THE QUEEN'S AWARDS
FOR ENTERPRISE
2009

T24 Technical Manual

Programming guide & advanced documentation

User Manual
www.mantracourt.co.uk

mantracourt

Wireless Telemetry Range 2.4Ghz

Introduction / Overview

This manual contains advanced information on T24 telemetry range of devices. This includes more detailed information than supplied in the device manuals and also programming information.

To communicate with T24 devices a base station is required. Base stations will offer RS232, RS485 and USB interfaces.
Refer to the Base Station section **T24-BSi and T24-BSU** for details on connections and interfacing.

2.4GHz Radio General

Communicating with T24 Devices

To communicate with T24 devices a base station is required. Base stations offer RS232, RS485 and USB interfaces. In this section we will describe the interfaces and how data shall be sent to and retrieved from other T24 devices via the base station.
For details regarding device specific communications you will need to refer to the appropriate device section of the manual.

Packet Types

There are several different packet types which are used depending on the type of data carried.
Read and Write packets are used to communicate with a device (When it is awake) and can read or write parameter values.
Some devices transmit data at regular intervals and this data does not need requesting.
Woken packets are received when a device is successfully woken.

Packet Structure

All packets conform to the following structure. The Data Packet part changes depending on what packet is being transported.

****Length**	****Length**	**Base Address**	**Packet Type**	**Data Packet Structure**	***CRC1 LSB**	***CRC2 MSB**
1 Byte	1 Byte	1 Byte	1 Byte	Variable Bytes	1 Byte	1 Byte
* CRC calculated on this part						
			** Length refers to this section			

This **Transport Packet** is used to carry the **Data Packets** into and out of the target device via the base station.

Where:

- Length bytes are identical and contain the length of just the **Data Packet** section.
- The CRC bytes are CRC 16 values of all bytes from Length up to and including Data section.
- Base Address is the address of the base station used where multiple base stations are deployed. Base station addresses can range from 1 to 16 and is set by DIP switches on the base station. **NOTE:** The T24-BSU is fixed at address 1.
- The Packet Type byte defines the packet type thus defining the Data Packet Structure. In received packets this byte also indicates Error, Low Battery and Broadcast status.

Handling Base Station Data

The packets arriving at the base station serial or USB port are not handshaken. Data may arrive as a partial packet or many packets may arrive together. Therefore the recommended best practice to handle data is to place arriving data into a circular buffer and to detect the packets from this buffer by looking for a length byte pair. Then look forward in the buffer at the CRC position (if the buffer contains enough bytes) and check whether the CRC is valid. If so you can extract and use the packet. If not then advance the start of the circular buffer until you find a matching byte pair then check for a valid CRC again.

CRC

The CRC algorithm is identical to that used in Modbus communications and should be calculated for outgoing packets and checked on incoming packets. The following BASIC example is of a function that will calculate the CRC of a string and append the two CRC bytes to the end of the string

```
SUB GenerateCRC16(sTarget AS STRING)
```

```
    'reads from buffer
    DIM CRC AS LONG
    DIM LSB AS INTEGER
    DIM C AS LONG
    DIM D AS INTEGER
    DIM Res(1) AS BYTE
    CRC = 65535
    FOR C = 1 TO LEN(sTarget)
        'xor byte
        CRC = CRC XOR ASC(MID$(sTarget, C, 1))
        FOR D = 1 TO 8
            'get lsb
            LSB = (CRC AND 1) = 1
            'move right
            CRC = INT(CRC / 2)
            'if LSB was 1 xor with polynomial
            IF LSB THEN CRC = CRC XOR (&HA001&)
        NEXT D
    NEXT C
    sTarget = sTarget & CHR$((CRC AND 255))
    sTarget = sTarget & CHR$(INT(CRC / 256))
END SUB
```

Packet Type Byte

The Packet Type bytes indicates the type of packet and holds information regarding Error, Low Battery and Broadcast status of received packets.

bit7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0
Error	LoBatt	Broadcast		Packet Type			
0	0	0	0	0	0	0	0

Bit	Function
Error	Bit indicated an error is present. This is set and reset by the device which will include this information in the packet sent to the module.
LoBatt	Bit indicated a low battery. This is set and reset by the device which will include this information in the packet sent to the module.
Broadcast	Used to indicate that a routed packet was broadcast so the receiver knows not to respond.

Value	Type	Description
3	Data Provider	Used to provide unrequested data.
5	Read	Read data from a specific device.
6	Write/command	Write a value or execute a command to a specific device
7	Response ACK	Response - Acknowledged. May also contain data.
8	Response NAK	Response - Not Acknowledged. The command was not recognised.
9	Response Timeout	Response Timed out. A response was not received by the device.
10	Response Data Invalid	Response - Data invalid. The device has reported that the data in a Write was invalid or out of range.

Data Packet Structures

The following structures show how the data is defined within the Data Packet Structure of the overall packet.

Data Provider

These packets are sent at intervals by some devices and contain data. There is no need to request these packets as they arrive automatically. If you have multiple base stations and these are within the range of the transmitting device the packets will arrive from each base station.

Packet Type	Data Tag		Status	Data Type	Data	RSSI	CV
03	00	00	00	00	[...]	00	00

Packet Type

This is 0x3 hex (3 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

Data Tag

Every device that transmits **Data Provider** packets has a configurable 2 byte **Data Tag**. Devices that consume Data Provider Packets can be configured to look for specific Data Tags. The reason we use Data Tags and not just rely on a devices ID for identification is that in a working system multiple devices may be relying on data from a single device. If that device were ever replaced then its unique ID would change and therefore multiple devices would have to be reconfigured. By using a Data Tag we only need to change this tag on the replacement device and the rest of the system will work as required.

Status

The bit values in this byte are used to indicate certain things. Only two bits are allocated a global meaning. The rest are device specific and you will need to refer to the device manual for clarification.

Status Byte							
bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit0
X	X	X	X	X	X	Integrity	Shunt Cal

Data Type

This byte defines how the data is formatted in this packet and also indicates the best way to represent the data.

Function	Display As				Data Type		
Bit	7	6	5	4	3	2	1	0
Sample	0	1	1	1	1	0	0	1

Display As	Type	Description
0	Undefined	
1	Numeric	Numeric representation based on Data Type
2	Boolean	The data may be in any format but represents a boolean result where non zero numeric is True and string length > 1 or > 0 is True
3	Text	Can display as ascii text
4	Binary (unprintable)	Unprintable characters
5	Hex	Best represented as hex
6	Bit Map (10110101)	Each bit value should be shown
7	Percent	Numeric or string value has a value 0 - 100

Data Type	Description	Size In Bytes
0	No content/unknown	0
1	UINT8	1
2	UINT16	2
3	INT32	4
4	Float	4
5	String	0-64
6	Binary	0-64

NOTE: See **Data Type Formats** in **Appendix A**

The Display As bits should be used where possible as this can help in presenting the data for display purposes.

Data

This will be of variable length and will depend on the data type.

RSSI

This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A**.

CV

This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**.

See Advanced Data Provider Interface in

Read

The read packets are used to read parameters from a remote device or the base station itself. To talk to the base station just use the base station ID.

Packet Type	To ID			Command
05	00	00	00	00

Packet Type

This is 0x5 hex (5 decimal).

To ID

This is the ID of the device to read from (MSB first).

Command

The command number of the parameter you want to read. You will need to refer to the device manual for this information.

Write

The write packet is used to write parameter values to a device or execute commands.
You can write any supported data format to any other data format parameter but some formats are not very suitable. i.e. You can write an INT32 formatted value to a parameter that is just a UINT8 but if the value exceeds either the target data type limits or any other bounded limits imposed by the device you will receive an INVALID_DATA response.
When executing a command you do not need any data so it is usual to specify the data type as No Content (zero) and not include any data.

Packet Type	To ID			Command	Data Type	Data
06	00	00	00	00	00	[...]

Packet Type

This is 0x6 hex (6 decimal).

To ID

This is the ID of the device to write to from (MSB first). You can use the broadcast ID here of 0xFFFFFF (255 decimal for each of the To ID bytes) but be careful as this will write the value to all devices on the same channel and encryption key. You may have mixed device types so command numbers between devices may be different. Use broadcast with care.

Command

The command number of the parameter you want to write to. You will need to refer to the device manual for this information.

Data Type

Specify the data type of the data you are sending.
Data types are as follows:

Data Type	Description	Size In Bytes
0	No content/unknown	0
1	UINT8	1
2	UINT16	2
3	INT32	4
4	Float	4

5	String	0-64
6	Binary	0-64

NOTE: See **Data Type Formats** in **Appendix A**

Responses to Read and Write…

The response to either a read or write can be as follows:
Responses to Read: ACK, NAK, TIMEOUT
Responses to Write: ACK, NAK, TIMEOUT, DATAINVALID

ACK

If the ACK response is for a write then it will not contain data:

Packet Type	From ID			RSSI	CV
07	00	00	00	00	00

Packet Type

This is 0x7 hex (7 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

From ID

This contains the ID of the device that sent the packet.

RSSI

This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A.**

CV

This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**

If the ACK is in response to a READ then it will contain data:

Packet Type	From ID			Data Type	Data	RSSI	CV
07	00	00	00	00	[…]	00	00

Packet Type

This is 0x7 hex (7 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

From ID

This contains the ID of the device that sent the packet.

Data Type

This byte defines how the data is formatted in this packet and also indicates the best way to represent the data.

Function	Display As				Data Type		
Bit	7	6	5	4	3	2	1	0
Sample	0	1	1	1	1	0	0	1

Display As	Type	Description
0	Undefined	
1	Numeric	Numeric representation based on Data Type
2	Boolean	The data may be in any format but represents a boolean result where non zero numeric is True and string length > 1 or > 0 is True
3	Text	Can display as ASCII text
4	Binary (unprintable)	Unprintable characters
5	Hex	Best represented as hex
6	Bit Map (10110101)	Each bit value should be shown
7	Percent	Numeric or string value has a value 0 - 100

Data Type	Description	Size In Bytes
0	No content/unknown	0
1	UINT8	1
2	UINT16	2
3	INT32	4
4	Float	4
5	String	0-64
6	Binary	0-64

NOTE: See **Data Type Formats** in **Appendix A**

RSSI

This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A**.

CV

This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**

NAK

This packet is returned if the device receiving the read or write does not recognize the command number.

Packet Type	From ID			RSSI	CV
08	00	00	00	00	00

Packet Type

This is 0x8 hex (8 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

From ID

This contains the ID of the device that sent the packet.

RSSI

This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A**.

CV

This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**

TIMEOUT

This packet is returned if the device does not respond.

Packet Type	From ID			RSSI	CV
09	00	00	00	00	00

Packet Type

This is 0x9 hex (9 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

From ID

This contains the ID of the device that sent the packet.

RSSI

This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A**.
Note: Some versions of modules may not send the RSSI and CV bytes.

CV

This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**
Note: Some versions of modules may not send RSSI and CV bytes.

DATA INVALID

This packet is returned if the device has been written to and the data written is invalid.

Packet Type	From ID			RSSI	CV
0A	00	00	00	00	00

Packet Type

This is 0xA hex (10 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

From ID

This contains the ID of the device that sent the packet.

RSSI

This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A**.

CV

This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**

Pairing…

Pairing is a method of communicating between two devices so that they configure themselves to one or another's radio settings and enables them to identify each other by means of ID and default Data Tag.
Additionally the pairing mechanism can pause a device from performing its default behaviour as some devices operate in a low power mode where they are mostly asleep. This makes communications impossible so the pairing process stops the low power behaviour.
The pairing process is usually initiated by one device (a handheld for example or PC software using a base station) and this enters pairing master mode and is ready to pair for a user defined time period.

Next the other device is put into its pair mode at which time it negotiates with the other device and they will decide on what to do based on their function. Devices are normally put into pair mode by power cycling them. Please refer to the device documentation.

For the scope of this document we are concerned with manually controlling the pairing using a base station. You would use pairing for the following reasons:

- You have a device whose communications settings are unknown.
- You want to connect to a device that operates in low power mode and is mostly asleep.
- The device you want to talk to may have a normal operational function that you want pausing while you configure it.
- You just want to change the communications settings of a device to match it to a base station settings.

Pair Request

Packet Type	Data Tag		Direction	Config	Duration (optional)
13	00	00	00	00	00

Packet Type

This is 0x13 hex (19 decimal).

Data Tag

You need to supply a Data Tag which may be useable by the device to which you are pairing. Usually from a base station this is not required and can be set to 0x00, 0x00.
This is present as the same mechanism is used when two devices pair together and in that case they will each want to give the other their default Data Tag.

Direction

The value of this byte determines whether the remote device radio settings are configured to match the base station or if the base station is changed to match the remote device. Both the Channel and the encryption key are matched once pairing has completed.

Value	Meaning
0	The settings in the remote device are changed to match the base station settings.
1	The base station settings are changed to match the remote device.

Config

The value of this byte determines whether the remote device will enter configuration mode which will inhibit any low power operation, transmission of data provider packets and the ability to enter deep sleep mode. This mode is required otherwise communication whilst configuring could be very poor or impossible.

Value	Meaning
0	Do not change operation.
1	Cause the device to enter config mode to enable it to be configured.

NOTE: after pairing with a device and using the **Config** option it is recommended that the device be power cycled after so that it resumes its normal operation.

.

Duration

The value of this byte determines whether the base station will be in pair mode for the default time of 5 seconds or whether to use the user defined duration in seconds.
To use the default just omit this byte. If this byte is present its ASCII value will be used to determine how long it will be in pairing mode.

NOTE: While in pairing mode the base station will not operate as normal.

If the remote device enters its own pair mode (non master) then the communications negotiations will take place and the device may come out of any low power modes and a response will be sent to the base station.

Pair Response
This packet will arrive at the base station if another device enters pair mode while the base station is waiting to pair. Once this packet has arrived the base station will be free to talk to the device. It can also determine the device ID and Default Data Tag if it needs this information.

Packet Type	From ID			Data Tag		RSSI	CV
14	00	00	00	00	00	00	00

Packet Type
This is 0x14 hex (20 decimal) and may have higher bits set which indicate Error, Low Battery and Broadcast.

From ID
This contains the ID of the device that paired.

Data Tag
This contains the default Data Tag of the paired device.

RSSI
This indicates the signal strength that this packet was received at. See **RSSI & CV** in **Appendix A**.

CV
This indicates correlation value which equates to the quality of the signal when this packet was received. See **RSSI & CV** in **Appendix A**

NOTE: After configuration or calibration you should power cycle the paired device to return it to normal operation.

T24-BSi and T24-BSu [Base Station]

Overview

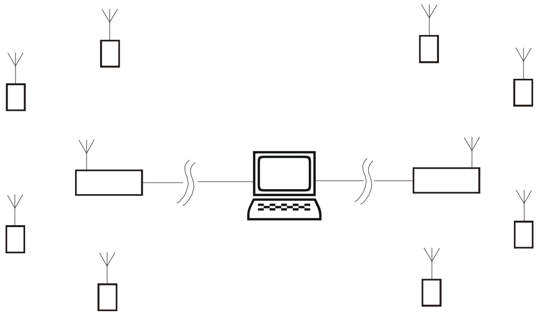
These devices are base stations and interface between the radio and a physical interface for a connection to a PC, PLC or other device.

Addressing

Usually only a single base station is required in a telemetry installation. If a telemetry device is outside the range of the base station a repeater may be deployed.
Some complex topologies may only be realized by using multiple base stations which may require changes to the **Address** switches. See Multipoint Base Station Section.

Multipoint Base Stations

Sometimes more than one base station is required in a system. This may simply be a central PC with two base stations wired off in opposite directions.



Where one base station handles devices on the left and the other those on the right.
Multiple base stations allow flexibility in routing requests from a PC as each time a packet is sent to a base station it is targeted to a particular base station **Address**. When a packet arrives back at a PC it contains the **Address** of the base station that routed it.
If a base station is the only one connected to a particular serial port then every base station can have **Address** 1 as the PC will send packets to a particular port to select which base station handles a packet, likewise packets arriving back at the PC will be identified by the port that they arrive on.
RS232 devices can only be connected one at time anyway but RS485 allows multiple devices on the same bus. This is where the **Addressing** is vital as it is this that distinguishes between base stations.
When using USB base stations you may only ever have one T24-BSu connected to a PC at any time. Using T24-BSi will allow multiple USB base stations to be connected to single PC. Unique **Addresses** are again required in this instance.

Note that broadcast packets can be received by multiple base stations so packets may appear duplicated at the PC end.
It is also possible for the PC to route a packet through all connected base stations by **Addressing** a packet to Address 0.

NOTE: Although it is possible to connect multiple USB base stations to a PC the **T24drv.dll** driver supplied by Mantracourt only supports one Base Station **Addressed** as 1.
So when using a T24-BSi which supports USB but also has a DIP switch to allow **Address** setting the **Address** must be set to 1. The T24-BSu devices are manufactured with a fixed **Address** of 1.

Connection

The interface can be selected from the DIP switches SW1 as can baudrates for serial interfaces and the Address of the base station.

SW1 Settings (T24-BSi only)

Switch positions 1 to 4 select the base station **Address**. This should normally be 1.

	1	2	3	4
Address				
1	Off	Off	Off	Off
2	On	Off	Off	Off
3	Off	On	Off	Off
4	On	On	Off	Off
5	Off	Off	On	Off
6	On	Off	On	Off
7	Off	On	On	Off
8	On	On	On	Off
9	Off	Off	Off	On
10	On	Off	Off	On
11	Off	On	Off	On
12	On	On	Off	On
13	Off	Off	On	On
14	On	Off	On	On
15	Off	On	On	On
16	On	On	On	On

Switch positions 5 to 7 set whether serial or USB is used. If USB is not selected then the chosen switch settings control the baudrate for the serial interface. Whether the serial interface is RS485 or RS232 is selected by switch position 8.

	5	6	7
Baudrate / USB			
USB	Off	Off	Off
9600	On	Off	Off
19200	Off	On	Off
38400	On	On	Off
57600	Off	Off	On
115200	On	Off	On
230400	Off	On	On
460800	On	On	On

NOTE:

A baudrate of 9600 (and in some cases 19200) is not suitable for 2 way communication with remote devices as it is too slow and causes timeouts. This baudrate has been included to enable the base station to be connected to a 9600 baud device to allow low rate Data Provider packets to be received.

At any rate below 230400 is may be possible to lose packets at high data rates as the serial cannot keep pace with the radio transmissions.

If USB is not selected as the interface (Switch positions 5 to 7) then this switch position selects whether the serial interface is RS232 or RS485.

	8
232/485	
RS232	Off
RS485	On

Interfaces

RS232

The RS232 interface uses TX, RX and GND to connect to a PC, PLC etc and uses standard RS232 voltage levels.

Handshaking	None
Data Size	8 bits
Stop Bits	1 bit
Parity	None

The baudrate can be selected by setting the DIP switches stated above. NOTE: the base station will require power cycling to utilise a baudrate change.

Example connection to a PC 9 way D serial connector.

PC 9 Way D Plug Pin	Signal Direction	Base Station Connection	
3 (TX)	->	RX	J6 Pin 2 or J7 Pin 3
2 (RX)	<-	TX	J6 Pin 3 or J7 Pin 2
5 (Gnd)		GND	J6 Pin 4 or J7 Pin 5
8 (CTS)	<-	CTS	J6 Pin 1 or J7 Pin 8

RS485

The RS485 interface (This is a 2 wire 485 interface and will not work with 4 wire 485 buses) uses TX, RX and GND to connect to a PC, PLC etc and uses standard RS485 voltage levels.

Handshaking	None
Data Size	8 bits
Stop Bits	1 bit
Parity	None

The baudrate can be selected by setting the DIP switches stated above. NOTE: the base station will require power cycling to utilise a baudrate change.

Example connection

Depending on the RS485 interface or hardware the connections vary and are not standard therefore we can only show the connections to the base station. You must refer to the user manual regarding your RS485 connection to ascertain the correct connections.

PC / PLC Connection	Signal Direction	Base Station Connection	
Refer to RS485 Device User Manual		A	J4 Pin 3 or J5 Pin 3
Refer to RS485 Device User Manual		B	J4 Pin 4 or J5 Pin 4
Refer to RS485 Device User Manual		GND	J4 Pin 5 or J5 Pin 5

NOTE: There are two connectors for RS485, J4 and J5. This is to facilitate easy daisy chaining of devices if required.

Serial Limitations

- When using RS232 or RS485 you should use the fastest baudrate possible. At lower rates data can be lost because it can arrive from the radio faster than the base station can send it serially.
- At 9600 baud you will experience communications problems when configuring devices. This baudrate is too slow for anything other than monitoring data provider packets from devices and even then these should be at a low rate (around 20 per second). The slow baudrates are provided to get low rate data into older systems.
- RS485 is a bus master system and is not ideally suited to full communications with devices when multiple devices are providing data. This is fine for the normal operation of data acquisition but it is recommended that only the device to be configured is active during configuration.

USB

Connection to the base station will be either a captive USB cable (T24-BSu) or a USB socket B for connection using a standard USB A-B cable (T24-BSi). There is an optional cable assembly for the T24-BSi to provide for a USB connection while the device is still fitted to the ABS case.
To communicate with the base station the connected device must use the USB HID Device Class and support USB 2.0 full speed interface (12mbits).
The USB connection will also power the base station.

USB Communications

Using the Mantracourt **T24drv.dll** driver is the easiest way to communicate with the base station. However, if you want to write your own communications software you will need the following information:
Vendor ID: 6017 (0x1781 hex)
Product ID: 2980 (0xBA4 hex)
Incoming packets are read from report 0 and contain 64 bytes of data. There will always be 64 bytes of even if there is only a few bytes of valid data. These bytes will need placing into a buffer and your software will need to detect and extract complete packets.
Outgoing data is written to report 0 and must always contain 64 bytes of data. Any unused bytes should be set to zero.
Please note that 65 bytes of data are actually sent and received but the first byte indicates the report number so this is always zero.

Parameter	Value
Vendor ID	0x1781 (6017 decimal)
Product ID	0xBA4 (2980 decimal)
Setup Class	HIDClass
Service Name	HidUsb

Parameter	Value
Connection Information	
ConnectionIndex	0x1
CurrentConfigurationValue	0x1
LowSpeed	FALSE
DeviceIsHub	FALSE
DeviceAddress	0x1
NumberOfOpenPipes	0x2
Pipe #0 Endpoint Descriptor	
bLength	0x7
bEndpointAddress	0x1 [OUT]
bmAttributes	0x3 (USB_ENDPOINT_TYPE_INTERRUPT)
wMaxPacketSize	0x40
bInterval	0x1
Pipe #1 Endpoint Descriptor	
bLength	0x7
bEndpointAddress	0x82 [IN]
bmAttributes	0x3 (USB_ENDPOINT_TYPE_INTERRUPT)
wMaxPacketSize	0x40
bInterval	0x1
Device Descriptor	
bLength	0x12
bcdUSB	0x110
bDeviceClass	0x0
bDeviceSubClass	0x0
bDeviceProtocol	0x0
bMaxPacketSize0	0x8
idVendor	0x1781
idProduct	0xBA4
bcdDevice	0x100
iManufacturer	0x1
iProduct	0x2
iSerialNumber	0x3
bNumConfigurations	0x1

Parameter	Value
Configuration Descriptor	
bLength	0x9
bDescriptorType	USB_CONFIGURATION_DESCRIPTOR_TYPE
wTotalLength	0x29
bNumInterfaces	0x1
iConfiguration	0x0
bmAttributes	0x80 (Bus_Powered)
MaxPower	0x64
Interface Descriptor	
bLength	0x9
bInterfaceNumber	0x0
bAlternateSetting	0x0
bNumEndpoints	0x2
bInterfaceClass	0x3 (Human Interface Device)
bInterfaceSubClass	0x0 (No Subclass)
bInterfaceProtocol	0x0 (None)
iInterface	0x0
Endpoint Descriptor	
bLength	0x7
bEndpointAddress	0x1 [OUT]
bmAttributes	0x3 (USB_ENDPOINT_TYPE_INTERRUPT)
wMaxPacketSize	0x40
bInterval	0x1
Endpoint Descriptor	
bLength	0x7
bEndpointAddress	0x82 [IN]
bmAttributes	0x3 (USB_ENDPOINT_TYPE_INTERRUPT)
wMaxPacketSize	0x40
bInterval	0x1

NOTE: If you do not want to use the Mantracourt supplied communications DLL (T24drv.dll) you may be interested in the following:
We have successfully tested EasyHID which supplies the mcHID.dll which is a great generic way of connecting to HID devices. This library is free and was written to ease both the programming of PIC devices and create sample code for VB, Delphi and Visual C++.
The USB interface has also been successfully used with Windows CE but we do not supply any drivers for this operating system.

LED Indication

Two LEDS indicate Power/Mode and Activity.
The red LED indicates mode and should flash at a 2Hz rate. If any errors are detected with the radio then the LED will remain lit.
The green LED flashes once for each packet received or transmitted via radio, USB or serial.

Communications

To configure the base station you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.
The base station may also be receiving packets from other devices. These will be Data Provider Packets and these may arrive at any time.

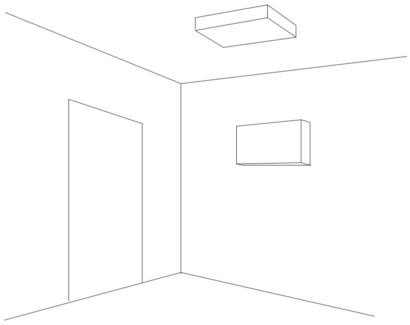
Parameter List

<table>
<tr><th>Parameter</th><th>Command Number</th><th>Description</th><th>Native Data Type</th><th>Read / Write</th></tr>
<tr><td>ID</td><td>3</td><td>Read the unique identifier ID for this device. (3 bytes)</td><td>BINARY 3 byte</td><td>R</td></tr>
<tr><td>Channel</td><td>11</td><td>The radio channel to operate on. (1-16) Requires power cycle or Reset to enable.</td><td>UINT8</td><td>RW</td></tr>
<tr><td>EncKey</td><td>15</td><td>The radio encryption key to operate on. Requires power cycle or Reset to enable. (16 bytes) Not supported in this release.</td><td>BINARY 16 bytes</td><td>RW</td></tr>
<tr><td>UseCSMA</td><td>18</td><td>Select whether to use Carrier Sense Multiple Access techniques on transmission.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>Disabled
The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED</td></tr><tr><td>1</td><td>Enabled
The Carrier Sense Multiple Access will be enabled.</td></tr></table>
See Unslotted CSMA/CA in Appendix A</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Power</td><td>12</td><td>Set or read the output power level. (0-100%)</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Name</td><td>10</td><td>Set or read a user defined name. (11 characters)</td><td>STRING 11 bytes</td><td>RW</td></tr>
<tr><td>WakerDuration</td><td>17</td><td>Set or read the duration in milliseconds to wait for a device to wake. Although WAKE commands are sent to the target device the base station actually intercepts this and handles the wake itself. Default = 12000 milliseconds.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>Save</td><td>24</td><td>Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 200mS recovery time after executing.</td><td colspan="2">Command</td></tr>
<tr><td>Reset</td><td>25</td><td>Restarts the device and utilises new channel and encryption keys if those have been changed and saved. Note after a Reset the device will be asleep.</td><td colspan="2">Command</td></tr>
</table>

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Installation

The base T24-BSi should be mounted horizontally on a wall or ceiling so that the side face containing the PCB antenna faces the general direction of the target devices.



The T24-BSu should also be positioned to present itself to the other radios in a 'landscape' aspect.

Specification

Parameter	Minimum	Typical	Maximum	Units	Notes
T24-BSi External Supply voltage Range	9	12	32	Volts	
T24-BSi, T24-BSu USB Supply Range	4.875	5	5.125	Volts	As defined by USB 2.0 Specification
Average Operational Current (T24-BSi)	-	TBD	500	mA	
USB Bus Powered Operational Current	100		200		
Operating Temperature Range	-40	-	65	Deg C	
Storage Temperature Range	-40	-	65	Deg C	
Reverse polarity Protection		-	-32	Volts	Maximum Supply level

T24-SA [Strain Acquisition]

Overview

The T24-SA is a strain acquisition module. This allows wireless remote viewing of strain gauge information using 2.4GHz radio.
The T24-SA acquires the weight information from the strain gauge and periodically transmits it. Between transmissions the device is optionally in a power saving sleep mode to conserve batteries.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

<table>
<tr><th>Parameter</th><th>Command Number</th><th>Description</th><th>Native Data Type</th><th>Read / Write</th></tr>
<tr><td>ID</td><td>3</td><td>Read the unique identifier ID for this device. (3 bytes)</td><td>BINARY 3 bytes</td><td>R</td></tr>
<tr><td>Version</td><td>53</td><td>Read the firmware version.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>Channel</td><td>11</td><td>Radio Channel</td><td>UINT8</td><td>RW</td></tr>
<tr><td>EncKey</td><td>15</td><td>The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.</td><td>BINARY 16 Bytes</td><td>RW</td></tr>
<tr><td>Power</td><td>12</td><td>Set or read the output power level. (0-100%)</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Name</td><td>10</td><td>Set or read a user defined name. (11 characters)</td><td>STRING 11 Bytes</td><td>RW</td></tr>
<tr><td>Model</td><td>51</td><td>Read the model number of the device.</td><td>STRING 11 Bytes</td><td>R</td></tr>
<tr><td>WakeChkInt</td><td>16</td><td>Set or read the interval in milliseconds that a sleeping device will wake to request a full wake from the base station. (default 3000)</td><td>UINT16</td><td>RW</td></tr>
<tr><td>UseCSMA</td><td>18</td><td>Select whether to use Carrier Sense Multiple Access techniques on transmission.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Disabled
The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED</td></tr>
<tr><td>1</td><td>Enabled
The Carrier Sense Multiple Access will be enabled.</td></tr>
</table>
See Unslotted CSMA/CA in Appendix A</td><td>UINT8</td><td>RW</td></tr>
<tr><td>BattLevel</td><td>69</td><td>The voltage measured on the battery.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>BattLowLevel</td><td>110</td><td>Set or read the battery voltage at which the low battery flag will be set in all received packets and in the Status parameter).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>LowPowerMode</td><td>75</td><td>Defines power save mode.
0 = Awake all the time and transmit at TxInterval.
1 = Sleep. Wake at TXInterval, acquire value, transmit value, sleep.</td><td>UINT8</td><td>RW</td></tr>
<tr><td>TxInterval</td><td>76</td><td>Time Interval between Transmissions. Set mS</td><td>INT32</td><td>RW</td></tr>
<tr><td>SampleTime</td><td>78</td><td>Set or read the SampleTime in milliseconds for acquiring a reading at each TxInterval interval. The larger the SampleTime the more accurate the reading but at the expense of battery life. (Default 5)</td><td>UINT16</td><td>RW</td></tr>
<tr><td>SleepDelay</td><td>77</td><td>Time period before switching to low power sleep mode if no StayAwake command or trigger received.
Setting to zero disables.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>DataTag</td><td>119</td><td>Set or read the 2 byte Data Tag that is used when transmitting the weight in a Data Provider Packet.
Note that default value is set to last 2 bytes of ID.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>NumCalPoints</td><td>79</td><td>Number of calibration points required. Range 2 to 9</td><td>UINT8</td><td>RW</td></tr>
</table>

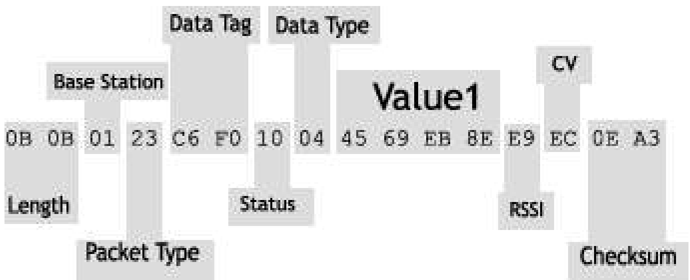
<table>
<tr><td>CalPointMVV1</td><td>80</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV2</td><td>81</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV3</td><td>82</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV4</td><td>83</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV5</td><td>84</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV6</td><td>85</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV7</td><td>86</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV8</td><td>87</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointMVV9</td><td>88</td><td>The MV/V value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain1</td><td>89</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>90</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>91</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>92</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>93</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>94</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>95</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>96</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>97</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset1</td><td>98</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset2</td><td>99</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset3</td><td>100</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset4</td><td>101</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset5</td><td>102</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset6</td><td>103</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset7</td><td>104</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset8</td><td>105</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset9</td><td>106</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value</td><td>72</td><td>Reads the calibrated weight.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>Counts</td><td>70</td><td>Raw A/D counts</td><td>INT32</td><td>R</td></tr>
<tr><td>mVV</td><td>71</td><td>Factory calibrated mV/V</td><td>FLOAT</td><td>R</td></tr>
<tr><td>DigitalOut</td><td>108</td><td>Read or set the digital output state.
<table>
<tr><th>Value</th><th>Definition</th></tr>
<tr><td>0</td><td>Turn digital output off</td></tr>
<tr><td>1</td><td>Turn digital output on</td></tr>
<tr><td>2</td><td>Make digital output mirror the LED state (V1.05 and later)</td></tr>
</table></td><td>UINT8</td><td>RW</td></tr>
<tr><td>ShuntCal</td><td>109</td><td>Read or set the shuntcal state.
<table>
<tr><th>Value</th><th>Definition</th></tr>
<tr><td>0</td><td>Turn shuntcal off</td></tr>
<tr><td>1</td><td>Turn shuntcal on</td></tr>
</table></td><td>UINT8</td><td>RW</td></tr>
<tr><td>Status</td><td>74</td><td>Live status where the bit values indicate status. The following table shows the decimal bit values and their meaning.
<table>
<tr><th>Bit Value</th><th>Definition</th></tr>
<tr><td>1</td><td>STATUS_SHUNT_CAL</td></tr>
<tr><td>2</td><td>STATUS_INPUT_INTEGRITY</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>8</td><td>Reserved</td></tr>
</table></td><td></td><td></td></tr>
</table>

		16 STATUS_POWER_UP 32 STATUS_BATT_LOW 64 STATUS_DIGITAL_INPUT 128 STATUS_DIGITAL_OUTPUT		
Reset	54	Restarts the device and utilises new channel and encryption keys if those have been changed and saved.	Command	
Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	
Wake	50	Wake the module from sleep	Command	
Sleep	56	Sends the module to Sleep	Command	
Pause	57	Stops the output streaming to allow configuration	Command	
Resume	59	Streaming continues.	Command	
StayAwake	58	No function other than to reset SleepDelay timer	Command	
SleepTrigger	120	Enter Data Tag to watch for that will trigger sleep mode	UINT16	RW
PauseTrigger	121	Enter Data Tag to watch for that will trigger pause mode	UINT16	RW
ResumeTrigger	123	Enter Data Tag to watch for that will trigger resume mode	UINT16	RW
StayAwakeTrigger	122	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW
DoSystemZeroTrigger	125	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Data Provider Format

At every TXInterval a Data Provider packet is transmitted that holds 1 value in FLOAT format (See Appendix A).



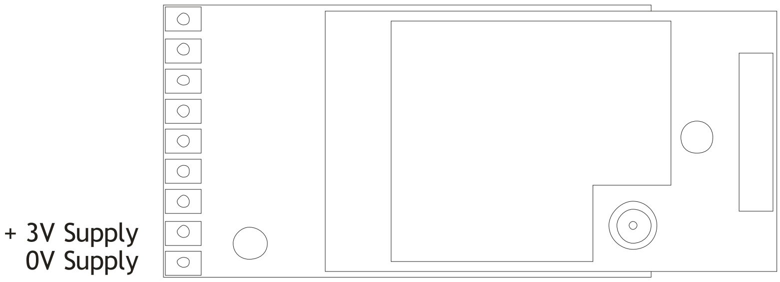
Measurement Resolution

The noise free resolution is dependant on the Sample Time (SampleTime)

SampleTime (mS)	Noise Free Resolution	Ratio
> 0	15.5 bits	1:50,000
> 9	16 bits	1:65,000
> 49	17.25 bits	1:150,000
> 99	18 bits	1:250,000
> 999	18.75 bits	1:400,000

Power Supply

Attach power supply wiring to the module as shown below:



Connect to a 3 Volt power supply or batteries.

WARNING: This module is not reverse polarity protected!

WARNING: The maximum voltage is 3.6V!

Battery Types

Battery Type	Notes
Alkaline Zn-MnO_2	Pairs of alkaline 1.5V cells are the most common. Use D cells for maximum life and AA cells where space is restricted. Example: Varta 4014 (D), Varta 4006 (AA) **Recommend T24-PSSA module** to maximise usable capacity.
Nickel Metal Hydride NiMh	Most cells are 1.2V so two in series gives 2.4 Volts. These can match alkaline batteries in capacity but as the charged voltage is lower they do not match the usable capacity. These batteries self discharge at a faster rate than alkalines. If charging these cells in circuit precautions must be taken to ensure that the maximum voltage on the T24-SA is not exceeded. Example: GP 270AAHC (AA) **Recommend T24-PSSA module** to maximise usable capacity.
Nickel Cadmium NiCad	Most cells are 1.2V so two in series gives 2.4 Volts. Three in series can be used to give 3.6 Volts. These do not have the usable capacity of an alkaline battery. These are generally only useful if they are to be charged on a regular basis. If charging these cells in circuit precautions must be taken to ensure that the maximum voltage on the T24-SA is not exceeded. Example: **Recommend T24-PSSA module to maximise usable capacity.**
Lithium Primary 3.6V Li-$SOCl_2$	Lithium cells can be used but note that the maximum voltage is 3.6 Volts. Select a cell with low internal resistance. Example: Saft LS17500 (A), Saft LSH20 (D) **Recommend T24-PSSA module** as these cells usually have a high internal resistance.
Lithium Iron Disulphide Li-FeS_2	These can be found at 1.5 Volts and can therefore be a direct replacement for Alkaline cells. The low internal resistance and high capacity make these batteries an ideal choice. Example: Energizer L91
Lithium Ion and Lithium Polymer LiON, LiPo	These generally start at 3.7V and exceed the maximum allowable voltage. These are usable if a regulator and charging circuit can be installed between the T24-SA and the battery. Care must be taken here that the regulator does not draw too much current when idle so that the low power modes are not compromised. **Recommend T24-PSSB module.**

In-line Battery Modules

Capacitor Module T24-PSSA

This is used for batteries which have an internal resistance of greater than 150mOhms overcoming voltage drops during high current phases of the low power mode cycle.

This problem becomes apparent when attempting to communicate with a T24-SA using the T24 Toolkit or power cycling when the battery is near the end of its life. In normal operation (Low power mode) with a handheld T24-HS where the T24-SA is connected to an uninterrupted battery this module is generally not required.
Using lower impedance strain gauges (or multiple parallel strain gauges) exacerbates this problem.
Consult Sales for details. Alternatively fit an electrolytic capacitor across battery of 2000uF or greater. This capacitor should be of low ESR (< 70mOhms).

Lithium Ion /Polymer Module T24-PSSB
Provides a means of charging the Lithium Ion or Polymer battery from a nominal 5V DC supply and also providing a low quiescent current 3.3V regulator to supply the T24-SA. This overcomes the max voltage limitation of the T24-SA and the higher cell voltage and charging requirements of the Lithium Ion cell.

Battery Life

Rough Guide

As a rough guide battery life of a T24-SA connected to a 1K load cell with a 5 millisecond sample time is as follows:

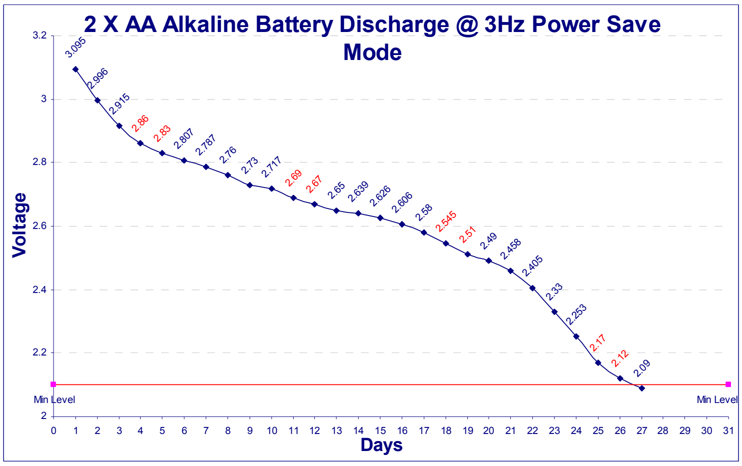
```
Years = Usable Battery Capacity
         (10 / TX per second)
```

Example of 2 X AA GP 15A with a usable capacity of 1.9Ah. The loadcell is 1K and the transmission rate is 3Hz with a 5 millisecond sample time.

```
Years =      1.9
         (10 / 0.33)

Years = 0.063 = 23.1 days
```

As can be seen below from an actual measured device on continuously this rough calculation is quite close.



It must be remembered that this calculation is for when the device is continuously on and not sent to deep sleep. So if the above device was used with a handheld and woken up 5 times a day for 5 minutes each time the total usage in a 24 hour period would be

```
5 X 5 = 25 mins = 0.416 hours
```

So we are only using a fraction of the daily 24 hours so battery life will be 24 / 0.416 times the continuously on life. i.e.

```
24 / 0.416 = 57.6
```

So

```
57.6 X 23.1 days = 1330.56 days
Or
44.3 months
Or
Over 3 and a half years.
```

Note that the above rough guide does not take into account the battery usage as the device periodically wakes from deep sleep to check whether it should wake up properly. If the device wake check interval is set to 5 seconds then we can modify the battery life from above by multiplying by a factor of 0.6 (We have only calculated the factor for a 5 second wake check interval.)

```
3.6 years X 0.6 = 2.1 years
```

Accurate Guide

The following shows how to more accurately calculate battery life. This does rely on an estimate of usable battery capacity which is not as high as manufacturers state their battery capacity to be except for batteries where the cuttoff voltage above the minimum voltage for the device.
To estimate usable capacity you will need to refer to manufacturers discharge graphs and find a curve closest to around 30mA and estimate the capacity as Amps X Time where time is the point where the battery falls below where the device would be supplied with 2.1V. This will be 1.05 in the case of 1.5V cells as we use two in series.

```
TXInterval = TXInterval Parameter / 1000
SampleTime = SampleTime Parameter/ 1000
LoadImp = Impedance of strain gauge in Ohms
HoursUsage = How many hours the device is NOT asleep in a 24 hour period
BattAH = Usable battery capacity in Amp Hours (Ah)
WakeInt = WakeChkInt parameter
FixedMeasurementCurrent = 45
```

Internally the device will adjust SampleTime if it is too long for the TXInterval so we need to take this into account for our calculations:

```
If SampleTime + 0.025 > TXInterval then we need to make SampleTime =
TXInterval - 0.025
```

Also note that we cannot use a TXInterval of less than 0.041 if we are in low power mode as this will cause unpredictable results.

Calculate measurement current

```
LoadCellCurrent = ((5000 / LoadImp) * 2)
```

If in Low Power Mode

```
'fixed block
U1 = 0.5 / TXInterval * 1
'Measurement block
U2 = (FixedMeasurementCurrent + LoadCellCurrent) / TXInterval * 0.006
'fixed block
U3 = (FixedMeasurementCurrent + LoadCellCurrent) / TXInterval *
SampleTime
AwakeCurrent = (U1 + U2 + U3) * HoursUsage / 24
```

If not in Low Power Mode

```
AwakeCurrent = (FixedMeasurementCurrent + LoadCellCurrent) * HoursUsage /
24
```

Calculate currents

```
Now calculate sleep current
SleepCurrent = 30 / WakeInt * 0.008
SleepCurrent = SleepCurrent * (24 - HoursUsage) / 24
Calculate total current
TotalCurrent = AwakeCurrent + SleepCurrent
Calculate battery life in hours
BattHours = (BattAH / TotalCurrent) * 1000
Allow a safety margin
BattHours = BattHours * 0.9
```

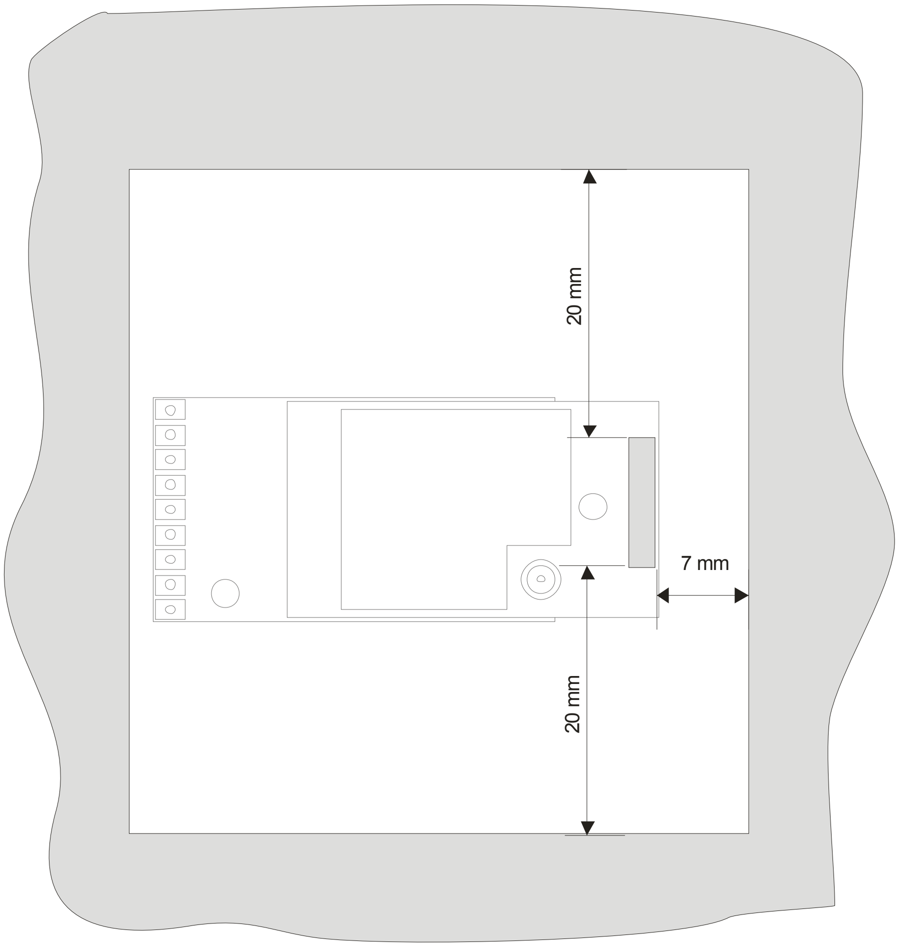
The calculated battery life in hours is **BattHours**

Installation

Antennas

Internal Chip Antenna

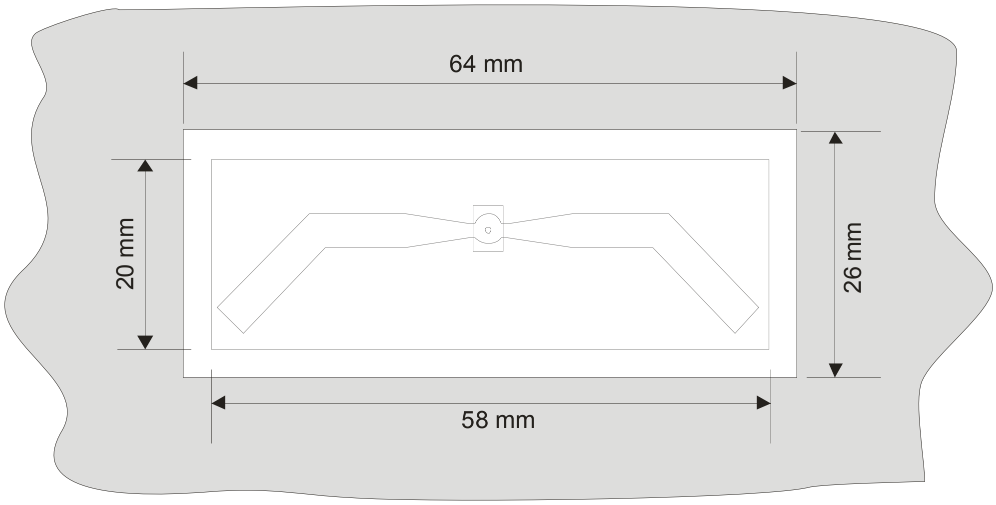
There must be no metal objects within 7mm of the antennas long edge and 20mm from the short edges. See diagram below


20 mm
7 mm
20 mm

External Antennas

The external antennas come in two styles.

The flat PCB antenna can be mounted inside a plastic housing or to the outside of a metal housing. The PCB requires 3mm Clearance on all edges, this also applies to the RF window.



The bulkhead mounting antenna can be used with metal or plastic housings. Care must be taken when mounting the Antenna to ensure the installation does not become directional.

T24-VA [0-10V Voltage Acquisition]

Overview

The T24-VA is a voltage acquisition module. This allows wireless remote viewing of voltage information using 2.4GHz radio.
The T24-VA acquires the voltage value (scales and linearises it to user defined specification) and periodically transmits it. Between transmissions the device is optionally in a power saving sleep mode to conserve batteries.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

Parameter	Command Number	Description	Native Data Type	Read / Write
ID	3	Read the unique identifier ID for this device. (3 bytes)	BINARY 3 bytes	R
Version	53	Read the firmware version.	FLOAT	R
Channel	11	Radio Channel	UINT8	RW
EncKey	15	The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.	BINARY 16 Bytes	RW
Power	12	Set or read the output power level. (0-100%)	UINT8	RW
Name	10	Set or read a user defined name. (11 characters)	STRING 11 Bytes	RW
Model	51	Read the model number of the device.	STRING 11 Bytes	R
WakeChkInt	16	Set or read the interval in milliseconds that a sleeping device will wake to request a full wake from the base station. (default 3000)	UINT16	RW
UseCSMA	18	Select whether to use Carrier Sense Multiple Access techniques on transmission. Value / Description: 0 – **Disabled** The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED 1 – **Enabled** The Carrier Sense Multiple Access will be enabled. See **Unslotted CSMA/CA** in **Appendix A**	UINT8	RW
BattLevel	69	The voltage measured on the battery.	FLOAT	R
BattLowLevel	110	Set or read the battery voltage at which the low battery flag will be set in all received packets and in the Status parameter).	FLOAT	RW
LowPowerMode	75	Defines power save mode. 0 = Awake all the time and transmit at TxInterval. 1 = Sleep. Wake at TXInterval, acquire value, transmit value, sleep.	UINT8	RW
TxInterval	76	Time Interval between Transmissions. Set mS	INT32	RW
SampleTime	78	Set or read the SampleTime in milliseconds for acquiring a reading at each TxInterval interval. The larger the SampleTime the more accurate the reading but at the expense of battery life. (Default 5)	UINT16	RW
SleepDelay	77	Time period before switching to low power sleep mode if no StayAwake command or trigger received. Setting to zero disables.	UINT16	RW
DataTag	119	Set or read the 2 byte Data Tag that is used when transmitting the weight in a Data Provider Packet. Note that default value is set to last 2 bytes of ID.	UINT16	RW
NumCalPoints	79	Number of calibration points required. Range 2 to 9	UINT8	RW

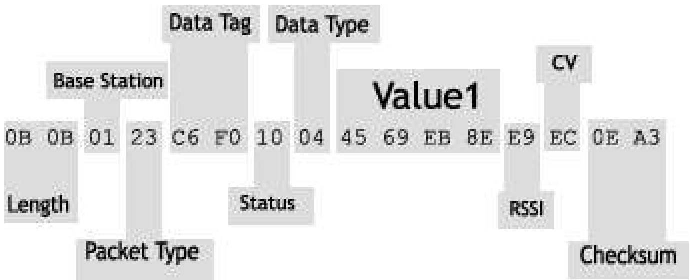
<table>
<tr><td>CalPoint1</td><td>80</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint2</td><td>81</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint3</td><td>82</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint4</td><td>83</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint5</td><td>84</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint6</td><td>85</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint7</td><td>86</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint8</td><td>87</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint9</td><td>88</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain1</td><td>89</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>90</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>91</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>92</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>93</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>94</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>95</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>96</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>97</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset1</td><td>98</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset2</td><td>99</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset3</td><td>100</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset4</td><td>101</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset5</td><td>102</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset6</td><td>103</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset7</td><td>104</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset8</td><td>105</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset9</td><td>106</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value</td><td>72</td><td>Reads the user calibrated output.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>Counts</td><td>70</td><td>Raw A/D counts</td><td>INT32</td><td>R</td></tr>
<tr><td>PFS</td><td>71</td><td>Factory calibrated percent full scale (0=0V, 100=10V)</td><td>FLOAT</td><td>R</td></tr>
<tr><td>DigitalOut</td><td>108</td><td>Read or set the digital output state.
<table>
<tr><th>Value</th><th>Definition</th></tr>
<tr><td>0</td><td>Turn digital output off</td></tr>
<tr><td>1</td><td>Turn digital output on</td></tr>
<tr><td>2</td><td>Make digital output mirror the LED state (V1.05 and later)</td></tr>
</table></td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Status</td><td>74</td><td>Live status where the bit values indicate status. The following table shows the decimal bit values and their meaning.
<table>
<tr><th>Bit Value</th><th>Definition</th></tr>
<tr><td>1</td><td>STATUS_SHUNT_CAL</td></tr>
<tr><td>2</td><td>STATUS_INPUT_INTEGRITY</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>8</td><td>Reserved</td></tr>
<tr><td>16</td><td>STATUS_POWER_UP</td></tr>
<tr><td>32</td><td>STATUS_BATT_LOW</td></tr>
<tr><td>64</td><td>STATUS_DIGITAL_INPUT</td></tr>
<tr><td>128</td><td>STATUS_DIGITAL_OUTPUT</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>Reset</td><td>54</td><td>Restarts the device and utilises new channel and encryption keys if those have been changed and saved.</td><td colspan="2">Command</td></tr>
</table>

Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	
Wake	50	Wake the module from sleep	Command	
Sleep	56	Sends the module to Sleep	Command	
Pause	57	Stops the output streaming to allow configuration	Command	
Resume	59	Streaming continues.	Command	
StayAwake	58	No function other than to reset SleepDelay timer	Command	
SleepTrigger	120	Enter Data Tag to watch for that will trigger sleep mode	UINT16	RW
PauseTrigger	121	Enter Data Tag to watch for that will trigger pause mode	UINT16	RW
ResumeTrigger	123	Enter Data Tag to watch for that will trigger resume mode	UINT16	RW
StayAwakeTrigger	122	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW
DoSystemZeroTrigger	125	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Data Provider Format

At every TXInterval a Data Provider packet is transmitted that holds 1 value in FLOAT format (See Appendix A).



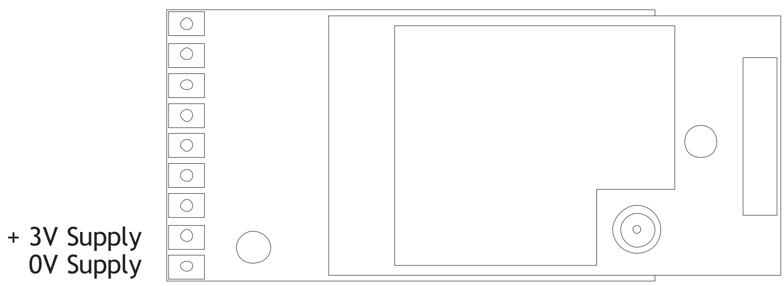
Measurement Resolution

The noise free resolution is dependant on the Sample Time (SampleTime)

SampleTime (mS)	Noise Free Resolution	Ratio
> 0	15.5 bits	1:50,000
> 9	16 bits	1:65,000
> 49	17.25 bits	1:150,000
> 99	18 bits	1:250,000
> 999	18.75 bits	1:400,000

Power Supply

Attach power supply wiring to the module as shown below:



Connect to a 3 Volt power supply or batteries.

WARNING: This module is not reverse polarity protected!

Battery Types

Battery Type	Notes
Alkaline Zn-MnO_2	Pairs of alkaline 1.5V cells are the most common. Use D cells for maximum life and AA cells where space is restricted. Example: Varta 4014 (D), Varta 4006 (AA) **Recommend T24-PSSA module** to maximise usable capacity.
Nickel Metal Hydride NiMh	Most cells are 1.2V so two in series gives 2.4 Volts. These can match alkaline batteries in capacity but as the charged voltage is lower they do not match the usable capacity. These batteries self discharge at a faster rate than alkalines. If charging these cells in circuit precautions must be taken to ensure that the maximum voltage on the T24-SA is not exceeded. Example: GP 270AAHC (AA) **Recommend T24-PSSA module** to maximise usable capacity.
Nickel Cadmium NiCad	Most cells are 1.2V so two in series gives 2.4 Volts. Three in series can be used to give 3.6 Volts. These do not have the usable capacity of an alkaline battery. These are generally only useful if they are to be charged on a regular basis. If charging these cells in circuit precautions must be taken to ensure that the maximum voltage on the T24-SA is not exceeded. Example: **Recommend T24-PSSA module to maximise usable capacity.**
Lithium Primary 3.6V Li-$SOCl_2$	Lithium cells can be used but note that the maximum voltage is 3.6 Volts. Select a cell with low internal resistance. Example: Saft LS17500 (A), Saft LSH20 (D) **Recommend T24-PSSA module** as these cells usually have a high internal resistance.
Lithium Iron Disulphide Li-FeS_2	These can be found at 1.5 Volts and can therefore be a direct replacement for Alkaline cells. The low internal resistance and high capacity make these batteries an ideal choice. Example: Energizer L91
Lithium Ion and Lithium Polymer LiON, LiPo	These generally start at 3.7V and exceed the maximum allowable voltage. These are usable if a regulator and charging circuit can be installed between the T24-SA and the battery. Care must be taken here that the regulator does not draw too much current when idle so that the low power modes are not compromised. **Recommend T24-PSSB module.**

In-line Battery Modules

Capacitor Module T24-PSSA

This is used for batteries which have an internal resistance of greater than 150mOhms overcoming voltage drops during high current phases of the low power mode cycle.
This problem becomes apparent when attempting to communicate with a T24-SA using the T24 Toolkit or power cycling when the battery is near the end of its life. In normal operation (Low power mode) with a handheld T24-HS where the T24-SA is connected to an uninterrupted battery this module is generally not required.
Using lower impedance strain gauges (or multiple parallel strain gauges) exacerbates this problem.
Consult Sales for details. Alternatively fit an electrolytic capacitor across battery of 2000uF or greater. This capacitor should be of low ESR (< 70mOhms).

Lithium Ion /Polymer Module T24-PSSB

Provides a means of charging the Lithium Ion or Polymer battery from a nominal 5V DC supply and also providing a low quiescent current 3.3V regulator to supply the T24-SA. This overcomes the max voltage limitation of the T24-SA and the higher cell voltage and charging requirements of the Lithium Ion cell.

Battery Life

Rough Guide

As a rough guide battery life of a T24-SA connected to a 1K load cell with a 5 millisecond sample time is as follows:

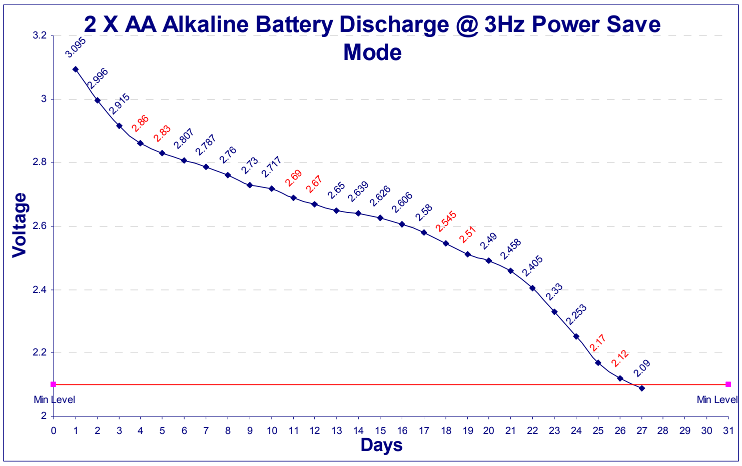
```
Years = Usable Battery Capacity
         (10 / TX per second)
```

Example of 2 X AA GP 15A with a usable capacity of 1.9Ah. The loadcell is 1K and the transmission rate is 3Hz with a 5 millisecond sample time.

```
Years =      1.9
         (10 / 0.33)

Years = 0.063 = 23.1 days
```

As can be seen below from an actual measured device on continuously this rough calculation is quite close.



It must be remembered that this calculation is for when the device is continuously on and not sent to deep sleep. So if the above device was used with a handheld and woken up 5 times a day for 5 minutes each time the total usage in a 24 hour period would be

```
5 X 5 = 25 mins = 0.416 hours
```

So we are only using a fraction of the daily 24 hours so battery life will be 24 / 0.416 times the continuously on life. i.e.

```
24 / 0.416 = 57.6
```

So

```
57.6 X 23.1 days = 1330.56 days
Or
44.3 months
Or
Over 3 and a half years.
```

Note that the above rough guide does not take into account the battery usage as the device periodically wakes from deep sleep to check whether it should wake up properly. If the device wake check interval is set to 5 seconds then we can modify the battery life from above by multiplying by a factor of 0.6 (We have only calculated the factor for a 5 second wake check interval.)

```
3.6 years X 0.6 = 2.1 years
```

Accurate Guide

The following shows how to more accurately calculate battery life. This does rely on an estimate of usable battery capacity which is not as high as manufacturers state their battery capacity to be except for batteries where the cuttoff voltage above the minimum voltage for the device.
To estimate usable capacity you will need to refer to manufacturers discharge graphs and find a curve closest to around 30mA and estimate the capacity as Amps X Time where time is the point where the battery falls below where the device would be supplied with 2.1V. This will be 1.05 in the case of 1.5V cells as we use two in series.

```
TXInterval = TXInterval Parameter / 1000
SampleTime = SampleTime Parameter/ 1000
HoursUsage = How many hours the device is NOT asleep in a 24 hour period
BattAH = Usable battery capacity in Amp Hours (Ah)
WakeInt = WakeChkInt parameter
FixedMeasurementCurrent = 45
```

Internally the device will adjust SampleTime if it is too long for the TXInterval so we need to take this into account for our calculations:

```
If SampleTime + 0.025 > TXInterval then we need to make SampleTime =
TXInterval - 0.025
```

Also note that we cannot use a TXInterval of less than 0.041 if we are in low power mode as this will cause unpredictable results.

If in Low Power Mode

```
'fixed block
U1 = 0.5 / TXInterval * 1
'Measurement block
U2 = (FixedMeasurementCurrent) / TXInterval * 0.006
'fixed block
U3 = (FixedMeasurementCurrent) / TXInterval * SampleTime
AwakeCurrent = (U1 + U2 + U3) * HoursUsage / 24
```

If not in Low Power Mode

```
AwakeCurrent = (FixedMeasurementCurrent ) * HoursUsage / 24
```

Calculate currents

```
Now calculate sleep current
SleepCurrent = 30 / WakeInt * 0.008
SleepCurrent = SleepCurrent * (24 - HoursUsage) / 24
Calculate total current
TotalCurrent = AwakeCurrent + SleepCurrent
Calculate battery life in hours
BattHours = (BattAH / TotalCurrent) * 1000
Allow a safety margin
BattHours = BattHours * 0.9
```

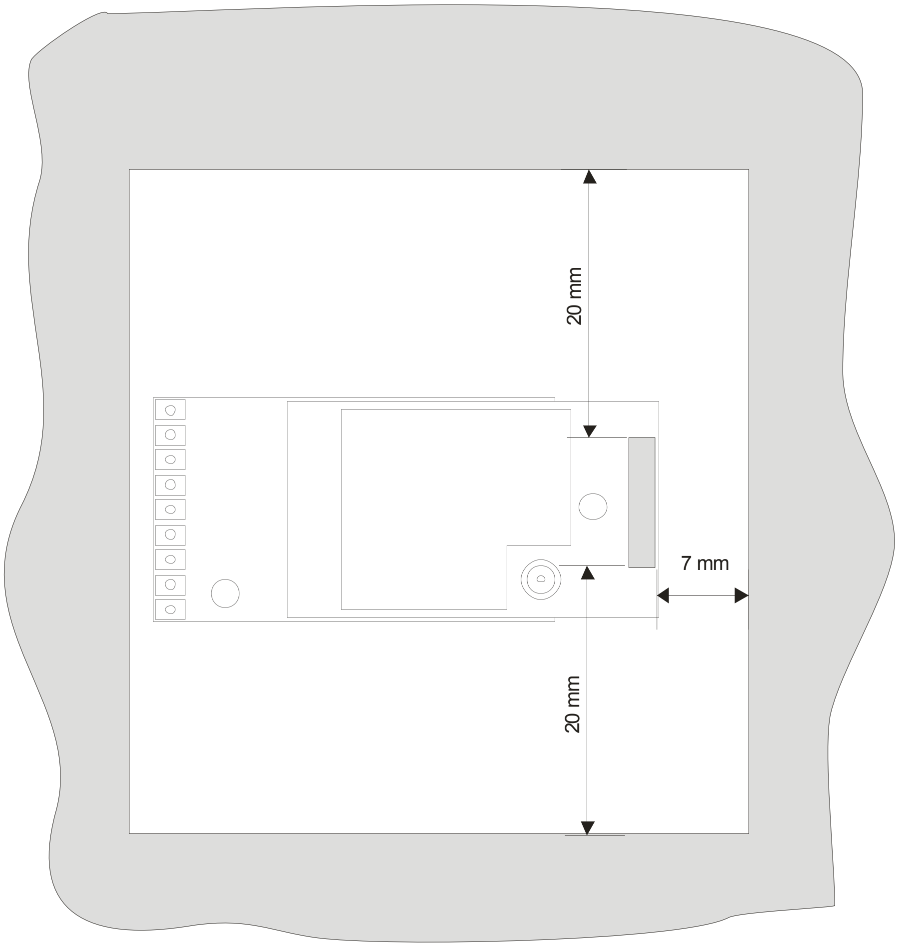
The calculated battery life in hours is **BattHours**

Installation

Antennas

Internal Chip Antenna

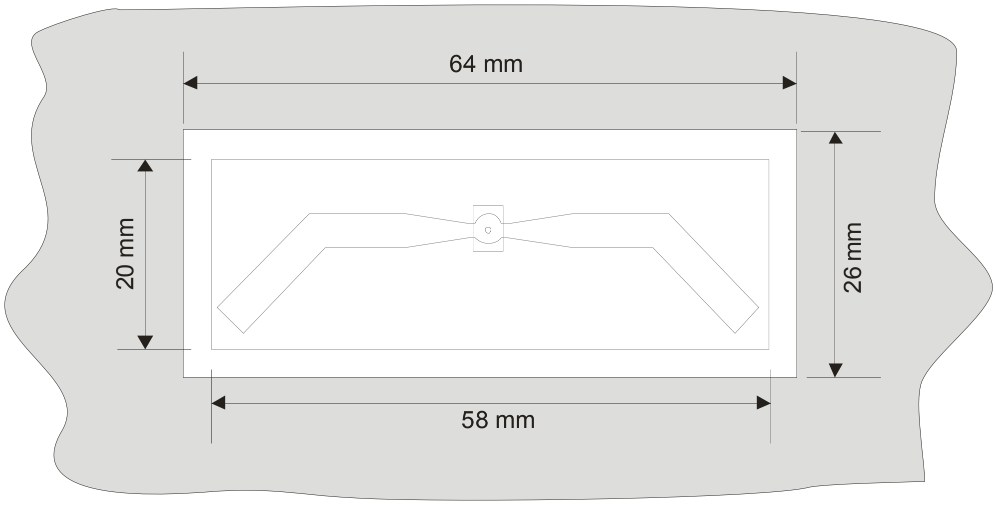
There must be no metal objects within 7mm of the antennas long edge and 20mm from the short edges. See diagram below



External Antennas

The external antennas come in two styles.

The flat PCB antenna can be mounted inside a plastic housing or to the outside of a metal housing. The PCB requires 3mm Clearance on all edges, this also applies to the RF window.



The bulkhead mounting antenna can be used with metal or plastic housings. Care must be taken when mounting the Antenna to ensure the installation does not become directional.

T24-IA [4-20mA Current Acquisition]

Overview

The T24-IA is a current acquisition module. This allows wireless remote viewing of current information using 2.4GHz radio.
The T24-IA acquires the current value (scales and linearises it to user defined specification) and periodically transmits it. Between transmissions the device is optionally in a power saving sleep mode to conserve batteries.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

Parameter	Command Number	Description	Native Data Type	Read / Write
ID	3	Read the unique identifier ID for this device. (3 bytes)	BINARY 3 bytes	R
Version	53	Read the firmware version.	FLOAT	R
Channel	11	Radio Channel	UINT8	RW
EncKey	15	The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.	BINARY 16 Bytes	RW
Power	12	Set or read the output power level. (0-100%)	UINT8	RW
Name	10	Set or read a user defined name. (11 characters)	STRING 11 Bytes	RW
Model	51	Read the model number of the device.	STRING 11 Bytes	R
WakeChkInt	16	Set or read the interval in milliseconds that a sleeping device will wake to request a full wake from the base station. (default 3000)	UINT16	RW
UseCSMA	18	Select whether to use Carrier Sense Multiple Access techniques on transmission. Value — Description 0 — **Disabled** The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED 1 — **Enabled** The Carrier Sense Multiple Access will be enabled. See **Unslotted CSMA/CA** in **Appendix A**	UINT8	RW
BattLevel	69	The voltage measured on the battery.	FLOAT	R
BattLowLevel	110	Set or read the battery voltage at which the low battery flag will be set in all received packets and in the Status parameter).	FLOAT	RW
LowPowerMode	75	Defines power save mode. 0 = Awake all the time and transmit at TxInterval. 1 = Sleep. Wake at TXInterval, acquire value, transmit value, sleep.	UINT8	RW
TxInterval	76	Time Interval between Transmissions. Set mS	INT32	RW
SampleTime	78	Set or read the SampleTime in milliseconds for acquiring a reading at each TxInterval interval. The larger the SampleTime the more accurate the reading but at the expense of battery life. (Default 5)	UINT16	RW
SleepDelay	77	Time period before switching to low power sleep mode if no StayAwake command or trigger received. Setting to zero disables.	UINT16	RW
DataTag	119	Set or read the 2 byte Data Tag that is used when transmitting the weight in a Data Provider Packet. Note that default value is set to last 2 bytes of ID.	UINT16	RW
NumCalPoints	79	Number of calibration points required. Range 2 to 9	UINT8	RW

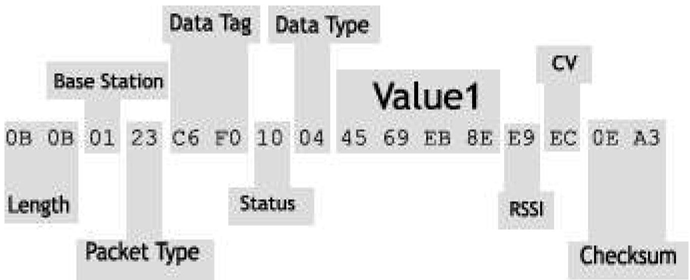
<table>
<tr><td>CalPoint1</td><td>80</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint2</td><td>81</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint3</td><td>82</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint4</td><td>83</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint5</td><td>84</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint6</td><td>85</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint7</td><td>86</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint8</td><td>87</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPoint9</td><td>88</td><td>The % full scale value of this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain1</td><td>89</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>90</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>91</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>92</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>93</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>94</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>95</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>96</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointGain</td><td>97</td><td>The gain to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset1</td><td>98</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset2</td><td>99</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset3</td><td>100</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset4</td><td>101</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset5</td><td>102</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset6</td><td>103</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset7</td><td>104</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset8</td><td>105</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>CalPointOffset9</td><td>106</td><td>The offset to apply to the input at this calibration point.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value</td><td>72</td><td>Reads the user calibrated output.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>Counts</td><td>70</td><td>Raw A/D counts</td><td>INT32</td><td>R</td></tr>
<tr><td>PFS</td><td>71</td><td>Factory calibrated percent full scale (0=0V, 100=10V)</td><td>FLOAT</td><td>R</td></tr>
<tr><td>DigitalOut</td><td>108</td><td>Read or set the digital output state.
<table>
<tr><th>Value</th><th>Definition</th></tr>
<tr><td>0</td><td>Turn digital output off</td></tr>
<tr><td>1</td><td>Turn digital output on</td></tr>
<tr><td>2</td><td>Make digital output mirror the LED state (V1.05 and later)</td></tr>
</table></td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Status</td><td>74</td><td>Live status where the bit values indicate status. The following table shows the decimal bit values and their meaning.
<table>
<tr><th>Bit Value</th><th>Definition</th></tr>
<tr><td>1</td><td>STATUS_SHUNT_CAL</td></tr>
<tr><td>2</td><td>STATUS_INPUT_INTEGRITY</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>8</td><td>Reserved</td></tr>
<tr><td>16</td><td>STATUS_POWER_UP</td></tr>
<tr><td>32</td><td>STATUS_BATT_LOW</td></tr>
<tr><td>64</td><td>STATUS_DIGITAL_INPUT</td></tr>
<tr><td>128</td><td>STATUS_DIGITAL_OUTPUT</td></tr>
</table></td><td></td><td></td></tr>
<tr><td>Reset</td><td>54</td><td>Restarts the device and utilises new channel and encryption keys if those have been changed and saved.</td><td colspan="2">Command</td></tr>
</table>

Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	
Wake	50	Wake the module from sleep	Command	
Sleep	56	Sends the module to Sleep	Command	
Pause	57	Stops the output streaming to allow configuration	Command	
Resume	59	Streaming continues.	Command	
StayAwake	58	No function other than to reset SleepDelay timer	Command	
SleepTrigger	120	Enter Data Tag to watch for that will trigger sleep mode	UINT16	RW
PauseTrigger	121	Enter Data Tag to watch for that will trigger pause mode	UINT16	RW
ResumeTrigger	123	Enter Data Tag to watch for that will trigger resume mode	UINT16	RW
StayAwakeTrigger	122	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW
DoSystemZeroTrigger	125	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Data Provider Format

At every TXInterval a Data Provider packet is transmitted that holds 1 value in FLOAT format (See Appendix A).



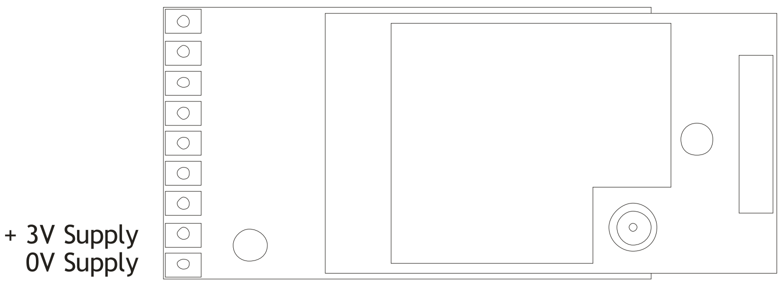
Measurement Resolution

The noise free resolution is dependant on the Sample Time (SampleTime)

SampleTime (mS)	Noise Free Resolution	Ratio
> 0	15.5 bits	1:50,000
> 9	16 bits	1:65,000
> 49	17.25 bits	1:150,000
> 99	18 bits	1:250,000
> 999	18.75 bits	1:400,000

Power Supply

Attach power supply wiring to the module as shown below:



Connect to a 3 Volt power supply or batteries.

WARNING: This module is not reverse polarity protected!

WARNING: The maximum voltage is 3.6V!

Battery Types

Battery Type	Notes
Alkaline Zn-MnO_2	Pairs of alkaline 1.5V cells are the most common. Use D cells for maximum life and AA cells where space is restricted. Example: Varta 4014 (D), Varta 4006 (AA) **Recommend T24-PSSA module** to maximise usable capacity.
Nickel Metal Hydride NiMh	Most cells are 1.2V so two in series gives 2.4 Volts. These can match alkaline batteries in capacity but as the charged voltage is lower they do not match the usable capacity. These batteries self discharge at a faster rate than alkalines. If charging these cells in circuit precautions must be taken to ensure that the maximum voltage on the T24-SA is not exceeded. Example: GP 270AAHC (AA) **Recommend T24-PSSA module** to maximise usable capacity.
Nickel Cadmium NiCad	Most cells are 1.2V so two in series gives 2.4 Volts. Three in series can be used to give 3.6 Volts. These do not have the usable capacity of an alkaline battery. These are generally only useful if they are to be charged on a regular basis. If charging these cells in circuit precautions must be taken to ensure that the maximum voltage on the T24-SA is not exceeded. Example: **Recommend T24-PSSA module to maximise usable capacity.**
Lithium Primary 3.6V Li-$SOCl_2$	Lithium cells can be used but note that the maximum voltage is 3.6 Volts. Select a cell with low internal resistance. Example: Saft LS17500 (A), Saft LSH20 (D) **Recommend T24-PSSA module** as these cells usually have a high internal resistance.
Lithium Iron Disulphide Li-FeS_2	These can be found at 1.5 Volts and can therefore be a direct replacement for Alkaline cells. The low internal resistance and high capacity make these batteries an ideal choice. Example: Energizer L91
Lithium Ion and Lithium Polymer LiON, LiPo	These generally start at 3.7V and exceed the maximum allowable voltage. These are usable if a regulator and charging circuit can be installed between the T24-SA and the battery. Care must be taken here that the regulator does not draw too much current when idle so that the low power modes are not compromised. **Recommend T24-PSSB module.**

In-line Battery Modules

Capacitor Module T24-PSSA

This is used for batteries which have an internal resistance of greater than 150mOhms overcoming voltage drops during high current phases of the low power mode cycle.
This problem becomes apparent when attempting to communicate with a T24-SA using the T24 Toolkit or power cycling when the battery is near the end of its life. In normal operation (Low power mode) with a handheld T24-HS where the T24-SA is connected to an uninterrupted battery this module is generally not required.
Using lower impedance strain gauges (or multiple parallel strain gauges) exacerbates this problem.
Consult Sales for details. Alternatively fit an electrolytic capacitor across battery of 2000uF or greater. This capacitor should be of low ESR (< 70mOhms).

Lithium Ion /Polymer Module T24-PSSB

Provides a means of charging the Lithium Ion or Polymer battery from a nominal 5V DC supply and also providing a low quiescent current 3.3V regulator to supply the T24-SA. This overcomes the max voltage limitation of the T24-SA and the higher cell voltage and charging requirements of the Lithium Ion cell.

Battery Life

Rough Guide

As a rough guide battery life of a T24-SA connected to a 1K load cell with a 5 millisecond sample time is as follows:

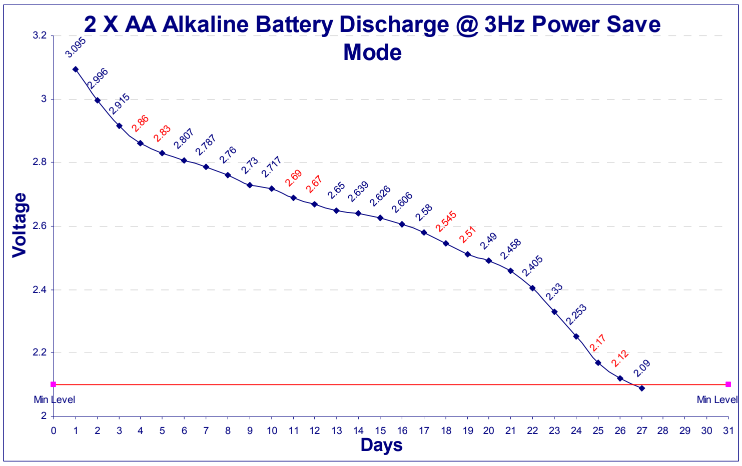
```
Years = Usable Battery Capacity
         (10 / TX per second)
```

Example of 2 X AA GP 15A with a usable capacity of 1.9Ah. The loadcell is 1K and the transmission rate is 3Hz with a 5 millisecond sample time.

```
Years =      1.9
         (10 / 0.33)

Years = 0.063 = 23.1 days
```

As can be seen below from an actual measured device on continuously this rough calculation is quite close.



It must be remembered that this calculation is for when the device is continuously on and not sent to deep sleep. So if the above device was used with a handheld and woken up 5 times a day for 5 minutes each time the total usage in a 24 hour period would be

```
5 X 5 = 25 mins = 0.416 hours
```

So we are only using a fraction of the daily 24 hours so battery life will be 24 / 0.416 times the continuously on life. i.e.

```
24 / 0.416 = 57.6
```

So

```
57.6 X 23.1 days = 1330.56 days
Or
44.3 months
Or
Over 3 and a half years.
```

Note that the above rough guide does not take into account the battery usage as the device periodically wakes from deep sleep to check whether it should wake up properly. If the device wake check interval is set to 5 seconds then we can modify the battery life from above by multiplying by a factor of 0.6 (We have only calculated the factor for a 5 second wake check interval.)

```
3.6 years X 0.6 = 2.1 years
```

Accurate Guide

The following shows how to more accurately calculate battery life. This does rely on an estimate of usable battery capacity which is not as high as manufacturers state their battery capacity to be except for batteries where the cuttoff voltage above the minimum voltage for the device.
To estimate usable capacity you will need to refer to manufacturers discharge graphs and find a curve closest to around 30mA and estimate the capacity as Amps X Time where time is the point where the battery falls below where the device would be supplied with 2.1V. This will be 1.05 in the case of 1.5V cells as we use two in series.

```
TXInterval = TXInterval Parameter / 1000
SampleTime = SampleTime Parameter/ 1000
HoursUsage = How many hours the device is NOT asleep in a 24 hour period
BattAH = Usable battery capacity in Amp Hours (Ah)
WakeInt = WakeChkInt parameter
FixedMeasurementCurrent = 45
```

Internally the device will adjust SampleTime if it is too long for the TXInterval so we need to take this into account for our calculations:

```
If SampleTime + 0.025 > TXInterval then we need to make SampleTime =
TXInterval - 0.025
```

Also note that we cannot use a TXInterval of less than 0.041 if we are in low power mode as this will cause unpredictable results.

If in Low Power Mode

```
'fixed block
U1 = 0.5 / TXInterval * 1
'Measurement block
U2 = (FixedMeasurementCurrent) / TXInterval * 0.006
'fixed block
U3 = (FixedMeasurementCurrent) / TXInterval * SampleTime
AwakeCurrent = (U1 + U2 + U3) * HoursUsage / 24
```

If not in Low Power Mode

```
AwakeCurrent = (FixedMeasurementCurrent ) * HoursUsage / 24
```

Calculate currents

```
Now calculate sleep current
SleepCurrent = 30 / WakeInt * 0.008
SleepCurrent = SleepCurrent * (24 - HoursUsage) / 24
Calculate total current
TotalCurrent = AwakeCurrent + SleepCurrent
Calculate battery life in hours
BattHours = (BattAH / TotalCurrent) * 1000
Allow a safety margin
BattHours = BattHours * 0.9
```

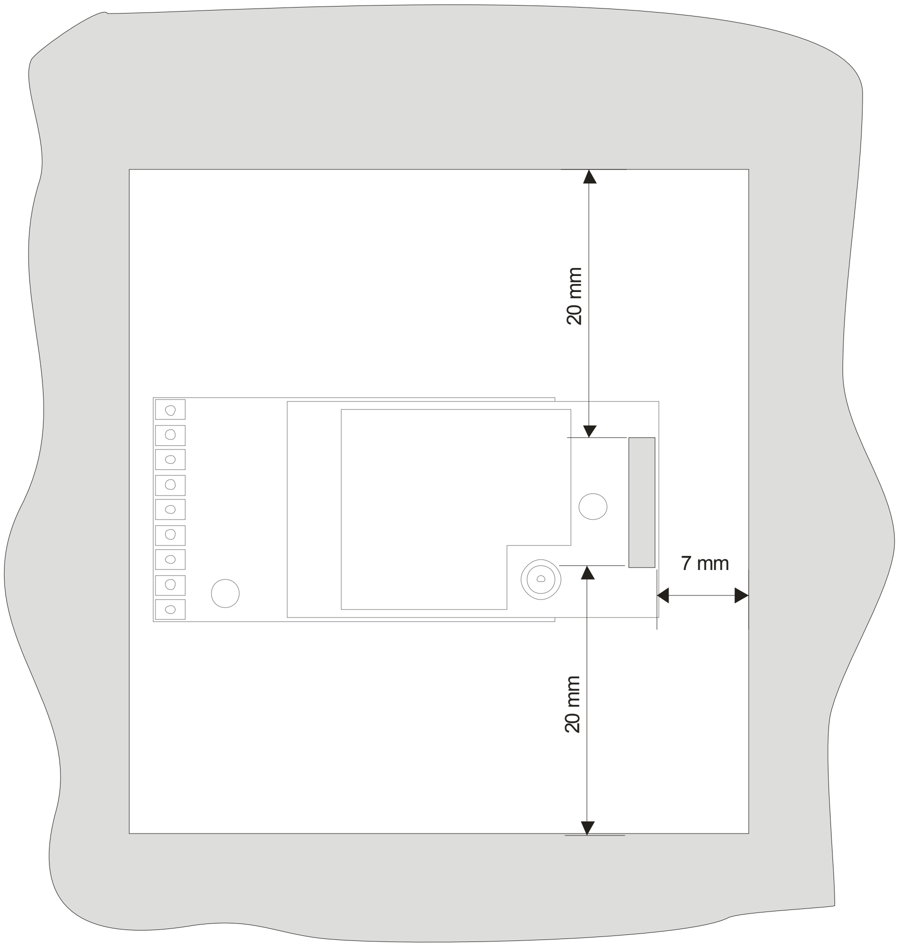
The calculated battery life in hours is **BattHours**

Installation

Antennas

Internal Chip Antenna

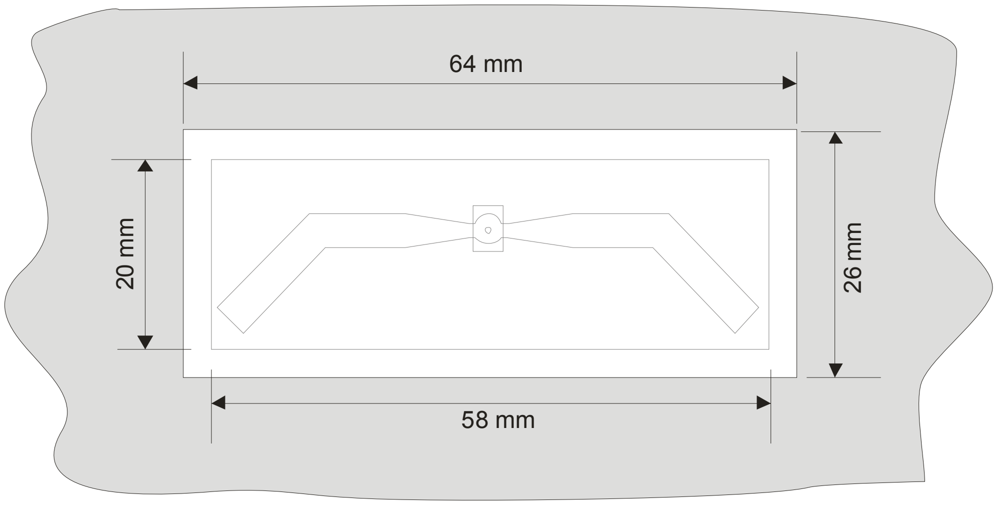
There must be no metal objects within 7mm of the antennas long edge and 20mm from the short edges. See diagram below



External Antennas

The external antennas come in two styles.

The flat PCB antenna can be mounted inside a plastic housing or to the outside of a metal housing. The PCB requires 3mm Clearance on all edges, this also applies to the RF window.



The bulkhead mounting antenna can be used with metal or plastic housings. Care must be taken when mounting the Antenna to ensure the installation does not become directional.

T24-SAf [Strain Acquisition Fast]

Overview

The T24-SAf is a strain acquisition module offering high speed wireless acquisition. This allows wireless remote viewing of strain gauge information using 2.4GHz radio.
The T24-SAf acquires the weight information from the strain gauge and transmits 10 readings per packet at a rate of 200 packets per second giving a measurement rate of 2KHz. There are fewer functions than the T24-SA and no operational low power mode although the device can be sent to sleep.
The values are delivered via a binary Data Provider packet and the data format is 32 bit integer factory calibrated to nV/V (nanovolts per volt).

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

Parameter	Command Number	**Description**	Native Data Type	Read / Write
ID	3	Read the unique identifier ID for this device. (3 bytes)	BINARY 3 bytes	R
Version	53	Read the firmware version.	FLOAT	R
Channel	11	Radio Channel	UINT8	RW
EncKey	15	The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.	BINARY 16 Bytes	RW
Power	12	Set or read the output power level. (0-100%)	UINT8	RW
Name	10	Set or read a user defined name. (11 characters)	STRING 11 Bytes	RW
Model	51	Read the model number of the device.	STRING 11 Bytes	R
WakeChkInt	16	Set or read the interval in milliseconds that a sleeping device will wake to request a full wake from the base station. (default 3000)	UINT16	RW
UseCSMA	18	Select whether to use Carrier Sense Multiple Access techniques on transmission. Value / Description: 0 – **Disabled** The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED 1 – **Enabled** The Carrier Sense Multiple Access will be enabled. See **Unslotted CSMA/CA** in **Appendix A**	UINT8	RW
BattLevel	69	The voltage measured on the battery.	FLOAT	R
BattLowLevel	110	Set or read the battery voltage at which the low battery flag will be set in all received packets and in the Status parameter).	FLOAT	RW
SleepDelay	77	Time period before switching to low power sleep mode if no StayAwake command or trigger received. Setting to zero disables.	UINT16	RW
DataTag	119	Set or read the 2 byte Data Tag that is used when transmitting the weight in a Data Provider Packet. Note that default value is set to last 2 bytes of ID.	UINT16	RW
Value	72	Reads the calibrated weight.	FLOAT	RW
Counts	70	Raw A/D counts	INT32	R
DigitalOut	108	Read or set the digital output state.	FLOAT	R
ShuntCal	109	Read or set the shuntcal state.	UINT8	R
Status	74	Live status where the bit values indicate status. The following table shows the decimal bit values and their meaning.		

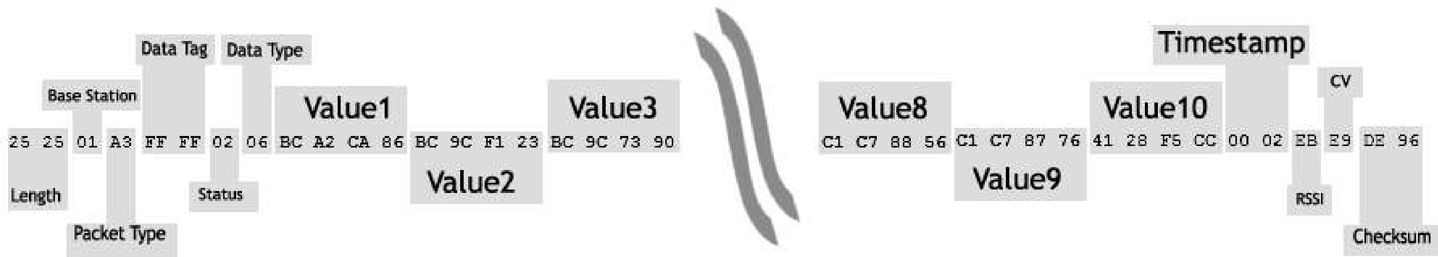
		Bit Value / Definition: 1 STATUS_SHUNT_CAL 2 STATUS_INPUT_INTEGRITY 4 Reserved 8 Reserved 16 STATUS_POWER_UP 32 STATUS_BATT_LOW 64 STATUS_DIGITAL_INPUT 128 STATUS_DIGITAL_OUTPUT		
Reset	54	Restarts the device and utilises new channel and encryption keys if those have been changed and saved.	Command	
Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	
Wake	50	Wake the module from sleep	Command	
Sleep	56	Sends the module to Sleep	Command	
Pause	57	Stops the output streaming to allow configuration	Command	
Resume	59	Streaming continues.	Command	
StayAwake	58	No function other than to reset SleepDelay timer	Command	
SleepTrigger	120	Enter Data Tag to watch for that will trigger sleep mode	UINT16	RW
PauseTrigger	121	Enter Data Tag to watch for that will trigger pause mode	UINT16	RW
ResumeTrigger	123	Enter Data Tag to watch for that will trigger resume mode	UINT16	RW
StayAwakeTrigger	122	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW
DoSystemZeroTrigger	125	Enter Data Tag to watch for that will reset SleepDelay timer.	UINT16	RW

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Data Provider Format

Ten readings are contained in each Data Provider packet and these are transmitted every 5mS (200 packets per second). Also in each packet there is a 16bit timestamp which indicates when the first data value was added to the packet where each unit equates to 500uS. Using this timestamp it is possible to reconstruct data even with missing packets. Note that the timestamp will restart from zero every 32.768 seconds.

The Data Provider packet is typed as Binary. The 10 readings are next, each formatted as an INT32 (See Appendix A) and these are followed by the timestamp formatted as a UINT16.

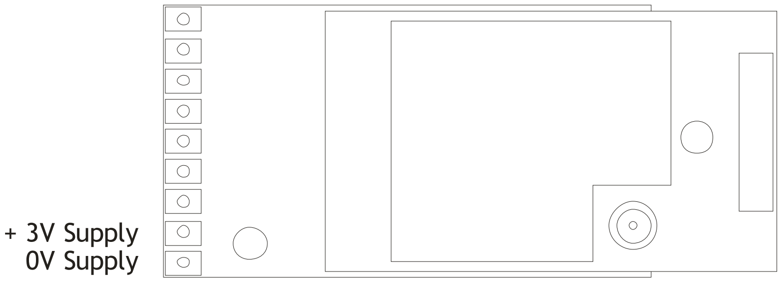


Measurement Resolution

The noise free resolution is 15.5 bits (1:50,000)

Power Supply

Attach power supply wiring to the module as shown below:



Connect to a 3 Volt power supply or batteries.

WARNING: This module is not reverse polarity protected!

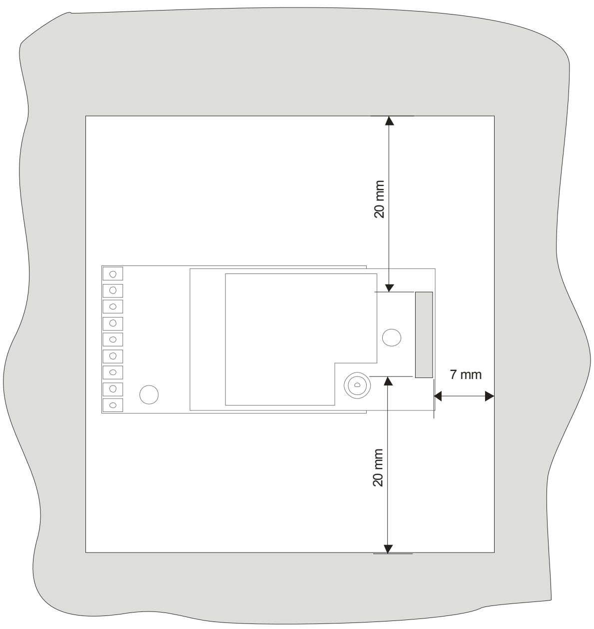
WARNING: The maximum voltage is 3.6V!

Installation

Antennas

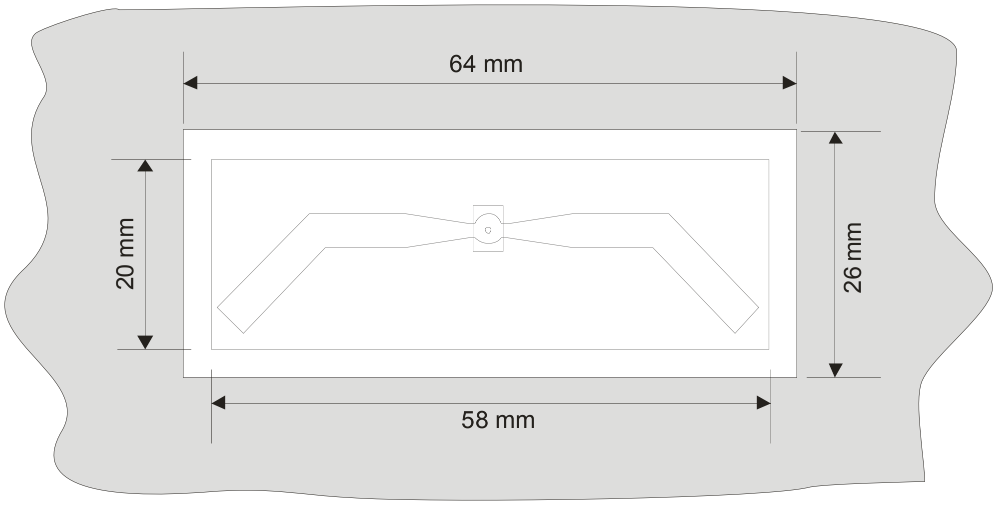
Internal Chip Antenna

There must be no metal objects within 7mm of the antennas long edge and 20mm from the short edges. See diagram below



External Antennas

The external antennas come in two styles.
The flat PCB antenna can be mounted inside a plastic housing or to the outside of a metal housing. The PCB requires 3mm Clearance on all edges, this also applies to the RF window.



The bulkhead mounting antenna can be used with metal or plastic housings. Care must be taken when mounting the Antenna to ensure the installation does not become directional.

T24-HS [Handheld Reader Simple]

Overview

The T24-HS captures Data Provider data and displays it. The T24-HS also performs the function of waking the remote device when it is turned on and sending it to deep sleep mode when it is turned off. If no buttons are pressed on the T24-HS it will turn off after 5 minutes.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

<table>
<tr><th>Parameter</th><th>Command Number</th><th>Description</th><th>Native Data Type</th><th>Read / Write</th></tr>
<tr><td>ID</td><td>3</td><td>Read the unique identifier ID for this device. (3 bytes)</td><td>BINARY 3 bytes</td><td>R</td></tr>
<tr><td>Version</td><td>53</td><td>Read the firmware version.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>Channel</td><td>11</td><td>Radio Channel</td><td>UINT8</td><td>RW</td></tr>
<tr><td>EncKey</td><td>15</td><td>The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.</td><td>BINARY 16 Bytes</td><td>RW</td></tr>
<tr><td>Power</td><td>12</td><td>Set or read the output power level.
(range:0 to 100 default:100)</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Name</td><td>10</td><td>Set or read a user defined name. (11 characters)</td><td>STRING 11 Bytes</td><td>RW</td></tr>
<tr><td>Model</td><td>51</td><td>Read the model number of the device.</td><td>STRING 11 Bytes</td><td>R</td></tr>
<tr><td>InputValue</td><td>60</td><td>The value that is being read by the device.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>DisplayValue</td><td>61</td><td>The value being displayed by the device.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>UseCSMA</td><td>18</td><td>Select whether to use Carrier Sense Multiple Access techniques on transmission.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>Disabled
The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED</td></tr><tr><td>1</td><td>Enabled
The Carrier Sense Multiple Access will be enabled.</td></tr></table>
See Unslotted CSMA/CA in Appendix A</td><td>UINT8</td><td>RW</td></tr>
<tr><td>BattLevel</td><td>69</td><td>The voltage measured on the battery.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>OffDelay</td><td>62</td><td>Time period in minutes before switching off if no button is pressed. Setting to zero disables.
(range:0 to 1440 default:5)</td><td>UINT16</td><td>RW</td></tr>
<tr><td>BoundDataTag</td><td>68</td><td>Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the display value.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>BoundID</td><td>69</td><td>Set or read the ID of the bound device. Used to wake the remote device.</td><td>BINARY 3 Bytes</td><td>RW</td></tr>
<tr><td>AutoZero</td><td>63</td><td>Set or read the value limit which may be automatically zeroed on startup.
When the handheld powers up and the input value is within ±AutoZero then the display will be zeroed. The value of the input will be placed in AutoZero. i.e. from this time onwards until powered off the display will show
input value - AutoZero</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>DoSleepWake</td><td>64</td><td>Set or read whether to perform wake and sleep on the paired device when the handheld is powered up and down.
(range:0 to 1 default:1)</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Timeout</td><td>65</td><td>Set or read the time in seconds that if exceeded</td><td>UINT16</td><td>RW</td></tr>
</table>

		between receiving Data Provider packets from the paired device will cause the display to show ------. Default = 3 (range:0 to 65535 default:3)		
KeepAwakeInt	66	Set or read the interval in seconds between the handheld transmitting StayAwake signals to the paired device. (range:0 to 65535 default:5)	UINT16	RW
DisplayUpdate	74	Set or read the interval between LCD updates. Default = 300	UINT16	RW
PairWait	67	Set or read the period in seconds that the handheld will wait for another device to pair when placed into pair mode. (range:0 to 65535 default:5)	UINT8	RW
Format	70	Set or read the format for the display. Here you can define how the value will be displayed and where the decimal point will appear. By including a non zero value this will define the resolution of the displayed value. i.e. the smallest step size of value changes. Default = 0000.001	STRING 8 bytes	RW
ZeroSupp	71	Set or read whether to show the value on the display with zero suppression. 0 = No zero suppression 1 = Zero suppression	UINT8	RW
ZeroBand	72	Set or read the band within which zero will be displayed. As soon as the value exceeds ±ZeroBand the actual value will be displayed. This will effectively mask small changes after taring the device.	FLOAT	RW
Overload	73	Set or read the value of the display above which instead of the value being displayed 'Overload' will be displayed.	FLOAT	RW
ScaleInLo	75	Set or read a low input value at which you know what display you require. Default = 0	FLOAT	RW
ScaleInHi	77	Set or read a high input value at which you know what display you require. Default = 1	FLOAT	RW
ScaleDisplayLo	76	Set or read a low display value for the input value stated in ScaleInLo. Default = 0	FLOAT	RW
ScaleDisplayHi	78	Set or read a high display value for the input value stated in ScaleInHi. Default = 1	FLOAT	RW
Reset	54	Restarts the device and utilises new channel and encryption keys if those have been changed and saved.	Command	
Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Power Supply

Recommend using alkaline AA cells as rechargeable are too low voltage and lithium may not be able to supply the current for the radio to start up.

Installation

There are no specific installation instructions.

T24-HA [Handheld Reader Advanced]

Overview

The T24-HS captures Data Provider data from multiple devices and displays it. The T24-HS also performs the function of optionally waking the remote device when it is turned on and sending it to deep sleep mode when it is turned off. If no buttons are pressed on the T24-HS it will turn off after 5 minutes.
The handheld can operate in two modes. The operation of the buttons and the automatic sleep/wake functions are dependant on these modes.

To attach devices to the handheld we must first ensure that the appropriate devices are transmitting their values at a suitable rate such as the default of 3 per second. Then we can tell the handheld which devices we want to communicate with by either automatic pairing or manual setting of the parameters.

Automatic Pairing

The handheld supports pairing replace an existing device. i.e. initially the handheld would be configured using manual configuration.
If then a T24-SA device required replacing and this was item 3 in the handheld we would follow the following procedure:

- First select this device even though the display may show ------ because of no communications. (In Result mode you would have to hold the **Next** key to enable selection of individual devices.)
- Next turn off the handheld then press and hold the **Power** key then press and hold the **Tare** key. Now both keys are held down until **PAIRING** is seen on the display. The keys can now be released.
- Now apply power to the T24-SA within 10 seconds.
- If unsuccessful the display will show **failed**. If successful the **Data Tag** and **ID** of the new device will have been configured within the handheld.
- Depending on how the replacement device was configured it **may** be necessary to reapply the system zero.

Manual Configuration

Use the parameters **ValueDataTag1** through to **ValueDataTag12** and **ValueID1** through to **ValueID12** and enter the Data Tags and IDs of the devices to connect to.
For example, to sum two T24-SA devices whose Ids are FFF123 and FFFABC.
The default data tags for these devices would be F123 and FABC so we would set the following:

ValueDataTag1=F123
ValueID1=FFF123
ValueDataTag2=FABC
ValueID2=FFFABC

We would ensure that the other unused **ValueDataTagx** and **ValueIDx** parameters were set to zero.

Available Modes

Item Mode

Opmode = 0.
Up to 12 individual devices can be connected to and the user can step through each one in sequence.
If DoSleepWake is set then the handheld will wake all configured devices when turned on and send them all to sleep again when turned off. NOTE: When the handheld wakes devices this achieved through the transmission of a broadcast wake. i.e. all devices on the same channel and with the same encryption key will wake.

Key Operation

Key	Operation
Sleep	Send the currently selected device to sleep.
Wake	Will attempt to wake the currently selected device.
Tare	Toggle between
Next	Step to the next device.
F1	If motion detection is activated then the reading must be steady to enable this key. Pressing this key with an unstable reading will do nothing. This transmits a Data Provider packet marked with a Data Tag held in **F1DataTag** and can also contain data as defined by **F1Data**.
Power	Toggles between on and off. Hold for 2 seconds to activate.

Result Mode

OpMode = 1.
Up to 12 individual devices can be summed and the result displayed.
If **DoSleepWake** is set then the handheld will wake all configured devices when turned on and send them to sleep again when turned off. NOTE: When the handheld wakes devices this achieved through the transmission of a broadcast wake. i.e. all devices on the same channel and with the same encryption key will wake.

In this mode there is an option of retrieving a system zero value from an external source. This is activated by supplying the Data Tag to the **ExtZeroDataTag** parameter. When activated the value supplied by the Data Provider packet marked with this tag will be used as the system zero and will be subtracted from the sum of all contributing inputs.
Usually in this mode only the result is displayed (In the initial devices the result will just be the sum) but by holding the **Next** key for 65 seconds will activate the ability to step through each contributing input using the **Next** key. See **AllowNext**

Key Operation when viewing the sum

Key	Operation
Sleep	No effect
Wake	Will attempt to wake any sleeping devices.
Tare	Toggle between displaying gross sum or tared sum.
Next	No effect unless held for 5 seconds to activate individual item view. This can be disabled by setting **NoNext** parameter.
F1	If motion detection is activated then the reading must be steady to enable this key. Pressing this key with an unstable reading will do nothing. This transmits a Data Provider packet marked with a Data Tag held in F1DataTag and can also contain data as defined by F1Data.
Power	Toggles between on and off. Hold for 2 seconds to activate.

Key Operation when viewing an individual item

Key	Operation
Sleep	No effect
Wake	Will attempt to wake any sleeping devices.
Tare	If sum was currently tared then this key will toggle between displaying gross or tared value of current device. If sum view was displaying gross then this key has no effect. If an external system zero is used then only gross values actually supplied to the handheld can be displayed.
Next	Selects next device to view.
F1	If motion detection is activated then the reading must be steady to enable this key. Pressing this key with an unstable reading will do nothing. This transmits a Data Provider packet marked with a Data Tag held in F1DataTag and can also contain data as defined by F1Data.
Power	Toggles between on and off. Hold for 2 seconds to activate.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

Parameter	Command Number	Description	Native Data Type	Read / Write
ID	3	Read the unique identifier ID for this device. (3 bytes)	BINARY 3 bytes	R
Version	53	Read the firmware version.	FLOAT	R
Channel	11	Radio Channel	UINT8	RW
EncKey	15	The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.	BINARY 16 Bytes	RW
Power	12	Set or read the output power level. (0-100%)	UINT8	RW
Name	10	Set or read a user defined name. (11 characters)	STRING 11 Bytes	RW
Model	51	Read the model number of the device.	STRING 11 Bytes	R
UseCSMA	18	Select whether to use Carrier Sense Multiple Access techniques on transmission. Value / Description: 0 – **Disabled** The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED 1 – **Enabled** The Carrier Sense Multiple Access will be enabled. See **Unslotted CSMA/CA** in **Appendix A**	UINT8	RW
OffDelay	62	Time period in seconds before switching off if no button is pressed. Setting to zero disables. Default = 5	UINT16	RW
AutoZero	63	Set or read the value limit which may be automatically zeroed on startup. When the handheld powers up and the input value is within ±ZeroBand then the display will be zeroed. The value of the input will be placed in AutoZero. i.e. from this time onwards until powered off the display will show input value - AutoZero	FLOAT	RW
DoSleepWake	64	Set or read whether to perform wake and sleep on the paired device when the handheld is powered up and down. Default = 1	UINT8	RW
Timeout	65	Set or read the time in seconds that if exceeded between receiving Data Provider packets from the paired device will cause the display to show ------. Default = 3	UINT16	RW
KeepAwakeInt	66	Set or read the interval in seconds between the handheld transmitting **StayAwake** signals to the paired device. Default = 5	UINT16	RW
DisplayUpdate	74	Set or read the interval between LCD updates. Default = 300	UINT16	RW
PairWait	67	Set or read the period in seconds that the handheld will wait for another device to pair when placed into pair mode. Default = 5	UINT8	RW
Format	70	Set or read the format for the display. Here you can define how the value will be displayed and where the decimal point will appear. By including a non zero value this will define the resolution of the displayed value. i.e. the smallest step size of value changes. Default = 0000.001	STRING 8 bytes	RW
ZeroSupp	71	Set or read whether to show the value on the display with zero suppression. 0 = No zero suppression 1 = Zero suppression	UINT8	RW

<table>
<tr><td>ZeroBand</td><td>72</td><td>Set or read the band within which zero will be displayed. As soon as the value exceeds ±ZeroBand the actual value will be displayed. This will effectively mask small changes after taring the device.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Overload</td><td>73</td><td>Set or read the value of the display above which instead of the value being displayed 'Overload' will be displayed.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>ScaleInLo</td><td>75</td><td>Set or read a low input value at which you know what display you require. Default = 0</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>ScaleInHi</td><td>77</td><td>Set or read a high input value at which you know what display you require. Default = 1</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>ScaleDisplayLo</td><td>76</td><td>Set or read a low display value for the input value stated in b. Default = 0</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>ScaleDisplayHi</td><td>78</td><td>Set or read a high display value for the input value stated in ScaleInHi. Default = 1</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>OpMode</td><td>122</td><td>Selects the operational mode.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Items Mode
Each of the configured input values are displayed one at a time and the Next button can be used to step through them.</td></tr>
<tr><td>1</td><td>Result Mode
The input values are summed and displayed.</td></tr>
</table></td><td>UINT8</td><td>RW</td></tr>
<tr><td>F1Data</td><td>128</td><td>Set or read what data to transmit when the F1 key is pressed.
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Always Gross
The gross value will be transmitted even if the display shows a zeroed net reading.</td></tr>
<tr><td>1</td><td>As Displayed
The gross or net value will be transmitted depending on what is selected at the time.</td></tr>
</table></td><td>UINT8</td><td>RW</td></tr>
<tr><td>F1DataTag</td><td>127</td><td>Set or read the 2 byte Data Tag to use in the Data Provider packet that is transmitted when the F1 key is pressed.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>ExtZeroDataTag</td><td>80</td><td>Set or read the 2 byte Data Tag of the Data Provider Packet that will supply a system zero value. This value will be subtracted from the gross or net summed values. This allows the same handheld to be used with different sets of data providers each supplying its own system zero value.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>ExtZeroID</td><td>100</td><td>Set or read the ID of the device acting as external system zero.</td><td>BINARY 3 Bytes</td><td>RW</td></tr>
<tr><td>MotionBand</td><td>123</td><td>Specify an engineering units band that the readings must stay within for the duration of the MotionTime for the reading to be considered steady.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>MotionTime</td><td>124</td><td>Specify the duration in seconds for the motion detection to operate.</td><td>UINT8</td><td>RW</td></tr>
<tr><td>MsgDuration</td><td>125</td><td>Specifies the duration in milliseconds that messages are displayed. i.e. the message that shows Input 1 or Input 2 as items are selected.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>ItemDuration</td><td>126</td><td>Specifies the duration in seconds that individual item</td><td>UINT8</td><td>RW</td></tr>
</table>

		values are displayed (in Result mode) before automatically switching back to display the sum.		
ValueDataTag1	81	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID1	101	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag2	82	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID2	102	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag3	83	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID3	103	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag4	84	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID4	104	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag5	85	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID5	105	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag6	86	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID6	106	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag7	87	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID7	107	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag8	88	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID8	108	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag9	89	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID9	109	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag10	90	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID10	110	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag11	91	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID11	111	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
ValueDataTag12	92	Set or read the 2 byte Data Tag that is used to match a Data Provider packet to use as the input value 1.	UINT16	RW
ValueID12	112	Set or read the ID of the device acting as input 1. Used to wake the remote device when Wake key pressed in Items Mode.	BINARY 3 Bytes	RW
AllowNext	129	Determines whether to allow the ability to view individual items when in Result mode. Set to zero to disable or set to a number representing	UINT8	RW

		the number of seconds to hold down the **Next** key to activate this feature. Once activated the **Next** key steps through all input values. Once the device is powered off this feature would have to be activated again. (range:0 to 30 default:6)		
AllowSysZero	130	Determines whether to allow the ability to perform system zero by pressing and holding the **Tare** key. Set to zero to disable or set to a number representing the number of seconds to hold down the Tare key to perform the system zero. (range:0 to 30 default:12)	UINT8	RW
Reset	54	Restarts the device and utilises new channel and encryption keys if those have been changed and saved.	Command	
Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	
DoSysZero	120	Perform a system zero on all devices. This will remove the current input values so from this point on the current input will give a value of zero. This can be removed by issuing the **RmSysZero** command.	Command	
RmSysZero	121	Reset the system zero settings so values will represent the actual inputs.	Command	

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Power Supply

Recommend using alkaline AA cells as rechargeable are too low voltage and lithium may not be able to supply the current for the radio to start up.

Installation

There are no specific installation instructions.

T24-HR [Handheld Reader Roaming]

Overview

The T24-HR is a roaming handheld that can be used to view the reading supplied by an unlimited number of acquisition modules. The acquisition Data Tags or IDs do not need to be known beforehand.

The handheld will automatically wake any device on the same channel and encryption key.
An internal list is maintained of the top ***n*** number of acquisition modules ordered by signal level and a **Next** key on the handheld allows cycling through this list.
The list size (***n***) is variable between 2 and 20 and this enables the viewing experience to be tailored to particular applications.

The acquisition modules are identified by their 4 character hexadecimal Data Tags and these may be set using the T24 Toolkit.

When in communication with a particular acquisition module the LED on that module is activated. This provides visual feedback of the selected and currently viewed module. The LED output can also appear optionally on the digital output.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

Parameter	Command Number	Description	Native Data Type	Read / Write
ID	3	Read the unique identifier ID for this device. (3 bytes)	BINARY 3 bytes	R
Version	53	Read the firmware version.	FLOAT	R
Channel	11	Radio Channel	UINT8	RW
EncKey	15	The radio encryption key to operate on. Requires power cycle or Reset to enable. Not supported in this release.	BINARY 16 Bytes	RW
Power	12	Set or read the output power level. (range:0 to 100 default:100)	UINT8	RW
Name	10	Set or read a user defined name. (11 characters)	STRING 11 Bytes	RW
Model	51	Read the model number of the device.	STRING 11 Bytes	R
InputValue	60	The value that is being read by the device.	FLOAT	R
DisplayValue	61	The value being displayed by the device.	FLOAT	R
UseCSMA	18	Select whether to use Carrier Sense Multiple Access techniques on transmission. Value / Description: 0 — **Disabled** The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED 1 — **Enabled** The Carrier Sense Multiple Access will be enabled. See **Unslotted CSMA/CA** in **Appendix A**	UINT8	RW
BattLevel	69	The voltage measured on the battery.	FLOAT	R
OffDelay	62	Time period in minutes before switching off if no button is pressed. Setting to zero disables. (range:0 to 1440 default:5)	UINT16	RW
KeyTest	64	Set or read the state of the keys. Each time the keys are pressed the equivalent bit will be set. Set to zero to reset. This property is used in ATE to test the keypad.	UINT8	RW
Timeout	65	Set or read the time in seconds that if exceeded	UINT16	RW

		between receiving Data Provider packets from the paired device will cause the display to show ------. Default = 3 (range:0 to 65535 default:3)		
PairWait	67	Set or read the period in seconds that the handheld will wait for another device to pair when placed into pair mode. (range:0 to 65535 default:5)	UINT8	RW
Format	70	Set or read the format for the display. Here you can define how the value will be displayed and where the decimal point will appear. By including a non zero value this will define the resolution of the displayed value. i.e. the smallest step size of value changes. Default = 0000.001	STRING 8 bytes	RW
ZeroSupp	71	Set or read whether to show the value on the display with zero suppression. 0 = No zero suppression 1 = Zero suppression	UINT8	RW
Overload	73	Set or read the value of the display above which instead of the value being displayed 'Overload' will be displayed.	FLOAT	RW
DisplayUpdate	74	Set or read the interval between LCD updates. Default = 300	UINT16	RW
ScaleInLo	75	Set or read a low input value at which you know what display you require. Default = 0	FLOAT	RW
ScaleInHi	77	Set or read a high input value at which you know what display you require. Default = 1	FLOAT	RW
ScaleDisplayLo	76	Set or read a low display value for the input value stated in ScaleInLo. Default = 0	FLOAT	RW
ScaleDisplayHi	78	Set or read a high display value for the input value stated in ScaleInHi. Default = 1	FLOAT	RW
ListSize	79	Set or read the size of the internal list of Data Tags. Can be between 1 and 20.	UINT8	RW
Reset	54	Restarts the device and utilises new channel and encryption keys if those have been changed and saved.	Command	
Save	55	Save any changes made to parameters. Required before power cycling or issuing a Reset command. Requires 500mS recovery time after executing.	Command	

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Power Supply

Recommend using alkaline AA cells as rechargeable are too low voltage and lithium may not be able to supply the current for the radio to start up.

Installation

There are no specific installation instructions.

T24-SO [Serial Output]

Overview

This device creates a serial output which can include data from up to 8 devices and optionally sum them. The output is suitable for connecting to a printer, serial display or for feeding directly into a PC or PLC.
The actual serial output can be designed by the user using 25 line data parameters which can include free text or tokens which can represent real data. i.e. **<V1>** would be decoded as the value from input 1 when the output is triggered. (Note each parameter can contain multiple lines so an actual printed output can exceed 25 lines)
The serial output can consist of a single line of data suitable for feeding into an LED display module or a more complex multi-line result that can contain a mixture of fixed and variable data suitable for tickets, receipts etc for printed output.

Configuration

Once it has been determined how many devices are feeding data to this device you need to know the **Data Tag** that each of these devices are attaching to their Data Provider packets.
These Data Tags are then entered into the **ValueDataTagx** parameters. Once the rate at which this data arrives is known you can also enter the **Timeoutx** values.
Leave unused **ValueDataTagx** parameters with a value of zero to ensure that they are not checked for timeouts and do not contribute to gross or net sums.

When a data provider packet arrives whose Data Tag matches one of those in the **ValueDataTagx** parameters the value it contains will be placed in the **Valuex** parameter.

If data does not arrive from a device within the **Timeoutx** period then any reference to either the individual **Vx** tokens or one of the summing tokens will result in **------** rather than a numeric value.

The actual serial output can now be constructed using **Line1** to **Line20**. These parameters take text into which you can insert tokens. When a 'Print' is generated these lines are parsed and tokens replaced with the values they represent and the resulting data sent to the serial port.

A 'Print' is generated by either issuing a **DoPrint** command, activating switch input when **SwitchMode** is set to zero or by receiving a Data Provider packet whose Data Tag matches the **PrintDataTag** parameter.
When a 'Print' is executed each of the parameters Line1 to Line 20 will be parsed. Every token will be evaluated and replaced with the live value. The data from all 20 lines will be sent to the serial port with a delay of **LineDelay** milliseconds after each occurrence of the user line delay character.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

Parameter	Command	Description	Native Data Type	R/W
ID	3	Read the unique identifier ID for this device. (3 bytes)	BINARY 3 byte	R
Version	53	Read the firmware version.	FLOAT	R
Channel	11	The radio channel to operate on. (1-16) Requires power cycle or Reset to enable.	UINT8	RW
EncKey	15	The radio encryption key to operate on. Requires power cycle or Reset to enable. (16 bytes) Not supported in this release.	BINARY 16 byte	RW
Power	12	Set or read the output power level. (0-100%)	UINT8	RW
Name	10	Set or read a user defined name. (11 characters)	STRING 11 byte	RW
Model	51	Read the model number of the device.	STRING 9 bytes	R

<table>
<tr><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>UseCSMA</td><td>18</td><td>Select whether to use Carrier Sense Multiple Access techniques on transmission.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>Disabled
The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED</td></tr><tr><td>1</td><td>Enabled
The Carrier Sense Multiple Access will be enabled.</td></tr></table>
See Unslotted CSMA/CA in Appendix A</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Reset</td><td>54</td><td>Restarts the device and utilises new channel and encryption keys if those have been changed and saved. Note after a Reset the device will be asleep.</td><td>Command</td><td></td></tr>
<tr><td>Save</td><td>55</td><td>Save any changes made to parameters. Required before power cycling or issuing a Reset command.
Requires 500mS recovery time after executing.</td><td>Command</td><td></td></tr>
<tr><td>DoPrint</td><td>129</td><td>Trigger an output (Print). Note that the outputs will not trigger at a rate faster than the interval set by MinInterval.</td><td>Command</td><td></td></tr>
<tr><td>DoSySZero</td><td>98</td><td>Perform a system zero on all devices. This will remove the current input values so from this point on the current input will give a value of zero. This can be removed by issuing the RmSysZero command.</td><td>Command</td><td></td></tr>
<tr><td>RmSySZero</td><td>99</td><td>Reset the system zero settings so values will represent the actual inputs.</td><td>Command</td><td></td></tr>
<tr><td>Value1</td><td>60</td><td>Read or write the value used as input 1 which can be represented with the <V1> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value2</td><td>61</td><td>Read or write the value used as input 2 which can be represented with the <V2> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value3</td><td>62</td><td>Read or write the value used as input 3 which can be represented with the <V3> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value4</td><td>63</td><td>Read or write the value used as input 4 which can be represented with the <V4> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value5</td><td>64</td><td>Read or write the value used as input 5 which can be represented with the <V5> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value6</td><td>65</td><td>Read or write the value used as input 6 which can be represented with the <V6> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value7</td><td>66</td><td>Read or write the value used as input 7 which can be represented with the <V7> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Value8</td><td>67</td><td>Read or write the value used as input 8 which can be represented with the <V8> token and is used in generating the result (sum).</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Timeout1</td><td>100</td><td>Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 1 (Set in ValueDataTag1) exceeds this value then the <V1> token and any tokens using this value will result in '------' instead of a real value.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>Timeout2</td><td>101</td><td>Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 2 (Set in ValueDataTag2) exceeds this value then the <V2> token and any tokens using this value will result in '------' instead of a real value.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>Timeout3</td><td>102</td><td>Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 3 (Set in ValueDataTag3) exceeds this value then the <V3> token and any tokens using this value will result in '------' instead of a real value.</td><td>UINT16</td><td>RW</td></tr>
</table>

Timeout4	103	Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 4 (Set in ValueDataTag4) exceeds this value then the <V4> token and any tokens using this value will result in '------' instead of a real value.	UINT16	RW
Timeout5	104	Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 5 (Set in ValueDataTag5) exceeds this value then the <V5> token and any tokens using this value will result in '------' instead of a real value.	UINT16	RW
Timeout6	105	Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 6 (Set in ValueDataTag6) exceeds this value then the <V6> token and any tokens using this value will result in '------' instead of a real value.	UINT16	RW
Timeout7	106	Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 7 (Set in ValueDataTag7) exceeds this value then the <V7> token and any tokens using this value will result in '------' instead of a real value.	UINT16	RW
Timeout8	107	Read or write the timeout in milliseconds. If the time between receiving data from the device defined as input 8 (Set in ValueDataTag8) exceeds this value then the <V8> token and any tokens using this value will result in '------' instead of a real value.	UINT16	RW
Format1	110	Read or set the format of the output value of <V1> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format2	111	Read or set the format of the output value of <V2> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format3	112	Read or set the format of the output value of <V3> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format4	113	Read or set the format of the output value of <V4> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format5	114	Read or set the format of the output value of <V5> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format6	115	Read or set the format of the output value of <V6> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format7	116	Read or set the format of the output value of <V7> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
Format8	117	Read or set the format of the output value of <V8> This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
FormatSum	118	Read or set the format of the output value of the **<GRO>** and **<NET>** tokens. This is specified using zeros and a decimal point. i.e. 000.0000	STRING 9 bytes	RW
ValueDataTag1	120	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
ValueDataTag2	121	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
ValueDataTag3	122	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored	UINT16	RW

		in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.		
ValueDataTag4	123	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
ValueDataTag5	124	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
ValueDataTag6	125	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
ValueDataTag7	126	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
ValueDataTag8	127	Read or set the 2 byte Data Tag of the Data Provider Packet that the device uses as input 1. This will be stored in Value 1 and is available to the token **<V1>** and the summing tokens **<GRO>** and **<NET>**. Leave as 0x00 to disable.	UINT16	RW
Line1	69	Read or set the data for line 1 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line2	70	Read or set the data for line 2 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line3	71	Read or set the data for line 3 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line4	72	Read or set the data for line 4 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line5	73	Read or set the data for line 5 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line6	74	Read or set the data for line 6 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line7	75	Read or set the data for line 7 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line8	76	Read or set the data for line 8 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line9	77	Read or set the data for line 9 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line10	78	Read or set the data for line 10 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line11	79	Read or set the data for line 11 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line12	80	Read or set the data for line 12 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line13	81	Read or set the data for line 13 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line14	82	Read or set the data for line 14 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line15	83	Read or set the data for line 15 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line16	84	Read or set the data for line 16 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line17	85	Read or set the data for line 17 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line18	86	Read or set the data for line 18 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
Line19	87	Read or set the data for line 19 of the serial output. You	STRING 32	RW

		can include text or tokens.	bytes	
Line20	88	Read or set the data for line 20 of the serial output. You can include text or tokens.	STRING 32 bytes	RW
ExtZero	68	Read the value derived from another device when **ExtZeroDataTag** is set. (The system zero is a value contained in the data from an external device)	FLOAT	R
ExtZeroDataTag	119	Set or read the 2 byte Data Tag of the Data Provider Packet that will supply a system zero value. This value will be subtracted from the gross or net summed values. This allows the same T24-SO assembly to be used with different sets of data providers each supplying its own system zero value.	UINT16	RW
PrintDataTag	128	Set or read the 2 byte Data Tag of the Data Provider Packet that will trigger a 'print'. The value contained in this packet can be referenced using the **<F1>** token.	UINT16	RW
LineDelay	130	Reads or sets the number of milliseconds between each line being sent out. This is useful to control the rate that a page is sent to a printer for example.	UINT16	RW
MinInterval	131	Set or read the sets the minimum interval between 'Prints'.	UINT16	RW
LogNumber	132	Set or read the log number that will be used next time a 'Print' output is generated.	FLOAT	RW
LogDigits	133	Set or read the number of digits to display the log number as.	UINT8	RW
NVLog	149	Set or read whether to store the log number between power cycles. As this writes to flash each time the <LOG> token is referenced it is recommended that this is set to zero (Off) if the log number is referenced at a rate greater then every 30 seconds.	UINT8	RW
Duplicate	134	Set or read whether to generate two 'Print' outputs for every trigger. This can be used with printers that do not have carbon copy capability.	UINT8	RW
SwitchMode	135	Set or read the action to take when the switch input is activated. Value | Description 0 | Perform 'Print'. 1 | Toggle between gross mode and net mode. When entering net mode all inputs will be tared.	UINT8	RW
NetMode	136	Set or read the mode of operation. Set to true to tare the inputs and enter net mode. Set to zero to remove tares and enter gross mode. Value | Description 0 | Remove tares and enter gross mode. 1 | Tare the inputs and enter net mode	UINT8	RW
Gross	145	Read the gross sum of all active inputs. Equivalent of value generated for <GRO> token.	FLOAT	R
Net	146	Read the net sum of all active inputs. Equivalent of value generated for <NET> token.	FLOAT	R
GrossText	137	Read the set the text used to replace the <GN> token when in gross mode.	STRING 10 bytes	RW
NetText	138	Read the set the text used to replace the <GN> token when in net mode.	STRING 10 bytes	RW
PrintOnError	139	Read the set whether to trigger a 'Print' output when an error first occurs on any of the inputs.	UINT8	RW

This is useful when there is only one input and that input is used to trigger the 'Print' output. Without this parameter being set a loss of the data would not trigger the 'Print'. With this set, once the data is lost the output will be triggered and any reference to the input value would appear as ------.

Value	Description
0	**Do not** trigger a 'Print' when loss of data/communications occur.
1	Trigger a 'Print' when loss of data/communications occur.

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

Tokens

The following tokens can be inserted into the **Line1** to **Line20** parameters and are decoded when a 'Print' output is triggered. Tokens are enclosed in triangular brackets.

Token	Function	Example
<V1> … <V8>	Substitutes token with the last value received from the input. This will already have system zero subtracted (If a DoSysZero command has been issued.) and tare subtracted. (If a DoTare command has been issued or the switch input has executed a tare.)	1.2345
<GV1> … <GV8>	Substitutes token with the last value received from the input. This will already have system zero subtracted (If a DoSysZero command has been issued.) but no tare subtracted. i.e. it will always contain the Gross value of the specified input.	1.2345
<RV1> … <RV8>	Substitutes token with the last value received from the input. This will NOT have system zero or tare values subtracted.	1.2345
<TV>	Substitutes token with the value carried in the Data Provider packet that has triggered the 'Print'.	1.2345
<LOG>	Substitutes token with the log value. Each time a 'Print' occurs the log number will be incremented.	0003
<G>	Substitutes token with the Gross sum of all active inputs. System zero values will have been extracted.	1.2345
<N>	Substitutes token with the Net sum of all active inputs. System zeros will have been subtracted and also if a Tare has been issued then the tare value will be extracted.	1.2345
<EZ>	Substitutes token with the External System Zero.	1.2345
<GN>	Substitutes token with the GrossText or NetText parameter contents depending on the NetMode.	Gross
<xx>	Substitutes token with the ASCII character whose ASCII value is xx where xx is a two digit hexadecimal value. i.e. <0D>	ÆӨ-ü■

Below are listed some useful hex codes.

Hex Value Token	Description
<0D>	Carriage Return
<0A>	Line Feed
<09>	Tab
<1B>	Escape

Configuration Examples

LED Display From a Single Source

We want to put data from a T24-SA onto a large LED display.
We will use the out of the box rate of 3 per second. The display only needs the ASCII data followed by a carriage return.

Assuming the T24-SA sends its data on Data Tag C675

```
Line1=<V1><0D>
V1Format=00.000
Timeout1=2000
ValueDataTag1=C675
PrintDataTag=C675
MinInterval=100
LineDelay=0
PrintOnError=1
SwitchMode=1
```

Summed LED Display From Dual Source

We want to put the summed Net data from a pair of T24-SAs onto a large LED display. We want the switch input of the T24-SO to toggle between Gross and zeroed net mode. (The printed output will reflect whether the device is in gross or zeroed net mode).
We will use the out of the box rate of 3 per second. The display only needs the ASCII data followed by a carriage return.
Assuming the T24-SAs send data on Data Tag C675 and FF34

Parameter settings:

```
Line1=<NET><0D>
FormatSUM=00.000
ValueDataTag1=C675
ValueDataTag2=FF34
PrintTrigger=C675
MinInterval=100
LineDelay=0
PrintOnError=1
SwitchMode=1
```

Print Gross Sum of 2 Devices To Printer

We need to print the gross sum of 2 devices to a printer with each time the switch input is activated on the T24-SO.
We need to display the value of each input as well as the gross sum.
The printer is not very fast so we can only send a line every 50mS. Also we do not want to print more often than once every 30 seconds even if the switch is pressed.
We want the printed output to look like:

```
Mantracourt Electronics Ltd
Weigh Station #1

Input 1: xx.xxxx Kg
Input 2: xx.xxxx Kg

--------------------
Sum:     xx.xxxx Kg

For assistance call
0871 345672
```

Parameter settings:

```
Line1=Mantracourt Electronics Ltd<0D><0A>
Line2=Weigh Station #1<0D><0A>
Line3=<0D><0A>
Line4=Input 1:<V1> Kg<0D><0A>
Line5=Input 2:<V2> Kg<0D><0A>
Line6=--------------------<0D><0A>
Line7=Sum:    <GRO>Kg<0D><0A>
```

```
Line8=<0D><0A>
Line9=For assistance call<0D><0A>
Line10=0871 345672<0D><0A>
V1Format=00.0000
V1Format=00.0000
SumFormat=00.0000
V1Trigger=C675
V1Trigger=FF34
PrintTrigger=0000
LineDelay=50
MinInterval=10000
SwitchMode=0
```

Customer Ticket From Handheld Device

We have a handheld device T24-HA already configured to sum data from 4 devices. We want the F1 button on the handheld to trigger a printout to a serial printer connected to the T24-SO.
We only want to print the gross sum that the handheld passes us. The handheld is configured to send the Gross value as Data Tag **ABCD** when the **F1** button is pressed.
The printer is not very fast so we can only send a line every 50mS. Also we do not want to print more often than once every 5 seconds even if the handheld tries to do so.
We also want two tickets printed each time it is triggered.
We want the printed output to look like:

```
Mantracourt Electronics Ltd
Weighment: xx.xxxx Kg
```

Parameter settings:

```
Line1=Mantracourt Electronics Ltd<0D><0A>
Line2=Weighment: <F1> Kg<0D><0A>
SumFormat=00.0000
PrintTrigger=ABCD
LineDelay=50
MinInterval=5000
Duplicate=1
```

LED Mode Indication

The red LED indicates certain states and modes:

LED Operation	Mode / State
Red Blinking	Device is operational

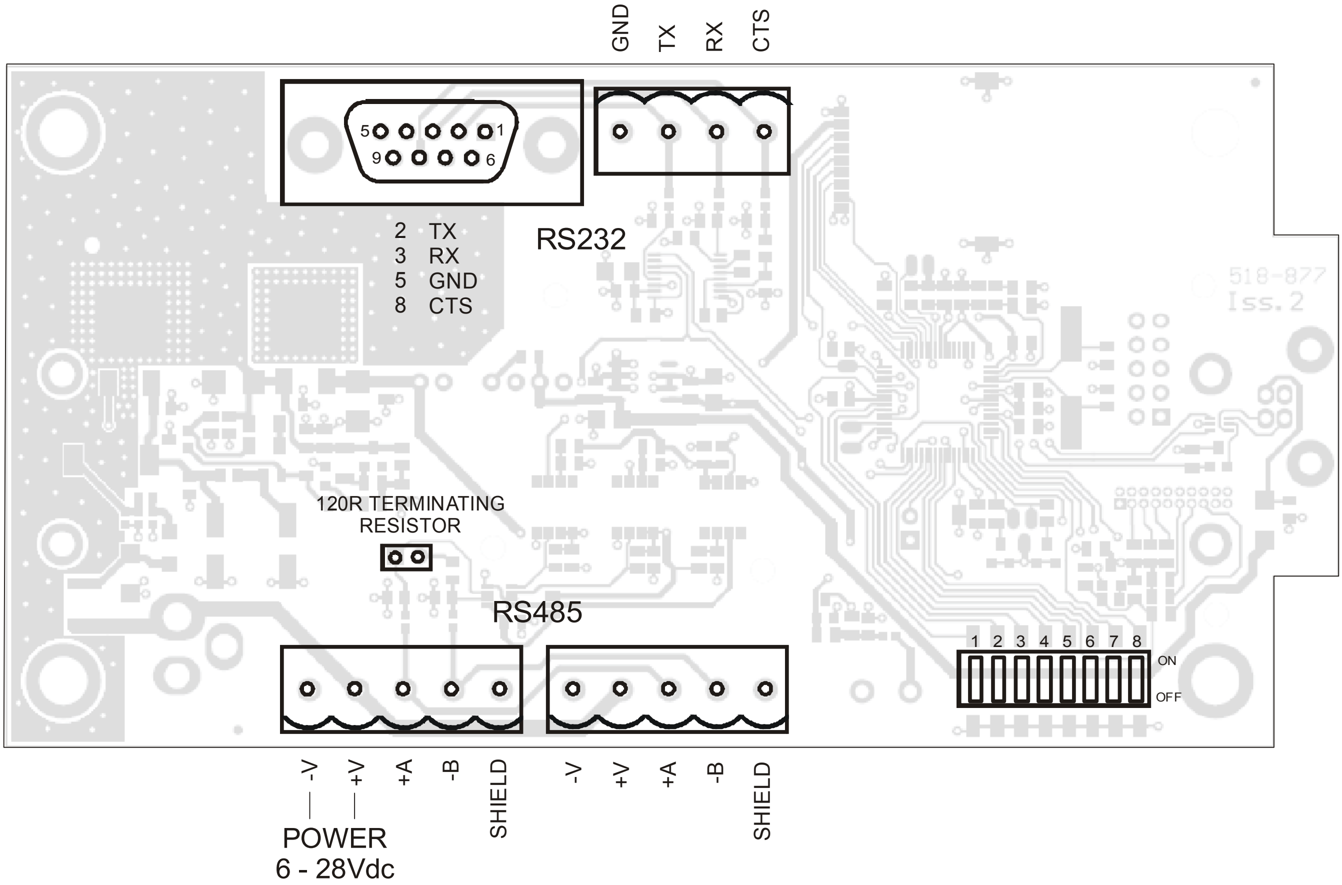
Power Supply

6 to 28 Volts dc.

Installation

The case can be mounted on a ceiling or wall.
The module can be removed from the case and fitted to a DIN rail using an option kit.

Connections



Serial Settings

The serial output is set at 8 data bits, 1 stop bit and no parity. The baudrate can be selected as can RS232 or RS485 operation.

SW1 Settings
Switch positions 1 to 4 are not used.

Switch positions 5 to 7 control the baudrate for the serial interface. Whether the serial interface is RS485 or RS232 is selected by switch position 8.

	5	6	7
Baudrate / USB			
NA	Off	Off	Off
9600	On	Off	Off
19200	Off	On	Off
38400	On	On	Off
57600	Off	Off	On
115200	On	Off	On
230400	Off	On	On
460800	On	On	On

This switch position selects whether the serial interface is RS232 or RS485.

	8
232/485	
RS232	Off
RS485	On

T24-AO1 [Analog Output]

Overview

The T24-AO1 and T24-AO1i provides an analogue output for the acquisition modules such as T24-SAx and T24-SAFx. The T24-AO1i is housed in an IP67 housing for industrial installation whilst the T24-AO1 is designed for desktop mounting.
The output can be selected from the following pre-calibrated Voltage and Current ranges. 0-10Volts, +/-10Volts, 0-5Volts, +/-5Volts, 0-20mA, 4-20mA both of which can be used in a 'sink' or source mode.
The T24-AO1 is configured by entering engineering values against the Output Minimum and Maximum Values. The analogue output is updated at a rate configured by the acquisition module 'TXInterval'.

LED's and in the case of the T24-AO1i, open collector outputs, provides indication of the state of the radio link, remote battery life and remote status.
A digital Input allows for zeroing of the incoming data value.

Configuration

The T24-AO1 is configured by setting the Data Tag of the device whose data you wish to reflect onto the analog output.
Once you know the data tag you then need to work out which calibrated values from the acquisition module you want represented by the selected analog output minimum and maximum levels.
For example: A T24-SA has been calibrated to give 0 to 10 tonnes output. You have selected a 4-20mA analog output and want the output to give 4mA at 0 tonnes and 20mA at 8 tonnes. Simply set the **In Minimum** to 0 and **In Maximum** to 8.
Next you set the desired actions when errors occur.

Communications

To configure the device you will use the Read and Write mechanisms described in the **Data Packet Structures** section to read and write parameters and execute commands.

Parameter List

<table>
<tr><th>Parameter</th><th>Command</th><th>Description</th><th>Native Data Type</th><th>R/W</th></tr>
<tr><td>ID</td><td>3</td><td>Read the unique identifier ID for this device. (3 bytes)</td><td>BINARY 3 byte</td><td>R</td></tr>
<tr><td>Version</td><td>53</td><td>Read the firmware version.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>Channel</td><td>11</td><td>The radio channel to operate on. (1-16) Requires power cycle or Reset to enable.</td><td>UINT8</td><td>RW</td></tr>
<tr><td>EncKey</td><td>15</td><td>The radio encryption key to operate on. Requires power cycle or Reset to enable. (16 bytes) Not supported in this release.</td><td>BINARY 16 byte</td><td>RW</td></tr>
<tr><td>Power</td><td>12</td><td>Set or read the output power level. (0-100%)</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Name</td><td>10</td><td>Set or read a user defined name. (11 characters)</td><td>STRING 11 byte</td><td>RW</td></tr>
<tr><td>WakerDuration</td><td>17</td><td>Set or read the duration in milliseconds to wait for a device to wake.</td><td>UINT16</td><td>RW</td></tr>
<tr><td>Model</td><td>51</td><td>Read the model number of the device.</td><td>STRING 9 bytes</td><td>R</td></tr>
<tr><td>UseCSMA</td><td>18</td><td>Select whether to use Carrier Sense Multiple Access techniques on transmission.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>Disabled
The Carrier Sense Multiple Access will be disabled. NOT RECOMMENDED</td></tr><tr><td>1</td><td>Enabled
The Carrier Sense Multiple Access will be enabled.</td></tr></table>
See Unslotted CSMA/CA in Appendix A</td><td>UINT8</td><td>RW</td></tr>
<tr><td>Reset</td><td>54</td><td>Restarts the device and utilises new channel and encryption keys if those have been changed and saved. Note after a Reset the device will be asleep.</td><td colspan="2">Command</td></tr>
<tr><td>Save</td><td>55</td><td>Save any changes made to parameters. Required before</td><td colspan="2">Command</td></tr>
</table>

<table>
<tr><td></td><td></td><td>power cycling or issuing a Reset command.
Requires 500mS recovery time after executing.</td><td colspan="2"></td></tr>
<tr><td>SelectedRange</td><td>60</td><td>Returns the currently selected output range.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>0V to +5V</td></tr><tr><td>1</td><td>-5V to +5V</td></tr><tr><td>2</td><td>0V to +10V</td></tr><tr><td>3</td><td>-10V to +10V</td></tr><tr><td>4</td><td>0 to 20mA (sink)</td></tr><tr><td>5</td><td>4 to 20mA (sink)</td></tr><tr><td>6</td><td>0 to 20mA (source)</td></tr><tr><td>7</td><td>4 to 20mA (source)</td></tr></table></td><td>UINT8</td><td>R</td></tr>
<tr><td>ErrorState</td><td>61</td><td>Read the current error state. Each bit value represents a different state.
<table><tr><th>Bit Value</th><th>Description</th></tr><tr><td>1</td><td>Timeout</td></tr><tr><td>2</td><td>Remote Error</td></tr><tr><td>4</td><td>Remote Battery</td></tr><tr><td>8</td><td>Scaling Error</td></tr></table></td><td>UINT8</td><td>R</td></tr>
<tr><td>Value</td><td>62</td><td>Read the current input value.</td><td>FLOAT</td><td>R</td></tr>
<tr><td>InMin</td><td>100</td><td>The input value at which the output will be at 0%.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>InMax</td><td>101</td><td>The input value at which the output will be at 100%.</td><td>FLOAT</td><td>RW</td></tr>
<tr><td>Timeout</td><td>102</td><td>The time allowed between data arrivals greater than which will trigger the TimeOutAction.</td><td>INT32</td><td>RW</td></tr>
<tr><td>TimeoutAction</td><td>103</td><td>Select the action to trigger when data does not arrive for the Timeout period.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>None</td></tr><tr><td>1</td><td>Minimum Full Scale</td></tr><tr><td>2</td><td>Maximum Full Scale</td></tr><tr><td>3</td><td>Minimum Output</td></tr><tr><td>4</td><td>Maximum Output</td></tr><tr><td>5</td><td>Half Full Scale</td></tr><tr><td>6</td><td>Hold Last Output</td></tr></table></td><td>UINT8</td><td>RW</td></tr>
<tr><td>RemoteErrAction</td><td>104</td><td>Select the action to trigger when the remote device reports an error.
<table><tr><th>Value</th><th>Description</th></tr><tr><td>0</td><td>None</td></tr><tr><td>1</td><td>Minimum Full Scale</td></tr><tr><td>2</td><td>Maximum Full Scale</td></tr><tr><td>3</td><td>Minimum Output</td></tr><tr><td>4</td><td>Maximum Output</td></tr><tr><td>5</td><td>Half Full Scale</td></tr><tr><td>6</td><td>Hold Last Output</td></tr></table></td><td>UINT8</td><td>RW</td></tr>
</table>

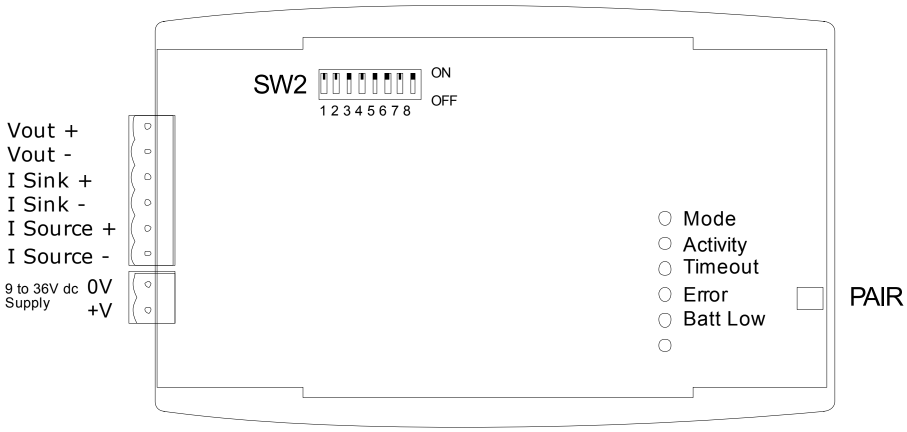
RemoteBattAction	105	Select the action to trigger when the remote device reports low battery. Value / Description: 0 – None 1 – Minimum Full Scale 2 – Maximum Full Scale 3 – Minimum Output 4 – Maximum Output 5 – Half Full Scale 6 – Hold Last Output	UINT8	RW
Smoothing	106	Select whether to smooth the output. When activated this will result in a latency of the interval between data packets arriving.	UINT8	RW
PairWait	107	The time to wait in seconds when pairing after pressing the Pair switch.	UINT8	RW
BoundDataTag	108	The Data Tag of the data being used to set the output.	UINT16	RW
ZeroValue	109	Set or read the system zero value which is subtracted from the value of the data arriving before mapping to the analog output.	FLOAT	RW
DoWake	110	Whether to wake paired module on power up. (1 or 0)	UINT8	RW
BoundID	111	Set or read the ID of the bound device. Used to wake the remote device.	BINARY 3 Bytes	RW

NOTE: All changes require a SAVE command to enable them to survive through power cycle or RESET command.

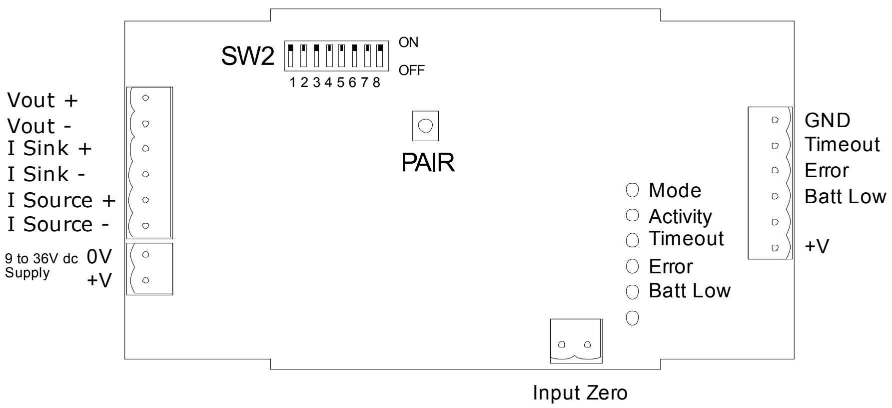
Connections

Depending on the analog output device you have you will need to refer to one of the two following diagrams:

T24-AO1



T24-AO1i



Output Range Setting

To configure the required output range the DIP switches (SW2) require setting as follows. To access the DIP switches you will need to remove the cover from the case.

	SW2 Switch Settings							
Range	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
0-10 V	ON	OFF	OFF	X	X	OFF	ON	OFF
+/-10 V	OFF	OFF	ON	X	X	OFF	ON	ON
0-5 V	ON	ON	OFF	X	X	OFF	OFF	OFF
+/-5 V	ON	OFF	ON	X	X	OFF	OFF	ON
0-20 mA Sink	X	X	X	OFF	ON	ON	OFF	OFF
0-20 mA Source	X	X	X	ON	OFF	ON	ON	OFF
4-20 mA Sink	X	X	X	OFF	ON	ON	OFF	ON
4-20 mA Source	X	X	X	ON	OFF	ON	ON	ON

Where X = Don’t care

Appendix A

Communications Software Overview

Every T24 module has a unique 3 byte ID. This is represented by a 6 character hexadecimal number on its yellow label.
Acquisition modules also have a Data Tag which is a 2 byte identifier and defaults to the last 2 bytes of the ID (or the last 4 hexadecimal digits). This Data Tag is used to identify data that is transmitted by the modules in their operational mode.

Operational Modes

Acquisition devices that supply data have 3 main modes of operation:

Deep sleep

The module is effectively off and draws negligible power from the battery but cannot be communicated with (Except to wake it).

Default Running

This default mode is how the module operates when power is applied initially. The module transmits its measured value at a specified interval and can optionally operate in Low Power Mode where the module enters a temporary deep sleep between transmissions.

Paused

This mode is required when you want to configure or calibrate the module. In this mode the module will neither return to deep sleep because of its internal SleepDelay nor will it transmit its Data Provider packets.

Operation

The T24 range of acquisition modules are designed so that once configured they would operate autonomously supplying data to all other modules that require it. There would be minimal interaction with the modules and would normally only include sending a module to deep sleep or waking a module from deep sleep.

Configuration

When initially setting up a module the T24 Toolkit is used to connect to a module and allows simple configuration or calibration.
As can be seen from the 3 operational modes listed above this is not always easy as the module may be asleep or operating in low power mode where communications cannot take place.
The T24 range of modules support PAIRING. This is supported by the T24 Toolkit software and is also available through the documented radio protocol. It is initiated by power supply removal and replacement so is not suitable for all occasions such as when the module batteries are not accessible. PAIRING has a distinct advantage in that forehand information about the target module is not required. PAIRING ensures that the radio channels are matched between the base station and the module and the ID of the module is not needed to be known beforehand. Also pairing can be used to make the module enter the PAUSED mode so it can be communicated with (As in the case of the T24 Toolkit) or just identified and then made to continue with its default run mode.
If pairing is not employed then a manual means of connecting to the module is required. NOTE: this is only required for configuration as once configured you would just consume the Data Provider packets and possibly wake/sleep so would not need to pair or otherwise connect to the module.
To configure a device that is in Deep Sleep it is first woken. This can be achieved by using a broadcast wake where ALL modules on the current radio channel will wake, or wake by ID where just the specific module is woken. This is preferred otherwise with multiple modules woken and in default running mode there may be lots of traffic from Data Providers being transmitted which will interfere with the connection/configuration process.
Once the module has been woken it will enter its default running mode and will be transmitting data provider packets. If the module is not running in low power mode then you could communicate directly using read/write packets to perform the configuration. It is recommended though to issue a Pause command to stop the module transmitting data providers and also stopping it going back to sleep after the SleepDelay time has elapsed if that is enabled.

If the module was operating in low power mode you cannot communicate using the usual read/write commands as

the module is mostly asleep so communications would be poor. In this case we use the Data Provider Control Interface to pause the module. This is a packet sent out as soon as a data provider packet is seen arriving. Once the module is paused you can continue with the configuration. After configuration and saving the module can be set running again with a targeted Continue/Resume command or it can be reset. Some changes may require a reset to activate.
NOTE: modules *do not* sleep when in Paused mode so will not sleep due to a direct command nor when the SleepDelay period would normally trigger. Therefore if you wish to send a module to sleep after configuration a sleep command should be sent followed by a continue/resume command.

Data Acquisition

If a module has been configured such that its battery life is acceptable for the given transmission rate it may be that it never has to enter deep sleep mode. In this case the data provider packets are available to all devices at all times and no interaction is ever required. i.e. transmission rate of 1 per second using a pair of AA batteries may yield 2.5 months of continuous operation.
When this battery life is not enough it can be extended by sending the acquisition module to sleep when it is not required. Thus the above example when used for 10 sessions lasting 6 minutes each per day utilising sleeping and waking will yield a battery life of 4.5 years!
It is recommended that the acquisition modules take advantage of the SleepDelay parameter which sets a period which once expired without the module receiving a KeepAwake command will cause the module to return to deep sleep mode. This ensures that the modules return to sleep even if communications is lost with the controller.

So we will look at an example scenario where an acquisition module sits in deep sleep for most of the day. An operator then uses a device to wake the module, take a few readings, then sends the module back to sleep again. The module can be woken with either a broadcast WAKE or a WAKEBYID. If a broadcast wake is used then ALL modules on the same radio channel will wake. If you target the wake to a specified ID then only that module will wake.
Once woken the module will be operating in default running mode and will transmit its value at the configured rate. Because we have activated the SleepDelay in the module we may need to issue STAYAWAKE commands to stop the module returning to deep sleep mode. NOTE: this may not be required if, for example, a SleepDelay of 30 seconds is used and you just rely on this to send the module to sleep. This is OK if the duration of the session is known to be less than the SleepDelay time. If not then use the STAYAWAKE commands to keep the modules awake until finished with.
To issue STAYAWAKE packets it is best to use the Data Provider Control Interface to periodically respond to the arrival of the data provider packets from the module.
Once the session has ended you can either stop issuing STAYAWAKE packets so the module sleeps due to its SleepDelay or you can force the module to sleep by just issuing a normal SLEEP command.
Depending on what drivers you are using you may have different options to achieve the above.
The following explains how to receive data provider packets, wake, issue StayAwake packets and sleep and for different drivers supplied by Mantracourt.

Windows DLL

Function	How To
Data Provider Packets	Callback activated when data provider packets arrive.
Wake	Use WRITEREMOTE function specifying the command number 50 and use the specific module ID or FFFFFF for broadcast wake
Pause	Via Data Provider Control Interface using WRITEPACKET
StayAwake	Via Data Provider Control Interface using WRITEPACKET
Sleep	Use WRITEREMOTE function to send appropriate sleep command to specific (or broadcast) ID

COM Driver or Dot Net Assembly

Function	How To
Data Provider Packets	An event will be raised which lets you know the Data Tag and the Value of the arriving data.
Wake	WakeByID(BaseStation,DeviceID) or WakeBroadcast(BaseStation)
Pause	Via Data Provider Control Interface using WritePacketNumeric i.e. **WritePacketNumeric**(1, DataTag, 0, 2, 255)
StayAwake	BroadcastStayAwake()
Sleep	Use SleepByDataTag(DataTag) or SleepBroadcastByDataTag() or RemoteWrite(BaseStation, ID, SleepCommand, “”)

Documentation for specific drivers supplied by Mantracourt will be included with the actual drivers which are available on the T24 Resource CD. This includes Windows DLL, Windows COM driver, Windows CE DLL and Windows CE Dot Net Assembly.

Data Type Formats

The following data formats are used when communicating with the base station. These formats apply to the raw data in the packets and also to the data parts of the Mantracourt supplied T24drv.dll driver.

Value	Data Type	Number Of Bytes	Example	Notes
1	UINT8	1	01	
2	UINT16	2	00 01	MSB First
3	INT32	4	00 00 00 01	MSB First
4	Float	4	3F 80 00 00	See Floating Point IEEE
5	String	0-64	Hello World	
6	Binary	0-64	"£$%^&*(	

UINT8

Represents an unsigned numeric value from 0 to 255 and consists of a single byte.

Byte							
7	6	5	4	3	2	1	0

UINT16

Represents an unsigned numeric value from 0 to 65535 and consists of 2 bytes. The bytes are in order of significance MSB first.

MSByte								LSByte							
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

INT32

Represents a signed numeric value from -2,147,483,648 to positive 2,147,483,647 and consists of 4 bytes and is stored in 2's compliment form. The bytes are in order of significance MSB first.

MSByte																								LSByte							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	16	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Sign Bit																															

Float

Represents a numeric value from n to n and consists of a 4 byte in IEEE 754 format.

MSByte																								LSByte							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	16	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	Exponent (7-bit excess-127)								Mantissa (-bit fraction with implicit 1)																						
Sign Bit																															

The byte containing the sign and exponent is sent first, with the LS byte of the mantissa being last.
The value of the number is thus

```
(-1)Sign * 2(Exponent-127) * 1.Mantissa
```

Note the 'assumed 1' before the mantissa. The exception to this is the special value 0.0, which is represented as 4 zeroes.
The precision of this format is to 7 digits.
eg. a floating-point number of -12345.678 is represented as - [hex] C640E6B6

String

Represents a textual string and is terminated by a NULL (ASCII 0).

Binary

The bytes have no set meaning and are just a string of bytes. These bytes can be any value and may contain non ASCII characters.

RSSI, CV and LQI

Packets received from remote devices have RSSI and CV bytes present at the end of the packet.

RSSI is Received Signal Strength Indication
This indicates the strength of the received signal. This approximates to dB and can be calculated from the RSSI byte which is stored in 2's compliment format. This value also has an offset of 45.
To convert the byte value to RSSI use the following algorithm.

```
RSSI = RSSIBYTE
If RSSI > 127 Then RSSI = ((RSSI - 1) Xor 0xFF) * -1
RSSI = RSSI - 45
```

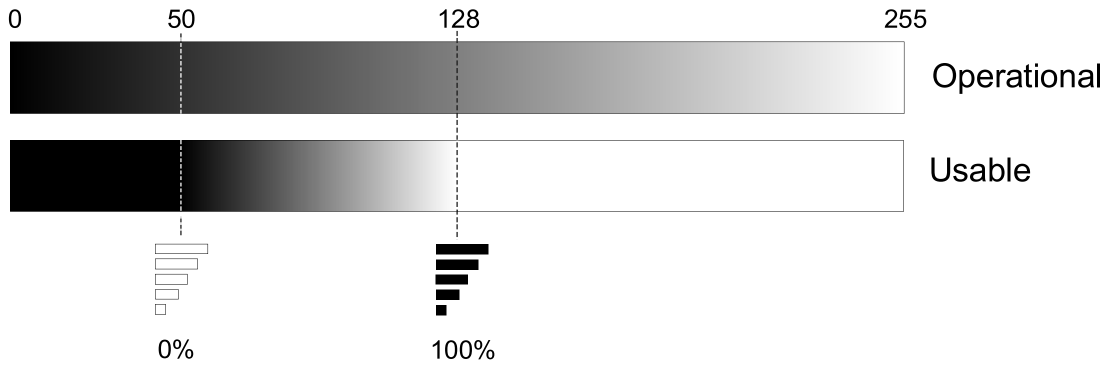
CV is Correlation Value
This indicates the quality of the signal. The value of the CV byte (0-255) needs the most significant bit masking off (AND with &H7F) where a poor CV is around 55 and a good CV is 110.

```
CV = CVBYTE
CV = CV AND &H7F
```

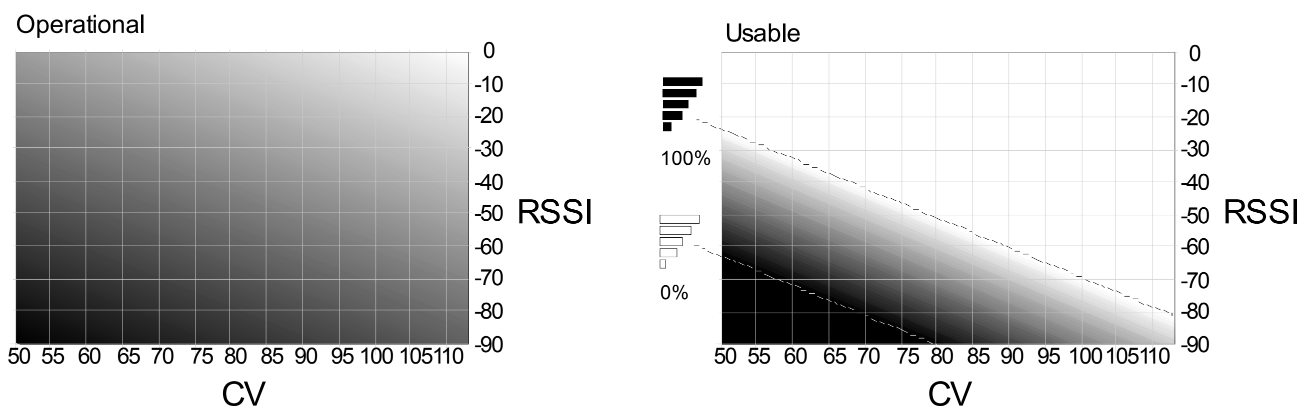
LQI is Link Quality Indication
Mantracourt may also refer to **Link Quality** which is derived from the RSSI and CV values:

```
LQI = (((94 + RSSI) + (CV - 55)) / 2) * 3.9
```

Which gives an **operational** range of approximately 0 to 255.
This operational range covers the extremes of very poor to very good connection quality so we usually take a portion of this to represent the **usable** range which gives the user a better representation of usable, real-world quality.
The LQI range from 50 to 128 can be thought of as to represent 0-100% **usable** quality.
This reduced portion of the range represents the **usable** range and may be represented, for example, by a signal strength indicator as found on a mobile/cell phone.



The charts below indicate the operational and usable combinations of RSSI and CV where black is poor and white is good.



Unslotted CSMA/CA

Most of the T24 range of devices will allow you to turn off the CSMA (Carrier Sense – Multiple Access).
This is recommended to be turned on but in some circumstances turning it off will increase data rate and reduce latency. For example a single deice transmits at 200Hz. With no other device on this channel CSMA can be disabled giving a more accurate 200Hz transmission.
CSMA is implemented to reduce the collisions between packets from different devices.

With CSMA Disabled

When a device wants to transmit it checks the channel to see if another device is transmitting. If not then the transmission takes place immediately. If the channel is busy then the transmission will occur as soon as the channel has been detected as clear.

With CSMA Enabled

When a device wants to transmit it checks the channel to see if another device is transmitting. If the channel is busy then we wait until it is clear.
Now we back off for a random period.
The first time we back off one of the following periods is randomly selected:

320uS	640uS	960uS

If the channel is now clear then the transmission takes place.
If the channel is busy then a new random backoff period is selected from the following:

320uS	640uS	960uS	1.28mS	1.600mS	1.920mS	2.240mS

If the channel is now clear then the transmission takes place.
If the channel is busy then a new random backoff period is selected from the wider range and the procedure repeated.

Certain packets are transmitted as if CSMA is disabled regardless of the device setting. These include the sleep/wake packets and responses to requests.

Data Tag Control Interface (Advanced)

When acquisition devices are operating in low power mode it is not easy to communicate using the full read/write packets as most of the time the device is asleep. Also in some cases the consumer of the data only knows the Data Tag from the Data Provider packet and does not know the ID of the sender. Therefore we need to utilise a control interface within the Data Provider packet scheme whereby devices such as a handheld can perform rudimentary control on another device while knowing no more than that devices default Data Tag.
Each device supplying data to a consumer only has one defined default data tag. We reuse that tag to enable communicating back to the data provider. This will not affect other consumers of the data as the data provider packet will contain a data type of FF which indicates our internal control interface.
All other consumers will automatically reject the FF data type anyway.
So to control the provider we simply send a data provider packet using the same data tag but containing data of type **FF** the data consists of a single **Function Byte** which has fixed functionality depending on its value. The status byte is not used and may be left at zero.

Value	Fixed Universal Function
0	None
1	SLEEP
2	PAUSE
3	STAYAWAKE
4	CONTINUE
5	DOSYSTEMZERO
6	REMOVESYSTEMZERO
7	SHUNTCALON
8	SHUNTCALOFF
9	DOTARE
A	REMOVETARE
B	LEDONUNTILNEXTTX

Using a Data Tag of FFFF will act as a broadcast data provider control interface and all recipients of an FFFF data tag will check the data type and if this is FF the device may perform the specified function.
To use this interface the sender must reply with the control interface packet within 8 milliseconds of receiving a Data Provider packet.

Packet Type	Data Tag		Status	Data Type	Function Byte
03	00	00	00	**FF**	00

Appendix B

Radio Range

When planning the installation of a radio net it is useful to consider a number of different arrangements and compare their relative merits before deciding on a final layout. One aspect to be considered is the useable signal strength at the receiver input represented by the Received Signal Strength Indicator (RSSI) figure.

RSSI is a negative number related to signal strength in dBm; a smaller number represents a stronger signal so -70 is much better than -80. To obtain a reliable link using Rad24 radios RSSI must be no worse than -85 to -90, beyond this figure packet loss rate increases and link quality drops off sharply. A table illustrating the relationship between receiver input power and RSSI is reproduced at Table 1 below.

Radiated energy diminishes over distance with an inverse square law; signal power is also lost due to absorption and scattering in the air between the transmit and receive antennas, these losses are referred to as Free Space Path Loss and vary according to the wavelength of the signal. At 2.4GHz Free Space Path Loss is given by:

Path Loss = $32.4+20\text{Log}_{10}\, d$

Where:
Path Loss is expressed in dB
d = Path length in metres

Example 1

Path Loss over 80metres = $32.4+20\text{Log}_{10}\, 80$

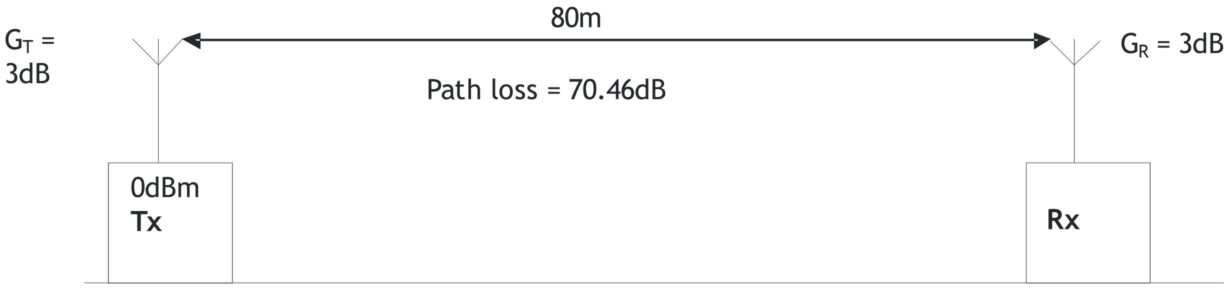
$20\text{Log}_{10}\, 80 = 38.06$

Path Loss = 32.4+38.06 = 70.46 dB

For convenience, Table 2 below gives path losses at range intervals of 5 metres.

Example 2

An estimate of signal power at the receiver input can be made by considering two Rad24i radios in the open separated by a distance of 80m. Rad24i output power is 0dBm and the peak gain of the integral antenna is 3dB as shown at Figure 1 below.



G_T = Gain of transmit antenna
G_R = Gain of receive antenna

Figure 1

Calculation of signal power at the receiver input is achieved by summing all the gains and then subtracting the sum of all the losses, in this case:

Signal power at the receiver input = (G_T+G_R) – Path Loss

or

6 – 70.46 = -64.46dBm

Signal power at the input of the receiver = -64.46dBm

Note that although the manufacturer's data sheet for the chip antenna gives gain as 3dBi Peak, this figure is rarely achieved in practice; between 1 and 1.5dBi is more usual.

Example 3

In practice the radios would be fitted inside enclosures and the antenna may be either inside the enclosure or mounted some distance from the radio and connected to it by an extended feeder. A practical example of this type is illustrated at Figure 2 below.

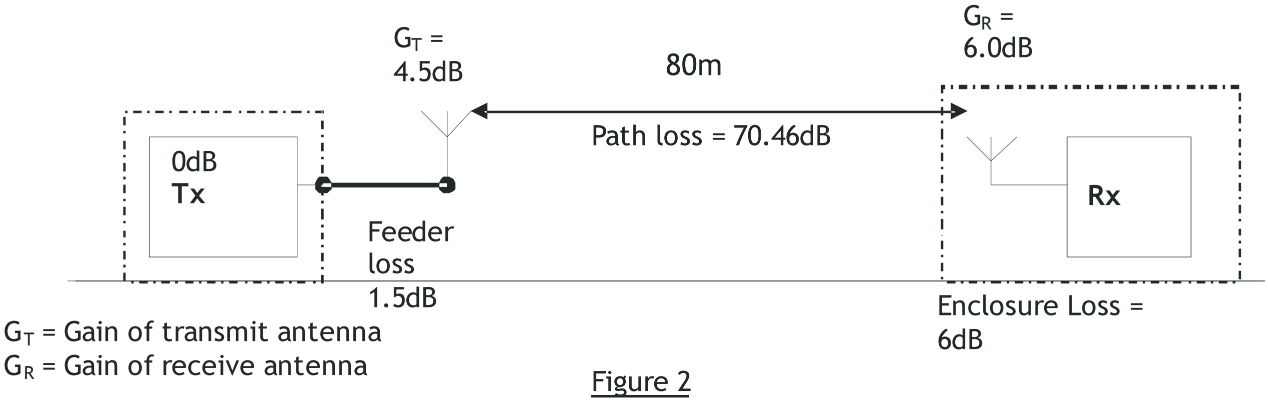


Figure 2

Sum of the gains = G_T+G_R

or: 4.5 + 6.0 = 10.5

Sum of the losses = Feeder Loss + Path Loss + Enclosure Loss

or: 1.5 + 70.46 + 6.0 = 77.96

Signal strength at the receiver input is: 10.5 – 77.96 = -67.46dBm

Refer to Table 1 below that relates receiver input power to RSSI, an input level of -67.46dBm will give an RSSI of around -74.

In this example the gain of the receive antenna and the receiver enclosure loss are identical and therefore cancel out, this is what happens in the T24-HS. In the case of the T24-BS however, peak gain of the PCB antenna is 6dB and the enclosure loss is between 3 and 5dB depending on composition of the ABS.

Example 4

In this final example a T24-SA is fitted inside a Loadlink transmitting data to a T24-BS base station. The T24-SA has an integral Rad24i radio and the Loadlink has been assembled with fibreglass RF windows for minimum signal loss. The T24-BS contains a Rad24e radio that is connected to an antenna of 2.9dBi gain by a 3m length of RG174 cable; attenuation at 2.4GHz is 1.67dB/metre in this cable assembly. The arrangement is illustrated at Figure 3.

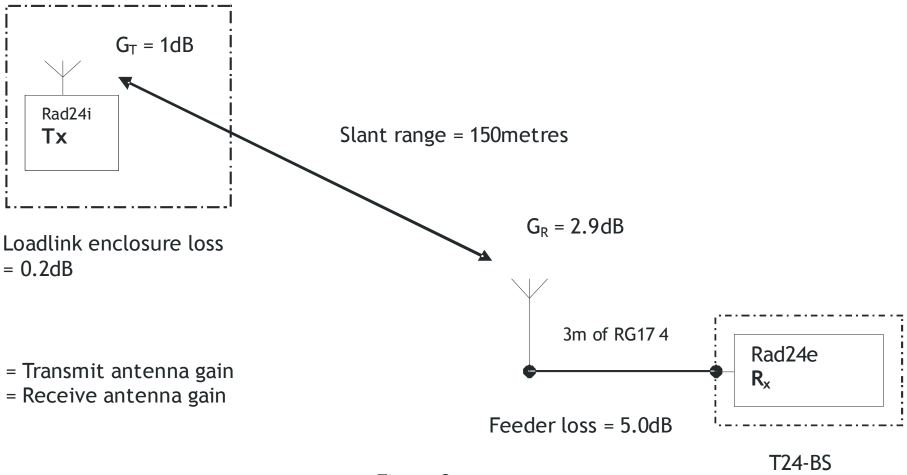


Figure 3

Sum of all the gains = $G_T + G_R$ = 1 + 2.9 = 3.9

Sum of all the losses = Enclosure loss + Path loss + Feeder loss
From the Path loss table we see that the loss over 150m is 75.92dB so the sum of losses is:

0.2 + 75.92 + 5.0 = 81.12

Subtract that from the sum of the gains: 3.9 – 81.12 = -77.22

So the estimated power at the receiver input is -77.22dBm

Refer to Table 1 below that shows the relationship between receiver input power and RSSI, an input level of -77.22dBm will result in an RSSI between -80 and -85.

Antenna Basics

Gain

For a particular antenna the stated gain figure applies only along the antenna bore-sight and often only in one plane; if the remote point is off-axis relative to the antenna electrical centre-line or bore-sight then the gain will depend on the degree of offset according to the polar diagram for that antenna.

For example, an antenna is advertised as having a gain of 12dBi and a beam-width of 60 degrees; this is normally taken to refer to the half power or -3dB beam-width. In other words the antenna gain at ±30degrees off the bore-sight will be 3db down on the peak gain or 9dBi. Beyond ±30 degrees off-axis the gain will be very much less.

For short vertical antennas of the “rubber duck” type the gain is fairly constant in the horizontal plane but the vertical beam-width may be as little as 12 degrees for a 9dB antenna making it necessary to mount the antenna slightly off vertical for best signal strength in a specific area; this of course means that the pattern on the opposite side might now be pointing into the ground or up in the air.

Polarisation

Antenna polar diagrams show coverage in terms of variations in gain over vertical and horizontal planes relative to the antenna. Depending on its method of construction the antenna will radiate the electric component of the Electro-Magnetic (EM) wave in one plane and the magnetic component in the other (Polar diagrams identify these two components as E for electric and H for magnetic). If the electric component of the EM wave is vertical then the antenna is said to be vertically polarised and vice-versa.

There are some exceptions to this (such as crossed and circular polarisation) but for the sake of simplicity they are not considered here.

For maximum power transfer all antennas on the same radio net must be mounted so that their signals have the same polarisation; it is sometimes possible to take advantage of this to allow operation of adjacent but otherwise unconnected radio nets on the same channel by having the antennas on one net vertically polarised and the other horizontally polarised.

Mounting Requirements

Objects or structures within the operating region of the antenna will distort the horizontal and vertical space pattern so that the antenna polar diagram no longer represents the actual coverage. For this reason, antennas should be mounted to maximise separation from buildings or structures and away from areas where large objects may be temporarily placed. This is usually achieved by fixing the antenna to a mast or tower by means of a bracket that allows adjustment of antenna orientation. The mounting method should also allow for adjustment of height as, very often, a small change in antenna elevation will improve signal strength.

Receiver Input Power and RSSI Relationship

During development of the Rad24 radio it was necessary to understand the relationship between signal power at the receiver input and the indicated RSSI figure. A calibrated signal source was used to set RSSI readings at intervals of 10 and the corresponding input levels recorded at each step. Figures in italics were not measured but extrapolated from the measured values.

Input signal power (dBm)	Indicated RSSI Value
-7	-10
-17	-20
-28.5	-30
-36.5	-40
-44.5	-50
-54	-60
-64	-70
-74	-80
-79	*-85*
-84	*-90*

Path Loss at 2.4GHz

Free Space Path Loss in dB = 32.4+20Log$_{10}$ d
Where d = Free space path length in metres

Path length (metres)	Loss (dB)	Path length (metres)	Loss (dB)	Path length (metres)	Loss (dB)	Path length (metres)	Loss (dB)
5	46.37	70	69.30	135	75.00	200	78.42
10	52.40	75	69.90	140	75.32	205	78.63
15	55.92	80	70.46	145	75.62	210	78.84
20	58.42	85	70.98	150	75.92	215	79.04
25	60.35	90	71.48	155	76.20	220	79.24
30	61.94	95	71.95	160	76.48	225	79.44
35	63.28	100	72.40	165	76.74	230	79.63
40	64.44	105	72.82	170	77.00	235	79.82
45	65.46	110	73.22	175	77.26	240	80.00
50	66.37	115	73.61	180	77.50	245	80.18
55	67.20	120	73.98	185	77.74	250	80.35
60	67.96	125	74.33	190	77.97	255	80.53
65	68.65	130	74.67	195	78.20	260	80.69

These figures are for free-space path loss only, when estimating signal power at the receiver input, take the sum of all the gains and then subtract the sum of all the losses.

Power Density

From the radar equation, power density at the target is given by:

$$Pd = \frac{PT\ GT}{4\pi\ r2}$$

Where:

Pd = Power density in W/m2
PT = Transmitter output power in Watts
GT = Antenna gain as a multiple of input power
r = Range to target in metres

From the Rad24 radio specifications:

Power output is 1mW Peak
Chip antenna peak gain is 3dBi or 2 times the input power

Measurement range is 20cm or 0.2m

```
Pd = 1x10-3 X 2
     12.568 X 0.22

Pd = 3.978x10-3 W/m2

Pd at 20cm range is 3.978mW/m2
```

Dividing this by 10,000 to express power density in W/cm2 gives:

```
397.8nW/cm2
```

This is the peak power density assuming the RF output is 1mW Continuous Wave; multiply this figure by the duty cycle and the average power density is reduced proportionately. Further, this calculation uses the peak gain of the chip antenna stated as 3dBi in the manufacturers data sheet, in practice this gain is rarely achieved being nearer to 1 to 1.5dBi.

RF Exposure Limits

Power density at the Rad24 Antenna is well below the Whole Body Average SAR (Specific Absorption Rate) of 80mW/Kg exposure limit given at ANSI/IEEE C95.1-2005 and OET Bulletin 65 Edition 97-01 dated August 1997. Under the terms of FCC CFR Title 47 Volume 1 Part 2.1091 and Part 2.1093 this equipment is categorically excluded from routine environmental evaluation for RF exposure.
Article 3(1) of Directive 2004/40/EC of the European Parliament and of the Council dated 29 April 2004 (The Physical Agents Directive) gives an Exposure limit for Whole Body Average SAR as 400mW/Kg. Rad24 Peak ERP is not more than 4mW assuming a 6dB antenna.

Appendix C

Customising T24 Toolkit

Some customers re-badge the Mantracourt instrumentation and this section explains how to ship a custom version of the T24 Toolkit with custom model names, images and descriptions.

To construct a customised setup the customer will need to create a sub-folder named **Custom** in the folder where the **setup.exe** file is located.

In this **Custom** folder you will need to have a file named **config.ini** and optionally a set of images in JPG or GIF format.

The config.ini file has the following structure:

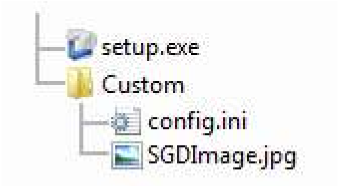
```
[Alias]
OriginalModelName=NewModelName
[Description]
OriginalModelName=NewDescription
[Image]
OriginalModelName=ImageFilename
```

The OriginalModelName is the model that the T24 Toolkit displays without any customisation.

The following example shows how to customise a **T24-SA** to make it appear to be a **SGD-990** and have a description of **SGD-990 Force Measurement Device**. This will also display a custom image on the toolkit Info page.

```
[Alias]
T24-SA=SGD-990
[Description]
T24-SA=SGD-990 Force Measurement Device
[Image]
T24-SA=SGDImage.jpg
```

The customised installation would normally be burned to a CD so the structure would look like this:



To customize multiple modules just add them to the appropriate sections in the config.ini file.

```
[Alias]
T24-SA=SGD-990
T24-SO=SOD-990
[Description]
T24-SA=SGD-990 Force Measurement Device
T24-SO=SOD-990 PLC Gateway
[Image]
T24-SA=SGDImage.jpg
T24-SO=SODImage.jpg
```

NOTE: The image files should have maximum dimensions of 220 pixels wide and 300 pixels high although if they are larger than this the toolkit will rescale them to fit. A smaller file takes up less space, installs and displays quicker.

Appendix D

Approvals

CE

Complies with EMC directive. 2004/108/EC
The Radio Equipment and Telecommunications Terminal Equipment (R&TTE) Directive, 1999/5/EC,

European Community, Switzerland, Norway, Iceland, and Liechtenstein

English:	This equipment is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.
Deutsch:	Dieses Gerät entspricht den grundlegenden Anforderungen und den weiteren entsprecheneden Vorgaben der Richtlinie 1999/5/EU.
Dansk:	Dette udstyr er i overensstemmelse med de væsentlige krav og andre relevante bestemmelser i Directiv 1999/5/EF.
Español:	Este equipo cumple con los requisitos esenciales asi como con otras disposiciones de la Directive 1999/5/EC.
Français:	Cet appareil est conforme aux exigencies essentialles et aux autres dispositions pertinantes de la Directive 1999/5/EC.
Íslenska:	Þessi búnaður samrýmist lögboðnum kröfum og öðrum ákvæðum tilskipunar 1999/5/ESB.
Italiano:	Questo apparato é conforme ai requisiti essenziali ed agli altri principi sanciti dalla Direttiva 1999/5/EC.
Nederlands:	Deze apparatuur voldoet aan de belangrijkste eisen en andere voorzieningen van richtlijn 1999/5/EC.
Norsk:	Dette utstyret er i samsvar med de grunnleggende krav og andre relevante bestemmelser i EU-directiv 1999/5/EC.
Português:	Este equipamento satisfaz os requisitos essenciais e outras provisões da Directiva 1999/5/EC.
Suomalainen:	Tämä laite täyttää direktiivin 1999/5/EY oleelliset vaatimukset ja on siinä asetettujen muidenkin ehtojen mukainen.
Svenska:	Denna utrustning är i överensstämmelse med de väsentliga kraven och andra relevanta bestämmelser i Direktiv 1999/5/EC.

This equipment is in compliance with the essential requirements and other relevant provisions of Directive 1999/5/EC.

FCC

Family: RAD24
Models: i and e for internal and external antenna variants. For antenna T24-ANTA and T24-ANTB
FCC ID:VHARAD24
This device complies with Part 15c 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.

CAUTION: If the device is changed or modified without permission from Mantracourt Electronics Ltd, the user may void his or her authority to operate the equipment.

Industry Canada

Industry Canada Industrie Canada

Models: i and e for internal and external antenna variants. For antenna T24-ANTA and T24-ANTB
IC:7224A-RAD24
This apparatus complies with RSS-210 - Low-power Licence-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment RSS.

OEM / Reseller Marking and Documentation Requirements

FCC

The Original Equipment Manufacturer (OEM) must ensure that FCC labelling requirements are met. This includes a clearly visible label on the outside of the final product enclosure that displays the contents as shown:

> Contains FCC ID:VHARAD24
>
> 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.

The T24-SAe device has been tested with T24-ANTA and T24-ANTB. When integrated in OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas other than T24-ANTA and T24-ANTB must be tested to comply with FCC Section 15.203 (unique antenna connectors) and Section 15.247 (emissions).

T24-SAi and T24-Sae modules have been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Changes or modifications not expressly approved by Mantracourt could void the user's authority to operate the equipment.

In order to fulfil the certification requirements, the OEM must comply with FCC regulations:
1. The system integrator must ensure that the text on the external label provided with this device is placed on the outside of the final product.
2. The T24-Sae module may be used only with Approved Antennas that have been tested by Mantracourt.

IC

Labelling requirements for Industry Canada are similar to those of the FCC. A clearly visible label on the outside of the final product enclosure must display the following text:

> Contains Model RAD24 Radio (2.4 GHz), IC:7224A-RAD24

Integrator is responsible for its product to comply with RSS-210 - Low-power Licence-exempt Radio communication Devices (All Frequency Bands): Category I Equipment RSS.

CE

The T24 series has been certified for several European countries.
If the T24-SA is incorporated into a product, the manufacturer must ensure compliance of the final product to the European harmonized EMC and low-voltage/safety standards. A Declaration of Conformity must be issued for each of these standards and kept on file as described in Annex II of the R&TTE Directive. Furthermore, the manufacturer must maintain a copy of the T24 device user manual documentation and ensure the final product does not exceed the specified power ratings, antenna specifications, and/or installation requirements as specified in the user manual. If any of these specifications are exceeded in the final product, a submission must be made to a notified body for compliance testing to all required standards.

OEM Labelling Requirements

The 'CE' marking must be affixed to a visible location on the OEM product.

CE

The CE mark shall consist of the initials "CE" taking the following form:
- If the CE marking is reduced or enlarged, the proportions given in the above graduated drawing must be respected.
- The CE marking must have a height of at least 5mm except where this is not possible on account of the nature of the apparatus.
- The CE marking must be affixed visibly, legibly, and indelibly.

Worldwide Regional Approvals

Region	Product Conforms To
Europe	CE
USA	FCC
Canada	IC
Australia	To Be Determined
China	To Be Determined
Japan	To Be Determined

Important Note

Mantracourt does not list the entire set of standards that must be met for each country. Mantracourt customers assume full responsibility for learning and meeting the required guidelines for each country in their distribution market. For more information relating to European compliance of an OEM product incorporating the T24 range of modules, contact Mantracourt, or refer to the following web site: **www.ero.dk**

CE

DESIGNED & MANUFACTURED IN THE UK

Code No. 517-908	Issue 2.4	09.09.10