



RFID Race Timing Systems

Operational Manual

V2.0

((EchoActive))

RFID

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1.0 Introduction

EchoActive is new timing technology that uses dual frequencies to trigger and then download data from active transponders worn by the participants. Because the transponders are battery powered the read performance is close to 100%. The transponder is triggered by a low frequency loop placed out on the road or path. A precise time is recorded when the transponder is exactly between the two 'tram-lines' of the loop and this time plus other data is sent back to the Base over a high frequency link. The benefit of this type of system is;

1. Very good precision on timing a transponder as it crosses a defined finish line.
2. 100% read performance even when the transponder is crossing at high speed up to 120km/hr.
3. The Base is a very small and portable unit with easy deployment.
4. The only antenna to be deployed is a simple wire loop that can be taped, nailed or laid out via a mat.
5. The microprocessor inside the transponder allows for many advanced features.

2.0 Transponder



Fig 1. The EchoActive Transponder

A transponder is carried by the participant either attached by leg ankle strap or cable tied to a bicycle/vehicle. The EchoActive transponder spends most of its time in deep sleep mode only being 'woken' by a signal from the wire loop on the ground. The transponder will reply with its unique 6 character code plus other data at the completion of the trigger phase. The reply signal is picked up by the Base and acknowledged. After this the transponder re-enters a sleep state waiting for the next trigger signal.

The transponder is fully sealed inside a polycarbonate housing for complete waterproofness and shock resistance. A lithium battery is also installed with a finite lifespan depending on the number of trigger events and time spent in different modes of operation. It is very important to understand the different modes of operation of the transponder to maximize the lifespan of the battery.

2.0.2 Sleep Mode

Transponders can go to sleep in two modes. Normally a transponder will go to sleep after being read by a Base until another trigger event. This mode is used at the beginning and during an event for maximum response when triggered by the wire loop. There is a special sleep mode called Low Power (LP) mode which puts the transponder into its lowest power use state. In this state the transponder will only use about 1.7uA of current. The amount of current in normal sleep mode is about four times this amount (typically 6uA). Because transponders spend almost their entire lives in sleep mode, putting a transponder into LP mode greatly improves the lifespan of a transponder. The correct procedure is to put the transponders into normal sleep mode by having LP mode turned off before running the transponder over the wire loop. This can be done a few days before the event, at pre-registration or even on a timing point placed on a non-critical timing point early in the race. The transponder can also be put back into LP mode on the finish line timing point as the setting only affects the next time the transponder is woken up. It is very important that the user understands this concept of different sleep modes and the effect on read performance and battery life.

2.0.3 Bluetooth Mode (BT)

This is a special setting that will immediately instruct the transponder to send periodic Bluetooth advertisements. The transmissions can be received by any Bluetooth device and a moderately precise timestamp can be recorded by this device based on strongest RSSI of transmission. The soon to be released EchoNano is the device that can receive these transmissions. This device has an inbuilt 4G modem and can relay the time and transponder code to a remote server. The data is also saved internally on the device for later download via USB. An android app is also being developed to do the same function as the EchoNano. If the BT mode is not needed then it should be turned off. The duration of BT mode can be set by the Base between 1 and 24 hours. BT mode can always be turned off prematurely by a Base set to 0 for BT mode. It is important to not choose too long a BT mode time if it is not needed to save battery usage.

2.0.4 Playback Mode

This is a special mode that when selected will ask the transponders to replay up to the last 40 records recorded within a 3 day period. If a 3 day time period is exceeded between the last transponder read and the latest read then all the transponders records are deleted before the current record is saved. In this way the data is automatically cleared and maintained without any user interaction. If this mode is selected the Base will receive these records in a data stream from the transponder immediately after a connection. The transponder immediately disconnects on completion of the transfer. It is important that this mode is only selected if required. For example, there may be multiple timing points along the course that are not online (no live data feed via modem) and this data can be downloaded on the finish line using Playback Mode. It is recommended that when multiple transponders are read within a very short time period that this mode is not used (i.e. 10 transponders in less than 1 second). It is best used in an event where athletes are finishing every few seconds. Such an example of an event would be a triathlon or trail run.

2.1 Base

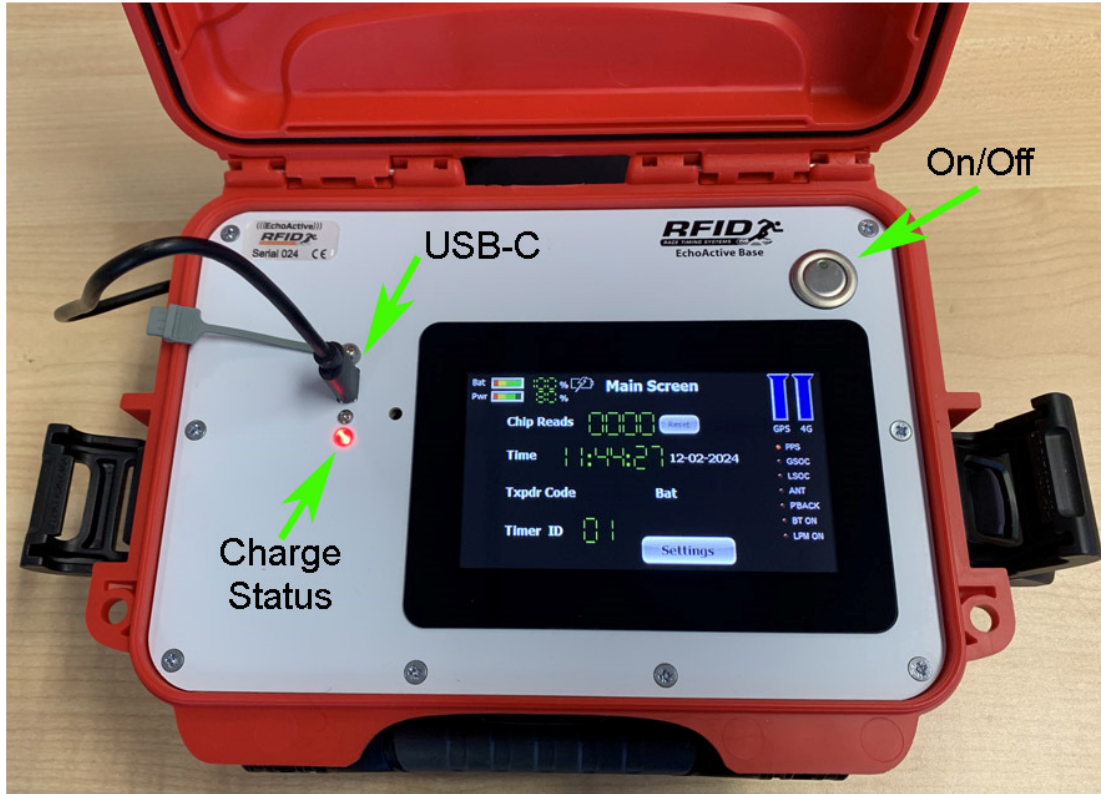


Fig 2. Top panel of the EchoBase

The Basestation (Base) houses all the systems that trigger and read transponders as well as set and keep accurate time. Data is saved in an internal flash file system for later 'rewind' over Ethernet. There is also an option to fit a 4G modem if data from the Base is to be sent remotely. The sim card slot is inside the case on the main PCB

2.1.1 LCD Screen

A sunlight readable, capacitive touchscreen is used to access many of the settings of the Base. It is advisable to use the screen sleep mode to greatly extend the battery life of the Base. The screen is splashproof.

2.1.2 USB

There is a USB-C socket for recharging the internal battery with the supplied wall plug and cable. A red LED indicates charging while a green LED indicates charging is complete. The LED is unlit if no charger is plugged in. The average power use (in amps) of the Base is less than the maximum charge current of the charger. The USB-C PD (power delivery) is set for multiple configurations depending on the wall charger.

It is recommended that a certified USB-C fast charger is used that can deliver 12V at 1.67A. Charging takes between 3 and 4 hours with a fast charger.

2.1.3 GPS

Setting the time of the Base is automatic and done via GPS. It will take between 50 seconds and several minutes for the GPS to get a valid satellite fix enabling accurate time calculation. The accuracy is within several micro-seconds of atomic UTC time. The GPS satellites will still be available with the lid closed. GSP time ensures all Base's are synchronized with the exact same time. The 1 second pulses on the PPS signal (Main Screen) signifies a valid time fix.

2.1.4 On/Off Button

The green momentary button immediately turns on the Base. After a few seconds the Base will go to the Main Screen and be ready to read transponders. The user should give the Base at least a few minutes for the GPS satellites to receive a time fix. Holding the button down for 3 seconds will turn off the Base.

2.1.5 4G modem and Sim Card Slot

The inbuilt 4G modem is an optional extra. It allows telemetry of the timing data to an Outreach™ server. RFID Race Timing Systems operates an Outreach server as well as other 3rd parties. Timing data is sent to the server and then this data is accessible using a PC software app. The Outreach server acts as the intermediary or relay between the Base and the timing software. Further info on Outreach can be read here <https://rfidtiming.com/wp-content/uploads/2017/02/OutReachManual.pdf>

The sim card slot is accessed by removing the panel from the case. Sim cards should remain in the slot due to the time consuming process of removing and accessing the main circuit board. Most data sims can be purchased cheaply and recharged via the vendors web app. To insert the full size SIM card, follow the sequence of photos below. The SIM card will click when inserted into the locked position. To remove the SIM card push on the edge and the card will unlatch and spring out.

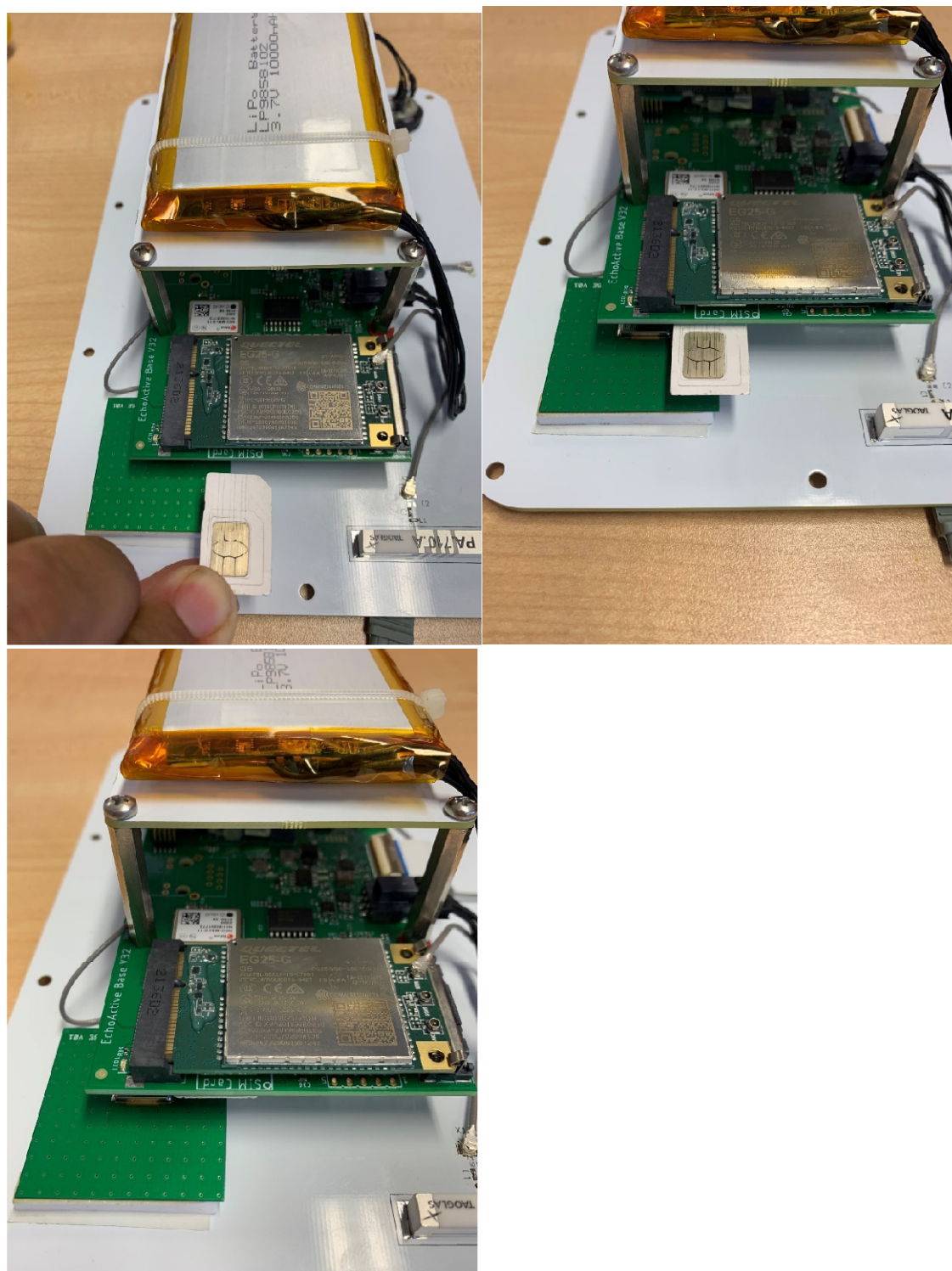


Fig 3. Insertion of the SIM card on the bottom of the main PCB board.

2.2 Rear of Base

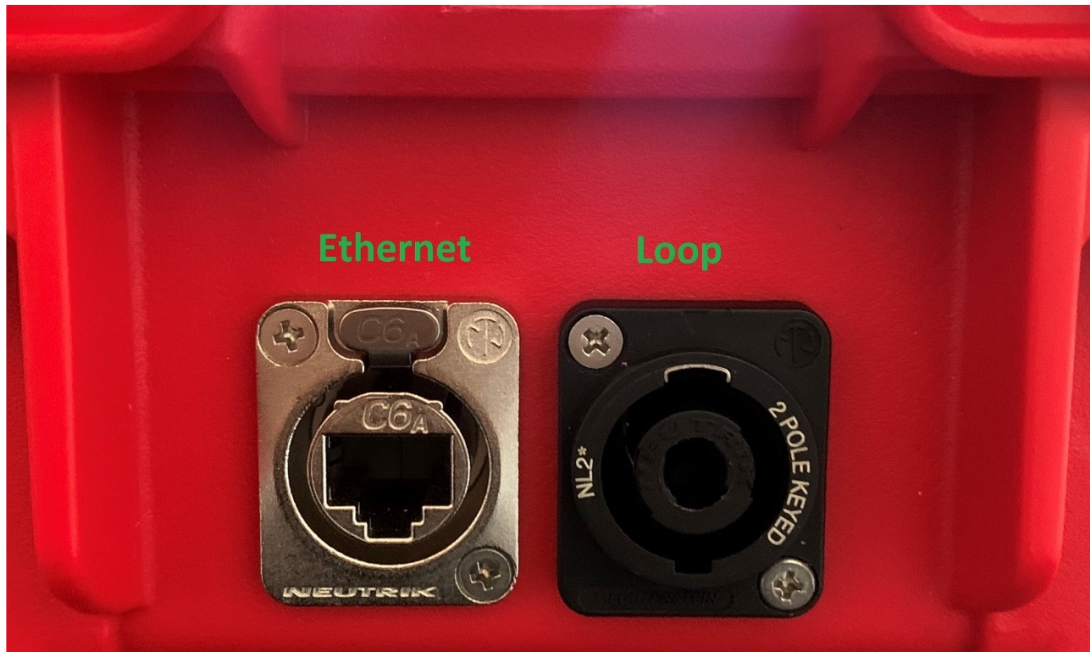


Fig 4. Rear of EchoActive Base showing panel connectors

2.2.2 Wire Loop Socket

On the rear of the Base enclosure is a 2 pole Neutrik plug (NL2MP) for the wire loop. Insert then twist for correct connection. To unlock, pull the metal locking tab back and twist the plug anti-clockwise.

2.2.3 Ethernet Jack

On the back of the box is the Ethernet jack used for communication with the system using a standard 10/100 base-T Ethernet cable. The socket accepts a positive lock Neutrik Ethernet shroud (NE8MX).

2.2.4 Wire Loop

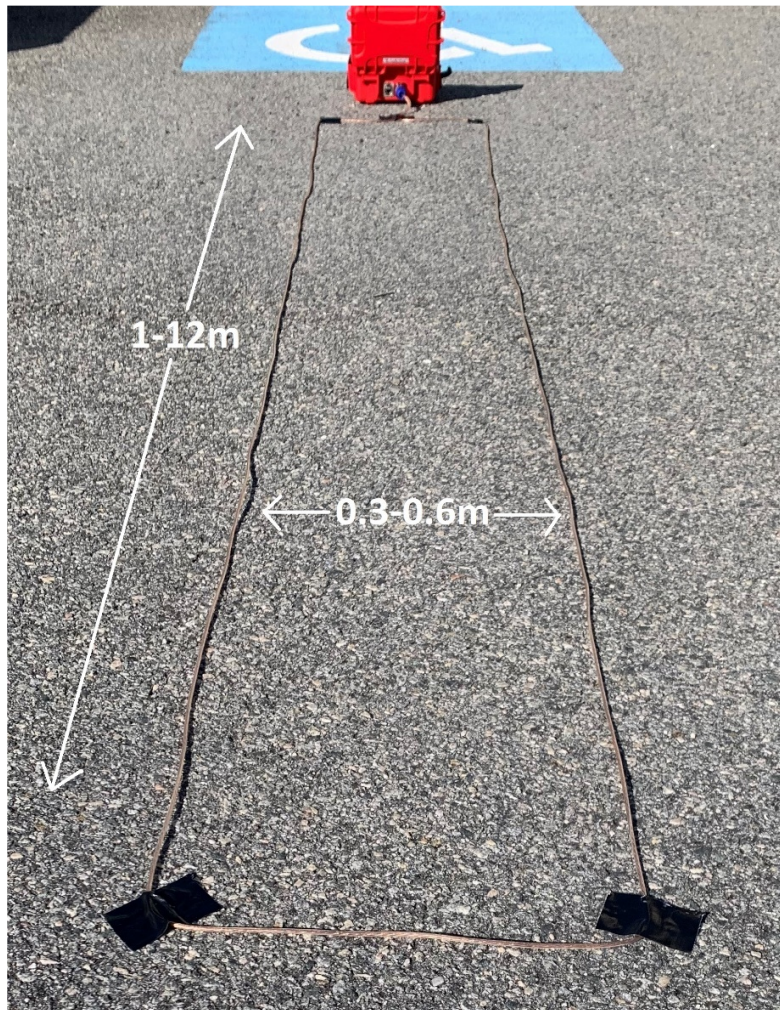


Fig 5. Example of initial placement of wire loop (example is 0.3 x 4m)

The specification of the wire loop is not stringent and most multistrand copper wire will suffice. The loop can be varied in size from 1 to 12m long with a gap in the 'tram-line' of between 30 and 60cm. Transponders passing across the loop at faster than 70km/hr should use the wider 60cm loop. The loop is connected to a 2 pole Neutrik plug which you insert and twist for a positive lock to the socket on the back of the Base. The rectangle loop shape is maintained using gaffers tape, bitumen nails or placed under grass using a small cable trench digger. The loop can also be placed within a rubber mat for easy deployment without the need to tape it down. This latter method is recommended for narrower timing points on grass and loose ground. Cycling events on road should use the tape down method. If the tape will not stick in wet conditions then the loop rectangle can be help down by bitumen nails. It is very important to make sure this loop stays on the ground during the passing of bicycles and vehicles or

injury to participants may occur.



Fig 6. Taping the loop wires down with gaffers tape. A white finishers line can be placed in the middle of the tram lines.

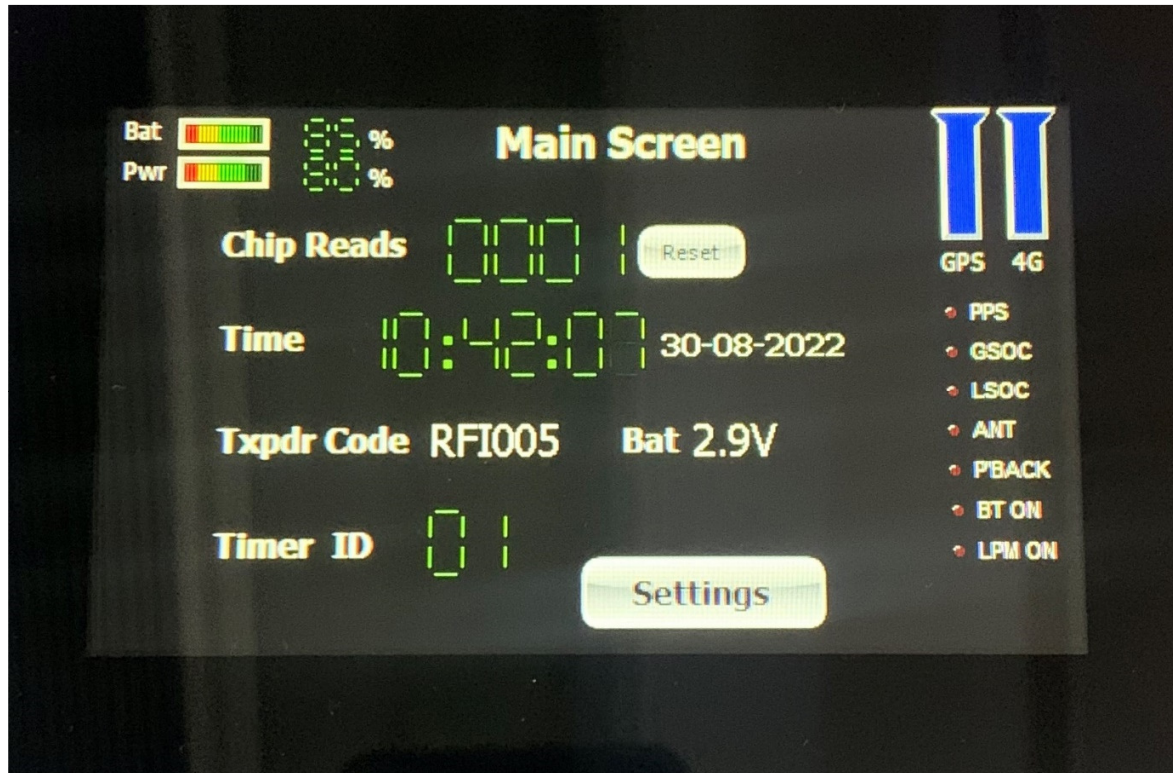
2.2. 5 Trigger Port (Optional)

An optional external trigger is available for recording multiple start times using the Base internal clock. This feature is turned on via the menu **Other** (see 7.0.3). It should be turned off if you are not interested in recording manual wave start times using the trigger. The trigger circuitry uses a schmitt trigger and a delay of 3 seconds between successive trigger presses for debouncing.



Fig 7. Optional external trigger button and panel port on the rear side of the Base.

2.3 Main Screen



2.3.1 Bat (Base Battery Percentage)

This denotes the amount of battery storage of the unit. The Base uses a sophisticated current counter IC that keeps track of the battery capacity and displays this value in percent. The system should be immediately charged below 10% and will shut-down below a pre-determined supply voltage which usually equates to about 5%.

2.3.2 Pwr (Power percentage)

This denotes the amount of power delivered to the loop. A lower value reduces the on time of the push pull transmitter reducing the peak voltage of the AC output signal. The user will notice a reduction in the height and distance from the loop that a transponder is triggered when the power is reduced. In most cases power can remain at 100% but the user can experiment with lower values to improve the precision of the triggered time on a transponder. Also if the transponder is low to the ground then the power can be reduced. There is negligible reduction in current use of the Base with reduced loop power.

2.3.3 Chip Reads

The number of transponders (chips) read since the unit was turned on. It can be reset to zero with the button.

2.3.4 Time

The local time of the internal clock. This time utilizes exact GMT (Greenwich Mean Time) with the timezone setting to determine time and date. When the unit powers up the time is immediately retrieved from the accurate internal time chip. When a PPS signal is fixed from the GPS the time is recalibrated to precise GPS time. This is currently only done once on a powered-up Base. The time drift of the internal time chip is less than 0.5 seconds over 24hrs.

2.3.5 Txpdr Code

The six character code of the last transponder to be read since power up of the Base. Codes start with 3 alpha characters followed by 3 digits. The codes can be requested by the user when transponders are programmed during manufacture and stay with the life of the transponder. The transponders code is thus read only. If the trigger is pressed (and turned on) then 'TRIGGR' will display.

2.3.6 Bat (Transponder battery voltage)

When a transponder is read by the Base, the battery voltage of the coin cell within the transponder is also measured. This measurement is taken during a high current draw on the battery and does not correlate to the voltage of the battery when the transponder is in sleep mode. The transponder is close to end of life when voltage is below 2.0V and may not trigger at a voltage of 1.8V and below. Voltage of new transponders will be above 3.0V but will spend most of their lives around 2.6V as the voltage to charge curve is not linear.

2.3.7 Timer ID

Each Base must have a unique Timer ID set in the RFID screen. The Timer ID is output on the loop so that only transponders triggered by that loop will be read. Having two Bases with the same TimerID will result in transponders being triggered on one loop and possibly being read on the other Base. **It is very important that Timer ID is set differently on multiple Base units.**

2.3.8 GPS and 4G

Both these 'tank symbols' in the top right hand corner of the screen denote GPS and 4G signal strengths. The 4G signal will only be shown if a modem is installed and Remote is turned on (see Networking). Currently GPS is always turned on and actively searching for satellites.

2.4 LED Status Bar

2.4.1 PPS – This LED will pulse on and off each second if a valid time is available on the GPS. If the synchronization of accurate time on each Base is required then it is important that this signal pulse can be seen.

2.4.2 GSOC – Active connection to the Outreach server. The Outreach Server is technology developed by RFID Race Timing Systems which accepts transmissions of raw timing data over the internet and stores this data on a server. Use the Outreach app on a laptop to download this data into your timing program.

2.4.3 LSOC – Ethernet socket connection is active. This will be lit if connected to an external computer and socket is active for 2 way data transmission.

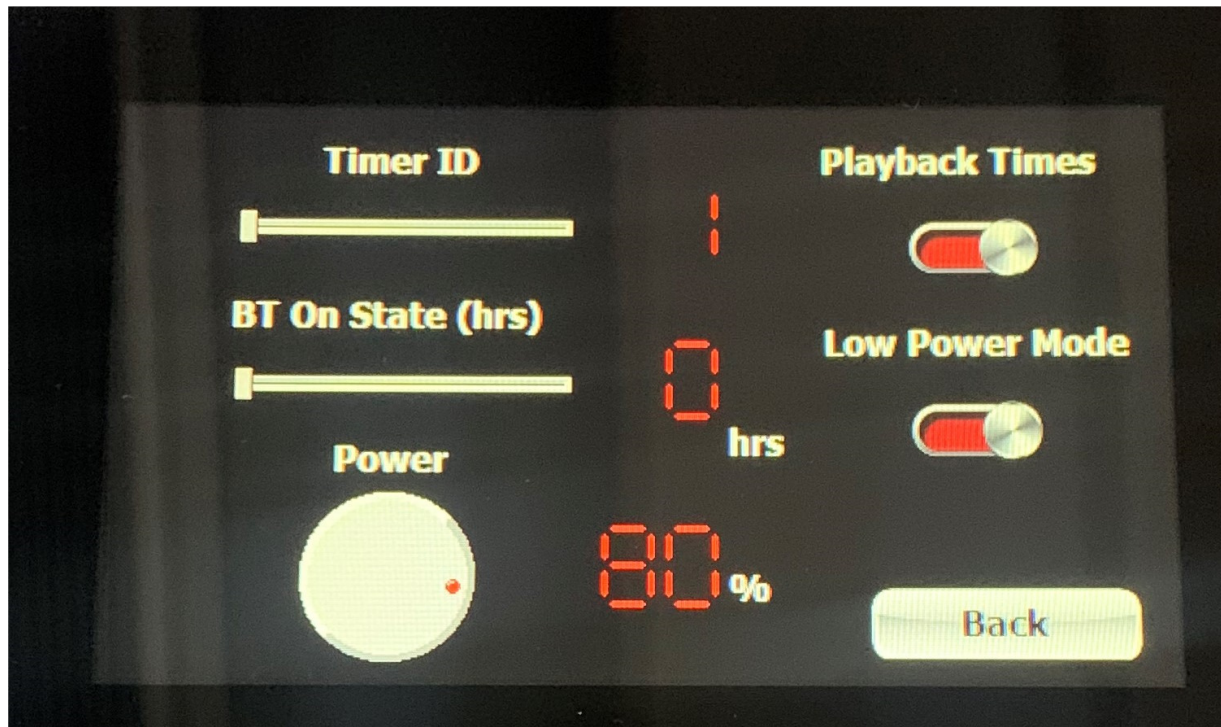
2.4.4 ANT – Not currently used.

2.4.5 PBACK – Playback mode of transponders. If this is set in the RFID menu, the transponders will reply with their most recently recorded times (see 2.0.4 Playback Mode). Normally this should be turned off as it will greatly reduce the number of transponders read per second.

2.4.6 BT ON – Bluetooth mode of transponders. This is also set in the RFID menu and when turned on will set the transponder to Bluetooth mode (see 2.0.3). Normally this should be turned off if you are not using another device to pick up the transponder in BT mode. These devices are currently not available at the time of writing this manual.

2.4.7 LPM ON– Low Power mode is on. Will put transponders in lowest power usage in sleep mode (see 2.0.2). This mode can be turned on if the timing point is the last one to be used in the event (i.e. finish line). Make sure this LED is lit before putting transponders to sleep prior to storage. Is set in the RFID menu.

3.0 RFID Menu



This menu is the first of the settings menus that can be selected from pressing the Settings button on the Main Screen. It controls the wire loop signals that turn on/off certain transponder functions.

3.0.1 TimerID

The slider control changes the TimerID from 1 to 16 allowing for up to 16 different Base's to be used in the same area (400m radius). This function ensures that a transponder triggered by a loop is read by the same Base only. If only one Base is being used then TimerID is of no importance.

3.0.2 BT On State (hrs)

This slider ranges in times from 1 to 24hrs and sets the transponder into Bluetooth mode (see 2.0.3). Once the transponder has crossed the loop with this set to greater than 0, it will emit a Bluetooth

advertisement every second. This data can be picked up by any Bluetooth central device. In future the EchoActive Nano will perform this function. There is also a free Android app that demonstrates this feature. In normal use this is set to 0 (off).

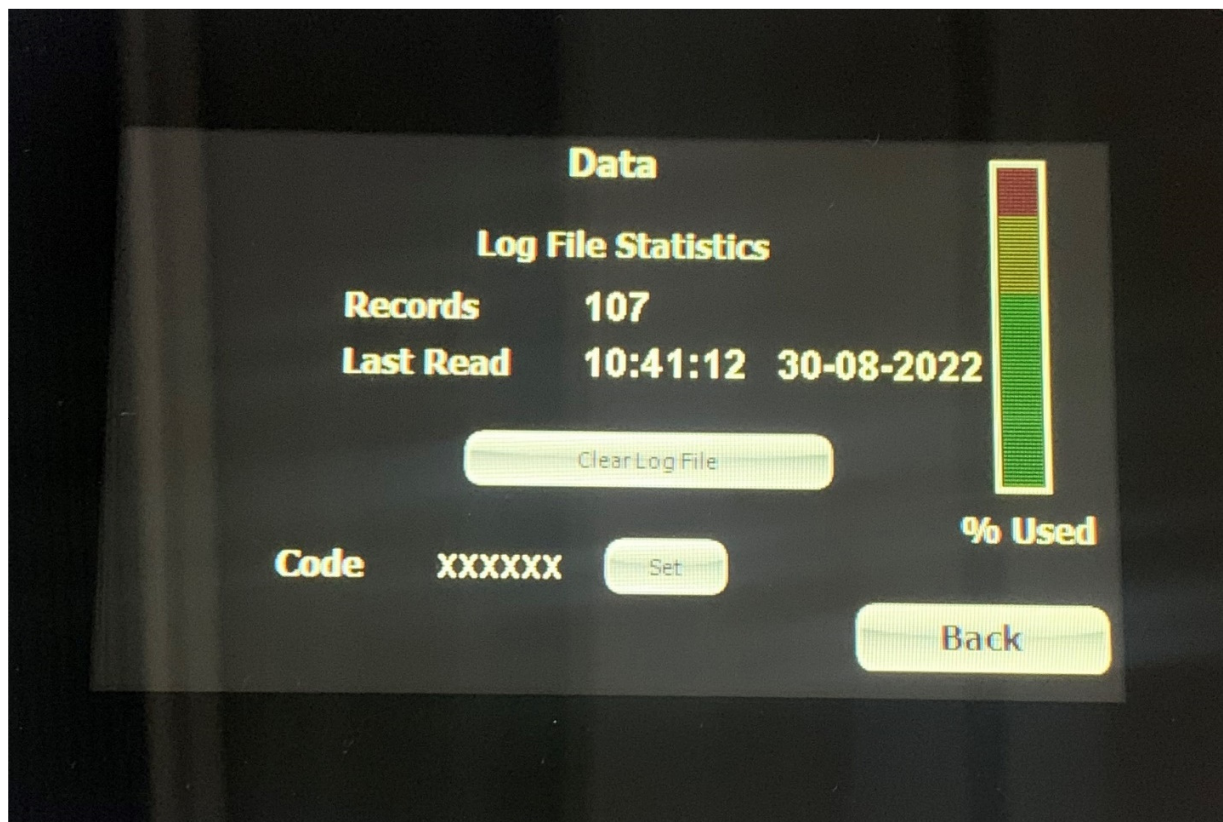
3.0.3 Power

Sets the power level of the loop signal. Normally set to 100%.

3.0.4 Playback Times (see 2.0.4)

3.0.5 Low Power Mode (see 2.0.2)

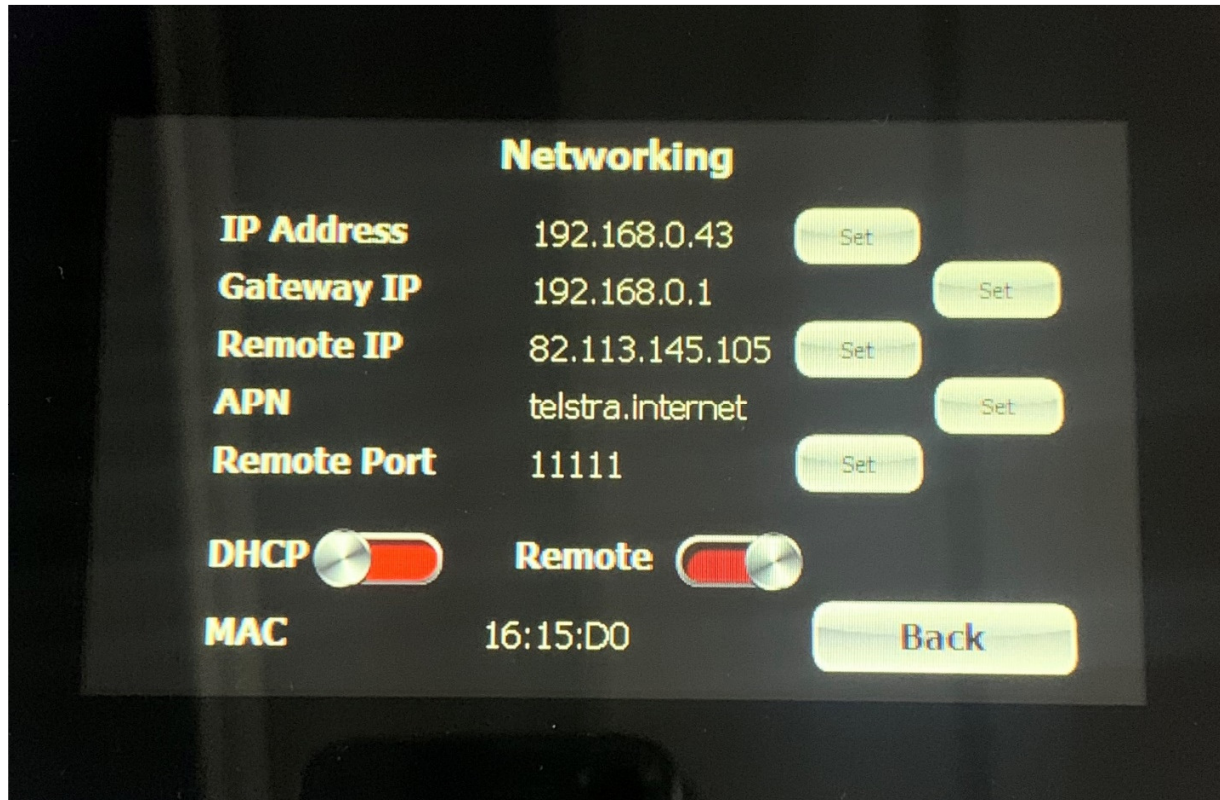
4.0 Data Menu



This simple menu is used to show how many records are saved on the Base internal flash memory. The system can hold approximately 23,000 records. The data is stored on the log file and this should be cleared periodically. Note that clearing the log file erases all records so do not do this until well after the event has been completed and results have been recorded. The % used bar gives an easy indication of how full the log file is.

The Code set button is disabled in the standard version of the firmware and only used for factory encoding of transponders. It is also possible to install new firmware on the transponders via this mechanism although this is not allowed on the standard firmware version.

5.0 Networking Menu



Communication with the Base is either done via ethernet or via the optional 4G modem. In most cases ethernet connection will be used. Ethernet requires a PC computer with an ethernet jack installed and an ethernet cable plugged into this jack and the rear jack of the Base. Basic networking principles are beyond the scope of this manual but the user should be familiar with how to set the IP address of the computer and the Base and the principles behind static and dynamically assigned IP addresses.

When an ethernet cable is plugged into an Echo Base (powered on) the firmware will immediately check for a DHCP server and allow that server to assign a dynamic IP address if the DHCP button is turned on. If no DHCP server is found the Base will use the static IP address set under IP Address. When the computer is directly connected to the Base there will be no DHCP server (router) so you will be using a static IP address on both machines. Make sure both IP address are on the same subnet (i.e. 192.168.1.XXX).

5.0.1 IP Address

This is the static IP address set at power up and will change to a dynamic IP address if DHCP is turned on and there is a DHCP server (i.e. router) on the LAN (Local Area Network). Setting is done by the adjacent button and make sure the IP address entered into the keypad contains the decimal character between the numbers.

5.0.2 Gateway IP

If a DHCP server is found this will be populated with the IP address of that server or router. You may also have a router on the LAN that is not in DHCP mode but you can set the gateway IP address to that of the router and data will be sent to the Outreach server via this gateway router. It is assumed the gateway has connection to the internet in this instance.

5.0.3 Remote IP

When using Outreach the public IP address of the server must be set here. Currently RFID RTS has one server situated in Europe and this can be used by the customer. Email info@rfidtiming.com for a username and password for Outreach access. Membership to the RFID Race Timing Systems website members portal is required. Outreach is downloaded via our firmware section of the website www.rfidtiming.com

5.0.4 APN

If you are using the 4G modem (optional) the APN is unique to the telco sim provider. Check with the sim provider for the correct APN required for data transmission over their 4G network. The modem is not standard to the base and must be fitted for it to work.

5.0.5 Remote Port

This is the port used by the remote Outreach server to accept Outreach transmissions. It is 11111 on the server used by RFID Race Timing Systems.

5.0.6 DHCP

Sets the Base to try and obtain a dynamic IP address from a DHCP server on the LAN

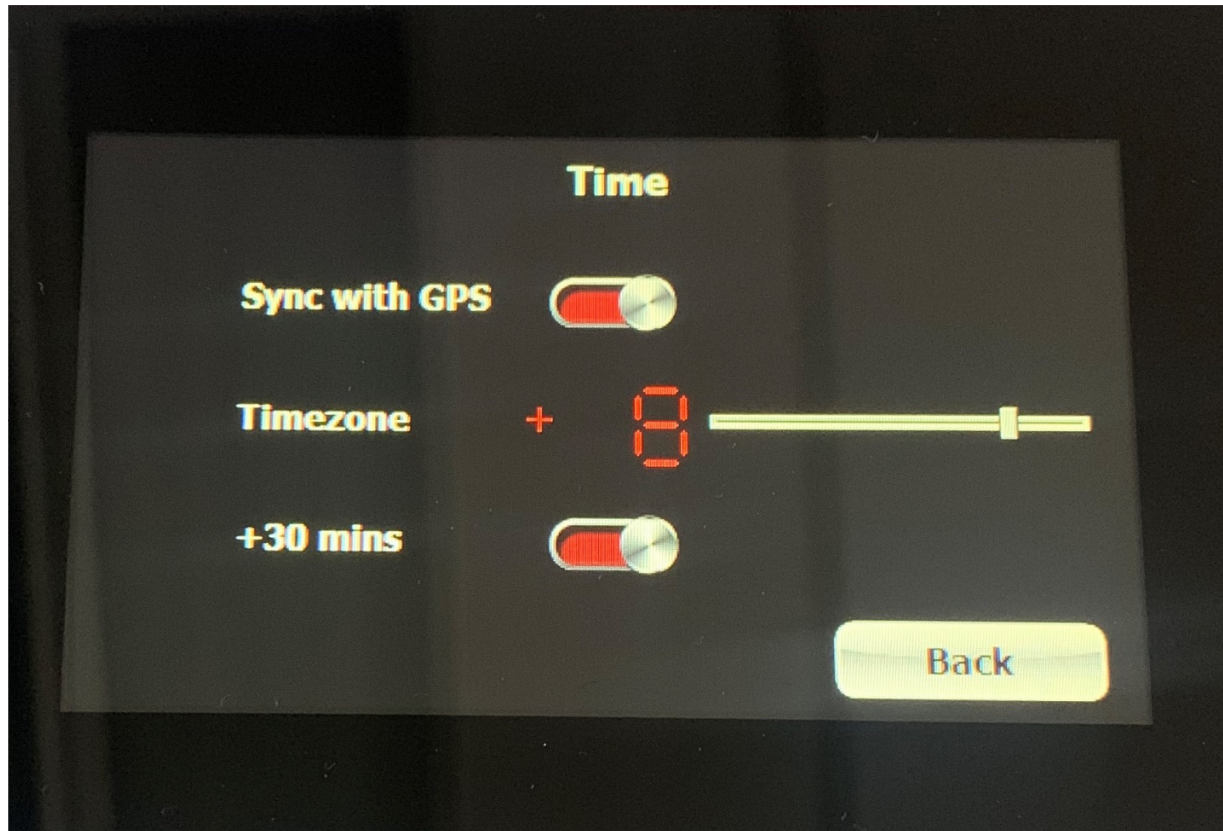
5.0.7 Remote

Timing data will be sent via Outreach using either a connected router on the internet or via the optional 4G modem. The router method is tried first before the modem.

5.0.8 MAC

This is the MAC address of the Base and is unique to the device. It identifies the Base when using Outreach and the Outreach PC app uses this address to map the Base to the user and their devices being used in an event. The MAC is derived from the ethernet chip on the internal rabbitcore processor.

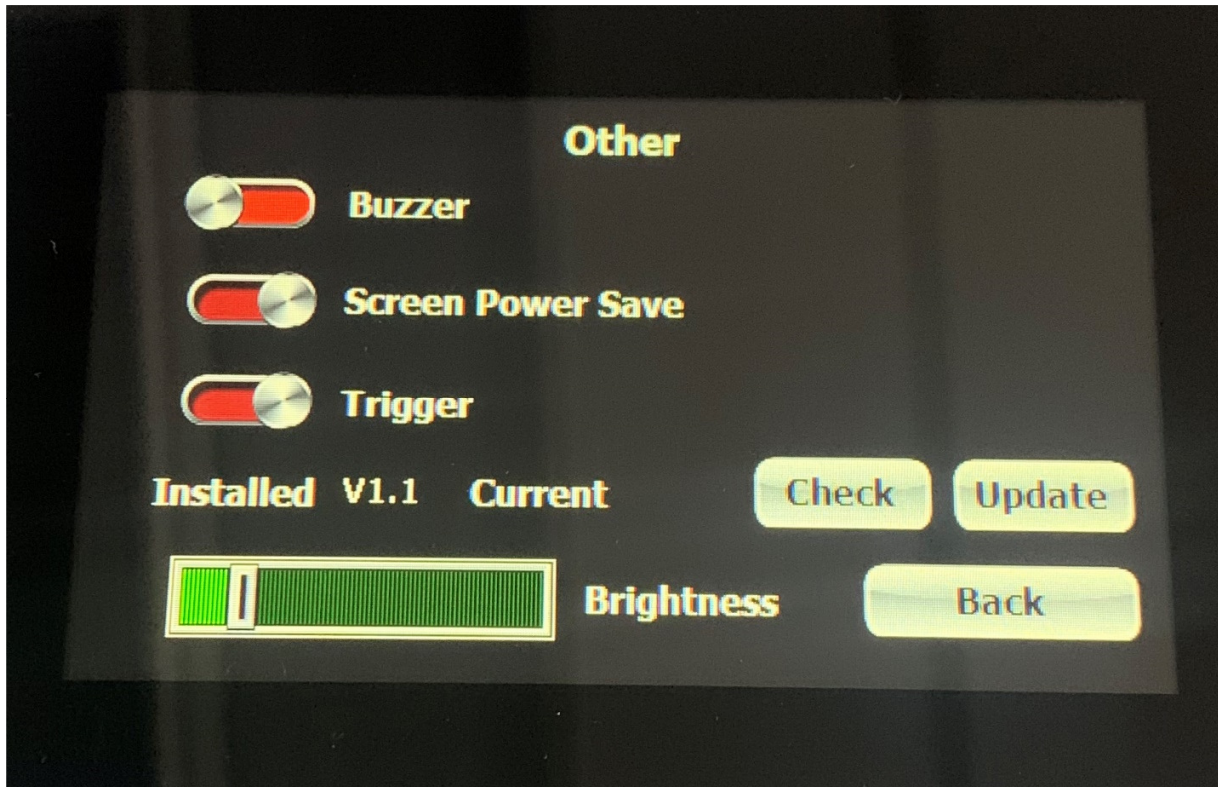
6.0 Time



The Time menu is rarely used as most Base's do not change these settings unless the unit is moving between timezones. The Sync with GPS option is currently disabled and the GPS is always on and will always set the time when the PPS signal is found.

Timezone is the time difference in hours from GMT. Use the slider to change the to the correct timezone you are living in. The value can be positive or negative depending on which side of the meridian one is. The +30 mins option adds a further 30 minutes to the timezone in the rare occurrence that the local timezone is not a round hour value.

7.0 Other



As the name suggest this menu contains any extra features and settings of the Echo Base V1.

7.0.1 Buzzer

All timing systems should have aural signal of a successful chip or transponder read. The buzzer should be turned on so that the timer has an indication that the system is working correctly.

7.0.2 Screen Power Save

The sunlight readable touchscreen display in full brightness uses up to 4W of power and this peripheral uses most of the Base power. The touchscreen is primarily used to set settings on the Base and during timing is only occasionally used to show that a transponder has been read. In most cases the buzzer is enough of a diagnostic tool for the user during an event. It is recommended that if the event is longer than 3hrs duration (Base fully charged prior) that the Screen Power Save feature is turned on. This will turn the backlight of the screen down to the lowest contrast setting within 15 seconds of no screen touch activity reducing power use by greater than 3W. This greatly lengthens battery life of the Base during operation. The touchscreen can be re-activated to the previous brightness setting at any moment by just touching it.

7.0.3 Trigger

This feature allows for an external button press to record a time. For example, the start of a wave of competitors. When this is turned on, the on/off button is also active as a trigger input. When either trigger button or on/off button is momentarily pressed the Base will beep and the exact time will be

saved to flash memory with the code 'TRIGGR'. If an ethernet socket connection is active then the timestamp will be sent out with the tag code '0'. This data can be used to determine exact wave start times based on the pressing of the trigger button.

Warning: When the trigger is active do not hold down the trigger for more than 2 seconds or you may turn off the Echo Base. Once the beep is heard, take the finger off the trigger.

7.0.4 Firmware Update

The current firmware version of the EchoActive Base is shown here as well as on the initial splashscreen of the unit on first power up. It is important that the latest firmware is installed. The process to check and install the firmware is thus;

1. Connect the Base via ethernet to a router that has internet access and make sure the Base has a dynamic IP address assigned to it by the router.
2. Press the Check button.
3. The Base will communicate with our server to see if a new version is available
4. If the Current version is a higher number than the installed version you will be able to press the update button.
5. The Base will download and install the new firmware version. Do not interrupt the ethernet or internet communication during this time.
6. The Base will automatically reboot after install. Note that all data will be erased on the log file so do not do this before downloading timing data from the Base for a current event.

Pressing the Update button also puts the internal Bluetooth chip into DFU mode for 30 seconds which allows the chip to have new firmware sent to it over the air using a smartphone app. Firmware updates for the Bluetooth chip are less frequent but may be required from time to time.

7.0.5 Brightness

As the name suggests this slider changes the brightness of the display. At maximum brightness the display will be readable in sunlight but will also use the most power.

8.0 Base Power Supply

The EchoActive Base V2 operates on an internal 5.0 and 3.3V system but external USB power input can vary between 5 and 12V depending on the specification of the USB-C charger. The power input must come from a certified USB-C plug and not exceed normal voltage ranges as per USB PD (Power Delivery) specifications. A wall plug charger with a minimum power output of 18W should be used with a full function USB-C cable for charging or external power during operation. Note that the USB-C cable (supplied) must have all the wiring pinouts to complete a USB-C PD fast charge handshake.

An approved external USB powerbank can also be used for extra battery supply and most powerbanks are hot swappable meaning they will not interrupt the Base functions when removed or attached. The internal Li-ion battery is charged by the external USB supply and the internal power management chip controls the supply of current to both battery and system. The internal lithium battery has an NTC circuit for temperature protection during charging.

When the green charging LED is lit then the unit is fully charged (with USB-C cable attached). If the LED blinks on and off at regular second intervals then the connection between battery and the main PCB may be damaged. This should then be reported to the manufacturer.

9.0 Further Information

(a) The EchoActive Base enclosure is opened and closed using the 2 side latches. To open the latch pull down with both thumbs on the grey section in the middle of the latch. The case can be closed and latched during operation.

(b) On very hot days try to keep the case in the shade. The unit does not generate much heat but direct sunlight on a hot day could put internal temperatures above 80 degrees C. This is particularly important if a USB-C charge source is attached.

(c) The closed case is not waterproof but water resistant. The open case is not water resistant and should be closed if it is raining.

(d) The case should be placed on the ground or on a small table and the rear should face the timing point. **The top panel has an integrated 2.4GHz antenna on the top rear of the panel and nothing should be placed near this.** This antenna picks up the 2.4Ghz transmissions of the transponders.

(e) Similar to the 2.4Ghz antenna there should be no objects placed near or over the top of the panel. The GPS antenna on the inside of the top panel requires a clear view to the GPS satellites in the sky.

(f) The main PCB inside contains a CR2032 battery cell holder. This battery should be replaced every 2 years as it maintains the internal time of the accurate time keeping chip.

(g) Toggle settings on the LCD screen are switched on when the toggle is in the left position and the toggle is lit a brighter red colour.

9.1 Specifications

Item	Type	Ratings
Battery -main	Li-Ion pack with NTC	3.7V, 37Whr, 4.5hrs run time ¹
-coin cell	CR2032	3.0V, 220mAHr
USB	USB-C PD	12V, 1.87A max
	Charge Time	3-5hrs
LCD Screen	Capacitive Touch LCD brightness	Max 880 Nits
Operating Temperature	Base	-25 to +50 degrees C
	Transponder	-40 to +85 degrees C
Transponder	Lifespan	Typically 7 years ²
	Read gating period	3 seconds
	Weight and dims	15g, 39mm x 32mm x 12mm
Timekeeping	Temperature compensated crystal	5PPM (± 0.432 sec per day)
Base	Transponder codes/sec	80 sustained
	Loop Transmit Frequency	125Khz
	Receiver	2.4Ghz BLE
	Modem (optional)	4G LTE (standard sim slot)
	Flash memory storage	Max 28,000 records
	Weight and dims	1.15kg, 231 mm x 173 mm x 97 mm

Notes:

1. 100% Power, 100% Brightness on Display, Ethernet attached and connected.
2. Based on 3000 reads, 100hrs of BT mode and 90% in low power sleep mode, per annum.