RSTAR Affinity
Field App User Guide

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1 INTRODUCTION

1.1 RSTAR AFFINITY CONNECTIVITY SOLUTION

The RSTAR Affinity Connectivity Solution comprises gateways, data loggers, secure communications for data telemetry, and mobile and desktop applications. RSTAR Affinity is a complete industrial internet of things (IIoT) solution for reliable, real-time data flow from your worksite to your desktop – all from a single vendor.

The RSTAR Affinity Connectivity Solution is a scalable and flexible system that can be customized to satisfy the complex and demanding requirements for data collection. The topology and communications options including cell and LoRaWAN radio protocol (for better signal and range), cover all on-site and remote monitoring scenarios.

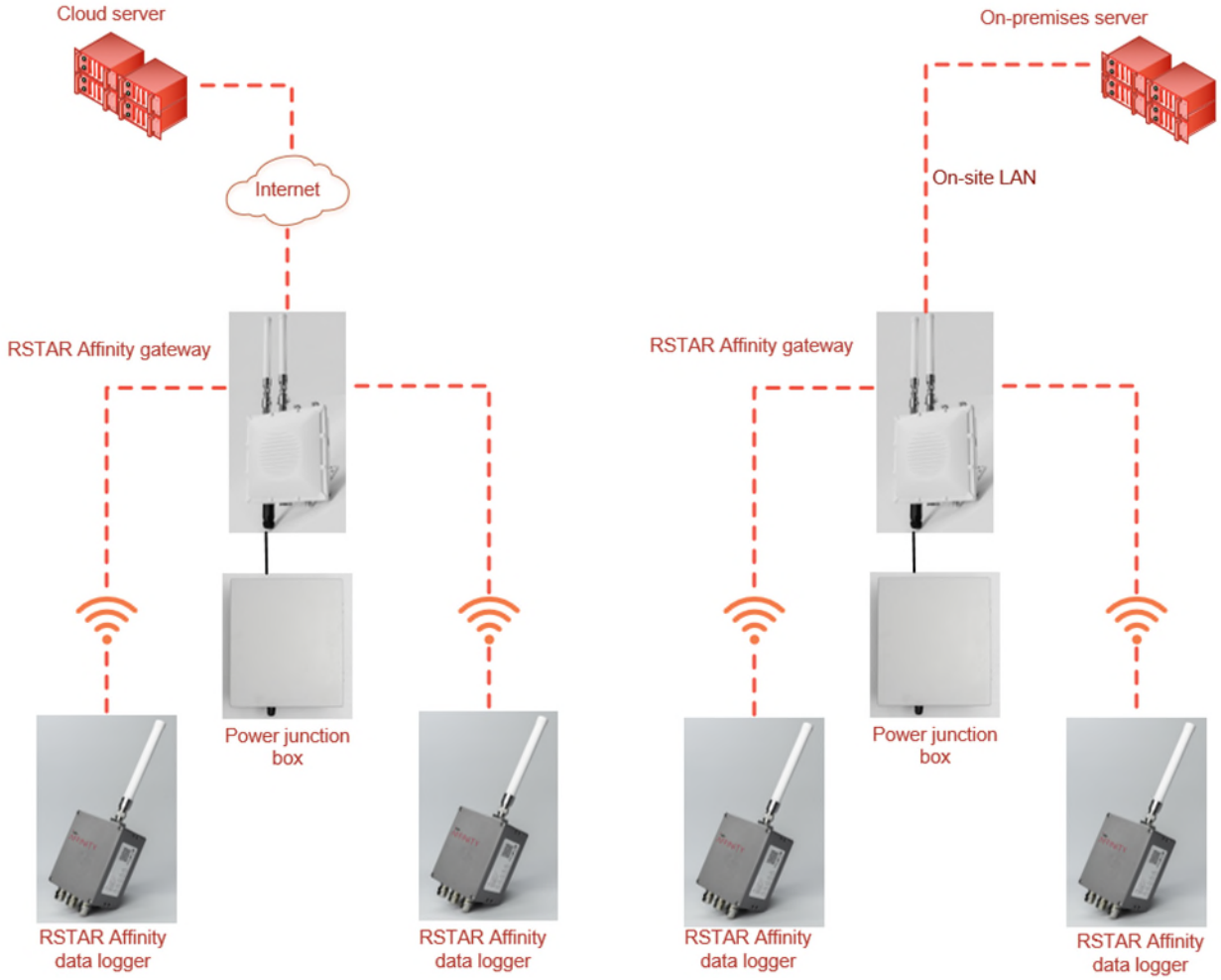


Figure 1: RSTAR Affinity Cloud and On-premise Solution

1.2 INTENDED AUDIENCE

This guide is for the service personnel responsible for installing and commissioning an RSTAR Affinity data logger using the RSTAR Affinity field app.

1.3 ABBREVIATIONS AND ACRONYMS

This section lists abbreviations and acronyms used in the document.

Abbreviation or acronym	Definition
Claim	To “claim” means to register a data logger to a site. When a data logger is claimed to a site, it cannot be used for another site unless it is first unclaimed.
GUID	Global Unique Identification Number is a unique 128-bit identification number that RSTAR Affinity uses in all data communication between the gateway, data loggers, and server endpoints.
IIoT	Industrial Internet of Things refers to interconnected sensors, instruments, and devices networked together with computers for industrial application.
LoRa	From the term “long range” is a proprietary low-power wide-area network modulation technique which allows a gateway to communicate with data loggers.
LoRaWAN	From the term “Long Range Wide Area Network” is a networking communication stack based on the LoRa wireless technology.
QR code	A Quick Response (QR) code is a type of two-dimensional (2D) bar code that provides easy access to online information through the digital camera on a smartphone or tablet.
Pair	To “pair” means to establish LoRa communication between a gateway and a data logger. During the pairing process, authentication keys are exchanged to secure the data link between the gateway and the data logger. Once a data logger is paired with a gateway, the data logger can only communicate with the paired gateway.
Unclaim	To “unclaim” means to unregister a data logger from a site so it can be claimed to another site.

1.4 RSTAR AFFINITY FIELD APP

The RSTAR Affinity field app is the companion application for RSTAR Affinity data loggers. It is designed for the field service personnel to commission and manage the data logger’s operation and data collection functions. Its account-based sign-in feature ensures security and creates an audit trail.

The field app runs on Android handheld devices with Bluetooth connectivity and a QR code scanner. The QR code scanner make for quick, easy, and accurate instrument installation and commissioning, saving an average of four hours per sensor and eliminating possibility of human error during setup. The information

automatically syncs with digital tags for each instrument to seamlessly carry data sets to the RSTAR Affinity dashboard (the desktop platform).

Highlights of the field app's features include the following:

- communication between the data logger and the field app is through wireless Bluetooth with distance of up to 10 meters,
- an instrument with a QR code can be scanned using an Android handheld device's built-in scanner or camera to get the instrument's calibration parameters,
- a configuration wizard which uses a logical progression to configure each instrument allowing you to do integrity checks for each instrument,
- the lightweight and small form factor of compatible rugged Android devices reduce your exposure to physical fatigue,
- ability to work in online (internet-accessible) or offline mode. In online mode, the field app synchronizes the configurations between the RSTAR Affinity server and the data logger immediately,
- the field app is the only interface required to manage the data logger's features such as sensor data retrieval, firmware updates, and diagnostics.

1.5 EQUIPMENT COMMUNICATION HIERARCHY

Commissioning an RSTAR Affinity data logger requires configuring and managing equipment using the RSTAR Affinity field app. Access to components of the solution is configured by your organization administrator. The equipment communication hierarchy defines the order of communication between various equipment.

1.5.1 RSTAR Affinity Server

The RSTAR Affinity server holds all your organizations RSTAR Affinity assets. It can hold several sites (a site is defined as one physical location). Each site comprises of one or more gateways.

1.5.2 RSTAR Affinity Gateway

A gateway is a communication hub that routes data to and from one or more data loggers. Each gateway can only be assigned to one site.

1.5.3 RSTAR Affinity Data Logger

A data logger is a device that collects data from geotechnical sensors or instruments attached to it. A data logger may only be claimed to one site.

1.5.4 Sensors and Instruments

Sensors and instruments are devices that converts measurements from transducers to data and sends information to the data logger for processing.

2 COMMISSIONING OVERVIEW

This section gives an overview of the procedures to commission data loggers, sensors and instruments using the RSTAR Affinity field app.

Set Up the RSTAR Affinity field app

The procedure to set up the field app on an on-premises server or with RST's Azure cloud-based solution requires the following:

- internet access to allow the field app to transfer data,
- site created by the organization admin, with the gateway's GUID in the RSTAR Affinity dashboard. Refer to the RSTAR Affinity Gateway Installation and Commissioning Guide for more information,
- user accounts and permissions created by the organization admin.

Commissioning a Gateway

Your organization's RSTAR Affinity administrator is responsible for commissioning a gateway following the RSTAR Affinity Gateway Installation and Commissioning Guide. The gateway must be connected to the RSTAR Affinity server and the data logger (or loggers) to be commissioned over a wireless network.

Commissioning a Data Logger

The procedure to add a data logger to the RSTAR Affinity solution using the field app requires the data logger to ideally be located where the field app can communicate directly with the RSTAR Affinity server over a wireless internet connection. If internet connection is not available, you can commission the data logger, sensor, or instrument by uploading the information cached in the field app to the server as soon as you can connect to the internet.

Commissioning a data logger involves claiming the data logger, pairing the gateway, and adding instruments.

Claim the Data Logger

During the procedure to claim a logger to a specific site, the field app collects information from the data logger and uploads the information to the RSTAR Affinity server which then sends the information to the gateway during a subsequent pairing process. Once the data logger is successfully claimed and the information uploaded to the server, the data logger is locked to the site and cannot be re-claimed unless the data logger is unclaimed first.

Pair the Gateway

This procedure pairs a data logger to a gateway using internal security keys between the data logger and the gateway over the LoRa wireless network. If internet connection is available, the pairing process is completed immediately. If internet connection is not available, the pairing process can only be completed if the data logger's information was successfully previously uploaded to the RSTAR Affinity server.

For sites where internet coverage is not always available, you must claim the data logger where there is internet connection before commissioning the data logger on site.

Add Instruments

This procedure uses an installation wizard to configure and test the instrument.

2.1 COMMISSION DATA LOGGER (RECOMMENDED PROCEDURE)

This section details the recommended sequence to commission a data logger.

2.1.1 Android Device Requirements

The following are the minimum requirements for the Android device used with the RSTAR Affinity field app:

- Android version 10 or higher,
- Bluetooth 4.2 or higher,
- Google Mobile Services (GMS) certified,
- internet connection through Wi-Fi or cellular,
- screen with resolution of 1440 X 720, 1920 X 1080, or 2160 X 1080*.

* Tested for compatibility, although other screen resolutions may also work.

2.1.2 Install the App

Download and install the RSTAR Affinity field app from the Google Play Store on your Android device. Search for “RSTAR Affinity” on the Google Play Store. Updates to a version already installed on your device are also available on the Google Play Store. After downloading and installing the app, look for the RSTAR Affinity field app icon on your apps list.

2.2 CONFIGURE YOUR ANDROID DEVICE

The RSTAR Affinity field app requires your Android device to have the following:

- internet access through Wi-Fi, cellular, or both to allow the field app to log in and synchronize settings with the RSTAR Affinity server. Since internet connection may not always be available, the field app still allows instrument commissioning, but you must synchronize the field app with the RSTAR Affinity server as soon as internet connection is available,
- a Google Gmail account from where the field app can send diagnostic information to the RST technical support team by email,
- screen zoomed and initially configured with the smallest font size. This is because font size and screen zoom settings affect the appearance and layout of the field app and may result in words being truncated or shortened. You can adjust the settings incrementally after the initial set up,
- screen timeout to be set to a longer time such as 30 minutes. This setting specifies the time before your Android device enters sleep mode,
- date and time settings to be set correctly, as the field app synchronizes the date and time information with the data loggers.

3 FIELD APP SET-UP WORKFLOW

3.1 OVERVIEW

The RSTAR Affinity field app set-up workflow follows the sequence of steps below:

1. log in to RSTAR Affinity field app,
2. select the site,
3. claim a new data logger to a site or select a previously claimed site,
4. pair the data logger to the gateway if a gateway has not been previously claimed,
5. add (or edit) instruments to the data logger,
6. set configuration attributes and verify instrument,
7. perform additional configuration settings specific to client workflows, if required.

3.2 FIELD APP NAVIGATION

The field app allows users to intuitively navigate within the app, with features are logically grouped. Figure 2 shows how the field app's navigation branches out.

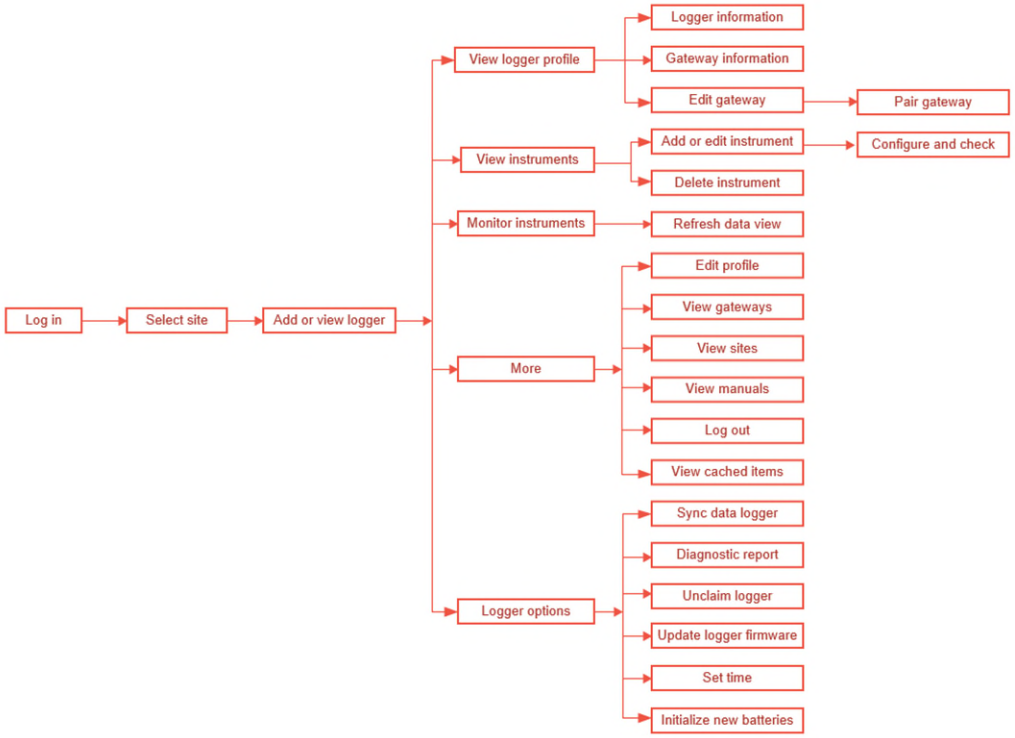


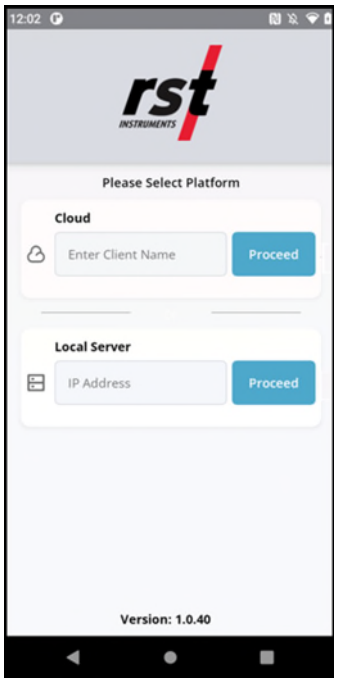
Figure 2: RSTAR Affinity Field App Navigation Diagram

3.3 SELECT PLATFORM AND LOG IN

3.3.1 Select Platform

Your RSTAR Affinity platform can either be cloud-based or on-premises. Check with your organization's RSTAR Affinity administrator which platform the organization is using. The field app can use either platform. If logging in for the first time, you will be prompted to select the server platform.

- If using a cloud solution, enter your organization's name in the **Enter Client Name** field, and then tap **Proceed**.
- If using an on-premises solution, enter the IP address for the on-premises server in the **IP Address** field, and then tap **Proceed**.



3.3.2 Log In

Your organization's RSTAR Affinity administrator is responsible for registering your email address in the RSTAR Affinity software server.

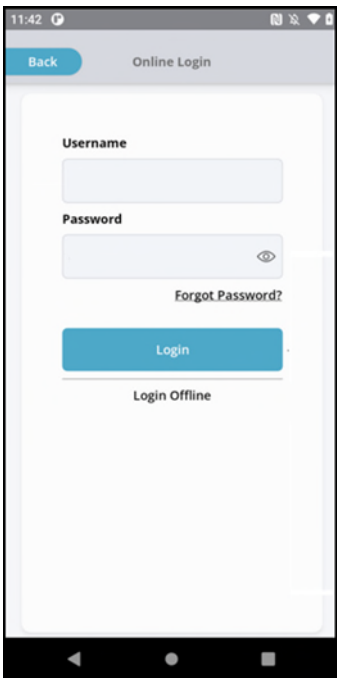
In the Online Login screen, enter your email address in the **Username** field, your password in the **Password** field, and then tap **Login** (or **Login Offline** if you are logging in to the field app offline).

If you need to reset your password, tap **Forgot Password?** and follow the prompt to create a new password from the email you will receive.

NOTE: You must be connected to the internet when logging in for the first time for the field app to retrieve your assigned permission and attributes from the RSTAR Affinity server. Your log in credentials, passwords and permissions are then saved in the Android device and keeps you logged in for a week before the app automatically logs out. This allows you to use the field app even without internet connection.

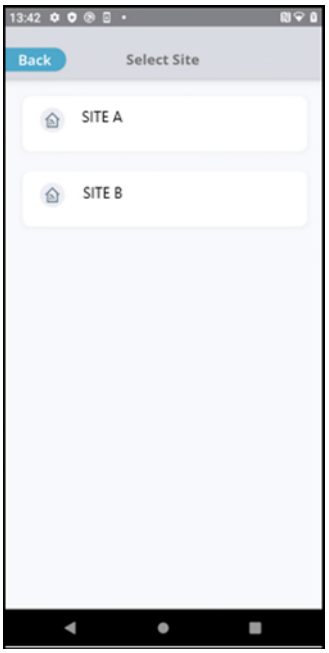
Whenever the Android device resumes internet service and has networking service with the RSTAR Affinity server, launching the app will extend the offline service for another week.

You can complete most field installation procedures even without internet coverage.



3.4 SELECT A SITE

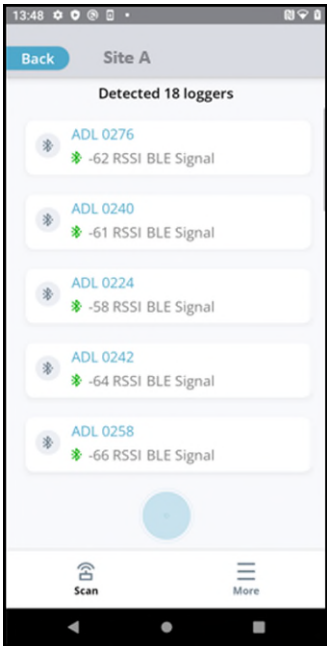
The Select Site screen appears once you're logged in. You will see sites that you can access or sites your RSTAR Affinity administrator assigned to you. Tap the site you want to access.



3.5 SELECT A DATA LOGGER

The Select Logger screen shows the data loggers within range of the field app. Depending on the Android device, the Bluetooth range may vary between a few meters to over 10 meters. The RSTAR Affinity software typically locates data loggers in the Bluetooth vicinity within five seconds. If the data logger you want is not on the list, check and make sure Bluetooth is enabled on your device, and the data logger is within a few meters from your device.

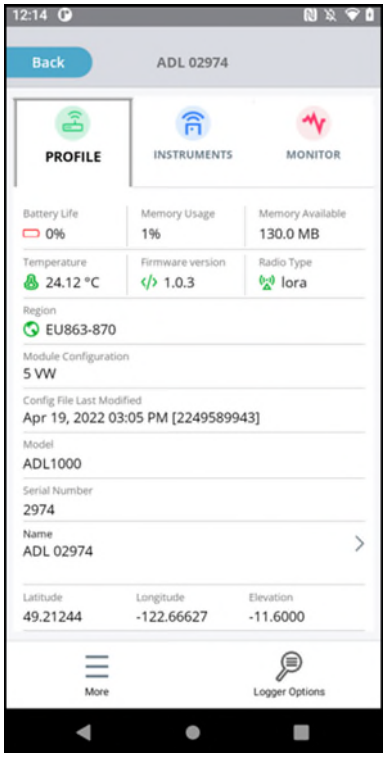
The data loggers appear in the list with their serial numbers. Tap the one you want to claim or work on.



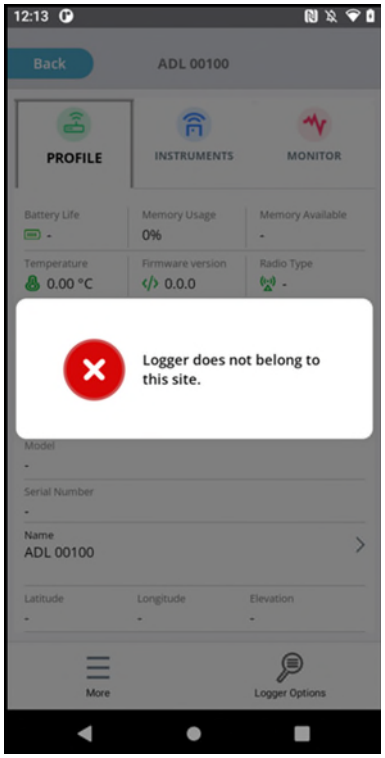
A data logger may be in one of the following states:

- Logger is already claimed for this site
- Logger does not belong to this site
- Logger is not claimed to any site

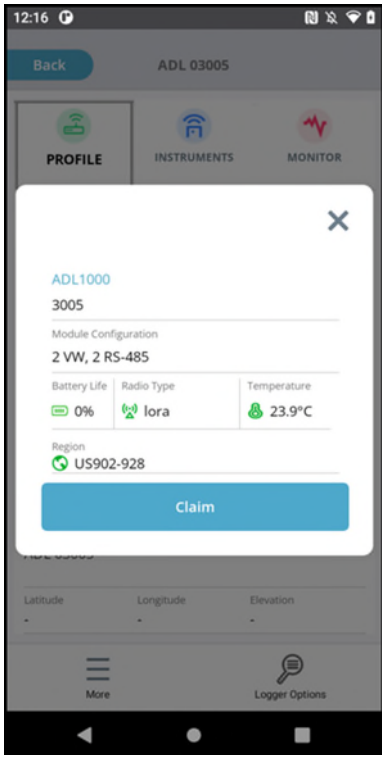
Logger is already claimed for this site – the data logger is available, and you can perform maintenance and configuration work on it.



Logger does not belong to this site – the logger is not accessible to this site. Claimed to Different Site - Decline request to access the data logger as the data logger is claimed for a different site. For this logger, no further action can be performed on this logger. The RSTAR Affinity field app reverts to the data logger selection screen.



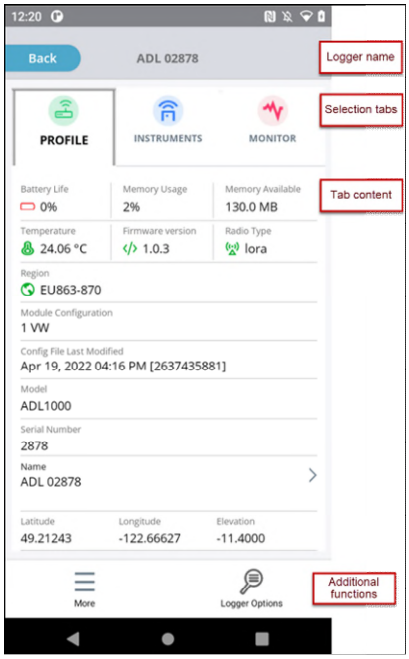
Logger is not claimed to any site – the logger is available to be claimed to this site. Tap **Claim** to claim the data logger to the site, and then can perform maintenance and configuration work on it.



3.5.1 Configure Data Logger

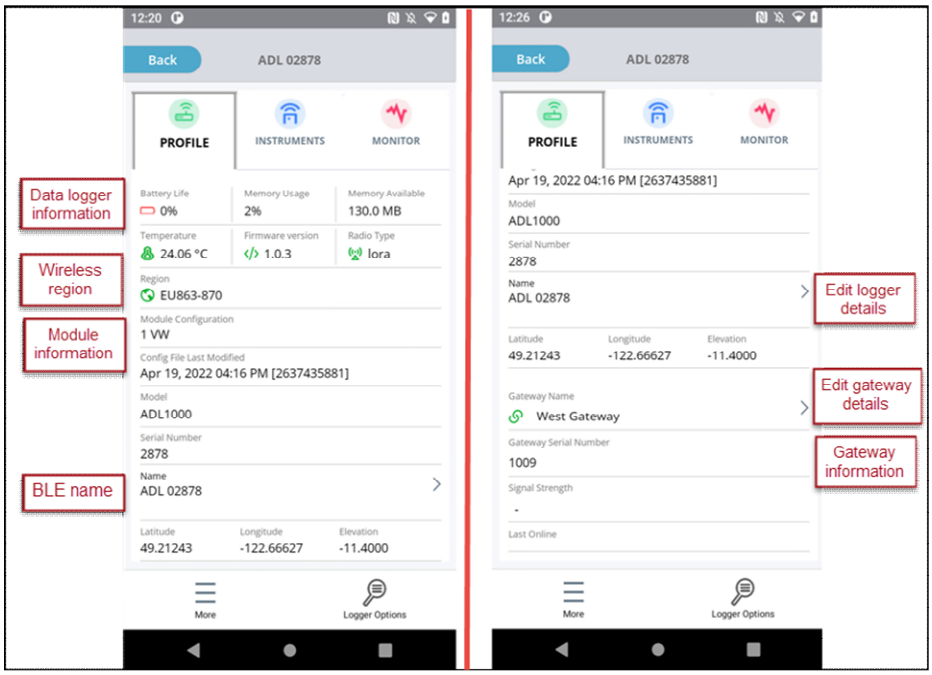
The Logger Screen shows information about a data logger. It has the Profile, Instruments, and Monitor tabs. Tap any of the tabs to see more information about the data logger appear in the centre of the screen.

Tap additional functions at the bottom of the screen for more information on the data logger.



3.5.2 View Profile Screen

The RSTAR Affinity field app retrieves data logger information during initial connection. Scroll down to see more information on the data logger and gateway.



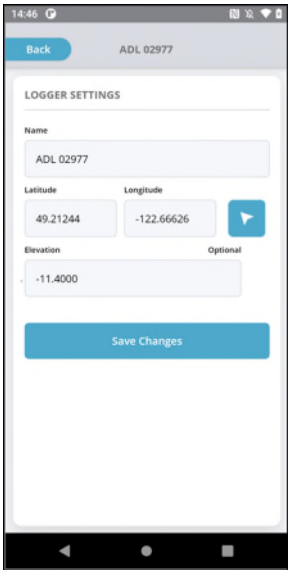
Data Logger Profile Information

Tab Name or Label	Information Displayed
Battery Life	percentage of remaining charge of all the batteries combined in the data logger
Memory Usage	percentage of sensor storage memory in use
Memory Available	total on-board storage memory in megabytes
Temperature	temperature reading in the data logger
Firmware Version	logger firmware version number
Radio Type	wireless radio module type LoRa or Stand alone
Region	wireless region
Module Configuration	list of instruments configured on the data logger
Config File Last modified	date and time the configuration was last modified
Model	data logger's model number
Serial Number	data logger's serial number
Name	name given by the user to the data logger
Latitude, Longitude, Elevation	location of the logger
Gateway Name	name of the gateway paired to the data logger
Gateway Serial Number	gateway's serial number
Signal Strength	signal strength of last communication between the data logger and the gateway
Last Online	date and time of last communication between the data logger and the gateway

3.5.3 Configure Logger Settings

The Logger Settings screen allows you to change the data logger's name, location, and elevation.

Tap the corresponding field to edit the data logger's information and then tap **Save Changes** to save the changes in the data logger and RSTAR Affinity dashboard.



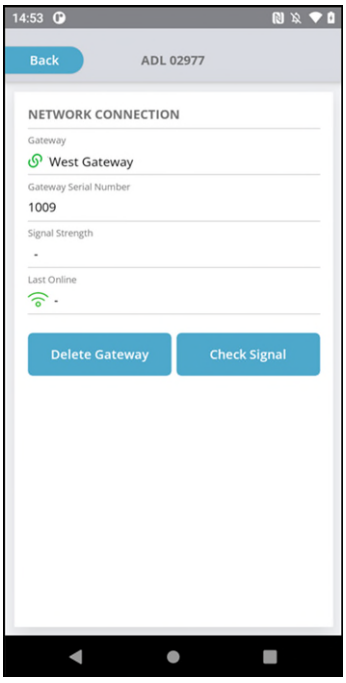
3.5.4 Check Network Connection

The Network Connection screen shows information about the gateway including its name, serial number, signal strength (from the last it was checked) and the las time it was online.

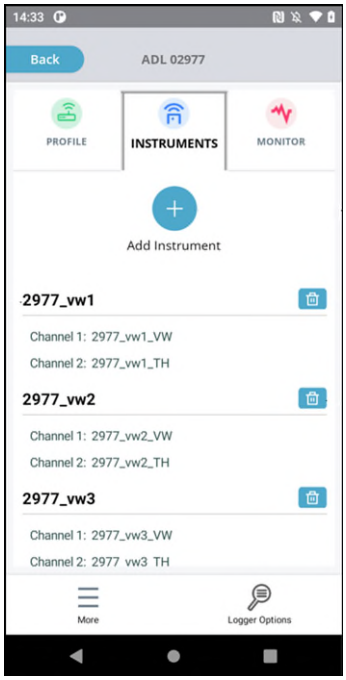
Tap the gateway's name from the Logger Settings screen to see the Network Connection screen.

Tap **Delete Gateway** to un-pair the gateway from the data logger.

Tap **Check Signal** to check the signal between the gateway and the data logger.



3.5.5 Add or Edit Instruments



The Instruments screen shows a list of instruments already configured for the data logger. RSTAR Affinity data loggers are equipped with factory-installed interface modules (IIM) customized to each specific installation. The instruments listed depends on the data logger's installed instrument type. Multi-channel (sensor) interfaces such as the RS485 multi-drop sensor arrays may have more than one sensor for each interface.

The Instruments screen allows you to add and delete instruments, and view and edit instrument configuration.

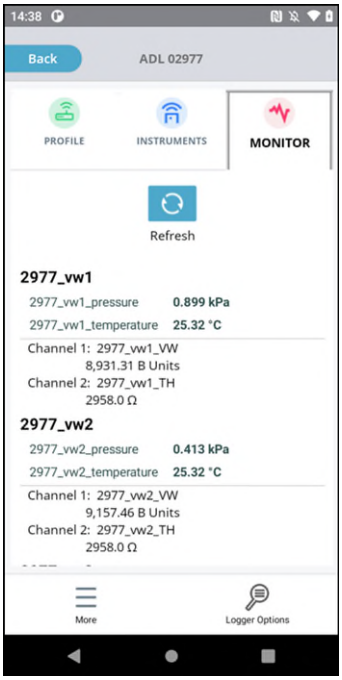
Tap the **Instruments** tab from the Logger Settings screen to see the Instruments screen.

Tap **Add Instrument** and then follow the prompts to add an instrument. You can add an instrument anytime after you've claimed a data logger. See section 3.6 for more information on adding instruments.

Tap an instrument's name to edit. Or tap the **Delete** icon next to it to delete.

You can add and remove installed instruments to and from a data logger. If the RSTAR Affinity field app has Wi-Fi coverage, instruments added immediately shows in the RSTAR Affinity dashboard. If the RSTAR Affinity field app does not have Wi-Fi coverage, you must manually upload the changes as soon as you have internet access.

3.5.6 Monitor Instruments



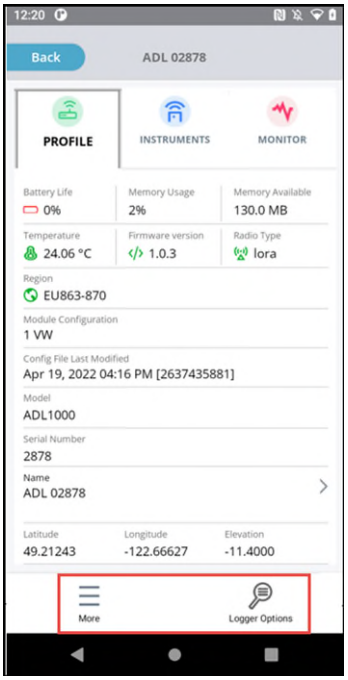
The Monitor screen allows you to view engineering and raw units information of instruments added to a data logger.

Tap the **Monitor** tab from the Logger Settings screen to see the Monitor screen.

Tap the **Refresh** icon to have the data logger update instrument measurements. You will then see the quality and reliability of the instrument's data collection services.

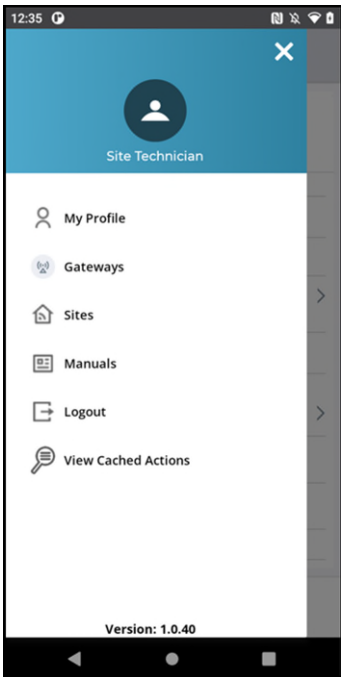
3.5.7 More and Logger Options

The More and Logger Options at the bottom of the Logger screen gives you access to additional app features.

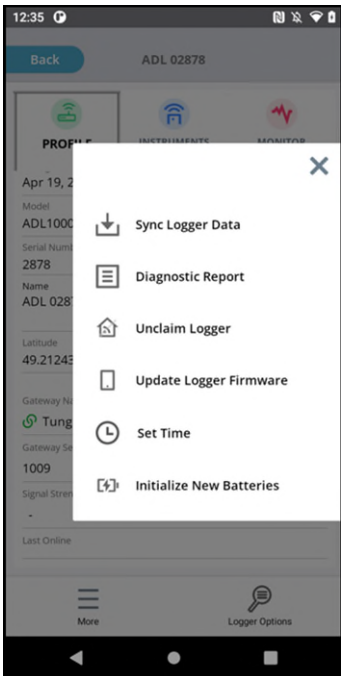


Tap the **More** icon to log out or access the following:

- My Profile – shows existing user profile and allows you to edit your profile and change your field app password. All changes are uploaded to the RSTAR Affinity dashboard when you are back online.
- Gateways – this feature is currently not enabled.
- Sites – takes you to the Select Site screen.
- Manuals – this feature is currently not enabled.
- View Cached Actions – shows information collected but has not been uploaded to the RSTAR Affinity dashboard because the Android device is not connected to Wi-Fi. The list shows the transactions to be uploaded once the device connects to Wi-Fi.



Tap the **Logger Options** icon to access the following:



- Sync Logger Data – to retrieve historical data from a specific time interval, upload only new instrument data accumulated since the last upload or upload all instrument data since the data logger was first commissioned.

After retrieving the data, the field app synchronizes the collected data with the dashboard over a cellular or Wi-Fi connection. If internet access is not available, the field app stores the data in the mobile device and uploads to the dashboard once it reconnects to the internet.

- Diagnostic Report – to review diagnostic reports and information intended for the RST technical support team. The diagnostic report is typically sent though Gmail to one or more email recipients.
- Unclaim Logger – to remove a data logger from the site currently assigned. Unclaiming a data logger is typically done if it needs to be decommissioned or claimed to another site. When unclaiming a data logger, you will be asked to retain or delete the historical data and configurations stored in the data logger.
- Update Logger Firmware – to update the data logger's four separate firmware:
  - Logger – primary firmware all logger services
  - BLE – application on the Bluetooth chipset*
  - Bootloader – boot code to launch the logger firmware*
  - Wireless module – LoRa firmware

You must use the USB interface to transfer the firmware file to the Android device, and then select the file to download it to the data logger over Bluetooth. This takes approximately 4 minutes to complete.

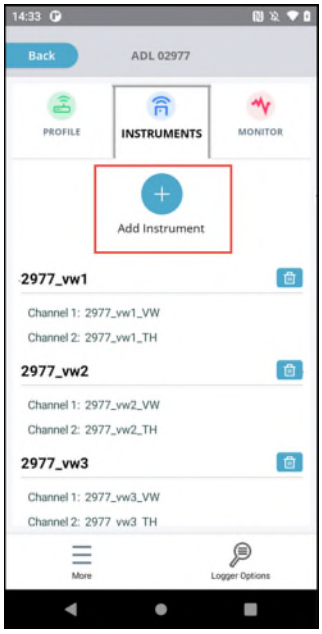
- Set Time – set the data logger's real-time clock. The field app retrieves the date and time information from the Android device and automatically sends Universal Time Coordinated (UTC) to the data logger. You typically only need to set the time for those data loggers that are operating in stand alone mode. Data loggers connected to the dashboard over LoRa has its real-time clock synchronized periodically.
- Initialize New Batteries – reset the battery meter after installing new batteries.

3.6 ADD INSTRUMENT

The data logger is pre-configured with specific instrument modules for instruments at the factory. Sensors are installed in the data logger to specific modules on the data logger. Sensors must be installed into the data logger before adding instruments on the RSTAR Affinity field app.

Some instruments share a common technology base and configuration options but are designed for different applications. See Appendix 1 for a list of instrument types and their configuration options..

Tap **Add Instrument** in the Instruments tab to add or specify special attributes of a specific sensor in one of the data logger's modules.



3.6.1 Add Instrument Using Wizard

Adding an instrument in the RSTAR Affinity field app uses the Add Instrument wizard. The wizard follows the workflow shown in Figure 3 to set up instruments.

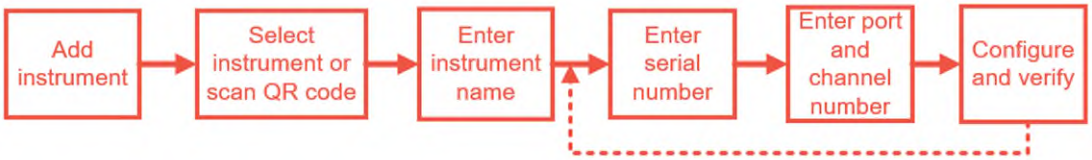


Figure 3: Instrument Setup Wizard Workflow

3.6.2 Select Instrument or Scan QR Code

Select the instrument type you want to add. If it has a QR code, use the camera in your Android device. Using the QR code could automatically allow the wizard to capture some of the instrument's calibration and configuration parameters.

3.6.3 Enter Instrument Name

Enter a name for the instrument that you want to display in the both the field app and the dashboard.

3.6.4 Enter Serial Number

The serial number is typically encoded on the instrument. On some instruments, the serial number is used in the data communication between the data logger and the instrument.

3.6.5 Enter Port and Channel Number

Each instrument is installed onto one of the available ports. A data logger may have up to five ports and up to two channels per port.

3.7 CONFIGURE AND VERIFY INSTRUMENTS

Instrument calibration procedures are instrument specific. The set-up wizard allows you to complete the steps to:

- select module,
- select channel, if applicable to the instrument,
- calibrate and configure the instrument,
- test sensor and take reading,
- specify engineering units and data labels,
- specify general notes that are logged and recorded on the dashboard,
- specify instrument location and instrument read interval.

Follow the set-up wizard to configure and verify the instrument. Refer to the configuration parameters for the different instruments in the following sections:

- Section 3.7.1 Vibrating Wire
- Section 3.7.2 Thermistor Only
- Section 3.7.3 Vibrating Wire and Thermistor Combination
- Section 3.7.5 Horizontal and Vertical ShapeArray

3.7.1 Vibrating Wire Only

The vibrating wire sensor measures the resonant frequency proportional to the tension in the wire. You can convert the resonant frequency measurement to a pressure measurement. This vibrating wire only interface uses one of the two channels of the module. For one module, two vibrating wires may be connected in a single module. Below are examples of screens you would typically see in the field app when configuring a vibrating wire.

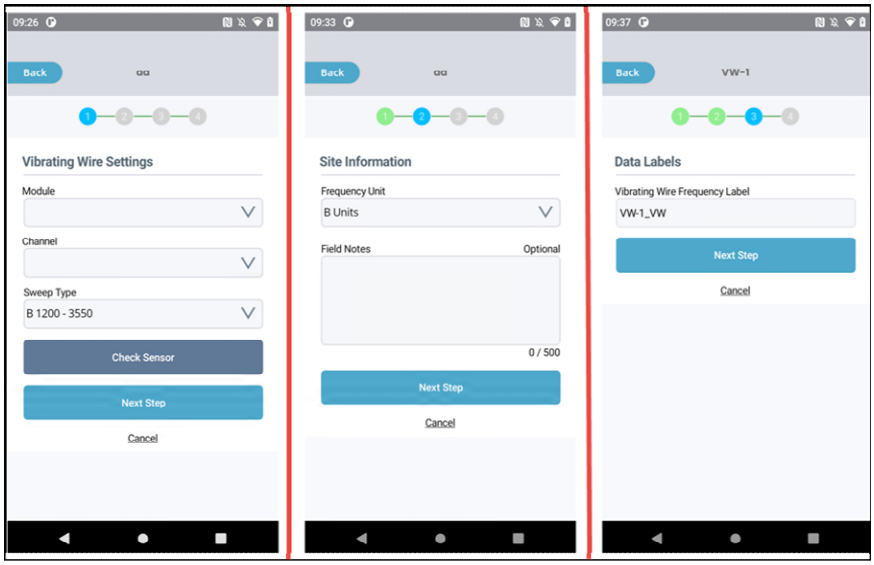


Figure 4: Vibrating Wire Configuration Screens

3.7.1.1 Sweep Type

The Sweep Type drop-down lists the following attributes for six common vibrating wire types and the user-configurable generic type:

- A 450-6000
- B 1200-3550
- C 450-1200
- D 450-1200
- E 1000-3600
- F 2500-6000
- U-Custom

Sweep Type	Start Frequency (Hz)	End Frequency (Hz)	Delay After Sweep (ms)	Received Pulse Count (cycles)	Half Cycle Count (count)	Decrement	Sweep Time (ms)
A 450-6000	450	6000	75	100	2	25	700
B 12000-3550	1200	3550	75	100	2	9	500
C 450-200	450	1200	75	100	2	19	700
D 440-1200	450	1200	75	100	2	15	700
E 1000-3600	1000	3600	75	100	1	13	500
F 2500-6000	2500	6000	75	100	2	2	500
U-Custom	user entry	user entry	user entry	user entry	user entry	user entry	user entry

Table 1: Vibrating Wire Sweep Type Attributes

3.7.1.2 Frequency Unit

The Frequency Unit drop-down lists the following measurement unit options:

- B-Units is the raw measurement units ($f^2 \times 10^{-3}$),
- Hz is the engineering units in frequency (Hz).

3.7.2 Thermistor Only

The thermistor sensor is a resistive sensor that is strongly dependent on temperature. This interface supports negative temperature coefficient (NTC) sensors.

This Thermistor Only interface uses one of the two channels of the module. So for one module, two thermistors may be connected in a single module.

3.7.2.1 Thermistor Sensor Type

The Thermistor Sensor Type drop-down lists the following four common thermistor types and the one user-configurable generic type:

- 3K NTC
- 2252 NTC
- 5K NTC

- 10K NTC
- Custom

Thermistor Sensor Type	Steinhart Coefficient A	Steinhart Coefficient B	Steinhart Coefficient C
3K NTC	1.046097 x 10-4	2.367562 x 10-4	1.020266 x 10-7
2252 NTC	1.470582 x 10-4	2.377594 x 10-4	1.044123 x 10-7
5K NTC	1.288845 x 10-3	2.355150 x 10-4	9.588520 x 10-8
10K NTC	1.129298 x 10-4	2.341034 x 10-4	8.774217 x 10-8
Custom	user entry	user entry	user entry

Table 2: Thermistor Coefficients

3.7.2.2 Default Temperature Unit

The Default Temperature Unit drop-down lists the following measurement unit options:

- C – Celsius units
- F – Fahrenheit units
- K – Kelvin units

3.7.3 Vibrating Wire and Thermistor Combination

The vibrating wire and thermistor combination is a vibrating wire with a built-in thermistor sensor designed to provide higher accuracy measurements by introducing temperature compensation to measurements. This combination uses both channels of one module on the data logger.

The Vibrating Wire and Thermistor combination includes the following instruments.

Instrument Type	Model Number Prefix
VW Piezometer	VW2100, VW2090, VW2191
VW Pressure Transducer	VW2190
VW Push-in Pressure Cell	VWPC2100
VW Total Earth Pressure Cell	LPTPC06, LPTPC09, LPTPC12
VW NATM Stress Cell	VW3291
VW Liquid Settlement	SSVW105
VW In-Line Extensometer	EXINLINE
VW Multi-Point Borehole Extensometer	VW2100, VW2090, VW2191
VW Crack Meter	VWCM
VW Soil Extensometer	EXSR
VW Joint Meter	VWJM
VW Arc Weld Strain Gauge	VWSG-A

Instrument Type	Model Number Prefix
VW Embedment Strain Gauge	VWSG-E
VW Spot Weld Strain Gauge	VWSG-S
VW Sister/Rebar Strain Gauge	VW5000
VW Load Cell	VWS, VWA

Each transducer is shipped from the factory with a calibration sheet. The calibration sheet details the calibration constants which are specific to each transducer. You can manually enter the information included in sheet into the app or scan the QR code. The following are some of the configurable parameters:

- Sensor serial number,
- Sweep Type,
- Thermistor Sensor Type,
- Temperature Factor
- Linear Calibration Factor*,
- Polynomial Calibration Factor A*,
- Polynomial Calibration Factor B*,
- Gauge Factor*.

(*) Instrument-specific calibration constants

Below are examples of screens you would typically see in the field app when configuring a vibrating wire and thermistor.

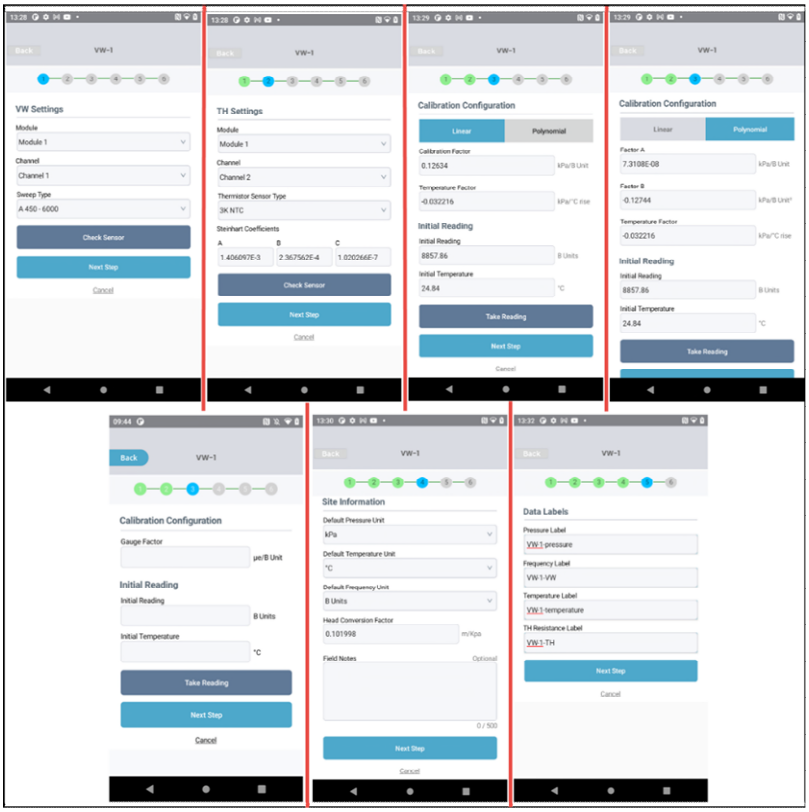


Figure 5: Vibrating Wire and Thermistor Configuration Screens

3.7.3.1 Sweep Type

The Sweep Type drop-down lists attributes for six common vibrating wire types and the user-configurable generic type:

- A 450-6000,
- B 1200-3550,
- C 450-1200,
- D 240-1200,
- E 1000-3600,
- F 2500-6000,
- U-Custom.

Sweep Type	Start Frequency (Hz)	End Frequency (Hz)	Delay After Sweep (ms)	Received Pulse Count (cycles)	Half Cycle Count (count)	Decrement	Sweep Time (ms)
A 450-6000	450	6000	75	100	2	25	700
B 12000-3550	1200	3550	75	100	2	9	500
C 450-1200	450	1200	75	100	2	19	700
D 440-1200	450	1200	75	100	2	15	700
E 1000-3600	1000	3600	75	100	1	13	500
F 2500-6000	2500	6000	75	100	2	2	500
U-Custom	user entry	user entry	user entry	user entry	user entry	user entry	user entry

Table 3: Vibrating Wire and Thermistor Sweep Type Attributes

3.7.3.2 Thermistor Sensor Type

The Thermistor Sensor Type drop-down lists common thermistor types and the user-configurable generic type:

- 3K NTC,
- 2252 NTC,
- 5K NTC,
- 10K NTC,
- Custom.

Thermistor Sensor Type	Steinhart Coefficient A	Steinhart Coefficient B	Steinhart Coefficient C
3K NTC	1.046097 x 10-4	2.367562 x 10-4	1.020266 x 10-7
2252 NTC	1.470582 x 10-4	2.377594 x 10-4	1.044123 x 10-7
5K NTC	1.288845 x 10-3	2.355150 x 10-4	9.588520 x 10-8
10K NTC	1.129298 x 10-4	2.341034 x 10-4	8.774217 x 10-8
Custom	user entry	user entry	user entry

Table 4: Thermistor Sensor Coefficients

3.7.4 Calibration Configuration

The Calibration Configuration option allows you to incorporate instrument-specific calibration formulas to convert the vibrating wire raw sensor readings to engineering units. The available engineering conversion formulas are instrument specific.

- **Linear** – a traditional calibration formula suited for most application where the sensor is operating in the linear range of the sensor.
- **Polynomial** – more suitable if the sensor is subjected to wider operating temperature or pressure variation where a non-linear polynomial interpolation may get better results.
- **Gauge Factor** – is a linear formula to convert vibrating wire raw readings to units of micro-strain.

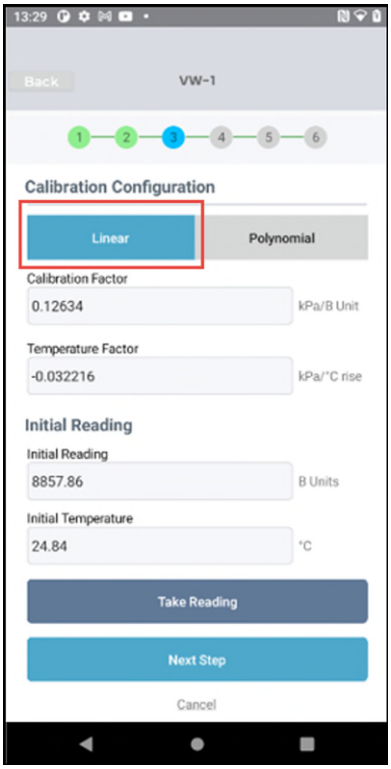
3.7.4.1 Calibration Configuration: Linear

The linear calibration configuration applies the following formula:

$P = CF * (L_0 – L) – Tk * (T_0 - T)$

Where:

- P = pressure (MPa)
- CF = linear calibration factor (MPa / B Unit)
- L_0 = initial (baseline) vibrating wire reading (B Unit)
- L = current vibrating wire reading (B Unit)
- Tk = temperature correction factor (MPa / °C)
- T_0 = initial (baseline) temperature reading (°C)
- T = current temperature reaing (°C)



3.7.4.2 Calibration Configuration: Polynomial

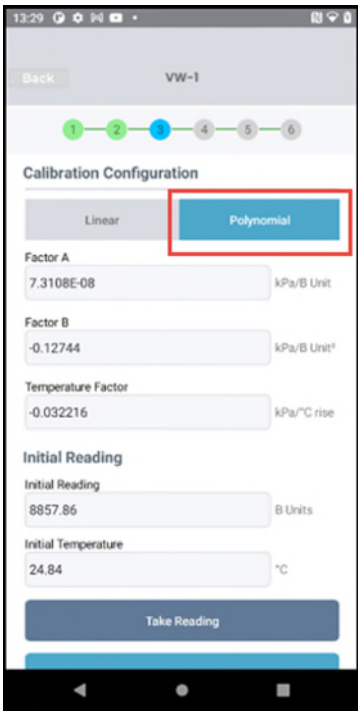
The polynomial calibration configuration applies a second order polynomial to the following formula:

$P = A * (L2) + B * (L) + C – Tk * (T0 - T)$

Where:

- P = pressure (MPa)
- A = polynomial gage A factor (MPa / (B Unit)^2)
- L = current vibrating wire reading (B Unit)
- B = polynomial gage B factor (MPa / (B Unit)
- L_0 = initial (baseline) vibrating wire reading (B Unit)
- C = polynomial C = - [A (L_0^2) + B (L_0)] (MPa)
- Tk = temperature correction factor (MPa / °C)
- T_0 = initial (baseline) temperature reading (°C)
- T = current temperature reaing (°C)

Polynomial Factor A, Polynomial Factor B, and Temperature Factor are parameters applied in the polynomial calibration configuration formula. You must manually enter these three constants from the instrument calibration sheet or scan the QR code when you're selecting the instrument.



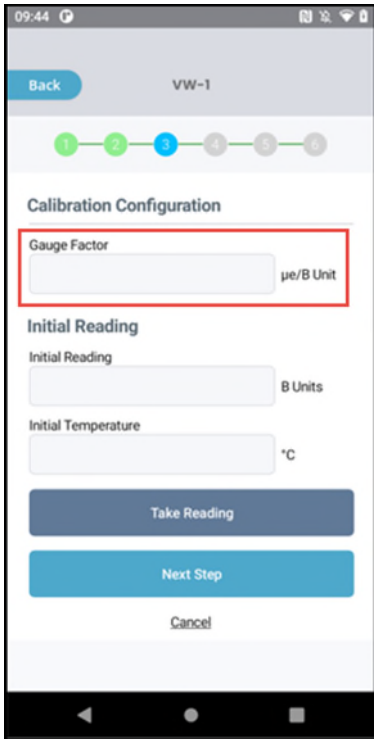
3.7.4.3 Calibration Configuration: Gauge Factor (Strain)

The Strain Gauge Factor calibration configuration applies a second order polynomial to the following formula:

$S = CF * L$

Where:

- S = Strain - micro-strain (με)
- CF = Strain Gauge Facotr (με / (B Unit))
- L = current vibrating wire reading (B Unit)



3.7.4.4 Take Reading

Tap **Take Reading** in the Calibration Configuration screen to automatically populate the Initial Temperature section of the app. The reading that appears will be the baseline reading where all subsequent readings will be computed against.

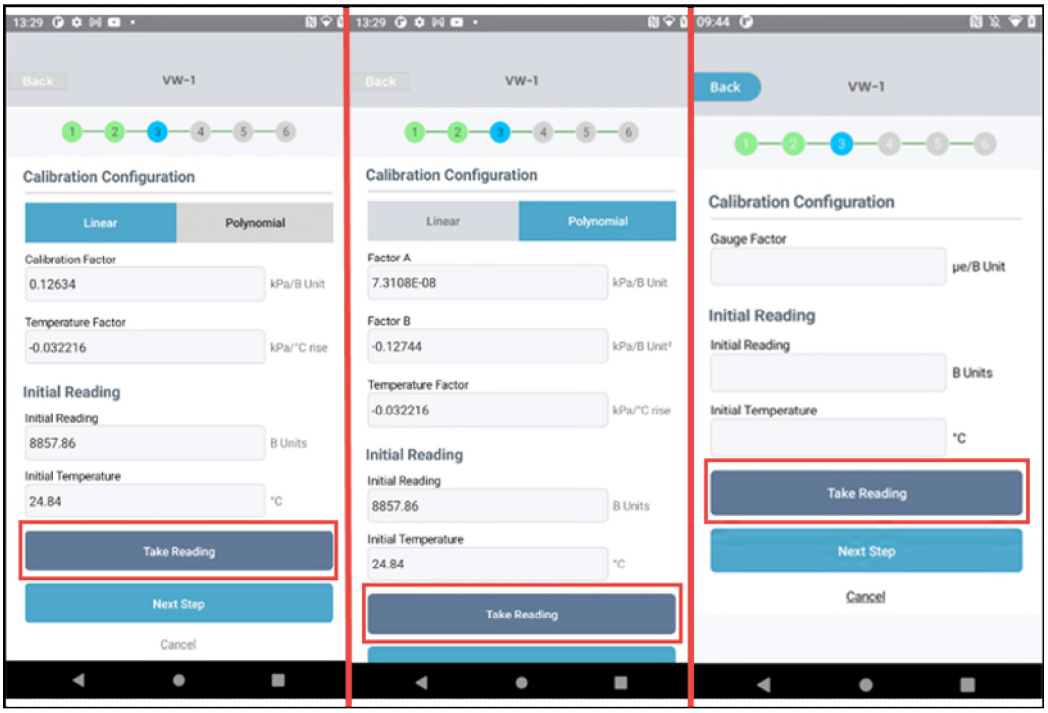


Figure 6: Take Reading Example Screens

3.7.5 Horizontal and Vertical ShapeArray

The Measurand ShapeArray™ instrument monitors deformation in soil and structures such as dams, tunnels, walls and buildings. The ShapeArray™ is a versatile and automated shape-measuring instrument.

The following are the configurations required for the vertical and horizontal ShapeArray™:

- Reference Point,
- Casing Size,
- Cyclical Correction (vertical ShapeArray only),
- Bias Shift,
- Anti-rotation.

Below are examples of screens you would typically see in the field app when configuring horizontal or vertical ShapeArray™.

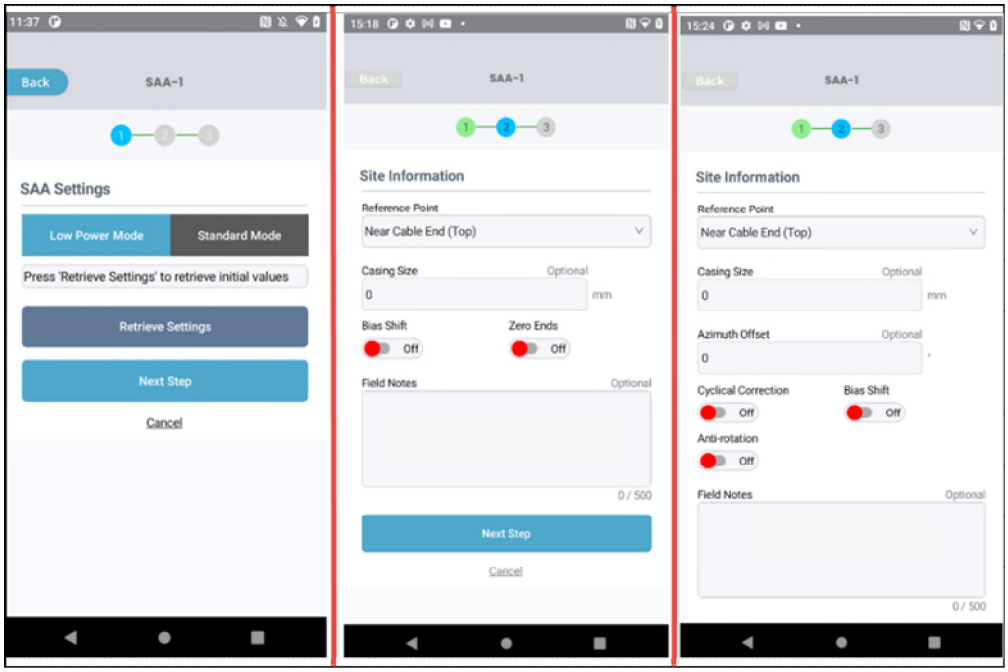


Figure 7: Horizontal and Vertical ShapeArray™ Configuration Screens

3.7.5.1 Reference Point

Indicates which end of the ShapeArray™ instrument will be used as the reference end. The reference end of the instrument will be treated as the origin point (0,0,0) in the resulting Cartesian output.

3.7.5.2 Casing Size

The internal diameter (I.D.) of the casing into which the ShapeArray™ is installed. The I.D. of the casing is used in the calculation to determine whether a vertically installed ShapeArray™ has been sufficiently compressed.

3.7.5.3 Cyclical Correction (Vertical ShapeArray™ Only)

Cyclical (zigzag) Installation adjustment applies medial axis math for cyclical installations where the ShapeArray™ instrument zigzags within the casing. This adjustment should only be applied to vertical SAAV installations.

3.7.5.4 Bias Shift

The Bias Shift adjustment corrects for small instability (exclusively in sensor X, Y, or Z) in legacy accelerometers used in older SAAF ShapeArray™. Next-generation models, such as those used in SAAV ShapeArray™ do not have instability. The Bias Shift adjustment can be inappropriate for discrete shapes that change suddenly.

3.7.5.5 Anti-rotation

The Anti-rotation adjustment adjusts ShapeArray™ data for instances where segments in the instrument roll (rotate) but do not have a significant change in their tilt.

APPENDIX 1: INSTRUMENT TYPES AND CONFIGURATION OPTIONS

The RSTAR Affinity field app incorporates the following configuration options:

- Vibrating Wire Only Configuration – uses one of two channels of a VW/TH module
- Thermistor Only Configuration – uses one of two channels of a VW/TH module
- Vibrating Wire and Thermistor Combination Configuration
- Digital Tilt Bus Configuration (RS485 interface)
- Shape Array Configuration (RS485 interface)
- Modbus Configuration (RS485 interface)
- 4-20mA dual channel or single channel Setup (4-20mA interface)
- Voltage Divider Configuration

Instrument Type	Model Numbers Prefix	Configuration Option
Generic Vibrating Wire	Generic	Vibrating Wire Only
Generic Thermistor	Generic	Thermistor Only
Generic Vibrating Wire and Thermistor	Generic	Vibrating Wire and Thermistor
VW Piezometer	VW2100, VW2090, VW2191	Vibrating Wire and Thermistor
VW Pressure Transducer	VW2190	Vibrating Wire and Thermistor
VW Push-in Pressure Cell	VWPC2100	Vibrating Wire and Thermistor
VW Total Earth Pressure Cell	LPTPC06, LPTPC09, LPTPC12	Vibrating Wire and Thermistor
VW NATM Stress Cell	VW3291	Vibrating Wire and Thermistor
VW Liquid Settlement	SSVW105	Vibrating Wire and Thermistor
VW In-Line Extensometer	EXINLINE	Vibrating Wire and Thermistor
VW Multi-Point Borehole Extensometer	VW2100, VW2090, VW2191	Vibrating Wire and Thermistor
VW Crack Meter	VWCM	Vibrating Wire and Thermistor
VW Soil Extensometer	EXSR	Vibrating Wire and Thermistor
VW Joint Meter	VWJM	Vibrating Wire and Thermistor
VW Arc Weld Strain Gauge	VWSG-A	Vibrating Wire and Thermistor
VW Embedment Strain Gauge	VWSG-E	Vibrating Wire and Thermistor
VW Spot Weld Strain Gauge	VWSG-S	Vibrating Wire and Thermistor
VW Sister/Rebar Strain Gauge	VW5000	Vibrating Wire and Thermistor
VW Load Cell	VWS, VWA	Vibrating Wire and Thermistor
Generic Modbus	Generic	Modbus
Shape Array	SAAV, SAAX, SAA Extend	Shape Array
Digital Tilt Meter	IC6556, IC6656	Digital Tilt

Instrument Type	Model Numbers Prefix	Configuration Option
Digital Submersible Tilt Meter	IC6750, IC6756	Digital Tilt
Vertical Tilt Beam	IC6017, IC6018	Digital Tilt
Horizontal Tilt Beam	IC6082, IC6083	Digital Tilt
Tunnel Profile Monitor System	ICTCCST	Digital Tilt
Track Monitoring Settlement System	IC9000, IC9003, IC9050, IC9053, IC9100	Digital Tilt
Vertical In Place Inclinometer – Legacy	IC7565B, IC7575B, IC7570B, IC7525B, IC7555B, IC7520B, IC7550B	Digital Tilt
Horizontal In Place Inclinometer – Legacy	IC32003H, IC32005H, IC32075H, IC3200H, IC32015H, IC32205H	Digital Tilt
Vertical In Place Inclinometer	IPI27050-U	Digital Tilt
Horizontal In Place Inclinometer	IPI27050-D	Digital Tilt
Precision Liquid Settlement Array	SS5010, SS5020, SS5030	Digital Tilt
Digital Bus Strain Gauge Piezometer	ELSGP510S, ELSGP511S	Digital Tilt
4-20mA Generic Sensor	Generic	
4-20mA Strain Gauge Transducer	ELSGT610, ELSGT611	
4-20mA Strain Gauge Total Earth Pressure Cell	LPTPC09, LPTPC12	
4-20mA Strain Gauge Piezometer		
4-20mA Tilt Meter	IC6550, IC6650	
4-20mA Submersible Tilt Meter	IC6752, IC6753	

Table 5: RSTAR Affinity Configuration Options for Instruments