



Operational Manual

High Density System

RFID Race Timing Systems

December 2008



HiDef Digital System



Introduction

Congratulations on buying the RFID Race Timing System. The acronym RFID stands for Radio Frequency Identification and is widely used in the electronics industry to describe the reading of tags or transponders using a radio frequency based communication protocol. This product should give many years of service if well maintained and transponders have an infinite lifespan since they contain no moving parts or batteries. The RFID Race Timing System comes with a 1 year warranty from the date of delivery.

How it Works

The RFID Race Timing System uses low frequency (134.2khz) radio signals to communicate between small coded transponders and an intelligent control module via a fixed antenna. This communication cycle is performed in 50 milliseconds so that there can be up to 18 read cycles per second. In a read cycle, the antennas are firstly charged with an electric current which produces a strong electromagnetic flux both above and to the side of the antenna mat. This electromagnetic energy is partially captured by a small antenna coil in the transponder. This powers a chip which sends its unique 16 digit code back to the antenna. The antenna then listens for 20 milliseconds so that it can receive the analogue signal from the transponder and decode it within the TIRIS control modules. Transponder codes and the time of day to the nearest 1/10 second are saved in memory and can be sent to a PC via an Ethernet network in real-time or downloaded afterwards.

Important Rules

1. Be very careful when removing the control box panel. The internal components are sensitive to static electricity if touched and can be irreparably damaged. The panel should only be removed to replace the lead acid battery.
2. Never connect or remove any leads or plugs with the control box power already turned on. This may lead to permanent damage of the internal components. The correct procedure is to plug in all cables prior to switching the control box on.
3. Never operate the control box with the panel removed. There are high voltages within the components and these can cause injury.
4. Never allow water or large amounts of dust to fall on the panel. The control box can be operated in the rain as long as a good plastic cover is put over the unit. The control box is fully waterproof when closed. Mats are fully waterproof.
5. Replace all damaged cables. High voltages pass through the antenna mat cables. Damaged communication cables (Data and Synchronisation cables) will result in poor system performance.
6. If the ambient temperature surrounding the control box exceeds 30 °C, keep the control box in a shaded position. The internal components get quite hot after prolonged operation and can be damaged if operated in very hot environmental conditions. The internal control modules will shutdown if the temperature inside the control box exceeds 70 °C
7. Try to keep sync and data cables away from other cables such as power, PA and television camera cables.
8. Always test the equipment well before the race to ensure that there is no metal or airborne interference.

Basic Operation

1. Antenna Mat - Connect the blue charge up cable plug and the 4 silver read antenna cable plugs to the control box
2. Plug in the necessary sync and data cables
3. Turn on the control box power.
4. Initialize Logger
5. Set the synchronisation (attach synchronisation cables if necessary)
6. Start reading
7. Tune the antenna

Parts List

- Control Box (yellow or orange plastic case)
- Single Roll Out Antenna Mat - (4.0m x 2.0 m) or 4 EVA foam mats
- Cat 5 Ethernet cables (shielded only)
- Breakout box (if needed for use with the Dual Antenna System MKII)

High Density System LED's

There are three sets of LED's showing the status of the control box. When the control box is in the read mode, each red LED of each internal reader will be flashing rapidly. These LED's flash at 18 times per second. When a transponder is read on any antenna mat, the green LED's of each respective mat will flash. Furthermore, an LED on the LCD keypad will flash green indicating that a transponder code has been time-stamped and recorded. The final LED is an orange sync LED which tells the operator whether the unit is a master or a slave. A lit orange LED signifies that the unit is a master.

Antenna Mat Care

We suggest that the antenna mat is rolled up with the carpet layer on the outside. This will improve the appearance of the mat when it is unrolled and put in place on the timing point. The puckering in the mat will also be reduced the longer the mat is left flat, and in warmer weather. The mat will withstand car and truck's driving over them but heavy vehicles with harder tyres (like forklifts) should not go over the mat. There are numerous antenna wires inside the mat and if they are damaged, the mat cannot be repaired. Wet mats should be left to dry before rolling up after use. The marine carpet used has anti-fungal qualities but will still deteriorate if left rolled up wet. The mat can be vacuumed to remove dirt from the carpet surface.

Charging and External Power

There are two common sockets for use in charging the internal lead acid battery, or supplying external 12V DC power. Never use a switched mode power supply (SMPS) to supply power to the unit as this can induce interference at the 100kHz band. A linear power supply or SMPS with an operating frequency of greater than 200kHz should be used. The CTEK battery chargers supplied with the system can be used to power the system from AC power. Never put a direct AC power source into these sockets. The supplied CTEK battery charger puts out a maximum of 3.3A making

the total charge time about 6 hours for a fully discharged 18A/Hr internal SLA battery. It is good practice to not fully discharge the internal lead acid battery as this will reduce the lifespan of the battery. An external battery can be attached to the system through the power ports making sure that the correct polarity is used. **ALWAYS ENSURE THE CORRECT POLARITY OF ANY EXTERNAL POWER SOURCE.** Incorrect polarity will damage the internal components and short the fuse in the fuse holder on the positive (red) battery lead. The correct pinout for a Neutrik Powercon connector (grey) is N = positive and L = ground. The GND pin is not used. We suggest that only qualified RFID Race Timing Technicians prepare these connectors. Damage due to incorrect wiring of these connectors will not be covered in the 1 year warranty of the system.

Tuning procedure

-Single Carpet Mat

The blue plug of the single carpet mat must be plugged into the control box before tuning the mat. The control box needs to be set as a master, or running as a slave with a synchronized master unit in read mode prior to tuning. The readers are started (see Logger software page 5) and tuning is optimized by turning the tuning knob whilst viewing the current meter. The tuning knob is turned until the peak current is being drawn from the antenna array. This should be in the vicinity of 0.85mA but may vary between control boxes.

-EVA Mats

All antennas must be connected and the plugs locked in clockwise before the array can be tuned. There is no fifth blue antenna plug like with the single carpet mat. If one antenna plug is not connected, the charge antenna will be open circuit and will not work. The antenna mats should be arranged and plugged in as per Figure 2. The way these antenna leads are plugged in effects the read field down the centre line of the mats. The correct setup will ensure that runners are not missed down the centre line in the direction of travel. Incorrect order of plugging the antennas in will also affect the tuning range of the antenna array.

The control box needs to be set as a master, or running as a slave with a synchronized master unit in read mode prior to tuning. The readers are started (see Logger software page 5) and tuning is optimized by turning the tuning knob whilst viewing the current meter. The tuning knob is turned until the peak current is being drawn from the antenna array. This should be in the vicinity of 0.5mA but may vary between control boxes.

-All Mats

The presence of metal under the antennas (i.e. Steel reinforced concrete) will result in a lower peak current being drawn from the antenna array. This also results in a reduction in the read range of transponder timing bands. On some surfaces with high metal content the read range can be substantially reduced resulting in poor read rates of transponders. It is advisable to check the tuning on these surfaces and possibly reposition the mats to a better location. The higher the current, the higher the read range off the mats.

Synchronisation

Without correct synchronization, there will be poor transponder reads (or no transponders read) because one control box will be charging transponders whilst another will be trying to read

transponders. When this occurs, the systems are said to be out of synchronization. The powerful charge up signal from one set of mats will swamp the small signal transmitted from a transponder at another set of mats. The receivers within the control box are extremely sensitive and any interference in the vicinity of 134 kHz will have a drastic effect on the reading performance of the system. The charge and receive modes of each mat will occur simultaneously if all control boxes are synchronized together. It takes experience and on-site testing to determine how far systems need to be separated before synchronization is not required. It is often good practice to synchronise all units since in many applications it is desirable to create a local area network (LAN) so that data can reach a central laptop from all timing points. Be aware that interference from the charge up of one mat can travel down a sync cable and reduce the performance of an un-synced control box if the sync cable is attached between control boxes. The sync pulses will travel up to 400m (and often further) but be aware that Ethernet should not exceed 90 metres between High Density Systems, or between Ethernet switches. A specialised box can be ordered which extends the range and sits between two lengths of up to 90 metres each of shielded Cat 5 Ethernet cable.

In a synchronized system, one control box is set as a master and the other units as slaves. The master unit will be responsible for sending the synchronization pulse and oscillation signal to all other units. The most important LED on the HD control box is the sync LED (orange) which indicates clearly whether the unit is set as a slave or master. If the LED is on, then the master is a master. If it is unlit it is a slave.

Be aware that the master unit MUST be reading (the red READ LED flashing) before the slave units will be able to read transponders. The Master must also be reading if the synchronized Slave units are being tuned. Only when the master is in the read mode will the oscillation signal be sent down the synchronization line. The oscillation signal determines the frequency of the charge up phase (134kHz).

When do I need to Sync?

The charge-up magnetic field produced by the antenna mat is quite powerful and can easily interfere with the sensitive receiver circuitry of the readers. This is a problem only if the charge up signal is stronger than the received signal of a transponder. However the transponder field strength output is quite weak and needs to be amplified greatly for correct reading. Any source of noise in the 134kHz region will interfere with transponder reading and this is clearly observed by a reduction in read height off the antenna mats. The closer together an un-synced pair of HDD Systems, the worse the read range becomes. The separation distance required is influenced by several factors and can really only be determined by testing prior to use. A safe distance where there is line of sight between units is usually more than 70 metres. However, metal fencing and barricades can couple the charge-up energy along its length between units. If units are placed either side of a hill, they can be placed quite close without any interference.

The best solution is to synchronise all units. This will also allow all units to send their data in real-time to RFIDServer.

Sync and Data Ports

There are 4 Ethernet style sockets where data cables can be plugged between control boxes, and between computers. Two ports are just Ethernet (data) only and will route data to another control box, Ethernet switch, router or PC computer. A cross-over cable is not required but can be used as can the usual straight through Ethernet cable. These two ports are connected to an internal Ethernet switch. The other two ports (Sync/Data) combine synchronization signals with Ethernet communication. These are the two ports that are used to 'daisy chain' multiple control boxes together so that the group of timing points are all synchronized together. The Sync port is crucial to

the systems performance where more than one box is used in a system. The Sync port carries several signals that tell each box when to charge-up transponders.

The first pulse (two wire differential interface) tells each unit when to start and finish a charge-up cycle. The Master unit is responsible for sending this pulse and all other units on the sync line must be set as Slaves. Reads will be sporadic if two Masters are wired together and long term use will damage the control box. When two Masters are sync'ed up, you will notice that the tuning meter will rise and fall over a 5 to 10 second period. The red READ LED will flash when the sync pulse is being received.

The second sync pulse is a 134kHz pulse (2 wire differential line) coming from the master. This is an important pulse that ensures all units are 'in-phase'. This is more critical when mats from two units are put in close proximity. The Slave units will not read transponders without this sync pulse.

It is important that an Ethernet patch lead is not connected between the Data/Sync ports and an external Ethernet switch or laptop computer. The twisted pair lines used for the sync pulse are not used by the Ethernet and most Ethernet switches and computers ground these lines making their use not possible. All patch cables to computers should route via the Data Only ports.

The HDD System has an inbuilt Ethernet switch to route data between units and to PC computers. Please note that Ethernet cabling should not exceed 90m between units for the Ethernet to work properly. The Sync pulse can run longer distances (up to 500m).

Specification of Ethernet cable

Systems of two or more control boxes are supplied with the necessary sync/data cables. However the lengths supplied are less than 10 metres in length. When systems are setup for a triathlon or events where timing points are separated by more than 10 metres, more data/sync cables are needed. We recommend that only the best Cat5 shielded Ethernet cable is used for this purpose. We recommend Eurocable which has multiple shields and is made of stranded twisted pairs. The RJ45 jacks must be of the shielded type and the cable shield must be soldered to the RJ45 jack for a reliable ground connection. This cable is designed for outdoor use and should be kept on high quality cable reels (we suggest Schill cable reels). We suggest either ordering this cable from RFID Race Timing Systems or sourcing the cable locally and preparing the cables using a qualified network technician. The Ethernet jacks are protected by Neutrik Ethernet jack protectors.

The type and condition of Sync/Data cables is very important for the correct functioning of the system. Problems with the timing system are usually due to faulty sync cables.

Buzzer

The buzzer signifies a read of a transponder. The buzzer has two volumes and can be turned off. Buzzer control is via the Logger software under Preferences.

Battery Indicator

The battery indicator tells when the system is turned on and also the status of the battery. On older units this is an analogue meter with red, yellow and green zones. The system should be recharged if the needle dips into the red zone. It is normal for needle to quiver when in read mode.

On newer models there is an LED battery indicator. If only the red LED is lit (or no LED's are lit) then the battery should be recharged. Note that it is likely that the LED's will flicker if the battery voltage

drops below 12.2 volts. This is due to a small voltage drop due to the high current use during charge-up of the transmitter and is normal.

Fitting of Battery

The HDD System utilises two (2) sealed lead acid batteries for 12V internal power. The batteries are hooked up in parallel and the leads supplied inside the control box should be connected correctly. Extreme care must be observed with correct polarity when placing the spade connectors onto each battery. Red leads = positive and black leads = negative. Reversing polarity will possibly damage the circuits of the HDD System and this is not covered under the warranty agreement. Reversing polarity will cause the 7.5A fuse on the main HDD PCB board to blow and could possibly irreversibly damage the Ethernet switch. The spade connectors should firmly fit the connectors on each battery so that they are unlikely to come loose.

The battery type should be 12V (7 to 7.2 Amp/hour) with the dimensions 151mm x 65mm x 97.5mm and should be placed on its side with the connectors to the left hand side. Once the leads have been connected (and checked for correct polarity) the control box should be turned on to check that the power supply is correct. There should be full LED's shown on the battery indicator. Turn off the control box and carefully secure the aluminium battery holding plate down onto the batteries using the supplied hex head bolts. The bolts should not be over-tightened but enough so that the battery is held firmly in the compartment.

Battery life depends on the amount of use of the system and the care is recharging used batteries. ALWAYS CHARGE AFTER USE. A partially or fully discharged battery that is left in this state for a long time prior to charging will be damaged. As a result the control box will have reduced operation time when in read mode. Batteries are inexpensive and should be replaced every 3 – 4 years.

Logger Software

Logger for HD V1.6

LCD Display

The LCD display is used to change settings of the HDD Control Box and also show read transponder codes. When the Control Box is powered up, it shows an initial start up screen and then goes automatically into the Main Menu. The yellow Sync LED on the panel will be lit if the unit is configured as a Master and unlit if configured as a Slave. When in read mode, the LCD screen will show the number of transponders read, the static IP address of the unit, transponder code and time when a transponder is read.

LCD Display LED's

There are 7 LED's below the LCD screen and above the keypad. They signify some diagnostic information. LED 2 (green) indicates that the unit is in read mode, LED 3 (green) signifies a transponder code has been read and saved to the unit's memory. LED 6 (yellow) indicates that the unit has networking turned on and LED 7 (yellow) indicates that a unit has a socket connection open with RFIDServer.

LCD Keypad

The keypad allows navigation through the various settings of the unit. Reading on the HDD can be stopped by pressing any key down on the keypad. This will show menu options.

Menu Options

1. Start Reading - Starts the unit reading transponders
2. Synchronisation – sets the unit as a Master or a Slave (Auto function currently not used)
3. Set Date and Time – used to manually set the date and time of the unit. Use the up and down arrows (+ and – keys for 10 step increments).
4. Display Date and Time – shows current date/time
5. Preferences – pressing this brings up the Preferences menu

Preferences Menu

1. Buzzer Volume – this sets the read buzzer (this may be replaced with “Split”). Split is not used in the HDD.
2. Network – used to plug in the static IP address of the box. Use the arrow keys to increase/decrease each subnet value. The + and – keys are used for 10 value steps.
3. Antennas – Not used in the HDD system
4. Gating – The default setting here is Time Gate (3 Sec). Gating is used to control the flow of transponder codes over time. If a transponder is placed onto one antenna of the antenna mat, it will only be read once on that antenna. As soon as the transponder is removed from the antenna read zone it can be read again provided 3 seconds has elapsed before the second read. Gating is very important to reduce the processing overhead of the inbuilt computer, especially when timing a start line. Turning gating off will allow all antennas to read chips continuously. This setting is only used for diagnostic testing of the unit. Gating should be used during normal use of the HDD System

Networking

Many mistakes are made with setting up an outdoor local area network (LAN). The true power of the RFID Race Timing System is realized when real-time data is sent to a central computer for results processing. There is a number of software packages that interface well with the RFID Race Timing System and allow results to be calculated on the fly as well as allowing import of raw timing data after the event.

The best way to capture the data is to add the control box to the LAN and give each unit a unique static IP address. The control box does not currently support DHCP so routers and PC computers should be given not conflicting static IP addresses. The recommended IP addresses are in the range 10.10.0.1 to 10.10.2.254 or 192.168.0.1 to 192.168.2.254.

If you cannot connect to the control box using your PC race timing software check;

1. The IP address of the control box
2. The IP address of the PC computer
3. The subnet mask of the PC computer (see TCP/IP in network settings)
4. The Logger program has been initialized from power on (press enter to get to the main menu)

5. The data or data/sync cable is not damaged or exceeds 80 metres length between control boxes, Ethernet switches or PC computers.

Breakout Box (for use only with the Dual Antenna System MKII)

Because the HD System uses a single cable to connect both data and sync between control boxes, the pinout of the cable differs to that used in the Dual Antenna System. The Dual Antenna System utilizes a separate cable for Ethernet and for synchronization. The Breakout box supplied to owners of both types of system is a simple aluminium box that allows the HD System to connect to the Dual Antenna System. The box consists of RJ45 socket on one end, and 2 sockets on the other end. Simply put a shielded (with shielded RJ45 as per HD specification) cable from HD system to the single input side of the Breakout Box, and a straight through Ethernet cable (shielded or unshielded) from the silver socket to the Sync In of the Dual Antenna System. Another Ethernet cable (can be unshielded) runs from the black socket (side of the Breakout Box that has two sockets) to the data port of the Dual Antenna System MKII. The Breakout Box is not waterproof so keep it safe in the event of wet weather.

The Dual Antenna System MKIII does not need a breakout box and uses the same cable setup as the HD System.

HD System – Antenna Tuning

The new HD System can drive 4 EVA mats or 1 single 4 x 2m carpet mat. There is a difference in the inductance of the charge up antenna between these configurations. The PCB board that attaches to the external antenna output plugs has a series of jumpers that can be changed to alter the tuning of the charge up loop. The diagram above shows the schematic for these jumpers. Note that when two capacitors are put in series that the values in series are halved. For example if a jumper is put between 7 and 8, this will put two capacitors with individual values of 33nF in series. The resultant capacitance is $33/2 = 16.5\text{nF}$. Putting capacitors in parallel results in addition of the capacitor values. For example if a jumper is put between 1 and 2, and between 9 and 10, the resultant capacitance is $47 + 4.7\text{nF} = 51.7\text{nF}$.

The single antenna mat ideally uses a jumper between 7 and 8, and between 9 and 10. The capacitance equals 21.2nF. The EVA mats use jumpers between 1 and 2 which equals 47nF. Sometimes the mats will not tune in fully with the limited range of the tuning knob. The tuning knob varies the inductance of the antenna circuit and balances capacitance with the natural inductance of the antenna loop to resonate at 134kHz. If you find that the tuning knob needs to be turned all the way up, then the capacitance needs to be increased. Try adding more capacitance (say a jumper between 13 and 14 = 2.2nF) and you will find the antenna will tune with the tuning knob screwed further down. The rule is, increasing inductance (screwing the tuning knob further down), means that the capacitance can be reduced. Sometimes the presence of metal in the ground can alter the inductance of the charge up antenna. You may need to add capacitance to bring the antenna back into tuning range.

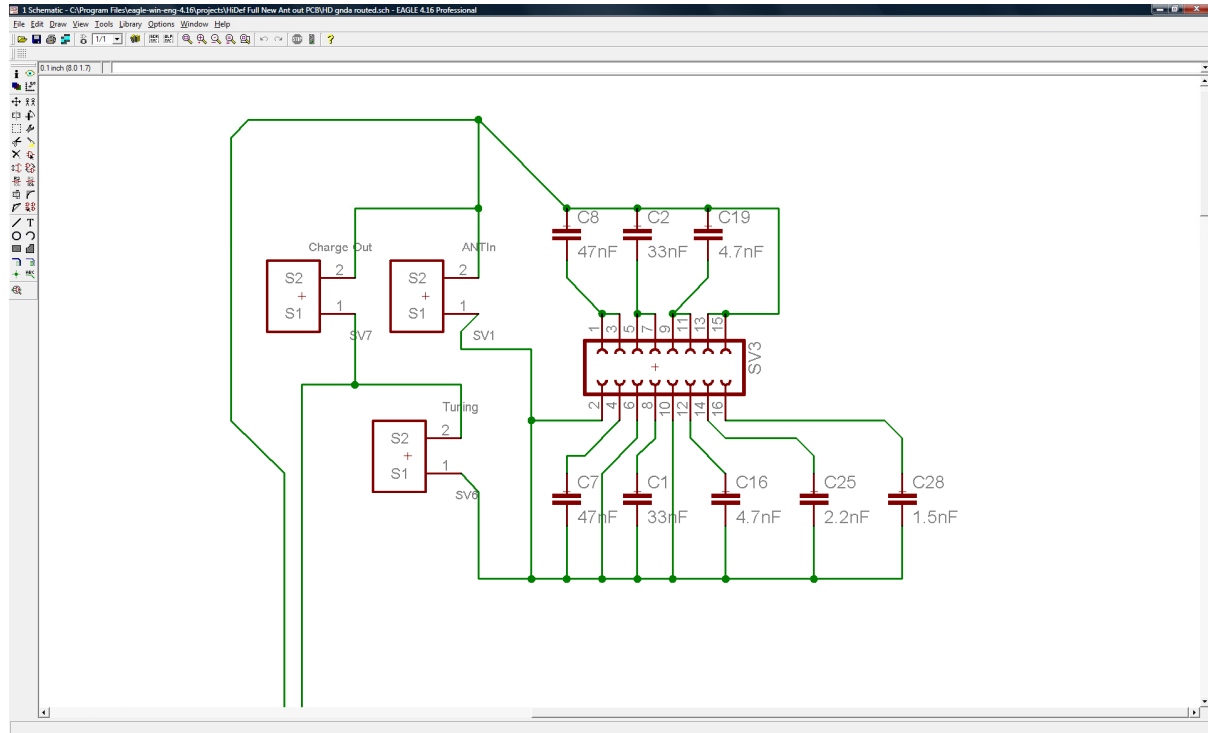


Figure 1. The schematic for the jumpers selecting capacitance of the antenna circuit

Type of mat	Jumpers	Capacitance (nF)
Single Carpet Mat (4m x 2m)	8	16.5
Single Carpet Mat (4m x 2m)	8 and 16	18
Single Carpet Mat (4m x 2m)	8 and 14 and 16	20.2
Single Carpet Mat (4m x 2m)	8 and 10	21.2
EVA Mats (X4)	2	47
EVA Mats (X4)	2 and 16	48.5
EVA Mats (X4)	2 and 14	49.2

RFID Race Timing Systems – HD Mat Layout

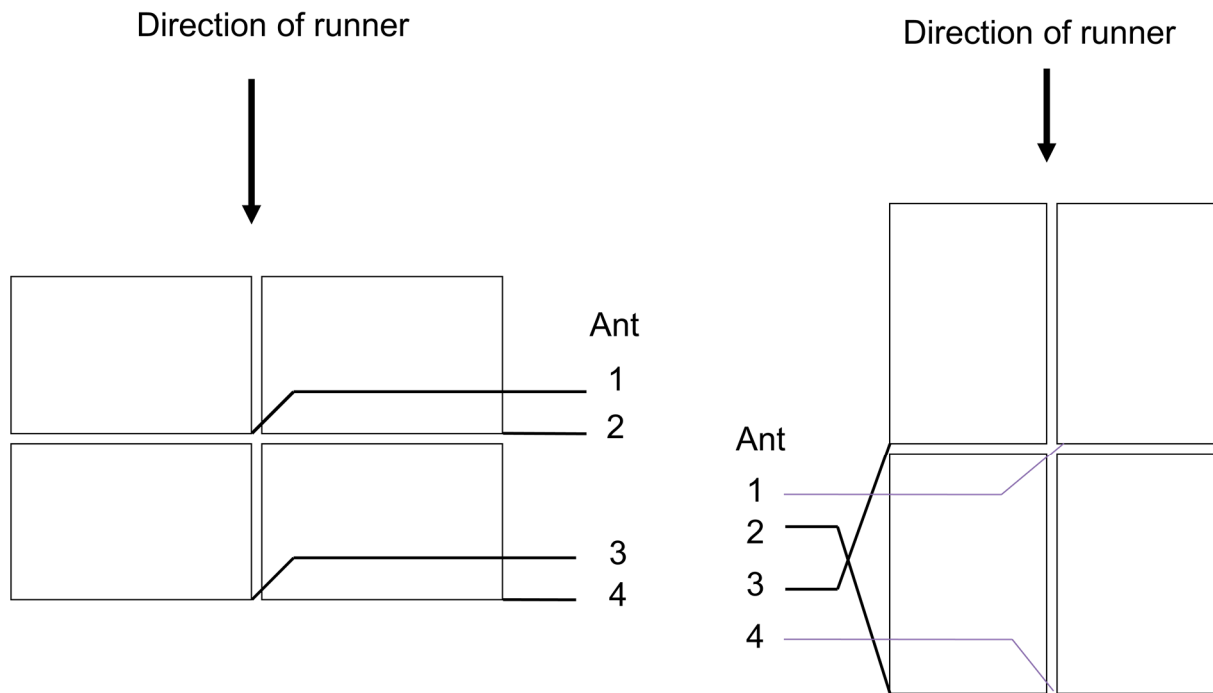


Figure 2. Correct setup of each EVA mat when used as an array for a timing point

HDD Mat setup (single carpet mats)

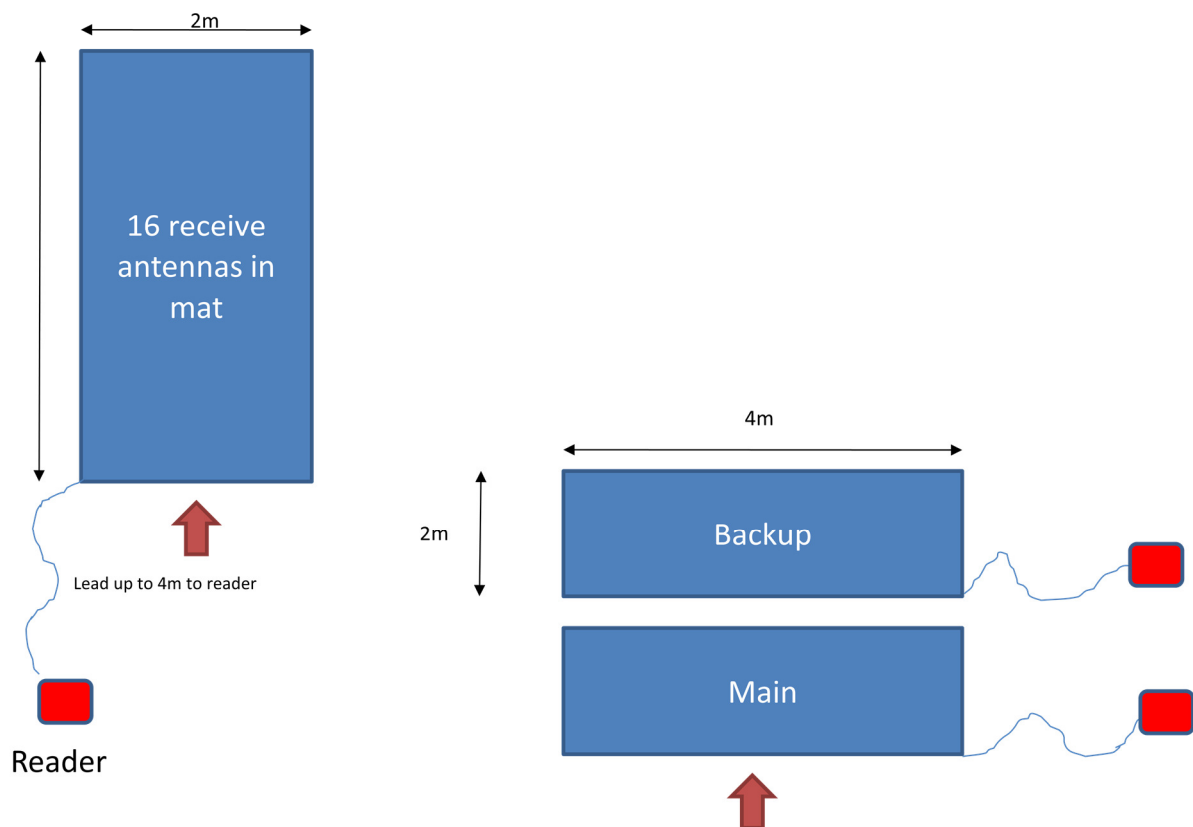


Figure 3. Setup of HDD single carpet mats.

The diagram above shows the way the EVA mats should be connected to the antenna plugs. The configuration is necessary to improve the read height down the centre line of the mats. Swapping configuration will also change the tuning of the mat array. The 4 EVA mats have one charge up loop each and these loops are connected as one when all the mats are plugged in. The charge up antenna is essentially an open circuit until all EVA mats are plugged into the control box. Also note that antenna 1 on each plug is the charge up loop of each EVA mat so that there effectively only 12 reader loops in a set of 4 EVA mats. For this reason, antenna 1 on each mat will not be connected to a reader and this LED (LED's 1,5,9 and 13) will not light when a chip is run across the mats.

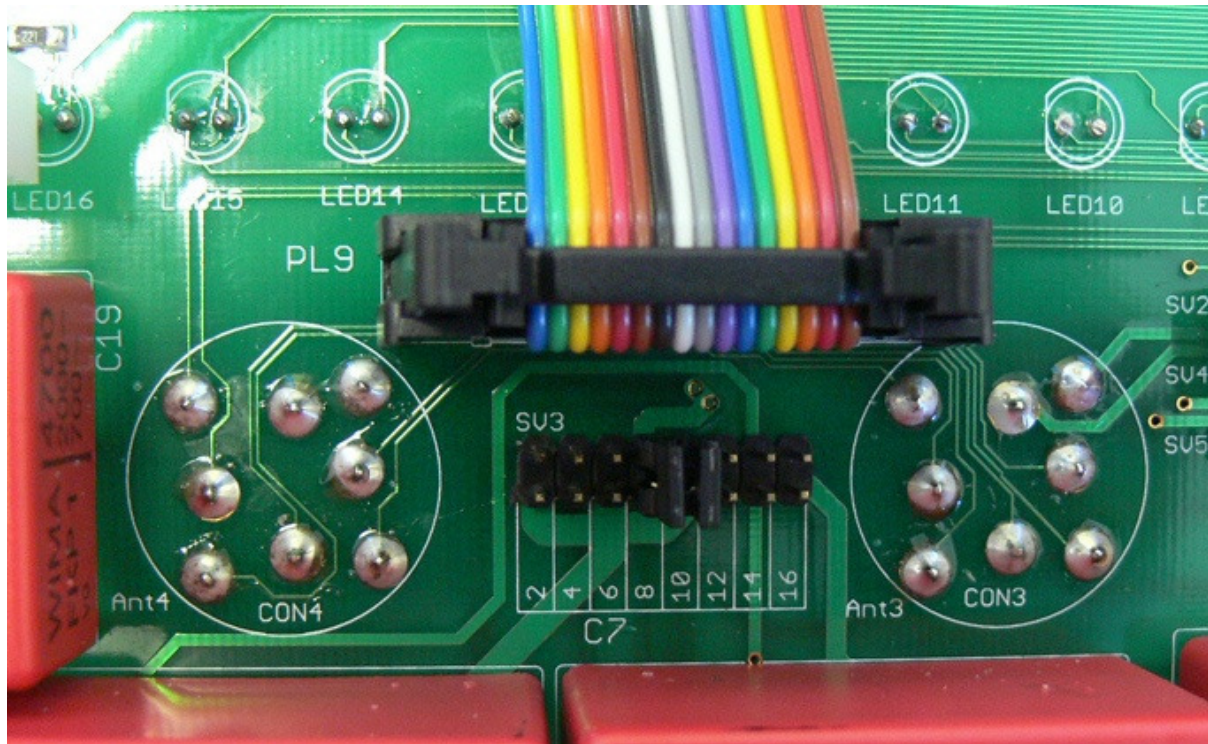
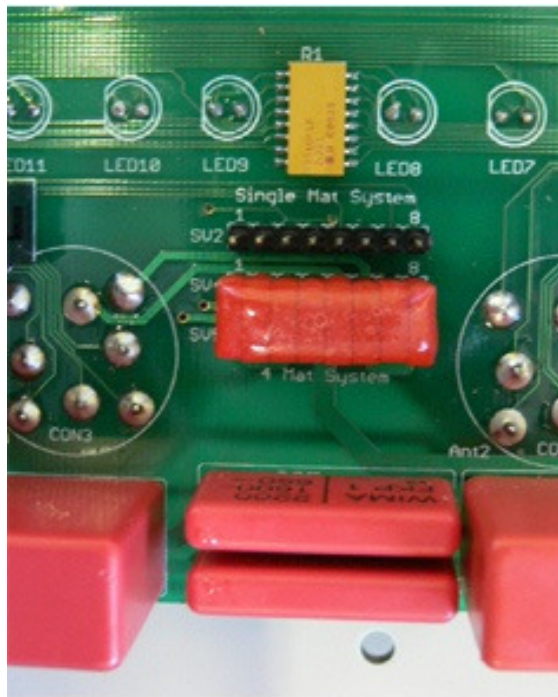


Figure 4. Picture showing jumper selections altering the capacitance of the antenna circuit. Setting shown is typically used for the 4 x 2m single carpet mat although 8 and 16 can also be used.

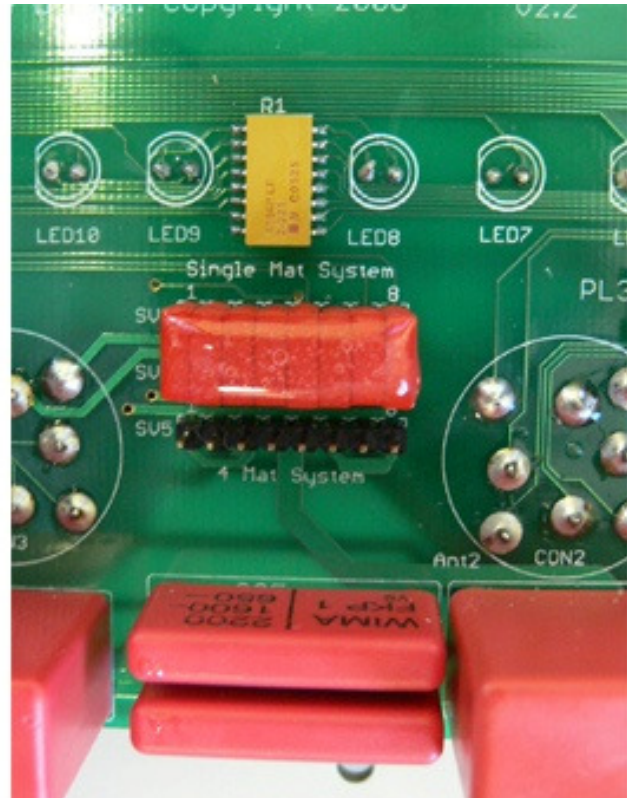
The single carpet mat uses the full complement of 16 readers within the control box and uses a single charge up loop. This charge up loop is served by the single blue connector. This charge up loop gives a good charge up field strength but can be more affected by metal in the ground. The capacitance of the charge up loop may need to be changed to bring the mat back into resonance (peak current on the meter). This is done by changing the jumpers.

There is a further set of 8 jumpers that are glued together. These need to be changed according to whether the single mat, or 4 EVA mats are used. The correct setting is written on the PCB board in white lettering.

The single carpet mat can be used with another mat to time up to 8 metres wide. The mats can also be overlapped at the centre region and this is recommended to improve the reading between the mats. Putting mats in close proximity may drop the current on the tuning meter. The meter will also show a reading if in close proximity to an antenna mat that is reading, even if this unit is not reading. This is due to energy being coupled from one mat to another.



EVA MAT Setup



Single Carpet Mat Setup

Figure 5. The two different settings of the Block Jumpers for EVA Mats (x4) and Single Carpet Mat.

Appendix - HDD System Specifications

Transmitter

The HDD System transmitter operates at a fundamental frequency of 134.0kHz (+/- 0.2kHz). Power output on the antenna is limited according to the various PTT/FCC Regulations for the country the unit is to be used. For example, in Australia the transmitter must not produce an output greater than 1.54×10^{-4} volts at 3m from the charge up loop. First and second order harmonics are negligible due to the high Q of the transmitter's antenna (>100). Field strength is adjusted by PWM on the power RFM within the HDD control box.

Prior to sale in the specific country, the transmitter power output is set to be 2 uV/m below the maximum allowable field strength for the particular country.

Transponders

Transponders transmit a weak signal between 123kHz and 137 kHz. The signal is well within PTT/FCC regulations. Transponders are battery-less and hence have no spark potential making them safe in dangerous gas environments.

Microprocessor

The HDD System uses a 44mHz Rabbitcore microprocessor with spectrum splitter for low RF emissions. The internal electronics have met CE certification levels for EMI.

Maximum Power at transmitter	24W @ 12V input
Supply voltage (sealed lead acid battery)	11.5 to 14V
Transmitter frequency	134kHz +/- 0.2kHz
Antenna Voltage (AC) at terminals	250V peak
Charge up antenna Q	105
Networking	Ethernet 100BaseT
Power use (average)	1.2A at 13.8V (16.5W)
Charger	AC 240/120V charger with 14V output