Type Acceptance Information for TS4000 Radio Modem with 3412 Transceiver
Proposed FCC ID JWFTS4000B

MODEM BOARD CIRCUIT DESCRIPTION

Microcontroller and Memory

The microcontroller, U16, controls and manages all activity on the modem board. The microcontroller operates at an internal clock rate of 25.1 MHz that is derived from crystal Y1 which oscillates at 32768 Hz. The microcontroller reset is controlled by U2 which monitors the power supply.

The program for the microcontroller is stored in flash memory U18. This program can be updated by downloading a new version through the serial port using PC based upgrade software supplied by Teledesign Systems. The chip selects for the flash memory are controlled directly by the microcontroller.

The dynamic data for the microcontroller is stored in SRAM (static RAM) U17. Serial EEPROM U15 provides non-volatile storage for the microcontroller. The serial EEPROM is interfaced to the microcontroller through an SPI bus which provides high speed synchronous serial communication.

The microcontroller interfaces to a number of other chips on the board through either the SPI bus or through the 16 bit parallel data bus. For the parallel interface, the microcontroller provides all the address decoding for the chip selects.

Data Interface

There are two serial data interfaces that are used to connect to external equipment.

Serial interface 1 is an asynchronous serial interface which is controlled with the SCI (Serial Communications Interface) of the microcontroller. The serial interface lines of the microcontroller are fed into U13 and U27 which provide signal buffering and level translation. The RS-232 buffer, U13, generates its own high (+6 to +10 VDC) and low (-6 to -10 VDC) voltages with a charge pump circuit which oscillates at about 10 kHz. The low voltage of the charge pump is regulated with D5 and is used for some of the analog circuits in the modulation and demodulation sections. The TTL buffering is handled by U27. Serial interface 1 can be configured to operates at either RS-232 or TTL signal levels using jumper block JB1. The RS-232 standard defines voltage signal levels between -25 and +25 volts. TTL signal levels are between 0 and 5 volts.

Serial interface 2 is a synchronous or asynchronous serial interface and is controlled with one of the ports of the SCC (Serial Communications Controller) U21. The SCC is controlled by the microcontroller using the parallel bus. To provide the correct parallel interface timing between the SCC and the microcontroller, U25 is used to delay the SCC chip select. Serial interface 2 operates at RS-232 signal levels using U12 to provide signal buffering and level translation. The RS-232 buffer, U12, generates its own high (+6 to +10 VDC) and low (-6 to -10 VDC) voltages with a charge pump circuit which oscillates at about 10 kHz.

Power Regulation

The power input into the modem can be from 9 to 28 volts DC. This input is diode protected with D22, D23 and D20. The main power regulation is provided by dual switching regulator U20 in conjunction with level adjuster U24. The switching regulator switches at a frequency of approximately 300 kHz. To produce the voltages the switching regulator uses diodes D17, D19, D14, D13, D18 and D21 and transistors Q4 and Q5.

The switching regulator produces a 13.0 volt power source and a 5 volt power source. The 13.0 volt power source feeds into the final stage of the radio frequency amplifier of the radio transceiver. The 5 volt power source is used for most of the modem board's digital circuitry. For the analog circuits, linear regulator U11 produces a temperature and voltage stable 5 volt power source from the 13.0 volt source.

Diagnostics
The microcontroller monitors a number of signals using an A/D (analog to digital) converter internal to the microcontroller. To prevent over and under voltage into the A/D converter, diodes D15, D16, D6, D7, D8, D9, D10, and D11 are used.

To monitor the temperature on the board, U1 is fed into the microcontroller's A/D converter.

To indicate the state of the modem, LEDs DS1, DS2, and DS3 are used. These are controlled by the microcontroller using transistors Q12, Q13, and Q14 to buffer the signals.

Clock Circuitry
The modem board generates a variable rate modulation clock which controls the over the air data rate of the modulator and demodulator circuits. The modulation clock can be varied between 1 and 10 MHz.

The modulation clock is derived from the microcontroller's main clock. The microcontroller's main clock is fed into a divider U23 which generates the modulation clock. The divide ratio of U23 is partially set and by latch U19 that is loaded through the SPI bus. The divide ratio is tweaked using decoder U26 and divider U22. The divide ratio of U22 is set through the microcontroller's SPI port.

Modulation and Demodulation
ICs U7 and U9 perform the modulation and demodulation of data. The modulation used by the modem board is selectable for GMSK (Gaussian Minimum Shift Keying) or four level FSK (Frequency Shift Keying). This is selectable by the user using the TS4000 configuration software.

<u>GMSK</u>
When GMSK modulation is used, U9 provides the modulation and demodulation functions. Data is fed into and out of this chip through one port of the SCC (Serial Communications Controller), U21. The GMSK chip filters the transmit waveform by passing NRZ (Non-Return to Zero) data through a Gaussian low pass filter with a BT of 0.5. The BT of 0.5 indicates that the 3 dB bandwidth of the Gaussian filter is 0.5 of the bit rate. Q7 and Q6 are used to adjust the demodulation performance of U9.

<u>Four Level FSK</u>
When 4LFSK (Four Level Frequency Shift Keying) modulation is used, U7 provides the modulation and demodulation functions. Data is fed into and out of this chip using the parallel bus of the microcontroller. The 4LFSK chip filters the transmit waveform by first converting the data to be transmitted into 4 level symbols. These symbols are then passed through a linear phase low pass filter with a Root Raised Cosine response. This filter is has a 3 dB bandwidth of approximately 0.5 of the symbol rate (0.25 of the bit rate). The specific filter response is characterized by the following equations.

$$H(f) = 1 \qquad \text{for } 0 <= f < (1-b)/(2T)$$
$$= \text{square root of } (0.5(1 - \sin(\Pi T(f - 0.5/T)/b)) \qquad \text{for } (1-b)/(2T) <= f <= (1+b)/(2T)$$
$$= 0 \qquad \text{for } (1+b)/(2T) < f$$

where: $b = 0.2$, $T = 1/\text{symbol rate}$

Q3 and Q2 are used to adjust the demodulation performance of U9.

<u>Transmit Signal Path</u>
The modulated data signal from either U7 or U9 is fed through the transmit signal path before being sent out the radio interface connector J11 to the radio transceiver. This path provides amplitude and DC voltage level adjustment. The transmit signal is first buffered and amplified by op amps U3A, U3B, and U3C. The amplification of U3B and U3C is adjusted with the electronically variable potentiometers U4E and U4F. These potentiometers are controlled via

the SPI port of the microcontroller. The signal is then buffered, amplified and DC level shifted by op amp U8C. The DC level value is set with DAC (Digital to Analog Converter) U10B and U10C.

A separate version of the transmit signal is buffered, amplified and DC level shifted using op amps U3D and U8D in conjunction with DAC U10D and electronically variable pot U4G. This signal provides an alternative version of the transmit signal which is not used when the modem board is interfaced with the radio transceiver.

The reference voltages of U7 and U9 are buffered by U8A before being used by the transmit and receive signal path circuits.

Receive Signal Path
The receive signal from the radio transceiver comes into the modem board via connector J11. This signal is buffered, DC level shifted and amplified before being fed into the modulation/demodulation circuits U7 and U9. The signal is first buffered and DC level shifted by op amp U5A and DAC U10E. The signal is then amplified by op amps U5B and U5C. This amplification is adjusted using electronically variable potentiometers U6E and U6F. This signal is then fed to the demodulation circuits U7 and U9. In addition, this signal is fed to an alternate demodulation circuit made up of op amp U5D, diodes D1, D2, D3, D4 and transistor Q1B.

Radio Transceiver Interface
To switch the radio transceiver between receive and transmit mode, several voltage lines must be set. These are controlled by the microcontroller using transistor switches Q9, Q8, and Q1. In addition, there is an adjustable radio power voltage that is controlled by DAC (Digital to Analog Converter) U10A. This adjustable radio power voltage is buffered with op amp U8 and transistors Q10 and Q11. This adjustable radio power voltage feeds into the transmit pre-amplifier stage of the radio transceiver.

The RSSI (Receive Signal Strength Indicator) from the radio transceiver is fed into the microcontroller A to D converter. It is also compared by op amp U14 to the voltage of DAC U10H. The result of the comparison is then fed into the microcontroller.

There are several DAC output signals from DACs U10F and U10G that feed out of the radio interface connector J11. These outputs are not used with the DL3412 radio transceiver.