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Over 50 years of excellence through ingenuity

USERS' MANUAL

WIRELESS TILT METER

MODEL EAN-95MW

Doc. # WI 6002.116 Rev. 02| Oct 2020

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Declaration of Conformity

FCC Declaration of Conformity

FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

FCC RF Radiation Exposure Statement:

1. This Transmitter must not be co-located or operated in conjunction with any other antenna or transmitter.
2. This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment.
3. This equipment should be installed and operated with a minimum distance of 20cm between the radiator & your body.

Contents

1 INTRODUCTION

1.1 Wireless tilt meter overview

Encardio-rite model EAN-95MW wireless tilt meter is suitable for long term monitoring inclination and vertical rotation of structures. Continuous data logging and real-time monitoring helps to provide early warning in case of impending failure allowing time for corrective action to be taken or if necessary for safe evacuation of the area.

Tilt change in a structure may be caused by construction activity like excavation, tunneling or de-watering that may affect the ground supporting the structure. Change in tilt could also result from loading of the structure, such as loading of a dam during impoundment, loading of a diaphragm wall during excavation or loading of a bridge deck due to wind and traffic. Data from the tilt meter provides early warning of threatening deformations, allowing time for corrective action to be taken or if necessary for safe evacuation of the area.

1.2 Tilt meter applications

EAN-95MW tilt meter is widely used in following applications:

- Monitoring vertical rotation of retaining walls.
- Monitoring inclination and rotation of dams, piers, piles and other structures.
- Monitoring stability of structures in landslide areas.
- Monitoring tunnels for convergence and other movement.
- Monitoring safety of structures around zones of excavation or tunnelling.
- Monitoring deflection in bridges and struts under different loading conditions.

1.3 Wireless network

Wireless sensors are vital in monitoring construction sites, large structures and landslide areas. They are extensively used in applications where geotechnical and other sensors are used for data collection and transfer to a central server for access by multiple users. Encardio-rite offers an innovative network solution that allows real-time monitoring of not only wireless tilt meter but also other geotechnical and structural sensors in challenging conditions with reliable data transfer without any delay.

In an end-to-end wireless monitoring system from Encardio-rite, the tilt meters are interfaced with the long range, low power radio frequency network to **gateway**. The tilt meter sends recorded data to the gateway through the RF network with utmost reliability. The gateway then uploads the collected data from sensors to the central/cloud server.

The system operates on ISM sub 1 GHz operating frequency bands adjustable to requirement of each territory. The system can be adjusted to different frequency bands; for example:

India	865 – 867 MHz
Europe	868 MHz
USA/Canada/Singapore/Australia	915 MHz

A detailed reference for frequency bands allowed in different Countries is available at:

https://www.thethingsnetwork.org/docs/lorawan/frequencies-by-country.html

The gateway has provision to set the frequency band, depending upon the Country.

1.4 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 the regular text to draw the users' attention.

1.5 How to use this manual

This users' manual is intended to provide you with sufficient information for making optimum use of tilt meters in your applications.

To make the manual more useful we invite valuable comments and suggestions regarding any additions or enhancements. We also request to please let us know of any errors that are found while going through the manual.

NOTE: Installation personnel must have a background of good installation practices and knowledge of 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 best of instruction manuals cannot provide for each and every condition in field that may affect performance of the sensor. Also, blindly following the instruction manual will not guarantee success. Sometimes, depending upon field conditions, installation personnel will have to consciously depart from written text and use their knowledge and common sense to find solution to a particular problem.

Installation of a tilt meter requires expertise. It is recommended that potential users themselves practice all the operations laid down in this manual by repeated installations.

NOTE: The sensor is normally used to monitor site conditions and will record even a minor change that may affect behaviour of structure being monitored. Some of these factors amongst others, are, seasonal weather changes, temperature, rain, barometric pressure, nearby landslides, earthquakes, traffic, construction activity around site including blasting, tides near sea coasts, fill levels, excavation, sequence of construction and changes in personnel etc. These factors must always be observed and recorded as they help in correlating data later on and also may give an early warning of potential danger or problems.

2 GENERAL DESCRIPTION

2.1 Model EAN-95MW wireless tilt meter

Model EAN-95MW wireless tilt meter combines high precision Micro-Electro Mechanical System (MEMS) sensor with radio transmission network to provide accurate tilt data. The unit is mounted inside a compact weatherproof enclosure. The tilt sensor provides a bipolar DC voltage output proportional to the sine of tilt angle measured by the beam. The sensor gives 4 V nominal output at ± 15°. The output is zero volts for a truly vertical or horizontal position.

This output is transmitted through the long range, low power radio frequency network to the gateway without any signal degradation. Each unit is individually calibrated to provide high system accuracy and repeatability.

The tilt meter can be fixed to any vertical surface, horizontal floor or ceiling by means of suitable mounting accessories consisting of anchors (and brackets – optional). These are available separately when ordered.

The model EAN-95MW tilt meter is not intended for absolute determination of tilt of structures. It measures change in tilt of a structure to which it is attached. The initial tilt reading for each tilt sensor is recorded after it has been mounted on the structure to be monitored. Subsequent tilt readings will be displayed w.r.t. initial reading.

2.2 Model EWG-01 gateway

Encardio-rite model EWG-01 gateway is used as a main networking hardware, which uploads data gathered from all the tilt meters (or other geotechnical sensors) to the Encardio-rite cloud server or a third party server. The gateway enabled wireless network provides reliable data transfer over long distances, without any delay. The wireless system eliminates the need for running lengthy cables. This is especially useful at locations where sensors are distributed over a wide area and running cables to long distances can be tricky and risky.

The data is accessible 24 x 7 to all the stakeholders. With Drishti, a cloud-hosted data management and configuration software, the system can be programmed to generate automatic reports and provide automated alerts over SMS or email for any reading crossing the pre-defined alert levels.

With the real-time data collected from wireless tilt meters and gateway, information about the slightest of change taking place at specific location is available. This allows timely decisions, increased safety and also cost effectiveness.

2.3 System components

Provided by Encardio-rite

- Model EAN-95MW- wireless tilt meter with antenna
- Model EWG-01 Gateway with GSM antenna
- OTG cable type B
- Application software for Android Smartphone

To be arranged by Client

- Laptop
- Android smartphone
- Activated data SIM card (for Gateway)
- D-Cell Li-SOCl2 3.6 V 14 Ah batteries nominal Voltage - 2 no (1 no. each for tilt meter and Gateway)

3 SAMPLE TEST CERTIFICATE

TEST CERTIFICATE

(for 'A' axis calibration)

Item	:	Wireless Tilt meter	Date :	15.02.2020
Model	:	EAN-95MW	Temperature:	19 ºC
Range	:	±15º		
Serial no.	:	TM-xxxxxx		
Node ID	:	xxxx		

Next calibration due on : 14.02.2021

Test data

Test position Arc degrees (A)	SinA	*Calculated output (V_1)	**Ideal output (V_2)	Observed output (V_3)	Offset corrected output (V_4)	Error (V_4 - V_2)	Non-conformance % fs
		Volts	Volts	Volts	Volts	Volts	
15	0.2588	4.1408	4.1330	4.1280	4.1308	0.0022	0.053
12	0.2079	3.3264	3.3201	3.3150	3.3178	0.0023	0.056
9	0.1565	2.5032	2.4985	2.4930	2.4958	0.0027	0.065
6	0.1046	1.6728	1.6696	1.6650	1.6678	0.0018	0.045
3	0.0524	0.8376	0.8360	0.8340	0.8368	0.0008	0.019
0	0.0000	0.0000	0.0000	-0.0028	0.0000	0.0000	0.000
-3	-0.0524	-0.8376	-0.8360	-0.8370	-0.8342	0.0018	0.044
-6	-0.1046	-1.6728	-1.6696	-1.6700	-1.6672	0.0024	0.059
-9	-0.1565	-2.5032	-2.4985	-2.4980	-2.4952	0.0033	0.079
-12	-0.2079	-3.3264	-3.3201	-3.3230	-3.3202	0.0001	0.002
-15	-0.2588	-4.1408	-4.1330	-4.1380	-4.1352	0.0022	0.053

Max non-conformance (% fs) : 0.08

Sensor gauge factor 'A' Axis : 15.970 Volts/Sin(90)

Calculation of tilt value (arc degree) :

SinA = Observed output / gauge factor

A = Sin^{-1}(observed output / gauge factor)

Note :

* Calculated output Voltage (V_1) worked out based on nominal gauge factor of 16.000 V/g (i.e. 16 V X Sin A).

** Ideal output Voltage (V_2)' calculated from sine curve passing through sensitivity calibration points (@ ±15º)

Tested by :

TEST CERTIFICATE
(for 'B' axis calibration)

Item	:	Wireless Tilt meter	Date :	15.02.2020
Model	:	EAN-95MW	Temperature :	19 ºC
Range	:	±15º		
Serial no.	:	TM-xxxxxx		
Node ID	:	xxxx		

Next calibration due on : 14.02.2021

Test data

Test position Arc degrees (A)	SinB	*Calculated output (V_1) Volts	**Ideal output (V_2) Volts	Observed output (V_3) Volts	Offset corrected output (V_4) Volts	Error (V_4 - V_2) Volts	Non-conformance % fs
15	0.2588	4.1408	4.1435	4.1650	4.1420	0.0015	0.036
12	0.2079	3.3264	3.3286	3.3520	3.3290	0.0004	0.010
9	0.1565	2.5032	2.5048	2.5320	2.5090	0.0042	0.101
6	0.1046	1.6728	1.6739	1.7000	1.6770	0.0031	0.075
3	0.0524	0.8376	0.8381	0.8650	0.8420	0.0039	0.093
0	0.0000	0.0000	0.0000	0.0230	0.0000	0.0000	0.000
-3	-0.0524	-0.8376	-0.8381	-0.8180	-0.8410	0.0029	0.069
-6	-0.1046	-1.6728	-1.6739	-1.6530	-1.6760	0.0021	0.051
-9	-0.1565	-2.5032	-2.5048	-2.4820	-2.5050	0.0002	0.004
-12	-0.2079	-3.3264	-3.3286	-3.3070	-3.3300	0.0014	0.035
-15	-0.2588	-4.1408	-4.1435	-4.1220	-4.1450	0.0015	0.036

Max non-conformance (% fs) : 0.10

Sensor gauge factor 'B' Axis : 16.010 Volts/Sin(90)

Calculation of tilt value (arc degree) :

SinB = Observed output / gauge factor

B = Sin^{-1}(observed output / gauge factor)

Note :

* Calculated output Voltage (V_1) worked out based on nominal gauge factor of 16.000 V/g (i.e. 16 V X Sin A)

** Ideal output Voltage (V_2)' calculated from sine curve passing through sensitivity calibration points (@ ±15º)

.

Tested by :

4 PRE-INSTALLATION PREPARATIONS

4.1 Pre-installation checks

- Check the tilt meter and gateway for any physical damage.
- Open the tilt meter box and check if the internal wiring is intact.

4.2 Setting up the Gateway and Tilt meter location

Settling up correct locations for Gateway and tilt meter is important, especially in case more than one tilt meter are being installed at site and connected to single gateway. The first step is to install the Gateway at a location that is in line of sight with all the installed tilt meters or in line of sight with most tilt meters. The best location will have to be determined at the site itself. For best results, the link between the gateway and the tilt meter should be strong, preferably better than -100 dBm. If it is not strong i.e. less than -100 dBm, use a **relay node** at an appropriate location (between tilt meter and gateway) to get to a signal strength better than -100 dBm. A two way switch is provided on the node to switch it to a single hop position. For best results, please ensure that the link between the relay node and the tilt meter is also stronger than -100 dBm. Please note, the stronger the link (-95 dBm or -90 dBm) the better will be the results.

NOTE: Refer to user's manual # WI6002.117 on gateway for details on how to determine signal strength at any location. If signal strength is not good, a relay node should be added between the gateway and the sensor. For details on relay node, please contact factory.

4.3 Setting up the Gateway

NOTE: For setting up and configuring the gateway, refer to user's manual # WI6002.117 on gateway.

5 INSTALLATION PROCEDURE

5.1 Tilt meter installation

The model EAN-95MW tilt meter (biaxial) is used to measure rotation of structures in the plane parallel as well as perpendicular to the surface/wall on which the tilt meter is mounted.

- The tilt meter box is provided with mounting holes as in figure below.

Figure 5-1 Model EAN-95MW wireless tilt meter

- For installing the tilt meter on wall, mark locations of the four mounting holes. Ensure that position of the holes are aligned vertically using a spirit level.
- Drill holes depending on the mounting fasteners being used for fixing the tilt meter and fix the tilt meter on wall ensuring its vertical position. (Do not close the box before configuring it. Configuration details are given in next section)

NOTE: For installation of Gateway, please refer to users' manual # WI 6002.117 on Gateway.

6 CONFIGURING TILT METER

1. Install the apk file (provided with the supply) for "Encardio Rite" app on the phone. App shortcut will be available in the list of application software, as shown below (left figure).
2. Connect the Android phone to the '*EnRite_Beam_DAC0'* Gateway Wi-Fi network. The password is *adminadmin.*

NOTE: Refer to the users' manual # WI 6002.117 on Gateway to learn how to switch on the EnRite_Beam_DAC0 Gateway Wi-Fi network.

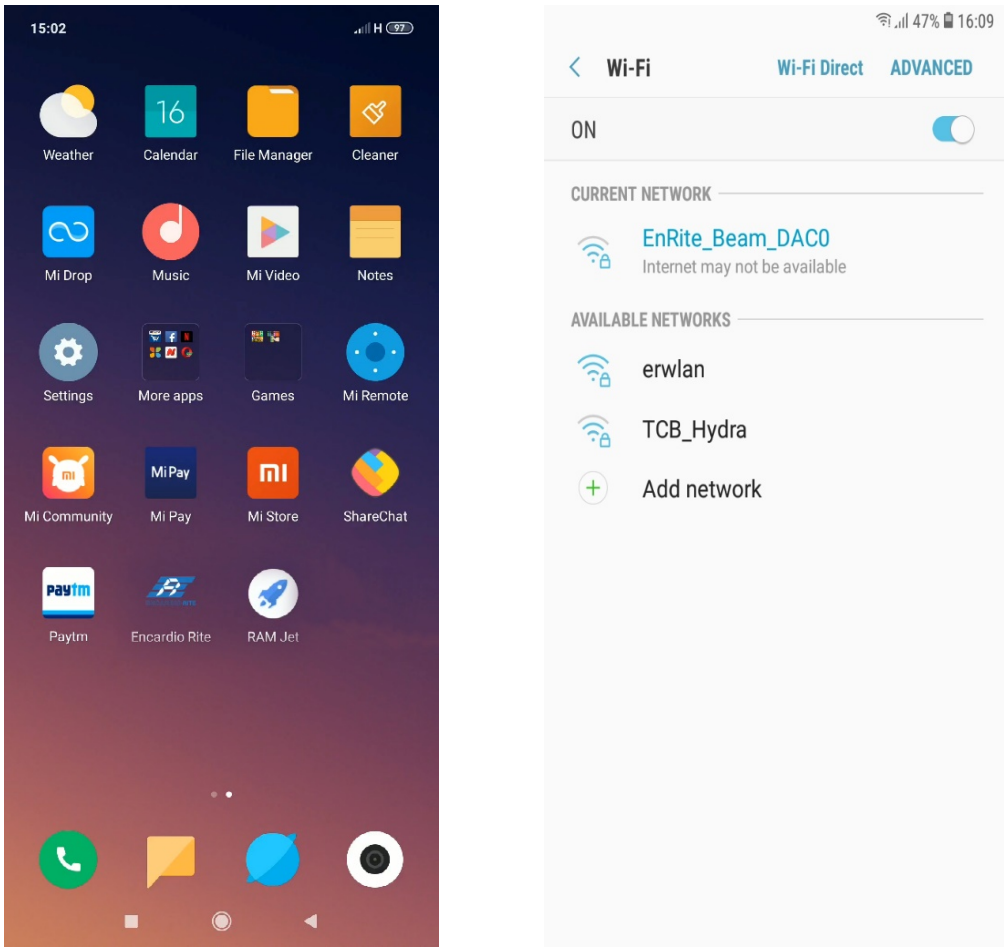

Figure 6-1

3. Connect the Smartphone to tilt meter's RF node using the OTG adaptor provided with supply, as shown in figure below

CAUTION: Please make sure the tilt meter's RF node is switched off before connecting to the phone.

Figure 6-2 Tilt meter connected to Android phone with USB cable via OTG adaptor

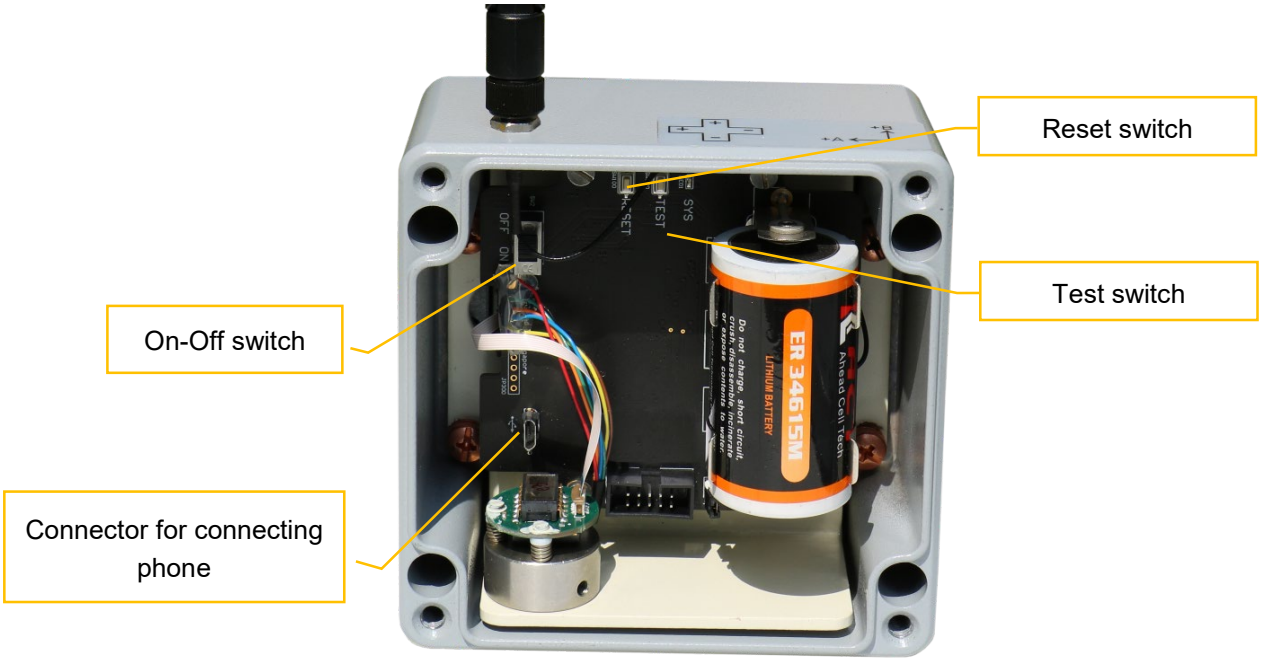

Figure 6-3

4. Switch on the Node with On-Off switch as shown in figure 6-3 above.

5. Open the 'Encardio Rite' app by clicking the Software Icon (extreme left screenshot in figure below). Screen as shown in the middle screenshot will appear. Click on 'Start' button. A prompt window will appear as shown in the extreme right screenshot in figure below, asking to access the USB device. Tick the circle (for 'Use by default for this USB device') and click on OK.

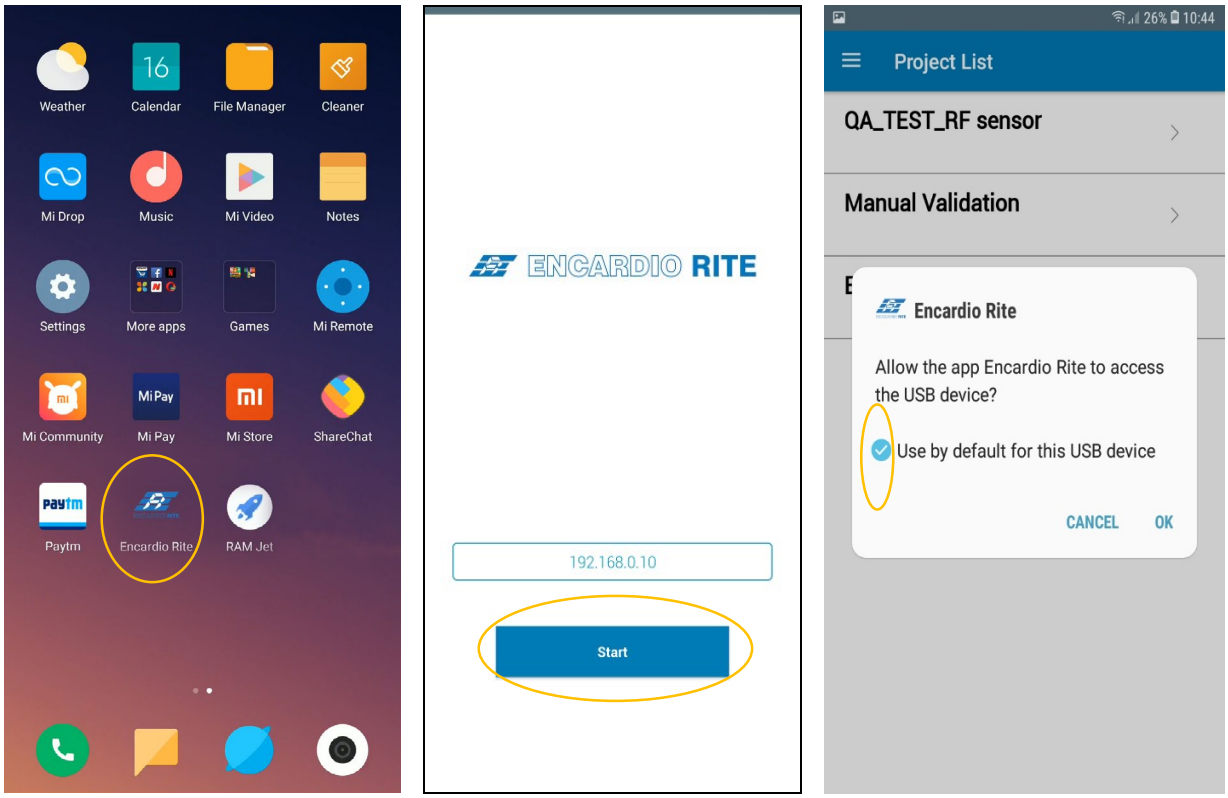

Figure 6-4

NOTE: Add the tilt meter (i.e. it's RF node) and create the project first before you commission the tilt meter. Please refer to 'Setting up the Gateway' section in the users' manual # WI 6002.117 for Gateway for creating project.

6. Once the 'Encardio Rite' app opens, the project already created (while configuring Gateway) can be seen. Select the project and click the download button (shown in figure below) to download the project.

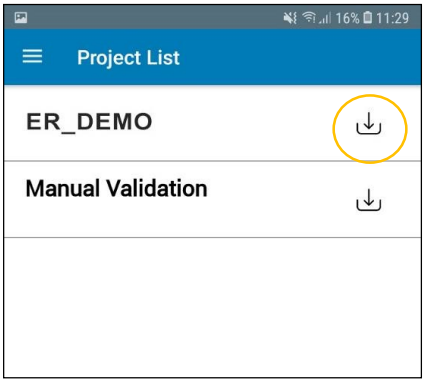

Figure 6-5

7. Once downloaded, enter the project. Screen showing project details can be seen as shown in the left figure below. Press "Reset" button on the Node (as shown in figure 6-3). Now click on "Pair Node" on the menu (figure 6-6).

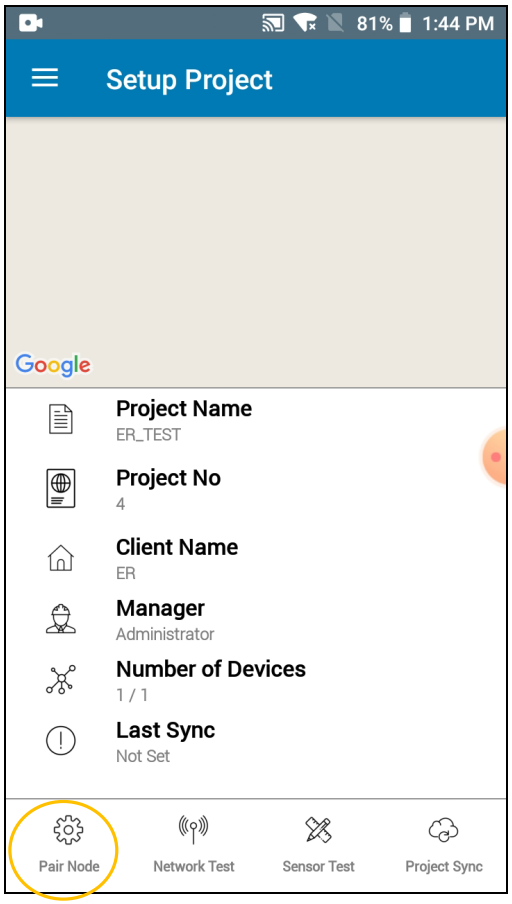

Figure 6-6

NOTE: If the connection is unsuccessful, press "Reset" button on Node and connect again by clicking on 'Pair Node'.

8. Once connection is done by clicking on 'Pair Node', the app will show connected node information on "Node Setup' screen as show in figure below.

NOTE: **Optional Step:** If "**Relay**" function is to be deployed, click on "Wireless Mesh" toggle button to enable i.e. in case the Node needs to be used as a relay node (as shown in right side figure below).

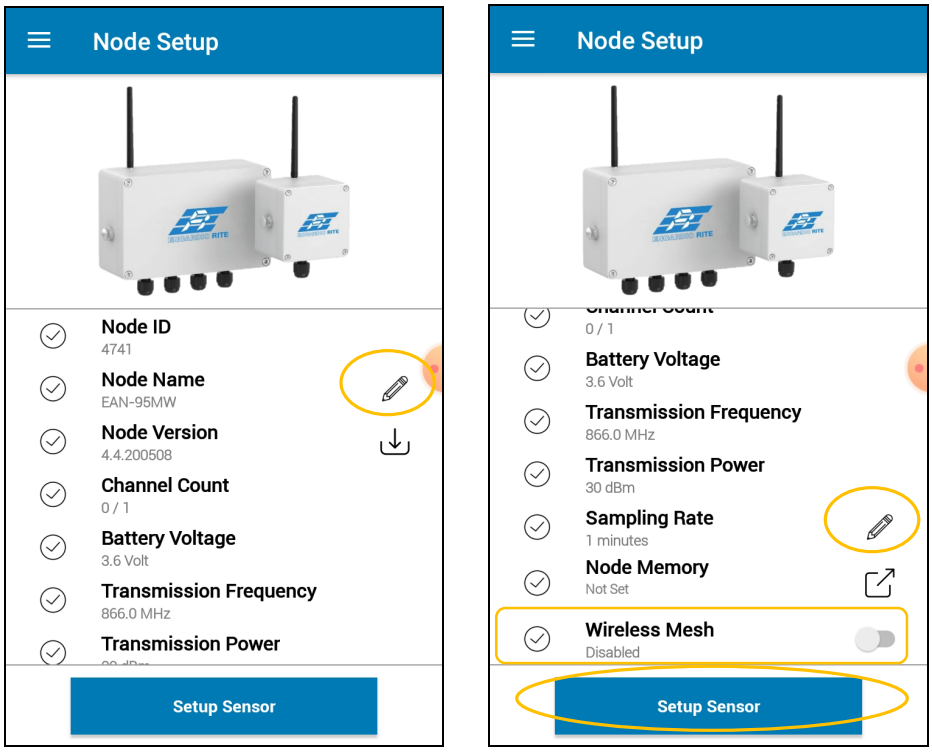

Figure 6-7

9. In case required, the 'Node Name' and 'Sampling Rate' inputs can be edited here by clicking on the pencil icon. Setting Sampling Rate is shown in figure below. Please note that the sampling rate should be set between 1 minute to 2 hours. Factory setting is 2 hours.

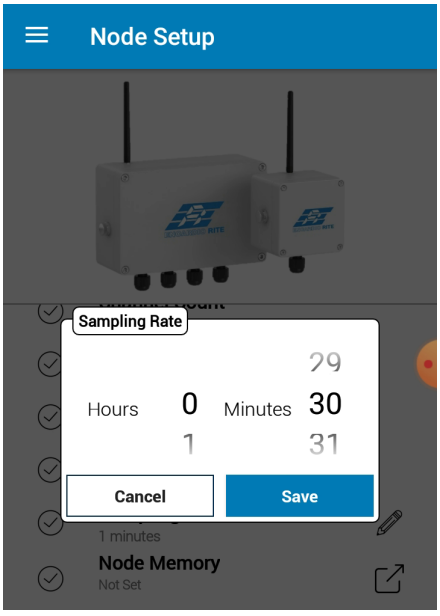

Figure 6-8

10. Once done, click on 'Setup Sensor' button to configure the sensor settings as explained in next section.

6.1 Sensor (tilt meter) settings

1. Sensor setting can be made as follows:

Sensor Code: Your desired sensor name.
Sensor Type: Select respective sensor type.
Parameters: Turn on the parameters as connected to the Node.
Excitation: Set the warm up time required for the sensor (for tilt meter, it can be set as 5 seconds).
Excitation Voltage: Select 24 (for tilt meter)

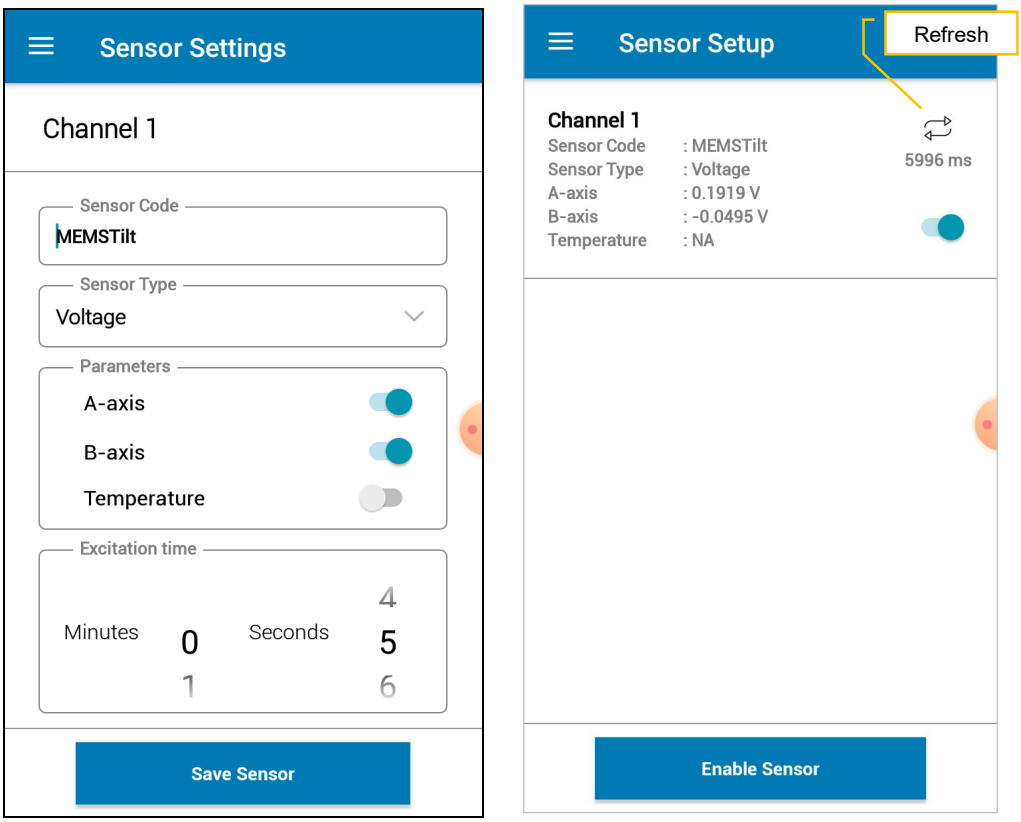

Figure 6-9

2. Click on 'Save Sensor'. The Node will now read the configured sensor, displaying the sensor readings, as shown in figure on the right above.
3. To get another reading (in case more than one sensor is connected), click on the refresh button (shown in the right side screenshot in figure above).
4. Once the tilt meter is configured, click on "Enable Sensor" as shown in the right side screen in figure above. "Scanning Network" function will operate, which will scan the wireless signal strength (RSSI) between the Tilt meter's RF node and Gateway (as shown in figures below).

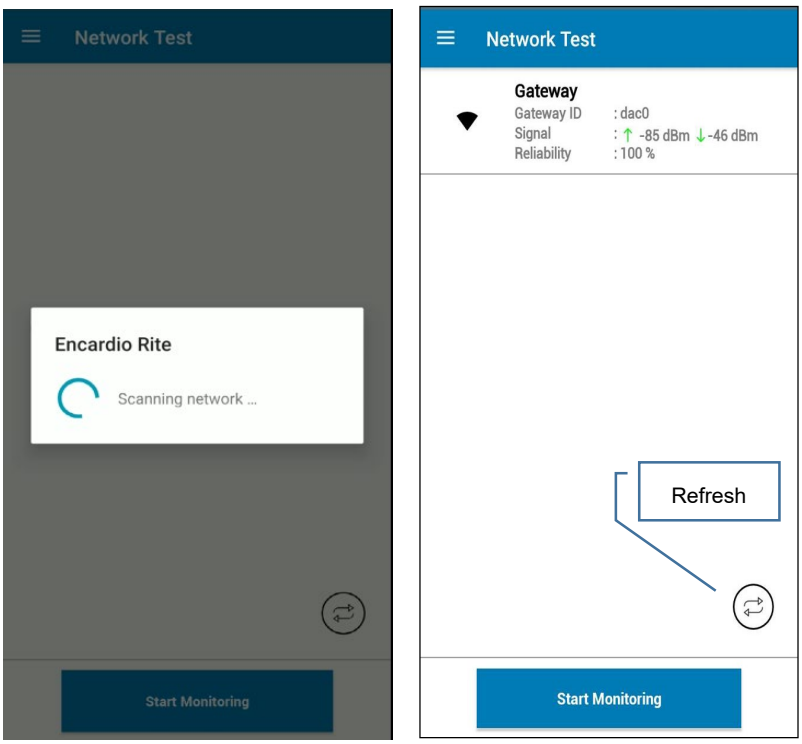

Figure 6-10

5. After receiving the Network Test information, if required, another network test can be performed by pressing the 'Refresh' button located at the lower right corner, as shown in the right side screenshot in figure above.

6. Next, click "Start Monitoring" button (shown in the right side screenshot in figure above). The app will prompt, "Node commissioned" as shown in left side screenshot in the figure below. Click OK.

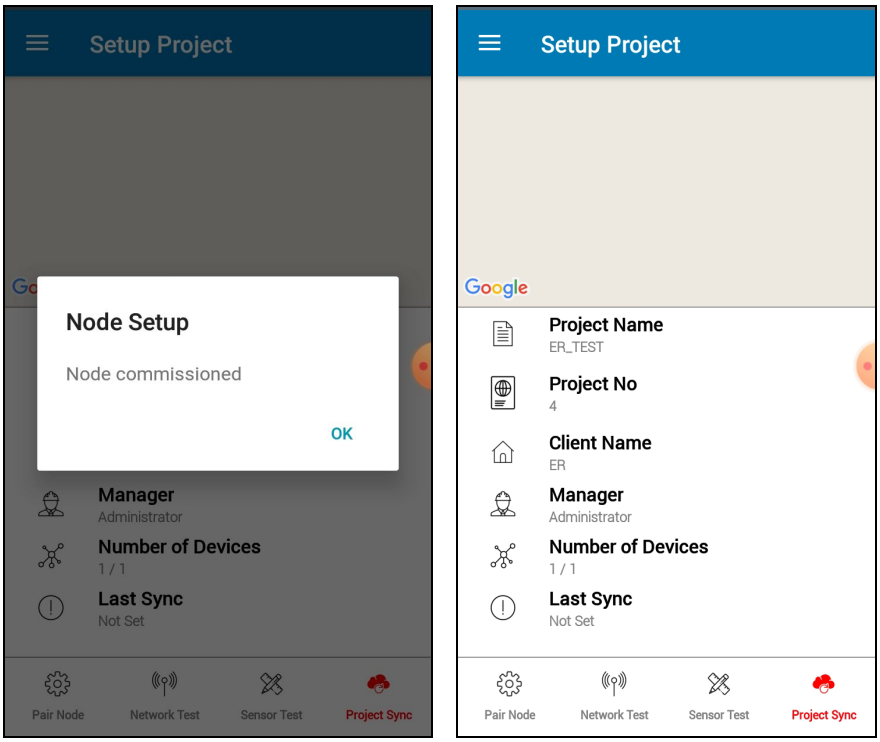

Figure 6-11

7. Press the 'Project Sync' button at the bottom right of screen to send all the configuration information back to the gateway (shown in the right side figure above).
8. To test, press the "TEST" button provided in tilt meter (shown in figure 6-3). The Node will immediately send a reading to the Gateway.
9. Tilt meter's RF node configuration is now complete. Close the tilt meter box.
10. The field engineer can now leave the site. The remaining configuration/changes can be done with the Gateway software dashboard on laptop by selecting the related project. The commissioned devices can be now seen under "Device Summary" Section.

NOTE: Refer to users' manual # WI6002.117 on Gateway and the test certificate provided with the tilt meter to put the gage factor and final configuration of the tilt meter for taking readings.

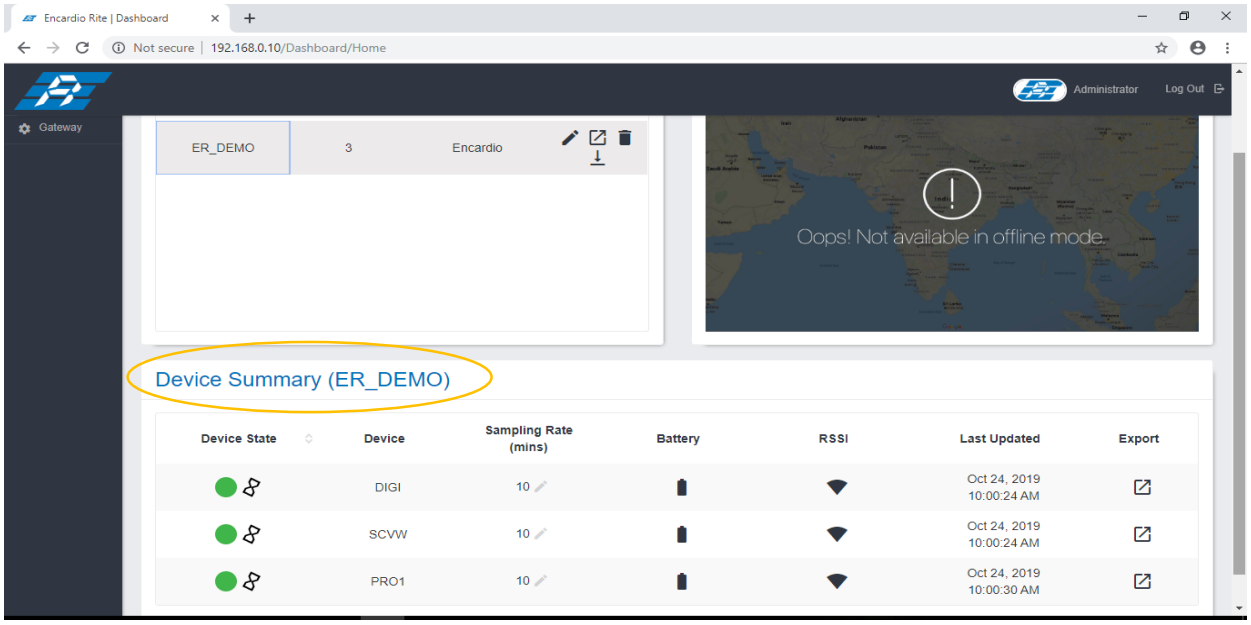

Figure 6-12

6.1.1 *Protection of tilt meter*

Avoid installation of tilt meter in parts of the structure exposed to direct sunlight. If this is not feasible, a box made from Thermocole or similar heat insulating material should be installed covering the tilt meter and protecting it from direct sunlight.

If certain degree of mechanical protection is also required, wooden or fibreglass protection boxes may be considered. Heat insulating tape can be fixed to the inner surface of such boxes for thermal insulation.

6.1.2 *Other considerations*

Install tilt meter on a structural member of a building and not on the façade or boundary wall which may behave in a different manner than the main building. Do not install it at a location having vibrations, for example caused by a heavy rotary machinery. Avoid installing at location where it can be vandalized or get hit by pedestrians.

7 MEASUREMENT OF TILT

The output of model EAN-95MW tilt meter is transmitted via mesh wireless (RF) network. The tilt meter is interfaced with the long range, low power wireless mesh network that allows tilt meter to send recorded data to the Gateway. The Gateway then uploads all the collected sensor data to the central/cloud server.

The data management and application software is provided with the supply to configure and manage the tilt meter data.

7.1 Sign convention

Carefully orient the tilt sensor during installation. A (+) sign is on the top right side of the enclosure. If the enclosure is tilted counter-clockwise then readings show an increase (with positive sign) as shown in figure 7-1 (left). If the enclosure tilts clockwise then readings show a decrease (with a negative sign) as shown in figure 7-1 (right).

If the tilt meter is installed on the plane of a building, the B (+) sign is towards the plane and B (-) sign is away from the plane.

Figure below shows view from side and convention used for direction/output signal polarity. After the enclosure is fixed to the structure, the sensor is adjusted to the zero reading (initial). Subtracting the initial tilt reading from the subsequent tilt reading gives change in tilt of structure over a period of time.

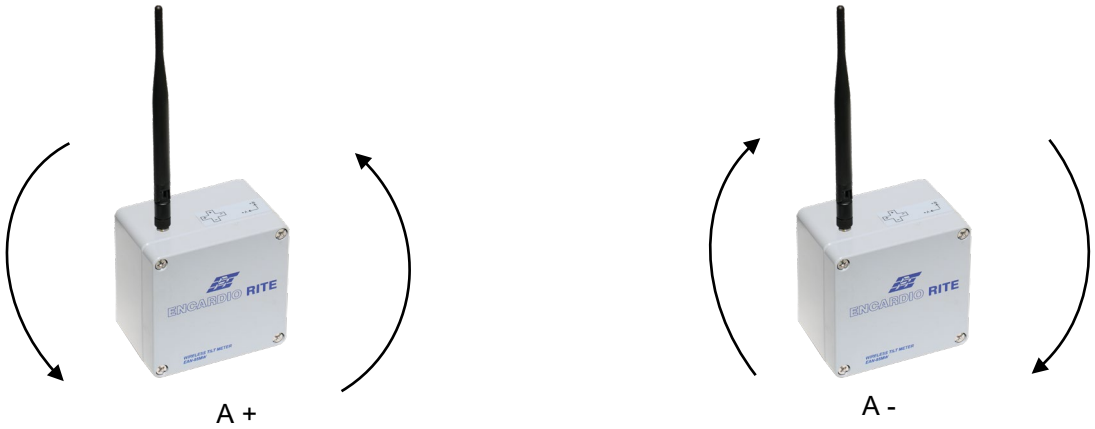

Figure 7-1 Sign Convention of tilt for EAN-95MW tilt meter

7.2 Environmental factors

Several factors can influence the behavior of the structure being monitored for change in tilt using the tilt meter. Having a knowledge of the factors influencing the behavior of the structure is essential for analyzing the tilt meter data. Data related to factors such as rain fall, tidal or reservoir levels, excavation or fill levels, construction activities nearby the structure, movement of traffic near the structure and its type, wind, ambient temperature, barometric pressure etc. should also be observed and collected along with the tilt meter data.