Tinytag Radio Data Loggers

Technical Manual

Tinytag

Gemini
DATA LOGGERS
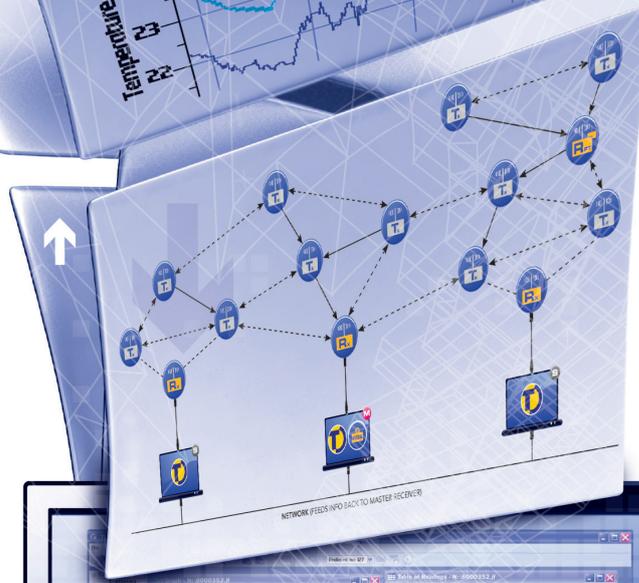
1   Tinytag Radio Data Logger Technical Manual

1.1   About this Document

This document describes the Tinytag radio data logger system.

This document also describes characteristics of the Tinytag Explorer software and the Radio Gateway Service that are used to manage the system.

All users are encouraged to upgrade to the latest version of Tinytag Explorer.

Users of Tinytag Ultra Radio products will need to run Tinytag Explorer version 4.9 or above.

Users of Tinytag Plus Radio products will need to run Tinytag Explorer version 4.10 or above.

The latest version of the software can be downloaded from:

www.tinytag.info/support

The information in this document covers versions 4.7 of the software and above.

2   Table of Contents

3   Radio Gateway Service Computer Requirements

The requirements for running the Radio Gateway Service on a computer are shown below. Note that additional requirements apply if you are running Tinytag Explorer on the same computer.

Operating System:	Windows Vista, 7, 8, 8.1 or 10 (x86 and x64 bits versions)
Processor:	200MHz Pentium III processor or better
Memory:	512Mb
Hard Disk Space:	At least 30Mb available
Monitor for installation:	Minimum 256 colours, resolution 800 x 600
	The requirements for running the Radio Gateway Service on an existing server are shown below.
CPU time:	Negligible
Memory:	20Mb
Hard Disk Space:	Typically 10Mb for

4   Radio System Component Overview

Tinytag Radio System Components Key

 Tinytag Radio Logger

 Tinytag Repeater

 Tinytag Receiver

 Tinytag Explorer

 Tinytag Radio Gateway Service

 Tinytag Receiver Cables

 Server

 Master

 Slave

4.1   Tinytag Explorer Software

The radio edition of Tinytag Explorer is installed with the same installation disk as regular Tinytag Explorer but uses a different activation code. This activation code adds the "radio" tab to the radio configuration dialog box which allows the user to configure a Radio Gateway Server, which Tinytag Explorer can then connect to.

The rest of Tinytag Explorer is unchanged. The graphing and data export features behave identically between wired and radio loggers. It is possible to create an overlay with data from mixed wired/radio sources, and it is possible to view this overlay on normal (non-radio) versions of Tinytag Explorer. This allows users with an existing investment in wired loggers to start using radio with minimal impact on their current processes.

4.2   Radio Gateway Service

The Radio Gateway Service is installed with Tinytag Explorer.

The Radio Gateway is a windows service. This means it runs in the background as soon as the computer is turned on. Its purpose is to connect to the radio receiver, collate measurements, and make information available to Tinytag Explorer. The Radio Gateway Service buffers measurements (and other data) on disk in files with a .jf extension which use a proprietary file format.

On a networked system, the Radio Gateway Service must be installed on the computer which is connected directly to the receiver. It then makes this information available to any networked computers running the radio edition of Tinytag Explorer.

This can be used in various configurations:

1. Standalone. The Radio Gateway Service and Tinytag Explorer don't have to be on the same computer, but they very often are. This configuration is the most common, because it is the simplest.

2. The Radio Gateway Service installed on a server. Many other users in the same office run Tinytag Explorer.
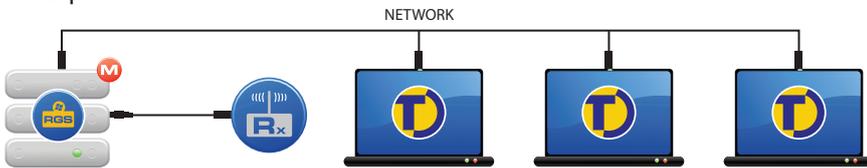
3. The Radio Gateway Service installed on one user's computer. Many other users in the same office run Tinytag Explorer.
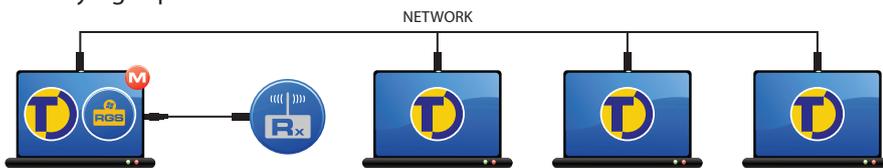
4. The Radio Gateway Service installed on one old computer in a dirty location near the receiver. Tinytag Explorer runs on a nice computer in a nice office.
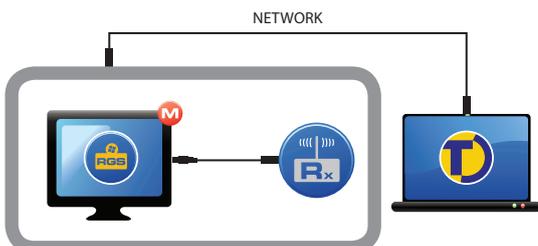
Note that this generally means there will only be one computer running the Radio Gateway Service in the system. It is possible to run it on more than one computer; this configuration is described later in the "Receiver Configurations" section.

Ideally the Radio Gateway Service would be left running 24/7 to allow it to collate all data. No measurements will be lost if the computer is shut down for up to 2 weeks (at a 10 minute measurement interval), however this will affect battery life and there may be a delay in displaying new measurements due to the need to retransmit cached measurements. If the Radio Gateway Service is shut down, it will detect any measurements that weren't collated on their first transmission and arrange retransmission. This ensures that no data is permanently lost.

Ensure the following settings are correct for best performance if your custom software solution relies on the Radio Gateway Service.

"Autostart service when the computer is turned on" needs to be ticked. Tinytag Explorer knows to start the windows service if it is not running, but your software may not. It needs to be started automatically.
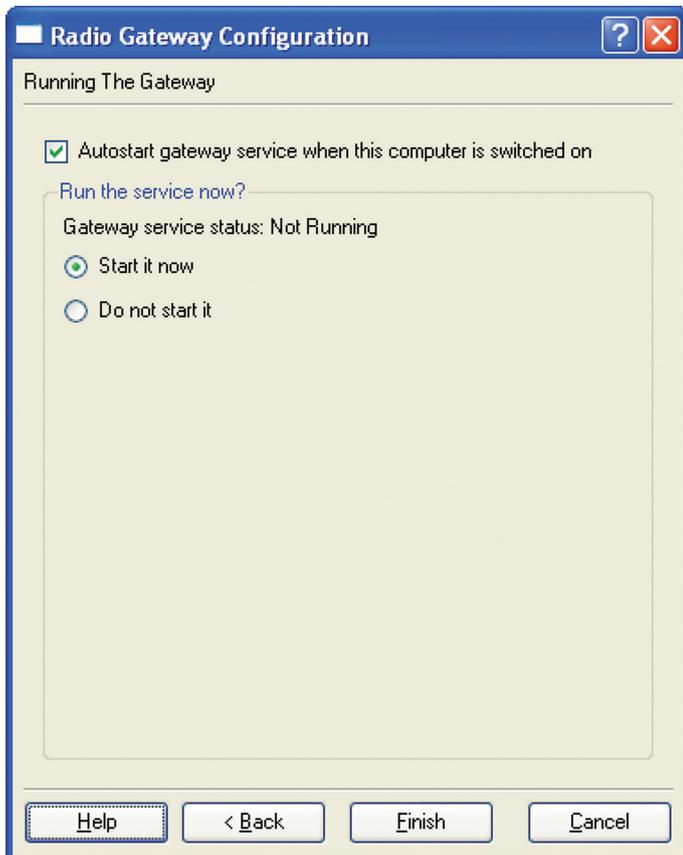
4.3   Receiver

When a receiver is connected to the Radio Gateway Service, this connection becomes the point where information enters and leaves the mesh network system.

The primary purpose of the mesh network is to find a way to funnel information downstream towards the computer running the Radio Gateway Service. It is this behaviour which gives the "receiver" its name. At the physical layer (point-to-point radio layer) a logger and receiver behave identically – they are both radio transmitters and radio receivers.

Receivers can be used in a variety of configurations, not all of which involve connecting the Receiver directly to the Radio Gateway Service. These are described in a later chapter.

If the computer the receiver is connected to is turned off, communications between the Radio Gateway Service and the receiver will stop, but back-up batteries in the receiver will keep it powered and the mesh network will be maintained. Individual data loggers will store their measurements until communications with the gateway can be re-established. When the computer is turned on again, the radio gateway will request transmission of any stored data.

4.4   Radio Logger

The radio logger participates in the mesh network like any other device, but most importantly it also takes measurements.

After a measurement has been taken, it is stored locally and then transmitted to the computer (and the Radio Gateway Service) via the mesh network.

4.5   Repeater

A receiver which is not connected to any computer can act as a repeater to improve the range of an installation and to connect to other devices which have poor communications.

4.6   Receiver Cables

Receiver cables are USB cables that are 5m long. This appears as a virtual com port.

4.7 Mesh Network

All devices in the radio system participate in a mesh network.

Tinytag Radio System Components Key

- Tinytag Radio Logger
- Tinytag Receiver
- Tinytag Repeater
- Radio Gateway Service
- Tinytag Explorer
- Obstacle
- → Communication Route
- ← - - → Alternative Communication Route
- - - - - Out of Range
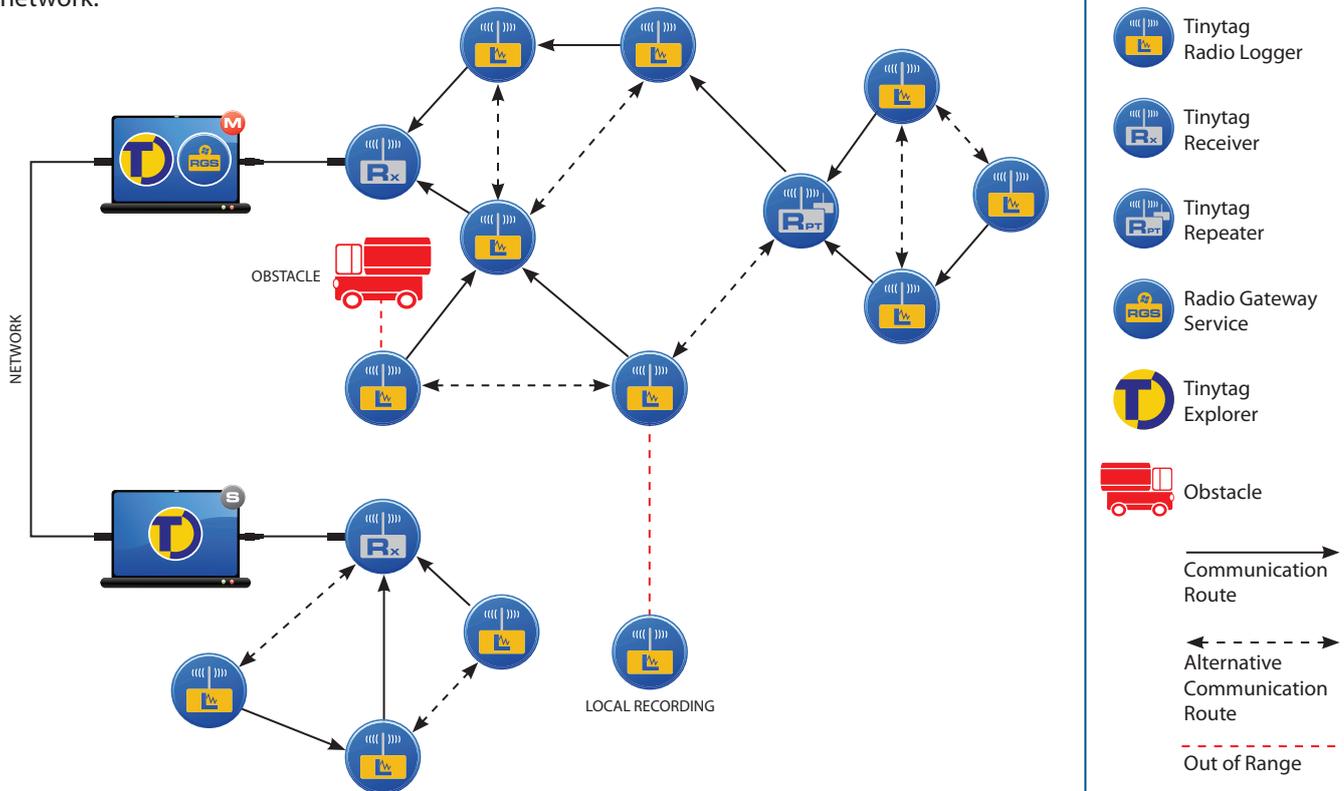
There is a good overview of the general operation of Mesh networks in the Tinytag Explorer Radio online help, in the "Parts of the System" section.

Mesh networks are ideally suited to data logging because they have the following characteristics:

1. Robustness. The mesh network allows information to be routed around obstacles. For example a van parked in front of a data logger will not cause a problem, because that logger will be able to transmit its information to the receiver via another device. The mesh will adapt to moving obstacles – it is self-healing.

2. Low set-up costs. In general it is possible to throw data loggers into a measurement site and it "just works". The system will be able to automatically establish a mesh which connects all devices. This avoids the "radio survey" step which is necessary for point-to-point radio links.

Several advantages are unique to the Tinytag mesh network:

1. All devices are capable of meshing. Some mesh network systems from other vendors differentiate between "mesh routing hubs" (which are often mains powered, and may need to be placed with some care) and non-meshing "transmitters". The Tinytag solution is more robust because having a larger number of mesh-capable devices will allow it to form a more effective mesh. The number of redundant routing options is a key parameter that will be discussed later.

2. All devices can be reconfigured remotely. This is possible because all devices "listen" across the mesh network.

3. All devices are loggers, and data will not be lost due to momentary interruptions (a van driving in front of the logger) or temporary interruptions (the van is parked overnight) to the radio service. This capability also relies on devices being able to "listen" across the mesh, because that enables the Radio Gateway Service to request retransmissions.

5   Point-to-Point Radio

Different radio frequencies are used for different countries.

869.8MHz	Used in the EU. Devices using this frequency can be identified by their part number ending –A. Older part numbers which do not have a single letter part number suffix also use this frequency.
917.8MHz	Used in Australia. Devices using this frequency can be identified by their part number ending -B.

Naturally, parts using different frequencies can not interoperate.

The radio uses FSK modulation, with +/-32 kHz deviation.

The transmission power is <5mW in EU & <3mW in Australia.

Typical range in free space: 100m - Ultra Radio

200m - Plus Radio

These frequencies will easily penetrate most internal or external walls; however the range may be reduced.

Indoors the range is quite variable. It is usually reduced to between 30% and 80% of full range. However it will sometimes be increased, maybe up to double the nominal range, due to "lucky" reflections off other buildings, steel roofs, etc. This variability works to the advantage of the mesh network because the unlucky majority will be able to relay their information via the lucky one with the extra-long range.

The radio system works well indoors and out. The frequencies will usually penetrate steel-walled rooms, through door seals, windows, ventilation etc. Even though the radio waves cannot penetrate a metal wall (whether a fridge, or corrugated iron shed), the signal will probably still get through gaps around door seals and other openings.

These frequencies are very slightly absorbed by water. Wet walls are not a problem, but the signal will not get through a room filled with shelves full of fruit, for example.

Ideally the antenna should be oriented vertically. Most of the energy is emitted perpendicular to the antenna.

Ultra Radio products can be wall mounted or placed flat on a surface, such as a shelf or a table top. They should be oriented as shown below, and not with the logger and antenna both mounted vertically.


The radio is affected by line of sight. Please note that "line of sight" means that of the antenna – not your line of sight while standing over a logger on the floor!

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6   Receiver Configurations

6.1   Direct

Normally the receiver is connected directly to the computer running the Radio Gateway Service (via a 5m long USB cable).
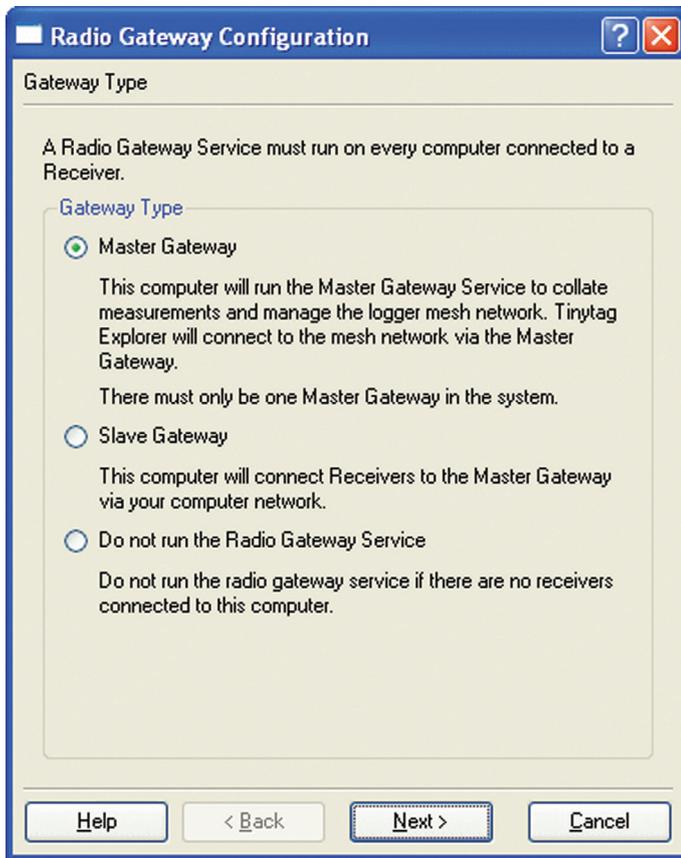
It is configured as a Master Gateway which means it collates measurements, stores them locally on the hard disk, manages retransmission to fill in any missed data, and makes all the information available to Tinytag Explorer and other software.

An extension cable is available for ASCRF part number receivers if the ideal site for the receiver is not within easy reach of a PC. This is CAB-0023-XM (where X is the length of the cable in metres, up to 50m).

It is possible to use an rs232/Ethernet converter if the receiver must be located a larger distance from the PC. The Radio Gateway software is unaware that the receiver is remote provided this rs232/Ethernet converter provides a 'virtual com port' on the computer where it is running.

The default configuration of the Radio Gateway Service will automatically scan all com ports to find any receivers. A manual com port configuration option is provided for use if your computer has other devices using com ports.

6.2   Multiple Receivers

Multiple receivers can provide:

Redundancy

The radio system will continue to function if one receiver fails.

Range

Consider a radio system covering two warehouses, but the radio link between each warehouse is unreliable when all doors are closed overnight.

It may be appropriate to locate one receiver in each warehouse.

Capacity

There is a limit to the amount of radio traffic that can be handled by one receiver. Having multiple receivers can improve capacity because they can share traffic.

It is better to locate the two receivers at opposite ends of a large warehouse containing many radio devices. Each radio logger will find a mesh to its nearest receiver. For this traffic sharing to occur, they must not be within radio range of each other. If the two receivers in the warehouse were adjacent then they would both hear all traffic.

6.3   Multiple Computers Running the Radio Gateway Service

All computers connected to a receiver must be running the Radio Gateway Service.

One of these must be configured as the Master Gateway. As described in the section describing the "Direct" configuration, the Master Gateway collated all measurements, and makes information available to Tinytag Explorer and other software.

All other computers connected to a receiver must be configured as a Slave Gateway. The Slave Gateway is a very lightweight program which simply relays data between any connected receivers and the Master.

	Master Gateway	Slave Gateway
Connects to Receivers?	Yes. It connects to any receivers plugged in to this computer.	Yes. It connects to any receivers plugged in to this computer.
Information from Receivers	Processed locally.	Shuttled to the Master Gateway for processing.
Readings collated?	Yes.	No.
Readings stored on hard disk?	Yes.	No.
Information made available to Tinytag Explorer?	Yes.	No.
Minimum number in one system.	1	0
Maximum number	1	no limit

There is a minor difference to the behaviour of a receiver depending on whether it is connected to Master or Slave Gateway. A receiver that loses contact with the Master Gateway (maybe because the computer has shut down) will continue to maintain the mesh network centred around that receiver. This ensures that the mesh is ready for use as soon as the computer running the Radio Gateway Service reboots.

NETWORK (FEEDS INFO BACK TO MASTER RECEIVER)
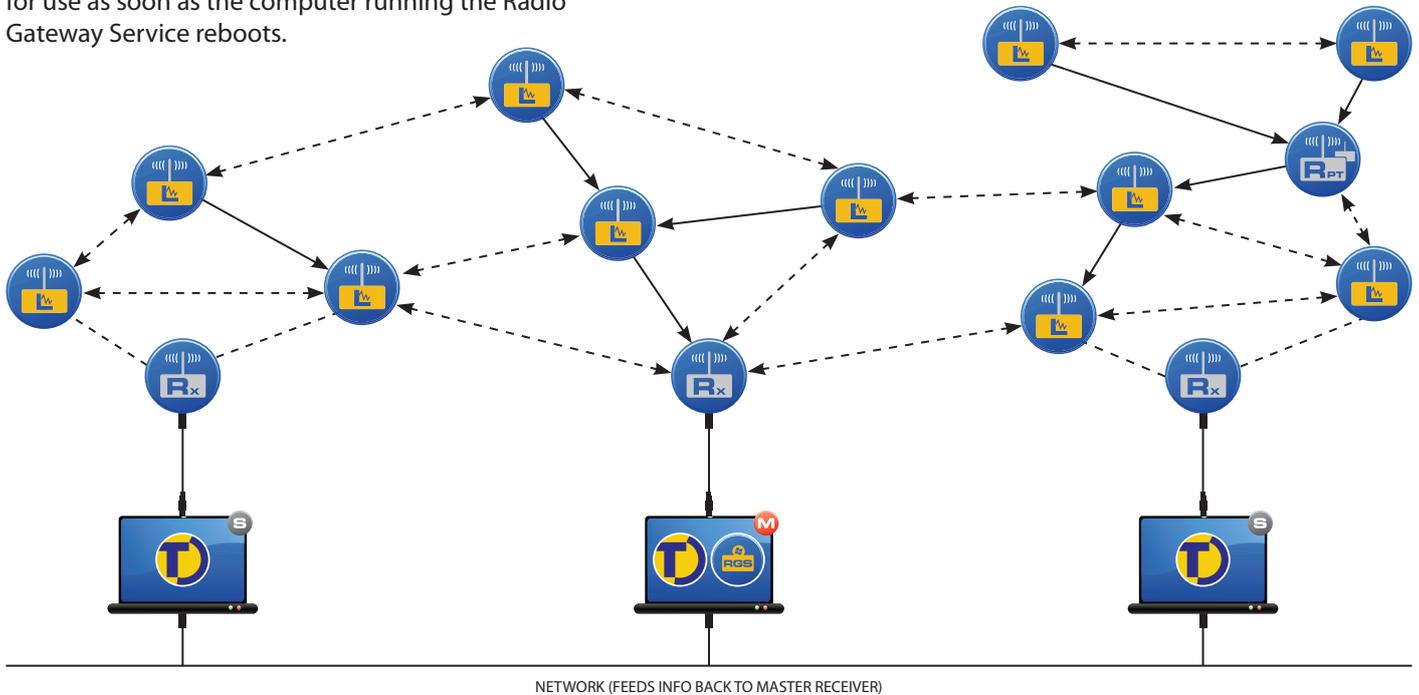
A receiver that loses contact with a Slave Gateway will cease to maintain its local mesh, and other radio devices will switch over to another receiver within an hour. It is therefore less critical that any computers running the Slave Gateway be left running 24/7.

NETWORK (FEEDS INFO BACK TO MASTER RECEIVER)
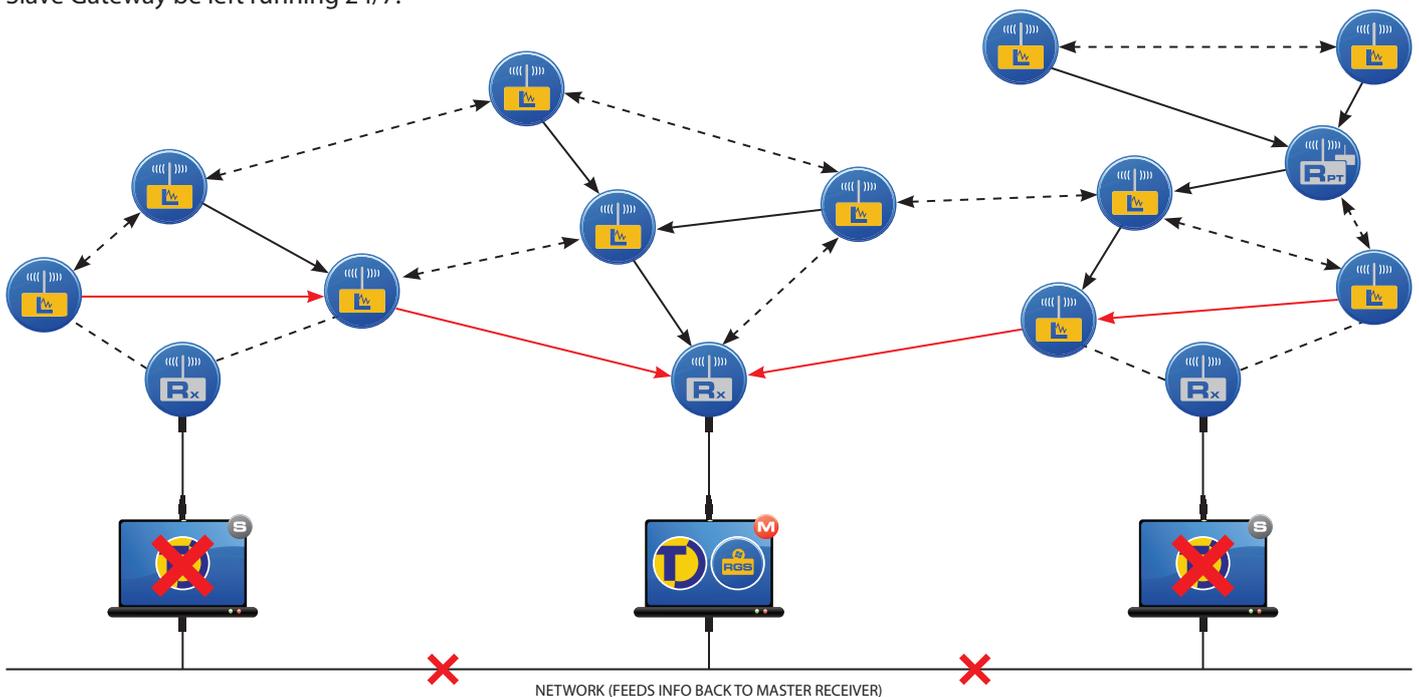
6.4   Repeater

A receiver which is not connected to any computer will, like every radio device, continue to participate in the mesh network. It can act as a repeater for other devices which have poor contact with other devices in the mesh, or to improve the range of an installation.

6.5   Back-to-Back Receivers

An ASCRF part number receiver can be connected to another receiver of the same type using a CAB-0026-XM cable (where X is the length in metres, up to 50m).

In this mode the pair of receivers will participate in mesh networking over the cable. They relay information from one to the other, in either direction, more effectively than using radio for the same hop.

This configuration can be used to bridge between islands of the mesh network; for example, bridging between a warehouse and a steel-walled cold store. In general this approach should only be used where it is not possible for the receiver to be connected to a computer.

WALL
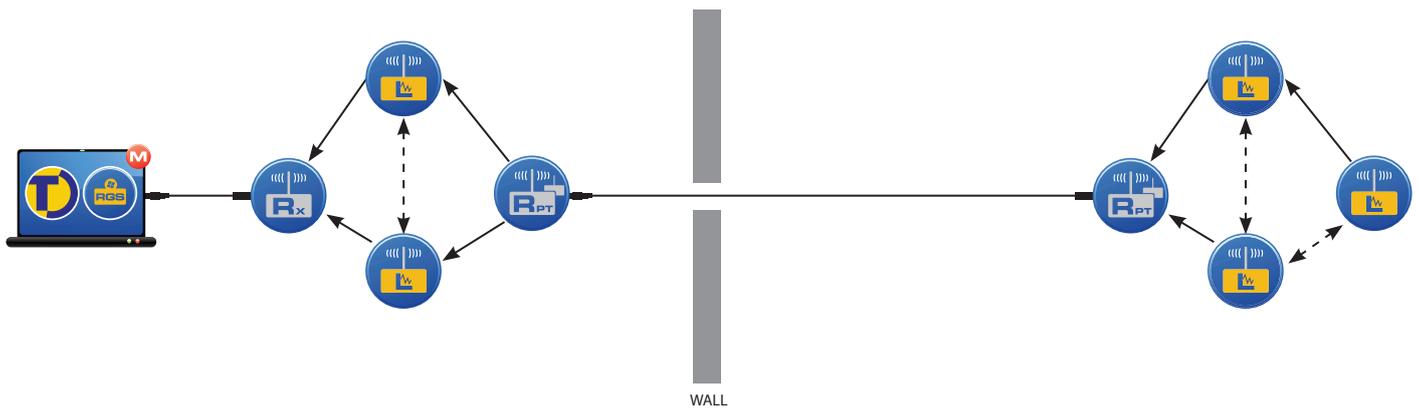
7 Mesh Network Behaviour

7.1 Switching On a Device

When a device is first switched on it will send new measurements downstream as soon as it has any radio contact with another device. If there is a mesh established this should happen within a few minutes.

When the Radio Gateway Service sees the first of these measurements it knows that the new logger exists. At this point it should quickly determine the identity of the logger, and begin collating measurements and requesting retransmissions if any measurements are lost.

7.2 Moving a Device

When a device is moved from one place in the mesh to another it may take between 30 and 60 minutes to work out its new place in the mesh.

This meshing process works on a 30 minute cycle. After being moved the logger may not fully adapt until after one whole cycle.

7.3 Starting the Radio Gateway Service

When the Radio Gateway Service is first started it needs to wait for a packet to arrive from each logger before it knows which loggers are present in the mesh. This is another process which will take up to one logging interval for each logger.

An exception is loggers which had previously established a direct connection to the receiver (that is, not via any mesh repeaters) within the last 4 days. It will probe these loggers immediately to see if they still exist within direct range.

This again assumes that there is a well established mesh; in particular, that the receiver is not just being switched on at the same time.

7.4 Switching On the Receiver

Receivers need to find their place in the mesh exactly like a logger. This adds an extra 30 minutes on to the "Starting the Radio Gateway Service" scenario.

If the Radio Gateway Service is being shut down, possibly over night, it is desirable to avoid this delay by leaving the receiver running. For receivers which rely on external USB power it is possible to leave the receiver powered from USB hub while the computer is switched off. This solution does rely on retaining power for the USB hub.

7.5 Redundant Routing

The best way to ensure reliable communications is to provide redundant routing options. Every device should have at least two other devices in front of it, but preferably more.

Very often a radio device will find that an individual packet is not being received by its chosen downstream neighbour, either due to a momentary obstacle or momentary radio interference. The Tinytag radio mesh devices can respond to this very quickly by immediately switching to the second best downstream route. It is not a problem even if this is a sideways hop – the information still gets through with a few seconds delay. In this way the mesh is constantly adapting to changing radio interference patterns to ensure reliable delivery.

However this strategy only works if every node has at least two possible devices in front of it. A device with only one possible route is very much more fragile.

In most cases this redundancy is easy to achieve - just scatter plenty of loggers within the measurement area, and locate the receiver so that it is within range of plenty of loggers. (a)

(a) Good – plenty of redundant routing options for all devices.
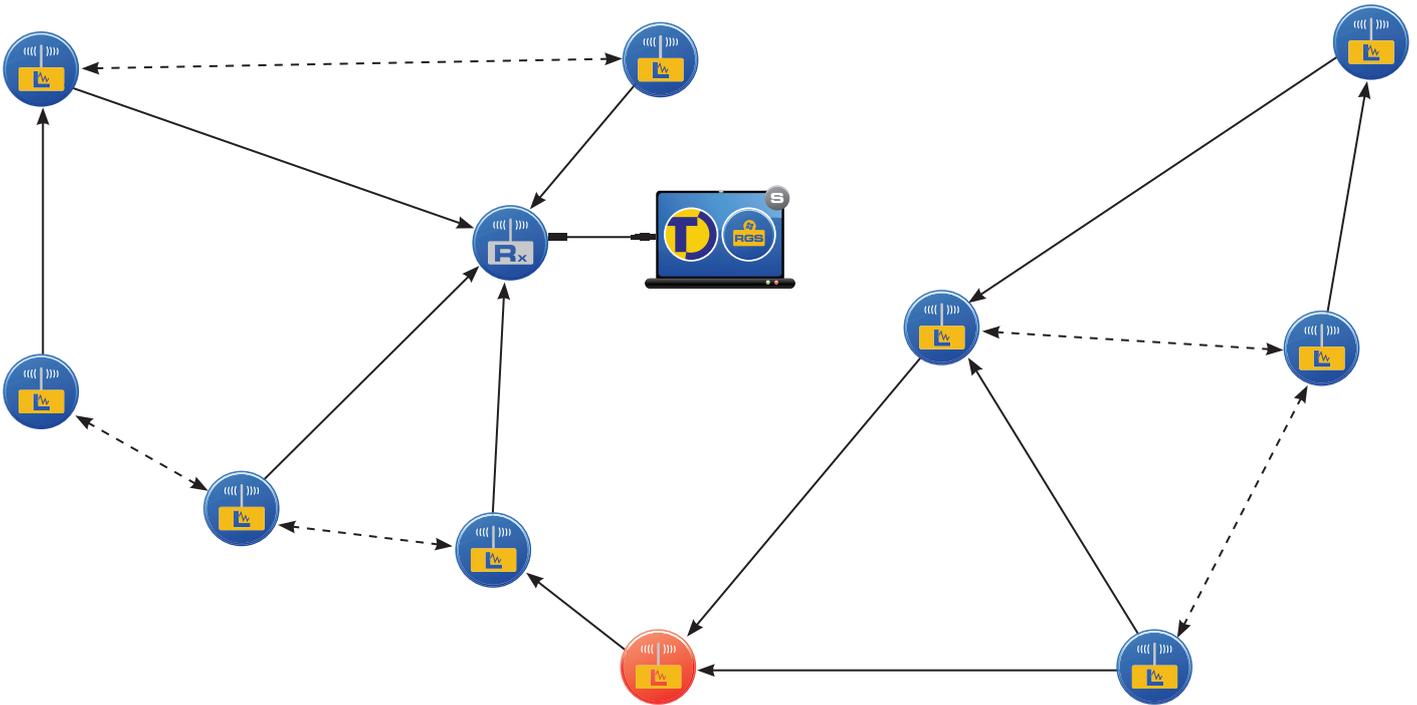
(b) Not Good – the red logger has only one place to send its data, so everything upstream of there (to the right) will not be reliable.
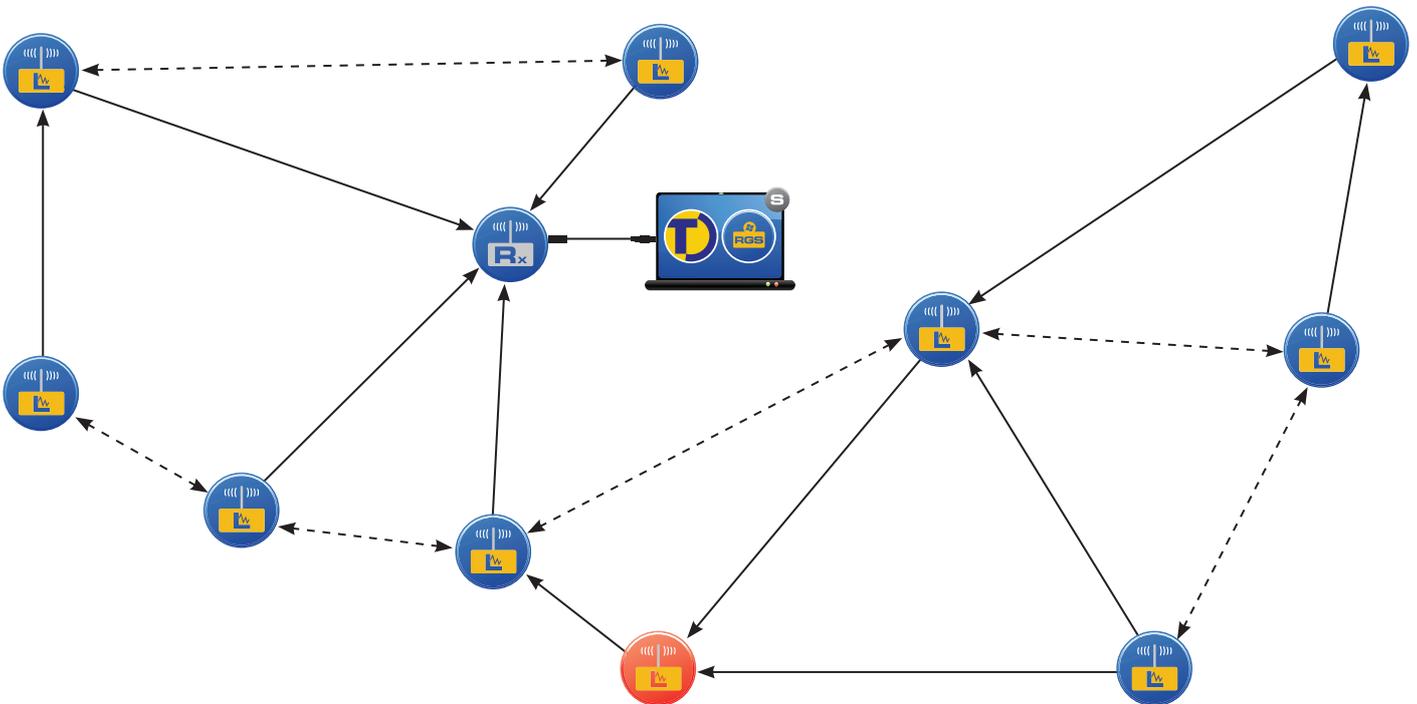
(c) Modifying the position of the red logger, so it has more than one place to send its data, will improve the range and therefore the reliability of the communications.

In some cases it can be beneficial to add or move a device to improve redundancy:

1. If there is a radio restriction, for example a narrow doorway through a thick steel wall, then it is good to have a pair of devices on either side of the doorway (better than just a single device on either side).
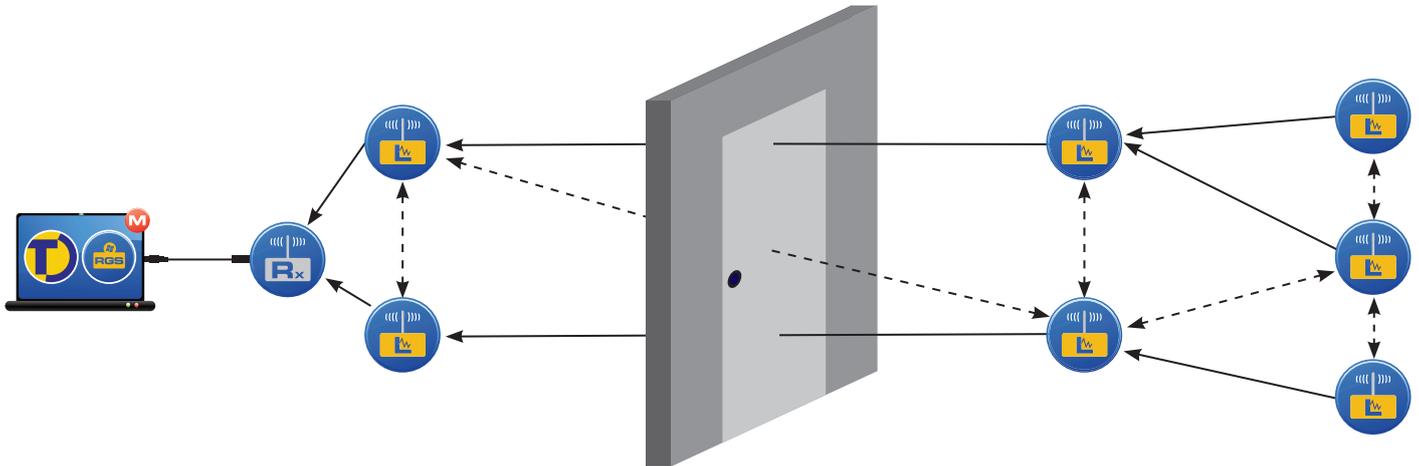
2. In some cases it is not possible to provide a clean radio path for loggers that are physically close to each other, perhaps because they are at ground level on an undulating ground. In this case it may be possible to elevate a small fraction of the loggers so that they can overlook the others. The majority of loggers will need to relay via the elevated minority. If it is not possible to move the logger in this way, it may be possible to install a receiver as a repeater.

The network is affected by the number of redundant routing options (the number of peer loggers within range of each other):
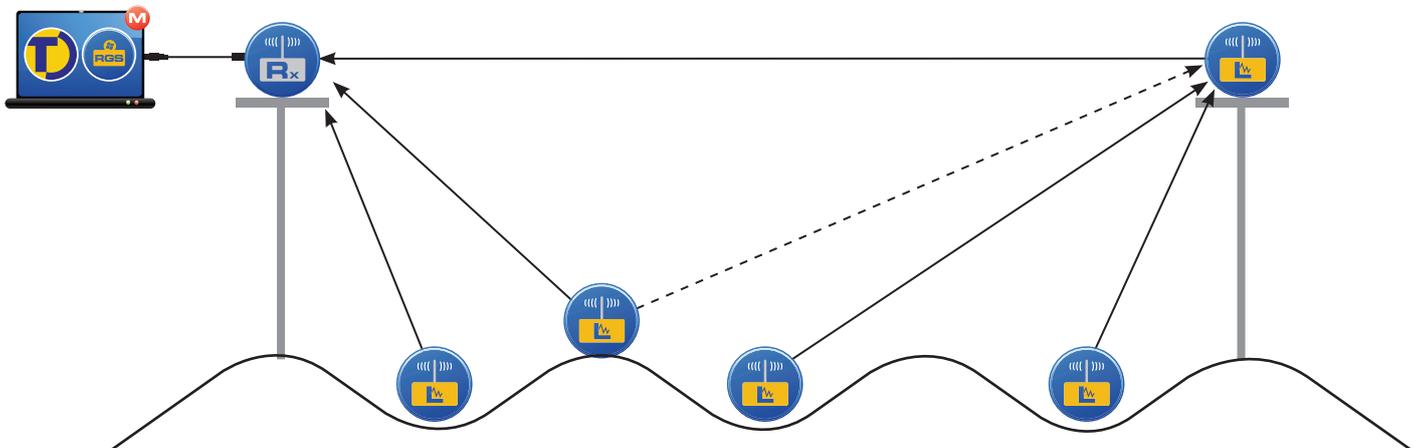
The network is affected by the number of redundant
routing options (the number of peer loggers within range
of each other):

| Number of Peer Loggers Within Range	Effect
1	A single point of failure. Not ideal.
2-3	A mesh with alternative routes. Good.
4-15	A dense mesh. Ideal.
15-20	More peers than it needs. Could reduce range to increase battery life, but probably not worth it.
20+	Reducing range (by adjusting sensitivity, then transmit power) will increase battery life, and can help if the system will not form a robust mesh automatically.

7.6   Radio Configuration

7.6.1   Adjusting the Radio Range

This section details how the Radio Range can be adjusted for each logger in the mesh network by changing the values of the parameters in the Radio Configuration program. Reducing the radio range can be beneficial when there are 20 or more loggers within range of each other, as this situation can make the mesh network less robust.

In most cases these parameters do not need to be adjusted, and incorrect configuration may adversely affect the performance of your radio network. We therefore advise that you only use this feature following the advice of Tinytag Technical Support.

7.6.2   Receive Sensitivity

The primary parameter to affect radio performance is Receive Sensitivity. This parameter adjusts the threshold at which the receiver will decode a receiver signal, relative to a baseline threshold of 9dB above the noise floor.
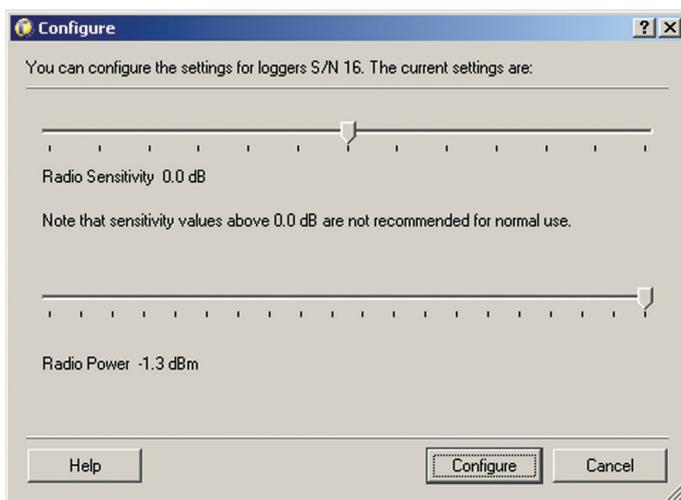
The default value for this parameter is zero dB, and may be adjusted between -6dB and +6dB.

In the default configuration, radio range is typically 200m for Plus Radio products and 100m for Ultra Radio products.

Radio range may be reduced by reducing the sensitivity:

Change in dB	Radio Range
0dB	100% of range
-3dB	~75% of range
-6dB	~50% of range

Reducing the range in this way will have an affect on the mesh network connections established by the loggers. In some circumstances the mesh can be less robust for loggers which are within range of more than 20 other loggers.

Reducing the range can also increase battery lifetime. It is possible to reduce the total amount of radio traffic processed by one device, by allowing it to ignore irrelevant distant traffic. However, this may also have the opposite effect, if it results in increasing the number of hops required for data to reach the receiver.

The radio range may be increased by increasing the sensitivity:

Change in dB	Radio Range
0dB	100% of range
+3dB	~130% of range
+6dB	~180% of range

Sensitivity values above 0dB will adversely affect the power consumption of a device.

The higher sensitivity means that it is less able to distinguish between good signals and background noise, and will spend extra battery power decoding spurious signals.

For a device with a permanent external DC supply this may not be a problem.

Note that this figure is a typical measurement, and not a guaranteed minimum. It may be affected by many factors including the surrounding physical environment (buildings, equipment, etc) or other local radio transmitters.

7.6.3   Transmit Power

The radio range can also be adjusted by changing the transmit power. The default configuration is for devices to transmit at their maximum power. If you wish to reduce the range of a logger the transmit power may be reduced in steps with the slider control. Minimum power will result in a range of typically 10% of normal.

In general it is preferable to reduce sensitivity before reducing transmit power in order to reduce the radio range. This ensures the signal to noise ratio is maximised.

7.7   Very Slow Logging Intervals

Some of the connection timings above depend on the logging interval. The logging interval affects the time taken for a logger to connect to the Radio Gateway Service, because that service will normally only discover that a logger is present when it transmits a measurement.

Other information which can also trigger this connection process is transmitted hourly; therefore loggers with very slow logging intervals will still connect without unreasonable delay.

7.8   Very Fast Logging Intervals

Normally loggers will transmit every measurement as it is taken. If the logging interval is faster than 2 minutes then multiple measurements are sent in a burst. This batching process avoids radio congestion, and maximises capacity.

The Replication Timebase Parameter can be changed to adjust the interval between measurement transmissions. A data logger will not transmit measurements more frequently than between one and two multiples of the Replication Timebase.

The default value for this parameter is one minute.

Note that this parameter is different from the Measurement Interval, which can be controlled using Tinytag Explorer and is typically set to 10 minutes. Under normal circumstances, measurements are transmitted as soon as they are taken, and arrive on the computer system almost immediately.

The Replication Timebase Parameter may be increased to save battery power, at the expense of less frequent measurement updates onto the computer system.

For example, if the Measurement Interval is 10 minutes, and the Replication Timebase is 30 minutes, the radio data logger will record between three and six measurements (30 to 60 minutes) before transmitting them all back to the computer system.

This saves battery power due to reduced transmission overheads.

7.9   Data Organisation

Every measurement is written to memory and transmitted downstream as soon as it is taken. Every measurement transmission carries the logger serial number and a measurement sequence number, therefore it is impossible for measurements to be mixed up between devices or recorded in the wrong order.

The Radio Gateway Service uses these sequence numbers to control retransmissions. If the sequence numbers are not consecutive then it requests a retransmission to cover the gap.

If the Radio Gateway Service is aware of a gap when a logger is downloaded into Tinytag Explorer then it will ask the user whether they want to see the data so far, or wait until the gap has been filled in.

Data is transferred at approximately 6k per minute.

Data can be transferred from multiple loggers simultaneously. It will prioritise loggers that Tinytag Explorer is waiting for, and loggers that are nearly complete.

If the data gap can not be filled in because too much time has passed (approximately two weeks in the default configuration) and the logger has overwritten its memory then Tinytag Explorer will leave a gap on the graph.

7.10   Alarms

When configuring the radio network, you can enable alarm notification emails. When an alarm is triggered, an email will be sent to the address provided during setup, detailing the logger and probe that triggered the alarm.

If an alarm is configured then the critical parameter is sampled every few seconds. An alarm indicator will be sent downstream immediately, and this will show up in Tinytag Explorer immediately.

However, the Radio Gateway Service does not send an alarm warning email/SMS immediately; it delays for five minutes in case another logger should raise another alarm so that it can deliver all the alarm warnings in one email/SMS.

Also note that the batching process described under "very fast logging intervals" also applies to alarm indicators. An alarm indicator may have to wait up to 2 minutes before radio transmission on loggers that have a fast logging interval.

8   Buttons and Lights

Tinytag Radio devices have an LED indicator that shows the current status of the unit:

Action	LED	Status/Operation
n/a	No Indicators	Device is powered off
n/a	Red flashing every 4 seconds	The device is powered on and has a problem. Either: a) Battery is Low. b) Device has not yet established its place in the mesh network. c) An alarm indicator is signalled. Check the nature of the problem using Tinytag Explorer.
n/a	Green flash every 4 seconds	The device is powered on, and does not have any problems.
Press and briefly hold the on/off switch.	Green indicator shows for one second. It then briefly flashes green then red.	The device has been switched on.
Press and hold the on/off switch for 3 seconds.	Red indicator shows for one second.	The device has been switched off.

9 Rapid Installation

9.1 Introduction

This section describes best practices for installing a system to minimise the time necessary to prove that the mesh network is working as expected.

Note that deviating from this process will not cause any significant problem; at worst it may take an extra hour before all the devices show up.

9.2 Receiver First

The first step in setting up a demonstration system should be placing the receiver. It should be in a location where it will be within range of plenty of the data loggers. An elevated position may help.

Configure and start the Radio Gateway Service.

Check using Tinytag Explorer that:

1. Tinytag Explorer has been able to connect to the Gateway Service, and

2. The Gateway Service has been able to connect to the receiver.

This should only take a few seconds. Do all of this before powering up any loggers.

9.3 Nearby Loggers Next

The first loggers to be switched on should be those nearest to the receiver.

These loggers should be within direct range of the receiver, they should connect at full performance within a few minutes.

Do not hold the logger with your hand around the antenna. A logger sends its first transmission within a few seconds of switching on, and this should prompt the Radio Gateway Service to start its connection process. If your hand is around the antenna then this first transmission may be lost. In this case (or if the receiver does not catch this first transmission for some other reason) the Radio Gateway Service will start connecting on the next logging interval.

9.4 Distance Order

Power up the remaining loggers, starting with those closest to the receiver – this order will minimise the time necessary for them all to connect.

In most cases these loggers should establish a preliminary place in the mesh and connect within a few minutes, otherwise the full meshing process will allow them to connect after 30 minutes.

9.5 Don't Rush It

If one logger is not working it may be tempting to move it a little. Then move it again. Then reboot it. And it is still not working so maybe you move it again.

Then you give up and go for lunch, and find it is working when you return.

It does take time to establish the mesh network, and moving its location may increase the time taken for the meshing to stabilise. Some patience is necessary.

9.6 Transplanting the Network to a New Location

Some additional steps are appropriate if you are moving an entire mesh network system to a new location to minimise your setup time.

Set the logging interval on all loggers to 2 minutes. Fast enough to prompt them to connect quickly, but not so quick that any delay in connecting will cause them to fill up their memory with data which would then need to be downloaded.

Clear the logger's memory. Note that this will erase any readings already taken. This ensures that the Radio Gateway Service will not need to transfer all historic data during the installation at the new location.

10   Troubleshooting

10.1   Tinytag Explorer Status Bar Indicator Flashes Red

The connection between Tinytag Explorer and the Radio Gateway Service has been broken. Click on the Status Bar and press the Connect button. This may be either a computer network connection or a software connection within the same computer.

If it cannot connect, then the Radio Gateway Service has a problem. If the Gateway Service is running on a different computer then maybe that computer is turned off. If it is running on the same computer then maybe the service has not started.

Note that this indicator shows Connected as soon as Tinytag Explorer has connected to the Radio Gateway Service. This does not indicate that the Gateway Service has connected to its receiver (via USB) or any loggers (via radio).

10.2   Firewall Configuration

Tinytag Explorer needs to be able to communicate with the Radio Gateway Server. They connect using TCP and UDP which allows them to run on different computers.

This connection will be under the control of any firewall running on these computers.

The Tinytag Explorer installer automatically configures the windows firewall to allow this connection, so most likely no action is necessary.

Any third party firewall will need to be configured to permit the following connections:

UDP port 3927:   For autodetection

TCP port 3927:   For all other communications

11   Data Logging

11.1   No stopping

Tinytag radio data loggers will start logging as soon as they are switched on. They do not need to be 'launched'. It is possible to adjust any configuration option (logging interval, channels, etc) without stopping the logging process.

11.2   Time zones

Radio data loggers store a timestamp with every measurement. This timestamp is traceable to GMT.

Note that Tinytag Explorer will display this timestamp in your local time zone. This means that timestamps displayed on the graph or readings view will be different for users in different time zones, or will change when users move in and out of daylight savings time.

Timestamps are not affected in any way by the time zone of the user who installed or configured the data logger.

11.3   Current Readings

Current Readings are updated every few seconds. The update interval will be extended when viewing current readings from multiple devices (or if multiple users are viewing current readings simultaneously). Note that extensive use of this feature may affect battery life due to the extra radio activity.

12 Other Radio Gateway Functions

12.1 Modbus

The Radio Gateway Service is a windows service which runs 24/7 to collate data from radio loggers.

This data is made available to other software – primarily to Tinytag Explorer, but also to other software through various protocols.

The Radio Gateway Service provides a standard modbus-over-TCP interface, providing read-only access to data logger configuration and instantaneous measurements (instantaneous measurement means the last received logged measurement).

Modbus may be a convenient option for software which uses Tinytag data loggers as part of an industrial process control or SCADA system.

For more details about Modbus, see Section 13.

12.2 Data Export

Radio Loggers transmit measurements and other information to a single Radio Receiver device using radio. The Receiver relays this information over a USB cable where it is collected by the Radio Gateway Service.

The Radio Gateway Service provides access to historic logged measurements for third party software by downloading CSV files over http. There is one CSV file per logger. The URLs are listed on the Radio Gateway Server's pages.

The content of these downloads is a snapshot of the data, generated on demand when the download is requested. The following example was downloaded from http://hostname:3927/Exports/all_readings/8000455.csv
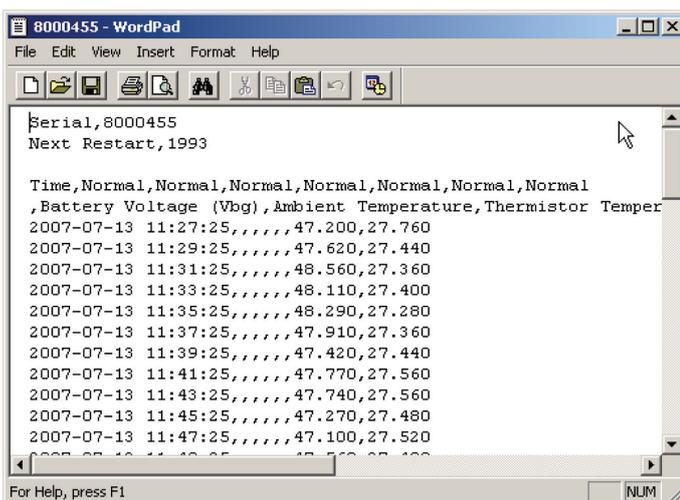
The first few lines of this file is a header which consists of:

- Various properties, name and value in the first two columns, for example 'Serial' and 'Next Restart'.

- A blank line.

- Two rows of titles for measurement columns. For example "Maximum" and "Temperature". For loggers that do not support maximum and minimum readings, this row will contain "Normal" rather than "Maximum".

Measurements are in the subsequent rows after the header.

The first column contains the time stamps. Timestamps always use GMT time, and are written in ISO format (yyyy-mm-dd hh:mm:ss). The second and subsequent columns contain measurements in SI units.

- Measurements listed in time order.

- If there is a gap because of a communications delay then measurements will be held back until the Radio Gateway Service has been able to fill the gap in. (i.e. guaranteed to preserve time order)

- Multiple users can access the CSV data without interfering with each other.

In rare cases it is possible that one 'row' of measurements is split between consecutive transfers. The last line of one transfer will contain half of the expected measurements. The first line of the next will contain the same timestamp, and the other half of the measurements. This will happen if the transfer is started part way through the Radio Gateway Service receiving measurements from the logger.

To access these files, first click 'Radio Gateway Status: Connected' in the bottom right hand corner of Tinytag Explorer. The pop-up box that appears should say 'Connection Established to Radio Gateway Server'. Clicking on Radio Gateway Server will take you to the Radio Gateway Server's pages.

The 'Exports' tab at the top of the page shows all files available to download. In the left hand column ('raw data') the data can be downloaded to view in Tinytag Explorer. The right hand column will download the data in CSV format. Each file is identified by the loggers' serial number.

The CSV files linked from the Exports page will always download every measurement, which is inefficient and cumbersome for systems which need to keep up to date by tracking new measurements as they arrive. In order to download only new measurements it is necessary for a custom software solution to keep track of the Next Restart value from its previous download, and add this to the URL which is downloaded. For example, the measurements received after the snapshot shown above can be downloaded from http://hostname:3927/Exports/all_readings/8000455.csv?restart=1993

Note that this URL – ending in ?restart=1993 – does not appear anywhere in the Radio Gateway Service web pages. It must be generated by the software solution which wants to perform incremental transfers.

12.3   Proprietary Radio Gateway Service Protocol

The Radio Gateway Service supports a simple text-based proprietary network protocol which provides read-write access to logger configuration. This is the protocol used by Tinytag Explorer to access the Radio Gateway Service.

13 Modbus

13.1 Properties and Registers

The modbus protocol provides read/write access to numbered 16-bit registers. The radio loggers natively use numbered properties which are somewhat similar to modbus registers.

The Radio Gateway Service automatically translates between these two systems. The translation primarily involves changing data types. Modbus registers are always 16-bit integers, while radio logger properties have high-level data types. For example, the logger description is a length limited string. Logging interval is a 32-bit integer.

This property-to-register mapping is generated automatically. Different types of device have different properties; therefore they may have different registers too.

13.2 Devices

The web view in the Radio Gateway Service site includes a Devices tab which contains an index of all devices currently or recently connected to the Radio Gateway Service, with links to a page showing detail for each individual device. Near the top of these device detail pages is a link labelled Modbus Registers which links to a page showing:

- Which logger properties are exposed as Modbus registers

- Which Modbus address is used for each property

- How many Modbus registers are used for each property. For example, 32-bit properties will be spread over two 16-bit registers.

13.3 Expected Values

The Modbus tab on the Radio Gateway Service web view shows the current value of every register on every device.

The Properties tab shows the equivalent in high-level data types.

13.4 Unit Identifiers

The Modbus protocol supports up to 254 devices, identified by a unit identifier. Unit identifiers are automatically assigned to device serial numbers.

The unit identifier of each device is shown on the Modbus tab page of the Radio Gateway Service web view. These values are stored under the Tinytag Explorer program files, in json format, in the file:

\Program Files\Tinytag\Tinytag Explorer\var\storage\units.db

It is possible to manually adjust the assignment of unit identifiers to serial numbers by stopping the Radio Gateway Service, editing this file, and restarting.

It is also possible to clear the current assignments by stopping the Radio Gateway Service, deleting this file, and restarting. This may be necessary at sites where more than 254 devices have been used and decommissioned, because the unit identifiers will remain reserved for the decommissioned devices.

13.5 Function Codes

The Radio Gateway Service supports only Modbus function code 0x03: Read Holding Registers.

13.6 32-bit Values

All values wider than 16 bits are mapped onto multiple 16 bit registers.

The request packet for function code 0x03 (Read Holding Registers) includes a byte containing the "quantity of registers" to be read. This is interpreted as the number of 16-bit words which should be transferred.

For example, when requesting the 32-bit value starting at address 50688, this "quantity of registers" byte should contain the value 2. The response will contain the content of two registers: four bytes.

13.7 Freshness

Most registers have a corresponding register containing the number of seconds since the property was refreshed from the device. Some properties are refreshed daily, others are never refreshed. Properties containing 'current measurements' are updated every time a measurement is received from the device.

These registers will contain the value 0xFFFF if some error occurred in processing that property. The maximum normal value (for example, if the property was refreshed more than 65535 seconds ago) is 0xFFFE.

13.8 Device Connection

No Modbus interaction is possible until a device is fully connected. That is, when the device leaves the Connecting group in Tinytag Explorer's Radio Navigator pane, and the device detail page in the Radio Gateway Service site shows its state as HAPPY.

It is not possible to read any registers from a device which is not yet fully connected. The Radio Gateway Service will return an Illegal Data Address error code.

At this point, the Current Readings registers may not yet have been refreshed, and will all contain 0xFFFF. For the floating point registers, this corresponds to NaN. These registers will be refreshed when the first measurement is received, at the next logging interval.

13.9   Missing Properties

The Radio Gateway Service will return an Illegal Data Address error code if the requested property has not been fetched, or is missing from the device. This should not happen under normal circumstances, but may occur if:

- Requesting a register corresponding to a diagnostic/debugging property, and the Radio Gateway Service is not in a diagnostic mode.

- The device does not contain an expected property. The device's characteristics are inconsistent with its driver in the Radio Gateway Service. This may happen if using prototype devices, or a pre-release version of the Radio Gateway Service.

- The device detail page can be used to confirm exactly which properties have been received by the Radio Gateway Service.

13.10 Concurrent Connections

The Radio Gateway Service enforces a limit of no more than 4 concurrent modbus TCP connections.

There is no additional limit to concurrent modbus transactions.

TCP connections are closed after being idle for 10 seconds.

13.11 Modsak

Modsak is a third party modbus diagnostic tool, available at: http://www.wingpath.co.uk/modbus/modsak.php. Gemini Data Loggers is a user of Modsak, but does not endorse or support this product.

The device detail page in the Radio Gateway Service site contains a download link for a Modsak configuration file. When opened, this configures Modsak to show most registers from that device, and, when you press the Start button, it continuously polls for new values.

Note that Modsak can not format modbus registers as text strings; therefore these registers are omitted from the download Modsak configuration line.

Also note that Modsak does not distinguish signed and unsigned values: all numbers are formatted as signed in Modsak, which may or may not be correct.

14   Power

14.1   Batteries

Radio data loggers and receivers are provided with alkaline batteries which are widely available and cheap to replace.

If a longer battery life or a wider temperature operating range is required, lithium battery versions of the Plus Radio products can be supplied (due to transportation regulations, lithium battery powered loggers will be supplied to overseas customers without batteries).

Loggers and receivers using alkaline batteries require two batteries. Devices using lithium batteries require one battery.

Mains powered radio loggers are also available.

Mains powered Ultra Radio loggers should only be used with the ACS-0005 power supply; Plus Radio loggers should only be used with the ACS-0044 power supply.

14.2   Low Power Warnings

Tinytag Explorer displays a low battery flashing icon in its navigator pane for devices where the battery voltage is below a critical threshold.

Battery voltage is heavily temperature dependent. When the battery begins to be flat, it is quite likely that the warning may show during a cold night and them clear during the day as the temperature rises, and this will continue for several weeks before the low battery indicator remains on.

Low battery warnings are not indicated using the same email/SMS system as alarms (because you would not want to be woken up in the night with a text message saying that the batteries need to be changed sometime in the next week.)
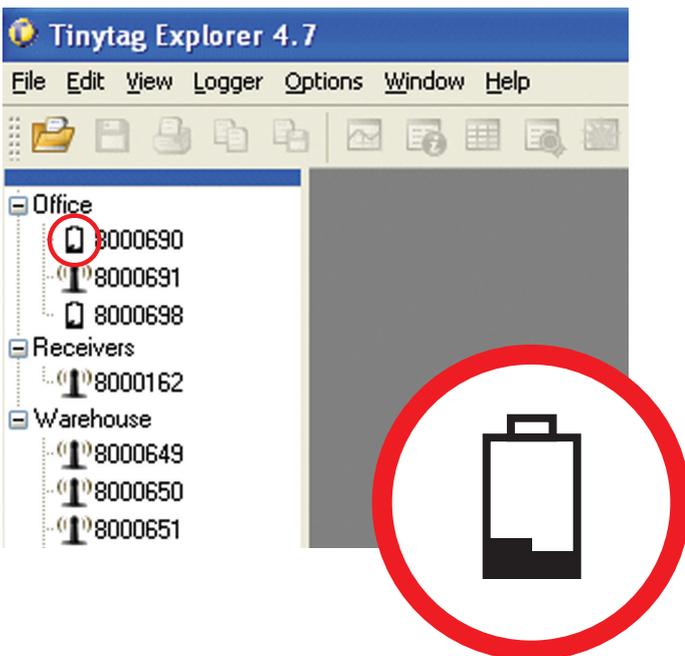
14.3   The Effect of the Mesh Network

A common assumption is that loggers which are acting as repeaters in the mesh will drain their batteries faster than those that do not. This is false.

The effect on battery life of the mesh network primarily depends on the number of radio messages that a logger will hear. Battery life will be slightly shorter in:

1. Networks with many devices.

2. Networks carrying data with a fast logging interval.

3. In networks spread over a large area, devices near the receiver. (In smaller networks, all devices are near the receiver).

Interference from other devices using a close frequency may also have an impact on battery life.

Low Battery Warning

15   Regulatory Compliance

For the specific standards our radio products comply with, please see individual product data sheets.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

Notes

Tinytag

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DATA LOGGERS