DRAFT

MARSIS TX/Antenna Radiated Power Test Plan

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1.0 Test Objectives

This test will measure the power radiated from the integrated combination of the MARSIS TX and antenna elements, deployed in a flight-like configuration. This test provides design verification of the TX matching network.

As a secondary objective, E-field measurements will be taken at several locations around the test configuration to evaluate computer models of the MARSIS induced E-field during transmit operations, using both the flight antenna and a shortened test version built specifically for EMI testing.

2.0 Test Configuration

2.1 TX (Flight) segment

The MARSIS TX/Ant system uses a single 40m tip-to-tip dipole to transmit in a frequency range of 1.3MHz to 5.5MHz. As a result, the matching network design is very challenging, since the antenna impedance varies from a very high impedance at low frequencies and half wave resonance, through low impedance at quarter wave resonance. The matching network is designed using a computer model of the antenna. This antenna is represented as being in free space, which is of course the nominal operating mode of the system. This presents significant problems in the verification of the system, since proximity to the ground will significantly affect the antenna impedance and as a result, change the voltage induced on the antenna by the matching network.

To reduce errors caused by ground effects, we plan to lift the test article a minimum of 10 wavelengths off of the ground. This gets the antenna near field away from ground proximity effects. At the low frequencies of interest, this amounts to an altitude of ~10,000ft above ground level. This capability has been demonstrated during antenna impedance testing, and the intention is to use the same lifting apparatus that has been used for this testing. In addition, the test article must be suspended downrange from the calibrated ground receiver by a minimum of the same distance to allow the field measurements to be made in the far field of the antenna pattern.

Testing will be done using discrete CW tones, to allow a loose degree of synchronization between the TX and RX segments. The TX will be commanded to a frequency via ground control, and the ground RX will be tuned to that frequency. This allows avoidance of interference signals which will be very common in this frequency range. The capability exists to implement microsecond level time synchronization between ground and flight segments, using GPS receivers. Detection of the time domain envelope may be necessary if it is determined that ionospheric reflections are interfering with the measurements. (See Figure 2)

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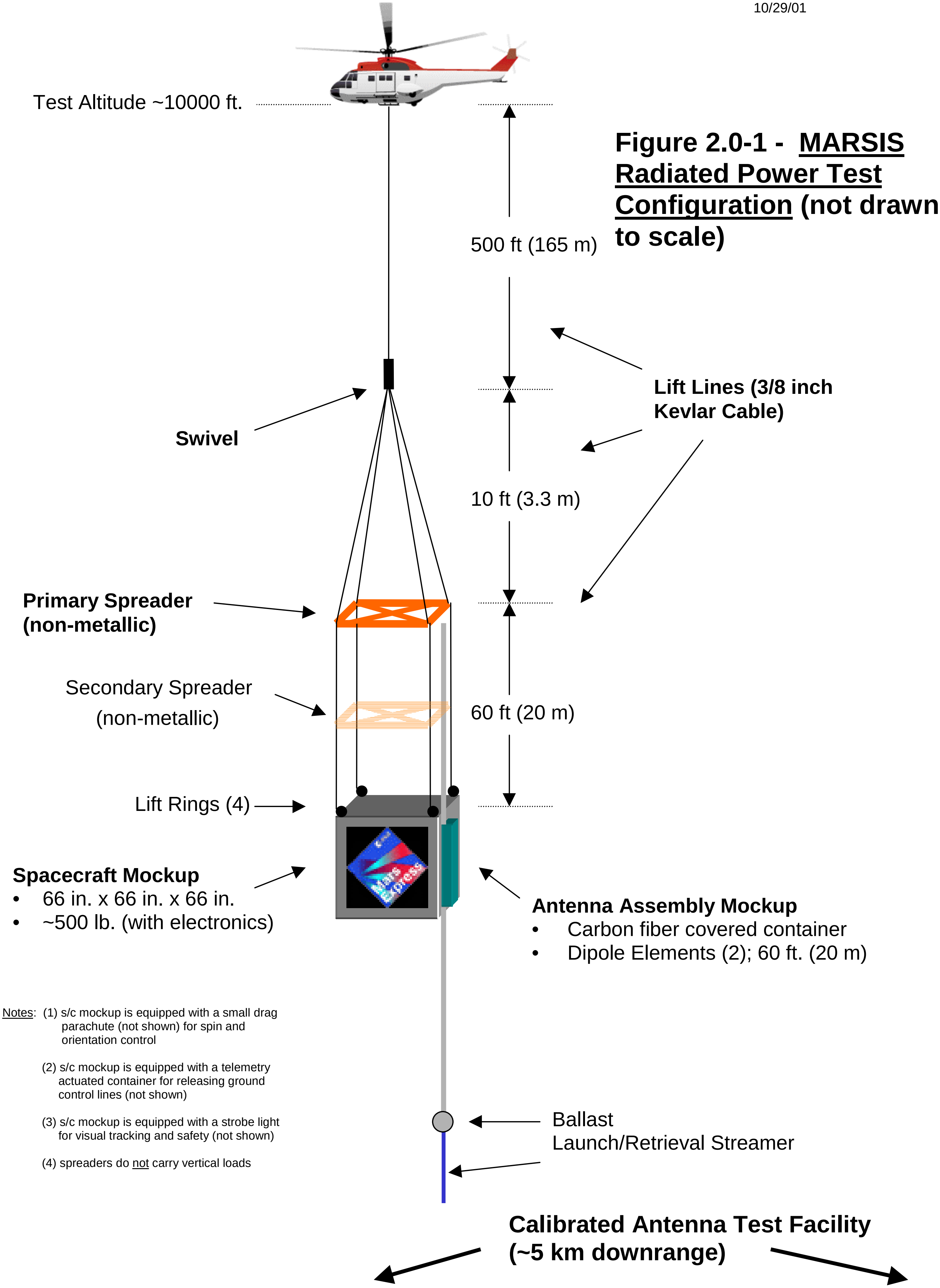

Figure 2.0-1 - MARSIS Radiated Power Test Configuration (not drawn to scale)

Notes: (1) s/c mockup is equipped with a small drag parachute (not shown) for spin and orientation control

(2) s/c mockup is equipped with a telemetry actuated container for releasing ground control lines (not shown)

(3) s/c mockup is equipped with a strobe light for visual tracking and safety (not shown)

(4) spreaders do not carry vertical loads

Since the TX was designed for a 10% duty cycle chirp, modifications will be needed to the standard TX configuration for this test. The power supply will be replaced with a lab supply which will allow the higher average power required for a CW mode. In addition, some amount of forced air cooling will be provided to prevent overheating of certain TX components. The TX is based on a class-D switching amplifier designed by Rockwell-Collins, and sold commercially as the HF-6550. This design has been modified to withstand spaceflight environmental conditions by the University of Iowa. The estimated radiated power levels based on computer models and test data from antenna simulators is attached as Figure 3.

To allow monitoring of the local E-field, four individual probes will be provided. Each will have a high-impedance amplifier to avoid loading effects, and will be monitored via a wideband detector. The output of the detector will be included in the downlink telemetry, as well as a monitor of the antenna terminal voltage.

Onboard telemetry and control will be accomplished via Linux based PC, which will manage the test activities and communicate with the ground segment via amateur 2 meter FM AX-25 packet protocol. Hardware timeout controls are implemented in the event of software malfunction for all RF transmit operations. See Figures 4 and 5.

2.2 Ground segment

The ground measurements will be made using a calibrated antenna test range. Using this facility, we will be able to make narrow-band field measurements and avoid ambient interference from broadcast and amateur stations. Tuning will be accomplished by locating a clear frequency using the ground system, and commanding the TX to transmit on that frequency. Ideally, a set of clear test frequencies will be identified prior to flight, and pre-programmed into the system to avoid the time overhead of programming each frequency individually.

We have identified a suitable test site, Liberty Labs in Elk Horn, Iowa. (Coordinates: 41º 42.013’N 95º 5.751’W) This facility has a well calibrated outdoor antenna test range. Several small airports are available nearby for helicopter flight support, and for lifting the test payload.

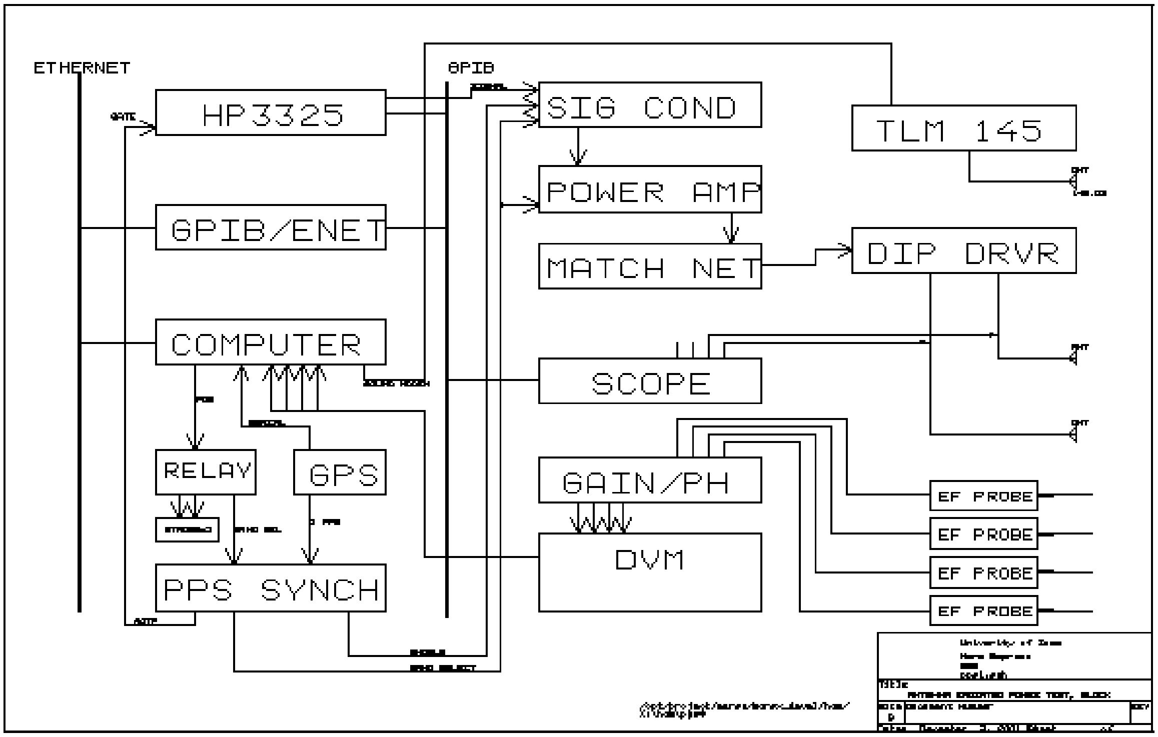

Figure 1: Flight Segment block diagram

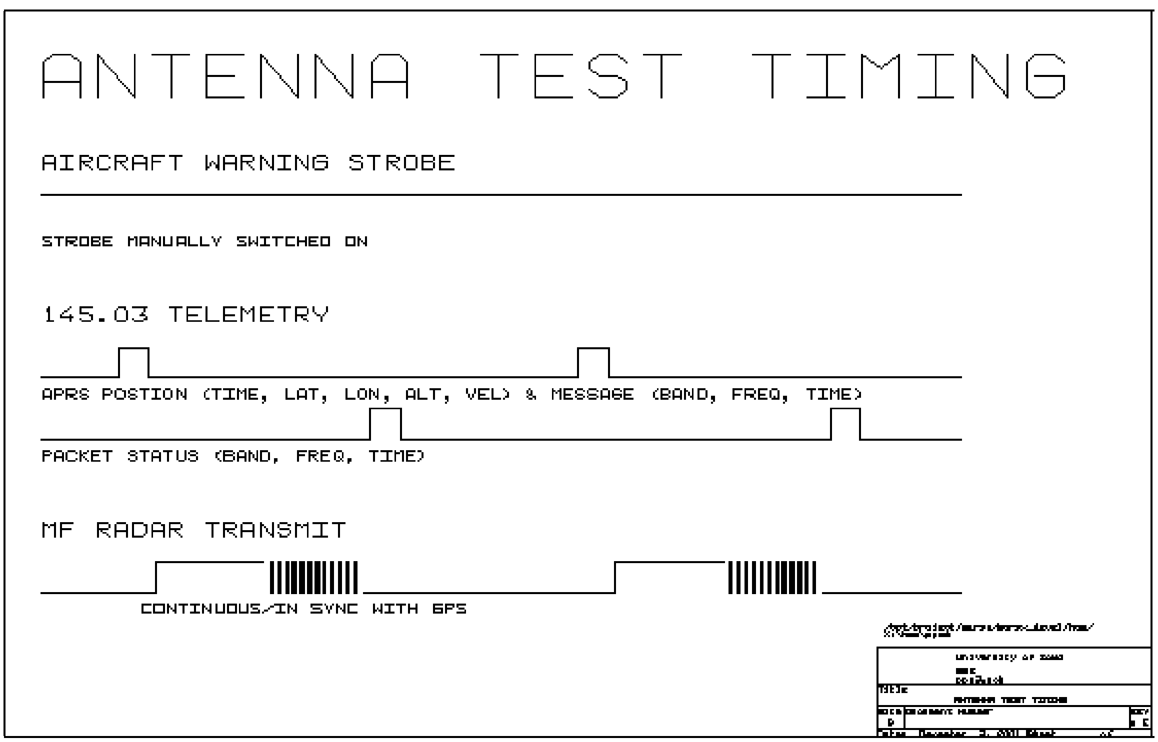

Figure 2: Signal Timing

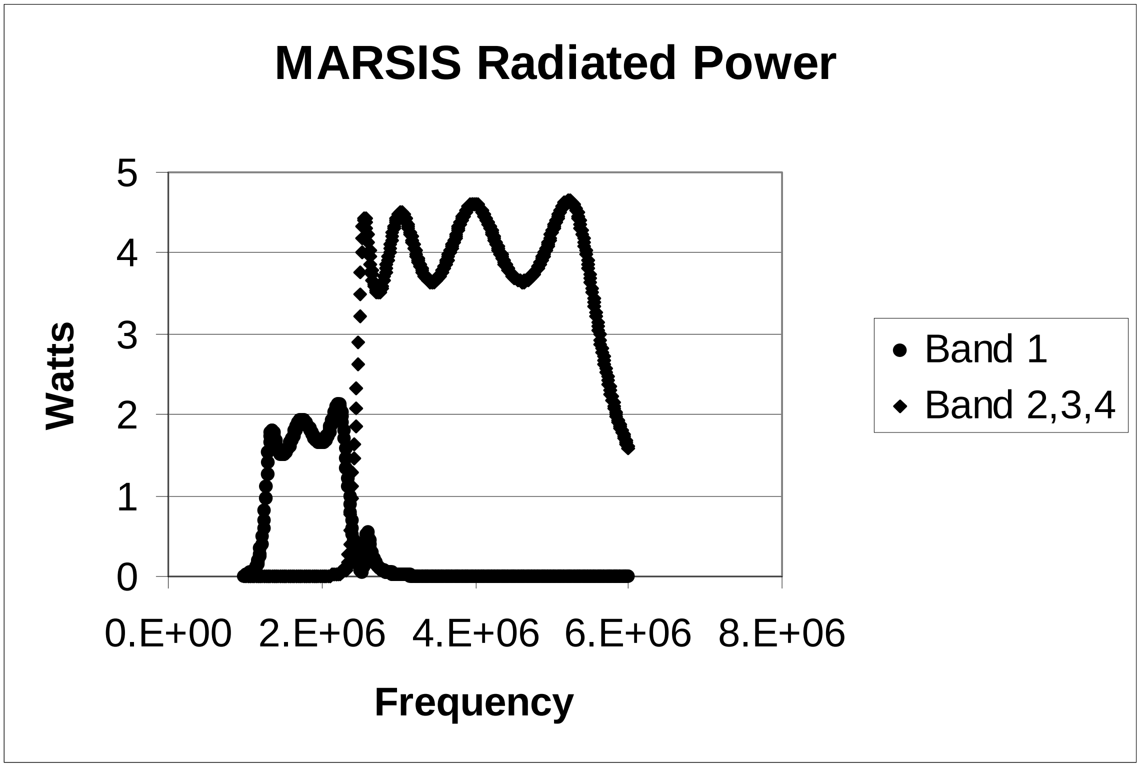

Figure 3: Estimated Radiated Power

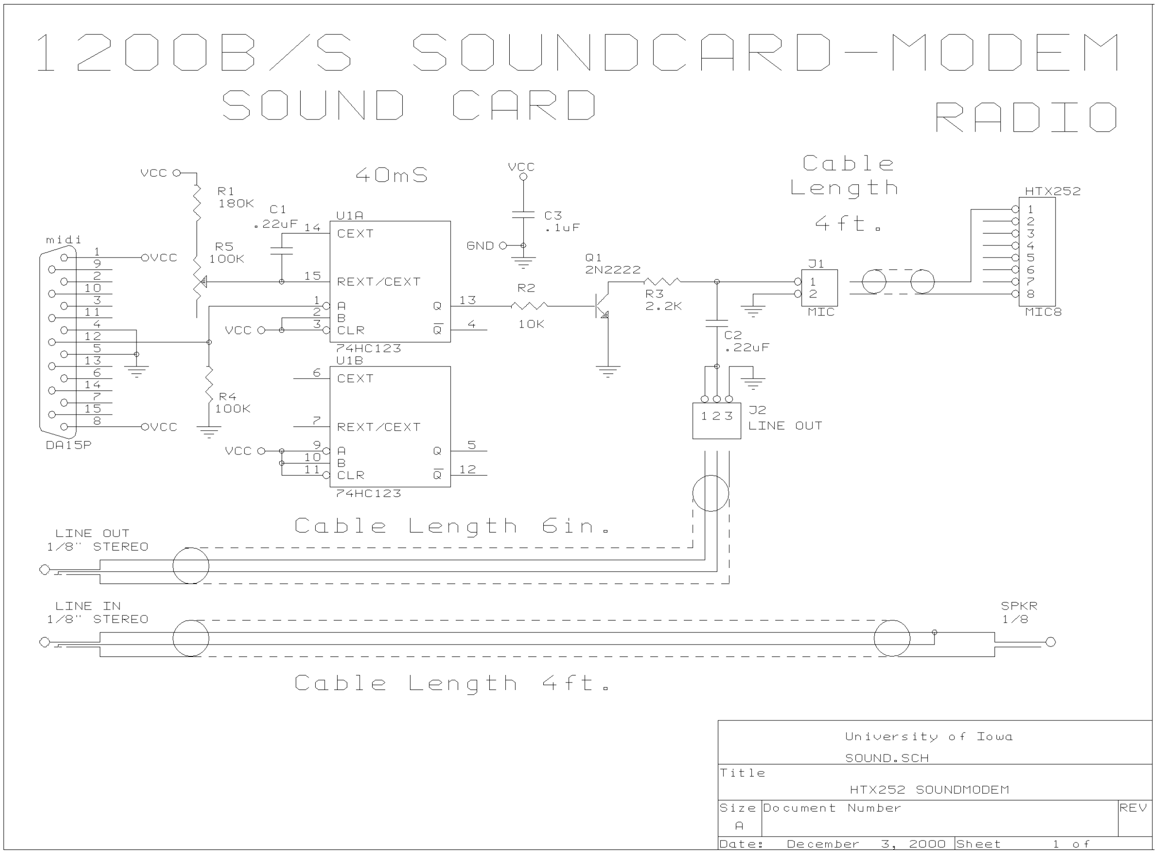

Figure 4: Hardware Transmitter Timeout Circuit – VHF Xmtr

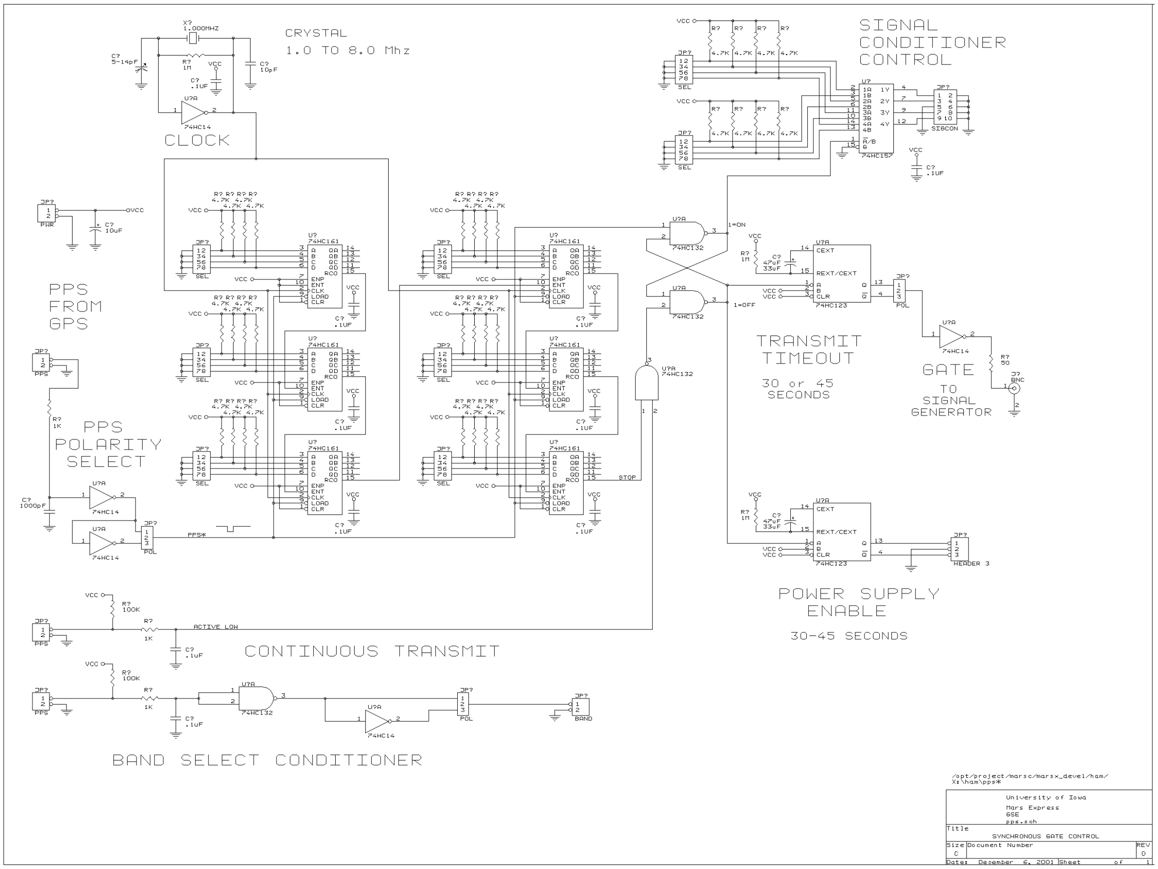

Figure 5: Hardware Timeout Circuit – MF Xmtr