TBSL1
and TBSL1 GUI

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1 Introduction

The TBSL1-LO from Tekbox acts as an SDI-12 data logger with integrated LoRaWAN communications. In addition the unit has a single pulse input and an analogue input.

The SDI12-LoRa GUI is used to program the TBSL1-LO via a serial connection. It can be used to set all the board's operational parameters (time settings, SDI-12 commands, LoRaWan settings) and send commands to SDI-12 sensors or the LoRaWAN module on the board and to display the received responses.

2 Hardware setup

The picture below shows the designations of the various connectors on the TBSL1.

The TBSL1 connects to a PC using a USB connection, You can connect to the Type A connector on the case or, with the case open, to the Type B (printer style) connector on the PCB.

Using a Number 1 Philips Screwdriver, remove the 4 screws holding the cover to the TBSL1 case and remove the cover.

Before fitting the battery, make sure that the antenna is screwed on to the TNC connector on top of the case and that the UFL cable from the antenna is fitted to the upper most socket on the LoRaWAN PCB.

For the standard TBSL1 the battery is a 3.6V Lithium-Ion cell with internal thermistor and 3 pin JST connector. Connect the battery lead to the matching socket on the upper left of the TBSL1 PCB.

If your TBSL1 is going to be powered via a solar cell, wire the solar panel up according to the diagram below (Port 3). If the solar panel has been supplied with your unit it will be pre-wired with the required connector. In most applications a 6V 2W solar panel will operate the TBSL1 although a 5W unit can be used if you have concerns about the power budget.

CAUTION: Do not use the TBSL1 with 12V solar panels. The maximum permissible open circuit panel voltage is 7.2V. Using a panel with a higher voltage rating may damage the TBSL1.

1: ADC_CH0
2: GND
3: ADC_CH1
4: RAIN GAUGE
5: SDI-12 DATA
6: VCC-SDI_12
7: SHIELD

1: SP+
2: SP-
3:
4:
5: NC
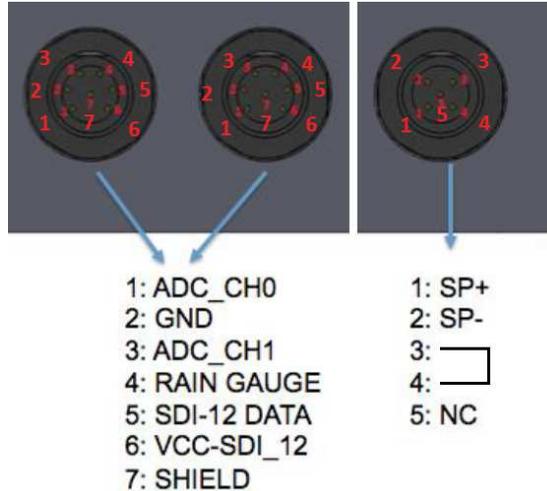
The two input connectors are wired in parallel. This allows you to easily connect two SDI-12 sensors. Should you need to connect more than two cables, you can add a TBS04 Junction Box.
The colour code for the cables supplied with the TBSL1 is as follows:

Pin	Sensor (7 pin)	Solar (5 pin)
1		Green – SP +
2	Brown - GND	Brown – SP -
3		Link to Pin 4
4		Link to Pin 3
5	White - SDI-12	-
6	Green - PWR	-
7		-

The back of the TBSL1 case is fitted with a mounting bracket. This can be used to secure the unit to a 40 to 50mm post using a stainless steel hose clamp.

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Radio range is governed by a number of factors including terrain. Radio range can be maximised by:
- raising the height of the Gateway antenna
- raising the height of the TBSL1 antenna.

Often a compromise must be sought between raising the antenna height for best coverage versus keeping it low to allow machinery to pass over the site. If regular machinery movement is an issue, consider using a tilt down base pole.

The following factors will cause a decrease in range:
- hills between the TBSL1 and the Gateway
- tree canopy between the TBSL1 and the Gateway, particularly trees with fine needle leaves which act can absorb signal when they are wet
- metal objects placed close to the TBSL1 antenna.

When using the TBSL1 with a solar panel, mount the solar panel facing North (south in the Northern Hemisphere) and the fit TBSL1 on the opposite side of the pole, facing south. This way the solar panel helps shade the TBSL1 from the sun. If you are fitting the TBSL1 with an external antenna, you can mount the antenna as high as possible on the post and the TBSL1 unit directly below the solar panel.

3 Software Installation

To avoid issues with permissions, copy the GUI application files to the AppData/Local folder for the current user:

C:/<user name>/AppData/Local/TBSL1

After creating the folder and copying the files, you can make a new desktop shortcut, linked to the file "TBSL1_GUI.exe".

After creating the Shortcut, right click it and select Properties, then set the option to "**Always run as Administrator**"

- failure to do this will result in Windows blocking some of the programs functions such as writing updated configuration files
- if you find the GUI is misbehaving, close it, check this setting the re-start the GUI.

The TBSL1 GUI program and TBSL1 Firmware must be maintained at the same version

- you can check the TBSL1 firmware version in the Info tab of the TBSL1 configuration screen.

If you received an update to the TBSL1 firmware, always ensure you update the GUI at the same time. This will ensure that configuration incompatibilities do not create errors

- the GUI software checks the TBSL1 firmware version whenever it connects
- if the versions do not match, an error will display on the screen
- the error message will clear once the two are brought to the same versions.

4 Using the TBSL1 GUI

To open the GUI application, run the file TBSL1-GUI.exe from the directory where the application files are located or by clicking on the desktop shortcut you created during installation.
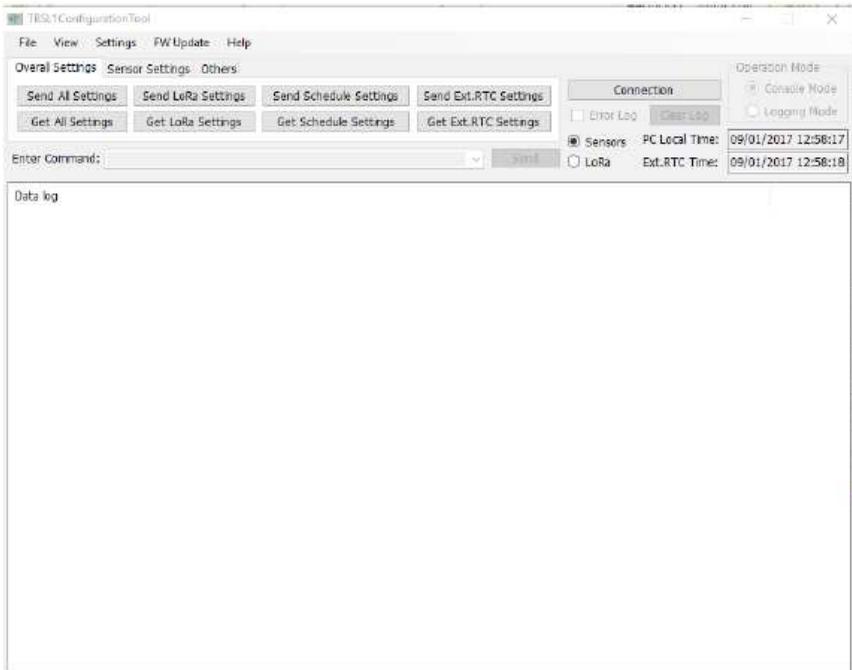
4.1 Connecting to the TBSL1

In order to configure the TBSL1, the unit must have the Solar Panel connected. This is because the start link (between Pins 3 & 4) on the socket is used to activate the unit. If you are regularly setting up TBSL1 units you can use a spare 5 pin plug to make up a dummy plug: simply solder a link between pins 3 and 4 on the back of the plug. Note that you can also solder wires to pins 1 (+) and 2 (-) to allow you to charge the battery from a 6V plugpack or bench power supply.

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To work with the TBSL1, you must connect to the unit using the COM port allocated to the device by your PC when the unit is plugged in. Use the Windows Device Manager to identify the port.
To select the Port:

- From the menu select ***Settings / Com Port Configuration***
- When the communications dialogue box opens, click on COM Port and select the port allocated to the device form the drop down list box
- If the port has not displayed, click on REFRESH COMMS to have the program re-scan for the available ports
- Leave all the other settings on the default values

Once you have selected the port, the GUI will attempt to communicate with the TBSL1. The result of the communications between the GUI and the device are shown in the Data Log section of the screen

- Transmitted commands display in red   **>>**
- Responses from the TBSL1 are shown in blue   **<<**
- If you want to see more detailed information about the log information, open the log file from the folder **C:\Users\<User name>\AppData\Local\TBSL1\Logs**

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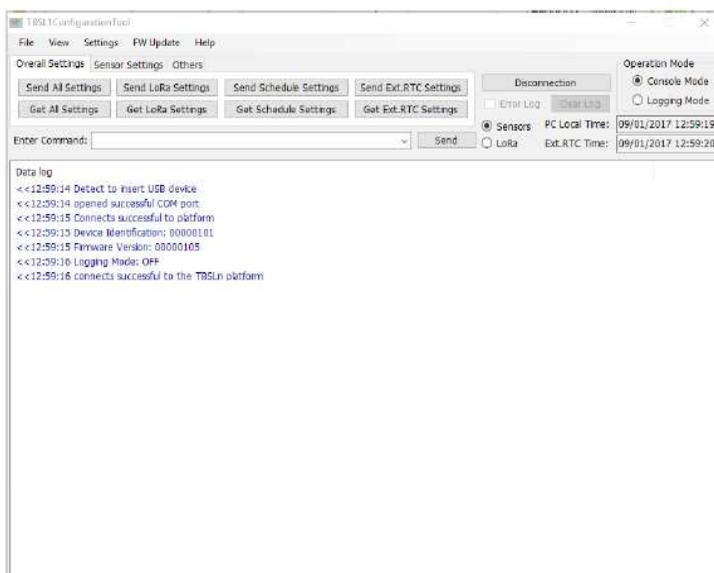
The GUI can operate in two modes: **Console** and **Logging**:

- Console Mode: this mode is the default and is used to configure and test the TBSL1
    - In console mode, the board doesn't perform any measurement/ transmission operations. It only receives the commands from the application, executes the commands on sensor/LoRa module and send responses to the application.
- Logging Mode: units must be set back to this mode to enable logging
    - This is the normal mode of operation for devices in the field
    - While in logging mode the GUI displays the results of commands as they are executed on the TBSL1.

When powered-up, the board will send a "PING" command to the PC and wait for a response from the application. If the application has started and the COM port is open, it should answer with an "OK" response, after which the date and time are automatically programmed into the unit and the board will switch to "C*onsole*" mode.

4.2 Create and Save a Configuration File for the Device

The TBSL1 will load with a default configuration, which is saved as ..\ TBSL1\JsonFile\defaultsettings.json. If you wish to change the default settings you can edit this file (Notepad++ is a suitable editor).

To enable you to easily recall and modify configurations for specific TBSL1 units, you should save a configuration file for each one:

- To create a new Configuration file select *File / Save As* and then give the file a suitable name e.g. TBSL1_SN_13423 or TBSL1_Jones_Block_34
- to identify the Serial Number of the TBSL1, from the menu select *Settings / TBSL1 Configuration* and then click on the INFO tab
    - the serial number is shown in the Board ID field.

Once you have saved configurations, you can re-load them at any time. In this fashion you can create one device configuration file and then use it as a template for future devices. You can also save a file for each of the

standard configurations you use (for instance your standard soil moisture probe site or standard weather station).

4.3 Changing Operating Mode

Normally, the application will stay in **"Console"** mode. In this mode, the board will wait for data and commands to be sent. Any settings sent from the application at this time will only be saved in the board memory; they will not be activated.

Operation Mode

◉ Console mode
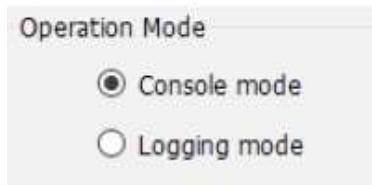
◯ Logging mode

When you click on **"Logging mode"** button, the application will send a command to the board,telling it to go to **"Logging"** mode. In **"Logging"** mode, the board will activate the new settings. After that, the board will go to sleep – and will wake up according to its logging and transmission settings.

From here you have two options:

- Switch to **"Console"** mode by clicking on the **"Console mode"** button, which will send a command to the board. When the board next wakes up, it will receive that command and switch to **"Console"** mode.
- Stay in **"Logging"** mode. In this state, the board will stay in its normal logging mode of *measure data -> go to sleep -> wake up -> measure again and/or transmit data -> go to sleep again and go on*. The time between each sleep and wake up depends on the Interval settings in the application.

NOTE : the TBSL1 will not return to Console Mode until it wakes from its sleep cycle. If the measurement interval is 15 minutes it could this take 15 minutes for the unit to respond. To avoid having to wait:

- Click on the Disconnection button
- Unplug the battery from the TBSL1 and remove the Programming cable
- After 5 seconds, plug in the programming cable and battery and then click on the Connect button.

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4.4 Configuring the TBSL1

Configuration can be broken down into a number of functional areas:

- LoRaWAN settings
- Measurement/Logging settings
- Sensor Settings

4.4.1 LoRaWAN Settings

Before setting up the TBSL1 you must obtain all the relevant information on the network to which it is being connected and the Join type to be used

- If you are using Over the Air Activation (OTAA) you will need:
  - Device EUI
  - APP EUI
  - APP Key
- If you are using Activation by Personalisation (ABP) you will need
  - Device Address
  - Device EUI
  - Network Security Key
  - Application Security Key

To configure the LoRaWAN parameters:

- From the menu select *Settings / TBSL1 Configuration*
- When the Board Configuration menu, click on the **LoRaWAN** tab
- In the LoRaWAN Settings section:
  - Select the activation type – ABP or OTAA
  - The fields required for each activation type will be editable and those not needed will be greyed out
  - Fill in the required information with the values given to you by your LoRaWAN provider
  - Note that all fields are in "Big Endian" format i.e. with high order bytes first

4.4.1.1 Packet Acknowledgement Settings

LoRaWAN offers two methods to avoid errors caused by two or more devices transmitting at the same time

- The simplest method is to transmit the packets of data multiple times (No Ack from Server)
- The alternative is to have each Packet acknowledged by the LoRaWAN Server (Wait Ack from server). If this option is selected, the device will continue trying to send a packet until it receives a

message saying it has been received. This is done by maintaining a Frame Counter which is incremented each time a new packet is sent
- For simple devices such as water meters, you can use No Ack and 3 retries
- For Soil moisture and weather monitoring you should use the Acknowledged packets option.

4.4.1.2   LoRa Frequency Settings

The LoRaWAN protocol defines a number of different channel plans base don the region in which the devices will be operated. The standard channel plan for Australia is AU915. This channel plan supports 64 channels broken up in to 8 sub bands, each with 8 channels. This limitation is imposed because the standard Gateway chip set only supports 8 channels. While some early networks used sub band 0, most now use sub band 1 (Ch 8 to 15). Note also some operators in Australia and New Zealand have also elected to use the Asian region channel plan (AS923). This channel plan is supported by the TBSL1 and TBSL1 GUI.

The RF parameters are set in the LoRa RF section of the screen
- Adaptive Data Rate (ADR)   set to ON
  - Devices close to the Gateway will have a higher signal strength and their transmissions will be less prone to errors than those form devices with low signal strength
  - ADR allows devices close to the Gateway to transmit at a higher speed than those further out. This technique ensures that more air time will be available for transmissions than would be the case of all devices were operated on the speed needed for the most remote units
- Freq Scheme: this is where you choose the channel plan which is being used by the Gateway
  - If you have not been advised of what to use, select AS915
  - Then click on the SET CH button to bring up a list of the available channels and their operating frequencies
  - The image above shows the settings for AU915 sub band 1. If using Sub band 0, set the first channel to 915.2 with each subsequent channel 0.2 MHz higher. Clicking on Default Setting will reload the Sub band 0 settings (CH 0-7).

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Channel	Freq	DRmin	DRmax	EnableCH
LC0	916.8	DR0	DR3	☑
LC1	917.0	DR0	DR3	☑
LC2	917.2	DR0	DR3	☑
LC3	917.4	DR0	DR3	☑
LC4	917.6	DR0	DR3	☑
LC5	917.8	DR0	DR3	☑
LC6	918.0	DR0	DR3	☑
LC7	918.2	DR0	DR3	☑

Channel Setting — ChannelConfig

Default Setting   Save   Close

- Data Rate: if ADR is not being used, select the data rate to use
  - The default is 3
  - You can use a higher rate of your network is small
- TX power: this setting controls the power of the transmitter in the unit
  - This can be left on the default (max) setting i.e. 14.

4.4.2 Time Settings

The TBSL1 units are intended to be used with the time set to UTC (Universal Coordinated Time, which was referred to for a long period as GMT or Greenwich mean Time). This allows the data from devices anywhere in the world to be compared and avoids issues with time stamps changing when daylight savings starts and finishes (which causes a 1 hour gap in the data).

To time settings are locate din the RTC Settings of the configuration screen:

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- First click on the **Time Zone** drop down list and then select the Time Zone for the location in which the unit is being installed e.g. UTC + 9:30 Adelaide
- If you want to fetch the time zone from the PC you are using, click on the **Get User PC Time Zone** button
- To write the time to the TBSL1 click on **Set Time for External RTC**

4.4.3 Schedule Settings

These control how often measurements are made and transmitted. Normally the Measurement Interval (found in the SDI-12, Analogue or Pulse sensor settings) and Transmit Interval will be set to the same value

- Transmission Interval: set to suit your application e.g. 15 min for soil moisture and weather sites
- Watchdog Interval (Seconds): this is used to detect fault conditions in the TBSL1
  - It is currently not implemented and will be enabled in a future firmware release
- Battery Information: to save air time, you can reduce the rate at which the battery information is sent. For example set this to every 4 cycles (2 hours for 30 min read)
- Transmission Delay:
  - Within the LoRaWAN ecospace, it is assumed that nodes will wake at random and send values. This approach is fine when nodes only transmit a few packets once a day
  - But in our applications (with lots of data and frequent transmission) we need to manage transmissions so that they don't all occur at once (collisions)
  - First estimate how long it will take for the node to read the sensors (e.g. 10 seconds), then allow another 10 second buffer and start to add your Nodes with a 10 or 20 second offset: first Node Delay = 30, 2nd Node Delay = 40, 3rd Node Delay = 50 etc
  - If you can't make an estimate, start on a 30 second delay. Once you have exhausted all the 30 sec "slots" start filling the 15 second intervals
  - You may need to maintain a separate list of what Delay you allocate to each node (if you save each configuration file you can easily recall the settings at a later time)
- Power Management: this setting is currently disabled and will be activated in a future firmware release.

4.4.4 EHS6 Settings

This tab is provided for the Cellular version of the TBSL1 and is used to control the transmission of readings from the unit to the Tekbox Broker

- a LoRaWAN unit may be converted to cellular operation by removing the LoRaWAN sub board and replacing it with the Cellular module
- the "Detected Modem" field on the GUI will display the type of cellular modem fitted.

This tab can be ignored in the LoRaWAN versions of the TBSL1 as it will be greyed out. The cellular version uses the MQTT protocol to send data to the Broker. MQTTi s a bir-directional protocol: it is used to send data to the server but may also send firmware updates and configuration changes to the unit.

The settings used in the configuration must match those entered in to the MQTT Server: set the MQTT server up first, then replicate the settings in the TBSL1

If you fit the 4G modem, the modem tab will activate and the LoRa WAN tab will be greyed out. The settings for the 4G modem should be set as follows:

- Select SXRAT: this controls the data mode used. For 4G in Australia select either **UTRANS** or **Dual Mode (UMTS Preferred)**
- Client ID: enter the name of the MQTT broker you will be using
- Board ID: set to the Serial Number of the TBSL1
- Topic Publish: the name used to identify this feed
- APN: the APN being used e.g. telstra.internet
- Network User: the APN User Name (blank for telstra.internet)
- Network Pass: the APN Password (blank for telstra.internet)
- Server URI: the type of security used for the connection to the server
  - you can start with **TCP No Security** and then switch to **SSL/TLS** once you are comfortable with using the system
- Broker address: should be set to the address of the Tekbox Broker
  - ssl://a1bz5x8fy56cyr.iot.us-east-1.amazonaws.com:8883
- Broker Port: leave blank to use the default port

- Broker User: will be greyed out if you have select TCP No Security but must be set if you are using TCP with security or SSL.TLS
- Broker Pass: will be greyed out if you have select TCP No Security but must be set if you are using TCP with security or SSL.TLS
- Downlink: the path to the folder in which the data will be stored
  - this is made up of the TBSL1 ID followed by the topic name (from the field Topic Publish)
- Service Quality: leave at 1

4.4.5 SDI Settings:

Prior to configuring the SDI-12 sensors in the GUI, you should connect the sensors to the input ports on the TBSL1

- note that the SDI-12 pins on the two connectors are wired in parallel so it does not matter which connector you use
- when the GUI sends a configuration to the TBSL1 the TBSL1 attempts to read the sensors. If the sensors are not connected, the commands will time out and you will receive an error message
    e.g. >>17:32:48 Exception in sysCmdSendLoraUsingSerialStream: The operation has timed out.
    >>17:32:57 Sending command:
    PROBE_ADD_MEAS_CMD, 1 0C2! 0D0!.
- If you receive this message, connect the sensors and try again. You can use the SDI-12 sensor test commands to verify that the sensors are properly connected.

In the SDI tab you add details of the SDI-12 commands used by the various sensors connected to the TBSL1.

Because SDI-12 supports multiple sensors, each of which may make multiple measurements, the TBSL1 allows you to define "Probes" (defined as a sensor on a give address) and Commands (the individual measurements taken)

- a 120cm 9 sensor Otto Soil Moisture Probe will count as a Single Probe but will have 2 Command entries (1) for Soil Moisture on 0C! And (2) for Soil Temperature on 0C2!
- An HT03 air temperature and relative humidity sensor will count as a single Probe with 1 command entry (0C1! For RH & Temp).

To add your SDI-12 sensors:

- first locate the **Number of Probes** field and enter the number of "Probes" you will connect

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- this will be 1 if you have a single sensor (e.g. Air Temperature and Relative Humidity)
- a weather station with Air Temp/RH, Wind Speed, Wind Direction would have a count of 3
- then, for the first Probe, click on the **SDI-12 Probes ID** field and select 1 to enter the settings for this sensor
- Click on **Measurement Interval** and set it to the desired rate e.g. 15 min
- for sensors which need a warm up time in addition to the standard SDI-12 time (for example with WS01 sensors operated in Advance mode or with ultrasonic wind sensors) you can specify a **Warm Up Delay** for each Probe. Tick the check box to activate the delay, then enter the number of seconds to wait
- in the **SDI-12 Sensor Settings** field, change the Description to one appropriate for the Sensor e.g. Otto SM or HT03
- then set the **Measurement Command** to match the SDI-12 command used to make this measurement e.g. 0C! For soil moisture on the Otto probe, 0C1 for a HT03
- then in the **Data Command** field, enter the command used to fetch the data e.g. 0D0!
- Repeat this process for each additional sensor (each will be on a different address).

LoRaWAN	EHS6	SDI-12	Pulse	Analog	Alarm	Info

SDI Settings

Number of Probes:	2		
SDI-12 Probes ID:	ProbeID_0	⌄	
Number of Command:	2	in probe	ProbeID_0
Measure Interval:	15	minutes	
☑ Warm Up Delay	2	second ranges: 0 - > 30	

SDI Sensor Setting

	Ordinal	Description	Measurement Command
▶	0	Otto SM	0C!
	1	Otto ST	0C2!

The figure above shows the SDI-12 configuration for an Otto Probe which is one of two probes connected to this TBSL1. Note the two Command lines: one for soil moisture and the second for soil temperatureTo add your next Probe, click on the SDI-12 Probes ID list box and select it, then repeat the process. The figure below shows the configuration for a HT03 Temp-RH probe on this same RTU:

4.4.6 Adding Pulse Sensors

Pulse inputs are normally used to connect to flow meters and rain gauges. The TBSL1 can support up to two pulse inputs although only one is active in the current firmware.

To add a Rain Gauge or flow meter:
- click on the **Pulse** tab
- leave the **Number of Pulse Sensors** to 1 (more will be supported in a future firmware release
- leave the **Pulse ID** list box at 1
- in the **Pulse Sensor Parameters** section, record the configuration for this sensor:
  - Pulse Type: Select Rain Gauge or Flow Meter
  - Name: give the sensor a name e.g. Precipitation

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- Pulse Measurement Interval: set to the same rate as the SDI-12 sensors
- Units per pulse: set to match the sensor e.g. 0.2mm per pulse for rain gauge
- Starting Totaliser value: if you are using the TBSL1 on a flow meter and want the Totaliser value to match the value on the meter's mechanical dials, set the totaliser to the current value shown on the dials.
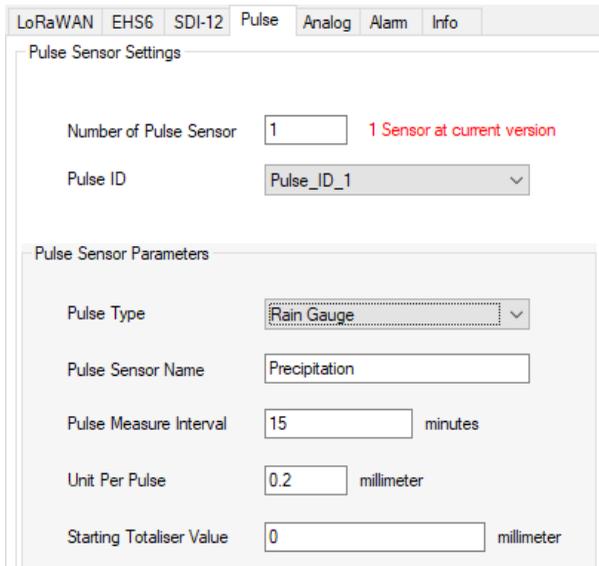
```
LoRaWAN  EHS6  SDI-12  Pulse  Analog  Alarm  Info

  Pulse Sensor Settings

    Number of Pulse Sensor    1          1 Sensor at current version

    Pulse ID                  Pulse_ID_1              ∨

  Pulse Sensor Parameters

    Pulse Type                Rain Gauge              ∨

    Pulse Sensor Name         Precipitation

    Pulse Measure Interval    15          minutes

    Unit Per Pulse            0.2         millimeter

    Starting Totaliser Value  0                       millimeter
```

4.4.7 Adding Analogue Sensors

The TBSL1 carries two analogue inputs A9although only one is enabled in the current firmware) which may be used with 0 to 5V analogue sensors. The analogue sensors are configured in the Analog tab. To add an Analogue sensor:

- click on the **Analog** tab
- click on the **Number Analogue Sensors** field and set it the total number of analogue sensors you will connect (0, 1, 2)
- in the **Analogue Channel ID** list box, select the first sensor

- Analog Power Supply: click on this button if you require the sensor to be permanently powered
- Analogue Sensor Name: give the sensor a suitable name
- Analogue Measurement Interval: set this to a rate suitable for the sensor e.g. 15 min
  - Port: the first sensor will be on Port 1
- Warm Up Delay: the time needed to wait before the sensor will give a stable reading (use 1 or 2 sec if unsure)
- Number of Samples: this setting allows you to apply averaging over a number of readings which will help reduce noise. But more samples mean higher power consumption.
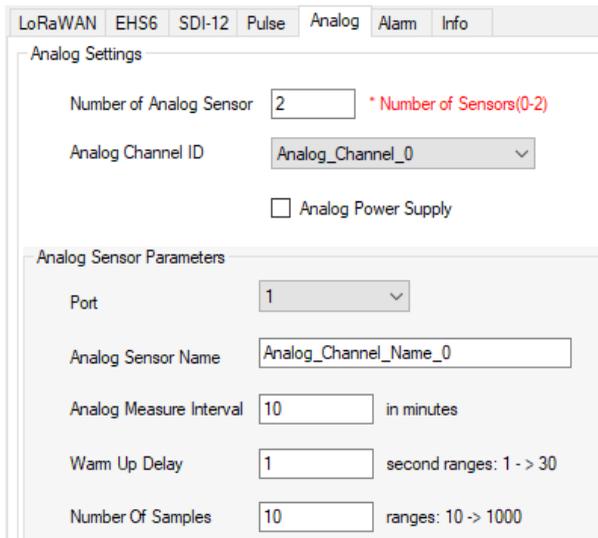
If you have a second sensor, add it but this time select Analogue Channel 2.

You can make an immediate analogue measurement as follows:
- click on the **Others** tab
- click on the **Analogue Measure** button
- the RTU will read the analogue sensors and display the result on the log screen

4.4.8 Setting up Alarms

The TBSL1 allows you to create an alarm if a parameter goes outside of preset limits. Alarms can be generated based on the value of any of the SDI-12, analogue or pulse sensors.

To create an alarm:
- if you have changed any configuration settings, click on Save to update the stored configuration
- from the Board Configuration dialogue box, click on the Alarm tab
- now, click on the Update Sensor List button so the GUI reads in a list of all of the sensors currently configured on this device
- click on the Choose Sensor list box and select the sensor you wish to add the alarm to e.g. Water Level
  - the Alarm Type will change to match the type of sensor
- Alarm name: set this to an appropriate descriptive name e.g. High Level
- Alarm Conditions: from the list box select the type of alarm to be generated and then the limits to apply according to the alarm type
  - Over: generates an alarm if the value exceeds the Max Value e.g. over 40
  - Under: generates an alarm if the value is below the Min Value e.g. under 20
  - Inside Limit: generates an alarm if the value is below the Max Value and above the Min Value e.g. between 20 and 40
  - Outside Limit: generates an alarm if the value is above the Max Value and below the Min Value e.g. is not between 20 and 40
- Hysteresis: this is the range the value must recover before a new alarm can be triggered and is designed to prevent multiple alarms being generated if a value is sitting close to the alarm point
  - for a high alarm, if the Max Value is 40 and the hysteresis 4, the value must fall to below 36 before a new alarm will be recognised
- Enable Alarm: activate this check box to enable processing of the alarm
- Actions: the method by which alarms can be notified varies according to the type of communications module fitted to the TBSL1

- ○ SMS to mobile Phone – only available on cellular unit. If this option is selected, enter the phone number in the field below the action type
- ○ Email – only available on cellular unit. If this option is selected, enter the recipient's Email address in the field below the action type
- ○ Data to Packet Server – available on LoRaWAN and Celullar units. This will send a data packet to the server where it can be actioned by the limit testing functionality provided by the vendor
- Toggle GPIO: this function enables you to turn on one of the TBSL1 outputs in response to the alarm condition
  - ○ note that in the present firmware only PC0 is available.

4.4.9 Setting the Board ID

You can allocate your own Serial Number or ID to each unit as it is programmed. This can be helpful in keeping track of units, particularly if you move them from one LoRa App Server to another.

The Serial Number is set in the Info tab
- after selecting **TBSL1 Configuration**, click on the *Info* tab
- the **Board ID** will display the default value
- change this to the required number
- click on the *Save* button to save the changes.

4.4.10 Checking TBSL1 Firmware Version

You can read the TBSL1 firmware version form the GUI:
- after selecting **TBSL1 Configuration**, click on the *Info* tab
- the **Firmware Version** will display under the Board ID.

This must match with the GUI version, which you can view by selecting *Help / About*.

4.5 Writing Configuration to the TBSL1

Once configuration is complete, you need to write it to the TBSL1
- make sure that the TBSL1 is in Console mode and that it has connected to the GUI
- click on the **SEND ALL SETTINGS** button

- ○ the GUI will send the settings to the TBSL1
- ○ if the GUI can send the commands, you will see a message in the Data Log section showing that each command was successful
- ○ if you receive an error with every command, the TBSL1 is not yet active (wait or cycle the power and retry)
- ○ if you receive an error on 1 or 2 commands, the GUI and TBSL1 may be set to different firmware versions. Contact us to organise an update to the GUI and / or TBSL1 firmware
- • you can send settings for specific functions by selecting the tab corresponding to that area and then clicking on the relevant send button
  - ○ Overall Settings: send All, Modem, Schedule or Clock settings
  - ○ Sensor Settings: send All, SDI-12, Pulse or Analogue settings
  - ○ Others: make an immediate Analogue measurement, get board version and serial number.

Note that it will take some time to send the complete configuration to the TBSL1. During this period, you will lose access to the program. Be patient and wait until the upload is complete: you can follow progress in the Logs section of the screen.

5 Sensor and LoRaWAN Testing

The TBSL1 GUI allows you to send commands to either the SDI-12 sensors or to the LoRaWAN modem. You select which to use by clicking on either the **Sensors** or **LoRa** radio buttons.
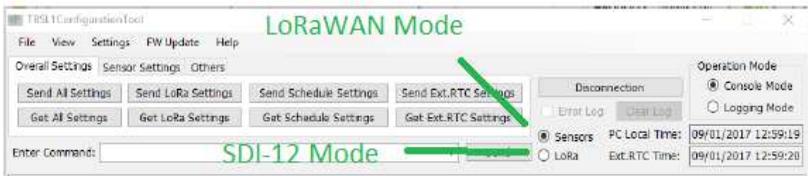
5.1 SDI-12 Sensor Testing

You can use the GUI to send commands to the attached SDI-12 sensor. This can be viewed as a transparent command mode: commands you type must be terminated with the "!" used by SDI-12. When you click on Send, the command will be sent over the SDI-12 bus. The Log screen will then echo any response given by the sensor

- note that if you are working with an Otto-LO probe, make sure you do not send any A or address command changes: if you change a sensor address the probe column may need to be dismantled in order for the sensor address to be corrected
- in the SEND COMMAND TO section, click on the SENSORS tick box
- in the ENTER COMMAND line, type in the command to send to the sensor
    - to make a test measurement on the third sensor on the probe (address 2) type   2C1!   And press enter
    - to read the command result type   2D0!   "   "

5.2 LoRaWAN Testing

In the same way that you can test the SDI-12 sensors, you can also send commands to the Rising HF LoRa WAN modem on the TBSL1.

With the GUI open and the TBSL1 connected, locate the Send Command To area and activate the *LoRa* check box. Commands you type in the Enter Command window will now be directed to the LoRaWAN module. As you type each setting, check it against those in the LoRaAppServer.

To check the LoRaWAN Join mode   **AT+MODE=?**
The unit should return either LWABP (ABP) or LWAOTAA (OTAA)

>>11:15:45.614 CMD,LORA,AT+MODE=?
<<11:15:45.699 RES,LORA,+MODE: LWABP

To check the Node settings   **AT+ID**

>>11:17:24.938 CMD,LORA,AT+ID
<<11:17:25.065 RES,LORA,+ID: DevAddr, 00:89:5B:63
<<11:17:25.135 RES,LORA,+ID: DevEui, 00:04:A3:0B:00:1B:34:28
<<11:17:25.205 RES,LORA,+ID: AppEui, 52:69:73:69:6E:67:48:46

To check the APP EUI (Application EUI)   **AT+ID=APPEUI**

>>11:19:10.246 CMD,LORA,AT+ID=APPEUI
<<11:19:10.417 RES,LORA,+ID: AppEui, 52:69:73:69:6E:67:48:46

Network Session Key (NWKSKEY) and Application Session Key (APPSKEY)
- the commands for both keys are set only
- for security reasons, you can not send a command to check either the Network Session Key or Application Session Key

To send an confirmed test message   **AT+CMSGHEX="xx yy zz …"**
- when a confirmed message is sent, the receiving Gateway will send a message acknowledging receipt of the packet

- after sending the message monitor traffic on the Gateway to see if it has been received.

e.g. AT+CMSGHEX="11 22 33 AA BB FF"

```
<<08:40:25 AT+CMSGHEX="11 22 33 AA BB FF"
>>08:40:25 +CMSGHEX: Start
>>08:40:25 +CMSGHEX: Wait ACK
>>08:40:25 +CMSGHEX: ACK Received
>>08:40:25 +CMSGHEX: RXWIN1, RSSI -94, SNR 7.3
>>08:40:25 +CMSGHEX: Done
>>08:40:25 LRWCS_CMD: PASS
```

In Loriot this shows up in the history for the device:

SNR	14 dB
Frequency	917.600 MHz
SF	9
Bandwidth	125 kHz
Gateway	B827EBFFFF876E49

Gateways in range

RSSI	SNR	Seen
-93	14	a minute ago

Last data (10 latest records)

SeqNo	Time	Port	Data
1	a minute	8	11 22 33 aa bb ff

To send an unconfirmed message   **AT+MSGHEX="xx yy zz ...."**

- in a system using unconfirmed messages, messages are sent multiple times to ensure they get through
- after sending the message monitor traffic on the Gateway to see if it has been received.

e.g. AT+MSGHEX="11 22 33 AA BB FF"

- you should then be able to check on your LoRa App Server for the message.

```
<<08:42:29 AT+MSGHEX="11 22 33 AA BB FF"
>>08:42:29 +MSGHEX: Start
>>08:42:29 +MSGHEX: Done
>>08:42:29 LRWCS_CMD: PASS
```

5.3
Starting the TBSL1 Logging

5.3.1 Starting the TBSL1 immediately

After completing the setup of the TBSL1, make sure you save any changes to the configuration file. You must then switch the unit from Console mode to Logging Mode:
- with the TBSL1 GUI open, click on the Logging Mode radio button in the Operation Mode section at the top right of the screen
- the console log will display a message indicating that the unit has switched to Logging mode
- you can now disconnect the USB terminal
- note that if you leave the USB terminal connected, you can watch as the unit goes through its measurement and log cycle.

```
<<13:32:29 Platform is switching to Logging Mode...
>>13:32:29 Closing COM Port: PASSED
```

5.3.2 Using the Hibernate Function

The Hibernate function allows you to configure a TBSL1 then put it to sleep. It will wake up and go to Logging mode as soon as either the Solar Panel or USB connector is plugged in. The link between pins 3 and 4 on the Solar panel plug are used to signal the unit to come out of hibernation.

To set a unit to Hibernate mode:
- complete the configuration of the unit
- save any changes to the configuration file for the unit

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- write the updated configuration to the unit
- on the GUI menu, click on the Logging button and wait unil the TBSL1 shows that it has finished writing its settings and is in log mode
- unplug the Solar Panel
  - the unit will go to sleep mode
  - when you connect the solar panel again, the TBSL1 will wake and go back to Logging mode.

6 Firmware and GUI Update

The version of the GUI and RTU must be kept the same for the device to operate correctly. If the versions are different, when the GUI connects to the RTU, it will give a warning message.

6.1 To Check Current Versions

To check the GUI version:
- from the menu select   Help / About
- the GUI version will display in the field "Application Version" at the bottom of the dialogue box.

To check the RTU firmware version:
- with the RTU connected to the GUI, click on View / Get Firmware Version

6.2 Upgrading the GUI

To upgrade the GUI, simply copy the files for the new version over top of the files in the directory in which you initially installed the program.

Note that if the GUI Upgrade changes the format of any of the configuration files, you may have to re-create them in the format used by the new version.

6.3 Upgrading the TBSL1 Firmware

6.3.1 Upgrading Via GUI

To upgrade the firmware you first need to download the "DFUse" utility from ST Micoelectonics:
https://www.st.com/en/development-tools/stsw-stm32080.html

After downloading the software, install it on your PC.

Next you will need to obtain a copy of the updated firmware. This can be obtained from TOIP and is usually supplied in conjunction with the GUI update. Save the firmware in a convenient location on your PC.
Performing the Upgrade:

- connect the TBSL1 to your PC and open the GUI in Console mode
- from the Menu select **FW Update / Update**
- you will receive a message indicating that the unit has been set to DFU Bootloader mode: this mode allows the unit's firmware to be upgraded over the USB connection

```
<<12:30:30 Switching platform to DFU Bootloader mode
>>12:30:30 Switch to DFU Bootloader mode: OK
<<12:30:30 Closed COM port: OK
<<12:30:30 COM Port connection is not available during DFU Bootloader mode!!!
<<12:30:30 Please open DFUse Tool to perform firmware update!!!
<<12:30:30 Unplug and plug USB cable again to exit DFU Bootloader mode!!!
<<12:30:30 Detect removal of USB device
```

- once you see this message, open the DF Use Demo program
- the "Available DFU Devices" list box should show an "STM Device in DFU Mode". If not, then the program has not correctly detected the TBSL1. If this happens., repeat the process.
- In the lower right of the screen, you will see the Upgrade options
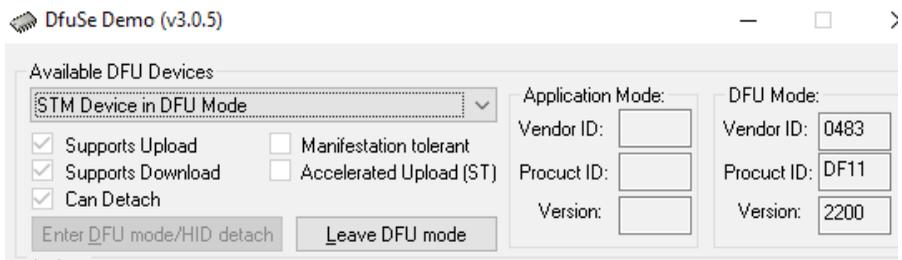
- Click on Upgrade and then select the new firmware file from the location you saved it in the previous step
- now click on the Upgrade button and, when prompted, confirm that you wish to perform the upgrade

- a progress indicator will display showing the status of the update
- when the update completes, close DFU, then close and re-open the GUI and verify that the GUI and firmware now have the same version.
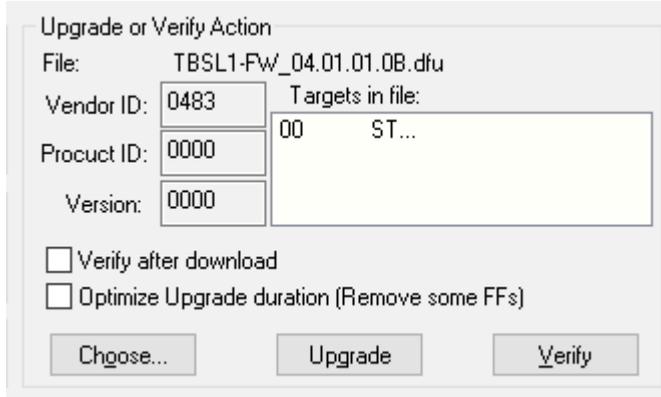
Upgrade or Verify Action

File: TBSL1-FW_04.01.01.0B.dfu

Vendor ID: 0483   Targets in file:

00   ST...

Procuct ID: 0000

Version: 0000

☐ Verify after download
☐ Optimize Upgrade duration (Remove some FFs)

Choose...   Upgrade   Verify

6.3.2 Upgrading Via ST-Link

This option is only available if you have an ST-Link module and an appropriate header connector.

7 TBSL1 Packet Format

The TBSL1 sends data to the LoRa WAN Server as one or more packets. Each packet is time stamped and includes an identifier to signify the type of information it holds. This flexibility is important because each of the different measurement types may be sent at a different rate: e.g. SDI-12 soil moisture data every 15 minutes, battery voltage every 4 hours.

Two primary message types are used:
- C   Common data messages
- P   Parameter messages (hold data)

The Parameter (P) messages are then further broken down according to the type of data they contain:
- Pulse counter values
- A   Analogue sensor values
- S   SDI-12 sensor values

7.1 Common Data Messages

The content of the Common Data Messages is shown below

Message for Common Data Report							
Report ID	Device ID	FW Version	Power Supply ID	Sensors Number	Battery Voltage	Space character	RSSI
1 byte	4 bytes	4 bytes	1 byte	1 byte	5 bytes	1 byte	RSSI format

The fields hold the following:

Report ID	C	Signifies a Common Data message
Device ID	e.g. 1001	The ID for the TBSL1. This is in hexadecimal format
FW Version	e.g. 4010	The current firmware version
Power Supply ID	0	For solar panel and rechargeable Li-Ion battery
Sensor	e.g 4	The total number of sensors in the

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Numbers		configuration e.g. total of SDI-12, pulse and analogue
Battery Voltage	e.g. 03.56	The battery voltage as a floating point number
Space	-	To separate battery voltage from RSSI
RSSI	e.g. -67	The signal strength in dBm. May be 1 to 7 digits with a range of +20 to - 130

Sample Message:
    C4AC140100073.851 -3

Content	C	Common message
	4AC1	Device ID 4AC1
	4010	Firmware version 4.01.0
	0	Solar power supply with Li-Ion battery
	07	7 sensors in config
	3.851	Battery voltage 3.851 V
	-3	Signal strength -3 dBm

7.2 Data Messages

The Data messages contain sensor readings and are always time stamped. They also include an identifier for the type of sensor.

7.2.1 Pulse Data Messages

The format of the data for the pulse sensors is as follows:

Message for Pulse Count Sensors Report					
Report ID	Sensor Type ID	Timestamp	Sensor Index	Space Character	Parameter
1 byte	1 byte	17 bytes	1 byte	1 byte	variable

The fields hold the following:

Report ID	P	Signifies a Parameter message
Sensor Type ID	P	To signify a Pulse sensor message

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Timestamp	e.g. 18:08:28:09:15:00	The date and time of the reading in the format YY:MM:DD:hh:mm:ss
Sensor Index	e.g.0	The index for this sensor. The range is 0 to 9
Space		Separates sensor index from value
Parameter	e.g. 1201	The current value of the pulse counter

Sample Message:

    PP18:08:28:09:23:562 1204

Content	P	Parameter message
	P	Pulse counter
	18:	Year
	08:	Month
	28:	Day
	09:	Hour
	23:	Minute
	56:	Seconds
		Space
	1204	Pulse counter value

7.2.2 Analogue Sensor Messages

The format of the data for the Analogue sensors is as follows:

Message for Analog Sensors reporting									
Report ID	Sensor Type ID	Timestamp	Sensor Index	Space	Min Parameter	Space	Avg Parameter	Space	Max Parameter
1 byte	1 byte	17 bytes	1 byte	1 byte	variable	1 byte	variable	1 byte	variable

The fields hold the following:

| Report ID | P | Signifies a Parameter message |
| Sensor Type ID | A | To signify an Analogue sensor message |

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Timestamp	e.g. 18:08:28:09:15:00	The date and time of the reading in the format YY:MM:DD:hh:mm:ss
Sensor Index	e.g.0	The index for this sensor. The range is 0 to 9
Space		Separates sensor index from value
Min Parameter	e.g. 0.23541	The minimum value recorded in the measurement interval (1 to 7 digits)
Space		Separator
Avg Parameter	e.g. 1.65567	The average value recorded in the measurement interval (1 to 7 digits)
Space		Separator
Max Parameter	e.g. 2.01339	The maximum value recorded in the measurement interval (1 to 7 digits)

Sample Message:

PA18:08:28:09:23:560 0.23541 1.65567 2.01339

Content	P	Parameter message
	P	Pulse counter
	18:	Year
	08:	Month
	28:	Day
	09:	Hour
	23:	Minute
	56:	Seconds
		Space
	0.2354	Min value
	Space	
	1.65567	Avg value
	Space	
	2.01339	Max value

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7.2.3 SDI-12 Sensor Messages

The format of the data for the SDI-12 sensors is as follows:

Message for SDI-12 Sensor reporting										
Report ID	Time stamp	Sensor Type ID	SDI-12 Probe ID	SDI-12 Ordinal	Number of Parameters	Space Character	Parameter 1	....	Space Character	Parameter n
1 byte	17 bytes	1 byte	1 byte	1 byte	1 byte	1 byte	variable	...	1 byte	variable

The fields hold the following:

Report ID	P	Signifies a Parameter message
Timestamp	e.g. 18:08:28:09:15:00	The date and time of the reading in the format YY:MM:DD:hh:mm:ss
Sensor Type ID	S	To signify an SDI-12 sensor message
SDI-12 Probe ID	e.g. 1	The position in which this probe appears in the SDI-12 configuration for the device (range 0 to 9 where 0 is first probe). This typically indicates a given SDI-12 address
SDI-12 Ordinal	e.g. 1	An identifier for the measurement command for this probe. For a soil moisture probe on address 0 which returns soil moisture (SM) and soil temperature (ST), SM will be ordinal 0 and ST ordinal 1
Number of Parameters	e.g. 3	The number of sensor values which follow where 0 = 1 value, 9 = 10 values
Space		Separates sensor index from value
Parameter 1	e.g. 0.23541	The first sensor value (1 to 7 digits)
Space		Separator
Parameter 2	e.g. 1.65567	The second sensor value (1 to 7 digits)

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Space   Separator

Parameter 3   e.g. 2.01339   The third sensor value (1 to 7 digits)

Sample Message:

     P1018:08:28:09:23:56S3 0.23541 1.65567 2.01339

Content	P	Parameter message
	18:	Year
	08:	Month
	28:	Day
	09:	Hour
	23:	Minute
	56:	Seconds
	S	SDI-12 data
	3	Number of parameters =3
	1	Probe ID 1
	0	First measurement command
		Space
	0.2354	First sensor value
		Space
	1.65567	Second sensor value
		Space
	2.01339	Third sensor value