Simulator for Checkout of Telemetry Receiving Systems

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ABSTRACT

Reception of missile telemetry data on board Navy ships is accomplished by using portable telemetry receiving systems which must be assembled/ disassembled for every missile firing exercise. In some cases, system setup problems have resulted in the loss of telemetry data when the missile is fired. The telemetry test simulator was developed by the Naval Surface Warfare Center (NSWC) to generate a telemetry stream identical to that of the missile telemeter. This simulated stream allows for an end to end checkout of the receiving system prior to missile launch which greatly reduces the chance of lost telemetry data upon actual missile firing.

INTRODUCTION

Telemetry reception of Navy missile firings is accomplished from both land and ship based receiving systems. However, a large number of missile firings are supported solely by shipboard telemetry receiving systems.

The Navy's shipboard telemetry receiving systems are portable and must be moved from ship to ship to support different missile firings. The systems consist of telemetry receiving gear mounted in portable transit cases which stack on top of each other. For every missile firing, these portable transit cases must be loaded onto the ship, stacked up and cables run between the various pieces of equipment as required.

In some cases, problem's in the telemetry receiving system, which were not discovered while setting up the system, have resulted in the loss of part or all of the telemetry data when a missile is fired. These problems includes such things as broken cables, cables not making good connection, RF receiver malfunctions, tape recorder malfunctions or incorrect setup of system matrix switches or patch panels.

As a result of these problems, it was decided that some type of a portable test source needed to be developed to find and correct these problems before missiles were fired. The Telemetry Test Simulator (TTS) was developed by the Naval Surface Warfare Center as this portable test source.

DESIGN AND DEVELOPMENT

The design and development process for the TTS was initiated by defining the requirements for a test source. Inputs were gathered from relevant Navy organizations involved with missile telemetry.

The TTS was designed and developed to meet these requirements providing a lightweight, portable test unit which outputs a telemetry stream identical to that produced by the missile it is simulating. A motherboard/daughterboard concept was used to switch between different missile telemeter formats. Each missile telemeter supported has it's own plug in daughterboard which contains all specific information and electronics necessary to simulate the chosen telemeter.

The TTS is packaged in a 5.25 inch tall, 10 inch deep , half rack width enclosure and weighs only 8 pounds. It operates on 110 VAC and consumes 80 watts of power. Figure 1 is a picture of the Telemetry Test Simulator.

FUNCTIONAL DESCRIPTION

The TTS is designed to generate both PAM/FM and PCM/FM telemeter streams since these are the types of modulation most Navy missiles use for telemetry. The TTS is best functionally described in four sections: PCM operation, PAM operation, doppler generation and RF section operation. Figure 2 is an overall functional diagram of the TTS.

PCM Operation

Figure 3 is a block diagram of the TTS with a PCM daughterboard installed.

An 80C51 microcontroller chip is used as the central processor for the TTS. Each time the TTS is reset, the microcontroller begins by reading in the address of the daughterboard which is currently installed in the TTS. Each type of daughterboard has a unique 4 bit address which the microcontroller uses to determine the correct timing parameters for the telemeter being simulated.

Five complete major frames of telemetry data are stored in the data ROM located on the daughterboard. The microcontroller sets up three divide by N timers (T1, T2 and T3) to allow the data to be clocked out of the data ROM at the correct rate and in the correct format for simulating the chosen telemeter.

Data is clocked out of the ROM using two binary counters. The first counter (frame selection counter) is connected to the top three address lines on the data ROM. PCM data in the ROM is organized into 8 pages. Each of the first five pages of ROM contains 1 major frame of telemetry data. The last three pages are not used at this time. Each time the frame selection counter is incremented, the next major frame of telemetry data stored in the ROM is selected. The second counter (word selection counter) is connected to the remaining lower address lines (up to 12). Each time this counter is incremented, the next PCM data word stored in the ROM is addressed and output on the ROM's data lines.

The first timer, T1, divides down a clock oscillator located on the daughterboard to generate a clock rate equal to the PCM word rate divided by 10. This clock is used as an interrupt signal to the microcontroller. When this clock goes high, an interrupt is generated in the microcontroller, causing 10 clock pulses to be output to the word selection counter. On the rising edge of each of these pulses, the PCM data ROM outputs the next PCM data word in the ROM. On the falling edge of these pulses, each data word is loaded into a 16 level first in first out (FIFO) buffer where it is buffered until unloaded by the PCM output circuit. This process repeats every time the interrupt clock goes high.

The second timer, T2, divides down the interrupt rate from timer T1 to generate the major frame rate. This clock output is used as a reset signal to the word selection counter. Each time this clock signal goes high, it indicates the word selection counter has output all data for one major frame and must be reset to zero so the major frame can be output again.

The third timer, T3, divides the major frame rate from timer T2 down to a 1 Hz clock output. This clock output is used to increment the frame selection counter. Each time this clock goes high, the next major frame of telemetry data stored in the data ROM is selected for output.

The net result of this timing sequence is to output 5 unique frames of telemetry data, with each frame repeating for 1 second before a new frame is transmitted. These five unique frames represent a 5 point calibration, ultimately appearing at the stripchart recorder as a familiar stairstep type calibration.

On the output side of the FIFO, the data is clocked out of the FIFO and into a parallel to serial converter at the PCM word rate in an 8 bit parallel format. A serial PCM stream is then created by clocking the data out of the parallel to serial converter at the PCM bit rate (which is the PCM word rate multiplied by 8).

in some formats, this serial PCM stream is applied to a subcarrier oscillator. The stream may also be applied to a linear summer where it is scaled and summed with a doppler signal if it is applicable to the telemeter being simulated. This video signal is then routed to the RF section of the TTS which is discussed later.

Pam Operation

Figure 4 is a block diagram of the TTS with a PAM daughterboard installed. Much of the functional operation of the motherboard for PAM is the same as for a PCM daughterboard. There are, however, two major differences in the operation of the motherboard. First, the input to the T1 timer is a 2 Mhz reference signal generated by the microcontroller. The T1 timer divides this signal down to the PAM channel rate which is used as the interrupt signal for the microcontroller. Second, the microcontroller outputs one pulse on every interrupt instead of ten.

Data from the telemetry data ROM on the daughterboard is clocked into a 1 byte buffer on the falling edge of the pulse from the microcontroller. On the rising edge of the next pulse from the microcontroller the data is clocked out of the 1 byte buffer and into an 8 bit digital to analog converter (DAC). This DAC converts the parallel digital data from the data ROM into the analog output (2.5 volts) format required for PAM.

This analog output is then fed into a linear summer where it is scaled and summed with doppler to form the video signal. This video signal is then fed to the RF Section of the TTS.

Doppler Generation

Doppler shift is transmitted as part of the telemetry data in most Navy missiles. This doppler signal is summed linearly with the PCM or PAM stream for transmission on an RF carrier. Simulated doppler is created by applying a ramp function to the input of a voltage controlled oscillator (VCO) such that the VCO frequency “sweeps” through a range of doppler shift much like it would in the missile.

RF Section Operation

Figure 5 is a block diagram of the RF section of the TTS.

The video signal from the installed PAM or PCM daughterboard is applied to the modulation input of an RF telemetry transmitter. This transmitter provides an FM modulated output of the video signal in the 2.2 to 2.3 Ghz frequency range. Carrier frequency is programmable by the user in 1 Mhz steps.

This RF signal is then applied to a network of 2 coaxial switches, a 60 dB fixed attenuator and a 0 to 60 dB digitally programmable attenuator, forming a user programmable 0 to 120 dB RF attenuator.

The user sets an attenuation from the TTS’s front panel in the 0 to 120 dB range in 1 dB steps. This setting is then translated by the attenuation translation board into 2 outputs. The first controls the coaxial switches and determines whether the 60 dB fixed attenuator needs to be included in the RF path. The second output sets the 0 to 60 dB attenuator to the correct attenuation so that the final RF attenuation will be correct when the setting of the 60 dB fixed attenuator and the programmable attenuator are added together.

RF output power is adjusted so that when 0 dB of attenuation is dialed in the user gets 1 milliwatt (0 dBm) of power at the front panel RF connector. This allows the user to select output power levels form 0 to -120 dBm in 1 dB steps.

FRONT PANEL CONTROLS AND OUTPUTS

Figure 6 is a drawing of the front panel for the TTS.

Three different signals are output from the TTS: RF, video and PAM/PCM.

RIF out, a female N type connector, is the output of the RF section of the TTS. Video out is the linear scaled sum of the PAM or PCM stream and doppler from the daughterboard. PAM/PCM out is the PAM or PCM stream being generated by the daughterboard. Both video out and PAM/PCM out utilize female BNC connectors.

AC power is turned on and off via a toggle switch on the left side of the front panel. AC power is applied to the TTS through a three pin MS connector located in the lower left corner of the front panel.

Attenuation and frequency of the RF output signal are controlled by thumbwheel switches located along the top of the TTS's front panel.

The RF section of the TTS may be turned off to conserve power via the TRANSMITTER ON/OFF switch on the front panel.

An external modulation signal may be applied to the input of the RF transmitter through a female BNC connector (EXT MOD) on the front panel. The external/internal modulation switch on the front panel controls which source the modulation input on the transmitter is connected to.

The system reset pushbutton switch on the front panel simply resets the microcontroller in the TTS thereby reinitializing the internal modulation stream.

APPLICATION

The TTS is used to check out Navy shipboard telemetry receiving systems.

There are two basic modes of operation. The first is to connect an omnidirectional stub antenna to the RF output of the TTS and place the antenna in the proximity of the telemetry receiving antenna. The TTS should be set up for maximum RF output power (1 mW). This provides the receiving systems operator with an end to end system checkout capability.

The second is to connect the TTS's RF output directly to the input of the RF telemetry receiver. This allows the user to make system sensitivity measurements (exclusive of antenna/transmission lines) by attenuating the RF output power of the TTS. This assures the operator that the system is working to it's fullest capability.

If the user finds a problem with a particular piece of equipment in his receiving system, this does not inhibit him from testing the rest of his system. He can use either the video output or PCM/PAM output and inject these signals at the appropriate points in the system. This allows the user to work around a broken piece of equipment in his system while checking out other parts of the system.

CONCLUSIONS

The telemetry test simulator has been a valued piece of test gear to the receiving system operators for the Navy. It has helped operators to find problems in their receiving systems so they can be corrected before missiles are fired. In short, the telemetry test simulator has done it’s job in giving the Navy a greater assurance that when missiles are fired, the shipboard telemetry receiving systems will be fully functional and ready to receive telemetry data.

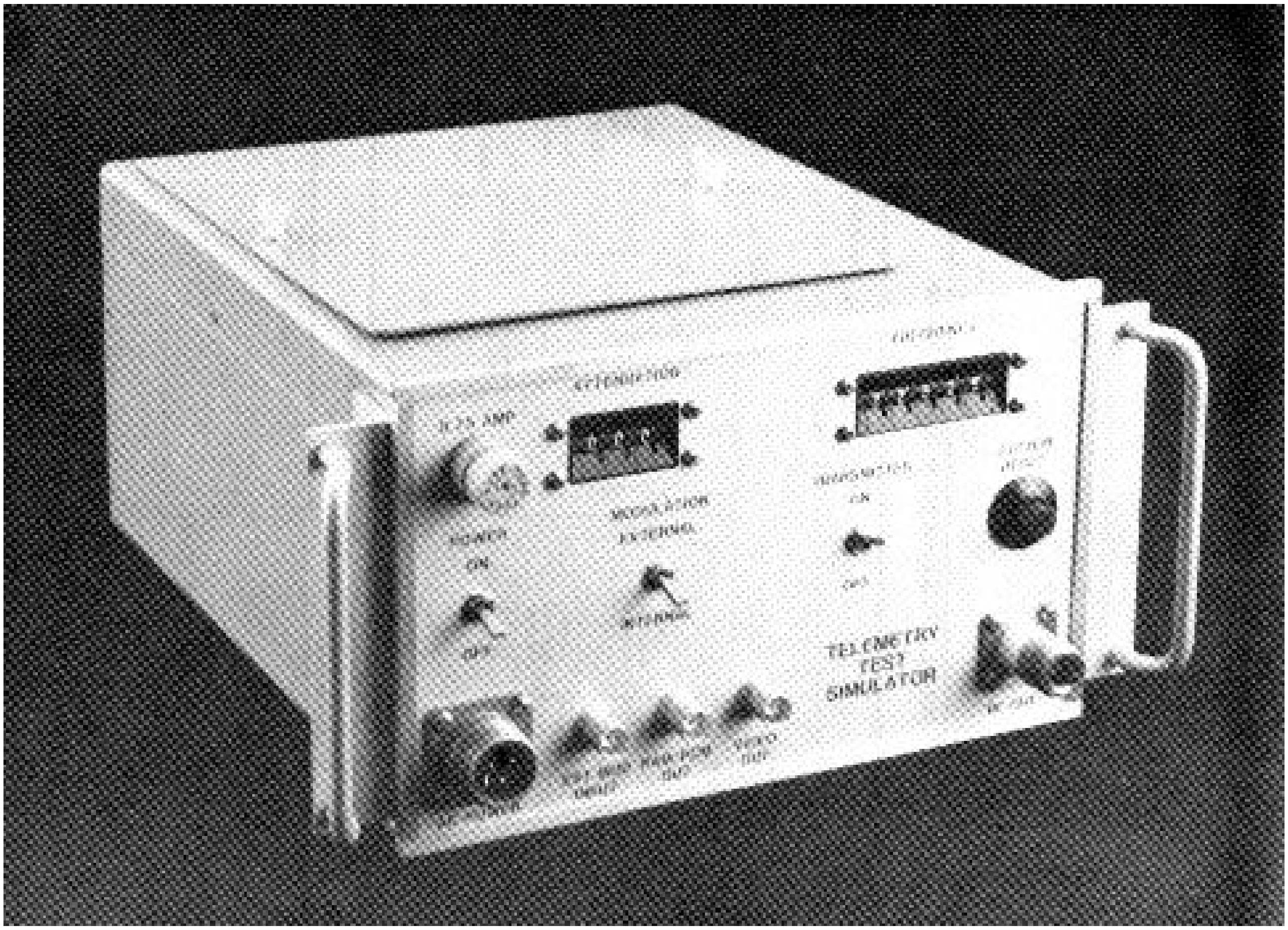

Figure 1. Telemetry Simulator

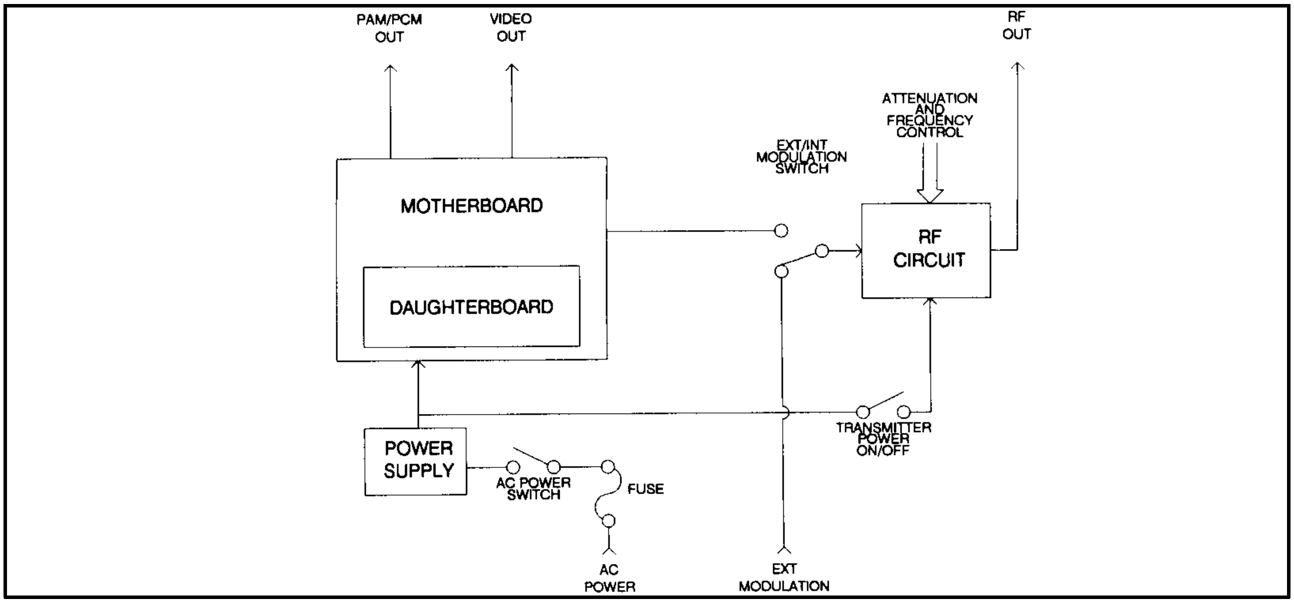

Figure 2. TTS Functional Block Diagram

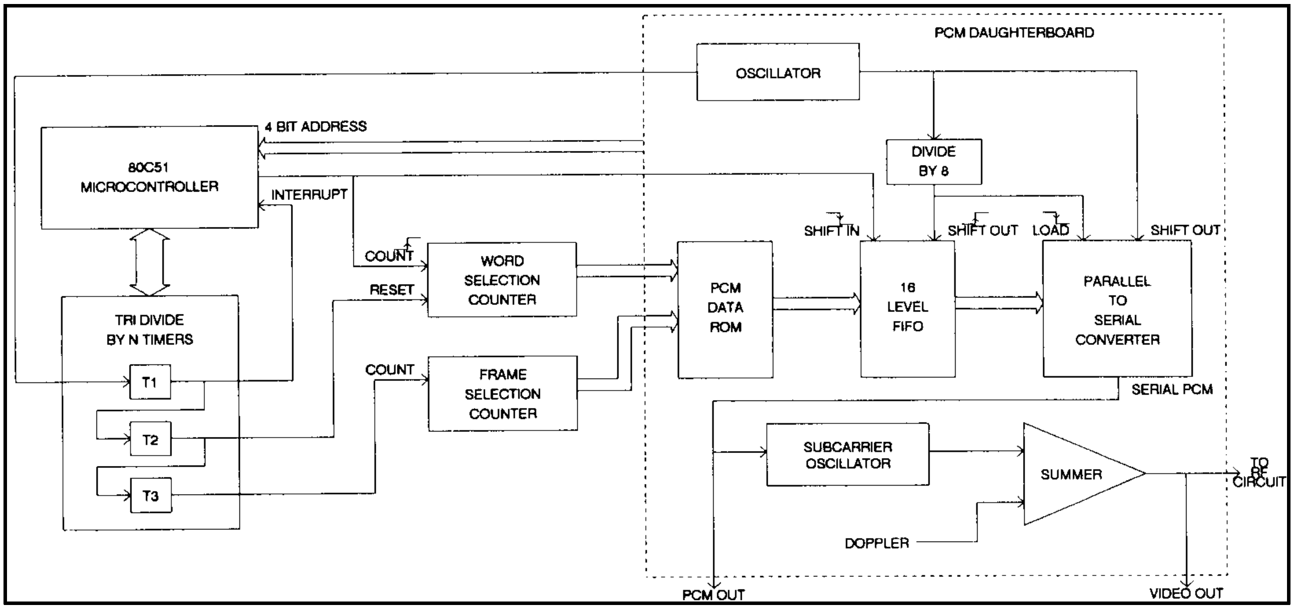

Figure 3. TTS PCM Operation

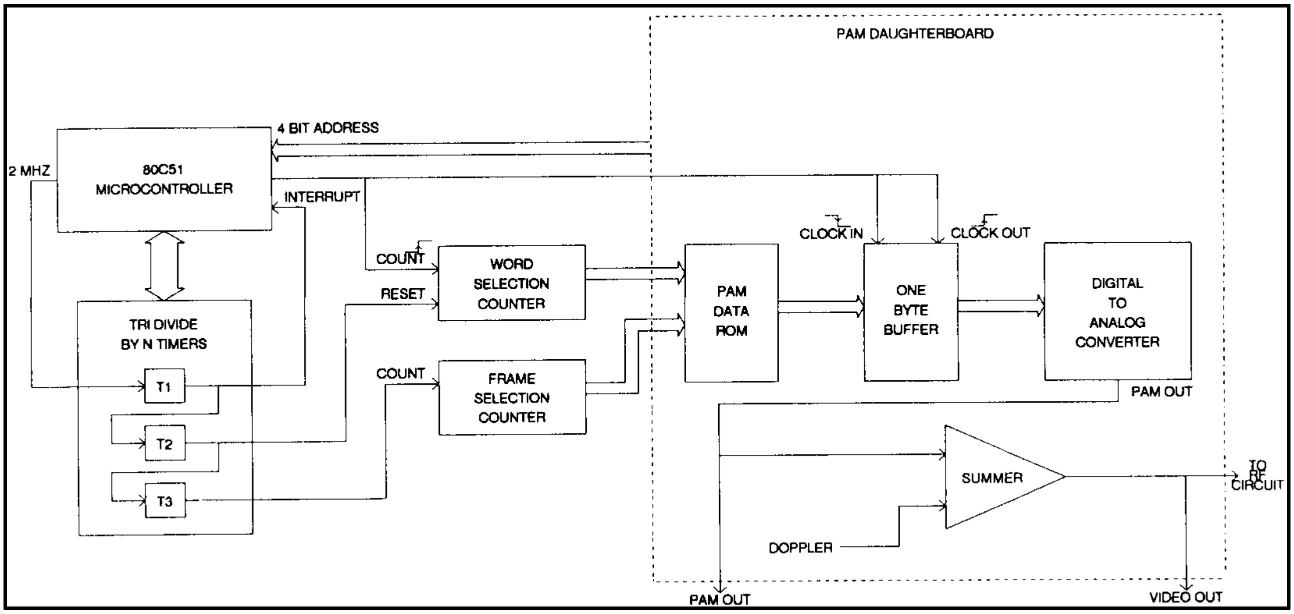

Figure 4. TTS PAM Operation

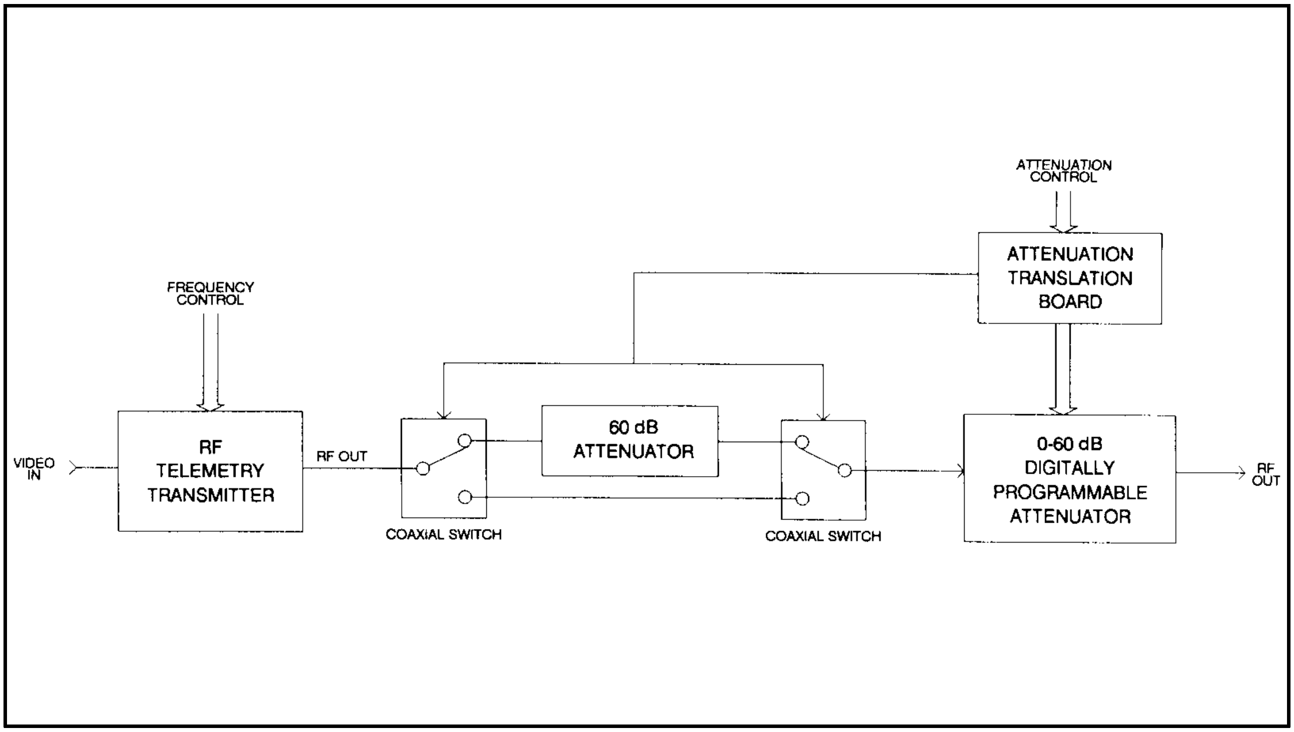

Figure 5. TTS RF Circuit

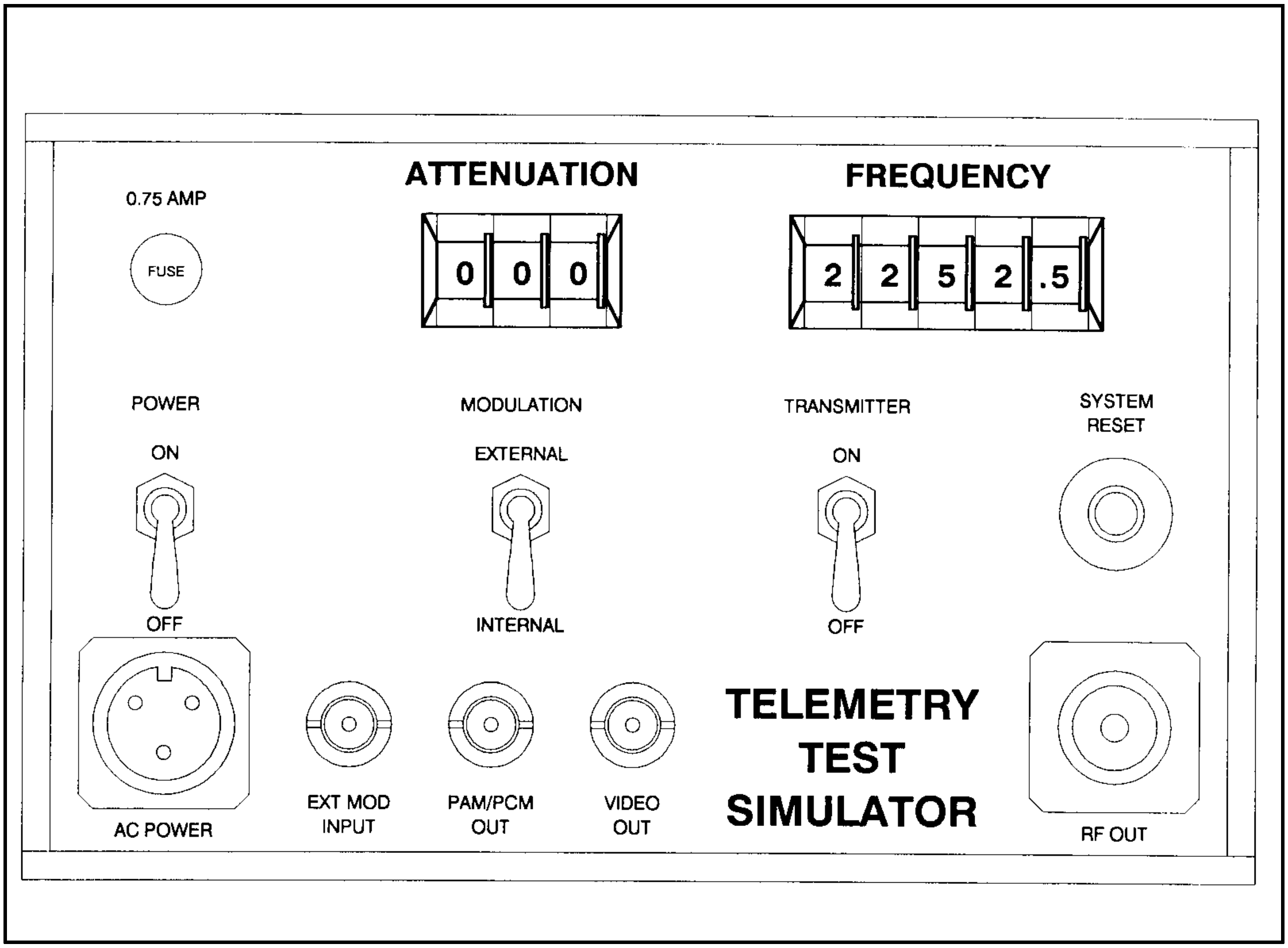

Figure 6. TTS Front Panel Drawing