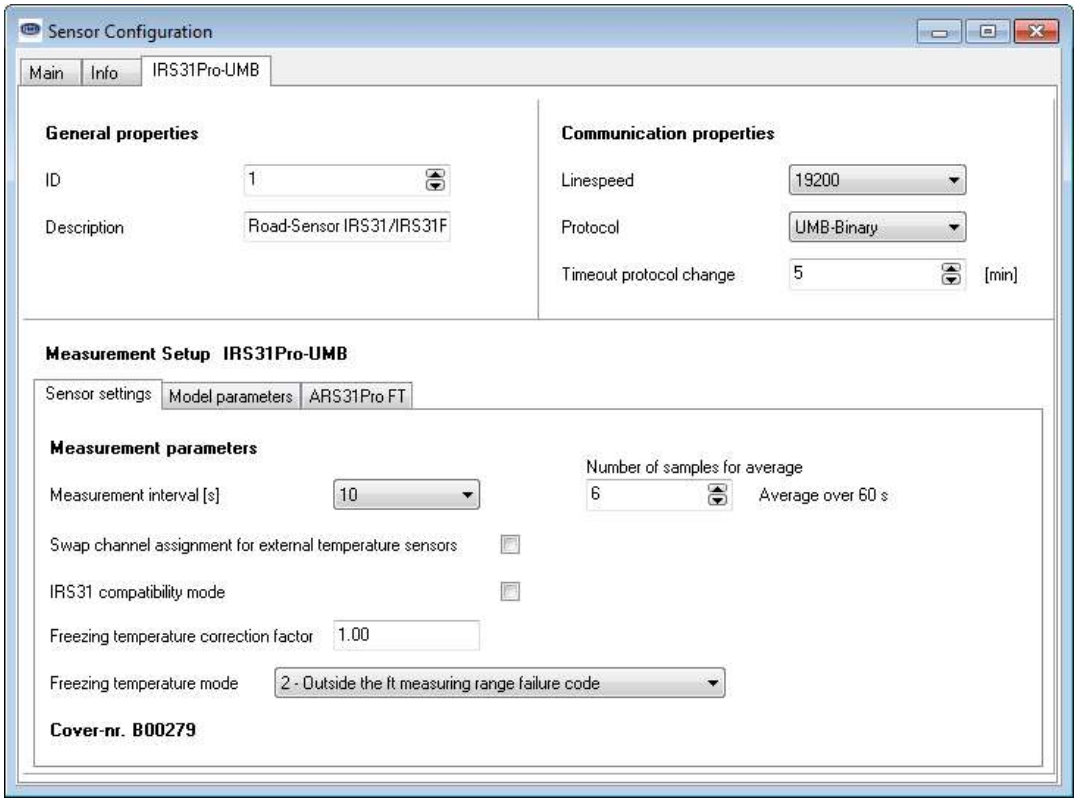


Figure 2: UMB Config Tool: Sensor Configuration / Sensor Settings Menu

6 Transmission of Measurements

The factory default setting for the transmission of measurements is UMB binary protocol.

You can find an example of a measurement request for the various protocols and a complete summary of the list of channels (including TLS channels) in the Appendix.

6.1 Measurements

6.1.1 Data Types Used

uint8 unsigned char (8 bit unsigned integer)

uint16 unsigned short (16 bit unsigned integer)

float32 float (32 bit floating-point number according to IEEE-754)

6.1.2 Road Surface Temperature

Sampling rate: adjustable 10, 20, 30, 60s; *see section 5.3 Sampling Rate, page 9*

Units: normalized, °C; °F

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
100			105	Road temperature	uint16	0	65520	norm value
101			106	Road temperature	float32	-40.0	80.0	°C
102			107	Road temperature	float32	-40.0	176.0	°F

6.1.3 External Temperature 1 (5cm depth)

Sampling rate: see section 5.3

Units: normalized, °C; °F

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
110			115	External temperature 1	uint16	0	65520	norm value
111			116	External temperature 1	float32	-40.0	80.0	°C
112			117	External temperature 1	float32	-40.0	176.0	°F

6.1.4 External Temperature 2 (30cm depth)

Sampling rate: see section 5.3

Units: normalized, °C; °F

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
120			125	External temperature 2	uint16	0	65520	norm value
121			126	External temperature 2	float32	-40.0	80.0	°C
122			127	External temperature 2	float32	-40.0	176.0	°F

6.1.5 Freezing Temperature NaCl

Sampling rate: see section 5.3

Units: normalized, °C; °F

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
150			155	Freezing temp. NaCl	uint16	0	65520	norm value
151			156	Freezing temp. NaCl	float32	-40.0	0.0	°C
152			157	Freezing temp. NaCl	float32	-40.0	32.0	°F

6.1.6 Freezing Temperature $MgCl_2$[1]

Sampling rate: see section 5.3

Units: normalized, °C; °F

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
170			175	Freezing temp. MgCl2	uint16	0	65520	norm value
171			176	Freezing temp. MgCl2	float32	-40.0	0.0	°C
172			177	Freezing temp. MgCl2	float32	-40.0	32.0	°F

6.1.7 Freezing Temperature $CaCl_2$[1]

Sampling rate: see section 5.3

Units: normalized, °C; °F

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
190			195	Freezing temp. CaCl2	uint16	0	65520	norm value
191			196	Freezing temp. CaCl2	float32	-40.0	0.0	°C
192			197	Freezing temp. CaCl2	float32	-40.0	32.0	°F

6.1.8 Water Film Height

Sampling rate: see section 5.3

Units: normalized, µm; mil

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
600			605	Water film height	uint16	0	65520	norm value
601			606	Water film height	float32	0.0	10000.0	µm
602			607	Water film height	float32	0.0	393.70	mil

6.1.9 Saline Concentration NaCl

Sampling rate: see section 5.3

Units: normalized, % percentage by weight, g/m^2, lbs. p. l. mile

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
800			805	Saline concent. NaCl	uint16	0	65520	norm value
801			806	Saline concent. NaCl	float32	0	100	%
910			915	Saline concent. NaCl	float32	0	100	g/m^2
920			925	Saline concent. NaCl	float32	0	1280	lbs.p.l.mile

6.1.10 Ice Percentage

Sampling rate: see section 5.3

Units: %

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
810			815	Ice percentage	float32	0.0	100	%

6.1.11 Friction

Sampling rate: see section 5.3

[1] experimental implementation

Units: none

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
820			825	Friction	float32	0.0	1.0	

6.1.12 Saline Concentration $MgCl_2$ [2]

Sampling rate: see section 5.3

Units: normalized, % percentage by weight, g/m², lbs. p. l. mile

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
830			835	Saline concent.MgCl2	uint16	0	65520	norm value
831			836	Saline concent.MgCl2	float32	0	100	%
911			916	Saline concent.MgCl2	float32	0	100	g/m²
921			926	Saline concent.MgCl2	float32	0	1280	lbs.p.l.mile

6.1.13 Saline Concentration $CaCl_2$ [2]

Sampling rate: see section 5.3

Units: normalized, % percentage by weight, g/m², lbs. p. l. mile

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
840			845	Saline concent.CaCl2	uint16	0	65520	norm value
841			846	Saline concent.CaCl2	float32	0	100	%
912			917	Saline concent.CaCl2	float32	0	100	g/m²
922			927	Saline concent.CaCl2	float32	0	1280	lbs.p.l.mile

6.1.14 Road Condition

Sampling rate: see section 5.3

Units: logical coding

Request channels:

UMB-Chanel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
900			905	Road condition	uint8	0	99	

Coding	Meaning	Description
10	Dry	There is no liquid water on the road or the water film height is below the dry-moist threshold.
15	Moist	There is liquid water on the road and the water film height is between the dry-moist and moist-wet thresholds.
20	Wet	There is liquid water on the road; the water film height has raised above the moist-wet threshold.
25	Moist with salt	Describes a moist road condition where the freezing temperature is lower than -0.1°C.
30	Wet with salt	Describes a wet road condition where the freezing temperature is lower than -0.1°C.
35	Ice	There is frozen water on the road, mostly in the form of ice or snow.
40	Snow	There is snow on the road
45	Frost	There is frost on the road

The factory settings for the moist and wet thresholds are 10 and 200 µm, respectively. These settings can be adjusted in the sensor configuration (see screenshot).

[2] experimental implementation

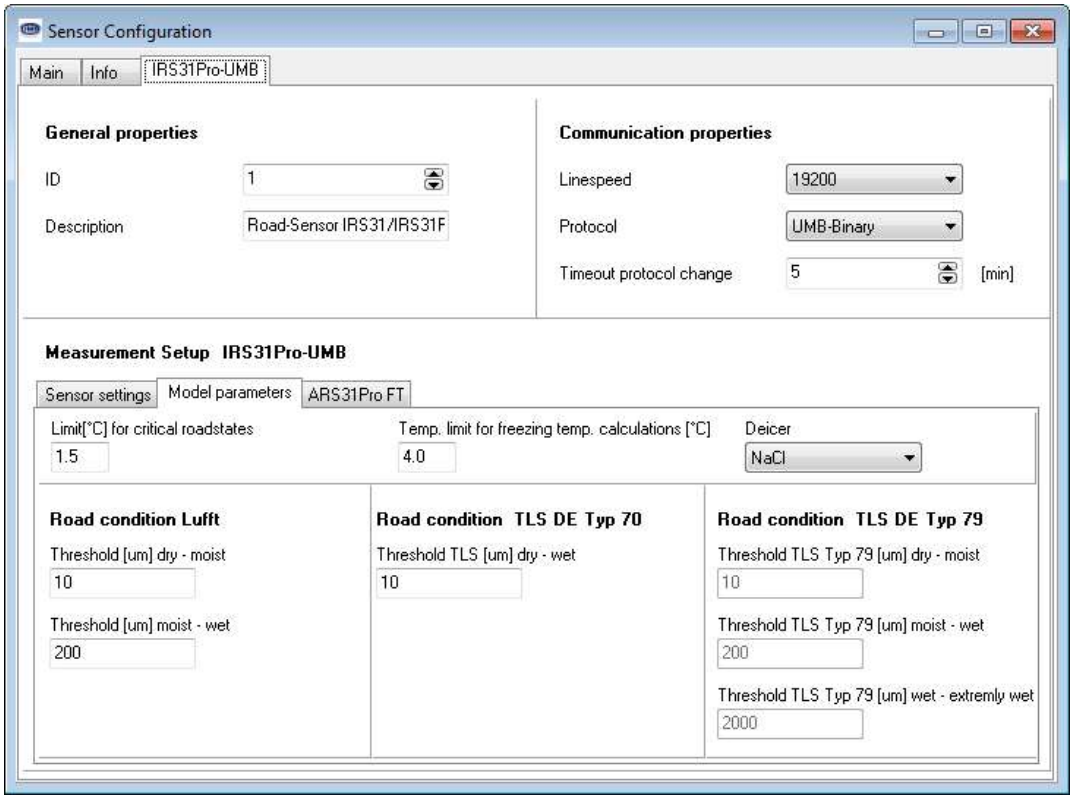


Figure 3: Set Moist / Wet Thresholds

6.1.15 State of Coupling

Sampling rate: see section 5.3

Units: none

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
950				State of coupling	uint8	0	99	

6.1.16 Measurement Counter

Sampling rate: see section 5.3

Units: none

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
20001				Measurement counter	uint16	0	65520	

6.1.17 Resistance

Sampling rate: see section 5.3

Units: Ohm

Request channels:

UMB Channel						Measuring Range		
act	min	max	avg	Measured Value	Data Type	min	max	Unit
			32210	resistive_avg	float32	-1.0E15	1.0E15	ohm

7 Installation

The road sensor must be installed in the centre of the road lane. On two lane carriageways installation takes place in the left-hand lane.

7.1 Preparation

A drill hole of diameter > 16 cm and depth 6 cm is required for inserting the sensor. For the connection cable, a slot of width 2 cm and depth 5 cm is cut into the road surface.

Attention! Be careful not to damage the insulation layer when working on bridges. (In this case it is not always possible to maintain a depth of 6 cm.)

For temperature sensor 1 (optional), a slot is required at an angle of approximately 68º in relation to the connection cable slot. The slot is cut into the road with a width of 2 cm, depth of 5 cm and length of 35 cm.

For temperature sensor 2 (optional), a drill hole is required with a depth of 30 cm and a diameter of 2 cm. In relation to the connection cable slot, this must be positioned at an angle of approximately -68º, approximately 20 cm from the outer rim of the road sensor drill hole (see Figures 2 and 3). A slot of width 2 cm must be cut between the two drill holes.

If necessary, the slot lengths must be adjusted in accordance with the installation conditions at the site.

For sensors with only one temperature sensor, temperature sensor 2 is omitted. In this case, temperature sensor 1 can also be installed at a depth of 30 cm (see installation instructions for temperature sensor 2).

The external temperature sensors are protected to IP67. Constant use under water must be avoided.

One of the external temperature sensors is marked with a red cable flag, on which the intended installation depth is given. If the sensor is not installed in the designated depth, the channel assignment must be changed in the sensor configuration. See chapter 10.2.4 Device Settings.

7.2 Installation

Warning: The cable connections must not be opened under any circumstances!

Shortening the supply cable is only permitted at the cabinet end of the cable. The supply cable must be placed in a protective tube that prevents any expansion of the road surface from being transmitted to the cable. Be careful not to expose the cables of the road sensor to tensile stress during the installation.

Warning: Damage to the sheathing of the supply cable or external sensors will lead to the ingress of water into the sensor! Sensors with damaged cables must not be installed and can only be repaired by Lufft.

Insert the road sensor into the designated drill hole in such a way that it is flush with the road surface. In order to achieve this, place the installation aid - which is already mounted on delivery - on the surface of the road. If necessary, adjust the sensor position by bending the installation aid.

Under no circumstances must the road sensor project beyond the surface of the road (possible damage due to snow-clearing vehicles!).

Fill the cavities with casting resin concrete.

Only such concrete casting systems may be used in which the temperature during the curing process remains below 80°C (176ºF), as otherwise the road sensor will be damaged. After the concrete has hardened, remove the installation aid and the green protective foil. Re-insert the fixing screws of the installation aid into the open holes of the sensor. All 6 fastening screws of the cover are then tightened with a torque of 2 Nm.

7.2.1 Extending the Supply Cable (e.g. 100 m)

Important: The original cable **must** be shortened after the shortest possible distance (curbside 5 m) and extended from there. The loop impedance of the entire cable must not exceed 10 Ω.

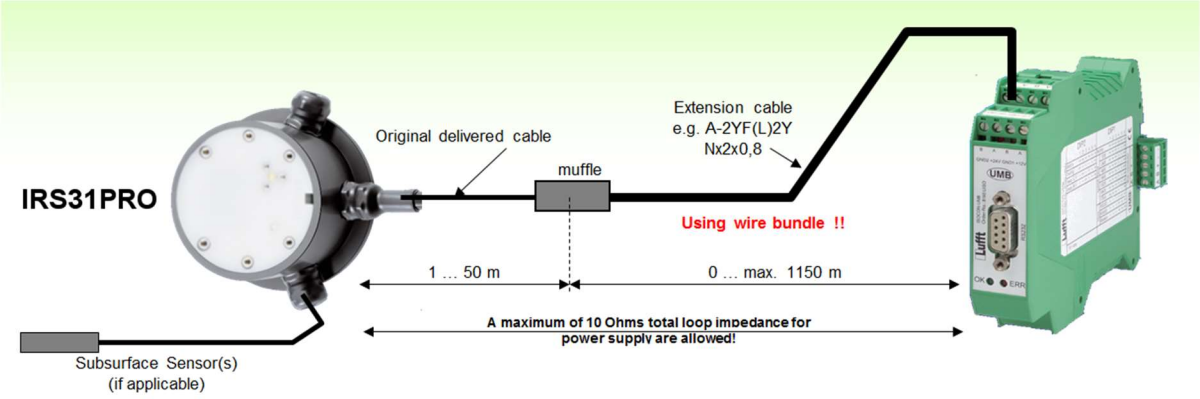


Figure 4: Cable Extension

Example: Extension to 100 m with a 0.5 mm² cable with loop impedance of 73.2 Ω/km and parallel connection of 4 wires in each case:
At 100 m the result per wire is a loop impedance of 7.3 Ω.
By connecting 4 wires in parallel the result is a loop impedance of 7.3 Ω / 4 = 1.83 Ω

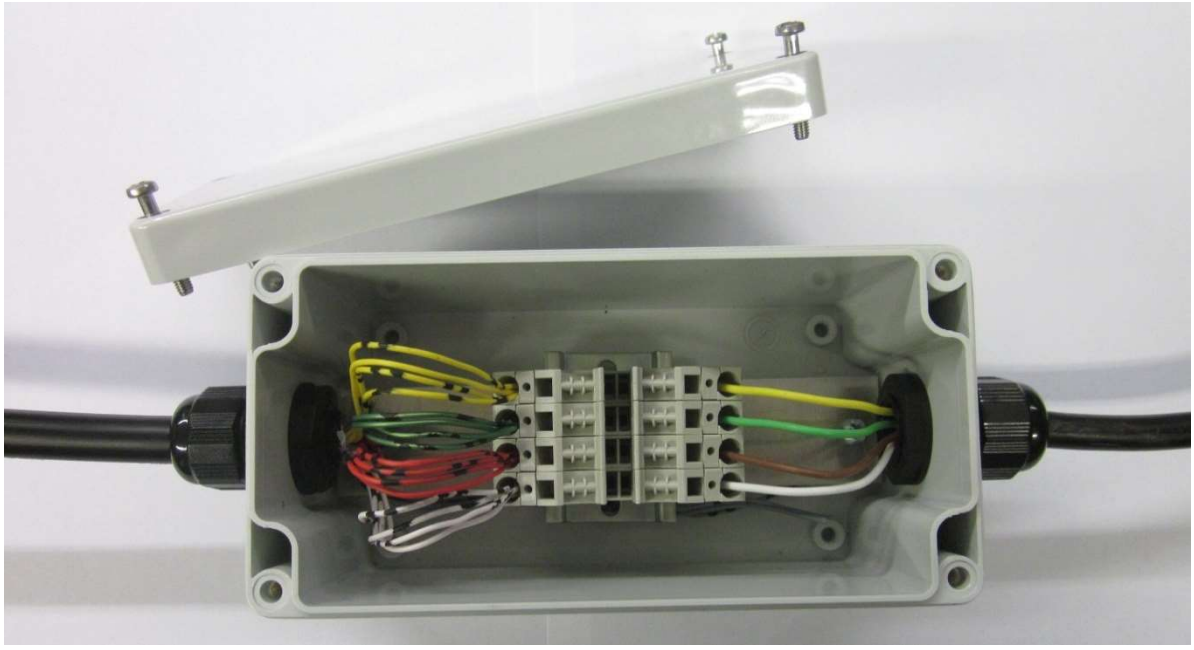


Figure 5: Example of an Extension Box

7.2.1.1 Extension Table for IRS31Pro-UMB Passive Road Sensor

Total Distance	RS485 Terminator Required	IRS31Pro-UMB Original Cable	Extension Cable A-2ZF(L)2Z **N**x2x0.8		
Wire Range		0.5mm²	0.8mm²	Power Supply Wire Bundle	Total Wire Pairs
[m]		max. [m]	up to…[m]	x times	N
100	-	100	--	--	
200	-	50	150	3x	4
300	-	50	250	4x	6
400	YES	50	350	6x	10
500	YES	50	450	7x	10
600	YES	50	550	9x	10
700	YES	50	650	10x	20
800	YES	50	750	11x	20
900	YES	50	850	13x	20
1000	YES	50	950	14x	20
1100	YES	50	1050	16x	20
1200	YES	50	1150	17x	20

Notes:
Recommended extension cable: A-2YF(L)2Y Nx2x0, 8 or similar;
Core pair 2x (2 times) means 2 pairs of wires, e.g. 2x2x0.8, because 2 individual wires are 1 pair for the power supply (+ & -).
RS485 termination resistance required means that a resistance of 120 ohms should be connected parallel to the RS485 2-wire interface, either on the sensor inlet or sleeve.

7.3 Connecting the Supply Cable

The road sensor supply cable is connected to the power supply and the bus system (e.g. ISOCON-UMB) in the control panel.

The data lines and the supply voltage of each IRS31Pro-UMB must be electrically isolated from each other. This can be achieved for example by means of a LUFFT ISOCON-UMB. If the sensor is operated without electrical isolation, the sensor may be destroyed and the warranty expires!

The screening of the connecting cable MUST be laid to earth in the control panel! Under no circumstances is it allowed to connect the negative supply voltage (GND1) with the cable shield (connected to earth) of the sensor.

For Sensors with 12 VDC power supply the end of the cable in the cabinet is marked by the manufacturer with a red heat shrink tubing!

Figure 6: Example of a Standard Lufft UMB Control Cabinet

Figure 7: Examples of the Earthing of the Cable Screening

The sensors are delivered with two different cables: color coded or numerically coded.

Connection of the road sensor supply lead:
1.....white..... negative power supply
2.....brown..... positive power supply
3.....green ..... RS485_A
4.....yellow ..... RS485_B

If colored cables are not used, the numbers apply.

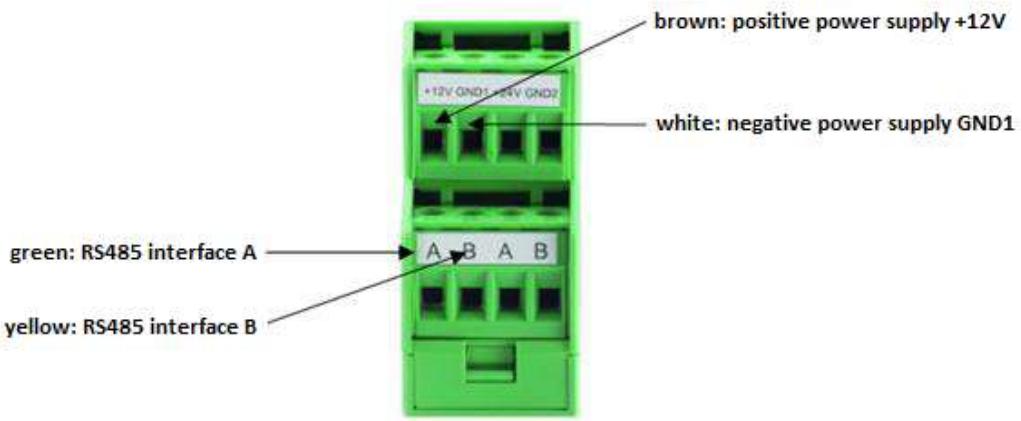


Figure 8: ISOCON-UMB Connection

Note: When installing the system, please also pay attention to the operating instructions for the ISOCON-UMB.

Attention: Errors in connection will destroy the road sensor!

Attention: A connection of the sensor to 24 VDC leads after a short time to the destruction of the sensor.

7.3.1 Cable Connection for SDI12 Operation

There are two options to connect the sensor to a SDI12 logger:

Connecting the road sensor with power supply by the SDI12 bus
1 .....white ..... SDI12 GND
2 .....brown..... SDI12 +12V
3 .....green ..... not connected
4 .....yellow ..... SDI12 Signal

Attention: In this case SDI12 GND may **not** be connected to earth!

Connecting the sensor with isolated power supply:
1 .....white ..... negative power supply
2 .....brown..... positive power supply
3 .....green SDI12-GND
4 .....yellow ..... SDI12 Signal

Attention: The power supply lines may **not** be connected to earth!

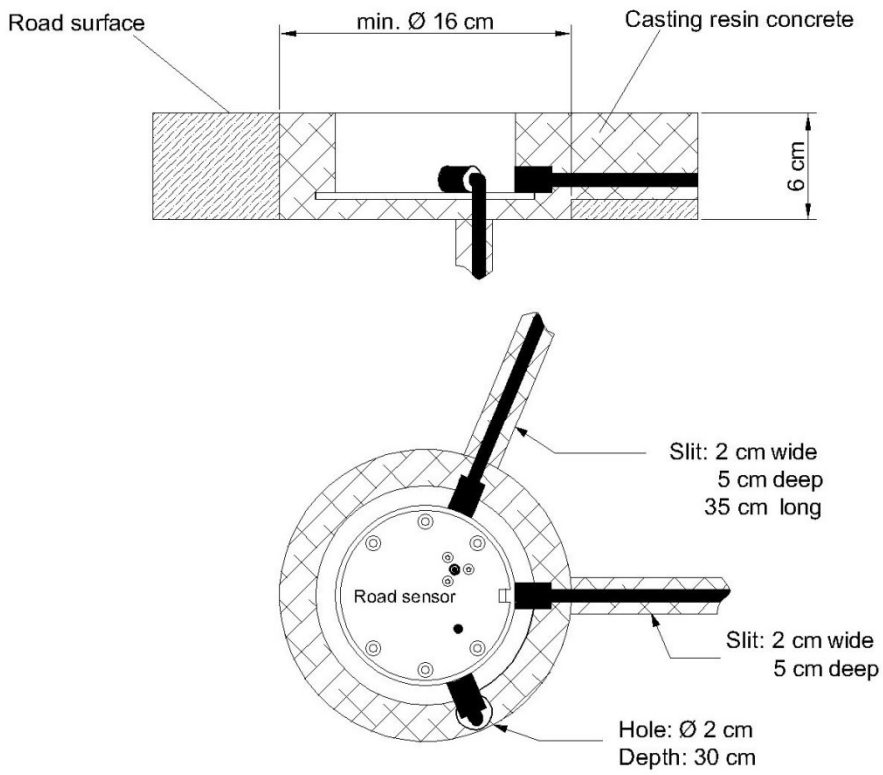


Figure 9: IRS31Pro-UMB Installation in the Road with 2 External Temperature Sensors

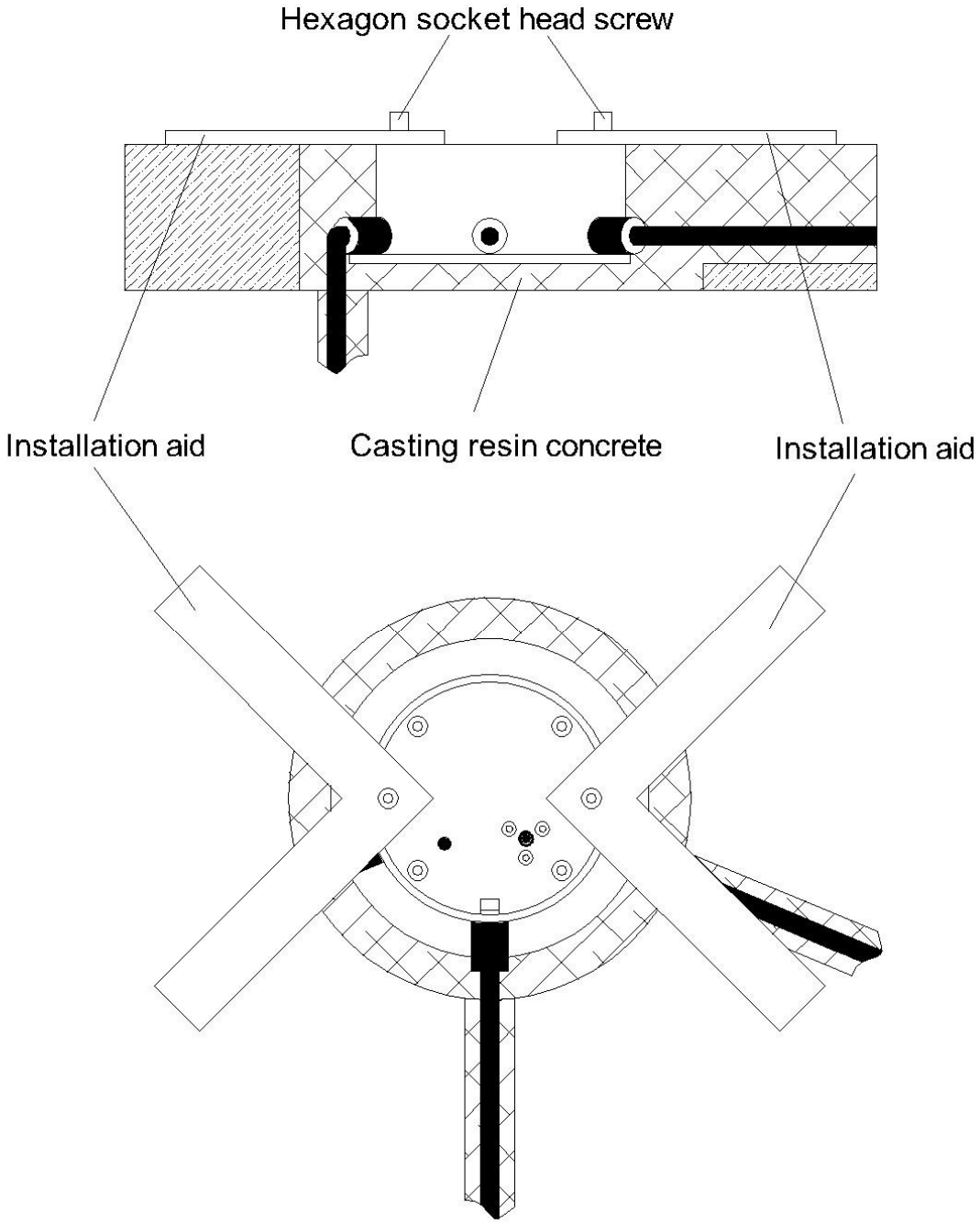


Figure 10: Installing the IRS31Pro-UMB

7.4 Use of Surge Protection (8379.USP)

When using surge protection (order no.: 8379.USP), please note the connection example in the operating instructions for surge protection.

7.5 Commissioning and Testing

Once the device has been properly installed and connected to the permissible supply voltage, initialization takes place and measuring begins.

After successful installation of the road sensor, its correct functioning must be checked. To do this, connect the sensor to an evaluation device. Check that communication between the sensor and the evaluation unit is working properly. The road condition determined by the sensor should be checked with dry and wet sensor.

The functional test is described in section 10, Configuration and Testing.

8 Maintenance

The road sensor should be serviced annually. This includes the visual inspection of the housing. It is recommended to clean the sensor surface when very dirty. Cleaning should be done with a cloth. As a cleaning agent isopropanol may be used.

Note: In no case, the electrodes may be processed with sandpaper or wire brush.

Where there is significant mechanical damage to the sensor, which could influence the tightness of the housing, it is recommended to exchange the sensor. This also applies in the case where the plastic assembly of the sensor is heavily degraded by wear and tear.

Note: If water gets into the housing of the sensor, the sensor with housing and cable must be replaced.

8.1 Replacing the Sensor

If the plastic assembly of the road sensor becomes unusable due to mechanical effects, or the sensor electronics are damaged, the plastic assembly can be replaced without the need to change the entire housing.

Attention: Replacement must only be carried out when the road is dry!

To uninstall the plastic assembly, remove all six hexagonal screws. On the edge of the cover there is a small opening that serves to provide access for a screwdriver. This allows the plastic assembly to be lifted out. Take care not to pull out the connection cables on the underside of the sensor. The plug connections must be removed without tensile strain on the cables.

Important: when changing the sensor, the ring gasket must always be replaced and a new drying agent bag must be inserted.

The housing must be cleaned carefully before inserting a new sensor. Even tiny dirt particles in the seal may lead to sensor failure in the long term. No moisture must be trapped in the housing. The new drying agent bag must be taken out of the sealed protection cover only shortly before being placed in the housing. The sticker indicates its functionality (blue: ok, pink: the drying agent is spent).

When connecting the plug connectors to the new sensor, be careful not to touch the electronics of the sensor. Electrostatic discharge can destroy the sensor.

The seal must be fitted using silicone grease. It must not cant when the plastic cover plate is inserted. The plastic cover plate must fit into the housing without the use of force. Grease the thread of the fixing screws. First lightly fasten the screws and then tighten evenly (torque 2 Nm).

9 Connections

9.1 Supply Cable

See section 7.3 Connecting the Supply Cable

9.1.1.1 Power Supply

The IRS31Pro-UMB is supplied by a voltage of 12 VDC. The power supply unit used must be approved to operate devices of protection class III (SELV).

9.1.1.2 RS485 Interface or SDI12

The device has a half-duplex 2 wire RS485 interface with the following settings:

Data bits:.....8

Stop bit.....1

Parity.....None

Adjustable baud rates: 1200, 2400, 9600, 19200*, 38400
*=factory setting and baud rate for firmware update

This interface can be switched to SDI12 via the sensor configuration.

The screening of the supply cable MUST be laid to earth in the control cabinet.

If the equipment is not connected correctly

- It may not function
- It may be permanently damaged
- There may be a possibility of an electrical shock

9.1.2 Connections in the Housing

There are two 4-pin connectors on the underside of the plastic insert. These are used to connect the supply voltage and the interface to the associated cable, as well as the optional connection of external temperature sensors.

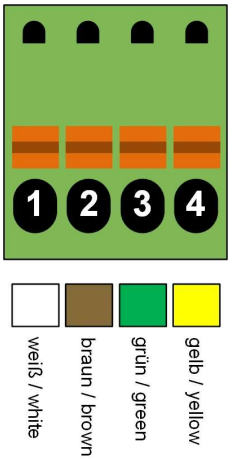
Pin assignment supply voltage / RS485 (uncoded):

1..... white ..... negative supply voltage

2..... brown..... positive supply voltage

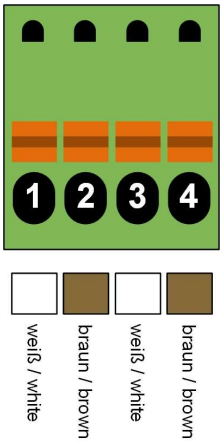
3..... green ..... RS485_A

4..... yellow ..... RS485_B



Pin assignment external temperature sensors (coding Pin1):

1..... white ..... ext. temperature right 1
2..... brown..... ext. temperature right 2
3..... white ..... ext. temperature left 1
4..... brown..... ext. temperature left 2



The cable markings are based on DIN 47100.

10 Configuration and Testing

Lufft provides PC software for configuration purposes. With the aid of this software the device can be adjusted in accordance with the user's requirements.

10.1 Factory Settings

The IRS31Pro-UMB is delivered with the following settings:

Class ID: ..... 9 (cannot be modified)
Device ID: ..... 1 (gives address 9001h = 36865d)
Baud rate: 19200
RS485 protocol: ..... UMB binary
Calculation interval: ..... 6 measurements
Water film moisture threshold: ..... 10 µm
Water film wetness threshold: ..... 200 µm

Note: The device ID must be changed if several IRS31Pro-UMB sensors are operated on a UMB network, as each device requires a unique ID. It makes sense to start from ID 1 and continue in ascending order.

10.2 Configuration with PC Configuration Software UMB Config Tool

The main functions of the configuration software are described in detail in the Online Help. For this reason only the menus and functions specific to the sensor are described here.

10.2.1 Sensor Selection

In ‘Sensor Selection’, the road sensor is displayed as IRS31Pro-UMB (Class ID 9).

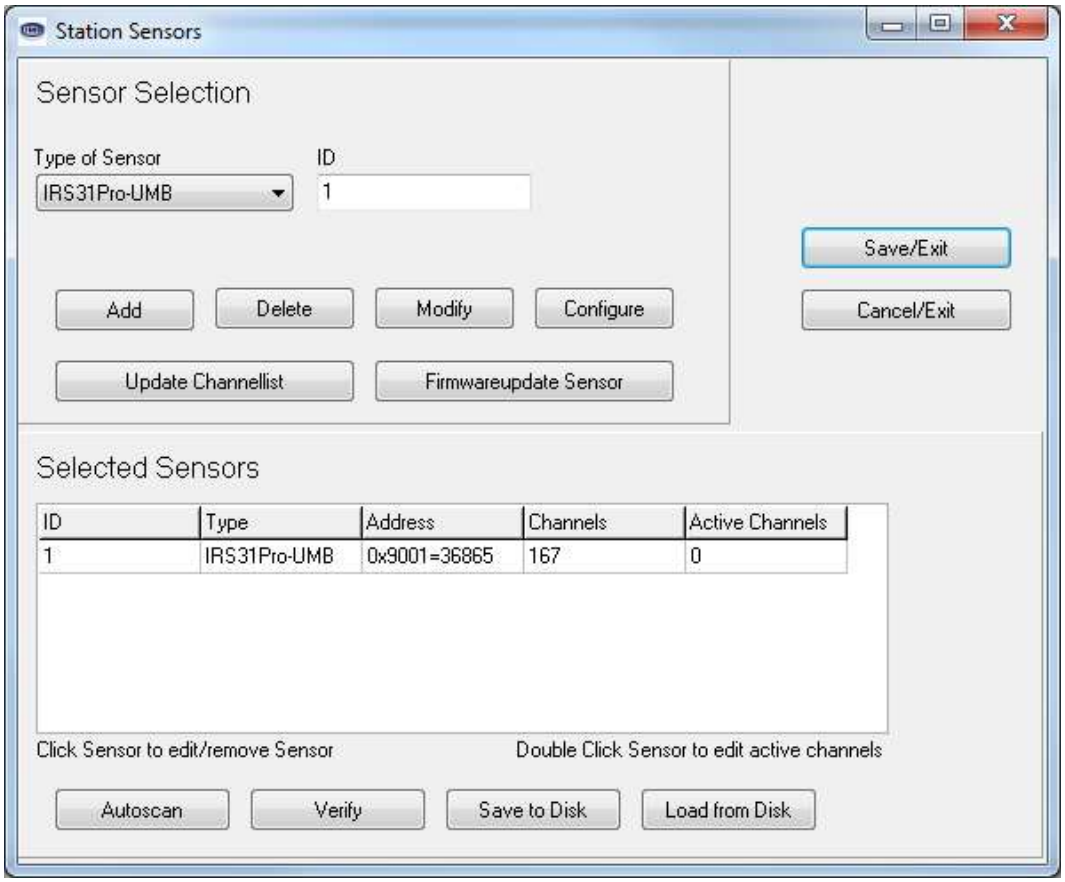


Figure 11: Sensor Selection

10.2.2 Configuration

After an IRS31-UMB configuration has been loaded, all relevant settings and values can be adjusted.

10.2.3 General Settings

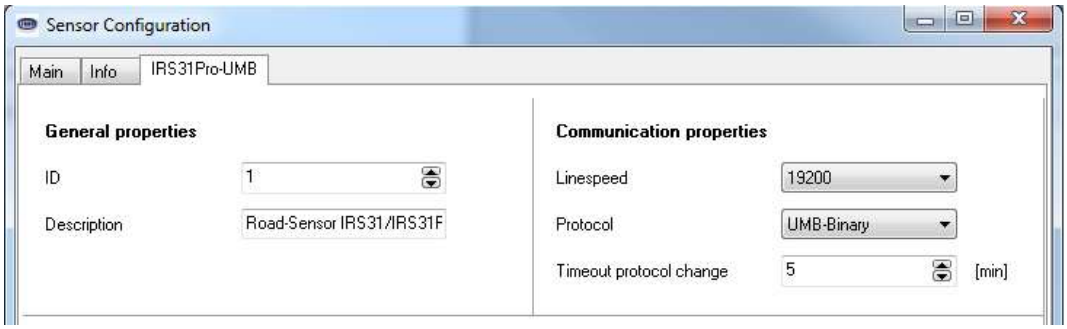


Figure 12: Sensor Configuration – General Settings

ID: Device ID (factory setting 1; assign device IDs to additional devices in ascending order)

Description: In order to differentiate the devices you can enter a description here, e.g. location.

Baud rate: Transmission speed of the RS485 interface (factory setting 19200; **DO NOT CHANGE for operation with ISOCON-UMB**). Firmware updates can only be made in the factory setting of the baud rate (19200 BD).

Protocol: Sensor communications protocol (UMB-Binary, UMB-ASCII)

Timeout: In the event of a temporary changeover of the communications protocol, the system switches back to the configured protocol after this time (in minutes). For further information, please consult the operating manual of the UMB Config Tool.

Important note: If the baud rate is changed, after saving the configuration on the sensor, the sensor communicates at the new baud rate. When operating the sensor in a UMB network with ISOCON-UMB, **this baud rate must not be changed**; otherwise the sensor is **no longer addressable** and can no longer be configured.

10.2.4 Device Settings

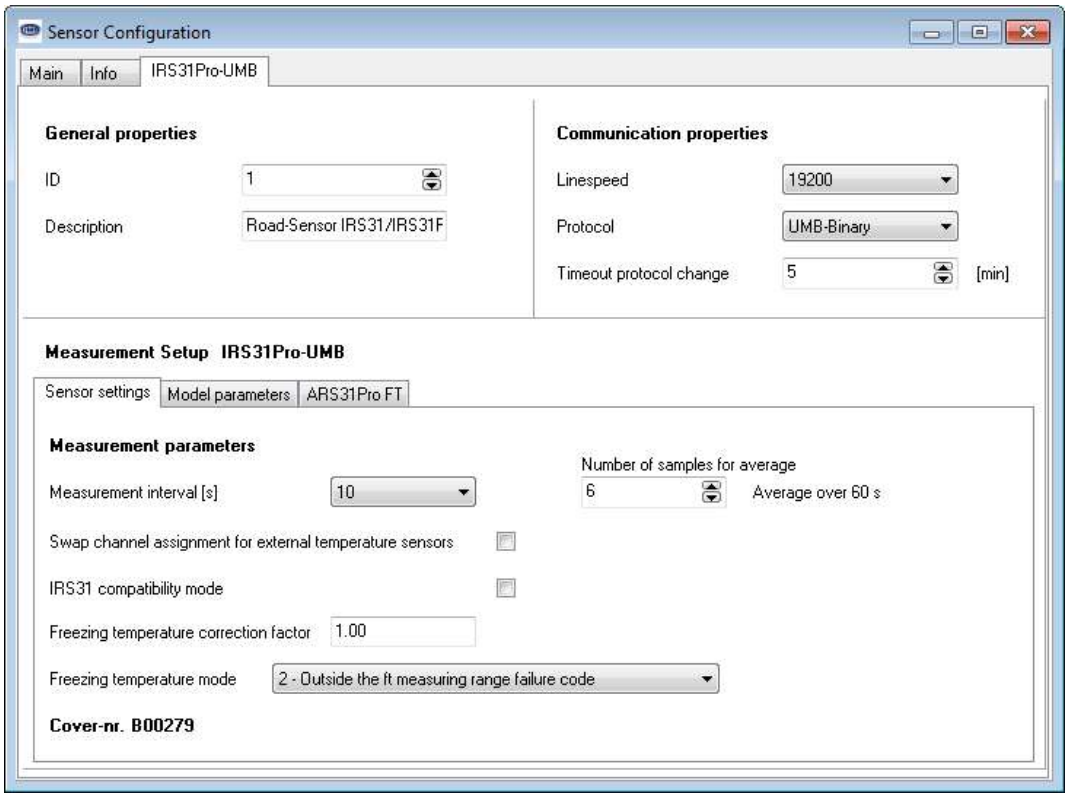


Figure 13: Sensor Configuration: Sampling Rate, Averaging and Freezing Temperature Correction Factor

Sampling rate: The sampling rate indicates how often a new measurement cycle is started. This value is configurable and can be set at 10, 20, 30 or 60 seconds. (Factory setting: 10 seconds)

Number of measurements for average: The number of measurements that are used to generate the moving average. This can be configured between 1 and 20.

	(Factory setting: 6)
Swap channel assignment of external temperature sensors:	This option is used to swap the assignment of the external temperature sensors.
IRS31 compatibility mode:	switches the Sensor into compatibility mode to IRS31-UMB. The setting compatibility mode to IRS31-UMB changes the class ID of the sensor to the class ID of an IRS31-UMB.In the IRS31-UMB compatibility mode the sensor possesses an IRS31-UMB compatible channel list and road condition coding. See chapter 11
Freezing temperature correction factor:	This factor influences the calculation of the freezing temperature. (Factory setting: 1) A factor between 0 and 1 increases the freezing temperature. A factor greater than 1 reduces the freezing temperature. Example: Measured freezing temperature -7°C Factor 0.5: Freezing temperature -2.69°C This influence of this factor on the calculation of the freezing temperature is non-linear.
Freezing temperature mode:	Determines how the freezing temperature is output when the road temperature is above the temperature limit for freezing temperature calculations or the water film height is below the dry threshold. This setting does not apply to IRS31 compatibility mode. The output of the freezing temperatures in compatibility mode is compatible with firmware version 5.2 of the IRS31-UMB. 0: the freezing temperature is transmitted as long as water film height is above the dry threshold, otherwise the freezing temperature of -0.1 ° C is reported. 1: the freezing temperature is transmitted as long as the sensor can measure it (also below the dry threshold), otherwise the freezing temperature of -0.1 ° C is reported. 2: the freezing temperature is transmitted as long as water film height is above the dry threshold, otherwise the error value 55h(85d) is reported. When the temperature is above the temperature limit for freezing temperature calculations the error value 55h(85d) also is reported. This error message means that the sensor is unable to measure due to ambient conditions.

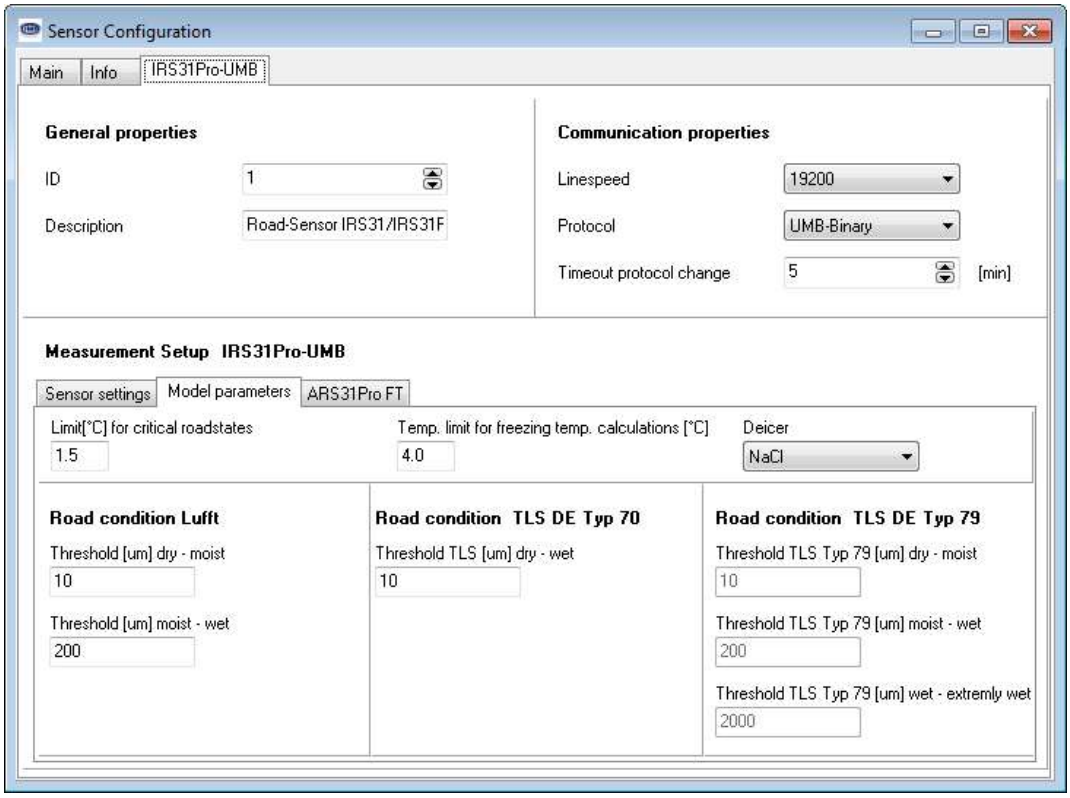


Figure 14: Sensor Configuration: Setting Thresholds

Threshold [°C] for critical road conditions:	Critical road conditions such as ice, wet / moist with salt can occur below this threshold.
Threshold temperature for determining freezing temperature [°C]:	The freezing temperature is calculated when the measured road surface temperature is less than or equal to the set threshold temperature. (Factory setting 4°C)
Deicer	The freezing temperature of the used deicer is included in the model calculations for the road conditions. It therefore has an effect on the derived channels. Friction and ice percentage at the moment is only supported for NaCl.
Threshold [µm] dry-moist:	When the water film height lies below the threshold set here, the IRS31PRO-UMB transmits the road surface condition "dry" (provided that no ice is detected) and no longer calculates the freezing temperature. (Factory setting 10µm)
Threshold [µm] moist-wet:	Threshold between the Lufft road surface conditions "moist" and "wet".
Threshold TLS[µm] dry-wet:	For adaptation to the different thresholds in the different versions of TLS; for TLS2012: 10µm, for TLS 2003 and older: 30µm.

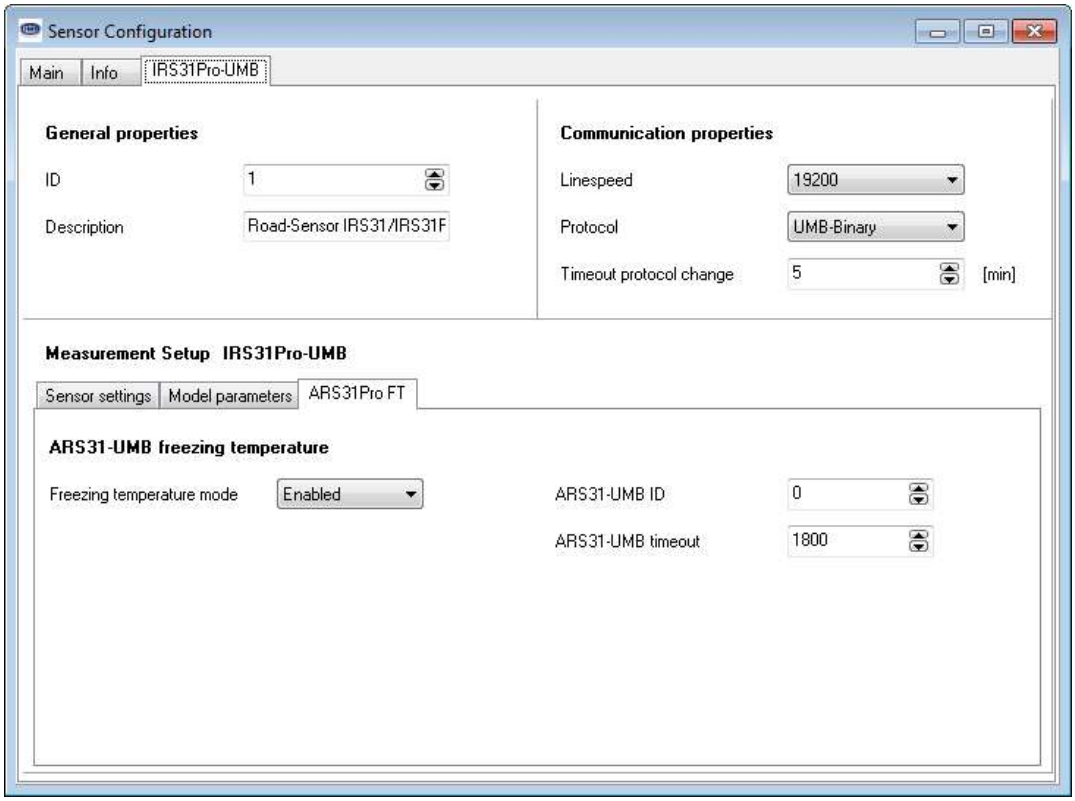


Figure 15: Sensor Configuration: Coupling of IRS31Pro-UMB with ARS31

Coupling with the ARS31Pro-UMB see chapter 12.

10.2.5 Measurement Polling Channels

Each channel can be enabled for measurement polling by clicking the respective channel.

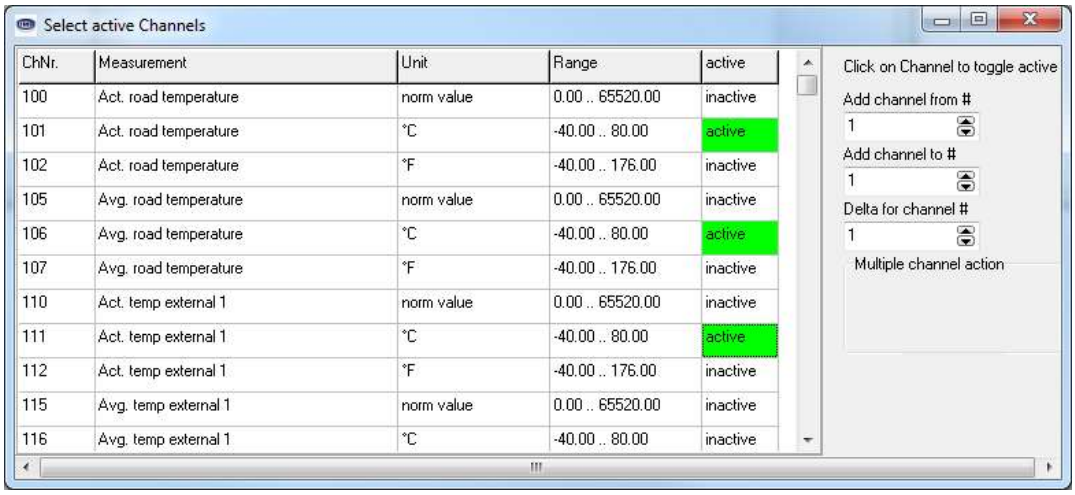


Figure 16: Select the Channels for Measurement Polling

10.2.6 Firmware Update

Firmware updates can only be made in the factory setting of the baud rate (19200 BD). To keep the sensor in accordance with the latest state-of-the-art, it is possible to carry out a firmware update on site with no need to remove the sensor and return it to the manufacturer.

The firmware update is carried out with the aid of the UMB Config Tool.

The description of the firmware update can be found in the instructions for the UMB Config Tool. Please download the latest firmware and UMB Config Tool from our website www.lufft.de and install it on a Windows® PC. You can find the instructions in the installation directory of the UMB-Config-Tool.

Figure 17: Operating instructions UMB-Config-Tool

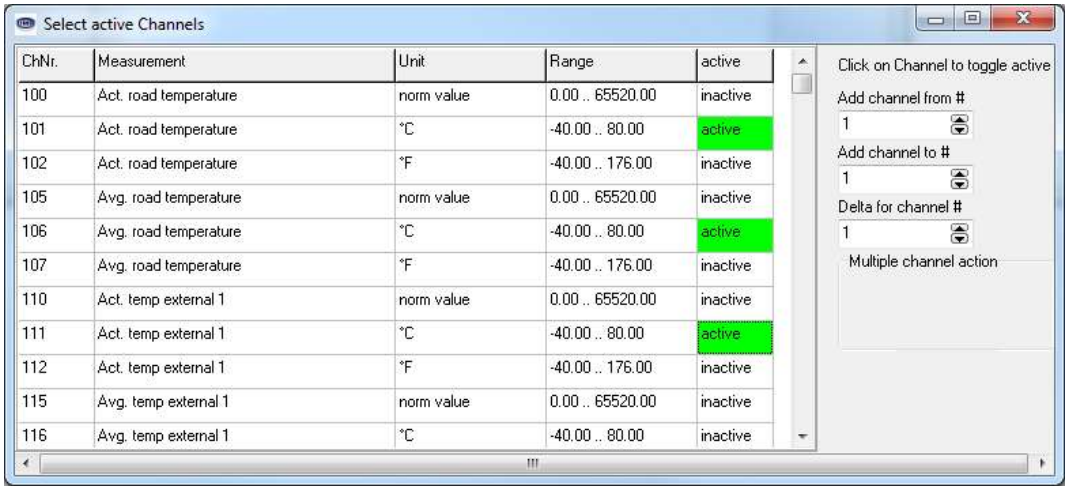
10.3 Function Test with the UMB Config Tool

The function of the sensor can be tested with the UMB Config Tool by polling various channels.

Note: All other devices which are used in the polling process, e.g. modems, LCOM etc., must be disconnected from the UMB network during the function test.

10.3.1 Channels for Measurement Polling

You can select the channel for measurement polling by the UMB Config Tool by clicking on the respective channel.

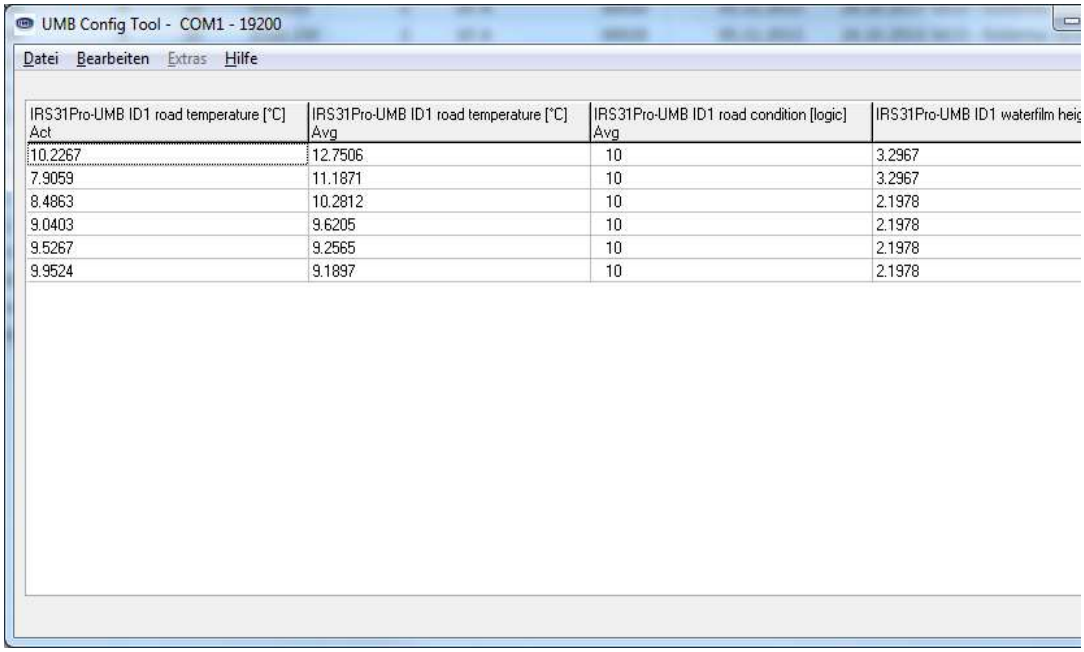


ChNr.	Measurement	Unit	Range	active
100	Act. road temperature	norm value	0.00 .. 65520.00	inactive
101	Act. road temperature	°C	-40.00 .. 80.00	active
102	Act. road temperature	°F	-40.00 .. 176.00	inactive
105	Avg. road temperature	norm value	0.00 .. 65520.00	inactive
106	Avg. road temperature	°C	-40.00 .. 80.00	active
107	Avg. road temperature	°F	-40.00 .. 176.00	inactive
110	Act. temp external 1	norm value	0.00 .. 65520.00	inactive
111	Act. temp external 1	°C	-40.00 .. 80.00	active
112	Act. temp external 1	°F	-40.00 .. 176.00	inactive
115	Avg. temp external 1	norm value	0.00 .. 65520.00	inactive
116	Avg. temp external 1	°C	-40.00 .. 80.00	inactive

Figure 18: Channel Selection in the UMB Config Tool

Note: Channel selection relates to measurement polling for the UMB Config Tool only. In general, all channels are always available for polling and do not need to be enabled in the sensor.

10.3.2 Example of Measurement Polling



IRS31Pro-UMB ID1 road temperature [°C] Act	IRS31Pro-UMB ID1 road temperature [°C] Avg	IRS31Pro-UMB ID1 road condition [logic] Avg	IRS31Pro-UMB ID1 waterfilm heig
10.2267	12.7506	10	3.2967
7.9059	11.1871	10	3.2967
8.4863	10.2812	10	2.1978
9.0403	9.6205	10	2.1978
9.5267	9.2565	10	2.1978
9.9524	9.1897	10	2.1978

Figure 19: Measurement Polling with the UMB Config Tool

Note: The UMB Config Tool is provided for test and configuration purposes only. It is not suitable for the permanent acquisition of measurement data. We recommend the use of professional software solutions for this purpose, e.g. SmartView3.

11 IRS31-UMB Compatibility mode

The compatibility mode to the IRS31-UMB allows:

- the addressing of the sensor with the class ID of an IRS31-UMB
- the query of measurement channels of an IRS31-UMB
- the query of IRS31 encoded road conditions

11.1 Important notes for using Sensor in compatibility mode

- When an IRS31Pro-UMB is set to IRS31-UMB compatibility mode, you have to add an IRS31-UMB to your measurement setup to configure or test the sensor.
- When a firmware update should be carried out on an IRS31-UMB, make sure that the sensor is not an IRS31Pro-UMB in the IRS31-UMB compatibility mode.
- It is possible to carry out a firmware update of an IRS31Pro-UMB in the IRS31-UMB compatibility mode directly (without switching off the IRS31-UMB compatibility mode first).
- If an IRS31-UMB firmware is programmed to the IRS31Pro-UMB Sensor, the adjustment data of the sensor is lost, and the sensor must be adjusted new at the factory.

11.2 Configuration possibilities

With the option "IRS31 compatibility mode", the compatibility mode to IRS31-UMB can be activated and deactivated.

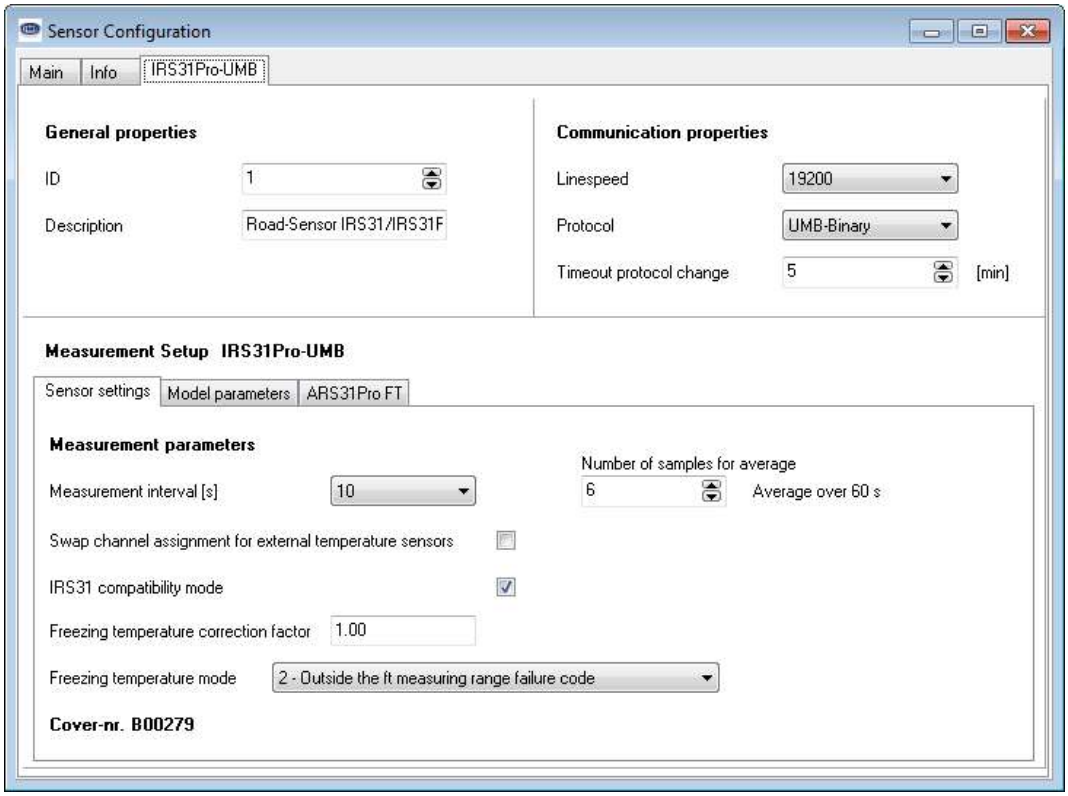


Figure 20: Sensor settings for IRS31-UMB compatibility mode

After the activation of this function and storing the profile on the sensor, the sensor can be addressed or tested only with the class ID of an IRS31-UMB (the class-ID for the road sensor IRS31-UMB is 1).

When configuring a measurement station with IRS31-UMB sensors, please make sure that the activation of the compatibility mode of an IRS31Pro-UMB doesn't cause double addressing (if necessary change the ID).

With the option "Number of samples for Average" the number of measurements that are used to generate the moving average can be configured (Factory setting: 6, Setting Range: 1…20).

Setting this number to 1 deactivates the moving average.

"Limit (°C) for critical roadstates" is relevant for the determination of the road condition states.

The road sensor detects the conditions “dry”, “damp” and “wet” above this limit (factory setting 1,5 °C). Below this limit, there are, in addition, the conditions of “freezing wet” and “critical“ (Figure 21).

For other device settings see chapter 10.2.4

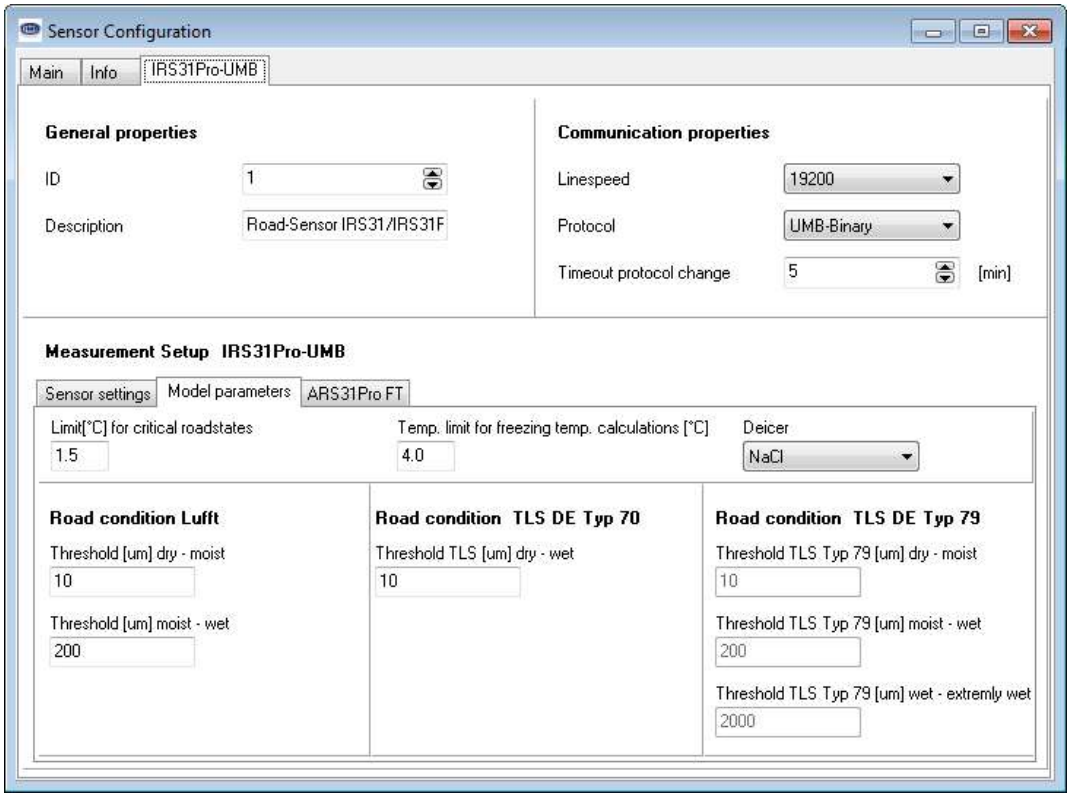


Figure 21: Model parameters

11.3 Examples for the Creation of Addresses

If, for example, a road sensor IRS31Pro-UMB is to be addressed with the device ID 1, this is achieved as follows:

Class ID for the road sensor IRS31Pro-UMB is 9 = 9h

Device ID is 1= 1h

Placing the class and device ID’s together gives the following address 9001h = 36865d.

Activating compatibility mode changes the class ID to 1.

Class ID for the road sensor IRS31Pro-UMB is 1 = 1h

Device ID is 1= 1h

Placing the class and device ID’s together gives the following address 1001h = 4097d.

11.4 Firmware-Update

With an IRS31Pro-UMB in the compatibility mode it is very slightly possible that mistakenly an IRS31-UMB firmware is programmed into the sensor. The adjustment data of the sensor thereby becomes useless, and the sensor delivers no longer correct measuring values. The sensor can be repaired only by a new calibration at the manufacturing plant.

Important Note: Before implementing any update, please check the name of Sensor.

To do this, load the current configuration via ‘Load profile from Sensor’. The current name of the sensor is shown under ‘Name’ on the ‘Info’ page.

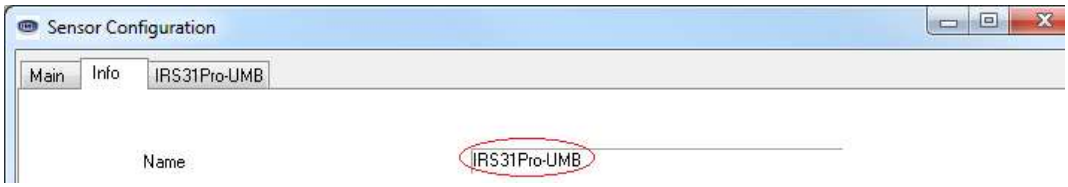


Figure 22: Name of the sensor

11.5 Overview channel list of an IRS31-UMB (IRS31Pro-UMB in IRS31-UMB compatibility mode)

The channel assignment applies to online data requests in UMB protocol.

The data types used are described in section 6.1.1

The change between average value and current measurement is done on an IRS31-UMB with the sensor configuration.

UMB-Channel						Measuring Range		
act	**min**	**max**	**avg**	**Measurement Variable**	**Data type**	**min**	**max**	**Unit**
Road surface temperature								
100			100	Road Temperature	uint16	0	65520	norm value
101			101	Road Temperature	float32	-40,0	80,0	°C
102			102	Road Temperature	float32	-40,0	176,0	°F
External temperature								
110			110	Temperature 1	uint16	0	65520	norm value
111			111	Temperature 1	float32	-40,0	80,0	°C
112			112	Temperature 1	float32	-40,0	176,0	°F
120			120	Temperature 2	uint16	0	65520	norm value
121			121	Temperature 2	float32	-40,0	80,0	°C
122			122	Temperature 2	float32	-40,0	176,0	°F
Freezing temperature								
150			150	Freezing Temperature	uint16	0	65520	norm value
151			151	Freezing Temperature	float32	-40,0	0,0	°C
152			152	Freezing Temperature	float32	-40,0	32,0	°F
160			160	Freezing Temp. NaCl	uint16	0	65520	norm value
170			170	Freezing Temp. NaCl	float32	-40,0	0,0	°C
180			180	Freezing Temp. NaCl	float32	-40,0	32,0	°F
Water film height								
600			600	Water Film Height	uint16	0	65520	norm value
601			601	Water Film Height	uint16	0,0	10000,0	µm
602			602	Water Film Height	float32	0,0	393,70	mil
Saline concentration								
800			800	Saline Concentration	uint16	0	65520	norm value
801			801	Saline Concentration	float32	0	100	%
810			810	Saline Concentr.NaCl	uint16	0	65520	norm value
820			820	Saline Concentr.NaCl	float32	0	100	%
910			910	Salinity NaCl	float32	0	1000	g/m2
920			920	Salinity NaCl	float32	0	1000	lbs.p.l.mile
Ice percent								
830			830	Percent Ice NaCl	uint16	0	65520	norm value
840			840	Percent Ice NaCl	float32	0	100	%
Road condition								
900			900	Road Condition def.	uint8	0 dry 1 moist 2 wet 3 ice 4 snow 5 residual salt 6 freezing wet 7 critical >90 undefined		
902			902	Road Condition	uint8	0 dry 1 moist 2 wet 3 ice 4 snow 5 residual salt 6 freezing wet 7 critical >90 undefined		
State of coupling								

950				State of coupling	uint8	0: Off 1: On, freezing temperature of an ARS31(Pro)-UMB received 2: On, freezing temperature of an ARS31(Pro)-UMB not received		
Supply Voltage								
10000				Supply Voltage	float32	0	18,05	V
Resistance								
32210				resistive_avg	float32	0	1.0E12	Ohm

The following channels are available specifically for data requests for further processing in TLS format. These channels are available in binary protocol only.

DE Type	UMB Channel	Meaning	Format	Range	Resolution	Coding
49	1049	Result message Road surface temperature FBT	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
52	1052	Result message Residual salt (NaCl) RS	8 bit	0 … 100%	1%	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)
65	1065	Result message Freezing temperature (NaCl) GFT	16 bit	-30 … 0°C	0.1°C	0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
67	1067	Result message Below-ground temperature at depth 1 TT1 (5 cm)	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
68	1068	Result message Below-ground temperature at depth 2 TT2 (0…30 cm)	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
69	1069	Result message Below-ground temperature at depth 3 TT3 (30cm)	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
70	1070	Result message Road surface condition FBZ	8 bit	0 … 255		0 Road is completely dry and free of snow and ice. 1 Road is moist or wet, or covered with ice or snow 32 Road is wet with liquid water / aqueous solution. 64 Road is fully or partially covered with frozen water / solid aqueous solution. 65 Road is covered with snow or slush. 66 Road is covered with ice (solid, frozen water and frozen aqueous solution). 67 Frost. 255 Sensor is unable to determine the road surface condition due to the prevailing conditions.

72	1072	Result message Water film height WFD	16 bit	0.00…10.00 mm	0.01 mm	0 = 0d = 0000h 10.00 = 1000d = 03E8h Error (65535d = FFFFh=
73	1073	Result message Thawing material concentration TSK	8 bit	0…100	1%	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)
74	1074	Result message Thawing material per square meter TSQ	8 bit	0…100	1g/m^2	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)

12 Coupling with ARS31/ARS31Pro-UMB

When the coupling IRS31-ARS31 is active, the IRS31Pro-UMB uses the mixture independent freezing temperature reported by an ARS31(Pro)-UMB Sensor instead of its own for the calculations of road condition, ice percentage and friction. When the coupling is active the IRS31Pro-UMB delivers the status code 0x36h = 54d (channel_off) on every freezing temperature and salt concentration channel.

System requirements:

- UMB system with at least one IRS31Pro-UMB and at least one ARS31-UMB or ARS31Pro-UMB.
- From ARS31 (Pro)-UMB at least (better: exactly) one of the channels 150, 151, 152, 153, 154, 155, 160, 161, 162 or 1065 must be polled cyclically using the UMB binary protocol. Whether or not the command for multi-channel query, or the single-channel query is used is not relevant.
- The ID of the associated ARS31 (Pro)-UMB must be configured in IRS31Pro-UMB.

12.1 Configuration of coupling within IRS31Pro-UMB:

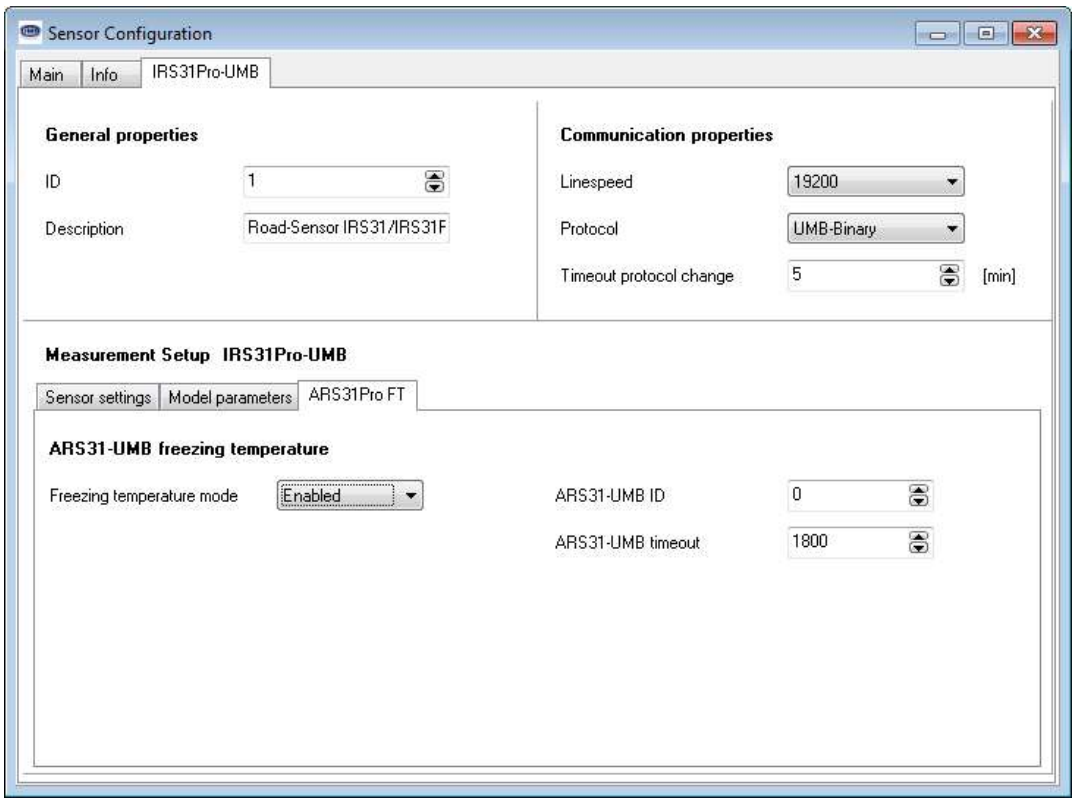


Figure 23 Configuration of coupling IRS31-ARS31

With the control “freezing temperature mode” Active/Switched off the takeover of the freezing temperature of an ARS31(Pro)-UMB can be enabled or disabled.

ARS31-UMB ID contains the ID of the ARS31-UMB sensor from which the freezing temperature channels are monitored. When this is set to 0 (the default) the responses of all ARS31(Pro)-UMB are evaluated.

ARS31-UMB timeout sets the time after which the IRS31Pro-UMB resets a freezing temperature reported by an ARS31(Pro)-UMB. After this time an IRS31Pro-UMB uses a freezing temperature of -0.1°C for all model calculations. This usually should be a time 3-5 times the time between 2 measurement queries of an ARS31(Pro)-UMB.

Example 1: A Lufft LCom queries measured values from a UMB system once in 60 seconds. As recommended timeout a value of 3-5 times 60 seconds (180-300 seconds) is calculated.

Example 2: A Smartview3 queries measured values from a UMB system once in 10 Minutes. As recommended timeout a value of 3-5 times 10 times 60 seconds (1800-3000 seconds) is calculated.

With polling of channel 950 "State of coupling" (State of the coupling), the current state of the freezing temperature acquisition from the ARS31(Pro)-UMB can be determined.

The following code applies:

Value	Meaning
0	The freezing temperature mode is off, the takeover of ARS31(Pro)-UMB freezing temperature is disabled in the sensor configuration of the IRS31Pro-UMB.
1	The freezing temperature mode is switched on, and in the IRS31Pro-UMB a valid freezing temperature of the configured ARS31(Pro)-UMB exists.
2	The freezing temperature mode is switched on, and in the IRS31Pro-UMB exists no valid freezing temperature of the configured ARS31(Pro)-UMB exists.

The coupling IRS31-ARS31 may be used in the IRS31 compatibility mode as well.
For best results, an IRS31Pro-UMB Firmware Version 2.3 or newer is required.

13 Technical Data

Power supply:	12 VDC
Operating voltage range:	0.75 .. 1.15 * Power supply
Current consumption:	Typically approx. 8.5 mA (sampling rate 10 s) Typically approx. 5 mA (sampling rate 1 min.) at 12VDC
Inrush current:	Approx. 1A (5ms) at 12VDC
Sensor dimensions:	Height 50 mm ∅ 120 mm
Sensor weight:	Approx. 800g without cable and without external Temperature sensor
Protection class:	III (SELV)
Protection type:	IP68

Storage conditions

Permissible storage temperature:	-40°C … +70°C (in packing)
Permissible relative humidity:	0 … 95% RH non-condensing (in packing)

Operating conditions

Permissible ambient temperature:	-40°C … +80°C
Permissible relative humidity:	0 … 100% RH
Permissible altitude above sea level:	3000 m

Interface SDI12 or RS485, 2 wire, half-duplex

Data bits:	8
Stop bit:	1
Parity:	None
Adjustable baud rates:	1200, 2400, 9600, 19200[1], 38400

13.1 Measuring Range / Accuracy

13.1.1 Road Surface Temperature

Measurement process:	ntc
Measuring range:	-40°C … +80°C
Resolution:	< 0.02°C (-20…+20), otherwise +/-0.1
Accuracy:	+/- 0.1°C (-20…+20), otherwise +/-0.2
Sampling rate:	Variable (10 s….60 s)
Units:	°C; °F

13.1.2 Water Film Height

Measurement process:	Radar
Measuring range:	0 … 4000 µm
Resolution:	Better than 0.01mm
Accuracy:	0.2mm to 4mm: better than +/-30%
Sampling rate:	Variable (10 sec….60 sec)
Units:	µm, mil

13.1.3 Freezing Temperature

Measurement process:	Calculated from saline concentration
Measuring range:	-40°C … 0°C
Resolution:	0.1°C

[1] Factory setting and baud rate for firmware update

Accuracy: (Wfh > 50µm):	0 °C to –2,5 °C, (+/-0,5 °C), otherwise +/-20% f. mv (**with NaCl**)
Sampling rate:	Variable (10 sec….60 sec)
Units:	°C; °F

13.1.4 Ice Percentage

Measurement process:	Passive
Measuring range:	0% … 100%
Resolution:	0.1%
Sampling rate:	Variable (10 sec….60 sec)
Units:	%

13.1.5 Saline Concentration

Measurement process:	Passive
Measuring range:	0% … 100%
Resolution:	0.1%
Accuracy:	see freezing temperature
Sampling rate:	Variable (10 sec….60 sec)
Units:	%

13.1.6 Friction

Measurement process:	Calculated from ice percentage
Measuring range:	0 … 1
Resolution:	0.01
Sampling rate:	Variable (10 sec. ….60 sec.)

14 Fault Description

Fault Description	Cause - Remedy
Device does not allow polling or does not respond	- Check supply voltage - Check interface connection - Incorrect device ID → check ID; devices are delivered with ID 1
Device delivers implausible values	- Check for compliance with the sensor installation instructions
Device transmits error value 24h (36d)	A channel was requested that is not available on this device
Device transmits error value 28h (40d)	Device is in initialization phase after start-up → wait until first measurement is complete
Device transmits error value 50h (80d)	Device is being operated above the specified measuring range
Device transmits error value 51h (81d)	Device is being operated below the specified measuring range
Device transmits error value 55h (85d)	The device is unable to execute a valid measurement due to the ambient conditions. This may be due to the following reasons: - The road surface temperature is too high to perform the freezing temperature measurement - The water film height is too low to perform the freezing temperature measurement - The freezing temperature cannot be determined, because of an firm layer of ice on the sensor
Device transmits error value 2Bh (43d)	The device returns this error value in the channel because there is a fault on one of the variables on which this channel is based.
Device transmits error value 36h (54d)	Coupling IRS31-ARS31 is active, and a freezing temperature or saline concentration channel of the IRS31Pro-UMB is queried.
Device transmits error value 54h (84d)	Internal measurement error. Can be ignored for one-time occurrence. In case of permanent occurrence, check whether the installation notes / power supply correspond to the specifications in the operating instructions.
Device transmits an error value not listed here	There may be several reasons for this behavior → contact the manufacturer's technical support service
Device transmits error value 32h (50d)	contact the manufacturer's technical support service
Device transmits error value 33h (51d)	contact the manufacturer's technical support service
Device transmits no freezing temperature	- The Sensor is too warm - The Sensor is dry - The sensor is covered with ice

15 Certifications

Certifications for the IRS31-Pro are listed below.

15.1 CE

The IRS31-PRO Sensor is in conformity with all relevant requirements of the RED Directive (2014/53/EU) and RoHS (2011/65/EU). This device is compliant with the following standards:

- **Safety: EN 62368**
- **EMC: EN 301 489**
- **SRD: EN 300 440**
- **RoHS: EN 50581**

A formal DoC is available from www.lufft.com

15.2 FCC

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and

2. This device must accept any interference received, including interference that may cause undesirable operation.

Any changes or modifications not expressly approved by the responsible party for compliance (G. Lufft Mess- und Regeltechnik GmbH) could void the user's authority to operate the equipment.

FCC RF Radiation Exposure Statement:

This device complies with FCC radiation exposure limits set for an uncontrolled environment. This transmitter meets mobile/fixed limits as demonstrated in the RF Exposure Analysis (Section 2.5.2).

Labeling

The FCC identifier (FCC ID: **UF9-IRS31PRO**) is to be found on outer serial number sticker.

15.3 IC

IC (English)

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt RSS(s). Operation is subject to the following two conditions:

1. This device may not cause interference.

2. This device must accept any interference, including interference that may cause undesired operation of the device.

RF Exposure Statement

This device complies with the ISED radiation exposure limits set for an uncontrolled environment as it meets the 2.5.2 Exemption Limits for Routine Evaluation – RF Exposure Evaluation for mobile/fixed as defined in RSS-102

Labeling

The IC certification number (IC: **6650A-IRS31PRO**) is to be found on outer serial number sticker.

IC (français)

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes :

1. L'appareil ne doit pas produire de brouillage ;

2. L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Déclaration d'exposition aux RF

Cet appareil est conforme aux limites d'exposition aux radiations ISDE définies pour un environnement non contrôlé car il répond aux 2.5.2 Limites d'exemption pour l'évaluation de routine - Évaluation de l'exposition RF pour mobile / fixe comme défini dans RSS-102.

16 Disposal

16.1 Inside the EU

In accordance with the European Union guideline 2012/19/EU, Lufft takes back old devices within the member countries of the European Union and disposes of them in an appropriate way.

For further information on the return procedure, please contact your local sales contact. You will find the addresses of all sales partners in the internet on "www.lufft.com". Please take into consideration also the national implementation of the EU guideline 2012/19/EU of your country.

16.2 Outside the EU

Please comply with the applicable regulations for the proper disposal of waste electrical and electronic equipment in your respective country.

17 Repair / Corrective Maintenance

Please arrange for any faulty equipment to be checked and, if necessary, repaired by the manufacturer exclusively. Do not open the equipment and do not under any circumstances attempt to carry out your own repairs.

In matters of guarantee or repair please contact:

G. Lufft Mess- und Regeltechnik GmbH

Gutenbergstraße 20
70736 Fellbach

Postfach 4252
70719 Fellbach
Germany

Phone: +49 711 51822-0
Hotline: +49 711 51822-52
Fax: +49 711 51822-41

E-mail: info@lufft.de

or your local distributor.

17.1 Technical Support

Our hotline is available for technical questions via the following e-mail address:

hotline@lufft.de

You can also consult frequently asked questions at www.lufft.de (Menu header: Support → FAQs).

For support questions, please read the configuration of the sensor with the UMB Config Tool and store it on disk. Include the saved configuration in your support request.

18 Appendix

18.1 Channel List Summary

The channel assignment applies to online data requests in UMB protocol.

The data types used are described in section **Fehler! Verweisquelle konnte nicht gefunden werden.**

UMB Channel						Measuring Range		
act	min	max	avg	Measurement Variable	Data Type	min	max	Unit
Road surface temperature								
100			105	Road temperature	uint16	0	65520	norm value
101			106	Road temperature	float32	-40.0	80.0	°C
102			107	Road temperature	float32	-40.0	176.0	°F
External temperature								
110			115	External temperature 1	uint16	0	65520	norm value
111			116	External temperature 1	float32	-40.0	80.0	°C
112			117	External temperature 1	float32	-40.0	176.0	°F
120			125	External temperature 2	uint16	0	65520	norm value
121			126	External temperature 2	float32	-40.0	80.0	°C
122			127	External temperature 2	float32	-40.0	176.0	°F
Freezing temperature								
150			155	Freezing temp. NaCl	uint16	0	65520	norm value
151			156	Freezing temp. NaCl	float32	-40.0	0.0	°C
152			157	Freezing temp. NaCl	float32	-40.0	32.0	°F
170			175	Freezing temp. MgCl2[1]	uint16	0	65520	norm value
171			176	Freezing temp. MgCl2	float32	-40.0	0.0	°C
172			177	Freezing temp. MgCl2	float32	-40.0	32.0	°F
190			195	Freezing temp. CaCl2[1]	uint16	0	65520	norm value
191			196	Freezing temp. CaCl2	float32	-40.0	0.0	°C
192			197	Freezing temp. CaCl2	float32	-40.0	32.0	°F
Water film height								
600			605	Water film height	uint16	0	65520	norm value
601			606	Water film height	float32	0.0	10000.0	µm
602			607	Water film height	float32	0.0	393.70	mil
Saline concentration								
800			805	Saline concent. NaCl	uint16	0	65520	norm value
801			806	Saline concent. NaCl	float32	0	100	%
910			915	Saline concent. NaCl	float32	0	100	g/m^2
920			925	Saline concent. NaCl	float32	0	1280	lbs.p.l.mile
830			835	Saline concent.MgCl2[1]	uint16	0	65520	norm value
831			836	Saline concent.MgCl2	float32	0	100	%
911			916	Saline concent.MgCl2	float32	0	100	g/m^2
921			926	Saline concent.MgCl2	float32	0	1280	lbs.p.l.mile
840			845	Saline concent.CaCl2[1]	uint16	0	65520	norm value
841			846	Saline concent.CaCl2	float32	0	100	%
912			917	Saline concent.CaCl2	float32	0	100	g/m^2
922			927	Saline concent.CaCl2	float32	0	1280	lbs.p.l.mile
Ice percentage								
810			815	Ice percentage	float32	0.0	100	%
Friction								
820			825	Friction	float32	0.0	1.0	
Road condition								
900			905	Road condition	uint8			

900			905	road condition	uint8	10 Dry 15 Moist 20 Wet 25 Moist with salt 30 Wet with salt 35 Ice 40 Snow 45 Frost		
State of coupling								
950				state of coupling	uint8	0: Off 1: On, Freezing temperature of a ARS31(Pro)-UMB received 2: On, Freezing temperature of a ARS31(Pro)-UMB not received		
Measurement Counter								
20001				Measurement counter	uint16	0	65520	
Resistance								
			32210	resistive_avg	float32	-1.0E15	1.0E15	ohm

[1] experimental implementation

18.2 Channel List Summary per TLS2012 FG3

The following channels are available specifically for data requests for further processing in TLS format. These channels are available in binary protocol only.

DE Type	UMB Channel	Meaning	Format	Range	Resolution	Coding
49	1049	Result message Road surface temperature FBT	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
52	1052	Result message Residual salt (NaCl) RS	8 bit	0 … 100%	1%	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)
65	1065	Result message Freezing temperature (NaCl) GFT	16 bit	-30 … 0°C	0.1°C	0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
67	1067	Result message Below-ground temperature at depth 1 TT1 (5 cm)	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
68	1068	Result message Below-ground temperature at depth 2 TT2 (0…30 cm)	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)
69	1069	Result message Below-ground temperature at depth 3 TT3 (30cm)	16 bit	-30 … +80°C	0.1°C	80.0 = 800d = 0320h 0.0 = 0d = 0000h -0.1 = -1d = FFFFh -30.0 = -300d = FED4h Error (32767d = 7FFF)

70	1070	Result message Road surface condition FBZ	8 bit	0 … 255		0 Road is completely dry and free of snow and ice. 1 Road is moist or wet, or covered with ice or snow 32 Road is wet with liquid water / aqueous solution. 64 Road is fully or partially covered with frozen water / solid aqueous solution. 65 Road is covered with snow or slush. 66 Road is covered with ice (solid, frozen water and frozen aqueous solution). 67 Frost. 255 Sensor is unable to determine the road surface condition due to the prevailing conditions.
72	1072	Result message Water film height WFD	16 bit	0.00…10.00 mm	0.01 mm	0 = 0d = 0000h 10.00 = 1000d = 03E8h Error (65535d = FFFFh=
73	1073	Result message Thawing material concentration TSK	8 bit	0…100	1%	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)
74	1074	Result message Thawing material per square meter TSQ	8 bit	0…100	1g/m^2	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)
75	1075	Result message Snow film height SFD	8 bit	0 … 50 mm	1 mm	0 = 0d = 00h 50 = 50d = 32h Error (255d = FFh)
76	1076	Result message Ice film height EFD	16 bit	0.00…2.00 mm	0.01 mm	0 = 0d = 0000h 2.00 = 200d = 00C8h Error (255d = FFh)
77	1077	Result message Road grip GR	8 bit	0.00…1.00	0.01	0.00 = 0d = 00h 1.00 = 100d = 64h Error (255d = FFh)
79	1079	Result message Road surface condition for winter services FZW	8 bit	0 … 255		0 Dry 16 Moist 32 Wet 48 Extremely wet 64 Icy
129	1129	Result message Ice percentage EP	8 bit	0…100 %	1%	0 = 0d = 00h 100 = 100d = 64h Error (255d = FFh)

18.3 Communication in Binary Protocol

Only one example of an online data request is described in this operating manual. Please refer to the current version of the UMB Protocol for all commands and the exact mode of operation of the protocol (available for download at www.lufft.de).

Note: Communication with the sensor takes place in accordance with the master-slave principle, i.e. there may only be ONE requesting unit on a network.

18.3.1 Framing

The data frame is constructed as follows:

1	2	3 – 4	5 – 6	7	8	9	10	11 … (8 + len) optional	9 + len	10 + len 11 + len	12 + len
SOH	<ver>	<to>	<from>	<len>	STX	<cmd>	<verc>	<payload>	ETX	<cs>	EOT

SOH Control character for the start of a frame (01h); 1 byte

<ver> Header version number, e.g.: V 1.0 →<ver> = 10h = 16d; 1 byte

<to>	Receiver address, 2 bytes
<from>	Sender address; 2 bytes
<len>	Number of data bytes between STX and ETX; 1 byte
STX	Control character for the start of payload transmission (02h); 1 byte
<cmd>	Command; 1 byte
<verc>	Version number of the command; 1 byte
<payload>	Data bytes; 0 – 210 bytes
ETX	Control character for the end of payload transmission (03h); 1 byte
<cs>	Check sum, 16 bit CRC; 2 bytes
EOT	Control character for the end of the frame (04h); 1 byte

Control characters: SOH (01h), STX (02h), ETX (03h), EOT (04h).

18.3.2 Addressing with Class ID and Device ID

Addressing takes place by way of a 16 bit address. This breaks down into a Class ID and a Device ID.

Address (2 bytes = 16 bits)				
Bits 15 – 12 (upper 4 bits)		**Bits 11 – 8 (middle 4 bits)**	**Bits 7 – 0 (lower 8 bits)**	
Class ID (0 to 15)		**Reserve**	**Device ID** (0 – 255)	
0	Broadcast		0	Broadcast
9	IRS31Pro-UMB Road Sensor		1 – 255	Available
15	Master / Control Devices			

ID = 0 is provided as broadcast for classes and devices. Thus it is possible to transmit a broadcast on a specific class. However this only makes sense if there is only one device of this class on the bus; or in the case of a command, e.g. reset.

18.3.3 Example for Creating Addresses

If, for example, you want to address an IRS31Pro-UMB device with the device ID 001, this takes place as follows:

The class ID for IRS31Pro-UMB is 9d = 9h

The device ID is e.g. 001d = 01h

Putting the class and device IDs together gives the address 9001h (36865d).

18.3.4 Example of a Binary Protocol Request

If, for example, an IRS31Pro-UMB device with the device ID 001 is to be polled from a PC for the current road surface temperature, this takes place as follows:

Sensor:

The class ID for the IRS31Pro-UMB is 9 = 9h

The device ID is 001 = 01h

Putting the class and device IDs together gives a target address of 9001h.

PC:

The class ID for the PC (master unit) is 15 = Fh

The PC ID is e.g. 001d = 01h

Putting the class and device IDs together gives a sender address of F001h.

The length <len> for the online data request command 4d = 04h.

The command for the online data request is 23h.

The version number of the command is 1.0 = 10h.

The channel number is in <payload>; as can be seen from the channel list (page 44), the current road surface temperature in °C in channel 101d = 0065h.

The calculated CRC is 85DCh.

The request to the device:

SOH	<ver>	<to>	<from>	<len>	STX	<cmd>	<verc>	<channel>	ETX	<cs>	EOT

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
01h	10h	01h	90h	01h	F0h	04h	02h	23h	10h	65h	00h	03h	85h	DCh	04h

The response from the device:

SOH	<ver>	<to>		<from>		<len>	STX	<cmd>	<verc>	<status>	<channel>	<typ>
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
01h	10h	01h	F0h	01h	90h	0Ah	02h	23h	10h	00h	65h	00h	16h

<value>				ETX	<cs>		EOT
15	**16**	**17**	**18**	**19**	**20**	**21**	**22**
ECh	F2h	C4h	41h	03h	24h	51h	04h

Interpretation of the response:

<status> = 00h device o.k. (≠ 00h signifies error code; see chapter 18.3.5)

<typ> = Data type of the following value; 16h = float (4 bytes, IEEE format)

<value> = 41C4F2ECh corresponds to a float value of 2.46186E+0001 = 24.6

The road surface temperature is therefore 24.6°C.

Correct data transmission can be checked with the aid of the check sum (5124h).

Note: Little Endian (Intel, low byte first) applies when transmitting word and float variables of addresses or the CRC, for example. This means first the low byte and then the high byte.

18.3.5 Status and Error Codes in Binary Protocol

If a measurement request delivers the <status> 00h, the sensor is working correctly. You can find a complete list of additional codes in the description of the UMB protocol.

Extract from list:

<status>	Description
00h (0d)	Command successful; no error; all o.k.
10h (16d)	Unknown command; not supported by this device
11h (17d)	Invalid parameter
24h (36d)	Invalid channel
28h (40d)	Device not ready; e.g. initialization / calibration running
2Bh (43d)	Error in measurement
50h (80d)	Measurement variable (+offset) is outside the set display range
51h (81d)	
52h (82d)	Measurement value (physical) is outside the measuring range (e.g. ADC over range)
53h (83d)	
54h (84d)	Error in measurement data or no valid data available
55h (85d)	Device / sensor unable to carry out valid measurements due to ambient conditions

18.3.6 CRC Calculation

CRC is calculated according to the following rules:

Norm: CRC-CCITT

Polynomial: 1021h = $x^{16} + x^{12} + x^5 + 1$ (LSB first mode)

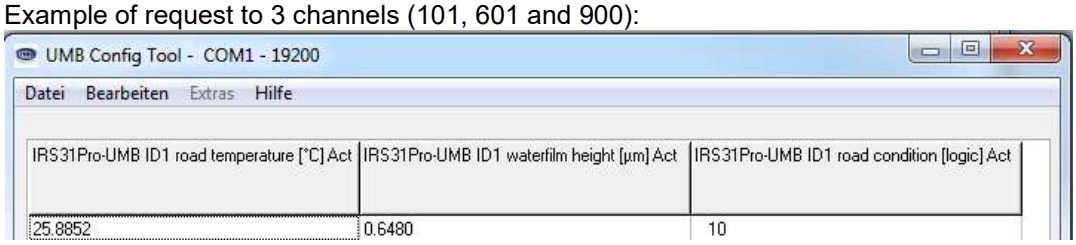
Start value: FFFFh

You can find further information in the description of a CRC calculation in the UMB protocol.

18.3.7 Recording of a Communication with the UMB Config Tool

The UMB Config Tool uses the command ‘Online data request multiple channels’ (2Fh) for the data request.

Example of request to 3 channels (101, 601 and 900):




```
Request by UMB Config Tool:
01 10 01 90 01 F0 09 02 2F 10 03 65 00 59 02 84 03 03 D2 6C 04
Response from IRS31Pro-UMB sensor:
01 10 01 F0 01 90 1C 02 2F 10 00 03 08 00 65 00 16 ED 14 CF 41 08 00 59 02 16 80 E3
25 3F 05 00 84 03 10 0A 03 FC A2 04
```

18.4 Communication in ASCII Protocol

Text-based communication with devices is possible using ASCII protocol.

To do this, in the device configuration, interface settings, the protocol mode must be set to ASCII (see Configuration with PC Configuration Software UMB Config Tool, 10.2.3 page 26).

ASCII protocol is network-compatible and serves exclusively for online data requests. The device does not respond to incomprehensible ASCII commands.

Note: The use of binary protocol is recommended for lengthy transmission routes (e.g. network, GPRS/UMTS), as ASCII protocol is unable to detect transmission errors (not CRC-secured).

Note: TLS channels are not available in ASCII protocol.

18.4.1 Structure

An ASCII command is introduced by the '&' character and completed by the CR (0Dh) sign. There is a space character (20h) between the individual blocks in each case; this is represented by an underscore character '_'. Characters that represent an ASCII value are in ordinary inverted commas.

18.4.2 Summary of ASCII Commands

Command	Function	BC	AZ
M	Online data request		l
X	Switches to binary protocol		k
R	Triggers software reset	●	k
D	Software reset with delay	●	k
I	Device information		k

These operating instructions describe the online data request only. You can find the description of the other commands in the UMB protocol.

18.4.3 Online Data Request (M)

Description: By way of this command, a measurement value is requested from a specific channel.

Request: '&'_<ID>[5]_'M'_<channel>[5] CR

Response: '$'_<ID>[5]_'M'_<channel>[5]_<value>[5] CR

<ID>[5] Device address (5 decimal places with leading zeros)

<channel>[5] Indicates the channel number (5 decimal places with leading zeros)

<value>[5] Measurement value (5 decimal places with leading zeros); a measurement value normalized to 0 – 65520d. Various error codes are defined from 65521d – 65535d. The necessary min and max values for the calculation should be taken from the description of the channels in chapter 6.1.

Example:

Request: `&_36865_M_00100`

By way of this request, channel 100 of the device with address 36865 (IRS31Pro-UMB with device ID 001) is requested.

Response: `$_36865_M_00100_34785`

This channel outputs a temperature from –40 to +80°C; this results in the following calculation:

0d	corresponds to	-40°C
65520d	corresponds to	+80°C
34785d	corresponds to	[+80°C – (-40°C)] / 65520 * 34785 +(-40°C) = 23.7°C

Note: TLS channels are not available in ASCII protocol.

18.4.4 Switch to Binary Protocol (X)

Description: This command is used to switch temporarily into the binary mode.

Request: '&'_<ID>_'X' CR

Response: '$'_<ID>_'X' CR

<ID>5 Device address (5 decimal places with leading zeros)

Note: ATTENTION!! Immediately after the response, the device can only be accessed via the binary protocol. If you want the device to work in ASCII mode again, it must be switched to ASCII mode using the binary command for a protocol change.

After a reset or device-specific timeout, the device communicates again in the previously set mode. If the device is to operate permanently in the binary mode, for example, the device configuration in the EEPROM must be changed.

18.4.5 Software Reset (R)

Description: This command is used to trigger a software reset. Alternatively, the factory settings can be restored before the reset.

Request: '&'_<ID>_'R'_<reset> CR

Response: '$'_<ID>_'R' CR

<ID>5 device address (5 decimal places with leading zeros)

<reset>3 010: Reset; 011: Reset with default

Note: The response occurs immediately before the reset.

18.4.6 Software Reset with Delay (D)

Description: This command is used to trigger a software reset after a delay <delay> (e.g. for firmware update).

Request: '&'_<ID>_'D'_<delay> CR

Response: '$'_<ID>_'D' CR

<ID>5 device address (5 decimal places with leading zeros)

<delay>3 Delay time in seconds (max. 255)

Note: The response occurs at the start of the delay time.

18.4.7 Device Information (I)

Description: This command is used to transmit device information.

Request: '&'_<ID>_'I' CR

Response: '$'_<ID>_'I'_<Ser.no.>_<MMYY>_<Project>_<PartsList>_<SPlan>_<hardware>_<software>_<e2version>_<deviceversion> CR

<ID>[5] device address (5 decimal places with leading zeros)

<Ser.no.>[3]

<MMYY>[4]

<Project>[4] <PartsList>3

<SPlan>[3]

<hardware>[3]

<software>[3]

<e2version>[33]

<deviceversion>[5]

18.4.8 Normalization of Measurement Values in ASCII Protocol

The normalization of measurement values from 0d – 65520d corresponds to the measuring range of the respective measurement variable.

Measurement Variable	Measuring Range		
	min	max	Unit

Temperature			
Road surface temperature	-40.0	80.0	°C
	-40.0	176.0	°F
External temperatures	-40.0	80.0	°C
	-40.0	176.0	°F
Freezing temperature	-40.0	0.0	°C
	-40.0	32.0	°F
Water Film Height			
Water film height	0.0	10000.0	µm
Percentage			
Ice percentage	0.0	100.0	%
Saline concentration	0.0	100.0	%
Friction	0.0	1.0	none

18.4.9 Status and Error Codes in ASCII Protocol

In addition to the normalization of the output of measurement values, various error codes are defined from 65521d – 65535d.

Codes:

<code>	Description
65521d	Invalid channel
65523d	Measurement value outside measuring range (too high)
65524d	Measurement value outside measuring range (too low)
65525d	Measurement data error or no valid data available
65526d	Device / sensor unable to execute valid measurement due to ambient conditions
65527d	Measurement error
65528d	Channel off (deactivated)
65534d	Invalid calibration
65535d	Unknown error

18.5 Communication in SDI12 Protocol

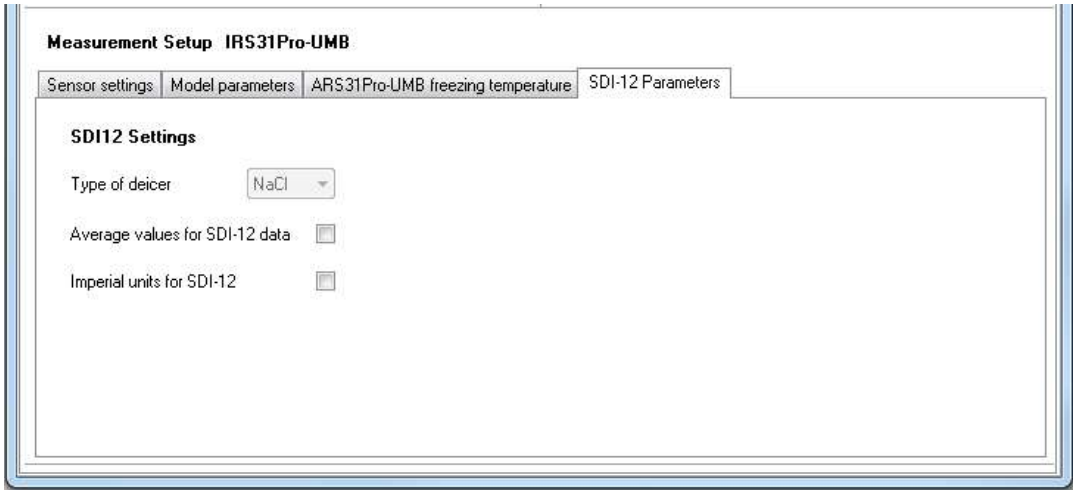
The communication in the SDI-12 mode of the IRS31Pro-UMB is conforming to the standard defined in ‚SDI-12 A Serial-Digital Interface Standard for Microprocessor-Based Sensors Version 1.3 January 12, 2009‘ .
The station may be operated in bus mode together with other SDI-12 sensors, connected to one SDI master (logger).

18.5.1 Preconditions for SDI-12 Operation

As the interface settings defined in the SDI-12 standard are significantly different from the UMB default settings the related parameters have to be set properly by the UMB Config Tool.

The protocol mode of the station has to be set to “SDI-12”. The sensor will set the required interface parameters (1200bps, 7 bits, even parity) automatically.

Measurement data can be transmitted alternatively in metric or US units. Additionally the transmission of spot values or average values can be selected. The selection is done by the UMB Config Tool.



Attention: When connecting the sensor to a SDI12 logger make sure to see chapter 7.3.1 first!

When operating the device in SDI-12 mode it is basically no more possible to access the device with the UMB Config Tool, due to the different interface parameter settings. To enable configuration access nevertheless the interface is operated in standard UMB mode (19200 8N1) for the first 5 seconds(*) after reset / power on. If a valid UMB telegram is received within this 5 sec, the device will stay in UMB mode for the configured timeout (several minutes) so that the configuration can be modified.

- Connect the PC to the sensor through an RS-485 converter (e.g. ISOCON)
- Start the UMB Config Tool and create an IRS31Pro-UMB with the address of the actual device and activate at least one channel. Start the measurement with a measuring rate of 5 sec or faster (will report connection error at first)
- Reset the device (Power off / on)
- When measurement values are received the measurement can be terminated, the interface is now open for configuration.

(*) Remark: The 5 seconds UMB communication are available from program start. Under consideration of the operating system start, where no communication is possible, the device will be ready for SDI12 requests after 7.0 – 7.5 seconds.

18.5.2 Command Set

For details of the SDI-12 protocol please refer to the above mentioned standard document.

Following commands are available for the IRS31Pro-UMB:

Note: The examples in the following sections use italics to print the requests from the logger (*`0V!`*)

Command	Function
?!	Address search (Wildcard request, one device only on bus!)
a!	Request device active?
aI!	Request device identification
aAb!	Address change to b (0 … 9, A …Z, a … z)
aM!	Measurement basic minimal data set
aMC!	Measurement, basic minimal data set, transmit values with CRC
aC!	Concurrent measurement, full basic data set
aCC!	Concurrent measurement, transmit values with CRC
aD0!	Data request buffer 0
aD1!	Data request buffer 1
aD2!	Data request buffer 2
aR0!	Data request from continuous measurement, data set 0
aR1!	Data request from continuous measurement, data set 1
aR2!	Data request from continuous measurement, data set 2
aRC0!	Data request from continuous measurement, data set 0 with CRC
aRC1!	Data request from continuous measurement, data set 1 with CRC
aRC2!	Data request from continuous measurement, data set 2 with CRC
aV!	Command verification: Evaluate sensor status and heating temperatures, data request with aD0!, aD1!

Command	Function
aXU<m/u>!	Change the unit system for SDI data
aXA<a/C>!	Change between average and spot value transmission
aXD<n/m/c>!	Select defrosting agent (currently not yet available)
aXM+nnn!	Set threshold for road condition “moist”
aXW+nnn!	Set threshold for road condition “wet”
aXT+nn.n!	Set temperature threshold for critical road conditions
aXR!	Device reset

Due the applied measurement processes the device will, different from other sensors described in the SDI-12 document, in always measure continuously. This causes some special properties:

- The device does not need a “Wakeup” and does not have a sleep mode. So the reactions to “Break” signals and any related timings are inapplicable. “Break” will be ignored.
- Data requested with M- or C- commands are always available immediately. The device will always respond with `a000n` resp. `a000nn`. This means the device will not send any service request and will ignore measurement abort signals. The logger should request the data immediately.
- M- and C- command only differ in the number of values made available in the buffers (in both cases the maximum permitted by the standards of 9 resp. 20).

18.5.3 Address Configuration

UMB Device-ID and SDI-12 Address are connected, but the different address ranges and the fact, that UMB ID's are integer numbers, while SDI-12 addresses are ASCII characters, have to be considered.

The SDI-12 address is built from the UMB device ID as follows:

UMB Device ID 1 (default) corresponds to SDI-12 Address '0' (SDI-12 default).

Changing the SDI12 address by SDI12 setting command also modifies the UMB device ID accordingly.

Valid Address Ranges:

UMB (dec)			SDI-12 (ASCII)		
1	to	10	'0'	to	'9'
18	to	43	'A'	to	'Z'
50	to	75	'a'	to	'z'

18.5.4 Data Messages

In the interest of simplified evaluation the assignment of measurement values to data buffers '0' ... '9' has been defined unified for all measurement commands. For this reason the responses to C-requests have been restricted to 35 characters, not using the 75 characters permitted for these requests

Currently buffers '0' to '2' are in use.

As with M-requests max. 9 values may be transmitted; the base data set of 9 values has been assigned to buffers '0' and '1'. Buffer '2' contains further measurement values. This definition guaranties the compatibility to loggers designed according to older versions of the SDI-12 standard.

If the measurement value is not available for some reason, e.g. sensor failure, this is indicated by a value of +999.0. or -999.9 The logger can then evaluate the reason of failure by a aV! Verification request. The following tables show the measurement values in the sequence they are arranged in the telegram (see example).

Depending on the configuration of the device the values will be transmitted in metric or US units.

Another setting defines if the sensor transmits average or spot values of the measurement data. Default setting and recommended is the transmission of average values.

Optionally the defrosting agent in use can be selected. (this option is currently not yet available).

Note: The configured system of units and the average/sot setting is not indicated in the data messages. The logger may request this setting with the I-command and adjust the evaluation of the data messages accordingly

Example: M Request

0M!

00009<CR><LF> 9 measurement values are available

0D0!

0+1.5+2.7+3.5-5.5+3.7<CR><LF>

Road temperature 1.5°C, external temperature 1 2.7°C,
external temperature 2 3.5°C, freezing temperature -5.5°C
Salzkonzentration 3,7%

0D1!

0+183+0.0+0.78+15<CR><LF>

Water film height 200um, ice percentage 0.0%
friction 0.78, road condition 15 (moist)

Example: C-Request from IRS31Pro-UMB

0C!

00010<CR><LF> 10 measurement values are available

0D0!

0+1.5+2.7+3.5-5.5+3.7<CR><LF>

Road temperature 1.5°C, external temperature 1 2.7°C,
external temperature 2 3.5°C, freezing temperature -5.5°C
Salzkonzentration 3,7%

0D1!

0+183+0.0+0.78+15<CR><LF>

Water film height 200um, ice percentage 0.0%
friction 0.78, road condition 15 (moist)

0D2!

0+5.1<CR><LF>

Saline concentration 5.1 g/m2

Buffer Assignment Basic Data Set

The related UMB channel is shown for spot and average value:
spot / average

Device configured for measurement values in metric units:

Measurement Value	UMB-Channel	Min	Max	Unit
Buffer ‘0’				
Road Surface Temperature	101/106	-40.0	80.0	°C
External Temperature 1	111/116	-40.0	80.0	°C
External Temperature 2	121/126	-40.0	80.0	°C
Freezing Temperature	151/156	-40.0	0.0	°C
Saline Concentration	801/806	0.0	100.0	%
Buffer ‘1’				
Water Film Height	601/606	0.0	10000.0	µm
Ice Percent	810/815	0.0	100.0	%
Friction	820/825	0.0	1.0	
Road Condition	900/905	10, 15, 20, 25, 30, 35, 40, 45		
Buffer ‘2’				
Saline Concentration g/m^2	910/915	0,0	100,0	g/m^2

Device configured for measurement values in imperial units:

Measurement Value	UMB-Channel	Min	Max	Unit
Buffer ‘0’				
Road Surface Temperature	102/107	-40,0	176,0	°F
External Temperature 1	112/117	-40,0	176,0	°F
External Temperature 2	122/127	-40,0	176,0	°F
Freezing Temperature	152/157	-40,0	32,0	°F
Saline Concentration	801/806	0,0	100,0	%
Buffer ‘1’				
Water Film Height	602/607	0,0	393,70	mil
Ice Percent	810/815	0,0	100,0	%
Friction	820/825	0,0	1,0	
Road Condition	900/905	10, 15, 20, 25, 30, 35, 40, 45		
Buffer ‘2’				
Saline Concentration lbs/mi	920/925	0,0	1280,0	lbs/mi

18.5.5 Message Device Identification

The device responds to the identification request with following message (example for SDI-12 device address ‘0’:

0I!

013Lufft.deIRSxyznnn

x: Metric / US units (m = metric, u = US)

y: Spot value or average value (a = average, c = spot)

z: Defrosting agent (n = NaCl, m = MgCl2, c = CaCl2) (optional, currently not yet available)

nnn: Software version

i.e. configured for US units, average, NaCl:

0I!

013Lufft.deIRSumn022

18.5.6 Message Verification

The command verification aV! is used to evaluate status information of the device. The device responds with

a0004<CR<LF>

to the request, i.e. 4 values are available in the buffers.

The first 3 “measurement values”, transmitted in buffer ‘0’ contain the status information of the measurement channels.

The status data of the channels are assembled to form “fake measurement values”, where each digit represents one status. See below for the coding of states. Generally each sensor has two status values, one for the direct value and another for the measurement value buffer used for the evaluation of the average, min, and max values.

The last shows the measurement counter.

Buffer ‘0’				
Status group1: +nnnn	road temperature, road temperature buffer, ext. temp. 1, ext. temp 1 buffer			
Status group 2: +nnnn	ext. temp. 2, ext. temp. 2 buffer, saline concentration, saline concentration buffer			
Status group 3: +nnnn	water film height, water film height buffer, road condition, road condition buffer			
Measurement value	UMB Channel	min	max	Unit
measurement counter	20001	0	65520	

Sensor status codes:

Sensor status	Code
OK	0
UNGLTG_KANAL	1
E2_CAL_ERROR E2_CRC_KAL_ERR FLASH_CRC_ERR FLASH_WRITE_ERR FLASH_FLOAT_ERR	2
MEAS_ERROR	3
MEAS_UNABLE	4
INIT_ERROR	5
VALUE_OVERFLOW CHANNEL_OVERRANGE	6
VALUE_UNDERFLOW CHANNEL_UNDERRANGE	7
BUSY	8
other sensor status	9

Example (SDI-12 Address ‘0’, no error):

```
0V!
00004<CR><LF>
0D0!
0+0000+0000+0000+523<CR><LF>
```

Example (SDI-12 Address ‘0’, measurement of saline concentration not possible):

```
0V!
00004<CR><LF>
0D0!
0+0000+0044+0000+738<CR><LF>
```

18.5.7 Message Change of Unit System

The command is used to change the unit system used for the SDI12 data between metric and US units. It is implemented as manufacturer specific X command.

Command: `aXU<u/m>!`

Response: `aXU<u/m><CR><LF>`

u : US units

m: metric units

Example: change to metric units, SDI-12 address ‘0’

`0XUm!`

`0XUm<CR><LF>`

18.5.8 Message Selection of Spot or Average Value

The command is used to select average or spot value for transmission. It is implemented as manufacturer specific X command.

Command: `aXA<a/c>!`

Response: `aXA<a/c><CR><LF>`

a : average

c: spot

Example: change to average values

`0XAa!`

`0XAa<CR><LF>`

18.5.9 Message: Setting of the Threshold for Road Condition “Moist”

The command sets the threshold of water film height, above which the road condition is set to “moist”.

Command: `aXM+nnn!`

nnn: water film height threshold in µm

Response: `aXM+nnn<CR><LF>`

The response to the attempt of setting of an invalid value is

`aXMf<CR><LF>`

Example: The threshold is set to 20 µm

0XM+20!

`0XM+20<CR><LF>`

18.5.10 Message: Setting of the Threshold for Road Condition “Wet”

The command sets the threshold of water film height, above which the road condition is set to “wet”.

Command: `aXW+nnn!`

nnn: water film height threshold in µm

Response: `aXW+nnn<CR><LF>`

The response to the attempt of setting of an invalid value is

`aXWf<CR><LF>`

Example: The threshold is set to 220 µm

0XW+220!

`0XW+220<CR><LF>`

18.5.11 Message: Setting of the Threshold for Critical Road Conditions

The command sets the threshold of road surface temperature, below which critical road conditions are set.

Command: `aXT<+/->nn.n!`

nn.n: road surface temperature threshold in °C

Response: `aXT<+/->nn.n<CR><LF>`

The response to the attempt of setting of an invalid value is

`aXTf<CR><LF>`

Example: The threshold is set to -0.5°C

`0XT-0.5!`

`0XT-0.5<CR><LF>`

18.5.12 Message: Station Reset

The command initiates a station reset.

Command: `aXR!`

Response: `aXRok<CR><LF>`

The response is followed by the station reset, i.e. the station will be offline for a few seconds.

Example:

`0XR!`

`0XRok<CR><LF>`

19 List of Figures

Figure 1: Sensor 8
Figure 2: UMB Config Tool: Sensor Configuration / Sensor Settings Menu 9
Figure 3: Set Moist / Wet Thresholds 13
Figure 4: Cable Extension 15
Figure 5: Example of an Extension Box 15
Figure 6: Example of a Standard Lufft UMB Control Cabinet 17
Figure 7: Examples of the Earthing of the Cable Screening 17
Figure 8: ISOCON-UMB Connection 17
Figure 9: IRS31Pro-UMB Installation in the Road with 2 External Temperature Sensors 19
Figure 10: Installing the IRS31Pro-UMB 20
Figure 11: Sensor Selection 25
Figure 12: Sensor Configuration – General Settings 26
Figure 13: Sensor Configuration: Sampling Rate, Averaging and Freezing Temperature Correction Factor 26
Figure 14: Sensor Configuration: Setting Thresholds 28
Figure 15: Sensor Configuration: Coupling of IRS31Pro-UMB with ARS31 29
Figure 16: Select the Channels for Measurement Polling 29
Figure 17: Operating instructions UMB-Config-Tool 30
Figure 18: Channel Selection in the UMB Config Tool 30
Figure 19: Measurement Polling with the UMB Config Tool 30
Figure 20: Sensor settings for IRS31-UMB compatibility mode 32
Figure 21: Model parameters 33
Figure 22: Name of the sensor 33
Figure 23 Configuration of coupling IRS31-ARS31 37

20 Index

A

Accessories 7
Accuracy 39
Address, creating…example 47
ASCII Protocol 49
Average value 9

B

Binary Protocol Request, Example 47
Binary-Protocol 46

C

$CaCl_2$, freezing temperature 11
$CaCl_2$, saline concentration 12
Channel List per TLS2012 45
Channel List, Summary 44
Class ID 47
Commissioning 21
Compatibility mode 32
Config Tool, general settings 26
ConfigTool 25
Configuration 25
Connections in the housing 23
Control Cabinet, example of a… 17
Coupling with ARS31 37
CRC Calculation 48

D

Data types 10
Designated use 5
Device ID 47
Dimensions 39

E

Disposal 43
Error-Codes 48, 51
Extending the supply cable 15
External Temperature 10

F

Factory Settings 25
Fault Description 41
Firmware Update 29
Freezing Temperature 40
Freezing Temperature $CaCl_2$ 11
Freezing Temperature $MgCl_2$ 11
Freezing Temperature NaCl 10
Friction 11, 40

G

General Settings 26

H

Housing, connections in the… 23

I

Ice Percentage 11, 40
ID, device and class... 47
Incorrect use 5
Installation 14

M

Maintenance 22
Measurement Counter 13
Measurements 10
Measurements, generation of…. 9
Measurements, transmission of.... 10
Measuring range 39
$MgCl_2$, freezing temperature 11
$MgCl_2$, saline concentration 12

N

NaCl, freezing temperature 10
NaCl, saline concentration 11

O

Operating Conditions 39
Order numbers 7

P

PC conviguration software 25
Power Supply 23
Protection 39

R

Replacing the sensor 22
Resistance 13
Road Condition 12
Road Surface Temperature 10
Road, installation in the…. 19
RS485 Interface 23

S

Safety instructions 5
Saline Concentration 40
Saline Concentration $CaCl_2$ 12
Saline Concentration $MgCl_2$ 12
Saline Concentration NaCl 11
Sampling rate 9
Scope of delivery 6
SDI12 Protocol 52
SDI12-Protocol 18
Sensor, replacing the…. 22
Settings, general… 26
Storage conditions 39
Supply cable, extending the…. 15
Symbols used 5

T

Technical Data 39
Technischer Support 43
Testing 25
TLS2012, Channel List per…. 45
Transmission of measurements 10

U

UMB-ConfigTool 25

W

Water Film Height 11
Weight 39

Lufft