



1.0 General description of the system.

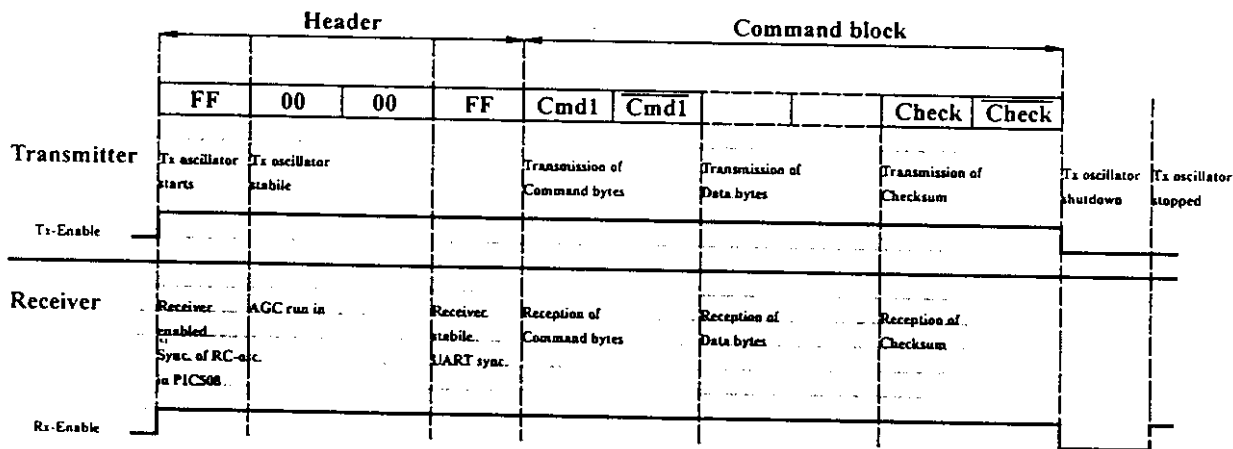
A complete system consists of following: PC installed with WIN 95, serial cable between Tower Unit and PC, Tower unit and Mobile Unit with 3 sensors connected to the analog inputs and a motor connected to the external motoroutput.

Tower unit communicates with the Mobile Unit in a 26.995MHz half duplex radiolink system. Tower Unit and Mobile Unit can operate in either transmit or receive mode.

The transceiver works in half duplex mode, which demands a quick startup/stop time for the transmitter and receiver. The transmitter and receiver can not be active at the same time (full duplex). This demands a methode that describes when the transmitter is active and the receiver is active. In a half duplex system there is always a master. In this system the PC is the master. The timing is controlled by the PC.

1.1 Header.

On the lowest level (The physical layer in ISO 7 layermodel) the header is a central part in the superior timing. Through the header and the following commandstructur the controlsignals Tx-Enable and Rx-Enable is derived.



1.) The first Headerbyte, from PC to Tower Unit, is also used for synchronisation of the internal RC-oscillator inside the PIC508 microcontroller. Because of this, is the first byte, from the PC to Tower Unit, not FF, but FE instead.

The picture above schematically shows how a single command is constructed. Each byte in the four byte long header has several functions. A detailed description in this document of the header and the protocol will be to comprehensive, and therefore not conducted.

As a comment to note 1 (below picture), it should be mentioned that the first headerbyte (FE) from PC to Tower Unit, is used to determine if the baud rate is correct or not. In case of wrong baud rate, the Tower Unit shuts down immediately. This feature is implemented to ensure that the Tower Unit only transmits data, when used with the right LEGO application software.



1.2 Receiver in Tower Unit.

The antenna signal is guided to the base of Q4 via the coil (L2) in the antenna filter in the transmitter. Q4 and Q6 constitutes the HF-stage. This stage becomes via Q6, located in the emitter of Q4, automatic gain controlled (AGC). The AGC control is done by changing the current through Q4, and thereby changing the quiescent point of Q4. From L4 in the collector of Q4 the signal is guided via C35 parallel with C37 to the base of Q5 (the mixer). C35, C37 and C36 is used to tune the collector circuit (L4) to 26.995MHz. The tuning of the collector circuit is done via C37. C35 parallel with C37 and C36 provides impedance matching to the mixer. The mixer is also AGC regulated. The AGC voltage is normally in the range of 0 to 2 volt.

From the collector of Q5 (mixer) the signal is guided through the ceramic filter (CF1). The ceramic filter has a bandwidth of 13kHz by 455kHz. The intermediate frequency (IF) signal is amplified approx. 400 times in the IF-amplifier (Q11 and Q7). The amplified signal is guided to the AM-detector (Q9) via C7. The LF signal with a amplitude of approx. 1 V can now be found on the emitter of Q9. R38 and C10 makes up the time constant in the AM-detector. When transmitting, the detector can be shut down via Rx-Enable. This is done to preserve the voltage on the AGC filter capacitor (C16) while the transmitter is active. D1 together with R51, R57 and C16 implements a double peak detector. R51 is used together with C17 during the AGC settling time. The receiver is designed to change the amplification from max. to min. in 2 bytes (9.2 ms). R57 is used to keep the "negative" part of the signal. R42 prevents the AGC loop to self-oscillate. The AGC voltage is guided to a -4.5 times amplifier (IC1C) via a buffer amplifier (IC1B). The filtered AGC voltage, that controls the amplification in the HF-stage and the mixer, is now present on the output of IC1C. The amplification in the receiver can be set to minimum via Rx-Enable while transmitting. Data is present at the output of IC1D (Rx-Data).

1.3 Local-oscillator in Tower Unit.

The local-oscillator (LO) is a colpitts type and build around Q8. The oscillator frequency is 26.540MHz. The oscillator signal is taken from the emitter of Q8. The oscillator delivers approx. 1 V_{pp}.

1.4 Transmitter in Tower Unit.

The oscillator in the transmitter is build around Q1 and Q2, and the frequency is 26.995MHz. The oscillator is started by enabling Tx-Enable and thereby providing base voltage to Q1. Q2 is as a buffer for Q1, and connected as a darlington stage. The oscillator reaches full amplitude after max. 5 ms. The crystal in the oscillator is 20 ppm. The oscillator signal of approx. 1 V_{pp} is guided to the output stage (Q3) via C29. The output stage is neither working in class A or class C but something in between. The necessary modulation (approx. 85%) is done by changing the quiescent point of Q3. The data from the PC is converted to 5 V logic and then RC-shaped via R15 and C26. These filtered data is used to change the bias of Q3, and thereby generating the AM modulation on the collector of Q3. The collector circuit (L3, C34 and C31) is tuned to 26.995MHz, and R32 reduces the Q.

The relative high impedance level of Q3's collector is reduced by C34 and C31. The low impedance signal is now transformed up to approx. 10 V_{rms} on the antenna via the antenna filter (L2 and C33).

2. harmonic from the output stage is reduced by the antenna filter.



1.5 Controller part in Tower Unit.

The controllerpart in Tower Unit is build around a microcontroller (IC3) from Microchip, PIC12C508. Q10 and Q17 converts Rx-Data from PC (RS-232) to 5 volt logic. Q13 and Q16 converts Tx-Data from 5 volt logic to RS-232 (PC). The supply to the radiopart can be switched on/off via Q12 and Q15. The resetcircuit for IC3 is build around Q14. IC2 is the 5 V voltageregulator. The GREEN-LED (D2) indicates when data is transmitted. The controller part generates following signals to the radiopart: Tx-Enable, Rx-Enable, Tx-Data and RF-5V.

The controllerpart receives following signals: Rx-Data.

1.6 Receiver in Mobile Unit.

See the description of the receiver in section **1.2 Receiver in Tower Unit.**

Note: Rx-Enable and Rx-enable2 is in fase.

1.7 Local-oscillator in Mobile Unit.

See the description of the local oscillator in section **1.3 Local-oscillator in Tower Unit.**

1.8 Transmitter in Mobile Unit.

See the description of the transmitter in section **1.4 Transmitter in Tower Unit.**

1.9 Controller part in Mobile Unit.

The controllerpart in Mobile Unit is build around a Microcontroller (IC6) from Hitachi, H8/3294. The firmware controls the two internal motors (IC2 and IC3) and one external motor (IC4). On the two internal motors there is also a tacho reading (IR1 and IR2). The Mobile Unit has 3 inputs (IN0, IN1 and IN2). The Mobile Unit furthermore has following features:

Sound (piezo1), Supply measurement (9V-check) and current-measurement on the external motor.

All of the above mentioned functions can be controlled/read by the PC via the radiolink.

The resetcircuit for the Microcontroller (IC6) consists of IC7, R61 and C48. IC5 is the 5 V voltage regulator. D11 (dual LED) indicates datacommunication/Power On/Run Mode. The Microcontroller controls all functions in the radiopart. The supply to the radiolink can be switched on/off via Q13.

The controller part generates following signals to the radiopart: Tx-Enable, Rx-Enable, Rx-Enable2, Tx-Data and RF-5V.

— The controllerpart receives following signals: Rx-Data and AGC.