S & A Systems
***Fleetwatch* Series**
TRM303 Transceiver
Version 1.0.0
Operational Overview
December 4, 2001

Operational Overview

The TRM303 is controlled by a Microchip PIC16F876-04I/P RISC microcontroller. When instructed by serial command, the unit emits a beacon signal designed to trigger a Fleetwatch Electronic Trip Recorder. This beacon signal is a 4.25 second burst consisting of a 770 Hz stream of pulses with a 25% duty cycle over the 303.875 MHz transmitter (Refer to diagram "*Data Transmit Modulation Scheme*"). At the end of the beacon signal, the T/R Switch connects the receiver to the antenna and the unit looks for data on the same 303.875 MHz band. A small delay (approximately 1 second) occurs between the end of the beacon signal and the beginning of the data chain coming back to the TRM. This delay is required for backwards compatibility with previous readers, which required time for the Automatic Gain Control (AGC) circuitry to readjust to read the low-power signals returned by the RF devices, as well as for the transmitter circuitry in the device being read to power up. This delay is not required by the TRM.

The microcontroller waits and examines the received data line from the receiver. A serial message is sent (over the RS-232 channel) indicating whether data was received or not, and passes either the data or a code indicating why the data could not be decoded.

System Overview

The TRM303 circuitry consists of three principal sections:

1) Processing Circuitry
2) Power Control & Distribution
3) Transmitter/Receiver

The block diagram entitled *"TRM303 Block Diagram"* shows how each group interacts with each other. The Processing circuitry is the heart of the system. It controls all facets of the unit and is responsible for communication, RF control, and power operations. The Power Control system provides regulated power to the system and to monitor for out of tolerance voltages. This enables the system to turn itself off in order to prevent either damage or errant operation. It is also provided with sufficient intelligence to enable the unit to shut itself down to conserve power. Note that the unit is actually responsible for turning itself on and off. There is no mechanical on/off switch. In an error condition, the unit will default off. The receiver system is responsible for accepting and multiplexing signals from the RF link. It is designed to work at 303.825 MHz in the USA, but can be easily modified to other frequencies of interest. The Transmitter circuitry is responsible for reliably sending data over the RF link. It is also designed to work at 303.825 MHz in the USA, but can easily be modified to operate at other frequencies. The circuitry is equipped to modify it’s power level on the fly, allowing it to operate under the rules/regulations specified by different countries.

Processing Circuitry

The processing circuitry is the “brain” of the device. It is responsible for all aspects of control and communication. The heart of the design is the microcontroller **U4**, a Microchip PIC16LF876. This unit is equipped with 8K of onboard flash memory, 368 bytes of SRAM, 256 bytes of EEPROM, and a UART (as well as many other peripherals). The controller receives power from a single VDD line. The line is filtered for low frequency transients by **C30**.

Manual reset of the controller is provided by switch **SW1**, which grounds the **/RESET** line through **R20/D14** combination when pressed. Reset control is also available to an external controller through the use of the RESET line on the external connector. Any voltage between approximately 0-.5V will reset and hold in reset the TRM (active low). **D1** prevents any positive voltages from entering the unit. **D14** is present to prevent the voltage present from the In Circuit Programming (ICP) unit from shorting it’s +5Vdc supply to the TRM303 unit’s +3.3Vdc supply and damaging either device.

The processor is timed off of crystal **X1** running at 3.6864 MHz. **C31** and **C32** provide the parallel resonant circuit for the crystal oscillator. This frequency supplies only the microcontroller and does not traverse any distance on the PC board.

Command input to the microcontroller is through **COM1**, which is an RS-232e port. The COM port is level shifted by **U3**, a standard RS232 level shifter. The inputs of this device (Sipex Part #SP3222ET or equivalent) are protected from ESD to +- 15kv. **C11**, **C12**, **C13**, **C17**, and **C20** provide voltage doubler circuits for the level shifting. The comm port can be powered down (except for one receiver port) to conserve battery power. Status LEDs (**D9** and **D11**) light during communications on the Tx and Rx lines, respectively. Theses lights are on a timing circuit which causes them to stay lit past the active time (approximately ½ second). These timing circuits are made from the not gates of **U5**(gates A,D, E, and F), diodes **D3** and **D8**, capacitors **C18** and **C25**, and resistors **R12** and **R15**. The timing circuits work identically for both Tx and Rx. The Tx signal enters gate **F** of **U5** and is inverted. This produces a normally low signal. When the Tx signal goes active (low), a high is produced. This voltage flows through **D3** and charges (very rapidly) **C18**. This voltage is then re-inverted by **U5A**, producing a low which allows current to flow through the current limiting resistor **R16**, through the status LED **D9** (thus lighting it), grounded into the output of **U5A**. When the Tx signal goes back high, the voltage on **C18** slowly discharges through the parallel resistor **R12** (according to the RC time constant). **D3** prevents the voltage on **C18** from being shunted back through the output of **U5F**. When the **C18** voltage discharges to a sufficiently low voltage, the LED (**D9**) is turned back off. In this way, even fast communication signals will trigger a viewable pulse on the LED.

Connection to the outside world is made by a shielded RJ45 jack (**CONN1**). This connection provides for Tx, Rx, and the standard RTS/CTS lines. A test connector (**CONN3**) provides for quick input/tap capabilities

The controller is responsible for sending the digital data to the transmitter circuit, as well as decoding the digital data from the receiver. It also controls the modes of operation of the transceiver (OOK/Rx/Off) and provides control of the attenuator **U1**.

Power Control & Distribution

The Power Control & Distribution circuitry performs the job of regulating and distributing the appropriate voltages to the different parts of the circuit. This circuitry is equipped to enable the microprocessor to turn off power on its own so as to keep from running down the battery, or to turn itself on when a communications signal is present.

Power can be provided to the board from either the battery connector **CONN4** or an input on the RJ45 jack **CONN1**. Allowable voltages are 4.5-10Vdc on **CONN4** and 4.5-15Vdc on **CONN1**. Only the voltage from **CONN4** is monitored for a low battery condition. Both connections have the same RF filtering to prevent any generated signals from back feeding into the power supply circuit.

Power is applied (through either connector) and travels through **D4**/**D6** to prevent reverse power connections. The cathode of both diodes are high frequency filtered by **C19**/**C22**. The power then goes through a ferrite (**L6**) to provide more high frequency filtering. **C23** provides lowpass filtering into the regulator (**U6**). **C26** provides high frequency filtering at the input to the regulator. The regulator **U6** is a National LP2985.

This regulator provides an **On/Off** input. This input is tied low (off) by **R14**. Voltage above .8V applied through one of three inputs will turn the device on. If jumper **JP1** is jumpered, it shorts power from the filtered voltage input through **D2** and into the **On/Off** input, thus keeping the unit powered at all times. A signal from the external connector (**CONN1**) can also be applied to turn the device on manually. This line normally connects to the **DTR** pin on an RS-232 port. When the terminal equipment signals it is ready to communicate, the TRM is activated. **C10** provides additional filtering on this line to prevent the escape of any RF signals. **D2** prevents any signal back flow through this line, as well as blocking any negative voltages (as would be expected of an RS-232 signal). Finally, a signal from the microcontroller **U4** can activate, or keep the device activated, by applying a high signal from pin 7 through **D5**. **D5** again blocks any signal higher than that being output from the microcontroller, preventing any damage to **U4**.

Once an **ON** signal is applied, capacitor **C24** is rapidly charged. This prevents chatter on the **On/Off** input from placing the TRM into an unexpected state. When the signal is removed, **C24** slowly discharges through **R14** and the TRM turns off. **D7** is an overvoltage protection circuit designed to limit the input to the regulator to 3V. Current flows into the input and is limited by **R11**, and anything over 3.0V is shunted to ground.

3.3VDC is provided at the output of the regulator **U6**. **C29** provides a bypass to the regulator to improve ripple and response. The output is low pass filtered by **C28** and high frequency filtered by **C27**. **R19** and **D13** provide a visual indication that power is active on the board.

Low power detection is provided on the battery input. **U7** can monitor voltages up to 10V and signals a low battery at 4.5V. **R17** provides the pull up function for the active low output, which goes to pin 14 on the microcontroller.

Transceiver Circuitry

The transceiver is based on the RF Monolithics chip TRxxxx. For the US version, a TR3003 **U2** is used. This chip provides all of the functionality needed to provide a 303.825MHz RF link based around a *Surface Acoustic Wave* (SAW) technology. Although the device is always powered, it is normally kept in the power down mode until specifically instructed to search for an RF unit. Two output lines from the microcontroller control the state of the transceiver, **Ctrl1** and **Ctrl0**.

To transmit data, a 01 is placed on the control lines. This places the device into OOK Transmit mode. Digital data is then sent to the TR3003 **U2** from the microcontroller pin 2. This signal from the micro splits off. One end goes to **U5B**, which drives LED **D10** through **R13** to light when we are actively transmitting. The other end goes through current limiting resistor **R7** into the transmit pin of **U2**. By varying the value of **R7** from 278K to 11K, the output power can be set to match local rules & regulations. Power for the transmit side of **U2** is provided at pin 2. This power is filtered by ferrite **L1**. The output signal appears at pin 20.

To receive a signal, the control lines are set to 11. Power is provided to the receive side and filtered through the **R2**/**C14**/**C8** network. **C16** forms an AC pass signal. **C15** (which is not normally used) can be stuffed to decrease the amount of noise in the output signal. This does, however, result in a lower sensitivity. **R9**, **R5**, and **R6** form low pass filters and set the trigger level for the data slicers in **U2**. Finally, the digital output is provided at Pin 7 of **U2**, where it is pulled low by **R10**. This signal then splits. First, it goes to pin 6 of the microcontroller **U4**, where it is decoded by the firmware. Secondly, it goes to the **U5C**/**D12**/**R8** circuitry, which provides the user/technician with a visual indication of when the TRM is receiving a signal.

Any signal from (also to) the TR3003 (**U2**) appears at pin 20. **L4/L5** provide a 50 Ohm matching network and also serve to shunt any ESD to ground. Note that this pin is VERY sensitive to ESD (approximately 200V tolerance). The signal is then AC coupled into the attenuator **U1**. Five control lines into the attenuator allow the signal to be controlled over a 0-31dB range. Each of these control lines goes back to the microcontroller and has a high frequency filtering capacitor (**C1**, **C2**, **C3**, **C5**, and **C6**) connected to it to prevent any signals from being coupled onto it. The signal out of (into) the attenuator is provided a DC path by **R1**, and AC coupled to the 50 ohm matching network of **L2** (**L3** may be needed at certain frequencies) and out the SMA connector into the antenna. This SMA connector **CONN2** is a reverse polarity connector, which has been cited as satisfying the requirements of FCC Part 15.