WIO400
Water in oil sensor

User manual Rev. 1.26

111881-941 Rev. 1.26 User manual 400

Date: 2026-05-01

PAJ EMS ApS (branded under ”PAJ Group”) • Ellegårdvej 25P • DK-6400 Sønderborg
CVR: 34591199 • www.paj-group.com • e-mail: paj@paj-group.com

Table of contents

Table of contents 2
Introduction 3
Compliance Information 4
Safety Advice 4
Function 5
Normal operation 6
Failure indication 7
Self test for alarm functions 7
Before installation 9
WIO Sensor dimensions in mm 13
Terminal box dimensions in mm 15
WIO Sensor Variants 16
Technical Data Terminal Box 17
Technical Data Terminal Display Box 18
Technical Data Terminal Box Alarm 21
Technical Data Terminal Box Alarm Buzzer 23
Technical Data Terminal Box Alarm Buzzer 26
Communication protocol for Modbus on RS485 30
Communication examples for function code 01 31
Communication examples for function code 03 31
Communication examples for function code 04 32
Communication examples for function code 05 32
Communication examples for function code 06 32
Communication examples for function code 10 33
CRC Calculation 33
Error codes 33
Table for aW to HEX value 34
WIO-Software 34
RS485 Guidelines 35
Appendix A1: Install 1 Terminal Box with 1 display 36
Appendix A2: Install 1 Terminal Box with no display 37
Appendix A3: Install 2 Terminal Boxes with 3 display 38
Appendix A4: Install 2 Terminal Boxes with 1 display 39
Appendix A5: Install 2 Terminal Boxes with 2 display 40
Appendix A6: Install 3 Terminal Boxes with 4 display 41
Appendix A7: Install 3 Terminal Boxes with 3 display 43
Appendix A8: Install 3 Terminal Boxes with 2 display 44
Appendix A9: CABLE Specification 45
How to adjust the display in a WIO 46
Appendix A10: Error / failure FAQ 55

Introduction

This user manual provides technical data regarding the WIO (water in lubrication oil, gear box oil, diesel oil, hydraulic oil or transformer oil) sensor system. The system consist of a WIO Sensor, terminal box and cables. The WIO Sensor is an insitu sensor which measures water content in lubrication oils on ship engine or similar. The Terminal box connects the sensor to power supply and to the ships surveillance system. The supplied cables are for connection between the WIO Sensor and the Terminal box



Compliance Information

The WIO system complies with:

- EMC Directive 2014/30/EU
- Low Voltage Directive 2014/35/EU
- RoHS Directive 2011/65/EU

A copy of the EU Declaration of Conformity is available upon request.

Safety Advice

For your safety

The *WIO400* (WIO) is designed as a water-in-oil monitoring and advisory system with alarm relay outputs and RS485 communication based on Modbus protocol.

Before use please read the user manual and carefully store it in a safe place. Install and operate the device only after reading and comprehending the instruction manual, and after you are familiar with the valid rules on work safety and accident prevention.

Please use the device only as specified. For this purpose please also note the values in section "Technical data".

During transport, storage and operation please adhere to the conditions listed in "Technical data".

IMPORTANT

Only qualified personnel may assemble start-up and maintain the unit when it is in a zero voltage state. Only qualified electricians may work on electrical installations.

The connection and instruction manual contains information that enables the proper and efficient use of the WIO monitoring system. PAJ EMS ApS is not liable for damage caused by improper use of this device. This manual is an integral part of the basic knowledge necessary for proper use of the system.

Rights

PAJ EMS ApS reserves the right to alter its products without prior notice.

Copying and using the instruction manual for other purposes is only allowed with the acceptance from PAJ EMS ApS.

PAJ EMS ApS accepts no responsibility for possible errors and deficiencies in brochures, catalogues and other printed material.

Proper operation of the WIO monitoring system requires installation, connection and use in accordance with this manual and the specified operating conditions.

Safety observations

The comments about safety in this document will not discuss safety observations of individual machine parts where safety devices (usually safety relays) are applied. Here the respective instruction manuals will be referenced! This document merely describes how to establish a WIO and how to start it up.

WARNING

The monitoring system during machine operation cannot be guaranteed if the system is connected incorrectly or not used as specified. This may lead to fatal injuries. Interventions and changes to the WIO monitoring system are not permitted, unless they are explicitly described in this user manual or be written from PAJ EMS ApS.

The regional legal regulations and conditions of the liability insurance of the employer must be maintained.

Area of application

The WIO monitoring system is usually used in engines were a WIO will monitor the water content in lubrication oil, gear box oil, diesel oil, hydraulic oil or transformer oil.

The advantage of this monitoring system is the simple 4-20 mA interface and the two relays indicating alarms, with digital readout.

Normally the WIO sensor is calibrated in Taro30 lubrication oil, if nothing else are defined from customer.

Function

Short description of the function

PAJ EMS ApS has developed a water in oil (WIO) monitoring system. The fundamental idea of the WIO system is to easily and continuously monitor the water activity (a_w) in oil. The output is converted into a standard 4-20 mA output.

The system also includes two relays indicating when too much water is present in the oil. Default alarm values are set to 0,5 a_w (high alarm) and 0,9 a_w (high high alarm)

By use of the WIO-Software it is possible to change HHA and HA levels. Furthermore you can continuously read out and graph the a_w (or PPM) of water in the oil.

For detailed technical specifications, operating limits and performance data, please refer to the WIO400 Datasheet.

WARNING

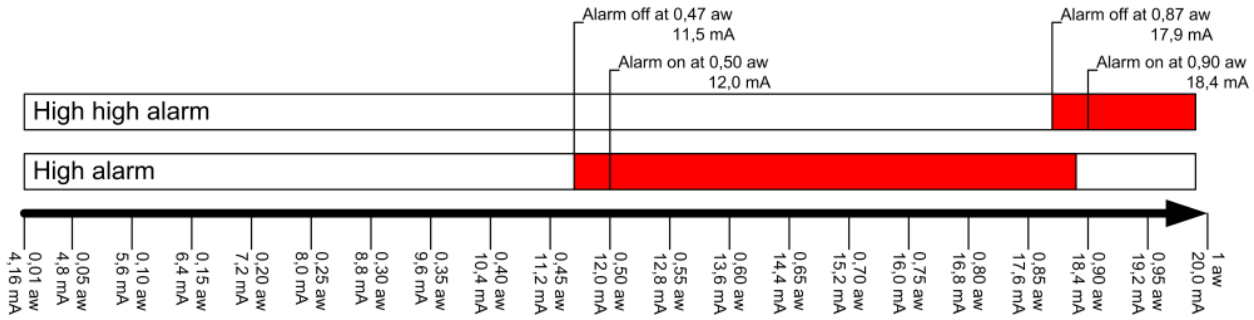
Do not use the sensor or relays to automatically enable/turn on or disable/shut down engine. The decision to enable/turn on or disable/shut down an engine, based on the sensor data, must be taken by proper trained crew personnel, not by the sensor system.

Normal operation

Water activity (a_w) provides the relative availability of water in oil where pure oil has an activity of zero and oil saturated with distilled water has an activity of exactly one. Under normal operation the WIO400 continuously supplies an output analogue signal of 4 to 20 mA corresponding to 0.01 to 1.00 a_w. Alarm indications with 0.03 a_w hysteresis via 2 relays are provided for each sensor. These data can also be read out from the sensor on the RS485 Modbus communication line.

Default alarm values are 0,5 a_w and 0,9 a_w. Assumes these alarm values:

High alarm on at 0,50 a_w (12 mA).
High alarm off at 0,47 a_w (11,5 mA)
High high alarm on at 0,90 a_w (18,4 mA).
High high alarm off at 0,87 a_w (17,9 mA).
High high alarm will disable high alarm, thus only one alarm can be active.



Failure indication

Internal function failure will be indicated by activating both alarm relays at the same time, or indicated as defined in the NAMUR NE43.

Internal failures includes:

- Sensor reading out of range.
- Sensor reading CRC error.
- Unstable Sensor reading.

NAMUR NE43 is a German fault detection standard for 4-20mA analogue signals. It allows the user to know if there is a fault within the instrument, by sending analogue signal below 4mA and/or above 20mA. In accordance with NAMUR NE43, the failure is indicated by:

- Fault indicated by analogue output =<2,0 mA

Self test for alarm functions



On the WIO Sensor there is a button for testing the alarm functions. By pushing the Test button for 5 sec the high alarm relay turns on, and by pushing the Test button for 10 sec the high alarm relay turns off and the high high alarm turns on. When the Test button has been pushed continuously for more than 15 sec, it will be ignored by the software, and the relays return to normal operation.

Test Button	***Mode***	***Output Relay***	***Analogue Output***
Un-pressed	Normal operation and ***no alarm***	Relay 1 Open Relay 2 Open	Normal
Pressed longer than **5 sec**	Test of high alarm	Relay 1 Closed Relay 2 Open	Normal
Pressed longer than **10 sec**	Test of high high alarm	Relay 1 Open Relay 2 Closed	Normal
Pressed longer than **15 sec**	Normal operation	Normal	Normal

Test Button	**Mode**	**Output Relay**	**Analogue Output**
Un-pressed	Normal operation, with ***high alarm active***	Relay 1 Closed Relay 2 Open	Normal
Pressed longer than **5 sec**	Test of high alarm	Relay 1 Closed Relay 2 Open	Normal
Pressed longer than **10 sec**	Test of high high alarm	Relay 1 Open Relay 2 Closed	Normal
Pressed longer than 15 **sec**	Normal operation	Normal	Normal

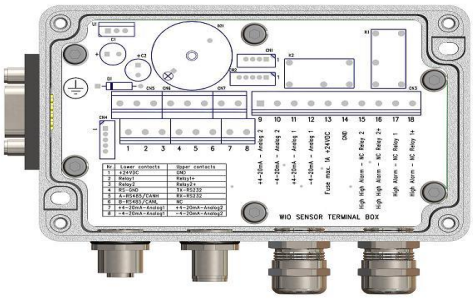
Before installation



IMPORTANT

Only qualified personnel may assemble and maintain the unit. Only qualified personnel may install the unit.

Screw in probe pressure-tight directly in the center of the oil pipe where the measurement is to take place. The threads should be sealed with PTFE tape (TopSeal). The sensor should be mounted with max. torque of 35 Nm. Connect the cables from the WIO sensor to the Terminal box. Use a hexagon wrench size 30.



To sensor Power and Alarms

IMPORTANT

Only qualified personnel may assemble start-up and maintain the terminal box(s) when it is in a zero voltage state. Only qualified electricians may work on electrical installations.

Install +24 VDC and GND into the terminal box and connect the 4-20 mA to an external device if needed. Connect the relay to external device if needed.

If the terminal box has a (a_w) or PPM display, there must be a short circuit between terminals 11 and 12. This short circuit produces the needed closed loop for mA measurement.

If the terminal box has a °C or °F display, there must be a short circuit between terminals 9 and 10. This short circuit produces the needed closed loop for mA measurement.

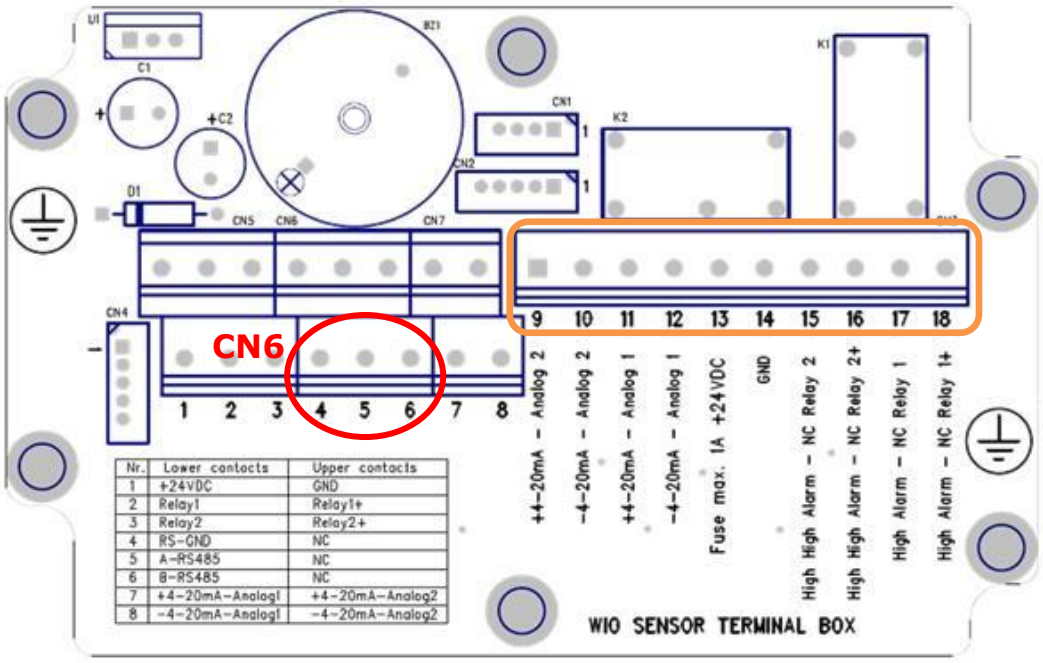
After installing the WIO-Software can PC and terminal box be connected through DB9 connector.

Last connect the cables from the Terminal box to the sensor.

It is allowed (but not necessary) to connect screw terminal 10 and 12 "-4-20 mA" to screw terminal 14 "GND", thus creating common ground for the output and the power.

Terminal boxes with display. Screw terminal pin 11 and 12 or screw terminal pin 9 and 10 can be connected to external equipment, but only in a closed loop for mA measurement.

Terminal Box Connection



Nr.	Lower contacts	Upper contacts
1	+24VDC	GND
2	Relay1	Relay1+
3	Relay2	Relay2+
4	RS-GND	NC
5	A-RS485	NC
6	B-RS485	NC
7	+4-20mA-Analog1	+4-20mA-Analog2
8	-4-20mA-Analog1	-4-20mA-Analog2

Contact Assignment

There is only one connector CN3 for using of the terminal box contacts.

Contact-Number	CN Nr.	Description
9	CN3	+4 – 20 mA positive analog output signal for indication of temperature in oil. This option is not available for WIO200
10	CN3	-4 – 20 mA return analog signal for indication of temperature in oil. This option is not available for WIO200
11	CN3	+4 – 20 mA positive analog output signal for indication of a_w or PPM in oil.
12	CN3	-4 – 20 mA return analog signal for indication of a_w or PPM in oil.
13	CN3	Power supply, 24VDC ±10% and with max. residual voltage ripple 10%
14	CN3	Power supply ground terminal contact
15	CN3	Relay contact for HH Alarm
16	CN3	Relay contact for HH Alarm
17	CN3	Relay contact for H Alarm
18	CN3	Relay contact for H Alarm
4, Lower	CN6	RS-GND, Isolated Grounding for RS-485 communication
5, Lower	CN6	A-RS485, Terminal A for RS-485 communication

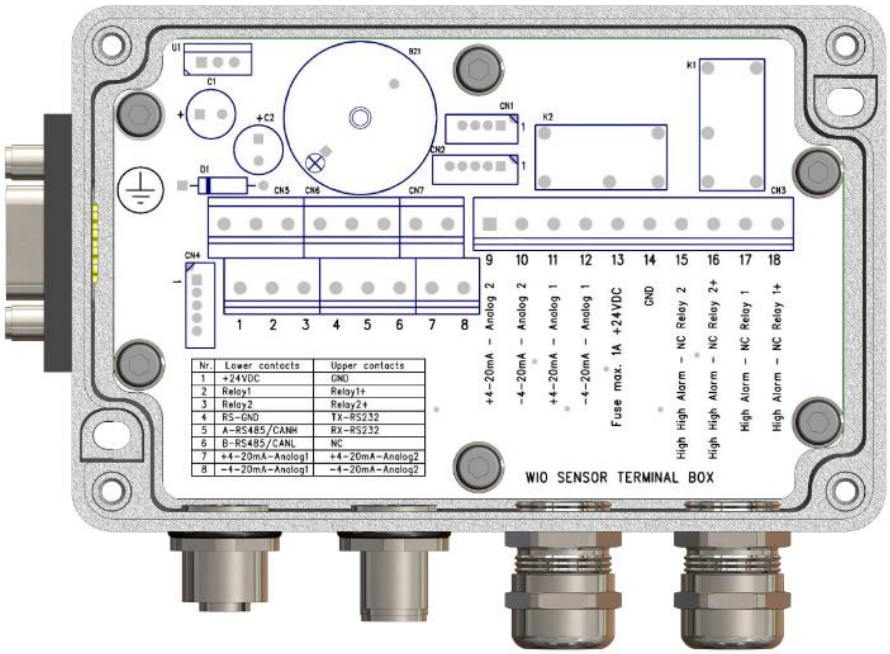
6, Lower	CN6	B-RS485, Terminal B for RS-485 communication

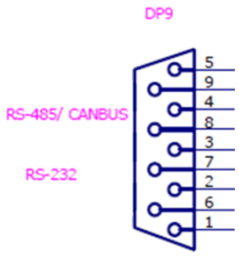
For connection more than one terminal box please refer to:

- Appendix A1
- Appendix A2
- Appendix A3

Pin assignment of D-Sub9 connector

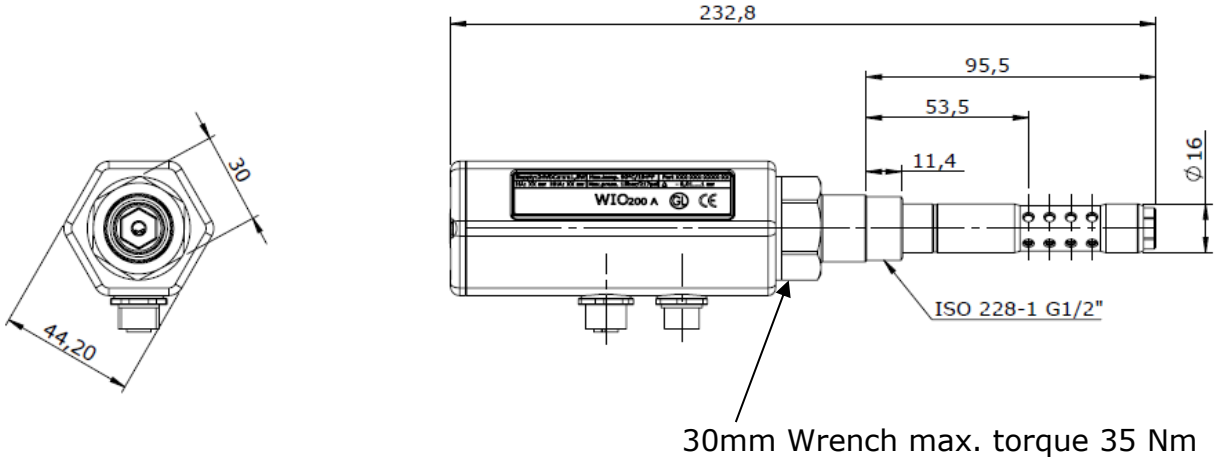
Communication



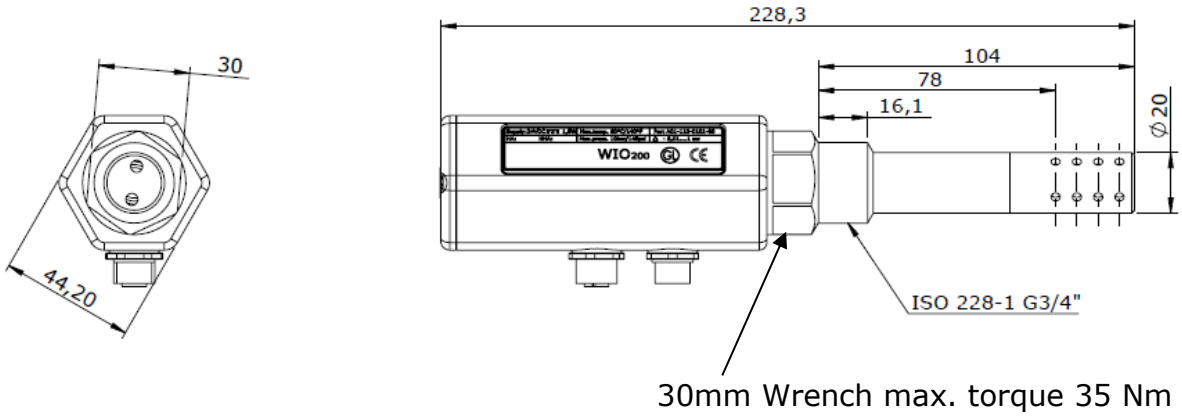
D-Sub9 connector pin layout			
Illustration	Assignment		
	1	NC	-
	2	NC	-
	3	NC	-
	4	NC	-
	5	Black	RS-GND
	6	NC	-
	7	Blue	B-RS485
	8	NC	-
	9	White	A-RS485

WIO Sensor dimensions in mm

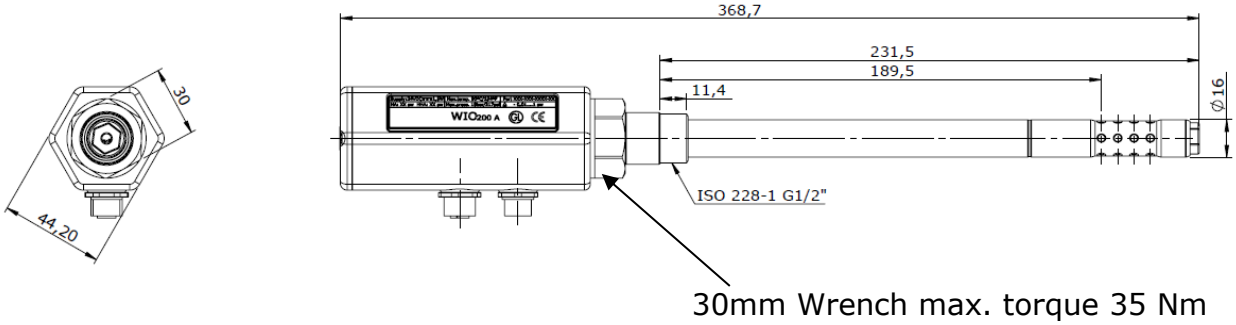
WIO Standard ½" thread Sensor, Short dimensions in mm:



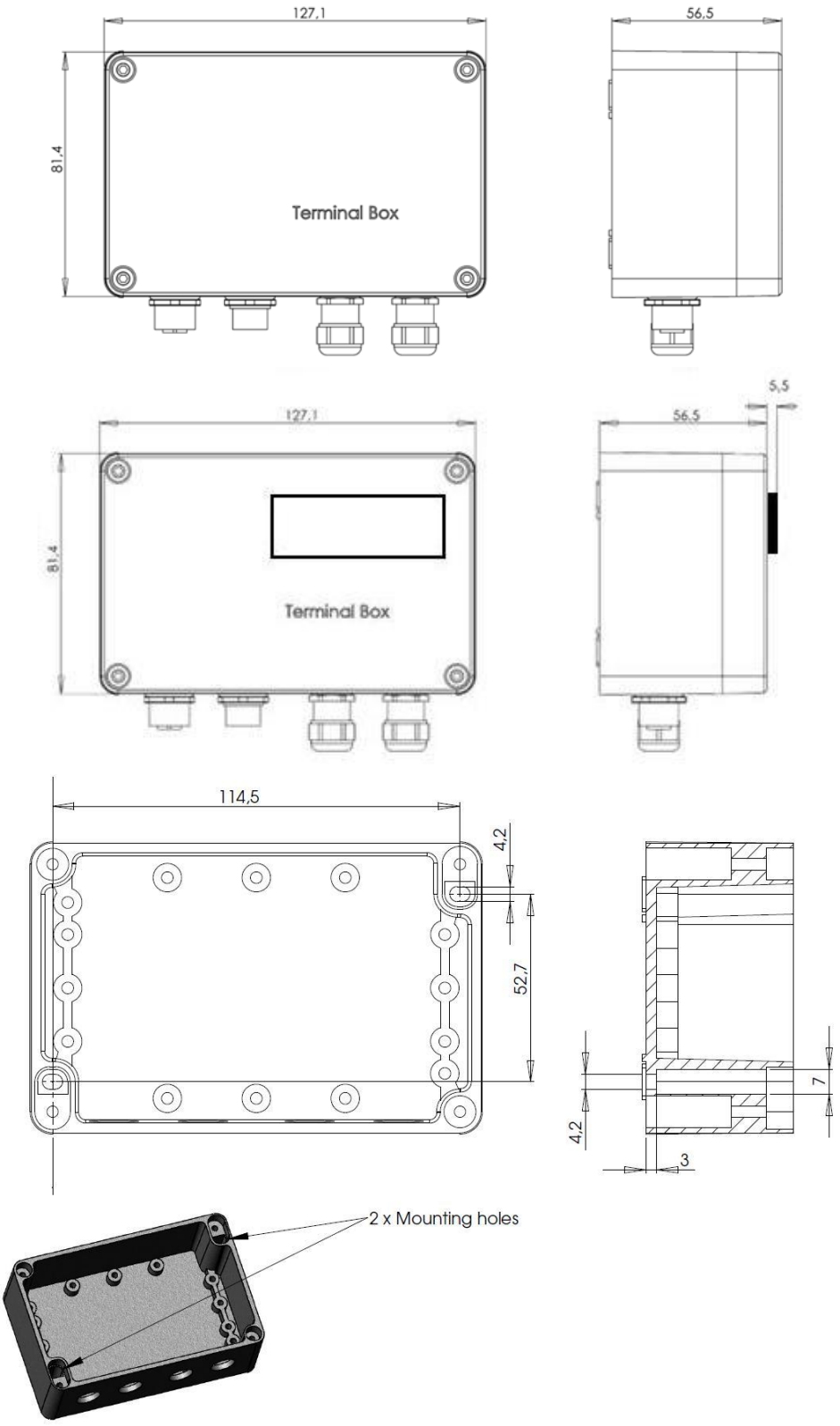
WIO Standard ¾" thread Sensor, Short dimensions in mm:



WIO Ball Valve pipe ½" thread Sensor, Long dimensions in mm:



Terminal box dimensions in mm



WIO Sensor Variants



WIO Standard ¾” (ISO 228-1 G¾”), Short



WIO Standard ½” (ISO 228-1 G½”), Short



WIO ½” Ball Valve pipe, Long

Technical Data Terminal Box



Output	
Analogue output	See the specifications for sensor's analogue output
Digital output	See the specifications for sensor's digital output
Input	
Supply nominal voltage	24V DC ± 10%
Max. residual voltage ripple	10%
Maximum Load current	200 mA
Max. Power input	< 4,8 VA
Relays	
Contact arrangement	2 x Normally Open (NO)
Rated voltage	250 VAC
Max. switching voltage	400VAC
Rated current	2A
Breaking capacity max.	1250VA
Enclosure	
Weight	650 grams
Connection to sensor (mechanical)	2 x 8-pole connectors, male and female, M12x1 thread
Connection (mechanical)	2 x M20 gland, cable diameter 6 to 12 mm 1 x D-sub9, male
Enclosure material	Aluminum
Protective type	IP66
Warranty	1 year

FUNCTIONING

Terminal box shall be provided with 24vdc.
Terminal box supply 24vdc on to WIO sensor.
WIO sensor delivers mA, digital values and relay status to the terminal box.

Technical Data Terminal Display Box



Output	
Analogue output	See the specifications for sensor's analogue output
Digital output	See the specifications for sensor's digital output
Input	
Supply nominal voltage	24V DC ± 10%
Max. residual voltage ripple	10%
Maximum Load current	200 mA
Max. Power input	< 4,8 VA
Relays	
Contact arrangement	2 x Normally Open (NO)
Rated voltage	250 VAC
Max. switching voltage	400VAC
Rated current	2A
Breaking capacity max.	1250VA
Display version - a_w (water activity from 0,01 to 1,00**)**	
Accuracy (0,05-0,95 a_w)	± 0,03 a_w
Resolution	<0,004 a_w
Display version - PPM (H_20)	
Accuracy (0,05-0,95 a_w)	±30%
Resolution	1 PPM
Enclosure	
Weight	650 grams
Connection to sensor (mechanical)	2 x 8-pole connectors, male and female, M12x1 thread
Connection (mechanical)	2 x M20 gland, cable diameter 6 to 12 mm 1 x D-sub9, male
Enclosure material	Aluminum
Protective type	IP66
Warranty	1 year

FUNCTIONING

Terminal box shall be provided with 24vdc.
Terminal box supply 24vdc on to WIO sensor.
Terminal box measuring mA from the sensor, and convert it to a_w or PPM value.
WIO sensor delivers mA, digital value and relay status to the terminal box.

IMPORTANT

The display is an indication of the water level in the oil. Display can be shipped as PPM or a_w.

Upon ordering a PPM display the customer must specify the water saturation point in PPM of the used oil at the preferred working temperature of the oil. The saturation point is typically between 3000-10000 PPM. Alternatively the customer can ship 10 liters of oil to PAJ EMS ApS for inspection including specification of the working oil temperature.

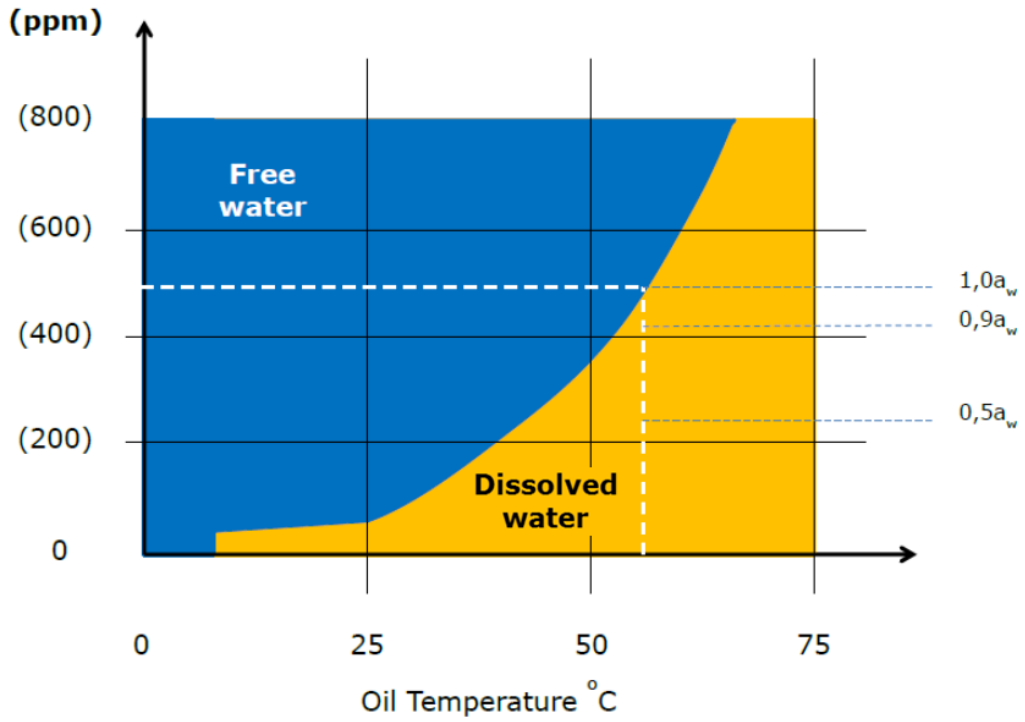
WARNING

All displays will show from positive values when operating properly. There will appear a negative value during start-up, after 5 seconds the value will be in positive measurement range. Otherwise, if a negative value is present the Terminal box might have been installed incorrectly.

NOTE

WIO400 uses 3 different units for the measurement of water in oil:

1) **a_w**: WIO measures humidity in **a_w**. The range is 0.01…1.00 a_w.
2) **%RH** (relative humidity) is identical to the unit a_w multiplied by 100. The range is 1…100 %RH
3) **ppm**: WIO can convert **a_w** to **ppm**. In this case the saturation point, at a given temperature, must be known. Output in ppm is only reliable at this temperature.


(ppm)
(800)
(600)
(400)
(200)
0
Free water
Dissolved water
1,0a$_w$
0,9a$_w$
0,5a$_w$
0
25
50
75
Oil Temperature °C

Technical Data Terminal Box Alarm



Output	
Analogue output	See the specifications for sensor's analogue output
Digital output	See the specifications for sensor's digital output
Input	
Supply nominal voltage	24V DC ± 10%
Max. residual voltage ripple	10%
Maximum Load current	200 mA
Max. Power input	< 4,8 VA
Relays	
Contact arrangement	2 x Normally Open (NO)
Rated voltage	250 VAC
Max. switching voltage	400VAC
Rated current	2A
Breaking capacity max.	1250VA
Buzzer	
Oscillation frequency	3000±500 Hz
Sound pressure level	85db by open housing
Tone	pulsed
Button with LED	
Blink frequency	2 Hz
Color	RED
Enclosure	
Weight	530 grams
Connection to sensor (mechanical)	2 x 8-pole connectors, male and female, M12x1 thread
Connection (mechanical)	2 x M20 gland, cable diameter 6 to 12 mm 1 x D-sub9, male
Enclosure material	Aluminum
Protective type	IP66
Warranty	1 year

FUNCTIONING

Terminal box shall be provided with 24vdc.
Terminal box supply 24vdc on to WIO sensor.
Terminal box indicate the relay status from the WIO sensor.
WIO sensor delivers mA, digtal values and relay status to the terminal box.

H-Alarm LED is for indication of the High Alarm relay state from the WIO sensor. When the alarm condition is generated by the WIO sensor, then the High Alarm relay is open and the H-Alarm LED flash red ON/OFF sequence to show the High Alarm state, and the alarm signal buzzer will be switched ON.

HH-Alarm LED is for indication of the High High Alarm relay state from the WIO sensor. When the alarm condition is generated by the WIO sensor, then the High High Alarm relay is open and the HH-Alarm LED flash red ON/OFF sequence to show the High High Alarm state, and the alarm signal buzzer will be switched ON.

The H-Alarm LED or HH-Alarm LED will stay in blinking mode until the H-Alarm or HH-Alarm button is pressed, then the LED constantly turned on. The alarm signal buzzer will stay on until the H-Alarm or HH-Alarm button is pressed.

Abstract representation of the H-Alarm and HH-Alarm button and LED function:

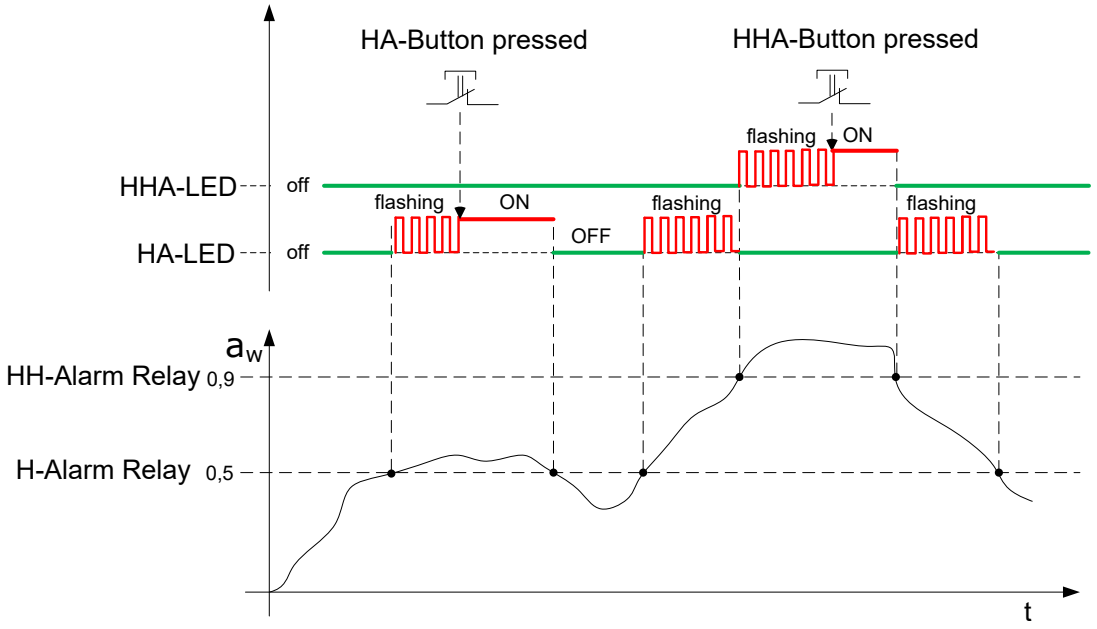


Figure 1: H-Alarm and HH-Alarm button function

Technical Data Terminal Box Alarm Buzzer



Output	
Analogue output	See the specifications for sensor's analogue output
Digital output	See the specifications for sensor's digital output
Input	
Supply nominal voltage	24V DC ± 10%
Max. residual voltage ripple	10%
Maximum Load current	200 mA
Max. Power input	< 4,8 VA
Relays	
Contact arrangement	2 x Normally Open (NO)
Rated voltage	250 VAC
Max. switching voltage	400VAC
Rated current	2A
Breaking capacity max.	1250VA
Display version - a_w (water activity from 0,01 to 1,00**)**	
Accuracy (0,05-0,95 a_w)	± 0,03 a_w
Resolution	<0,004 a_w
Display version - PPM (H_20)	
Accuracy (0,05-0,95 a_w)	±30%
Resolution	1 PPM
Buzzer	
Oscillation frequency	3000±500 Hz
Sound pressure level	85db by open housing
Tone	pulsed
Button with LED	
Blink frequency	2 Hz
Color	RED
Enclosure	
Weight	650 grams

Connection to sensor (mechanical)	2 x 8-pole connectors, male and female, M12x1 thread
Connection (mechanical)	2 x M20 gland, cable diameter 6 to 12 mm 1 x D-sub9, male
Enclosure material	Aluminum
Protective type	IP66
Warranty	1 year

FUNCTIONING

Terminal box shall be provided with 24vdc. Terminal box supply 24vdc on to WIO sensor. Terminal box measuring mA from the sensor, and convert it to a_w or PPM value. WIO sensor delivers mA, digital values and relay status to the terminal box.

H-Alarm LED is for indication of the High Alarm relay state from the WIO sensor. When the alarm condition is generated by the WIO sensor, then the High Alarm relay is open and the H-Alarm LED flash red ON/OFF sequence to show the High Alarm state, and the alarm signal buzzer will be switched ON. HH-Alarm LED is for indication of the High High Alarm relay state from the WIO sensor. When the alarm condition is generated by the WIO sensor, then the High High Alarm relay is open and the HH-Alarm LED flash red ON/OFF sequence to show the High High Alarm state, and the alarm signal buzzer will be switched ON. The H-Alarm LED or HH-Alarm LED will stay in blinking mode until the H-Alarm or HH-Alarm button is pressed, then the LED constantly turned on. The alarm signal buzzer will stay on until the H-Alarm or HH-Alarm button is pressed.

Abstract representation of the H-Alarm and HH-Alarm button and LED function:

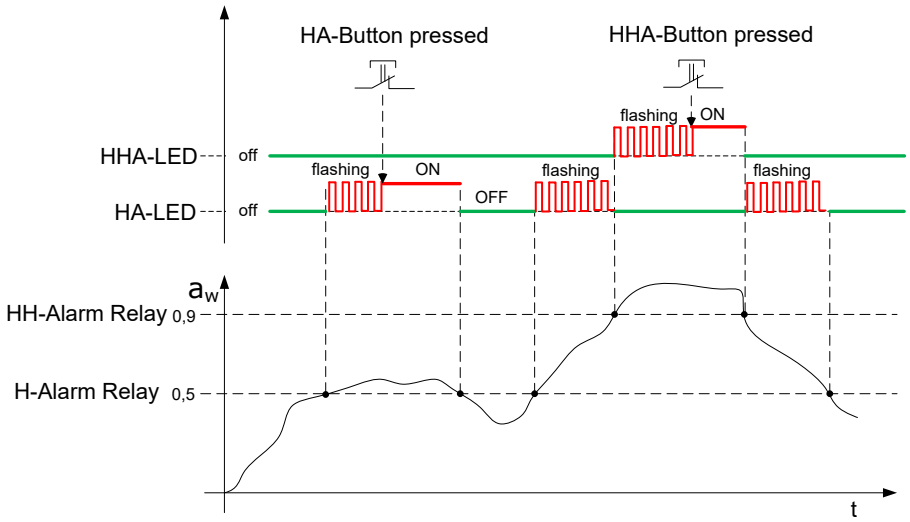


Figure 2: H-Alarm and HH-Alarm button function

IMPORTANT

The display is an indication of the water level in the oil. Display can be shipped as PPM or a_w.

Upon ordering a PPM display the customer must specify the water saturation point in PPM of the used oil at the preferred working temperature of the oil. The saturation point is typically between 3000-10000 PPM. Alternatively the customer can ship 10 liters of oil to PAJ EMS ApS for inspection including specification of the working oil temperature.

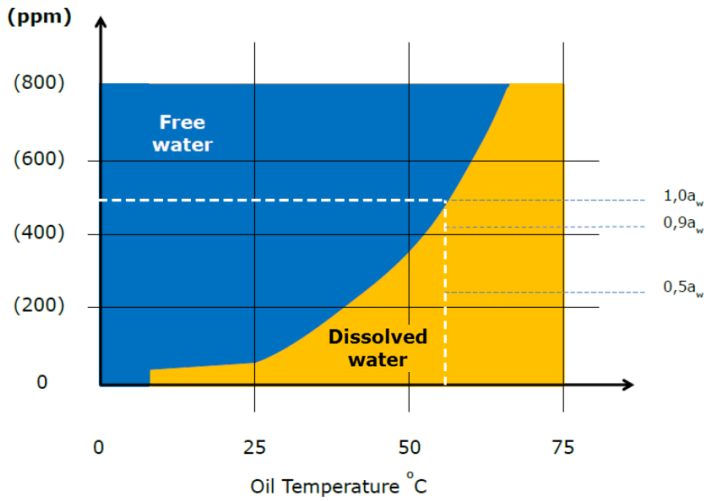
WARNING

All displays will show from positive values when operating properly. There will appear a negative value during start-up, after 5 seconds the value will be in positive measurement range. Otherwise, if a negative value is present the Terminal box might have been installed incorrectly.

NOTE

WIO400 uses 3 different units for the measurement of water in oil:

1) **a_w**: WIO measures humidity in **a_w**. The range is 0.01…1.00 a_w.
2) **%RH** (relative humidity) is identical to the unit a_w multiplied by 100. The range is 1…100 %RH
3) **ppm**: WIO can convert **a_w** to **ppm**. In this case the saturation point, at a given temperature, must be known. Output in ppm is only reliable at this temperature.



Technical Data Terminal Box Alarm Buzzer



Output	
Analogue output	See the specifications for sensor's analogue output
Digital output	See the specifications for sensor's digital output
Input	
Supply nominal voltage	24V DC ± 10%
Max. residual voltage ripple	10%
Maximum Load current	200 mA
Max. Power input	< 4,8 VA
Relays	
Contact arrangement	2 x Normally Open (NO)
Rated voltage	250 VAC
Max. switching voltage	400VAC
Rated current	2A
Breaking capacity max.	1250VA
Display version - a_w (water activity from 0,01 to 1,00**)**	
Accuracy (0,05-0,95 a_w)	± 0,03 a_w
Resolution	<0,004 a_w
Display version - PPM (H_20)	
Accuracy (0,05-0,95 a_w)	±30%
Resolution	1 PPM
Display version - °C	
Accuracy	± 2°C
Resolution	0,01 °C

Buzzer	
Oscillation frequency	3000±500 Hz
Sound pressure level	85db by open housing
Tone	pulsed
Button with LED	
Blink frequency	2 Hz
Color	RED
Enclosure	
Weight	750 grams
Connection to sensor (mechanical)	2 x 8-pole connectors, male and female, M12x1 thread
Connection (mechanical)	2 x M20 gland, cable diameter 6 to 12 mm 1 x D-sub9, male
Enclosure material	Aluminum
Protective type	IP66
Warranty	1 year

FUNCTIONING

Terminal box shall be provided with 24vdc.
Terminal box supply 24vdc on to WIO sensor.
Terminal box measuring mA from the sensor, and convert it to a_w or PPM value.
WIO sensor delivers mA, digital values and relay status to the terminal box.

H-Alarm LED is for indication of the High Alarm relay state from the WIO sensor. When the alarm condition is generated by the WIO sensor, then the High Alarm relay is open and the H-Alarm LED flash red ON/OFF sequence to show the High Alarm state, and the alarm signal buzzer will be switched ON.

HH-Alarm LED is for indication of the High High Alarm relay state from the WIO sensor. When the alarm condition is generated by the WIO sensor, then the High High Alarm relay is open and the HH-Alarm LED flash red ON/OFF sequence to show the High High Alarm state, and the alarm signal buzzer will be switched ON.

The H-Alarm LED or HH-Alarm LED will stay in blinking mode until the H-Alarm or HH-Alarm button is pressed, then the LED constantly turned on.
The alarm signal buzzer will stay on until the H-Alarm or HH-Alarm button is pressed.

Abstract representation of the H-Alarm and HH-Alarm button and LED function:

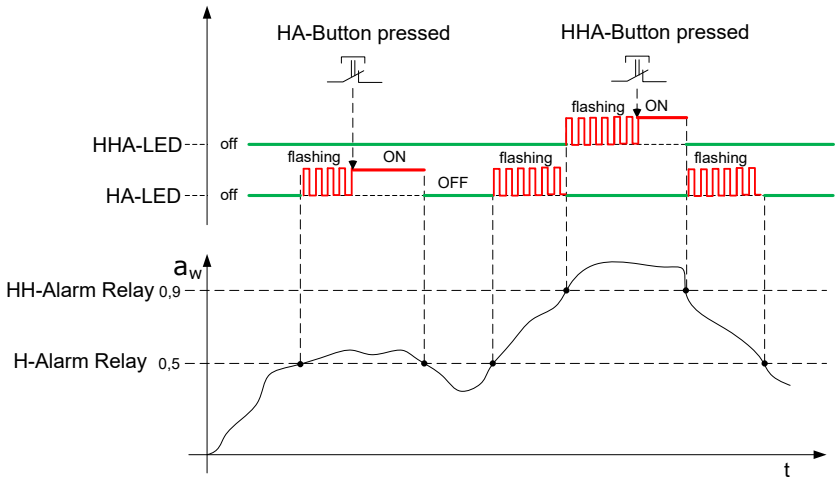


Figure 2: H-Alarm and HH-Alarm button function

IMPORTANT

The display is an indication of the water level in the oil. Display can be shipped as PPM or a_w.

Upon ordering a PPM display the customer must specify the water saturation point in PPM of the used oil at the preferred working temperature of the oil. The saturation point is typically between 3000-10000 PPM. Alternatively the customer can ship 10 liters of oil to PAJ EMS ApS for inspection including specification of the working oil temperature.

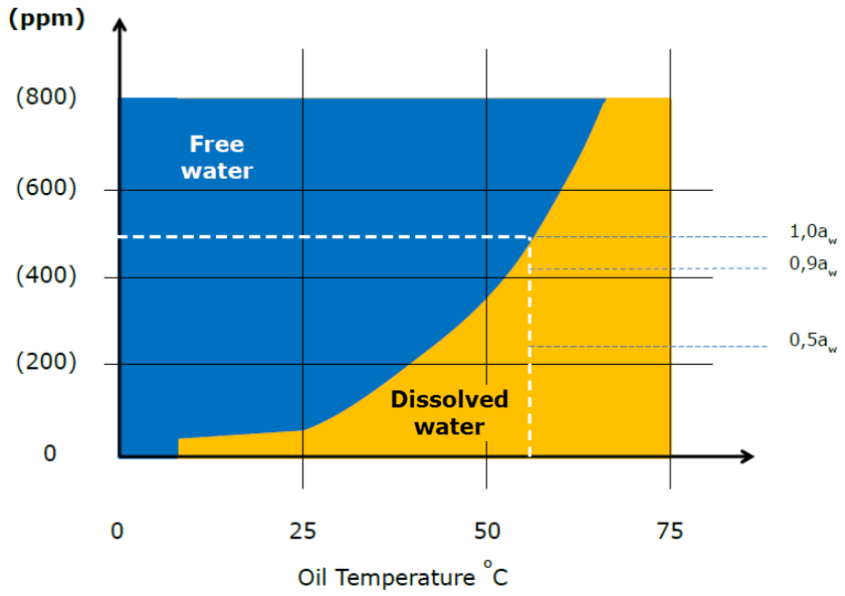
WARNING

All displays will show from positive values when operating properly. There will appear a negative value during start-up, after 5 seconds the value will be in positive measurement range. Otherwise, if a negative value is present the Terminal box might have been installed incorrectly.

NOTE

WIO400 uses 3 different units for the measurement of water in oil:

1) **a_w**: WIO measures humidity in **a_w**. The range is 0.01…1.00 a_w.
2) **%RH** (relative humidity) is identical to the unit a_w multiplied by 100. The range is 1…100 %RH
3) **ppm**: WIO can convert **a_w** to **ppm**. In this case the saturation point, at a given temperature, must be known. Output in ppm is only reliable at this temperature.


(ppm)
(800)
(600)
(400)
(200)
0
Free water
Dissolved water
1,0a$_w$
0,9a$_w$
0,5a$_w$
0
25
50
75
Oil Temperature °C

Communication protocol for Modbus on RS485

PAJ EMS ApS have used the MODBUS application protocol V1.1b3, which can be downloaded from http://modbus.org.

Command list all value are HEX value

Item	Function code	Address	descriptions
Read relay status of HA	01	26	Relay is enabled = 1 => no alarm
Read relay status of HHA	01	27	Relay is enabled = 1 => no alarm
Read factory reset bit status	01	2A	Data = 1 => WIO is ready for factory reset
Read termination resistor status	01	29	Data = 1 => Resistor is omitted (see RS485 guideline)
Read HA alarm level	03	1E	Data have to be recalculated to aW value for HA alarm
Read HHA alarm level	03	20	Data have to be recalculated to aW value for HHA alarm
Read WIO S/N	03	04	S/N of connected WIO device
Read calibration date	03	31&32	Date of calibration. Year month day
Read WIO type	03	23	Data = 4 => WIO400
Read PPM max value	03	2D	PPM saturations point at a given °C
Read °C	04	06	The measured temperature of the sensor
Read aW	04	07	The measured moist in aW from the sensor
Read mA output for aW	04	2C	The mA output for aW from WIO sensor
Read mA output for °C	04	2E	The mA output for °C from WIO sensor
Read current PPM value	04	34	mA value converted into a PPM value
Read °F	04	35	The measured temperature of the sensor
Set factory reset bit	05	2A	Make the Wio ready for factory reset
Set termination resistor	05	29	Activate the termination Resistor (see RS485 guideline)
Complete factory reset	06	08	Before complete factory reset, must factory reset bit = 1
Change Modbus ID on WIO	06	24	Change the ID nr (Valid data is 01 – FA) from factory 01
Change HA alarm level	10	1E	aW must be calculated to HEX. Factory value is 0,50aW
Change HHA alarm level	10	20	aW must be calculated to HEX. Factory value is 0,90aW
Change Modbus ID on WIO	00	24	Change the ID nr (Valid data is 01 – FA) from factory 01

All read out value in function code 04, must be rewritten for decimal numbers, and divided by 100.
WIO-Software will automatically use the appropriate commands for displaying data.

Com Port setting

Baudrate	9600
Data bits	8
Parity	0 (none)
Stop bits	1

Communication examples for function code 01

Read factory reset bit status

Request from user		Response from WIO	
Modbus ID	01	Modbus ID	01
Function code	01	Function code	01
Starting address Hi	00	Byte count	01
Starting address Lo (factory reset bit status)	2A	Output status	00
Quantity of outputs Hi	00	CRC	51
Quantity of outputs Lo	01	CRC	88
CRC Hi	DC		
CRC Lo	02		

Communication examples for function code 03

Read WIO type

Request from user		Response from WIO400	
Modbus ID	01	Modbus ID	01
Function code	03	Function code	03
Starting address Hi	00	Byte count	02
Starting address Lo (WIO type)	23	Output status Hi	00
Quantity of outputs Hi	00	Output status Lo	03
Quantity of outputs Lo	01	CRC	F8
CRC Hi	75	CRC	45
CRC Lo	C0		

Communication examples for function code 04

Read measured temperature

Request from user		Response from WIO (22,25°C)	
Modbus ID	01	Modbus ID	01
Function code	04	Function code	04
Starting address Hi	00	Byte count	02
Starting address Lo (Read °C)	06	Output status Hi	08
Quantity of outputs Hi	00	Output status Lo	B1
Quantity of outputs Lo	01	CRC	7E
CRC Hi	D1	CRC	84
CRC Lo	CB		

08B1 is a HEX value, rewritten for decimal numbers is 2225, it must be divided by 100 and the result is 22,25°C
All read out value in function code 04, must be rewritten for decimal numbers, and divided by 100.

Communication examples for function code 05

Set factory reset bit

Request from user		Response from WIO	
Modbus ID	01	Modbus ID	01
Function code	05	Function code	05
Starting address Hi	00	Starting address Hi	00
Starting address Lo (factory reset bit status)	2A	Starting address Lo	2A
Register Value Hi	FF	Output status Hi	FF
Register Value Lo	00	Output status Lo	00
CRC Hi	AC	CRC	AC
CRC Lo	76	CRC	76

Communication examples for function code 06

Complete the factory reset

Request from user		Response from WIO	
Modbus ID	01	Modbus ID	01
Function code	06	Function code	06
Starting address Hi	00	Starting address Hi	00
Starting address Lo (factory reset complete)	08	Starting address Lo	08
Quantity of outputs Hi	00	Output status Hi	00
Quantity of outputs Lo	01	Output status Lo	01
CRC Hi	C9	CRC	C9
CRC Lo	C8	CRC	C8

Before complete factory reset, the factory reset bit must be set to 01

Communication examples for function code 10

Change HA alarm level to 0,55 aW

Request from user		Response from WIO	
Modbus ID	01	Modbus ID	01
Function code	10	Function code	10
Starting address Hi	00	Starting address Hi	00
Starting address Lo (HA alarm level)	1E	Starting address Lo	1E
Quantity of outputs Hi	00	Output status Hi	00
Quantity of outputs Lo	02	Output status Lo	02
Byte count	04	CRC	21
Register Value Hi	CD	CRC	CE
Register Value Lo	CC		
Register Value Hi	0C		
Register Value Lo	3F		
CRC Hi	C8		
CRC Lo	AC		

CRC Calculation

Use google, search for: on-line Modbus CRC calculation.
Put in the calculator (only HEX value) 0101002A0001.
The calculator can give you 2 result 02DC or DC02.
If the result is 02DC, then just put 02 behind DC, and the CRC result will be DC02.
If the result is DC02. Then you have the CRC value

Error codes

If you get a response back by a factor of 80 higher, as in the example shown, it is 3. digit explanation of the error code.

Example 1.
Request from user to WIO: 01 01 00 25 00 01 EC 01
Response from WIO: 01 81 02 C1 91

Message 81 means that there is an error in the transmitted function code 01.
Message 02 means that it is the wrong address.

Example 2.
Request from user to WIO: 01 10 00 1D 00 02 04 00 00 10 3F 7E EA
Response from WIO: 01 90 02 CD C1

Message 90 means that there is an error in the transmitted function code 10.
Message 02 means that it is the wrong address.

Example 3.
Request from user to WIO: 01 05 00 28 00 FF 0D 82
Response from WIO: 01 85 03 02 91

Message 85 means that there is an error in the transmitted function code 05.
Message 03 means that it is the wrong data for this address.

There are 4 possible error digit.

01 function code not supported
02 wrong address
03 to many output registers are selected or wrong input of data
04 error in reading the selected register

Table for aW to HEX value

aW value	HEX value	aW value	HEX value
0,10	CD CC CC 3D	0,15	9A 99 19 3E
0,20	CD CC 4C 3E	0,25	00 00 80 3E
0,30	98 99 99 3E	0,35	33 33 B3 3E
0,40	CD CC CC 3E	0,45	66 66 E6 3E
0,50	00 00 00 3F	0,55	CD CC 0C 3F
0,60	9A 99 19 3F	0,65	66 66 26 3F
0,70	33 33 33 3F	0,75	00 00 40 3F
0,80	CD CC 4C 3F	0,85	9A 99 59 3F
0,90	66 66 66 3F	0,95	33 33 73 3F

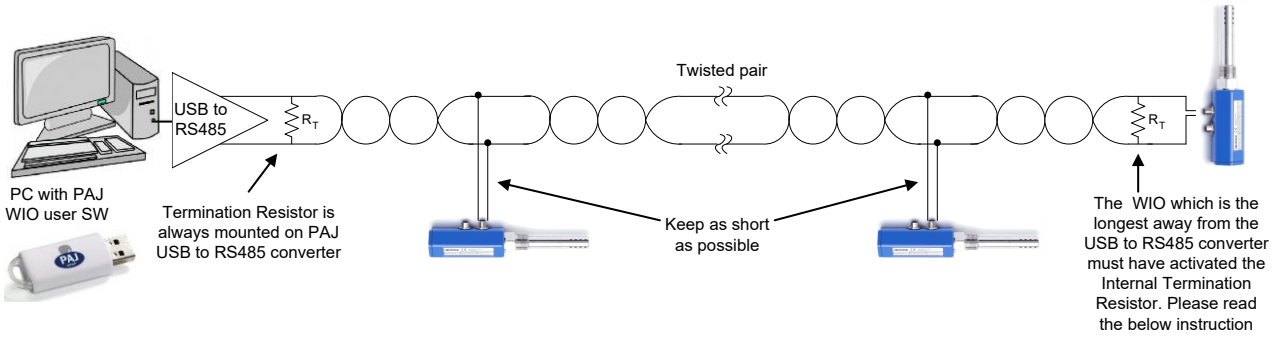
WIO-Software

Connect the USB-Stick to the PC and wait for windows has installed driver for this USB-Stick on PC. Then select Setup and wait until everything is installed. After install is completed, restart the PC and start WIO-Software, WIO-Software will even find the current communication port.

RS485 Guidelines

As its name implies, a twisted pair is simply a pair of wires of equal length and twisted together. Using a twisted-pair wire reduces two major sources of problems for users of high-speed long distance networks. It reduces noise on the transmitted and received signals.

An important condition for communication over long distance is that the transmission lines are properly terminated with a termination resistor (R_T) of 120 Ω. Which is typically is the characteristic impedance of a twisted-pair wire. If the resistance is omitted, the signals sent on the wire, will be reflected where the cable physically ends and hike back on the cord. Here they will interfere with subsequent transmitted signals. For long cable runs, this can cause data errors, especially at high speeds.



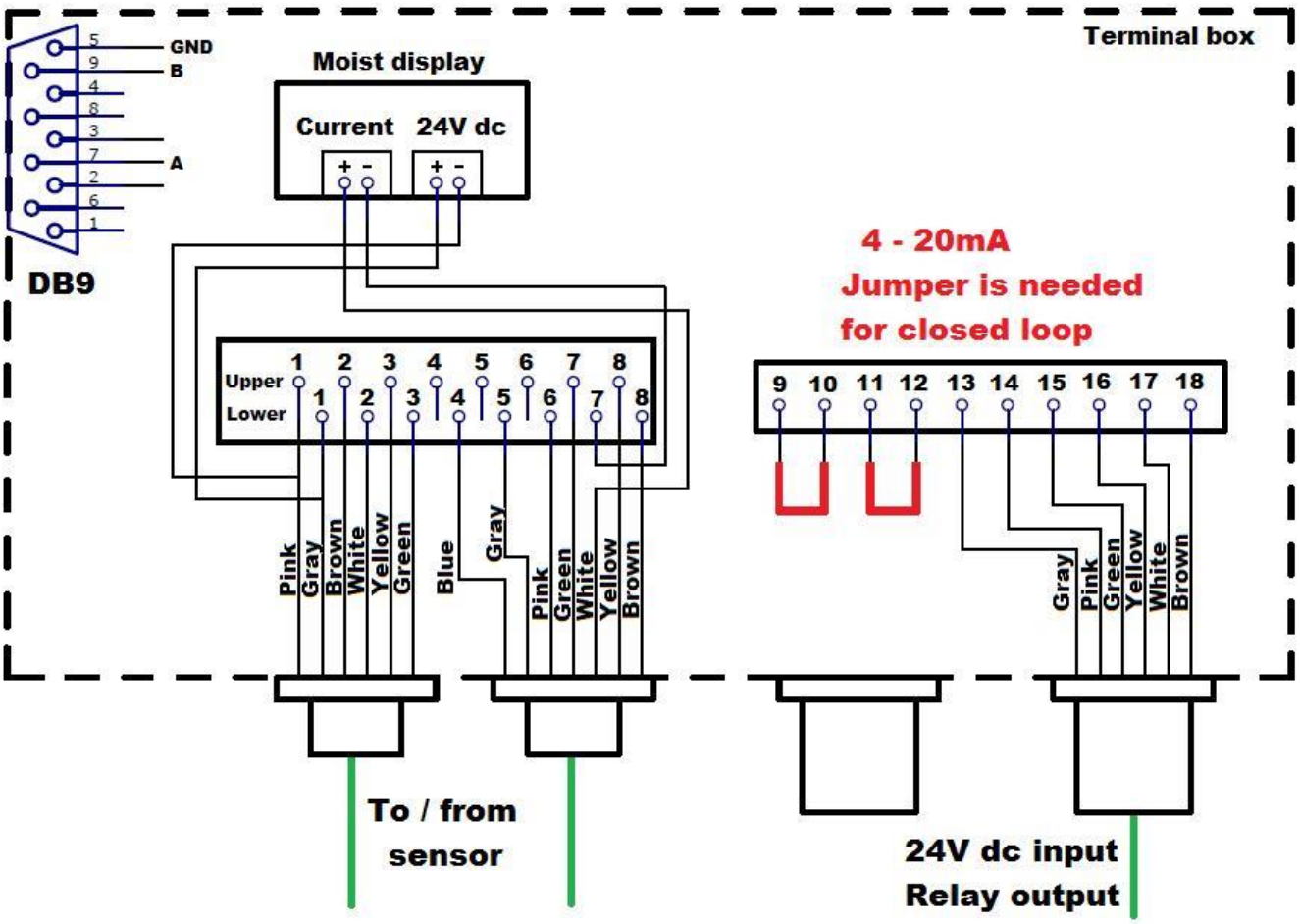
There is a built-in termination resistor in the WIO, which can be connected with Function code 05 address 29 or use PAJ WIO user software.

The maximum number of unit loads allowed on a twisted pair, assuming a properly terminated cable with a characteristic impedance of 120 Ω or more, is 32 units.

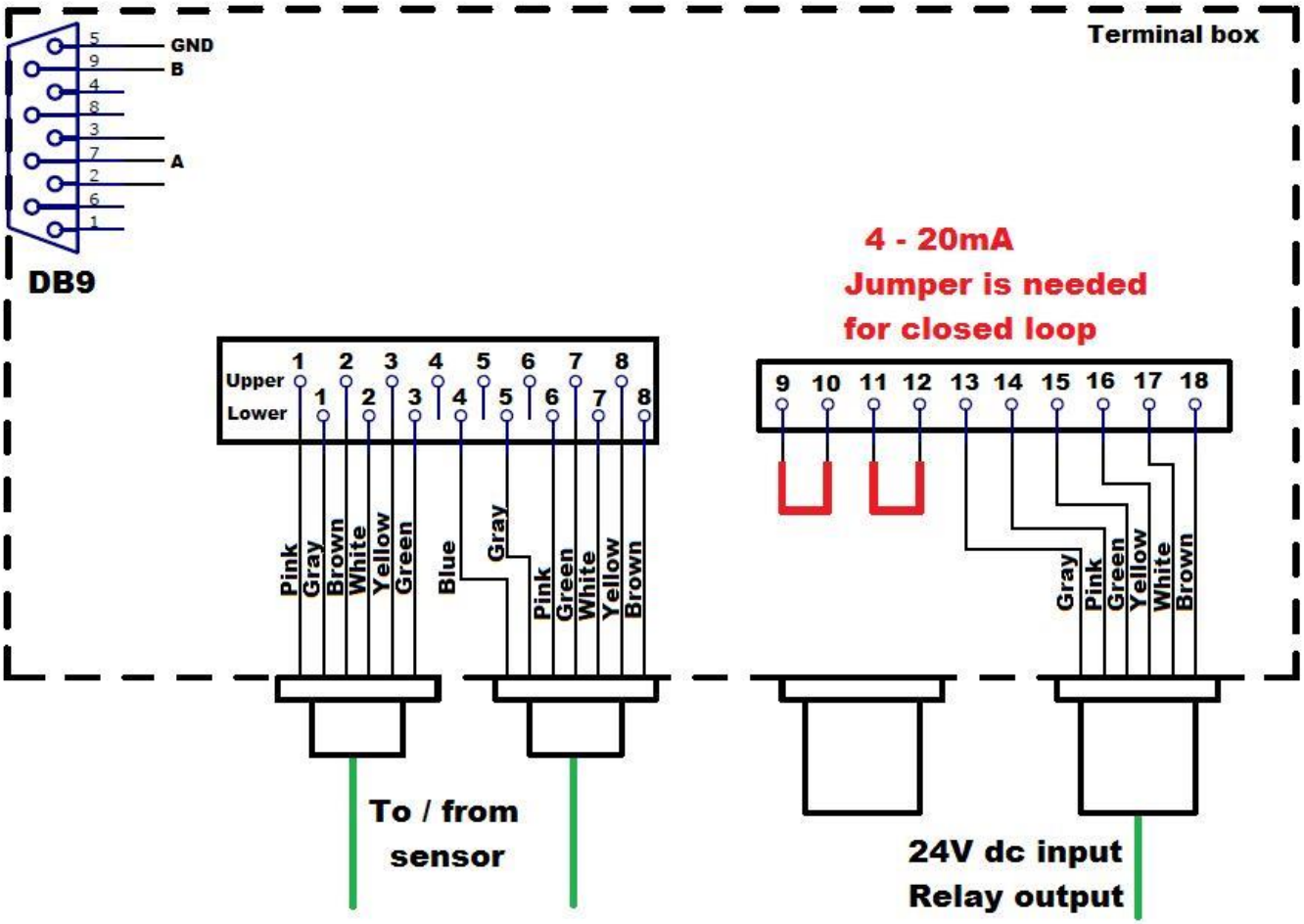
For RS485 communication is the maximum cable length 1200 meter.

Each WIO must have an individual ID nr, for communication. Connect one WIO to the system and change the ID nr on the connected WIO, then connect the next WIO and then change the next ID nr on the connected WIO.
Change an ID can be done with function code 06 address 24 or use PAJ WIO user software.

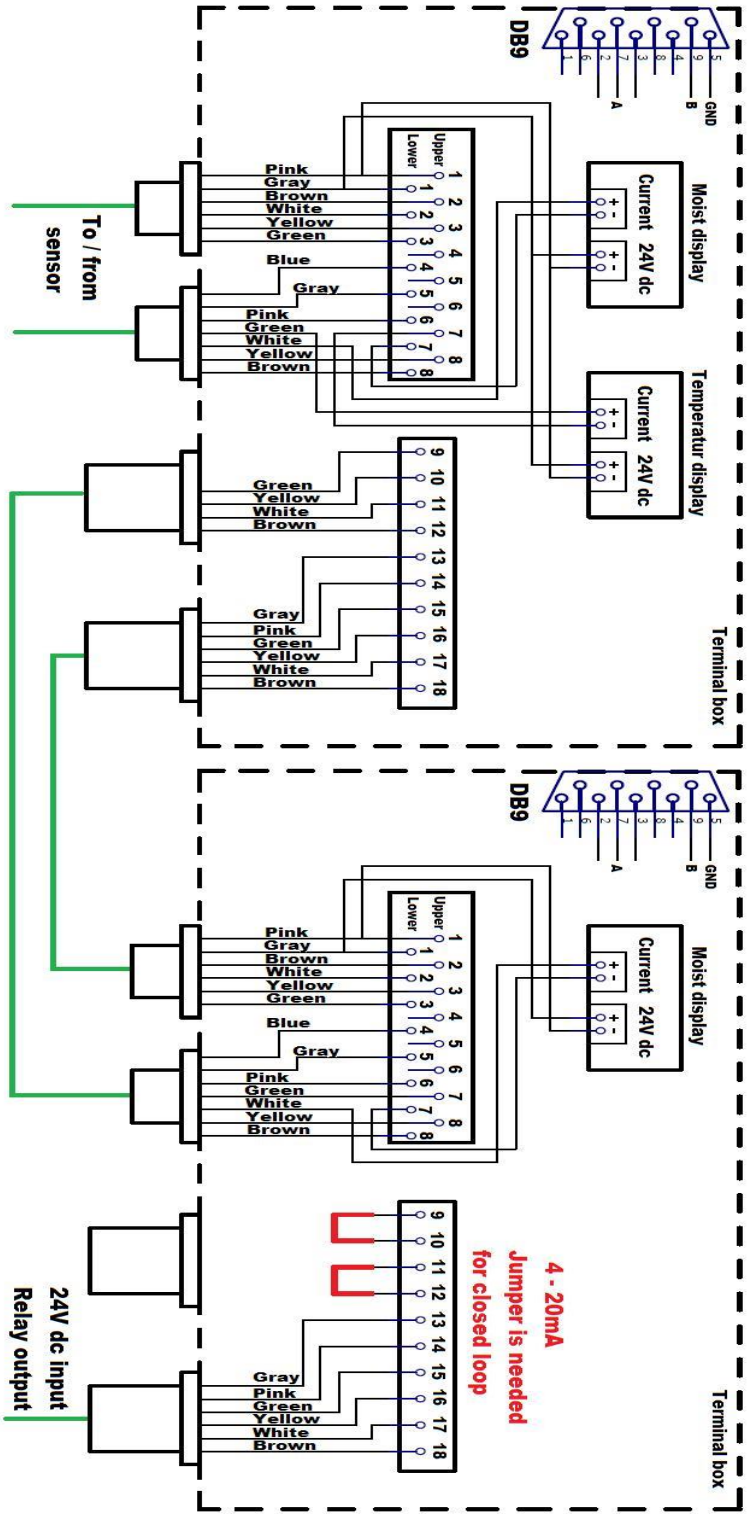
Appendix A1: Install 1 Terminal Box with 1 display



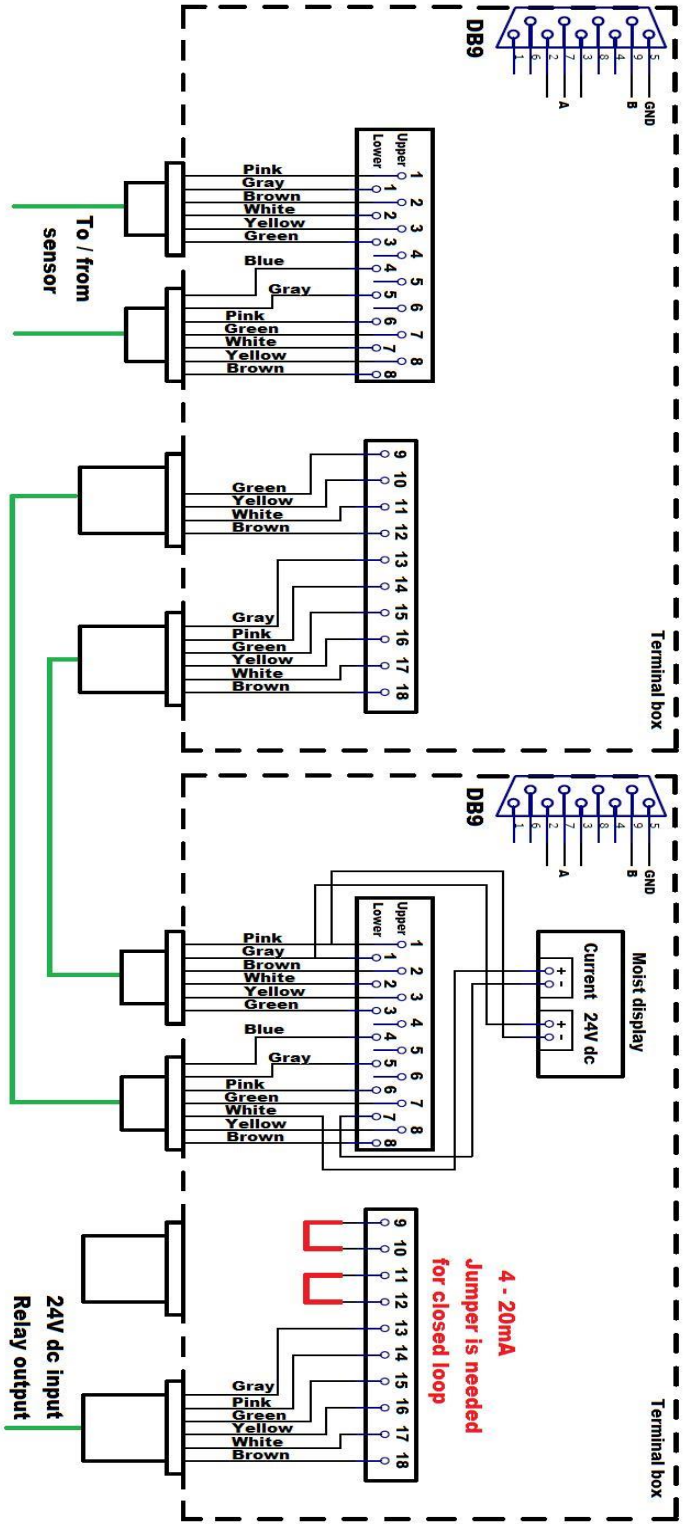
Appendix A2: Install 1 Terminal Box with no display



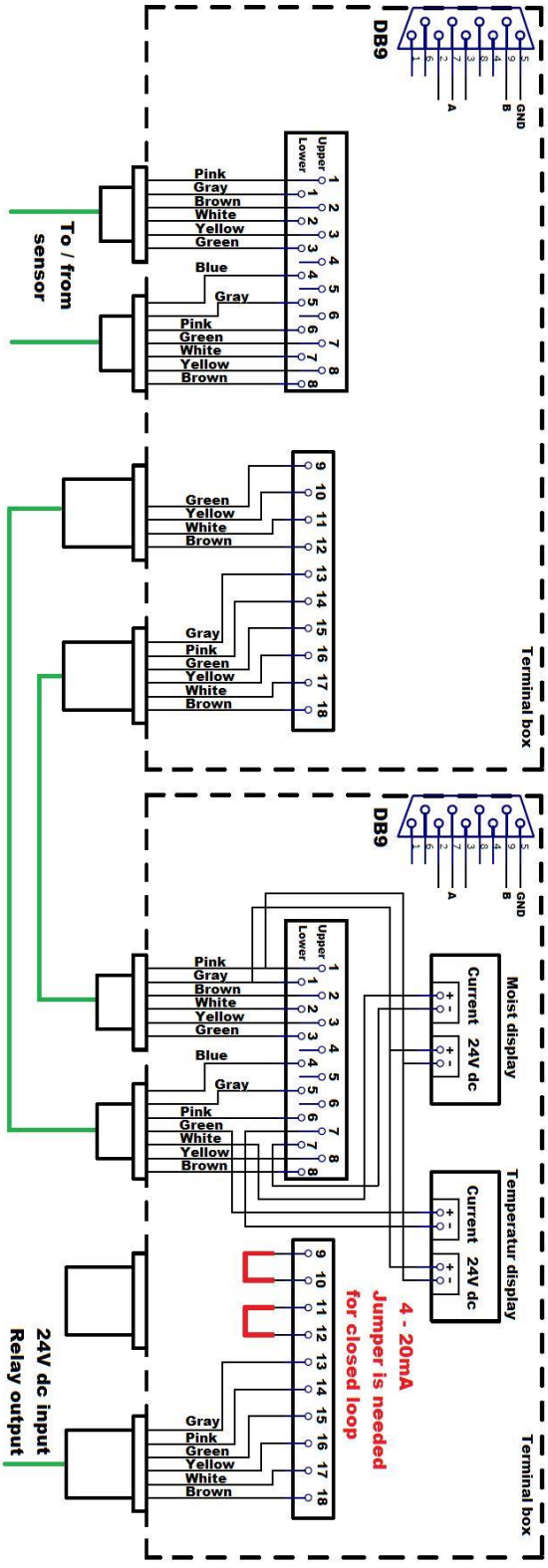
Appendix A3: Install 2 Terminal Boxes with 3 display



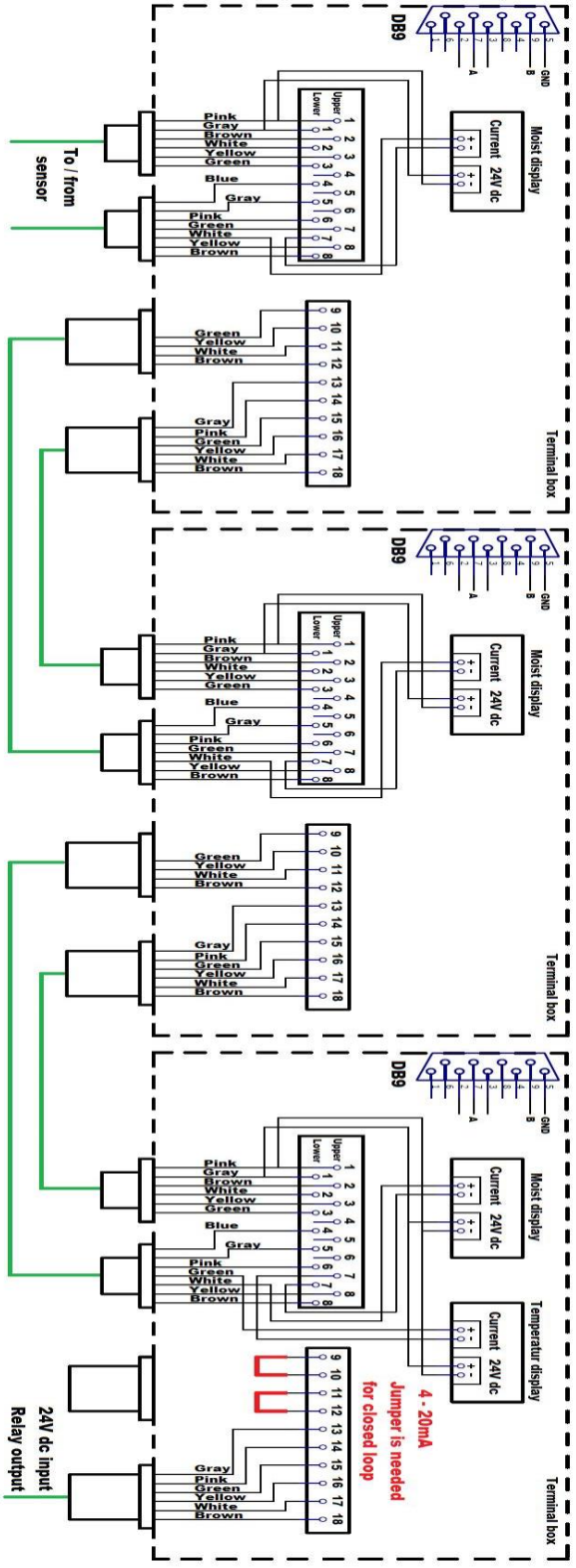
Appendix A4: Install 2 Terminal Boxes with 1 display



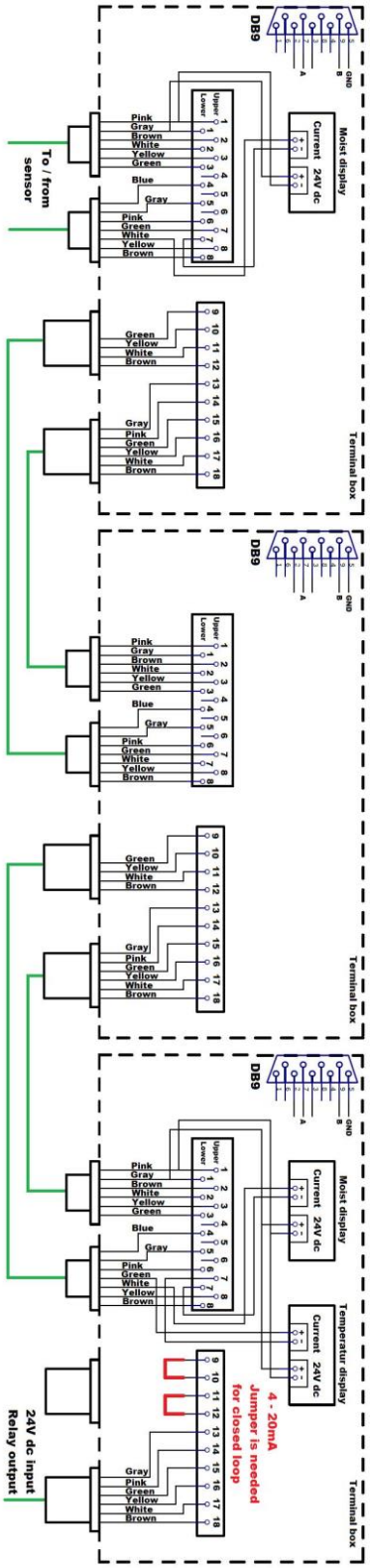
Appendix A5: Install 2 Terminal Boxes with 2 display



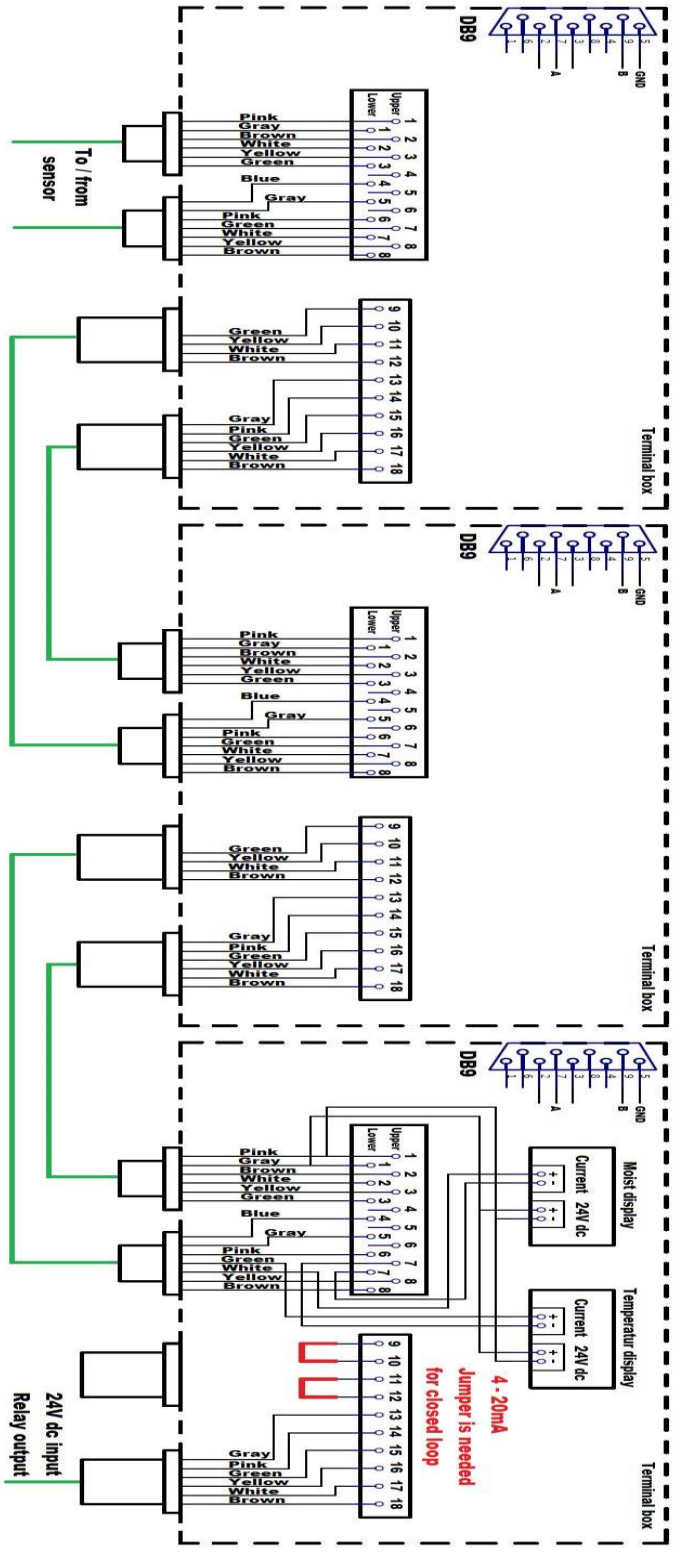
Appendix A6: Install 3 Terminal Boxes with 4 display



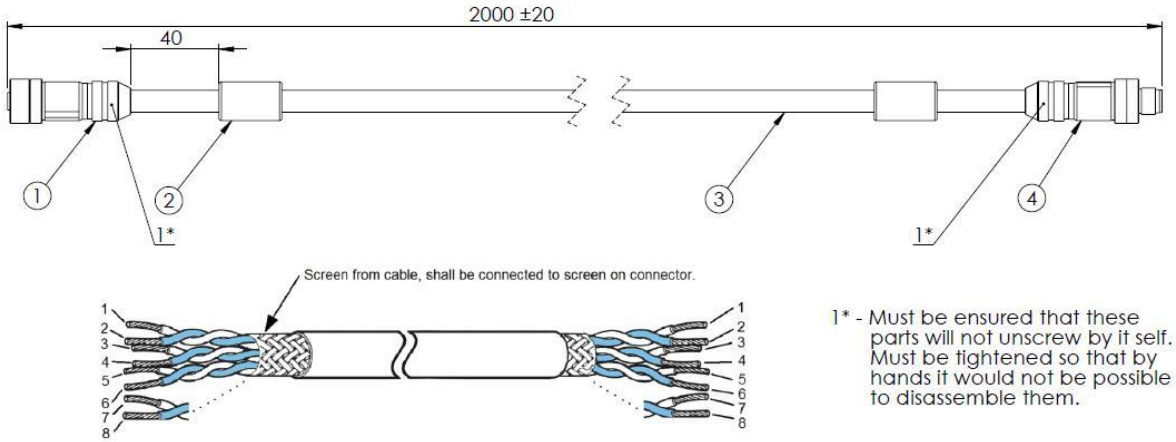
Appendix A7: Install 3 Terminal Boxes with 3 display



Appendix A8: Install 3 Terminal Boxes with 2 display



Appendix A9: CABLE Specification



8 pol. Connectors pin layout						
Female				Male		
A	Assignment			B	Assignment	
	Socket	Wire			Plug	Wire
	1	1			1	1
	2	2			2	2
	3	3			3	3
	4	4			4	4
	5	5			5	5
	6	6			6	6
	7	7			7	7
	8	8			8	8

Item No.	Description	Qty.
1	Female Plug	1
4	Ferrite Core	2
2	CL105 4x2x0.75-PO – 2m	1
3	Male Plug	1

How to adjust the display in a WIO

When the display is adjusted by PAJ Group, it is adjusted for either **aw** or **ppm** reading.
aw reading: 4 mA = .0000 a_W 20 mA = 1.0000 a_W
ppm reading: 4 mA = 0000 ppm 20 mA = * ppm
*If a customer wishes the display to indicate ppm-values, he must specify to PAJ Group:

a) The specific temperature of the sample/medium, at which, WIO/WIOI shall measure.
b) Which ppm-value equals 1.00 a_W, at that specific temperature.

However, a few customers wish to be able to adjust the display or change the **ppm**-value-range of the display.
Here is a description of how to do it:
DISCLAIMER: The warranty of WIO is void, if you adjust the display yourself.

Connection diagram

Make a wire connection with two power supply equipments as shown below:

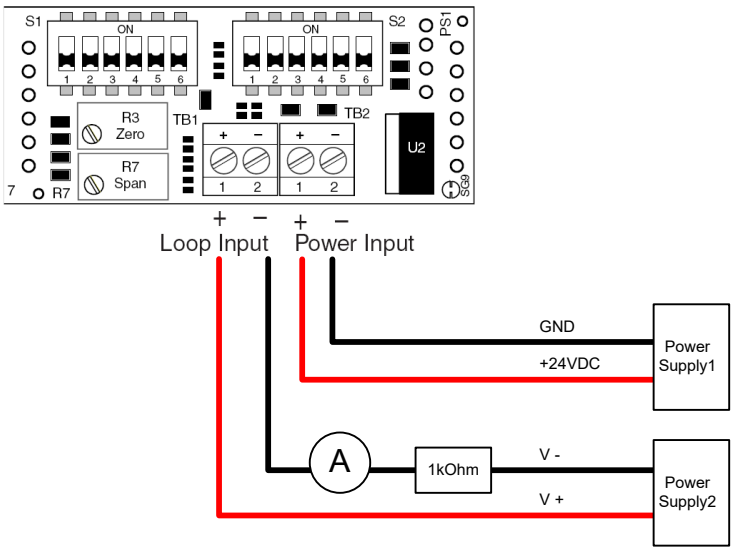


Figure 1

Start condition

Set R3(zero point adjust) and R7(max. point / span adjust) fully clockwise, roughly 20 turns.

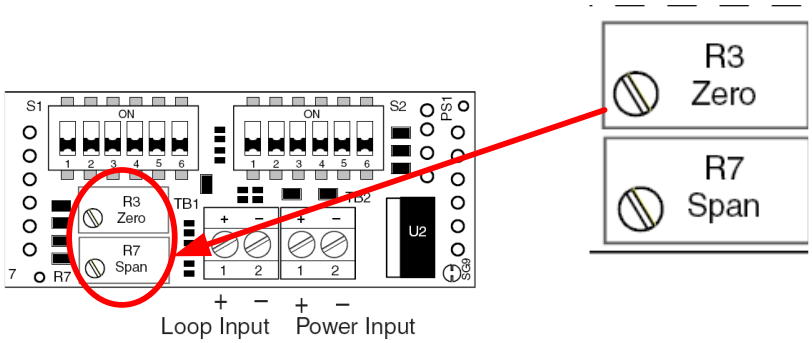


Figure 2

Setting DIP-switches on S1 and S2:

The range/span of the display is set by DIP-switches, located on the back of the display.

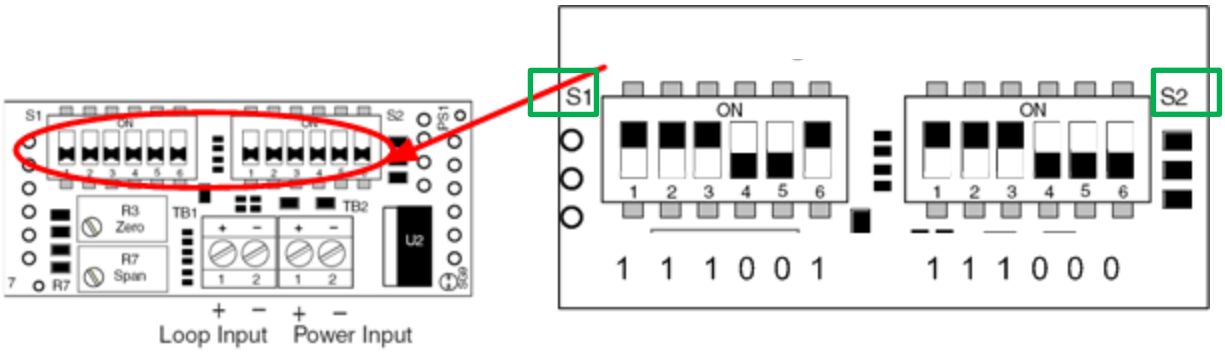


Figure 3

The display in WIO is a newer revision, than shown in figure 3. It has a different physical appearance (figure 4), but the DIP-switches have same functionality. The switch-sliders (figure 3) are indicated as black. In reality they are white.



Figure 4

Setting DIP-switches for aW-reading:

Desired readings:
4 mA = .0000 a_W
20 mA = 1.0000 a_W

DIP-switch settings (for aw):
The switch-sliders are indicated as black. In reality they are white.

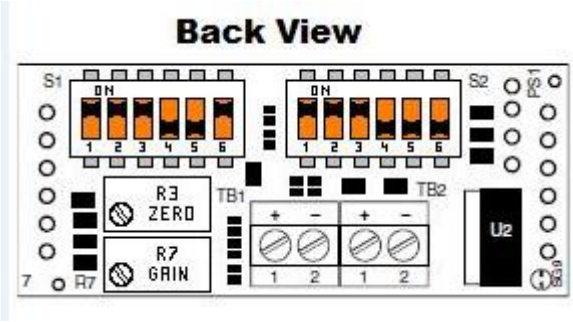


Figure 5

Setting DIP-switches for ppm-reading:

DIP-switches must be set according to Table 1 and Table 2.

Table 1. DIP-Switch Settings

	Display Reading		Switch S1						Switch S2	
			SW1	SW2	SW3	SW4	SW5	SW6	SW1	SW2
	4mA	20mA								
1.	0000	2250-2500	Off	On	On	On	Off	Off	On	On
2.	0000	2500-2800	Off	On	On	On	Off	Off	Off	On
3.	0000	2800-3200	Off	On	On	On	Off	Off	On	Off
4.	0000	3200-3850	Off	On	On	On	Off	Off	Off	Off
5.	0000	3850-4300	On	Off	On	On	Off	Off	On	On
6.	0000	4300-4900	On	Off	On	On	Off	Off	Off	On
7.	0000	4900-5600	On	Off	On	On	Off	Off	On	Off
8.	0000	5600-6200	On	Off	On	On	Off	Off	Off	Off
9.	0000	6200-6800	Off	Off	On	On	On	Off	On	On
10.	0000	6800-7750	Off	Off	On	On	On	Off	Off	On
11.	0000	7750-8600	On	On	Off	On	On	Off	On	On
12.	0000	8600-9850	On	On	Off	On	On	Off	Off	On
13.	0000	9850-11000	On	On	On	Off	Off	On	On	On
14.	0000	11000-12000	On	On	On	Off	Off	On	Off	On
15.	0000	12000-13000	On	Off	Off	On	Off	On	On	On
16.	0000	13000-14000	On	Off	Off	On	Off	On	Off	On
17.	0000	14000-15300	On	Off	On	Off	On	On	On	On
18.	0000	15300-16300	On	Off	On	Off	On	On	Off	On
19.	0000	16300-17800	Off	Off	On	Off	On	On	On	On
20.	0000	17800-20000	Off	Off	On	Off	On	On	Off	On

Table 2. Decimal Point Settings

Switch S2			
SW3	SW4	SW5	SW6
DP1	DP2	DP3	DP4

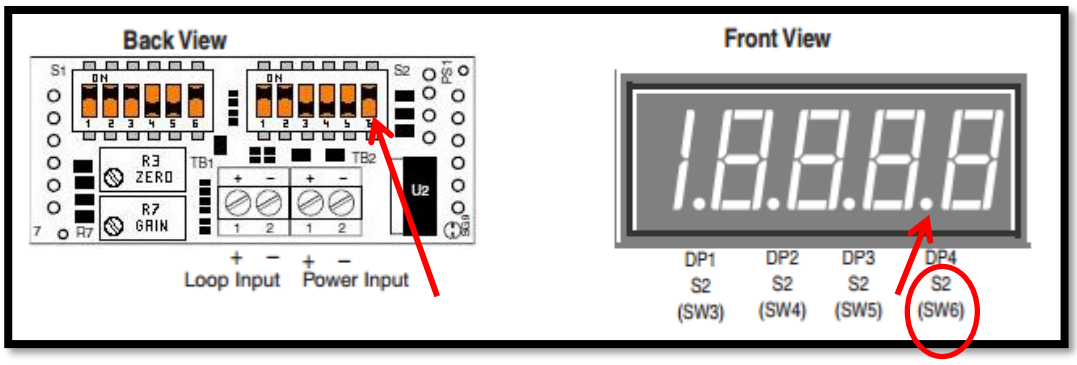


Figure 6

Decimal points 1 through 4 (DP1) is switched ON by setting S2/SW3 through S2/SW6 to ON (see Table 2)

Example (figure 6): Decimal point 4 (DP1) is switched ON by setting S2/SW6 to ON.

Table 1. DIP-Switch Settings

	Display Reading		Switch S1						Switch S2	
	4mA	20mA	SW1	SW2	SW3	SW4	SW5	SW6	SW1	SW2
1.	0000	2250-2500	Off	On	On	On	Off	Off	On	On
2.	0000	2500-2800	Off	On	On	On	Off	Off	Off	On
3.	0000	2800-3200	Off	On	On	On	Off	Off	On	Off
4.	0000	3200-3850	Off	On	On	On	Off	Off	Off	Off
5.	0000	3850-4300	On	Off	On	On	Off	Off	On	On
6.	0000	4300-4900	On	Off	On	On	Off	Off	Off	On
7.	0000	4900-5600	On	Off	On	On	Off	Off	On	Off
8.	0000	5600-6200	On	Off	On	On	Off	Off	Off	Off
9.	0000	6200-6800	Off	Off	On	On	On	Off	On	On
10.	0000	6800-7750	Off	Off	On	On	On	Off	Off	On
11.	0000	7750-8600	On	On	Off	On	On	Off	On	On
12.	0000	8600-9850	On	On	Off	On	On	Off	Off	On
13.	0000	9850-11000	On	On	On	Off	Off	On	On	On
14.	0000	11000-12000	On	On	On	Off	Off	On	Off	On
15.	0000	12000-13000	On	Off	Off	On	Off	On	On	On
16.	0000	13000-14000	On	Off	Off	On	Off	On	Off	On
17.	0000	14000-15300	On	Off	On	Off	On	On	On	On
18.	0000	15300-16300	On	Off	On	Off	On	On	Off	On
19.	0000	16300-17800	Off	Off	On	Off	On	On	On	On
20.	0000	17800-20000	Off	Off	On	Off	On	On	Off	On

Table 2. Decimal Point Settings

Switch S2			
SW3	SW4	SW5	SW6
DP1	DP2	DP3	DP4

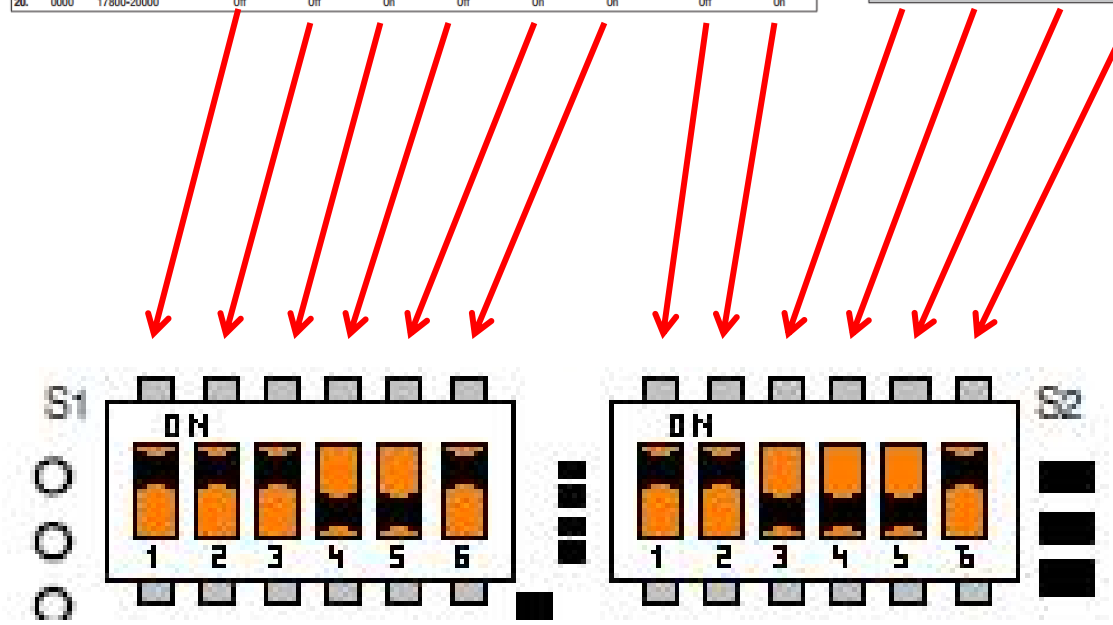


Figure 7

Since these tables can be difficult to overview, we will show a couple of examples:

Example 1:

Desired readings:
4 mA = 0000 ppm
20 mA = 1000.0 ppm

DIP-switch settings:
The switch-sliders are indicated as black. In reality they are white.

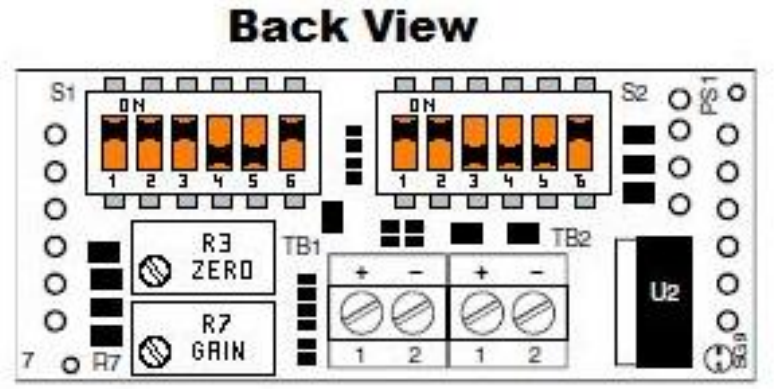


Table 1. DIP-Switch Settings

	Display Reading		Switch S1						Switch S2	
			SW1	SW2	SW3	SW4	SW5	SW6	SW1	SW2
	4mA	20mA								
1.	0000	2250-2500	Off	On	On	On	Off	Off	On	On
2.	0000	2500-2800	Off	On	On	On	Off	Off	Off	On
3.	0000	2800-3200	Off	On	On	On	Off	Off	On	Off
4.	0000	3200-3850	Off	On	On	On	Off	Off	Off	Off
5.	0000	3850-4300	On	Off	On	On	Off	Off	On	On
6.	0000	4300-4900	On	Off	On	On	Off	Off	Off	On
7.	0000	4900-5600	On	Off	On	On	Off	Off	On	Off
8.	0000	5600-6200	On	Off	On	On	Off	Off	Off	Off
9.	0000	6200-6800	Off	Off	On	On	On	Off	On	On
10.	0000	6800-7750	Off	Off	On	On	On	Off	Off	On
11.	0000	7750-8600	On	On	Off	On	On	Off	On	On
12.	0000	8600-9850	On	On	Off	On	On	Off	Off	On
13.	0000	9850-11000	On	On	On	Off	Off	On	On	On
14.	0000	11000-12000	On	On	On	Off	Off	On	Off	On
15.	0000	12000-13000	On	Off	Off	On	Off	On	On	On

Table 2. Decimal Point Settings

Switch S2			
SW3	SW4	SW5	SW6
DP1	DP2	DP3	DP4

Example 2:

Desired readings:
4 mA = 0000 ppm
20 mA = 4700 ppm

DIP-switch settings:
The switch-sliders are indicated as black. In reality they are white.

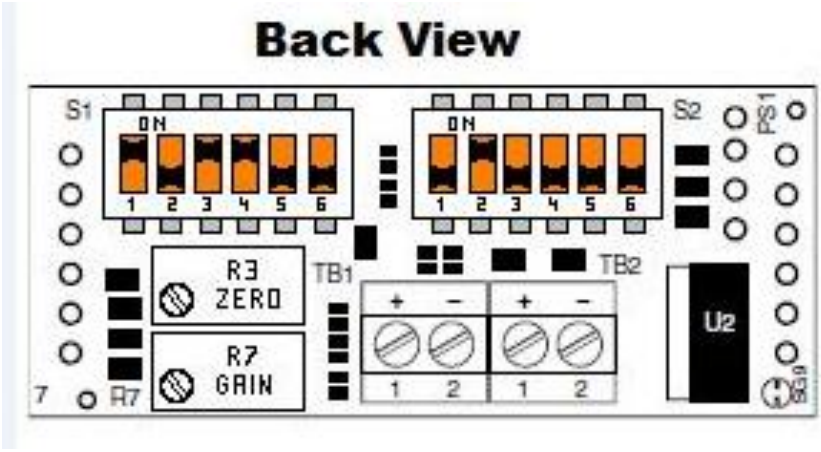


Table 1. DIP-Switch Settings

	Display Reading		Switch S1						Switch S2	
			SW1	SW2	SW3	SW4	SW5	SW6	SW1	SW2
	4mA	20mA								
1.	0000	2250-2500	Off	On	On	On	Off	Off	On	On
2.	0000	2500-2800	Off	On	On	On	Off	Off	Off	On
3.	0000	2800-3200	Off	On	On	On	Off	Off	On	Off
4.	0000	3200-3850	Off	On	On	On	Off	Off	Off	Off
5.	0000	3850-4300	On	Off	On	On	Off	Off	On	On
6.	0000	4300-4900	On	Off	On	On	Off	Off	Off	On
7.	0000	4900-5600	On	Off	On	On	Off	Off	On	Off
8.	0000	5600-6200	On	Off	On	On	Off	Off	Off	Off
9.	0000	6200-6800	Off	Off	On	On	On	Off	On	On
10.	0000	6800-7750	Off	Off	On	On	On	Off	Off	On
11.	0000	7750-8600	On	On	Off	On	On	Off	On	On
12.	0000	8600-9850	On	On	Off	On	On	Off	Off	On
13.	0000	9850-11000	On	On	On	Off	Off	On	On	On
14.	0000	11000-12000	On	On	On	Off	Off	On	Off	On
15.	0000	12000-13000	On	Off	Off	On	Off	On	On	On

Table 2. Decimal Point Settings

Switch S2			
SW3	SW4	SW5	SW6
DP1	DP2	DP3	DP4

Zero point adjustment

Set PowerSupply1 to 24VDC and switch ON.
Set PowerSupply2 to 4V (1V/(1kOm +$R_{display)}$ = 1mA) and switch ON.

Adjust PowerSupply2 until the Ampere meter indicates 4.00 mA.

Adjust R3 potentiometer until the display reads **"0000"**

Max. point adjustment

Set PowerSupply2 to 20V.

Adjust PowerSupply2 until the Ampere meter indicates 20.00 mA.
Notice: The signal from the WIO/WIOI Sensor to the Terminalbox/display, is as follows:
20 mA = 1.0000 a_W = 100 %RH (=)* The desired max.-ppm-value adjusted on display

*ppm-displayadjustment will only be correct at 1 specific temperature measured in a medium, which has the desired max.-ppm-value (= 1.0 a_W) at this specific temperature.

Adjust R7 potentiometer until the display reads **"1.0000"** (or **desired max.-ppm-value**), as shown below:



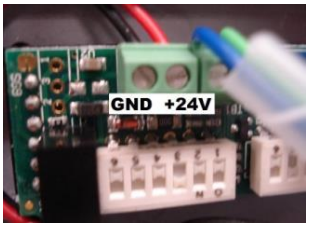
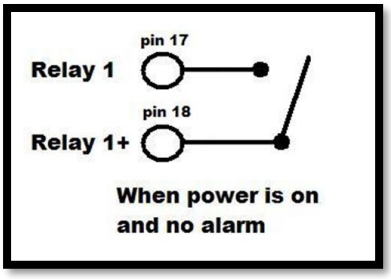
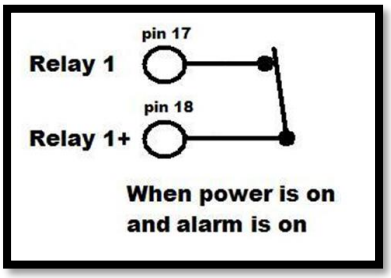
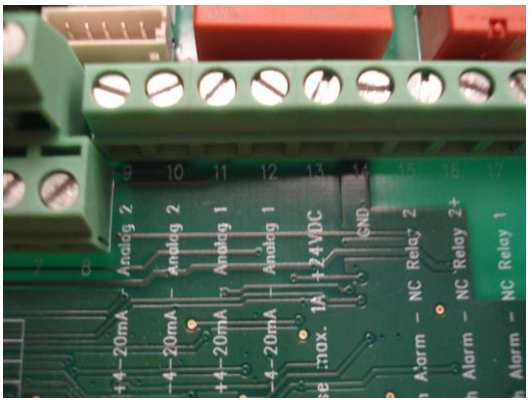
END OF SETTING

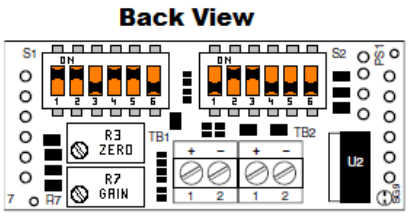
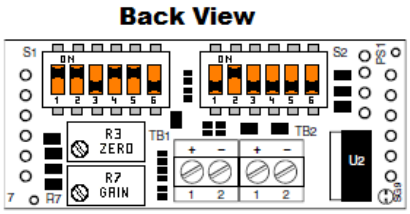
Remove the display from power supply equipments.

The display is now ready for reading the analog signal from 4mA up to 20mA and it is configured for the indication
from 0.0000 to 1.0000 a_W or
from 0000 to desired max.-ppm-value

Appendix A10: Error / failure FAQ

Failure type	Description	Possible reasons
PPM display failure	Display shows only negative numbers 	1. Sensor is not connected. 2. The error caused by missing jumper in terminal box pin 11 and pin 12. See Appendix A1 3. Check that the jumper is properly installed, it is seen that the jumper has been installed but the jumper had no proper connection 4. The wires are reversed in terminal box pin 7 and pin 8 lower part. After changing and there is no change in the display, then the fault is either 1, 2 or 3.
a_w display failure	Dispay shows only negative numbers 	1. Sensor is not connected. 2. The error caused by missing jumper in terminal box pin 11 and pin 12. See Appendix A1 3. Check that the jumper is properly installed, it is seen that the jumper has been installed but the jumper had no proper connection 4. The wires are reversed in terminal box pin 7 and pin 8 lower part. After changing and there is no change in the display, then the fault is either 1, 2 or 3.

Dead display	Display indicate nothing 	Maybe is 24V dc supply interrupted to the display. There shall be 24V dc at this connector. 
Relay	Relay-state while alarm is on	 
Sensor	How to check the mA output from sensor? 	Remove jumper in pin 11 and pin 12. In order to ensure that there can be measured mA must pin 11 and pin 12 must be screwed. Remember to set the measuring instrument in dc mA and connect test leads correctly in the measuring instrument. Sensor is alright when measuring a value between 4 and 20 mA. Is the result about 2 mA then there is an internal sensor error, so the sensor must be sent for repair. Is the result 0 mA, tjek if the sensor get 24 Vdc power.

Dip Switch a_w	Are the dip switches still positioned correctly?	Correct positions: 
Dip Switch PPM	Are the dip switches still positioned correctly?	Correct positions: 
Broken cables between Sensor and terminal box	No mA will can be measured on: Analog 1: Terminal 11 and 12 and Analog 2: Terminal 9 and 10	