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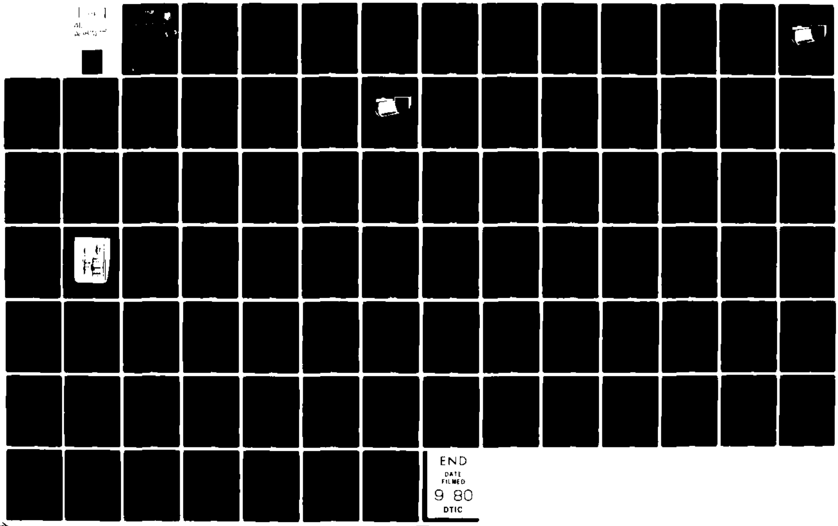

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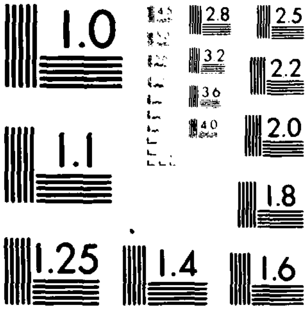

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RADC-TR-80-181
Final Technical Report
May 1980

MULTIPLE THREAT GENERATOR (MTG-100)

Republic Electronic Industries Corp.

J. Michaels

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ROME AIR DEVELOPMENT CENTER
Air Force Systems Command
Griffiss Air Force Base, New York 13441

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This technical report describes the Multiple Threat Generator (MTG-100) designed, developed, fabricated, installed and tested at Rome Air Development Center, by Republic Electronic Industries Corp. The report describes the purpose of the equipment, gives a functional description with a technical overview of both the hardware and software. Included in the report is an operational and maintenance procedure for the Multiple Threat Generator.

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Item 19 (Continued)

Doppler
Active ECM

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LIST OF ILLUSTRATIONS (cont'd.)

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EVALUATION

This is a final report on the Multiple Threat Generator (MTG-100) successfully developed by the Republic Electronics Industries Corp. for the Rome Air Development Center. It describes the purpose of the equipment and gives a functional description with a technical overview of both hardware and software. In addition, it provides operational and maintenance procedures.

The MTG provides an important capability for simulation of simultaneous threat events (targets and ECM) for use in radar design and evaluation procedures. It specifically relates to RADC's surveillance equipment development program which in 1981 will be a part of TPO 1, Tactical C^3.

EDWARD F. KRZYSIAK

TECHNICAL REPORT SUMMARY

FOR THE

MULTIPLE THREAT GENERATOR (MTG-100)

I Technical Problem

The program required the design, fabrication, installation and test of an experimental model Multiple Threat Generator (MTG-100) capable of generating microwave signals at L-band and S-band to simulate in real time that portion of an electromagnetic environment comprised of multiple airborne targets, multiple chaff events dispensed by the simulated targets, and ECM waveforms emanating from selected simulated targets. The ECM waveforms are capable of both denial and confusion techniques.

The MTG-100 provides the capability to simulate up to six simultaneous airborne targets capable of static or dynamic flight paths and nine chaff events. All signals are properly affected by the various scintillation aspects on inputted target cross section, Doppler offset and actual antenna pattern effects in synchronism with the radar.

This equipment provides the RADC Signal Processing Laboratory with the capability of performing laboratory tests, via microwave stimulation, of prototype radar equipment operating in a hostile environment.

II General Methodology

The design, development, fabrication, test and installation of the Multiple Threat Generator progressed through the following phases to completion:

A) Literature review (some examples):

   1. Radar cross section (RCS) distribution, fluctuations and modeling
   2. Chaff dispersion, polarization and meteorology
   3. Target detection and radar range performance computations
   4. ECM modeling
   5. Doppler shift phenomena
   6. Antenna pattern generation

B) Theoretical analysis

C) Functional partitioning and system organization

D) Software development

E) Hardware design (digital and R. F.)
(Breadboard and test where required)

F) Packaging

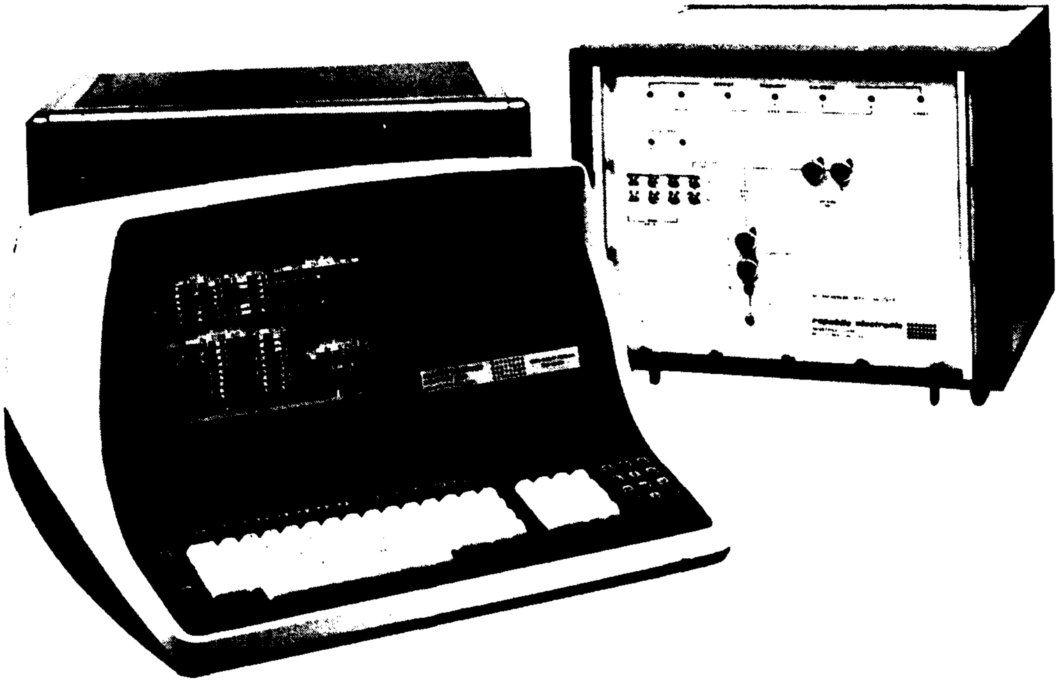
G) Fabrication

H) Test

I) Delivery, installation and test at RADC

III Technical Results

The MTG-100 was delivered and installed at RADC on 10 December 1979, and successfully completed acceptance testing in accordance with the approved acceptance test procedure on 12 December 1979.



MULTIPLE THREAT GENERATOR (MTG-100)

The equipment successfully met all objectives stipulated in the Statement of Work for the Multiple Threat Generator, PR No. A-8-1306.

The MTG-100 provides real time coordinated electromagnetic signatures of targets, chaff and active ECM for the purpose of evaluating radar system performance. This modeling includes extremely accurate simulation of:

1. Signal strength variation due to target radar cross section (RCS) fluctuations
2. Slant range and radar transmitter power
3. Modulation due to target position in the antenna pattern (main and side lobes)
4. Doppler shift and Doppler noise

This simulator utilizes a microprocessor controlled display terminal and a keyboard for data entry. This gives the MTG-100 the ability to program or reprogram any one or more emitter parameters in a complex scenario.

IV The objectives of this contract--to design, fabricate, install and test an experimental model Multiple Threat Generator (MTG-100) capable of demonstrating the feasibility of laboratory tests of prototype equipment--have more than been achieved. In using a microprocessor controlled display terminal and a keyboard for data entry, the equipment realizes a flexibility that goes hand in hand with the modularized architecture designed in for future system expansion.

V Recommendations

To fully assess a radar's ability to perform in a hostile environment requires a number of additional features that can be readily incorporated into the existing Multiple Threat Generator (MTG-100).

Republic recommends that the following equipment modifications be considered, to name a few:

1. 100 Target/Chaff Capability
2. 360° Antenna Pattern Coverage
3. Chaff Air Mass Motion/Screening/Altitude Effects

4. Full Control of Phase and Amplitude
5. Target/Chaff Cross Section and Doppler in Real Time
6. Barker Code Modulation
7. Pseudorandom Binary Coding up to 200 Megabit Rate
8. Complex Radar Waveforms
9. Frequency Coverage Expansion
10. Background Land or Sea Clutter
11. Environmental Anomolies
12. Tape Cartridge Scenario Capability
13. Noncoherent Channel Frequency Agility
14. Jammer PRI Jitter, Stagger and Interleave
15. Coherent Jammer Range Gate Pull-Off
16. No Restriction on Flight Path Dynamics

FINAL TECHNICAL REPORT

MULTIPLE THREAT GENERATOR
(MTG-100)

I PROLOGUE

Radar and radar warning receiver manufacturers and users need to test, stress and prove out equipment performance in an environment as close to reality as possible. Not only should the test environment be real, it must also be flexible and, most importantly, repeatable ... Yes, repeatable over and over again to check and verify flaws, corrections and improvements.

The Multiple Threat Generator (MTG-100), provides real time coordinated electromagnetic signatures of targets, chaff and active ECM. It permits one to:

- Perform R & D studies and design verification tasks
- Evaluate ECM and ECCM effectiveness
- Satisfy factory system testing requirements
- Support maintenance efforts
- Conduct operator training

The MTG-100 provides complex, repeatable microwave stimuli to various classes of receiving equipment.

- **It provides a true response to a radar paint of multiple aircraft targets and associated chaff events. The synchronous responses provide the environment required for an accurate test of the radar.**

The MTG-100 generates a precise replication of the target, whether it be from the aircraft or chaff. The echo reflects:

- Doppler
- Radar Cross Section
- Scintillation
- Range and Bearing
- Bearing Rate
- Scan Modulation

- It provides a true representation of airborne collocated jammer sources.

Unlike other simulators, the MTG-100 places the jammer platforms on the aircraft targets, at R.F., with all of the associated aerodynamic motion characteristics. The generation of denial and confusion countermeasures provides the background for a true test of the radar warning receiver. Parameter sorting, identification, look-through capability and jammer immunity are some of the features that can be quantitatively evaluated.

II THE PROBLEM

The need for realistically testing radar systems has been met in the past by two major approaches:

A) Individual subsystem tests

B) Tests utilizing aircraft and the actual environment

Recently an approach which goes beyond subsystem tests and permits total system evaluation, but does not require expensive and extensive flight testing, has become popular. This approach creates a simulated R.F. environment for the radar system which, in its most ideal form, cannot be distinguished from a real world input. Among the many advantages accrued by this approach are that it is fully controllable, repeatable, and relatively inexpensive.

An invaluable tool in system evaluation is the ability to create the illusion to the radar of actual radar returns with parameter control of:

Doppler Shift

Radar Cross Section

Scintillation Noise and Other Noise Components

Range and Bearing

Bearing Rate

Scan Modulation and Antenna Gain

Range Loss

Chaff and Jammer Effects

The ability to replay a complex scenario allows a true quantitative measurement to be made of any improvements or degradations due to changes in the radar system alignment or design.

The Multiple Threat Generator (MTG-100), shown in Figure II-1, not only creates and controls the true response to the radar paint of multiple targets but also any associated chaff parameters. Unlike other simulators, control and placement of jammers on aircraft platforms may be made with the simulator. This ability allows true testing of radar warning receivers and radar ECM immunities to both denial and confusion techniques.

The MTG-100 provides a realistic synchronous skin return which includes the effect of Doppler, noise effects (due to aircraft motion, antenna motion related to both time, frequency and spatial parameters), and antenna beam width. Provision has been made to include simultaneous coherent and noncoherent radiation from collocated jammers. The replication of these jammer platforms is accomplished with independent ERP control and various operation modes. Among these are coherent range deception, inverse gain or cover pulse. Noncoherent swept CW, spot and barrage noise, plus synchronous and nonsynchronous pulses, are available. Since virtually all parameters are generated and controlled by self-contained microprocessors, the system is adaptable to a wide variety of equipments and need not become obsolete. Total flexibility is assured by software control.

The system easily pays its way if compared to the alternative, that is, flight testing. Situations can be created electromagnetically which, if created conventionally, would be tactically dangerous and undesirable.

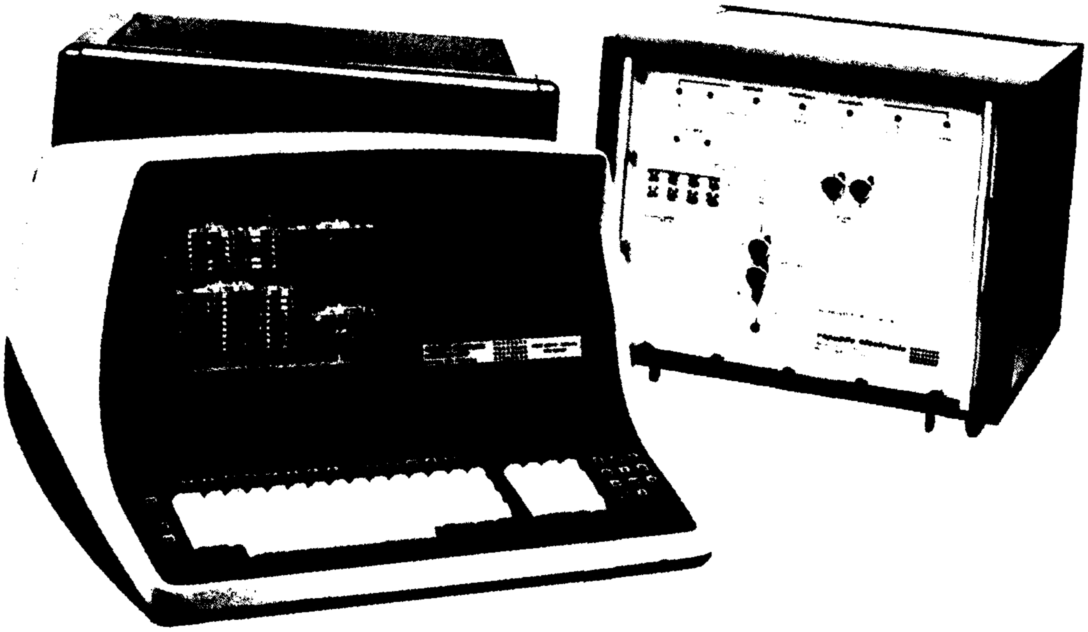


FIGURE II-1
MULTIPLE THREAT GENERATOR (MTG-100)

III FUNCTIONAL DESCRIPTION

The functional aspects of the simulator, its system integration and operator interfaces are shown in the following illustrations.

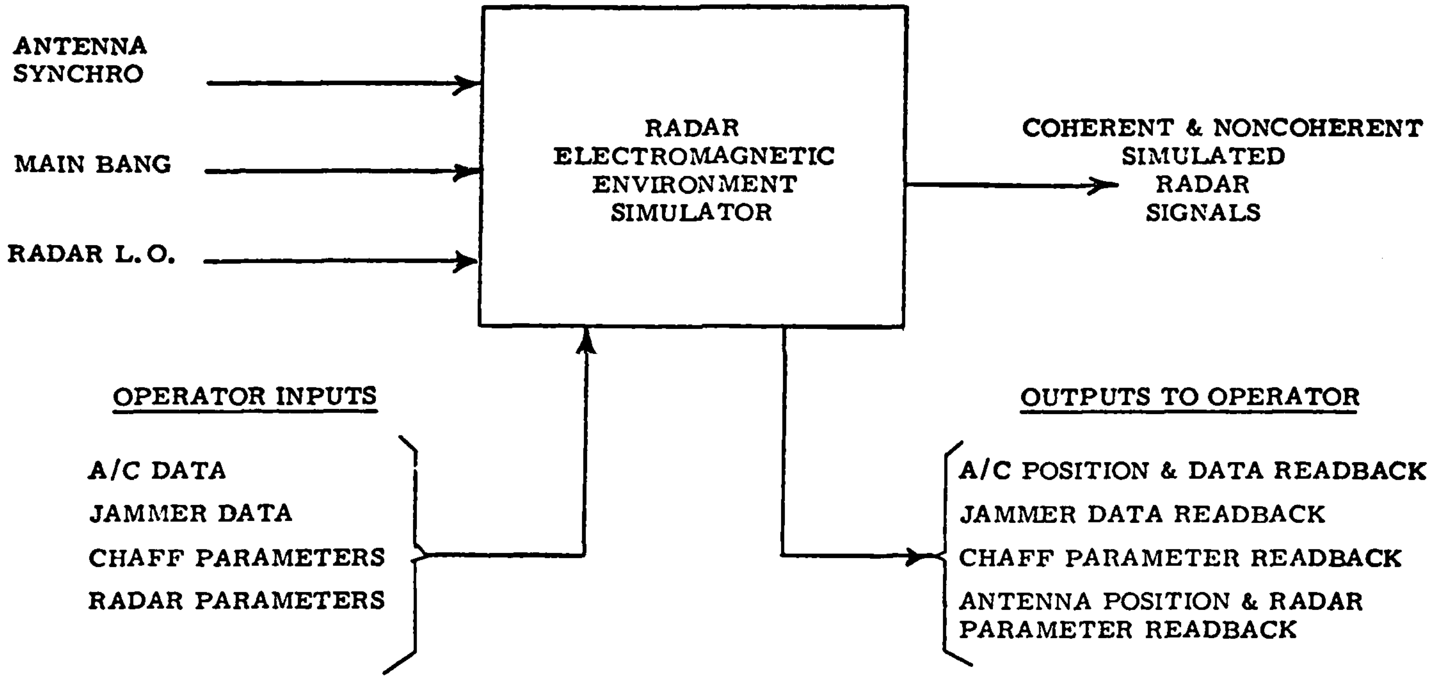


FIGURE III-1. MTG-100 INTERFACES

TABLE III-1.   OPERATOR INPUTS AND DISPLAYED OUTPUTS

AIRCRAFT (A/C) DATA

PARAMETER	OPERATOR INPUT	DISPLAYED OUTPUT
AIRCRAFT NUMBER (NO)	X	X
RANGE	X	X
RANGE RATE (RDOT)	X	X
AZIMUTH	X	X
AZIMUTH RATE (AZDOT)	X	X
TARGET CROSS SECTION (SIGMA)	X	X

TABLE III-2. OPERATOR INPUTS AND DISPLAYED OUTPUTS

JAMMER DATA

PARAMETER	OPERATOR INPUT	DISPLAYED OUTPUT
TYPE:		
COHERENT (COHO)	X	X
NONCOHERENT (NCOHO)	X	X
MODE:		
OFF	X	X
SWEEP CW (SWCW)	X	X
SPOT NOISE (SNSE)	X	X
BARRAGE NOISE (BNSE)	X	X
RANGE DECEPTION (RDCP)	X	X
INVERSE GAIN (INVG)	X	X
SYNCHRONOUS (SYNC)	X	X
ASYNCHRONOUS (ASYNC)	X	X
JAMMER POWER (ERP)	X	X
NUMBER OF PULSES (PN)	X	X
PULSE WIDTH (PW)	X	X
PULSE SPACING (PS)	X	X
NONCOHERENT FREQUENCY (NCOHO FREQ)	X	X

TABLE III-3. OPERATOR INPUTS AND DISPLAYED OUTPUTS

CHAFF PARAMETERS

PARAMETER	OPERATOR INPUT	DISPLAYED OUTPUT
CHAFF EVENT (NO)	X	X
TYPE:		
POINT	X	X
MODERATE	X	X
LARGE	X	X
PULSE WIDTH (PW)	X	X
CROSS SECTION (SIGMA)	X	X
AIRCRAFT (A/C)	X	X
RANGE	X	X
AZIMUTH	X	X

TABLE III-4. OPERATOR INPUTS AND DISPLAYED OUTPUTS

RADAR PARAMETERS	OPERATOR INPUT	DISPLAYED OUTPUT
FREQUENCY (FREQ)	X	X
PULSE WIDTH (PW)	X	X
AZIMUTH*		X
PEAK POWER (PK PWR)	X	X
RADAR MINIMUM RANGE (MIN R)	X	X
RADAR MAXIMUM RANGE (MAX R)	X	X
*NOT AN OPERATOR INPUT -- RADAR ANTENNA POSITION (AZIMUTH)		
		X

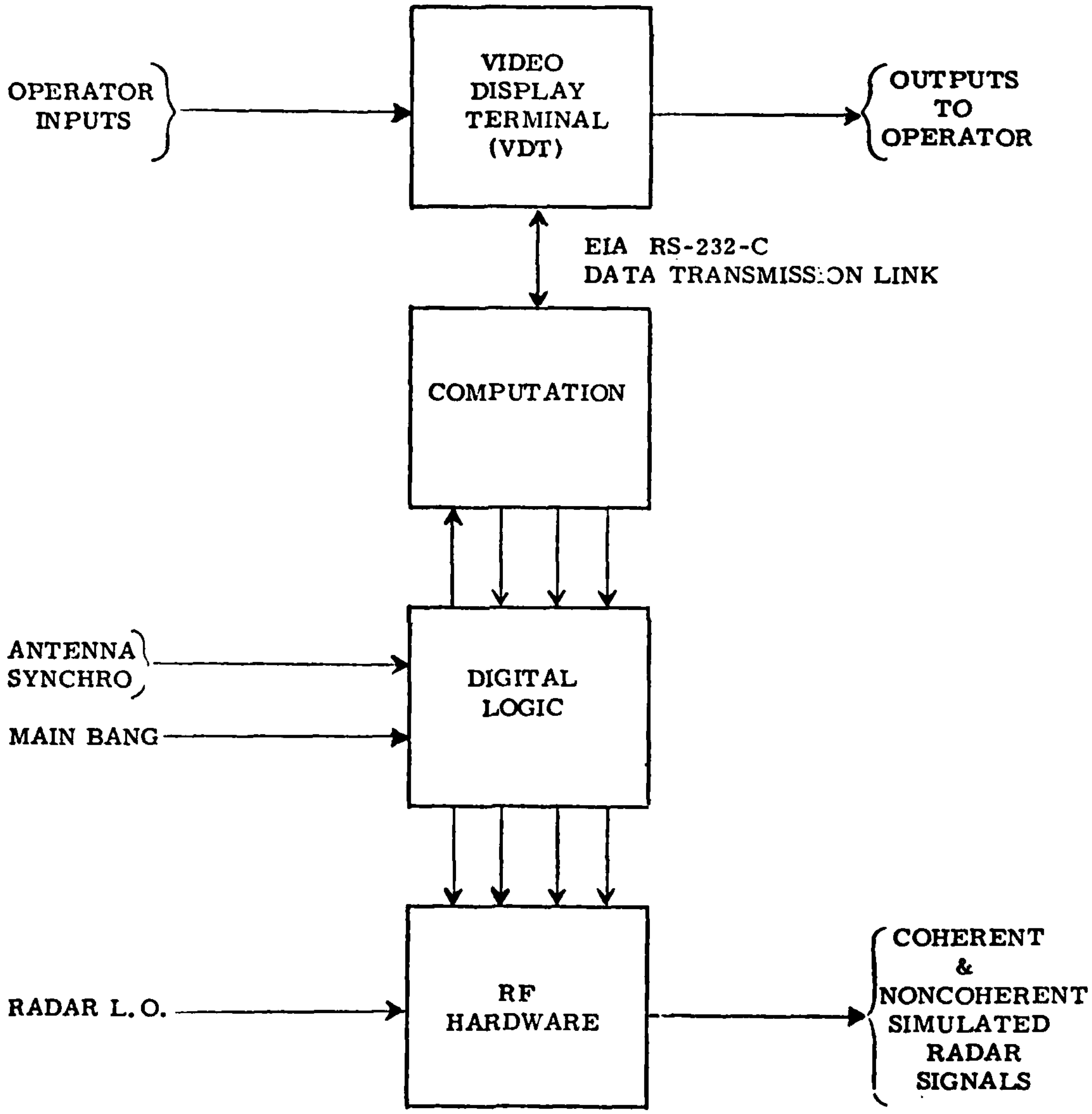


FIGURE III-2. FUNCTIONAL BLOCK DIAGRAM

TABLE III-5. MTG-100 FUNCTION PARTITIONING

- VDT
    - OPERATOR INTERFACE
    - DATA INPUT
    - SIMULATION STATUS
- COMPUTATION
    - CONTROL OF VDT
    - STATIC DATA
    - DYNAMIC DATA
    - AM NOISE MODEL
- DIGITAL LOGIC
    - STATIC DATA
    - DYNAMIC DATA
    - SIGNAL AMPLITUDE CIRCULATION
    - PULSE GENERATION
    - SYNCHRO CONVERSION
    - NOISE GENERATION
- RF HARDWARE
    - COHERENT FREQUENCY GENERATION
    - DOPPLER SIMULATION
    - NONCOHERENT FREQUENCY GENERATION
    - SIGNAL SUMMATION

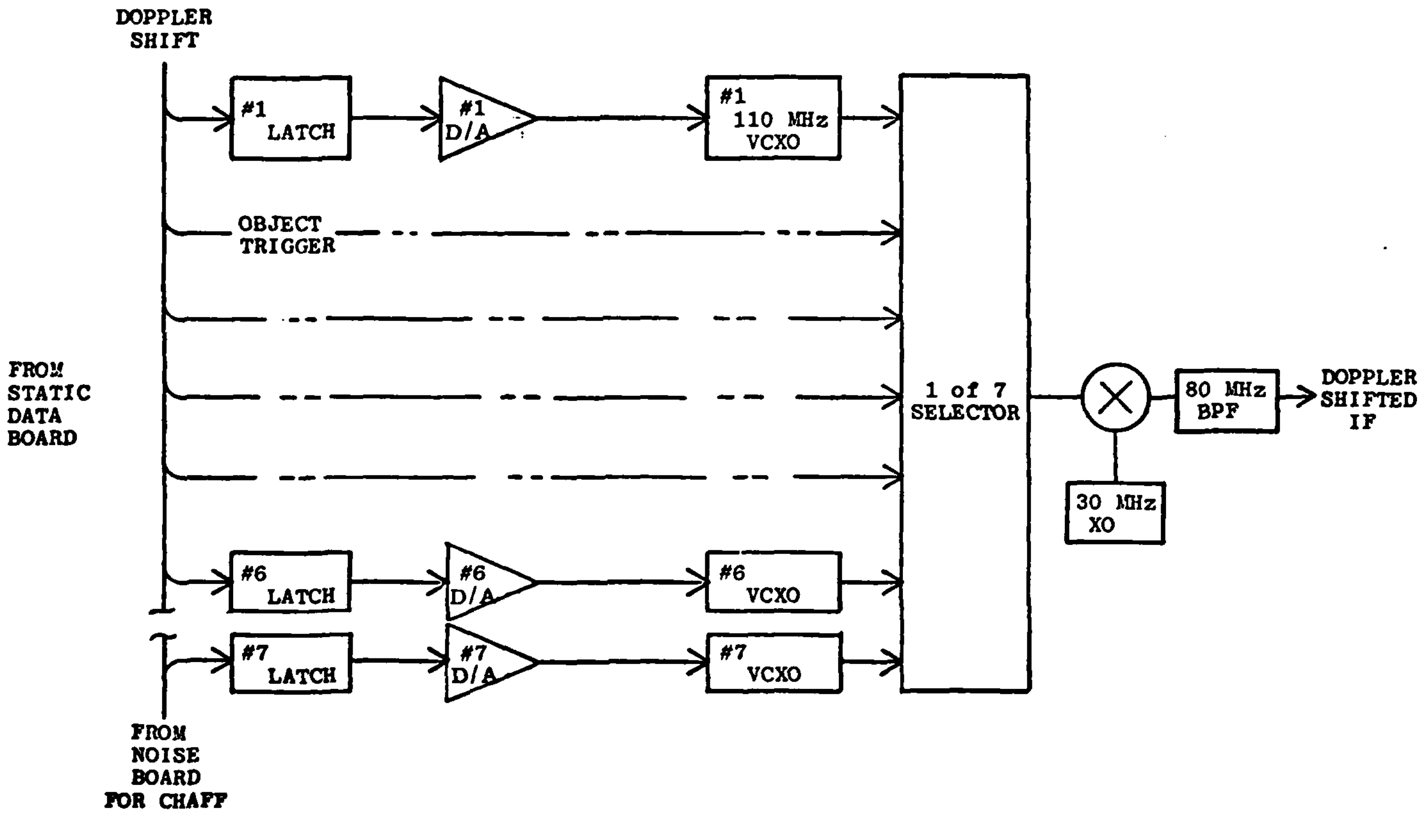


FIGURE III-3. DOPPLER SIMULATION

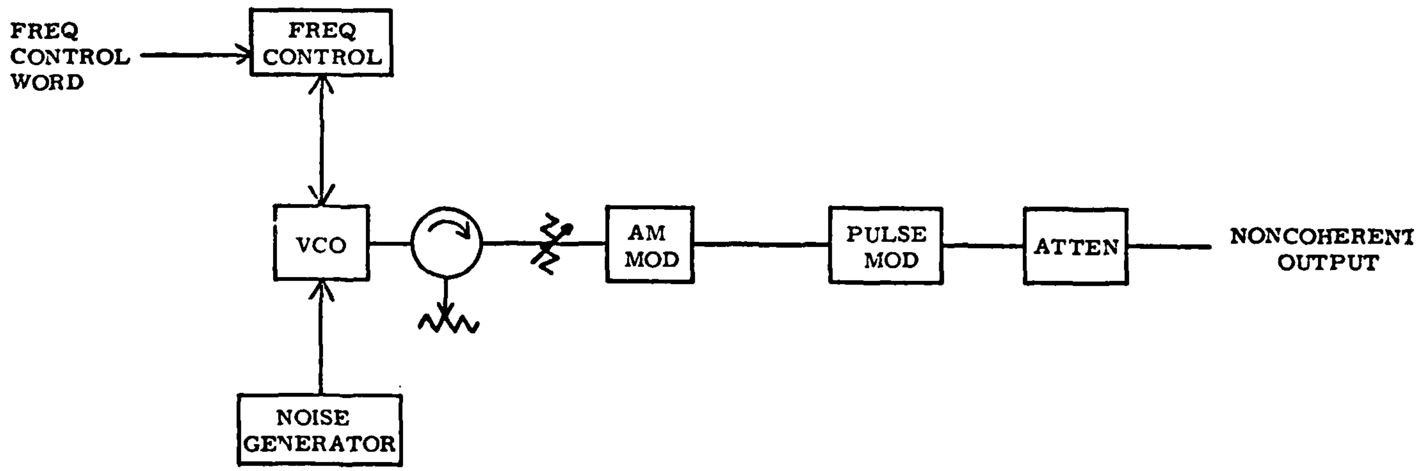


FIGURE III-4. NONCOHERENT R. F. GENERATOR

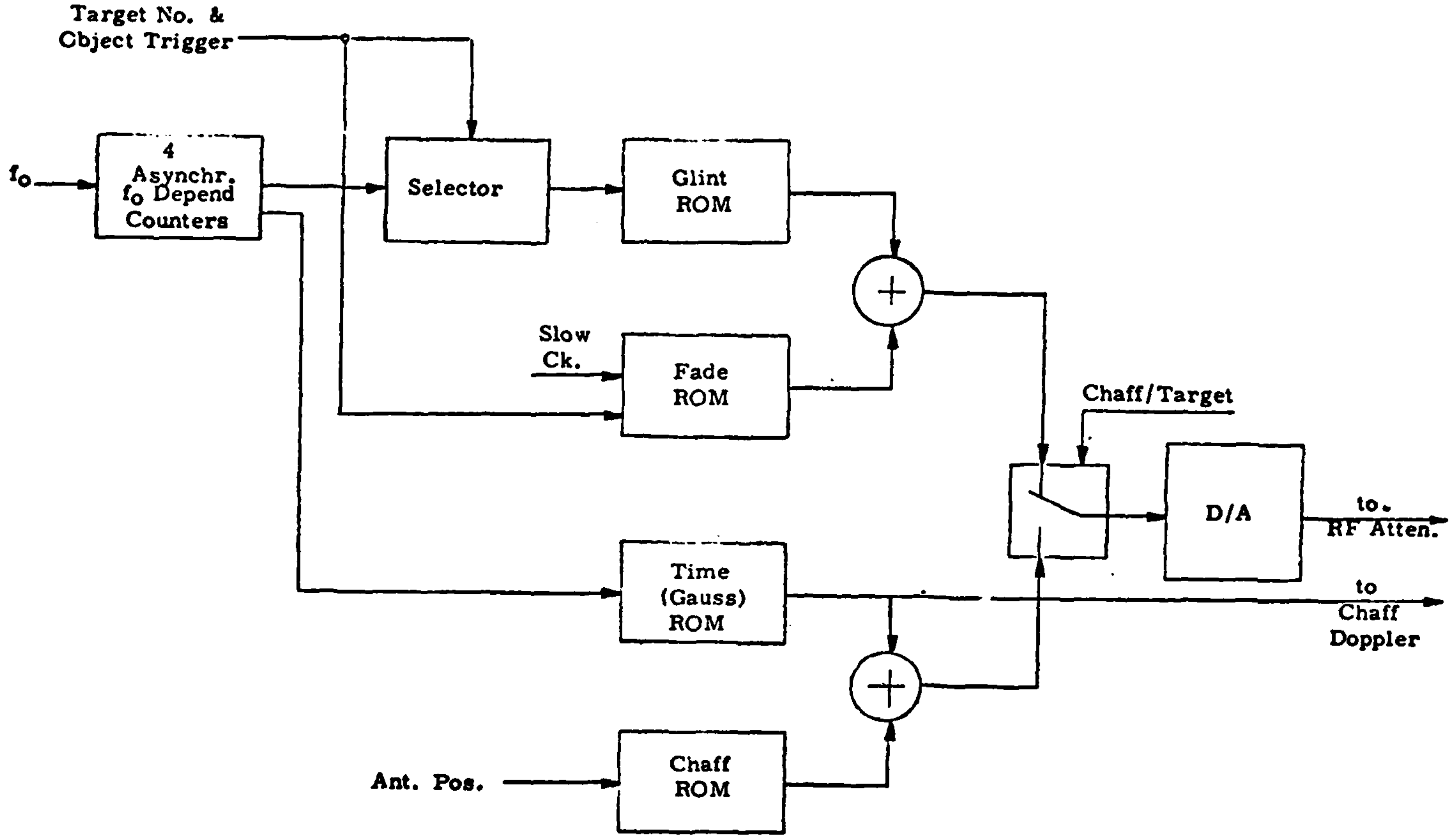


FIGURE III-5. NOISE GENERATOR

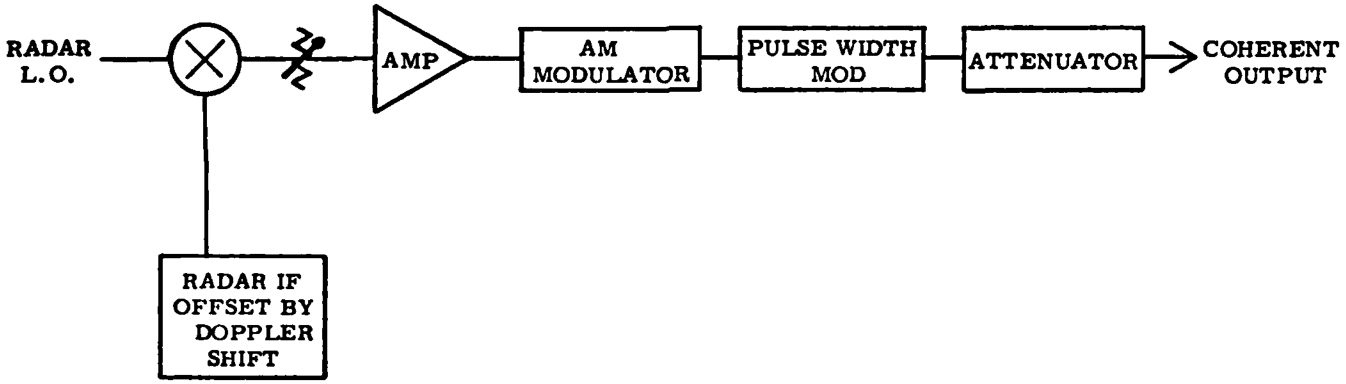


FIGURE III-6. COHERENT R.F. GENERATOR

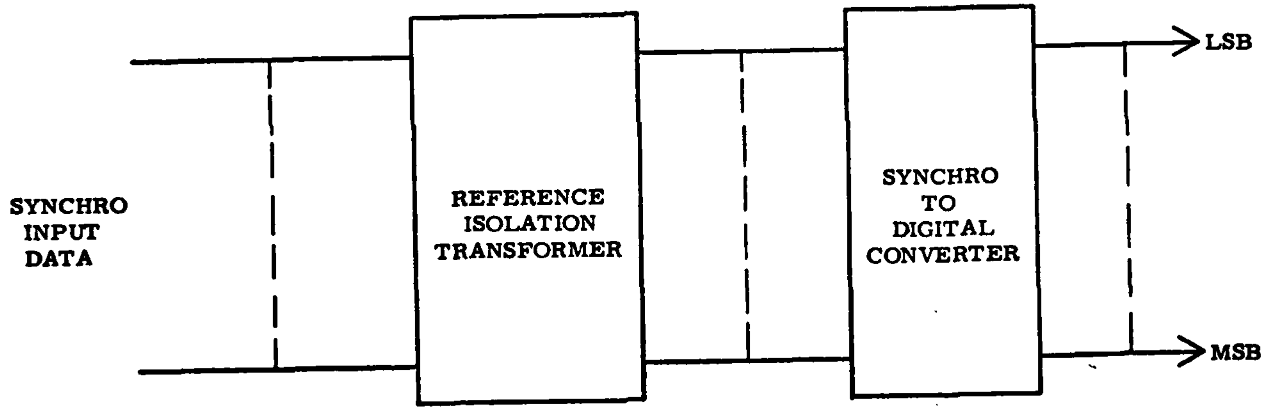


FIGURE III-7. SYNCHRO CONVERSION

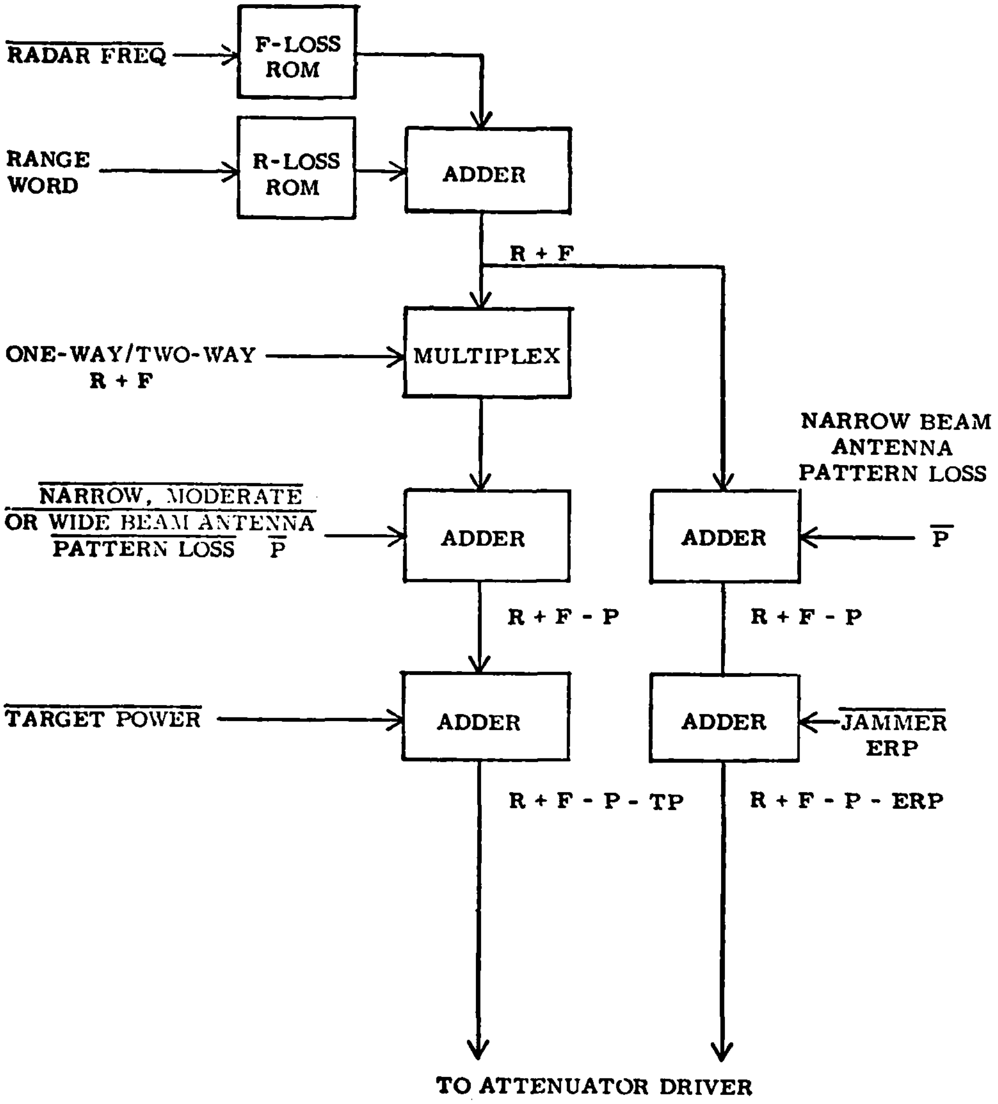


FIGURE III-8. SIGNAL SUMMATION

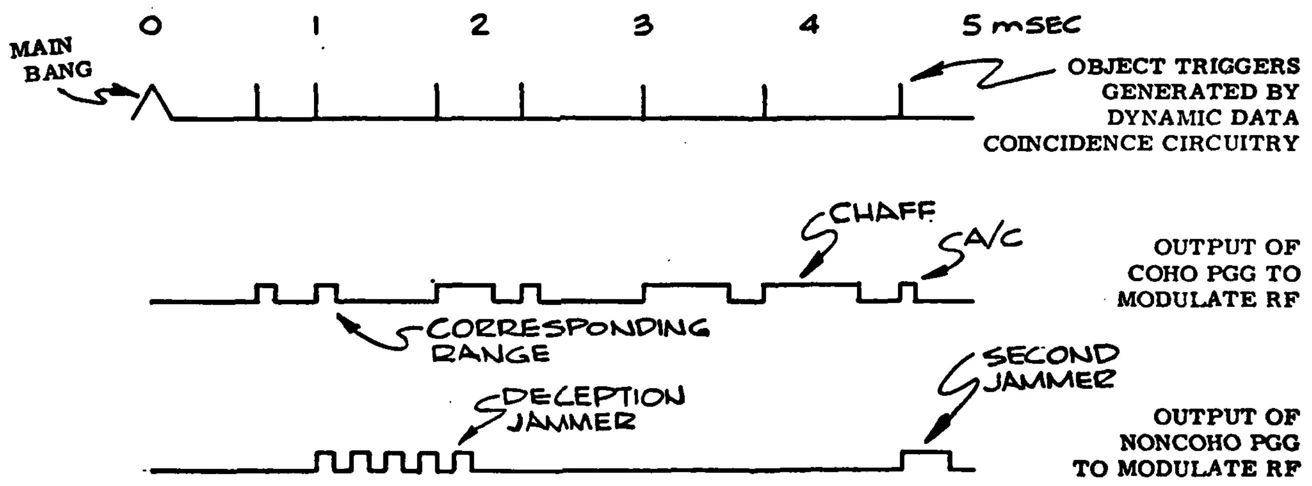


FIGURE III-9. PULSE GENERATION TIMING CHART

TABLE III-6. MTG-100 STATUS

BUILT-IN-TEST (BIT)

MICROPROCESSOR INTERNAL SELF TEST

- VDT INTERFACE VERIFICATION
- RF PROCESSOR
  READ/WRITE RAM CHECK
- RF PROCESSOR
  ADDRESS AMBIGUITY CHECK
- DISPLAYED TEST PROGRAM

IV TECHNICAL OVERVIEW - HARDWARE

Figure IV-1 shows the simulator and its radar interconnections and Figure IV-2 is a simplified block diagram of the simulator with its interconnections. A more detailed block diagram depicting a single channel of the MTG-100 is shown in Figure IV-3. One such channel is available for each R.F. band the simulator is to be operated in.

Each channel consists of two chains, a coherent and a noncoherent chain. The input frequency of the coherent chain is determined by a signal derived from the radar local oscillator.

In the system chosen as illustration, the radar transmitted frequency is 80 MHz above the local oscillator frequency. The output frequency is derived by mixing an 80 MHz signal with the local oscillator input. The 80 MHz oscillators are crystal controlled VCO's, one dedicated for each target, allowing Doppler shift simulation to be achieved by offsetting the XVCO's.

The mixed product is amplified to compensate for mixer conversion loss and component insertion losses.

A series of control elements (i.e., linear attenuator, R.F. switch, digital attenuator) is used to control the amplitude of the R.F. signal. The 30 dB linear attenuator superimposes the noise modulation generated by digital noise circuits.

The R.F. switches are used to pulse modulate the signal (with pulse widths as narrow as 100 nanoseconds to full CW) with an on-off ratio of 120 dB.

The actual control of the R.F. circuitry is the responsibility of the digital interface circuitry under the control of a microprocessor. The microprocessor performs the calculations for the proper attenuator word, computes the range delay, and sets the pulse width. In addition, there is circuitry for azimuth gating based on radar antenna position and beam width.

The digital attenuator (.1 dB steps to 120 dB) is driven by the CPU and digital interface circuitry to provide the range, antenna pattern loss and other dynamic and static losses.

Both the coherent and noncoherent signals are combined at the output and are available at a single output port.

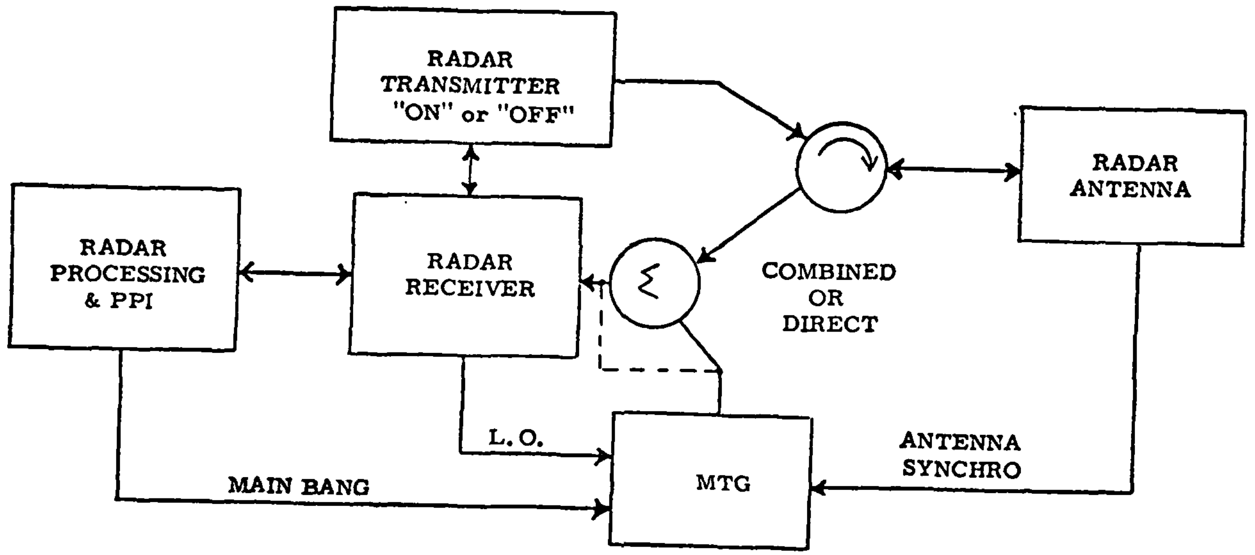


FIGURE IV-1. MTG CONCEPT

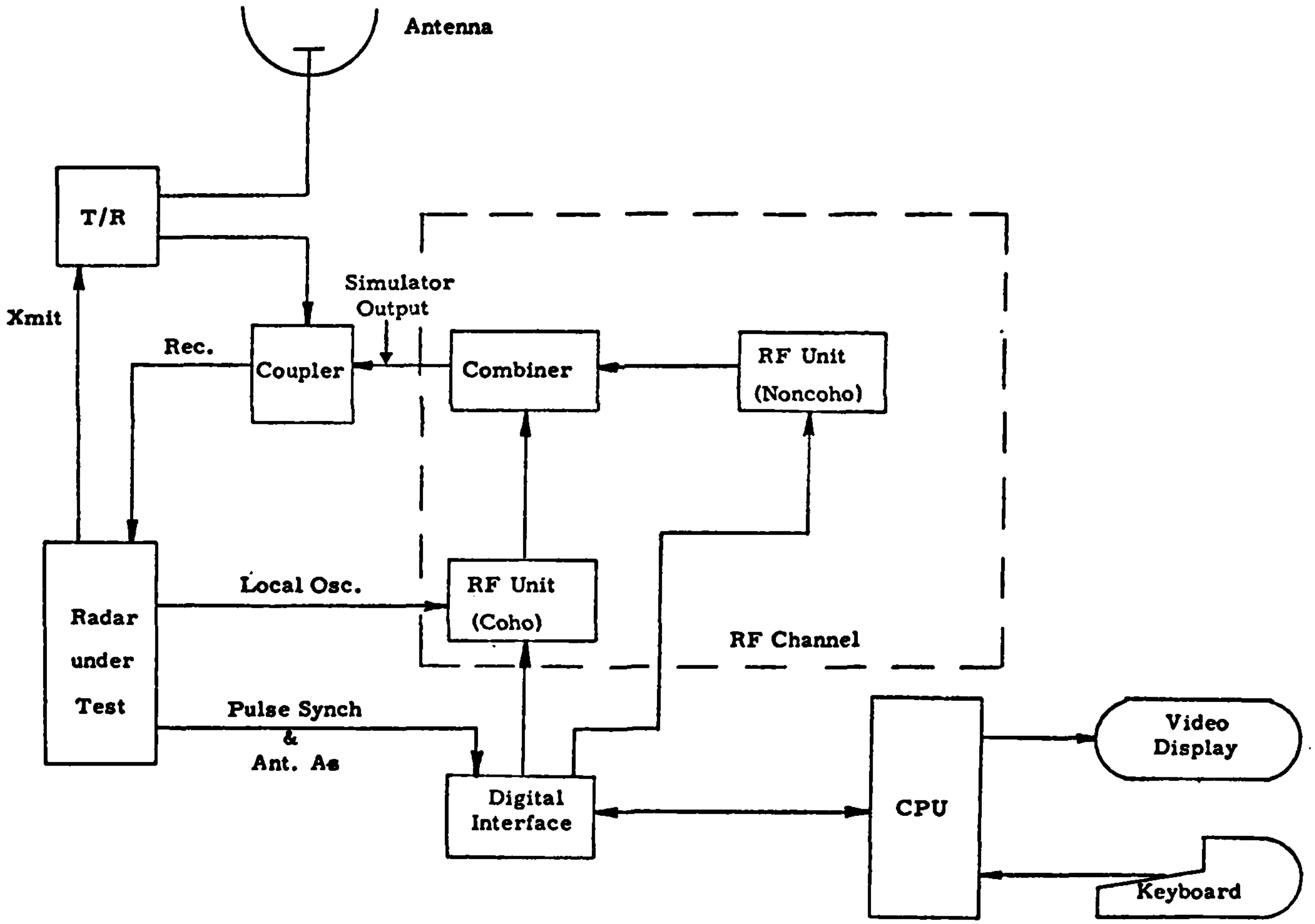


FIGURE IV-2. SYSTEM BLOCK DIAGRAM

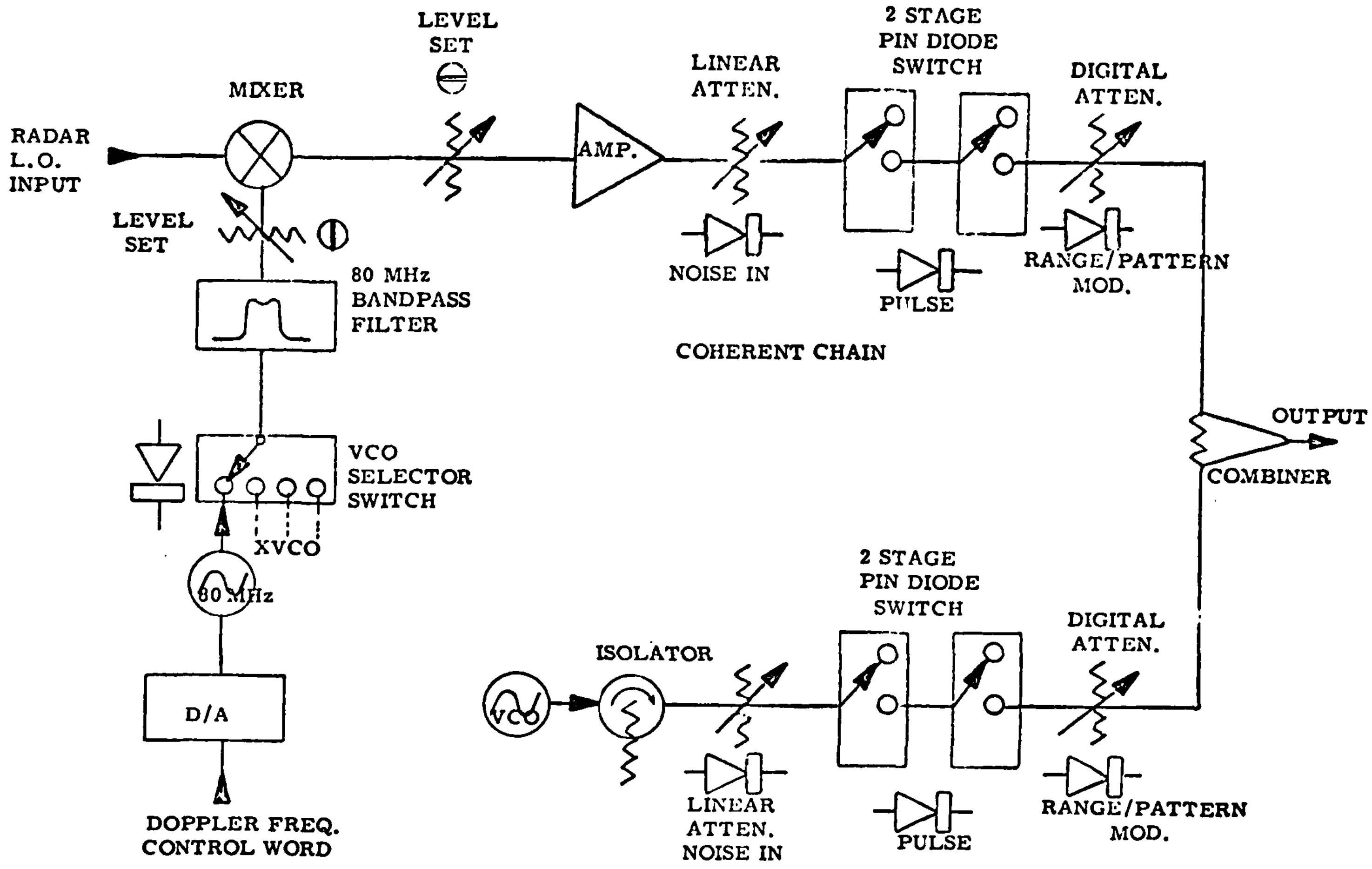


FIGURE IV-3. RADAR SIMULATOR R.F. BLOCK DIAGRAM

The R. F. coherent signal is combined with a signal generated by a voltage controlled phase lock loop oscillator whose output frequency is digitally selected. This second oscillator is the R. F. source for the noncoherent chain which provides simultaneous jammer signal capability.

The digital circuitry, Figure IV-4, consists of three main elements: a video terminal, the central processing unit, and the interface hardware circuitry. The video terminal is essentially the front panel of the radar simulator. This terminal may be used to enter all data, control commands and make scenario decisions. The operator obtains current status and other housekeeping information from the display as may be seen in Figure IV-5.

Both dynamic real time and static processing is achieved with the assistance of two 8080 microprocessors with both independent RAM and common memory. The microprocessors perform the radar power and cross section calculations, as well as range ordering and bearing positioning. The computers also provide the routing of data in and out of the video terminal for both display and operator interactivity.

Range Ordering and Azimuth Gating

Updating of the scenario and formatting of video data is performed by the CPU's. The mainline program is stored in less than 8K of PROM. The CPU's perform a range ordering task and provide a "shadowing" signal whenever two targets are within 10 μs of each other. The range ordering, which at present is a modified "bubble sort," arranges the aircraft in the order of radar response at their computed ranges. This order, which is strictly range dependent, is then gated with the antenna azimuthal information. Each time the azimuth gate (representing the antenna beam painting of a particular angular sector) repeats a particular sector, the order of the range of targets could possibly be different. A comparison is made between each target, its radial range component is considered, and all of the targets are repositioned.

The data transmitted to the interface hardware consists of static data, computed once each time data is entered from the terminal, and dynamic data, computed during the scenario update about once each 5 millisecond interval. Range and range related phenomena is computed on a 50 foot resolution interval and Doppler frequency from 0 to ± 2100 knots in 1 knot increments.

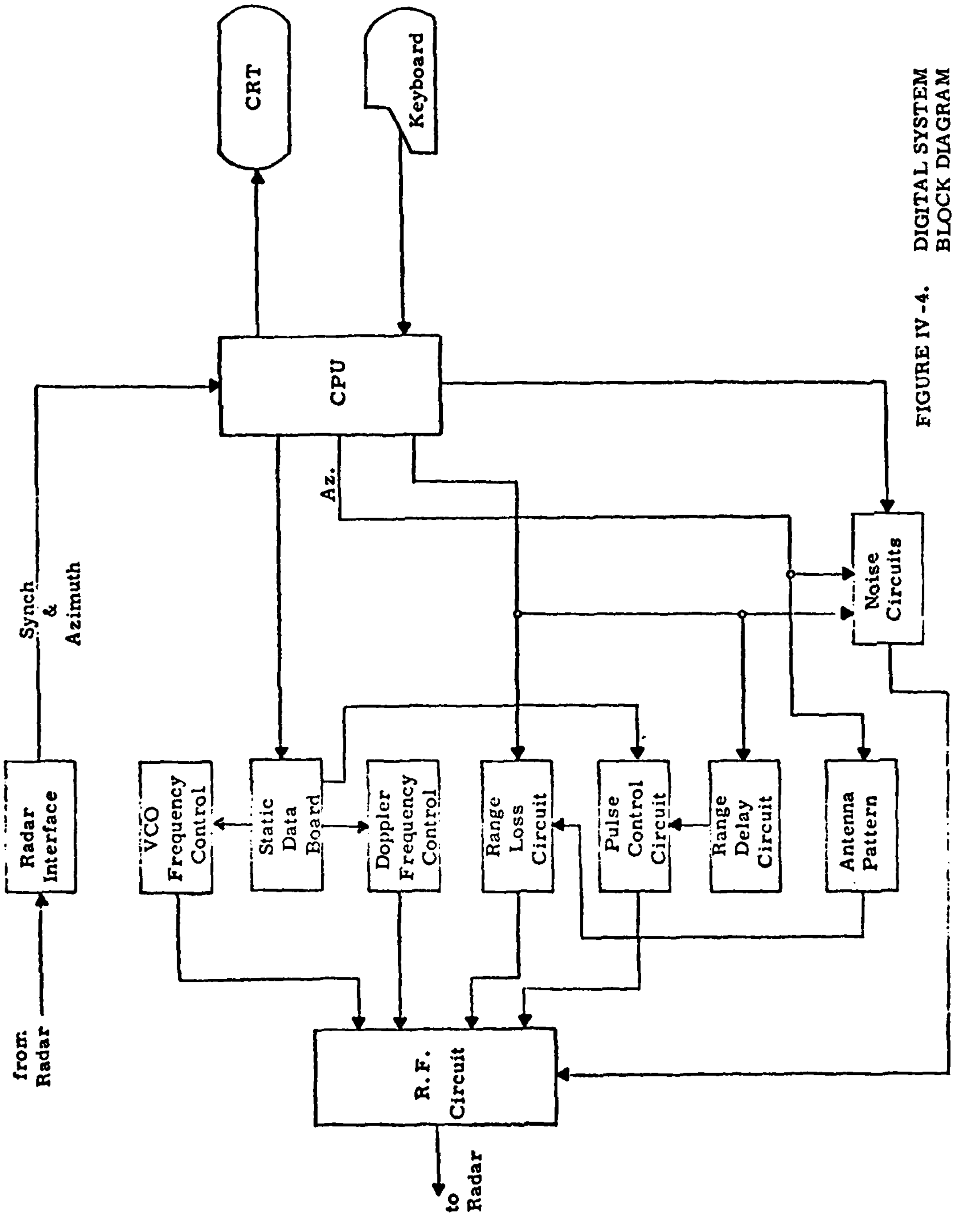
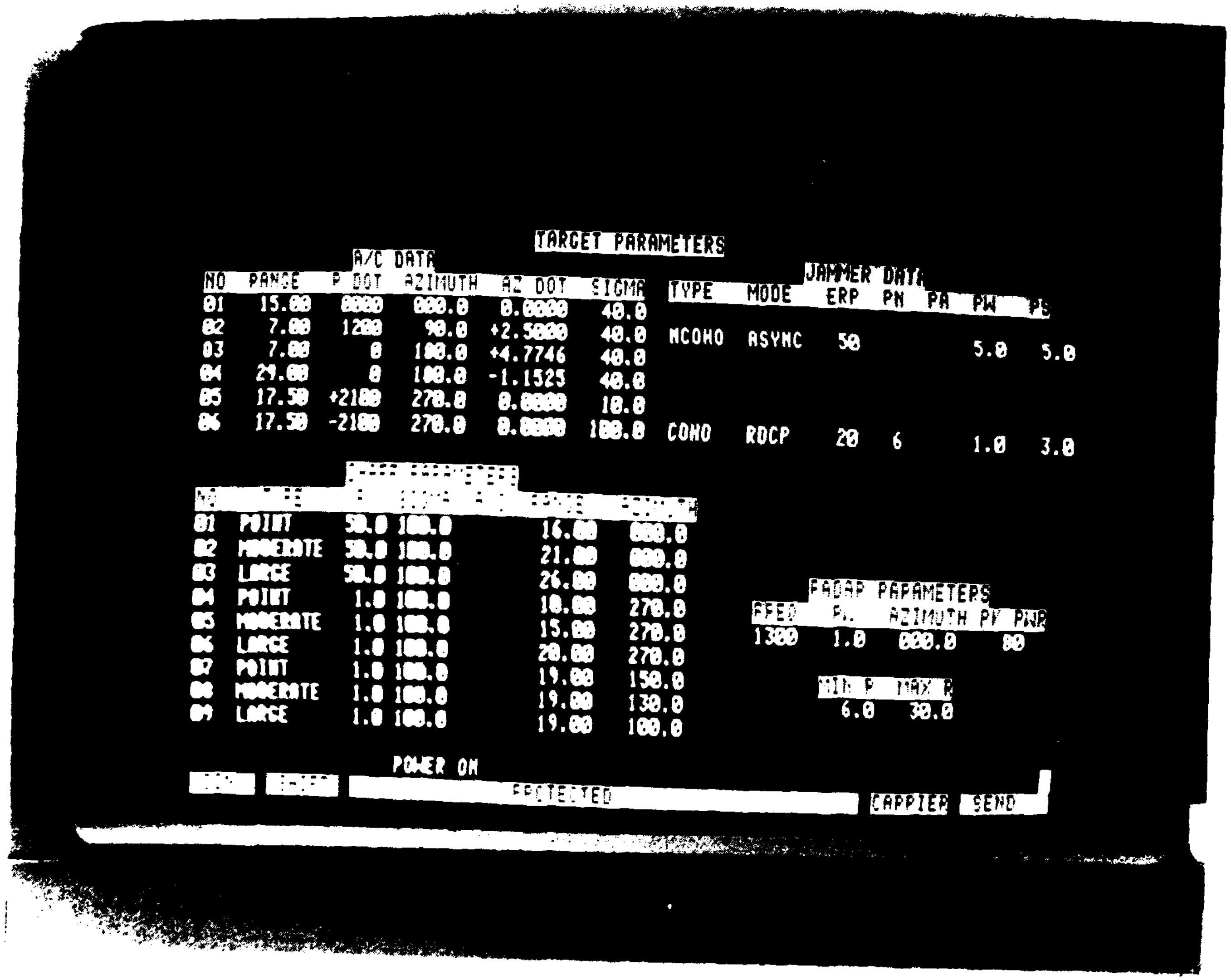


FIGURE IV-4. DIGITAL SYSTEM BLOCK DIAGRAM



```
                              TARGET PARAMETERS
                  A/C DATA                                                JAMMER DATA
NO  RANGE    P DOT  AZIMUTH   AZ DOT    SIGMA  TYPE   MODE    ERP  PN  PA   PW    PS
01  15.00    0000   000.0    0.0000     40.0
02   7.00    1200    90.0   +2.5000     40.0  NCOHO  ASYNC    50            5.0   5.0
03   7.00       0   100.0   +4.7746     40.0
04  29.00       0   100.0   -1.1525     40.0
05  17.50   +2100   270.0    0.0000     10.0
06  17.50   -2100   270.0    0.0000    100.0  COHO   RDCP     20   6        1.0   3.0

01  POINT     50.0 100.0          16.00   000.0
02  MODERATE  50.0 100.0          21.00   000.0
03  LARGE     50.0 100.0          26.00   000.0
04  POINT      1.0 100.0          10.00   270.0            RADAP PARAMETERS
05  MODERATE   1.0 100.0          15.00   270.0      FREQ    P.   AZIMUTH PV PWR
06  LARGE      1.0 100.0          20.00   270.0      1300   1.0   000.0     80
07  POINT      1.0 100.0          19.00   150.0
08  MODERATE   1.0 100.0          19.00   130.0            MIN P  MAX R
09  LARGE      1.0 100.0          19.00   100.0             6.0   30.0

               POWER ON
                                 PROTECTED                             CARRIER  SEND
```

FIGURE IV-5 VIDEO DISPLAY TERMINAL

Dual CPU's

In order not to disturb the simulation when new data is available from the CPU's, two data registers (Readout Files) are used in the interface hardware. Data is read in and changed in one, while read out on the other file. By this "ping-pong" approach, a smooth update is maintained and synchronization between the radar main bang and the CPU clock is not needed.

Noise Modeling

In order to create as realistic a target simulation as possible, the noise characteristics shown in Table IV-1 were included in the noise generation circuitry for aircraft and chaff targets.

A) Each aircraft's noise components are fully independent of other aircraft.

B) The glint component is chi-square distributed, time correlated, target number correlated, and frequency dependent.

C) The fade component is an empirical cyclic time only related function which is also target correlated.

For the chaff noise modulation implementation:

A) A Gaussian distributed, antenna position related, random walk pattern was used, plus -

B) A Gaussian distributed time and frequency dependent noise distribution.

The noise seen by a radar when receiving a skin return is comprised of several elements which are both time dependent and target dependent. One element of noise is a result of temporal displacement (GLINT).

There is another element that is a spatial contribution which is related to antenna position, target cross section and target orientation. A further distinction has to be made between noise from aircraft returns and that from chaff returns.

For a single aircraft the amplitude modulation, whose probability density function is a chi-square distribution, decorrelates both with time (pulse to pulse) and frequency. It also provides scan to scan

TABLE IV-1. NOISE MODEL

AIRCRAFT

EACH AIRCRAFT : FULLY INDEPENDENT OF OTHER AIRCRAFT

AMPLITUDE (dB) - SUM OF:

"A"	"GLINT"	NOISE: CORRELATED: CHI-SQUARE TIME/FREQUENCY DEPEND TARGET NUMBER CORR	**RANGE: 0 TO -30 dB** **MEAN: -6 dB**	**STEP RATE: 2 TO 6 KHz** **DECORR TIME: 5 MSEC APPROX**
"B"	"FADE"	MODULATION: CYCLIC EMPIRICAL TIME (ONLY) DEPENDENT TARGET NUMBER CORR	**RANGE: 0 TO -6 dB** **MEAN: -2 dB**	**CYCLE TIME: ONE PER 5 TO 10 SEC**
		TOTAL RANGE LIMITED TO:	**0 TO 30 dB**	

CHAFF

ALL CHAFF MODULATION TREATED AS SINGLE MODEL

AMPLITUDE (dB) - SUM OF:

"C"	"CHAFF"	CORRELATED-GAUSSIAN ANTENNA POSITION DEPEND	**RANGE: 0 TO -5 dB** **MEAN: -2.5 dB**	**BEAM WIDTH CORRELATION: 1°**
"D"	"TIME"	UNCORRELATED-GAUSSIAN TIME/FREQUENCY DEPEND	**RANGE: 0 TO -5 dB** **MEAN: -2.5 dB**	**DECORRELATION: 2 TO 6 KHz**
		TOTAL RANGE LIMITED TO:	**0 TO 10 dB**	

independence. This component of noise represents the GLINT portion of the noise modulation.

The second element of the noise modulation is the contribution due to target fading. This fade pattern is a slow change in target return amplitude due to aspect angle changes. This spatial component was instrumented using a cosine^4 function with a variation in the period as a function of the target. The "Fade" component, therefore, was empirically derived and assures different noise behavior for different targets.

The amplitude range of the total aircraft noise is limited to 30 dB with the mean at 6 dB. The chaff noise modulation has a 10 dB variation (± 5 dB) with a mean also of 6 dB. This assures that the mean return power is the same for identical cross sectional areas.

In the case of chaff, a time invariant antenna position component must be generated. This models the expected variation in noise as the antenna sweeps different portions of the chaff. The noise will be highly correlated for angular changes which are small compared to the half power beamwidth of the antenna and completely decorrelated when the antenna moves greater than the half power beamwidth.

Figure IV-6 is a block diagram of the noise generator for the coherent channel.

Four counter outputs, whose clock rate is frequency dependent based on radar operating frequency, are added and multiplexed to provide up to ten different clocking rates. The multiplexed outputs are used to address the "Glint" ROM. Each aircraft will then have an associated "sample" rate based on radar frequency and pulse repetition rate and its aircraft target number.

A separate slow clock is used to provide the seven least significant bits of the "Fade" ROM address. The aircraft number is used to provide the three most significant address bits. In this way, each aircraft has its own unique "fade" pattern.

The sum of the two ROM outputs is then selected by a multiplexer (decision based on aircraft or chaff event) and fed to a digital to analog (D/A) converter. This analog voltage is used to drive a linear attenuator which modulates the R. F. signal.

The chaff noise generation technique is similar except that the ROM addresses are generated by both a time frequency derived clock

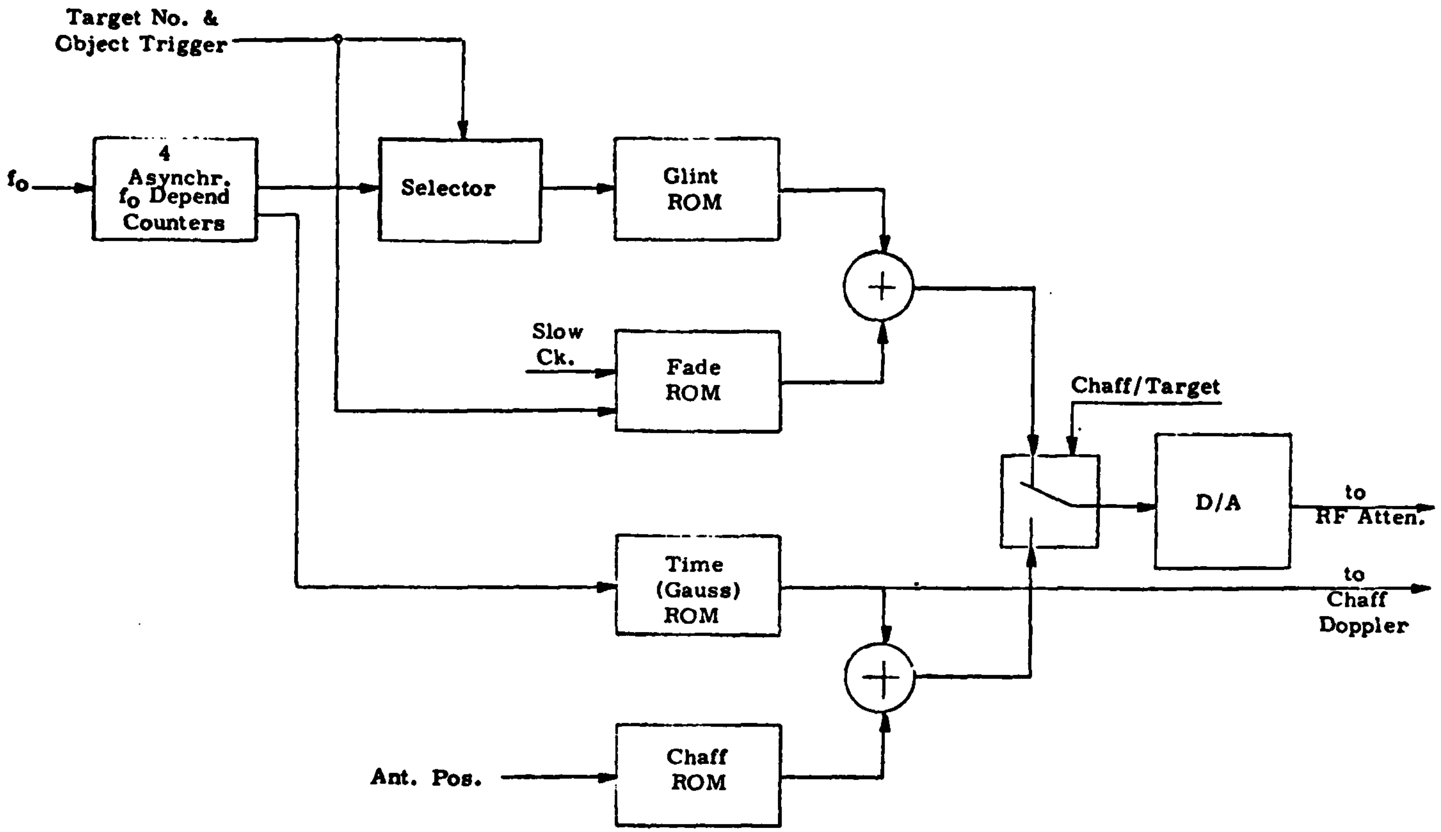


FIGURE IV-6. NOISE GENERATOR

and the antenna position obtained from the synchro data. This combination models the variation due to chaff motion (time) and decorrelation due to frequency. It also accounts for the non-homogenous distribution of chaff particles for a given chaff event.

Noise Jammer

While the coherent noise distribution is determined by the data stored in the various ROM s dedicated for this task, it is also necessary to generate noise to be used as modulation for on-board jammers. (The airplane is the jammer platform.) This is done in an analog circuit using a noise diode and amplifier as source voltage for a linear attenuator. This modulator affects the noncoherent signal (representing jammers) only. For broad band (barrage) noise, it was necessary to use a somewhat different approach than amplitude modulation. The linear modulator's modulation bandwidth is only about 300 KHz. Barrage noise should produce a spectral bandwidth in excess of 20 MHz. To accomplish this, the same noise diode source is used, amplified, and superimposed on the error voltage of the VCO. The phase lock circuit cannot respond fast enough to correct this noise voltage and the result is a noise modulated FM signal. This signal occupies a bandwidth of better than 20 MHz and spectrally simulates a barrage jammer.

Antenna Pattern Generation

The MTG-100 system is capable of modeling the effect of gain, side lobe structure and half power beamwidth of an actual or ideal antenna pattern. The values of antenna gain relative to the peak are stored in 1024 locations where the address location is determined by the angle away from boresight. There is no restriction on the antenna pattern symmetry. The only restriction is based on the storage capacity and the bits allocated for ROM addressing. Generally, a 60 to 70 dB dynamic range may be programmed with resolution steps of .1 dB.

For the usual radar target return loss, the antenna gain is used both in the transmit link and the receive link. For the jammer case, it is only needed for the receive calculation. Therefore, only the "one way" gain of the antenna is stored in the ROM's and the interface circuitry doubles the gain in the "two way" case.

If, as an example, we store about $\pm 11^{\circ}$ of an antenna pattern, then we can store values every $.022^{\circ}$ of the pattern. This should be adequate even for the highest gain antenna in use today.

Doppler Shift

Of the many ways to implement a Doppler shift (i.e., Serrodyne, single sideband generator, etc.), only one method can produce the pulse to pulse phase coherency needed along with low unwanted spurious signals; that is, using a separate XVCO per target. Refer to Table IV-2.

Regardless of the Doppler processing techniques of the radar under test, the Doppler shift associated with a particular target must maintain its offset frequency and phase continuity. Because the radar only sees the target for a small portion of the Doppler cycle, it must take several samples and reconstruct the Doppler shift. Therefore, even though the radar is not looking at the target, the Doppler phase must not contain discontinuities or else an error will be introduced during the next sample (pulse) period. In addition, unwanted sidebands and carrier leak-through, if excessive, can produce errors during processing.

At present, the Serrodyne method or the single sideband method at best would produce spurious frequencies and carrier leak-through that would be between 20 and 35 dB below the carrier. To assure that spurious outputs are 50 to 55 dB below the desired output, a separate oscillator was used for each target. Each of the oscillators are continuously operating and are assigned to individual targets. The outputs are selected under CPU control when that target is to appear. The selector switch presents a load to the oscillator at all times, thereby eliminating possible pulling during switching. The oscillators (crystal controlled VCO's) are capable of being offset up to ± 30 KHz as a function of a DC control voltage.

The CPU was used to calculate the Doppler shift needed based on operator inputs of velocity and radar frequency used. The calculated Doppler shift word was applied to a digital to analog converter whose reference voltage provided the scaling factor to convert the frequency word to a correct shift of the XVCO frequency.

The simulation of chaff Doppler presents a different challenge. The chaff cloud requires a random shift correlated with time and operating frequency. The signal produced for amplitude modulation of the chaff noise has a component which is related to both time and frequency. By using this component before it is combined with the spatial noise component the chaff Doppler was derived both as a function of operating frequency and time. The four least significant bits of the chaff noise ROM were used as the control word for the XVCO digital to analog converter. This simulates the effect of wind shear, dipole tumbling, turbulence and falling of the chaff cloud.

TABLE IV-2. DOPPLER FREQUENCY SIMULATION

REQUIREMENT: 6 TARGETS PLUS CHAFF

TARGET VELOCITY FROM -2100 TO +2100 KNOTS

CHAFF VELOCITY FROM -24 TO +24 KNOTS

SPURIOUS PLUS FUNDAMENTAL LEAKAGE 60 dB DOWN

PHASE COHERENCE: ---EACH TARGET---
---PULSE TO PULSE---
---ANT BEAM TO ANT BEAM---

RADAR RESOLUTION---PHASE DEPENDENT---8 KNOTS

APPROACHES CONSIDERED:

PHASE SHIFT---DIGITAL/ANALOG---FUNDAMENTAL/IF

SINGLE SIDE BAND MODULATION (SSB)

MULTIPLE VOLTAGE CONTROLLED CRYSTAL OSCILLATORS (VCXO)

SELECTED APPROACH:

MULTIPLE VCXO

ADVANTAGES:
- INHERENT MEMORY
- DESIRED STABILITY
- SPURIOUS REJECTION
- DESIRED LINEARITY

IMPLEMENTATION:

TARGET RESOLUTION:	104 Hz	8.2 KNOTS
CHAFF RESOLUTION:	≅15 Hz	1.2 KNOTS

A review of Simulator Capabilities

The MTG-100 places the jammer aboard the aircraft targets with all the associated aerodynamic motion characteristics. In addition, it has the capability to "drop" chaff upon command at a location determined automatically by aircraft position.

The simulator can provide real time coherent simulation superimposed in an environment of coherent and noncoherent jamming. A summary of the more significant MTG-100 capabilities is presented in Section VI.

V TECHNICAL OVERVIEW - SOFTWARE

A description of the software approach is presented in the following pages in tabular form. Timing diagrams and flow charts are included to assist in the understanding of the concept.

TABLE V-1. SOFTWARE OVERVIEW

CONSTRAINTS

- REAL TIME APPLICATION
- GROWTH REQUIREMENTS
- FLEXIBILITY

APPROACH

- DISTRIBUTED PROCESSING
- MODULAR PROGRAMS

TABLE V-2. TOP LEVEL PARTITIONING

MCS-2	MCS-1
VDT INTERFACE	RANGE ORDERING
STATIC DATA	AZIMUTH GATING
SCALING & CONVERSION	SHADOW CHECK
POSITION UPDATING	DYNAMIC DATA
SELF TEST	SELF TEST

TABLE V-3. MCS INTERACTION

MCS-2 - UPDATES & WRITES RANGE INTO MEMORY & TELLS MCS-1.

MCS-1 - STARTS ORDERING RANGE DATA.

MCS-2 - UPDATES & WRITES AZIMUTH INTO MEMORY & TELLS MCS-1.

MCS-1 - COMPLETES RANGE ORDERING, MAKES SHADOW CHECK & OUTPUTS RANGE.

MCS-1 - AZIMUTH GATING & CHECK LIST DONE. AZIMUTH & OBJECT NUMBERS OUTPUT. TELLS MCS-2 IT IS DONE.

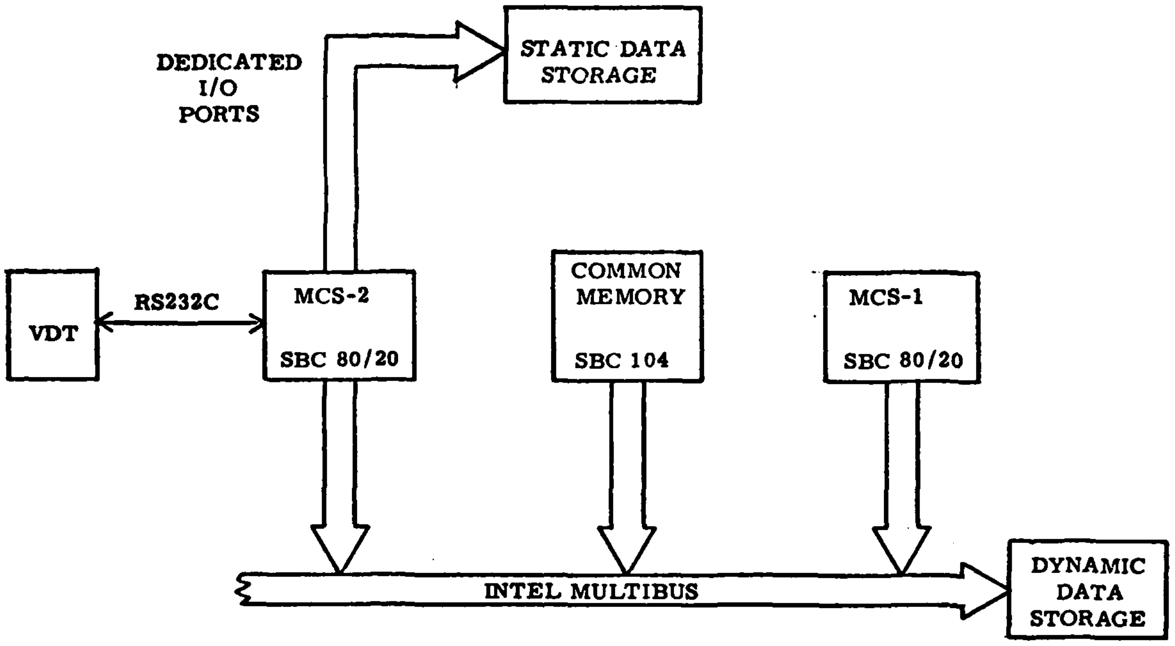


FIGURE V-1. BUS INTERFACE

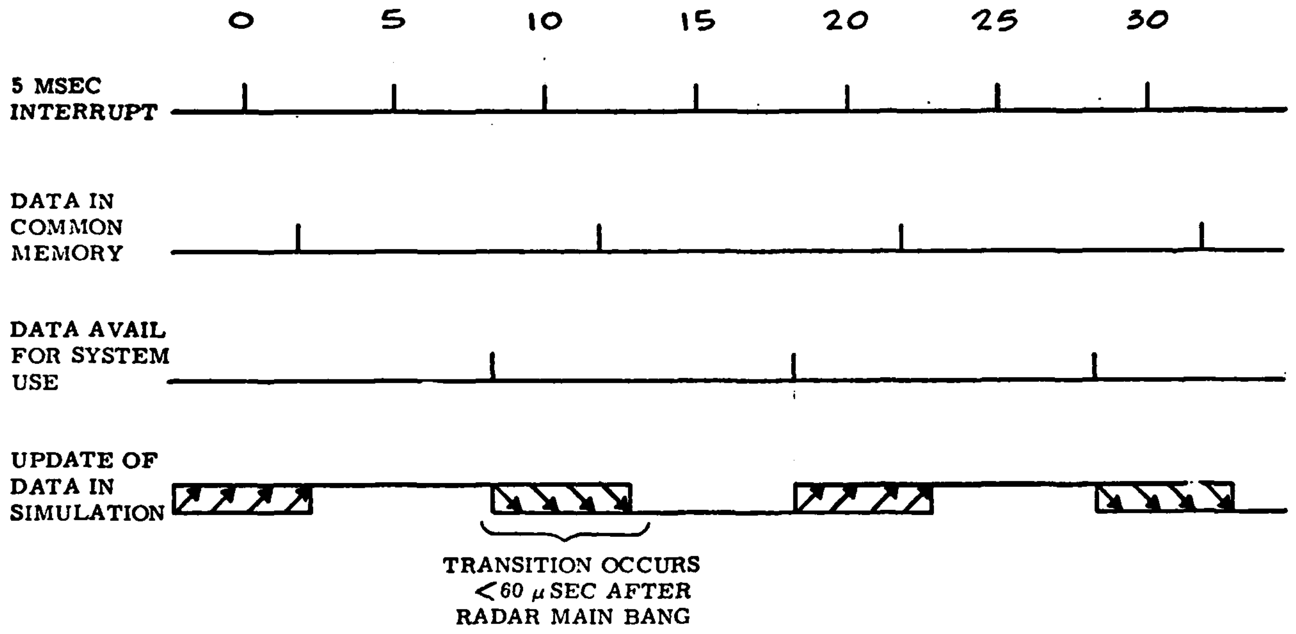


FIGURE V-2. SYSTEM DATA REFRESH TIMING CHART

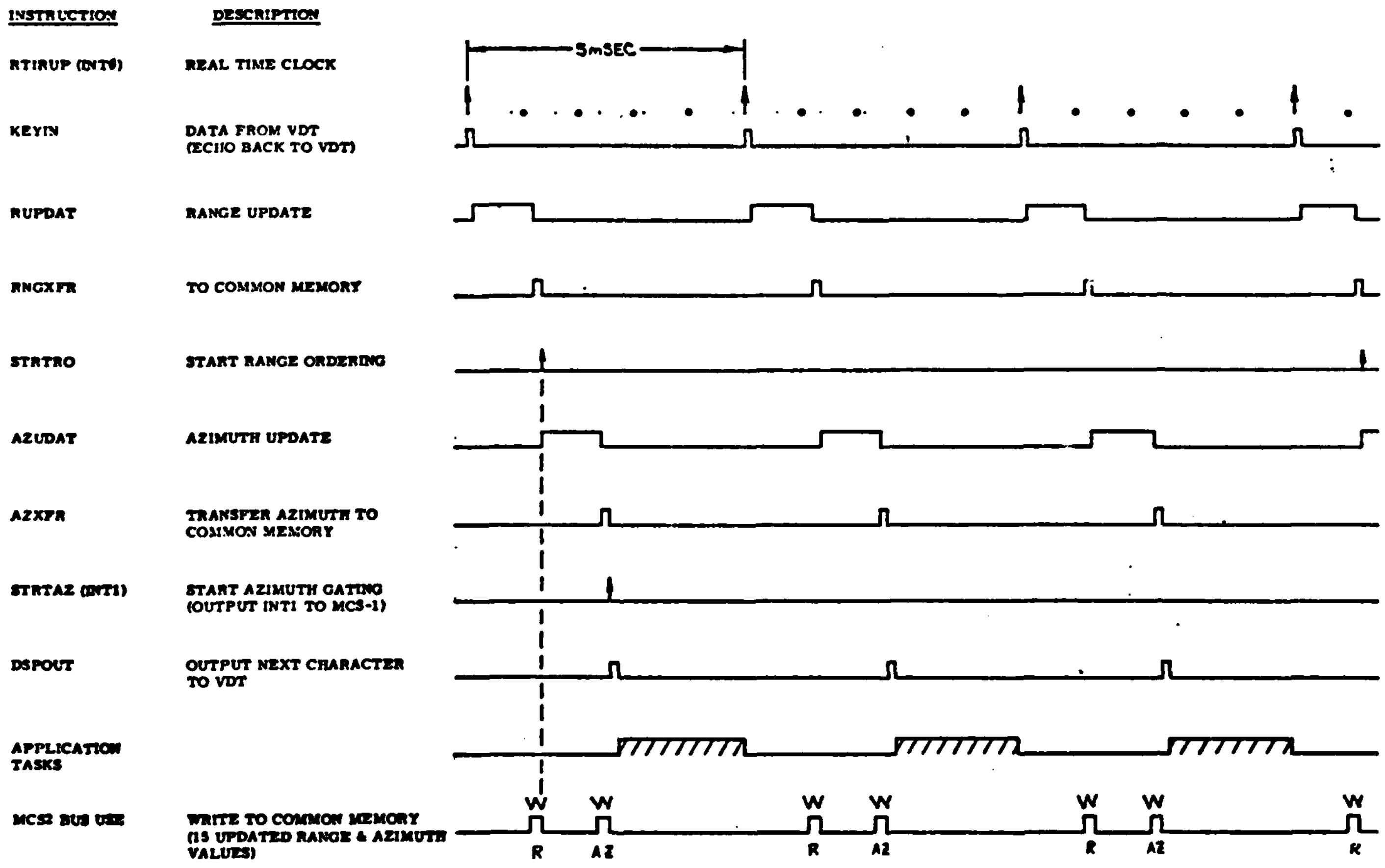


FIGURE V-3. SYSTEM TIMING DIAGRAM - MCS-2

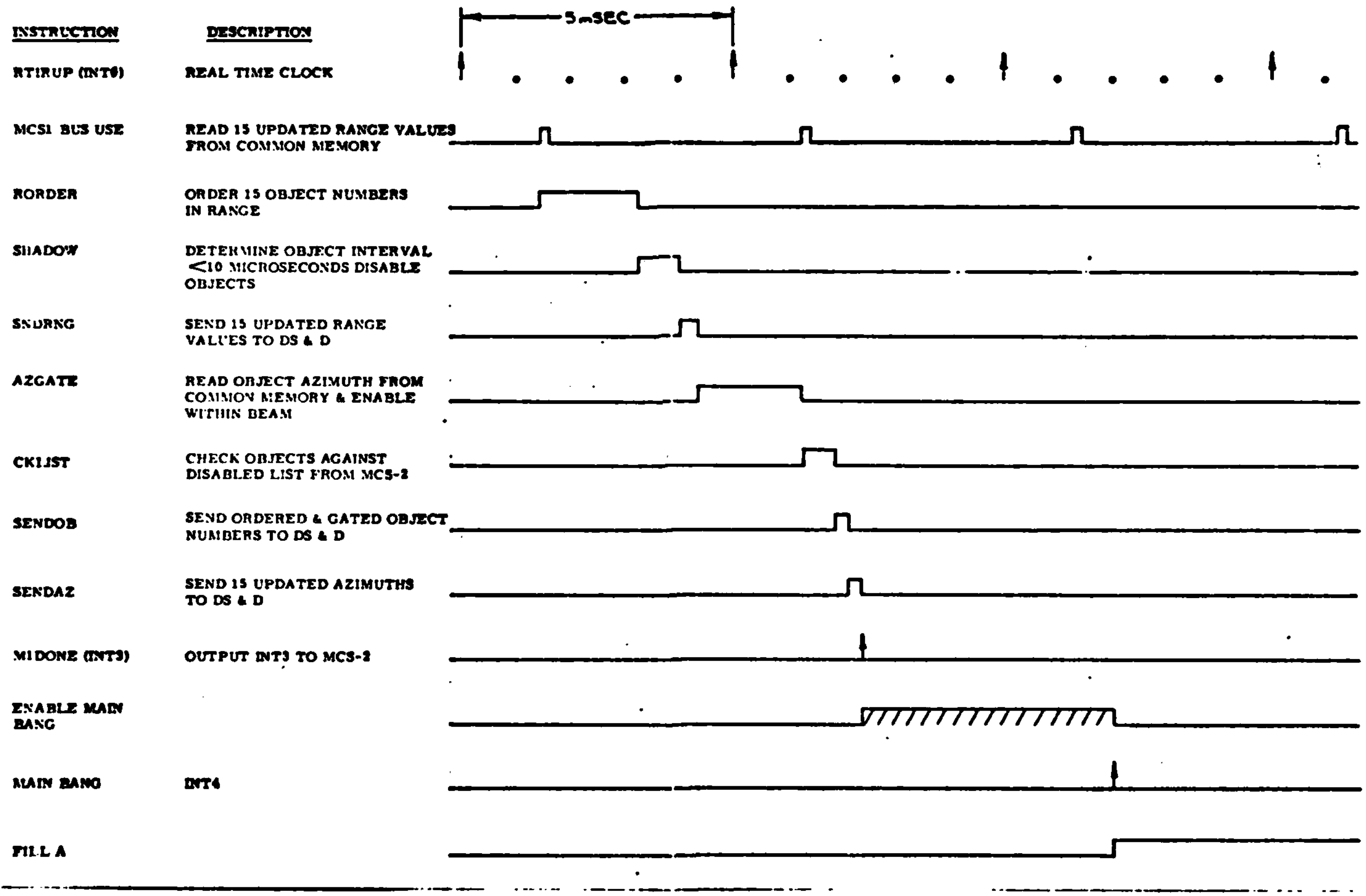


FIGURE V-4. SYSTEM TIMING DIAGRAM - MCS-1

TABLE V-4. STATIC DATA

- STORES "INVARIANT" DATA WHICH CHANGES ONLY AS OPERATOR INPUTS NEW VALUES.
- OUTPUTS STATIC DATA COMMANDED BY DYNAMIC DATA BOARD.
- EXAMPLES OF STATIC DATA ARE PULSE WIDTH, RADAR CROSS SECTION, RADAR FREQUENCY & JAMMER CHARACTERISTICS.

TABLE V-5. DYNAMIC DATA

- STORES RANGE & AZIMUTH FOR EACH OBJECT IN DOUBLE BUFFER MEMORY.
- STORES RANGE ORDERED OBJECT NUMBERS IN DOUBLE BUFFER MEMORY.
- DETERMINES COINCIDENCE BETWEEN RADAR RANGE AND OBJECT RANGE TO TRIGGER MTG RESPONSE.
- CALCULATES PATH LOSS TERM FOR USE IN ATTENUATOR COMMAND WORD SUMMATION.

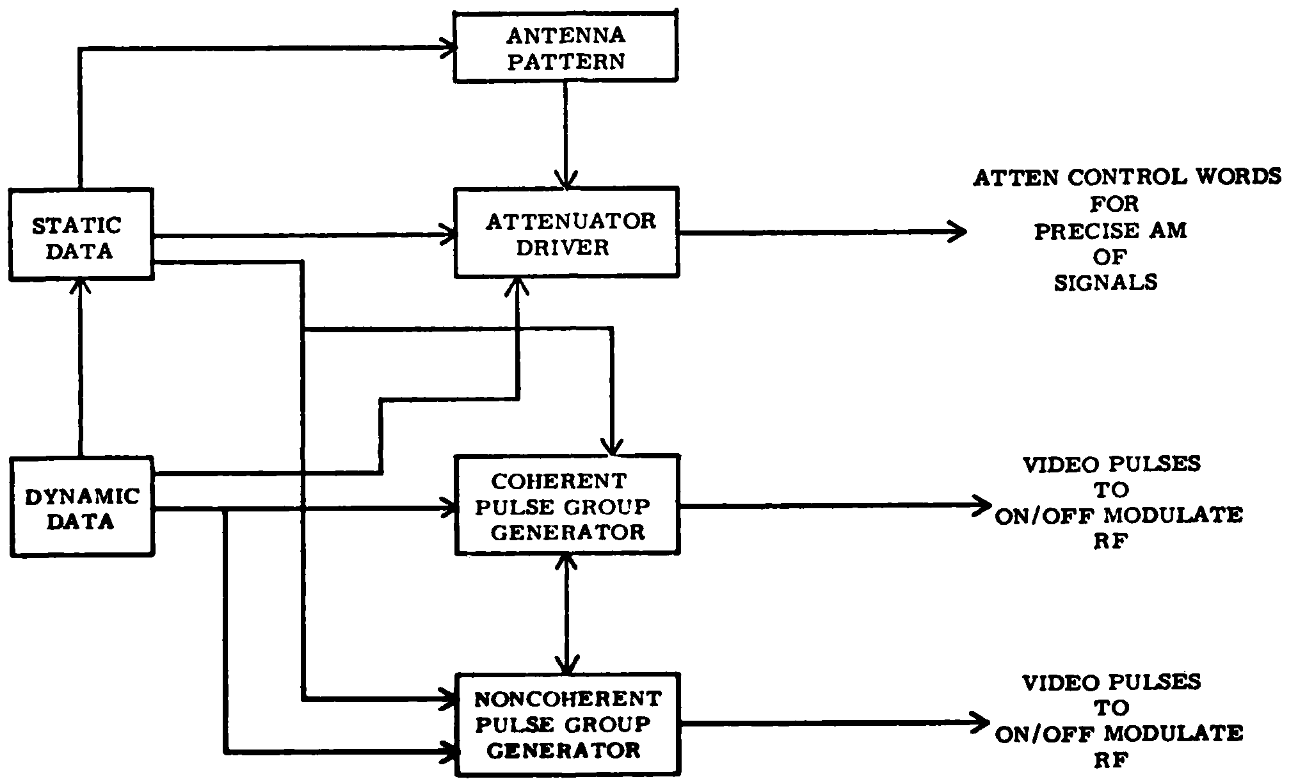


FIGURE V-5. SIGNAL AMPLITUDE CIRCULATION

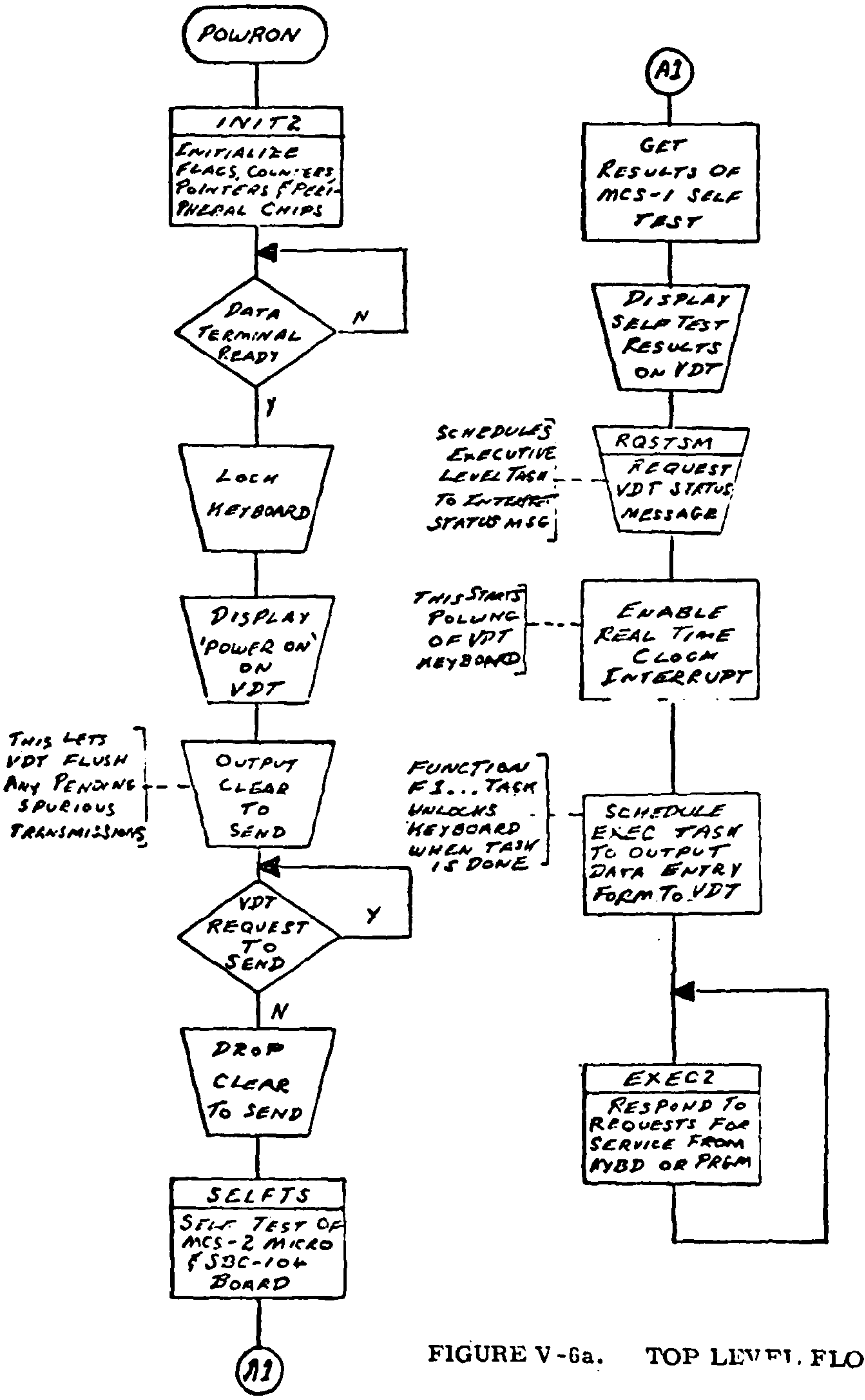


FIGURE V-6a. TOP LEVEL FLOW CHART - MCS-2

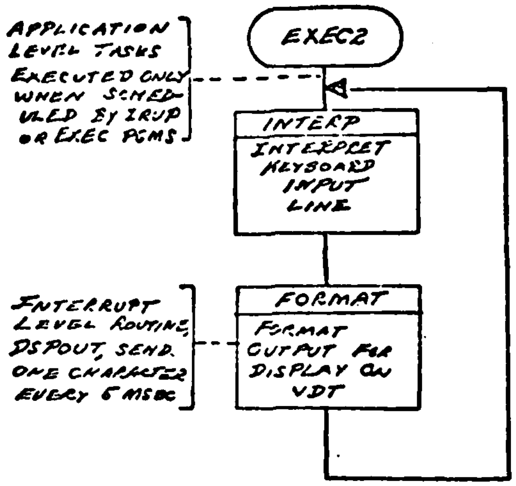


FIGURE V-6b. MCS-2 EXECUTIVE

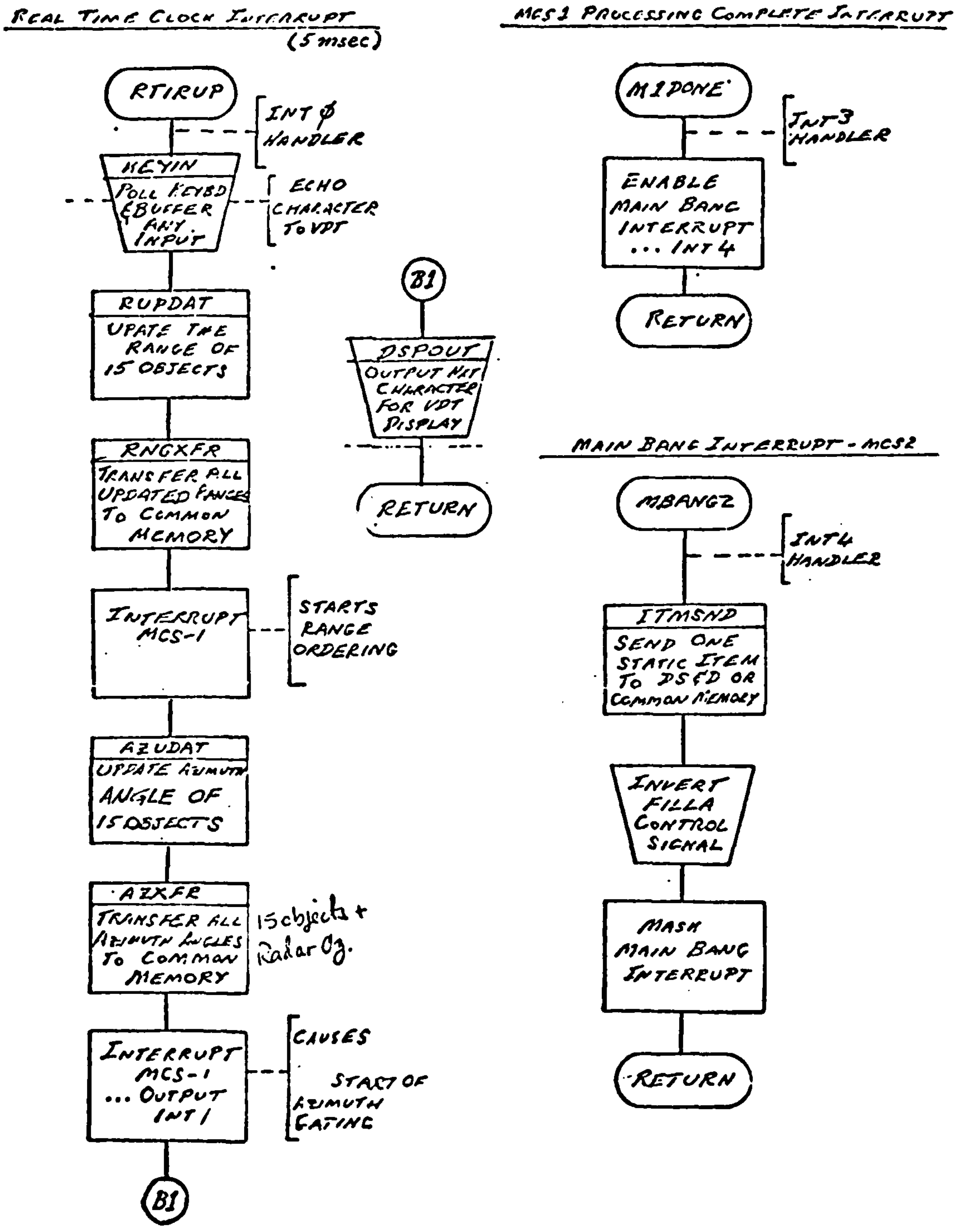


FIGURE V-7. MCS-2 INTERRUPT HANDLERS

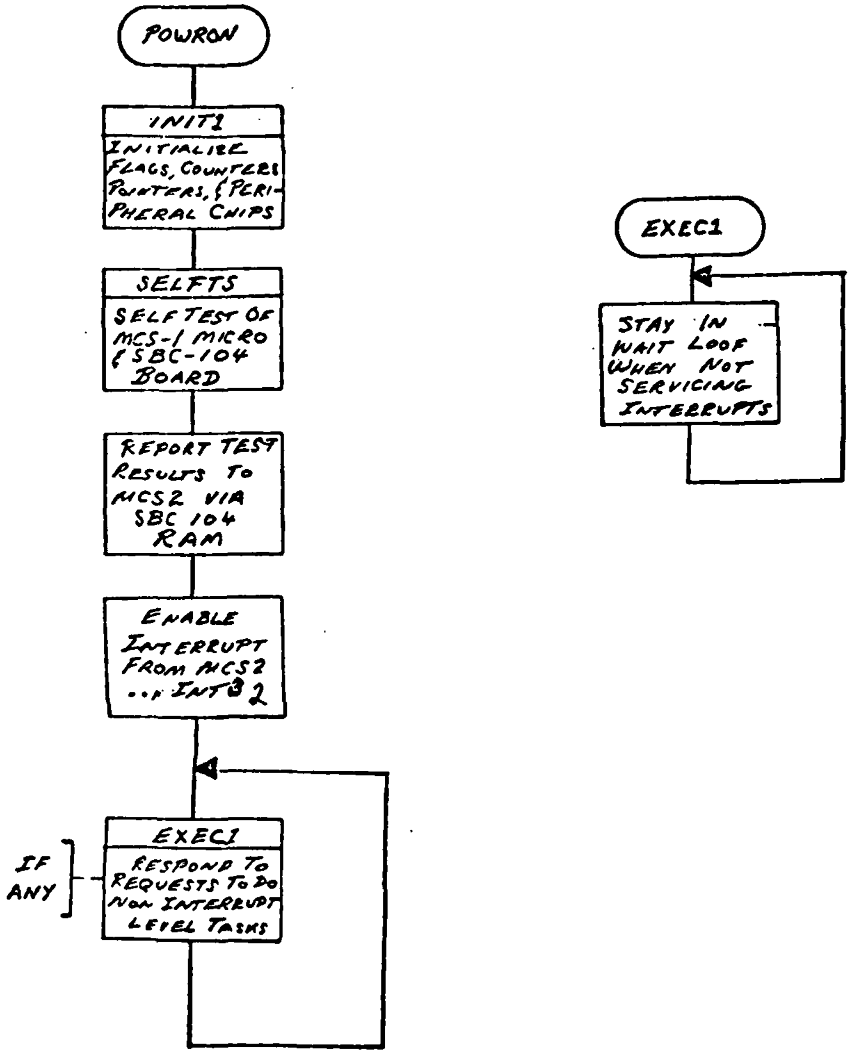


FIGURE V-8. TOP LEVEL FLOW CHART - MCS-1

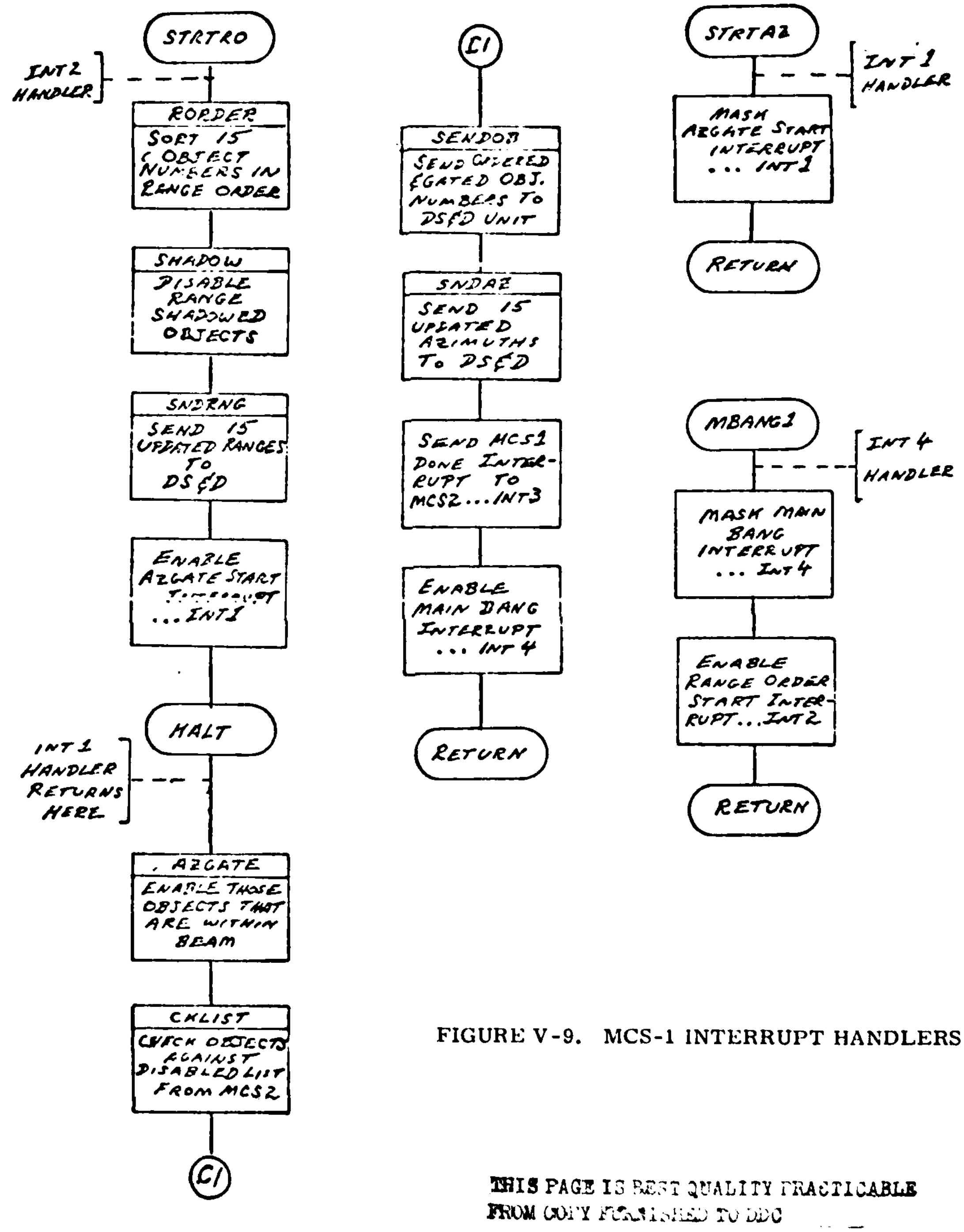


FIGURE V-9. MCS-1 INTERRUPT HANDLERS

VI PERFORMANCE SPECIFICATIONS

	Baseline	Options
Frequency:	1250 - 1350 MHz 2900 - 3700 MHz (1 MHz steps)	0.5 to 18 GHz
Output Power:	Coherent Channel: -6 dBm Noncoherent Channel: 0 dBm	
Dynamic Range:	>100 dB (0.1 dB steps)	
Doppler Simulation:	0 to ±2100 knots	
Target Capability:	6 Aircraft, 9 Chaff Events (Point, Medium, Large)	127 Aircraft plus Chaff Events
Chaff Motion & Effects:	Stationary	Air Mass Motion, Screening, Altitude
Environmental Anomolies:		Clouds, Snow, Rain, etc.
Target RCS Range:	0.1 to 1000 $meters^2$	
RCS Dynamics:	Static Mean plus Scintillation	Dynamic Tracking
Target Pulse Width:	0.3 to 50 microseconds	
Target Range:	6 to 400 NM	
Target Azimuth:	0 to 360°	

	Baseline	Options
Azimuth Rate:	±6 degrees/second	
Radar/Jammer Power:	0 to 100 dBW	
Jammer Simulation:		
Number	2	Heavy Density Model
Type	Coherent & Noncoherent	
Modes	Range Deception (including Cover Pulse), Inverse Gain, Synchronous & Nonsynchronous Pulses, Swept CW, Spot Noise, Barrage Noise	
Antenna Pattern Data:	Azimuth Coverage	Azimuth & Elevation
Complex Waveforms:		Pseudo Random Binary Phase Coding 200 Megabit Clock Rate
Identification:		IFF SIF, Mode 4, (SLS)

VII SYSTEM APPLICATION

The MTG-100 because of its ability to create controlled scenarios makes an excellent tool for evaluation of new radar and ECCM techniques. Changes made to the system under evaluation may be tested under identical conditions to determine quantitative improvements or degradation. The scenario may be replayed even to the point of repeating the identical noise pattern if desired.

Similarly, when testing a number of systems (either identical or different), a true quantitative evaluation may be made under dynamic conditions. With the simulator, the entire system may be tested (end-to-end), and not as a subsystem on a piecemeal basis. Flight line or depot testing using the radar simulator will exercise many functions simultaneously and permit evaluation of functions which may be difficult, if not impossible, to achieve any other way.

Another application for the simulator is in training programs. By being able to create electromagnetic situations which will require judgment and operator skill to evaluate and respond to, operator training under realistic conditions results.

VIII HARDWARE COMPLEMENT

A photograph of the three units making up the MTG-100 has been included in Section II of this report. The size of the three units that comprise the simulator is shown in Table VIII-1.

The complement of subassemblies in the R. F. /Processor is contained in Table VIII-2. Table VIII-3 illustrates the power supplies that are used.

TABLE VIII-1. MTG HARDWARE COMPLEMENT

UNIT	SIZE
1. VIDEO DISPLAY TERMINAL	14 5/8"H X 21 3/8"W X 23 1/8"D
2. RF/PROCESSOR	16 1/4"H X 19 3/4"W X 21 1/4"D
3. POWER SUPPLY	14" H X 23" W X 16" D

TABLE VIII-2. R.F./PROCESSOR SUBASSEMBLIES

1. DIGITAL PRINTED CIRCUIT BOARDS

    STATIC DATA
    VCO CONTROL/AƵ SUBTRACTOR
    COHERENT PULSE GROUP GENERATOR
    NONCOHERENT PULSE GROUP GENERATOR
    AM NOISE GENERATOR
    ANTENNA PATTERN GENERATOR
    DOPPLER FREQUENCY CONTROL
    ATTENUATOR DRIVER

2. COMPUTER

    MICROCOMPUTER SYSTEM - 1 (MCS-1)
    MICROCOMPUTER SYSTEM - 2 (MCS-2)
    MEMORY EXPANSION
    DYNAMIC DATA

3. R.F.

3	MIXERS
6	LEVEL SET ATTENUATORS
2	RF AMPLIFIERS
4	AM MODULATORS
8	PIN DIODE SWITCHES
4	VOLTAGE CONTROLLED ATTENUATORS
2	RF COMBINERS
7	VOLTAGE CONTROLLED CRYSTAL OSCILLATORS
2	VOLTAGE CONTROLLED OSCILLATORS
2	CRYSTAL CONTROLLED OFFSET OSCILLATORS
1	7 POLE DOUBLE THROW SWITCH
2	BAND PASS FILTERS
1	STEP RECOVERY DIODE
2	ISOLATORS

TABLE VIII-3. POWER SUPPLY

1. COMPUTER

	TYPE	-	SWITCHING REGULATOR
	VOLTAGES	-	±12 VDC ± 5 VDC

2. R.F./DIGITAL

A)	TYPE	-	SWITCHING REGULATOR
	VOLTAGES	-	±15 VDC ± 5 VDC +12 VDC
B)	TYPE	-	CONVENTIONAL
	VOLTAGES	-	+100 VDC + 24 VDC

IX MTG-100 OPERATING INSTRUCTIONS

1. MTG-100 Description.

1.1 Purpose. The MTG-100 will synthesize targets, chaff and ECM events coordinated in real time with an operating radar. The microwave output of the MTG-100 can be summed with actual radar signals from the radar antenna and input to the radar receiver.

1.1.1 Composition. The MTG-100 is comprised of a Video Display Terminal (MTG-100/VDT) for operator interface; the R.F. Processor (MTG-100/RFP), which includes the microcomputer systems for control, entry of data, azimuth gating, range ordering, other data routing and control functions, interface circuitry and R.F. chains at L and S-band; and a Power Supply (MTG-100/PS).

1.1.2 Input Interfaces. In addition to operator initiated data and status information from the VDT, inputs to the MTG-100 include the range sweep trigger, antenna pointing direction and local oscillator R.F. from the host radar.

1.1.3 Output Interfaces. Two R.F. channels are provided in the MTG-100: One, locked to the radar's first local oscillator, is concerned with targets, chaff and coherent ECM; the other, operating from an oscillator within the MTG-100, provides noncoherent ECM. The output R.F. signals of these two channels are combined to form a composite signal which can be coupled with the actual radar return signal and applied to the radar receiver.

2. Operating Instructions.

2.1 Electrical Interface. Transmission of data between the VDT and the R.F. Processor is by means of an EIA RS-232-C Data Transmission Link.

2.1.1 Communication Mode. Communication between the VDT and the R.F. Processor takes place one line at a time on a message basis as determined by the R.F. Processor.

2.2 Power-Up Routine. Upon power-up of the system, the VDT runs through an internal self-diagnostic program. As a result of this test, a status message is printed on line 25 of the display screen and also sent to the R.F. Processor.

2.2.1 Internal Test. Receipt of a successful VDT test result instructs the MTG-100 to initiate an internal test program of itself. This test is described in Table IX-1.

2.2.2 Test Unsuccessful. If the result of this internal MTG-100 test is unsuccessful, a status message describing the type of failure is originated by the R.F. Processor and printed out on line 24 of the display. If the type of failure prevents any intelligent reply by the MTG-100, line 24 remains blank.

2.2.3 Test Successful. If the internal MTG-100 test is acceptable, the VDT format of Figure IX-1 is displayed, less any data entries, and an acceptable self-test message is printed out on line 24 by the MTG-100. The operator is then able to enter the operating mode of the system.

2.3 Operating Routine. The operating mode can be initiated following successful completion of the self-test. This causes the display format shown in Figure IX-1 to be generated without any of the data entries. The operator is prevented from writing over or modifying this display format when the cursor is located in one of the format fields.

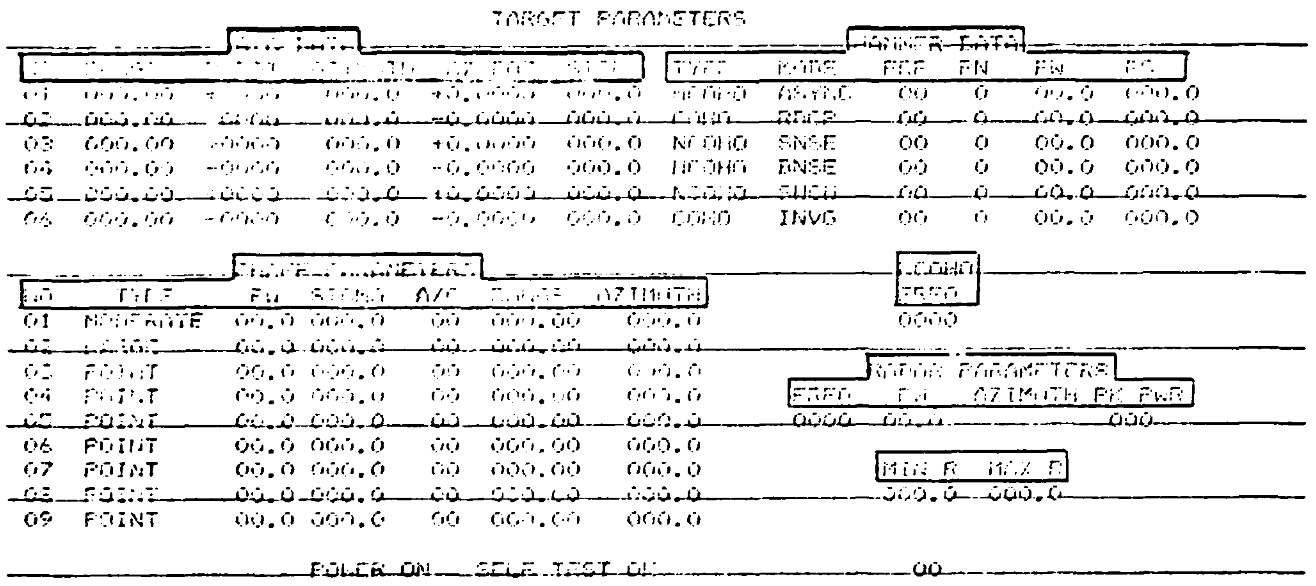
2.3.1 Test Program. It is possible to generate a test program whose initial conditions are stored in the MTG-100 by depressing the F1 pushbutton on the VDT. This program, as shown in Table IX-2 configured for L-band operation, involves the simulation of six target aircraft, three of each of the three types of chaff, and other ECM. Having filled the display field with the internally stored data, the operator can subsequently change or modify any of the displayed parameters to simulate other tactical scenarios which may be required. The initial conditions are shown in Figure IX-2 as they might appear on a radar PPI.

2.3.2 Data Entry. To enter data on any line, the cursor is positioned at the desired point of entry. This is accomplished by depressing the "HOME" key and then depressing the cursor positioning controls in any desired sequence. After a line is entered ("NEW LINE"), the "HOME" control is actuated prior to new cursor positioning. (Note: Actuating the "TAB" key after "HOME" automatically positions the cursor at the beginning of the first character entry on the first line. The "TAB" key is then used to reposition the cursor to each successive data entry point on the line.) Data entry for aircraft is determined on a line by line basis. Radar parameters, chaff parameters and noncoho frequency are entered after keying in appropriate data since these functions do not occupy an entire line by themselves.

Since it affects all data, radar parameters-including MIN R and

TABLE IX-1. MICROPROCESSOR INTERNAL TEST

- VDT INTERFACE VERIFICATION
- RF PROCESSOR
  READ/WRITE RAM CHECK
- RF PROCESSOR
  ADDRESS AMBIGUITY CHECK
- DISPLAYED TEST PROGRAM



```
                              TARGET PARAMETERS
          [illegible]                                     JAMMER DATA
[illegible]                                 TYPE    MODE   PRF  FN   FW    FC
01  000.00  +0000  000.0  +0.0000  000.0  [illegible] ASYNC 00  0   00.0  000.0
02  000.00  -0000  000.0  -0.0000  000.0  [illegible] [illegible] 00 0 00.0 000.0
03  000.00  +0000  000.0  +0.0000  000.0  NCOHO   SNSE    00   0   00.0  000.0
04  000.00  -0000  000.0  -0.0000  000.0  NCOHO   BNSE    00   0   00.0  000.0
05  000.00  +0000  000.0  +0.0000  000.0  [illegible] SWCH 00  0   00.0  000.0
06  000.00  -0000  000.0  -0.0000  000.0  COHO    INVG    00   0   00.0  000.0

          [illegible]                               COHO
NO    TYPE        FW   SIGMA  A/C   RANGE   AZIMUTH     FREQ
01  MODERATE     00.0  000.0   00  000.00   000.0       0000
02  LARGE        00.0  000.0   00  000.00   000.0
03  POINT        00.0  000.0   00  000.00   000.0      RADAR PARAMETERS
04  POINT        00.0  000.0   00  000.00   000.0   FREQ   FW   AZIMUTH PK PWR
05  POINT        00.0  000.0   00  000.00   000.0   0000   00.0           000
06  POINT        00.0  000.0   00  000.00   000.0
07  POINT        00.0  000.0   00  000.00   000.0      MIN R   MAX R
08  POINT        00.0  000.0   00  000.00   000.0      000.0   000.0
09  POINT        00.0  000.0   00  000.00   000.0

                      POWER ON   SELF TEST ON                 00
```

Note: 1) Data entries are shown for reference only. The display format consists of the titles and the protected and variable fields necessary to format the data to be displayed.

FIGURE IX-1. DISPLAY FORMAT

TABLE IX-2. TEST PROGRAM

NO	RANGE	RDOT	AZIMUTH	AZDOT	SIGMA	TYPE	MODE	ERP	PN	PW	PS
1	15.00		0.0	0.0	40.0 ▽						
2	7.00	+1200	90	+2.5	40.0 ▽	NCOHO	ASYNC	(50)		5.0	5.0
3	7.00		180	+4.7746	40.0 ▽						
4	29.00		180	-1.1525	40.0 ▽						
5	17.50	+2100	270	0.0	10.0 ▽						
6	17.50	-2100	270	0.0	100.0 ▽	COHO	RDCP	(20)	6	1.0	3.0

NO	TYPE	PW	SIGMA	A/C	RANGE	AZIMUTH	NCOHO FREQ			
1	POINT	1.0	100 ▽	---	16.00	0.0	1300			
2	MODERATE	50.0	100 ▽	---	21.00	0.0				
3	LARGE	50.0	100 ▽	---	26.00	0.0				
4	POINT	1.0	100 ▽	---	10.0	270.0				
5	MODERATE	1.0	100 ▽	---	15.0	270.0	FREQ	PW	AZIMUTH	PKPWR
6	LARGE	1.0	100 ▽	---	20.0	270.0	1300 ◻	1.0 *		80 △
7	POINT	1.0	100 ▽	---	19.0	150.0				
8	MODERATE	1.0	100 ▽	---	19.0	130.0	MINR		MAXR	
9	LARGE	1.0	100 ▽	---	19.0	100.0	6.0		30.0	

* SELECTED FOR RADAR NOMINAL VALUE
△ " " " " "
◻ " " " " "
▽ " " " " "

Revised 9-27-79

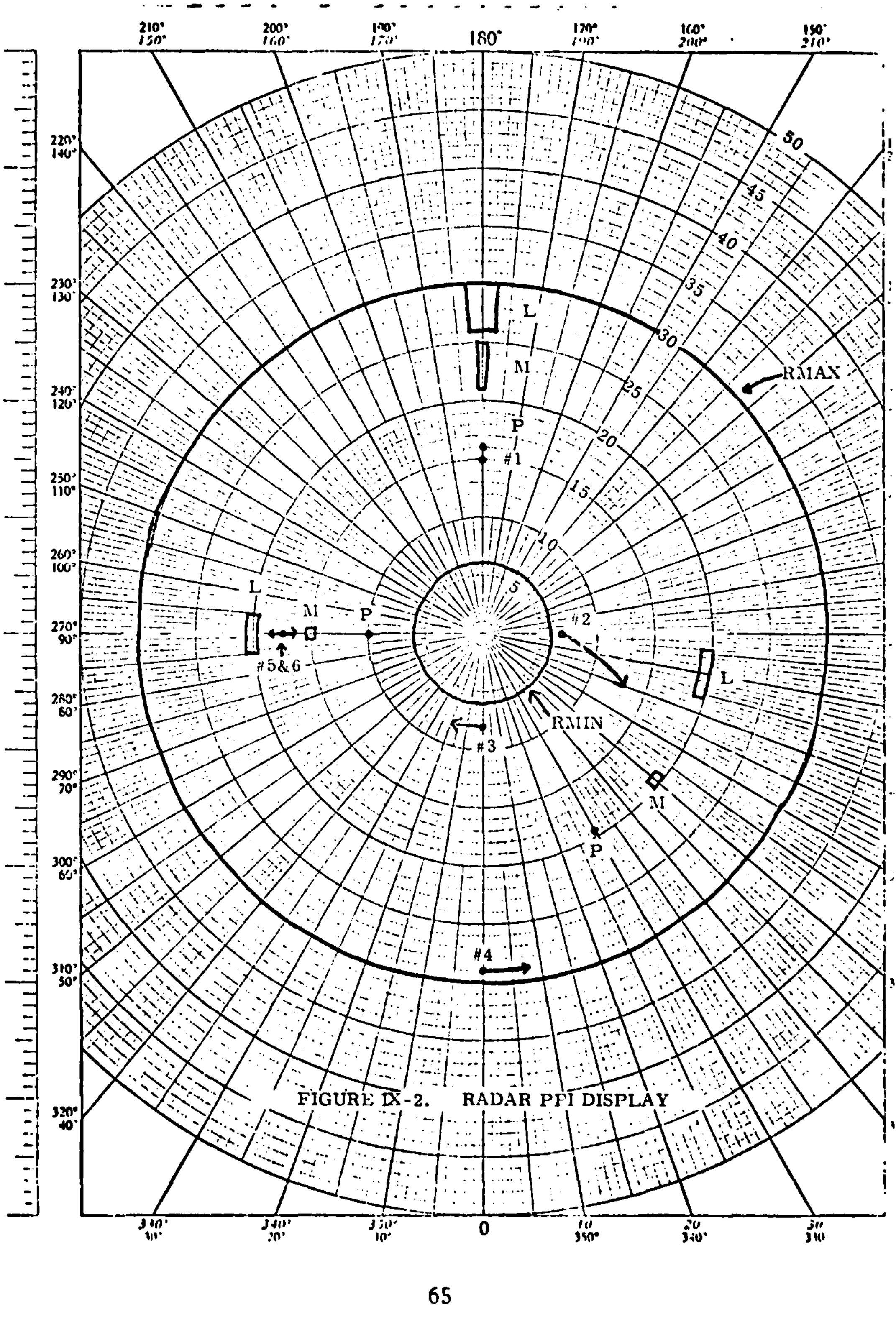


FIGURE IX-2. RADAR PPI DISPLAY

MAX R-must be entered prior to all other data. In the event that a radar parameter is modified by the operator, all displayed data must be re-entered. This is accomplished by positioning the cursor over the first character on that line, keying in that character again, and then depressing the "NEW LINE" key. Alternatively, the complete line can be re-entered. In the event that a parameter is desired to be modified on any other line of the display, the cursor is positioned over the first character on that line and that character is keyed in again. The parameters desired to be modified on that line are then keyed in over the existing characters.

Once the operator has updated a line, with the cursor still positioned on that line, he depresses the "NEW LINE" key. This initiates the processor to read that entire line and update all the system parameters affected. Note that position of character entry is critical. Figure IX-1 indicates the only position for all characters for the data entry to be valid. Lack of an entry automatically is a zero. Data input formats are described in Table IX-3. Rather than entering the test program parameters stored in the MTG-100, the operator can elect to fill the display field manually. This is accomplished in the manner described above.

2.3.3 Simulation Initiation. Following the data entry, the MTG-100 operates with the entered data and provides R.F. outputs to the host radar. All system functions are enabled except the updating of target range and azimuth based upon the input rate values. The operation begins the program by depressing the F3 function button (the "RUN" command). The range and azimuth values of all moving targets are then observed to be changing while the VDT is updated at a one second rate for radar azimuth and a six second rate for target range and azimuth positions.

2.3.4 Simulation Halt. At any time during program operation, depressing the F4 function button (the "STOP" command) causes all moving targets to cease their motions. In this condition, all parameters remain static with their most recently updated values stored in memory. Subsequent to this "STOP" command, if the F3 function button is depressed, the target aircraft having non-zero rate functions will continue their previous motions from the locations where they were previously halted.

2.3.5 Data Modification. It is possible to make major modifications of displayed parameters or elimination of specific targets, chaff objects, or radar parameters with the function keys. The allocation of these function keys is summarized in Table IX-4. The general sequence of key strokes for use with the shifted function keys is: "SHIFT" and the function key simultaneously, affected target or chaff number, and "NEW

TABLE IX-3. DATA INPUT FORMATS

Parameter	Data Source	Max. Value	Min. Value	Res.	Units	Notes
A/C Number	VDT	6	1	01		
A/C Range	VDT	406	6	.01	nmi	
A/C Range Rate	VDT	±2100	0	1	knots	
A/C Azimuth	VDT	359.9	0	.1	degrees	
A/C Azimuth Rate	VDT	±6	0	0.0001	deg/sec	
A/C Sigma	VDT	999.9	0	.1	m^2	
Jammer Type	VDT					1
Jammer Mode	VDT					2
Jammer ERP	VDT	90	0	1	dBW	
Jammer PW	VDT	50.0	.3	.1	μsec	
Jammer PS	VDT	100	10	.1	μsec	
Jammer PN	VDT	8	1	1		
Chaff Event #	VDT	9	0	01		
Chaff Type	VDT					4
Chaff PW	VDT	50.0	.3	.1	μsec	
Chaff Sigma	VDT	999.9	0	.1	m^2	
Chaff A/C #	VDT	06	01	01		
Chaff Range	VDT	406	6	.01	nmi	
Chaff Azimuth	VDT	359.9	0	.1	degrees	
Radar Freq.	VDT	1350	1250	1	MHz	
		3700	2900	1	MHz	
Ncoho Freq.	Same as Radar Freq.					
Radar Peak Pwr	VDT	100	0	1	dBW	
Radar PW	VDT	50.0	.3	.1	μsec	
Radar Max Range	VDT	406	6	.1	nmi	
Radar Min Range	VDT	406	6	.1	nmi	
Radar Azimuth	S/D Conv	16,383	0	1	ppt	
Radar Main Bang	Hdwr					

TABLE IX-3 (cont'd.)

NOTES

1. Jammer Type

NCOHO - When noncoherent is selected, all modes are selectable.

COHO - When coherent is selected, only Range Deception, Inverse Gain, or OFF modes are selectable.

2. Jammer Mode

OFF - When OFF is selected, it is possible to select ERP, P/W, P/S and P/N.

SWCW - When Sweep CW is selected, a value for P/W and P/S must be entered to have it recognized.

SNSE - When Spot Noise is selected, a value for P/W and P/S must be entered to have it recognized.

BNSE - When Barrage Noise is selected, a value for P/W and P/S must be entered to have it recognized.

RDCP - When Range Deception is selected, values for P/W, P/S and P/N must be entered.

INVG - When Inverse Gain is selected, P/W is entered as the radar pulse width and P/N is entered as 1. P/S values are not recognized.

SYNC - When Synchronous is selected, values for P/W and P/S must be entered. All values of P/N are not recognized.

ASYNC - When Asynchronous is selected, values for P/W and P/S must be entered. All values of P/N are not recognized.

3. Chaff Type

POINT - When Point chaff is selected, the chaff P/W is automatically preset to the radar pulse width.

MODERATE - When Moderate chaff is selected, a value for chaff P/W must be entered.

LARGE - When Large chaff is selected, a value for chaff P/W must be entered.

TABLE IX-4. FUNCTION KEY ASSIGNMENTS

Function Key	Operation
F1	Fill display format with stored program
F2	Reserved for growth
F3	Start range and azimuth update
F4	Freeze range and azimuth
F5	Reserved for growth
F6	Initiate chaff object #
F7	Reserved for growth
F8	Reserved for growth
F1 Shifted	Reset to power-up sequence
F2 "	Reserved for growth
F3 "	Reserved for growth
F4 "	Reserved for growth
F5 "	Reserved for growth
F6 "	Reserved for growth
F7 "	Reserved for growth
F8 "	Reserved for growth

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LINE" key.

2.4 Chaff Initiation. Initiation of chaff is accomplished by either specifying an aircraft to drop the chaff or the location the chaff is to be dropped. Chaff characteristics (type, pulse width and cross section) are entered and echoed back before chaff can be initiated. Actuation of the F6 followed by the chaff object number and the "NEW LINE" key causes the processor to enable the chaff simulation. If an aircraft number is assigned, the chaff is initiated at the position of that aircraft and the position of the chaff is automatically displayed and updated on the VDT. If no aircraft has been assigned, then the chaff is placed at the position entered by the operator.

2.5 Target Conflicts. A conflict is defined to exist either between coherent objects or between noncoherent objects if the trailing edge of the last pulse of an object is within 10 microseconds of the leading edge of another object. No conflict exists between coherent and noncoherent objects. In the event that a conflict is determined to exist, the object furthest in range is disabled until relative motion of the objects eliminates the conflict.

2.6 Coherent Objects. Targets, chaff and coherent ECM are disabled when they are outside the 22.5^{o} region centered on the radar antenna pointing angle.

2.7 Noncoherent Objects. Noncoherent ECM events are disabled when they are outside the 22.5^{o} region centered on the radar antenna pointing angle. Certain specific noncoherent ECM (spot noise, barrage noise, synchronous pulses, asynchronous pulses) are considered azimuth initiated functions. When these events are within $\pm 11.25^{o}$ of the radar pointing angle, all other noncoherent ECM are disabled. When two or more events are within $\pm 11.25^{o}$ of the radar pointing angle, the first of them to have entered the 22.5^{o} sector has priority and the others are disabled. When the priority event leaves the 22.5^{o} sector, the next event to have entered the sector is enabled.

X ALIGNMENT SUMMARY

The following list enumerates the adjustments and calibrations needed prior to operation or testing of the MTG-100:

A) Absolute frequency setting of the 9 oscillators in the MTG-100. Measurements performed directly at each oscillator output:

Doppler Frequency Calibrate	
Target 1 through 6 plus Chaff	110 MHz ± 20 Hz
IF Calibrate	
S-Band	80 MHz ± 20 Hz
L-Band	30 MHz ± 20 Hz

B) Adjustment of the upper limits of the D/A reference, of the 7 Doppler oscillator circuits, located on the Doppler Frequency Control Board Assembly. Test set-up and limits as defined in the Acceptance Test Procedure for Doppler shift.

C) Power level settings of mixer inputs (Front Panel "S" and "L" IF adj.). Adjustments made in combination with coherent and noncoherent R.F. Level Set controls on front panel to achieve limits specified in the Acceptance Test Procedure, and adjusted to that level where a further increase no longer affects output power level.

D) Output power level setting for both L and S-band coherent chains. (COHO R.F. Level Set front panel controls.) Levels adjusted in accordance with Acceptance Test Procedure.

E) Output power level setting for both L and S-band noncoherent chains. (NCOHO R.F. Level Set front panel controls.) Levels adjusted in accordance with Acceptance Test Procedure.

F) Maximum deviation setting for barrage noise output. Adjustment made to meet requirements of Acceptance Test Procedure.

G) Noise diode current adjust for spot and barrage noise. Adjustment made to meet requirements of

Acceptance Test Procedure.

Note: Items C, D and E are performed with a radar L.O. input level of + 7 dBm.

Reference Documents:

1. MTG Test Plan, REIC Document No. 4413-2
2. MTG Test Equipment List, REIC Document No. 4413-3
3. Multiple Threat Generator MTG-100 Acceptance Test Data, REIC Document No. 4413-5

LIST OF
ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ASYNC	Asynchronous
BNSE	Barrage noise
COHO	Coherent
CPU	Computer Processing Unit
CW	Continuous wave
D/A	Digital to analog conversion
dB	Decibel
DC	Direct Current
ECCM	Electronic counter/countermeasures
ECM	Electronic countermeasures
ERP	Effective radiated power
FM	Frequency modulation
IF	Intermediate frequency
INVG	Inverse gain
K	X 1000
KHz	Kilohertz
MAX R	Maximum range
MHz	Megahertz
MIN R	Minimum range
MTG	Multiple Threat Generator
NCOHO	Noncoherent
Noncoho	Noncoherent
P/N	Pulse Number
PPI	Plan Position Indicator
PRI	Pulse Repetition Interval
PROM	Programmable Read Only Memory
PS	Power Supply
P/S	Pulse Spacing
P/W	Pulse Width
RAM	Random Access Memory
RCS	Radar Cross Section
R & D	Research and Development
RDCP	Range Deception

LIST OF

ABBREVIATIONS, ACRONYMS, AND SYMBOLS

(cont'd.)

REES	Radar Electromagnetic Environment Simulator
R.F.	Radio frequency
RFP	Radio frequency processor
SNSE	Spot noise
SYNC	Synchronous
SWCW	Swept CW
μs	Microsecond
VCO	Voltage controlled oscillator
VDT	Video display terminal
SVCO	Crystal controlled voltage controlled oscillator

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