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Transportable Automated Electromagnetic Compatibility Measurement System (TAEMS)

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Henry Geller, Assistant Secretary for Communications and Information

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TRANSPORTABLE AUTOMATED ELECTROMAGNETIC COMPATIBILITY MEASUREMENT SYSTEM (TAEMS)

C. J. Chilton, A. H. Diede, W. M. Welch, R. A. McLean, and F. G. Stewart*

An automated, computer-controlled receiver system developed by ITS for the U.S. Army Communications Command provides a unique solution to such problems as spectrum management, EM hazards measurements, and site surveying. This receiving system is designed around a commercially available automatic receiver system and covers the frequency band 1 kHz-40 GHz, thus extending the capability of the receiver system by providing extended frequency coverage, multiple antenna selection, improved noise figure performance, built-in test capability, noise figure measurement capability, and 160 dB measurement range; as well as 10 Hz frequency resolution to 40 GHz, computer-controlled directional antenna pointing, and automatic real-time calibration to 40 GHz. Three rf preselector/down converters were developed by ITS for use with the receiver to cover frequencies between 2 and 40 GHz. High sensitivity and low transmission loss was achieved by attaching the down converters directly to the antennas and mounting the complete system package on the elevation/azimuth (EL/AZ) positioner. The down converters mix the rf signals to IF (150 MHz), and this IF signal is transmitted through the EL/AZ pedestal via coaxial cable to the bus structure interface unit, mixed to 50 MHz and then fed to the rf-microwave section of the automatic spectrum analyzer for further processing. In addition, a real-time-executive (RTE) software operating system was developed for the receiver system by ITS to extend the operating capability of the receiver system. The RTE allows multiprogram execution, as well as program scheduling, file manipulations, and editing. Using the editor, FORTRAN measurement routines can quickly be written or modified. Both source and object programs are stored on magnetic disc with measurement data stored on magnetic tape for further analysis.

Key words: computer controlled receiver; 1 kHz to 40 GHz; electromagnetic compatibility spectrum management; EM hazard measurement

1. INTRODUCTION

A new computer-controlled receiver system developed by ITS for the U.S. Army Communications Command provides a unique solution to such problems as spectrum management, EM hazards measurements and site surveying. Indeed, the hardware and software systems are sophisticated enough that, once the system is deployed, it is possible for a measurement mission to be executed with minimum operator intervention. The ITS receiving system is designed around a commercially available automatic receiver system and covers the frequency band 1 kHz-40 GHz.

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The ITS receiver system extends the capability of the commercial system by providing: extended frequency coverage, multiple antenna selection, improved noise figure performance, built in test capability, noise figure measurement capability, and 160 dB measurement range. In addition, the system features 10 Hz frequency resolution to 40 GHz, computer-controlled directional antenna pointing, and automatic real-time calibration to 40 GHz.

The significant developments of the ITS system are the three rf preselector/down converters developed for use with the system to cover frequencies between 2 and 40 GHz. To achieve high sensitivity and low transmission loss, the down converters are attached directly to the antennas and the complete package is mounted on the Elevation/Azimuth (EL/AZ) positioner. The down converters mix the rf signals to IF (150 MHz), and this IF signal is transmitted through the EL/AZ pedestal via coaxial cable to the bus structure interface unit, mixed to 50 MHz, and then fed to the rf-microwave section of the automatic spectrum analyzer for further processing in the system. The boundary conditions placed on the design of the down converters were that operation had to be user compatible both in the automatic and manual modes. This requirement was imposed so that operators would not be required to learn separate operation techniques for frequencies above and below 2 GHz. The system software was designed so as not to require extensive rewrite to make the system functional, and any new software developed for other systems could be expected to execute with little or no modification.

Essentially the same approach was used for each of the three down converters to achieve selectivity, sensitivity, and frequency accuracy. The selectivity is obtained by using a yig-tuned microwave filter; the sensitivity is accomplished by using a low-noise microwave mixer; and the frequency accuracy is achieved by phase-locking the local oscillator to a frequency reference generated by frequency synthesis from a highly stable 10 MHz oscillator. A significant technical improvement available in these down converters is a built-in noise source and comb generator which permits complete system calibration except for antenna gain. Since the calibration is generated under computer control, a complete system calibration can be performed as often as may be required.

2. SYSTEM DESIGN

A number of commercially available computer-controlled radio receivers were investigated and considered as the basis for designing an integrated system that would work from 20 Hz to 40 GHz. After evaluating the performance specifications of all these receivers and comparing them with the requirements of the Army, it was clear that these requirements could not be met by any of the commercially available systems alone. In this section, the system boundary conditions, the phase-lock loop design, yig filter, and oscillator tracking characteristic for the integrated receiver systems design are discussed in detail.

2.1. System Boundary Conditions

The basic problem in the system design was one of synthesizing a receiver system that would meet the Army's performance specifications and also have minimum impact on the system hardware and software systems. The requirements which helped to define the system design were:

(1) Receiver operation in both automatic computer controlled and manual modes.

(2) Receiver remote control from a distance of 75 feet from the measurement van.

(3) High sensitivity and high dynamic range.

(4) High frequency accuracy and resolution.

(5) Real-time rf calibration.

(6) Provision for frequency extension to 40 GHz.

(7) Unambiguous signal display.

(8) Dual linear polarized direction finding and omni-directional antennas from 1 kHz-40 GHz.

(9) Elevation-over-azimuth antenna positioner mounted on a 50 foot variable height tower.

In addition, the system must operate over the following environmental ranges: -35°C to 50°C, up to one-hundred percent humidity, and winds up to 100 km/hr.

Requirements 8 and 9 imply that the directional antennas (and for some bands, the omni-directional antennas) be mounted on the elevation/azimuth rotator atop the 50 foot, variable height tower. Since a number of antennas are required to cover the 1 kHz-40 GHz range, a switch matrix is necessary to allow selection of a particular antenna. This switch matrix must also be located on the EL/AZ positioner, otherwise a large number of long transmission lines would have to go through the positioner and down the tower. Clearly this would be undesirable and impractical. Digital control of the switch matrix is also required since the antenna selection must be remotely controlled.

Having the antenna system 75 feet away was a significant engineering problem. Initially we considered transmitting the rf signal from the antenna subsystem via transmission line to the receiver system. However, the high transmission loss of coaxial cable and waveguide, and the finite bandwidth of both, demanded another solution. In addition, waveguide transmission lines were not consistent with the concept of a transportable measurement system. By down converting the rf signals above 2 GHz to an IF, the limitations of coaxial cable could be minimized.

Once it was realized that the rf signal must be converted to an IF, it was clear that only a preselected superheterodyne receiver with a synthesized local oscillator could meet the requirements for sensitivity, frequency accuracy and resolution, dynamic range, calibration, and spurious response.

2.2. Phase Lock Loop

As was indicated above, a synthesized local oscillator (LO) was the only solution capable of meeting the frequency resolution and accuracy requirements. Since the 2-4 GHz first LO of the system is a synthesized signal and available at a test port of the spectrum analyzer, it was logical to use this signal to generate the local oscillator signal for the receiver.

Two direct multiplication techniques were considered: active multipliers and yig-tuned multipliers. Active multipliers were eliminated because their sub-octave bandwidth was not compatible with the required multi-octave receiver coverage; i.e., the hardware design would have required more components. Yig-tuned multipliers were examined, but such problems as tracking over wide temperature ranges and inadequate power output up to 20 GHz eliminated their further consideration. (Since 1975, great progress has been made in the tracking of yig multipliers and in wideband amplifiers. Had these improved devices been available in 1975, an alternative design might have been considered. However, to properly evaluate this new alternative, a prototype would have to be built and tested.)

Fundamental yig-tuned oscillators were chosen as the most suitable source of LO power because of their wide bandwidth, output power, tuning linearity, and spectral purity. To achieve the required frequency accuracy and resolution requirements, it was necessary to phase lock the receivers' local oscillator to the synthesized first LO of the system.

Figure 1 is a simplified block diagram of the phase-lock loop used in this receiver. The phase detector compares the phase of the IF signal from the harmonic

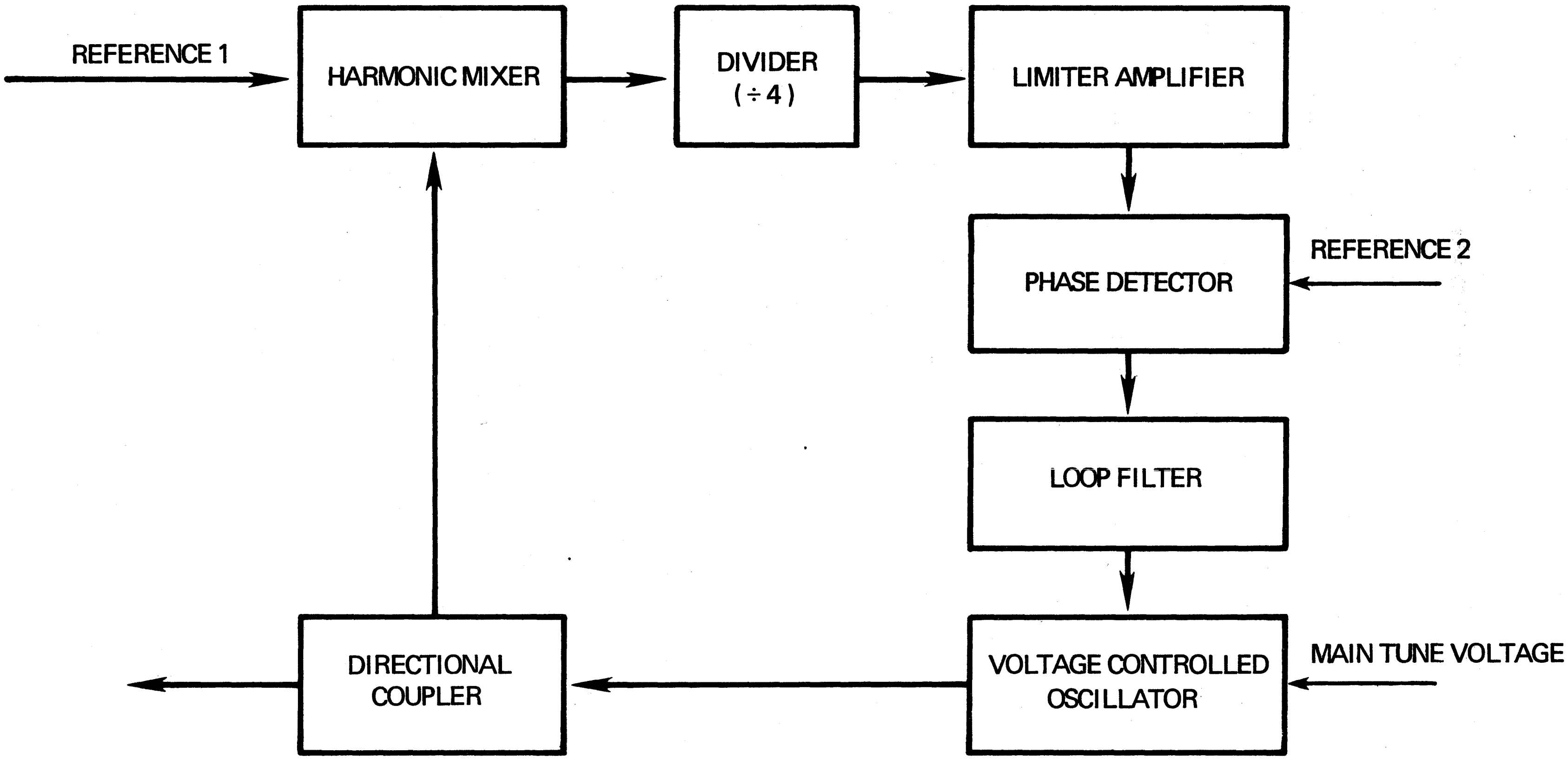


Figure 1. Simplified diagram of the phase lock-loop used in the ITS receiver.

mixer with a stable offset reference. The error voltage from the phase detector is low-pass filtered and applied to the fast tune port of the voltage controlled oscillator in such a way that the phase of the oscillator must track the phase of the two input reference signals.

A fundamental requirement of the receiver was of a subtle nature. Basically, this requirement was that the tuning equation for the system be satisfied in the automatic and manual modes:

$$F_{RF} = N\left(F_{REF}\right) \pm .550 \text{ GHz} \tag{1}$$

where

F_{RF} = signal frequency,

F_{REF} = 2-4 GHz first LO signal, and

N = harmonic number (1,2,3,4,5,...10).

The + sign is chosen for upper sideband mixing, with respect to $N\left(F_{REF}\right)$, and is denoted N^+. This requirement arose out of the desire to preserve all essential operating features of the basic system, in particular, its manual tuning accuracy and capability. Thus, the down converter must tune to the frequency indicated on the spectrum analyzer; i.e., the down converter and spectrum analyzer must satisfy Equation (1).

Thus, the design question to be answered was: "How to design a phase-lock receiver that satisfies Equation (1)?" An answer to this question was found by rewriting the tuning equation (1) as:

$$F_{RF} = (N\left(R_{REF}\right) \pm F_{OS}) \pm (.550 - F_{OS}) \tag{2}$$

where

F_{RF} = the receiver signal frequency in GHz,

F_{REF} = the 2-4 GHz first LO of the ARS-400,

N = 1,2,3,...10, and

F_{OS} = OFFSET frequency.

If we define

$$F_{LO} = (N\left(R_{REF}\right) \pm F_{OS}) = \text{receiver LO signal} \tag{3}$$

and

$$F_{IF} = (.550 - F_{OS}) = \text{receiver IF signal,} \tag{4}$$

we can rewrite Equation (2) as:

$$F_{RF} = F_{LO} + F_{IF}.$$

At this point one may wonder what advantage may be gained by this algebraic manipulation. Equation (3) defines a "translation loop" (Gardner, 1966) where the local oscillator is offset from the Nth harmonic of the reference signal. There are real advantages to $F_{OS} \neq 0$. One of the most important advantages of this type of phase-lock loop is that it allows us to stabilize the loop gain by using a constant phase-limiter amplifier to limit the offset signal level before it is applied to the phase detects. Initially an F_{OS} = 1.1 GHz is chossen. This gave a convenient receiver IF frequency of 550 MHz. However this offset frequency had a problem when the reference signal was approximately 2.2 GHz. For this reference frequency, there are essentially two 1.1 GHz signals: one from the Nth harmonic and one from the (N+1)th harmonic. The extra IF signal results in undesirable modulation which could not be removed by filtering. This scheme was abandoned because of this undesirable feature. Thus one rule in building phase-lock loops can be stated: the offset frequency cannot approach $1/2F_{REF}$. Next, the offset frequency was chosen to be 100 MHz. In this case, the receiver IF turned out to be 450 MHz. This loop had the very undesirable feature of randomly locking at a frequency 50 MHz away from the desired frequency about half the time. The key to the solution of this problem came from the following simple analysis: Equation (3) can be rewritten as:

$$F_{LO} - N\left(F_{REF}\right) = F_{OS}. \tag{5}$$

When the LO is tuned to a slightly different frequency, F_{LO}', the harmonic mixer also generates a product given by:

$$MF_{LO}' - LF_{REF} = F_{OS}$$

where F_{LO}' is a different receiver LO frequency.

For fixed F_{REF} and arbitrary L, M, and N, we can solve for the general relationship between F_{LO} and F_{LO}'. The relationship is:

$$F_{LO} = M\left(N/L\right) F_{LO}' \pm (L - N)/L)\ F_{OS}. \tag{6}$$

For the harmonic mixer that we have chosen, the equation with M = 2, L = 2N turned out to be the harmonic product that caused our loop to false lock. For this case, Equation (6) becomes:

$$F_{LO} = F_{LO}' \pm .5 \left(F_{OS}\right). \tag{7}$$

Simply stated, Equation (6) shows that a false lock frequency also tracks the desired lock frequency, irrespective of the loop offset frequency. For F_{OS} = 100 MHz, the equation predicts that the false lock points will be above (N^+ Band) and below (N^- Band) the desired lock frequency by 50 MHz. As mentioned above, this was the observed loop behavior. A search oscillator was used to acquire lock in our phase-lock loop design, and depending on exactly how lock was acquired, the loop could lock at the correct frequency or the false lock frequency. Basically it depended upon whether the false lock or the correct lock frequency was encountered first as the search oscillator swept the local oscillator over its range. To test this hypothesis, the amplitude of the search oscillator was reduced so that the local oscillator was deviated less than ± 50 MHz from its commanded frequency. When this is done, the false lock problem disappears.

This analysis pointed to a significant criteria to be used in selecting the values of F_{OS}. Thus, F_{OS} must be greater than the maximum expected tuning error of the yig-oscillator so that there will be no possibility of acquiring a false lock.

There are several sources of yig tuning error. They are tuning nonlinearity, temperature drift, hysteresis, and dc electronic drift. Typically these errors might give a worse case tuning error of approximately 30-50 MHz. Thus, there is some advantage to picking F_{OS} large.

At this point, it should be pointed out that amplitude could have been used to discriminate against the M x L harmonic product. However, over the extremely wide receiver bandwidths used in this system, and over an 80° C temperature range, the required amplitude discrimination was difficult to achieve reliably. Thus, a large loop offset frequency was chosen as the means to achieve this discrimination. Again, the idea in using this technique is to place the "spurs" far enough away from the desired lock points that they are of no consequence.

Our final choice for F_{OS} was 400 MHz for the 2-8 GHz and 8-18 GHz receivers, and 200 MHz for the 18-26 GHz and 26-40 GHz receivers. These selected values for F_{OS} allowed the search oscillator to deviate the receiver local oscillator by a maximum of ± 150 MHz for the two lower frequency receivers and ± 70 MHz for the two higher frequency receivers. In both cases, the receiver IF frequency was 150 MHz.

Considerable effort was also expended in identifying a suitable harmonic mixer for the phase-lock loop subsystem. Six different mixers were examined, and all had problems with harmonic conversion flatness. Ideally, a mixer which was designed specifically to function as a harmonic mixer would have been most suitable. However, few of this type were available with the required rf and LO bandwidths.

The most efficient harmonic mixer was assembled from discrete components in the ITS laboratories. The block diagram of Figure 2 shows this device. The mixer diode's performance was limited to about 12 GHz and therefore was inadequate. Figure 3 shows the second harmonic conversion loss of this mixer. A double balanced mixer (RHG DM 1-18) was finally chosen to be used in all four receivers. The principle disadvantage of this mixer was its low, even-order harmonic conversion due to its double balanced structure. Figure 4 shows the DM 1-18 second harmonic conversion. This problem was dealt with by choosing odd order mixing modes when possible.

Several interesting effects were discovered which substantially influenced the design of the analog portion of the phase-lock loop. Initially, the FM coil was driven by two power transistors, biased so that one transistor drove current in one direction through the coil while the other drove current in the opposite direction. With this design, as the phase-error signal approached zero, the phase noise on the local oscillator increased substantially. We attributed this effect to the imperfect matching of the two transistors used to drive the FM coil. The loop gain decreased as the error voltage (dc components) went to zero, and the phase noise went up as a consequence. The effect was eliminated by restricting the phase error to be monopolar.

A second effect was related to the dynamic performance of the operational amplifier used to realize the active low-pass filter of the loop. It was discovered that the slewing rate (V/μsec) quoted for linear operations was not always representative of the slewing rate coming out of saturation. When the loop is unlocked, the operational amplifier (op-amp) is driven to one of its output limits. The slewing rate can depend upon which limit (+ or -) the op-amp was driven to during the searching process. If the slew rate coming out of saturation is different from its normal slew rate, then the time required to drive the loop to the locked condition can be excessive. If the slew rate is too slow, the search oscillator may actually drive the VCO past the desired lock point before lock can be acquired. This problem was resolved by selecting an op-amp whose slew rate was not effected by being driven into saturation. A final requirement was that the bandwidth of the op-amp must be considerably in excess of the loop bandwidth so that the external circuit elements determine the loop bandwidth.

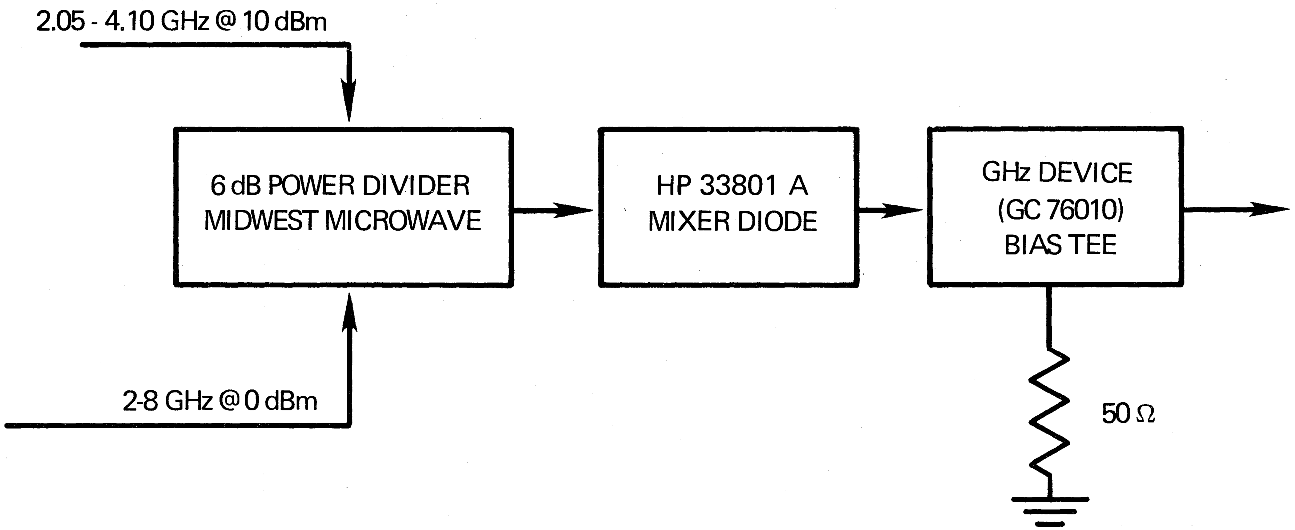


Figure 2. Block diagram of the harmonic mixer for the phase-lock loop subsystem.

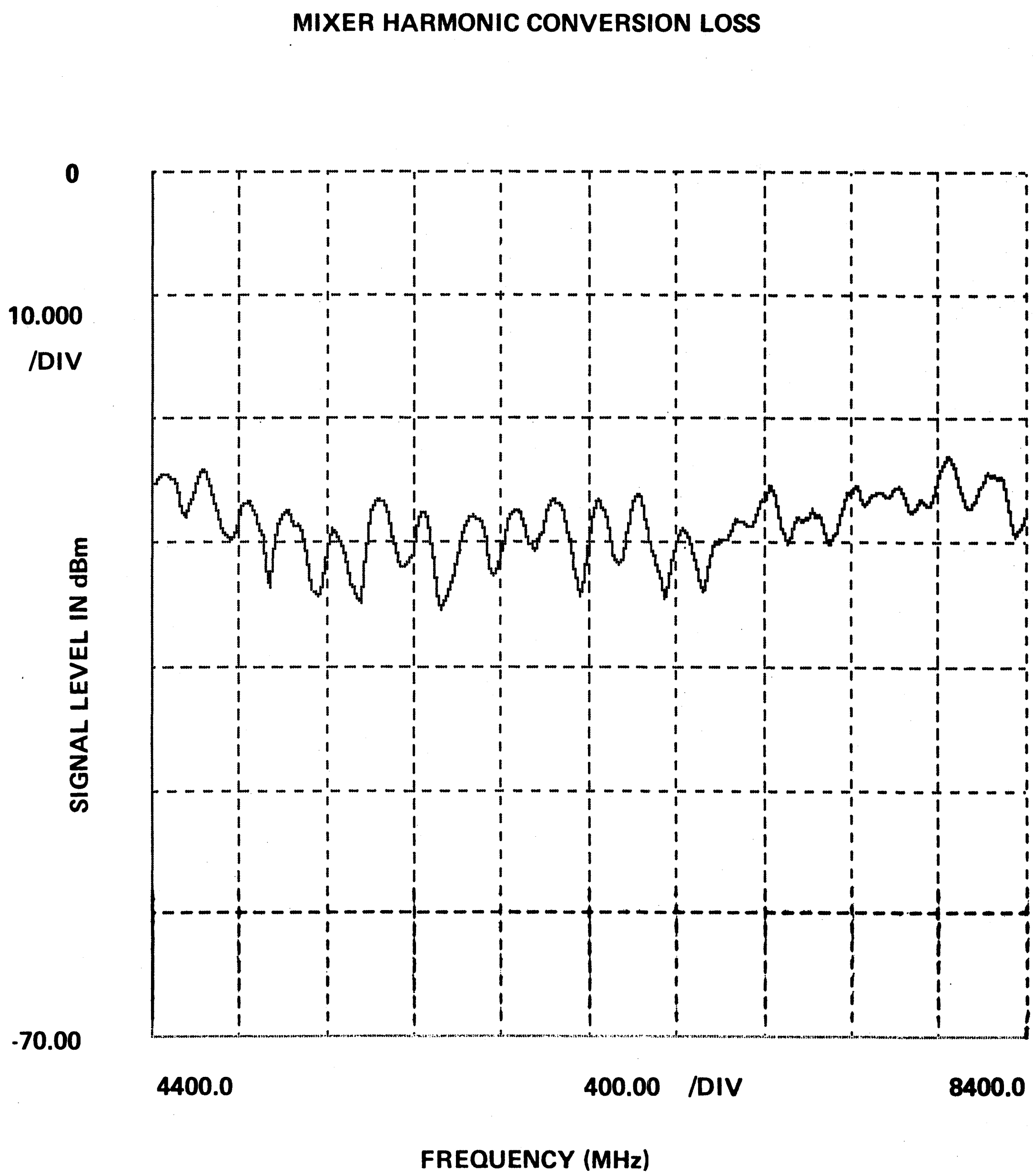


Figure 3. Second harmonic conversion loss of harmonic mixer used in discrete component R&D prototype. LO Input: 2-4 GHz @ 0 dBm, RF Input: 2-8 GHz @ 10 dBm, Tuning equation: $F_{rf} = F_{lo} + .400$.

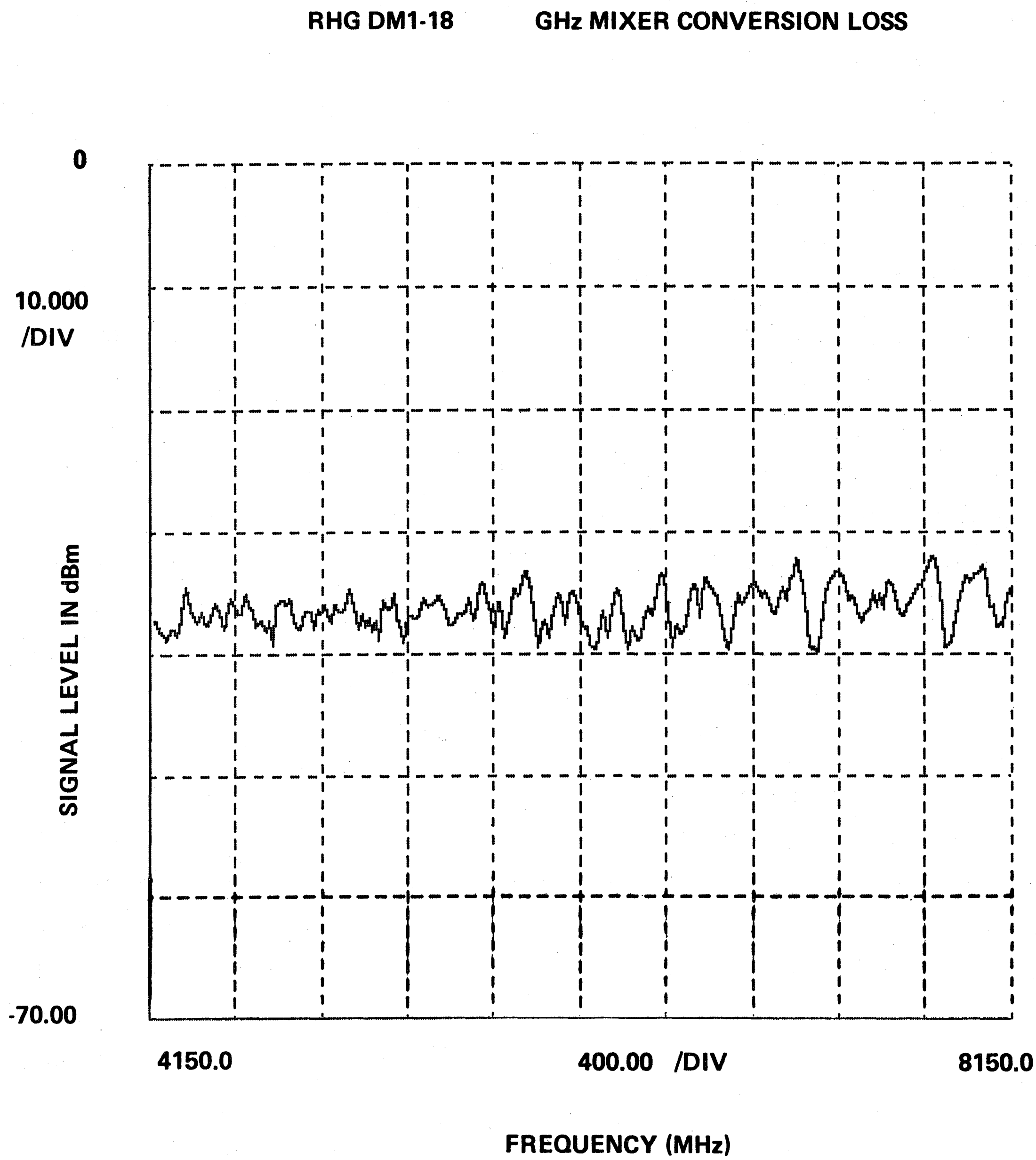


Figure 4. Second harmonic conversion loss of harmonic mixer used in final equipment configuration. LO Input: 2-4 GHz @ 0 dBm, RF Input: 2-8 GHz @ 10 dBm, Tuning equation: $F_{rf} = F_{lo} + .15$.

Acquisition of lock is a very important aspect of any phase-lock loop system. From a systems point of view, it is this factor that primarily influences the tune/amplitude measurement cycle time. Generally, an auxiliary technique such as a search oscillator is used to speed up the acquisition of lock. Our approach to this problem was somewhat unique and is outlined below.

An up/down counter and D/A converter are used to generate a digital sawtooth voltage which is applied to the main tuning coil of the oscillator when the loop is unlocked. This approach has the advantage of being linear, and of having an easily adjusted period and amplitude. In addition, the counter has an "infinite" memory so that, when the up/down counter is disabled, the final count is latched at the input to the D/A converter.

The digital search oscillator and the quadrature channel of the phase detector, along with two analog voltage comparators, are combined to form a closed loop acquisition circuit as shown in the block diagram (Figure 5). The technique has definite advantages in lock acquisition time compared to open-loop acquisition techniques. (See, for example, "Phase-Locked Loop Sweep Acquisition," by P. Wakeman, CRC Report No. 1305, 1977.)

The dynamic operation of the loop can be explained in the following way. Suppose the receiver has been commanded to a new frequency. Lock is broken as the yig-tuned oscillator (YTO) tunes to the new frequency. The quadrature output of the phase detector goes low and enables the search generator. The search oscillator drives the YTO oscillator toward the lock point. As lock is approached, the filtered output of the quad phase detector exceeds a preset threshold and disables the search oscillator. The FM coil then tracks out the residual frequency error. Should the phase error exceed either the upper or lower phase-error limit, the up/down counter is enabled, and the dc component of the error is fed back to the main tuning coil. When the phase error has been driven back into the preset phase error window, the up/down counter is again disabled. Thus, the range over which the FM coil can tune the oscillator is limited by the window chosen for the phase error limits. Typically, this phase-error window is limited to 2 MHz.

There are also restrictions on the operation of the search oscillator. This circuit is used to sweep the local oscillator through the desired lock frequency. The choice of the sweep rate in MHz/μsec is not arbitrary, as will be shown by the following considerations: If the loop bandwidth is 100 kHz, this implies a settling time of 10^{-5} sec. This means that the frequency of the yig oscillator cannot

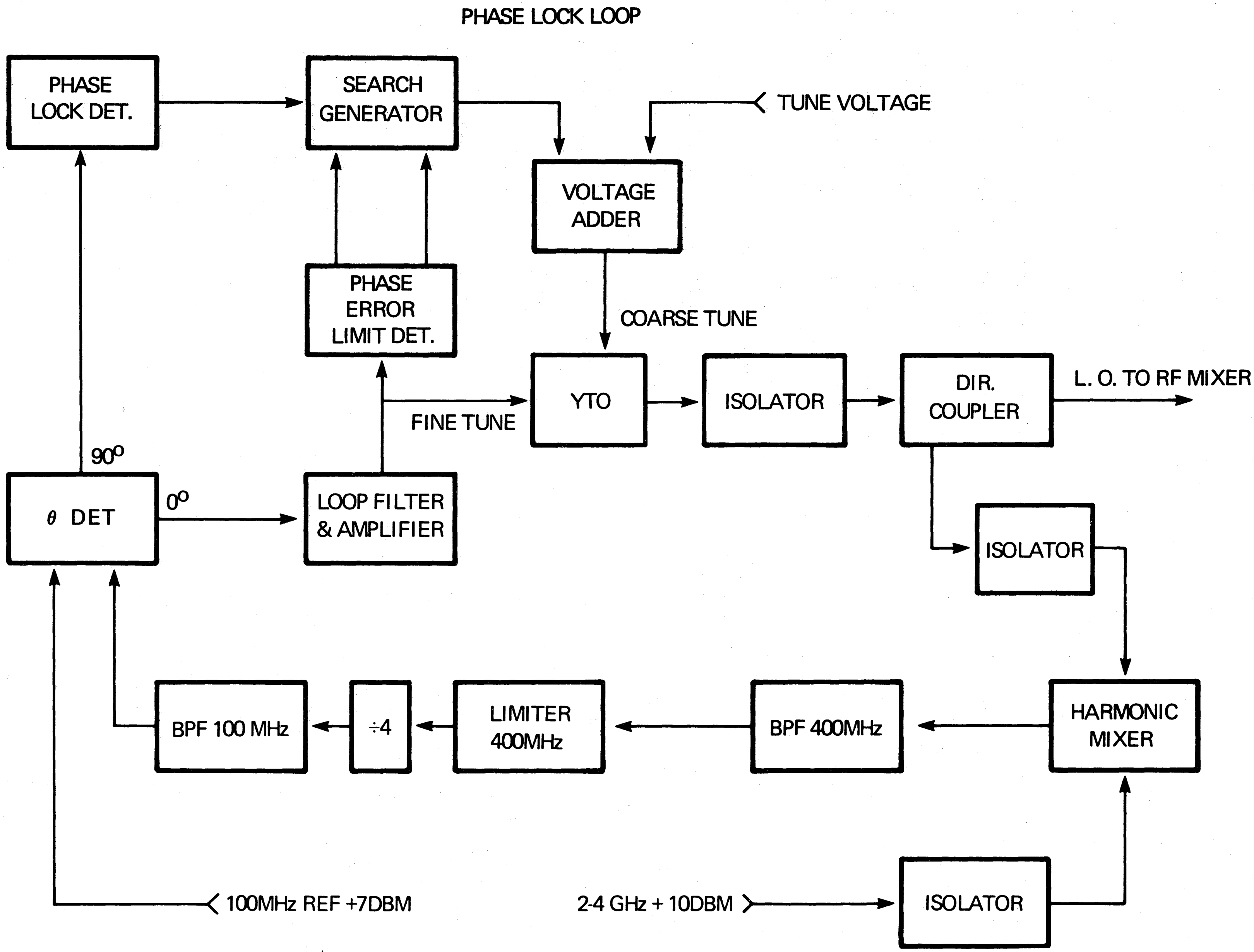


Figure 5. The phase-locked loop acquisition circuit comprising the digital search oscillator, quadrature channel of the phase detector, and the analogue voltage comparators.

change by more than the loop bandwidth in this period of time. The sweep time for a 100 MHz sweep can be estimated by computing the number of loop bandwidths for the required sweep range and multiplying the number of loop bandwidths by the loop settling time. Numerically,

$$\frac{10^8 \text{ Hz}}{10^5 \text{ Hz}} \quad 10^{-5} \text{ sec} = 10^{-2} \text{ sec.}$$

Thus, to sweep 100 MHz will require 10 milliseconds if the loop bandwidth is 100 kHz. Experimentally, it was determined that reliable lock could be acquired in 7 milliseconds.

It should be noted that, for small frequency steps of 1 MHz or less, the loop does not normally lose lock. Again this was verified by tuning across the 8-18 GHz receiver band in 1 MHz frequency steps. It was found that the average tune/measure cycle required only 2.4 milliseconds.

2.3. Yig Filter/Oscillator Tracking

The yig-tuned filter and yig-tuned oscillator of each receiver must track a harmonic of the 2-4 GHz oscillator of the receiver system. For the receiver yig oscillator and filter to track, the 0-10 VDC signal used to tune the 2-4 GHz oscillator must be scaled; i.e., since there is only one tune voltage available, this voltage must be used for each frequency band used by the receiver system and the tuning parameters of both the receiver's yig filter and oscillator. The tuned frequencies of the 2-4 GHz reference, and the receiver local oscillator and filter can be written as:

$$F_{REF} = F_{REF_o} + m_{REF} V_{REF} \tag{8}$$

$$F_{LO} = F_{LO_o} + m_{LO} V_{LO} \tag{9}$$

$$F_F = F_{F_o} + m_F V_V \tag{10}$$

where F_{REF_o}, F_{LO_o}, F_{F_o} are the tuned frequencies when the tune voltages V_{REF}, V_{LO}, and V_F are 0 VDC. The tuning rates m_{REF}, m_{LO}, and m_F are given in gigahertz per volt.

We know that the receiver local oscillator's frequency is given by:

$$F_{LO} = N F_{REF} \pm F_{OF}. \tag{11}$$

By combining the above equations, the scale tune voltage for the receiver local oscillator is shown to be:

$$V_{LO} = [N \; F_{REF_o} \left(F_{LO_o}\right) \pm F_{OS}]/m_{LO} + [N \left(m_{REF}/m_{LO}\right)] \; V_{REF}. \tag{12}$$

Likewise, for the receiver's yig-tuned filter

$$F_{RF} = F_{LO} \pm F_{IF} \tag{13}$$

giving the scaled filter tune voltage as

$$V_F = [F^o_{LO} \pm F_{IF} + F^o_F]/m_F + [m_{LO}/m_{rf}] \; V_{LO}. \tag{14}$$

Thus, only one scaling network is required to tune both the local oscillator and the receiver quantities. The m_{LO}, F_{LO_o} or m_F, F_{F_o} are determined by measuring the tuning characteristic of the yig device, and least squares fitting this data to a straight line using the software program FIT (see Appendix). These constants are used by the program TRAK to determine the parameters in Equations (12) and (14). The tables following program TRAK in the Appendix are examples of the output.

A unique approach was used to realize this scaling network. For each harmonic band, there is a system-generated 5-bit binary word. This word is used to select a preprogrammed 10-bit switch for both the gain and the offset. These 10-bit switches are used to program an offset digital to analog converter (DAC) and a multiplying DAC. The analog tune voltage is applied to the reference input of the multiplying DAC, and the output summed with the offset to generate the scaled tuned voltage. The advantages to this approach are:

1. It avoids the use of large numbers of precision resistors and trim pots.
2. The offsets and gains can be quickly reprogrammed as required.
3. Improved dc stability is achieved.

Our initial design philosophy, as formulated in Equation (14), relied explicitly on the stability of the tuning characteristics of the yig filter and oscillator over the -30°C to 50°C temperature range. Besides the deviation from linearity of these devices, there are two other sources of tracking error: hysteresis of the filter and FM coil tuning of the local oscillator. Hysteresis of the filter results when it is tuned to a specific frequency from a lower or higher frequency. Depending on the direction it is tuned, a significant frequency error can be incurred. The Coil tuning error results when the FM coil is used to tune the oscillator to achieve lock. To minimize the effect of filter hysteresis, the ramp generator voltage (used to acquire lock) is applied to both the filter and the oscillator. This ramp sweeps the LO (and filter) from 100 MHz below the command frequency to 100 MHz above the command frequency. When lock is detected, the up-down counter used to generate the ramp is disabled. Since lock can only be achieved by going from a lower frequency to a higher frequency, filter hysteresis is minimized. The FM coil tuning errors are minimized by limiting the phase-error voltage to a window between 0 and 2 Volts. When the error exceeds one of the limits, the up-down counter is enabled and the main tuning coil voltage adjusted until the phase-error voltage is within the window. The error voltage is fed back, and it is applied to both the filter and the oscillator, limiting this error to approximately 2 MHz.

To minimize frequency drift of the yig devices with temperature, our final design incorporated a proportionately controlled heater to maintain the temperature of the mounting bracket for the yig devices at approximately 54°C.

2.4. Receiver System Integration

The final receiver system design is shown in block diagram form in Figure 6. The 2-8 GHz, 8-18 GHz (and 1 kHz-2 GHz switch tree), and the 18-40 GHz receivers are housed in waterproof enclosures and mounted on the EL/AZ antenna positioner where they serve the dual purpose of receiver and antenna counterbalance (Figure 7). The 18-40 GHz assembly (3) is shown mounted on top of the EL/AZ pedestal, the 8-18 GHz assembly (1) is shown in the lower front, and the 2-8 GHz assembly (2) is located at the lower rear of the pedestal.

The tower systems interface mounts in one of the system equipment bays. The tower systems interface is a multifunctional unit which interfaces the receivers to the system, the EL/AZ positioner controller, and downconverts the receiver IF frequency. Figure 8 is a simplified block diagram of the tower systems interface.

Figures 9, 10, 11, and 12 are simplified block diagrams of the individual receivers. Figure 13 details the 1 kHz-2 GHz switch matrix, the 2-4 GHz and 100 MHz reference signal control, as well as the digital and analog control signals. Key features of the receiver design are:

(1) multi-throw input switch allowing selection of antenna input, noise source, and comb generator;

(2) programmable rf attenuator (0-70 dB) to prevent receiver saturation;

(3) tracking yig filter to minimize spurious response; and

(4) phase-locked local oscillator for precise frequency measurement.

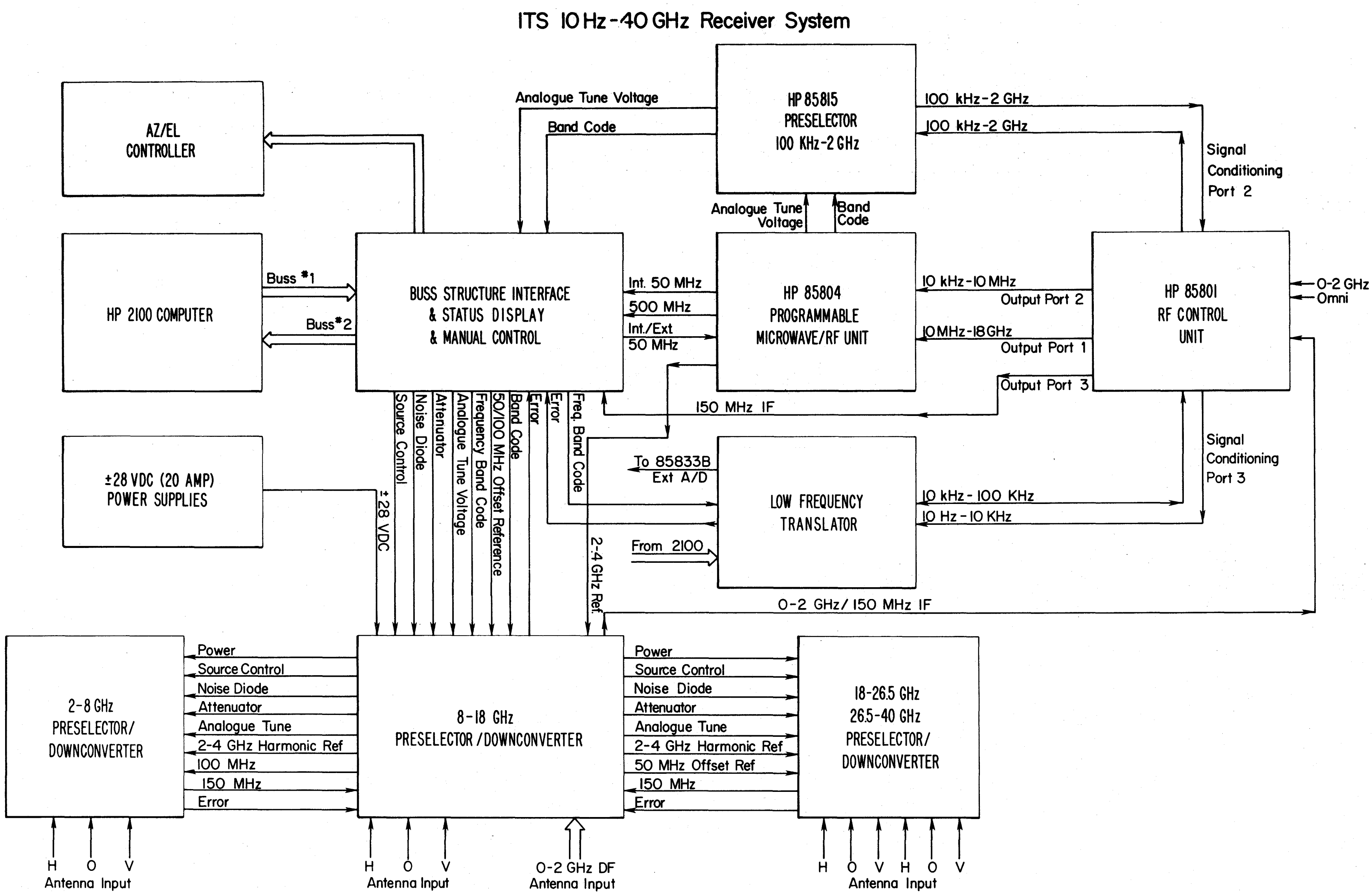


Figure 6. The final ITS system design for the 10 Hz - 40 GHz receiver.

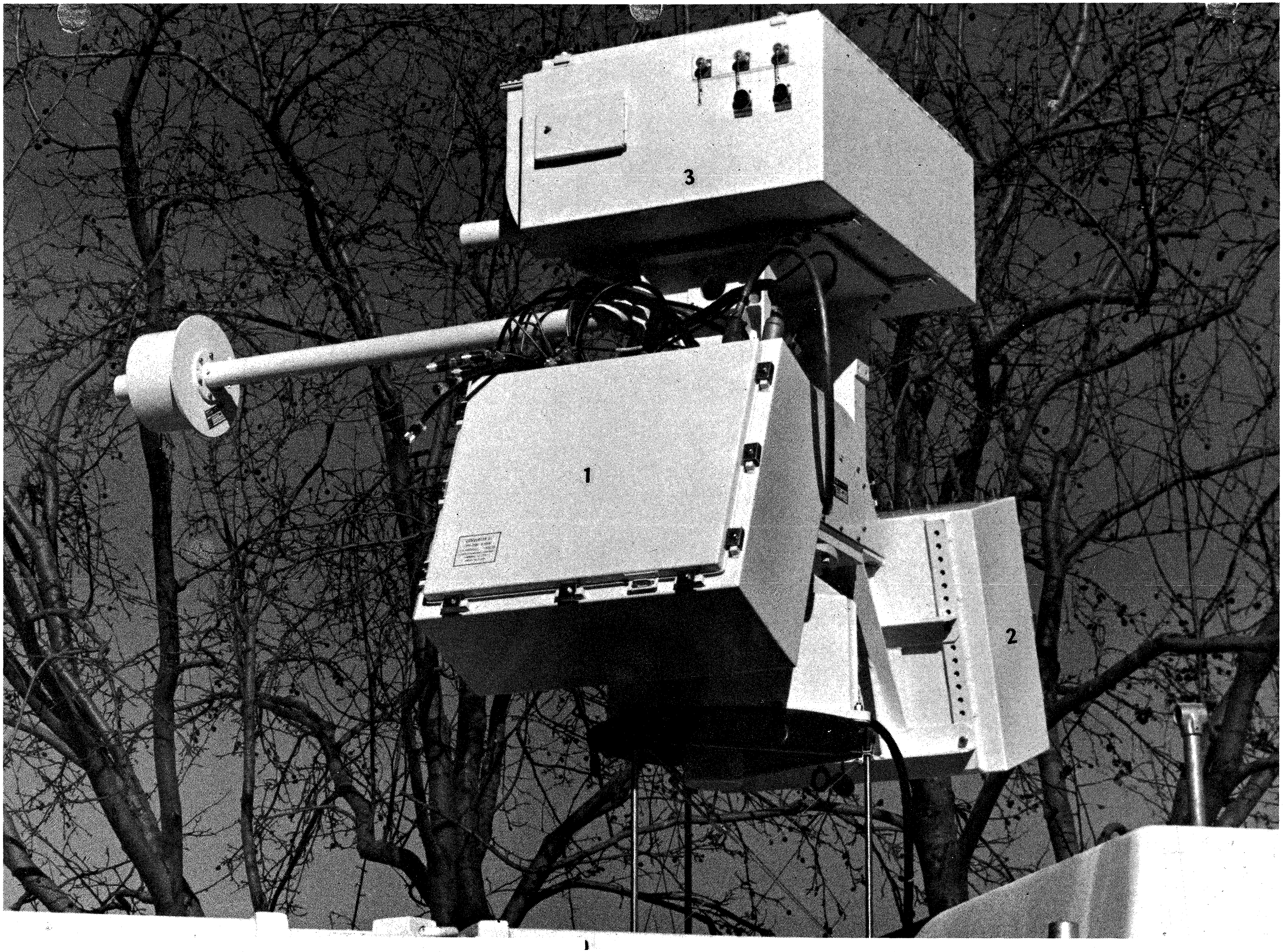


Figure 7. The EL/AZ positioner showing the 18-40 GHz assembly (3) mounted on top tne pedestal, the 8-18 GHz assembly (1) located in the lower front, and the 2-8 (assembly (2) located at the lower rear of the pedestal.

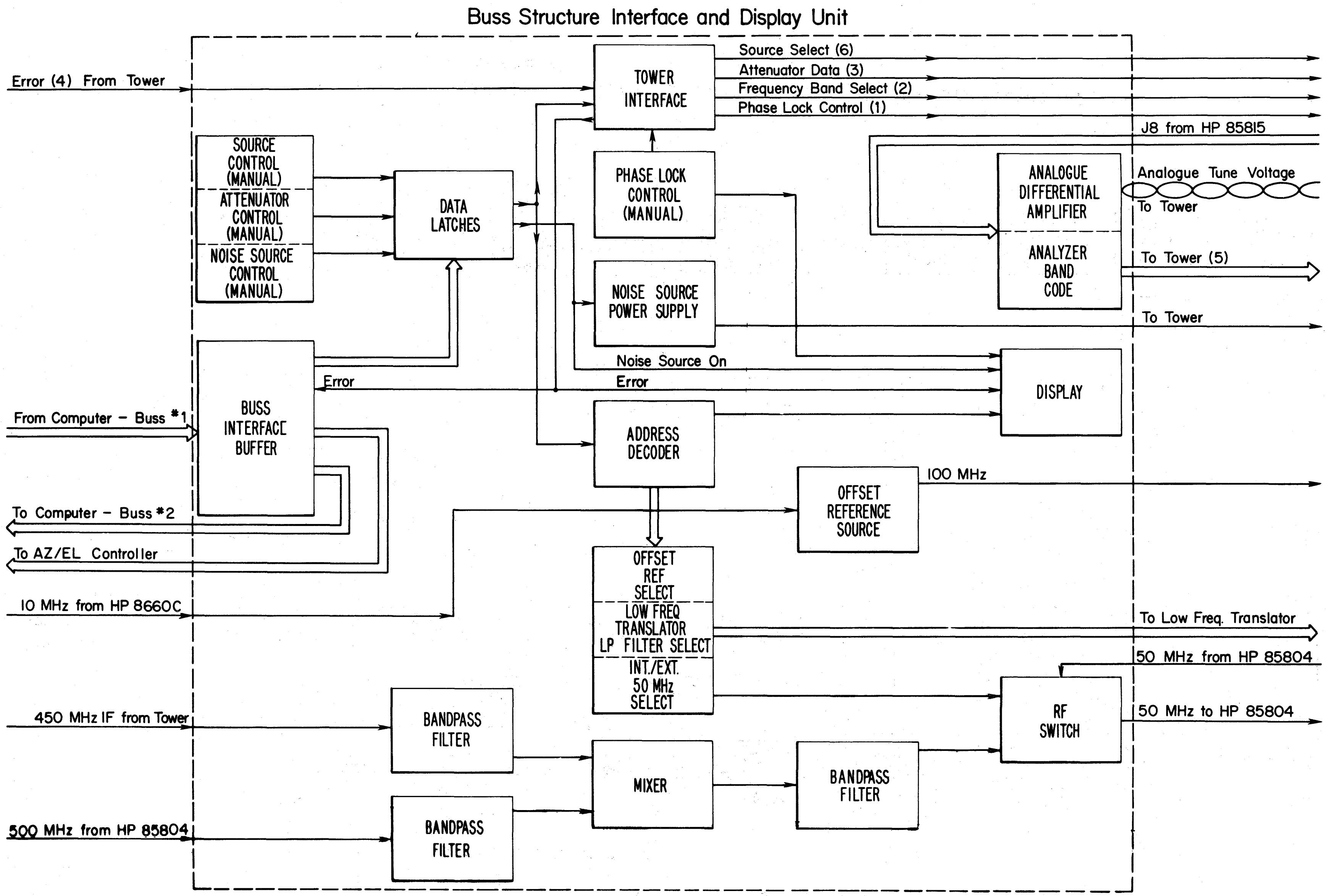


Figure 8. The tower system interface which interfaces the receivers to the ARS-400 system, the EL/AZ positioner controller, and down converts the receiver IF frequency.

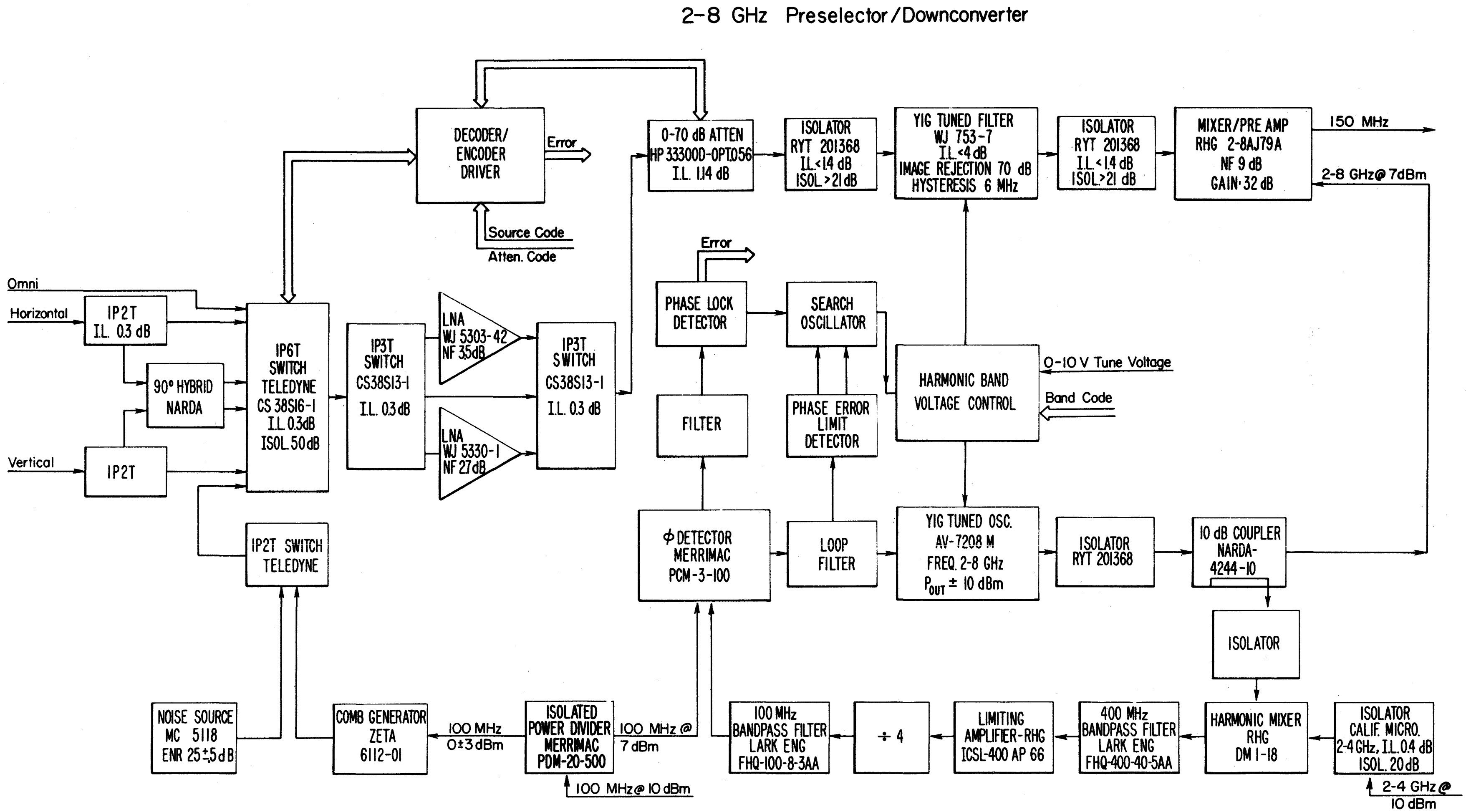


Figure 9. Simplified block diagram of the 2-8 GHz preselector/down converter.

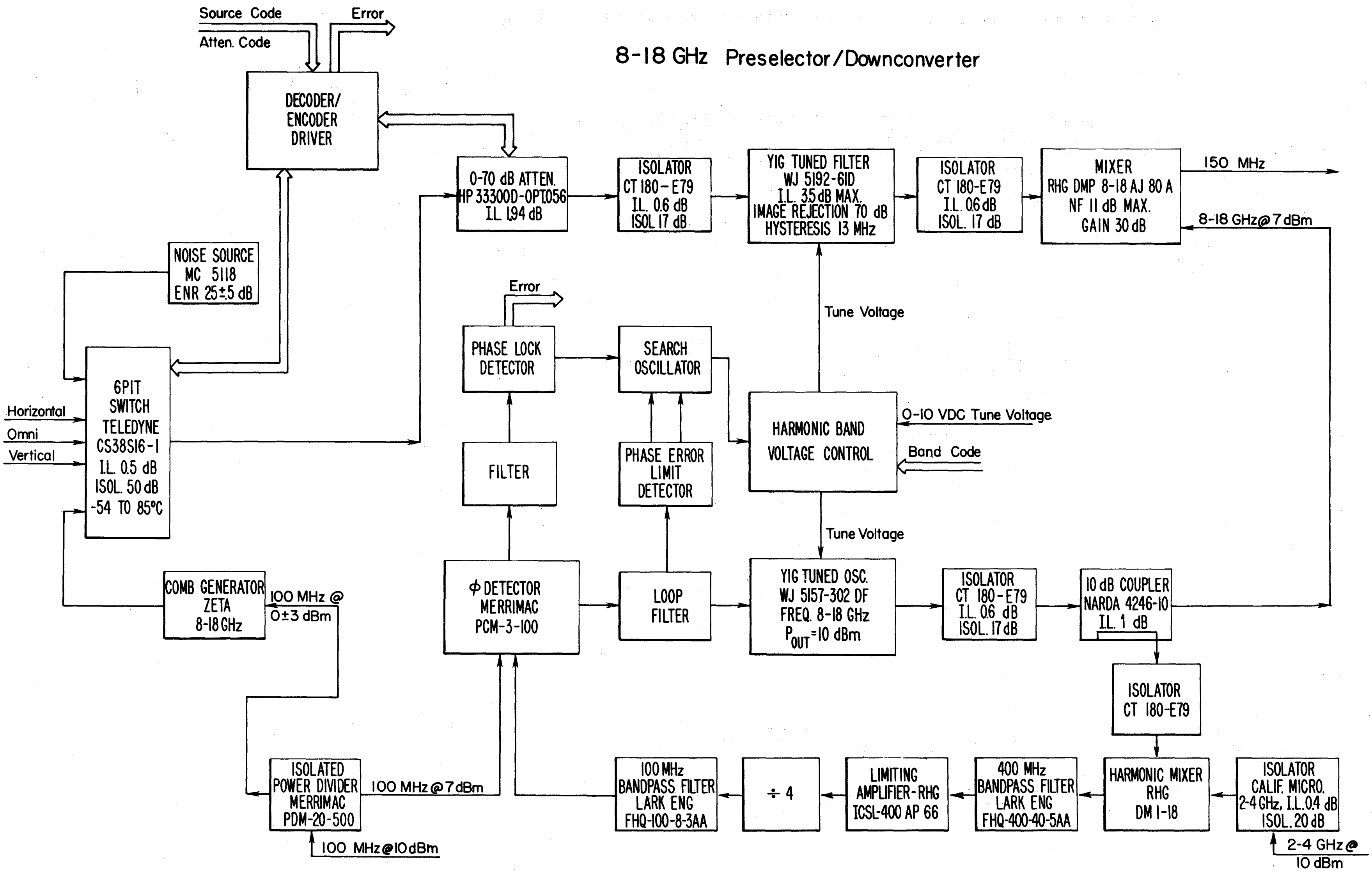


Figure 10. Simplified block diagram of the 8-18 GHz preselector/down converter.

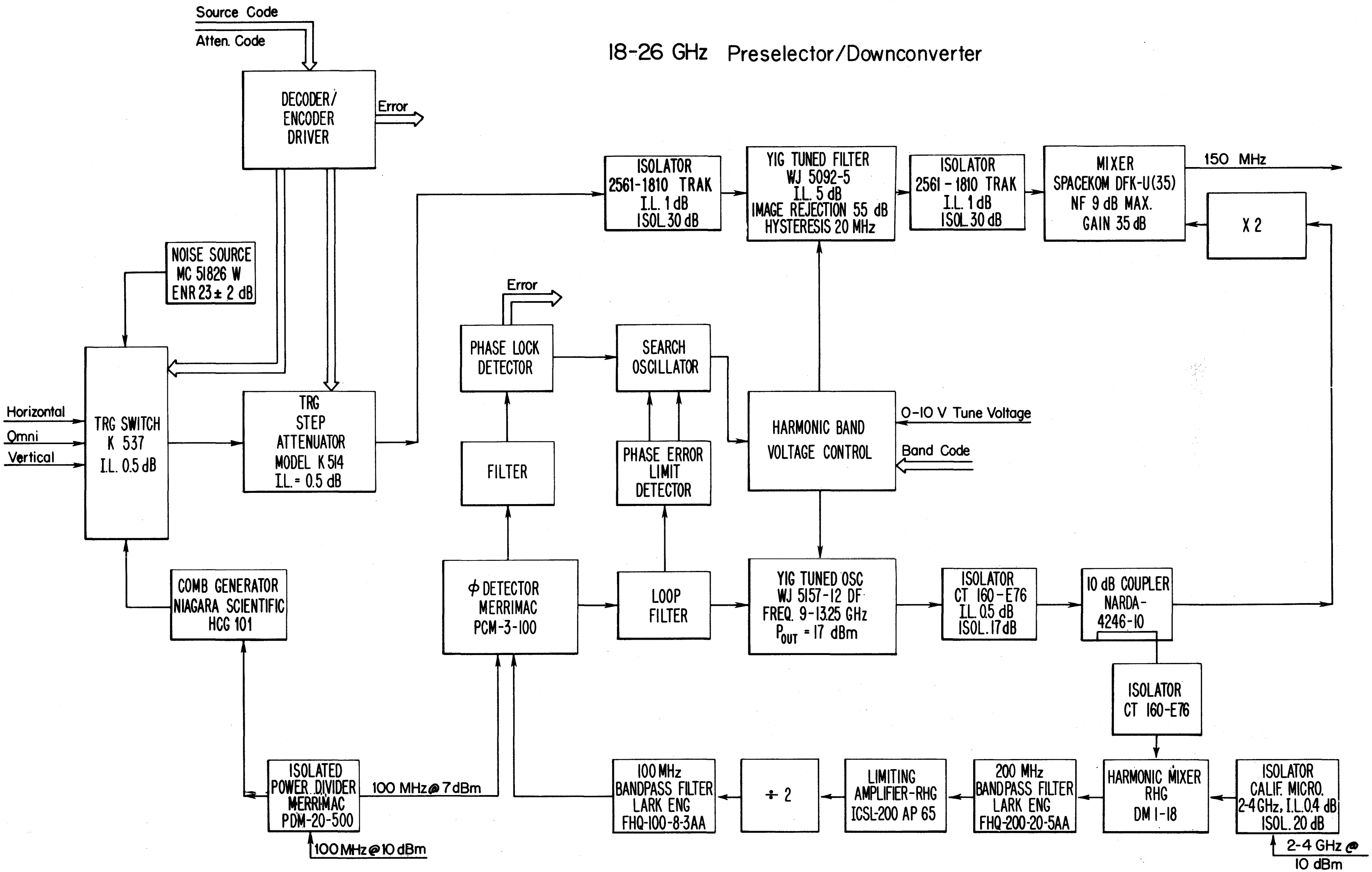


Figure 11. Simplified block diagram of the 18-26 GHz preselector/down converter.

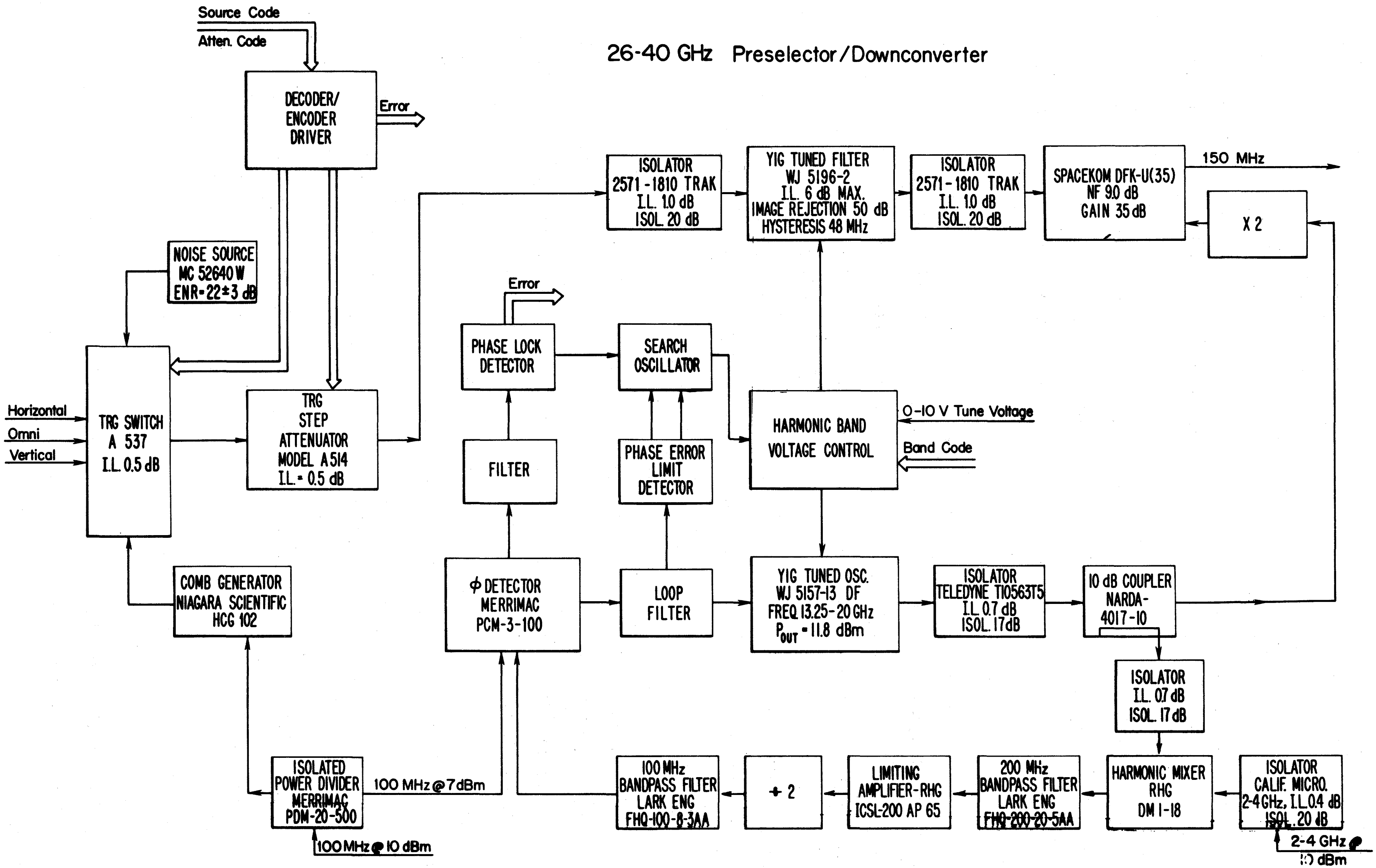


Figure 12. Simplified block diagram of the 26-40 GHz preselector/down converter.

These features are common to the 2-8, 8-18, and 18-40 GHz receivers. The 2-8 GHz receiver, in addition, has two low noise frequency channels (3.7-4.2 GHz and 7.25-7.75 GHz). Also, the 8-18 GHz receiver contains the 1 kHz-2 GHz switch tree rf which routes rf signals from the antenna system to the receiver for down conversion (Figure 13). The design for the 18-40 GHz receivers uses a combination yig-tuned local oscillator and frequency doubler to produce fundamental local oscillator power for the balanced waveguide mixers. The advantages of the approach were reduced cost of local oscillators, lower power consumption, reduced weight, and the added advantage of realizing the phase-lock loop using coaxial cable rather than waveguide technology. A concentrated effort was made to make all the receivers as similar as possible, and to use as many commutual microwave components as possible.

3. SYSTEMS PERFORMANCE

The comb generator spectra (Figures 14, 15, 16, and 17) demonstrate the frequency coverage of the receivers. The comb generator multiplies a 100 MHz input to 400 MHz. The 400 MHz signal is applied to the step recovery diode to generate the harmonic comb lines. As an example, Figure 15 clearly shows that both 400 MHz and 200 MHz comb lines are also present in the output. The comb generator spectrum provides a standard for quick assessment of the receiver performance and may also be used to generate rf attenuator correction factors.

Noise figure measurements provide an accurate measure of the real-time sensitivity of the receiver. Generally, a degradation in noise figure is indicative of degradation in the yig filter/oscillator tracking; however, it can also be indicative of a change in LO output power or the noise figure performance of the receiver's double balanced mixer.

The noise figure of the receiver is measured using the receiver's noise diode and the Y factor noise figure measurement technique. The equation for noise figure then, is

$$F = R/(Y-1). \qquad (15)$$

Here, R = the excess noise ratio of the receiver's noise diode (approximately 25 dB) and $Y = P_2/P_1$ = the ratio of the receiver's output noise power when the noise diode is ON (P_2) to the receiver output noise power when the noise diode is OFF (P_1).

Figures 18, 19, 20, and 21 show the noise figure performance of the 2-8 GHz, 8-18 GHz, 18-26 GHz, and 26-40 GHz receivers. Figures 22 and 23 demonstrate the low noise performance of the receiver in the 3.7-4.2 GHz and the 7.25-7.75 GHz satellite bands. Corrections for noise diode excess noise variations were included. The measurement program (noise) is included in Appendix A-3.

Tower Interface & RF Control
(Located in 8-18 GHz Preselector/Downconverter)

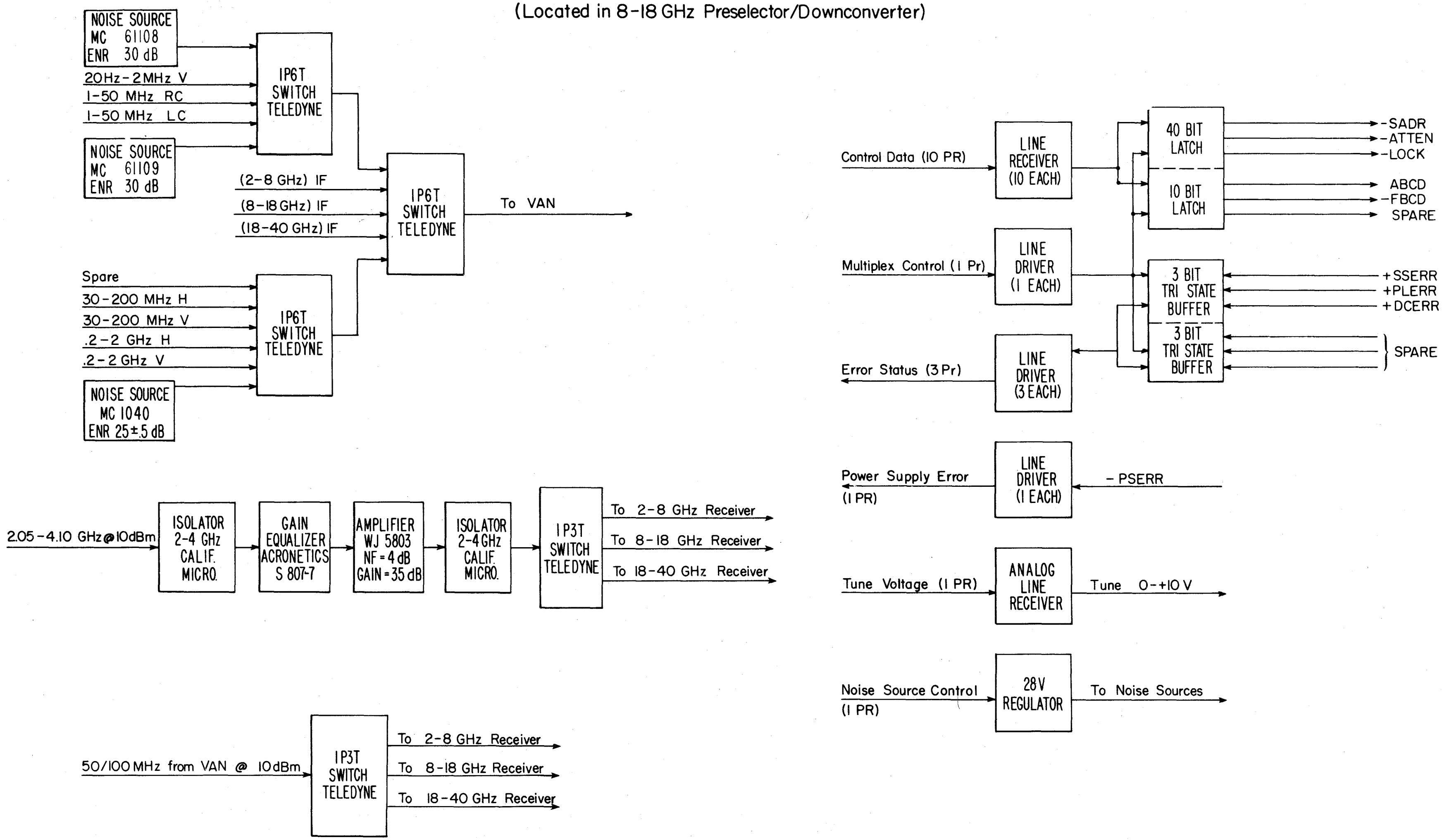


Figure 13. Digital analog and rf control detailing the 1 kHz - 2 GHz switch matrix, 2-4 GHz and 100 MHz reference signal control, as well as the digital and analog control signals.

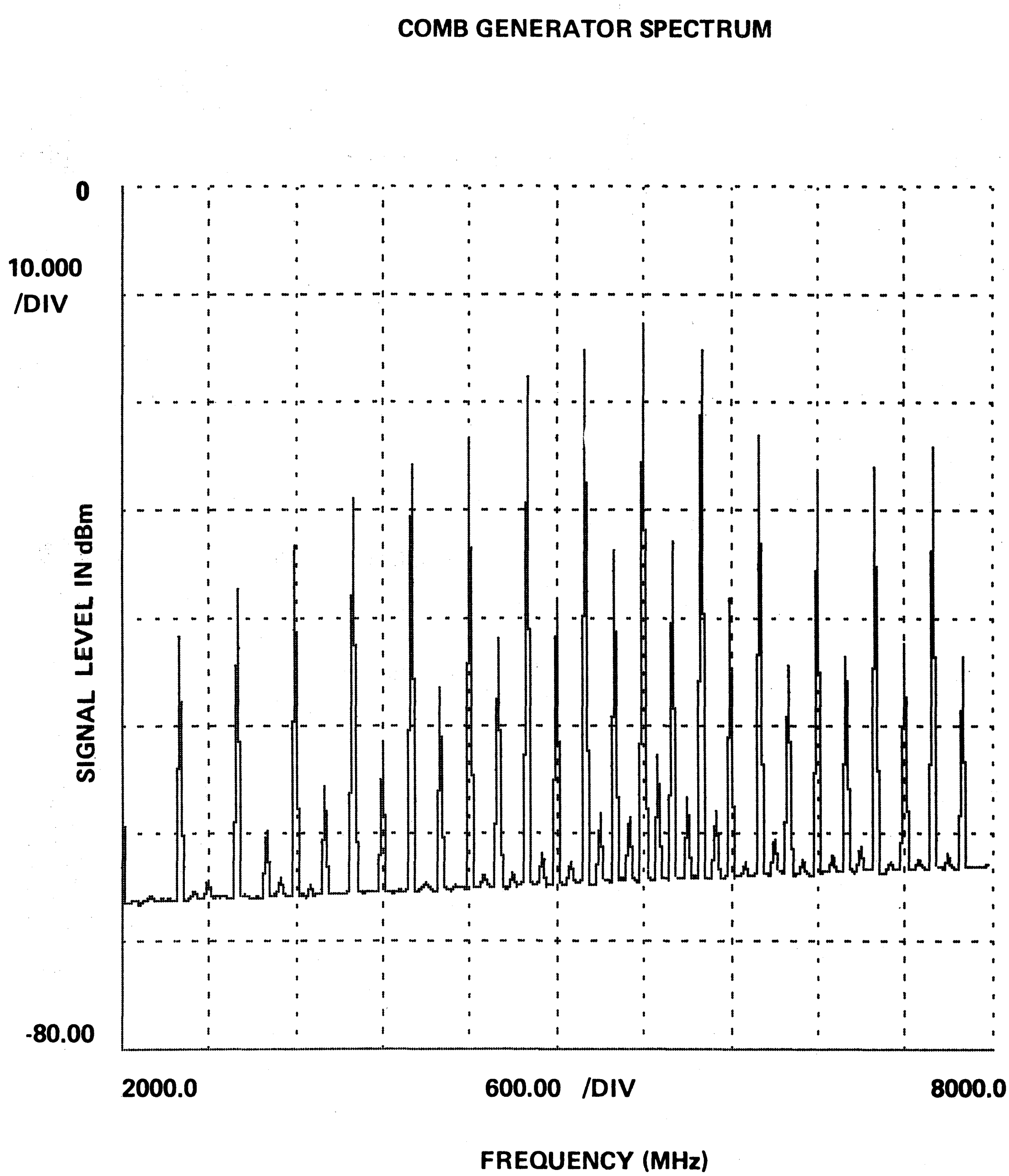


Figure 14. Comb generator spectrum showing the frequency coverage of the 2-8 GHz receiver.

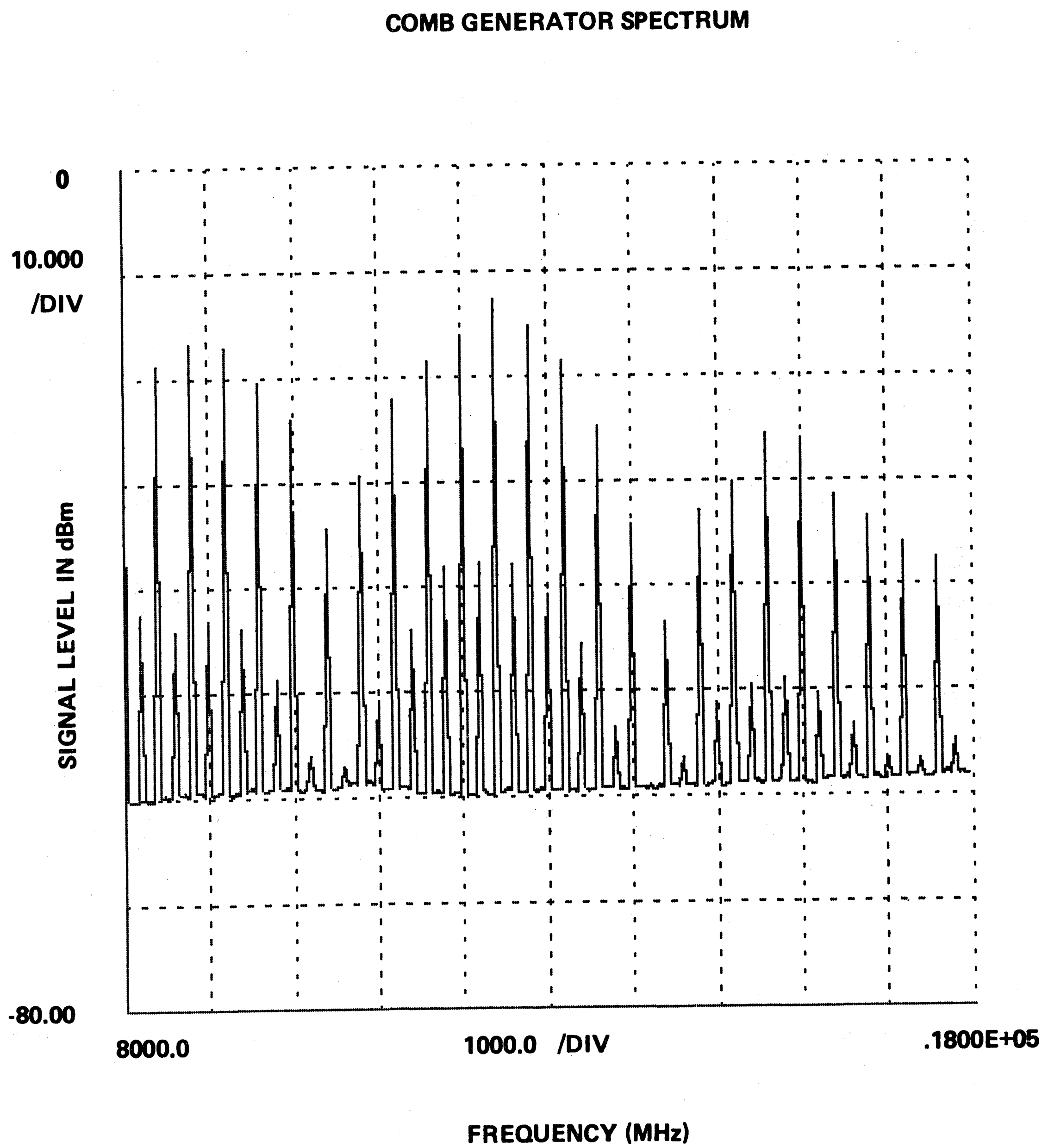


Figure 15. Comb generator spectrum showing the frequency coverage of the 8-18 GHz receiver.

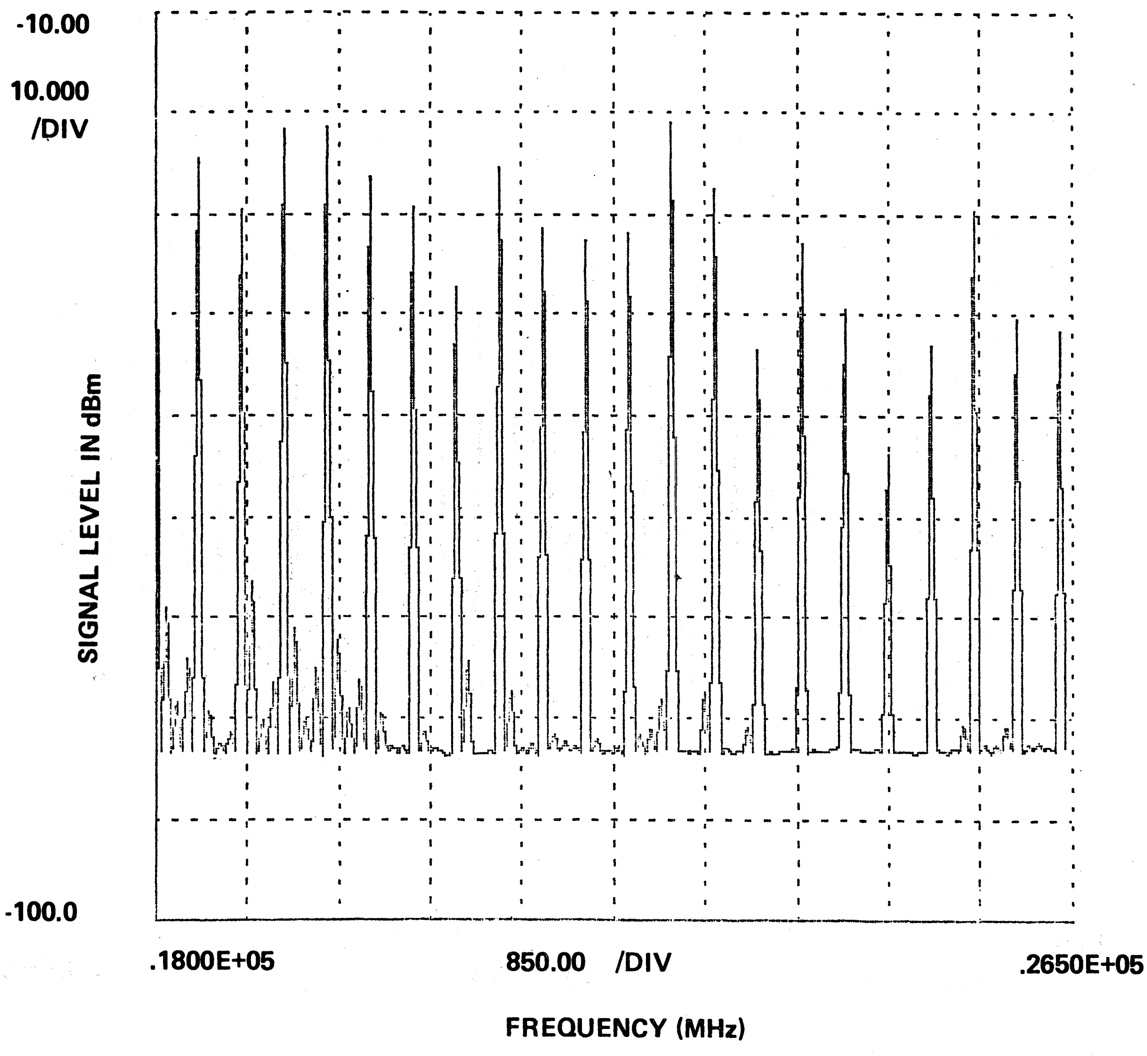


Figure 16. Comb generator spectrum showing the frequency coverage of the 18-26 GHz receiver.

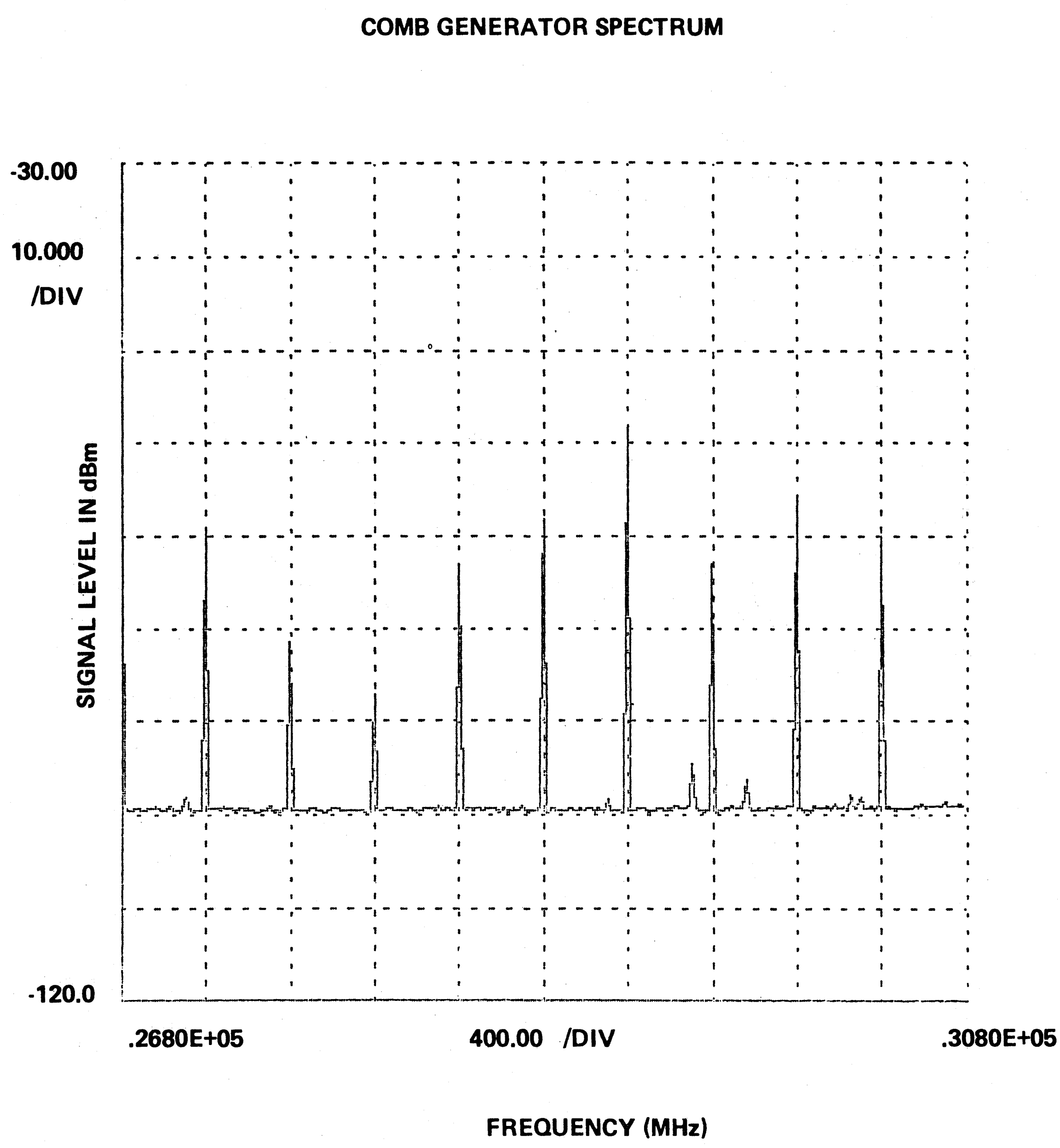


Figure 17. Comb generator spectrum showing the frequency coverage of the 26-40 GHz receiver.

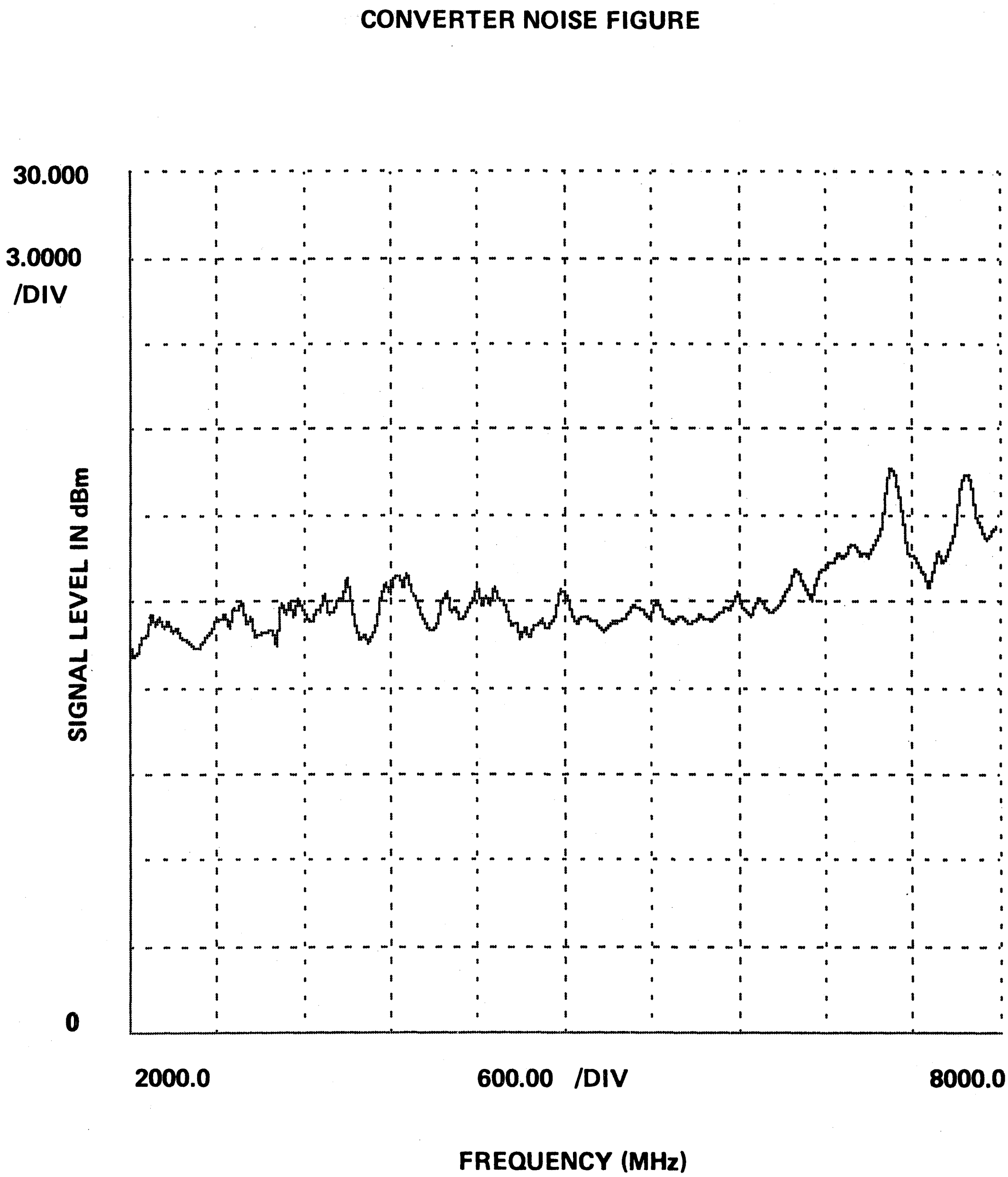


Figure 18. The converter noise figure performance of the 2-8 GHz receiver.

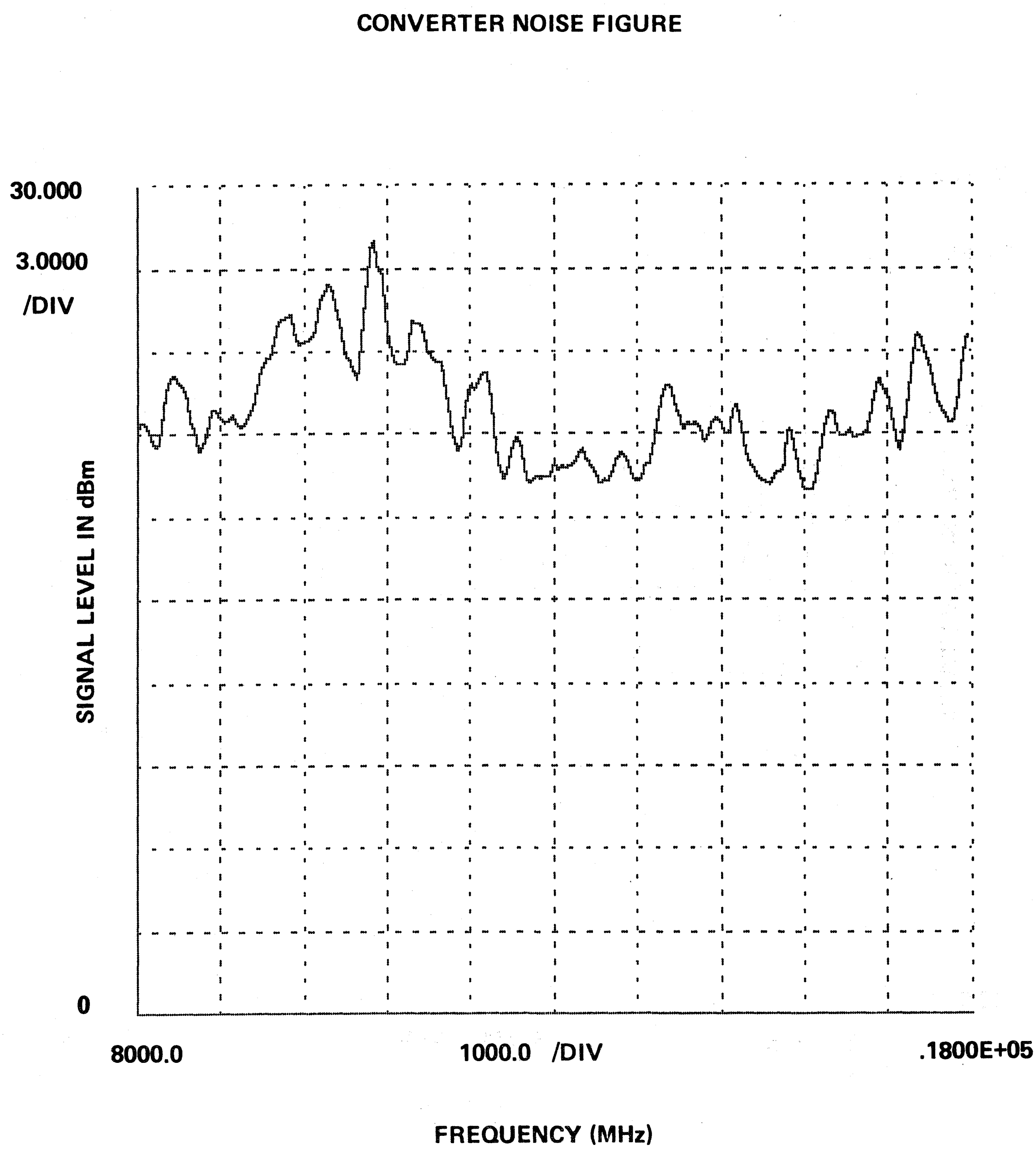


Figure 19. The converter noise figure performance of the 8-18 GHz receiver.

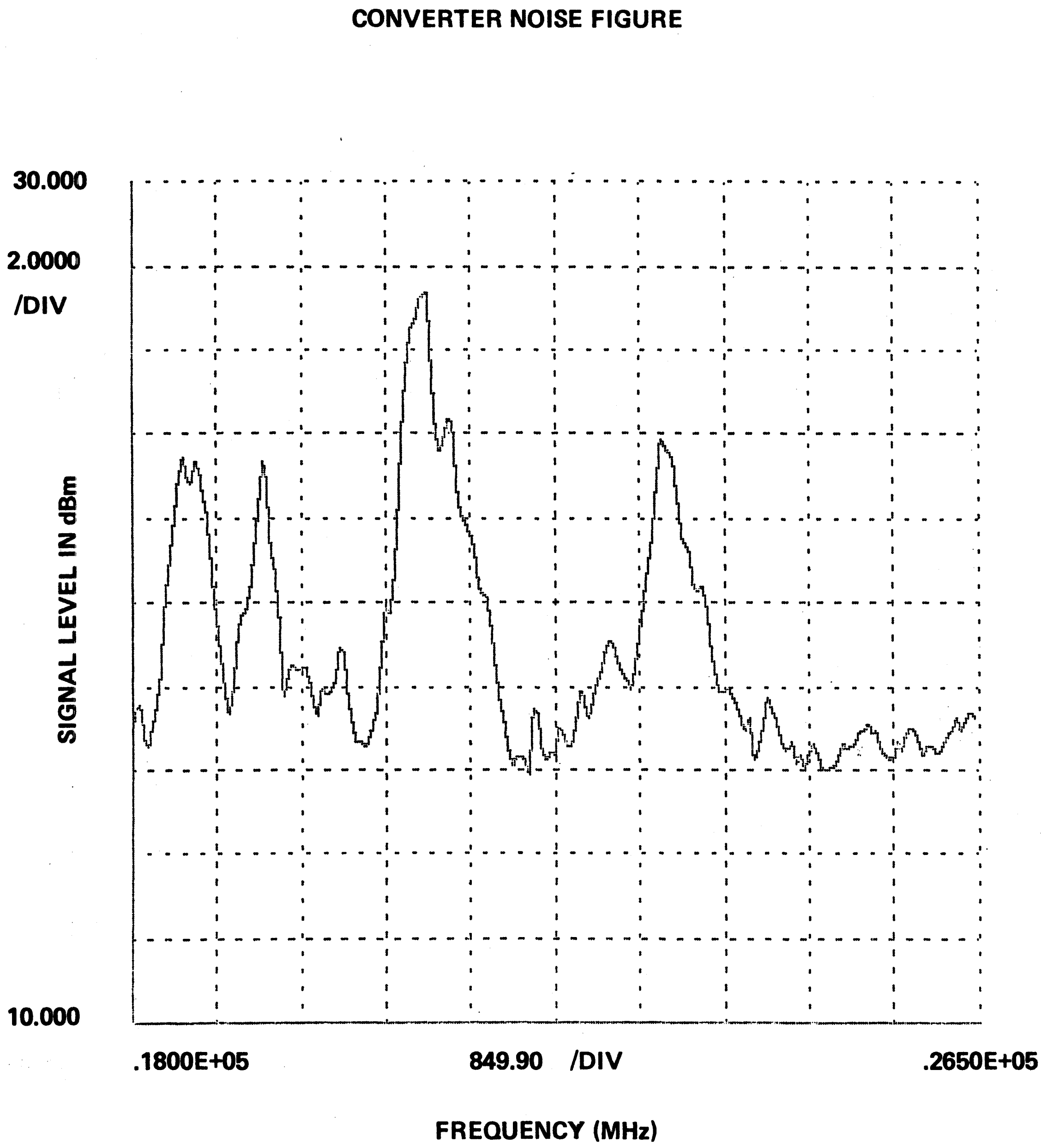


Figure 20. The converter noise figure performance of the 18-26 GHz receiver.

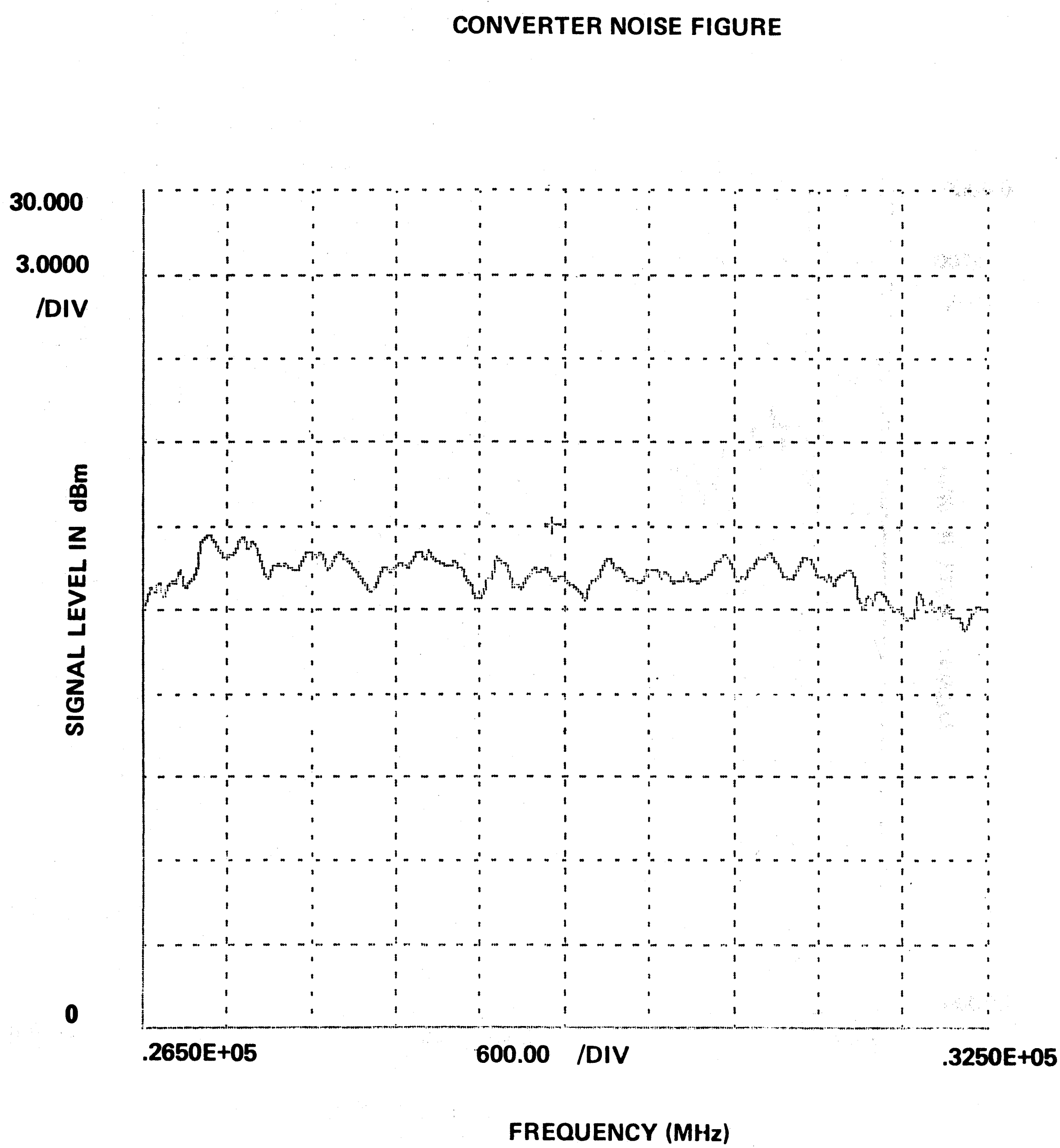


Figure 21. The converter noise figure performance of the 26-40 GHz receiver.

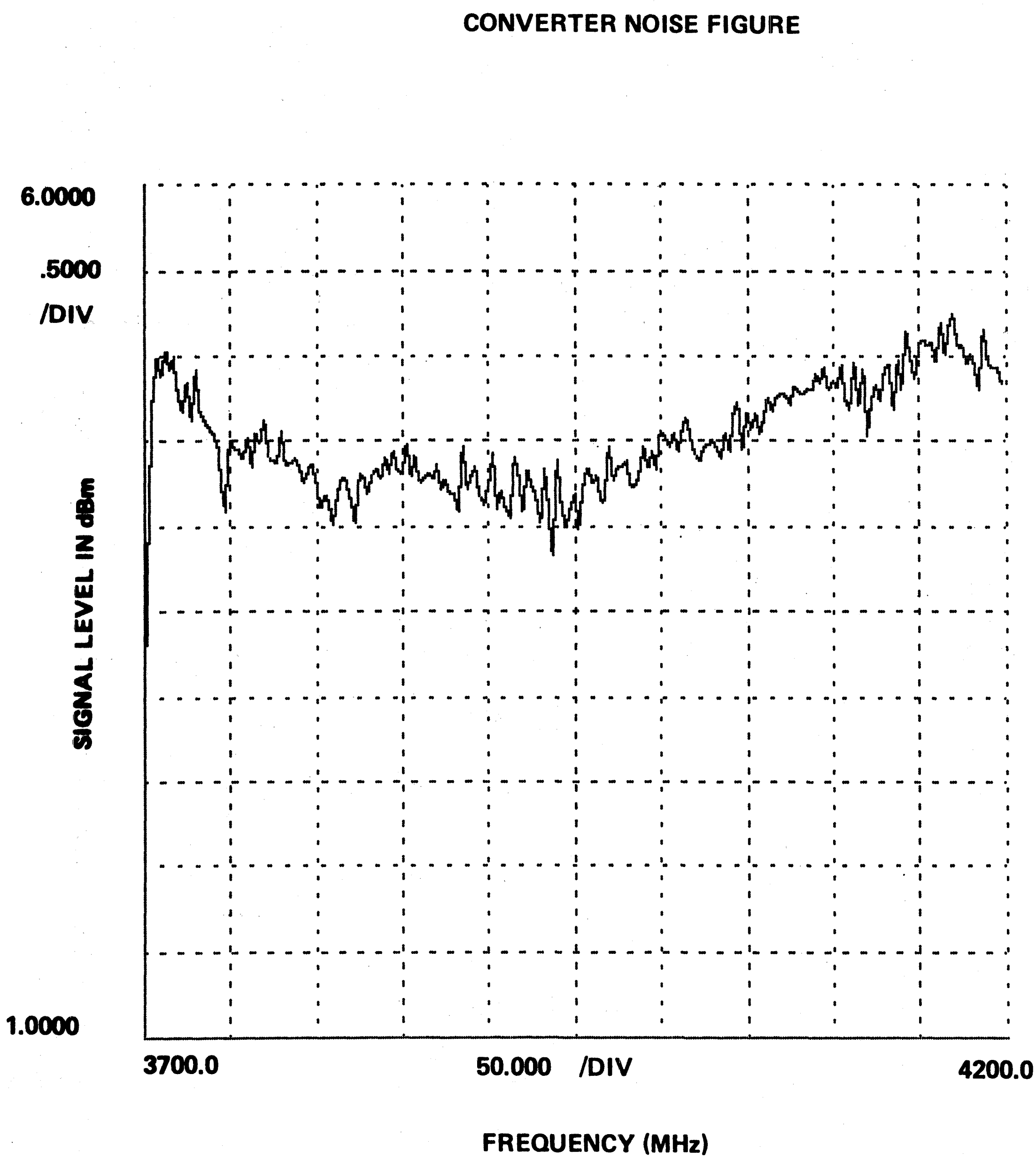


Figure 22. The low noise performance of the receiver in the 3.7-4.2 GHz satellite band.

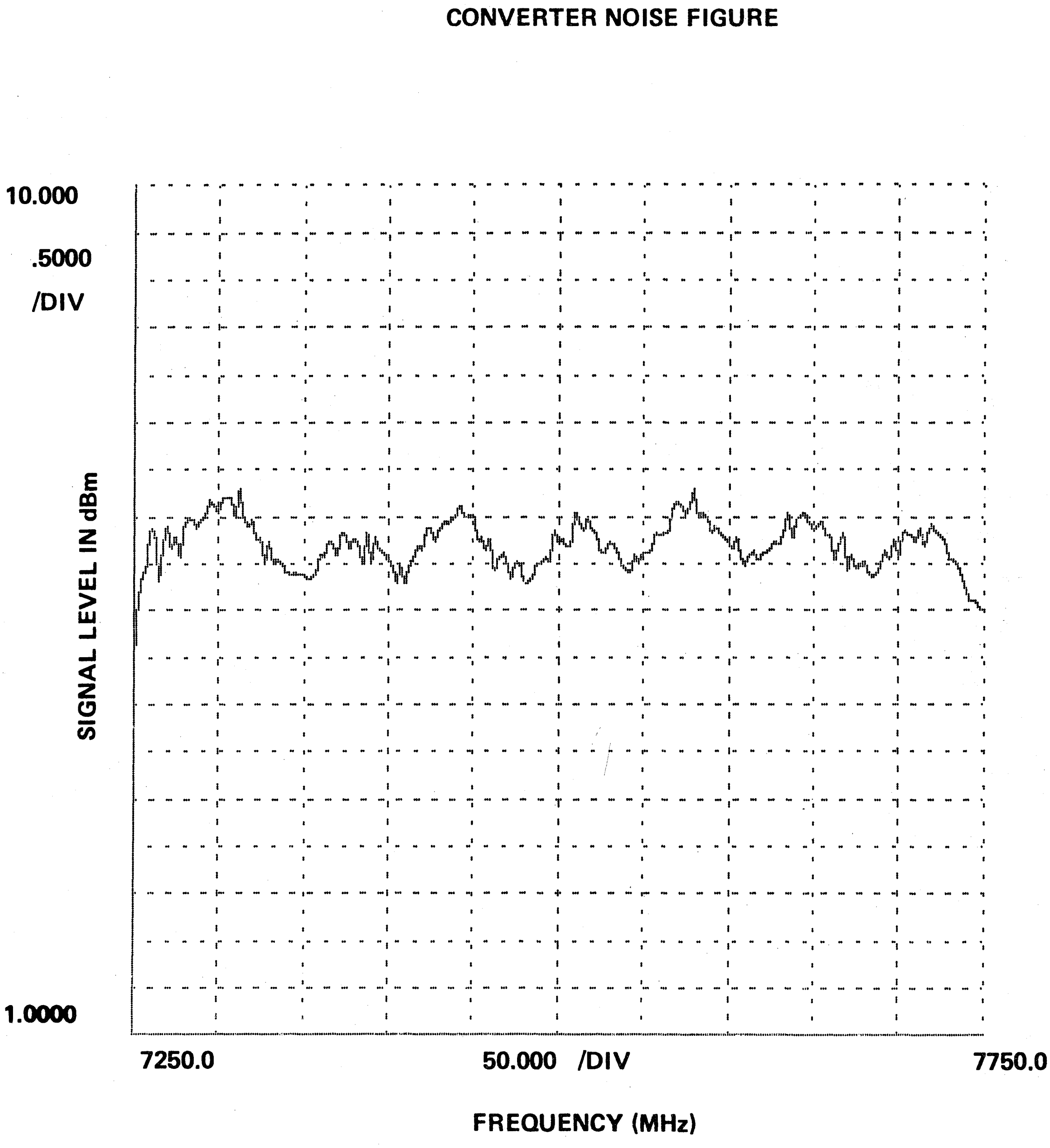


Figure 23. The low noise performance of the receiver in the 7.25-7.75 GHz satellite band.

Figures 24 and 25 demonstrate the two-tone intermodulation response of the 2-8 and 8-18 GHz receivers, respectively. These measurements indicate that, for a 30 kHz IF bandwidth, the distortion free dynamic range is greater than 55 dB for two -50 dBm input signals separated by 1 MHz. This performance is primarily a function of the non-linear transfer characteristic of the double balanced mixer which is used in the down converters.

4. SYSTEM CALIBRATION

Accurate and repeatable measurements are a fundamental requirement for any EMC measurement system, and in general, the accuracy of the measurements will depend upon the precision of the calibration of the system.

Generally, the calibration factors which convert the measured power to absolute power and which linearize the system response will be at least a function of time and temperature. Thus, ideally, the measurement system should be recalibrated often enough to minimize measurement errors due to calibration factor changes. Periodic calibration has the added advantage of providing a permanent record with which to monitor changes in the receiver due to misalignment, slow degradation of components, and other factors. By establishing performance degradation thresholds, the system's operator may be informed that the system requires realignment or repair.

An outstanding feature of the TAEMS is its ability to calibrate each receiver in real-time. The noise diodes are also used for this measurement. Advantages of this method of calibration are that the devices are small and lightweight, consume little power, are very wideband, quite stable, and inexpensive. In addition, the noise diodes require no tuning during the calibration process, and the excess noise ratio (R) is furnished by the manufacturer of these devices.

The calibration procedure is as follows: With the noise diode off, the output power of the receiver is measured at 200 frequencies across the receiver band. Then the noise diode is turned on, and the output power of the receiver is measured at the same 200 frequency points.

The noise power at the receiver output when the noise diode is off is

$$P_1 = KGB\ (T_1 + T_e) \tag{16}$$

where

T_1 = noise temperature of the diode when it is off,

T_e = effective noise temperature of the receiver,

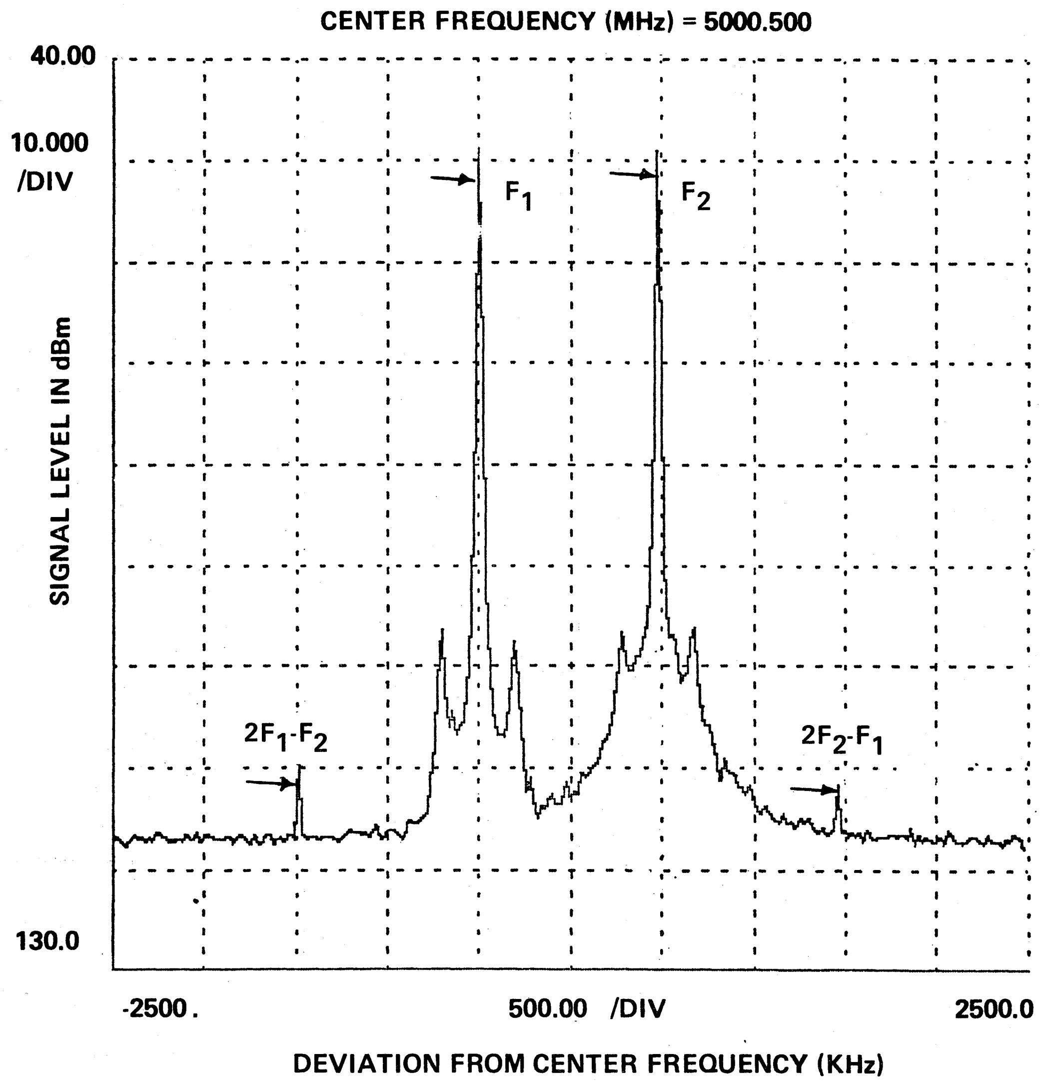


Figure 24. The two-tone intermodulation response of the 2-8 GHz receiver showing the intermodulation response of the converter A2. For input signals at approximately -50 dBm, the IM response is suppressed by approximately 61 dB.

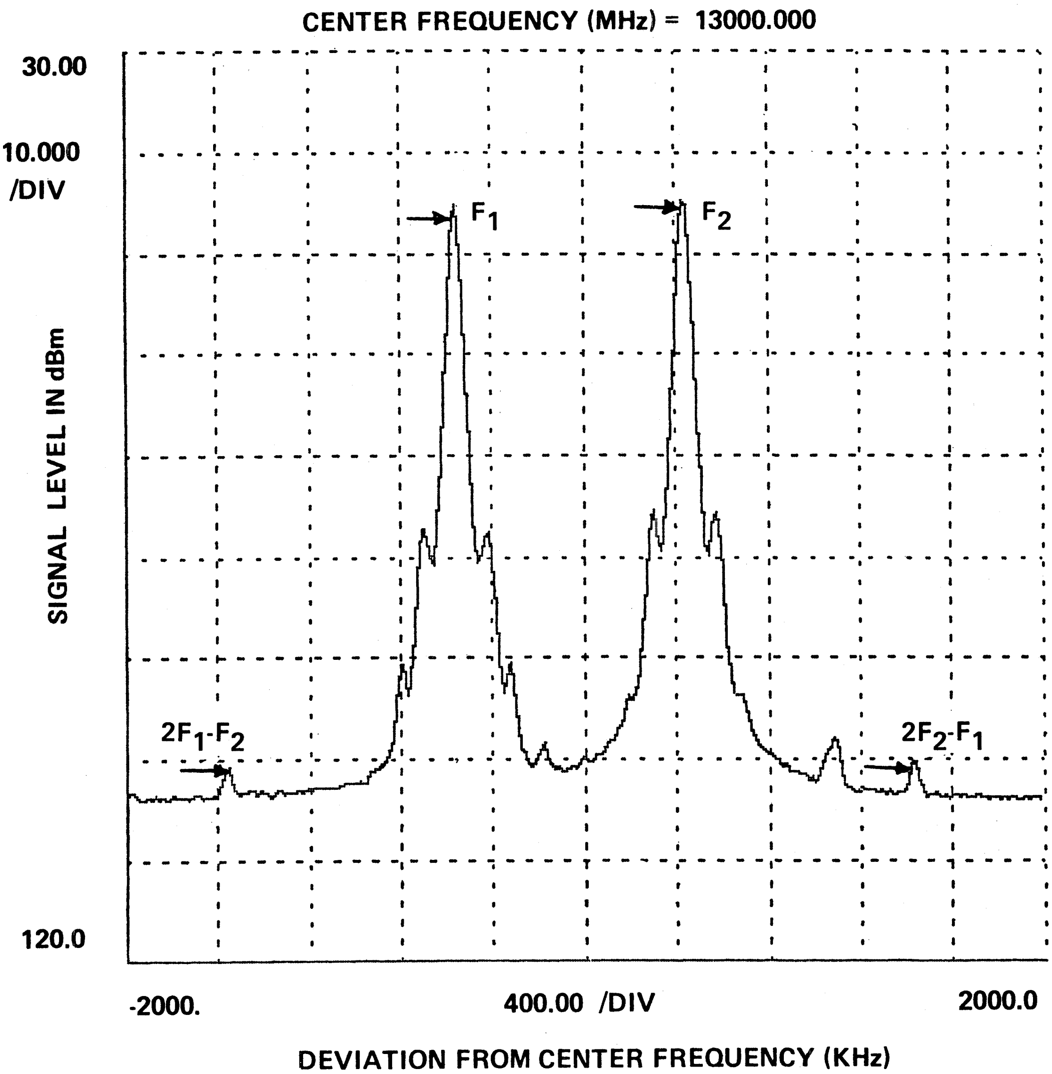


Figure 25. The two-tone intermodulation response of the 8-18 GHz receiver showing the intermodulation response of the converter A1. The signal levels are approximately 2 dB higher than shown, due to deviation from actual calibration correction factor at 13 GHz. The third-order IM products are the outermost signals which are approximately 2 dB above noise floor (the other low level signals are not IM products). The IM suppression is approximately 55 dB for -47 dB signals approximately 1 MHz apart.

B = noise power bandwidth of the receiver,

G = receiver system gain, and

K = Boltzmann's constant (1.38066×10^{-23} mw Hz^{-1} K^{-1}).

When the noise diode is turned on, the receiver output noise power is

$$P_2 = KGB\ (T_2 + T_e) \qquad (17)$$

where T_2 = noise temperature of the diode when it is on. Subtracting Equation (16) from Equation (17) gives the following expression for the receiver gain:

$$G\ (dB) = 10 \log\ (P_2 - P_1) - 10 \log KBT_o\ (T_{ex})$$

where T_{ex} is the excess noise temperature of the noise diode and T_o is 290° Kelvin.

The first term in the expression for the receiver gain is a measured quantity while the second term is a computed quantity. It can be shown that a noise signal which has been logarithmically amplified and envelope detected will measure 2.5 dB lower than an equivalent cw signal. Therefore, this measurement correction factor must be applied to the second term. Then the expression for the gain of the receiver is

$$G\ (dB) = 10 \log\ (P_2 - P_1) - 10 \log KBT_o\ (T_{ex}) - 2.5. \qquad (18)$$

Notice that the determination of the receiver gain depends on the power difference, $(P_2 - P_1)$, and the excess noise temperature of the noise diode.

As noted above, the second term in the above expression is a computed quantity. In the measurement of P_2 and P_1, the software system automatically applies correction factors to these measurements. Therefore this term should have the same correction factors applied to it so that the measured and computed quantities are comparable. The final expression then is

$$G(dB) = 10 \log\ (P_2 - P_1) - \text{COREC}\left(\text{IADCR}\ [10 \log KBt_o\ (T_{ex})]\right) - 2.5 \qquad (19)$$

where COREC and IADCR are the software system calls required to apply the receiver calibration factors to the second term (computed noise power).

After P_1 and P_2 have been measured at 200 frequencies across the receiver band, the gain measurements are least squares fitted to a straight line model. The two resulting parameters are gain, in decibels, and gain slope, in dB/GHz.

A "fine grain" correction algorithm is used to account for deviations from the straight line model when required. In actual use, the calibration cycle for all four receivers requires about two minutes and should be executed approximately every four hours. Figures 26, 27, 28, 29, 30, and 31 display the gain, gain slope, the variance of the gain and the gain slope, and standard deviation. The deviations from the straight line model are plotted. Generally, the deviations are less than 3 dB for the full band and about 1 dB for the satellite bands. The calibration program, KALND, used to make these calculations, is listed in Appendix A-2.

In EMC measurements, the power density in dBm/m^2 is the most useful quantity in predicting interference and hazards problems. One reason that the power density is such a useful quantity is that it is an antenna independent quantity. Therefore, measurements made at different times with different antennas may be compared quite easily.

Software routines apply the frequency and antenna dependent corrections required to convert the measured signal power to power density. These routines can easily be edited to reflect changes in the antenna subsystem configuration.

The signal power density is related to the signal power measured by the receiver in the following way:

$$P_R \text{ (mw)} = A_{eff} \, P \text{ (mw/m}^2\text{)} \tag{20}$$

where

P_R = the received signal power in milliwatts,

A_{eff} = the effective area of the receiving antenna in square meters, and

P = the signal power density in mw/m^2.

In the TAEMS system there are cable losses associated with the transmission of the signal from the antenna to the receiver. Therefore,

$$P_R = L \, (P_{MEAS}) \tag{21}$$

where

L = the cable loss factor, and

P_{MEAS} = the power measured by the ARS-400.

The effective area of the receiving antenna is defined in terms of antenna gain by

$$A_{eff} = \frac{\lambda^2}{4\pi} G \tag{22}$$

where

λ = wavelength of the received signal in meters, and

G = antenna gain factor.

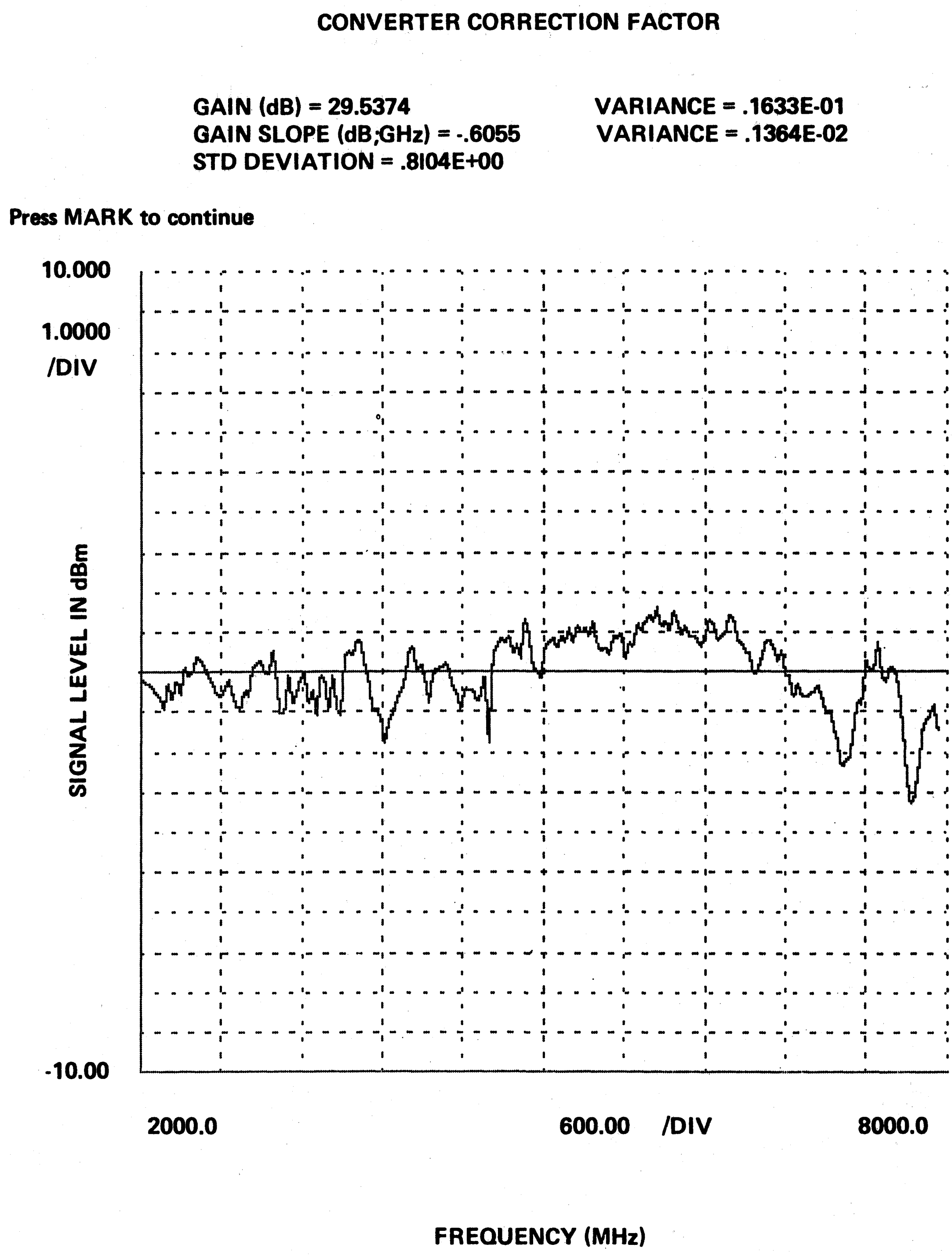


Figure 26. The gain, gain slope, the variance of the gain and of the gain slope, and standard deviation for the 2-8 GHz receiver converter correction factors.

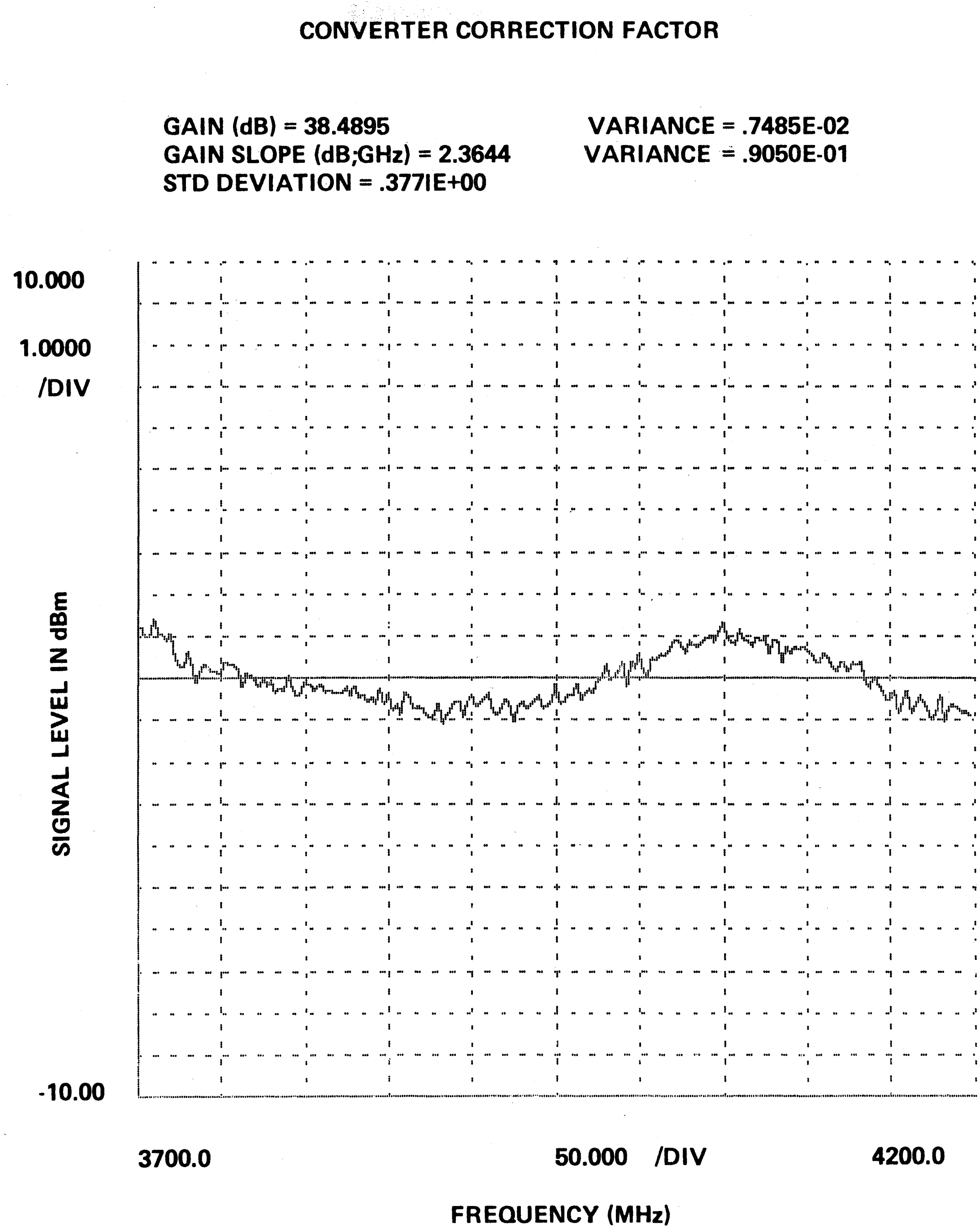


Figure 27. The converter correction factors for the 3.7 - 4.2 GHz satellite band receiver.

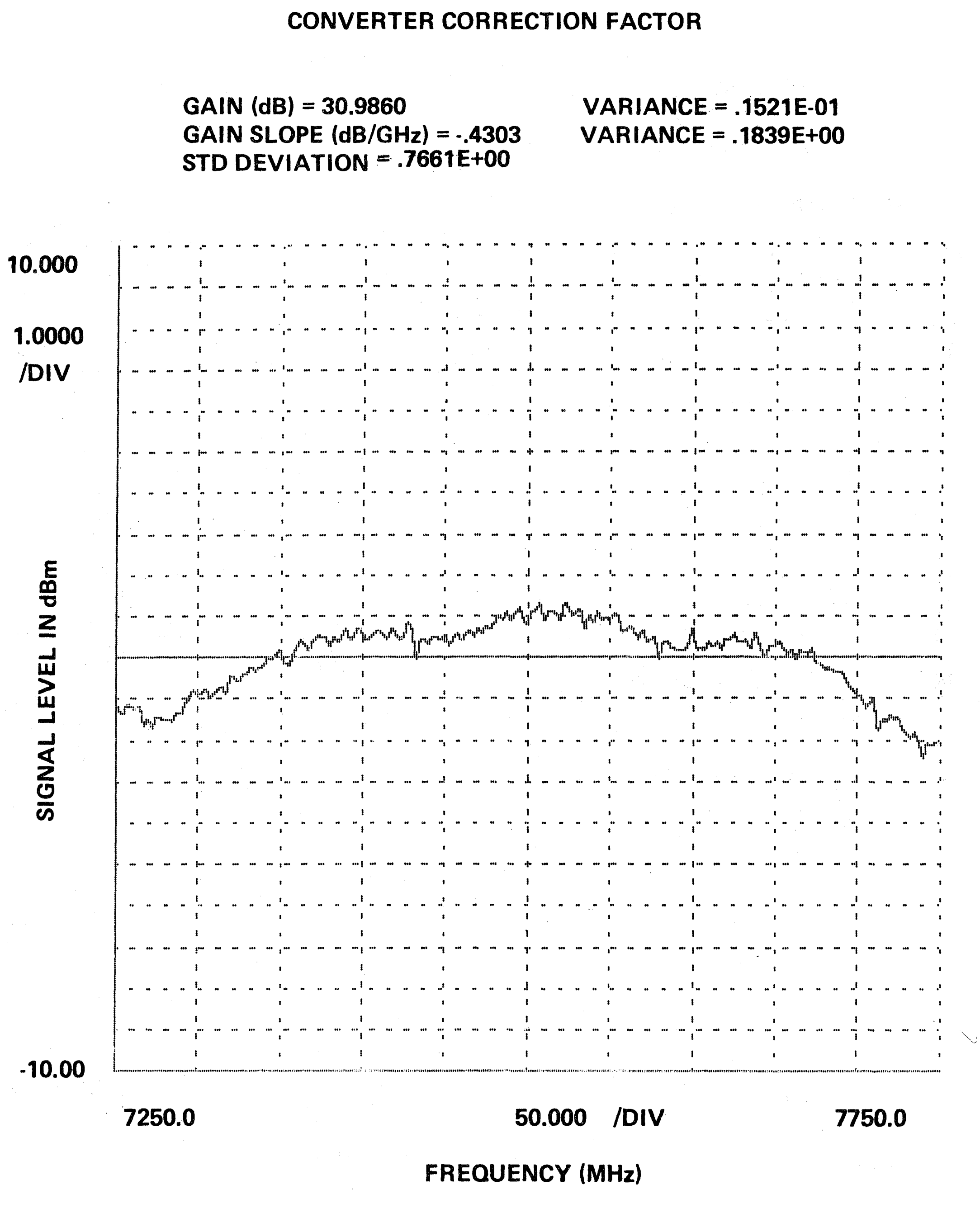


Figure 28. The converter correction factors for the 7.25 - 7.75 GHz satellite band receiver.

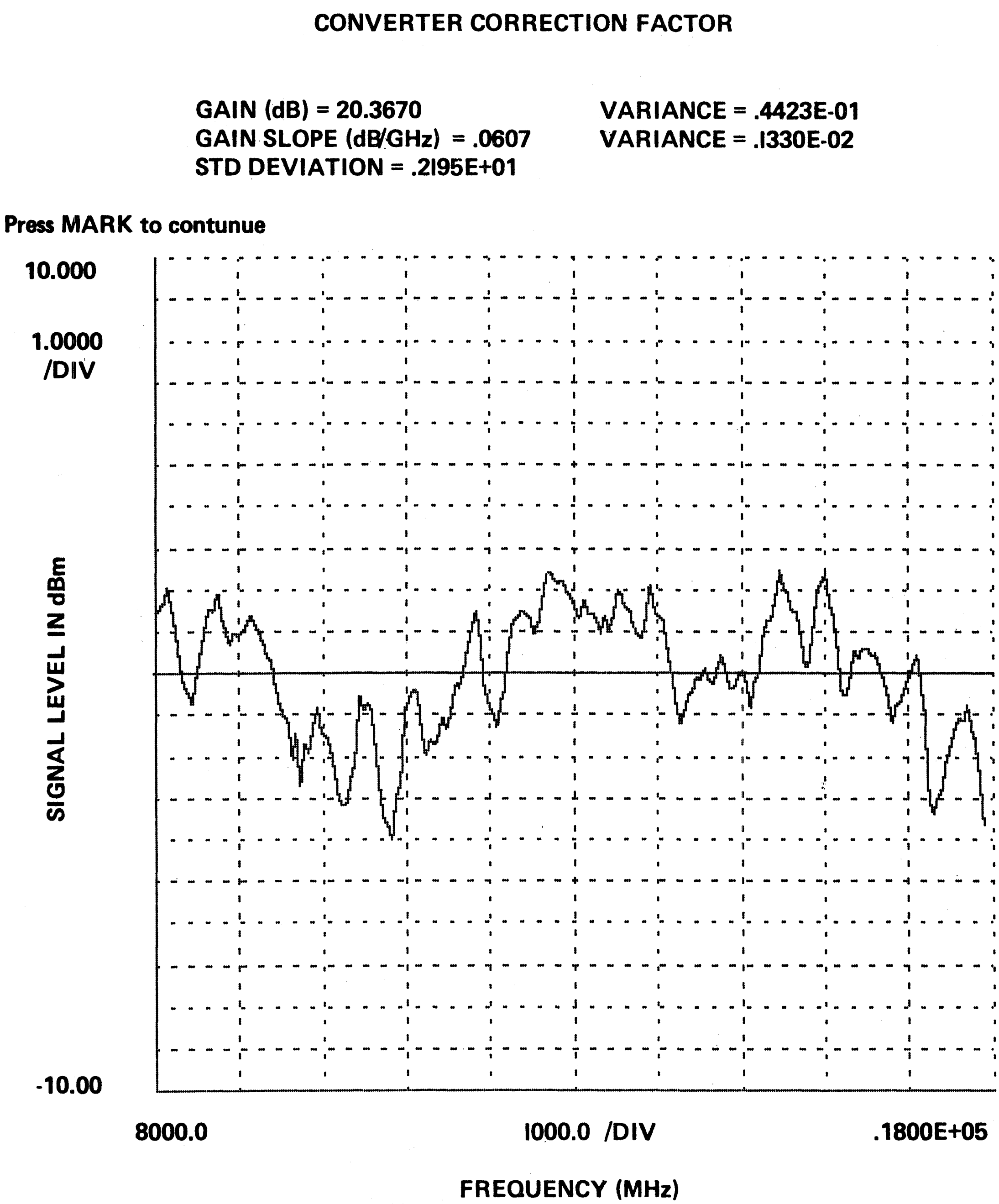


Figure 29. The converter correction factors for the 8-18 GHz receiver.

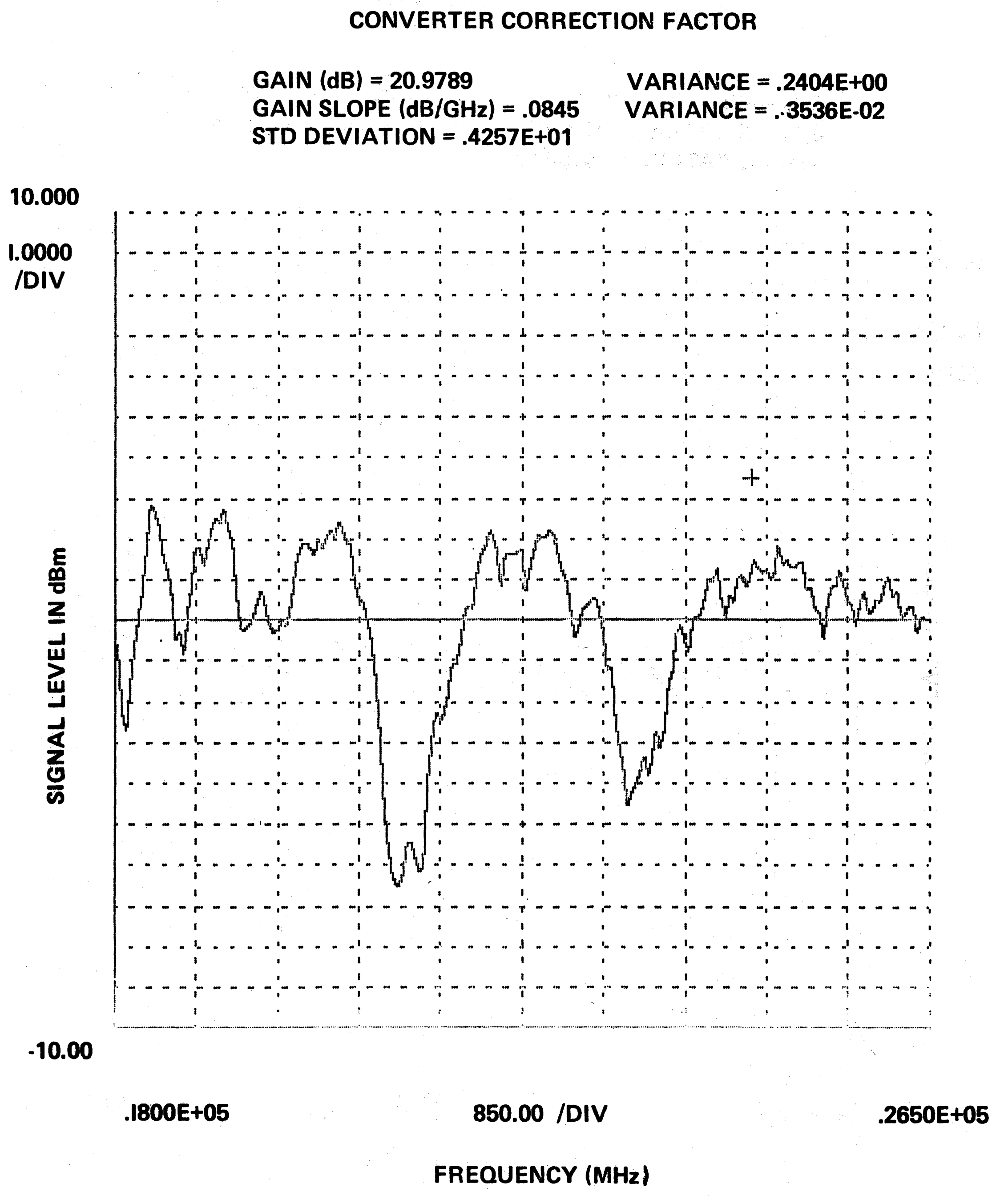


Figure 30. The converter correction factors for the 18-26 GHz receiver.

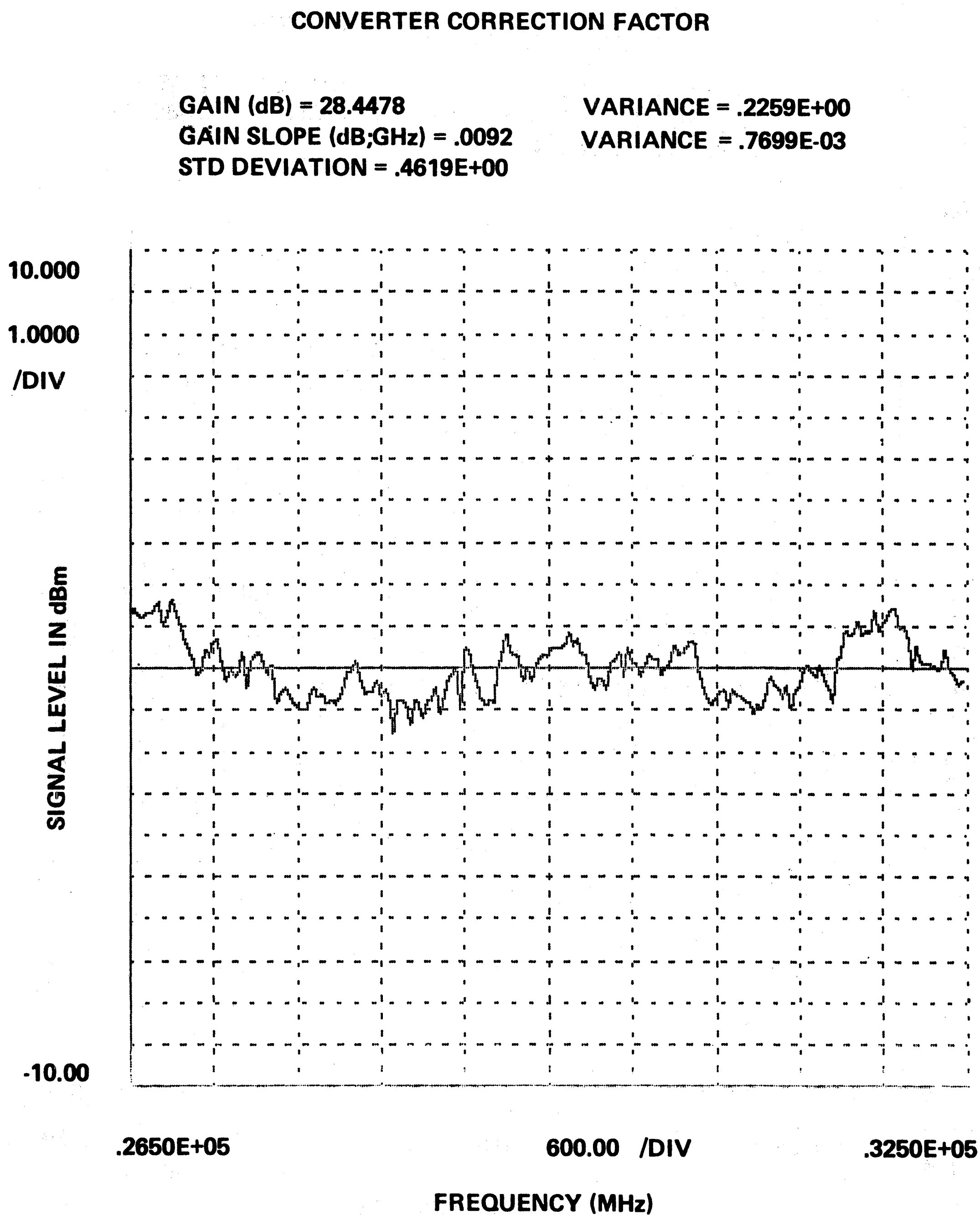


Figure 31. The converter correction factors for the 26-40 GHz receiver.

The signal power density is given by

$$P\ (dBm/m^2) = P_{MEAS}\ (dBm) - [G(dB) - L(dB)] - 27.55 + 20 \log F \qquad (23)$$

where

F = the received signal frequency in MHz.

The quantity in brackets is computed by the system function AGAIN (ISA,F), where the parameter ISA is the antenna source address and F is the signal frequency in megahertz. When the source address parameter, (ISA), is the address of one of the noise diodes in a particular receiver, the excess noise ratio of that noise diode is returned instead of an antenna gain. Having the noise diode excess noise ratio data stored in this function represents an efficient usage of the allocated core storage. A listing of AGAIN is included in Appendix A-1 for reference.

5. ANTENNA SUBSYSTEM

The antenna subsystem consists of an array of antennas to provide frequency coverage from 1 kHz-40 GHz (Figures 32 and 33). Other principal components of the antenna subsystem are a 50-foot guyed tower (Figure 34), and an elevation over azimuth (EL/AZ) pedestal shown mounted on the tower assembly (Figure 35). The accompanying antenna control unit (Figure 36) is rack mounted inside the van where it can be manually or computer controlled.

The selection of an antenna was based on the following requirements:

(1) dual linear polarization coverage from 30 MHz-40 GHz,

(2) omnidirectional coverage from 1 kHz-40 GHz,

(3) space restrictions requiring the antennas to be physically small and weight restrictions of the 50-foot tower and EL/AZ mount, and

(4) an antenna gain of 10 dB for G/T in the 7.25-7.75 GHz satellite band fixed the size of the 2-8 GHz antenna at 5 feet in diameter.

To simplify the overall receiver design, antenna bandwidths were matched to those of the down converters. For instance, an 8-18 GHz parabolic dish (2 ft.) and an 8-18 GHz omni were chosen to go with the 8-18 GHz receiver.

Below 2 GHz, the selection of antennas was based mainly on size and weight. In addition, antennas with large bandwidths were chosen to minimize the total number of antennas. For a number of reasons, two antenna configurations were chosen (Figures 37 and 38). The main reason, however, was that is was not possible to deploy all the directional antennas and receivers on the antenna tower/mount simultaneously without exceeding the tower/mount weight limit. Figure 37 shows

Figure 32. Final antenna configuration A(Mid-Band Antennas) shown mounted on EL/AZ pedestal with associated down converters.

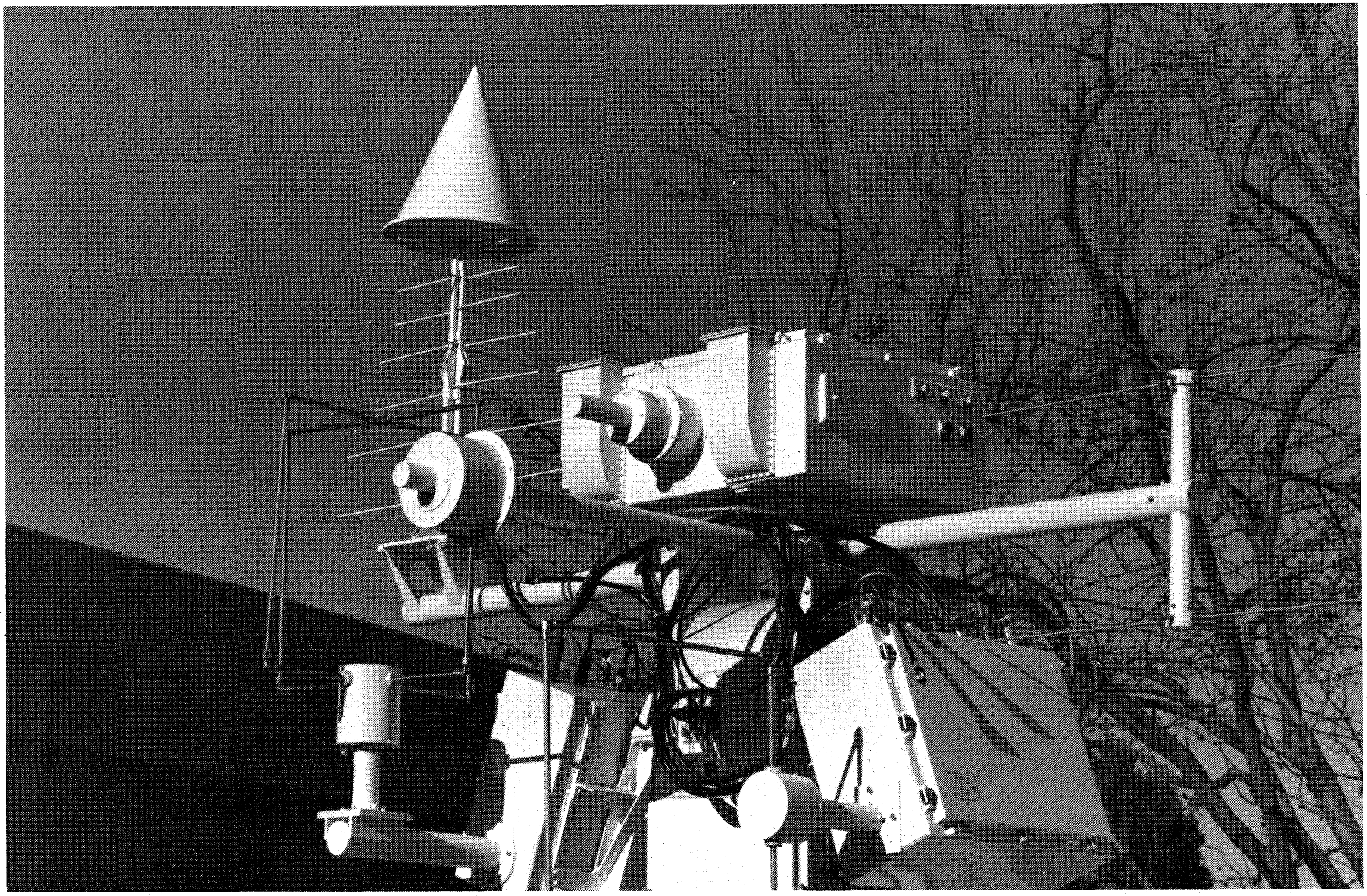


Figure 33. Final antenna configuration B(Wide-Band Antennas) shown mounted on EL/AZ pedestal with associated down converters.

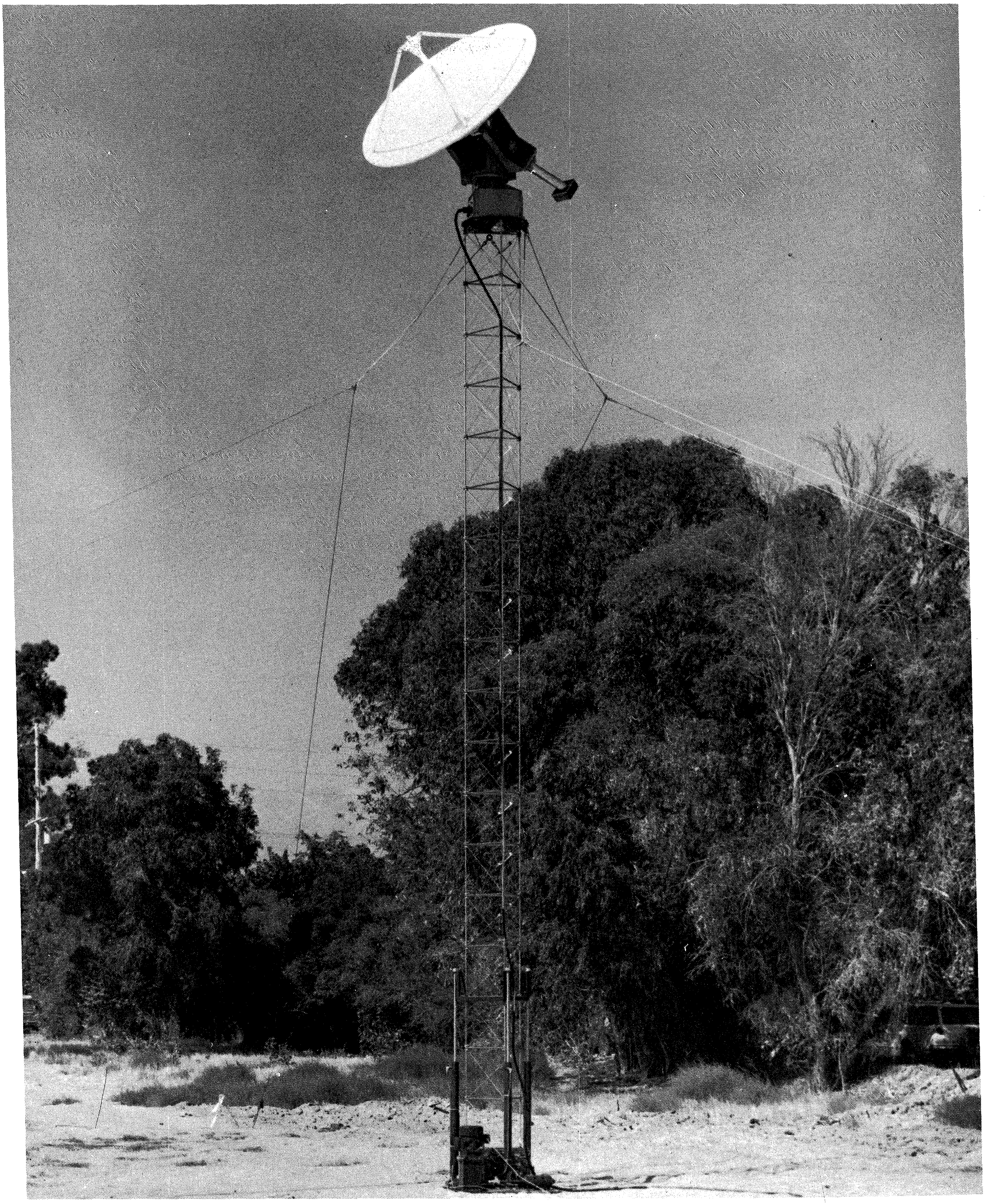


Figure 34. Guyed tower used in TAEMS system shown erected to full 50 ft height with EL/AZ pedestal, 2-8 GHz parabolic antenna and simulated test load.

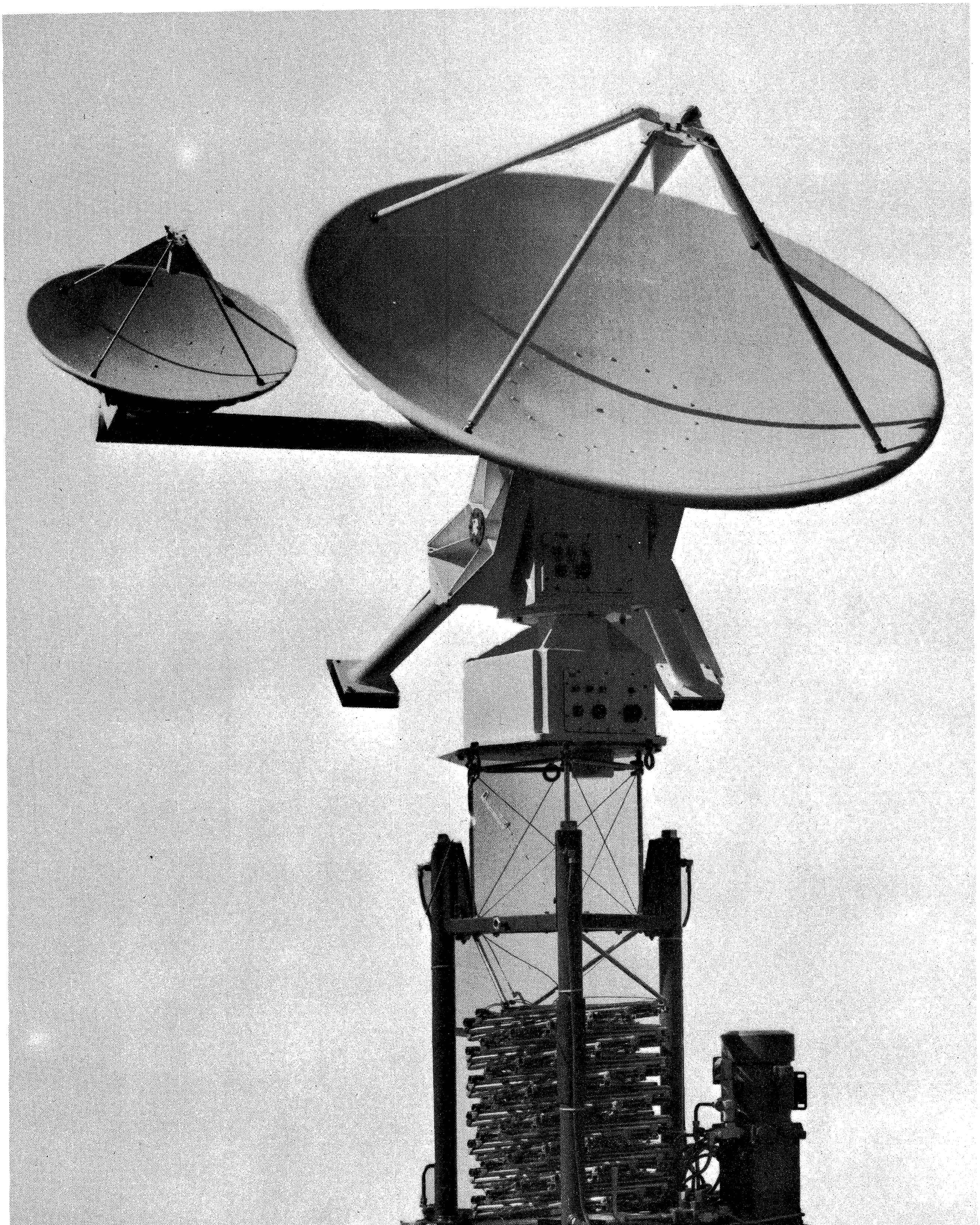


Figure 35. The elevation over azimuth (EL/AZ) pedestal shown mounted on the tower assembly with mid-band antennas attached.

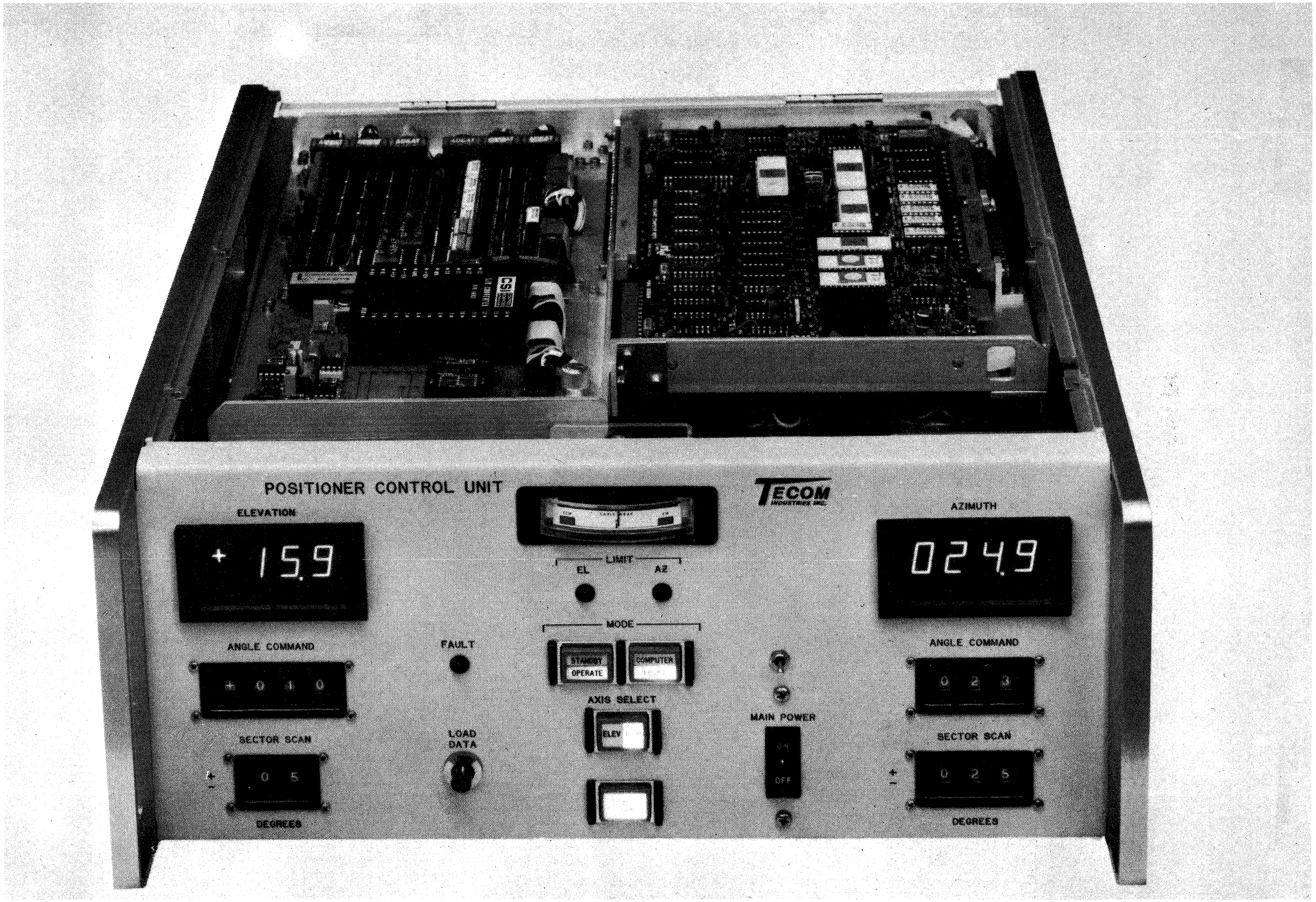


Figure 36. Antenna positioner control unit used in the antenna subsystem.

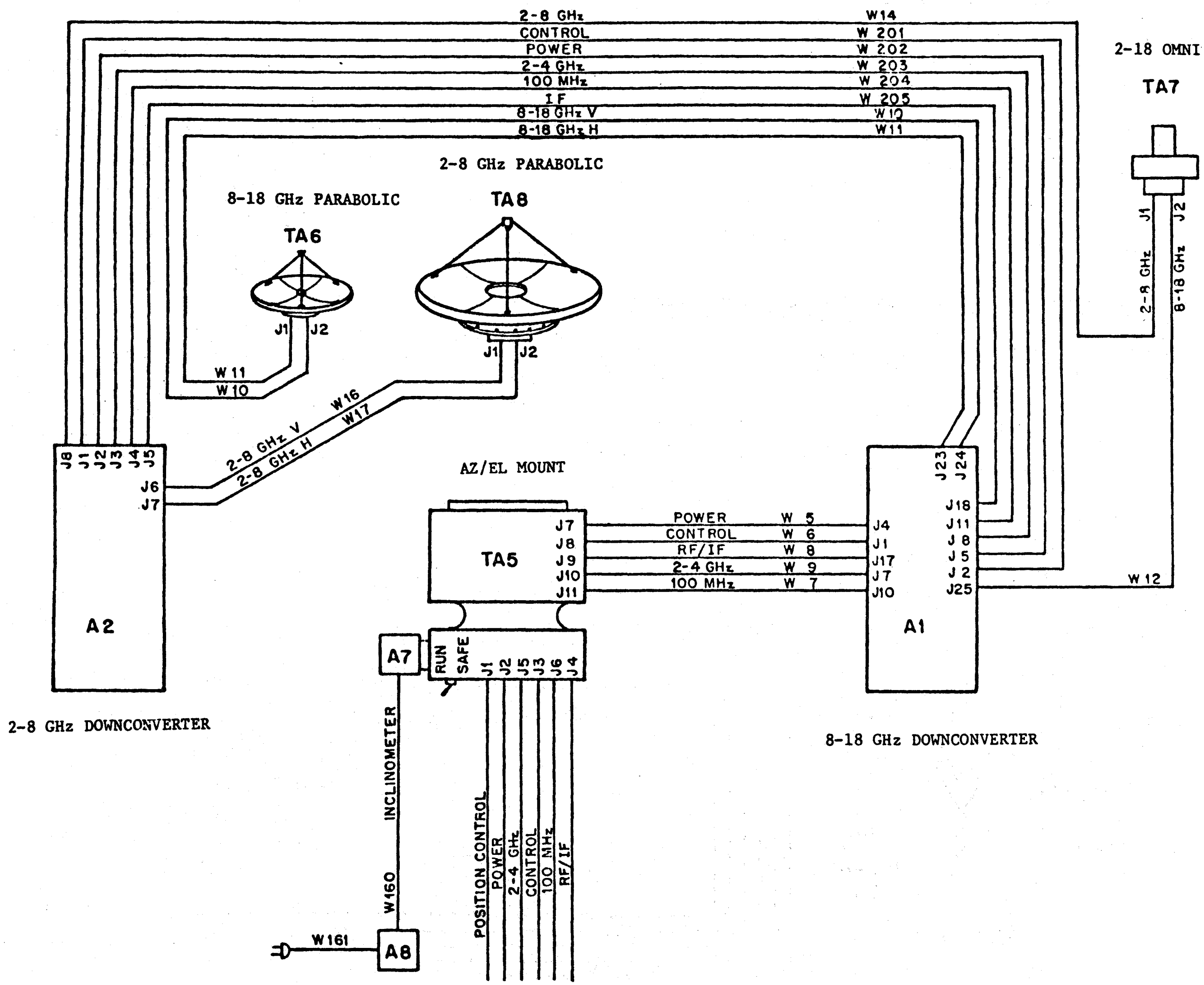


Figure 37. Schematic drawing showing the interconnections for antenna configuration A(Mid-Band Antennas).

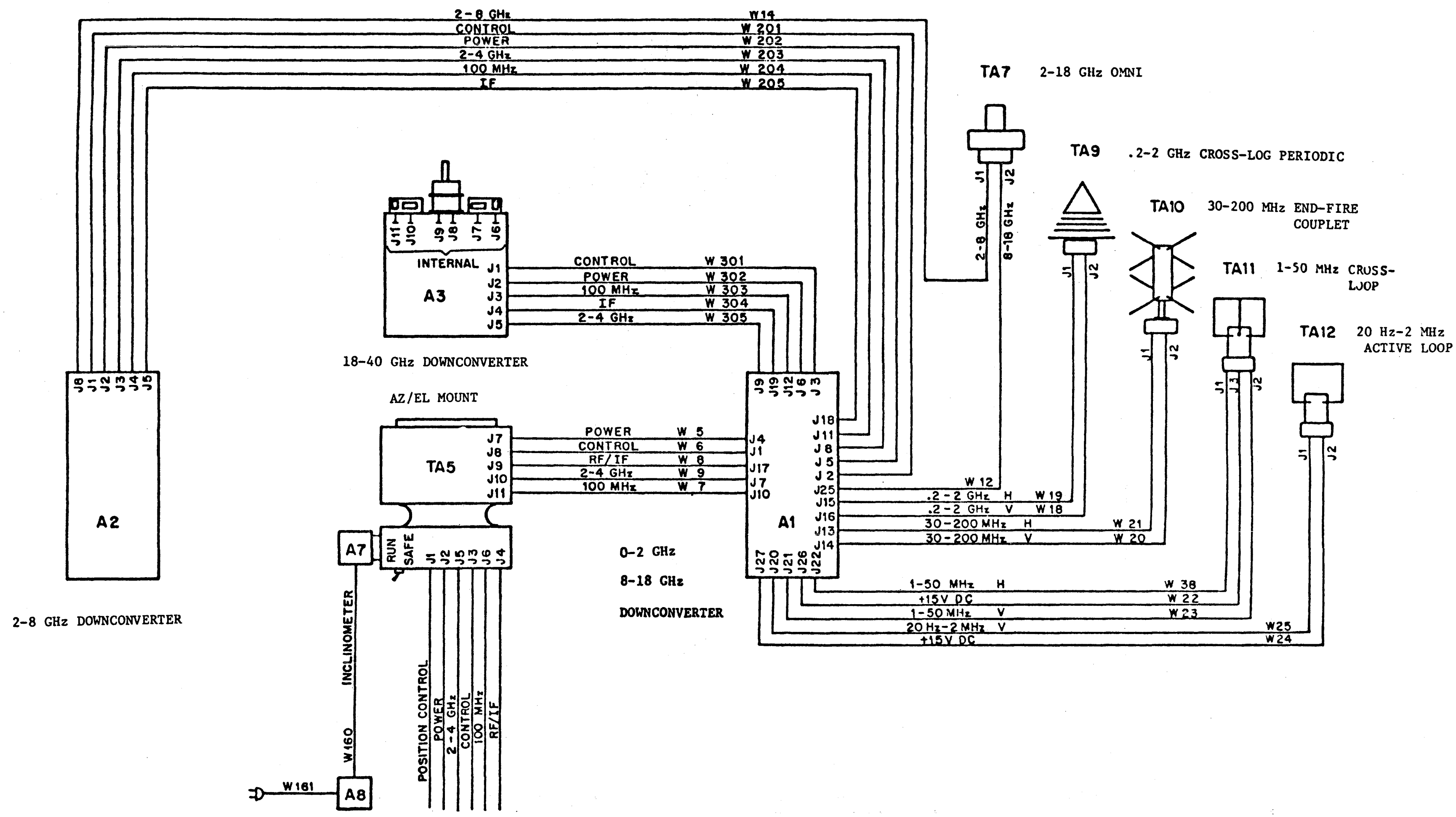


Figure 38. Schematic drawing showing the interconnections for antenna configuration B(Wide-Band Antennas).

the antenna configuration which provides omni and directional coverage from 2-18 GHz as well as omnidirectional coverage from 0-26 GHz. Figure 38 shows the second antenna configuration which provides omni and directional coverage from 18-40 GHz and 0-2 GHz as well as omnidirectional coverage from 2-18 GHz.

Together, these two antenna configurations provide E-field coverage over the entire frequency range of 20 Hz to 40 GHz and H-field coverage from 20 Hz to 50 MHz Linear polarization characteristics can be measured with the E-field antennas from 30 MHz to 40 GHz and with the H-field antennas below 50 MHz. Both directional and omnidirectional coverage are provided throughout the entire frequency range. In Table 1, each antenna type is identified along with its frequency range, gain, polarization, and voltage standing wave ratio (VSWR). The gain model for the antennas from 2-40 GHz is given by,

$$\text{GAIN} = \text{A}\emptyset + \text{A1} (\log \text{F})$$

where F is in megahertz, and AØ and A1 were determined by filtering experimental data into the above model. Since the antenna factor data was available for antennas below 200 MHz, the gain model used in this case is

$$\text{GAIN} = -29.8 + 20 \log \text{F} + \text{AF}$$

where AF is the antenna factor. The gain model data thus obtained is summarized in Table 1. The system function AGAIN (I,F) is used to compute the frequency dependent gain of each antenna in the system.

6. SOFTWARE SYSTEM

A real-time-executive (RTE) software operating system was developed for the automatic receiver by ITS to extend the operating capability of the system. Real-time-executive allows multiprogram execution, as well as program scheduling, file manipulations, and editing. Using the editor, FORTRAN measurement routines can quickly be written or modified. Both source and object programs are stored on magnetic disc, with measurement data stored on magnetic tape for further analysis.

At the time development was started on the computer-controlled receiver system, a cassette operating system (COS) was included. This operating system was based on a cassette tape unit as the primary storage device and used BASIC as the primary programming language. It was felt that the speed and reliability of a cassette system could be drastically improved by development of a disc based (DOS) operating system.

Therefore, a disc based system was provided as the starting point. The chosen system is a multiprogramming system where up to four programs may simultaneously

TABLE 1

TAEMS ANTENNA CHARACTERISTICS

FREQUENCY RANGE	GAIN	POLARIZATION	VSWR	ANTENNA TYPE
1 KHz-2 MHz	-29.8 + 20 log F + AF	V	<2.0	Active loop
1-50 MHz	-29.8 + 20 log F + AF	Dual Linear (DL)	<2.0	Active cross loop
30-200 MHz	-29.8 + 20 log F + AF	DL		End fired
0.2-2 GHz	7.5	DL	<2.5	Cross log periodic
2-8 GHz	-49.3 + 22.7 log F	DL	<2.5	Parabolic
8-18 GHz	-43 + 18.4 log F	DL	<3.0	Parabolic
18-26 GHz	-61 + 18.5 log F	DL	<1.5	Std. gain horn
26-40 GHz	-58 + 17.3 log F	DL	<1.5	Std. gain horn
1 KHz-2 GHz	0 ± 3 dBi	Vertical		Modified biconical
2-8 GHz	0 ± 1.5	Slant Linear	<3.0	Bicone
8-18 GHz	0 ± 2.5	Slant Linear	<3.0	Bicone
18-26 GHz	0 ± 2	Slant Linear	<3.0	Bicone
26-40 GHz	0 ± 2.5	Slant Linear	<3.0	Bicone

occupy memory and share computer execution time. All input/output is handled by the operating system with extensive and general capabilities. Programs may be scheduled to run automatically at various times of the day. When several programs are competing for the central processor unit, a priority associated with each program is used to schedule the program to be executed. The system also handles all file management. An extensive list of system requests for operators and for programmers is available. In addition, the disc based system was a proven system that was well supported. FORTRAN, ALGOL, and assembly language are the principle programming languages used.

Almost all the equipment of the automatic receiving system is connected to the computer through an equipment bus. Also, a display console, keyboard, printer, and hard-copy device are connected to the equipment bus. The power meter is one piece of equipment that is connected through its own I/O interface and is not on the bus. The main part of the effort in the operating system consisted in writing drivers for these devices. The largest and most complex is the driver for the equipment bus. The devices on the bus are now operated under interrupt. Another driver is used to control the display generator, and another is used for the power meter. These three drivers provide the interface between the DOS standard operating system and the receiver system.

The next level up from the DOS system itself involves the software necessary to operate the graphics and automatic receiver equipment. This software consists of a set of subroutines that controls the graphics on the display and another set that controls the settings of the receiver and takes measurements from it. A user program, for example, calls one of these subroutines to clear the display, draw a vector on the display, change the receiver bandwidth, or measure the currently received signal amplitude. In the cassette operating system (COS), a similar set of subroutines is available. One of the design criteria for the DOS version of this software was that, from a user's point of view, the subroutines should be like the COS version. This allows a maximum of compatibility between user software written for the standard commercial system and the EMC Measurement System. The way each subroutine carries out its particular function may or may not be similar to the original COS version as long as the end result to the user is the same. This criteria was largely met, but some exceptions occur because of the differences in the two operating systems. A few things that are done in the COS software are inappropriate or unnecessary to do in DOS.

The fundamental approach to operating the graphics display that was decided upon differs from the COS approach. This necessitated writing the lower level graphics subroutines from scratch. For example, it was decided that the memory used to provide a buffer for all the graphics information should be allocated from the DOS system as needed and returned to the system when not needed. The normal text information displayed on the screen (analogous to the COS text buffer) is handled by the bus driver. The analog to the COS graphics buffer, which takes care of all lines drawn on the screen and some text information, is handled by this set of graphics subroutines. A few of the graphics routines are at a somewhat higher level. For example, one draws a set of axes for graphs on the screen and draws appropriate labels. These higher level routines are written so that they depend on the lower level subroutines rather than any particular buffer structure. These subroutines needed little modification to run under DOS once the lower level routines were changed.

The first step in modifying the software that runs the receiver was to make it run the standard automatic receiver system. Later new subroutines were added and old ones modified to reflect the hardware differences between the standard receiver system and the final EMC Measurement System. Under COS, the common area of memory is used for storage of about 450 words of information containing calibration data and current receiver status. Under this method, the calibration data is read into memory from a cassette. Under RTE, this block of data is kept in high core and is referenced by externals, with the common area all reserved for programmer use. Variables in this area which have initial values (as from the calibration data) are initialized automatically when the DOS system is "booted-up." Some of the calibration data is stable over long periods of time. This is kept in a subroutine in the system library. The advantage of this is that memory is not used for these constants except in programs that reference them. The constants are loaded into core when needed by the RTE loader without operator intervention.

Because all input/output is handled by DOS, the subroutines required modifications to make I/O requests rather than handling it themselves. This results in more overhead occurring on each I/O operation as DOS will make some unnecessary checks. However, the amount of time used in overhead is low compared to equipment operation times. Therefore it was felt the overhead was justifiable. This does not mean that the programs run slower under DOS. Because COS uses BASIC primarily, which is an interpretive language and relatively slow, and the main language for DOS is FORTRAN, which is quite fast, programs run faster under DOS than COS.

Because of the additional hardware required on the EMC Measurement System, some new subroutines to handle this equipment were necessary. First of all an antenna selection routine was needed. By calling for a particular source, any of the various antennas with their available polarizations may be selected. Also various noise diodes and comb generators may be used instead of an antenna. Another subroutine turns a selected noise diode on or off. Because the down converters have their own selectable attenuators, another subroutine was needed to select the desired value of attenuation. A subroutine to drive the azimuth-elevation position of the antennas was also added. The AZ/EL controller includes a microprocessor that always moves the positioner through the shortest angle in moving to a new azimuth position. This feature will sometimes move the antenna positioner into a rotation stop. This is rather cumbersome in that manual intervention is necessary to back the positioner off the stop. The subroutine that handles the antenna position must keep track of the current position angle and must make a decision on which way to rotate the antenna while still allowing a 720° rotation range for efficient positioning. In order for the system to know the current antenna position, the approximate antenna position is input and the antenna commanded to that angle automatically during the boot-up procedure. These subroutines to handle the extra hardware are listed in the Appendix under New System Calls. The system initilization program used to set constants in the high memory area and to set the antenna controller to a known start position is also listed in the Appendix under SINIT.

Some additional changes in the subroutines were necessary to wait for the down converters to phase lock. The new receiver uses three output ports for the input control unit. The software automatically selects the correct output port, depending on the tuned frequency. This also is an extension of the old software. Another subroutine was added to calculate the antenna gain and line loss of the operating antennas. The line loss calculated here is only for the transmission line between the antenna and the down converter. The line loss down the tower to the receiver input is measured and corrected for in the calibration procedure. This allows absolute power measurements to be made.

Another change was necessary to allow the new receiver to tune through its full 40 GHz range. In the old software, the megahertz portion of the frequency is frequently held as a single word integer. On this computer, the largest integer is 32767, which is insufficient. A method of tuning the full range was devised and implemented.

During the development period the commercial supplier introduced a new operating system for the receiver called TODS-II. This operating system is disc based and corrects the main deficiencies of the original COS system. It was felt that RTE had significant advantages over TODS-II, and that the main development effort would still be in this area. TODS-II is now available as a backup system.

7. APPLICATIONS SOFTWARE

In order to use the TAEMS efficiently a set of applications software was developed. Presently there have been two primary missions identified for the TAEMS. These have resulted in two scenarios:

1. Application Scenario for Electromagnetic Radiation Hazards (EMRH).
2. Application Scenario for Evaluating Defense Satellite Communication Systems.

Each of these scenarios is basically a plan for taking measurements and doing the proper analysis for these two missions. The applications software consists of a set of programs implementing each of these scenarios and also a third set of generally useful programs and subprograms.

7.1 Application Scenario for Electromagnetic Radiation Hazards

The objective of this application scenario is to describe a sequence of events and actions which must be undertaken to acquire, analyze, and characterize the electromagnetic radiation environment in the vicinity of ordnance and artillery sites worldwide in support of the U.S. Army Nuclear and Chemical Surety Program.

The basic idea in the scenario is to measure the entire electromagnetic spectrum from 10 kHz to 18 GHz. The signals that are measured are then analyzed to determine the total field strength received. This is then compared against allowable levels to determine whether a hazard exists or not. Because weak signals do not contribute significantly to the total field strength, the measurement procedure can be optimized to more accurately measure the stronger signals at the expense of very weak signals.

The software can be broken into three categories: (1) measurement software, (2) analysis software, and (3) utility software. The utility software consists of various programs to aid in bookkeeping that list and graphically display the data, measure and display requested parts of the spectrum, etc., and will not be discussed further (see Appendix A-3).

There are three measurement programs which take data from the spectrum analyzer. The basic program is the off-site emitter measurement program. This is the program that scans the entire spectrum from 10 kHz to 18 GHz. A variety of antennas are used to cover the desired range of frequencies. In addition, both E and H field antennas are used. Because many of the antennas are directional, each of these must be rotated to cover the full hemisphere of reception. Likewise, both horizontal and vertical polarizations are measured. Bands which may contain radars are input to program. This allows special techniques to be used in measuring these radars. All measurements made are recorded on magnetic tape for later analysis.

The second measurement program is to measure on-site radars, that is, radars located on the same base as the ordnance site being surveyed. Emitters which are on the measurement site are the most likely to have the greatest field strength and therefore present the greatest hazard. For these on-site emitters, special measurement programs were developed which measure the worst case hazard. For radars, the transmitting antenna is pointed directly at the measurement antenna located at the site of interest. Measurements of the peak power, pulse width, and pulse repetition rate are made. This data is also stored on magnetic tape for later analysis.

The last measurement program is for on-site communications equipment. Various communications on the base including mobile transmitters are measured separately and also while simultaneously transmitting on the same channel. The mobile radios can also be moved to various positions and measured. As previously stated, this data is also recorded on magnetic tape.

The analysis starts by reducing the data. The off-site data goes through a pre-pass program which orders the measurements by frequency and reduces the data by only taking the maximum of several measurements at every frequency. Usually the off-site measurements will be made many times in order to increase the likelihood of measuring emitters that are intermittent. To provide for this, a data merging program is provided to allow the various sets of data to be combined. Data merging programs are also provided for the on-site data. Each type of data set has an analysis program which combines the signals to find the total field strength. For any desired set of bands, the field strength for the band is computed. These can be combined in various ways (for example combining the on-site radios with on-site radars for a total on-site figure or combining on-site with off-site data). Finally, each band can be compared to the allowable limits to determine if a hazard exists at a site.

7.2 Application Scenario for Evaluating Defense Satellite Communication Systems

The objective of this scenario is to evaluate the communication and interference environments for fixed and transportable satellite earth terminals.

The general approach is to measure the environment looking for signals which may cause interference to a satellite earth terminal. The signals that are measured are analyzed in a program that includes a model of the satellite earth terminal. The signals that are potentially interfering are identified and a guard band around these signals is calculated.

There are three measurement programs. The first of these searches for signals which are in the region of the actual satellite and might be received in an earth antenna's main beam. Because even very weak signals in this area are potential interferers, this area is searched with high sensitivity. Any signals found are recorded on magnetic tape.

The second measurement program measures non-pulsed signals at or near the horizon. This is the area where most of the emitters can be found. Even though an earth terminal's antenna is pointing up at the satellite, signals originating near the horizon can cause interference if they are strong enough to be received on one of the antenna's sidelobes. Because signals in this region must be stronger to cause interference, the search need not be as sensitive. Signals found by this program are also recorded on magnetic tape.

The third measurement program measures pulsed emitters such as radars. The above two programs are not suited for measuring some pulsed emitters. Therefore, when this type of signal is encountered, this program is used. A spectrum of the signal measured using peak-hold circuitry is recorded on magnetic tape.

There are several preliminary analysis programs. The culmination is a program which models an earth terminal receiver. This model includes such things as the antenna, rf filter, IF-filters, modem filters, and interference threshold of the receiver. The various signals that were measured are processed through the model to see if they will cause interference or not. If a signal does cause interference, a guard band around that signal is calculated. The guard band is a frequency range that should not be used by an earth terminal. Various utility and housekeeping programs are also included in this scenario.

7.3 Non-Scenario Programs

This category includes some programs and subprograms which may be used in many applications.

The most important of these is a general scanning program called GSCAN. This program allows an operator to look at any part of the spectrum with a large variety of options. Basically it allows the spectrum analyzer to be operated under computer control, but used much as it would be under manual control. The operator types in the various spectrum analyzer settings when asked. He can also type in a selection from a large variety of detector and scanning options. Most of these options are provided by software and are not available to the user of the manual system. The resulting spectrum that is measured is then displayed on the screen. The operator has the option at any time to change the spectrum analyzer settings or program options to look at the same portion of the spectrum in a different way or to look at a different part of the spectrum. In addition some special options are available to measure a signal that is displayed. Appendix A-3 has a complete listing of the GSCAN program.

A group of subprograms provided has to do with enhanced plotting. Capabilities are provided for linear and logarithmic plots. Other subroutines allow polar graphs to be plotted.

A group of programs dealing with the systems calibration data is provided. One program allows the spectrum analyzer's current calibration data to be examined and, if desired, to be saved on the disc. Another program allows previously saved data on the disc to be restored to the system. A third program allows calibration data to be changed and either restored to the system or saved on the disc.

A program is provided to find the direction of a signal. A variety of geographical transformations and mathematical functions are also provided.

The computer controlled spectrum analyzer has proved to be a very versatile instrument with some significant advantages over manual systems. (Manual systems also have the advantage of fast scans. The ideal system is one which can be used either manually or under computer control, as the TAEMS.) The applications for this sort of instrument are virtually endless and have only begun to be explored.

8. CONCLUSIONS AND RECOMMENDATIONS

Our overall system design philosophy was to make the mechanical and electrical architecture of the receiver as flexible as possible to allow easy incorporation of improved microwave components as they become available and as their incorporation is required to upgrade system performance.

The down-converter circuitry was state-of-the-art at the time it was designed in 1975. Since that time, numerous component improvements have been made. The performance of each of these components should be continually evaluated to determine the advantage of replacing components in the down converters presently in operation as new components become available.

For instance, advances have been made in FET oscillators, low noise FET amplifiers, yig-tuned filters, rf switches, attenuators, and mixers. We can look at each of these devices and evaluate the improvements that might be expected.

Let us first consider the rf switches. This component has been particularly troublesome, not in terms of its rf performance, but with respect to the dc indicator contacts. These indicator contacts have not performed well. However, in the meantime, the manufacturer has improved his screening techniques, and this problem has been substantially reduced. Also in the original design, feedback of the rf switch closure was regarded as critical. Consequently, due to the intermittent behavior of the dc contacts, this function had to be disabled. Replacement of the present switches would then allow for a more reliable indication of the state of the switches.

The attenuators are fairly simple to evaluate. New models are available with lower insertion loss. These attenuators, having significant improvement in noise figure, could be incorporated with minimal impact on the system design.

Advances in low noise amplifiers are being made so rapidly that it is difficult to track their progress. Nevertheless, significant progress has been made to warrant replacement of the 3.7-4.2 GHz and 7.25-7.75 GHz band amplifiers. The gain requirement of these devices should be carefully evaluated so as to maximize the dynamic range of these two frequency bands.

Yig-tuned FET oscillators are now available which cover the 2-8 GHz and 8-18 GHz frequency bands, and they now have guaranteed performance over the full -54° to 71°C temperature range. New, more reliable drivers have also been designed to tune these FET oscillators. It is fairly clear that the 0-60°C temperature range FET oscillator and driver in the 2-8 GHz receiver should be replaced by the new devices.

Significant advances are being made in the performance of yig-tuned filters. Perhaps the most significant advance in components has been the auto tracking feature of these new filters. This feature should eliminate tracking problems over time and temperature. The possibility of improved insertion loss, VSWR, and in band ripple are also definite improvements which would result from the use of these new components.

Mixers are key components in the down converters. New designs are being developed which may offer improved intermodulation performance without paying a noise figure penalty. Certainly, the gain in the present mixer/preamp could be lowered with an attendant increase in dynamic range and essentially negligible change in the down converter noise figure performance. So, a first step in improved system design would be to replace these devices with the new, lower gain devices.

It should be emphasized again that almost all of the devices discussed above can be incorporated with little or no impact on the down converters and with the possibility of considerably improved performance and reliability.

A further recommendation would be to eliminate the 90° hybrid and the SPDT switches that were included to synthesize circular polarization from the two linear inputs in the 2-8 GHz down converter. It is felt that the benefit of this configuration is so marginal that it should be eliminated. The alternative benefit would be approximately 1 dB improvement in sensitivity.

Other areas of consideration would include replacing the analog and digital components with the new, improved versions that are now available; replacement of the 10 Bit DAC with 12 Bit DAC in the preset and gain circuits; redesigning the PLL board; and devising techniques to cut the lock acquisition time, as well as investigating other PLL offset/converter IF frequency options.

In perspective, the system developed by ITS to extend the capabilities of the commercial receiver system represents a significant advance in computer-controlled remote receiver design in the 18-40 GHz region of the frequency spectrum.

The TAEMS is a versatile tool for measuring electromagnetic radiation. In order to use its potentialities, a set of applications programs had to be developed. Because of the practically infinite number of possible applications of TAEMS, the applications programs presently developed only scratch the surface of its potential.

Several programs have been written which can be useful in almost any situation. Also, two specific measurement scenarios have been devised and applications programs written for them. One of these measures rf hazards and the other electromagnetic interference at satellite receiver sites.

The most important of the general programs is GSCAN (see Appendix). The GSCAN program, which stands for General Scanning Program, allows the user to measure and display any portion of the spectrum he wishes from 10 kHz to 40 GHz. The program allows the user to specify what portion of the spectrum he wishes to see, the receiver settings required to use it, and the particular measurement techniques to use it. A user may look at one signal or a wide spectral range including many signals. By varying system settings for the antenna used, the direction to point at, bandwidth, etc., the analyzer may be optimized for any type of signal reception. The wide variety of measurement techniques also allows many types of real time analysis to be made. If one signal is being displayed, the user may have the computer calculate and display the signal's parameters. Just this one program greatly extends the uses of the automatic, computer-controlled spectrum analyzer over a manually operated spectrum analyzer. In addition, the general application category of programs includes such things as a plotting package that allows data to be displayed on a wide variety of graphs including polar coordinates, a direction finding program, spectrum occupancy measurement and analysis programs, antenna pattern measurement and plotting, and various geographic coordinate transformation programs.

The first specific scenario was developed to measure the electromagnetic radiation present at a particular site and analyze this data to determine whether the site has an actual or potentially dangerous level of radiation. The measurement part of this is done by three programs. The first of these measures the entire spectrum of interest (10 kHz to 18 GHz) repeatedly using various antennas and polarizations. This data is recorded on magnetic tape. Because the signals which are likely to pose the greatest threat are those on the site, the other two programs make more careful measurements of these emitters. These data are also recorded on tape. A variety of analysis and data reduction programs are available to produce a graphical display that represents an overall measure of the radiation for any specified band. These results can then be compared with allowable levels to determine if a hazard exists or not. Also included in the scenario are several utility programs to ease the bookkeeping required and to display the data for human interpretation if desired.

The second scenario involves measuring the electromagnetic environment at an actual or potential satellite receiver earth terminal and analyzing these data to determine if the signals present might cause interference to the satellite receiver. Again, there are three measurement programs. The first measures signals that might be received in an antenna's main beam. Special techniques are used to insure that TAEMS is measuring at its maximum sensitivity. This is done because even weak signals are potential interference sources. The second measurement program scans the horizon at different elevation settings looking for signals that might be received in a side lobe of the satellite receiver antenna. Because a signal must be stronger than a given level to be a potential interferer, the program can use less sensitive but more efficient measurement methods. A third program measures wide-band pulsed signals. Since these signals must be analyzed as a spectrum of frequencies rather than as a single frequency, this program records the entire spectrum of the signal. All of these measurement programs record their data on magnetic tape. Again, a variety of data analysis and reduction programs are provided. The analysis programs culminate in a program which models a satellite receiver. The measured data for a signal are input to the program. The analysis traces the signal through the receiver to determine whether it will cause interference or not. This program will also handle signal pairs to check for intermodulation interference. It will also handle the signal data representing an entire spectrum of data. Several preliminary programs in this scenario handle details such as making a file of the satellite receivers parameters for use by other programs, calculating a threshold level below which a signal is not a potential interferer, calculating a satellite's expected position, and measuring its actual radio position. There are also available bookkeeping and data display programs.

As mentioned before, these programs are only a beginning to using the full capabilities of the TAEMS. Further applications are now being planned and will probably continue to increase as long as the system is in use.

9. REFERENCES

Gardner, F. M. (1966), Phase-Lock Techniques, (John Wiley and Sons, New York).

Wakeman, P. (1977), Phase-locked loop sweep acquisition, Communications Research Centre Report No. 1305, Ottawa.

APPENDIX

EXAMPLE SOFTWARE AND PROGRAMMING DETAILED STRUCTURE

```
ASMB,L
      HED SOURC, NOISD, AND RATTN DOWNCONVERTER ROUTINES
      NAM SOURC,7
      ENT SOURC,RATTN,NOISD
      EXT .ENTR,EXEC,ERROR,MAST,SFACT
*
*************************************************
*
*                         29 JUNE 1978
*
*  CALL SOURC(I)
*  I IS AN INTEGER PARAMETER THAT SPECIES WHICH SOURCE DEVICE
*  (ANTENNA, COMB GENERATOR, OR NOISE DIODE) IS TO BE INPUT
*  FROM.
*
*  CALL RATTN(I) SETS THE REMOTE RF ATTENUATOR ON THE MAST.
*  I IS AN INTEGER THAT MUST BE 0 TO 70 DB IN INCREMENTS
*  OF 10.
*
*  CALL NOISD(I)
*  I IS AN INTEGER PARAMETER THAT TURNS THE NOISE DIODE
*  ON OR OFF.
*    I = 0 FOR OFF
*    I = 1 FOR ON
*
**********************************************
*
DEVIC NOP
SOURC NOP
      JSB .ENTR
      DEF DEVIC
      LDA MAST       ZERO THE CURRENT SOURCE BITS
      AND =B1777      IN THE DOWNCONVERTER STATUS WORD
      STA BUF
      LDA DEVIC,I    MASK DEVICE NUMBER TO 6 BITS
      AND B77
      ALF,ALF        SHIFT TO BIT POSITIONS 10-15
      RAL,RAL
      JSB OUTP       OUTPUT THE WORD
      JMP SOURC,I
*
OUTP  NOP
      IOR BUF        PUT BITS IN CURRENT WORD
      STA BUF         AND STORE.
      STA MAST       ALSO STORE IN MAST STATUS.
      JSB EXEC       CALL EXEC TO OUTPUT TO DEVICE
      DEF *+5
      DEF .2
      DEF .28
      DEF BUF
      DEF .3
      LDA BUF+1      CHECK FOR ERRORS
      AND =B177700   MASK OF EXTRA ERROR BITS
      XOR BUF
      SZA            IF NO MATCH, ERROR
      JMP ERR
      LDA BUF+2
      SLA,RSS
      JMP OUTP,I     ALL OK, SO RETURN
*
```

```
ERR    JSB ERROR
       DEF *+3
       DEF .3
       DEF ERMS
       JMP OUTP,I
*
*
*
ATTN   BSS 1
RATTN  NOP
       JSB .ENTR
       DEF ATTN
       LDA MAST         ZERO THE ATTN BITS IN THE CURRENT WORD
       AND =B176177
       STA BUF
       LDA ATTN,I       CONVERT THE ATTN TO 0-7
       CLB
       DIV .10
       AND =B7
       ALF,ALS          SHIFT TO BITS 7-9
       ALS,ALS
       JSB OUTP         AND OUTPUT
       JSB SFACT        UPDATE CORRECTION FACTORS
       JMP RATTN,I
*
*
*
ONOFF  BSS 1
NOISD  NOP
       JSB .ENTR
       DEF ONOFF
       LDA MAST         CLEAR THE ONOFF BIT
       AND =B177677
       STA BUF
       LDA ONOFF,I      MASK THE ONOFF PARAMETER
       AND .1
       ALF,ALS          SHIFT TO BIT 6
       ALS
       JSB OUTP         OUTPUT IT
       JMP NOISD,I
*
*  CONSTANTS AND STORAGE
*
.1     DEC 1
.2     DEC 2
.3     DEC 3
.10    DEC 10
.28    DEC 28
B77    OCT 77
BUF    BSS 3
ERMS   DEC 5
       ASC 3,SOURC
*
       END
```

```
ASMB,L
      HED AZEL - ROTATE ANTENNA MAST
      NAM AZEL,7
      ENT AZEL
      EXT .ENTR,EXEC,ERROR,CBD,IFIX,BUSY1
      EXT AZ,EL
*
*************************************************************
*
*                    23 APRIL 1979
*
*   CALL AZEL(AZIM, ELEV)
*   AZIM AND ELEV ARE FLOATING POINT NUMBERS SPECIFYING
*   THE DIRECTION TO POINT THE ANTENNA MAST.
*     0.0 .LE. AZIM .LE. +360.0
*     -5. .LE. ELEV .LE. +91.0
*
*   ERROR AZEL-2 IS FOR A PARAMETER OUT OF RANGE.
*   ERROR AZEL-5 MEANS THE HARDWARE IS UNABLE TO DO
*     THE OPERATION CALLED FOR.
*
*************************************************************
*
AZIM  NOP            ENTRY POINT AND
ELEV  NOP            ARGUEMENT PICKUP
AZEL  NOP            SEQUENCE
      JSB .ENTR
      DEF AZIM
      DLD AZIM,I     LOAD THE AZEMUTH VALUE
      FMP F10        MULT. BY TEN TO GET TENTHS
      JSB IFIX       CONVERT TO FIXED POINT NUMBER
*
*   CHECK FOR VALID RANGE AND NO ROTATION PAST STOPS
*
      LDB AZ         LOAD CURRENT AZIM FROM COMMON AREA
      SSB            IS THE CURRENT AZIM NEG.(-180<AZ<180)
      ADB .3600      YES, ADD 360.0 TO IT(180 TO 360)
      CMB,INB        TAKE THE NEG. OF THE CURRENT POS. AZIM
      ADB 0          ADD THE NEW AZIM
      SZB,RSS        ARE THE AZEMUTHS THE SAME
      JMP DOEL       YES GO DO ELEVATION THING
      STA 1          COPY NEW AZIM INTO THE B REG.
      SSB            IF AZIM NEGATIVE,
      JMP ERR1        ERROR.
      CMB,INB        GET NEG. OF NEW AZIM
      ADB .3600      ADD 360.0 TO IT
      SSB            IS THE NEW AZIM GREATER THAN 360.0
      JMP ERR1       YES, TAKE ERROR EXIT
      SZB,RSS
      CLA
      STA NEW        STORE THE NEW COMMAND ANGLE
      LDB AZ         LOAD CURRENT AZIM
      CMB,INB        TAKE THE NEG. OF THE CURRENT AZIM
      ADB 0          ADD THE NEW ANGLE
      STB DIF        SAVE AS ANGLE DIFFERENCE
      ADB .1800      ADD 180.0 TO THE DIF ANGLE
      SSB,RSS        IS THE DIF ANGLE LESS THAN -180.0
      JMP TSBIG      NO, GO DO MORE CHECKING
      LDB .3600      YES, GET 3600 CONSTANT
      ADB DIF        MAKE DIF ANGLE POS.
```

```
      STB DIF         AND RESET IT
      JMP TSEQ        GO TEST IF ANGLE EQUAL -180
TSBIG LDB M1800       GET NEG. 1800
      ADB DIF         ADD DIF ANGLE
      SSB             IS DIF ANGLE GREATER THAN +180.0
      JMP TSEQ        NO, GO TEST IF ANGLE = -180
      LDB M3600       YES, TAKE THE COMPLEMENT OF THE
      ADB DIF         ANGLE AND RESET
      STB DIF         DIF ANGLE THEN
      JMP TSBIG       GO CHECK ANGLE AGAIN
TSEQ  LDB DIF         LOAD DIF ANGLE (-180 TO 540)
      ADB .1800       ADD 180 TO DIF ANGLE
      SZB             IS THE DIF ANGLE -180
      JMP NT180       NO, GO PROCESS DIF ANGLE .GT. -180
      LDA AZ          LOAD CURRENT ANGLE
      SSA             IS IT NEG.
      JMP AZNEG       YES, GO MOVE MAST IN 90 DEGREE INCREMENTS
      ADA M900        SUBTRACT 90 FROM CURRENT ANGLE
      SSA             IS IT NEG
      ADA .3600       YES, TAKE THE COMPLIMENT
      JSB OUTP        GO MOVE THE MAST 90 DEGREES
      LDA NEW         GET NEW COMAND ANGLE
      JSB OUTP        MOVE MAST TO NEW ANGLE
      LDB AZ          GET OLD ANGLE VALUE
      ADB M1800       SUBTRACT 180 DEGREES
      STB AZ          SAVE AS NEW AZEMUTH ANGLE
      JMP DOEL        GO DO ELEVATION THING
*
AZNEG ADA .900        CURRENT AZEMUTH WAS NEG.
      SSA             IS IT LESS THAN -90 DEGREES
      ADA .3600       YES, TAKE THE COMPLIMENT OF THE ANGLE
      JSB OUTP        GO MOVE THE MAST 90 DEGREES
      LDA NEW         GET NEW ANGLE
      JSB OUTP        MOVE THE MAST TO THE NEW ANGLE
      LDB AZ          LOAD THE OLD ANGLE VALUE
      ADB .1800       INCREMENT IT BY 180
      STB AZ          RESTORE AS THE NEW ANGLE VALUE
      JMP DOEL        GO DO ELEVATION THING
*
NT180 LDA DIF         ANGLE WAS NOT -180 DEGREES
      SSA             IS DIF ANGLE NEG.
      JMP DIFNG       YES, GO HANDLE NEG. ANGLE
      ADA AZ          GET SUMM OF DIF AND CURRENT ANGLE
      STA 1           STORE SUM INTO B
      ADA M3600       SUBTRACT 360 DEGREES
      SSA             IS THE SUM .GE. 360 DEGREES
      JMP ROTAZ       NO, GO MOVE MAST TO THIS ANGLE
      LDA AZ          LOAD CURRENT ANGLE
      ADA M900        SUBTRACT 90 DEGREES
      JSB OUTP        MOVE MAST BY 90 DEGREES
      LDA AZ          LOAD CURRENT ANGLE
      ADA M1800       SUBTRACT 180 DEGREES
      JSB OUTP        MOVE MAST ANOTHER 90 DEGREES
      LDA NEW         GET NEW ANGLE
      STA AZ          SAVE AS CURRENT MAST ANGLE
      JSB OUTP        GO MOVE MAST TO NEW ANGLE
      JMP DOEL        GO DO ELEVATION THING
*
ROTAZ STB AZ          SET CURRENT ANGLE TO THE SUM (DIF+AZ)
      LDA NEW         GET NEW ANGLE
```

```
      JSB OUTP        GO MOVE MAST TO NEW ANGLE
      JMP DOEL        GO DO ELEVATION THING
*
DIFNG ADA AZ          THE DIF ANGLE WAS NEG.
      STA 1           ADD AZ AND SAVE IN B REG.
      ADA .3600       ADD 360 DEGREES
      SSA,RSS         IS ANGLE NOW NEG.
      JMP ROTAZ       NO, GO MOVE MAST TO ANGLE OF (DIF+AZ)
      LDA AZ          YES, LOAD CURRENT ANGLE
      ADA .900        ADD 90 DEGREES
      JSB OUTP        GO MOVE THE MAST 90 DEGREES
      LDA AZ          LOAD CURRENT ANGLE
      ADA .1800       ADD 180 DEGREES TO IT
      JSB OUTP        GO MOVE MAST ANOTHER 90 DEGREES
      LDA NEW         LOAD NEW ANGLE COMMAND
      JSB OUTP        MOVE MAST TO NEW ANGLE
      LDB NEW         LOAD NEW ANGLE
      ADB M3600       SUBTRACT 360 DEGREES
      STB AZ          AND SAVE AS CURRENT ANGLE
      JMP DOEL        GO DO ELEVATION THING
*
*  OUTPUT AZIMUTH ANGLE TO BUSS
*
OUTP  NOP             ENTRY POINT TO ACTUAL OUTPUT ROUTINE
      SSA             IS THE NEW ANGLE NEG.
      ADA .3600       YES, ADD 360 DEGREES TO IT TO MAKE POS.
      JSB CBD         CONVERT ANGLE TO BCD
      STA BUF         MOVE TO OUTPUT BUFFER
      JSB BUSY1       WAIT UNTIL BUSS NOT BUSY
      JSB EXEC        CALL EXEC FOR OUTPUT
      DEF *+5         RETURN ADDRESS FROM EXEC
      DEF .2          WRITE COMMAND
      DEF .27         LOGICAL UNIT
      DEF BUF         BUFFER ADDRESS
      DEF .3          BUFFER COUNT
      LDA BUF+2       GET THE STATUS
      SLA             ANY ERRORS?
      JMP ERR2        YES, GO PRINT ERROR
      LDA BUF+1       LOAD THE OUTPUT LATCHES
      XOR BUF         CHECK AGANST WHAT WAS SENT OUT
      SZA             ARE THEY THE SAME
      JMP ERR2        NO, GO PRINT ERROR
      JMP OUTP,I      RETURN FROM OUTPUT ROUTINE
*
*  ELEVATION ANGLE PROCESSING
*
DOEL  DLD ELEV,I      LOAD FLOATING POINT VALUE FOR ELEVATION
      FMP F10         MULT BY 10 TO GET TENTHS
      JSB IFIX        CONVERT TO FIXED POINT NUMBER
      STA 1           SAVE IN B REG
      CMB,INB         TAKE THE NEG. OF THE ANGLE
      ADB EL          ADD THE CURRENT ELEVATION ANGLE
      SZB,RSS         ARE THEY THE SAME
      JMP AZEL,I      YES,RETURN TO CALLING ROUTINE
      STA 1           NO, RESTORE B TO NEW ASNGLE
      ADB .50         CHECK IF LESS THAN -5 DEGREES
      SSB
      JMP ERR1        YES, PRINT ERROR MESSAGE AND RETURN
      STA 1
      ADB M910        CHECK ELEV NOT OVER +91.0
```

```
      SSB              IS IT .GT. 91
      JMP ELOK         NO,ELEVATION REQUEST OK
ERR1  JSB ERROR        PARAMETER OUT OF RANGE
      DEF *+3
      DEF .2
      DEF ERMS
      JMP AZEL,I
*
ELOK  SSA              CHECK IF ANGLE NEGATIVE
      ADA .3600        IF NEG, ADD 360 DEGREES
      STA EL           STORE AS PRESENT ELEV ANGLE
      JSB CBD          CONVERT TO BCD
      IOR =B40000      SET BIT TO INDICATE ELEVATION
      STA BUF          STORE IN OUTPUT BUFFER
      JSB BUSY1        WAIT UNTIL BUSS NOT BUSY
      JSB EXEC         OUTPUT TO DEVICE
      DEF *+5          RETURN ADDRESS FROM RTE
      DEF .2           WRITE COMMAND
      DEF .27          LOGICAL UNIT
      DEF BUF          BUFFER ADDRESS
      DEF .3           BUFFER WORD COUNT
      LDA BUF+2        LOAD THE STATUS FROM THE BUFFER
      SLA              ANY ERRORS
      JMP ERR2         YES GO PRINT AN ERROR MESSAGE
      LDA BUF+1        LOAD THE OUTPUT LATCHES
      XOR BUF          ARE THEY THE SAME AS
      SZA              OUTPUT COMAND WORD
      JMP ERR2         NO, GO PRINT ERROR MESSAGE
      JMP AZEL,I       NO ERRORS, RETURN
*
ERR2  JSB ERROR
      DEF *+3
      DEF .5
      DEF ERMS
      JMP AZEL,I
*
*  CONSTANTS AND STORAGE
*
M3600 DEC -3600
M1800 DEC -1800
M910  DEC -910
M900  DEC -900
.2    DEC 2
.3    DEC 3
.5    DEC 5
.20   DEC 20
.27   DEC 27
.50   DEC 50
.900  DEC 900
.1800 DEC 1800
.3600 DEC 3600
F10   DEC 10.
ERMS  DEC 4
      ASC 2,AZEL
DIF   NOP
NEW   NOP
BUF   BSS 3
*
      END
```

```
FTN4,L
      FUNCTION AGAIN(ISA, F)
C THE PURPOSE OF THIS FUNCTION IS TO COMPUTE THE GAIN
C OF AN ANTENNA SPECIFIED BY THE SOURCE ADDRESS "ISA"
C AS A FUNCTION OF FREQUENCY IN MEGAHERTZ.
C CABLE LOSSES ARE ALSO ESTIMATED FOR EACH ANTENNA.
C THE MODEL USED FOR ANTENNA GAIN IS
C AGAIN=B+M*LOG(F).
C
C  THE SUBROUTINE ALSO INCLUDES THE EXCESS NOISE RATIO OF
C  THE NOISE SOURCES. THESE ENR'S ARE FOR THE DOWNCONVERTER
C  SYSTEM # 3 ON VAN # 2.
C
C  SOURCE  S/N  FREQ RANGE        ENR
C    2     764  10K-30MHZ         25.5
C    7     264  10-2000MHZ        25.8
C    19    343  2 - 8 GHZ         25.8
C    26    343  3.7-4.2GHZ        25.7
C    33    343  7.25-7.75GHZ      25.9
C    49    337  8-18 GHZ          34.76-2.27*LOG(F)
C
      DIMENSION A0(64),A1(64)
      REAL LOGF,LOGF2
      DATA A0/-29.3,0.,25.5,-30.9,-30.9,-28.3,-28.3,25.8,
     1 23.9,23.9,0.,0.,0.,-30.4,-27.6,0.,-41.4,-41.3,
     2 6.9,25.8,0.,-40.4,-40.3,-41.4,-41.3,6.9,25.7,0.,
     3 -40.4,-40.3,-41.4,-41.3,6.9,25.9,0.,-40.4,-40.3,0.,
     4 0.,0.,0.,0.,0.,0.,0.,0.,-12.8,-6.9,16.9,34.76,
     5 0.,0.,-61.0,-61.0,0.,25.9,0.,0.,-58.0,-58.0,0.,
     6 21.6,0.,0./
      DATA A1/20.,0.,0.,20.,20.,18.2,18.2,0.,-8.1,-8.1,
     1 0.,0.,0.,20.,15.6,0.,20.,20.1,-2.3,0.,0.,
     2 20.,20.1,20.,20.1,-2.3,0.,0.,20.,20.1,20.,20.1,
     3 -2.3,0.,0.,20.,20.1,0.,0.,0.,0.,0.,0.,0.,0.,
     4 0.,9.67,8.40,-5.1,-2.27,0.,0.,18.5,18.5,0.,0.,0.,
     5 0.,17.3,17.3,0.,0.,0.,0./
C THE CABLE LOSSES(IN db/FT) FOR TIMES WIRE CO.
C SF-214 FROM 10-200 MHZ ARE ESTIMATED BY:
C -.01464+.0174*LOG(F)
C FROM .2-2 GHZ BY
C -.1513+.0752*LOG(F)
C AND FROM 2-8 GHZ BY:
C -.6094+.2139*LOG(F)
C THE CABLE LOSSES(IN dB/FT) FOR TIMES WIRE CO.
C SF-142B FROM 2-8 GHZ ARE ESTIMATED BY:
C -1.0349+.3647*LOG(F)
C AND FROM 8-18 GHZ BY:
C -2.4186+.7203*LOG(F)
C TOTAL ANTENNA CABLE LOSSES(IN dB) AS A
C FUNCTION OF FREQUENCY  ARE FOUND BY MULTIPLYING
C THE APROPRIATE EXPRESSON BY CABLE LENGTH AND
C AND SUMMING OVER CABLE TYPES IF NECESSARY
      LOGF=ALOGT(F)
      LOGF2=LOGF*LOGF
      AGAIN=A0(ISA+1)+A1(ISA+1)*LOGF
C FOR THE LOW FREQUENCY LOOPS & THE END FIRED
C COUPLET ONLY APPROXIMATE ANTENNA FACTOR DATA
C WAS AVAILABLE AS OF 11/27/77. ANTENNA GAIN
C WAS COMPUTED USING THE FOLLOWING EQUATION:
C GAIN=-29.8+20*LOG(F)-AF(dB). THIS EQUATION
```

```
C ASSUMES 377 & 50 OHMS RESPECTIVELY FOR THE
C FREE SPACE AND RECEIVER IMPEDANCES.
      AF=0.
      IF(ISA.EQ.0) AF=18.74-10.19*LOGF+3.39*LOGF2
      IF(ISA.EQ.3 .OR. ISA.EQ.4) AF=20.1-18.8*LOGF+12.2*LOGF2
      IF(ISA.EQ.5 .OR. ISA.EQ.6) AF=100.1- 88.4*LOGF+21.7*LOGF2
      IF(ISA.EQ.13 .AND. F.LE. .007) AF=-12.5-6.9*LOGF+1.87*LOGF
  2
      IF(ISA.EQ.13 .AND. F.GT. .007 .AND. F.LT. 40) AF=12.
      IF(ISA.EQ.13 .AND. F.GE. 40) AF=599.5-662.8*LOGF+185.5*LOG
  F2
      IF(ISA.EQ.14) AF=118.4-101.6*LOGF+23.1*LOGF2
      AGAIN=AGAIN-AF
      RETURN
      END
      END$
```

```
ASMB,L
      HED RFCON - READ OR MODIFY RF CONSTANTS
      NAM RFCON,7
*
***********************************************************
*
*                    16 AUGUST 1978
*        READ OR MODIFY RF CONSTANTS
*
*        CALL RFCON(ADDR, VALUE)
*          ADDR = THE NUMBER OF THE RF CONSTANT
*                POSITIVE IF READING CONSTANT
*                NEGATIVE IF WRITING CONSTANT
*          VALUE = RETURNS THE VALUE OF THE CONSTANT IF
*                  READING OR THE VALUE TO PUT IN THE CONSTANT
*                  IF WRITING
*
*      CAUTION: CHANGING THE VALUE OF THE RF CONSTANTS IN THE
*      SYSTEM AREA CAN OFTEN CAUSE SUBTLE ERRORS. THIS
*      SUBROUTINE SHOULD BE USED WITH CAUTION.
*
***********************************************************
*
      ENT RFCON
      EXT .ENTR,AFRQ
ADDR  NOP
VALUE NOP
RFCON NOP
      JSB .ENTR
      DEF ADDR
*  RESOLVE ANY INDIRECTS IN THE ADDRESS OF AFRQ
      LDA SADDR       GET THE ADDRESS OF AFRQ
IND   SSA,RSS         INDIRECT BIT SET?
      JMP GO          NO, GO AHEAD
      AND =B77777     YES, GET RID OF INDIRECT BIT
      LDA 0,I         LOAD FROM THAT ADDRESS
      JMP IND         TRY IT AGAIN
GO    STA SADDR       STORE AWAY THE GOOD ADDRESS
*  IS IT A LOAD OR A STORE
      LDA ADDR,I
      SSA
      JMP STORE
*  LOAD
      ADA M1          CALCULATE ADDR = ADDR + AFRQ - 1
      ADA SADDR
      LDB 0,I         GET THE VALUE
      STB VALUE,I     PASS IT BACK
      JMP RFCON,I     RETURN
*  STORE
STORE CMA             CALCULATE ADDR = ADDR + AFRQ - 1
      ADA SADDR
      LDB VALUE,I     GET THE VALUE TO STORE
      STB 0,I         STORE IT IN RF CONSTANT AREA
      JMP RFCON,I     RETURN
M1    DEC -1
SADDR DEF AFRQ
      END
      END$
```

```
FTN,L
      PROGRAM KALND
C
C               03 APRIL 1979
C
C  THIS PROGRAM CALIBRATES THE DOWNCONVERTERS.
C  MEASUREMENTS ARE MADE OF THE NOISE DIODES THROUGH THE
C  DOWNCONVERTERS. FOR EACH BAND ABOVE 2 GHZ, LINEAR
C  CORRECTION FACTORS (CONSISTING OF AN OFFSET AND SLOPE)
C  ARE CALCULATED. THESE ARE STORED IN THE BAND TABLE.
C  THIS CALIBRATION WILL TAKE INTO ACCOUNT ALL DOWNCONVERTER
C  AND ARS400 FACTORS ASSOCIATED WITH THE BAND FROM THE
C  NOISE DIODE DOWN.  ANY ANTENNA GAIN OR LINE LOSS FROM THE
C  ANTENNA TO THE DOWNCONVERTER PORT IS NOT CALIBRATED HERE.
C
      DIMENSION P1(200),CF(200),FREQS(5),ISA(10),SLOPE(10),
     1  Y0(10),IEQ(40),F8555(10)
      EQUIVALENCE (SLOPE,IEQ),(IEQ(21),Y0)
C F8555 ARE THE START FREQUENCIES FOR THE 1-,1+,2-,2+,3-,
C 5+,6-,10+,10-,10+ HARMONIC BANDS.
      DATA F8555/1500.,2600.,3550.,4650.,5600.,10800.,11750.,
     1  21050.,19950.,21050. /,
     2  ISA/19,49,55,61/,
     3  C1/4.342944819/,
     4  FREQS/2000.,8000.,18000.,26500.,40000./
C
C  SET UP THE ANALYZER
C
      CALL ARSET
      CALL ALGRS(2)
      CALL ATTEN(0)
      CALL BWDTH(100.)
      CALL GAIN(30)
      CALL PORTS(5,1,3)
      CALL VIDEO(1)
5     DO 110  IB = 1, 10
C
C  ZERO OUT THE CURRENT BAND CORRECTION FACTORS
C
      CALL RFCON(-206 - 9 * IB, 0)
      CALL RFCON(-207 - 9 * IB, 0)
      CALL RFCON(-208 - 9 * IB, 0)
 110  CALL RFCON(-209 - 9 * IB, 0)
      JBND=1
      DO 500 IB=1,2
C IF 18-40 GHZ DOWNCONVERTERS USED CHANGE INDEX LIMIT TO 4
      CALL CLEAR(0)
      F1 = FREQS(IB)
      F2 = FREQS(IB + 1)
      WRITE(1,120)
 120  FORMAT(14X,"CONVERTER CORRECTION FACTOR")
      CALL SCALE(F1,F2,-10.,10.)
      CALL SAXES(.1*(F2-F1),1.)
      CALL VECT(1,0,126,480)
      CALL VECT(2,3,896,480)
      CALL FTUNE(F1)
      CALL SOURC(ISA(IB))
      CALL RATTN(0)
      CALL NOISD(0)
      DF=(F2-F1)/201.
```

```
      SUM0=0.
      SUM1=0.
      SUM2=0.
      SUM3=0.
C AVERAGE 100 MEASUREMENTS
      CALL DIGSU(0,-100,0.,10.)
C MEASURE NOISE POWER WITH NOISE DIODE OFF
      DO 150 I=1,200
      F=F1+I*DF
      CALL FTUNE(F)
      CALL DIGGO(A,PEAKP,PEAKM)
      P1(I)=EXP(A/C1)
150   CONTINUE
      CALL NOISD(1)
C TURN NOISE DIODE ON AND MEASURE NOISE DIODE POWER
      CALL FTUNE(F1)
      DO 250 I=1,200
      F=F1+I*DF
      CALL FTUNE(F)
      CALL DIGGO(A,PEAKP,PEAKM)
      P2 =EXP(A/C1)
C GET EXCESS NOISE RATIO FROM FUNCTION AGAIN(ISA,F)
      ENR = AGAIN(ISA, F)
C COMPUTE EXCESS NOISE TEMPERTURE FROM ENR
      TEX=EXP(ENR/C1)
C COMPUTE NOISE POWER OUTPUT OF NOISE DIODE FOR 100 KHZ
C BANDWIDTH,AND APPLY SAME CORRECTIONS AS APPLIED TO P2
C AND P1(I).
      PCAL=COREC(IADCR(10.*ALOGT(4.42E-13*TEX) ) )
C COMUTE CORRECTION FACTOR AT EACH FREQUENCY.
C 2.5 dB ACCOUNTS FOR EFFECT OF LOG AMPLIFICATION AND
C ENVELOPE DETECTION.
      CF(I)=10.*ALOGT(P2-P1(I) )-(PCAL-2.5)
      FGHZ=.001*(F-F1)
      SUM0=SUM0+CF(I)
      SUM1=SUM1+FGHZ
      SUM2=SUM2+CF(I)*FGHZ
      SUM3=SUM3+FGHZ*FGHZ
250   CONTINUE
      D=200.*SUM3-SUM1*SUM1
C COMPUTE GAIN SLOPE FOR THE DOWNCONVERTER.
      SLOPET=(200.*SUM2-SUM0*SUM1)/D
C COMPUTE GAIN OF DOWNCONVERTER @ DOWNCONVERTER START
C FREQUENCY ,F1.
      Y0T = (SUM0*SUM3 - SUM2*SUM1)/D
      IEND=2
      IF(IB.EQ.1) IEND=4
      DO 320 I=1,IEND
      SLOPE(JBND)=SLOPET
C COMPUTE DOMWNCONVERTER GAIN @ 8555 BAND EDGE
      Y0(JBND)=Y0T+SLOPET*.001*(F8555(JBND)-F1)
320   JBND=JBND+1
      SIGMA=0.
      CALL BLOCK(IB2)
      DO 400 L=1,200
      F=F1+(L-1)*DF
      FGHZ=.001*(F-F1)
C COMPUTE DEVIATION OF CORRECTION FACTOR FROM LINEAR ESTIMATE
      R=CF(L)-(Y0T+FGHZ*SLOPET)
      SIGMA=SIGMA+R*R
```

```
ASMB,L
      HED SINIT - SYSTEM INITIALIZATION
      NAM SINIT,3,1
*
*               8 MAY 1979
*
*  THIS PROGRAM RUNS WHENEVER THE SYSTEM IS BOOTED UP. IT
*  INITIALIZES SOME OF THE CONSTANTS IN THE HIGH AREA OF
*  THAT ARE NECESSARY TO RUN THE ARS-400.
*  IF BIT 15 IN THE S-REGISTER IS SET AT BOOTUP, THE
*  SECTION INITIALIZING THE AZEL POSITIONER IS SKIPPED.
*  THE S-REGISTER IS ALWAYS CLEARED AFTERWARDS.
*
*   BANDS TABLE VALID FOR VAN 2.
*
*
      EXT BNDS,ABNDS,AFRQ,AAFRQ,ANFRQ,ASTP,ADUMM,ADUM
      EXT ACTBL,ABWOF,ADTBL,ASTPP,ADIGP,ASTAT,AZ,EL
      EXT EXEC,AXSEL,ADCIN,AMEAS,BUSY1,CBD,FLOAT,IFIX
START NOP
      JSB MEMST      INITIALIZE ADDRESSES
*  INITIALIZE THE BNDS TABLE
      LDB M109       GET THE COUNTER
      STB CNTR       AND STORE IT
      LDB BNDS       GET THE ADDRESS OF THE BNDS TABLE
      STB ADDR       AND STORE IT
      LDB CBNDS      THE ADDRESS OF THE CONSTANTS GOES IN B-REG
ALOOP LDA 1,I        GET THE NEXT VALUE
      STA ADDR,I     STORE IT IN BNDS TABLE
      INB            INCREMENT ADDR IN CONSTANTS
      ISZ ADDR       INCREMENT ADDR IN BNDS
      ISZ CNTR       INCREMENT COUNTER
      JMP ALOOP      IF MORE, LOOP
*
      LIA 1          CHECK UPPER BIT OF S
      SSA,RSS        IF SET, SKIP AZEL INIT
      JSB AZLST
      CLA            ALWAYS SET S-REG TO ZERO
      OTA 1
*  STOP
      JSB EXEC       IF DONE, ASK FOR TERMINATION
      DEF *+3
      DEF .6
      DEF ZERO
*
*   CONSTANTS
*
CBNDS DEF DBNDS
DBNDS DEC -12
      DEC 0
      DEC 9
      DEC 2
      DEC 10
      DEC 50
      DEC -3.0566965
      DEC 0.
      DEC 10
      DEC 1999
      DEC 1
      DEC 2
```

```
400    CALL PLOT(F,R,3)
       SIGMA=SIGMA/200.
       VS=200.*SIGMA/D
       VY0=SIGMA*SUM3/D
       WRITE(1,475) Y0T,VY0,SLOPET,VS,SIGMA
475    FORMAT(8X,"GAIN(dB)=",F7.4,14X,"VARIANCE=",E9.6,/,
      1 8X,"GAIN SLOPE(dB/GHz)=",F7.4,4X,"VARIANCE=",E9.6,/,
      2 8X,"STD DEVIATION=",E9.6)
       WRITE (1, 45)
45     FORMAT("Press MARK to continue")
       I = 0
       CALL CRPOS(IX, IX, I)
500    CONTINUE
       DO 600 IB=1,6
       CALL RFCON(-206 - 9 * IB, IEQ(2 * IB + 19))
       CALL RFCON(-207 - 9 * IB, IEQ(2 * IB + 20))
       CALL RFCON(-208 - 9 * IB, IEQ(2 * IB - 1))
       CALL RFCON(-209 - 9 * IB, IEQ(2 * IB))
600    CONTINUE
       CALL CLEAR(0)
       WRITE(1,650)
650    FORMAT("SET SENSE SWITCH 1 TO UP POSITION TO REPEAT")
       WRITE(1,45)
       I=0
       CALL CRPOS(IX,IX,I)
       CALL SSW(1,M1)
       IF(M1.NE. 0) GO TO 5
 700   CALL ARSET
       CALL STOP
       END
       END$
```

```
DEC 2050
DEC 0.
DEC -.8254824
DEC 2000
DEC 2999
DEC 1
DEC 0
DEC 550
DEC 22.5
DEC 0.
DEC 3000
DEC 4599
DEC 1
DEC 1
DEC -550
DEC 22.5
DEC 0.
DEC 4600
DEC 5999
DEC 2
DEC 14
DEC 550
DEC 22.5
DEC 0.
DEC 6000
DEC 7999
DEC 2
DEC 15
DEC -550
DEC 22.5
DEC 0.
DEC 8000
DEC 10999
DEC 3
DEC 8
DEC 550
DEC 24.
DEC -.3
DEC 11000
DEC 17999
DEC 5
DEC 5
DEC -550
DEC 23.1
DEC -.3
DEC 18000
DEC 21999
DEC 6
DEC 12
DEC 550
DEC 22.5
DEC 0.
DEC 22000
DEC 26499
DEC 10
DEC 7
DEC -550
DEC 22.5
DEC 0.
DEC 26500
```

```
       DEC 31999
       DEC 10
       DEC 6
       DEC 550
       DEC 22.5
       DEC 0.
       DEC 32000
       DEC 32767
       DEC 10
       DEC 7
       DEC -550
       DEC 22.5
       DEC 0.
*
.3600  DEC 3600
.900   DEC 900
.360   DEC 360.
.1748  DEC 0.174805
.27    DEC 27
.15    DEC 15
.10    DEC 10.
.6     DEC 6
.3     DEC 3
.2     DEC 2
ZERO   NOP
M109   DEC -109
CNTR   NOP
ADDR   NOP
*
*  MEMST INITIALIZES SOME ADDRESSES IN SYSTEM PARAMETER AREA
*
MEMST  NOP
       LDA CN02
       AND =B77777
       LDB 0,I
       LDA CN03
       STA CNTR
LOOP   LDA CNTR,I
       SZA,RSS
       JMP MEMST,I
       AND =B77777
       LDA 0,I
       STA 1,I
       INB
       ISZ CNTR
       JMP LOOP
CN03   DEF CN01
CN02   DEF AFRQ
CN01   DEF AAFRQ
       DEF ANFRQ
       DEF ASTP
       DEF ADUMM
       DEF ADUM
       DEF ACTBL
       DEF ABNDS
       DEF ABWOF
       DEF ADTBL
       DEF ASTPP
       DEF ADIGP
       DEF ASTAT
```

```
        NOP
*
*   AZLST INITIALIZES THE AZEL PEDISTAL
*   THE APPROXIMATE AZIMUTH POSITION IS INPUT. THE AZEL MOUNT
*   IS THE DIRECTED TO GO TO THAT AZIMUTH AND TO AN ELEVATION
*   OF ZERO. THE NOW KNOWN POSITION OF THE PEDISTAL IS
*   STORED IN THE SYSTEM PARAMETER AREA.
*
AZLST   NOP
        JSB AXSEL
        DEF *+2
        DEF .2
        JSB ADCIN
        DEF *+2
        DEF .2
        JSB AMEAS
        JSB FLOAT
        FMP .1748        4090X=720,X=.1748
        FSB .360
        FMP .10
        JSB IFIX
        SSA
UP90    ADA .900
        STA AZ
        SSA
        ADA .3600
        JSB CBD
        JSB SENDR
        LDA AZ
        SSA
        JMP UP90
        CLA
        STA EL
        IOR =B40000
        JSB SENDR
        JSB AXSEL
        DEF *+2
        DEF ZERO
        JSB ADCIN
        DEF *+2
        DEF ZERO
        JMP AZLST,I
SENDR   NOP
        STA CNTR
        JSB BUSY1
        JSB EXEC
        DEF *+5
        DEF .2
        DEF .27
        DEF CNTR
        DEF .3
        JMP SENDR,I
        END START
```

```
FTN,L
      PROGRAM GSCAN
C
C                    11 SEPTEMBER 1978
C
      DIMENSION A(151),B(151),M(3)
      CALL TRAP(5)
      GO TO 90
10    NUMPTS = 151
      CALL ARSET
      CALL AXSEL(0)
      CALL CLEAR(0)
      IP8=-1
      WRITE(1,2)
2     FORMAT(//,29X,"GSCAN",/
     1 20X,"GENERAL SCANNING PROGRAM")
C*********SPECIFY HARDWARE PARAMETERS*********
501   WRITE (1,8)
8     FORMAT (5/,20X,"ANTENNA NUMBER FOR SOURCE? ←")
      CALL BELL
      READ (1,*) ISOURC
505   WRITE(1,510)
510   FORMAT(2/,20X,"MAX INPUT LEVEL(dBm)? ←")
      CALL BELL
      READ(1,*) IMAX
      IF(IP8  .GT.  0)GO TO 500
517   WRITE (1,9)
9     FORMAT (2/,20X,"ANTENNA POINTING AZIMUTH? ←")
      CALL BELL
      READ (1,*) AZ
      WRITE (1,11)
11    FORMAT (2/,20X,"ANTENNA POINTING ELEVATION? ←")
      CALL BELL
      READ (1,*) EL
      CALL AZEL (AZ, EL)
      IF (IP8  .LE.  0) GO TO 523
C*******************REDEFINE SCAN PARAMETER*****************
500   CALL CLEAR(0)
      WRITE(1,599)
599   FORMAT(5/,15X,"SPECIFY PARAMETERS"
     +        " TO BE REDEFINED",/
     +        15X,"1. ANTENNA SOURCE",/
     +        15X,"2. MAX. INPUT SIGNAL LEVEL",/,
     +        15X,"3. ANTENNA POINTING DIRECTION",/
     +        15X,"4. START AND STOP FREQUENCIES",/
     +        15X,"5. PRESELECTOR",/,
     +        15X,"6. I.F. BANDWIDTH",/
     +        15X,"7. MEASURED (DETECTOR) TYPE",/
     +        15X,"8. DISPLAY LOGIC MODE",/
     +        15X,"9. NO CHANGES: EXECUTE PROGRAM",/,/
     +        15X,"10. STOP PROGRAM ? ←",/,/
     +        15X,"PARAMETER? ←")
      CALL BELL
      READ(1,*)IP9
      IF (IP9  .EQ.  10) CALL STOP
      IF(IP9  .LE.  0  .OR.  IP9  .GT.  9)GO TO 500
      IP8 = 1
      CALL CLEAR(0)
      GOTO (501, 505, 517, 523, 536, 534, 12, 20, 522),IP9
522   IP9 = -1
```

```
      GO TO 540
523   CALL CLEAR(0)
      WRITE(1,525)
525   FORMAT(10/,20X,"START FREQUENCY (MHz)? ←")
      CALL BELL
      READ(1,*)F1
      WRITE(1,530)
530   FORMAT(20X,"STOP FREQUENCY (MHZ)? ←")
      CALL BELL
      READ(1,*)F2
533   IF(IP8  .GT.  0)GO TO 500
536   CALL CLEAR(0)
      WRITE (1, 537)
537   FORMAT(5X,"PRESELECTOR OFF (TYPE 0) OR ON (TYPE 1)? ←")
      CALL BELL
      READ (1, *) IPRSEL
      CALL PRSEL(IPRSEL)
      IF (IP8 .GT. 0)  GOTO 500
534   WRITE(1,535)
535   FORMAT(2/,5X,"I.F. BANDWIDTH (KHZ) [0 TO AUTO-RANGE]",
     1 "? ←")
      CALL BELL
      READ(1,*)BANDW
540   IF(BANDW  .EQ.  0) CALL BWATR(F2,F1,NUMPTS, BANDW)
      CALL TUNE(F1)
      STP = 1000.*(F2-F1)/(NUMPTS-1)
      IF (IP8 .GT. 0)  GOTO 42
12    CALL CLEAR(0)
      WRITE(1,13)
13    FORMAT(5/,15X,"SELECT MEASUREMENT TYPES",/
     +         15X,"1. INSTANTANEOUS AMPLITUDE",/
     +         15X,"2. MEAN AMPLITUDE",/
     +         15X,"3. PEAK AMPLITUDE",/
     +         15X,"4. TRUE RMS AMPLITUDE (DBM)",/
     +         15X,"5. TRUE RMS AMPLITUDE (MW)",/
     +         15X,"6. TRUE RMS AMPLITUDE(U-VOLTS)",/
     +         15X,"7. PEAK-AVERAGE AMPLITUDE(DB)",/
     +         15X,"8. MAX-MIN AMPLITUDE (DB)",/
     +         15X,"9. MINIMUM AMPLITUDE (DBM)",/,/
     +         15X,"TYPE? ←")
      CALL BELL
      READ(1,*)MESTYP
      WRITE(1,14)
14    FORMAT(2/)
      IADCIN = 3
      IF (MESTYP .NE. 3)  IADCIN = 2
      CALL ADCIN(IADCIN)
      IF(MESTYP  .GT.  1)GO TO 15
      TIMEAS=0.0
      GO TO 20
15    MESTYP=MESTYP-1
      CALL BELL
      IF(MESTYP  .GE.  3  .AND.  MESTYP  .LE.  5)GO TO 18
      WRITE(1,16)
16    FORMAT(15X,"MEASURE TIME(MSEC)? ←")
      READ(1,*)TIMEAS
      IP2=1
      IF(IP8  .GT.  0)GO TO 500
      GOTO 20
18    WRITE(1,1000)
```

```
1000  FORMAT(15X,"NUMBER OF MEASUREMENTS? ←")
      READ(1,*)TIMEAS
      IF(IP8  .GT.  0)GO TO 500
C*******************LOGIC TEST ENTRY POINT*****************
C*************L9 IS MOVING AVERAGE LOGIC FLAG*************
20    L9=-1
      CALL CLEAR(1)
      WRITE(1,25)
25    FORMAT(5/,15X,"SELECT DATA DISPLAY LOGICS:",/,/
     +       15X, "1. INDEPENDENT SCANS",/
     +       15X, "2. CUMULATIVE AVERAGE OF SCANS",/
     +       15X, "3. MOVING AVERAGE OF SCANS",/
     +       15X, "4. CUMULATIVE PEAK VALUES",/,/
     +       15X, "DISPLAY TYPE? ←")
      CALL BELL
      READ(1,*)L
      CALL CLEAR(1)
      N1=1000
      IF(L  .LE.  2)GO TO 40
C*******************MOVING AVERAGE******************
      IF(L  .EQ.  3)GO TO 30
      L=3
      GO TO 40
C*******************MOVING AVERAGE******************
30    WRITE(1,35)
35    FORMAT(15/,15X,"AVERAGE OF HOW MANY SCANS? ←")
      READ(1,*)N1
      L=2
      L9=1
40    IF(IP8  .GT.  0)GO TO 500
C*******************RESTART ENTRY POINT******************
42    CALL TTAB(IMAX, ISOURC, IPRSEL, ITT)
43    CALL SPECG(ITT,MESTYP,P,F1,F2,NUMPTS,JB1)
      IT9=0
      CALL SRSET
      CALL SCNBW(BANDW,0)
      DO 70 N=1,N1
      CALL CLEAR(1)
      IF1 = F1
      CALL SCNFQ(FLOAT(IF1), 1E6 * (F1 - IF1), STP)
      CALL SCNMS(MESTYP,TIMEAS,IP2,1.0)
      CALL SDATA(A,NUMPTS)
      CALL DLYBW
      CALL NSCAN(N,1,L)
      IF(IT9  .NE.  5)GO TO 44
      IMAX = IMAX + 10
      GO TO 42
44    IF(L9  .GT.  0  .AND.  N  .EQ.  N1) N=N1-1
      CALL SSW(1,IZ)
      IF(IZ  .EQ.  0)GO TO 63
C********REPLACE RAW DATA W/ SMOOTHED DATA*****************
      NAVG=5
      CALL ASMTH(A,1,B,1,NUMPTS,NAVG)
      CALL BLOCK (JB2)
      DO 45 IR=1,NUMPTS
      CALL PLOT(FLOAT(IR),B(IR),2)
45    CONTINUE
      CALL SIGBW(B,1,NUMPTS,10.0,F8,F9)
      B5=(F9-F8)*STP
      IF(B5  .LT.  1000.0) GO TO 595
```

```
      B5 = B5 / 1000.
      WRITE(1,56) B5
56    FORMAT(3/,20X,"-10 DB BW (MHZ) = ",F9.3)
      GO TO 59
595   WRITE(1,58)B5
58    FORMAT(3/,20X,"-10 DB BW (KHZ) = ",F7.3)
59    F5=F1+(STP/1000.)*((F8+F9)/2.-1.)
      WRITE(1,60)F5
60    FORMAT(20X,"CENTER OF FREQUENCY (MHZ) = ",F9.3)
      B5 = 100.0
      CALL SIGBW(B,1,NUMPTS,B5,F6,F7)
      B5 = INT(10. * B5 + .5)/ 10.
      WRITE(1,61) B5
61    FORMAT(20X,"S/N RATIO (DB) = ",F4.0,/)
      PAUSE
      GO TO 43
63    CALL MVPTR(JB1, 1)
      CALL SSW(2, IS)
      IF (IS .EQ. 0)  GOTO 64
      IS = 0
      CALL SCPOS(X, Y, IS)
      X = F1 + (F2 - F1) * X / NUMPTS
      CALL PEAK(.999 * X, 1.001 * X, X, A)
      CALL TUNE(X)
      WRITE (1, 65) X
65    FORMAT(3/,"FREQUENCY IS",F10.3)
      IS = 0
      CALL SCPOS(X, Y, IS)
      CALL CLEAR(1)
64    CALL SSW(7, IS)
      IF(IS .NE. 0) GOTO 42
      CALL SSW(8, IS)
      IF(IS .NE. 0) GOTO 500
70    CONTINUE
      GO TO 42
C*******************TRAP 5 FLAG-SET******************
90    IT9 = 5
      CALL RTRAP
      CALL STOP
      END
      SUBROUTINE BWATR(F2,F1,NUMPTS, BANDW)
C*********THIS IS A SUBROUTINE TO SET BANDWIDTH AUTO-RANGE***
      DIMENSION B9(11)
      DATA B9/3000.,300.,100.,30.,10.,3.,1.,.3,.1,.03,.01/
      BANDW = 3000.
      S = 1000.*(F2-F1)/(NUMPTS-1)
      DO 20 I=1,11
      IF (B9(I) .GT. .8 * S)  BANDW = B9(I)
20    CONTINUE
      RETURN
      END
      SUBROUTINE SPECG(ITT,MESTYP,TIMEAS,F1,F2,NUMPTS,JB1)
C*********THIS SUBROUTINE WILL DEFINE THE SPECTRUM GRAPHICS.****
  ****
      DIMENSION IBUF(40)
      CALL CLEAR(0)
      CALL VECT(1,0,128,1016)
      CALL CODE
      WRITE(IBUF,1)
1     FORMAT("SSW 1: SMOOTH DATA AND MEASURE SIGNAL ")
```

```
      CALL LABEL(19, IBUF)
      CALL VECT(1,0,128,984)
      CALL CODE
      WRITE(IBUF,5)
5     FORMAT("SSW 7: RESTART SCAN SEQUENCE")
      CALL LABEL(14,IBUF)
      CALL VECT(1,0,128,952)
      CALL CODE
      WRITE(IBUF,10)
10    FORMAT("SSW 8: REDEFINE SCAN CONDITIONS ")
      CALL LABEL(16,IBUF)
      Y1 = ITT - 70
      Y2 = ITT
      Y3 = 10.0
      IF(MESTYP  .GE.  1  .AND.  MESTYP  .LE.  3)GO TO 45
      IF(MESTYP  .EQ.  8)GO TO 45
      Y1 = 0.0
      IF(MESTYP  .GE.  5  .AND.  MESTYP  .LE.  7)GO TO 15
      CALL ASCAL(1,Y2,1,1)
      GO TO 20
15    IF(MESTYP  .GE.  6  .AND.  MESTYP  .LE.  7)GO TO 35
      CALL ASCAL(2,Y2,1,1)
20    Y = 1E-10
      IY0 = 1
25    IY0 = (2.6*IY0)
      IF(IY0  .LT.  10)GO TO 30
      IY0 = 1
      Y = Y*10.0
30    IF(Y  .LT.  (IY0*Y2))GO TO 25
      Y2 = Y
      Y3 = Y2/10.0
      GO TO 45
35    IF(MESTYP  .EQ.  7)GO TO 40
      Y2 = 20.0
      Y3 = 5.0
      GO TO 45
40    Y2 = 50.0
      Y3 = 10.0
45    CALL SCALE (F1,F2,Y1,Y2)
      CALL SAXES((F2-F1)/10.0,Y3)
      ANUMPT = NUMPTS
      CALL SCALE(1.,ANUMPT,Y1,Y2)
      CALL VECT(1,0,415,16)
      CALL CODE
      WRITE(IBUF,47)
47    FORMAT("FREQUENCY, MHZ")
      CALL LABEL(7,IBUF)
      IF (MESTYP .EQ. 1 .AND. TIMEAS .EQ. 0)  GOTO 51
      GOTO (53, 55, 57, 57, 57, 63, 65, 67)  MESTYP
51    CALL VECT(1,0,48,592)
      CALL CODE
      WRITE(IBUF,52)
52    FORMAT("INST")
      CALL LABEL(2,IBUF)
      GO TO 69
53    CALL VECT(1,0,48,592)
      CALL CODE
      WRITE(IBUF,54)
54    FORMAT("MEAN")
      CALL LABEL(2,IBUF)
```

```
      GO TO 69
55    CALL VECT(1,0,54,592)
      CALL CODE
      WRITE(IBUF,56)
56    FORMAT("PEAK")
      CALL LABEL(2,IBUF)
      GO TO 69
57    CALL VECT(1,0,54,592)
      CALL CODE
      WRITE(IBUF,58)
58    FORMAT("RMS ")
      CALL LABEL(2,IBUF)
      GO TO 69
63    CALL VECT(1,0,16,592)
      CALL CODE
      WRITE(IBUF,64)
64    FORMAT("PK-AVG")
      CALL LABEL(3,IBUF)
      GO TO 69
65    CALL VECT(1,0,32,592)
      CALL CODE
      WRITE(IBUF,66)
66    FORMAT("PK-PK ")
      CALL LABEL(3,IBUF)
      GO TO 69
67    CALL VECT(1,0,48,592)
      CALL CODE
      WRITE(IBUF,68)
68    FORMAT("MIN.")
      CALL LABEL(2,IBUF)
69    CALL VECT(1,0,48,560)
      CALL CODE
      WRITE(IBUF,70)
70    FORMAT("AMPL")
      CALL LABEL(2,IBUF)
      GO TO (71,71,71,73,75,77),MESTYP
71    CALL VECT(1,0,54,528)
      CALL CODE
      WRITE(IBUF,72)
72    FORMAT("dBm ")
      CALL LABEL(2,IBUF)
      GO TO 80
73    CALL VECT(1,0,54,528)
      CALL CODE
      WRITE(IBUF,74)
74    FORMAT("mW")
      CALL LABEL(1,IBUF)
      GO TO 80
75    CALL VECT(1,0,54,528)
      CALL CODE
      WRITE(IBUF,76)
76    FORMAT("µV")
      CALL LABEL(2,IBUF)
      GO TO 80
77    CALL VECT(1,0,54,528)
      CALL CODE
      WRITE(IBUF,78)
78    FORMAT(,"dB")
      CALL LABEL(1,IBUF)
80    CALL BLOCK(JB1)
```

```
C*******************END OF SPECTRUM GRAPHICS****************
      RETURN
      END
      SUBROUTINE TTAB(MAX, ISOURC, IPRSEL, ITT)
C
C  SET THE ATTENUATION AND GAIN FOR TOP OF TABLE.
C  SET SOURCE AND PORTS.
C  IF ISOURC = 13, THEN USE PORT 6.
C  IF ISOURC = 14, THEN USE PORT 7.
C  IF ANY OTHER ISOURC, THEN USE PORT 5.
C  IF ISOURC < 15 THEN USE 85801 ATTENUATORS ELSE USE
C  REMOTE ATTENUATORS
C
      CALL RNDUP(MAX, ITT)
      ISCR = MAX
      IF (ISOURC .GT. 15) GOTO 110
      IF (IPRSEL .NE. 0)  ISCR = ISCR + 21
      GOTO 120
110   ISCR = ISCR + 22
      IF (ISOURC.GE.23.AND.ISOURC.LE.36) ISCR = ISCR + 35
120   CALL RNDUP(ISCR, ISCR)
      IGAIN = 20
      IATTEN = ISCR + IGAIN + 10
130   IF (IATTEN .GE. 0)  GOTO 140
      IATTEN = IATTEN + 10
      IGAIN = IGAIN + 10
      IF (IGAIN .LT. 50)  GOTO 130
      IATTEN = 0
      GOTO 150
140   IF (IATTEN .LE. 70)  GOTO 150
      IATTEN = IATTEN - 10
      IGAIN = IGAIN - 10
      IF (IGAIN .GT. 0)  GOTO 140
      IF (IATTEN .EQ. 70)  GOTO 150
      IATTEN = 70
      CALL CLEAR(0)
      WRITE (1, 10)
10    FORMAT("WARNING - CANNOT ADJUST ANALYZER FOR",/,
     1 "MAXIMUM SIGNAL EXPECTED")
      CALL BELL
      PAUSE
150   CALL GAIN(IGAIN)
      IF (ISOURC .LT. 15)  GOTO 160
      CALL RATTN(IATTEN)
      CALL ATTEN(0)
      CALL PORTS(5, 1, 3)
      GOTO 180
160   CALL ATTEN(IATTEN)
      IF (ISOURC .LT. 13)  GOTO 170
      CALL PORTS(ISOURC - 7, 1, 1)
      GOTO 180
170   CALL PORTS(5, 1, 1)
180   CALL SOURC(ISOURC)
      RETURN
      END
      SUBROUTINE RNDUP(I, J)
      J = I
      IF (J .GT. 0)  J = J + 9
      J = 10 * (J / 10)
      RETURN
```

```
END
END$
```

```
ASMB,L
*
      HED NSCAN - 8580B SPECTRUM SCAN/PLOT ROUTINE
*                      (ARS-400 VERSION)
*
      NAM NSCAN,7
*
****************************************************
*                                                  *
*          NSN1A: NSCAN, PART 1 (ARS-400)          *
*                    (6-25-75)                     *
*                                                  *
****************************************************
*                        NSCAN                     *
*                                                  *
*  SUBROUTINE "NSCAN" IS A GENERAL PURPOSE SCAN-   *
*  NING AND PLOTTING ROUTINE FOR THE 8580B AUTO-   *
*  MATIC SPECTRUM ANALYZER.  REFER TO THE "NSCAN   *
*  USER'S GUIDE" FOR DETAILED APPLICATIONS AND     *
*  OPERATING INFORMATION.                          *
*                                                  *
*                                                  *
*                                                  *
****************************************************
*                 SRSET:  SCAN RESET               *
*                                                  *
*  SRSET(NO PARAMETERS)                            *
*                                                  *
*  ATS BASIC BRANCH TABLE ENTRY:           SRSET;  *
*                                                  *
****************************************************
*             SCNBW:  SCAN I.F. BANDWIDTH          *
*                                                  *
*  SCNBW(BW,VIDEO)                                 *
*        BW = I.F. BANDWIDTH (KHZ)                 *
*     VIDEO = VIDEO FILTER STATE (0=OFF; 1=ON)     *
*                                                  *
*  ATS BASIC BRANCH TABLE ENTRY:      SCNBW(R,I);  *
*                                                  *
****************************************************
*               SCNFQ: SCAN FREQUENCIES            *
*                                                  *
*  SCNFQ(F.MHZ,F.HZ,STEPI)                         *
*     F.MHZ = STARTING FREQUENCY, MHZ PART         *
*      F.HZ = STARTING FREQUENCY, HZ PART          *
*     STEPI = FREQUENCY STEP SIZE, KHZ             *
*                                                  *
*  ATS BASIC BRANCH TABLE ENTRY:    SCNFQ(R,R,R);  *
*                                                  *
****************************************************
*            SCNMS: SCAN MEASUREMENT TYPE          *
*                                                  *
*  SCNMS(MTYPE,TIME,INTRP,DELAY)                   *
*     MTYPE = MEASUREMENT TYPE                     *
*           = 1 FOR VIDEO AVERAGING                *
*           = 2 FOR SOFTWARE PEAK-HOLD             *
*           = 3 FOR TRUE RMS (DBM)                 *
*           = 4 FOR TRUE RMS (MW)                  *
*           = 5 FOR TRUE RMS (UVOLTS)              *
*           = 6 FOR PEAK/AVG (DB)                  *
```

```
*              = 7 FOR MAX/MIN (DB)                  *
*              = 8 FOR MIN (DBM)                     *
*                                                    *
*       TIME = MEASUREMENT TIME (MSEC)               *
*                FOR MTYPE = 1,2,6,7, AND 8.         *
*              = NO. OF MEASUREMENTS AVERAGED        *
*                FOR MTYPE = 3,4, OR 5               *
*                                                    *
*      INTRP = INTERRUPT STATE FOR MTYPE = 2.        *
*              = 0 FOR INTERRUPT OFF (FOR MAXIMUM    *
*                SAMPLING RATE, THUS MAXIMUM INTER-  *
*                CEPT PROBABILITY OF A PULSE).       *
*              = 1 TO ENABLE INTERRUPT SYSTEM (ALLOWS *
*                DMA INTERRUPTS FOR REFRESHING THE   *
*                GRAPHICS, PLUS TRAPS SENSING, ETC.  *
*                                                    *
*      DELAY = NO. OF TIME CONSTANTS OF DELAY        *
*                BETWEEN MEASUREMENTS.               *
*                                                    *
*   ATS BASIC BRANCH TABLE ENTRY:  SCNMS(I,R,I,R);   *
*                                                    *
******************************************************
*              SDATA: SCAN DATA STORAGE              *
*                                                    *
*   SDATA(DATA,NPTS)                                 *
*       DATA = FIRST STORAGE LOCATION (ARRAY) OF     *
*                MEASURED DATA FROM SCAN.            *
*                                                    *
*       NPTS = NO. OF FREQUENCY POINTS PLOTTED       *
*              = NO. OF ELEMENTS OF DATA ARRAY.      *
*                                                    *
*   ATS BASIC BRANCH TABLE ENTRY:       SDATA(R,I);  *
*                                                    *
******************************************************
*            DFSCN: DIFFERENTIAL SCAN MODE           *
*                                                    *
*   DFSCN(MODE,REF)                                  *
*       MODE = DIFFERENTIAL SCAN STATE.              *
*              = 1 TO ENABLE DIFFERENTIAL SCAN.      *
*              = 0 TO DISABLE DIFFERENTIAL SCAN.     *
*                                                    *
*        REF = REFERENCE DATA ARRAY; MUST HAVE SAME  *
*                NUMBER OF ELEMENTS AS DATA ARRAY IN *
*                SDATA.                              *
*                                                    *
*   ATS BASIC BRANCH TABLE ENTRY:       DFSCN(I,R);  *
*                                                    *
******************************************************
*              LKSCN: LINKED-SCAN MODE               *
*                                                    *
*   LKSCN(MODE,ISCAL)                                *
*       MODE = LINKED SCAN STATE.                    *
*              = 1 TO ENABLE LINKED SCAN.            *
*              = 0 TO DISABLE LINKED SCAN.           *
*                                                    *
*      ISCAL = INTEGER SCALING RATIO; EQUALS NO.     *
*                OF FREQUENCIES IN EACH SUB-SCAN OF  *
*                LINKED SCAN.                        *
*                                                    *
*   ATS BASIC BRANCH TABLE ENTRY:       LKSCN(I,I);  *
```

```
*                                                    *
******************************************************
*              NSCAN: EXECUTE N'TH SCAN              *
*                                                    *
*  NSCAN(N,IPLOT,LDSPL)                              *
*         N = SCAN NUMBER (USED FOR WEIGHTING DATA   *
*             IN CUMULATIVE AVERAGING MODE).         *
*                                                    *
*     IPLOT = PLOT STATE                             *
*           = 1 FOR DATA TO BE PLOTTED AS TAKEN.     *
*           = 0 FOR PLOT TO BE SUPPRESSED.           *
*                                                    *
*     LDSPL = DISPLAY LOGIC CODE                     *
*           = 1 FOR INDEPENDENT SCAN DISPLAYS        *
*           = 2 FOR CUMULATIVE, WEIGHTED AVERAGING   *
*               SCAN-TO-SCAN.                        *
*           = 3 FOR CUMULATIVE ENVELOPE (MAXIMUM)    *
*               SCAN-TO-SCAN.                        *
*                                                    *
*  ATS BASIC BRANCH TABLE ENTRY:    NSCAN(I,I,I);    *
*                                                    *
******************************************************
*
      EXT NFRQ
      EXT T20
      EXT .GP2F
*
*
      ENT SCNMS,SCNBW,LKSCN,DFSCN,SDATA
      ENT NSCAN,SCNFQ,SRSET
*
*     FROM STANDARD MAXI ARS-400 LIBRARY...
      EXT .ENTR,ERROR,.STOP
      EXT .FAD,.FSB,.FMP,.FDV,IFIX,FLOAT
      EXT BUSY1,BWDTH,HLDOF,.NFGO,PLOT
      EXT PSTEP,SSTEP,STEP,TUNEA,TWAIT,VIDEO
*
*     FROM CONTRIBUTED LIBRARY ...
      EXT AINIT,MSEL
*     NOTE:  MSEL REQUIRES ADDITIONAL CONTRIBUTED
*            LIBRARY SUBROUTINES MEASP,MSRMS,PKAVG,
*            AND VIDAV.
*
******************************************************
*                SRSET - SCAN RESET                  *
******************************************************
*
SRSET NOP               ENTRY.
      JSB .ENTR
      DEF SRSET
      LDA ATBL          PICKUP TABLE STARTING ADDRESS.
      STA TEMP          PUT IN TEMP.
      CLA               SET NOP IN A-REG.
      LDB ZTBL          PICKUP FINAL TABLE ADDRESS.
AGAIN STA TEMP,I        SET CURRENT TABLE ELEMENT = 0.
      CPB TEMP          DONE?
      JMP DONE          YES.
      ISZ TEMP          INCREMENT ADDRESS.
      JMP AGAIN         HANG IN THERE.
DONE  CCA
```

```
      STA OKSU        SET SETUP OK FLAG.
      JMP SRSET,I     RETURN.
*
**************************************************
*              SCNBW - SCAN BANDWIDTH            *
**************************************************
*
BW    NOP
VID   NOP
SCNBW NOP             ENTRY.
      JSB .ENTR
      DEF BW
      JSB ERRSU       HAS SRSET BEEN CALLED?
      JSB BWDTH       BW <= 300 KHZ.
      DEF *+2
      DEF BW,I
      JSB VIDEO       SET VIDEO FILTER.
      DEF *+2
      DEF VID,I
*
*  DEFINE BANDWIDTH FLAG:
*     BWFLG = 0.0 TO 5.0, DEPENDING ON I.F. BANDWIDTH AND
*     VIDEO FILTER STATES.
*
      DLD BW,I        GET BANDWIDTH.
      DST IFBW        SAVE.
      LDA T20         GET VIDEO FILTER STATE.
      JSB FLOAT
      JSB .FMP        SET FOR "TWAIT(5.)" IF
      DEF D5            VIDEO FILTER "ON".
      DST BWFLG        SAVE.
      DLD D10
      JSB .FDV        CALCULATE "TWAIT" TIME.
      DEF IFBW
      JSB .FAD        COMBINE.
      DEF BWFLG
      DST BWFLG       SAVE.
      JSB .FSB        SUBTRACT 5.
      DEF D5
      SSA             BWFLG >= 5.?
      JMP BWEND       BWFLG < 5.
      DLD D5          SET BWFLG = 5.
      DST BWFLG       SAVE AS BANDWIDTH FLAG.
*
BWEND JSB TWAIT       DEFINE SETTLING TIME.
      DEF *+2
      DEF BWFLG
*
      CCA
      STA OKBW        SET BWDTH OK FLAG.
      JMP SCNBW,I     RETURN
*
**************************************************
*             SCNFQ - SCAN FREQUENCIES           *
**************************************************
*
F.MHZ NOP
F.HZ  NOP
STEPI NOP
SCNFQ NOP             ENTRY.
```

```
      JSB .ENTR
      DEF F.MHZ
      JSB ERRSU       HAS SRSET BEEN CALLED?
*
      DLD F.MHZ,I     SAVE STARTING FREQUENCY.
      DST FMHZ
      DLD F.HZ,I
      DST FHZ
*
      DLD STEPI,I     GET STEP SIZE.
      DST ISTEP       SAVE.
*
      CCA
      STA OKFQ        SET FREQUENCY OK FLAG.
      JMP SCNFQ,I     RETURN.
*
****************************************************
*          SCNMS - SCAN MEASUREMENT TYPE           *
****************************************************
*
MTYPE NOP
TIME  NOP
INTRP NOP
DELAY NOP
SCNMS NOP             ENTRY.
      JSB .ENTR
      DEF MTYPE
      JSB ERRSU       HAS SRSET BEEN CALLED?
*
      LDA MTYPE,I     YES. GET MEASUREMENT TYPE.
      STA MSTYP       SAVE.
      DLD TIME,I      GET MEASUREMENT TIME.
      DST MTIME       SAVE.
      LDA INTRP,I     GET INTERRUPT FLAG
      STA NTRPT       SAVE.
      DLD DELAY,I     GET NO. OF TIME CONSTANTS DELAY.
      DST TCDLY       SAVE.
*
      CCA             SET MEASUREMENT OK FLAG.
      STA OKMES
      JMP SCNMS,I
*
****************************************************
*            SDATA - SCAN DATA STORAGE             *
****************************************************
*
DATA  NOP
NPTS  NOP
SDATA NOP             ENTRY.
      JSB .ENTR
      DEF DATA
      JSB ERRSU       HAS SRSET BEEN CALLED?
      LDA DATA        YES. GET ARRAY STARTING ADDRESS.
      STA DATA1       SAVE.
      STA ADATA       SAVE.
      LDA NPTS,I      GET NO. OF DATA POINTS.
      STA NPNTS       SAVE.
      CMA,INA         NEGATE.
      STA NREF        SAVE.
      STA COUNT       SAVE.
```

```
*
*  MAKE A TRIAL RUN THRU THE DATA ARRAY TO VERIFY
*  THAT IT HAS BEEN ADEQUATELY DIMENSIONED IN THE
*  CALLING ATS BASIC PROGRAM.  IN THE EVENT OF
*  PROGRAMMER ERROR, THE "ERROR DST-1" WILL THEN BE
*  ISSUED FOR THE LINE OF BASIC THAT CALLED "SDATA"
*  RATHER THAN FROM THE LATER "NSCAN" (WHERE AN
*  "ERROR DST-1" WOULD BE SOMEWHAT MORE AMBIGUOUS).
*
TESTD DLD ADATA,I    GET A DATA VALUE.
      DST ADATA,I    STORE IT BACK IN ITSELF.
      ISZ ADATA      CALCULATE THE NEXT ADDRESS.
      ISZ ADATA
      ISZ COUNT      DONE?
      JMP TESTD      NO; TEST NEXT DATA ADDRESS.
      CCA
      STA OKDAT      SET DATA DEFINITION OK FLAG.
      JMP SDATA,I    RETURN.
*
****************************************************
*         DFSCN - DIFFERENTIAL SCAN SPECS          *
****************************************************
*  NOTE - SDATA MUST BE CALLED BEFORE DFSCN, SINCE
*         THE DIMENSION OF THE REFERENCE ARRAY IS
*         SPECIFIED VIA SDATA.  (ERROR NSCAN-5).
*
DMODE NOP
REF   NOP
DFSCN NOP            ENTRY.
      JSB .ENTR
      DEF DMODE
      JSB ERRSU      HAS SRSET BEEN CALLED?
      LDB I5         YES. GET SDATA ERR CODE IN CASE.
      LDA OKDAT      GET SDATA OK FLAG.
      SZA,RSS        SKIP IF OK.
      JMP ERR        NOT OK.  ERROR NSCAN-5.
      LDA DMODE,I    GET DIFFERENTIAL SCAN MODE.
      STA FDIFF      SAVE AS DIFF'L SCAN FLAG.
      SZA,RSS        DIFFERENTIAL SCAN FLAG SET?
      JMP DFSCN,I    NO.  RETURN.
      LDA REF        YES. GET ARRAY STARTING ADDRESS.
      STA REF1       SAVE.
      STA AREF       SAVE.
      LDA NREF       GET (-) NO. OF DATA POINTS.
      STA COUNT      SAVE.
TESTR DLD AREF,I     RUN THRU THE REF ARRAY TO MAKE
      DST AREF,I       SURE IT IS DIMENSIONED OK.
      ISZ AREF         SEE NOTE IN "SDATA" FOR
      ISZ AREF         DETAILS.
      ISZ COUNT      DONE?
      JMP TESTR      NO; TEST NEXT REF ADDRESS.
      JMP DFSCN,I    RETURN.
*
****************************************************
*            LKSCN - LINKED-SCAN SPECS             *
****************************************************
*
LMODE NOP
LSCAL NOP
LKSCN NOP            ENTRY.
```

```
      JSB .ENTR
      DEF LMODE
      JSB ERRSU      HAS SRSET BEEN CALLED?
      LDA LMODE,I    YES. GET LINKED-SCAN STATE.
      STA FLINK      SAVE AS FLAG.
      LDA LSCAL,I    GET LINKED-SCAN SCALE FACTOR.
      CMA,INA        NEGATE.
      STA NSCAL      SAVE.
      JMP LKSCN,I    RETURN.
*
****************************************************
*             NSCAN - EXECUTE N'TH SCAN            *
****************************************************
*
N     NOP
IPLOT NOP
LDSPL NOP
NSCAN NOP            ENTRY.
      JSB .ENTR
      DEF N
*
*  CHECK THAT ALL REQUIRED PARAMETERS HAVE BEEN
*  SPECIFIED.
*
      JSB ERRSU      HAS SRSET BEEN CALLED?
      LDB I2         YES. GET NEXT ERROR CODE.
      LDA OKBW       CHECK FOR SCNBW.
      SZA,RSS        SKIP IF OK.
      JMP ERR        NO PRIOR SCNBW.  ERROR NSCAN-2.
      LDA OKFQ       CHECK FOR SCNFQ.
      INB            = 3
      SZA,RSS        SKIP IF OK.
      JMP ERR        NO PRIOR SCNFQ.  ERROR NSCAN-3.
      LDA OKMES      CHECK FOR SCNMS.
      INB            = 4
      SZA,RSS        SKIP IF OK.
      JMP ERR        NO PRIOR SCNMS.  ERROR NSCAN-4.
      LDA OKDAT      CHECK FOR SDATA.
      INB            = 5
      SZA,RSS        SKIP IF OK.
      JMP ERR        NO PRIOR SDATA.  ERROR NSCAN-5.
*
      JSB TUNEA      TUNE TO STARTING FREQUENCY.
      DEF *+3
      DEF FMHZ
      DEF FHZ
*
*  IF LINKED-SCAN MODE SELECTED, BACK UP INITIAL
*  TUNING BY 1/2 OF A SUBSCAN, EG:
*       CALL STEP(-FLOAT(LSCAL-1)*STEPI/2.)
*  SINCE NSCAL = -LSCAL, THIS REDUCES TO:
*       CALL STEP(FLOAT(NSCAL+1)*STEPI/2.)
*
      LDA FLINK      GET LINKED-SCAN FLAG.
      SZA,RSS        LINKED SCAN?
      JMP PRSET      NO.
      LDA NSCAL      YES. GET -NO. OF SUBSCAN STEPS.
      INA            =NSCAL+1
      JSB FLOAT      CONVERT TO REAL.
      DST TEMP       SAVE.
```

```
      DLD ISTEP      GET FREQUENCY STEP SIZE.
      JSB .FMP       =FLOAT(NSCAL+1)*STEPI
      DEF TEMP
      JSB .FDV       =FLOAT(NSCAL+1)*STEPI/2.
      DEF D2
      DST TEMP       SAVE TEMPORARILY.
      JSB STEP       ADJUST TUNING.
      DEF *+2
      DEF TEMP
*
*
*  PRESET ARRAY ADDRESSES, LKFLG, PLOT FREQUENCY
*  NUMBER, COUNTER, ETC.
*
PRSET LDA DATA1      GET MAIN DATA ARRAY ADDRESS.
      STA ADATA
      LDA REF1       GET REF ARRAY ADDRESS.  (TRASH
      STA AREF         IF DFSCN NOT DEFINED).
*
      LDA NREF       PRESET MAIN SCAN LOOP COUNTER.
      STA COUNT
*
      DLD D1         INITIALIZE PLOT FREQUENCY
      DST INDEX        INDEXING.
*
      JSB .FDV       CALCULATE ONE TIME CONSTANT
      DEF IFBW         (MSEC) OF BW (= 1/BW).
      JSB .FMP       CONVERT TO 100'S OF USEC.
      DEF D10
      DST TEMP       SAVE TEMPORARILY.
      LDA T20        GET VIDEO FILTER STATE.
      SZA            SKIP IF VIDEO FILTER OFF.
      LDA I33        FILTER ON, SET 3.3 MSEC.
      JSB FLOAT      CONVERT TO REAL.
      JSB .FAD       GET OVERALL TIME CONSTANT:
      DEF TEMP         = (BW + VID) DELAYS
      JSB .FMP       MULTIPLY BY NUMBER OF TIME
      DEF TCDLY        CONSTANTS SPECIFIED.
      JSB IFIX
      STA MSDLY      SAVE.
*
*  CALCULATE/STORE NEXT FREQUENCY TO BE TUNED.
*
      DLD ISTEP      GET STEP SIZE.
      JSB SSTEP
      JSB PSTEP
*
*  IF N=1, INITIALIZE DATA ARRAY TO -200.
*
      LDA N,I        GET N.
      STA NTHSN      SAVE AS "N-TH SCAN".
      ADA IM2        = N-2
      SSA,RSS        >= 0 ?   (N>1)
      JMP CONT2      N > 1
      CLA,INA        N <= 1; SET N=1.
      STA NTHSN      SAVE.
      JSB AINIT      INITIALIZE ELEMENTS 1 THRU NPTS
      DEF *+5          OF THE DATA ARRAY TO -200.
      DEF ADATA,I      (-200 DBM IS LESS THAN ANY-
      DEF I1           THING THE 8580 CAN MEASURE;
```

```
      DEF NPNTS        NOTE THAT YOU CAN'T SET 0
      DEF DM200        BECAUSE UNITS ARE DBM.)
*
*  START MAIN TUNE/MEASURE LOOP.
*
CONT2 LDA FLINK       GET LINKED-SCAN FLAG.
      SZA,RSS         LINKED-SCAN?
      JMP BWTST       NO.
*
*  START SUB-SCAN OF LINKED-SCAN.
*
      DLD DM200       YES.
      STA AMAX        PRESET AMAX TO -200.
      STB AMAX+1
      LDA NSCAL       GET (-) NO. OF SUB-SCAN ELEMENTS
      STA NSUB        SAVE.
*
*  SET BUS TIMER ACCORDING TO "BWFLG"
*
BWTST JSB BUSY1
      JSB HLDOF       ENCODE MEASUREMENT DELAY.
      DEF *+2
      DEF MSDLY
*
*  MAKE SPECIFIED MEASUREMENT.
*
      JSB MSEL
      DEF *+5
      DEF MSTYP
      DEF MTIME
      DEF NTRPT
      DEF AMPL
*
*  SET 100 MSEC DELAY IF BAND-CHANGE FLAG IS SET.
*
      LDA .GP2F       GET BAND-CHANGE FLAG.
      SZA,RSS         FLAG SET?
      JMP CONT3       NO BAND-CHANGE.
      JSB HLDOF       SET DELAY OF 100 MSEC.
      DEF *+2
      DEF I1000
      JSB BUSY1
*
*  GET SYNTHESIZER STARTED TUNING NEXT FREQUENCY.
*
CONT3 LDA NFRQ
      JSB .NFGO       OUTPUT PRE-CALCULATED FREQUENCY
      DLD ISTEP       CALCULATE NEXT FREQUENCY.
      JSB SSTEP
      JSB PSTEP
*
*  IS THIS A LINKED-SCAN?
*
CONT5 LDA FLINK       GET LINKED-SCAN FLAG.
      SZA,RSS         LINKED-SCAN?
      JMP CONT7       NO.
*
*  IS THIS THE LARGEST AMPLITUDE (SO FAR) OF THE
*  SUB-SCAN?
*
```

```
      DLD AMAX       YES. GET CURRENT MAX AMPL.
      JSB .FSB       =AMAX-AMPL
      DEF AMPL
      SSA,RSS        AMPL > AMAX?
      JMP CONT6      NO.
      DLD AMPL       YES.
      STA AMAX       REPLACE AMAX WITH AMPL.
      STB AMAX+1
*
*  INCREMENT SUB-SCAN.
*
CONT6 ISZ NSUB       SUB-SCAN COMPLETE?
      JMP BWTST      NO.
      DLD AMAX       YES.
      STA AMPL       DEFINE AMPL=AMAX.
      STB AMPL+1
*
*  SELECT DISPLAY TYPE.
*
CONT7 DLD ADATA,I    GET LAST DATA VALUE AT THIS FREQ
      STA OLDAT      SAVE.
      STB OLDAT+1
      LDA LDSPL,I
      ADA IM3        = LDSPL-3
      SSA,RSS
      JMP SWCH3      LDSPL >= 3; CUMULATIVE ENVELOPE.
      INA
      SZA
      JMP SWCH1      LDSPL <= 1; INDEPENDENT SCANS.
      JMP SWCH2      LDSPL = 2; CUMULATIVE AVERAGING.
*
*  INDEPENDENT SCANS.
*
SWCH1 DLD AMPL       GET CURRENT MEASURED AMPLITUDE.
DSAVE DST ADATA,I    SAVE IT.
      ISZ ADATA      INCREMENT DATA ADDRESS.
      ISZ ADATA
      JMP CONT8
*
*  CUMULATIVE AVERAGING.
*     AMPL = (FLOAT(N-1)*OLDAT+AMPL)/FLOAT(N)
*
SWCH2 LDA NTHSN      GET N.
      JSB FLOAT
      STA TEMP       SAVE TEMPORARILY.
      STB TEMP+1
      JSB .FSB       =FLOAT(N)-1.
      DEF D1
      JSB .FMP
      DEF OLDAT      = FLOAT(N-1)*OLDAT
      JSB .FAD
      DEF AMPL       = FLOAT(N-1)*OLDAT+AMPL
      JSB .FDV       = WEIGHTED AMPL.
      DEF TEMP
      STA AMPL       REPLACE MEASURED AMPLITUDE WITH
      STB AMPL+1       WEIGHTED VALUE (FOR PLOT).
      JMP DSAVE
*
*  CUMULATIVE ENVELOPE.
*
```

```
SWCH3 DLD OLDAT      GET OLD DATA.
      JSB .FSB
      DEF AMPL       SUBTRACT CURRENT AMPLITUDE.
      SSA            OLDAT >= AMPL?
      JMP SWCH1      NO.
      DLD OLDAT      YES.  REPLACE AMPL WITH OLDAT.
      STA AMPL
      STB AMPL+1
      JMP SWCH1
*
*  PLOT OUTPUT?
*
CONT8 LDA IPLOT,I    GET PLOT ON/OFF FLAG.
      SZA,RSS        PLOT?
      JMP CNT10      NO.
      LDA FDIFF      YES.  GET DIFFERENTIAL FLAG.
      SZA,RSS        DIFFERENTIAL PLOT?
      JMP CONT9      STANDARD PLOT.
      DLD AMPL       DIFFERENTIAL PLOT.
      JSB .FSB
      DEF AREF,I     SUBTRACT REF FROM AMPL.
      STA AMPL       PUT BACK IN AMPL.
      STB AMPL+1
      ISZ AREF       INCREMENT AREF TWICE.
      ISZ AREF
CONT9 JSB PLOT       PLOT THE MEASURED,
      DEF *+4          "MASSAGED" DATA.
      DEF INDEX
      DEF AMPL
      DEF I3
*
*  DONE?
*
CNT10 DLD INDEX      INCREMENT PLOT FREQUENCY INDEX.
      JSB .FAD
      DEF D1
      STA INDEX
      STB INDEX+1
      ISZ COUNT      SCAN COMPLETE?
      JMP CONT2      NO.
      JMP NSCAN,I    YES. RETURN.
*
*************************************************
*                                               *
*           ERROR MESSAGE HANDLING              *
*                                               *
*     ERROR NSCAN-1:  NO PRIOR SRSET.           *
*     ERROR NSCAN-2:  NO PRIOR SCNBW.           *
*     ERROR NSCAN-3:  NO PRIOR SCNFQ.           *
*     ERROR NSCAN-4:  NO PRIOR SCNMS.           *
*     ERROR NSCAN-5:  NO PRIOR SDATA.           *
*                                               *
*************************************************
*
ERRSU NOP            ENTRY.
      LDB I1         GET SU ERROR CODE, JUST IN CASE.
      LDA OKSU       GET SETUP FLAG.
      SZA,RSS        FLAG SET?
      JMP ERR        NO.  ERROR NSCAN-1.
      JMP ERRSU,I    OK.  RETURN.
```

```
*
ERR   STB ERCOD      PUT ERROR CODE NUMBER IN ERCOD.
      JSB ERROR
      DEF *+3
      DEF ERCOD
      DEF ERRM
      JSB .STOP
*
ERCOD NOP            ERROR CODE STORAGE.
ERRM  DEC 5
      ASC 3,NSCAN
*
*****************************************************
*                                                   *
*             CONSTANTS AND POINTERS                *
*                                                   *
*****************************************************
*
*
DM200 DEC -200.
D1    DEC 1.
D2    DEC 2.
D5    DEC 5.
D10   DEC 10.
*
IM2   DEC -2
IM3   DEC -3
I1    DEC 1
I2    DEC 2
I3    DEC 3
I5    DEC 5
I33   DEC 33
I1000 DEC 1000
*
*****************************************************
*                                                   *
*                     STORAGE                       *
*                                                   *
*****************************************************
*
ATBL  DEF *+1
ADATA NOP        ADDRESS OF CURRENT DATA ARRAY ELEMENT
AMAX  NOP        MAX AMPLITUDE IN A SUB-SCAN.
      NOP         "      "     "  "  "    "
AMPL  NOP        CURRENT MEASURED AMPLITUDE
      NOP          (MAY BE DB, DBM, MW, OR UV)
AREF  NOP        ADDRESS OF CURRENT REF ARRAY ELEMENT.
BWFLG NOP        I.F. BANDWIDTH FLAG (FOR "TWAIT")
      NOP         "      "        "
COUNT NOP        COUNTER.
DATA1 NOP        FIRST ADDRESS IN DATA ARRAY.
FDIFF NOP        DIFFERENTIAL SCAN FLAG.
FHZ   NOP        STARTING FREQUENCY, KHZ PART.
      NOP          "        "        "    "
FLINK NOP        LINKED SCAN FLAG.
FMHZ  BSS 2      STARTING FREQUENCY, MHZ PART.
IFBW  NOP        I.F. BANDWIDTH.
      NOP         "      "
INDEX NOP        CURRENT PLOT FREQUENCY INDEX NUMBER.
      NOP          "     "      "        "
```

```
ISTEP NOP       SCAN STEP SIZE, KHZ.
      NOP         "     "    "    "
LKFLG NOP       8660 PHASE-LOCK FLAG.
MSDLY NOP       MEAS'MENT DELAY, 100'S OF USEC.
MSTYP NOP       MEASUREMENT TYPE.
MTIME NOP       MEASUREMENT TIME, MSEC.
      NOP            "       "     "
NPNTS NOP       NUMBER OF DATA (AND REF) POINTS.
NREF  NOP       (-) NO. OF DATA ELEMENTS.
NSCAL NOP       (-) NO. OF FREQ'S IN LINKED SUBSCAN.
NSUB  NOP       SUB-SCAN ELEMENT COUNTER.
NTHSN NOP       N-TH SCAN NUMBER (>= 1).
NTRPT NOP       INTERRUPT FLAG (FOR PEAK-HOLD MODE).
OKBW  NOP       BWDTH FLAG, =-1 AFTER SCNBW EXECUTION
OKDAT NOP       DATA FLAG, =-1 AFTER SDATA EXECUTION
OKFQ  NOP       FREQ FLAG, =-1 AFTER SCNFQ EXECUTION
OKMES NOP       MEAS FLAG, =-1 AFTER SCNMS EXECUTION
OKSU  NOP       SETUP FLAG, =-1 AFTER SRSET EXECUTION
OLDAT NOP       OLD DATA AT CURRENT FREQUENCY.
      NOP         "    "   "     "        "
REF1  NOP       FIRST ADDRESS IN REFERENCE ARRAY.
TCDLY NOP       TIME CONSTANTS OF DELAY
      NOP         BETWEEN MEASUREMENTS.
ZTBL  DEF *-1
*
*  THE PRECEEDING STORAGE LOCATIONS, COMMENCING WITH
*  (SRSET IS CALLED BY RDYMS).
*
TEMP  NOP       TEMPORARY DATA STORAGE.
      NOP            "      "      "
*
      END
```

```
ASMB,L
      HED PKAVG - 8580B MIN/MAX/AVG AMPLITUDE
*
      NAM PKAVG,7
***************************************************
*          8580B MIN/MAX/AVG AMPLITUDE             *
*                                                  *
*  PKAVG WILL BE CALLABLE FROM EITHER FORTRAN OR   *
*  ATS BASIC, AS:                                  *
*                                                  *
*              CALL PKAVG(TIME,AMIN,AVG,AMAX)      *
*                                                  *
*  WHERE:                                          *
*      TIME = AVERAGING TIME (MILLISEC).  THE      *
*             MAXIMUM ALLOWABLE VALUE OF "TIME"    *
*             IS 60000 MSEC (= 1 MINUTE); VALUES   *
*             OF TIME GREATER THAN 60000 WILL BE   *
*             LIMITED TO 60000 BY PKAVG.  VALUES   *
*             OF "TIME" <= 0 WILL RESULT IN A      *
*             SINGLE ADC READING BEING TAKEN (E.G. *
*             NO AVERAGING).                       *
*      AMIN = MINIMUM AMPLITUDE (DBM)              *
*       AVG = AVERAGE AMPLITUDE (DBM)              *
*      AMAX = MAXIMUM AMPLITUDE (DBM)              *
*                                                  *
*  NOTE: PKAVG'S DATA ACQUISITION CYCLE TIME IS    *
*  APPROXIMATELY 40 MICROSECONDS, RESULTING IN A   *
*  DATA SAMPLING RATE OF APPROXIMATELY 25 KHZ.     *
*                                                  *
***************************************************
*                                                  *
*  ATS BASIC BRANCH TABLE ENTRY:  PKAVG(R,R,R,R);  *
*                                                  *
***************************************************
*                                                  *
*     NO NON-STANDARD SUBROUTINES OR FUNCTIONS     *
*                      ARE USED.                   *
*                                                  *
***************************************************
*                                                  *
*                                                  *
*  RAM        27 JUNE 1977         MODIFIED FOR RTE *
*                                                  *
***************************************************
*
      ENT PKAVG
*
      EXT .ENTR,BUSY1,EXEC
      EXT COREK,FLOAT
      EXT IFIX,.FAD,.FDV
      EXT .FMP,.FSB
*
TIME  NOP
AMIN  NOP
AVG   NOP
AMAX  NOP
PKAVG NOP             ENTRY POINT.
      JSB .ENTR       ** PASS IN PARAMETERS.
      DEF TIME         *
*
```

```
      JSB BUSY1       ** WAIT UNTIL BUS IS NOT BUSY.
*
      CLA,INA         ** CLEAR REPEAT FLAG; SET TO -1.
      STA FIRST        * SET FIRST TIME FLAG.
      CMA,INA          * SET RPEAT: ASSUME ONLY 1 LOOP
      STA RPEAT       ** OF < 30K ADC VALUES NEEDED.
*
      DLD TIME,I      ** GET INTEGRATION TIME (MSEC).
      SSA,RSS          * TIME NEGATIVE?
      JMP CONT1        * TIME >= 0.
      CLA              * SET TIME TO 0.
      CLB              *
CONT1 DST NFLT         * SAVE "TIME".
      JSB .FSB         * TEST FOR MAX OF 60000.
      DEF D60K         * (SUBTRACT 60000.)
      SSA              * RESULT >= 0?
      JMP GETIT        * TIME < 60000, GET IT BACK.
      DLD D60K         * LIMIT TIME TO 60000.
      JMP CONT2        *
GETIT DLD NFLT        ** GET BACK TIME.
*
CONT2 JSB .FMP        ** SCALE "TIME" TO TOTAL NUMBER
      DEF FACTR        *  OF ADC READINGS REQ'D.
CONT3 DST NFLT         * SAVE IN NFLT.
      JSB .FSB         * SUBTRACT 30000.
      DEF D30K         *
      SSA              * REMAINDER >= 0?
      JMP CONT4        * < 30000 SAMPLES REQUIRED.
      LDA IM100        * >= 30000, MAKE INTEGER.
      STA RPEAT        * SET RPEAT FOR 100 LOOPS.
      DLD NFLT         * GET BACK "TIME".
      JSB .FDV         * DIVIDE NFLT BY 100
      DEF D100         *  AND ROUND OFF TO
      JSB .FAD         *  GET COUNT/LOOP, CREF.
      DEF PTFIV        *
      JSB IFIX         *
      STA CREF         *
      JSB FLOAT        * ACCOUNT FOR POSSIBLE
      JSB .FMP         *  TRUNCATION ERROR IN
      DEF D100         *  CALCULATION OF CREF BY
      DST NFLT         *  COMPUTING EXACT NFLT.
      LDA CREF         *
      JMP CONT5       **
*
CONT4 DLD NFLT        ** GET BACK REQ'D NO. OF TIMES.
      JSB .FAD         * ADD .5 TO ROUND
      DEF PTFIV        *  OFF VALUE.
      JSB IFIX         * TRUNCATE TO INTEGER.
      SZA              * ZERO?
      JMP CONT5        * NOT ZERO.
      CLA,INA          * ZERO, SET FOR 1 ADC READING.
      JSB FLOAT        * CONVERT TO REAL.
      JMP CONT3       **
*
CONT5 CMA,INA         ** NEGATE; STORE AS COUNT
      STA CREF        **  REFERENCE, CREF.
*
      CLA              * CLEAR A AND B
      CLB              *  REGISTERS;
      DST CSUM        **  INITIALIZE CSUM TO 0.
```

```
*
LOOP   CLA                ** INITIALIZE ASUM
       STA ASUM            *  AND OFLOW
       STA OFLOW           *  TO 0.
       LDA CREF            * GET COUNT REFERENCE;
       STA COUNT          **  STORE IN COUNT.
*
AM20   JSB EXEC           **
       DEF *+5             * TAKE AN ADC READING
       DEF .1              *  AND RESET THE ADC.
       DEF .20            **
       DEF VAL
       DEF .2
       LDA VAL
*
       STA ATEMP          ** SAVE ADC TEMPORARILY.
       LDB FIRST           * GET FIRST TIME FLAG.
       SSB,RSS             * SKIP IF NOT FIRST TIME.
       JMP INIT            * INITIALIZE MIN AND MAX.
       ADA MAX             * COMPARE ADC WITH MAX.
       SSA                 * SKIP IF POSITIVE.
       JMP TEST1           * OLD MAX IS OK.
       LDA ATEMP           * GET BACK ATEMP.
       CMA,INA             * NEGATE NEW MAX.
       STA MAX             * SAVE NEW MAX.
TEST1  LDA ATEMP           * GET BACK ATEMP.
       ADA MIN             * COMPARE ADC WITH MIN.
       SSA,RSS             * SKIP IF NEGATIVE.
       JMP RSUME           * OLD MIN IS OK.
       LDA ATEMP           * GET BACK ATEMP.
       CMA,INA             * NEGATE NEW MIN.
       STA MIN             * SAVE NEW MIN.
RSUME  LDA ATEMP           * GET BACK ATEMP.
       ADA ASUM            * ACCUMULATE DATA.
       SSA                 * IS ASUM POSITIVE?
       JMP FIXIT           * NO. ADJUST ASUM AND OFLOW.
ICONT  STA ASUM            * YES. SAVE ASUM.
       ISZ COUNT           * INCREMENT AND TEST COUNT.
       JMP AM20           ** GET NEXT ADC READING.
*
       LDA ASUM           ** COUNT LOOP FINISHED.
       JSB FLOAT           *
       DST ASUM            * GET FLOATING POINT
       LDA OFLOW           *  EQUIVALENT OF
       JSB FLOAT           *  TOTAL ADC SUM.
       JSB .FMP            *
       DEF CONST           *
       JSB .FAD            *
       DEF ASUM            *
       JSB .FAD            * CUMULATE WITH CSUM.
       DEF CSUM            *
       DST CSUM           **
*
       ISZ RPEAT          ** ALL LOOPS DONE?
       JMP LOOP           ** NO. DO NEXT LOOP.
*
       JSB .FDV           ** YES. GET AVERAGE ADC VALUE:
       DEF NFLT           ** (DIVIDE CSUM BY NFLT).
*
       JSB IFIX           **
```

```
       JSB COREK        * CONVERT TO DBM.
       DST AVG,I        *
       LDA MIN          * GET MIN.
       CMA,INA          * MAKE POSITIVE AGAIN.
       JSB COREK        * CONVERT TO DBM.
       DST AMIN,I       * RETURN AS AMIN.
       LDA MAX          * GET MAX.
       CMA,INA          * MAKE POSITIVE AGAIN.
       JSB COREK        * CONVERT TO DBM.
       DST AMAX,I       * RETURN AS AMAX.
       JMP PKAVG,I     ** EXIT SUBROUTINE.
*
FIXIT  RAL,CLE,ERA     ** CLEAR SIGN BIT.
       ISZ OFLOW        * INCREMENT OVERFLOW
       JMP ICONT       **  ACCUMULATOR.
*
*    NOTE: OFLOW IS ALWAYS POSITIVE, SO IT CAN NEVER
*          GET SO LARGE AS TO CAUSE THE "ISZ OFLOW"
*          TO JUMP TO "INIT".
*
INIT   CMA,INA         ** INITIALIZE MIN AND MAX
       STA MIN          *  TO NEGATIVE OF THE
       STA MAX          *  FIRST ADC VALUE.
       CMB,INB          * NEGATE FIRST TIME FLAG.
       STB FIRST        * STORE BACK IN "FIRST".
       JMP RSUME       ** RESUME MEASUREMENTS.
*
****************************************************
*                                                  *
*               CONSTANTS & STORAGE.               *
*                                                  *
****************************************************
*
ASUM   BSS 2            ADC ACCUMULATION (SEE OFLOW).
ATEMP  NOP              CURRENT ADC VALUE.
CMMND  OCT 100001       ADC ADDRESS.
CONST  DEC 32768.       SCALING FOR OFLOW.
COUNT  NOP              ADC COUNTER (=ADC'S/LOOP).
CREF   NOP              COUNT REFERENCE VALUE.
CSUM   BSS 2            CUMULATIVE SUM (ASUM+OFLOW)'S.
VAL    BSS 2
.1     DEC 1
.2     DEC 2
.20    DEC 20
D100   DEC 100.         NUMBER OF LOOPS FOR >30K ADC'S.
D30K   DEC 30000.       MAX NO. OF ADC'S PER LOOP.
D60K   DEC 60000.       MAX. "TIME" (MSEC).
FACTR  DEC 25.          SCALE FACTOR (= ADC RATE, KHZ).
FIRST  NOP              FIRST=1 IF 1ST ADC (=-1 AFTER).
IM100  DEC -100         RPEAT COUNT FOR >30000 ADC'S.
MAX    NOP              MAXIMUM ADC VALUE.
MIN    NOP              MINIMUM ADC VALUE.
NFLT   BSS 2            TOTAL NUMBER OF ADC READINGS.
OFLOW  NOP              OVERFLOW COUNTER (INTEGER MATH).
PTFIV  DEC .5
RPEAT  NOP              NO. OF REPETITIONS OF ADC LOOP.
*
       END
```

```
FTN,L
      SUBROUTINE ASMTH(ARRY1,N1,ARRY2,N2,NTOTL,NAVG)
C     ASMTH:  ARRAY SMOOTHING
C
      DIMENSION ARRY1(1),ARRY2(1)
C
C     **********************************************************
C     *                                                        *
C     *  ASMTH SMOOTHS THE DATA VALUE VARIATIONS IN ARRY1,     *
C     *  CREATING A NEW ARRAY, ARRY2.  EACH ELEMENT IN ARRY1   *
C     *  IS AVERAGED WITH ITS NAVG ADJACENT ELEMENTS (E.G.     *
C     *  NAVG=1 AVERAGES THREE ADJACENT ELEMENTS; NAVG=2       *
C     *  AVERAGES FIVE ADJACENT ELEMENTS; ETC.)  THIS AVERAGE  *
C     *  IS STORED IN ARRY2.  N1 AND N2 ARE THE STARTING       *
C     *  ADDRESSES IN ARRY1 AND ARRY2;  NTOTL IS THE NUMBER    *
C     *  OF ELEMENTS IN ARRY1 TO BE ADJUSTED.  NTOTL MUST BE   *
C     *  GREATER THAN 2*NAVG+1.                                *
C     *                                                        *
C     **********************************************************
C     *                                                        *
C     *  ATS BASIC BRANCH TABLE ENTRY:    ASMTH(R,I,R,I,I,I);  *
C     *                                                        *
C     **********************************************************
C     *                                                        *
C     *  NO NON-STANDARD SUBROUTINES OR FUNCTIONS ARE CALLED.  *
C     *                                                        *
C     **********************************************************
C     *                                                        *
C     *                                                        *
C     *                                                        *
C     **********************************************************
C
      D0=0.
      I1=1
      N1END=N1+NTOTL-I1
      N2TMP=N2
      NSTOP=N1+NAVG
   50 ATEMP=D0
      DO 100 J=N1,NSTOP
  100    ATEMP=ATEMP+ARRY1(J)
C
      NTEMP=NSTOP-N1+I1
      ARRY2(N2TMP)=ATEMP/FLOAT(NTEMP)
      NSTOP=NSTOP+I1
      N2TMP=N2TMP+I1
C
      IF (NTEMP-2*NAVG)50,200
C
  200 N1TMP=N1+NAVG-I1
  210 N1TMP=N1TMP+I1
      J1=N1TMP-NAVG
      J2=N1TMP+NAVG
      ELMTS=2*NAVG+I1
      ATEMP=D0
      DO 300 J=J1,J2
  300    ATEMP=ATEMP+ARRY1(J)
C
      ARRY2(N2TMP)=ATEMP/ELMTS
      N2TMP=N2TMP+I1
C
```

```
      IF (J2-N1END)210,400
C
  400 N1TMP=N1TMP+I1
      ATEMP=D0
      DO 500 J=N1TMP,N1END
  500    ATEMP=ATEMP+ARRY1(J)
C
      ARRY2(N2TMP)=ATEMP/FLOAT(N1END-N1TMP+I1)
      N2TMP=N2TMP+I1
C
      IF (N1TMP-N1END)400,600
C
  600 END
      END$
```

```
FTN,L
      SUBROUTINE SIGBW(DATA,NSTRT,NSTOP,DB,FSTRT,FSTOP)
C     SIGBW:  SIGNAL BANDWIDTH (& S/N ESTIMATION) OF ARRAY DATA
C
      DIMENSION DATA(1),RMMM(4)
C
C     ************************************************************
C     *                                                          *
C     *  SUBROUTINE SIGBW SEARCHES THE ARRAY "DATA" FROM         *
C     *  ELEMENT NSTRT TO NSTOP, INCLUSIVE, LOCATING THE         *
C     *  LARGEST DATA VALUE.  NSTOP MUST BE >= NSTRT.            *
C     *                                                          *
C     *  A SEARCH IS THEN CONDUCTED IN EACH DIRECTION FROM       *
C     *  THIS MAXIMUM TO FIND THE FIRST ELEMENTS WITH A MAG-     *
C     *  NITUDE OF "DB" LESS THAN THE "DATA" MAXIMUM.  ORDI-     *
C     *  NARILY, THIS WILL REQUIRE INTERPOLATION BETWEEN         *
C     *  ADJACENT "DATA" VALUES.  THE INTERPOLATED VALUES OF     *
C     *  THESE POINTS ARE RETURNED AS FSTRT AND FSTOP.           *
C     *                                                          *
C     *  IF THE REQUESTED "DB" FOR WHICH THE BANDWIDTH IS TO     *
C     *  BE DETERMINED IS TOO LARGE FOR THE ACTUAL S/N RATIO     *
C     *  OF THE DATA (SO THE SEARCH WOULD RUN OFF THE ENDS OF    *
C     *  THE ARRAY), "FSTRT" AND "FSTOP" WILL BE RETURNED FOR    *
C     *  A REDUCED VALUE OF "DB".  THIS NEW VALUE OF "DB" WILL   *
C     *  ALSO BE RETURNED TO THE CALLING PROGRAM, SO CHECK THE   *
C     *  VALUE OF "DB" RETURNED TO BE SURE YOU GOT WHAT YOU      *
C     *  WANTED!  A SPECIAL CASE OF THE ABOVE OCCURS WHEN THE    *
C     *  "DATA" MAXIMUM IS EITHER THE FIRST OR LAST ELEMENT OF   *
C     *  THE ARRAY.  IN THIS CASE, "DB" IS RETURNED AS ZERO.     *
C     *                                                          *
C     *  SMOOTHING OF THE DATA (SUBROUTINE "ASMTH") IS OFTEN     *
C     *  A USEFUL SIGNAL PROCESSING CALL TO MAKE PRIOR TO A      *
C     *  CALL TO "SIGBW".  SUBROUTINE "NFLCT" IS A PARTI-        *
C     *  CULARLY USEFUL CALL TO PRECEDE "SIGBW" WHEN THERE       *
C     *  MAY BE MORE THAT ONE SIGNAL IN THE "DATA" ARRAY;        *
C     *  "NFLCT" WILL LOCATE ALL THE LOCAL MINIMA AND MAXIMA     *
C     *  IN THE ARRAY "DATA".  THE PAIRS OF MINIMA BRACKETING    *
C     *  A PARTICULAR MAXIMUM ARE THEN USED BY "SIGBW" AS ITS    *
C     *  SEARCH LIMITS.                                          *
C     *                                                          *
C     ************************************************************
C     *                                                          *
C     *  ATS BASIC BRANCH TABLE ENTRY:    SIGBW(R,I,I,R,R,R);    *
C     *                                                          *
C     ************************************************************
C     *                                                          *
C     *     NON-STANDARD EXTERNAL SUBROUTINES CALLED ARE:        *
C     *                        AMMMS                             *
C     *                                                          *
C     ************************************************************
C     *                                                          *
C     *                                                          *
C     *                                                          *
C     ************************************************************
C
      I1=1
C
C     *** FIND LOCATION AND VALUE OF "DATA" MAXIMUM.
      CALL AMMMS(DATA(1),NSTRT,NSTOP,LMIN,LMAX,RMMM(1))
      DMAX=RMMM(3)
```

```
C
C      *** IS LMAX=NSTRT OR LMAX=NSTOP?
       IF (LMAX-NSTRT-I1)50,10
   10  IF (NSTOP-LMAX-I1)50,100
   50  DB=0.
       FSTRT=FLOAT(LMAX)
       FSTOP=FSTRT
       RETURN
C
C      *** CALCULATE TEST LEVEL, DBM.
  100  TDBM=DMAX-DB
C
C      *** SEARCH FROM LMAX TOWARD NSTOP.
       INCMT=I1
       ISTOP=NSTOP
  110  ITEST=LMAX
  120  LAST=ITEST
       ITEST=ITEST+INCMT
C
C      *** HAVE WE REACHED THE END OF THE ARRAY?
       IF (INCMT*(ISTOP-ITEST))300,200
C
C      *** NO.  IS THE NEXT DATA VALUE LESS THAN THE TEST DBM
C      *** VALUE, "TDBM"?
  200  IF (TDBM-DATA(ITEST))120,400
C
C      *** END OF ARRAY, WITHOUT SATISFYING "DB" TEST.
C        * FIND MIMIMUM DATA VALUE BETWEEN LMAX AND ISTOP,
C      *** THEN RE-DEFINE "DB".
  300  N1=LMAX
       N2=NSTOP
       IF (INCMT)310,320
  310  N1=NSTRT
       N2=LMAX
  320  CALL AMMMS(DATA(1),N1,N2,LMIN,LMAX,RMMM(1))
       DB=FLOAT(IFIX(DMAX-RMMM(1)))
       GOTO 100
C
C      *** CALCULATE INTERPOLATION SCALING FACTOR.
  400  SCALF=(TDBM-DATA(ITEST))/(DATA(LAST)-DATA(ITEST))
C
C      *** CALCULATE FSTRT OR FSTOP?
       IF (INCMT)410,420
C
C      *** CALCULATE INTERPOLATED FLOATING-POINT FSTRT VALUE.
  410  FSTRT=FLOAT(ITEST)+SCALF
       RETURN
C
C      *** CALCULATE INTERPOLATED FLOATING-POINT FSTOP VALUE.
  420  FSTOP=FLOAT(ITEST)-SCALF
C
C      *** SEARCH ARRAY FROM LMAX TO NSTRT.
       INCMT=-I1
       ISTOP=NSTRT
       GOTO 110
C
       END
       END$
```

```
FTN,L
      SUBROUTINE ASCAL(ITYPE,DATA,NSTRT,NSTOP)
C     ASCAL:  ARRAY AMPLITUDE DATA SCALING
C              (DBM TO/FROM MW, UV, OR ADC VALUES)
C
      DIMENSION DATA(1)
C
C     ************************************************************
C     *                                                          *
C     *             8580B - AMPLITUDE UNIT CONVERSIONS           *
C     *                                                          *
C     *  ASCAL CONVERTS (SCALES) THE AMPLITUDE VALUES IN THE     *
C     *  ELEMENTS NSTRT THROUGH NSTOP OF ARRAY "DATA" FROM       *
C     *  FROM ONE SET OF UNITS TO ANOTHER, E.G.:                 *
C     *                                                          *
C     *       ITYPE        INPUT UNITS     OUTPUT UNITS          *
C     *         1              DBM          MILLIWATTS           *
C     *         2              DBM     MICROVOLTS (50 OHMS)      *
C     *         3              DBM              ADC              *
C     *                                                          *
C     *                                                          *
C     *  FOR NEGATIVE VALUES OF ITYPE, THE INPUT AND OUTPUT      *
C     *  UNITS ARE INTERCHANGED.  E.G. ITYPE = -1 CONVERTS       *
C     *  MILLIWATTS TO DBM.                                      *
C     *                                                          *
C     *  NSTOP MUST BE >= NSTRT.                                 *
C     *                                                          *
C     ************************************************************
C     *                                                          *
C     *  ATS BASIC BRANCH TABLE ENTRY:         ASCAL(I,R,I,I);   *
C     *                                                          *
C     ************************************************************
C     *                                                          *
C     *  NO NON-STANDARD SUBROUTINES OR FUNCTIONS ARE CALLED.    *
C     *                                                          *
C     ************************************************************
C     *                                                          *
C     *  HRI             JULY 11, 1973         REV. 4: 5-31-75   *
C     *                                                          *
C     ************************************************************
C
      IATYP=IABS(ITYPE)
      DO 1000 I=NSTRT,NSTOP
         DATAI=DATA(I)
         IF (ITYPE)100,500
C
  100    GOTO (200,300,400)IATYP
C
C        *** CONVERT MILLIWATTS TO DBM.
  200    DATAI=4.342945*ALOG(DATAI)
         GOTO 1000
C
C        *** CONVERT MICROVOLTS TO DBM (50 OHMS).
  300    DATAI=8.68589*ALOG(DATAI*4.47214E-06)
         GOTO 1000
C
C        *** CONVERT ADC TO EQUIVALENT DBM.
  400    DATAI=COREC(IFIX(DATAI))
         GOTO 1000
C
```

```
  500     GOTO (600,700,800)IATYP
C
C         *** CONVERT DBM TO MILLIWATTS.
  600     DATAI=EXP(DATAI*.2302585)
          GOTO 1000
C
C         *** CONVERT DBM TO MICROVOLTS (50 OHMS.)
  700     DATAI=.223607E+06*EXP(DATAI*.115129)
          GOTO 1000
C
C         *** CONVERT DBM TO EQUIVALENT ADC VALUES.
  800     DATAI=IADCR(DATAI)
C
 1000     DATA(I)=DATAI
C
        END
        END$
```

```
FTN,L
      SUBROUTINE AMMMS(DATA,NSTRT,NSTOP,LMIN,LMAX,RMMMS)
C     AMMMS:  MIN, MEAN, MAX, AND SUM (OF ELEMENTS) OF
C             AN ARRAY
C
      DIMENSION DATA(1),RMMMS(1)
C
C     **********************************************************
C     *                                                        *
C     *  SUBROUTINE AMMMS DETERMINES THE MINIMUM AND MAXIMUM   *
C     *  VALUES IN THE ARRAY "DATA(I)" FOR I=NSTRT TO NSTOP,   *
C     *  INCLUSIVE.  AMMMS ALSO CALCULATES THE MEAN OF THE     *
C     *  "DATA" VALUES BETWEEN THESE TWO BOUNDS OF I.  THE     *
C     *  MIN, MEAN, MAX, AND SUM ARE RETURNED TO THE CALLING   *
C     *  ROUTINE VIA REAL ARRAY RMMMS, AS FOLLOWS:             *
C     *                                                        *
C     *                  RMMMS(1) = MINIMUM                    *
C     *                  RMMMS(2) = MEAN                       *
C     *                  RMMMS(3) = MAXIMUM                    *
C     *                  RMMMS(4) = SUM                        *
C     *                                                        *
C     *  SUBROUTINE AMMMS ALSO RETURNS THE LOCATION OF THE     *
C     *  MINIMUM AND MAXIMUM, AS "LMIN" AND "LMAX".            *
C     *                                                        *
C     *  NSTOP MUST BE >= NSTRT.                               *
C     *                                                        *
C     **********************************************************
C     *                                                        *
C     *  ATS BASIC BRANCH TABLE ENTRY:  AMMMS(R,I,I,IP,IP,R);  *
C     *                                                        *
C     **********************************************************
C     *                                                        *
C     *  NO NON-STANDARD SUBROUTINES OR FUNCTIONS ARE CALLED.  *
C     *                                                        *
C     **********************************************************
C     *                                                        *
C     *                                                        *
C     *                                                        *
C     **********************************************************
C
C     *** INITIALIZE POINTERS, MIN/MAX DATA VALUES, ETC.
      LMIN=NSTRT
      DMIN=DATA(NSTRT)
      LMAX=NSTRT
      DMAX=DMIN
      DSUM=0.
C
C     *** SEARCH DATA ARRAY.
      DO 130 I=NSTRT,NSTOP
C
C         *** NOTE: THE CURRENT DATA VALUE, DATA(I), IS RE-
C           * ASSIGNED TO A SIMPLE VARIABLE, DATAI, TO SPEED UP
C           * EXECUTION (THE SUBSEQUENT REFERENCES TO DATA(I)
C           * NEED NOT RE-COMPUTE THE ADDRESS OF A SUBSCRIPTED
C         *** VARIABLE).  THIS ALSO SAVES SOME CORE.
          DATAI=DATA(I)
          DSUM=DSUM+DATAI
          IF (DMAX-DATAI)100,110
  100     DMAX=DATAI
          LMAX=I
```

```
  110     IF (DATAI-DMIN)120,130
  120     DMIN=DATAI
          LMIN=I
  130     CONTINUE
C
C      *** ASSIGN VALUES TO RETURNED MIN/MEAN/MAX ARRAY.
       RMMMS(1)=DMIN
       RMMMS(2)=DSUM/FLOAT(NSTOP-NSTRT+1)
       RMMMS(3)=DMAX
       RMMMS(4)=DSUM
C
       END
       END$
```

```
FTN,L
      SUBROUTINE AINIT(DATA,NSTRT,NSTOP,VALUE)
C     AINIT:  ARRAY INITIALIZATION
C
      DIMENSION DATA(1)
C
C     ****************************************************************
C     *                                                              *
C     *  SUBROUTINE AINIT INITIALIZES ELEMENTS NSTRT THROUGH         *
C     *  NSTOP OF THE ARRAY "DATA", SETTING EACH ELEMENT EQUAL       *
C     *  TO "VALUE".                                                 *
C     *     .                                                        *
C     *  NSTOP MUST BE >= NSTRT.                                     *
C     *                                                              *
C     ****************************************************************
C     *                                                              *
C     *  ATS BASIC BRANCH TABLE ENTRY:          AINIT(R,I,I,R);      *
C     *                                                              *
C     ****************************************************************
C     *                                                              *
C     *  NO NON-STANDARD SUBROUTINES OR FUNCTIONS ARE CALLED.        *
C     *                                                              *
C     ****************************************************************
C     *                                                              *
C     *                                                              *
C     *                                                              *
C     ****************************************************************
C
      DO 100 I=NSTRT,NSTOP
  100    DATA(I)=VALUE
C
      END
      END$
```

```
FTN,L
      SUBROUTINE MSEL(MTYPE,TIME,INTRP,AMPL)
C     MSEL:  8580B MEASUREMENT SELECT
C
C     ***********************************************************
C     *                                                         *
C     *                8580B MEASUREMENT SELECT                 *
C     *                                                         *
C     *                                                         *
C     *  SUBROUTINE MSEL SELECTS A MEASUREMENT TYPE ACCORDING   *
C     *  TO THE VALUE OF "MTYPE".
C     *                                                         *
C     *       MEASUREMENT                                       *
C     *  MTYPE  SUBROUTINE      MEASUREMENT TYPE      UNITS     *
C     *                                                         *
C     *    1       DIGGO             AVERAGE           DBM      *
C     *    2       DIGGO               PEAK            DBM      *
C     *    3       MSRMS             TRUE RMS          DBM      *
C     *    4       MSRMS             TRUE RMS          MW       *
C     *    5       MSRMS             TRUE RMS          UV       *
C     *    6       PKAVG           PEAK/AVERAGE        DB       *
C     *    7       PKAVG             MAX/MIN           DB       *
C     *    8       PKAVG               MIN             DB       *
C     *                                                         *
C     *  THE PARAMETERS "TIME" FOR "DIGGO" OR "PKHLD", "MSEC"   *
C     *  FOR "DIGGO", AND "NAVG" FOR "MSRMS" ARE PASSED INTO    *
C     *  MSEL VIA "TIME".  THE PARAMETER "INTRP" IS IGNORED.    *
C     *                                                         *
C     ***********************************************************
C     *                                                         *
C     *  ATS BASIC BRANCH TABLE ENTRY:         MSEL(I,R,I,R);   *
C     *                                                         *
C     ***********************************************************
C     *                                                         *
C     *   NON-STANDARD SUBROUTINES OR FUNCTIONS CALLED ARE:     *
C     *                     MSRMS, PKAVG                        *
C     *                                                         *
C     ***********************************************************
C     *                                                         *
C     *                                                         *
C     *                                                         *
C     ***********************************************************
C
      ITIME=IFIX(TIME)
C
C     *** INITIALIZE MEASUREMENT SWITCHING POINTERS.
C       * MSELR = MSRMS SWITCHING POINTER
C     *** MSELP = PKAVG SWITCHING POINTER
      MSELR=MTYPE-2
      MSELP=MTYPE-5
C
C     *** SELECT MEASUREMENT TYPE.
      GOTO (100,110,120,120,120,150) MTYPE
C
100   CALL DIGSU(0, -30*ITIME-1, 0., 50.)
      CALL DIGGO(AMPL, P1, P2)
      GOTO 9999
C
110   CALL DIGSU(1, 0, TIME, 30.)
      CALL DIGGO(A, AMPL, P2)
```

```
      GOTO 9999
C
  120 CALL MSRMS(ITIME,POWER,AMPL)
      GOTO (9999,130,140)MSELR
C
  130 AMPL=POWER
      GOTO 9999
C
  140 AMPL=SQRT(POWER*.5E+11)
      GOTO 9999
C
  150 CALL PKAVG(TIME,AMIN,AVG,AMAX)
      AMPL=AMAX-AVG
      GOTO (9999,160,170)MSELP
C
  160 AMPL=AMAX-AMIN
      GOTO 9999
C
  170 AMPL=AMIN
C
 9999 END
      END$
```

```
FTN,L
      SUBROUTINE MSRMS(N,AMW,ADBM)
C     MSRMS:  RMS MEASUREMENT ROUTINE
C
C
C     ***********************************************************
C     *                                                         *
C     *       MSRMS - 8580B TRUE RMS MEASURING ROUTINE          *
C     *                                                         *
C     *  SUBROUTINE MSRMS MAKES N MEASUREMENTS AT THE CURRENT   *
C     *  TUNED FREQUENCY.  EACH IS CONVERTED TO MILLIWATTS FOR  *
C     *  CALCULATION OF THE SUM, AND ULTIMATELY THE RMS (MEAN)  *
C     *  VALUE.  THE RMS VALUE IS CONVERTED TO DBM AND          *
C     *  RETURNED AS ADBM.  THE RMS VALUE IN MILLIWATTS IS      *
C     *  RETURNED AS AMW.                                       *
C     *                                                         *
C     *  FOR THE NARROWER BANDWIDTHS (<= .1 KHZ), A 1/2 BAND-   *
C     *  WIDTH TIME CONSTANT DELAY IS INSERTED BETWEEN MEAS-    *
C     *  UREMENTS.                                              *
C     *                                                         *
C     *   ***************************************************   *
C     *   *                                                 *   *
C     *   *     THE VIDEO FILTER IS TURNED OFF DURING       *   *
C     *   *     EXECUTION OF MSRMS.  IT IS RESTORED AFTER   *   *
C     *   *     EXECUTION OF MSRMS (IF IT WAS ON WHEN       *   *
C     *   *     MSRMS WAS CALLED).                          *   *
C     *   *                                                 *   *
C     *   ***************************************************   *
C     *                                                         *
C     ***********************************************************
C     *                                                         *
C     *  ATS BASIC BRANCH TABLE ENTRY:          MSRMS(I,R,R);   *
C     *                                                         *
C     ***********************************************************
C     *                                                         *
C     *   NON-STANDARD SUBROUTINES OR FUNCTIONS CALLED ARE:     *
C     *                        BWSTP                            *
C     *                                                         *
C     ***********************************************************
C     *                                                         *
C     *                                                         *
C     *                                                         *
C     ***********************************************************
C
C     *** DETERMINE VIDEO FILTER CONDITION.
      CALL RFCON(36, IVID)
      CALL VIDEO(0)
C
C     *** DETERMINE I.F. BANDWIDTH; CALCULATE DELAY (IN 100'S OF
C     *** MICROSECONDS.)
      CALL BWSTP(0,BW)
      IDLY=IFIX(5./BW)
C
C     *** CHECK FOR N <= 0.
      N0=N
      IF (N0-1)10,20
   10 N0=1
   20 SUM=0.
C
C     *** MEASUREMENT LOOP.  (ACCUMULATE SUM OF MILLIWATTS.)
```

```
      DO 100 I=1,N0
         CALL MEAS(AMPL)
         CALL HLDOF(IDLY)
  100    SUM=SUM+EXP(.2302585*AMPL)
C
C     *** CALCULATE AVERAGE POWER (MW) AND CONVERT TO DBM.
      AMW=SUM/FLOAT(N0)
      ADBM=4.342945*ALOG(AMW)
C
C     *** RESTORE VIDEO FILTER (IF NECESSARY).
      CALL VIDEO(IVID)
C
      END
      END$
```

```
FTN,L
      SUBROUTINE BWSTP(NSTEP,BWF)
C     BWSTP:  BANDWIDTH STEP ROUTINE
C
      DIMENSION BW(10)
C
C     ***************************************************************
C     *                                                             *
C     *   SUBROUTINE BWSTP INCREMENTS (OR DECREMENTS) THE           *
C     *   CURRENT I.F. BANDWIDTH BY NSTEP.  THE FINAL I.F.          *
C     *   BANDWIDTH IS RETURNED AS BWF.  IF NSTEP = 0, THE          *
C     *   CURRENT I.F. BANDWIDTH IS RETURNED.                       *
C     *                                                             *
C     *   IF AN ATTEMPT IS MADE TO INCREMENT BEYOND THE 300         *
C     *   KHZ BANDWIDTH (OR DECREMENT BEYOND THE .01 KHZ BAND-      *
C     *   WIDTH), THE BANDWIDTH IS SET AT 300 KHZ (OR .01 KHZ)      *
C     *   AND BWF IS RETURNED AS -BWF.                              *
C     *                                                             *
C     ***************************************************************
C     *                                                             *
C     *   ATS BASIC BRANCH TABLE ENTRY:              BWSTP(I,R);    *
C     *                                                             *
C     ***************************************************************
C     *                                                             *
C     *   NO NON-STANDARD SUBROUTINES OR FUNCTIONS ARE CALLED.      *
C     *                                                             *
C     ***************************************************************
C     *                                                             *
C     *                     27 JUNE 1977                            *
C     *                                                             *
C     ***************************************************************
C
C     *** SET UP BANDWIDTH REFERENCE TABLE.
      BW(1)=300.
      BW(2)=100.
      BW(3)=30.
      BW(4)=10.
      BW(5)=3.
      BW(6)=1.
      BW(7)=.3
      BW(8)=.1
      BW(9)=.03
      BW(10)=.01
C
C     *** CALCULATE NEW BANDWIDTH CODE, NEWBW.
C
C     *** (FLAG IOK CHECKS WHETHER THE BANDWIDTH LIMITS HAVE
C     *** BEEN EXCEEDED WHILE EXECUTING BWSTP.)
      IOK=1
      CALL RFCON(32, ICURBW)
      NEWBW=ICURBW+1-NSTEP
      IF (NEWBW-11)10,20
   10 IF (-NEWBW)100,30
   20 NEWBW=10
      GOTO 40
   30 NEWBW=1
   40 IOK=-1
C
  100 CALL BWDTH(BW(NEWBW))
      BWF=BW(NEWBW)*FLOAT(IOK)
```

```
C
      END
      END$
```

```
FTN,L
      PROGRAM COMB
      DIMENSION IARR(10),FL(4),FU(4),DFMHZ(4)
      DATA FL/2000.,8000.,18000.,26500./
      DATA FU/8000.,18000.,26500.,40000./
      DATA DFMHZ/25.,40.,50.,100./
      CALL ARSET
      L1=0
      B=300.
      CALL ATTEN(0)
      CALL CLEAR(0)
      CALL PORTS(5,1,3)
      CALL VIDEO(1)
10    FORMAT("ENTER START AND STOP FREQUENCIES")
      WRITE(1,20)
20    FORMAT("ENTER COMB GENERATOR ADDRESS")
30    FORMAT("ENTER IF BANDWIDTH")
40    FORMAT("ENTER MAXIMUM AMPLITUDE")
      READ(1,*) ISA
45    CALL CLEAR(0)
      ICOMB=0
      IF(ISA.EQ.20) ICOMB=1
      IF(ISA.EQ.50) ICOMB=2
      IF(ISA.EQ.56) ICOMB=3
      IF(ISA.EQ.62) ICOMB=4
      IF(ICOMB.EQ.0) GO TO 10
      F1=FL(ICOMB)
      CALL FTUNE(F1)
      F2=FU(ICOMB)
      DF=DFMHZ(ICOMB)
 50   CALL CLEAR(0)
      CALL SOURC(ISA)
      IRA=L1+40
      IF(IRA.LT.0) IRA=0
      IF(IRA.GT.70) IRA=70
      IGAIN=-(L1+40)
      IF(IGAIN.LT.0) IGAIN=0
      IF(IGAIN.GT.50) IGAIN=50
      CALL GAIN(IGAIN)
      CALL BWDTH(B)
      CALL RATTN(IRA)
      WRITE(1,60)
60    FORMAT(20X,"COMB GENERATOR SPECTRUM")
      CALL SCALE(F1,F2,L1-80.,L1)
      CALL SAXES(.1*(F2-F1),10.)
      CALL CODE
      WRITE(IARR,70)
70    FORMAT("FREQUENCY(MHz)")
      CALL VECT(1,0,440,30)
      CALL LABEL(7,IARR)
      CALL BLOCK(IB1)
80    F=F1
90    CONTINUE
      CALL TUNE(F)
      CALL SSW(1,M1)
      IF(M1.NE.0)GO TO 500
      CALL SSW(2,M2)
      IF(M2.NE.0)GO TO 600
      CALL SSW(3,M3)
      IF(M3.NE.0)GO TO 700
```

```
      CALL SSW(4,M4)
      IF(M4.NE.0) GO TO 800
      CALL SSW(5,M5)
      IF(M5.NE.0) GO TO 900
      CALL SSW(6,M6)
      IF(M6.NE.0) GO TO 1000
      CALL SSW(7,M7)
      IF(M7.NE.0) GO TO 1100
200   CONTINUE
C     CALL BUSYP
      CALL MEAS(A)
      CALL PLOT(F,A,3)
      F=F+DF
      IF(F.LT.F2) GO TO 90
      CALL MVPTR(IB1,1)
      GOTO 80
500   CALL CLEAR(0)
      WRITE(1,10)
      READ(1,*) F1,F2
      DF=.004*(F2-F1)
      GO TO 50
600   CALL CLEAR(0)
      WRITE(1,30)
      READ(1,*) B
      GO TO 50
700   W=0
      CALL SCPOS(F0,P0,W)
      WRITE(15,710) F0,P0
710   FORMAT(10X,"F0=",F9.3,10X,"P0=",10X,F9.3)
      CALL CLEAR(0)
      GO TO 50
800   CONTINUE
      GO TO 200
900   CALL CLEAR(0)
      WRITE(1,40)
      READ(1,*) L1
      GO TO 50
1000  CALL CLEAR(0)
      WRITE(1,20)
      READ(1,*) ISA
      GO TO 45
1100  CALL CLEAR(0)
      CALL ARSET
      CALL STOP
      END
      END$
```

```
FTN,L
      PROGRAM NOISE
      DIMENSION  F1(9),F2(9),P1(201)
      DIMENSION YL(9),YH(9),YSCALE(9),IGAIN(9)
      REAL NF
      DATA YL/2*3.,10.,2*1.,3*10./,YH/2*33.,30.,2*6.,3*30./
      DATA YSCALE/2*3.,2.,2*.5,3*2./,IGAIN/2*30,40,2*10,3*40/
      DATA F1/.01,10.,2000.,3700.,7250.,8000.,18000.,26500./
      DATA F2/10.,2000.,8000.,4200.,7750.,18000.,26500.,40000./
      DATA C1/4.3429/
      CALL ARSET
      CALL PORTS(5,1,3)
      CALL ATTEN(0)
      CALL ALGRS(2)
5     CALL CLEAR(0)
      WRITE(1,15)
15    FORMAT("ENTER NOISE DIODE ADDRESS")
      READ(1,*) ISA
      L=0
      IF(ISA.EQ. 2) L=1
      IF(ISA.EQ. 7) L=2
      IF(ISA.EQ. 19) L=3
      IF(ISA.EQ. 26) L=4
      IF(ISA.EQ. 33) L=5
      IF(ISA.EQ. 49) L=6
      IF(ISA.EQ.55) L=7
      IF(ISA.EQ.61) L=8
      IF(L.EQ.0) GO TO 5
      IF(L.LT.7) CALL BWDTH(3.)
      CALL FTUNE(F1(L))
      CALL SOURC(ISA)
      IF(F2(L) .LE. 2000.) CALL PRSEL(1)
      CALL RATTN(0)
60    CONTINUE
      CALL BWDTH(300.)
      CALL VIDEO(1)
      CALL GAIN(IGAIN(L))
      CALL NOISD(0)
      CALL BLOCK(IB1)
      CALL CLEAR(0)
      WRITE(1,100)
100   FORMAT(19X," CONVERTER NOISE FIGURE")
      CALL SCALE(F1(L),F2(L),YL(L),YH(L))
      CALL SAXES(.1*(F2(L)-F1(L)),YSCALE(L))
      CALL BLOCK(IB2)
      DF=.005*(F2(L)-F1(L))
      CALL DIGSU(0,-100,0.,10.)
      DO 150 I=1,200
      F=F1(L)+(I-1)*DF
      CALL FTUNE(F)
      CALL DIGGO(A,PEAKP,PEAKM)
      P1(I)=EXP(A/C1)
150   CONTINUE
      CALL NOISD(1)
      CALL FTUNE(F1(L))
      DO 250 I=1,200
      F=F1(L)+(I-1)*DF
      CALL FTUNE(F)
      CALL DIGGO(A,PEAKP,PEAKM)
      Y=( EXP(A/C1)/P1(I) )
```

```
      ENR=AGAIN(ISA,F)
      NF=ENR-10.*ALOGT(Y-1.)
      CALL PLOT(F,NF,3)
250   CONTINUE
      WRITE(1,450)
450   FORMAT("SET SENSE SWITCH 1 TO UP POSITION TO REPEAT")
      WRITE(1,500)
      I=0
500   FORMAT("Press MARK to continue")
      CALL CRPOS(IX,IX,I)
      CALL SSW(1,M1)
      IF(M1.NE. 0) GO TO 5
      CALL ARSET
      CALL STOP
      END
      END$
```

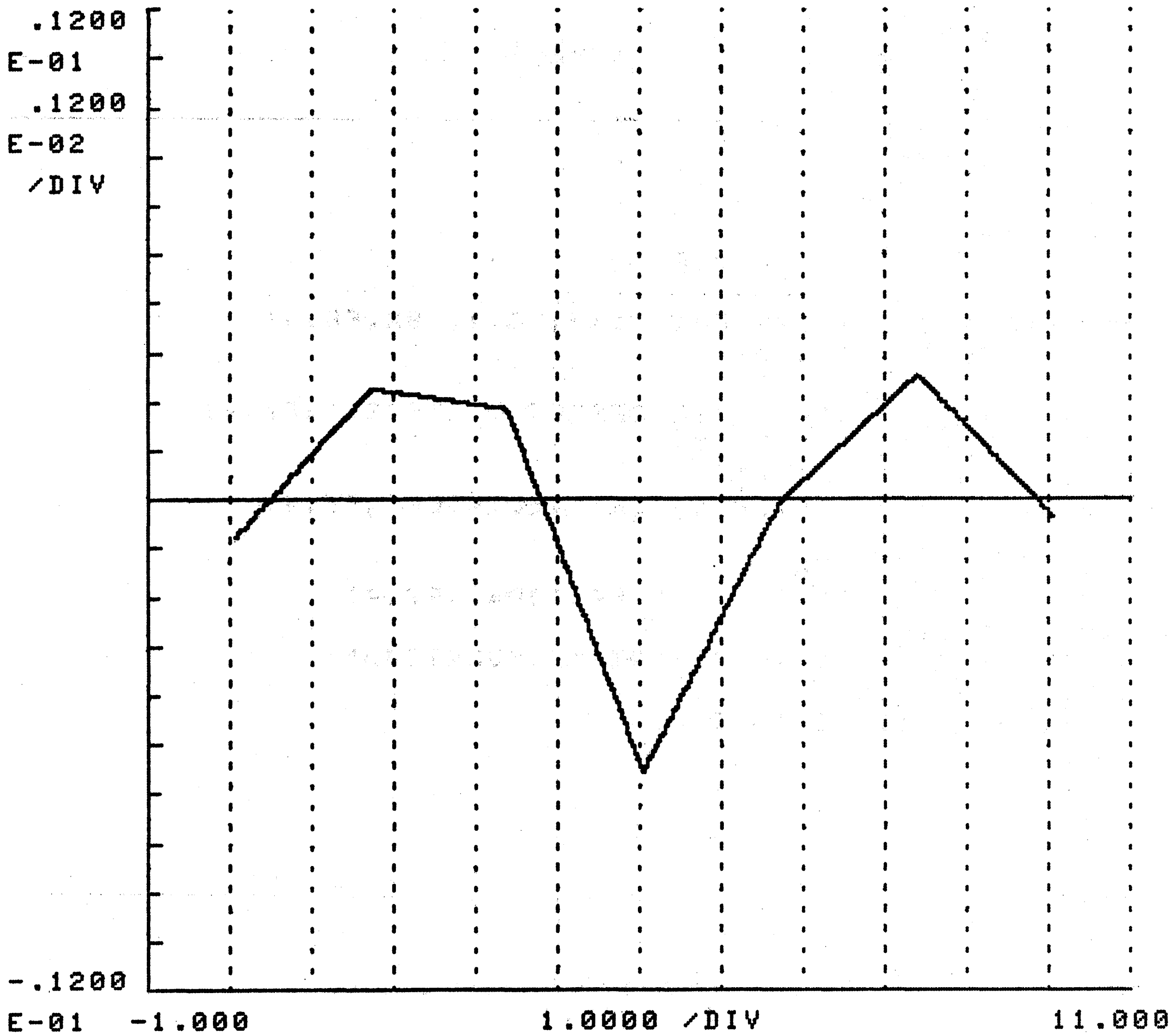
```
      FTN4,L
      PROGRAM FIT
      DIMENSION DIFF(50),ICHAR(20),F(50),FCAL(50),V(50)
10    CALL CLEAR(0)
20    ICOUNT=0
      WRITE(1,30)
30    FORMAT(10X,"ENTER MONTH,DATE,YEAR")
      READ(1,*) MONTH,IDATE,IYEAR
      WRITE(1,40)
40    FORMAT(10X,"ENTER DEVICE TYPE")
      READ(1,50) ICHAR
50    FORMAT(20A2)
      WRITE(1,60)
60    FORMAT(10X,"ENTER DEVICE SERIAL NUMBER")
      READ(1,*) ISN
      WRITE(1,70)
70    FORMAT(10X,"INPUT NUMBER OF DATA POINTS")
      READ(1,*) NPTS
      WRITE(1,75)
75    FORMAT(2X,"TOGGEL SSW 1 TO CONTINUE")
76    CALL SSW(1,IPOS)
      IF(IPOS .EQ. 0) GO TO 76
77    CALL SSW(1,IPOS)
      IF(IPOS .NE. 0)GO TO 77
80    CALL CLEAR(0)
85    WRITE(1,90)
90    FORMAT(10X,"ENTER FREQUENCY (GHZ) & VOLTAGE PAIR")
      ICOUNT=ICOUNT+1
      READ(1,*) F(ICOUNT),V(ICOUNT)
      IF(ICOUNT.LT.NPTS) GO TO 85
      WRITE(1,75)
95    CALL SSW(1,IPOS)
      IF(IPOS .EQ. 0)GO TO 95
96    CALL SSW(1,IPOS)
      IF(IPOS .NE. 0) GO TO 96
100   S0=0.
      S1=0.
      S2=0.
      S3=0.
      DO 110 I=1,NPTS
      S0=S0+F(I)
      S1=S1+V(I)
      S2=S2+F(I)*V(I)
110   S3=S3+V(I)*V(I)
      D=NPTS*S3-S1*S1
      SLOPE=(NPTS*S2-S0*S1)/D
      Y0=(S0*S3-S2*S1)/D
      TEMP=0.
      S=0.
      DO 120 I=1,NPTS
      FCAL(I)=SLOPE*V(I)+Y0
      DIFF(I)=FCAL(I)-F(I)
      TEMP1=ABS(DIFF(I))
      S=S+DIFF(I)*DIFF(I)
120   IF(TEMP1.GT. TEMP) TEMP=.002*IFIX(1000.*TEMP1)
      S4=S/NPTS
      S5=NPTS*S4/D
      S6=S4*S1/D
      CALL BLOCK(IB1)
      CALL CLEAR(0)
```

```
      CALL SCALE(-1.,11.,-TEMP,TEMP)
      CALL SAXES(1.,-.1*TEMP)
      CALL VECT(1,0,128,480)
      CALL VECT(2,3,896,480)
      CALL BLOCK(IB2)
      DO 133 J=1,NPTS
      CALL PLOT(V(J),DIFF(J),3)
133   CONTINUE
      WRITE(1,75)
134   CALL SSW(1,IPOS)
      IF(IPOS .EQ. 0) GO TO 134
135   CALL SSW(1,IPOS)
      IF(IPOS .NE. 0) GO TO 135
      CALL CLEAR(0)
      WRITE(1,130) MONTH,IDATE,IYEAR
 130  FORMAT(10X,"DATE:",I2,"/",I2,"/",I4)
      WRITE(1,140) ICHAR,ISN
140   FORMAT(10X,20A2,/,10X,"DEVICE SERIAL NUMBER-",I6,/)
      WRITE(1,150)
150   FORMAT(5X,"TUNING VOLTAGE     F(MEASURED)     F(CALCULATED
  )")
      DO 154 J=1,NPTS
154   WRITE(1,155) V(J),F(J),FCAL(J)
155   FORMAT(5X,F6.3,15X,F6.3,10X,F6.3)
      WRITE(1,160) Y0,S6
160   FORMAT(//,5X,"START    FREQUENCY=",F6.3,5X,"VARIANCE=",E9.
  4)
      WRITE(1,170) SLOPE,S5
      WRITE(1,180) S4
170   FORMAT(5X,"TUNING SENSITIVITY=",F6.3,5X,"VARIANCE=",E9.4)
180   FORMAT(5X,"SAMPLE VARIANCE=",E9.4)
      WRITE(1,190)
190   FORMAT(10X,"IF DATA PONT CORRECTION REQUIRED,ENTER 1")
      READ(1,*) M1
      IF(M1.EQ.1) GO TO 500
      GO TO 900
500   CONTINUE
      CALL CLEAR(0)
      WRITE(1,510)
510   FORMAT(10X,"ENTER I,F(I),V(I) ")
      READ(1,*) I,F(I),V(I)
      WRITE(1,520)
520   FORMAT(10X,"IF MORE CORRECTIONS REQUIRED, ENTER 1")
      READ(1,*) M2
      IF(M2.EQ.1) GO TO 500
      CALL CLEAR(0)
      GO TO 100
900   WRITE(1,600)
600   FORMAT("ENTER 1 TO START NEW FIT")
      READ(1,*) M3
      IF(M3.EQ.1) GO TO 10
      END
      END$
```

```
FTN4,L
      PROGRAM TRAK
      CALL CLEAR(0)
5     WRITE(1,10)
10    FORMAT(5X,"CONVERTER FREQUENCY BAND 2=2-8GHZ")
      WRITE(1,20)
20    FORMAT(5X,"CONVERTER FREQUENCY BAND 3=8-18GHZ")
      WRITE(1,30)
30    FORMAT(5X,"CONVERTER FREQUENCY BAND 4=18-26.6GHZ")
      WRITE(1,40)
40    FORMAT(5X,"CONVERTER FREQUENCY BAND 5=26.5-40GHZ")
50    WRITE(1,60)
60    FORMAT(5X,"ENTER CONVERTER FREQUENCY BAND")
      READ(1,*)IBND
      WRITE(1,70)
70    FORMAT(5X,"ENTER 15 FOR OUTPUT TO PRINTER; 1 FOR OUTPUT TO
   CRT")
      READ(1,*) LU
      WRITE(1,100)
100   FORMAT(5X,"ENTER OSC. START FREQ. IN GHZ/ &TUNING SENS GHZ
  / VOLT")
      READ(1,*) F0,T0
      WRITE(1,110)
110   FORMAT(5X,"ENTER FILTER START FREQ. & TUNING SENSITIVITY")
      READ(1,*) F1,T1
      CALL CLEAR(0)
      WRITE(LU,120) F0
120   FORMAT(10X,"OSCILLATOR START FREQUENCY=",F7.4)
      WRITE(LU,130) T0
130   FORMAT(10X,"OSCILLATOR TUNING SENSITIVITY(GHz/VOLT)=",F6.4
  )
      WRITE(LU,140) F1
140   FORMAT(10X,"FILTER START FREQUENCY(GHz)=",F7.4)
      WRITE(LU,150) T1
150   FORMAT(10X,"FILTER TUNING SENSITIVITY(GHz/VOLT)=",F6.4)
      WRITE(LU,160)
160   FORMAT(//,18X,"OSCILLATOR TUNING VOLTAGE CONSTANTS",//)
      WRITE(LU,170)
170   FORMAT(" HN ",10X,"+PRE(VOLTS)",10X,"-PRE(VOLTS)",10X,"GAI
  N")
      GO TO (200,200,250,270,300),IBND
200   DO 210 I=1,3
      HN=I
      A=(2.05*HN-F0+.4)/T0
      B=(2.05*HN-F0-.4)/T0
      C=HN*(.205/T0)
210   WRITE(LU,320)HN,A,B,C
      K=1
      GO TO 350
250   DO 260 I=2,5,1
      HN=I
      A=(2.05*HN-F0+.4)/T0
      B=(2.05*HN-F0-.4)/T0
      C=HN*(.205/T0)
260   WRITE(LU,320)HN,A,B,C
      K=1
      GO TO 350
270   DO 280 I=1,5,2
      HN=I
      IF(HN.EQ.1) HN=2.5
```

```
      A=(2.05*HN-F0+.2)/T0
      B=(2.05*HN-F0-.2)/T0
      C=HN*(.205/T0)
      HN=2.*HN
280   WRITE(LU,320) HN,A,B,C
      K=2
      GO TO 350
300   DO 310 I=5,5
      HN=I
      A=(2.05*HN-F0+.2)/T0
      B=(2.05*HN-F0-.2)/T0
      C=HN*(.205/T0)
      HN=2.*HN
310   WRITE(LU,320) HN,A,B,C
      K=2
320   FORMAT(1X,F3.1,12X,F8.4,13X,F8.4, 8X,F8.4)
350   OFSET=(K*F0-F1+.15)/T1
      WRITE (LU,360) OFSET
360   FORMAT(//,10X,"+FILTER OFFSET VOLTAGE=",F7.4)
      OFSET=(K*F0-F1-.15)/T1
      WRITE(LU,370) OFSET
370   FORMAT(10X,"-FILTER OFFSET VOLTAGE=",F7.4)
      FGAIN=K*T0/T1
      WRITE(LU,380) FGAIN
380   FORMAT(10X,"FILTER GAIN FACTOR=",F7.4)
400   WRITE(1,410)
410   FORMAT("ENTER 1 TO REPEAT CALCULATION")
      READ(1,*) IGO
      IF(IGO.EQ.1) GO TO 5
      END
      END$
```

TOGGEL SSW 1 TO CONTINUE



DATE: 2/20/ 80

YIG OSCILLATOR

DEVICE SERIAL NUMBER- 141

TUNING VOLTAGE	F(MEASURED)	F(CALCULATED)
.064	2.000	1.999
1.738	3.000	3.003
3.405	4.000	4.002
5.058	5.000	4.993
6.737	6.000	6.000
8.410	7.000	7.003
10.072	8.000	8.000

START FREQUENCY= 1.961 VARIANCE=.6293E-06

TUNING SENSITIVITY= .600 VARIANCE=.1241E-06

SAMPLE VARIANCE=.9670E-05

IF DATA PONT CORRECTION REQUIRED,ENTER 1

Δ

OSCILLATOR START FREQUENCY= 1.9610

OSCILLATOR TUNING SENSITIVITY(GHz/VOLT)= .5996

FILTER START FREQUENCY(GHz)= 1.9930

FILTER TUNING SENSITIVITY(GHz/VOLT)= .6002

OSCILLATOR TUNING VOLTAGE CONSTANTS

HN	+PRE(VOLTS)	-PRE(VOLTS)	GAIN
1.0	.8155	-.5187	.3419
2.0	4.2345	2.9003	.6838
3.0	7.6534	6.3192	1.0257

+FILTER OFFSET VOLTAGE= .1966

-FILTER OFFSET VOLTAGE= -.3032

FILTER GAIN FACTOR= .9990

ENTER 1 TO REPEAT CALCULATION

Δ

FORM OT-29
(3-73)

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

An automated, computer-controlled receiver system developed by ITS for the U.S. Army Communications Command provides a unique solution to such problems as spectrum management, EM hazards measurements, and site surveying. This receiving system is designed around a commercially available automatic receiver system and covers the frequency band 1 kHz-40 GHz, thus extending the capability of the receiver system by providing extended frequency coverage, multiple antenna selection, improved noise figure performance, built-in test capability, noise figure measurement capability, and 160 dB measurement range; as well as 10 Hz frequency resolution to 40 GHz, computer-controlled directional antenna pointing, and automatic real-time calibration to 40 GHz. Three rf preselector/down converters were

(continued next page)

16. Key works *(Alphabetical order, separated by semicolons)*

Key words: computer controlled receiver; 1 kHz to 40 GHz; electromagnetic compatibility spectrum management; EM hazard measurement

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15. ABSTRACT (cont.)

developed by ITS for use with the receiver to cover frequencies between 2 and 40 GHz. High sensitivity and low transmission loss was achieved by attaching the down converters directly to the antennas and mounting the complete system package on the elevation/azimuth (EL/AZ) positioner. The down converters mix the rf signals to IF (150 MHz), and this IF signal is transmitted through the EL/AZ pedestal via coaxial cable to the bus structure interface unit, mixed to 50 MHz and then fed to the rf-microwave section of the automatic spectrum analyzer for further processing. In addition, a real-time-executive (RTE) software operating system was developed for the receiver system by ITS to extend the operating capability of the receiver system. The RTE allows multiprogram execution, as well as program scheduling, file manipulations, and editing. Using the editor, FORTRAN measurement routines can quickly be written or modified. Both source and object programs are stored on magnetic disc with measurement data stored on magnetic tape for further analysis.

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