UltraRad Radio Control System

Introduction

The ***Timpdon Electronics UltraRad*** model railway radio control system represents a radical departure from the more conventional form of model radio control. ***UltraRad*** is a complete, integrated control system comprising radio transmitter, radio receiver and a range of controllers to suit almost any type of application.

The main differences between ***UltraRad*** and conventional radio control are:

- It operates in the 433 MHz UHF frequency band for licence exempt short range devices and complies with all UK legislation for licence free operation. Note, however that licence free operation in this band may not be legal in other countries.
- It uses narrow band frequency modulation to eliminate problems of multi-path reception and interference commonly encountered in low frequency amplitude modulation systems. An operating range of up to 30 metres can be reliably achieved in a normal model or garden railway environment.
- It uses a single type of transmitter and receiver, operating on a single frequency.
- All transmitters and receivers are identical. All calibrations are performed within the vehicle controller, permitting any vehicle to be controlled by any transmitter without adjustment or calibration, except for certain live steam systems where a reverser servo trim may be required from the transmitter during normal operation.
- Each transmitter controls one analogue speed channel, a digital forward/reverse/stop channel and two digital auxiliary channels for the control, for example, of horns and lights. Not all controllers are equipped with auxiliary channel outputs.
- All transmitters have a unique serial number, and a controller will respond only to a single transmitter to whose serial number it is locked. Any controller can be locked to any transmitter at any time by the user.
- Multiple transmitters can be operated in close proximity at the same time without interference or loss of performance.
- Control information is transmitted intermittently as a serial, encoded binary data stream including speed setting, direction, control and auxiliary control information, together with synchronising, data validation and transmitter serial number information. This data is decoded by the controller and used to control the vehicle either directly, in the case of battery electric controllers, or via conventional radio control servos in the case of live steam controllers.

This technical note describes, in outline, some of the technical features of the ***UltraRad*** system. For more detailed information on individual system components, reference should be made to the user manuals for each component.

At present, ***UltraRad*** range comprises the following components:

UltraRad Vehicle Speed Control System

Radio Transmitter	Model UTX1	For battery electric vehicles
Radio Transmitter	Model UTX2	For battery and live steam vehicles
Radio Transmitter	Model UTX3	Multi-Channel Version of UTX2
Radio Transmitter	Model UTX5	Version of UTX2 with full reverser control
Radio Receiver	Model URX1	

Controller	Model URC1	For battery electric vehicles
Controller	Model URC2	For battery electric vehicles
Controller	Model URC3	For live steam vehicles with separate regulator & reverse servos
Controller	Model URC3	For live steam vehicles with single combined regulator / reverse servos
Controller	Model URC5	For battery electric vehicles with separate ESC
Controller	Model URC7	Point and Signal Controller
Controller	Model URC8	For live steam vehicles with separate regulator & reverse servos – Full reverser control
Controller	Model URC9	For battery electric vehicles – with directional lighting
Controller	Model URC10	For Tolhurst live steam vehicles with three dual action servos controlling trumpet valves
Controller	Model URC11	For higher voltage battery electric vehicles - G Scale and Gauge 1
Controller	Model URC12	Combined receiver and controller for battery electric vehicles

Radio Transmissions

In the ***UltraRad*** system, radio control data is transmitted as a binary serial data packet comprising a total of 104 bits. These are formatted as

24 bits	Synchronising Block
48 bits	Control Data Block
32 bits	Validation and Transmitter Serial Number Block

Data transmission speed is 256 µs per bit, representing a total packet length of 26.6 ms.

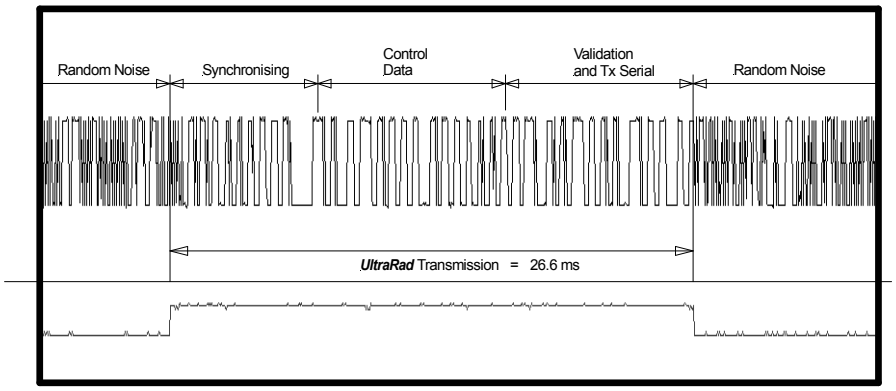
The transmitter is energised only during the transmission of each data packet.

In normal operation, a new data packet is transmitted at an average interval of 1.0 seconds, but in addition, a new transmission is made every time any change is made to a control setting, up to a maximum transmission rate of one packet every 300 ms. The transmitter therefore has a normal duty cycle of 2.7%, rising to a maximum of 8.9%, within the limit of 10% imposed by the regulations covering the UHF band used.

Data Decoding

In the absence of any transmission, the data output from the ***UltraRad*** receiver is a random series of binary pulses of variable duration, but shorter than that used by the ***UltraRad***.

When a data packet is transmitted by the ***UltraRad*** transmitter, the initial synchronising block is used both the lock the receiver on to the transmission, and to signal to the ***UltraRad*** controller the presence of a new data packet. The oscilloscope trace below shows the data output of an ***UltraRad*** receiver before, during and after a transmission.



UltraRad Receiver Output

UltraRad Transmitter energised

All data received by an ***UltraRad*** receiver from any source is passed to the controller. The controller continuously scans the output of the receiver looking for the pre-defined **synchronising** block of an ***UltraRad*** transmission. Whenever this is detected, the controller reads the next 80 data bits at 256 µs intervals, comprising the **control data** and **validation** blocks. On completion:

- It validates that the data is uncorrupted by comparing a computed checksum derived from the 48 bit control data block with a transmitted validation checksum.
- It verifies that the transmitter serial number included in the validation data matches that to which the controller has been locked – *see below*.

If either of these two tests is failed, the data is discarded and the outputs from the controller to the vehicle are not changed.

Only if the data validates correctly and it has been received from the transmitter to which the controller has been locked, is further action taken:

- The **Data Valid** indicator is flashed to indicate that a valid data packet has been received.
- A 10 second safety **fail safe** timer is restarted – *see below*.
- The contents of the control data block are decoded and the control outputs to the vehicle are set to the transmitted data values. The actual form of the control outputs depends on the controller model.

Transmitter Lock

As described above, an ***UltraRad*** controller will respond only to transmissions from an ***UltraRad*** transmitter with a single serial number to which it has been locked. All ***UltraRad*** transmitter serial numbers are unique, and are embedded during manufacture.

To permit a controller to be locked to a transmitter, each controller is fitted with a **Transmitter Lock** push button switch. While this switch is pressed, whenever an ***UltraRad*** data packet is received, the transmitter serial number is read from the contents of the packet and stored within the controller, in non-volatile memory.

Subsequently, when the transmitter lock switch is released, the stored transmitter serial number is used to validate all future data packets, until changed again.

It should be noted that more than one controller can be locked to the same transmitter at the same time. This technique permits automatic double heading with two coupled vehicles responding identically to a single transmitter.

Multiple Transmitter Operation

All ***UltraRad*** transmitters operate on the same frequency. However, because data is transmitted in short packets at relatively long intervals, multiple ***UltraRad*** systems can be operated in close proximity, at the same time, without mutual interference, because:

- Each controller will react only to transmissions from the transmitter to which it has been locked.

- Normally, with an average 1 second transmission interval, each transmitter is operating for only 2.7% of the time, increasing to 8.9% maximum at the minimum 0.30 second transmission interval. Thus there are ample gaps for other transmitters to occupy.

- The average 1 second transmission interval is randomly varied between 0.8 and 1.2 seconds to minimise the risk that if the transmissions of two transmitters happen to coincide on one interval, resulting in corrupted data, they will be unlikely to do so on the next.

The ***UltraRad*** system has been comprehensively tested with four systems operating together on the same layout, with no significant degradation in performance or control.

Fail Safe

As data transmission in the ***UltraRad*** system is not continuous, normally a controller will not change its output until a new valid data packet is received. This has safety implications, however, in the event of loss of radio transmission and could result, for example, in a vehicle running at full speed with no means of stopping it.

To protect against this condition, all ***UltraRad*** controllers are equipped with a fail safe mechanism. If, at any time, a period of 10 seconds elapses with no valid transmitted data packet being received by the controller, the output of the controller is automatically set to zero speed, to bring the vehicle to a halt. This condition will only be over-ridden when radio communication is re-established and a new valid data packet is detected.

To special order, *Timpdon Electronics* can supply all ***UltraRad*** controller models with the fail safe disabled, to accommodate users who wish their vehicles to continue in normal operation in the absence of a valid radio transmission.

Interference from Non-UltraRad Radio Systems

The 433 MHz UHF band used by the ***UltraRad*** system is not a dedicated model radio control band. It is used in addition by other short range radio systems, mainly for industrial telemetry applications. Transmissions from such equipment may also be present, giving the possibility of interference with the ***UltraRad*** system.

Because of the coded nature of ***UltraRad*** transmissions, there is no possibility of unsafe operation of a vehicle from some other transmission. At worst, interference will prevent valid data being received by an ***UltraRad*** controller which will result only in the vehicle being stopped.

Extensive tests in typical model railway environments have shown no evidence of interference from other users of this band, although you should be aware that, if your system is used in close proximity to other equipment operating at the same frequency, 434.20 MHz, problems may occasionally be encountered.