USER'S GUIDE
ORG-815-DS
OPTICAL PRECIPITATION SENSOR

Revision 08/09/19

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Revision Record

Rev Date	Description of Changes
6/28/00	Changes company name from ScTi to OSI, added revision log
7/25/00	Added new mounting bracket details to Sec 2.2, updated TST-700 to TST-800 and PSB-715 to PSB-815
05/05/10	Re-edit User's guide to current level.
12/02/10	Make specific for ORG 815-DS
01/14/11	Restore "Q" poll and other edits per customer request
03/07/14	Add erratum notes re: firmware 42S dated 07/19/12 "A" Poll 17 byte data length in Section 4 to be ignored Remove QwikCollect Software reference
09/08/16	Update cable to include 1102-302-4
03/15/17	Added MODBUS-RTU capability re: firmware 44s dated 03/15/17 and later
05/11/17	Corrected DC wire assignment Fig. 2.5
04/18/18	Add LDM option and Appendix A
05/16/18	Update Tech Support & Customer Service phone numbers
02/25/19	Update Figures 1.1, 1.2, and 1.3
08/09/19	Heater status added on byte 20 (4th byte of status code)

Read the entire User=s Guide before proceeding with installation or maintenance of the ORG!

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CAUTIONARY NOTES

Note :
Used to call attention to a special feature or procedure which must be followed for correct operation of the equipment

Caution :
Used to call attention to a concern where damage to the equipment or injury to personnel may occur unless certain steps are followed

Warning :
Used to call attention to a concern where serious personal injury or death may occur unless basic safety procedures are followed

WARRANTY

Optical Scientific warrants its products to be free of defects in workmanship and material for a period of 12 months from date of shipment. During the warranty period, OSI will repair or replace defective products at its own expense, subject to the following conditions:

1. The Buyer prepays all shipping, insurance, and associated costs to return the defective item to OSI. OSI pays return shipping and insurance.
2. The product must not have experienced misuse, neglect, accident or have been altered or repaired by the Buyer during the warranty period.
3. This warranty and OSI's obligation are in lieu of all other warranties. Implied warranties shall not apply.
4. OSI is not liable for consequential or incidental damages, labor performed in conjunction with removal and replacement, loss of production, or any other loss incurred because of interruption of service or production of incorrect or incomplete weather information.

Disclaimer

Optical Scientific, Inc. will not be held liable for any accident, injury, or damage incurred while installing, operating or servicing this equipment; or as a result of improper installation or operation. Implementation and enforcement of proper safety procedures is solely the responsibility of the user, user employees or contracted personnel.

GLOSSARY

AC	Alternating Current
AGC	Automatic Gain Control
AWG	American Wire Gauge
ASCII	American Standard Code For Information Exchange
ASOS	Automated Surface Observing System
CR	Carriage Return
CTRL	Control
CXR	Carrier Signal
CW	Continuous Wave
DC	Direct Current
FAA	Federal Aviation Administration
LDM	Limited Distance Modem
LED	Light Emitting Diode
IR	Infrared
MOV	Metal Oxide Varistor
NEMA	National Electrical Manufacturer's Association
NWS	National Weather Service
ORG	Optical Rain Gauge
PSB	Power Supply Box
PTC	Positive Temperature Thermistor
RX	Receiver
OSI	Optical Scientific, Inc.
TX	Transmitter
VDC	Voltage Direct Current

ENGLISH/METRIC CONVERSION FACTORS

1 inch = 25.4 mm	1 mm = 0.039 in
1 foot = 0.305 m	1 meter = 3.28 ft
1 pound = 0.454 kg	1 kilogram = 2.2 lbs
EF = 9/5 EC + 32	EC = 5/9(EF – 32)

1 INTRODUCTION TO THE ORG-815-DS OPTICAL PRECIPITATION GAUGE

1.1 THE ORG-815-DS IMPROVES YOUR ABILITY TO MEASURE RAIN AND SNOW

The ORG7 measures rain and snow and applies algorithms to automatically determine the precipitation type, rate, and water equivalent accumulation. The ORG is vastly superior to traditional type sensors and offers the reliability and proven performance you need!

OSI's ORG-815-DS precipitation sensor provides accurate measurement of precipitation in all weather conditions. Designed for rugged, unattended operation, ORGs have been field proven in adverse environments around the world and, unlike other sensors, on ocean deployed data buoys and ships.

Optical Measurement Benefits

OSI Optical Rain Gauges are not affected by many of the environmental factors which cause significant errors with traditional rain and snow gauges. Applications using traditional gauges such as tipping bucket, siphon, weighing, and electrical grid type gauges can all be upgraded with the OSI ORG sensors. OSI ORG's have many advantages including:

- **Easy Installation**
- **High Sensitivity**
- **Low Maintenance**
- **Minimal Wind Effects**
- **Wide Dynamic Range**
- **No Evaporation or Splash Errors**
- **Works on Ships & Buoys**
- **Operates 24/7/365**

Now with available 5-sec update rates for fine structure analysis of rain intensity!

Reliability

The electro-optical design provides for an extremely reliable sensor with a calculated MTBF in excess of 60,000 hours. Unlike mechanical gauges which collect precipitation to measure it, the ORG has no collectors, buckets, or siphons to corrode or clog. The sensors use AGC circuitry to eliminate the effects of LED output power or dirty optics. In fact, sensor performance is maintained even when over 75% of the light is blocked! Diagnostics alert the user if the signal strength is too low for normal operation. Preventative maintenance, suggested every 6 months, is as simple as cleaning the 2 optical windows on the unit.

Proven Technology

The ORG-815-DS sensors are based on technology developed and patented by OSI. OSI has been granted patents in the following countries: USA 4754149, UK 22001510, and Canada 1285044. This technology is the basis for the present weather sensor supplied to the FAA/NWS/U.S. Navy for the Automated Surface Observing System (ASOS).

Figure 1.1 OSI ORG-815-DS Series Optical Sensor

ORG® is a registered trademark of OSI.

1.2 PERFORMANCE SPECIFICATIONS FOR THE ORG-815-DS

The ORG-815-DS is designed to measure rain and snow in all weather conditions.

Performance Specification	
Rain Dynamic Range	0.1 to 500 mm/hr
Rain Accumulation	0.001 to 999.999 mm
Rain Accuracy	5% Accumulation
Rain Resolution	0.001 mm
Snow Dynamic Range	0.01 to 50 mm/hr water eq.
Snow Accumulation	0.001 to 999.999 mm water eq.
Snow Accuracy	10%
Snow Resolution	0.001 mm
Time Constant	10 seconds
ORG Data Update Rate	Once per minute - typical Every 5 seconds - available

Electrical Specification	
Supply Voltage	11 - 16 VDC
Current Drain (Current drain depends on ambient temperature - see Section 1.3 for details)	400-800 ma
Fusing	User supplied 1.0 A Slow Blow
Signal Output	RS-232
User Heater Control	n/a
Transient Protection	All power and signal lines protected by MOV

Environmental Specification	
Temperature	-40 to 50EC (-40 to 122EF)
Humidity	0-100%
Precipitation/Dust	NEMA-4 type protection

Physical Specification	
Size	763 mm L x 254 mm W x 102 mm H
Weight	3 kg w/o cables
Cable Length	15 meter

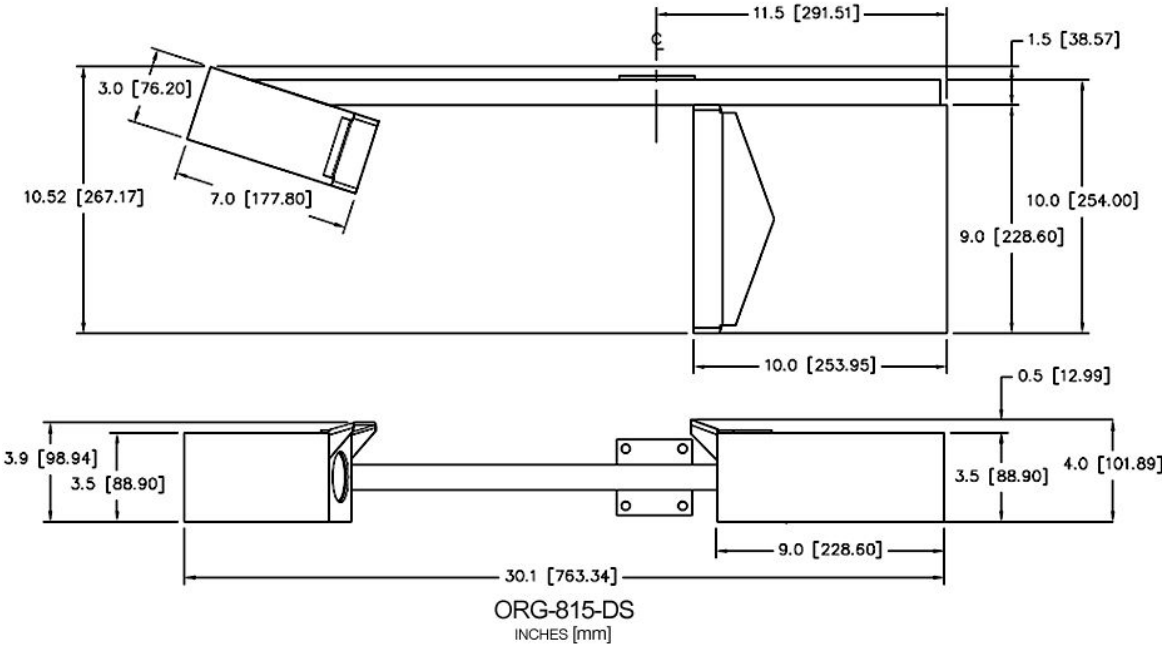


Figure 1.2 ORG-815-DS Dimensions

1.3 BASIC SENSOR DESCRIPTION

Precipitation is measured by detecting the optical irregularities induced by drops falling through an infrared optical beam. These irregularities, known as scintillation, have characteristic patterns which are detected by the sensor and converted to precipitation rate.

OSI's optical precipitation sensors measure rain and snow by detecting the optical irregularities induced within the sample volume by precipitation particles falling through a beam of partially coherent infrared light. These irregularities are known as scintillation. The twinkling of stars is a familiar example of scintillation. By detecting the intensity of the scintillations which are characteristic of precipitation, the actual rainfall rate can be determined.

The ORG consists of 1) a head frame which contains the transmit head, receive head, and electronics and 2) a 15 meter long power/signal cable, P/N 1102-302. The small box (transmit) contains an IRED diode and lens with disk heater. The large box (receive) contains a photodiode, lens with aperture slit, disk heater, electronics, external thermistor probe, and connector for the signal/power cable. All wiring between the transmit and receive heads is within the frame.

The transmit and receive lenses are heated by self-regulating positive temperature coefficient (PTC) thermistor disks, to a point above ambient temperature to reduce dew, frost, and snow buildup on the lenses. Depending on the ambient temperature, the current drain for the lens heaters can change more than 200 ma.

Data input and output are RS-232 digital expressed in ASCII characters

The ORG is completely sealed from water intrusion at the factory. Care should be taken to maintain the unit’s watertight integrity.

Note :
The ORG contains no user-serviceable parts - do not attempt to open it!
Doing so will compromise watertight seals and void any warranty.

Caution :
Do NOT drill holes in any portion of the ORG frame! Doing so will void the warranty and may allow water to enter the enclosure!

Figure 1.3 ORG-815-DS Major Components

1.4 ACCESSORIES FOR THE ORG

Several accessories are available from OSI for the ORG.
Contact the Sales Office for more information.

Electrical Box

The PSB-815 Power Supply Box is a NEMA-4 type enclosure with a hinged door for easy access. It houses a universal input AC/DC power supply, and terminal strips for connecting the ORG to the customer's equipment.

Figure 1.4 shows a typical PSB box. The PSB box operates with 100 to 230 VAC line voltage.

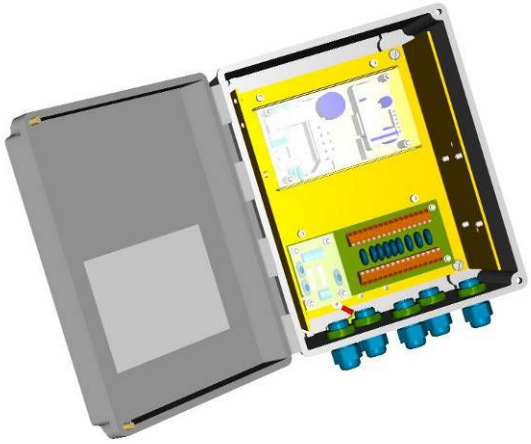


Figure 1.4 PSB Electrical Box

Limited Distance Modems (LDM)

A pair of LDMs is available if the distance between the ORG-815 and computer is more than the RS-232 specified distance of 100 feet. One LDM is installed inside the WIVIS power supply box and the other is connected to the user's computer. The LDMs operate over 2 unconditioned twisted wire pairs up to 14 km (9 mile) if the wire gauge is 19 AWG or larger. Detailed description of the LDM is in Appendix A.

Figure 1.5 Limited Distance Modem

2 INSTALLATION OF THE ORG-815-DS

2.1 SITING AND INSTALLATION GUIDELINES

The ORG may be installed almost anywhere outdoors, but an area free and clear of obstructions and contamination sources will help insure good sensor performance.

In general, ORG should be located on level or slightly sloping ground where the sensor site will be exposed to the same environment as the area around it. Ideally, the area around the site should be free of buildings, trees, and other obstructions.

OSI recommends that the siting and installation follow the general guidelines established by the Office of the Federal Coordinator for Meteorology (OFCM). The Federal Standard for Siting Meteorological Sensors at Airports, OFCM document # FSM-S4-1987, makes the following recommendations:

1. Distance from Obstructions - The distance between the sensor and obstructions such as trees or buildings should be at least 2 times the height of the obstruction on all sides. For example, if a 20 meter high tree is located alongside the ORG, the ORG should be at least 40 meters away from the tree. This restriction reduces the affects of wind turbulence created by the nearby obstruction and makes the ORG precipitation measurement more representative. Do not locate the ORG where tree branches or wires will hang over the sensor!

2. Separation from Turbulence & Contamination Sources - Do not mount the ORG near building exhaust vents, strobe lights, or sources of smoke or steam. Where possible, locate the ORG as far away from runways and roads as possible to reduce optics fouling from wind blown road dirt. An ideal minimum distance is at least 30 meters.

3. Sensor Height, Rigidity, Verticality, and Orientation - The OFCM recommends that the present weather sensor be mounted at a height of 10 feet (3 m). This height is not always possible due to constraints imposed by the site. Mounting the ORG head lower than 2 m or higher than 5 m is not generally recommended.

T The ORG installation must be rigid so that wind-induced vibration does not cause false alarms. This can be accomplished by mounting the sensor to a thick wall pipe such as "Schedule 40" type or to a rigid boom arm of 1 meter length or less. Mounting the ORG on the top of a building is acceptable if it is located near the center of the building away from the wind turbulence that may occur near the edges.

T The sensor head must be mounted vertical within +/- 2 degrees so that the line aperture on the in-beam lens is horizontal.

Hint - Standing at the ORG site, take a picture in each direction (north, east, south, & west) to record the topography and obstructions for future reference.

Siting Guidelines To Remember
T Sensor head mounted 2-5 meters high **T Rigid mounting pole** **T Receiver lens aperture horizontal to +/- 2 degrees** **T No overhanging trees, wires, or roof lines** **T Distance between ORG and closest obstruction at least 2 times obstruction height** **T As far from road, runway, and contamination sources as possible**

2.2 MOUNTING THE ORG-815-DS

ORG-815-DS installation is simple. A few precautions will insure good sensor performance.

The ORG is packed in one (1) heavy walled corrugated carton. Included in the carton are the sensor head, 15-meter cable, grounding wire, U-Bolts (2), Mounting Bracket, User=s Guide, and any accessories that were ordered. When opening the carton be careful to avoid spilling. Report any shortage or damage to the shipping company and OSI within 3 days.

User Supplied Items Required

T Mounting pole or tower to install sensor head.

T A copper-clad ground rod and large diameter copper wire if needed to properly ground the ORG per local electrical codes.

CAUTION :
Do NOT drill holes in any portion of the ORG head! Doing so will void the warranty and may allow water to enter the enclosure !

Step-By-Step Installation

1. Carefully choose the site using the guidelines in Section 2.1.

2. Attach the 2 ea U-bolts to the ORG mounting plate with the 1/4-20 hex locking nuts with the stainless-steel mounting bracket sandwiched between as shown in Figure 2. 1. To mount the ORG to a vertical pipe, install the U-bolts horizontally as shown. To mount to a horizontal pipe or boom arm, install them vertically using the same holes. Do not tighten the nuts completely until the sensor head is installed on the pole.

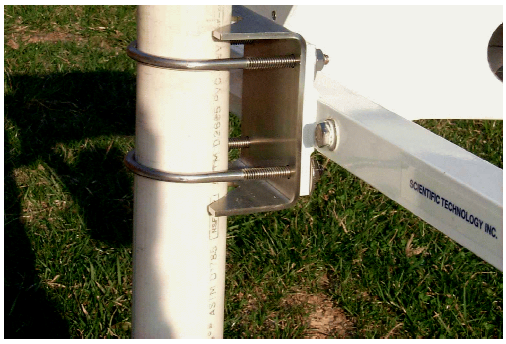


Figure 2.1 Installing Mounting Bracket & U-Bolts

3. Attach the sensor head to the mounting pole using the two (2) U-bolts. Do not tighten the U-bolt nuts completely until the head is oriented.

4. Tighten the U-bolt nuts when the orientation is correct. (Do not over tighten the bolts or the mounting plate may warp)

5. Plug the P3 end of the P/N 1102-302-3 cable into the J3 connector on the bottom of the ORG sensor head.

6. If required, connect a large diameter (8-12 AWG) ground wire to the 1/4-20 ground stud on the bottom of the ORG sensor head using the hardware supplied with the ORG.

7. Secure the head cables to the pole every 1 meter using tie-wraps or other straps.

8. A typical installation is shown in Figure 2.2.

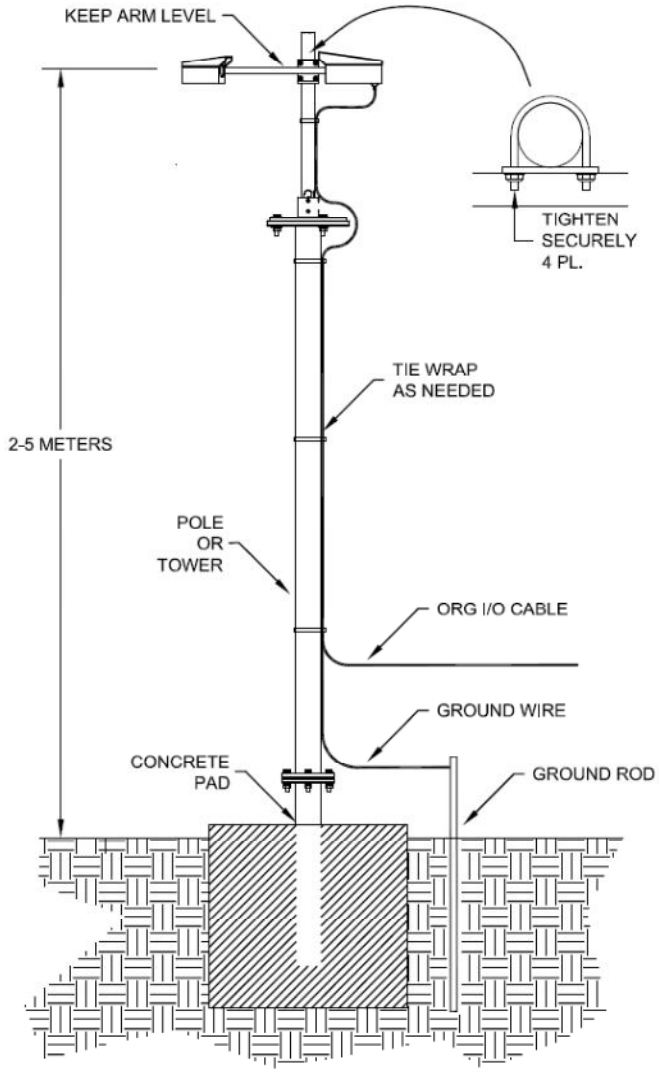


Figure 2.2 Typical ORG Installation

2.3 CONNECTING THE ORG SENSOR

ORG connecting cable design was upgraded in August of 2016.

- The existing cable 1102-302-3 is superseded by 1102-302-4.
- The cable has been changed from shielded twisted pair to shielded bundle.
- Color code assignments have also been changed.

Connect the ORG sensor according to the information in the following sections.

2.3.1 Connecting the Digital ORG Sensor Cable 1102-302-3

Connections are made to the free end of the ORG cable for all power, signal, and control functions.

The normal installation of the ORG requires a fused 12 VDC power source and junction box at the end of the cable. The customer may choose to provide these items, or the ORG sensor may be purchased with an Optical Scientific Inc. ORG 815 Power Supply Box (PSB).

In either case, proper wiring configuration is shown in the following pages.

Connect the wires in the ORG cable as shown in the table below and in Figure 2.3 and 2.4

Wire Pair	Function	DB9 Connector (if used)	DB25 Connector (if used)
Red Black	+ 12 VDC	DC Power Supply	DC Power Supply
	+ 12 VDC Common		
Yellow Black	+ 12 VDC Heater	DC Power Supply	DC Power Supply
	+ 12 VDC Heater Common		
Green Black*	Sensor TX	Pin 2 of DB9	Pin 3 of DB25
	TX Common		
Blue Black*	Sensor RX	Pin 3 of DB9	Pin 2 of DB25
	RX Common		
* both Black (TX/RX Common) from Green and Blue pair are spliced together to make single signal ground reference		Pin 5 of DB9	Pin 7 of DB25
Black	Cable Shield	Earth Ground	Earth Ground

Note :
Signal and power lines are protected from surge damage within the ORG sensor head. It is recommended that surge protection be provided at the user equipment end as well.

> ***Warning :***
> *Remember, the ORG-815-DS requires 12 VDC power.*
> ***Do not apply 110/220 VAC to the ORG cable!***

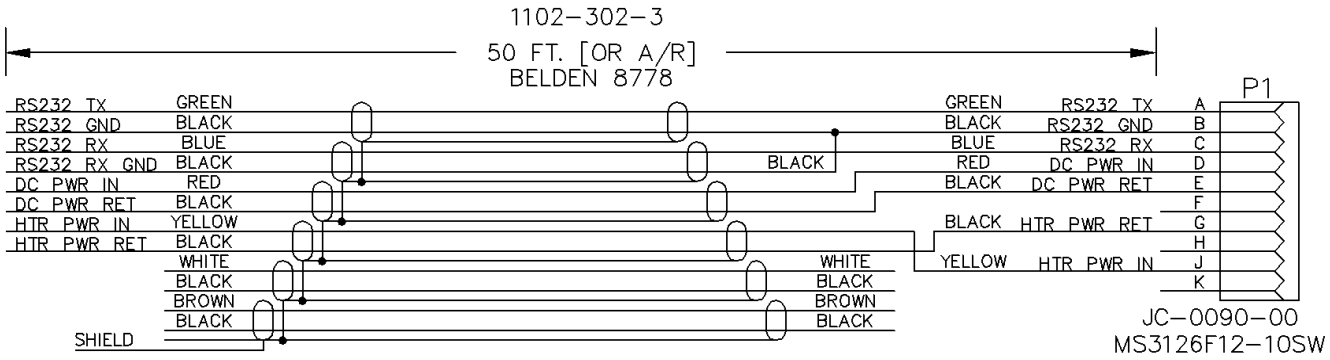


Figure 2.3 Cable 1102-302-3

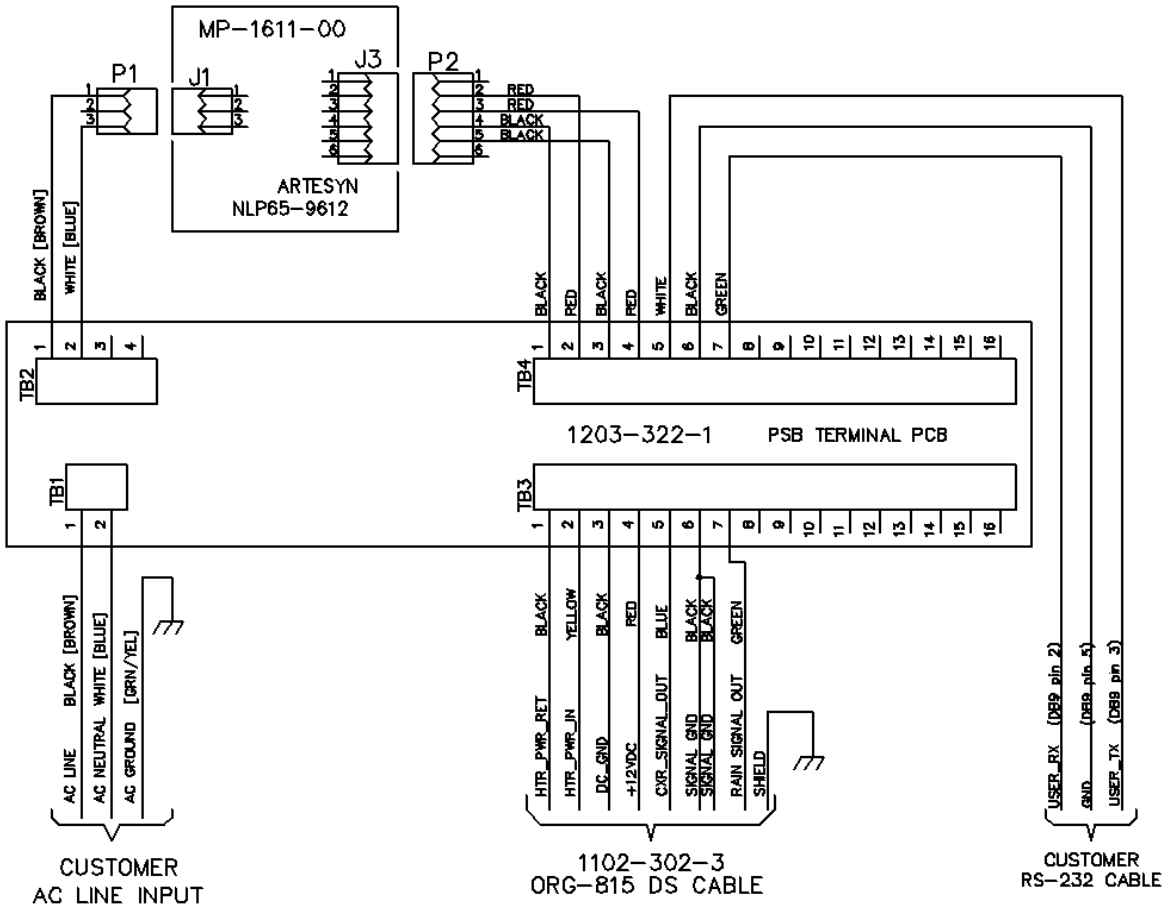


Figure 2.4 PSB Connections for 1102-302-3

2.3.2 Connecting the Digital ORG Sensor Cable 1102-302-4

Connections are made to the free end of the ORG cable for all power, signal, and control functions.

The normal installation of the ORG requires a fused 12 VDC power source and junction box at the end of the cable. The customer may choose to provide these items, or the ORG sensor may be purchased with an Optical Scientific Inc. ORG 815 Power Supply Box (PSB).

In either case, proper wiring configuration is shown in the following pages.

Connect the wires in the ORG cable as shown in the table below and in Figure 2.5 and 2.6

Wire	Function	DB9 Connector (if used)	DB25 Connector (if used)
Red	+ 12 VDC	DC Power Supply	DC Power Supply
Black	+12 VDC Return	DC Power Supply	DC Power Supply
Yellow	+ 12 VDC f/Heater	DC Power Supply	DC Power Supply
Gray	Heater +12VDC Return	DC Power Supply	DC Power Supply
White	Sensor TX	Pin 2 of DB9	Pin 3 of DB25
Green	Sensor RX	Pin 3 of DB9	Pin 2 of DB25
Brown	Sensor TX/RX Signal Gnd.	Pin 5 of DB9	Pin 7 of DB25
Black	Cable Shield	Earth Ground	Earth Ground

Note :
Signal and power lines are protected from surge damage within the ORG sensor head. It is recommended that surge protection be provided at the user equipment end as well.

Warning :
Remember, the ORG-815-DS requires 12 VDC power.
Do not apply 110/220 VAC to the ORG cable!

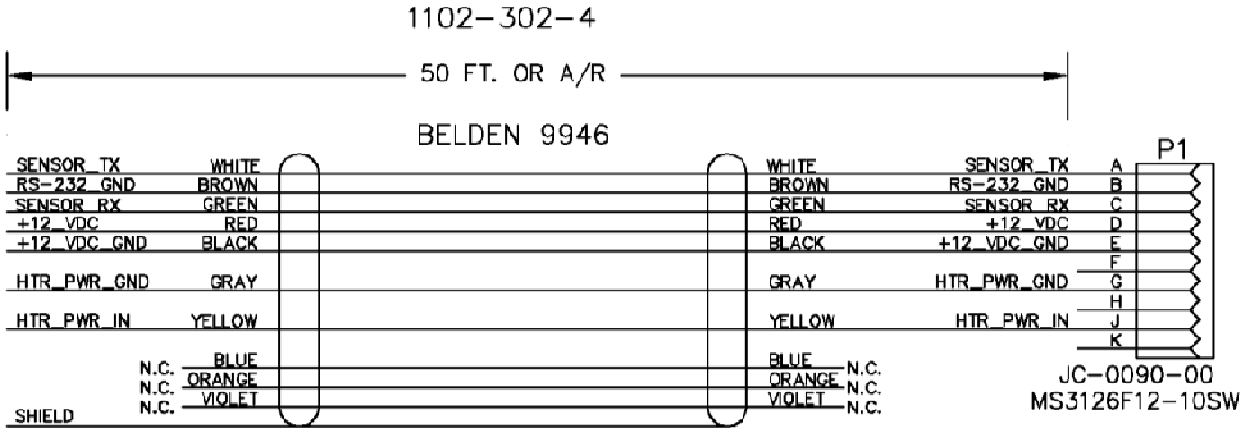


Figure 2.5 Cable 1102-302-4

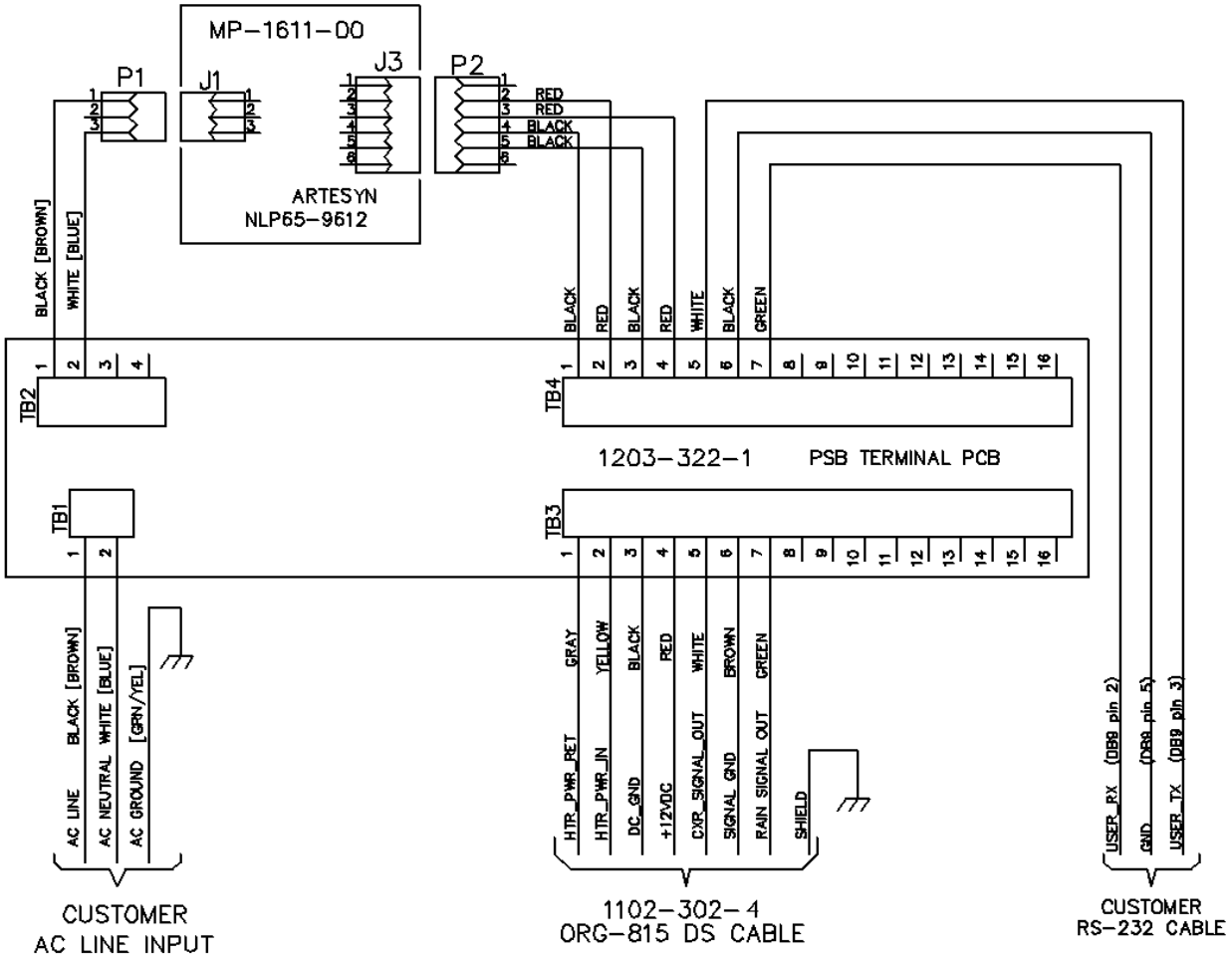


Figure 2.6 PSB Connections for 1102-302-4

3 ORG THEORY OF OPERATION

3.1 OVERALL SYSTEM THEORY

The ORG is an electro-optical sensor consisting of optics, analog signal processing electronics, and a digital microprocessor.

A block diagram of the ORG-815-DS Sensor is shown in Figure 3.1. The sensor consists of:

- Transmit modulator and IR Light Emitting Diode (TX)
- Transmitter optical lens assembly
- Receiver optical lens assembly
- PIN photo detector and preamplifier (RX)
- Digital Signal Processor (DSP)
- Temperature probe
- Microprocessor and communications subsystem

The ORG uses an infrared light emitting diode (IRED) as a light source. The IRED is modulated to eliminate interference in the system caused by background light. The IRED has a very long lifetime, is relatively low power, invisible to the eye, and presents no radiation hazard to the user.

The IRED is housed in the smaller of the two boxes, the entire subassembly being referred to as the transmitter or source. The IRED is driven by a square wave continuous wave (CW) modulation circuit at 50 percent duty cycle and at a fixed frequency. A lens is used to collimate the IRED's CW modulated light into a slightly diverged beam. The transmit and receive lenses are both heated by a self-regulating positive temperature coefficient (PTC) thermistor disc, to a point above ambient temperature to reduce dew and frost on the lenses.

The larger rectangular box houses the receive optics, DC regulator, the AGC, signal processing electronics, temperature probe, and microprocessor. The receive lens focuses the transmitted light onto a photo diode. The scintillations in light intensity are thus detected and amplified. A wide dynamic range Automatic Gain Control (AGC) circuit normalizes the precipitation induced scintillation signal to the (CW modulated) carrier. Thus errors from variations in the source intensity caused by LED aging or dirt on the lenses are eliminated. The demodulated scintillation signal is then further filtered, processed, and averaged. The statistical average of the measured scintillation signals give an accurate measurement of the instantaneous rain rates.

For the digital versions, a microprocessor uses an adaptive baseline technique to continually optimize the sensitivity of the ORG. This technique ensures that the ORG sensitivity is not affected by normal atmospheric turbulence and it minimizes the chance of false alarms (i.e.; reporting precipitation when none occurs). Using the scintillation signal and temperature probe data, the processor determines the precipitation type and calculates the total water equivalent by the following formula:

$$W\ (mm) = k * RR\ (mm/hr) * Time\ (hour)$$

where RR is the precipitation intensity and k is a constant dependent on the ambient temperature as follows:

For T > 30 C	k = 1
For T < -40 C	k = 0.607
For -40 C < T > 30 C	k = exp{(T - 3) / 12}

The ORG microprocessor also provides diagnostic data to the user about the condition of the sensor. The output of the digital ORG-815-DS is an RS-232 data string.

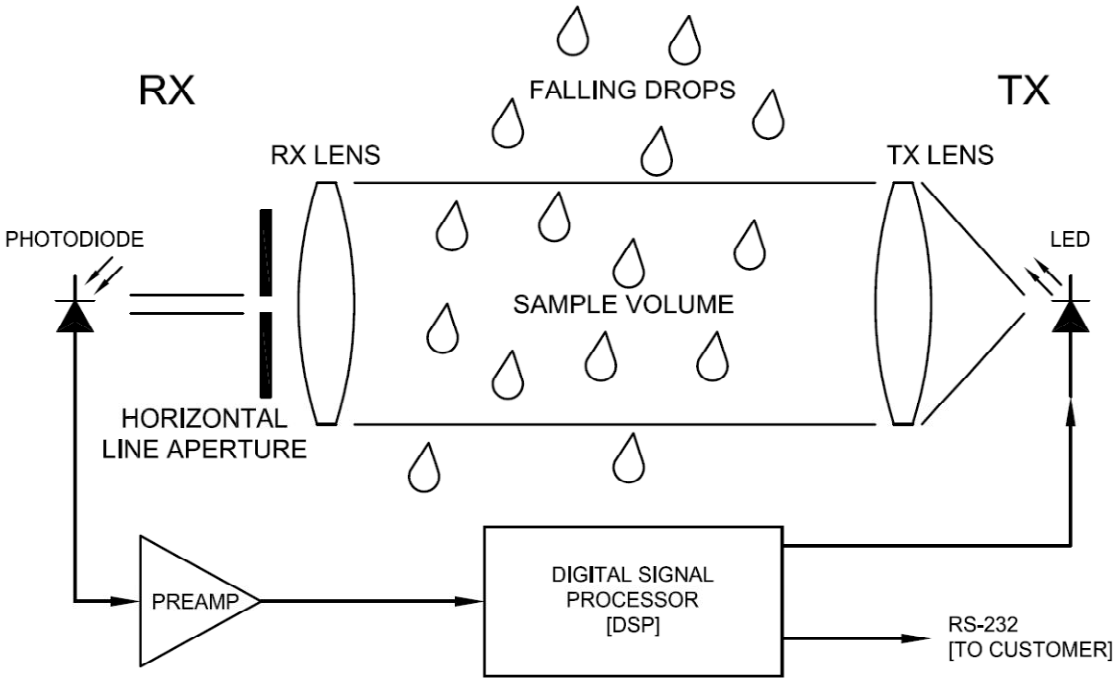


Figure 3.1 ORG 815 Sensor Block Diagram

4 USER INTERFACE / ORG OPERATION

4.1 RS-232 ORG INTERFACE

The ORG responds to a series of computer commands that the user may select during set-up, operation, and maintenance of the sensor.

T Physical Level

The Serial Input/Output (SIO) signal interface consists of a 3-wire RS-232-C connection. If cable length must exceed 100 feet between the ORG and computer, contact OSI about using limited distance modems (LDM).

T Link Level

Data transfer across the ORG / computer interface is implemented via a serial, ASCII encoded , full duplex, 1200 baud, asynchronous transfer link. Data transfer in the computer-to-ORG direction is limited to a simple, single character poll. Data transfers in the ORG-to-computer direction are simple fixed-format ASCII strings, terminated with a carriage return (<CR>).

T Frame Format

The standard ORG output frame format is shown below*. Details of the data fields are presented in a later section. Each of the transmitted characters are eight (8) bit (msb -- bit 7 -- always 0), no parity ASCII (decimal codes 0 to 127), with 1 stop bit. The status code and other information, is formatted in this way as printable ASCII characters to aid in system debugging and field maintenance.

The typical ORG transmit data string consists of a fixed number of characters, including the CR (ASCII 0DH)and is formatted as shown*:

Data:	S	S	_	R	R	R	R	_	A	A	A	.	A	A	A	[CR]
Position:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

The actual data field format is as follows:

SS	2 character alphanumeric field containing weather & status code information
_	Indicates ASCII space (20H), used as data field separator
RRRR	4 character numeric field indicating instantaneous rain rate / liquid water
AAA.AAA	7 character numeric field indicating total accumulation since reset or rollover

*Note: Firmware 42S (See “V” Poll) dated 07/19/12 features a 17-byte data string return from an “A” poll command. Byte 17 is set aside for possible future use. It contains no data, and should be ignored. This byte may, or may not, be removed in future releases. In all cases, it should be dismissed from any concern.

T Protocol

In order to keep the interface design effective and simple, the protocol does not support unsolicited ORG messages to the computer. In other words, the only time the ORG is allowed to transmit a message to the computer via this link is in direct response to single character poll transmission from the computer which requires the return of the standard data reply string.

Note that the ORG is continually sampling data (every 5 seconds) and processing the precipitation algorithm (once a minute typical). In most cases, the ORG's response time to a poll will begin within a second or two of having received the poll. On infrequent occasions, it is possible that the response time could be as long as several seconds. To avoid system hang-ups, the computer should poll the ORG and wait for 5-10 seconds before timing-out and trying a new poll.

T Poll / Frame Formats

The ORG responds to several different types of single character ASCII polls issued by the computer. The poll character transmitted to the ORG should be a single character only (also transmitted at 1200 baud, 1 start bit, 8 data bits, no parity, and 1 stop bit), not followed by any other characters or control codes. The poll codes (case sensitive) and description are listed below:

REQUEST	DESCRIPTION
A	Send routine data
B	Send accumulation data
C	Send routine and diagnostic data (NWS Codes)
D	Send routine and diagnostic data (WMO Codes)
Q	Send 5 second averaged data
R	Restart algorithm and reset accumulation counters
V	Send Software Version
Z	Reset accumulation

Note that the ORG commands are case sensitive and unless otherwise noted, require the use of capital letters, i.e.; "C" rather than "c".

4.1.1 "A" Poll Response

The "A" poll is used for normal operation to receive the precipitation type, rain rate and accumulated precipitation.

This poll should be issued once every 60 seconds, and in response, the ORG will transmit a 16 character string* that contains status, instantaneous rain rate, and accumulated rain (or liquid water equivalent). Note that the ORG algorithm recalculates precipitation data every 60 seconds. Therefore, it serves no purpose to poll the sensor more than once a minute. In fact excessive polling (once per 15 seconds, for example) could actually induce a minor sample-timing error on the sensor.

* Note: Firmware 42S (See "V" Poll) dated 07/19/12 features a 17-byte data string return from an "A" poll command. Byte 17 is set aside for possible future use. It contains no data, and should be ignored. This byte may, or may not, be removed in future releases. In all cases, it should be dismissed from any concern.

This section explains the format of the ORG data frame that is transmitted in response to a type "A" poll. The ORG ASCII Routine data string is sixteen (16) bytes long and is formatted as shown below:

Format:	S	S		R	R	R	R		A	A	A	-	A	A	A	[CR]
Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Byte	Description	Value
1-2	Present weather condition code	SS
3	Separator space	
4-7	Instantaneous precipitation rate	RRRR
8	Separator space	
9-15	Precipitation accumulation with fixed decimal point at position 12	AAA.AAA
16	Carriage Return	[CR]

SS is a two (2) byte field indicating present weather condition. Possible weather values are:

R- Light Rain	R Moderate Rain	R+ Heavy Rain
S- Light Snow	S Moderate Snow	S+ Heavy Snow
P- Light Precipitation	P Moderate Precipitation	P+ Heavy Precipitation (Note)

"P" is output when the ORG can not determine with certainty whether the precipitation is rain or snow. During normal operation with no precipitation, the data field SS is blank. If an error condition exists (usually something obscuring the optics), the output will be "ER". The present weather data field is updated once per minute.

RRRR is a four byte field indicating the instantaneous (one minute block average) rain rate or liquid water equivalent for frozen precipitation in millimeters per hour. It is a four digit floating point number that will vary from ".000" to "9999". This number is updated once a minute.

AAA.AAA is a seven byte field indicating the total accumulation of precipitation in millimeters. The number is a fixed decimal point format that will vary from "000.000" to "999.999". Accumulation is reset by an "R" poll from the computer, automatically at power on, or when accumulation exceeds 999.999 (i.e., rolls over). This number is updated once a minute.

At power turn-on this poll returns the following response for the first 2 minutes:

**** ---- ---.---**

4.1.2 "B" Poll Response

The "B" poll is used to obtain accumulated rain or liquid water equivalent.

This poll can be used when it is impractical to obtain data from the ORG on a continuous basis. An example would be a remotely located site where total precipitation was desired. In such a case, the ORG totalizes the precipitation accumulation and will transmit it when a "B" poll is received. This poll can be from a locally connected terminal or PC or remotely over a cable.

This section explains the format of the ORG data frame that is transmitted in response to a "B" poll. The ORG ASCII precipitation accumulation data string is eight (8) bytes long and is formatted as shown below:

Format:	A	A	A	-	A	A	A	[CR]
	|	|	|	|	|	|	|	|	
Byte:	1	2	3	4	5	6	7	8

Byte	Description	Value
1-7	Precipitation accumulation with fixed decimal point at position 4	AAA.AAA
8	Carriage Return	[CR]

AAA.AAA is a seven byte field indicating the total accumulation of precipitation in millimeters. The number is a fixed decimal point format that will vary from "000.000" to "999.999". Accumulation is reset by the "R" poll from the computer, automatically at power on, or when accumulation exceeds 999.999 (i.e., rolls over). This number is updated once a minute.

At power turn-on this poll returns the following response for the first 30 seconds:

---.---

4.1.3 "C" Poll Response

The "C" poll is used to obtain routine data in NWS weather code format and detailed system diagnostic data.

This section explains the format of the ORG data frame that is transmitted in response to a "C" poll. The ORG ASCII Routine and Diagnostic data string is 40 characters long and is formatted as shown below:

Format:	S	S		R	R	R	R		A	A	A	-	A	A	A	
Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Format:	0	1	*	*		X	X	X	X		X	X	X	X		X
Byte:	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Format:	X	X	X		X	X	X	[CR]								
Byte:	33	34	35	36	37	38	39	40								

Byte	Description	Value
1-2	NWS Present weather condition code	SS
3	Separator space	
4-7	Instantaneous precipitation rate	RRRR
8	Separator space	
9-15	Precipitation accumulation with fixed decimal point at position 12	AAA.AAA
16	Separator space	
17-18	Not Used (Value always “01”)	01
19	Not used / Reserved (always *)	*
20	Lens heater status (1/0 -> ON/OFF)	H
21	Separator space	
22-39	Additional diagnostic data	X...X
40	Carriage return	[CR]

Bytes 1-15 are identical to those described in the "A" response described above with the bytes 1-2 in NWS weather code formats as shown.

R- Light Rain	R Moderate Rain	R+ Heavy Rain
S- Light Snow	S Moderate Snow	S+ Heavy Snow
P- Light Precipitation	P Moderate Precipitation	P+ Heavy Precipitation

(Bytes 1-2 are blank for no precipitation)

Bytes 17and 18 are no longer used. Their values are set at “0” and “1” respectively.

Bytes 19 is reserved for future use and should normally display an asterisk (*).

Bytes 20 is used to indicate when the lens heater is on or off. The heater will be cycled on and off during normal operation to save power. It will be on constantly during precipitation events.

Bytes 21-39 contain additional system diagnostic information.

Bytes 22-25 are the carrier channel signal strength (typical value is 4999). Dust accumulation on the lenses and LED aging will cause this value to drop over time from 4999. Acceptable values during no precipitation range from 3000 to 4999. When the value is <1000, the ORG will output "ER" in the present weather field.

Bytes 27-30 contain the one minute averaged raw data. The value is typically <100 when there is no precipitation.

Bytes 32-35 contain the rain channel adaptive baseline data. When the sensor is first powered up, this value is typically 40. When precipitation begins, this field "locks-on" and does not begin to adaptively adjust until the precipitation ends.

Bytes 37-39 are the temperature data from the probe located on the underside of the ORG. The data is displayed in degrees C with byte reserved for the plus (+) or minus (-) sign. This temperature should not be used by the user as the true meteorological temperature.

At power turn-on the "C" poll returns the following response for the first 30 seconds:

**** ---- ----.---- 01*1 0000 4999 40 - 40**

After initial response is complete, the system should stabilize for 5 minutes before accepting output data.

4.1.4 "D" Poll Response

The "D" poll is used to obtain routine data in WMO weather code format and detailed system diagnostic data.

This section explains the format of the ORG data frame that is transmitted in response to a "D" poll. The ORG ASCII Routine and Diagnostic data string is 40 characters long and is formatted as shown below:

Format:	S	S		R	R	R	R		A	A	A	-	A	A	A	
Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Format:	0	1	*	*		X	X	X	X		X	X	X	X		X
Byte:	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Format:	X	X	X		X	X	X	[CR]								
Byte:	33	34	35	36	37	38	39	40								

Byte	Description	Value
1-2	WMO Present weather condition code	SS
3	Separator space	
4-7	Instantaneous precipitation rate	RRRR
8	Separator space	
9-15	Precipitation accumulation with fixed decimal point at position 12	AAA.AAA
16	Separator space	
17-18	Not Used (Value always “01”)	01
19	Not used / Reserved (always *)	*
20	Lens heater status (1/0 -> ON/OFF)	H
21	Separator space	
22-39	Additional diagnostic data	X...X
40	Carriage return	[CR]

Bytes 1-15 are identical to those described in the "A" response described above with the bytes 1-2 in NWS weather code formats.

61	Light Rain	62	Moderate Rain	63	Heavy Rain
71	Light Snow	72	Moderate Snow	73	Heavy Snow
41	Light Precipitation	41	Moderate Precipitation	42	Heavy Precipitation (Note)
00	No Precipitation				

4.1.5 "Q" Poll Response

The "Q" poll is used for special operation when 5-second instantaneous rain rate and accumulated precipitation are needed.

This poll can be issued as often as every 5 seconds, and in response, the ORG will transmit a 16 character string that contains the instantaneous rain rate and accumulated rain (or liquid water equivalent). Using “Q”, the ORG algorithm recalculates precipitation data every 5 seconds.

This section explains the format of the ORG data frame that is transmitted in response to a type "Q" poll. The ORG ASCII Routine data string is sixteen (16) bytes long and is formatted as shown below:

Format:				R	R	R	R		A	A	A	-	A	A	A	[CR]
Byte:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Byte	Description	Value
1-3	Separator -- space	
4-7	Instantaneous precipitation rate	RRRR
8	Separator -- space	
9-15	Precipitation accumulation with fixed decimal point at position 12	AAA.AAA
16	Carriage Return	[CR]

RRRR is a four byte field indicating the instantaneous (5 second block average) rain rate or liquid water equivalent for frozen precipitation in millimeters per hour. It is a four digit floating point number that will vary from ".000" to "9999". This number is updated every five seconds.

AAA.AAA is a seven byte field indicating the total accumulation of precipitation in millimeters. The number is a fixed decimal point format that will vary from "000.000" to "999.999". Accumulation is reset by an "R" poll from the computer, automatically at power on, or when accumulation exceeds 999.999 (i.e., rolls over). This number is updated every 5 seconds.

At power turn-on this poll returns the following response for the first 2 minutes:

**** ---- ---.---**

4.1.6 "R", "V", & "Z" Poll Responses

These miscellaneous polls are used during check-out and test of the ORG.

√ RESPONSE TO THE "R" POLL

This command is used to reset the ORG to the start-up mode. It performs a similar function as turning the power off/on. Note that the "R" poll also resets the precipitation accumulation to zero. The primary advantage is that the "R" poll can be sent remotely. Do not use the "R" poll once the ORG is operating in normal mode unless there is a problem with the sensor.

The type "R" poll (reset accumulation) is used to reset the accumulation to zero. In response, the ORG will transmit a 16 character data string (same format as AA@) of *total accumulated rain or liquid water equivalent prior to resetting the accumulator to zero*. Note that accumulation is also automatically reset to zero in any of the following conditions:

- At ORG power up
- Upon processor reset in the case of unrecoverable error detection, and
- Upon accumulation reaching and going over 999.999 (millimeters of precipitation).

√ RESPONSE TO THE "V" POLL

The type "V" poll is used to check the software version of the ORG.In response to the "V" command, the ORG returns the following response:

Ver_DSP_ORGMR_XXX_DD/MM/YYYY

where "XXX" is the software version number, "DD-MM-YYYY" is the day, month, and year of the revision, and _ is a space character.

√ RESPONSE TO THE "Z" POLL

This command is used to automatically reset the ORG precipitation accumulation to zero.

In response to receiving the "Z" poll, the ORG will output the following:

[STX] ACCUMULATION ZERO-OUT [CR]

4.2 ORG OPERATION EXAMPLES

4.2.1 Typical ORG-815-DS Output

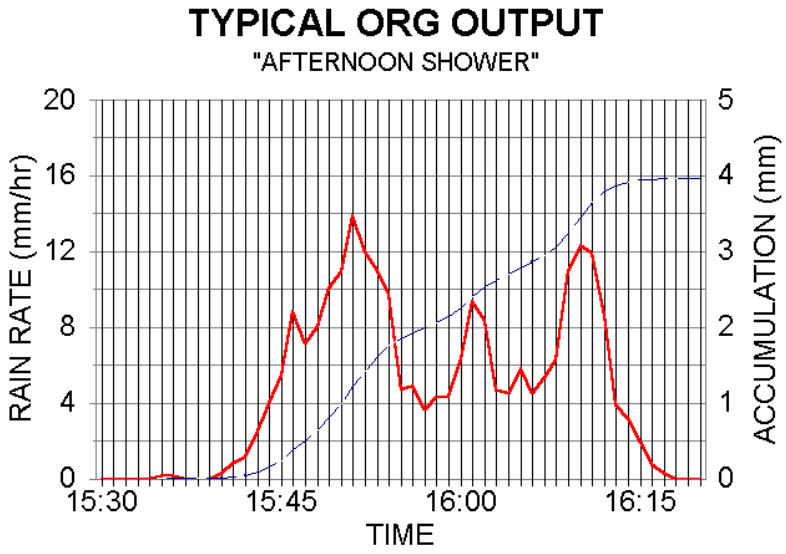
The ORG transmits a wealth of data including type of precipitation, rate, accumulation, as well as various raw and diagnostic information.

Below is a listing of one-minute "C" poll output from the ORG. The time field was added by the data acquisition software used in the OSI PC and is not a part of the ORG output. A description of some of the key events of the brief summer shower depicted in the data is provided to the right of the table.

Time	WX	RR	Accum	Status	Carrier	Raw Baseline Temp	
15:30:02		0	0.000	01*1	4999	0058 0060 +31	″ No Precipitation
15:31:02		0	0.000	01*1	4999	0058 0060 +31	
15:32:02		0	0.000	01*0	4999	0058 0060 +31	
15:33:02		0	0.000	01*0	4999	0058 0060 +31	
15:34:02		0	0.000	01*0	4999	0070 0060 +31	″ Light rain(R-)starts at 15:35
15:35:02	R-	0.149	0.002	01*1	4999	0090 0060 +31	
15:36:02	R-	0.149	0.004	01*1	4999	0090 0060 +31	
15:37:02		0	0.004	01*0	4999	0078 0060 +31	
15:38:02		0	0.004	01*0	4999	0078 0060 +31	
15:39:02		0	0.004	01*0	4999	0078 0060 +31	
15:40:02	R-	0.323	0.010	01*1	4999	0117 0060 +31	
15:41:02	R-	0.800	0.023	01*1	4999	0171 0060 +31	
15:42:02	R-	1.17	0.043	01*1	4998	0206 0060 +31	″ Rain switches to moderate (R)
15:43:02	R	2.56	0.086	01*1	4999	0303 0060 +31	
15:44:02	R	3.95	0.151	01*1	4998	0379 0060 +30	
15:45:02	R	5.47	0.243	01*1	4999	0449 0060 +30	″ Rain switches to heavy (R+)
15:46:02	R+	8.82	0.390	01*1	4999	0577 0060 +30	
15:47:02	R	7.15	0.509	01*1	4999	0517 0060 +30	
15:48:02	R+	8.03	0.641	01*1	4999	0549 0060 +29	
15:49:02	R+	10.1	0.812	01*1	4999	0620 0060 +29	
15:50:02	R+	10.9	0.994	01*1	4999	0647 0060 +29	″ Max rain rate (13.9 mm/hr) at 15:51
15:51:02	R+	13.9	1.227	01*1	4999	0735 0060 +28	
15:52:02	R+	12.0	1.428	01*1	4999	0680 0060 +28	
15:53:02	R+	11.0	1.611	01*1	4999	0649 0060 +28	
15:54:02	R+	9.72	1.773	01*1	4999	0607 0060 +28	
15:55:02	R	4.72	1.852	01*1	4999	0416 0060 +27	
15:56:02	R	4.92	1.934	01*1	4999	0425 0060 +27	″ Accumulation exceeds 2 mm
15:57:02	R	3.65	1.995	01*1	4999	0364 0060 +27	
15:58:02	R	4.28	2.067	01*1	4999	0395 0060 +27	
15:59:02	R	4.38	2.140	01*1	4999	0400 0060 +26	
16:00:02	R	6.34	2.254	01*1	4999	0485 0060 +26	
16:01:02	R+	9.37	2.402	01*1	4999	0596 0060 +26	
16:02:02	R+	8.35	2.541	01*1	4999	0561 0060 +26	
16:03:02	R	4.72	2.620	01*1	4999	0416 0060 +25	
16:04:02	R	4.50	2.695	01*1	4999	0406 0060 +25	
16:05:02	R	5.78	2.791	01*1	4999	0462 0060 +25	
16:06:02	R	4.52	2.867	01*1	4999	0407 0060 +25	
16:07:02	R	5.36	2.956	01*1	4999	0444 0060 +25	
16:08:02	R	6.28	3.061	01*1	4999	0483 0060 +25	
16:09:02	R+	11.0	3.245	01*1	4999	0650 0060 +25	
16:10:02	R+	12.3	3.451	01*1	4999	0689 0060 +25	
16:11:02	R+	11.9	3.650	01*1	4999	0678 0060 +24	
16:12:02	R+	8.65	3.794	01*1	4999	0571 0060 +24	″ Rain begins to taper off
16:13:02	R	3.90	3.860	01*1	4999	0377 0060 +24	
16:14:02	R	3.16	3.912	01*1	4999	0338 0060 +24	
16:15:02	R-	1.91	3.944	01*1	4999	0262 0060 +24	
16:16:02	R-	0.729	3.956	01*1	4999	0164 0060 +24	″ Rain ends at 16:18; total accumulation of 3.961 mm
16:17:02	R-	0.289	3.961	01*1	4999	0112 0060 +24	
16:18:02		0	3.961	01*0	4999	0076 0060 +24	
16:19:02		0	3.961	01*0	4999	0060 0060 +24	
16:20:02		0	3.961	01*0	4999	0058 0060 +24	

Note - In the table above, the time was added by the data acquisition system, not the ORG.

The data shown in the table may also be shown in graphical form using commonly available spreadsheet programs. The solid line is the one-minute rain rate in mm/hr while the dashed line is the accumulation in mm. The variability in the event, which is not too noticeable in the tabular data (rain rate switches between R and R+), is very obvious in the graph as three (3) peaks and lulls.



5 MODBUS COMMUNICATION

For additional versatility ORG815 DS firmware ORGMR44s and later is capable of communicating to a MODBUS PLC.

5.1.1 MODBUS RTU Protocol

ORG815 DS can communicate using MODBUS-RTU protocol. The setting for the MODBUS connections are baud rate 1200, 8 data bits, no parity and 1 stop bit (1200/8/N/1). Additionally, the sensor ID is fixed at 0x01 and the data output format is also fixed.

The firmware was tested using a Modbus Emulator program "Modus RTU Master" available from *www.simplymodbus.ca*. Screenshot below shows the various general parameters used on the program.

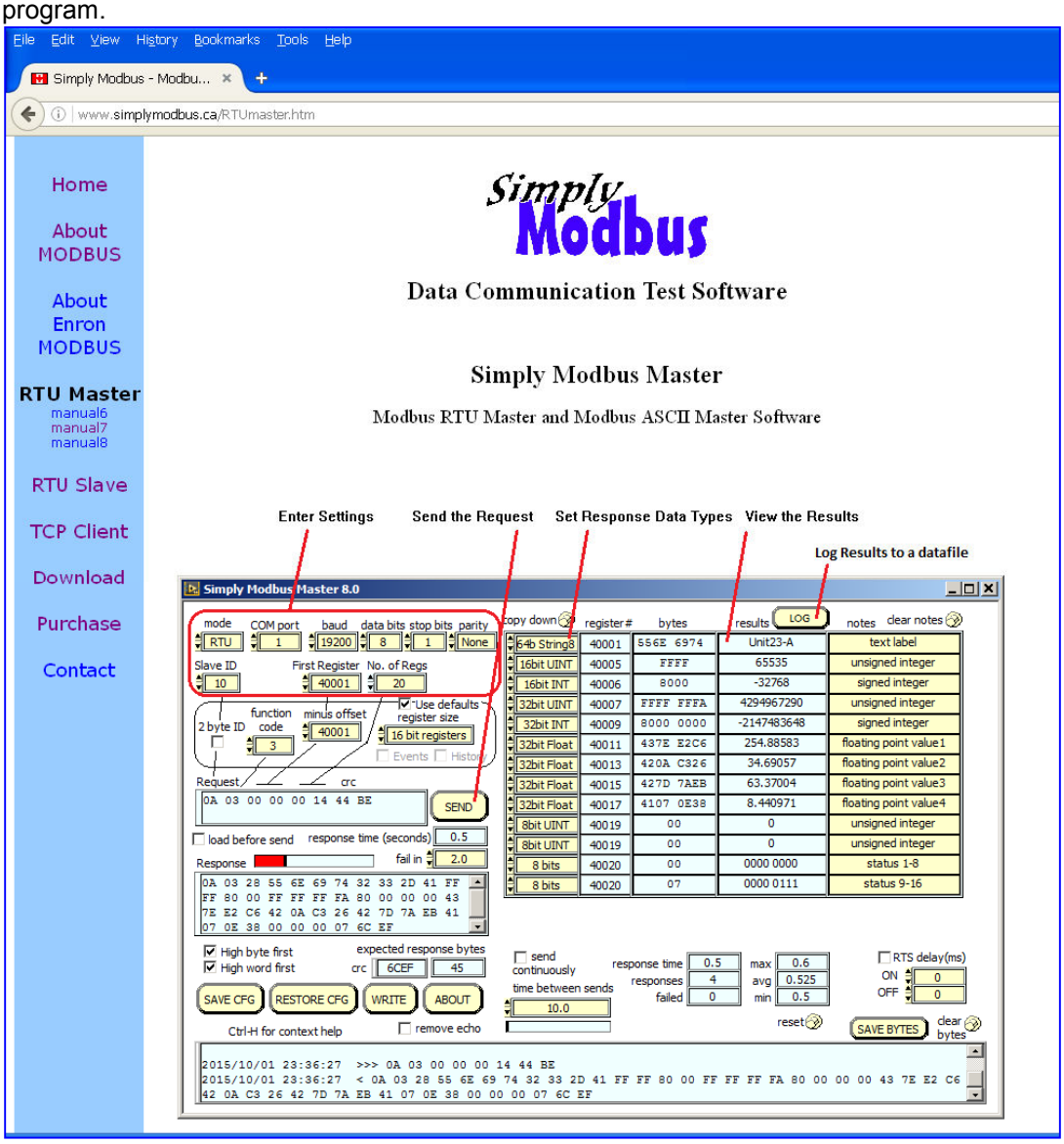


Figure 5.1 ModBus Example Screen

For configuring the Modbus Master PLC to communicate with the ORG815 DS, follow the steps listed below. Other Modbus Master application software may have a slightly different GUI, but the data structures should be the same.

- On top left, enter RTU as Mode and 1200/8/N/1 as the baud rate, data bits, parity and stop bits
- Select slave ID as 1, 4001 as the first register address and 11 as the numbers of registers
- Select function code as 3 (Read holding registers), minus offset as 4001 and 16 bit registers as register size
- Check the box for High byte/Low byte (Big-endian storage format)

With this setting, the Modus Master sends (all hex values) 0x01 0x03 0x00 0x00 0x00 0x0B plus 0x04 0x0D upon pressing the SEND button to request data.

According to the Modbus protocol, the master is requesting sensor ID 1 to send holding register data starting from memory address 0x00 0x00 to 0x00 0x0B. The 0x04 0x0D is CRC checksum of the request bytes. *Note that 0x0B hex is decimal 11 for the 11 registers in the sensor's memory.*

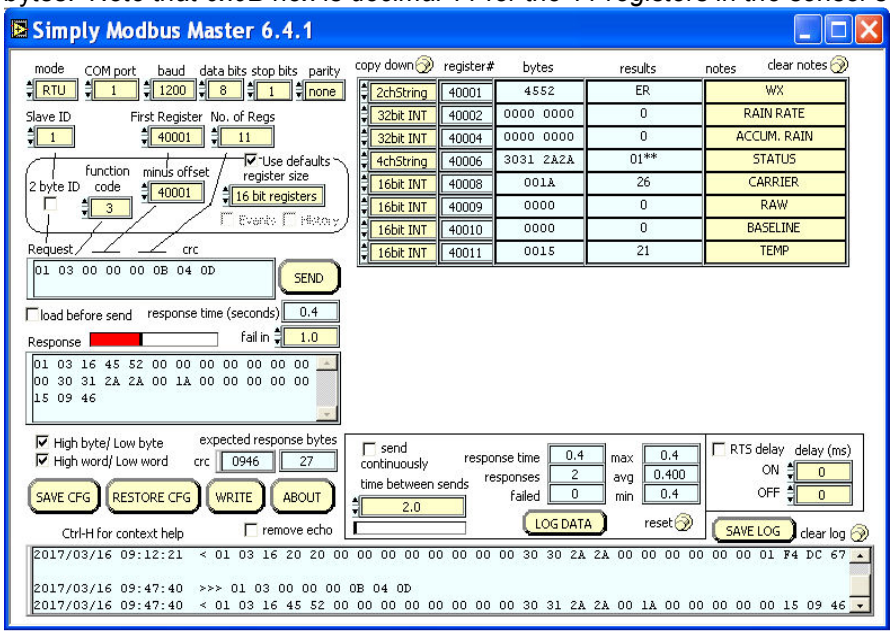


Figure 5.2 ModBus Master Screen

On receiving the proper request from the master, ORG815 DS responds with the data output. The data from the sensor is organized as shown on the right side of the screen.

Register Sequence	Data Type	Description
Register 1	Two characters	NWS Weather Code
Register 2-3	32 bit unsigned integer	Rain Rate in 1/1000th mm/Hour
Register 4-5	32 bit unsigned integer	Accumulated rain in 1/1000th mm
Register 6-7	Four characters	Status Code
Register 8	16 bit integer	Carrier Strength
Register 9	16 bit integer	Raw Received Signal
Register 10	16 bit integer	Received Signal Baseline
Register 11	16 bit integer	Temperature in Celsius

After the last register data is sent, the ORG815 DS sends a two byte CRC checksum per Modbus protocol. For the example above, the CRC checksum for this output is 0x09 0x46.

6 MAINTENANCE & TROUBLESHOOTING THE ORG-815-DS

6.1 ROUTINE MAINTENANCE AND QUICK CHECK

The ORG-815-DS takes only a few minutes every 3-6 months to maintain.
In most cases, only simple checks are required.

Equipment Required

1. Clean Cloth
2. Glass Cleaner
3. Ice Water and/or Freeze Spray (optional)

The ORG Sensors are designed for high reliability and low operator maintenance. The only scheduled maintenance is to periodically clean the lenses. In most locations, cleaning the lenses every six months is recommended. Historically, the sensors have operated unattended for several years without any degradation in performance. Use the table provided to record the maintenance performed.

T Clean Lenses

Cleaning the lenses should be done with lint-free cloth and cleaning solution. Clean the lenses by first spraying the lens cleaner on the lens and then wipe gently to prevent scratching the glass optics. In actual practice, moderate dust buildup and scratches on the lenses will not have any discernible effect on the instrument.

T Check Lens Heaters

After cleaning the lenses, a quick check of the lens heaters should be performed. With a clean finger, touch the lenses in front of the disc-shaped heater which is bonded to the lower inside surface of both lenses. The lens surfaces should be slightly warmer to the touch than the ambient temperature.

T Carrier Strength Check

Check the strength of the carrier signal by typing a "C" on the PC. The ORG should respond with a data string of routine and diagnostic data. The carrier strength in bytes 22-25 should be 3000 to 4999 if the optical path between the sensor head is clear and the unit is working well. Partial blocking of the beam will cause the carrier to decrease. If the beam is almost completely blocked for a few minutes or the signal strength is very weak, the carrier will drop below 1000 and bytes 1-2 will report "ER" after several minutes.

NOTE :

After any maintenance, test, or adjustment the ORG 815 should be re-initialized. This can be done by switching the unit power OFF, waiting a minute or two, and turning power "ON" again; or by sending an "R" poll command.

T Comb Test

Using a pocket comb, stroke it up and down vertically in front of the receiver lens as shown below for ~1 minute. Do not block the beam for any length of time. Send an "A" poll from the PC or terminal and verify that the sensor indicates rain rate. A typical sensor response might be R-12.5 002.005 where the "R-" indicates light rain, "12.5" indicates the rain rate in mm/hr, and "002.005" indicates the accumulation. (The actual rain rate reported will vary from the above number)

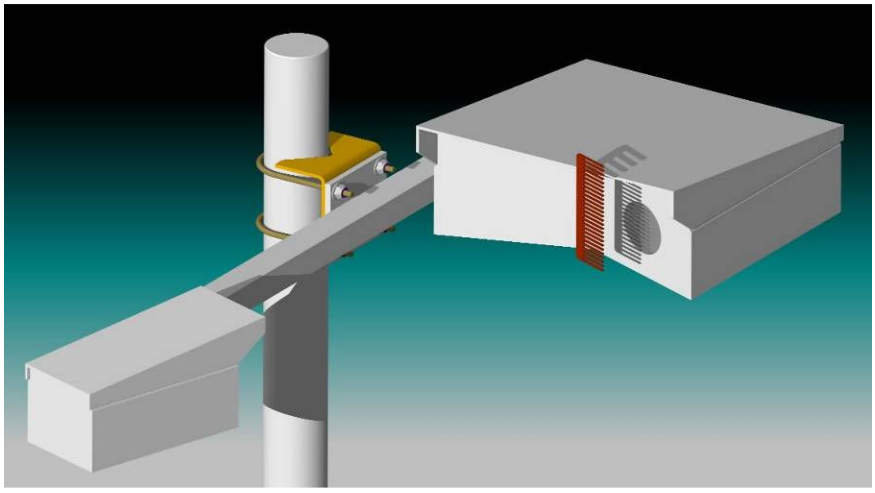


Figure 6.1 Comb Test Illustration

T Temp Probe Test

To further test the ORG, spray the temperature probe briefly several times over a 1-2 minute period with freeze spray (available at electronic stores) to lower the probe temperature to < 32 degree F. The weather identifier will be one of the "P or S" categories when the comb test is repeated.

NOTE :

After any maintenance, test, or adjustment the ORG 815 should be re-initialized. This can be done by switching the unit power OFF, waiting a minute or two, and turning power "ON" again; or by sending an "R" poll command.

Maintenance Check List

	Date _____	Date _____	Date _____
Clean Lenses			
Verify Lens Heaters			
Check Carrier			
Comb Test			

7 APPENDIX A - LIMITED DISTANCE MODEM OPTION

The LDM option is available for installations where it is not possible for the customers' computer to be located within 100 feet of the ORG-815 sensor. Two (2) LDMs are required to make the long distance connection between the ORG-815 and user PC. The LDMs operate transparently as if there were a standard cable connection. Figure 7.1 illustrates the key components of the LDM.

The LDM in the ORG-815 sensor is linked to the LDM at the customers' computer serial port with an RS-232 cable. This cable is fabricated at the site by the customer to suit their requirements. The ORG-815 operates at 1200 baud and can operate up to the following distances, depending on wire gauge:

19 AWG	14.5 km (9.0 miles)
24 AWG	10.0 km (6.2 miles)
26 AWG	6.9 km (4.3 miles)

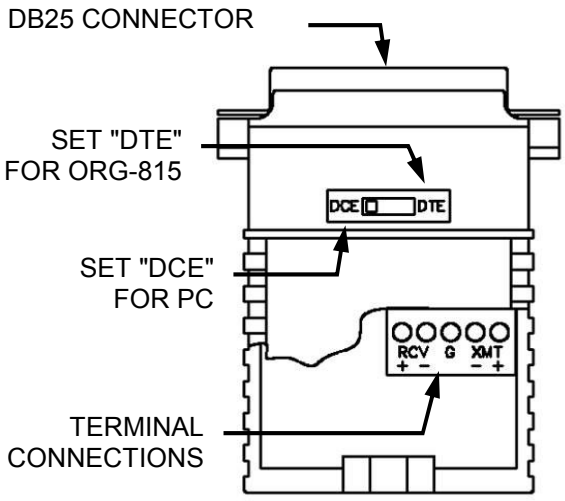


Figure 7.1 Limited Distance Modem

The LDM in the ORG-815 sensor is installed in the power supply box. The LDM at the user PC is connected to an available serial port such as COM2 on the back of the PC. The user makes connections to the small terminal strip on the LDM as shown in Figure 7.1.

Switch Settings

In order for communications to be properly established, both LDM's must be configured properly. The LDM at the sensor is switched to "DTE". The LDM, at the PC serial port is switched to "DCE".

Before proceeding, verify that the ORG-815 electrical power is turned "OFF".

LDM Connections

1. Attach a DB 25 cable to the LDM.
2. Connect the wires to the LDM as shown in the table below
3. Connect the cable shield wire to the LDM terminal marked "G".

4.Plug the wired LDM into an unused 25-pin serial I/O port on the PC (typically COM2)

LDM Cable Connection Table
(see sections 2.3.1 and 2.3.2 for wiring and pinouts)

1102-302-3	1102-302-4	ORG-815	Function	User PC
GREEN	GREEN	XMT+	Sensor TX	RCV+
BLACK	BROWN	XMT-/RCV-	TX & RX Return	COMMON-
BLUE	WHITE	RCV+	Sensor RX	XMT+
		SHIELD	Earth Ground	GND

8 TECHNICAL SUPPORT

OSI Technical Support
techsupport@opticalscientific.com
Tel: +01 301 963 3630 xt 316
Fax: +01 301 948 4670

Calls are monitored
Mon - Fri 9 AM – 5 PM ET
(except national holidays)

8.1 BEFORE CONTACTING TECHNICAL SUPPORT

Please have, or be able to provide:

- Unit or system serial number
- Unit or system model designation: "ORG-815-DS"
    - Data output ASCII text file showing a response to "C" poll. [See Section 4]
    - Software Version from "V" poll. [See Section 4.1.6]
- Details of the site and installation (site location, etc.)
- Your name, phone number, and e-mail address

8.2 FACTORY SERVICE

Warranty Service:
If the unit is within the warranty period OSI will handle the repairs according to the conditions outlined in our warranty guarantee.

Out-of-Warranty Service:
If the unit is out of warranty, OSI will require a purchase order or credit card number for billing purposes.

Returns: To return equipment, parts, or material to OSI, follow the procedure outlined below:

- Contact our customer service staff. [1 301 963 3630 xt 301 sales@opticalscientific.com]
- Determine warranty status and minimum service charge*.
- Get a **R**eturned **M**aterial **A**uthorization (**RMA**) number **.
- Package the unit to prevent damage in shipping and send it to our factory.

Your order will be handled expeditiously on a first-come first-served basis.

* Minimum service charge includes cleanup, calibration, and testing / troubleshooting and minor repairs. Repairs requiring replacement of part will cost extra. Minimum service charge must be paid per standard terms prior to issue of Return Material Authorization (RMA).

** OSI will NOT accept equipment, parts, or material of any kind without an RMA.