COMPUTER CONTROLLED TELEMETRY RECEIVE AND RECORD SYSTEM

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ABSTRACT

This paper will describe the Pacific Missile Test Center's (PMTC) approach to a computer controlled telemetry receive and record system. The advantages of this system include: fast, accurate equipment setup and interconnection, automatic verification of operational status, and simplified signal monitoring. PMTC personnel developed the system architecture and software. The system hardware is all unmodified off-the-shelf equipment. The main design drivers were cost, reliability, and minimizing the effect of any single point failure. The system uses many individual switches instead of a small number of large switch matrices. Manual patching capability has been maintained. This patching system provides a backup solution if all the computers get "zapped". The patching system also provides increased signal routing flexibility.

RECEIVE STATION DESCRIPTION

The telemetry receiving and recording facility (Building 738) has four 10-meter diameter antennas. These antennas receive signals in the 1435-1540, 1750-1850, and 2200-2290 MHz bands. The 2310-2390 MHz band will be added in the future. Figure 1 shows a simplified diagram of the receive and record system, The L- and S-band telemetry signals are converted to P-band (215 to 320 MHz) in the antenna pedestals,

The downconverted signals are connected to very high frequency (VHF) multicouplers, Each multicoupter output is connected to a 4-way power splitter. The power splitter outputs are applied to VHF switches. The VHF switches are configured so that all bands from all antennas are available to each receiver pair (see figure 2). The switches are magnetically latched and do not reset at power-up. The switch outputs are connected to a patch panel. These outputs are normally connected to the receiver inputs. The VHF multicoupler outputs also are present on this patch panel. The antennas can be manually patched to the receivers if the computer system fails.

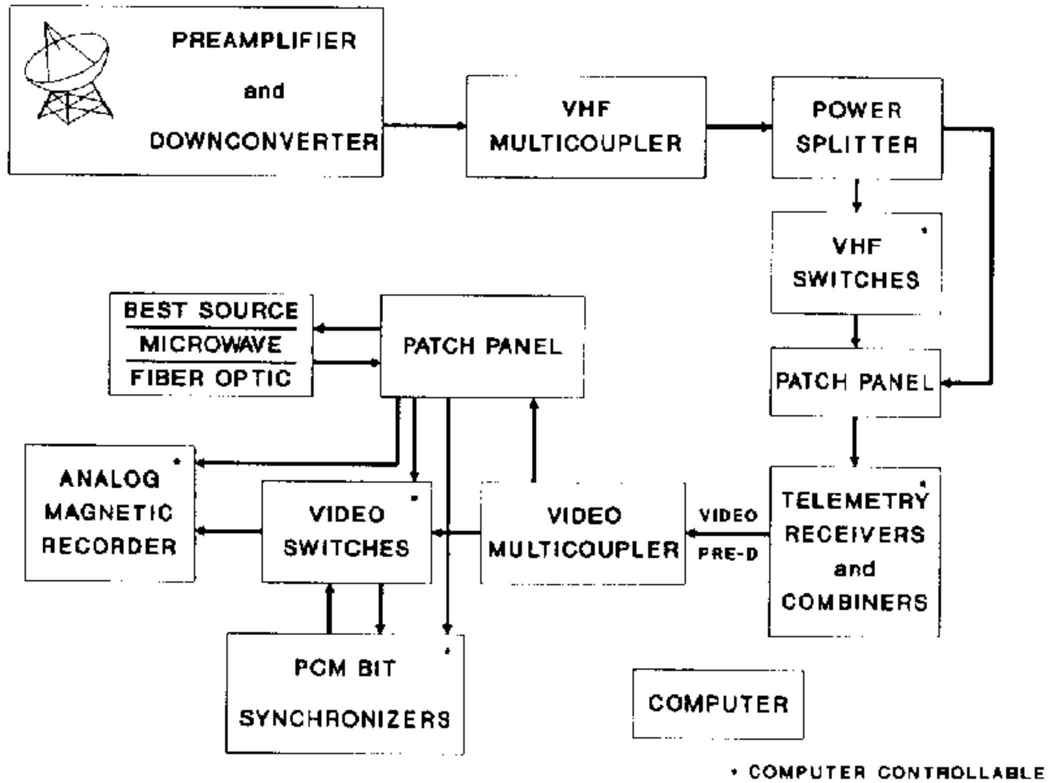

Figure 1. Receive and Record System Block Diagram.

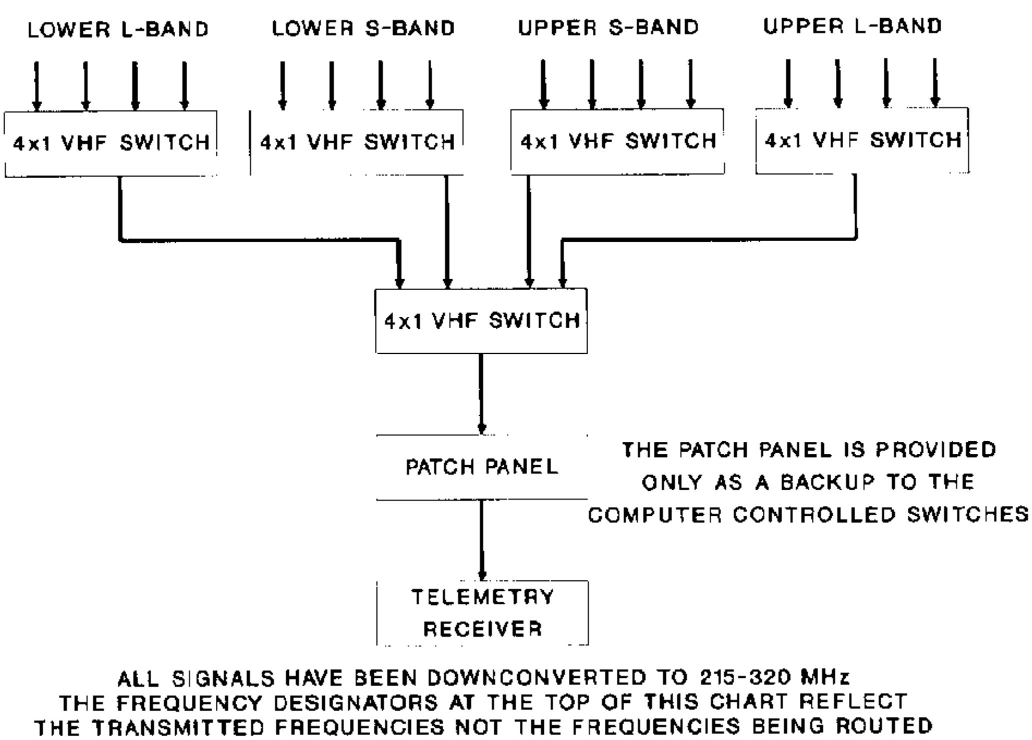

Figure 2. Antenna to Receiver Switching.

The receivers and combiners are configured into five stations. Each station consists of six sets of two receivers and one combiner. The upper receiver in each set is connected to the left-hand circular polarization. The lower receiver is connected to the right-hand circular polarization. The receiver and combiner video and predetection outputs are connected to video multicouplers. Each video multicoupler has eight isolated outputs. These outputs are connected to video switches and to a central patch panel. The video switches connect the receiver and combiner predetection and video outputs to the bit synchronizers and tape recorders. External inputs (microwave signals from San Nicholas Island (SNI), Vandenberg, etc.) are connected through the central patch panel. The "best" source signals are also connected through the central patch panel.

Each station has two 14-track analog magnetic tape recorders and four pulse code modulation (PCM) bit synchronizers. Any one video or predetection output of any receiver or combiner in a station can be connected to any track (tracks 2 through 13) of that station's recorders. This system has the capability of computer setup for most realistic operational interconnections. However, this system does not have the capability of connecting any arbitrary set of receiver outputs to an arbitrary set of recorder tracks without manual patch intervention. The plan is to handle the rare degenerate cases with manual patching where required.

A signal source is routed to a tape track by computer controlled switch closures. Figure 3 illustrates the switching configuration for the tape recorder input signals. Four tracks are grouped together as shown in figure 3. Each group of 4 tracks uses 32 4x1 switches and one 4x4 matrix. The groups consist of tracks 2 through 5, tracks 6 through 9, and tracks 10 through 13. Tracks 1 and 14 are usually used to record voice, timing, etc rather than received data. Every video, predetection, and bit synchronizer signal from the station is available to each group of four tracks. The 4x4 matrix allows any one input to be connected to any track. The 4x4 matrix outputs are connected to a patch panel. The outputs are normally connected (patched) to a video multicoupler. However, any signal can be manually patched to the video multicoupler input. Outputs from each video multicoupler are connected to the same track of both recorders. Therefore, the inputs of the two recorders in a station are identical (except for the tape servo signal which is unique to each recorder). Each pair of recorders can be used in a ping-pong fashion or to make duplicate originals.

The stations are interconnected as station pairs. When setting up a station to support an operation, the resources available can be increased by using receivers, bit synchronizers, and tape recorders from the other station in the pair. One of the outputs from each video multicoupler is connected to the same track of the paired station recorder input switch.

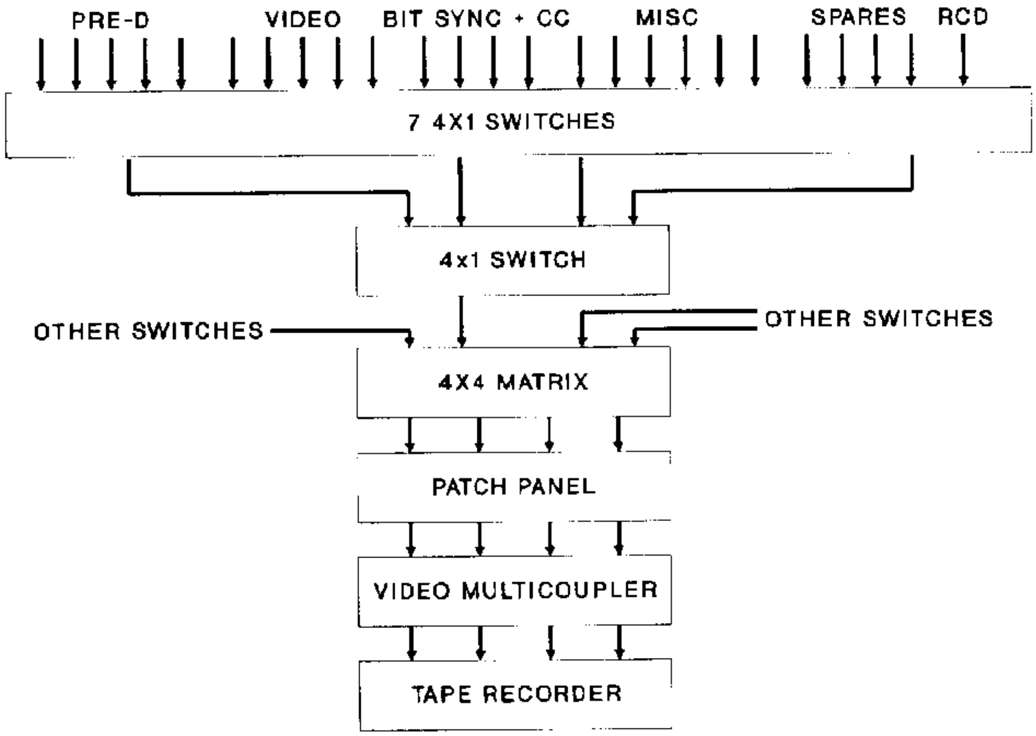

Figure 3. Recorder Input Switches (4 Tracks).

The computers used in this system are Hewlett-Packard series 200 models with color monitors, floppy and hard disk drives, and bus expanders. This computer was chosen because of the power and ease of use of its BASIC language for instrument control. All equipment is controlled using IEEE-488 buses. Liberal use is made of bus extenders. Each computer system uses one bus for disk drives, one for the printer and plotter, one for test equipment, three for operational equipment, and all computers share one bus for common test equipment. One computer can control all five stations if needed.

CALIBRATION AND TEST SYSTEM (CATS)

The purpose of CATS is to verify that the telemetry receiving and recording stations are ready to receive and record data. All five stations share the test equipment shown in figure 4. The vector signal generator is a Hewlett-Packard model 8780A. This generator can produce signals with frequencies between 10 and 3000 MHz. The output power can be varied in 0.1 dB steps. The modulation can be frequency modulation (FM), phase modulation (PM), amplitude modulation (AM), or any combination of in-phase (I) and quadrature (Q) amplitudes. The bit error test set outputs are connected to the vector generator modulation inputs. PCM/FM, PCM/PM, and binary phase shift keying (BPSK) signals can be generated. The RF generator output is connected to the preamplifiers via directional couplers. The attenuators are used to align and test the diversity combiners.

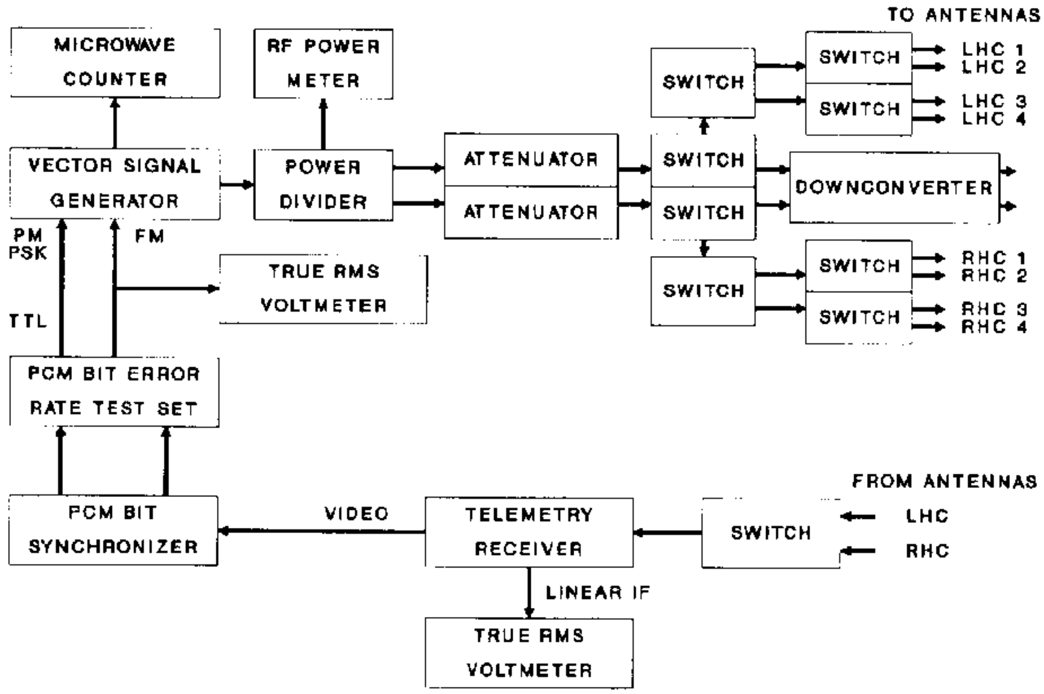

Figure 4. CATS Common Equipment.

Each pair of stations also shares a common group of test equipment. A block diagram of this equipment is shown in figure 5. This block contains the signal monitoring equipment including a spectrum analyzer, wave analyzer, counter, true rms voltmeter, DC voltmeter, predetection demodulator (playback receiver), and PCM bit synchronizer.

The following tests have been implemented: receiving system gain/temperature (G/T) (solar calibration); intermediate frequency (IF) signal-to-noise ratio (SNR); bit error rate (BER); and tape recorder bandwidth, SNR, and harmonic distortion. This system can also calibrate receiver automatic gain control (AGC) signals and display estimated IF SNR for any receiver at the operators console during an operation. The system can monitor the data at any of the recorder inputs and outputs. The incoming RF spectrum (P-band) or any receiver IF spectrum ran be displayed at the operator's console, plotted, or stored on, a floppy diskette.

CATS can measure the system G/T at the output of any of the operational receivers or the CATS receiver for any L-band or S-band telemetry frequency. The linear receiver method[1] of G/T measurement is used. The computer tells the operator the approximate location of the sun based on the current Greenwich Mean Time (GMT). The operator manually points the antenna at the sun and acquires track. The receiver gain is "frozen" while the antenna is tracking the sun. The rms voltage at the receiver linear IF output is then measured for each frequency and both polarizations while tracking the sun and while pointing at the cold sky. These values and the solar flux are used to calculate the system G/T.

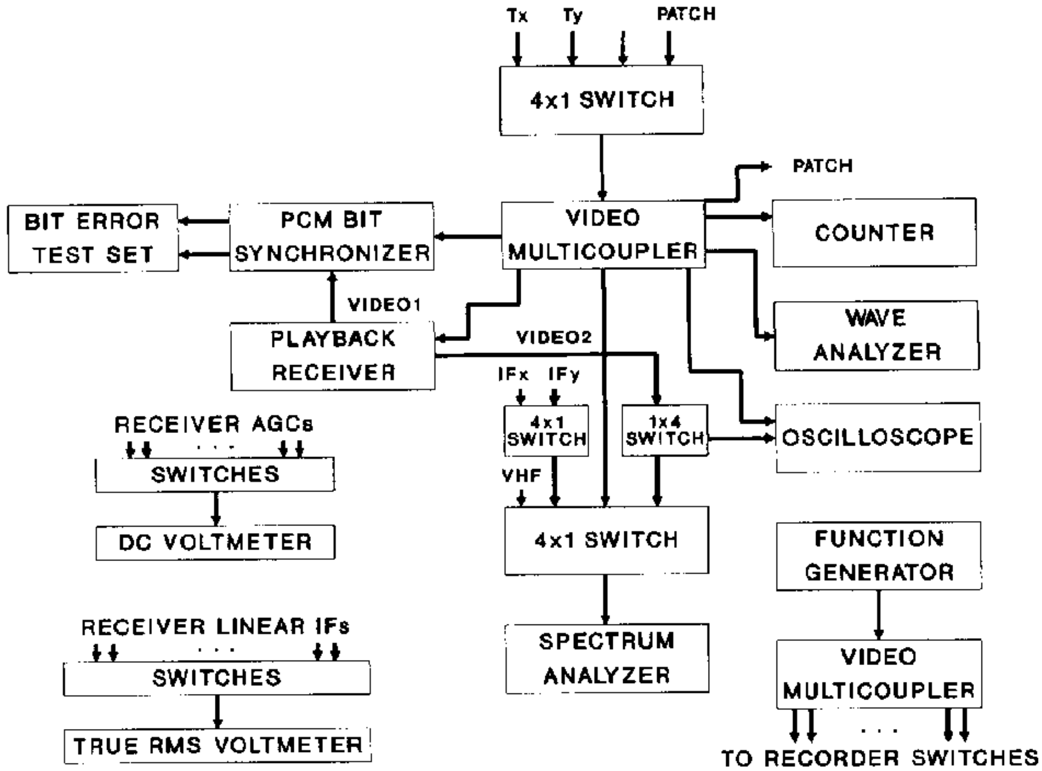

Figure 5. Station Test Equipment.

The primary method of verifying that the receiving and recording equipment is ready to support an operation is the BER test. First, the system is configured as desired to support the operation. The mission parameters are then simulated by modulating the vector generator with a standard 2047-bit pseudo-random bit stream. The RF frequency, bit rate, modulation type, and peak deviation are chosen to accurately reflect the data for each track. The RF power level is set to the level that should produce a 14 dB IF SNR in the receiver IF bandwidth. The vector generator output is then connected to the preamplifier input. The BER is measured for two intervals of 10^5 bits. This is done at the output of every magnetic tape recorder track with data recorded on it. If an output is error free during one of the two intervals, the interconnections and equipment are ready to support the operation. The vector generator output is then disconnected from the preamplifier input.

Other capabilities of CATS include:

1. Providing calibrated RF levels to aid in adjusting the subcarrier oscillators used for recording signal strength data

2. Providing appropriate signals to align a diversity combiner to an antenna and receivers at the mission frequency

3. Performing tests on receivers, combiners and magnetic tape recorders.

SOFTWARE

A single set of program has been developed to serve all five receive and record stations. Significant effort was expended to make the software "user friendly". The operator can correct or circumvent most problems as they arise. Sufficient prompts and help messages have been provided so that a person familiar with the system hardware should rarely have to refer to other documentation while using the system.

The software provides five main capabilities:

1. Preparation of setup files. These files are stored on floppy diskettes for use during an operation.

2. Use of these setup files to configure a receive and record station.

3. Maintenance of information about the status of equipment and the use of equipment.

4. Performance of system testing and monitoring.

5. Verification that the equipment parameters are reasonable. For instance, it would not be reasonable to record a 1.8 Mb/s non-return-to-zero level (NRZ-L) PCM/FM signal using a 900 kHz predetection tape carrier frequency.

Setup files are prepared using a series of menu pages. A typical menu page for setting up two receivers and a combiner is shown in figure 6. Switch closure routes for each signal are designated using mnemonics to name devices that the signal will pass through.

A station is usually configured to support an operation by using a setup file that was prepared earlier. Very few modifications are required to use the setup files with any of the five stations. The computer sets the equipment parameters on the equipment selected for use to support the operation. The parameters include receiver center frequency, IF bandwidth, video bandwidth, etc; bit synchronizer bit rate, code, etc; and tape recorder speed. The computer then commands the closure of the proper switches to interconnect the antennas, receivers, bit synchronizers, tape recorders, etc. The operator is prompted to perform any manual patching or front panel settings that may be required. The station setup is then printed and also saved for use by the test and monitoring programs. Tape labels can also be produced.

			PAGE 3 MENU
RECEIVER PAIR # (XX)	54		
ANTENNA # (X)	2	CENTER FREQ (XXXX.X MHz)	2216.5
IF BANDWIDTH (MHz)	1.0	FINE TUNE (SXX.X kHz)	0.0
VIDEO BANDWIDTH (kHz)	1000	VIDEO GAIN (XX dB)	45
AGC MODE	AGC	AGC TC (rnS)	0.1
AGC FREEZE	NORM		
2ND LO MODE	VFO		
AFC TC (FM) (mS)	/		
SWEEP (PM/PSK)	/		
LOOP BW (PM) (kHz)	/	ANTISIDEBAND (PM)	
LOOP BW (PSK) (kHz)	/		
CARRIER FREQ (kHz)	450	LOGIC	IN
SEARCH RATE	FAST	SEARCH RANGE	WIDE

Figure 6. Receiver and Combiner Setup Menu.

One goal of this development was to minimize the software development workload. therefore, a single set of programs was developed which can be used for all five stations. Hardware configurations for the stations are contained in lookup tables. These tables allow differences between stations to be handled easily. Future equipment changes can also be handled by modifying the tables. In addition to the normal configuration software, a series of “quick-setup” routines have been developed. These allow the operator to change the parameters of any piece of equipment or any switch closure path.

EQUIPMENT CONSIDERATIONS

A variety of problems were encountered during this development. The causes of some problems are discussed here.

1. Some telemetry equipment reverts to the front panel settings when the computer is reset or the equipment is put in local mode. Therefore, the equipment parameters will change unless the operator manually sets the front panel to match the computer settings.

2. Some telemetry equipment has a front panel switch which must be set to “remote” before the computer can control the equipment.

Many procedural problems can be avoided if the equipment is fully computer controlled and the front panel settings do not take over unless commanded.

CONCLUSIONS

1. A computer controlled telemetry receive and record system can be constructed using off-the-shelf equipment.

2. Fast, accurate tests of telemetry receive and record systems can be performed under computer control.

3. User-friendly computer controlled tests are much more likely to be performed than are manual tests.

ACKNOWLEDGEMENT

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REFERENCE

[1]Telemetry Group, Range Commanders Council (RCC), Test Methods for Telemetry RF Systems, RCC Document 118-89 Volume II.