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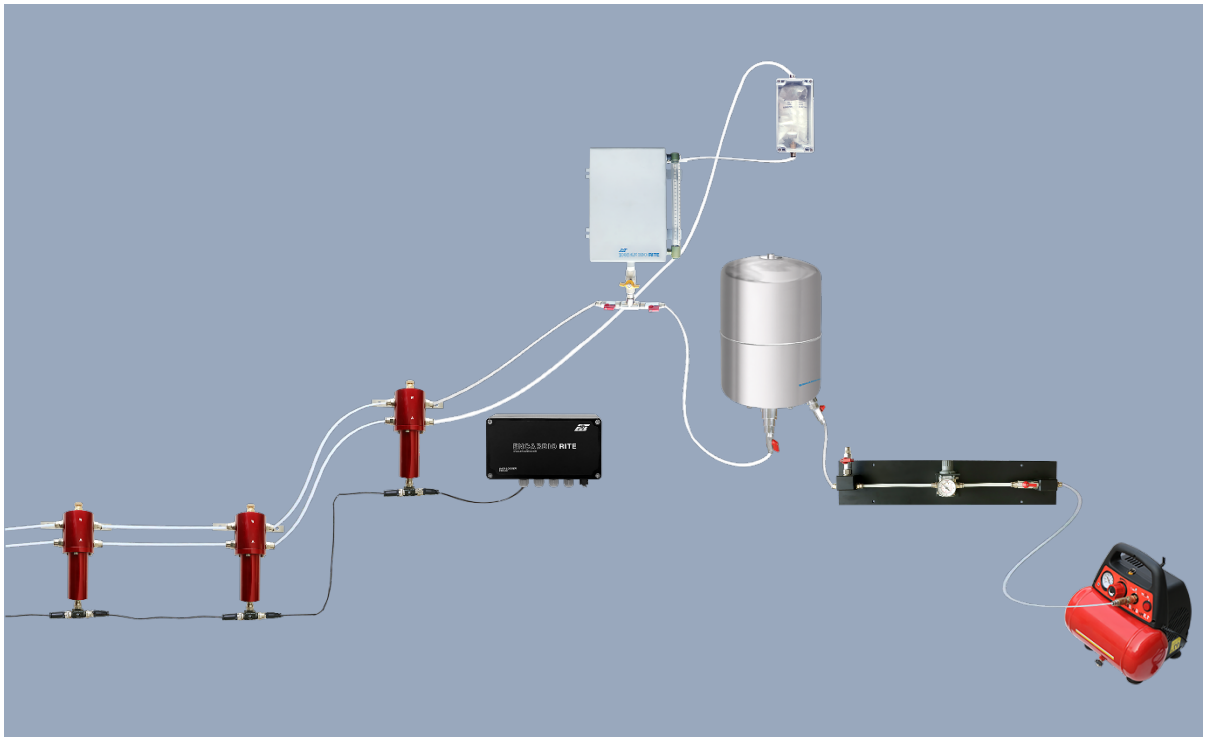
USERS' MANUAL

SETTLEMENT MONITORING SYSTEM USING DIGITAL SENSORS

MODEL ESM-40S



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ENCARDIO-RITE ELECTRONICS PVT. LTD.

A-7, Industrial Estate, Talkatora Road Lucknow, UP-226011, India | P: +91 522 2661039-42 | Email: geotech@encardio.com | www.encardio.com

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1 INTRODUCTION

1.1 ESM-40S high sensitivity liquid level settlement system

The Encardio-rite model ESM-40S liquid level settlement system is a precision settlement measuring system designed for remote measurement of small settlements at multiple spots or locations with high resolution.

It employs a number of settlement monitoring sensors connected together with a common liquid line. Each settlement monitoring sensor is equipped with a low pressure, high sensitivity digital transducer (with SDI-12 interface or Modbus output) to measure the liquid head with respect to the reservoir. One of the settlement measuring sensors in a system is installed near reservoir, at a stable reference location where either no significant settlement is expected or its elevation can be precisely determined by conventional surveying methods. Settlement of all other sensors are measured with reference to this reference sensor.

In practice the liquid vessel of each settlement monitoring sensor in a system are connected together with a liquid line or tubing so the level of liquid in each sensor tries to find a common level. If any settlement monitoring sensor goes up relative to the reference sensor liquid drains out of the liquid chamber to maintain the common liquid level. Similarly, if any of the sensor goes down more liquid fills in the sensor liquid chamber thus raising the level of the liquid inside the sensor. A larger liquid reservoir chamber at the reference location is also connected to the common liquid line to supply or absorb the liquid draining in or out of the sensors due to their upwards or downwards movement thus keeping the common liquid level at more or less the initially fixed level.

The digital sensors are supplied in two options - SDI-12 serial interface or Modbus (RS-485) output. The sensors are user friendly and convenient to configure. Encardio-rite model ESDL-30 datalogger can be used for remote automatic data collection from level sensors at desired intervals. Maximum distance of datalogger from the most distant SDI-12 settlement sensor can be up to 200 m. A maximum of 32 sensors can be used in a chain in case the output is Modbus and maximum distance from datalogger to remotest sensor can be 1.2 km. The datalogger has GSM/GPRS for wireless data transfer to central server (cloud or local) to provide near real time data at client's desk.

The ESM-40S liquid level settlement system can also be directly connected to RF Nodes and Gateway communication network for wireless data transfer.

Real-time settlement/heave (deformation) profile helps in observing the behaviour of structural movement during and after construction and indicates potentially dangerous conditions that may adversely affect stability of the structure. The authorities can learn about the slightest of change taking place instantly. This allows one to take timely decisions, increase safety, reduce project delays and be more cost effective.

1.2 Conventions used in this manual

WARNING! Warning messages calls attention to a procedure or practice, that if not properly followed could possibly cause personal injury.

CAUTION: Caution messages calls attention to a procedure or practice, that if not properly followed may result in loss of data or damage to equipment.

NOTE: Note contains important information and is set off from regular text to draw the users' attention.

1.3 How to use this manual

This users' manual is intended to provide you with sufficient information for making optimum use of the precision liquid level settlement monitoring system in your application. The manual is divided into a number of sections. Each section contains a specific type of information. The index will help to quickly look for specific information, when required.

To make this manual more useful we invite your valuable comments and suggestions regarding any additions or enhancements. We also request you to please let us know of any errors that you may find while going through this manual.

NOTE: The installation personnel must have a background of good installation practices and knowledge of the fundamentals of geotechnics. Novices may find it very difficult to carry on installation work. The intricacies involved in installation are such that even if a single essential but apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

A lot of effort has been made in preparing this instruction manual. However, the best of instruction manuals cannot provide for every condition in the field that may affect the performance of the sensor. Also, blindly following the instruction manual will not guarantee success. Invariably, installation personnel depending upon field conditions, will have to consciously depart from the written text and use their knowledge and common sense to find solution to a particular problem.

2 DIGITAL SETTLEMENT MONITORING SYSTEM

2.1 General description

Model ESM-40S high sensitivity liquid level settlement monitoring system consists of:

- Model ESM-40S/1 Settlement sensor
- ESM-40S/2 Reference reservoir with liquid level measuring scale, wall mounting accessories
- ESM-40S/3 Desiccant unit (moisture trap) with wall mounting accessories
- ESM-40S/4 Fluid tube, 8 mm od
- ESM-40S/4 Air vent tube, 8 mm od
- T connector with two (male female) connectors for signal cable
- CS-1002 3-core signal cable
- ESM-40S/5 Pressure gage assembly unit (required with pressure vessel system)
- ESM-40S/6 Pressure vessel and pump (to be arranged locally by user, or procured from Encardio-rite separately)
- De-aired fluid (to be arranged locally by user, or procured from Encardio-rite separately)
- Model ESDL-30 Datalogger or equivalent

The settlement sensors are also interconnected with an air vent tube that is eventually terminated at moisture trap with desiccant. The common vent line being open to atmosphere helps the settlement reading not being affected by local air current and changes in barometric pressure.

2.2 Operating principle

The settlement sensors are mounted at locations where settlement is to be monitored. These are connected in series by a fluid filled tube and finally to a reference reservoir mounted at a stable location. Stable location must be away from the zone of influence, where no displacement is expected.

All interconnected settlement sensors are mounted at almost same elevation and have a common fluid level initially. A reference settlement sensor is installed near the reference reservoir, to compensate any change in fluid level in the reservoir. It is mounted atleast 50 to 75 mm below the minimum water level mark on reservoir.

The settlement sensors' mounting location/elevation depends on amount of settlement or heave expected. Preferably, in case settlement is expected, the settlement sensors are mounted atleast 100 mm below the minimum water level mark on the reservoir.

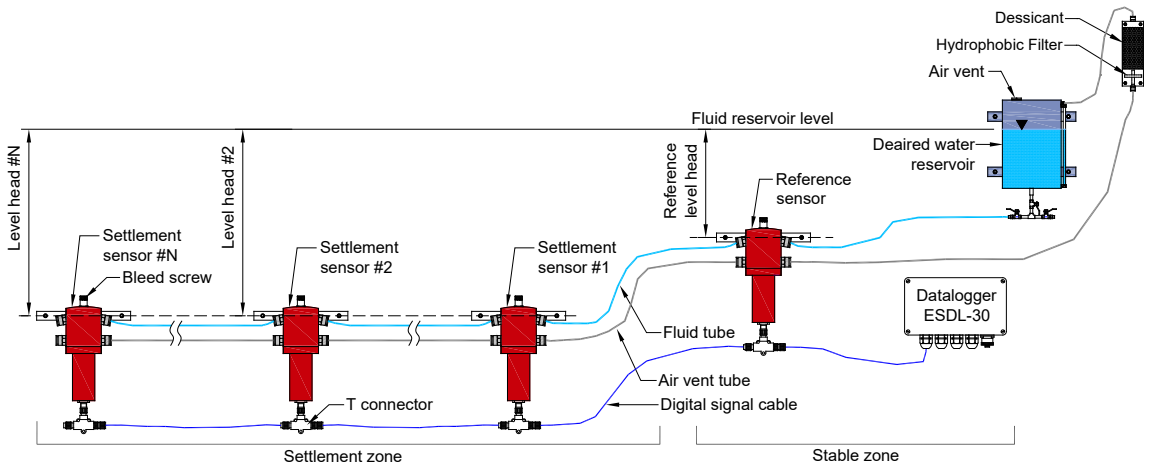

Figure 2-1 Schematic diagram of ESM-40S settlement monitoring system

The fluid level in the reference reservoir is maintained constant and monitored with the measuring tube of the reservoir. An air vent tube connects all the sensors to the moisture trap. This eliminates any error due to barometric pressure variation.

Settlement or heave of any sensor installed at settlement location, causes difference in elevation between the sensor and reference reservoir, resulting in change in liquid head, which is read by the low level pressure transducer. Settlement of sensor gives a higher liquid head while heave results in a lower liquid head.

The low range pressure transducer of the settlement sensor has a digital output. All the sensors are connected in series with a single 3 core signal cable. The signal cable is connected to our model ESDL-30 compact digital datalogger for remote online monitoring. With ESDL-30 datalogger and its configuration software, it is quite easy and fast to configure the whole system.

2.3 ESM-40S/1 Settlement sensor

Two or more high precision settlement sensors are used in the settlement monitoring system. One of the sensor is installed near the reservoir, as a reference sensor (at a stable location). Each settlement sensor consists of a low range pressure transducer with high sensitivity that monitors the head of liquid, quick connectors to connect fluid and air vent tubes, drain valve, male connector for signal cable and wall mounting fixing plate.

Figure 2-2 Settlement sensor

2.4 ESM-40S/2 Reservoir assembly

The reservoir assembly consists of a reference tank containing the fluid. A level measuring scale is provided to know the level of fluid inside tank. It is supplied with wall mounting plates attached, and with suitable fasteners. Capacity of the reservoir is 6 litre. Maximum and minimum water level is marked.

Figure 2-3 Reservoir (reference tank)

2.5 ESM-40S/3 Moisture trap

A moisture trap with desiccant and hydrophobic filter is used to terminate the vent line. It helps in maintaining the barometric pressure in the settlement monitoring system. When air pressure (barometric pressure) changes, the fluctuations are transmitted to the sensor through air vent tube. This results in cancelling out the effect of barometric pressure on the sensor. Desiccant and hydrophobic filter ensure that the air inside the moisture trap is dry. This prevents any moisture to enter into the vent line.

The moisture trap unit is mounted near the reservoir, preferably above the top level of the reservoir. It has two quick connectors – to connect to the vent line from the reference sensor and another vent tube from the reservoir.

Figure 2-4 Moisture trap with desiccant

2.6 ESM-40S/4 Fluid and air vent tubes

8 mm od tubes are used as fluid and air vent tubes. Air vent tube is required to compensate the barometric pressure inside the sensor. It ensures that the air pressure both inside and outside the sensor are same so that any change in atmospheric pressure does not affect the reading of the transducer.

2.7 ESM-40S/5 Pressure gage and valve assembly

Pressure gage and valve assembly consists of an air pressure gage with regulator to control the pressure. This is required when the water is being filled in the system using pressure vessel and compressor/pump. It also consist of suitable valves to maintain the pressure.

This system is very important to control the fluid pressure within limit (0.1 bar). The pressure transducer used in the settlement sensor is of very low range. Even a slightly higher pressure than 0.1 bar may damage the sensor.

Figure 2-5 Gage and valve assembly

2.8 ESM-40S/6 Pressure vessel with compressor

ESM-40S/6 Pressure vessel and compressor is required when the settlement system uses more than two sensors, to push the fluid till the last sensor (over long distances). The pressure vessel has the capacity of 10 litre. It consists of two valves – to connect to reservoir and to the compressor.

This system can be arranged locally by user, or can be procured from Encardio-rite separately.

Figure 2-6 Pressure vessel with valves and compressor

2.9 De-aired fluid

A fluid mixture containing 50% ethylene glycol and 50% de-aired distilled water is recommended for the settlement monitoring system. The mixture has a relative density of around 1.06 at 4°C. Ethylene glycol is a good wetting agent and also an antifreeze. The system responds better if the tubes are free of air bubbles.

The fluid mixture can be arranged locally by user, or can be procured from Encardio-rite separately. The quantity required will depend on the total length of fluid tube and the capacity of reservoir.

In case the installation location does not experience extreme cold climate, simple de-aired distilled water can also be used as the fluid.

2.10 Model ESDL-30 Datalogger

The bus cable from the settlement sensors is connected to the Encardio-rite model ESDL-30 datalogger for remote online monitoring. ESDL-30 datalogger is a compact datalogger that can be mounted easily near the sensor or in a control room in close vicinity.

Figure 2-7 ESDL-30 datalogger for digital sensors

The datalogger's configuration software is user friendly, which makes the commissioning of digital settlement monitoring system quite easy and fast.

At locations covered by a mobile network, the data from the ESDL-30 datalogger can be transmitted remotely to a central/cloud server.

3 TOOLS & ACCESSORIES REQUIRED FOR INSTALLATION

The following tools and accessories are required for installation of the settlement monitoring system.

- Impact or percussion electric drill with 8 mm and 6 mm drill bit for drilling in concrete or masonry (for fixing fasteners)
- Cable Cutter
- Wire Stripper
- Small spirit level (preferably bubble type)
- 3½ digit digital multimeter
- De-aired fluid – depending on site requirement (minimum 20 litre recommended)

4 INSTALLATION PROCEDURE

NOTE: Please read and understand this section fully before attempting to set up the liquid level settlement monitoring system.

4.1 Pre-installation checks

4.1.1 Sensor check

Check that the settlement sensors are functioning properly. The reading of the sensor should be zero.

4.1.2 Location of the reservoir and reference sensor

Decide the location of the reservoir and reference sensor. The location should be out of zone of influence, where no settlement is expected. If this is unavoidable, location should be decided at a place where the elevation of reference sensor can be accurately surveyed using conventional surveying practice.

4.1.3 Sensor locations

The settlement sensors have a small measuring range and the range of adjustment possible is also very small so all the sensors need to be initially mounted at the same elevation. Choose an elevation such that all the level sensors of that particular measurement group can be fixed at the same elevation at the chosen locations.

The sensors are supplied with the mounting plate attached. Mounting plate is designed for fixing the sensor to a vertical surface like a wall. Using conventional surveying or other available means mark a straight short horizontal line, at the same elevation, at all locations where the level sensors are to be mounted.

NOTE: The liquid head between the fluid level in reservoir and the installation level (fluid line level) of settlement sensors plus the expected settlement or heave should not exceed the full range of the sensor.

4.2 Installation of settlement and reference sensors

- Mark the location of holes for drilling, keeping the sensor (with mounting plate) at the installation location on wall. The plate should be kept such that the bottom edge of the bracket is visually aligned with the horizontal survey mark line put earlier.

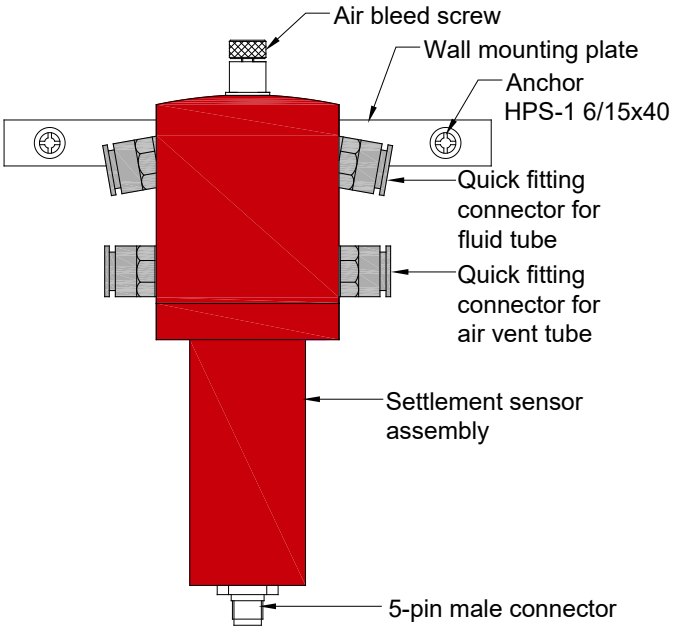

Figure 4-1 Settlement sensor

- Drill 6 mm dia x 40 mm deep holes. Fix the mounting plate (with sensor) using the two fasteners supplied with the plate. Epoxy fixed threaded anchors can also be used, if required

NOTE: It is very important that the sensor body is kept absolutely vertical while in operation. A tilted sensor will give erratic readings. Use a small spirit level (preferably bubble type). Adjust the fasteners so that the spirit level shows a perfect alignment.

4.3 Installation of reservoir & moisture trap

- Mark the location of the four holes for drilling. Drill 8 mm dia x 70 mm deep holes. Fix the mounting plates (with the reservoir) using the four fasteners provided in the supply.
- Mark the four holes for the moisture trap. Moisture trap is mounting in vertical position, with hydrophobic filter at the bottom. Location of moisture trap must be little above the top of reservoir (figure 4-6). Drill 6 mm dia x 50 mm deep holes. Fix the moisture trap using the four fasteners provided in supply.
- Connect the moisture trap to the reservoir with the desired length of 8 mm od air vent tube. Suitable quick connectors are provided on reservoir as well as on the moisture trap. Remove the plug from the quick connector of the moisture trap before connecting the air vent tube.
- Close the isolation valve of the reservoir.

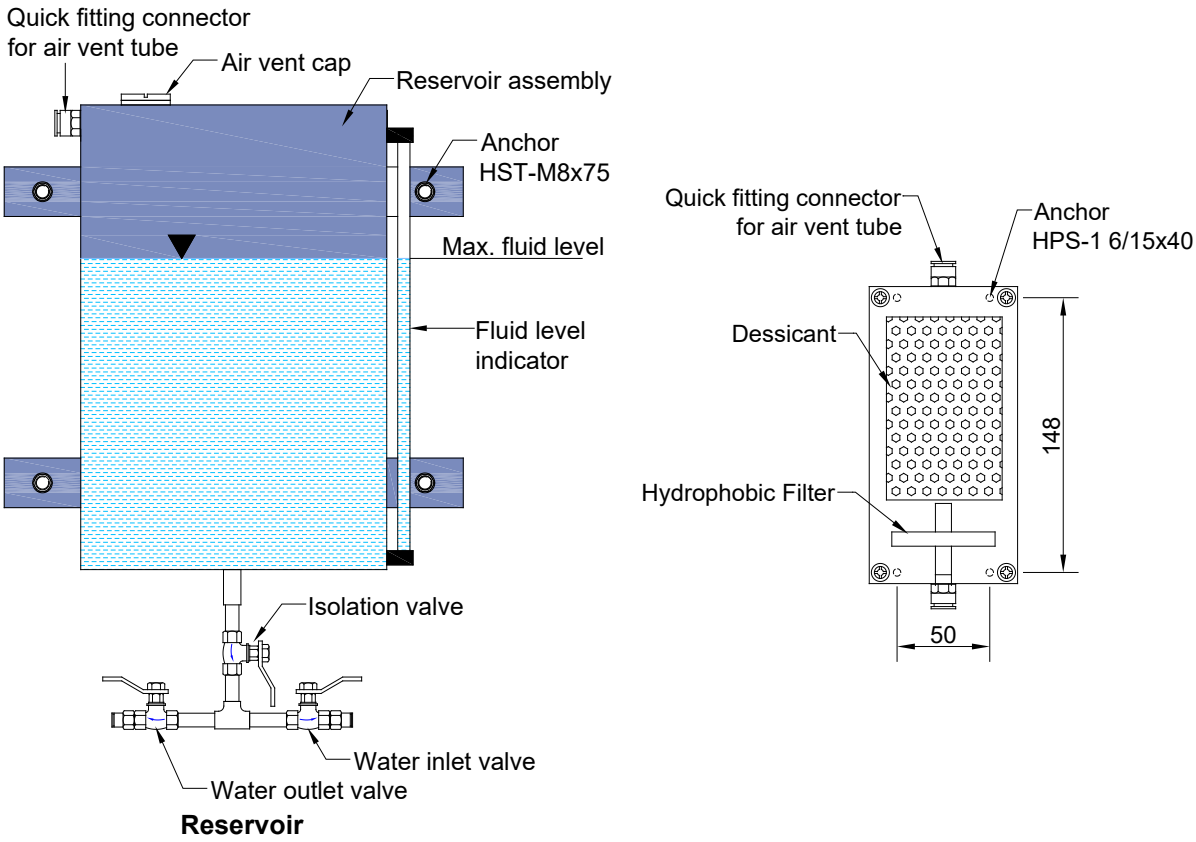

Figure 4-2 Reservoir and moisture trap

4.4 Installation of pressure gage and valve assembly

Mark the location of the four holes for drilling. Drill 6 mm dia x 40 mm deep holes. Fix the mounting plates (with the gage and valves) using the four fasteners provided in the supply. Ensure that the zero of the gage is towards bottom side.

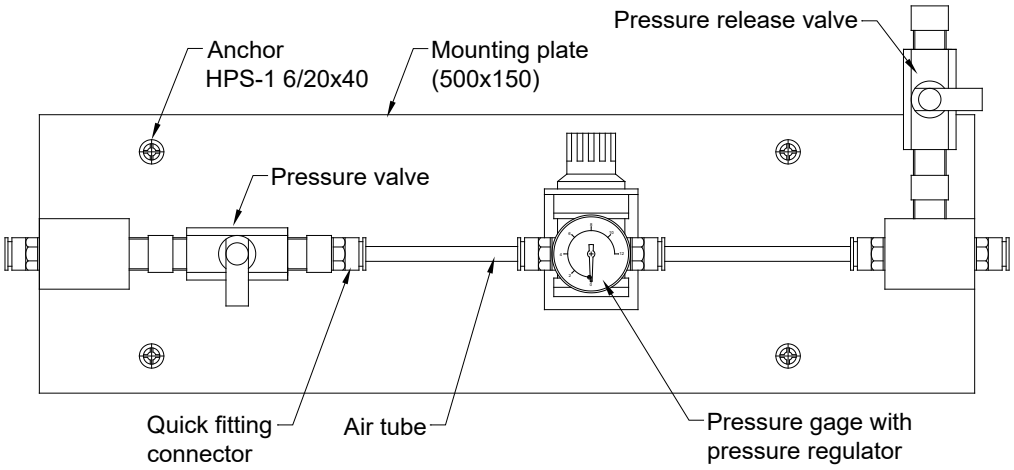

Figure 4-3 Pressure gage and valve assembly

4.5 Installation of datalogger

The ESDL-30 datalogger can be mounted near the reservoir, or in the monitoring room, as desired. A mounting details are shown in figure below. Mark the position of fasteners. Drill 6 mm dia x 40 mm deep hole. Fix the datalogger using Hilti HPS-1 6/15x40 fasteners provided.

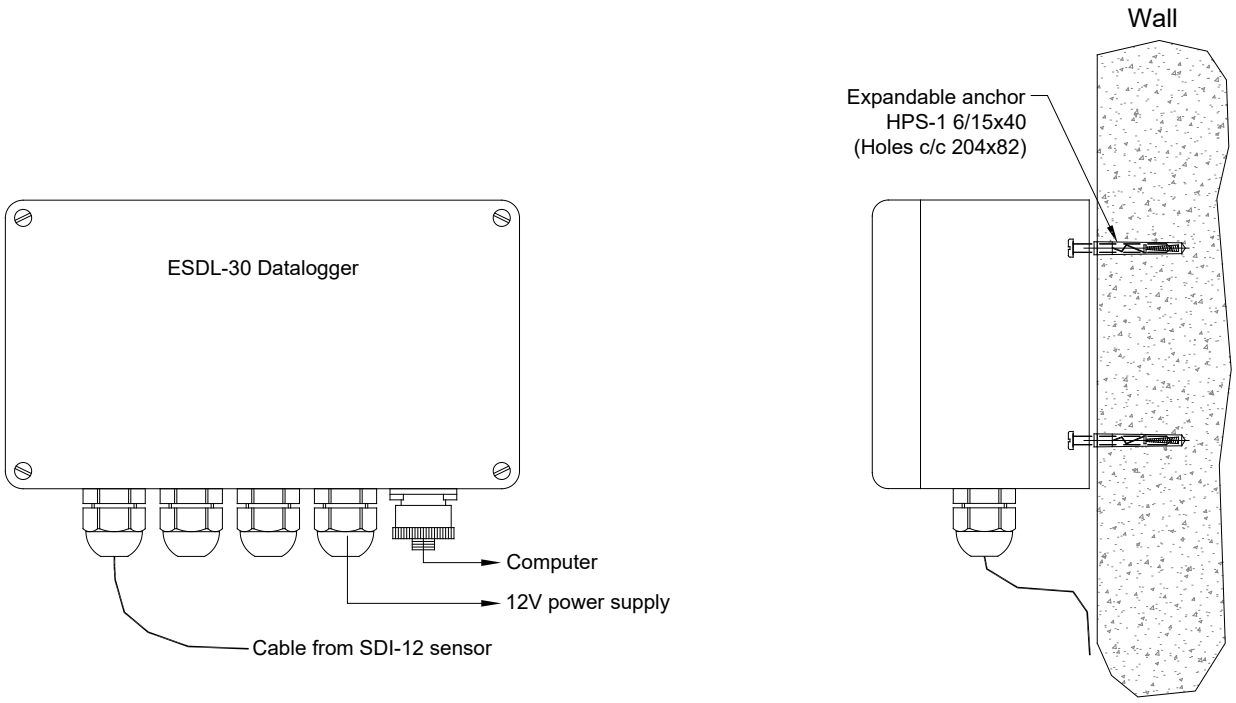

Figure 4-4 Mounting details for ESDL-30 datalogger installation on wall/vertical surface

4.6 Connecting the liquid line

Each settlement sensor has quick fitting connectors (slightly bent, top ones) for connecting the fluid to other sensors and reservoir. An 8 mm od tubing is used to connect the sensors and reservoir together.

Attach the fluid line from the reservoir to the reference level sensor and then to all the other sensors in sequence from the nearest to the farthest. Cut the desired length of tubes and connect them to the quick fittings. Close the outlet quick connector (of fluid line) from the last sensor properly with the plug provided in supply.

4.7 Connecting the air vent line

Each settlement sensor also has quick fitting connectors (straight, bottom ones) for connecting the air vent tube. An 8 mm od tubing is used as the air vent tube, connecting all the sensors and finally vented to atmosphere near the fluid reservoir through a desiccant (moisture trap) so that only dry air can enter the sensor vent line. The moisture content in air in the transducer vent line can, in course of time, coalesce to form water droplets and can damage the inside of the transducer

Cut the desired length of tubes and connect them to the respective quick fittings on the sensor and finally to the moisture trap.

NOTE: It is recommended to fix the fluid and drain tubes to the walls to prevent damage. This will also ensure that the tubes are always below the top quick connector (bent one for fluid line).

NOTE: Ensure to keep the drain valve of the sensors closed.

4.8 Filling the fluid in reservoir, fluid line and sensors

Once the complete system is installed, fluid will be filled into the reservoir, fluid line, reference settlement sensor and all the installed settlement sensors.

It is recommended to use a pressure vessel and air-pump (compressor) to fill in the fluid. A typical installation set-up is shown in figure 4-5.

1. Fill the pressure vessel with de-aired fluid from valve (4) of the pressure vessel.
2. Close both the valves of the pressure vessel. Place it upside down.
3. Connect the pressure vessel to the reservoir with required length of fluid tube through outlet valve (4).

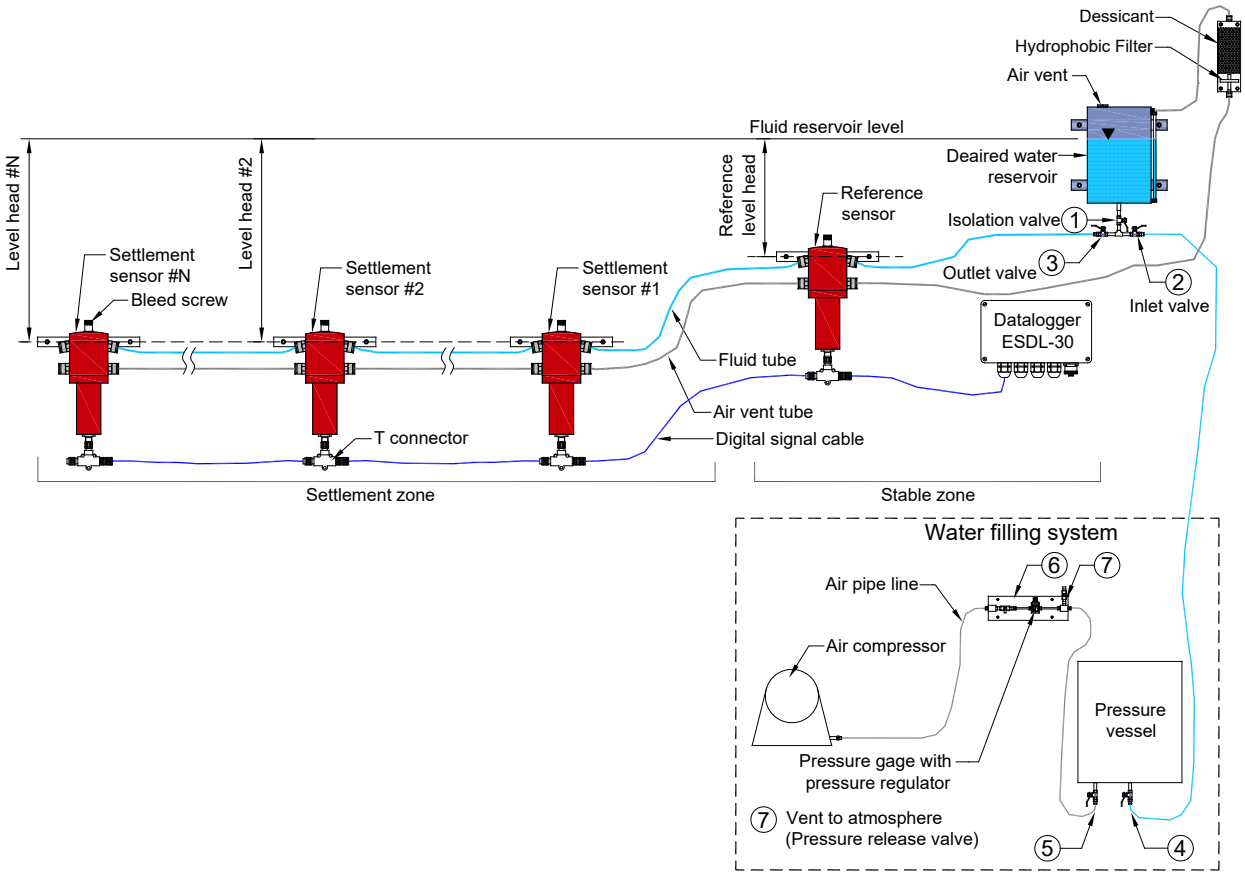

Figure 4-5 Typical installation scheme of ESM-40S settlement system

4. Connect pressure vessel system to the pressure gage assembly to an air vent tube through valve (5)
5. Open isolation valve (1) and inlet valve (2) of reservoir and the outlet valve (4) of pressure vessel
6. Switch on the compressor (maximum pressure 0.1 bar) and open valve (5) of pressure vessel and valve (6) of the pressure gage assembly unit.
7. Fill the reservoir with fluid up to the maximum level marked on the fluid level scale of reservoir
8. Switch off the compressor and close inlet valve (2) of reservoir and the outlet valve (4) of pressure vessel.
9. Open pressure release valve (7) of pressure gage assembly
10. Open outlet valve (3) of the reservoir. Fluid inside the reservoir will start flowing towards the sensors
11. Repeat the cycle (steps 1 to 10) till all the sensors are filled with fluid
12. Open air bleed screw of each sensor to remove trapped air. Open it for 3~4 seconds and close it immediately.

CAUTION!: Care should be taken while filling to ensure that no air is seen trapped in the liquid lines. Also check for any leakages near tubing/T-joint and the proper elevation of each sensor.

NOTE: The sensors are calibrated in the factory using distilled water (specific gravity taken as 1000 kg/m^3) and so the calibration coefficients given in the test certificate are valid when the fill liquid is de-aired distilled water. In case other fill fluids (mixture) has to be used, contact factory for new calibration coefficients suitable for the density of that fill fluid.

NOTE: After installation wait for the readings from the sensors to stabilize over a period of atleast 24 hours.

NOTE: The desiccant in the moisture trap should be changed in case it changes its color from blue to pink.

5 SENSOR WIRING

A T-type connector (with female connector port for connecting to sensor) along with two separate male female connector are provided for the signal cable connection.

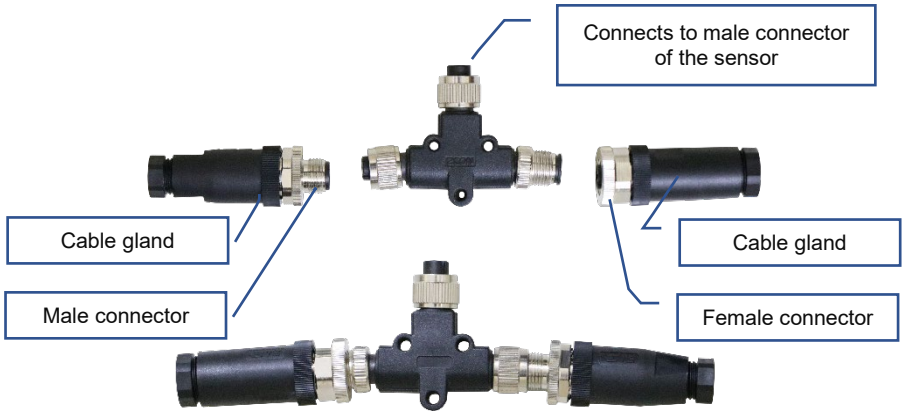

Figure 5-1 T type connector with male & female connectors for connecting sensor bus cable

5.1 For sensors with SDI-12 output option

The settlement sensor with SDI-12 interface output requires 3 core bus cable. SDI-12 is an acronym for "Serial Data Interface at 1200 Baud". It is an asynchronous ASCII, serial communications protocol. Instruments with SDI-12 interface are typically low power (12 V); often used in remote locations, and usually, communicate with a datalogger or RF Nodes and Gateways. In this master-slave configuration, the datalogger typically acts as the master (SDI-12 Recorder and Interrogator) to data monitoring instruments, which are the slaves (SDI-12 sensors). One master can communicate with multiple slaves; so the SDI-12 protocol requires that each device in the serial network be identified with a unique address, which is represented by a single ASCII character.

This communication is achieved by digital communication along a single serial line. The digital addressing system allows an SDI-recorder to send out an address over a single line that is connected to sensors. Only the pre-configured sensor matching that address will respond (handshake). The other sensors on the same line will not respond until called and typically stay in "sleep mode" (low power mode), until called (often in a sequence) at a later time by the SDI-Recorder (Master). The sensor with SDI-12 interface bears a manufacturing serial number and an identity or address can be assigned to it during the installation process. The identities are 0-9, a-z & A-Z.

The connection details of 3 core SDI-12 bus cable to male and female connectors is shown in figure below.

Figure 5-2 Wiring details for sensor with SDI-12 output

5.2 For sensors with Modbus (RS-485) output option

The settlement sensor with Modbus (RS-485) interface output requires 4 core bus cable. Connection details to male and female connectors is shown in figure below.

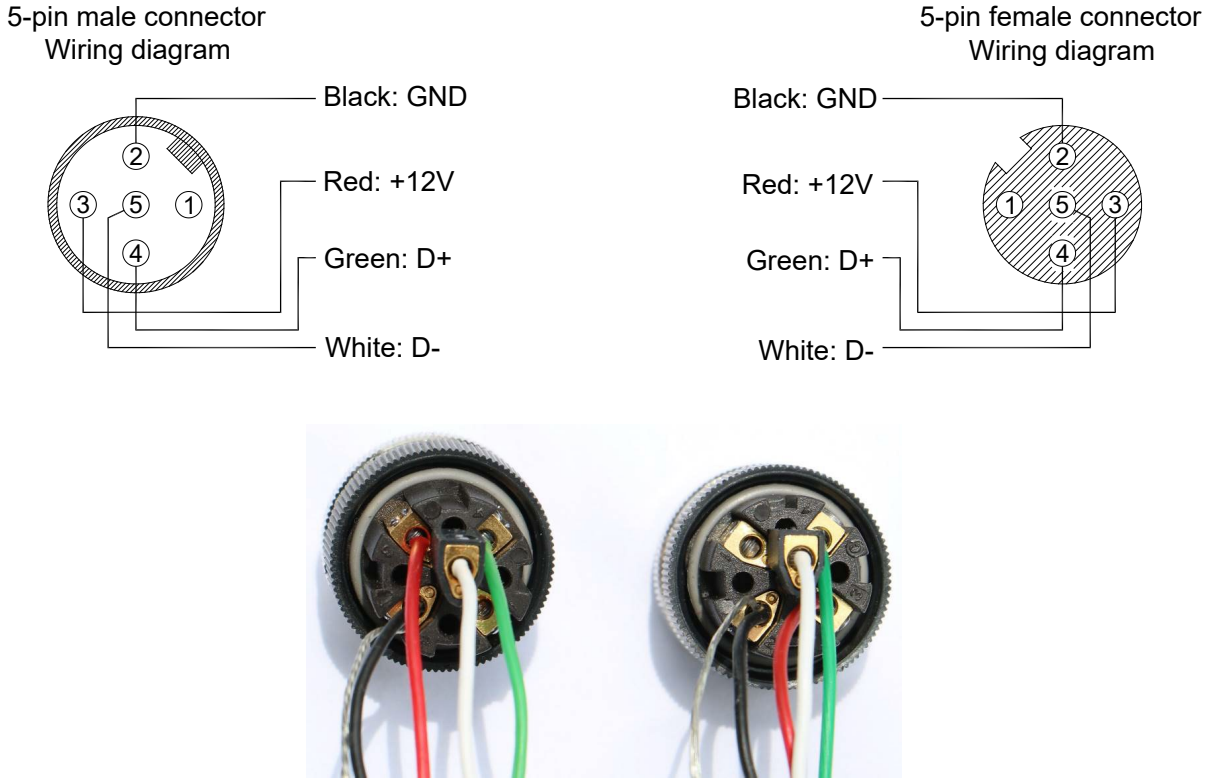

Figure 5-3 Wiring details for sensor with Modbus (RS-485) output

6 CONNECTING ESM-40S TO SDI-12 DATALOGGER

6.1 SDI-12 output

Model ESDL-30 datalogger

The settlement sensor with SDI-12 interface output requires 3 core bus cable. The digital communication along the bus cable requires a digital addressing system that allows an SDI-Recorder to send out an address over a single line that is connected to sensors. Only the pre-configured sensor matching that address will respond (handshake). The other sensors on the same line will not respond until called and typically stay in "sleep mode" (low power mode), until called (often in a sequence) at a later time by the SDI-Recorder (Master).

The sensor with SDI-12 interface bears a manufacturing serial number and an identity or address can be assigned to it during the installation process. The unique identities can be 0-9, a-z & A-Z.

6.2 Wiring details

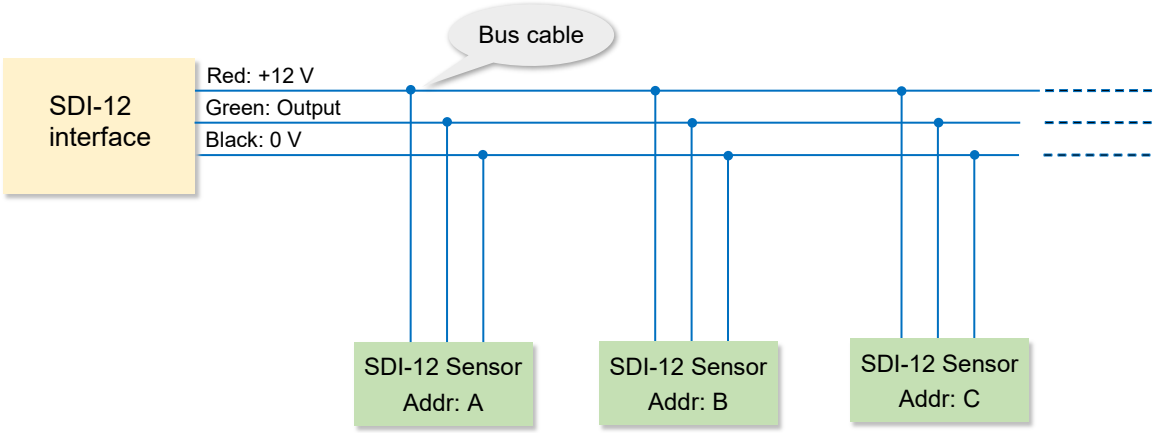

Figure 6-1 Wiring details to connect ESM-40S with SDI-12 output to suitable datalogger

6.3 Connecting to ESDL-30 SDI-12 datalogger

Encardio-rite model ESDL-30 datalogger can be used with ESM-40S settlement monitoring system with SDI-12 serial interface output. Data from the datalogger can be transmitted remotely to a central/cloud server via cellular (GSM/GPRS) network.

The datalogger is very easy to configure, especially for ESM-40S sensors. It provides data directly in engineering units. Each reading is stamped with date and time at which the measurement was taken. It has a non-volatile flash memory to store up to 2 million data points. The data files from the datalogger can be downloaded to PC using Configuration Manager Software by connecting logger with data cable or Bluetooth.

ESDL-30 with built in GSM/GPRS modem has capability to upload data records directly to remote FTP server. Upload schedule can be programmed in the datalogger using the software for automatic data upload to FTP server. Schedule can be set as fast as 5 minutes.

The datalogger has three SDI-12 ports (channels). Sensors with SDI-12 serial interface can be connected on a common SDI-12 bus. This bus can be connected to any SDI-12 port of the datalogger. Each of the 3 channels of the datalogger can have 61 sensors with ID 1-9 (ID 0 is used for factory purposes, hence not available for use), a-z or A-Z. For a given channel each sensor should have a different ID.

Connection detail is shown in figure below. Battery should be placed in the datalogger after the connections have been successfully done.

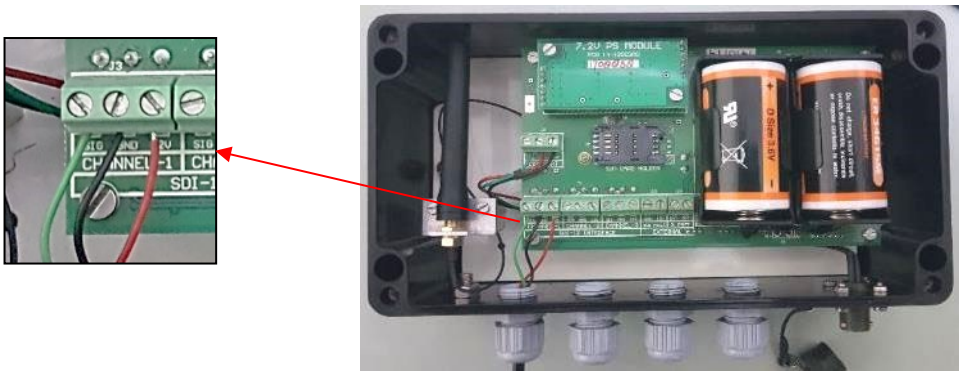

Figure 6-2 Connection of SDI-12 three-core cable bus (from settlement sensor chain) to ESDL-30 datalogger

7 CONFIGURATION OF ESM-40S WITH ESDL-30 DATALOGGER (SDI-12)

NOTE: For details on operation of model ESDL-30 datalogger, please refer to **Users' Manual # WI6002.111.1 on "Operation" of ESDL-30 datalogger.** For details of configuration with model ESDL-30 datalogger, please refer to **Users' Manual WI6002.111.2 on "Configuration Manager for Windows" of ESDL-30 datalogger.** The manuals are available at our website www.encardio.com/downloads

A brief on connection and configuration for model ESM-40S sensor with SDI-12 output is given below.

1. Double click the ESDL-30 datalogger software icon on the Desktop. The main screen of the application appears as displayed in figure below

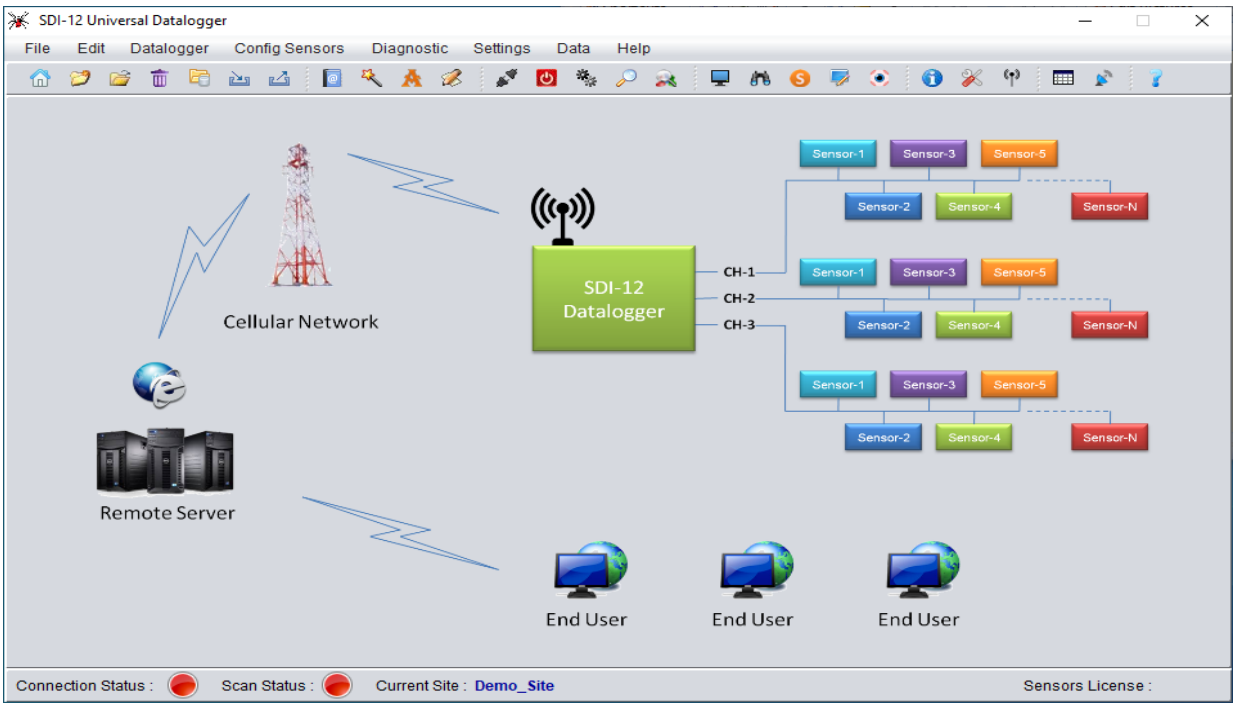

Figure 7-1 Main menu

2. Connecting Data Logger: Click "Datalogger" followed by "Connect/Disconnect Datalogger". A "Connection" window will appear as shown below. Select the usable "Com port" and then click "Connect". The progress bar appears on the screen as the application takes few seconds to get connected.
3. After successful connection, information message pops up on the screen confirming successful connection. Press "OK" to proceed. This will change "Connection Status", at the left bottom, from Red to Green.

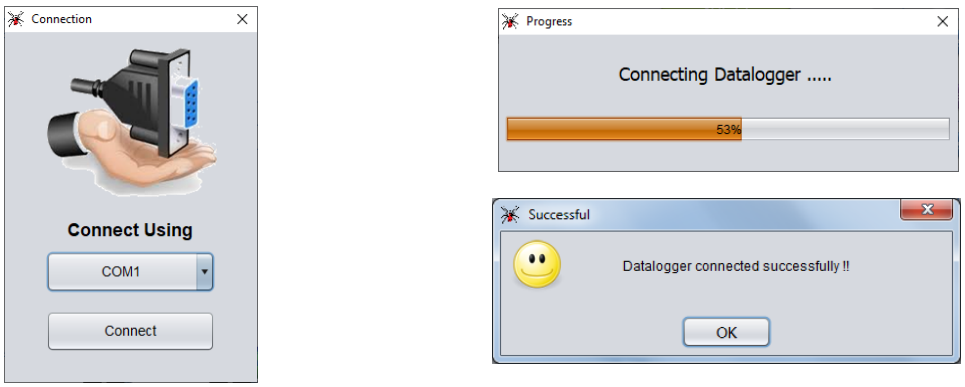

Figure 7-2 Connection

4. Application will display "Open site" window to select the site. Select the required site from "Select Site"

dropdown menu. Click on "Open" button to open the site for Datalogger. You can choose "Demo site" for first time.

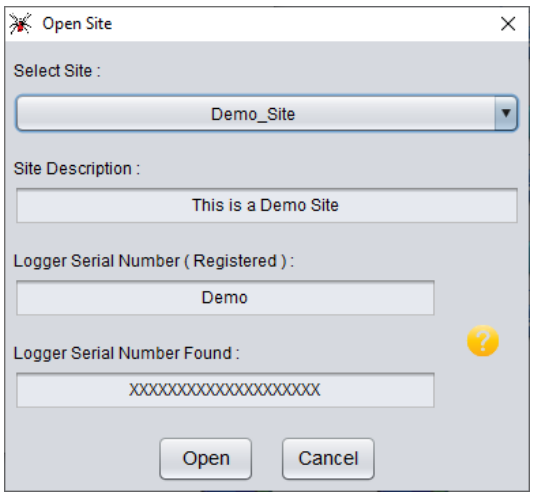

Figure 7-3 Select site to open

5. Click on "Config Sensors" tab and the select "Smart Config Sensor" as shown in figure below.

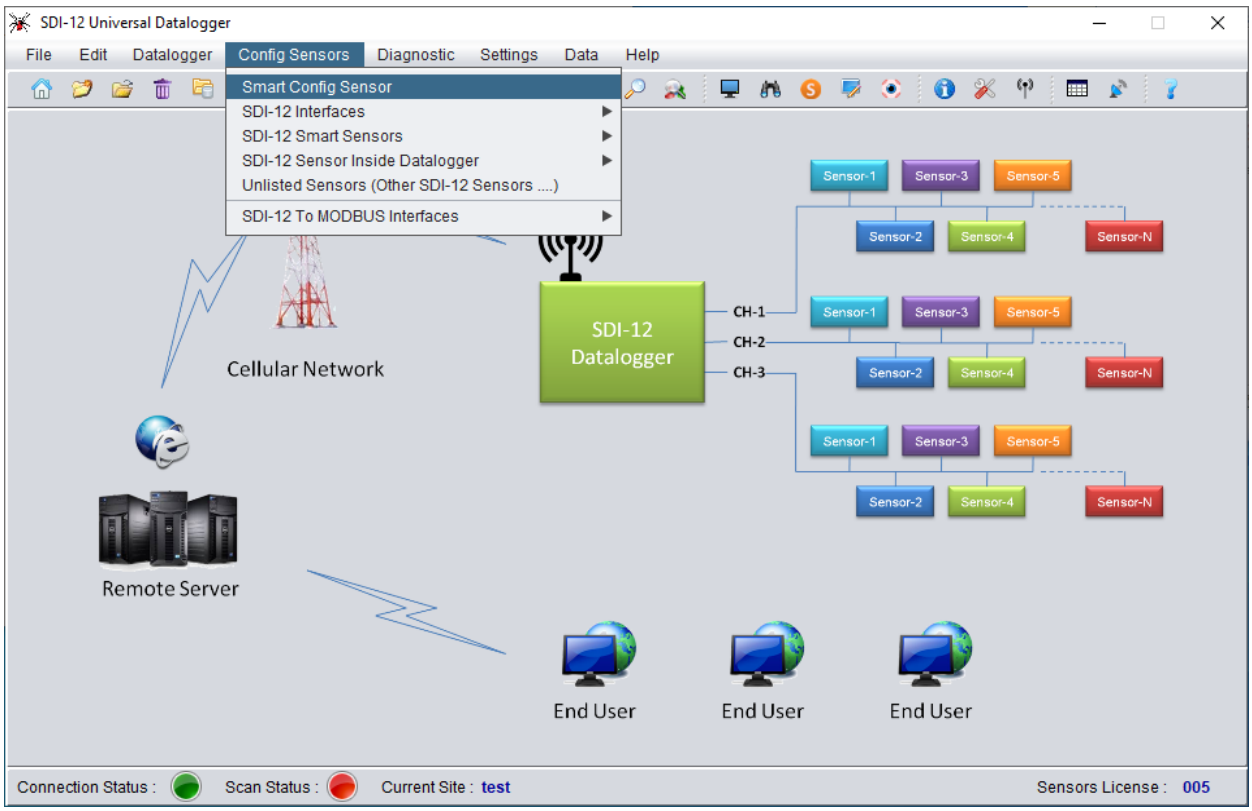

Figure 7-4

6. The screen as shown in figure 7-5 will appear. Select channel number at which the sensor is connected. Select the sensor's address and click on "Search" button to find the sensor on SDI-12 Bus. It will show the sensor details as shown in figure 7-6. Press on "Open sensor configuration window" to open configuration screen.

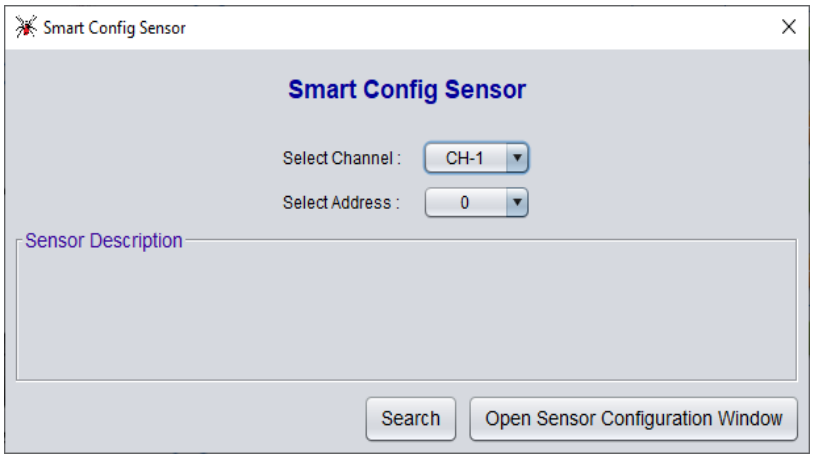

Figure 7-5

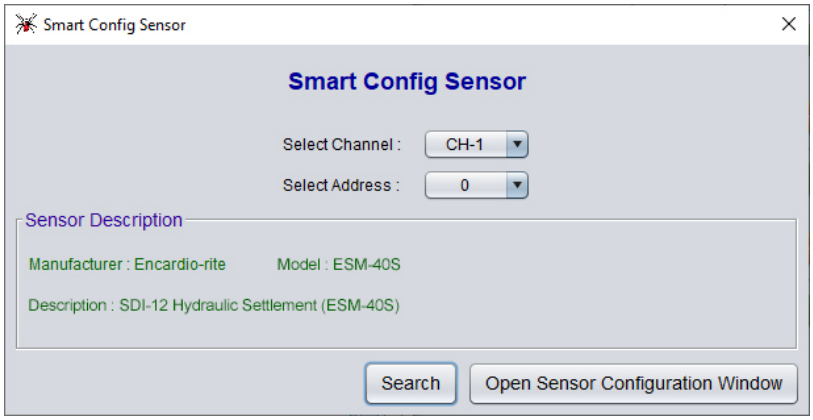

Figure 7-6 Smart config sensor screen

7. Screen as shown in figure 7-7 will appear. Press "Read" button. The application will fetch the information stored in the sensor as shown in figure 7-8.

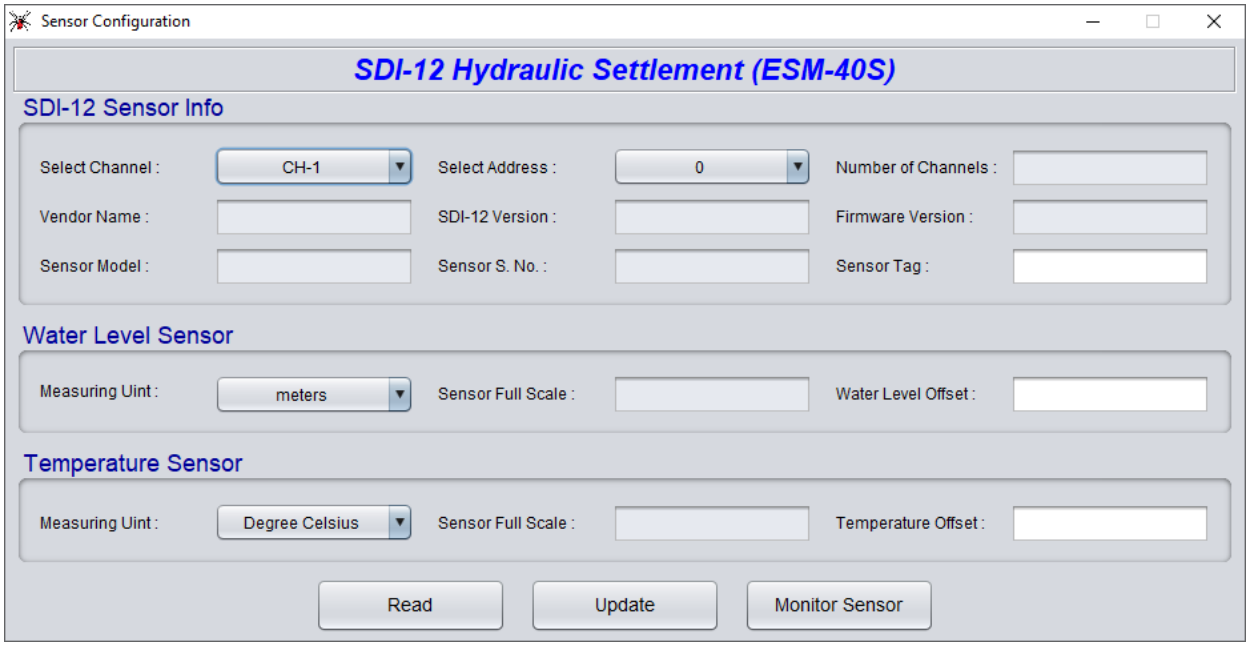

Figure 7-7

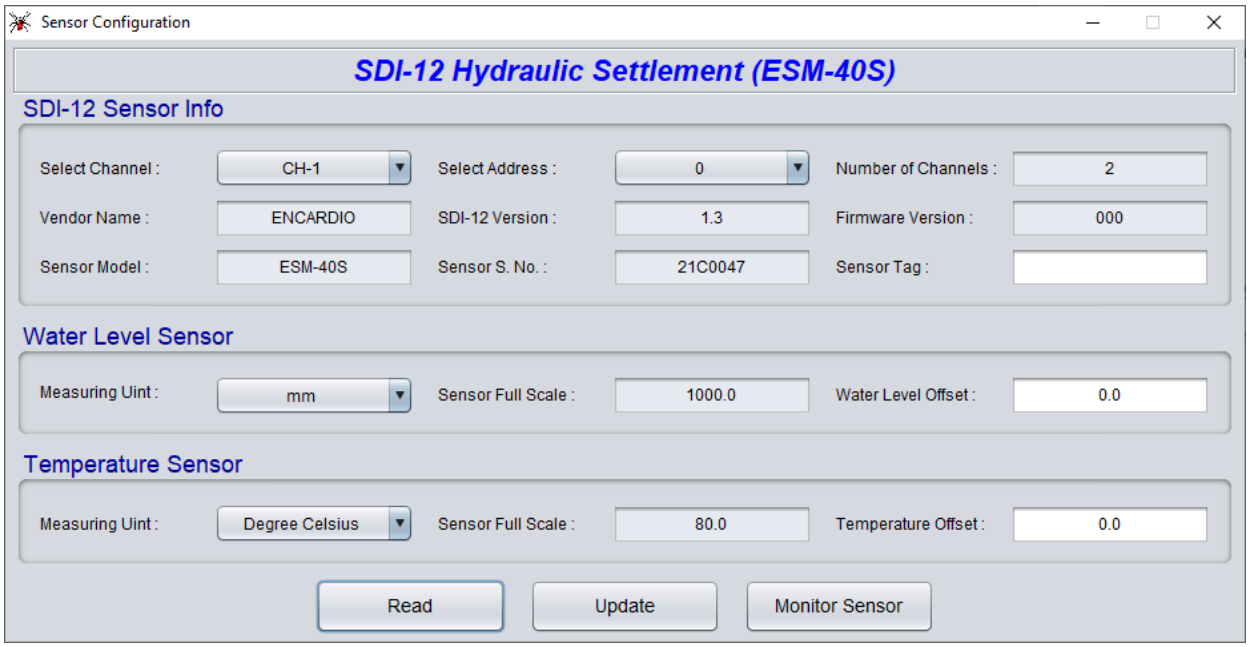

Figure 7-8 ESM-40S sensor details

8. Press "Monitor Sensor" button. The screen as shown in figure 7-9 will appear, showing the values of settlement reading (Parameter 1) and temperature reading (parameter 2) of the sensor.

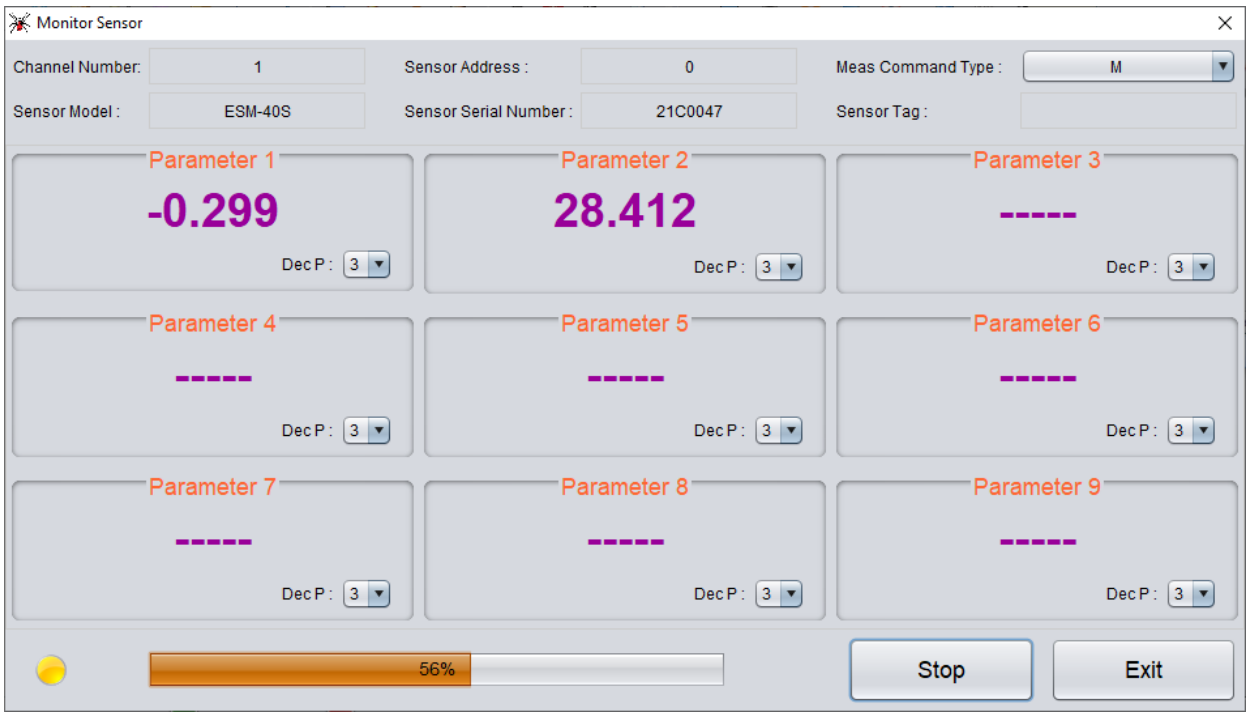

Figure 7-9 ESM-40S sensor readings

8 CONNECTING ESM-40S TO MODBUS DATALOGGER

8.1 Introduction

Encardio-rite model ESM-40S settlement monitoring system use the industry standard Modbus Remote Terminal Unit (RTU) protocol to communicate with dataloggers. As the name suggests, Modbus was designed to work on what is known as a bus network, meaning that every device receives every message which passes across the network.

Model ESM-40S sensors use the RS-485 electrical interface to communicate over long distance cables. Any suitable Modbus datalogger with either GSM/GPRS or RF transmission facility can be connected for datalogging and wireless data transmission. A maximum of 32 sensors can be used in a chain and maximum distance from Modbus datalogger to remotest sensor can be 1.2 km.

Encardio-rite model ESDL-30 datalogger can also be used with an additional Modbus card, if specifically ordered. However, maximum limit of Modbus settlement sensors that can be connected to this ESDL-30 datalogger version is seven.

8.2 Connection to ESDL-30 datalogger (with Modbus interface card)

ESDL-30 datalogger can be supplied with an additional Modbus card, when specifically ordered. Such an ESDL-30 will have a Modbus (RS-485) port also besides the three SDI-12 ports (channels). Sensors with Modbus (RS-485) output can be connected to the datalogger as shown in figure below. Battery should be placed in the datalogger after the connections have been successfully done.

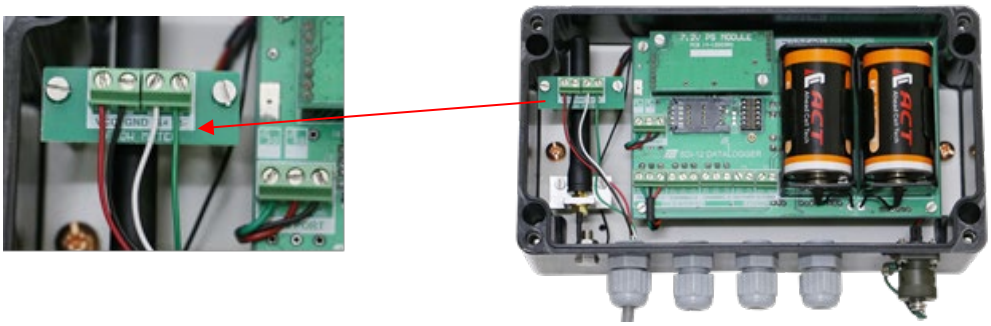

Figure 8-1 Connection of Modbus (RS-485) 4-core cable bus (from settlement sensor chain) to ESDL-30 datalogger

8.3 Modbus details for connection to any suitable Modbus datalogger

8.3.1 Wiring details for any suitable Modbus datalogger

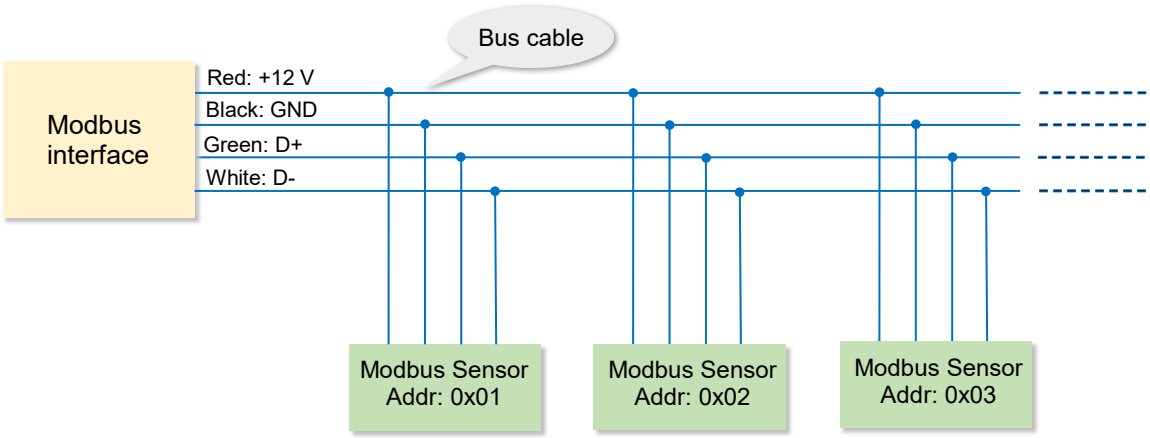

Figure 8-2 Wiring details to connect ESM-40S sensor with Modbus output to suitable datalogger

8.3.2 Modbus RTU overview

The Modbus RTU protocol uses packets (messages made up of multiple sections) to communicate and transfer data between devices on the network. The general format of these packets is as follows:

1. Modbus Address (1 byte) – The address of the specific device on the bus.
2. Function Code (1 byte) – The action to be carried out by the server device.
3. Data (multi-byte) – The payload of the function code being sent.
4. Cyclic Redundancy Check or CRC (2 bytes) – A 16-bit data integrity check calculated over the other byes in the packet.

8.3.3 Function code

The Modbus RTU protocol uses following Function codes:

Function Code	Description
03	Read Holding Registers
06	Write Single Register

8.3.4 Modbus register table

Modbus tables (maps) define the memory locations within each ESM-40S sensor interface and what information they contain. For example, the most recent sensor reading is stored in a table. This reading is presented in different formats in different sections of the table. The register location and size of these variables is detailed in the table below.

Modbus Register	Name	Data Length	Data Type	Description
0x00D8	Temperature Unit	2-bytes	16-bit Unsigned Integer	0 = deg C 1 = deg F
0x00D9	Parameter Unit	2-bytes	16-bit Unsigned Integer	0 = meters, 1 = mm 2= feet, 3=inches
0x00DA	Average Samples	2-bytes	16-bit Unsigned Integer	1 - 255
0x00DB	Settling Time	2-bytes	16-bit Unsigned Integer	0 – 255 seconds
0x00DD	Address of the Device	2-bytes	16-bit Unsigned Integer	0 - 247
0x00DE	Baud Rate	4-bytes	32-bit Unsigned Integer	1200, 2400, 4800, 9600, 19200, 38400, 115200
0x00E0	Endian Type	2-bytes	16-bit Unsigned Integer	0 = Little Endian Atomic 8 1 = Little Endian Atomic 16 2= Big Endian Atomic 8 3 = Big Endian Atomic 16
0x012C	Ch-1 Status	2-bytes	16-bit Unsigned Integer	0 = Measurement Ready 1 = Busy in measurement
0x012D	Parameter Value	4-bytes	32-bit float	0 – 1000 mm
0x012F	Ch-2 Status	2-bytes	16-bit Unsigned Integer	0 = Measurement Ready 1 = Busy in measurement
0x0130	Temperature	4-bytes	32-bit float	-20 to +80 deg C

8.3.5 Default settings

Sensor default settings are given below

Device Address	0x01
Baud Rate	115200
Data	8-bit
Stop Bit	1
Parity	None
Endian	Big Endian Atomic 16
Measuring Time	1 Sec

8.3.6 Modbus command format

Followings are some examples of Holding Registers Read and single register write.

- Reading Holding Registers (Ex: Reading sensor data)

BYTE	REQUEST	BYTE	ANSWER
(Hex)	Field name	(Hex)	Field name
02	Device address	02	Device address
03	Functional code	03	Functional code
01	Address of the first register Hi bytes	0C	Number of bytes more
2C	Address of the first register Lo bytes	00 00	Register value Ch-1 Status 16-bit unsigned
00	Number of registers Hi bytes	3B 21 3E 1B	Register value Parameter 32-bit Float (0.002460)
06	Number of registers Lo bytes	00 00	Register value Ch-2 Status 16-bit unsigned
05	Checksum CRC	41 DB E3 36	Register value Temperature 32-bit Float (27.485)
CE	Checksum CRC	B1	Checksum CRC
		82	Checksum CRC

- Write Single Register (Ex: Changing device address from 0x0001 to 0x0002)

BYTE	REQUEST	BYTE	ANSWER
(Hex)	Field name	(Hex)	Field name
01	Device address	01	Device address
06	Functional code	06	Functional code
00	Address of the Register Hi bytes	00	Address of the Register Hi bytes
DD	Address of the Register Lo bytes	DD	Address of the Register Lo bytes
00	Data (write) Hi bytes	00	Data (value) Hi bytes
02	Data (write) Lo bytes	02	Data (value) Lo bytes
98	Checksum CRC	98	Checksum CRC
31	Checksum CRC	31	Checksum CRC

9 CONNECTING TO NODE & GATEWAY

Wireless sensor network are becoming vital in civil engineering and geotechnical field. Encardio-rite offers an innovative wireless solution that allows real-time monitoring of geotechnical and structural sensors in challenging construction projects, with reliable data transfer over long distances without any delay.

The digital sensors (with SDI-12 or Modbus (RS-485) output) are interfaced with the long range, low power wireless network through model EWN-01D **digital node** that allows sensors to send recorded data to the model EWG-01 **gateway** with over 99% reliability, eliminating the need for running lengthy cables. The gateway then uploads all the collected sensor data to the central/cloud server.

Figure 9-1 Digital Node and Gateway

The digital node consists of a radio-transceiver with an antenna, a microcontroller, sensor module that reads the sensor; a wireless communication module that transmits the digital data to the gateway, and a processor that controls the two modules. It is a highly reliable integrated system, which is capable of collecting data from digital sensors and reporting measurements through RF wireless communication network to the gateway.

The node is housed in a rugged enclosure designed for use in harsh environments with wide temperature tolerance with resistance to moisture and humidity.

A cloud-hosted data management and configuration software can be used to manage the network. The configuration can be done with an easy to use smartphone application that comes free with the system.

The system can generate automatic reports and provide automated alerts over SMS or email for any reading crossing the pre-defined alert levels.

9.1 Sensors with SDI-12 output option

The sensor with SDI-12 output will be connected to the "SDI" port (right-most) of the digital node as shown in figure below.

Figure 9-2 Connection of digital sensor with SDI-12 output to digital node

9.2 Sensors with Modbus (RS-485) output option

The sensor with Modbus (RS-485) output will be connected to the "RS485" port (center one) of the digital node as shown in figure below.

Figure 9-3 Connection of digital sensor with Modbus (RS-485) output to digital node

For details on connection to Nodes and Gateway and their configuration, please refer to Users' Manual # WI6002.139 on Wireless (RF) Nodes and Gateway.

10 SAMPLE TEST CERTIFICATE

Test Certificate

Date: 29.10.2021

Temperature: 28^0C

Item : Automatic water level sensor

Model : ESM-40S

Serial no. : XXXX

Full Scale Value : 1000 mm

Observation Table :

Marking on Standard Tape (mm)	Reading Observed by Automatic level sensor (mm)	Error (mm)
0	0.00	0.10
200.00	200.10	0.25
400.00	400.25	0.25
600.00	600.25	0.15
800.00	800.15	0.25
1000.00	1000.25	0.10

Maximum Error (% FS) : 0.03

Wiring colour code:

Wire colour	Signal
Red	+ 12 V (supply)
Black	0 V (supply)
Green	Output signal

Note: The Offset value should be observed at site and fed with opposite sign in the datalogger to obtain the output in mm.

Tested by :

11 WARRANTY

The Company warrants its products against defective workmanship or material for a period of 12 months from date of receipt or 13 months from date of dispatch from the factory, whichever is earlier. The warranty is however void in case the product shows evidence of being tampered with or shows evidence of damage due to excessive heat, moisture, corrosion, vibration or improper use, application, specifications or other operating conditions not in control of Encardio-rite. The warranty is limited to free repair/replacement of the product/parts with manufacturing defects only and does not cover products/parts worn out due to normal wear and tear or damaged due to mishandling or improper installation. This includes fuses and batteries

If any of the products does not function or functions improperly, it should be returned freight prepaid to the factory for our evaluation. In case it is found defective, it will be replaced/repaired free of cost.

A range of technical/scientific instruments are manufactured by Encardio-rite, the improper use of which is potentially dangerous. Only qualified personnel should install or use the instruments. Installation personnel must have a background of good installation practices as intricacies involved in installation are such that even if a single essential but apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

The warranty is limited to as stated herein. Encardio-rite is not responsible for any consequential damages experienced by the user. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Encardio-rite is not responsible for any direct, indirect, incidental, special or consequential damage or loss caused to other equipment or people that the purchaser may experience as a result of installation or use of the product. The buyer's sole remedy for any breach of this agreement or any warranty by Encardio-rite shall not exceed the purchase price paid by the purchaser to Encardio-rite. Under no circumstances will Encardio-rite reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

A lot of effort has been made and precaution for accuracy taken in preparing instruction manuals and software. However best of instruction manuals and software cannot provide for each and every condition in field that may affect performance of the product. Encardio-rite neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damage or loss that results from use of Encardio-rite products in accordance with the information contained in the manuals or software.

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