Deeter Electronics®

deeternet®

Wireless Sensor System User Manual

v4_00

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Contents

1. Summary

The Deeter Wireless Sensor System consists of a remote sensor node that transmits data over an RF network to a Base Station.

The sensor node enables remote wireless sensing of:

- Switch inputs
- Analog resistive sensor inputs
- 4-to-20mA current loop circuits

The Base Station receives sensor signals and converts these to the following outputs:

- Open-collector transistors for controlling a wide range of devices
- A 4-to-20mA current-loop driver

The system communicates using the IEEE 802.15.4™ wireless network protocol, in the 2.4GHz ISM frequency band. This is an internationally approved, licence free radio band, with no subscription or operating charges.

This User Manual introduces the system components, explains how to install and setup a system, and includes specifications and product information.

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Figure 1: Base Station, Router, Sender

Figure 2: LVCS-RF

2. The Deeter Wireless Sensor System

2.1 System Devices

There are four devices in the Deeter Wireless Sensor product line:

- Base Station
- Wireless Sender
- LVCS-RF
- Wireless Router

The basic wireless sensor system comprises a Base Station and a single sensor node, either a Sender or LVCS-RF. A Router may be added to the system to improve communications reliability or to extend the wireless range. Up to four Routers may be used in a single system.

The sensor nodes can accept a range of input devices to suit the application:

- Four discrete switch inputs (Sender only)
- An analog resistive input (Sender and LVCS-RF)
- A 4-to-20mA current-loop sensing input (Sender only)

Figure 3: Wireless Sender with 40-Series Float Switches and LVCS

Figure 3 illustrates a possible arrangement of inputs to a Sender with four Deeter 40-Series Level Switches and a Deeter continuous level sensor.

The Base Station has a range of outputs to drive a wide variety of possible devices:

- Four open-collector transistors
- 4-to-20mA current loop driver
- Serial communications output via RS485, or RS232 or USB (requires an adapter)

(At present, serial communications is reserved for diagnostic data. Future developments are expected to include data-logging features.)

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2.2 System Applications and Features

The system was primarily designed for use in liquid level sensing, to complement the range of Deeter float-switches and continuous level sensors. Countless other applications are possible, including:

- remote monitoring of switch inputs to drive relay outputs
- converting a potentiometer input to a 4-to-20mA current loop output
- mirroring a 4-to-20mA current loop signal
- switching relays at preset input thresholds

The System has the following advanced features:

- Wireless Network capability based on the IEEE 802.15.4 protocol
- Fully automatic operation once the system is installed
- Battery powered remote sensors

2.3 RF Communications

The system uses high power RF transceiver modules and external antennas to achieve the best communications range. Range can be further extended by adding one or more Deeter Wireless Routers.

The Base Station acts as the coordinator for the wireless network, operating in the 2.4GHz ISM (Instrumentation Scientific and Medical) frequency band. This allows the system to be used world-wide without requiring a site radio operating licence. (Local regulations may restrict the maximum RF transmit power. Deeter provides different product variants of the Wireless System devices for the US, Canada and world market and CE marked models for the European market to satisfy these constraints.)

The IEEE 802.15.4 protocol allows several networks to share the same frequency without interfering with each other. The protocol uses advanced techniques to ensure good communications using very low power signalling. This allows the Deeter Wireless Sender or LVCS-RF to operate using battery power.

Once the system is installed it should operate without any further intervention. When several Routers are used they form a 'mesh' network, and signals can be re-routed around any broken links in the mesh. Thus, the system has a built-in self-healing capability, to further ensure communications reliability.

2.4 Wireless Range

At maximum transmission power (US version) the distance between sensor node and Base Station may be up to 4km in an ideal, open field installation. (European regulations restrict the maximum power and a range of up to 1000m may be attained under ideal conditions). However, in most practical environments the radio signal will be attenuated by obstructions and by multi-path fading caused by reflections. To improve range, a clearer signal path can often be achieved by increasing the height of the antenna. Deeter can supply an antenna extension kit for this purpose.

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A Deeter Wireless Router placed somewhere between the remote sensor and Base Station, or off to one side of the direct line between the two, will greatly extend the wireless range. Up to four Routers may be used in a single system.

2.5 System Setup Options

System parameters are selected during installations using the Base Station display menus. Parameters that are controlled by the sensor node are transferred by radio signal from the Base Station and saved in non-volatile memory at the sensor node. Parameters include:

- Sensor update interval
- Output assignments and set-point thresholds
- Initial RF Channel
- RF power

The sensor update frequency is how often the sensor node makes a measurement and transmits readings to the Base Station. There are seven user-selectable frequencies from once-per-second to once every 60 seconds. A slow update rate will improve battery life for a battery-powered sensor.

Each transistor output on the Base Station can be assigned to either a switch input at the sensor node or a set-point of the analog input. If a set-point is selected, there is also the option to choose whether to turn on the output above or below this set-point. There is also the option to add hysteresis by having two set-points, one as an on-threshold and the other as an off-threshold.

The Deeter Wireless System can operate on any of available RF channels in the 2.4GHz ISM band. The initial channel can be pre-selected at the Base Station if the user has knowledge of which channels are less prone to interference from other equipment sharing the ISM frequency band. If set to 'Auto' the Base Station will scan all channels and select the one with the least background activity at that time. This initial channel may change automatically later if the system experiences poor communications – there will be a temporary loss of communications over the network while a new channel is established. The sensor node and Routers will automatically re-assign to the channel selected by the Base Station and will find the Base Station if the channel changes.

The default RF power setting is 6dBm which is the maximum setting for compliance within Europe. Lower settings are available for installation testing purposes (see *Network Testing*), but the default will be restored on a device reset. US versions will allow the RF power to be raised to 18dBm and these higher settings will be restored after a reset.

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2.6 Wireless Base Station

Figure 4: Base Station

A Base Station is required in all systems. It receives data from a remote sensor node (either Sender or LVCS-RF) and converts these signals into useful process outputs. Each Base Station has:

- Four open-collector transistor outputs capable of sinking up to 50mA at 40V
- One 4-to-20mA current loop driver

The Base Station has a user-interface consisting of three push-button switches, four LED indicators and a 2-line by 16-character liquid crystal display. The buttons and LEDs are only accessible with the lid removed and are used in conjunction with the display to select a variety of output and installation options during initial setup. During normal operation the display shows various system parameters such as radio link quality and sensor node battery level.

The Base Station is housed in an ABS enclosure with clear polycarbonate window for viewing the display. It has an external antenna and three cable glands for power input and signal outputs. It can be powered by a supply between 12 and 24Vdc – a 12Vdc switch-mode mains adapter is supplied. A wall mounting kit is also supplied.

2.7 Wireless Sender

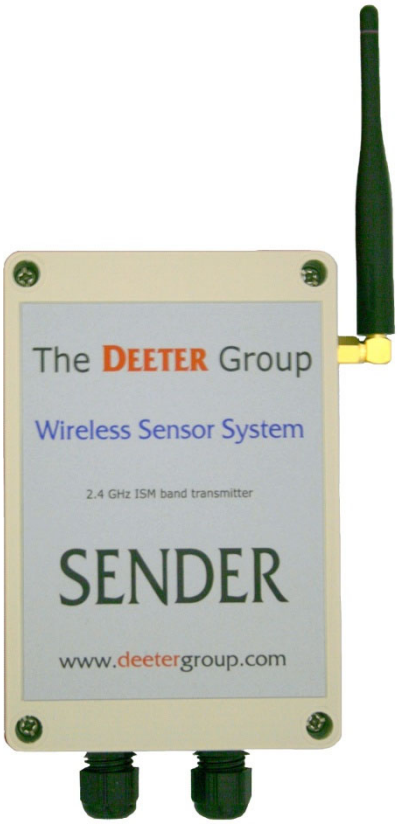

Figure 5: Wireless Sender

The Wireless Sender has three input types:

- Four switch inputs
- An analog resistive input
- A 4-to-20mA current loop sensing input

Only one of the analog inputs (resistive and current loop) can be used at a time, selected by jumper link.

The analog resistive input is designed for low-powered operation with a Deeter LVCS (Liquid Vertical Continuous Sensor) but can operate with other resistive sensors, such as Wheatstone bridges and potentiometers.

The Sender requires no user interaction during normal operation. It has an on/off switch and an LED, both only accessible with the lid removed. The LED provides an indication of the status of the wireless link to the Base Station.

The Sender has 4 power supply options:

- Mains only – via a 5Vdc switch-mode mains adapter, supplied
- Battery only – One or two 3.6V Lithium Thionyl Chloride, size AA, supplied ('C' size optional)
- Mains + Battery
- Battery + 4-to-20mA power scavenging

When a mains power adapter is fitted, the battery is only required during power outages. Switch-over between the two power sources is automatic.

If a 4-to-20mA current loop input is being monitored, power can be derived from the current loop to provide all that the Sender needs during normal operation, thus the life of the battery can be greatly extended. The battery will be called upon to assist during start-up and to re-establish a link if there is a break in wireless communications.

The Sender is housed in an ABS enclosure with an external antenna and two cable glands for power and signal inputs. A wall mounting kit is supplied. An optional extension lead and bracket kit is also available for mounting the antenna in a position more favourable to wireless communication.

2.8 LVCS-RF

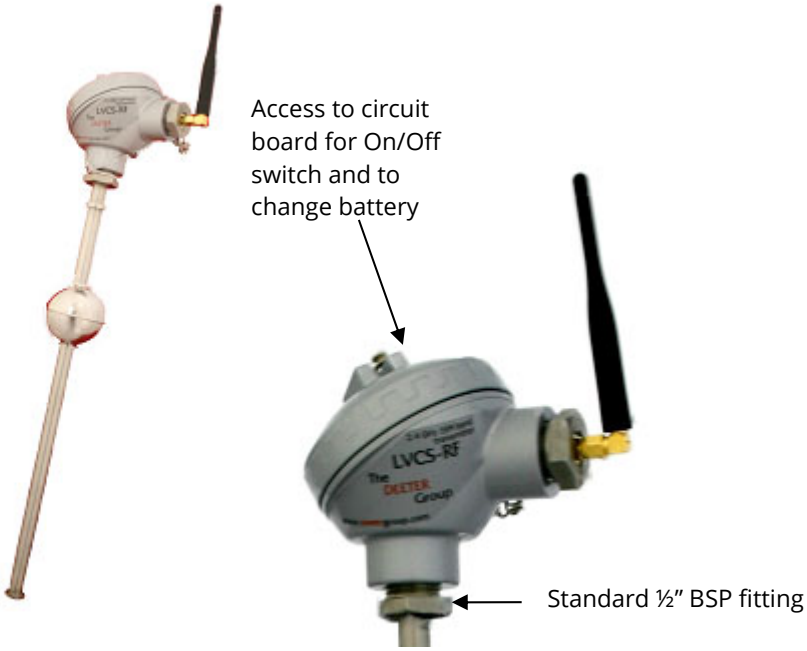

Figure 6: LVCS-RF

The Deeter LVCS (Liquid Vertical Continuous Sensor) uses a magnetic ball-float that can travel up and down a tube immersed in a tank, to measure fluid level. Standard versions are available with 4-to-20mA output, analog voltage output and analog resistive output. The LVCS-RF is a wireless version of the Deeter LVCS, which is battery operated and requires no external cabling.

The electronic circuit is a cut-down version of the Sender with only the analog resistive input and a battery power supply (½AA, 3.6V Lithium Thionyl Chloride). The reduced circuit size allows it to fit inside an aluminium alloy head that fits to the outside of the tank.

The standard sensing circuitry is housed in a stainless steel tube with a 55mm diameter stainless-steel ball-float and a sensing resolution of 5mm. Standard sensing lengths are 250mm, 500mm, 750mm and 1000mm. Custom lengths, alternative materials, alternative floats and other resolutions are available on request.

The antenna is supplied mounted to the head. An optional extension lead and bracket kit is available for mounting the antenna in a position more favourable to wireless communication.

The LVCS-RF requires no user interaction during normal operation. There is an on/off switch and an LED, only accessible with the head top unscrewed. The LED provides an indication of the wireless link to the Base Station during setup.

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Note that a Sender using the analog resistive input is functionally the same as an LVCS-RF. The Sender has the advantage of a range of power supply options and a longer battery life. The LVCS-RF has the advantage of being integrated with the LVCS sensing circuit in the more compact aluminium alloy head and without the need for any external wiring.

2.9 Wireless Router

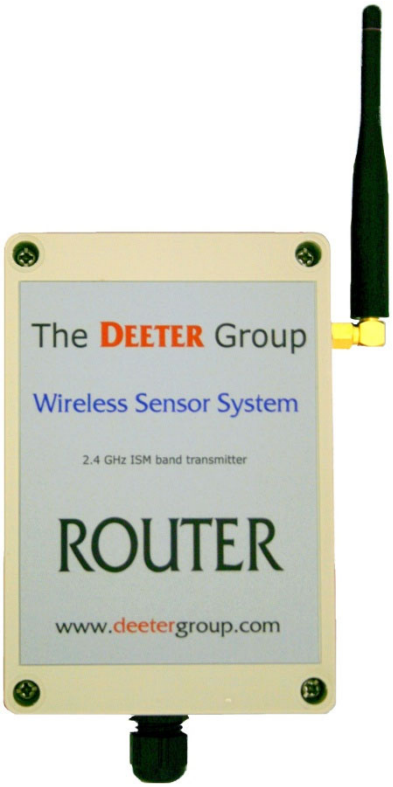

Figure 7: Wireless Router

A Deeter Wireless Router is required in systems where the remote sensor and Base Station are beyond the range of direct point-to-point transmission. A Router can greatly improve signal confidence when the wireless signals are weak due to obstructions in the direct path, interference from moving objects or changing environmental conditions. Up to four Deeter Wireless Routers can be used in a system.

The Router is housed in an ABS enclosure with an external antenna and a cable gland for power input from a switch-mode 5Vdc mains adapter (supplied). A wall mounting kit is also supplied. An optional extension lead and bracket kit is available for mounting the antenna in a position more favourable to wireless communication.

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3. Installation

3.1 Base Station Wiring and Setup

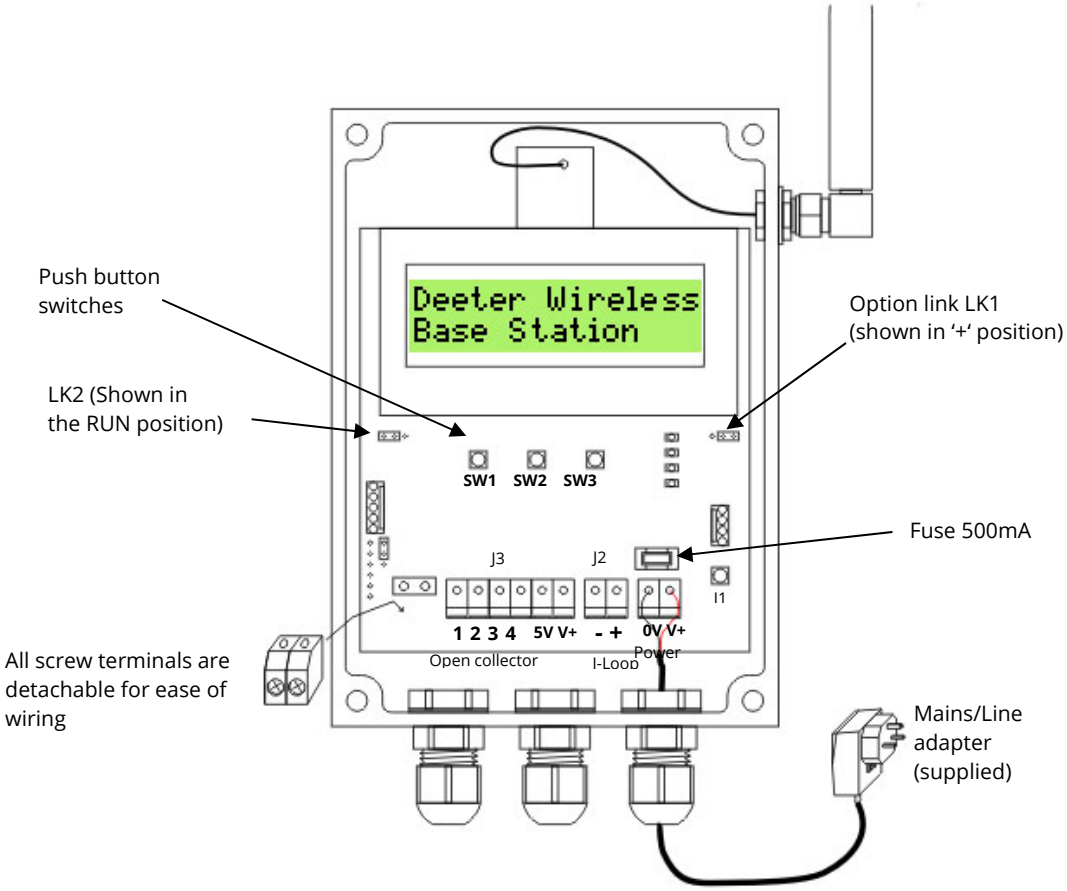

Figure 8: Wiring the Base Station

3.1.1 Power

The Base Station is powered from an external DC power supply. A wall mounted 12V DC power switch-mode mains adapter is supplied. If the current loop transmitter is to drive a heavy load then the Base Station can be supplied with up to 24V DC.

Connect the external supply to terminal block J1. Connect the positive wire from the power supply (identified by a red sleeve on the supplied mains adapter) to the +V terminal.

The power input is protected by a 500mA fuse (F1).

3.1.2 Process Inputs

All process inputs to the Base Station are received from remote sensor nodes by radio.

3.1.3 Process Outputs

The Base Station has two types of output; open-collector transistors and a 4-to-20mA current loop output. Screw terminals are provided and care must be taken to observe the correct polarity of signals, which are labelled on the PCB.

Connect the current loop circuit to J2. If the devices on the current loop circuit add up to a high resistance (>350 ohms), a higher voltage power supply may be required.

The open-collector outputs are on J3 and are suitable for voltages of up to 40V DC in the off state and will sink up to 50mA in the on state. Typical uses are to drive relays, indicator lamps, PLC inputs, etc. These outputs are short-circuit protected but should not be exposed to a continuous fault condition.

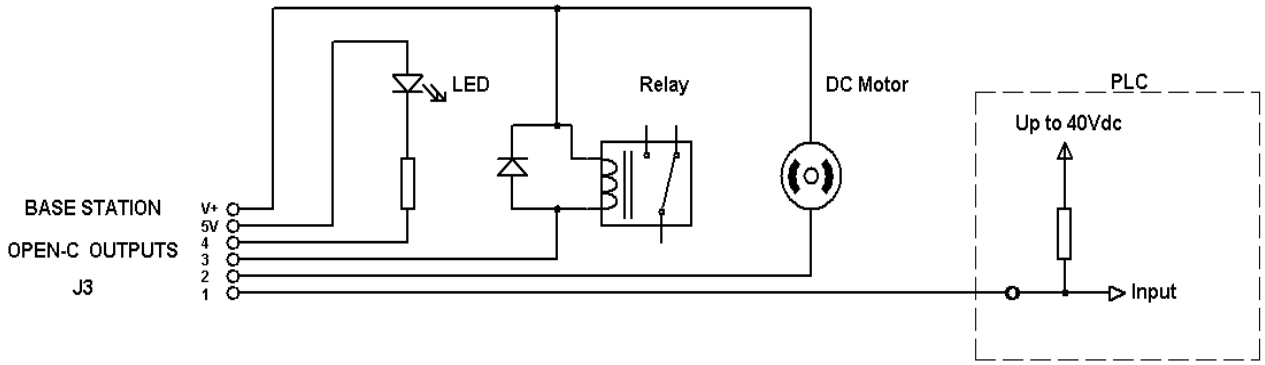

Figure 9: Example transistor output connections

J3 has two supply outputs that may be used to power external devices and act as pull-ups for the transistor open-collectors. The '5V' pin provides a regulated 5V output and the 'V+' pin is derived from the power supply input and can be up to 24Vdc. The total current that can be drawn is limited by the 500mA fuse.

3.1.4 Option links

Jumper link LK1 is used in the '–' position to enable additional menu options that allow previous network settings to be cleared from non-volatile memory. In normal use the link should be in the '+' position (or removed). In this position the unit will auto start when power in applied and auto restart after a temporary power interruption.

Link LK2 is used for programming software updates. This should be left in the 'RUN' position (or not fitted).

(Link LK3 enables or disables 120 ohm termination for the RS485 interface and is for future use.)

3.1.5 Output Configuration Setup

Remove the lid of the enclosure to gain access to the three push-button switches. In general, SW1 (the left switch) selects the next menu, SW2 (middle switch) changes settings or selects available options, and SW3 (the right switch) saves new settings and options.

To configure Base Station outputs:

- Press SW1 to get to the screen.

```
Base Station
    <Setup>
```

- Then Press SW2, the screen shows the firmware version

```
Base Station
v2.01 rev 04E
```

- Keep pressing SW1 until the screen shows Output Settings

```
Output Settings
Enable
```

- Pressing SW2 will toggle between 'Enable' and 'Disable'.

Selecting 'Disable' will force outputs to the default settings – transistor outputs 1 to 4 will mirror the Sender inputs 1 to 4 and the 4-to-20mA output will mirror the analog input of the sensor node (Sender or LVCS-RF). Selecting 'Enable' will allow further menus to set alternative output options.

- Press SW1 to reach the 'Output #1' menu.

```
Output #1
= IN1
```

output mirrors switch 1 input

- Pressing SW2 will cycle through the options for output 1 where IN1 is switch 1 at the sensor node and SP1 is setpoint 1

```
Output #1
1>SP1
```

output ON when analog reading is greater than setpoint

```
Output #1
1<SP1
```

output ON when analog reading is less than setpoint

- Press SW1 to reach the 'Output #2' menu.

```
Output #2
= IN2
```

output mirrors switch 2

- Pressing SW2 will cycle through the options for output 2, where IN2 is switch 2 at the sensor node and SP2 is set-point 2, a second analog threshold

```
Output #2
1>SP2
```

```
Output #2
1<SP2
```


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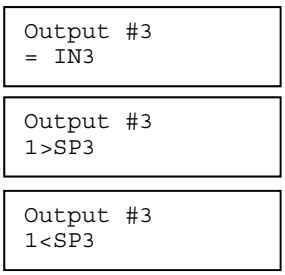
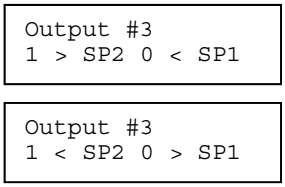
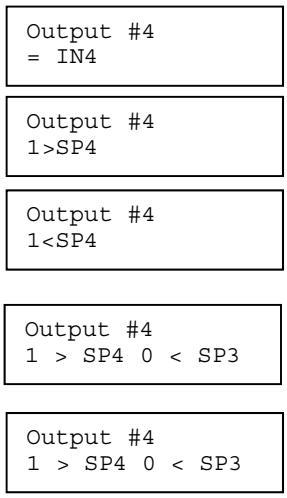
- Press SW1 to reach the ‘Output #3’ menu.
- Pressing SW2 will cycle through the options for output 3, where IN3 is switch 3 at the sensor node and SP3 is set-point 3, a third analog threshold



- there are 2 additional options for this output, these are explained in Figure 10
- These 2 options can be used to control fill-cycles or recirculation in a vessel



- Press SW1 to reach the ‘Output #4’ menu.
- Pressing SW2 will cycle through the options for output 4, where IN4 is switch 4 at the sensor node and SP4 is set-point 4, a fourth analog threshold
- The last 2 options are similar to those for Output #3 but acting between set-points SP3 and SP4



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Set-points are shown as integer percentages of the full analog input range. Each set-point has a hysteresis band of 5% to prevent rapid changes of the output when the input is hovering around the threshold. The latter two options for outputs 3 and 4 allow the hysteresis to be user-defined and greater than 5%. These options are best explained with the aid of the following diagrams.

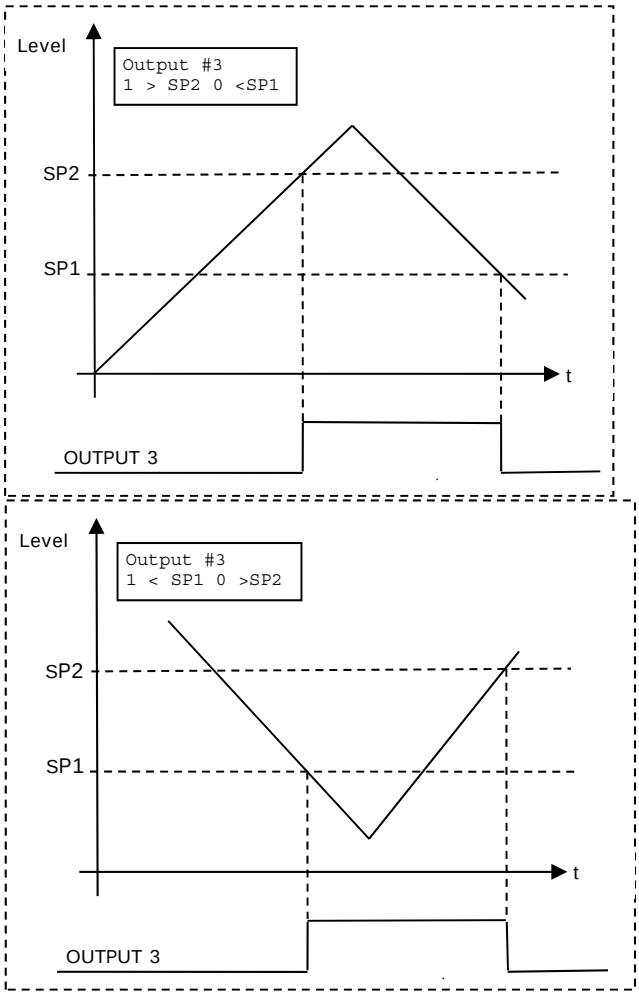

Figure 10: Setting hysteresis for Output 3

- Press SW1 to reach the 'SP1' menu
- Pressing SW2 increments the set-point and pressing SW3 decrements the set-point value in 1% steps.
- Press SW1 to reach the 'SP2' menu, then SW2 or SW3 to change Set-Point 2.
- Repeat for Set-Point 3 and Set-Point 4.

Note that SP2 will always be at least 5% greater than SP1, SP3 at least 5% greater than SP2, and SP4 at least 5% greater than SP3.

- Press SW1 to reach the 'Save Settings' menu. This will only appear if settings have been changed.
- Press SW2 to save. To exit without saving press SW3 or allow the screen to time-out.

Saving new settings will cause the Base Station to reset.

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3.1.7 Other Configuration Settings and Menu Options

Network Device Registration

Deeter supply the Base Station and sensor node device (Sender or LVCS-RF) in sets already registered to work with one another as a network. If adding a Router, or reconfiguring the network for other reasons, refer to the section *Registering Network Devices*.

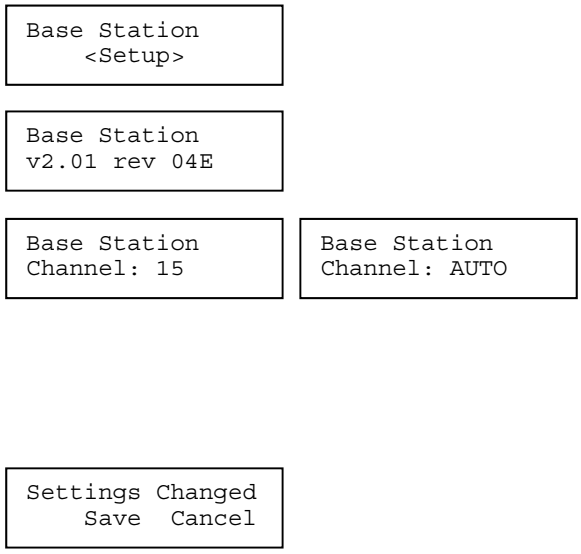
RF Channel

There are 16 channels available to the IEEE 802.15.4 protocol in the 2.4GHz ISM frequency band, these are numbered 11 to 26. RF channel 26 is too close to the upper boundary of the ISM band and so its use is precluded in high power systems. The 'Auto' setting will cause the Base Station to scan all channels and select the one with the least background activity at that time. This initial channel may subsequently change during operation if the system experiences poor communications.

The initial channel will be set during the registration procedure performed by Deeter. Changing the channel will not be necessary unless the user has a preference e.g. if they know of channels that are prone to interference. To select a new RF channel:

To configure RF Channel:

- Press SW1 to get to the screen.
- Then Press SW2, the screen shows the firmware version
- Keep pressing SW1 until the screen shows Base Station Channel
- Press SW2 to select a new channel this cycles through the list 11..25 and AUTO
- Note: Channel 26 has been excluded
- Press SW1 to advance to the screen.
- Press SW2 to save or SW3 to exit without saving.



When the settings are saved the system restarts.

Sensor Data Update Interval

Changing the update interval is best left until after the network is installed and working satisfactorily with the default transmit interval. See section *Setting the Sensor Data Update Interval* for details of how to change settings.

Analog Calibration

The 4-to-20mA analog input to the Wireless Sender is calibrated during manufacture and should not require recalibration. If for some reason recalibration is necessary, the procedure is described in *Analog Calibration,* below.

Transmit Power

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The transmit power can be changed and is described in the section *Network Testing* below. The default power setting will be restored on any device reset.

3.2 Wiring the Sender

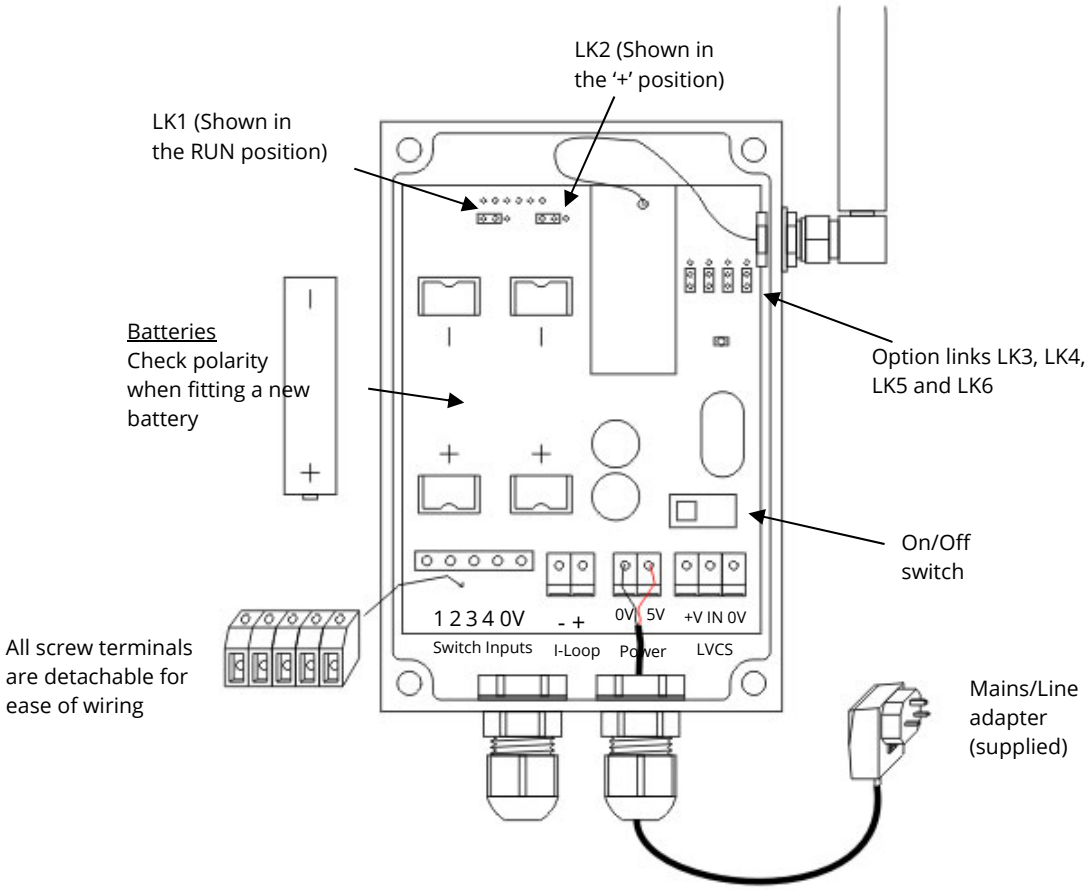


Figure 11: Connections to the Wireless Sender

All connections are via screw terminals and care must be taken to observe the correct polarity of signals.

If using the 5V power adapter supplied with the Sender, the +5V wire is indicated by a red sleeve.

Jumper link LK1 is reserved for programming the device and must be left in the RUN position. LK2 is used to clear network settings and should be in the '+' position – see *Registering Network Devices* for details of how to clear network settings.

There are two options for the analog input, either from a 4-to-20mA current-loop circuit or from a resistive sensor (e.g. Deeter resistive LVCS). The two options cannot be operated at the same time. Jumper link LK3 is used to select the analog input; fit between pins 1-2 (upper position) to select the LVCS (resistive) input and between 2-3 (lower position), for the current-loop option.

If the Sender is battery operated, to help conserve the battery it is best to power on other devices in the network (Base Station and Routers) before powering on the Sender. With the battery in place, move SW1 to the on position. Observe the LED – this will come on for long bursts until wireless communications are established, then it will flash periodically.

3.3 Fitting the LVCS-RF

Figure 12: Separating the LVCS-RF Head and Stem

During installation it will be necessary to separate the head from the stem and the 3-way connector (J2) must be disconnected and re-connected afterwards. This should be done by feeding the connector carefully past the PCB without removing the PCB or disturbing the antenna lead.

Figure 13: Reconnecting J2

The LVCS-RF has no external wiring (apart from the optional antenna extension kit).

Jumper link LK2 is reserved for programming the device and must be left in the RUN position. LK1 is used to clear network settings and should be in the '+' position – see *Registering Network Devices* for details of how to clear network settings.

To help conserve the battery, it is best to power on other devices in the network (Base Station and Routers) before powering on the LVCS-RF. With the battery in place, move SW1 to the on position. Observe the LED – this will come on for long bursts until wireless communications are established, then it will flash periodically.

3.4 Placing a Router

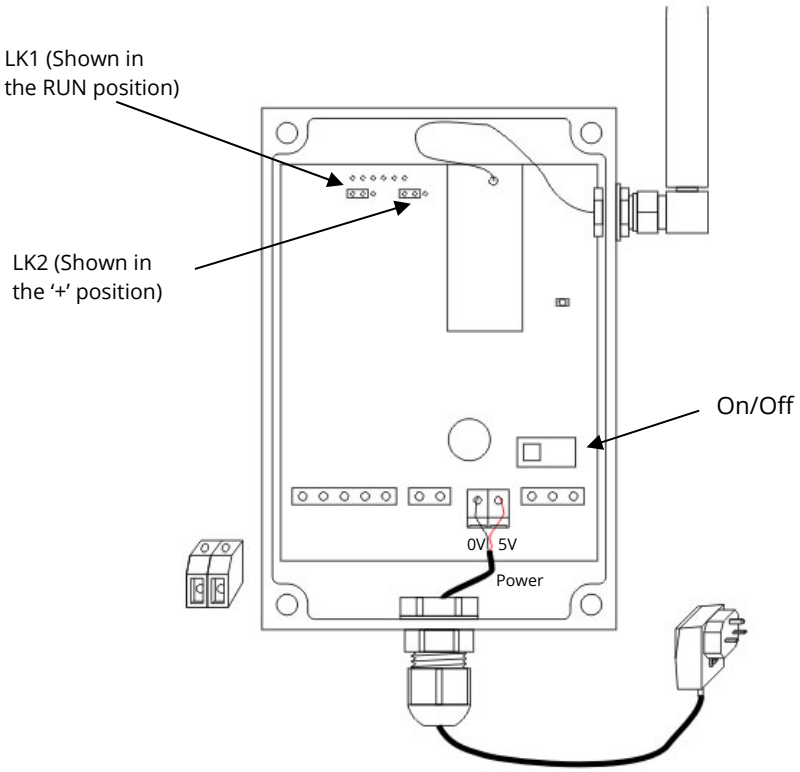


Figure 14 Wireless Router connections

The Router is supplied with a 5Vdc power supply. Feed the cable through the cable gland and connect the two wires to the screw terminal. The +5V wire has a red sleeve.

Jumper link LK1 is reserved for programming the device and must be left in the RUN position. LK2 is used to clear network settings and should be in the '+' position – see *Registering Network Devices* for details of how to clear network settings.

The Router must be registered to operate with a Base Station and this process is best performed close to the Base Station before installing the Router in its final location. See *Registering Network Devices* for details of how to register a device.

Up to four Routers may be used in a single system, with data messages passing in several hops between the remote sensor node and the Base Station. The Routers should be placed approximately equidistant between remote sensor and Base Station. It may be better to place a Router off to one side of the direct line between devices when there are obstructions in the direct path.

3.5 Antenna Location

For optimum range and reliable network connection, antennas should be placed as high as practical and pointed vertically. The recommended height for antennas at a range of 400m is 2.4m. An optional extension lead and bracket kit is available to help achieve a higher mounting for the antenna.

3.6 Antenna Installation Precautions

These devices operate at very low transmit power compared with mobile/cellular telephones and other similar portable devices. However regulatory precautions require that devices must not be placed so that the antennas are closer than 200mm from any person.

3.7 Registering Network Devices

The Deeter Wireless Base Station acts as the coordinator for an IEEE 802.15.4 wireless network. All devices on this network and any others that might be operating in the vicinity are identified by a unique MAC address. The Base Station starts the network and the other devices join the network in turn.

In order for the sensor node, either a Sender or an LVCS-RF, to send its data only to the intended Base Station, a registration process must be carried out. This only needs to be done once. It is recommended that the Sender or LVCS-RF is registered with its Base Station on the bench in close proximity before it is installed in its final operating position.

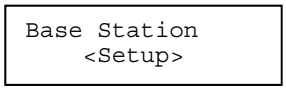
The Wireless Routers need to be registered with the Base Station so that they only join the intended network.

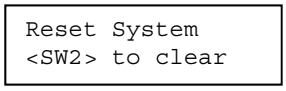
Once these devices have been registered with their network they will be automatically allowed to rejoin after any power interruption or temporary loss of radio contact.

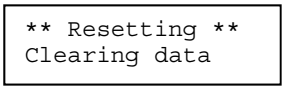
To make the process of installation easy for the customer, Deeter supply the Base Station and sensor node device (Sender or LVCS-RF) in sets already registered with each other and ready to communicate. Unless adding a Router or reconfiguring the network from scratch, the rest of this section may be skipped.

To clear previous network settings on the Base Station:

- Move link LK1 to the '–' position
- Power on the Base Station
- wait a few seconds until the LED stops flashing
- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup
- Press SW1 several times to get to the 'Reset System' screen, this screen is only shown when the link is in the '–' position
- Press SW2 to clear network settings this returns the system to factory default settings
- Move link LK1 back to the '+' position.







To clear previous network settings on a Sender, Router or LVCS-RF:

- Power off the device
- Move link LK1 (LVCS-RF), LK2 (Sender and Router) to the '–' position
- Power on the device
- Move the link back to the '+' position.

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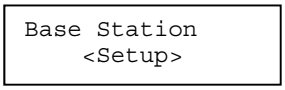
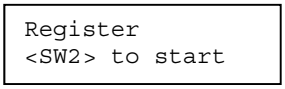
To register network devices

- Power on the Base Station
- wait a few seconds until the LED stops flashing
- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup
- Press SW1 several times to get to the 'Register' screen
- Turn on the device that is to join the new network
- Press SW2 to start the registration process.





The screen will show 'Allow join:' and a countdown in seconds of the time left for this process. If a new device joins during this time, the MAC address of the device will be shown on the screen. If unsuccessful, press SW2 again to repeat the process. If still unsuccessful, it may be because the device is already registered to another network – make sure settings have been cleared using the procedure described above.

To register another device, for systems with Routers, re-enter the 'Register' screen and press SW2 to repeat the process. More than one Sender can be registered with the Base Station provided only one is powered up at any time.

3.8 Network Testing

Power-on all network devices. After a brief pause the Base Station will automatically start the network. (If the Base Station 'Option Link' is in the '—' position it will be necessary to press SW1 to start. Move the link to the '+' position before completing the installation). Devices within range will join the network and establish a route automatically.

Successful connection of the Sender, LVCS-RF and Router will be indicated by a flash of the LED once every two seconds (the default transmit interval). Unsuccessful connection will be indicated by long bursts of LED activity.

At the Base Station, the display cycles through a number of screens. The one that shows 'Sensor Node' will also show the words 'Running' for a successful connection, 'Timeout' for an unsuccessful connection, or 'Not Registered'. If 'Not Registered' is displayed, then a Sender or LVCS-RF has not been registered with the network – see *Registering Devices* above.

If the Sender or Base Station indicate an unsuccessful connection, it may be necessary to reduce the distance between devices, move or adjust the antennas, or add one or more Deeter Wireless Routers to the network.

Once all devices are successfully connected, the next step is to determine the strength of the wireless links. If connections are borderline, minor disturbances to the environment could cause the network to break up.

A measure of the radio reception strength is called the "Link Quality Indicator" or LQI. This number will be displayed at the Base Station next to the word 'Running' in the 'Sensor Node' screen. (Pressing

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SW1 several times will reach a screen showing 'Node # 1 Last LQI' for a static display of the LQI.) The number shown will range from 0 to 255, with higher numbers indicating a stronger link.

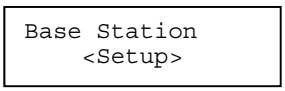
The default transmission power is +6dBm which is good for a range up to 1000m in open-field conditions and an antenna height of 2.4m or more. For network testing, the strength should be reduced to see whether it will work at lower power.

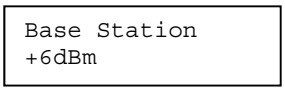
If the network continues to work at this reduced power, there will be greater confidence that it will operate at the proper power setting under worse environmental conditions (wet or cold weather conditions, RF interference, objects moving between antennas, weak battery, etc.). If the network fails to operate at reduced power, try relocating the antennas to improve the signal quality, or add a Router to the network.

Looking at the LQI figure for each power level will provide an indication of how close to break-up the network is. With an LQI below approximately 60 the next lower level is unlikely to work.

To set the transmit power level:

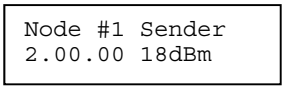
- Power on the Base Station
- wait a few seconds until the LED stops flashing
- Press SW1 to get to the 'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup
- Press SW1 several times to get to the transmit power screen
- Pressing SW2 will cycle through the power options
- Pressing SW3 will set the new power level.





The transmit power level of the remote devices is changed after receipt of a message from the Base Station.
Senders initialise at the highest available power setting and then adjust their power setting to match the Base Station.

The actual Sender power is shown in the Sender status screen. Press <SW1> several times to see this screen.



At the end of network testing, remember to set the transmit power back to +6dBm.

3.9 Setting the Sensor Data Update Interval

The choice of update interval will be crucial to determining battery life for an LVCS-RF and for a battery-only powered Sender. Longer intervals will extend the battery life but may not be suitable for some systems – the installer must decide on the best compromise between transmission rate and battery life.

The following sensor data update interval settings are available:

- 1 second
- 2 seconds
- 5 seconds

Longer update intervals are shown, but these are not recommended and will not work with the latest Sender firmware.

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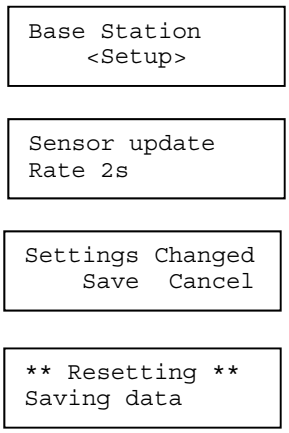
The sensor data update interval is set at the Base Station. The Sender starts transmitting at the default 2-second interval but is commanded to change the interval to agree with the Base Station setting when the first data packet is received.

To change the update interval:

- Press SW1 to get to the Base Station

  'Base Station <Setup>' screen.
- Press SW2 to enter Base Station setup
- Press SW1 several times to get to the Sensor update rate screen
- Press SW2 to cycle through the available interval settings.
- Note that setting 1, 2 and 5-seconds are the only recommended settings
- Press SW3 to select the new transmit interval.



3.10 Analog Calibration

The 4-to-20mA analog input to the Wireless Sender is calibrated during manufacture and should not require recalibration. However, a calibrations option is available on the Base Station display menu and the recalibration procedure is described here.

If the sensor node is an LVCS-RF or a Wireless Sender set for analog resistive input (LK3 in the upper position), calibration is not possible or necessary. The analog readings can be viewed on the Base Station display but the following calibration procedure will not change anything.

- Press SW1 to get to the 'Sensor Node <Setup>' screen
- Press SW2 to enter Sensor Node setup
- Press SW1 to get to the 'Node #1 Level' screen.

The 'Node #1 Level' screen shows the present analog reading it is receiving from the sensor node as a fraction of 200, e.g. 100/200. Calibration will only be possible if the readings are within 5% of the lower or upper limits, i.e. <10/200 and >190/200.

- Set the current loop input to the Sender to 4mA.
- If the display shows 0/200 recalibration is not necessary.
- Pressing SW3 will save a new setting for the low end of the analog input range and the screen will return to normal display mode.
- Re-enter 'Node #1 Level' screen and observe that the display now indicates 0/200. Set the current loop input to the Sender to 20mA.
- If the display shows 200/200 no calibration is necessary.
- Pressing SW3 will save a new setting for the high end of the analog input range and the screen will return to normal display mode.
- Re-enter 'Node #1 Level' screen and observe that the display now indicates 200/200.

Calibration data is transmitted to the Sender and saved in non-volatile memory so calibration should only need to be performed once.

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3.11 Low Battery Indication

The expected life of a LVCS-RF battery is greater than 6 months with a transmit interval of 5 seconds and infrequent breaks in the wireless network. The Sender AA size battery has twice the capacity and is expected to last more than 12 months at the same transmit interval. (A 'C' size battery option is available for the Sender on request with order. This has approximately 3 times the capacity of an AA cell.)

The sensor node measures its supply voltage and transmits this information to the Base Station for display. The Base Station will flash the voltage to indicate a flat battery when the readings go below a threshold.

Lithium thionyl chloride battery discharge characteristics are complex and the threshold chosen is best suited to a network that doesn't suffer frequent communications loss. Normal operating current drain is measured in micro-amps and the battery will maintain a high voltage almost up to the end of its life. Therefore, with good RF communications the battery will continue to work for several days after the low-battery threshold is reached. However, if the radio network should break-up when the battery is near the end of its life, current consumption will increase and cause the battery voltage to collapse. Under these conditions there may be little or no warning of imminent battery failure.

When replacing batteries pay particular attention to fit the batteries the correct way round – the positive terminal is marked with a '+' on the circuit board or battery holder. Replace only with lithium thionyl chloride batteries with a 3.6V (nominal) cell voltage. When two AA-size batteries are fitted these are in parallel. (Standard Lithium batteries or rechargeable cells will not work). See *Replacing Batteries* in the *Warnings* section below.

3.12 Loss of Radio Link

If the Base Station temporarily fails to receive a valid sensor data packet from the Sender in the expected time interval, then it will display the message MISSED PACKET.

When the third sensor data packet fails to arrive, this message changes to TIMEOUT. At this point any discrete or analog outputs revert to their inactive "fail-safe" states. The transistor outputs will be turned off. The 4-to-20mA output will go to zero milliamps; a level recognised by many current loop devices as a fault condition.

Eventually the Sender loses its allocated connection to the wireless sensor network and the message changes to NOT CONNECTED.

If the Base Station is set for AUTO RF Channel selection then after 3-minutes of not receiving sensor data it will automatically restart and perform a new energy-scan to discover the best (quietest) RF Channel. The Base Station will scan all RF channels and choose a new one that has low background activity.

If the RF Chanel has been pre-set by the User then this channel will not change.

The Sender will always perform a full network discovery scan on power up.

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After a brief loss of packets the Sender will continue to try on the agreed RF Channel.

After losing network connection, the Sender will once again scan all available channels and rediscover the network. If Routers are used then the best route is also rediscovered.

If the Base Station changes RF channel then the Senders have to perform an extended Network Discovery Scan in order to find the new channel.

If the Base Station is switched off or moves out of radio reception range then the Sender goes into a power saving mode. Eventually it spends one minute sleeping between scans. It is best to avoid switching the Base Station off for extended periods. Even in this power saving mode the Sender will expend more energy doing this intermittent scan than it would do in normal operation.

Once communications are re-established, Base Station outputs will be restored to match the sensor node inputs.

If communications break-up on a regular basis it may be necessary to check the installation again – see *Network Testing*. Perhaps the sensor node battery is low – see *Low Battery Indication*. Other solutions include moving the antennas to improve the link quality or adding a Router to the system.

Note: wireless devices are not suitable for safety-critical applications. In process control applications additional measures are taken to mitigate the consequences of a loss of communications.

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4. Specifications

4.1 Wireless Base Station

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 25 (Channel 26 is not available in High Power mode)
Transmit power:	Model BE01: 6dBm (to comply with ETSI limit) Model BU01: 18dBm
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

Supply Voltage	12V DC unregulated, external mains adapter (supplied)
Minimum supply voltage	10V DC
Maximum supply voltage	26V DC

Process Outputs

Discrete outputs	four open-collector transistor outputs (maximum current sink 50mA, maximum voltage 40VDC, for resistive loads)
Analog outputs	4-to-20mA current loop

Communications

Serial communications port	One UART Low voltage (internal connector J5), or RS232 (full duplex), or RS485 (half duplex, future software feature)
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 179mm, Width 138mm, Depth 51mm
Antenna	Height 88mm

Regulatory Compliance

Base Station Model BE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model BE01 is CE marked for sale in Europe. Model BE01 also complies with FCC Part 15 regulations.
Base Station Model BU01	A higher power model BU01 is available, which also complies with FCC Part 15 regulations. Model BU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

4.2 Wireless Sender

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26*
Transmit power:	Model SE01: 6dBm (to comply with ETSI limit) Model SU01: 18dBm
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

Battery Type	Lithium Thionyl Chloride
Battery Voltage	3.6V nominal
Battery Size	AA
External Supply Voltage	5V DC unregulated, external mains adapter (optional)

Process Inputs

Discrete inputs	four voltage free contact switched input (sense voltage 3.3V nominal, maximum contact resistance 1k Ω)
Analog inputs	potentiometer type (10k Ω minimum) 4-to-20mA current loop (sense resistor 100Ω)

Communications

Serial communications port	One UART, diagnostics only Low voltage (internal connector J5),
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 160mm, Width 120mm, Depth 62mm
Antenna	Height 88mm

Regulatory Compliance

Sender Model SE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model SE01 is CE marked for sale in Europe. Model SE01 also complies with FCC Part 15 regulations.
Sender Model SU01	A higher power model, which also complies with FCC Part 15 regulations. Model SU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

4.3 LVCS-RF Continuous Liquid Level Sensor Transmitter

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26
Transmit power:	Model LE01: 6dBm (to comply with ETSI limit) Model LU01: 18dBm (max)
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

Power Supply

Battery Type	Lithium Thionyl Chloride
Battery Voltage	3.6V nominal
Battery Size	½AA

Process Inputs

Analog inputs	potentiometer type

Communications

Serial communications port	One UART, diagnostics only Low voltage (internal connector J1),
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 125mm, Width 85mm, Depth 55mm
Antenna	Height 88mm

Regulatory Compliance

LVCS-RF Model LE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model LE01 is CE marked for sale in Europe. Model LE01 also complies with FCC Part 15 regulations.
LVCS-RF Model LU01	A higher power model, which also complies with FCC Part 15 regulations. Model LU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

4.4 Wireless Router

Radio

Frequency:	2.4GHz ISM band
Communications protocol:	IEEE 802.15.4
Channel:	11 to 26*
Transmit power:	Model RE01: 6dBm (to comply with ETSI limit) Model RU01: 18dBm
Antenna type:	Half-wave dipole
Antenna Gain:	2.2dBi
Receiver sensitivity:	-96dBm

* Note: Channel 26 cannot be used at the highest power setting

Power Supply

The Router must be continuously powered from an external supply.

External Supply Voltage	5V DC unregulated, external mains adapter (supplied)

Communications

Serial communications port	One UART, diagnostics only Low voltage (internal connector J5)
Baud rate	115200 baud
Protocol	8-bit, no parity, 1-stop bit

Environmental

Enclosure	IP64
Antenna	Fully weather-proof
Temperature	-20°C to +70°C

Dimensions

Enclosure	Height 160mm, Width 120mm, Depth 62mm
Antenna	Height 88mm

Regulatory Compliance

Router Model RE01	complies with ETSI regulations for use in the unlicensed ISM radio band. This limits the maximum transmitted power density to 1mW per MHz. Model RE01 is CE marked for sale in Europe. Model RE01 also complies with FCC Part 15 regulations
Router Model RU01	for use where the local regulations allow a higher transmitted radio power. Model RU01 complies with FCC Part 15 regulations. Model RU01 may not be used in Europe.

These devices may only be operated with the antenna supplied.

5. Warnings

5.1 Replacing Batteries

The batteries in the Wireless Sender and LVCS-RF are high power Lithium Thionyl Chloride primary cells. These must not be recharged. Replace only with equivalent parts as the system requires the higher 3.6V (nominal) cell voltage. Standard Lithium batteries or rechargeable cells will not work. Pay particular attention to fit the batteries the correct way round. The positive terminal is marked with a '+' on the circuit board or battery holder.

5.2 Fuses

The Base Station fuse is a 500mA anti-surge surface-mount type from Littelfuse (manufacturer's part number 0154.500DRT). This fuse is mounted in a socket marked F1. Replace the fuse with the same type.

5.3 Antenna

The system can only be used with the antennas supplied. Any attempted use with unapproved antenna types will invalidate the system compliance and may be illegal.

5.4 CE Marking

The models approved for use within the European Union bear the CE mark to show compliance with EU Directives and European regulations. In particular the maximum RF transmission power is limited to 6dBm in order to comply with ETSI regulations.

5.5 FCC Part 15 Compliance

The system uses an RF Transceiver module that complies with US Federal Communications Commission Part 15 Regulations for intended RF emissions.

Each device is permanently labelled with the following statement.

Contains:
FCC ID TYOJN5148M4

This covers the following RF module variant: JN5148-001-M04

This compliance requires the use of the approved antenna supplied.

5.6 High Power Module usage limitation

The high power RF modules are classified as 'mobile' device pursuant with FCC section 2.1091 and must not be used at a distance of < 20 cm (8") from any people.

5.7 High Power Module channel restriction

The FCC grant for the TYOJN5148M4 does not permit the use of channel 26. Access to channel 26 is forbidden by the 802.15.4 MAC layer when the JN5148 chip is in high power mode. Users will not be able to access channel 26 when using the JN5148-001-M04 module under any circumstances.

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5.8 Federal Communication Commission Interference Statement

The RF Module has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

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

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

WARNING!
FCC Radiation Exposure Statement:

This portable equipment with its antenna complies with FCC's RF radiation exposure limits set forth for an uncontrolled environment. To maintain compliance follow the instructions below;

1. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
2. Avoid direct contact to the antenna, or keep it to a minimum while using this equipment.

5.9 Industry Canada Compliance

Each device is permanently labelled with the following Industry Canada identifier.

Contains ID IC: 7438A-CYO5148M4

5.10 RF Exposure Compliance

The RF Transceiver Module has been granted FCC Modular Approval for mobile RF Exposure conditions. This grant requires that the antenna used for this transmitter must be installed to provide a separation distance of at least 200mm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

The user must not attempt to remove or install the RF Transceiver. Apart from battery and fuse, there are no user serviceable parts in any of the Deeter Wireless Sensor devices.

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5.11 Repair and Servicing

Do not attempt to repair this product yourself. Contact the Deeter Group for product servicing or repairs.

5.12 Disposal and Recycling

Dispose of used batteries according to local regulations.

At the end of the equipment life the product should be recycled according to the European Directive on Waste Electronic Equipment.

Outside the EU dispose of this product according to local recycling or waste disposal regulations.

This equipment is expected to have a long service life and the regulations will most likely change during that time.

This product must not be disposed in household waste.

6. List of Acronyms and Abbreviations

MAC	Media Access Control, network protocol layer
IEEE	The Institute of Electrical and Electronic Engineers, website www.ieee.org
IEEE 802	The IEEE standards for Local Area Networks
ISM	Industrial, Scientific and Medical, allocated frequency bands
dBm	power measurement expressed in decibels referenced to 1mW +6 dBm is 4mW 0 dBm is 1mW -6 dBm is ¼ mW
LVCS	Liquid Vertical Continuous Sensor, a range of sensor made by Deeter
LQI	Link Quality Indicator, a number between 0 and 255 that provides some indication of the radio signal strength. High numbers indicate stronger signals.

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7.Revision Details

Revision	*Detail*
3.5	Final version with JN5139 RF Module
4.0	JN5148-001-M04 RF Module
	Changes to RF Power Settings
	Sensor Update interval
	RF Channel selection