Functional Description of the Universal Remote Control

The Universal remote control is a wireless device used to operate and control model trains. Its most basic operation consists of receiving input from the operator of the model train and converting this information into digital information packets which are transmitted via a wireless 2.4 GHz band link to the model train. The Universal remote control is capable of controlling two different versions of model trains, those using Lionel's proprietary communication protocol and those using standard Bluetooth communications.

The Universal remote control can operate up to three trains at the same time. When first powered on it will scan for any trains transmitting using Lionel's proprietary protocol. The remote will initiate a pairing with up to three trains detected. If less than three proprietary protocol trains are detected the remote will begin scanning for any Bluetooth trains that are broadcasting and initiate a pairing with them until it has paired with a total of three trains.

The Universal remote control consists of a series of subsystems used in combination to perform the functions necessary to operate the model train. The central core of the remote control is a Bluetooth module built around a Texas Instruments CC2541 transceiver chip running the Texas Instruments Bluetooth 4.0 stack and the Lionel Universal remote control application. The Bluetooth module handles the Bluetooth communication, processes all operator inputs and controls the proprietary protocol communication. The module connects to the subsystems by either a parallel or serial interfacing techniques. The antenna for the Bluetooth module is a foil pattern on the module PCB.

The Bluetooth module operates in the 2.402 GHz to 2.480 GHz range using 40 individual channels spaced 2 MHz apart. The Bluetooth maximum output power is 1 mW. Information packets are transmitted and received using a GFSK encoding method at a data rate of 1Mbs. One data packet consisting of 20 bytes is transmitted every 500ms.

The Universal remote control uses a 2.4GHz RF transceiver module to handle the proprietary protocol communications. The RF transceiver module is connected to the Bluetooth module using a SPI serial interface. Information packets are passed between the RF transceiver module and the Bluetooth module as necessary. These packets contain both data and status information on the operation of the transceiver. The antenna for the RF transceiver module is a foil pattern on the module PCB.

The RF transceiver module operates in the 2.404 GHz to 2.476 GHz range using 18 individual channels. Information packets are transmitted and received using a GFSK encoding method at a data rate of 1Mbs. One data packet consisting of two bytes is transmitted every 20ms. CRC error detection is included to insure data integrity. If an error is detected during transmission it is corrected by using a proprietary protocol that uses retransmission techniques for correction.

Other Universal remote control interfaces include digital and analog signals generated by operator controls. Several digital inputs are connected to pushbuttons that are used to select the train to be controlled and the function to be performed. Three digital outputs are used to control LEDs to indicate the train being controlled. One analog to digital input reads the analog signal generated by a speed control knob to change the speed of the train.

The Universal remote control is powered using 3 AA alkaline batteries. A switching voltage regulator operating at 1.5MHz is used to maintain a stable operating voltage as the batteries discharge.