ABSTRACT

The WSMR Telemetry Tracking Systems consist of ten (10) automatic trackers and four (4) manual trackers. These trackers operate in the frequency ranges of 1435 to 1540 MHz and 2200 to 2300 MHz. Two Telemetry Acquisition Systems (TAS) with 24-foot parabolic antennas are located at fixed sites. A 6-foot parabolic antenna system has been converted from a mobile unit to a fixed-site system. Seven Transportable Telemetry Acquisition Systems (TTAS) with 8-foot parabolic antennas can be located on and off the range along with a mobile microwave relay station to support range tests.

The RF subsystems on the seven TTAS’s have been miniaturized and integrated with the feed assembly resulting in a vast improvement in autotrack reliability.

The digital slave tracking capability of the seven TTAS’s and two TAS’s has been improved by a joint effort between two WSMR organizations. Tracking System Interface (TSI) hardware and software were both developed in-house at WSMR by the Instrumentation Directorate. The National Range Operations Directorate, Data Collection Division, Telemetry Branch interfaced and installed the TSI to the tracking systems.

The TSI utilizes two (2) Z80 microprocessors and is capable of slaving to instrumentation RADAR data in one of two modes. The first mode is dependent on the UNIVAC 1108, WSMR real-time computer complex, to convert the RADAR XYZ data to site oriented azimuth and elevation data. The second mode allows the telemetry trackers to accept RADAR XYZ data directly and perform its own coordinate conversion. An additional feature of the TSI is the test mode for self-checks, servo tests, and system readiness tests.
INTRODUCTION

WSMR Telemetry Branch has modified the TTAS’s RF subsystem and the digital slave tracking mode resulting in increased tracking reliability.

The first major modification involved miniaturizing the RF subsystem and integrating it with the feed assembly into one unit. Part of this modification involved reinforcing the antenna support spars that previously had been inadequate to prevent feed skew and defocusing caused by the antenna pedestal responding to high dynamics. The scan driver card was also relocated from the original RF enclosure to a controlled environment inside the shelter. The scan driver conditions and directs the signals to develop the tracking errors. This card was also a source of autotrack failure due to the high vibrations it was subjected to on the side of the pedestal. The last RF modification eliminated the 3-port, 6 dB gain multicouplers. The 8-port, 0 dB gain multicouplers were reconfigured into 4-port multicouplers with 6 dB gain. This modification eliminated the condensation problems within the 3-port multicouplers located inside the pedestal and retained the same 6 dB gain. The reconfigured 4-port multicouplers were relocated inside the shelter within a temperature controlled environment.

The second major modification utilized two Z80 microprocessors to improve the digital slave tracking mode. Known as the Tracking System Interface (TSI), this system eliminated four units of a six unit Instrument Data Converter (IDC). The TSI retained the IDC’s capability to receive RADAR XYZ converted data from the main WSMR computer. In addition to this capability, the TSI can receive the RADAR XYZ data directly and perform its own coordinate conversion. Also, the TSI has a test mode which can be used to confirm the status of the TSI and the tracking servo system prior to supporting a range test.

RF SUBSYSTEM MODIFICATION

Original RF Configuration

The original RF subsystem consisted of two channels with one parametric amplifier and one solid state post amplifier per channel. An alternate solid state amplifier could be used in lieu of the parametric amplifiers with decreased gain and a higher noise figure. If the alternate configuration was going to be used, several cable changes were required. (See figure 1) The subsystem needed at least two hours of warm-up time to allow the parametric amplifiers to stabilize. Due to the mobile capability of the TTAS, the system would be turned off daily, which created problems with the parametric amplifiers. The turn-on turn-off operation decreased their life expectancy and increased the risk of autotrack failure. Another area of increased risk of autotrack failure was in the feed...
assembly. Excessive vibrations by the feed assembly were due to the mobile characteristics of the TTAS plus the poor spar support that contributed to the instability. The vibrations would break solder connections and phase shifters that would cause intermittent contact problems resulting in autotrack failure.

**New RF Configuration**

WSMR’s decision to modify the TTAS’s RF subsystem was influenced by the fact that we could no longer obtain spare parts for the parametric amplifiers. WSMR purchased the miniaturized components and wideband amplifiers for operational use. The modifications also included the capability to support frequencies within the 1710 to 1830 MHz range.

The new configuration eliminated the bulky RF enclosure that was mounted on the side of the pedestal (figure 2). The parametric amplifiers were replaced by one wideband solid state amplifier per channel. Short semirigid coaxial cables replaced the longer RF cables within the RF enclosure. By using miniaturized components, the new configuration was integrated as part of the feed assembly on two separate tiers and housed in a 5¼” x 10½” unit. (See figures 3 and 4) The unit added 10 pounds to the feed/antenna assembly and was located 8 feet from the pedestal centroid. The additional weight was appropriately counterbalanced using lead plates. Also, the scan driver card was installed on the equipment rack within the shelter and not subjected to temperature variations and pedestal vibrations.

**Antenna Reflector**

Prior to changing the RF subsystem, a major problem involved the antenna spar support. The combination of high tracking rates and the mobility over rough terrain would cause excessive vibrations that would defocus or skew the antenna plane. The problem was further complicated with the additional weight behind the feed assembly resulting from feed reconfiguration.

The solution to this problem involved redesigning the support spars (as shown in figure 5). This design prevented overflexing during antenna rotation without altering the sum and difference patterns or contributing additional RF blockage. The new configuration has been operational over two years with no component failure or antenna skewing. The vast improvements resulted in increased autotrack reliability.
ADVANTAGES

The following advantages have been realized from the modifications:

1. Lower system noise figure (3.5 dB over entire frequency band compared to 6 dB).
2. Increased G/T (3 dB/K° compared to 1 dB/K°).
3. No warmup time required due to the RF subsystem.
4. One wideband amplifier per channel with the appropriate filtering to operate between 1430 MHz to 2300 MHz.

DISADVANTAGES

1. Only one frequency band can be selected rather than all three simultaneously. This is a minor disadvantage since the overall system can accommodate two frequency bands. One via Right Circular Polarization (RCP) and one via the Left Circular Polarization (LCP) channel.
2. Two RF switches are required to select the 1430 to 1540 MHz and 1710 to 1830 MHz. 115 VAC is needed to enable the selected RF switch. The 115 VAC in the RF enclosure has not been a problem.

DIGITAL SLAVE TRACKING

The prime tracking mode for all telemetry trackers is the autotrack mode. The first backup is the Digital Slave Tracking mode (DST). To utilize the Digital Slave Tracking mode, WSMR identifies all of its tracking sites by conducting a geodetic survey of the selected location. The selected location is then assigned a site identification number (site ID).

ORIGINAL DIGITAL SLAVE TRACKING (DST)

The original DST consisted of six (6) units known as the Instrument Data Converter (IDC). The six units were the input unit (IU), output unit (OU), tracking error generator unit (TEGU), remote unit (RU), a basic timing unit (BTU) and a modem. The modem received a serial data message from the WSMR real-time computer complex consisting of site oriented angle information. The TEGU would compare the incoming data with the tracker angle data and derive a position error which was applied to the servo system to position the antenna. The input and output units required site identification programming in binary format by setting pins out (for a binary “11”) and pins in (for a binary “0”). Also,
the remote unit had to be programmed in octal format to an angle from the site location to a known reference point. Whenever AC power was removed from the IDC or tracker, the remote unit had to be reprogrammed. This enabled the TEGU to do the correct angle data comparison and apply the position error to the servo system.

NEW DIGITAL SLAVE TRACKING SYSTEM (DSTS)

The new DSTS, known as the Tracking System Interface (TSI) replaced four of the six IDC units. The TSI system kept the modem and the BTU.

The TSI (see figure 6) retained the IDC’s capability to receive site oriented data generated from the WSMR real-time computer complex. The additional capability enables the telemetry tracker to receive instrumentation RADAR data in XYZ format directly and perform its own coordinate conversion. This is accomplished using two Z80 microprocessors.

The TSI is all front panel operated. The site ID is dialed in using thumbwheel switches. Once the tracker is oriented to a known reference point, the TSI is calibrated by matching the tracker’s encoder readout with the TSI’s azimuth and elevation thumbwheels. No additional setup is required if power is turned off and on.

The TSI can be operated in one of two modes, normal or test. In the normal mode, the TSI will lock on the incoming serial message by matching the incoming site ID with the dialed-in site ID. The TSI distinguishes if the incoming data is computer generated or if it is RADAR data in XYZ format to be converted. If the incoming data is computer generated, no coordinate conversion takes place. The master Z80 CPU handles the data decoding and outputs the data to the azimuth and elevation drive signals. The master Z80 also performs all the front panel operations. If the incoming data is RADAR XYZ data, then the slave Z80 performs the coordinate conversion and interfaces with the master Z80. When the incoming site ID matches the dialed-in site ID, the correct site ID will be illuminated directly above the thumbwheels. If RADAR XYZ data is the incoming data then the site ID of the RADAR will be illuminated. The TSI can now be used to control the tracker.

In the test mode, the TSI generates all the drive signals independent of any incoming data. Up to 256 different tests can be programmed. At the present time telemetry trackers utilize five different tests to verify the servo subsystem static and dynamic response and ascertain the TSI’s capability to perform coordinate conversion.
The five tests are as follows:

Test No.

00  22.5° Position Test. Azimuth and elevation encoder calibration.

01  0.35° Step Input.

02  11.25° /sec² Acceleration Input.

03, 04  XYZ conversion tests for small and large angles.

*05  0-360° azimuth rotation for antenna patterns.

*06  0-36° azimuth rotation for verifying angle readout, 0-90° elevation rotation.

* The software for these tests are currently being developed.

The TSI consists of three S100 boards in one unit. These are the input/output board, front panel board, and the central processing unit. The master and slave Z80 assembly language programs are stored in two EPROMS utilizing approximately 4K of memory. The programs were developed in-house at WSMR for telemetry tracker applications. The block diagram of the TSI is shown in figures 7 and 8.

References:


FIGURE 1 ORIGINAL RF SUBSYSTEM
FIGURE 3 RF SUBSYSTEM

FIGURE 4 RF SUBSYSTEM
FIGURE 5  TTAS ANTENNA WITH REINFORCED SPARS AND RF SUBSYSTEM

FIGURE 6  TRACKING SYSTEM INTERFACE (TSI)
FIGURE 7 TSI FUNCTIONAL BLOCK DIAGRAM

FIGURE 8 TSI CENTRAL PROCESSING UNIT