NAVY SHIPBOARD WEAPON INFORMATION TELEMETRY SYSTEM

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SUMMARY

The paper presented by NSWSES at the 1975 ITC Conference in Washington, DC, described the Portable High Frequency Telemetry System (PUTTS) being assembled for NATO. This system used the best of the then standard state of the arts commercial components and was used for shipboard missile data receiving/recording and for quick look missile performance evaluation. In 1977 the Naval Sea Systems Command made funds available to update the AN/SKQ-3 system by utilizing the RF assembly similar to that used in PUTTS. This new RF assembly provided dual antennas for (1) a wide angle for verticle launch and initial acquisition; (2) narrow beam high gain for long range tracking. The RF unit also included frequency scan with automatic lock when a signal was received, and sector search. In 1978 funding was received from Australia and Iran to procure additional PUTTS. These units (PUTTS III) were updated to handle faster intercept rates as well as improved range tracking and adapt the new RF features from the SKQ-3 Mod. Added to this were the capability to handle both PAM and PCM data with light weight hardware. These systems were completed and the Australian unit system was delivered after acceptance tests with U.S. fleet operation in the Gulf of Mexico. As a result of these successful improvements a new portable system has been built to (1) adapt microprocessors to the set-up of data format; (2) Provide automatic selection remote control of the RF head within the antenna frame; (3) provide the basic data to make automatic processing possible when and if desired; (4) Add the new low noise GASFET preamp to the system to increase the range; (5) Add capability for four receivers in the space presently occupied by the dual receivers to permit the handling of the new missiles with dual RF outputs and (6) provide the capability of system checking of all modules from the antenna through the system to the paper read-out device. This paper now presents the new updated system combining the state of the art development in programming, remote control, low noise preamps, miniature RF assembly, matrix control programming as well as automatic data set up and selection for data processing.

INTRODUCTION

NSWSES, the developer of the Portable UHF Telemetry Test System (PUTTS), has combined advantages of the PUTTS III and updated SKQ-3 into a new light weight, portable assembly. This system will be capable of processing real time, PAM, PCM, or FM data from missiles and providing automatic quick-look evaluation of data between preset limits in ships. This new system is now known as the Weapon Instrumentation Telemetering System (WITS).

The WITS is based on modular unit construction in which each sub-unit is complete within itself and can be interchanged to meet the NAVY missile telemetry monitoring needs as dictated by changing program requirements. Figure 1 shows the evolution of the WITS antenna system. The PUTTS III dual antenna with large receiver (Microdyne), the same antenna system re-packaged into a operation/shiping container with the new small receiver, and the WITS configuration with dual antenna, test antenna, dual receivers and programmable by two wire.

REMOTE CONTROL

A programmer is built onto a common switching matrix which itself may be manually or electronically programmed, and provided in each sub-unit. This is based on the use of either manual switching or a multi-frequency tone code which permits microprocessors and memories to retain program requirements and set them up automatically from either a telephone dial, a printed card or magnetic tape.

This new type of matrix or program control was developed by NSWSES in 1978 and it was demonstrated at the SMS TLM Program Review at ECI in Tampa, Florida. It contained the matrix control and remote control assembly. The first model used a two-tone code system. The unit was updated in 1979 to use a five tone code which has the advantages of multi-toned, multifrequency receiver code utilization and the ability to actually discriminate between any frequencies. A rejection is achieved of all noise and any type of interference that is not compatible with the mixed tones. The actual algorithm used was developed imperically in actual telecommunication environments by using the statistical differences between noise, tone and speech. This then means that a two wire control using either (1) circuits combined on videocircuits; (2) circuits on two wire systems; (3) circuits on radiolinks or (4) on soundpowered lines on ships; can be used for giving detailed performance requirements to the units without jeopardizing the transmission with noise or jamming.

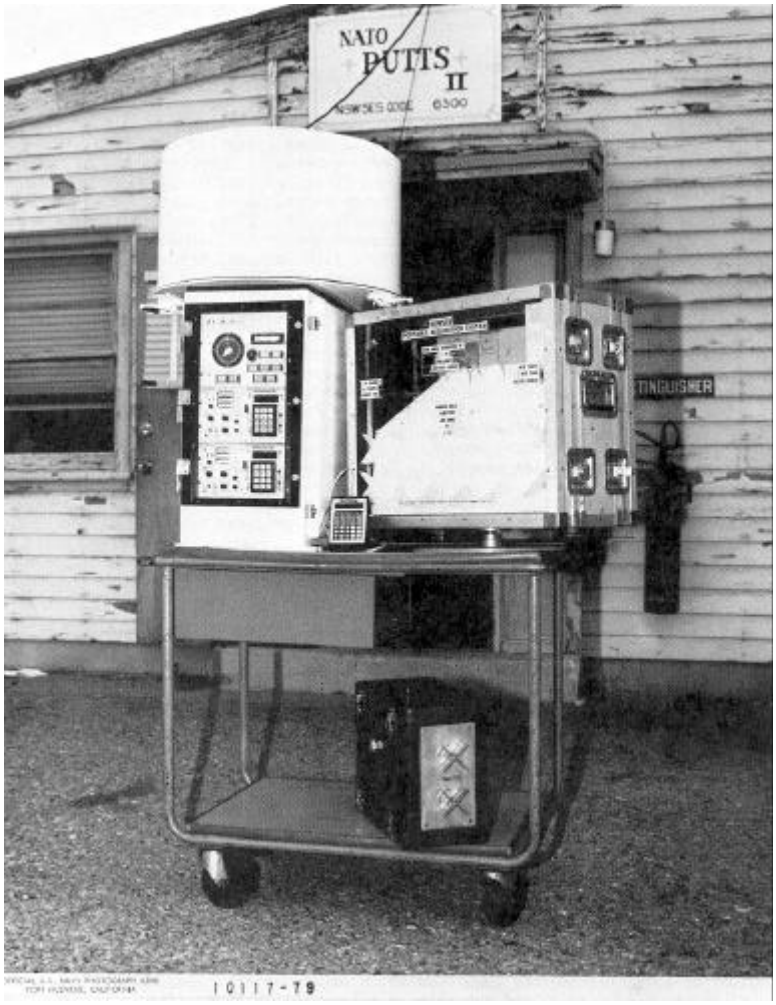

Figure 1. WITS Antenna System

This newer system was again demonstrated to an SMS TLM program review in 1979 at the Applied Physics Laboratory of John Hopkins University. An engineering development model is now undergoing evaluation in a PUTTS junior system used in USS GOLDSBOROUGH (DDG-20) during Ship Qualification Acceptance Tests.

This remote programmer unit uses a two wire signal distribution to all switchable elements of the TLM system. The source of the signal is (1) a 20 section system switching memory which is programmed by a normal telephone dial or (2) a telephone-type dial assembly may be used to set up all of the elements on a real time basis. Figure 2 shows the prototype programmer used in WITS. When final operations are started, the preprogramming material is fed into a common line to set up all the units in the configuration required.

A one digit action code is utilized to start all the active elements within the system. Thus tape recorders, power recorders, timing clocks and other dynamic devices are automatically started by dialing a one digit code. The recording on cassette tape and the instrumentation tape of the complete set up and the starting of these functions means that

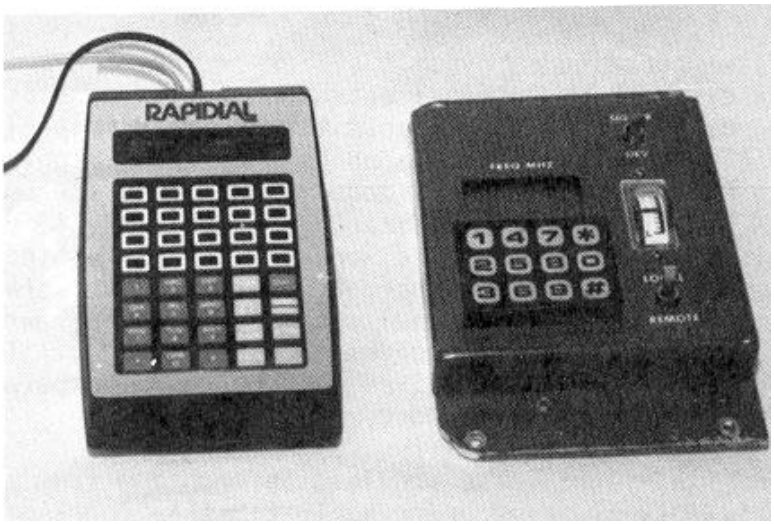

Figure 2. Protype Programmer with Receiver Control Elements

when the original tape is received for data processing the format is automatically defined on the main tape and that the cassette recorder tape can be utilized to set up automatic data processing if desired.

DYNAMIC SYSTEM TESTER

The original PUTTS System contained a dynamic system tester. This included a RF test frequency transmitter set up for external or internal antenna use with modulated so as to test the system. PUTTS III and utilized the same transmitter mounted in a plastic assembly (flashlight) in which the reflector had been replaced by a circularly polarized plated antenna. The case contained the RF transmitter and a coded signal generator microprocessor controlled for 64 channels of PAM binary code. This binary code would identify each of the 64 channels. That is channel one would have a binary code, one channel two a binary two, etc. Figure 3 shows the flashlight tester with battery charger. During test operation it would check thru the antenna, the preamp, the receiver the switchbox or switching matrix, and last but not least, it would write out on the paper recorder the selection out of the 64 channels that had been set up in the DECOM unit. This gives a thorough full operating system check, since this code is also placed on the tape recorder.

This RF dynamic tester (flashlight) also provided information from signal from the missile by indicating the relative transmitted power so that both a check of the missile and the receiving system could be made with one unit. The size of the flashlight is 4" x 6" x 4" without batteries and the weight is 2 pounds. In the new proposed WITS the flashlight is repackaged to physically mount in the RF assembly and under remote control would initiate a signal which will start the tester radiating. The tester will be coupled externally into the WITS receiving antenna to check antenna the full WITS without the need for an external test set.

Figure 3. Flashlight tester with Battery Charger

CONTAINERS

In order to provide improved portability over PUTTS the size of the sub systems comprizing WITS was reduced. These systems are packaged into containers which are set up with the tops and bottoms removable. When the equipment is set up for operation the bottom of the case is removed exposing all the plugs and wiring connections to the chassis of the modularized instrumentation. It was decided not to use slides and cord refractors since the increased cost and weight of these very desirable devices multiplies the physical size and shipping costs. Thus, WITS used a standard section case to provide the lightest weight and minimum size. Figure 4 shows a typical WITS sub assembly container, the RF assembly.

RF ASSEMBLY

The RF assembly of WITS contains two separate cross dipoles elements set for right hand circular polarization. The use of this dual antenna system with two receivers permits a antenna gain of three from each antenna to each receiver. If a single antenna was used to feed both receivers a loss of 3db results due to the power splitter. Provisions are made for two types of antenna and two types of operation with this RF assembly in the surface missile ship configuration.

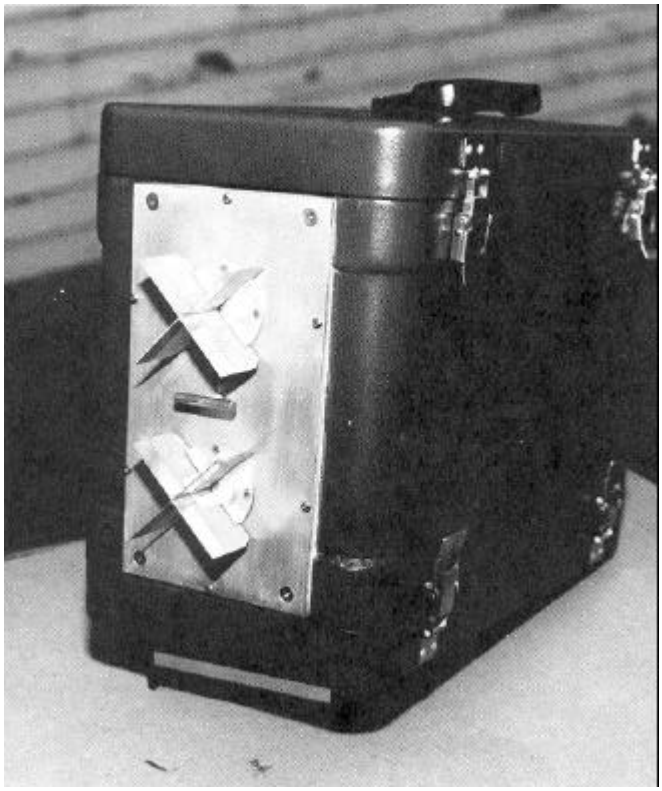

Figure 4. Typical WITS shipping container

MOUNTING

The RF assembly with two receivers, antenna preamps, filters and test transmitter are installed on the CCTV bracket normally a part of the missile fire control Radar Director. This unit fits on the CCTV mounting base of the director after the removal of one of the counterweights. The RF assembly that's added weighs approx 35 pounds. The unit receives its prime power (117 volts 400 Hz) from the director. The two coaxial outputs containing receiver video and receiver performance data are fed through the existing coaxial sliprings and through the mount into the data processing equipment located two decks below. There is no additional modifications to the director. The cover is then placed back on the RF assembly and the RF assembly is ready to use. Since the WITS TLM RF assembly is mounted on the target tracking radar, a autotrack assembly is not required for this mode of operation. Figure 5 shows the WITS RF assembly mounted on a AN/SPG-51 radar.

TLM RECEIVER

The WITS systems utilizes a new generation receiver, specifically developed for the NSWSES high performance protability requirement. The receiver utilizes a frequency synthesized local oscillator with 100 channel spacing at 1 MHZ intervals. Remote

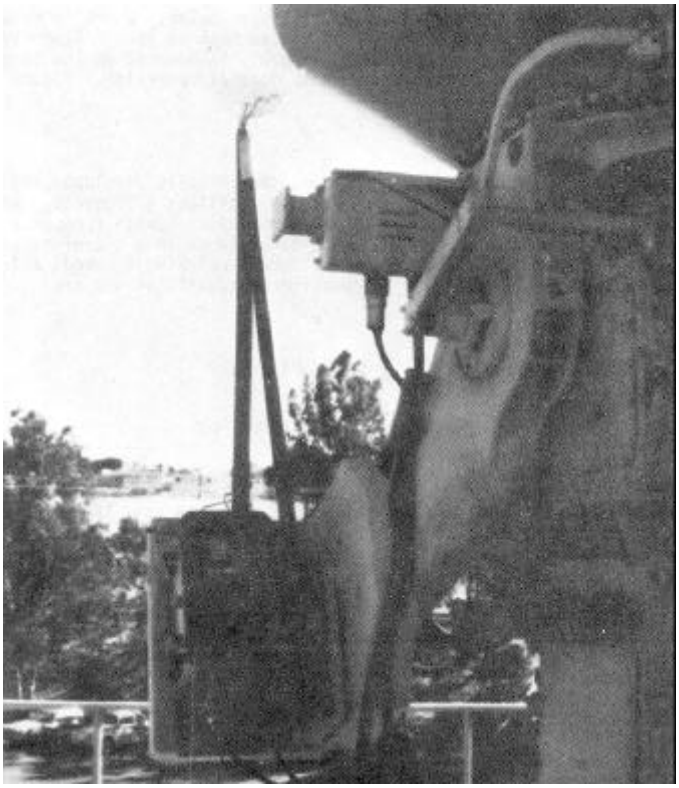

Figure 5. WITS RF assembly mounted on AN/SPG-51 Radar

frequency tuning is accomplished using the 4 x 4 multi frequency touch tone signal on a two-wire system. The receiver is housed in a aluminum housing 5 x 7 x 4 inches weighing 6 pounds and is manufactured by TRAK Microwave. A summary of the peformance specifications are:

FREQ: 2200-2300MHz
INUPUT NOISE: 2 db maximum
SENSITIVITY: 104 dBm. @ 6 db signal and noise to noise
FREQ STABILTIY: .0005%/C
OUT OF BAND RESPONSE: ≥ 40 dB 1980-2140 MHZ
≥ 60 db DC- 1099, 2600-10,000 MHZ
IF BANDWIDTH: 1.2 MHZ
DYNAMIC RANGE: 70 db

The receiver design allows for mounting four receivers in a standard 19 inch rack size. The TRAK model 1500-9303 is shown in Figure 6.

Figure 6. TRACK model 1500-9303 TLM receiver

TAPE RECORDER

In keeping with the portable, minimum size/weight requirement for WITS the Bell Howell Model M-1400 (Modified) was selected. This recorder has been modified to provide the following necessary features for shipboard telementary and reproduced applications:

(1) 2 MHz direct frequency response @ 120 IPS
(2) 14 Track record/reproduce head assembly from the M14G system for increased performance during reproduce
(3) 14 reproduce preamplifiers as part of M-14G head assemblies
(4) Special power supply with built in 3 channel reproduce amplifier, switch selectable with input/output level monitor
(5) Voice playback amplifier.

The M-1400 (Modified) tape recorder maintains all of the standard desirable IRIG tape recorder features such as: 14 track direct or FM record capability, 6 speed 3-3/4 to 120 ips, 14 inch NAB reel capacity, ruggedized configuration with RF1 shielding and pressure sealing to insure reliable operation even during condition of water run - off. The recorder used with PUTTS III with full 14 track six speed record/reproduce capability is shown in Figure 7.

OSCILLOGRAPH

The strip chart recorder chosen for the WITS system is the new all solid state CEC Model HR 2000 datagraph. This recorder was chosen to allow display of up to 28 data channels on any size direct print papers up to 12". The employment of the programmable light gate

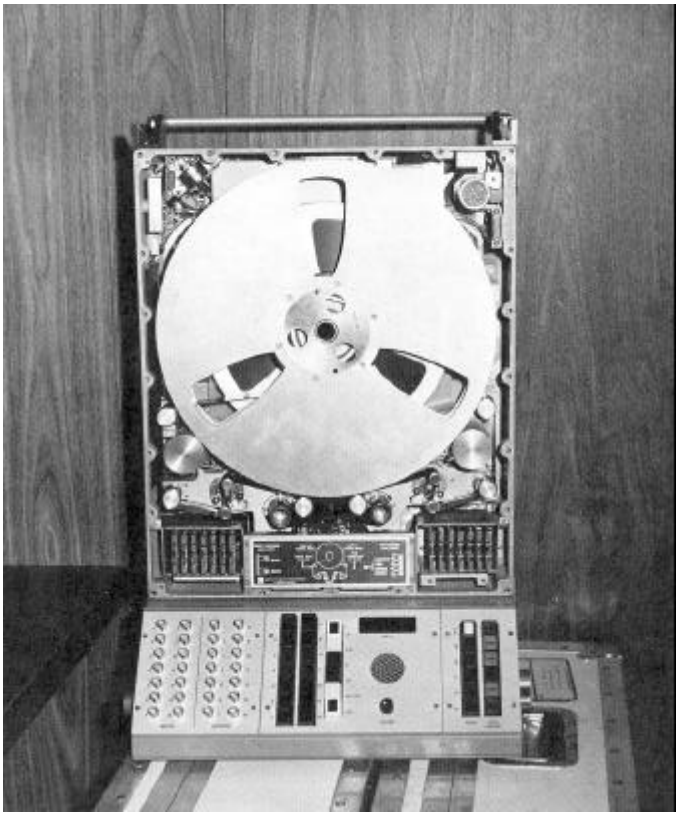

Figure 7. MARS 1400 Tape Recorder

array by CEC allows sinewave frequency responses to 5KHz and DC-10KHz square wave with signal amplitude up to 12". The standard HRZ000 has slight modification of a BNC input panel with trace positioning capability through the input comparator plug-in to allow system operation directly from the DAC in the PAM/PCM data DECOM system without additional pre-amplifiers.

PAM/PCM DECOM UNIT

The WITS is designed to handle both PAM, PCM, or FM data from Navy Missiles. The system selected to accomplish this is a compromise between large laboratory type systems and small portable field equipment. The system block diagram for the EMR 600 series equipment used in WITS is shown in Figure 8. As shown the unit consists of the EMR 691 PCM BIT sync., a EMR model 699 frame/subframe synchronizer, a EMR 686-03 digital/analog converter and a model 515M-23 PAM sychronizer. The PCM portion of the unit operate with selectable bit rates from 100 bps to 1 Mbps with NRZL or Biphase-L. The system will-handle variable word lengths from 4 to 16 bits. The bit synchronizer has four selectable bit rates, set by switch selection with rates of 100Kb, 244.K Kb, 614.4Kb or 755.75Kb. Others may be chosen as future requirements dictate. The frame/subframe synchronizer will be initially configured to meet special navy surface missile requirements. Up to 14 dual DAC will be mounted in the 600 series card cage to allow 28 continuous

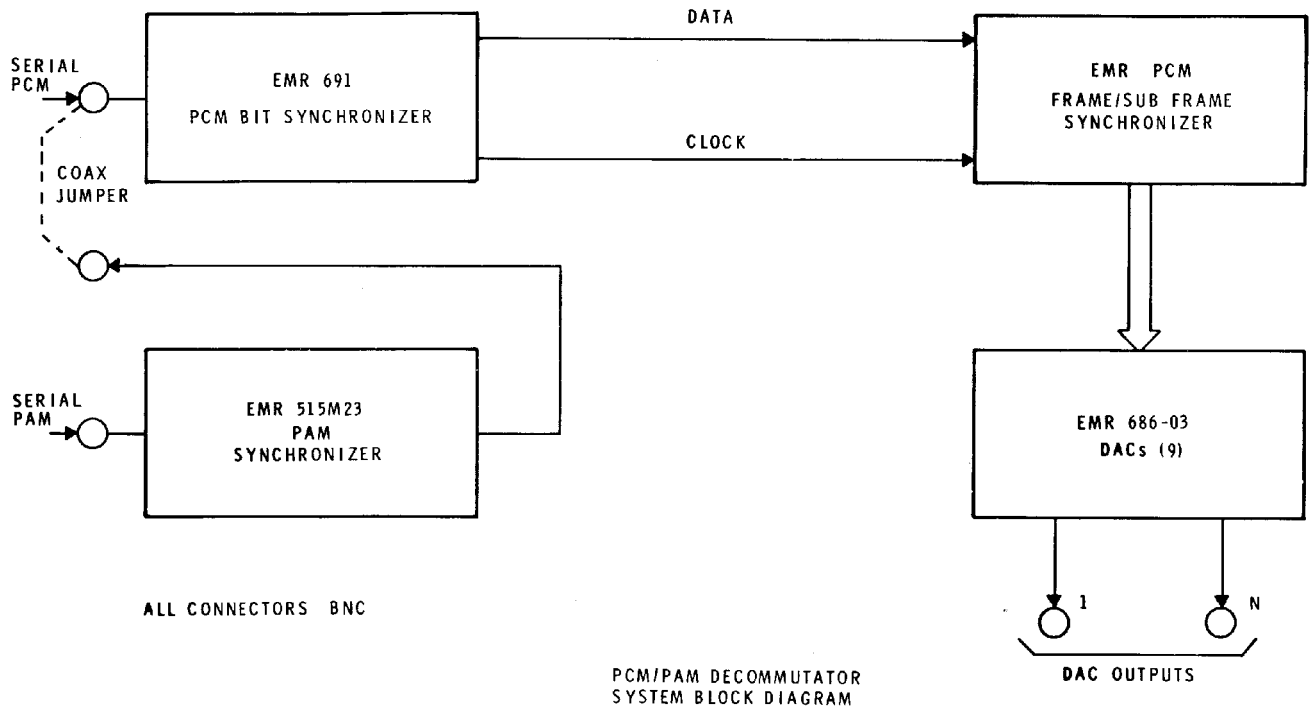

FIGURE 8.

analog outputs. When PAM data is received from missiles the PCM serial output from the Model 5115 PAM sychronizer will be patched into the PCM bit synchronizer for processing through to the DAC. The whole assembly fits into a portable carrying case 24 x 10½, x 20 and weighs 50 pounds. The unit is designed for 0-55°C operating temperature, 20g shock and 5% to 90% humidity.

AUTOMATIC DATA EVALUATION

It is now possible to combine a programmer, microprocessor controlled evaluation circuits, and a printer into a combined unit which will take fixed format data from the PAM/PCM DECOM, re format it for evaluation against pre set limits and prints. The data will be automatically annotated in engineering units with those outside program limits flagged. The unit in WITS selected for this function is the Digistrip II which allows for evaluation of 16 channels at a 8 channeled/sec. scan rate. This unit meets the WITS concept of modularity, stand alone capability with system integration by simple cable hook-ups. The unit weighs 45 lbs in a 17 x 12 x 19 inch container.

PROGRAMMING

Programming is entirely by the front panel keyboard. Front panel graphics guide the operation and built-in diagnostics test all entries. A valid entry is recognized with a short, audible beep-tone. An invalid entry generates a long beep-tone, and the invalid entry is

ignored automatically. The programmed instructions may be reviewed on the display or may be printed by pressing the LIST PROGRAM key.

The programming sequence includes: configuration, header programming, function definition and individual channel programming.

FUNCTION DEFINITION

In addition to the missile TLM program the functions program provides functions which the user can define for linear scaling and accumulation of data from Ships Fire Control System. These data can be recorded as analog voltages via a VCO multiplex signal and processed through FM discriminators. These FM discriminators outputs are then fed into the Digistrip II for post reduction processing.

CONCLUSION

The WITS concept is to provide a TLM ground station that achieves state of the art capability by utilizing as much as possible industry standard modules and instruments integrated into a small ruggedized portable system for shipboard use. This technique has highly desirable features for (1) achieving high performance at affordable prices (2) procurement and delivery without long development time; (3) modularity allowing re-configuration as state of the art hardware is produced by industry; (4) ease in system re-configuration to meet new program requirements; (5) size and weight reduction to allow portability and transportation ease; (6) data evaluation and matrix program control without complex computer hardware or software. These advantages make WITS a viarable option for shipboard telemetry system procurement.