

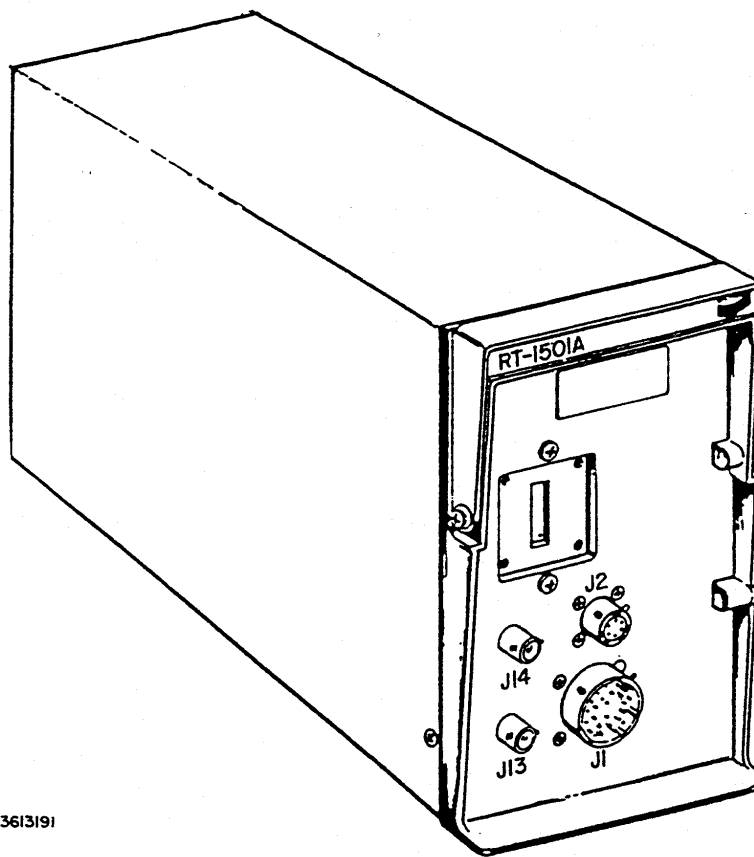


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This word document contains figures representing the Block Diagram (see pages 9 & 10) which is part of the Operational Description for the Receiver Transmitter RT-1501A. These figures are scanned images from Section I of the maintenance manual part number 006-15590-0000, Revision 2 dated October 1991. It should be noted that those pages "Intentionally Left Blank" were not scanned and are therefore not included here.

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I.B. 21500B
PART 4

RT-1501A Receiver-Transmitter
Figure 1-0

1-0
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SECTION I THEORY OF OPERATION

1. General

This section covers the theory of operation of the RT-1501A Receiver-Transmitter on three levels: overall operation within the RDR-1500B Radar System, block diagram discussion, and detailed theory.

2. Overall Operation

The RT-1501A Receiver-Transmitter is shown in figure 1-0. The receiver-transmitter (R-T) unit operates by emitting very short, intense pulses of microwave energy which are reflected within the range of the radar system. A portion of the radiated energy, reflected by an object having reflective characteristics, is returned along the same general path to the aircraft where it is received and converted into digital data that is representative of the target size. The reflected signal is received by a scanning antenna. The R-T unit amplifies and digitizes the signal and then sends the video signal to the interface unit (IU) for processing.

Except for search mode, the RT-1501A transmits 2.35-microsecond pulses at a pulse repetition frequency (PRF) of 200 Hz for all the radar ranges. The R-T unit transmits the radar signal at 9375 MHz in the beacon, weather, and search modes, and receives target-reflected radar signals at 9375 MHz and beacon signals at 9310 MHz.

The radar system has three pulse widths that are selectable by the operator on any range in the search mode. An auto-search mode is also available in which the pulse widths are controlled automatically depending upon the range selected. RDR-1500B pulse widths and associated PRF's are as follows:

<u>PULSE WIDTH</u>	<u>PRF RATE</u>	<u>PRF AVG</u>
0.1 us	1600 Hz	1200 Hz
0.5 us	800 Hz	600 Hz
2.35 us	200 Hz	200 Hz

Nine range scales are selectable by the operator, each with either four or five equidistant range rings. They are as follows:



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<u>RANGE (NM)</u>	<u>RANGE RINGS (NM)</u>	<u>AUTO SEARCH SELECTION PULSEWIDTH (us)</u>
0.625	0.125	0.1
1.25	0.25	0.1
2.5	0.5	0.1
5.0	1.0	0.1
10.0	2.0	0.5
20.0	5.0	0.5
40.0	10.0	2.35
80.0	20.0	2.35
160.0	40.0	2.35

The ability to select any pulse width for any range allows the radar operator to optimize the desired presentation depending upon the radar operating conditions. An additional feature is the use of a (fast time constant) control to reduce undesired clutter to enhance target detection and tracking. This control can be used in either sea search or terrain mapping operations.

The R-T unit provides automatic frequency control (afc) for accurate frequency detection of target and beacon returns. Its automatic gain control (agc) provides a constant gain reference over time and temperature for the proper video processing of received signals. Sensitivity timing control (STC) is used to equalize target returns from close and distant radar ranges.

In the system test mode, a test pattern is generated in the R-T unit and displayed on the indicator, providing a test of the system signal processing circuits. The power supply within the R-T unit operates from the aircraft +28 Vdc. The R-T unit is tray mounted in the aircraft.

The R-T unit interfaces with other units of the RDR-1500B Radar System through its front panel connectors. Figure 1-1 in Part 3 of this manual depicts the typical RDR-1500B Radar System. The front panel contains a waveguide flange, unit connector J1101, video coaxial BNC connectors J1113 and J1114, and test connector J1102.

The R-T unit delivers X-band-transmitted pulses to the AA-1504A Antenna Array, through a quick-disconnect waveguide connected to the waveguide flange. It outputs the video signals from connectors J1113 and J1114 to the IU-1507A Interface Unit. Connector J1102 is used for test purposes only. It provides access to receiver video signals. Multi-pin unit connector J1101 provides a signal and voltage interface between the RT-1501A and the IU-1507A Interface Unit, the CN-1506A Control Unit, and the aircraft. Table 1-1 lists the signals and voltages routed through connector J1101.

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J1101 PIN NO.	SIGNAL NAME AND DESCRIPTION
A	+28 Vdc; from aircraft power supply.
B	+28 Vdc; from aircraft power supply.
C	DC Ground; from aircraft power supply.
D	DC Ground; from aircraft power supply.
F	Mode 4; R-T mode from interface unit.
G	R/T On/Off; control signal from control unit.
H	VAR STC Return (see pin <u>j</u> , below).
N	System Trigger; control signal from interface unit.
P	Trigger Shield.
R	Search Gain Hi; from control unit potentiometer.
S	Search Gain Lo; from control unit potentiometer.
T	Monitor; to interface unit.
U	Mode 3; RT mode from interface unit.
X	Mode 2; RT mode from interface unit.
Y	Mode 1; RT mode from interface unit.
a	Suppression Pulse Out; to aircraft.
b	TRANS CONT; control signal from control unit.
c	CFAR; Reserved.
d	Beacon Gain Hi; from control unit potentiometer.
e	Beacon Gain Lo; from control unit potentiometer.
j	VAR STC; from control unit potentiometer.

Connector J1101, Inputs and Outputs
Table 1-1

Table 1-2 lists the modules and assemblies that make up the R-T unit. These are shown and identified in figure 6-1 of the Illustrated Parts List section.



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2.

MODULE/ASSEMBLY	BENDIX/KING PART NUMBER	REFERENCE SERIES	CONNECTORS
Front Connector Module	2040413-0501	1100	J1101, J1102, J1113, J1114, P1117
Interconnect Module	3606475-0501	1200	J1205, P1210, J1217, P1218, J1222
Pulse Transformer Assembly	2040524-0502	1400	J1439, P1432, P1433
Preamplifier-Limiter Module	3606479-0501	1900	J1937
Preamplifier Bias Module	3606482-0501	1900	P1934
Receiver Module	3606480-0501	2000	J2006, J2008, J2020, J2021, J2038
Beacon Receiver Module	2040416-0503	2500	P2508, P2538
Processor Module	3606476-0501	3000	J3007, J3009, J3010, J3012, J3034
STC Module	3606477-0501	3500	P3509
Regulator Module	3606486-0501	4000	J4010, J4029, P4015, P4016
S/L Pulse Modulator Module	3606487-0501	4500	J4516, P4519, P4529
Mid Pulse Modulator Module	3606472-0501	4600	J4615, J4625, J4627, J4628, J4630, J4632, J4633, J4635
Power Supply Control Module	2040523-0501	5100	P5101
Power Supply Power Module	2040420-0501	5200	J5201, J5211
Local Oscillator Assembly	2040691-0501	6000	P6012
Afc Module	2040421-0501	7000	J7023, J7031

Module Complement and Designations
Table 1-2

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3. Block Diagram Discussion (See figure 1-1.)

A. Waveform Synchronization and Transmitter Function

Basic synchronization signals for the radar system are generated by a crystal controlled oscillator located in the interface unit. The clock frequency is counted down to 1600 Hz for search short-pulse (0.1 us) mode and 800 Hz for search medium-pulse (0.5 us) mode. For all other modes, the clock frequency is counted down to 200 Hz. Either the 1600-Hz, 800-Hz, or 200-Hz system trigger is routed to the R-T unit where it keys the transmitter and provides other timing functions. The incoming trigger signal is buffered and then applied to the timing circuit, which controls the STC function generator and test pattern generator circuits. The buffered incoming trigger is also routed to the modulator driver where either the modulator short pulse (0.1 us), medium pulse (0.5 us), or long pulse (2.35 us) is selected. Pulse width selection is made depending upon operation mode selected at the control unit. Modulator long pulse is selected for modes using a 200-Hz trigger, modulator medium pulse is selected for modes using an 800-Hz trigger, and modulator short pulse is selected for modes using a 1600-Hz trigger. With either modulator pulse, a negative-going 1200-volt pulse is applied to the pulse transformer. The pulse transformer supplies the magnetron with a 6-kV, 6A positive-going pulse that causes the magnetron to oscillate at its 9375-MHz resonant frequency. A 10-kW, nominal, peak power rf output pulse is generated by the magnetron and is directed through the four-port E-plane circulator to the radar antenna.

B. Receiver Function

The R-T unit employs a single-conversion superheterodyne receiver. Signal returns received by the radar antenna are routed through the four-port E-plane circulator and the solid-state limiter to the low-noise preamplifier. The solid-state limiter is a microwave switch used to prevent damage to the receiver front end by the high-power microwave pulses from the magnetron oscillator. The preamplifier output is applied to a balanced mixer, which combines the echo signal with the signal from the first local oscillator. The first local oscillator operates at 9462 MHz to produce a difference frequency of 87 MHz. The mixer output is amplified and applied to a bandwidth switch, which selects either a 10-MHz for search short-pulse-mode operation, a 2-MHz bandwidth for search medium-pulse-mode operation, or a 0.5 MHz bandwidth for long-pulse-mode operation. The 87-MHz logarithmic-gain amplifier, following the bandwidth switch, provides for a great variance (approximately 60 dB) in signal levels that are usable by the R-T unit. Following the logarithmic-gain amplifier are a detector and a buffer. The detected, buffered video is acted upon by the FTC (fast time constant) circuit only in the search mode, when selected at the control



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3.B.

unit, and is used to reduce ground or sea clutter. In the A/D (analog-to-digital) converter following the switchable FTC circuit, the amplitude of the detected video signal is compared to three preset dc thresholds. The video switch located between the FTC circuit and A/D converter selects between weather/search radar or beacon video signals.

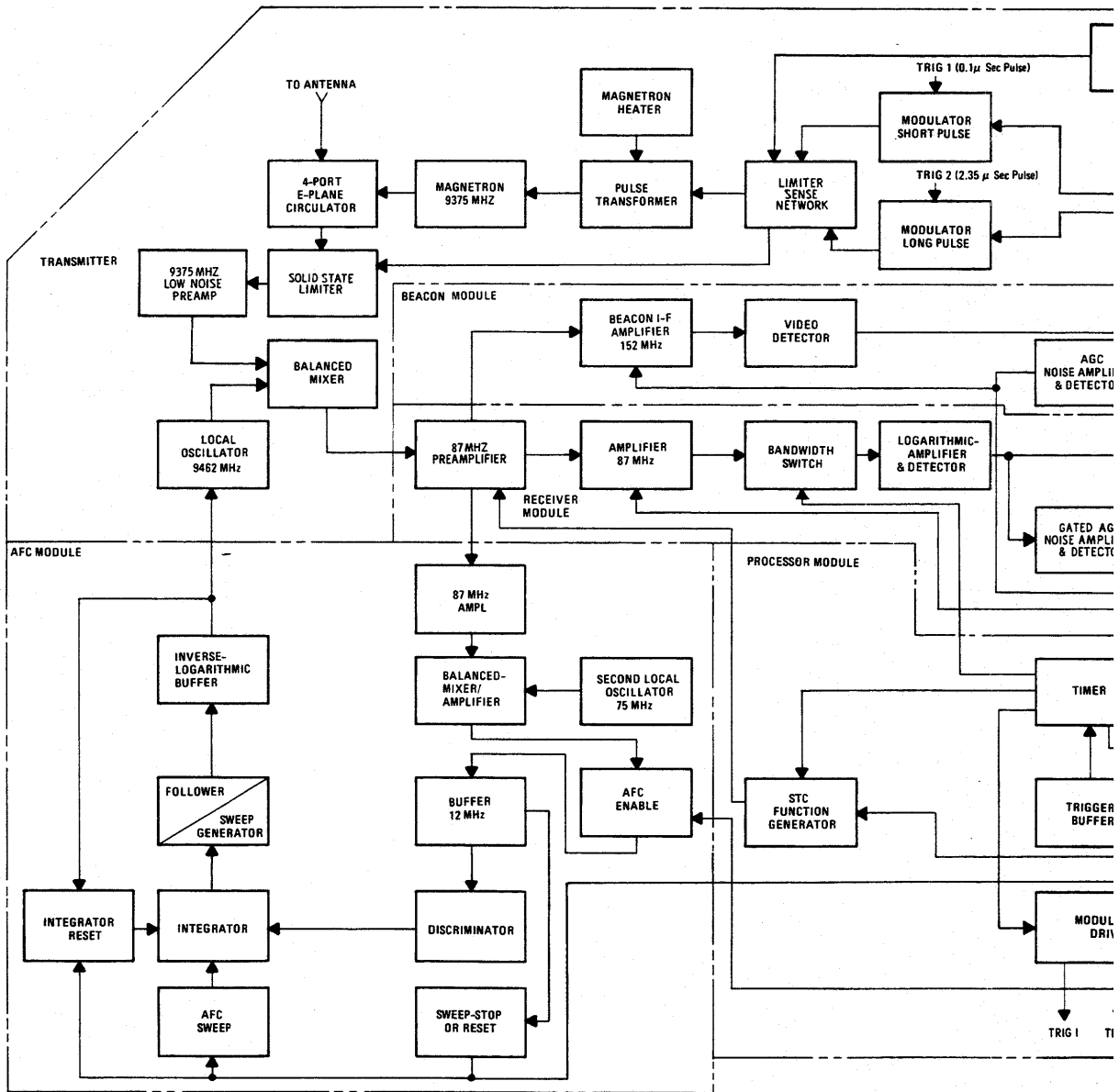
A two-bit logic code transmits to the interface unit the highest threshold level exceeded by the echo return. The thresholds in increasing levels represented by two-bit logic codes (data 1, data 2) are: 00, 01, 11, and 10.

C. Afc Function

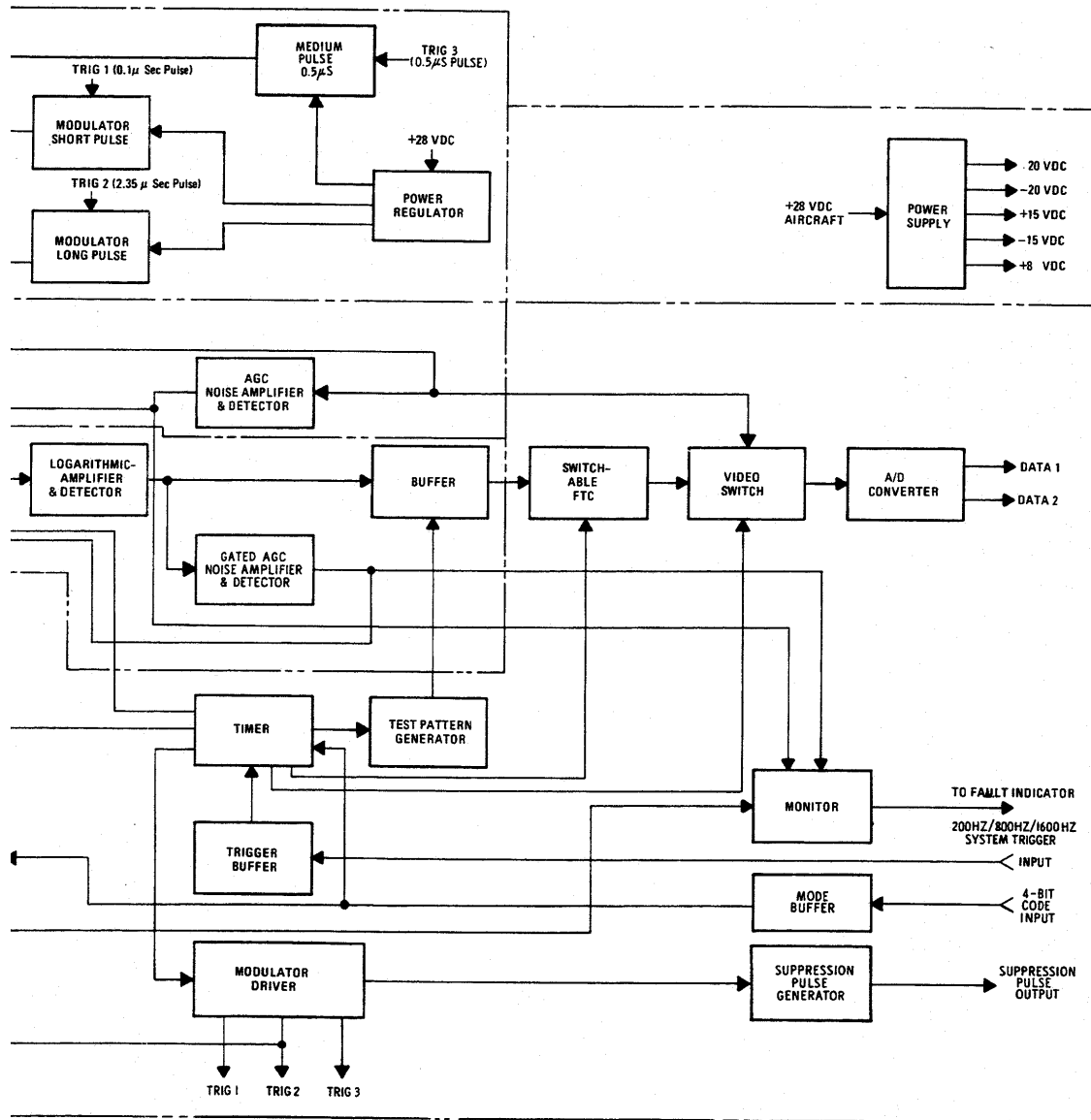
After the system trigger and while the magnetron is oscillating, the first local oscillator frequency must be adjusted to ensure a correct i-f echo-return signal. The afc is enabled by the long-pulse modulator trigger (TRIG 2). The afc does not lock onto the 0.1- or 0.5-microsecond pulses in the search short- or medium-pulse modes. The interface unit provides a long-pulse code at 100 pps for afc operation. Every eighth or sixteenth pulse position of a series of narrow pulses is a long pulse, which permits lock-on by the afc. The i-f signal from the 87-MHz preamplifier is applied to the afc mixer. Using the 75-MHz signal from the second local oscillator, the mixer converts the 87-MHz i-f signal to a 12-MHz second i-f. The discriminator following the 12-MHz buffer checks the i-f frequency. If the second i-f is exactly 12 MHz, the afc circuits remain stabilized. However, if the second i-f is not exactly 12 MHz, the discriminator produces a deviation voltage. The deviation voltage is amplified, integrated, buffered, and applied to a varactor in the first local oscillator to adjust the local oscillator frequency. An inverse logarithmic-gain buffer amplifier is used between the integrator and the first local oscillator to cancel the logarithmic voltage-to-frequency characteristic of the first local oscillator. If the first local oscillator is not very nearly 87 MHz above the magnetron frequency when the magnetron fires, the 12-MHz second afc i-f will be outside the discriminator capture range. In this case, the stop-sweep, or reset, circuit will initiate integrator reset and afc sweep. To ensure that the first local oscillator does not lock on the difference frequency 87 MHz below the magnetron frequency, the afc sweep circuit causes the first local oscillator to start at its highest frequency and sweep down. If the first local oscillator does not lock up during the down-sweep, the integrator is reset when the tune voltage reaches minimum and the sweep begins again.

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3.

D. Automatic Gain Control (Agc) Function

In weather or search long-pulse (SRCH L) operation, the detected video noise output from the receiver's logarithmic-gain amplifier and detector is gated through an agc gate to an agc amplifier and detector where the average noise level of the receiver is sampled. Approximately 4000 microseconds after the modulator driver issues the long-pulse modulator trigger, a positive 200-microsecond pulse is issued from the agc gate. This controls the operation of the gated agc noise amplifier and detector. During the 4000-microsecond period between the trigger and the start of the agc gate pulse, the agc noise amplifier and detector circuit is deactivated. This equates with the first 300 miles of return signal as displayed on the indicator. At the end of the 4000-microsecond period, the agc noise amplifier and detector is activated by the 200-microsecond agc gate pulse. The noise level present in the receiver is integrated. This sample is taken after the first 300 miles to obtain an average receiver noise sampling without interference from strong nearby returns. The agc noise amplifier and detector circuit compares the video noise level against a manually selected threshold. The resulting dc voltage, coupled to the 87-MHz i-f amplifier, controls the i-f gain to maintain the average receiver noise level constant.

In search short- and medium-pulse modes, the period from modulator triggering to agc gate is 2000-microseconds (150 miles), and the agc gate is issued only every eighth medium trigger pulse (TRIG 3) position or every sixteenth short trigger pulse (TRIG 1) position. Actually, for medium-pulse mode, a period consists of six medium pulses, one long pulse, and one blank position; for short-pulse mode, there are 12 short pulses, one long pulse, and one blank.

E. Sensitivity Time Control (STC) Function

The STC function generator is initiated after the transmitter output pulse. The generator causes the gain of the receiver preamplifier to increase exponentially. Attenuated returns from distant objects are amplified more than attenuated returns from nearer objects. Thus objects of the same size or density are made to look equal on the radar indicator, regardless of their distance.

F. Test Function

When the system is placed in the test mode, the transmitter is inhibited, and a test pattern generator is keyed. The triangular wave developed by the test pattern generator is injected into the video buffer. A resultant test pattern display on the radar indicator is indicative of system performance. The test pattern exhibits three colors (yellow, red, and green) in five bands. The center band is red, the bands closest to the center are yellow, and the outside bands are green.

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G. Beacon Amplifier

When operating in beacon mode, or plus BCN mode, the R-T unit transmits the standard 9375-MHz signal and receives the 9310-MHz transponder signal. To process the 9310-MHz signal, a separate 152-MHz i-f amplifier and video detector are used. These are located on the beacon module. The R-T unit first local oscillator operates at 9462 MHz to convert the standard 9375-MHz signal to a 87-MHz intermediate frequency. The same first local oscillator converts the 9310-MHz transponder signal to 152 MHz. The 152-MHz beacon i-f signal is amplified by the preamplifier and the 152-MHz i-f amplifier, detected, and then applied to the video switch.

H. Suppression Pulse Function

During the period of R-T unit transmit operation, the suppression pulse generator issues pulses which protect the other equipment aboard the aircraft against the R-T unit's transmitted pulses of high microwave energy, by blanking out receiver operation. A blanking-pulse timer produces suppression pulses that completely overlap the pulses transmitted during R-T unit operation.

The mode decoder circuit decodes the mode selected. When search short- or medium-pulse (SRCH S or SRCH M) mode is decoded, the timer generates +10-volt, nominal, 2.5-microsecond pulses that overlap the 100- or 500-nanosecond pulses being transmitted. When weather (WX, WXA), beacon (BCN), or search long-pulse (SRCH L) mode is decoded, the timer generates +10-volt, nominal, 5-microsecond pulses that overlap the 2.35-microsecond pulses being transmitted.

4. Detailed Theory of Operation

A. Power Supply Assembly (See figure 7-9.)

(1) General

The power supply assembly contains the RT-1501A power supply and a separate delay trigger enable circuit, which is discussed in paragraph 4.A.(7). The power supply furnishes regulated output voltages of +20V, +15V, and +8V for the R-T unit circuits. It maintains the output voltages to +5 percent tolerance, with the +20V regulated to +2 percent.

Power supply regulation is accomplished with push-pull, pulse-width modulation and averaging filter chokes in the output voltage circuit. The power supply has overvoltage protection and foldback current limiting to protect it and external circuits against shorts and current overloads.