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USERS' MANUAL

VIBRATING WIRE INDICATOR

MODEL EDI-54V (Revision 0)

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Disclaimer

Although the best effort has been made to ensure the completeness and accuracy of the information provided in this document, Encardio Rite instruments reserves right to change the information at any time and has no liability for accuracy.

List of Abbreviations

CSV	Comma Separated Values
LED	Light Emitting Diode
PC	Personal Computer
USB	Universal Serial Bus
VRLA	Valve Regulated Lead Acid
EDI-54V	Vibrating Wire Indicator

Introduction about the Manual

Purpose of this document

The purpose of this document is to show the entire functionality of the application for the device EDI-54V. Please refer to Introduction section to know about the application.

This document serves as a help guide by showing the workflow of the entire processes. The document guides its user by providing a clear idea about how things have to be done in the application. All efforts have been made to clarify each and every step.

What the manual contains

The document is designed to provide step-by-step guidance using actual screenshots from the application.

How to Use the Manual

The document is intended to guide the user in a step-by-step manner starting from installing the application, accessing the application, taking the readings, viewing the plots. The screenshot guides to complete the task.

Installation of Battery

Warning !!
In overseas supplies, EDI-54V Vibrating Wire Indicator is dispatched without the battery due to custom restrictions. Instructions below are described to install the battery in the EDI 54V VW Indicator box

Procedure for fixing battery inside EDI-54V indicator

- Remove the four screws from the front panel of the EDI-54V Indicator using the screw driver (figure 1)

Figure 1

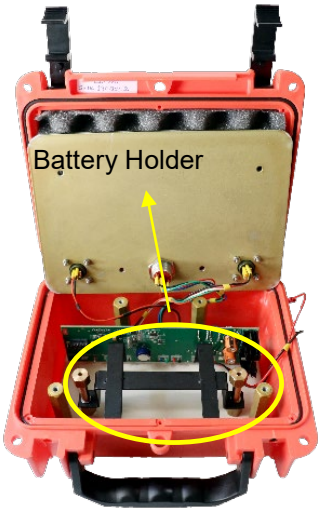

Figure 2

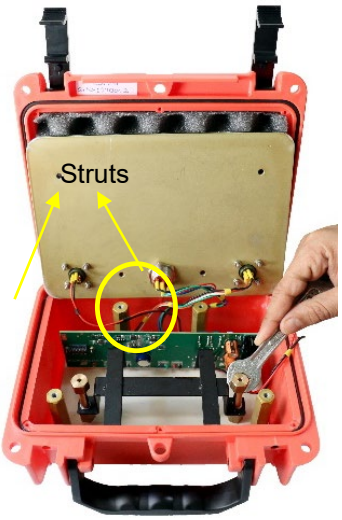

Figure 3

- Carefully lift up the front panel, ensuring the connector wires connected with the PCB are not disturbed and undamaged.(figure 2)
- Use Spanner (Size 13) to open up the struts mounted in the Indicator box (to hold the battery holder) (figure 3).
- Carefully lift the battery holder along with the connected PCB (figure 4).

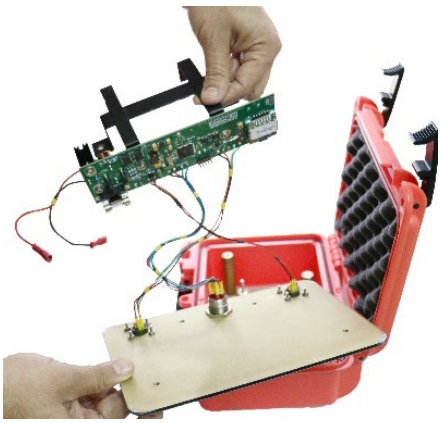

Figure 4

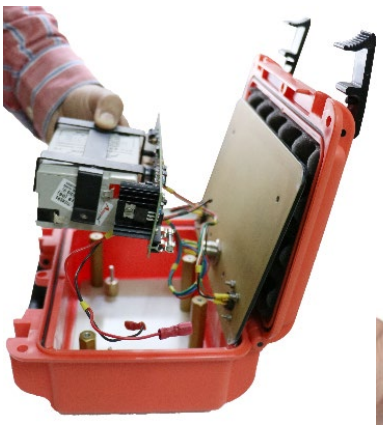

Figure 5

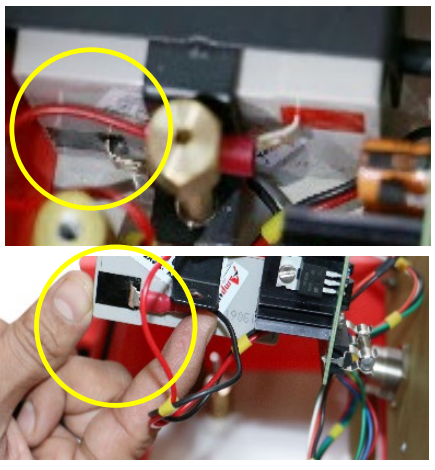

Figure 6

CAUTION: Do not stretch or pull the battery holder or the front panel apart,else it will damage the wiring.

- Place the battery in the battery holder ensuring the Positive terminal (Red) to be on the top end and Negative terminal (Black) facing down (figure 5).
- Plug in the black wire to the negative (black) battery terminal (figure 6).
- Place the battery along with the battery holder in between the strut slot (figure 7).

Figure 7

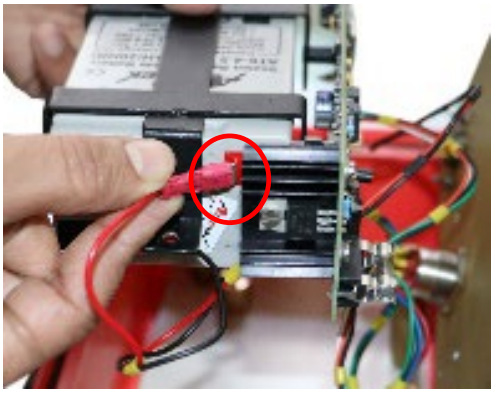

Figure 8

Figure 9

- Place the washer and spring washer on top of the battery holder holes.
- Insert the left side strut and tighten it with the spanner (size 13).
- Plug in the red wire to the positive (red) battery terminal (figure 8).
- Insert the right side strut and tighten it with the spanner (size 13) (figure 9).
- Place the front panel on the top of box and tighten the screws in the holes (figure 10 & figure 11)
- Switch the Indicator by pressing POWER ON button to verify the working of the digital indicator.

Figure 10

Figure 11

Battery Charging and care of Rechargeable Batteries

Warning !!
Always maintain VW Indicator battery in charged condition. Failure to do so will cause premature battery failure. A battery which gets damaged due to non-compliance with the instructions given below is not covered by our standard warranty and is also not eligible for free servicing

Indicator's battery

The EDI-54V Vibrating Wire Indicator uses a removable sealed rechargeable VRLA maintenance free battery as a power source. A separate battery charger unit operating from universal AC mains supply is supplied with each ESD-54V system. This battery charger operates from 90 to 270 V AC, 50 or 60 Hz which makes it suitable for operation from AC mains available throughout the world.

A fully discharged battery needs 6 hours of charge to get fully charged. A partially discharged battery will require proportionately less time but the time is difficult to calculate. As soon as the battery is fully charged the charging current gets automatically reduced to a safe value.

On receiving the EDI-54V system for the first time recharge the battery for 6 hours using the supplied mains powered battery charger.

If the EDI-54V is not going to be used for more than 30 days, fully charge the battery before storing the VW Indicator. Also fully charge the battery before use if the VW Indicator has not been used for more than 30 days.

If the data logger is not going to be used for more than 30 days, recharge the battery at least once every 30 days or so.

When battery voltage is showing 5.9 V in system information screen (at Readout unit) it means approximately 10 percent of battery capacity is left. Fully recharge the battery at the first opportunity.

Turn off mains AC supply to the charger before connecting to or disconnecting charger from the VW Indicator.

The rechargeable battery needs replacement every 3 to 5 years (irrespective of hours of use). Replace battery with AMPTEK AT6-4.5 or an equivalent from another manufacturer.

Phone's Battery

The EDI-54V VW Indicator uses a Smart Phone as a readout unit that has an internal sealed rechargeable Li-ion maintenance free battery as a power source. A separate battery charger/adaptor unit for the smart phone, operating from universal AC mains supply is supplied with each EDI-54V Indicator unit. This battery charger operates from 90 to 260 V AC, 50 or 60 Hz which makes it suitable for operation from AC mains available throughout the world.

On receiving the Readout unit for the first time discharge the battery fully and then recharge the battery for 2 hours using the supplied mains powered battery charger.

If the smart phone is not going to be used for more than 30 days, fully charge the battery and switch OFF the phone before storing the phone. Also fully charge the battery before use if the phone has not been used for more than 30 days.

Contents

1 INTRODUCTION

The Vibrating Wire Indicator unit is a microprocessor based indicator for use with Encardio-rite's range of Vibrating Wire Transducers. It can display the measured frequency in terms of time period, frequency or the value of the measured parameter directly in proper engineering units. It uses a smart phone with Android OS as readout having large display with capacitive touch screen which makes it easy to read the displayed VW sensor readings.

The EDI-54V indicator can store calibration coefficients of more than 10,000 vibrating wire transducers so that the value of the measured parameter from these transducers can be shown directly in proper engineering units. The user does not have to refer to look up tables or manually calculate the parameter values.

For transducers with a built in interchangeable thermistor, it can also display the temperature of the transducer directly in degree Centigrade or Fahrenheit.

The indicator has an internal non-volatile memory with sufficient capacity to store about 5,25,000 readings while scanning from any of the programmed transducer. Each reading is stamped with the date and time the measurement was taken.

EDI-54V is also has data logging feature and can be used as an automatic single channel Datalogger also. Readings can be stored either manually by accepting reading from reading screen or can be stored automatically by running scheduled scan.

The stored readings can be downloaded from Indicator's memory into Readout unit (Android Phone) by selecting download option. Logger records can be extracted in CSV file format.

Since readout unit is a mobile phone, most of the people are familiar with its operation. Working with readout unit is very easy and user friendly. It is as easy as we play games on mobile phone.

An internal 6V rechargeable sealed maintenance free battery is used to provide power to the indicator. A fully charged new battery provides nearly 100 hours of operation on a single charge. A separate universal battery charger is provided with the EDI-54V indicator to charge the internal battery from any AC mains supply.

The EDI-54V indicator is housed in a splash proof plastic moulded enclosure with weather proof connectors for making connections to the vibrating wire transducer and the battery charger.

Power ON/OFF push button cum status indicator has multifunction. Different status like Battery charging status, Bluetooth Modem status, Sensor scanning etc. can be easily recognized by viewing indicator's blinking speed or counts.

TRADEMARKS:

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2 OPERATING PRINCIPLE

The application is designed in a very user friendly manner which can be operated very easily for downloading of the data and analyzing the readings. Even users with little experience with Geotechnical Instruments can connect, download data and change settings as and when required.

2.1 Vibrating wire transducers

The vibrating wire transducer basically consists of a stretched music wire, one end of which is fixed to the transducer body and the other end is connected to a diaphragm (generally) which is acted on by the physical force to be measured.

The natural frequency of vibration, also known as the resonant frequency, of this stretched wire is proportional to the square root of the strain level in the wire provided other factors are held constant.

Mathematically we can also express this as:

$\varepsilon = k(1/T^2)$ micro strain

where ε is strain in the stretched wire in micro strains, T is the time period of vibration frequency and k is a proportionality constant.

If the strain level in the wire is increased (say, by stretching) or decreased, its natural frequency will also decrease or increase accordingly. The difference in the two strain levels will then be given by

$\delta\varepsilon = k[(1/T_2^2) - (1/T_1^2)]$ micro strain or we can also write this as

$\delta\varepsilon = k[(1/T_2)^2 - (1/T_1)^2]$ micro strain

where $\delta\varepsilon$ is the change in strain in wire, T_1 is the time period of vibration frequency of the wire before and T_2 the time period after the change.

So a vibrating wire transducer is basically a strain gage. However, we can design the transducer so that the physical parameter to be measured acts in such a way that the strain in the wire is affected in a known way. If the strain level in the wire changes linearly with the physical parameter we have

$X = C \times k[(1/T_2)^2 - (1/T_1)^2]$

where, X is the value of the parameter in engineering units and C is again a proportionality constant. We can now combine C and K together to form a new proportionality constant, say K, and write

$X = K[(1/T_2)^2 - (1/T_1)^2]$ … [Eqn. 1]

The relationship between frequency (f) and time period (T) is $f = 1/T$

so we can rewrite equation [1] as

$X = K(f_2^2 - f_1^2)$ … [Eqn. 2]

where, f_1 is reference frequency of vibration and f_2 is frequency of vibration after the change in strain in wire.

In the above two equations the term 'K' is called "Linear Gage Factor" and 'f_1' is called "Reference Frequency".

The EDI-54V indicator measures the time period and calculates the frequency, frequency^2 and the parameter value directly in engineering units. To calculate the parameter value in engineering units the "Gage Factor", "Reference Reading" and the "Units of measurement" has to be entered in the indicator memory for each transducer individually. "Reference Reading" has to be entered in terms of 'digits' that is equivalent to the square of reference frequency divided by 1000 (1 digit = 1000 Hz^2).

The "Gage Factor" and "Reference Reading" are referred to as the calibration coefficients for that particular vibrating wire transducer throughout this manual.

2.2 Non-linearity correction using polynomial calculation

It was mentioned in section 3.1 above that the strain level in the stretched wire is proportional to the square of the resonant frequency of the wire. It was also assumed that most vibrating wire transducers are so designed that a change in value of the physical parameter being measured causes the strain level in the wire to change linearly. However, this assumption is not true if a very high level of accuracy is desired (i.e. at higher resolutions the relationship does become significantly non-linear).

If errors due to repeatability and hysteresis of any non-linear transducer is smaller than the desired accuracy limits then polynomial calculation method can be used to calculate the parameter value to a better accuracy than that possible using a linear approximation.

For example, if a piezometer has a non-linearity error of say 0.3% using a linear approximation it may be possible to get an accuracy better than 0.1% using polynomial calculation provided errors due to its repeatability and hysteresis is less than 0.05%.

A second order polynomial takes the form

$Y = AX^2 + BX + C$ [Eqn. 3]

where, in our case, X is the square of the measured transducer frequency and Y is the value of the measured parameter in engineering units. A, B and C are three polynomial constants generally provided by the transducer manufacturer. These constants are determined by the transducer manufacturer during calibration of the transducer.

In EDI-54V the variable X is written in terms of the square of the measured frequency divided by 1000, known as 'digits'. That is

1 digit = $1000\ Hz^2$

A fifth order polynomial takes the form

$Y = A_5 f^5 + A_4 f^4 + A_3 f^3 + A_2 f^2 + A_1 f + A_0$ [Eqn. 4]

where, f is the measured transducer frequency and Y is the value of the measured parameter in engineering units. A_5, A_4, A_3, A_2, A_1 and A_0 are three polynomial constants generally provided by the transducer manufacturer. These constants are determined by the transducer manufacturer during calibration of the transducer.

2.3 Vibrating wire frequency measurement

The EDI-51V indicator basically measures the time period of the resonant frequency of the stretched wire inside the Vibrating Wire Transducer. The stretched wire inside a vibrating wire transducer does not vibrate on its own. It has to be plucked or excited to start the vibrations which then die down over a period of time (generally within a few hundred milliseconds).

Vibrating wire transducers are supplied either with an internal or an external magnet coil assembly. This magnet coil assembly is used for plucking (or excite) the wire and also to detect the vibration frequency of the wire. This magnet coil is referred to as the sensor coil.

EDI-54V indicator first excites the wire with a square wave signal whose frequency varies from say 500 Hz to 6000 Hz over a period of 0.1 seconds (Please check the Specifications section in this manual for correct values). This causes the wire to start vibrating at its own natural vibration frequency also known as the resonant frequency. The vibrating wire crosses the magnetic field of the magnet coil sensor which in turn induces a very small AC voltage across the coil terminals. The amplitude of this voltage depends on the amplitude of the vibrating wire and the frequency is same as the resonant frequency of the wire. As the amplitude of the vibrating wire dies down so does the signal voltage across the coils. For this reason the wire has to be excited by the indicator at periodic intervals which is generally in the range of 1 to 2 seconds.

The indicator amplifies the weak signal output from the sensor coil and converts it to a square wave. It then counts the number of cycles 'm' of a precision clock signal with a time period 't' over 'n' cycles of the vibrating wire frequency.

The time period of a single cycle of the resonant frequency of the wire is given by

$T = (m \times t) / n$

The frequency, $frequency^2$, $frequency^3$, $frequency^4$, $frequency^5$ and engineering units values are then computed by the internal microprocessor of the indicator from this value.

2.4 Thermistor temperature sensor

Many vibrating wire transducers are supplied with an internal thermistor for sensing the transducer temperature. Transducer temperature is required either to correct errors due to temperature dependence of the parameter values measured by the transducer or simply to sense the temperature of the surroundings of the sensor and save the cost of an additional temperature sensor.

The resistance of a thermistor varies in a predictable manner with temperature. However, the variation of the resistance with temperature is very non-linear. By measuring the resistance of the thermistor, the value of the temperature can be found out either from standard lookup tables or using a polynomial calculation.

Most manufacturers, including Encardio-rite, use an interchangeable thermistor type in their transducers which has a value of 3000 ohms at 25°C. Once the indicator is calibrated for any one thermistor the calibration is valid for all transducers.

The EDI-54V indicator measures the resistance of the thermistor by passing a known current through the thermistor and measuring the voltage developed across the thermistor. It then calculates the resistance and converts it to degrees Centigrade which is shown on display.

3 GETTING STARTED

3.1 Readout Unit

The EDI-54V Vibrating Wire Indicator uses a Mobile Phone as a Readout unit. The Phone running on Android operating system provides a powerful platform to manage applications efficiently. It has many features like phone calls, SMS, MMS, GPRS/3G/4G, Wi-Fi, Bluetooth, USB and high resolution Camera. User can use it as mobile phone for making calls. It has GPRS/3G/4G which enables user to access internet from site. Wireless Bluetooth can be used to send files to PC or any other Bluetooth device. High resolution camera can be helpful to take site conditions photographs and send them to the back office by sending MMS. It has an internal storage memory of 8GB or more that can store a large amount of data. Data backup can be taken on regular basis by connecting phone with PC through USB cable.

Fig 3-1: Readout

3.2 System requirements

The EDI-54V application runs on Android Smartphone. The mobile phone specifications are:

Mobile OS	-	Android version 2.2 or above
RAM	-	512MB (Recommended 1GB).
Storage memory	-	2 GB or above
Display size	-	480x800 or 720x1280 or 1080x1920 pixels
Display Type	-	Touch screen
CPU Speed	-	1 GHz or Above
Blue tooth	-	Version 3.0 or Above

3.3 Using the readout unit

The VW Indicator software running on phone can take vibrating wire sensor readings and store them into memory. VW Indicator software has ability to show sensor logs in tabular format and create plots of sensor data instantly after sensor reading is complete. Sensor data files are created automatically while saving sensor log. These files can be extracted from software database when needed. Sensor data files can be uploaded to remote server through mobile phone internet connection via GPRS/3G/4G/Wi-Fi.

3.4 Establishing Bluetooth connection

VW Indicator system is using Bluetooth connection for communicating Phone with EDI- 54V Indicator. Turn ON the Indicator's Bluetooth modem by pressing push button provided on Indicator's panel. Once push button is pressed LED blinks at faster rate till Bluetooth Modem becomes ON and ready to communicate. The indicator will glow in bright RED colour to ensure that Bluetooth modem is ready. Now power ON the Phone and go to settings and then Bluetooth settings. Turn ON the Bluetooth and click on "scan" button showing on phone's screen. Phone will show the list of Bluetooth devices found. Find the Indicator's serial number on phone screen and click for pairing the phone with Indicator. Once pairing button is pressed it will ask to enter passkey for authentication. Enter pairing code "6982698076" and then press OK. On successful authentication it will show that device is paired. Now Phone is paired with Indicator. This activity is required for first time connection with EDI-54V Indicator.

3.5 Application installation

It is strongly recommended to exit all programs before installation. Follow the steps below for installing the application for the first time.

Note Please make sure that option for Unknown sources (allow installation of non-Market apps) in Setting-> Security must be checked.

- Copy the "EDI-54V_xx.apk" into the mobile via Bluetooth or USB cable.
- Go to copied location in tap on EDI-54V_xx.apk. Then tap on install
- After installing press DONE or application can be opened directly by pressing OPEN. User can open the application through application launcher also. See Fig 3-2.

3.6 Running the application

Running VW Indicator application is very simple. It is as simple as playing games in mobile phone. The graphic user interface makes it users friendly and thus easy to operate. Go to applications and then click on Vibrating Wire Indicator application icon as shown in Fig 3-2.

Fig 3-2: Application launcher

Once Indicator application is clicked to run, it will show the name of the application and its version. This screen will splash for few seconds and then Main menu appears.

4 QUICK START GUIDE

4.1 Preparing setup

Use step by step procedure to prepare the setup connections.

Step 1: Press power on push button on the EDI-54V indicator once to turn ON the Indicator

Step 2: Press power button of Android smartphone to turn ON

Go to Settings >> Connections

Step 3: Turn ON the Smartphone Bluetooth

Step 4: Press on scan option to search nearby Bluetooth devices

Step 5: Press on Indicator's Serial Number in device list to pair

Step 6: Pair the Indicator with Android phone using passkey = 6982698076

Step 7: Connect the sensor cable to VW sensor

Step 8: Now open EDI-54V application on Android phone

Step 9: Press Connection button from home screen to connect the Indicator with Application

4.2 Configuring sensor's coefficients and information

VW sensor's calibration coefficients have to be loaded in the indicator so that the sensor can be reliably read and display the measured value in proper engineering units. Use step by step procedure to configure the sensor's parameters like model, coefficients, sensor serial number, sensor tag etc.

Step 1: Note down the model number, serial number and coefficients of VW sensor which is to be configured.

Step 2: Create a new site using create site option from home screen

Go to Home Screen >> Create Site or Add Sensor >> Site List >> Create

Step 3: Add a new sensor under created site

Go to Home Screen >> Create Site or Add Sensor >> Sensor List >> Create

Step 4: Provide all information like sensor manufacturer, model, serial no, coefficients, parameter name, unit etc. while creating new sensor profile and then press Update button. (Please do not change coefficients values if not known)

Step 5: System Information can be checked using System Information button from main menu

4.3 Take reading or start scanning

Use step by step procedure to monitor sensor data or to configure the sensors scan schedule for automatic data logging.

Step 1: Select the site and sensor from main menu to proceed further Go to Home Screen >> Select Site / Select Sensor

Step 2: Press Take Reading button from main menu to monitor or store sensor readings Go to Home Screen >> Take Reading

Step 3: Reading average and noise bar range can be set using Settings from Reading screen. Step 4: Reference Reading can be set any time from Settings option screen

Go to Home Screen >> Take Reading >> Settings

Step 5: Reading screen shows Current values of VW sensor and temp sensor. Additionally it shows two deviation values; deviation from last stored reading and deviation from initial reading.

Step 6: Last stored reading is also displayed on Reading screen to compare

Step 7: Press Accept button from reading screen to store the readings into memory.

Step 8: Press View data button from main menu or reading screen to view stored data

Step 9: EDI-54V Indicator can be used as Single Channel Datalogger also.

Step 10: Go to setup screen by pressing System setup button from main menu.

Go to Home Screen >> System Setup

Step 11: Choose scan interval and scan start time and then press Start button to start data logging.

Step 12: Press Stop button to stop scanning.

4.4 Downloading and viewing data

Use step by step procedure to download and view the logged file.

Step 1: Press download button to download data into phone's memory

Go to Home Screen >> System Setup >> Download

Step 2: Press View data button from main menu or reading screen to view stored data

Go to Home Screen >> View Data

Step 3: Data can be viewed in tabular form by selecting parameter options from drop down menu.

Step 4: Data can be viewed in graphical form by pressing graph icon from View data screen.

Step 5: To get logged data into CSV file format, go to database manager screen from main menu. Then select site, sensor, date range, file format etc. and then press extract button to get CSV file. Extracted data will be saved in CSV (comma separated values) format at specified file path.

File path: [Phone Memory] >> EDI_54V_CSV >> *.CSV

Step 6: Datalogger Date time always get automatically synced at connection to the phone's date/time so changing/updating logger date/time is not required.

5 MAIN MENU

Entering Main menu is the place where we can do many functions. Figure 5-1 shows the main menu items. We can make connection with a VW Indicator over Bluetooth using connection button. System information can be seen by pressing system info button. It will show the information about VW Indicator, Indicator Battery health, Bluetooth and phone etc. New site and sensor can be created using create Site button. Sensor parameters can be modified using edit sensor option. Sensor readings can be taken by pressing take reading button.

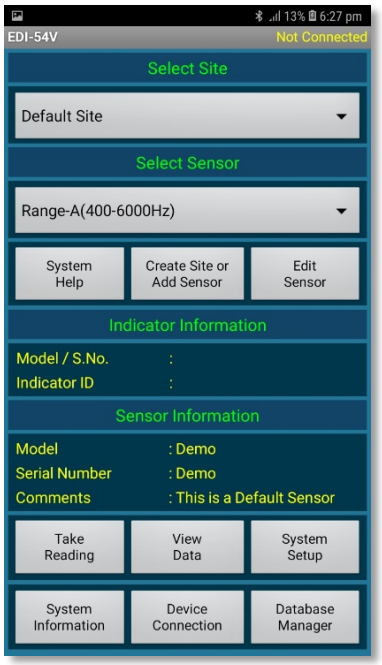


Fig 5-1: Main Menu

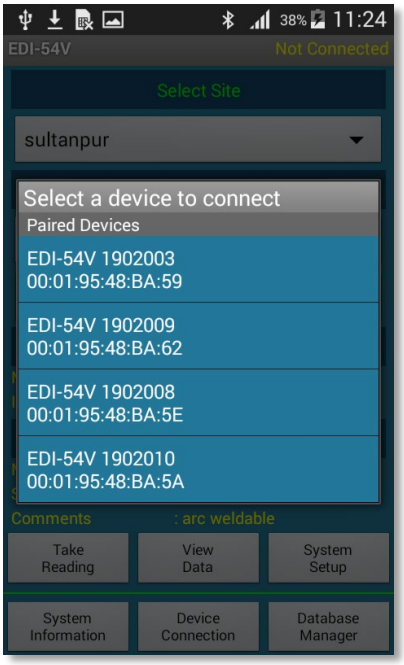


Fig 5-2: Device list

Sensor data can be viewed in tabular form or can be plotted on graph using view data option. Sensor log files can be extracted from Database Manager. Site list shows the list of total sites created in this readout unit. Sensor list is showing the list of Sensors created under a site name which is selected in site list. Sensor information shows the Sensor information of selected Sensor from Sensor list. Indicator information is showing Indicator's ID of currently connected Vibrating Wire Indicator.

Help information can be seen by pressing Help button from main menu. Help information is very useful while working on site. It may be helpful while troubleshooting.

5.1 Connecting a Vibrating Wire Indicator

Once the VW Indicator is turned ON and phone is paired with VW Indicator, we can connect phone with VW Indicator using connection button from main menu. Go to main menu and press connection button. It will show a list of paired Vibrating Wire Indicators as shown in Figure 5-2. List is showing the serial numbers and Bluetooth addresses of the VW Indicators. Click on desired VW Indicator to connect. Once clicked on a VW Indicator, it will try to connect and a progress window will appear to acknowledge that phone is connecting to the VW Indicator. Phone gets connected to the VW Indicator after few seconds.

6 SYSTEM INFORMATION

System information can be seen by pressing system info button from main menu. It shows the information about VW Indicator, Site, Sensor, Indicator Battery, Bluetooth and phone. On pressing system info button from main menu, it will show the system information menu. We can press any button to see the related information. Press on back key to exit from this screen.

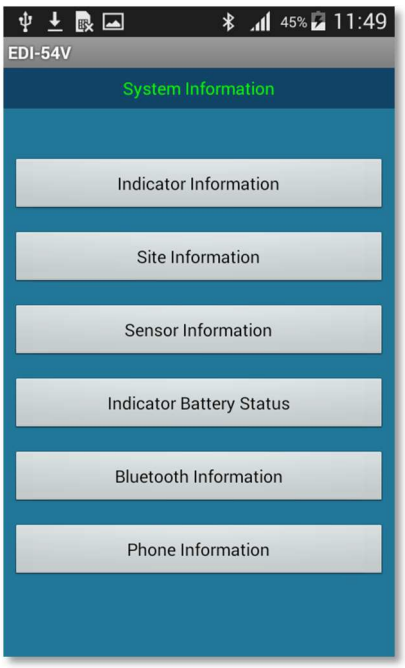


Fig 6-1: System information Menu

6.1 VW indicator information

Pressing on VW Indicator Information button will open VW Indicator Information screen. It shows the VW Indicator's model, serial number, VW Indicator ID, firmware version of VW Indicator's processor, firmware revision date, VW Indicator's connection time and connectivity.

6.2 Site information

Site Information screen shows the site details of the selected site. It shows the Site Name and Site comments.

6.3 Sensor information

Sensor Information screen shows the information of selected VW sensor. It shows the Selected Site ID, Selected sensor ID, Sensor comments, Sensor manufacturer, Sensor Model, Sensor serial number. It also shows the VW sensor excitation sweep frequency range (Start frequency, Stop Frequency and number of steps for sweep). This information is useful for data verification.

6.4 Indicator battery status

Indicator Battery Status screen shows the Battery health of VW Indicator. It shows the Battery Type, Battery Voltage, Battery Status (Charging/discharging), Battery Health, Battery Installation date, Last time Charger connection date/time, Last time battery full date/time. Battery voltage can be useful for VW Indicator's health monitoring. It is recommended to get battery fully charged before going to the site.

6.5 VW indicator Bluetooth information

Bluetooth Information screen shows the Bluetooth connection information. It shows the VW Indicator's Bluetooth Identification, Bluetooth address, run time and connectivity.

6.6 Phone information

Phone Information screen shows the phone information. It shows Mobile phone's brand, model, android version, LCD touch screen display resolution, phone's battery type, battery voltage, battery charge, battery temperature, IMEI number and the network service provider. It also shows the Vibrating Wire Indicator application software's version.

7 CREATING SITE / ADDING SENSOR

On pressing Create Site or Add Sensor button from main menu, it will show the Site and sensor list. Click on any site or sensor to see site or sensor comments. Figure 7-1 is showing an example of site and Sensor list. Press on back key to exit from this screen.

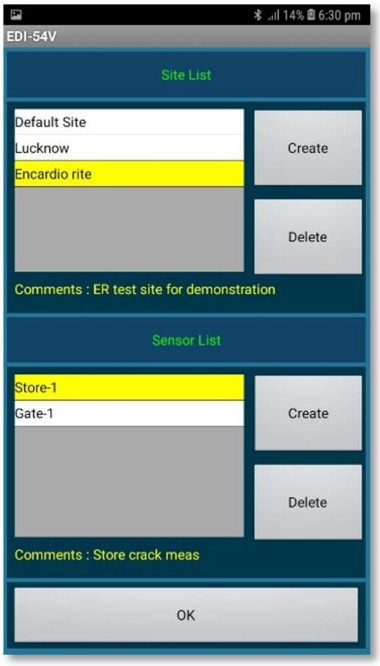


Fig 7-1: Site and Sensor List

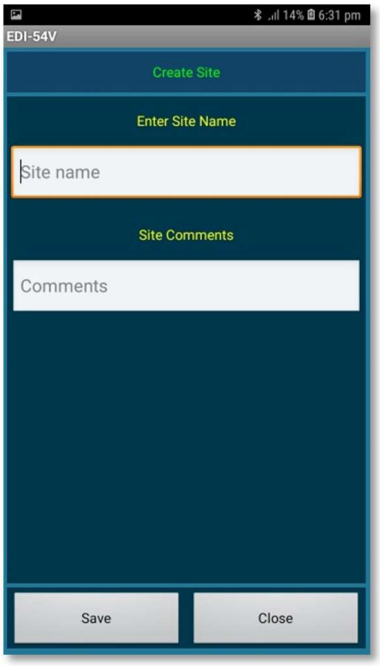


Fig 7-2: Site Creation Screen

7.1 Creating a site

On pressing create button under site list, it will open site creation menu as shown in Figure 7-2. Enter site code in edit box under site name. Enter site comments in edit box. Site details can be written here. Press on save button to create this site. Any site can be deleted by selecting a site name from site list and then press on delete button.

7.2 Creating a sensor

Open Site and Sensor menu on pressing create site button from main menu. Select site name under which new Sensor is to be created. On pressing create button under Sensor list, it will open Sensor creation menu as shown in Figure 7-3. Enter Sensor code and sensor comments/tag. Select sensor manufacturer and model name of VW sensor. On selection; sensor excitation settings (sweep frequency range and steps for sweep) will automatically fetch from saved settings. Enter serial number of VW sensor. Select thermistor type (default 3k). Press next button to proceed to next setting screen.

Figure 7-4 is showing an example of sensor coefficients setting screen. Enter coefficients of VW sensor for given equation. Enter parameter name, parameter unit and temperature unit and then press save to save the settings.

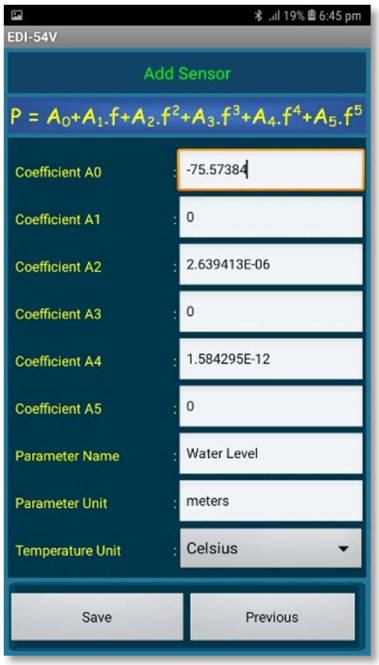


Fig 7-3: Sensor settings **Fig 7-4: Sensor coefficients** **Fig 7-5: Manufacturer List**

7.3 default site and default sensor

Default site and default Sensor are given only for reference. No Sensor can be created under default site. Default site and Default Sensor cannot be edited or deleted. Default Sensor readings can't be stored in database though Sensor readings can be taken. It can be used for demo purpose or quick measurements of a VW sensor.

7.4 Manufacturer list

VW sensor should be excited close to its operating frequency range to get noise free response. VW sensor's operating frequency range varies from model to model or manufacturer to manufacturer. Some manufacturer and their model numbers are listed by default. New manufacturers can be added to or removed from list. See Figure 7-5.

Provide sensor start frequency, stop frequency (operating range of VW sensor) and number of steps for frequency sweep (keep 300 if not known). Select thermistor type (generally 3k). Press add button to add new sensor under selected manufacturer.

7.5 Editing sensor parameters

Sensor parameter can be edited using edit Sensor option from main menu. Select site and Sensor from main menu and then press on Edit Sensor button to edit the parameters of selected Sensor. Change the settings and then press Save button to save Sensor settings.

8 SENSOR COEFFICIENTS

VW sensor gives frequency output. This frequency is then processed to get the Parameter value. VW Indicator uses following polynomial to get the parameter value

Parameter = A0 + A1 * f + A2 * f2 + A3 * f3 + A4 * f4 + A5 * f5

Where; f = frequency, A0, A1, …., A5 are polynomial coefficients

VW sensor manufacturer provides the value of calibration coefficients in their test certificates. Sensor manufacturer may use different polynomial equation and coefficients in their certificates. Follow the following procedure to apply the coefficient in above equation.

Case 1: When Coeff. are given for 4^{rth} order polynomial and raw output in frequency

Use Coefficient $A_5 = 0$

Parameter = $A_0 + A_1 * f + A_2 * f^2 + A_3 * f^3 + A_4 * f^4 + 0 * f^5$

Case 2: When Coeff. are given for 3rd order polynomial and raw output in frequency

Use Coefficient $A_5 = 0$ and $A_4 = 0$

Parameter = $A_0 + A_1 * f + A_2 * f^2 + A_3 * f^3 + 0 * f^4 + 0 * f^5$

Case 3: When Coeff. are given for 2nd order polynomial and raw output in frequency

Use Coefficient $A_5 = 0$, $A_4 = 0$ and $A_3 = 0$

Parameter = $A_0 + A_1 * f + A_2 * f^2 + 0 * f^3 + 0 * f^4 + 0 * f^5$

Case 4: When Coeff. are given for linear equation and raw output in frequency

Use Coefficient $A_5 = 0$, $A_4 = 0$, $A_3 = 0$ and $A_2 = 0$

Parameter = $A_0 + A_1 * f + 0 * f^2 + 0 * f^3 + 0 * f^4 + 0 * f^5$

Case 5: When Coeff. are given for 2nd order polynomial and raw output in Digits

Many manufacturer use Digits instead of frequency as variable and polynomial coefficients as A, B and C

We know; Digits = frequency^2 / 1000

So, use Coefficient $A_5 = 0$, $A_3 = 0$ and $A_1 = 0$

Parameter = $A_0 + 0 * f + A_2 * f^2 + 0 * f^3 + A4 * f^4 + 0 * f^5$
Where; A_0 = C
A_2 = B / 1,000
A_4 = A / 1,000,000

Case 6: When Coeff. are given for linear equation and raw output in Digits

Many manufacturer use Digits instead of frequency as variable and polynomial coefficients as Gage Factor (G) and offset (Offset)

We know; Digits = frequency^2 / 1000

So, use Coefficient $A_5 = 0$, $A_4 = 0$, $A_3 = 0$ and $A_1 = 0$

Parameter = $A_0 + 0 * f + A_2 * f_2 + 0 * f_3 + 0 * f_4 + 0 * f_5$
Where; A_0 = Offset
A_2 = G / 1,000

9 TAKE READING

Once the site and Sensor are selected from main menu and phone is connected with VW Indicator; readings can be started by pressing Take Reading button from main menu. Pressing on take reading button from main menu, will open reading screen as shown in Figure 8-1.

Fig 8-1: Reading Screen

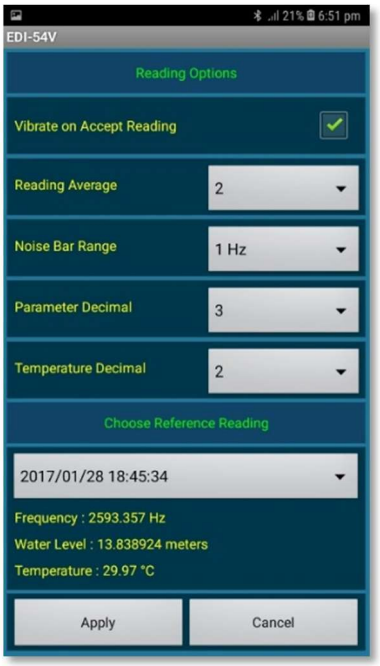


Fig 8-2: Reading Option Setting Screen

Current reading of parameter and temperature are showing on phone's screen. Output of VW sensor in terms of Frequency and Period are also displayed.

Deviation from last saved reading is displayed right below the current reading. Deviation from reference reading is displayed left below the current reading. Last saved record is also displayed. This information is useful in analysing the problem. Reference reading can be set from setting screen. Press Accept button to store reading into phone's memory.

The vertical noise bar on the right side of the screen represents the present noise level in the readings received from VW sensor. Present noise level in terms of frequency is showing the noise contents in electrical signal at input. Noise bar limit is showing in terms of frequency in green colour below noise bar to correlate the noise level in terms of frequency. Noise bar limit represents the 100% noise level in the noise bar. Red arrow above noise bar indicates that noise level is exceeding the noise bar limit. Noise window must be set from setting screen to check readings are stable or not. It is recommended to accept readings only when readings are stable.

Readings showing on screen are calculated by taking average of sample readings. Number of readings for averaging is showing on top left side of the screen. It can be set from option menu. It is good to take average of large number of readings but run-time become slower.

9.1 Reading option settings

Pressing setting button from readings screen opens options screen. Figure 8-2 shows the reading options screen. Number of readings for averaging data, data averaging, noise bar range, parameter/temp decimal digit and reference reading can be set.

10 SYSTEM SETUP

Datalogger can be configured to take automatic measurements at a specified interval. Go to System Setup menu from Home screen to open System Setup screen. Figure 9-1 shows an example of system setup screen. Data scan and download can be done here.

User can set Indicator/Datalogger name (or ID or tag) to identify the Datalogger if there are many indicators/Dataloggers being used. Datalogger ID can be changed by editing Datalogger ID in edit box and then pressing update button.

Choose Scan Interval and next scan start time to start scanning. Scan Interval can be set from 5 sec to 7 days (i.e. 168 hrs). Once log interval is set, data logger scanning can be started. Data logger will start scanning from Next scan start time.

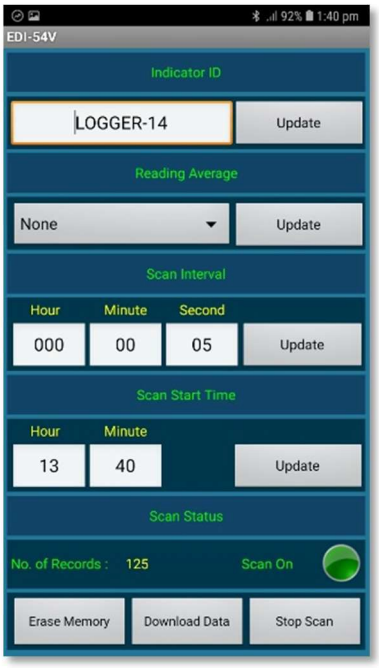


Figure 9-1: System Setup Screen

Scan status panel showing total number of records stored in data logger's memory. "Total Records" showing total number of records stored in Datalogger's memory since last erase. Data logger scanning can be started by pressing START button once. Pressing the start button starts the scanning and scan status becomes ON. Status indicator becomes GREEN. While scanning, the Start button becomes Stop. During scanning, the data logger scans sensor at specified log interval and the sensor readings gets stored in data logger's memory.

Data logger scanning can be stopped by pressing Stop button once. Pressing on stop button stops the scanning and scan status becomes OFF. Status indicator becomes RED. Stop button becomes start again.

Though data logger memory is very large with respect to record size, memory can get full if scan interval is very fast and memory not erased since a long time. If the memory becomes full, the readings will be recorded but it will overwrite from oldest records in a cyclic manner.

Readings being stored are calculated by taking average of sample readings. Number of readings for averaging can be set from option menu.

11 DATA DOWNLOAD

Readings (data) can be downloaded from data logger's memory into smartphone memory by pressing Download Data button from System Setup screen. Data download time depends on records size of data logger's memory. Progresses bar dialog displays download progress. It can take several minutes also in case of large number of records. After successful download, an information window pops-up.

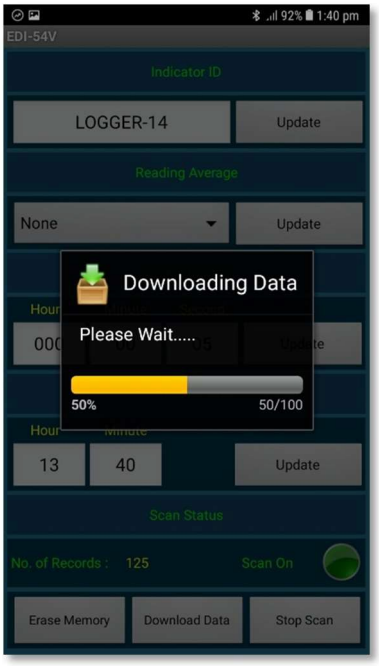


Fig 10-1: Downloading Data

Erase data logger memory by pressing Erase Memory button. It would erase all previous readings and the No. of Records would become zero. The application seeks permission to erase logger memory. Click Yes to proceed or No to abort. Clicking Yes, data logger's memory will be erased which will not affect other settings.

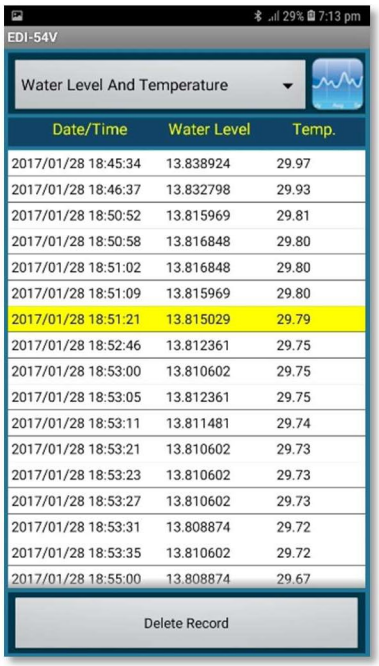
12 VIEWING DATA

Reading log can be viewed using view data option. Go to main menu and select site and Sensor for which Sensor data to be viewed. Pressing view data button will open view data menu as shown in Figure 11-1. Data can be plotted on graph by pressing graph icon.

12.1 Viewing data in table

On pressing view table button from view data menu application will show data in tabular format. Figure 11-1 is showing examples of a Sensor log in table form. Drop down list at top of the screen showing list of parameters.

Drop down list below file list is showing reading parameters list. Different data options can be selected from this drop down list. These options are Parameter and Temperature, Frequency and Temperature, Parameter and Deviation, Frequency and Deviation Temperature and Deviation etc.



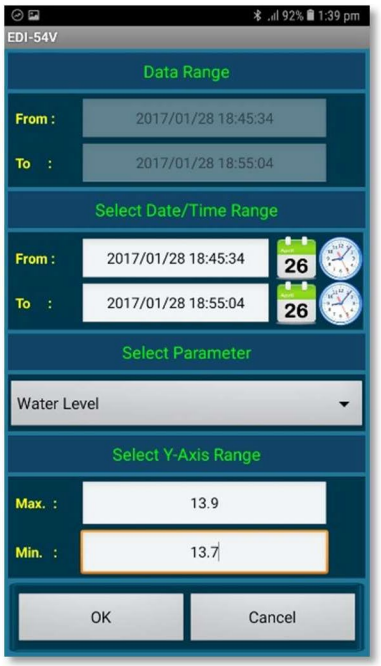


Fig 11-1: View Record **Fig 11-2: Delete Record** **Fig 11-3: Graph Options**

Wrong readings can be removed from memory. Click any record which you want to delete. Selected record will get highlighted in yellow color. See Figure 11-2. Press on delete record button to delete selected record.

12.2 Viewing data on graph

On pressing graph icon from view data menu (Figure 11-1) application will open graph options screen (Figure 11-3). Choose the date/time range, select parameter, choose Y-axis range and then click OK to plot data on a graph. Figures 11-4 is showing examples of a Sensor data on a graph.

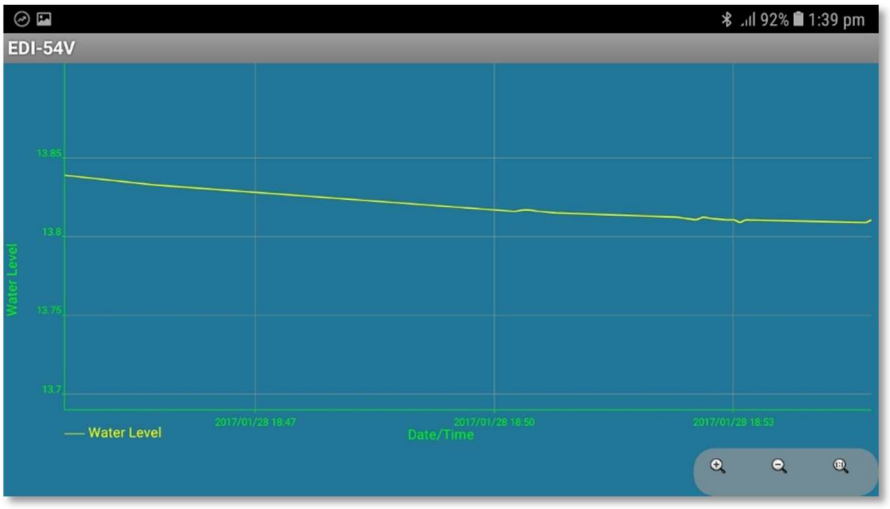


Fig 11-4: Graph View

Buttons given near right bottom side on the screen can be used for manipulating the zoom in, zoom out and pan. Since phone's screen is a touch screen so user can scale and move the graph using finger tips also.

13 DATABASE MANAGER

Stored records can be extracted in CSV file from smartphone memory using Database Manager. Database Manager can be seen by pressing Database Manager Button from main menu. Smartphone memory contains data of all sites. Choose file filter to filter the sites or sensors. Select site and then sensor, select date/time for which data to extracted and then press on Generate CSV File to extract records and generate report in CSV file format

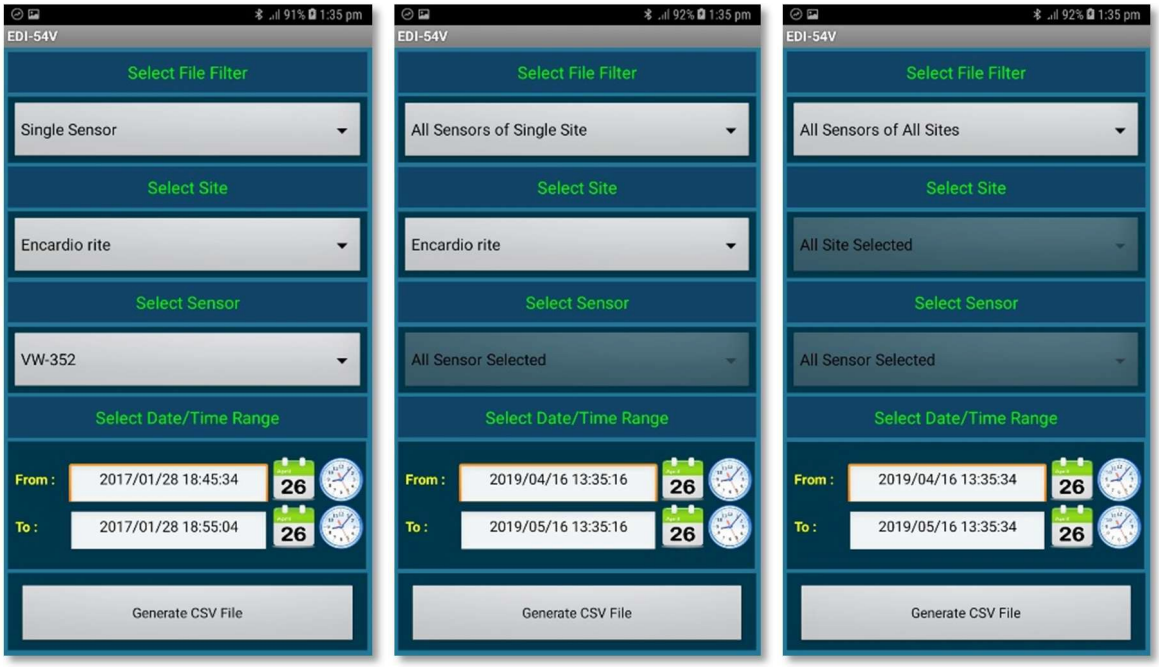


Fig 12-1: Database Manager Screen

13.1 Sensor files storage

Sensor files are stored at smartphone's memory (internal or SD card). Open phone's File manager and explore phone's memory. Explore root directory and find files at path

/memory/EDI_54V_CSV. This folder will be having CSV files of all sensors.

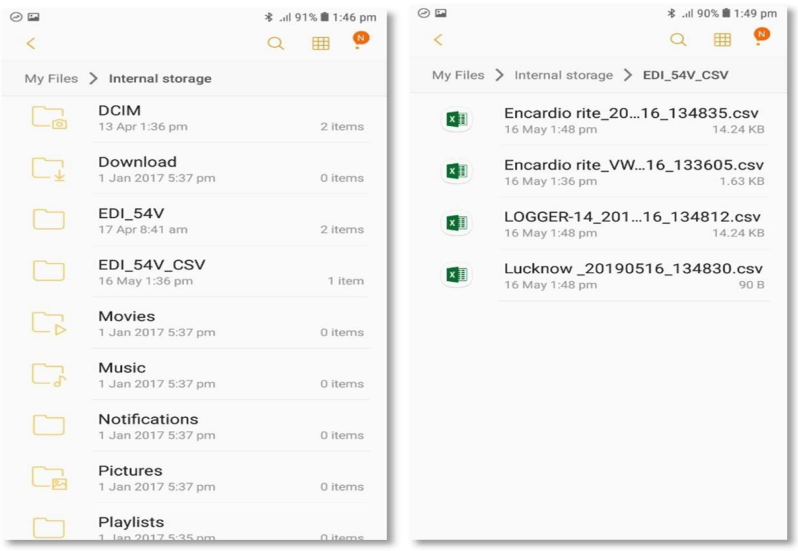


Fig 12-2: Data File Storage Path

14 DATA FILE FORMAT

The Sensor data files used for transferring Vibrating Wire Indicator data to other software have the following formats. All data is in standard ASCII text format (7 bit). Variables are separated with commas (,). Text strings are always enclosed within double quotes (" "). Numeric values are recorded as it is. Numeric values may or may not have a leading plus (+) sign but a minus (-) sign is always explicitly included. The contents of the data file are printed in Courier mono space font below.

This format is suitable for direct import in Microsoft Excel™ (All versions) or other commercially available spread sheet programs for formatted printing and graphical plotting.

"Site ID","Sensor ID","Date/Time","Frequency(Hz)","Parameter","Unit","Temperature(degC)"

"Encardio rite","Store-1","2019/04/18 13:34:26",2592.653,2592.653076,"Hz",32.18

"Encardio rite","Store-1","2019/04/18 13:35:58",2592.539,2592.539063,"Hz",32.20

"Encardio rite","Store-1","2019/04/18 13:55:38",2592.453,2592.452881,"Hz",32.46

"Encardio rite","Store-1","2019/04/18 13:57:37",2592.468,2592.468018,"Hz",32.47

"Encardio rite","Store-1","2019/04/18 14:19:34",2592.510,2592.510010,"Hz",32.57

"Encardio rite","Store-1","2019/04/18 14:28:59",2592.496,2592.496094,"Hz",32.66

"Encardio rite","Store-1","2019/04/18 14:29:03",2592.496,2592.496094,"Hz",32.66

"Encardio rite","Store-1","2019/04/18 14:29:14",2592.510,2592.510010,"Hz",32.67

"Encardio rite","Store-1","2019/04/18 14:29:22",2592.496,2592.496094,"Hz",32.66

……

……

"Encardio rite","Store-1","2019/04/18 14:32:58",2592.496,2592.496094,"Hz",32.69

"Encardio rite","Store-1","2019/04/18 14:33:23",2592.510,2592.510010,"Hz",32.69

"Encardio rite","Store-1","2019/04/18 14:33:30",2592.482,2592.481934,"Hz",32.69

This file format will be utilized for transferring data to Encardio-rite web based data monitoring software (WDMS). This file only transfers the logged Sensor data points. Each header line or record shall appear on an individual line and shall be terminated with a <CR> <LF> character.

In the temperature field you will notice that the temperature appears as -99 (i.e. -99°C) even if the associated transducer does not have an internal thermistor and no valid temperature reading is possible. This is so because the temperature field is a numeric value field and must have a numeric value. Otherwise the software in which you want to import the comma delimited ASCII data file will not be able to import it properly. The value of -99 (°C) unambiguously signals an error condition because in practice you can never get this temperature (the EDI-51V indicator cannot measure temperatures below -20°C). After importing this data file in any other software you can always set it to ignore the value of - 99 as an error (i.e. no thermistor) condition.

15 READOUT DATA BACKUP

The Readout data can be backed up to the PC. After taking Sensor readings in the field it is a good practice to backup up Sensor files at a safer location or multiple locations.

It is recommended to take Readout data backup on regular basis.

15.1 Connecting phone to the PC

Connect the Phone with PC through USB data cable. On connecting data cable phone will ask for connection type. Choose connection type to "Disk Drive" and then click on "Done". A popup screen will appear on Desktop/laptop's screen (see Figure 14-1). Select "open folders to view files" option and the click on "OK". Explorer will open the contents of phone's SD card. Figure 14-2 is showing an example of phone's SD card contents.

Fig 14-1

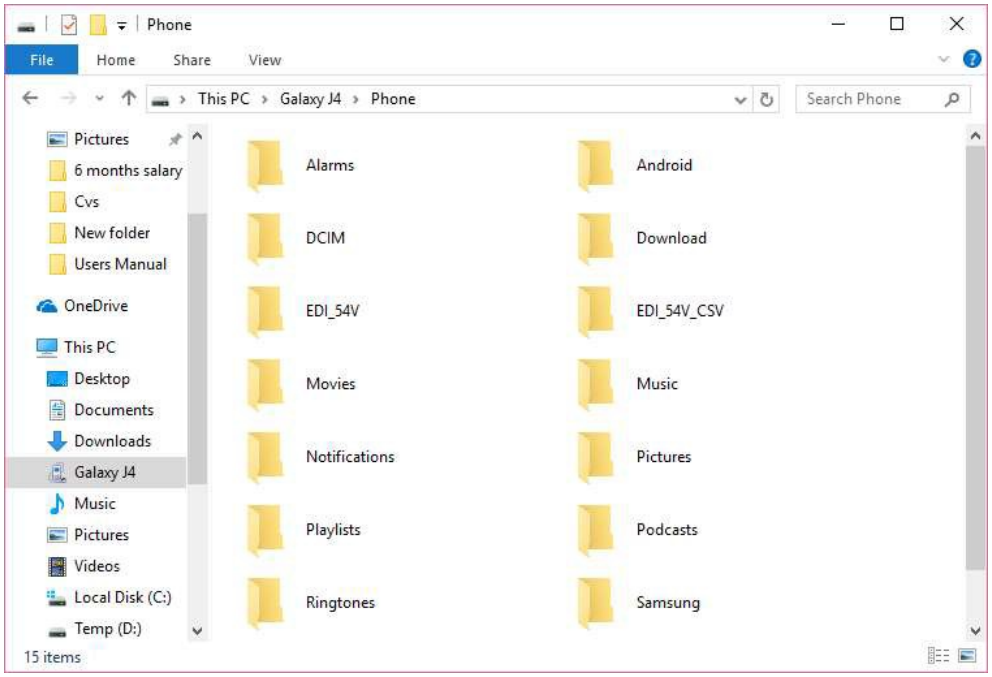


Fig 14-2

15.2 Backing up the site and sensor settings

Open folder "EDI_54V" to view its folder contents. Figure 14-3 is showing an example of folder contents. Select the MFR Folder (sensor manufacturers setting) and SITE Folder (site settings) and then copy these folders to a safe location (i.e. network servers etc.).

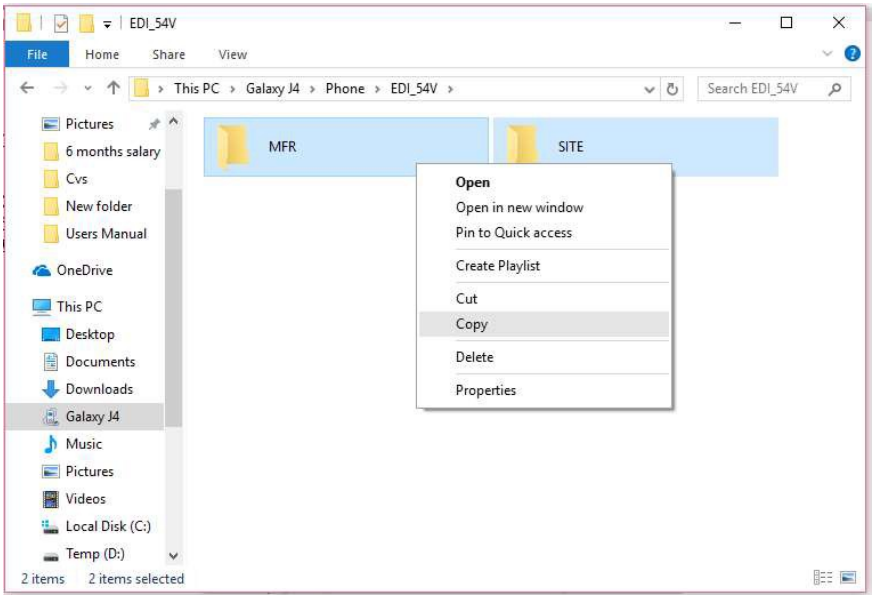


Fig 14-3

15.3 Backing up the sensor logs

Open folder "EDI_54V_CSV" to view folder contents. This folder contains sensor logs in CSV format.

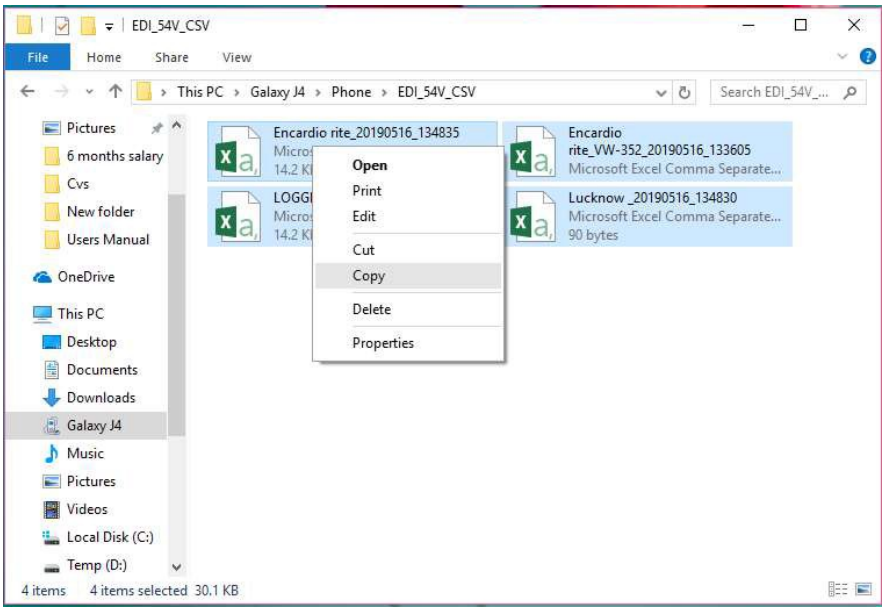


Fig 14-4

Figure 14-4 is showing an example of CSV files folder contents. Select the files for which backups are to be taken. Copy these files to a safe location (i.e. backup PC, network servers etc.).

16 RESTORING READOUT DATA

Backup data (sensor files and site settings) can be restored to Readout. Connect the phone with PC/Laptop through USB cable and explore phone's memory location as explained below.

16.1 Restoring the site and Sensor settings

Copy the preserved MFR Folder (sensor manufacturers setting) and SITE Folder (site settings) from safe location (i.e. backup PC, network servers etc.). Open folder "EDI_54V" in smartphone to view folder contents. Paste the copied folders here and overwrite the existing folder contents as shown in Figure 15-1.

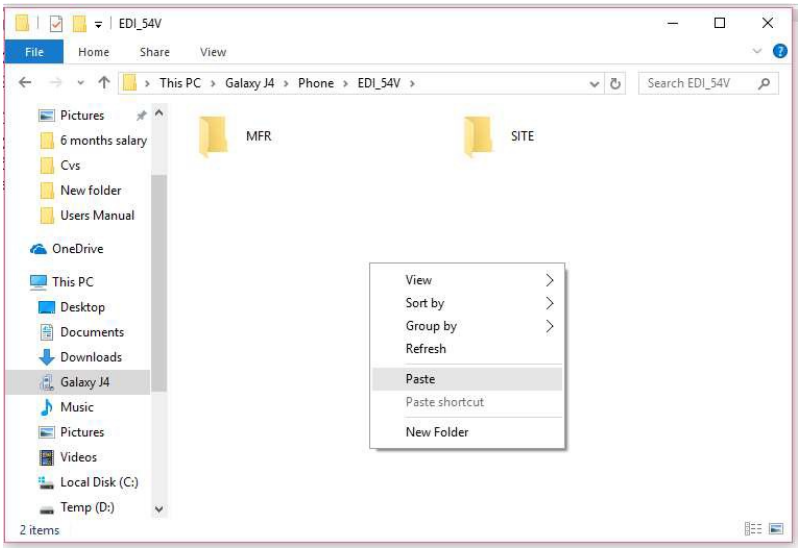


Fig 15.1

16.2 Restoring the sensor Logs

Copy the preserved inclinometer CSV files from safe location (i.e. network servers etc..). Open folder "CSV files" to view CSV files folder contents. Paste the selected CSV files here as shown in Figure 15-2.

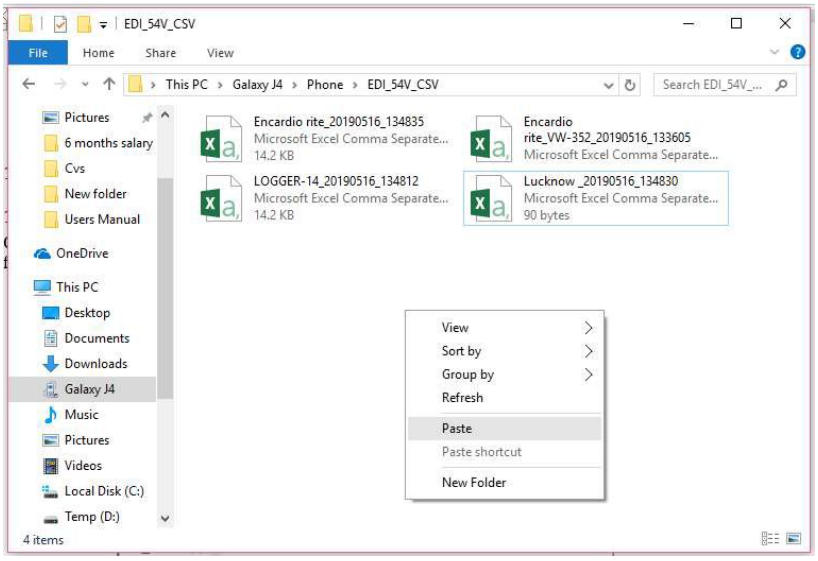


Fig 15-2

17 PUSH BUTTON AND STATUS LED INDICATOR

There is a push button with LED indicator given on VW Indicator's panel. Main function of push button is to turn ON and turn OFF the VW Indicator Bluetooth Modem. By pressing once it will change VW Indicator's Bluetooth Modem power state from ON to OFF or OFF to ON.

VW Indicator Bluetooth Modem power become auto OFF if it is kept idle (not connected to readout) for more than 5 minutes. This feature is given to save VW Indicator's battery power.

LED indicator is given to show the various status indications for diagnostic purpose. Status indicator modes are given below.

LED continuous OFF	:	VW Indicator Bluetooth Modem is OFF Battery Charging Status Indication is OFF
LED continuous ON	:	Bluetooth Modem is ON but not connected to Readout (mobile) Battery Charging Status Indication is ON
LED blinking at 1Hz	:	VW Indicator is connected to Readout
LED blinking at 5Hz	:	VW Indicator is taking Reading from Sensor
LED blinking at 10Hz	:	VW Indicator is turning Bluetooth Modem ON or OFF
LED Single blink in 4 Sec Period	:	VW Indicator Battery is charging
LED double blinks in 4 Sec Period	:	VW Indicator Battery is full charged

18 INSTALLING NEW EDI-54V SOFTWARE IN SMARTPHONE

Encardio-rite's Vibrating Wire Indicator software can be installed in any compatible mobile phone device. Mobile phone must meet minimum requirements specified elsewhere in this document.

18.1 Downloading application software

Connect mobile phone with Desktop PC (or laptop) via Bluetooth. Explore the CD shipped with EDI-54V Vibrating Wire Indicator system and find EDI-54V application (EDI- 54V_vxx.apk) file. Send "EDI-54V_vxx.apk" file to the mobile phone through Bluetooth.

Alternate method for downloading EDI-54V_vxx.apk file is through USB data cable. USB data cable is shipped with mobile phone (readout unit). Connect the mobile phone with PC through USB data cable. Explore the CD and copy EDI-54V_vxx.apk file to a folder in memory card of mobile phone.

18.2 Installing the application software

Open the Encardio-rite's Vibrating Wire Indicator application file "EDI-54V_vxx.apk" from memory card of mobile phone. Figure 17-1 is showing downloaded application file. Clicking on "EDI-54V_vxx.apk" will open software installation wizard. Click on install button to install the application. Once install button is pressed application installation starts and will complete within 2-3 seconds. Press on Done button to complete the installation.

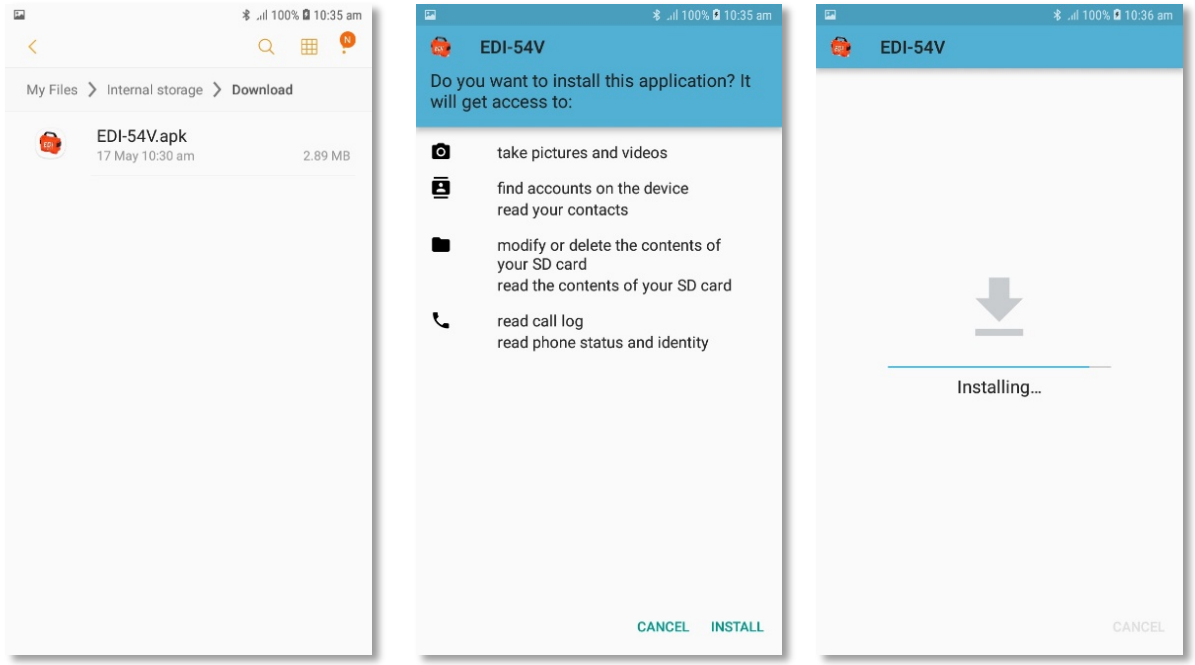


Fig 17-1: EDI-54V Android Application Software Installation

19 UNINSTALLING THE EDI-54V SOFTWARE

Encardio-rite's Vibrating Wire Indicator application software must be uninstalled before installing new software (same or upgraded). Software must be uninstalled if it gets corrupted for any reason and then install a fresh copy of the application.

19.1 Clearing application data

Application data must be cleared before uninstalling EDI-54V application. Open the mobile applications menu and go to "Settings" menu (see Figure 18-1). Press "applications" button from settings menu. Press "manage applications" button to manage the application we want.

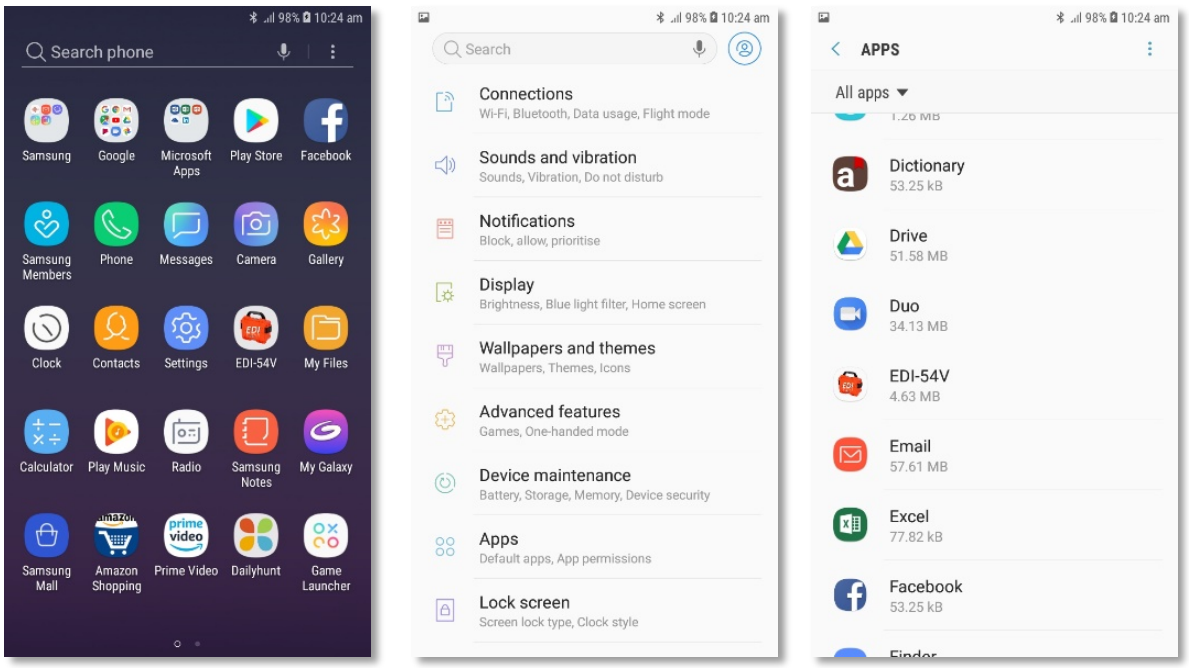


Fig 18-1: Clearing Data settings for EDI-54V Android Application

Figure 18-1 is showing an example of manage applications menu. Pressing on EDI-54V button will open application info menu. Now press on clear data button to clear application data. Delete confirmation window will appear on phone's screen. Press OK button to clear application data.

19.2 Uninstalling the application

Follow the steps explained in section § 18.1 to reach following screen as shown in Figure 18-2. Press on Force Close to close the application if it is running in background. Pressing on Uninstall button will open application uninstall wizard. Press on OK button to confirm un- installation. Now application has been uninstalled from mobile phone.

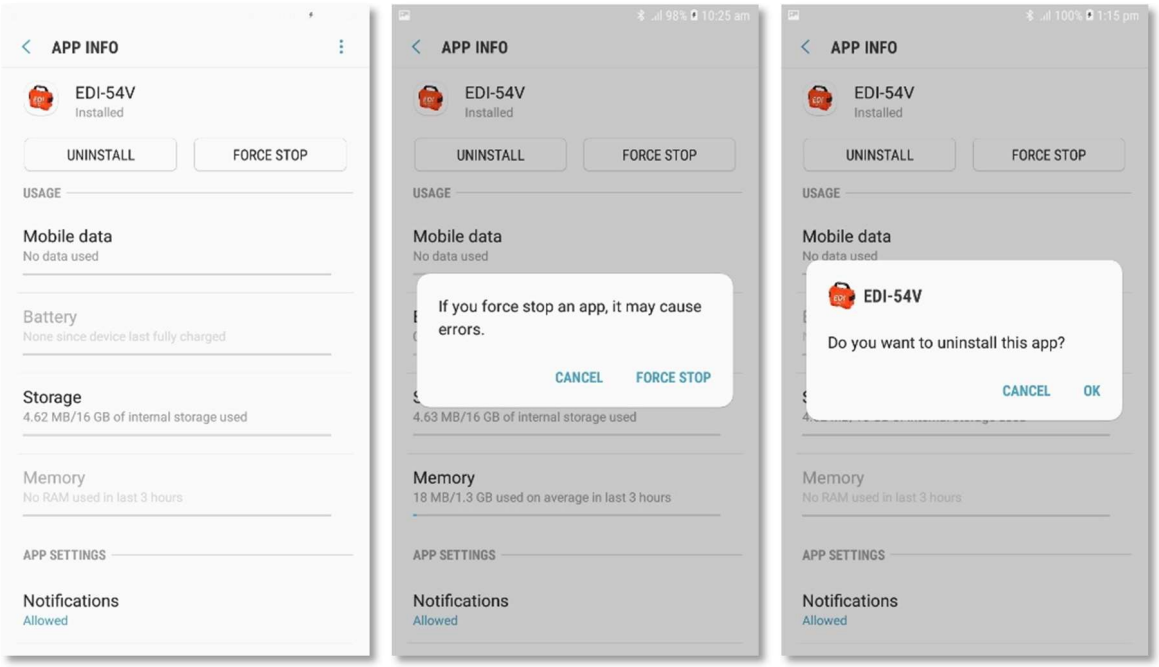


Fig 18-2: Uninstalling the EDI-54V Android Application Software

20 TROUBLESHOOTING

20.1 Unable to connect Bluetooth

- Phone's Bluetooth may not be enabled.
- VW Indicator may not be turned ON.
- VW Indicator may be out of Bluetooth range from phone.
- VW Indicator may not be paired with phone.
- VW Indicator's battery may be discharged.
- Un-pair the VW Indicator, Re-pair using passkey and then try to connect

20.2 Unable to connect to the VW Sensor

- Sensor connector may be loose.
- Check the sensor connector for damage.
- VW Indicator's cable may be broken.
- VW Indicator's battery may be discharged.

20.3 Inserting new SD card

- Always clear data from phone's application manager when inserting new SD card.

21 SPECIFICATIONS

Input

Suitable for input from all Encardio-rite make two wire Vibrating Wire Transducers with 110 to 150 ohms (nominal) sensor coil. Input from equivalent sensors of other manufacturers is also acceptable.

Thermistor input from sensors provided with integral 3k□ (@ 25□C) R-T curve matched thermistor for temperature sensing. Compatible thermistor part numbers from different manufacturers are listed below.

Manufacturer	Thermistor type
YSI, USA	44005
Dale, USA	# 1C3001-B3
Alpha, USA	#13A3001-B3

Excitation

Swept frequency excitation, 5 V (typ.) peak to peak square wave.

Frequency Measurement

Range : 400 Hz - 6 kHz

Measurement time : 128 cycles.

Measured parameter : Time period

Resolution : 0.01 micro-seconds (in time period display mode)

Accuracy : Period measurement ±(0.006% of reading. + 0.004μsec.)

Displayed parameters : Time period, frequency and engineering units.

Temperature Measurement

(Only for sensors provided with specified 3 kΩ thermistor)

Measurement range : -20 to +100 °C.

Resolution : 0.1 °C

Accuracy : beyond +70 °C decreases to ±1 °C

Memory

64 Mb Flash Memory

The VW Indicator has an internal non-volatile memory with sufficient capacity to store about 5,25,000 readings while scanning from any of the programmed transducer. Each reading is stamped with the date and time the measurement was taken.

Real Time Clock

A real time clock is provided for time and date stamping of stored data. RTC is power backed and will continue keeping time even if the indicator is kept off for short periods of time (up to 15 days). However, if the indicator is used only sparingly the internal backup power will drain off and the RTC will lose time whenever the indicator is turned off.

RTC time keeping accuracy: □ 30 seconds / month, typical, over the operating temperature range with indicator powered on.

Power Supply

Internal rechargeable 6 V, 4Ah sealed Valve Regulated Lead Acid battery (generally known as maintenance free battery). A suitable external battery charger is supplied with the indicator for charging the batteries. Do not use any ordinary AC/DC converter for charging the battery.

Use Exide (India) EP4-6 or Hitachi HP4-6(6M4) Sealed Maintenance Free battery or equivalent from other manufacturers for replacement.

Internal safety fuse (F1) rating : 2A Slow Blow

Input / Output Connectors

Circular splash proof 7-pin connector for sensor input and 6-pin connector for battery charger.

Environment

Operating temperature range : -20 to 70°C

Operating humidity range : 10% to 90% (no condensation)

Housing

Impact resistant plastic moulded housing. Dimensions: 220mm (W) □ 190 mm (H) □ 100 mm (D)

Readout

The EDI-54V application runs on Android Smartphone. The mobile specifications are:

Mobile OS : Android version 2.2 or later

RAM : 512MB or above

Storage memory : 2 GB or above

Display size : 480x800 or 720x1280 or 1080x1920 pixels

Display Type : Touch screen

CPU Speed : 1 GHz or Above

Bluetooth : Version 3.0 or above

Battery charger

Caution – Do not use any other battery charger for charging the EDI-54V internal battery

Input : 100 – 240 V AC, 50 or 60 Hz, 500 mA max.

Output : 9 V DC nominal, 2A max.

Dimensions : 93 mm (L) x 54 mm (W) x 36 mm (H), excluding power cords.

22 APPENDIX A -THERMISTOR TEMPERATURE DERIVATION

Thermistor Type : YSI 44005, Dale # 1C3001-B3, Alpha # 13A3001-B3

Resistance to Temperature Equation:

$$T = \frac{1}{A+B(LnR)+C(LnR)3} - 273.2$$

Where : T = Temperature in °C
LnR = Natural Log of Thermistor Resistance
A = 1.4051 x 10-3 (coefficient calculated over the -50 to +150 °C span)
B = 2.369 x 10-4
C = 1.019 x 10-7

Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms
-50	201100	-10	16600	30	2417	70	525.4	110	153.2
-49	187300	-9	15720	31	2317	71	507.8	111	149.0
-48	174500	-8	14900	32	2221	72	490.9	112	145.0
-47	162700	-7	14120	33	2130	73	474.7	113	141.1
-46	151700	-6	13390	34	2042	74	459.0	114	137.2
-45	141600	-5	12700	35	1959	75	444.0	115	133.6
-44	132200	-4	12050	36	1880	76	429.5	116	130.0
-43	123500	-3	11440	37	1805	77	415.6	117	126.5
-42	115400	-2	10860	38	1733	78	402.2	118	123.2
-41	107900	-1	10310	39	1664	79	389.3	119	119.9
-40	101000	0	9796	40	1598	80	376.9	120	116.8
-39	94480	1	9310	41	1535	81	364.9	121	113.8
-38	88460	2	8851	42	1475	82	353.4	122	110.8
-37	82870	3	8417	43	1418	83	342.2	123	107.9
-36	77660	4	8006	44	1363	84	331.5	124	105.2
-35	72810	5	7618	45	1310	85	321.2	125	102.5
-34	68300	6	7252	46	1260	86	311.3	126	99.9
-33	64090	7	6905	47	1212	87	301.7	127	97.3
-32	60170	8	6576	48	1167	88	292.4	128	94.9
-31	56510	9	6265	49	1123	89	283.5	129	92.5
-30	53100	10	5971	50	1081	90	274.9	130	90.2
-29	49910	11	5692	51	1040	91	266.6	131	87.9
-28	46940	12	5427	52	1002	92	258.6	132	85.7
-27	44160	13	5177	53	965.0	93	250.9	133	83.6
-26	41560	14	4939	54	929.6	94	243.4	134	81.6
-25	39130	15	4714	55	895.8	95	236.2	135	79.6
-24	36860	16	4500	56	863.3	96	229.3	136	77.6
-23	34730	17	4297	57	832.2	97	222.6	137	75.8
-22	32740	18	4105	58	802.3	98	216.1	138	73.9
-21	30870	19	3922	59	773.7	99	209.8	139	72.2
-20	29130	20	3748	60	746.3	100	203.8	140	70.4
-19	27490	21	3583	61	719.9	101	197.9	141	68.8
-18	25950	22	3426	62	694.7	102	192.2	142	67.1
-17	24510	23	3277	63	670.4	103	186.8	143	65.5
-16	23160	24	3135	64	647.1	104	181.5	144	64.0
-15	21890	25	3000	65	624.7	105	176.4	145	62.5
-14	20700	26	2872	66	603.3	106	171.4	146	61.1
-13	19580	27	2750	67	582.6	107	166.7	147	59.6
-12	18520	28	2633	68	562.8	108	162.0	148	58.3
-11	17530	29	2523	69	543.7	109	157.6	149	56.8
								150	55.6

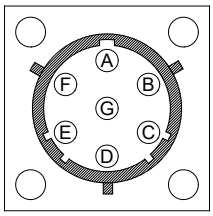
23 APPENDIX B – CONNECTOR WIRING DIAGRAM

SENSOR CABLE

Wire Color	Crocodile Clip Color	Signal
Red	Red	VW Sensor Coil
Black	Black	VW Sensor Coil
Red	Yellow	Thermistor
Black	Yellow	Thermistor

SENSOR CONNECTOR

Connector type Amphenol Part # 621N-12E-10-7P
(7 pin box mounting receptacle)

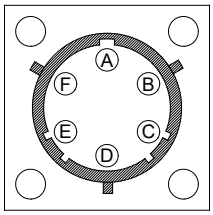


Front View

Pin No.	Signal
A	VW Sensor coil
B	VW Sensor coil
C	Thermistor
D	Thermistor

BATTERY CHARGER CONNECTOR

Connector type Amphenol Part # 621N-12E-10-6P
(6 pin box mounting receptacle)



Front View

Pin No.	Signal
A	GND
B	+9V