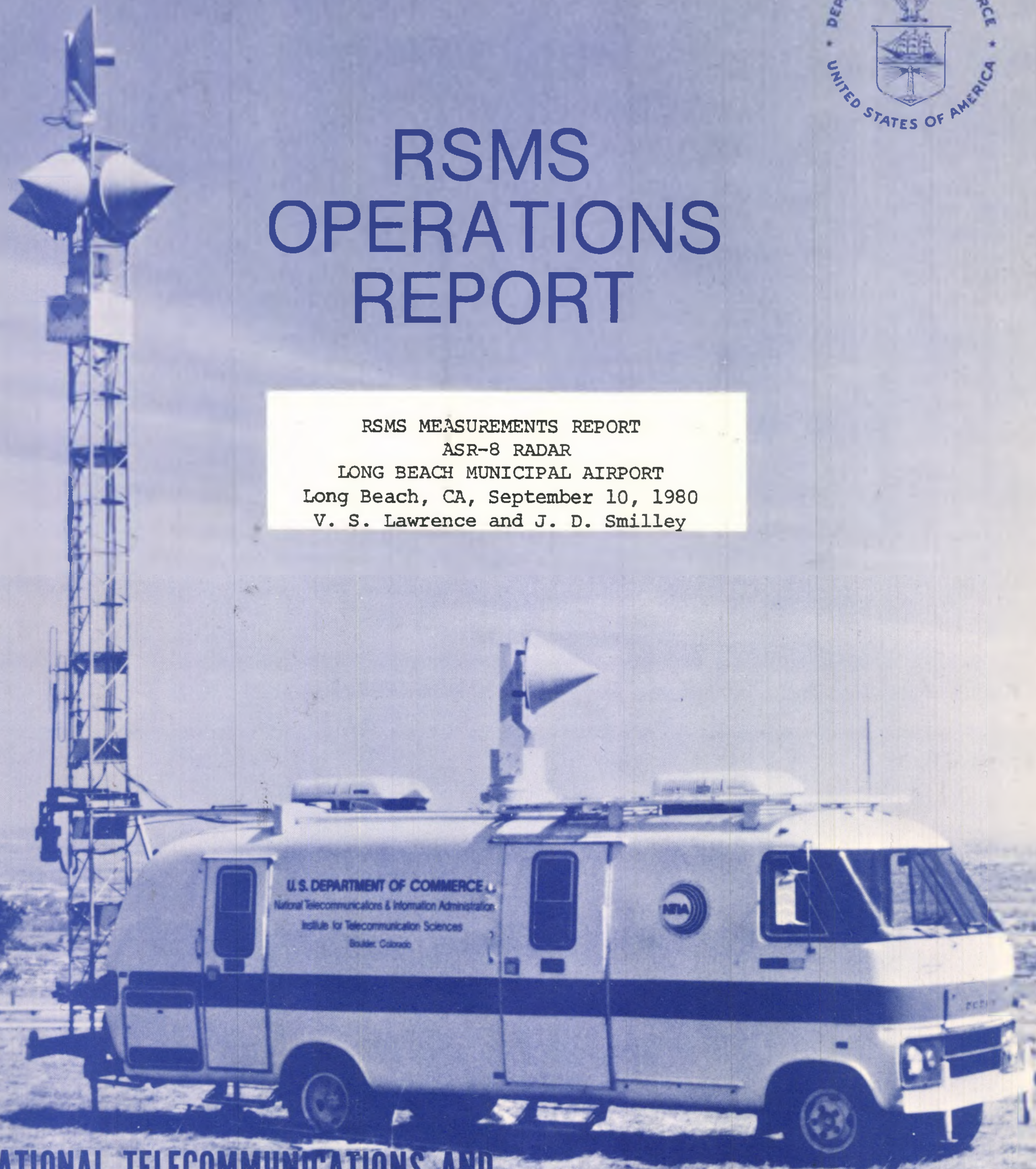
DEPARTMENT OF COMMERCE
UNITED STATES OF AMERICA

RSMS OPERATIONS REPORT

RSMS MEASUREMENTS REPORT
ASR-8 RADAR
LONG BEACH MUNICIPAL AIRPORT
Long Beach, CA, September 10, 1980

V. S. Lawrence and J. D. Smilley



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V. S. Lawrence and J. D. Smilley*

This report contains emission spectra and pulse characteristics of the ASR-8 radar. The measurement data was collected as part of the federal frequency management program of the National Telecommunications and Information Administration (NTIA), and is of special interest to the spectrum resource assessment in the 2700 to 2900 MHz band.

1. THE RADIO SPECTRUM MEASUREMENT SYSTEM (RSMS)

The RSMS is a computerized multi-stage superheterodyne receiver, tunable between 100 kHz and 18 GHz, that is integrated into a motor home-type van for easy transportation and operation at remote sites. The van contains environmental controls and two 6 KVA RFI-shielded motor-generator sets suitable for 36 hours of continuous operation without additional logistic support.

Essentially all functions of the receiving system (Figure 1.1.) are under computer control, and a very flexible digital data processing system is used to process real-time information or to record data for later analysis.

The antenna subsystem contains noise diodes to calibrate the system in absolute amplitude at the antenna terminals. RF relays are used to select the desired antennas. This technique automatically accounts for switching and transmission losses involved in bringing the received signal from the antennas to the signal processing inputs of the receiver.

As required, 0-70 dB input attenuation may be inserted to bring the input signal within the linear measurement range of the receiver. The system software automatically connects the proper preselector/preamplifier, based on the frequency of the signal being measured. Below 500 MHz, fixed-tuned bandpass filters are used to keep out-of-band signals from interfering with measurement of the desired signals. YIG-tuned tracking preselectors and post selectors are

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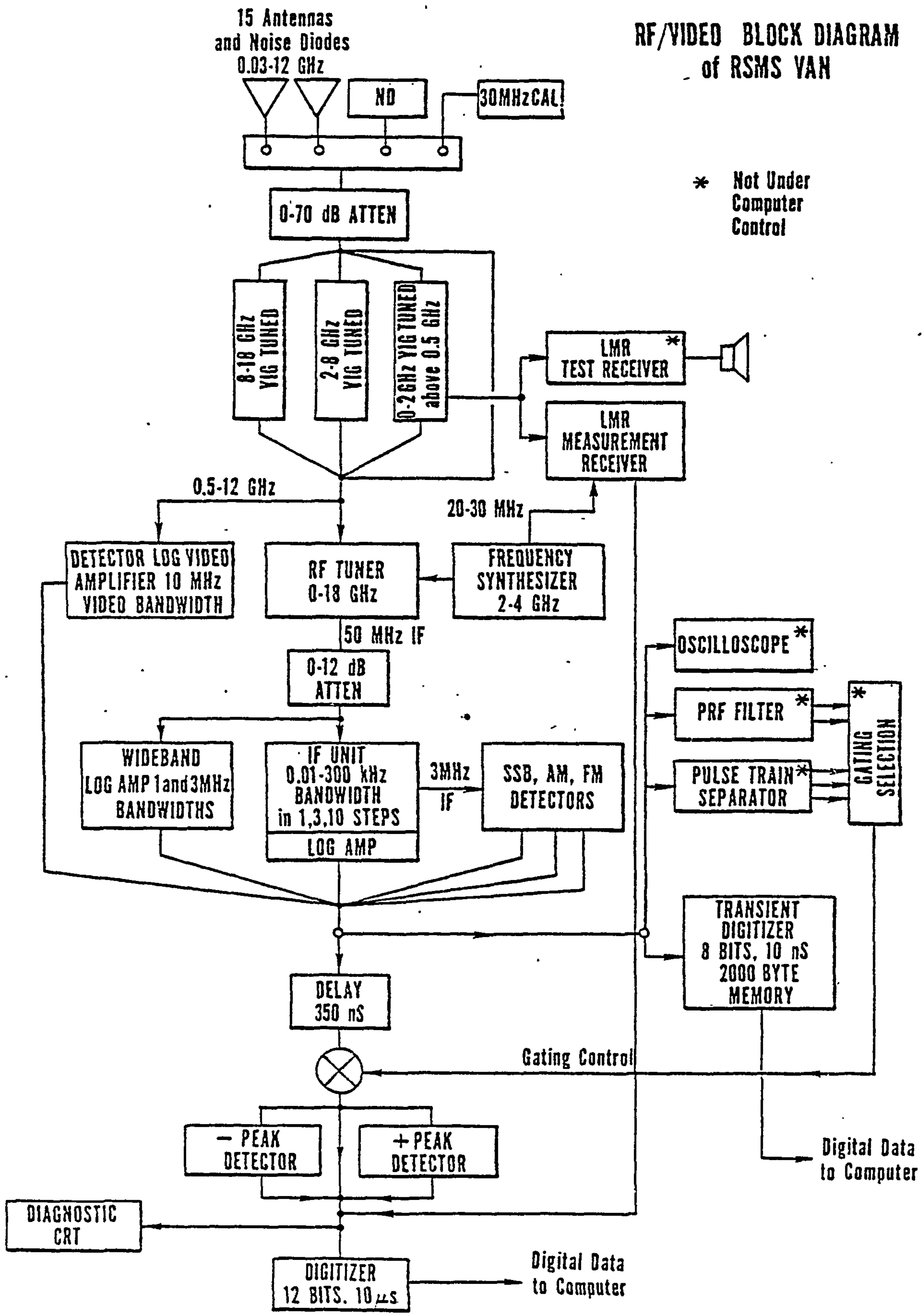


Figure 1.1. RF/video block diagram of RSMS van.

used for received frequencies above 500 MHz. Preamplifiers are used to decrease system noise figure for frequencies below 12 GHz.

The signal is converted to a final IF signal after several mixing stages. All of the local oscillators are derived from a single synthesized reference frequency, so that received signal frequencies can be tuned very accurately. Several IF/detector units are used for various types of measurements. A 3 MHz narrowband IF unit allows a choice of ten bandwidths between 10 Hz and 300 kHz and gain adjustment from 0 to 50 dB in 10 dB steps. A 50 MHz wideband IF unit allows a choice of 1 MHz or 3 MHz bandwidths. Video bandwidths in excess of 10 MHz are available from a detector/log amplifier module driven directly from the preamplifiers. AM, FM, CW, and SSB demodulator circuits are available to monitor the aural content of the signal. Peak and quasi-peak detectors are available to assist in making measurements of radar and broadband impulsive noise signals.

A pulse-blanking system is used to isolate a single radar from a multiradar environment, so that measurements may be made on that radar only. A pulse train separator and a pulse repetition frequency filter provide a means of determining when the desired radar pulses are present. This equipment operates with a high-speed switch to gate only the desired radar pulses into the measurement circuits where a peak detector is used to measure the selected pulse amplitude.

For additional information on the RSMS capabilities, refer to the references at the end of this report.

2. MEASUREMENT TECHNIQUES

2.1. Radar Emission Spectra Measurement Techniques

When making a measurement of the emission spectrum of a particular radar, several techniques are used to assure that only the desired radar is measured. First, the RSMS dish antenna is often used for these measurements. The gain of the dish gives considerable angular discrimination against other radars, in addition to providing extra system gain necessary to measure further down on the skirts of the radar spectrum. The pulse blanker capability may be used to eliminate other radars from the measured emission spectrum. In most cases, the RSMS van is positioned line-of-sight to the radar and measurements are made with sufficient signal strength that other radars in the band are generally not seen by the RSMS.

The radar spectra measurements utilize a program (Wide Band Scan) that allows the specification of many operating parameters, including frequency range, number of frequency steps within the specified range, dwell time on each frequency step, bandwidth, RF attenuation, IF gain, peak hold, and receiving antenna. The program makes a measurement of peak amplitude received at each frequency, starting at the lower end of the frequency range and continuing until the upper end of the frequency range is reached. At each frequency, the system waits for a specified dwell time (typically five seconds) continually measuring the peak amplitude of the signal and updating its measurement when a still stronger pulse occurs. If the dwell time is chosen somewhat longer than the rotation period of the radar antenna, one is assured that the measurement at each frequency will contain the period of time during which the radar antenna's mainlobe was aimed directly at the RSMS van. This situation will give the largest peak power reading, which is the power recorded for that frequency. As the measurements are made, the measured data is graphed. The operator may add or subtract attenuation in 10 dB steps whenever action is required to keep the signal within the linear measurement range of the system. The system software automatically compensates for input attenuation so that the graphed data is continuous and appears to have been measured with a system with very large dynamic range. For many of the measurements made with this program, a 200 MHz frequency range is specified (e.g., 2700-2900 MHz), with 200 steps within this range. This means that a measurement is made every 200/200 = 1.0 MHz, which compares with a measurement bandwidth of 1 MHz.

2.2. Radar Pulse Characteristic Measurement Techniques

To observe and photograph radar pulses that may have risetimes of 10 ns or less, a 150 MHz bandwidth oscilloscope is used. The radar output is coupled through appropriate attenuators to provide approximately 17 dBm to a detector on the scope input. Whenever possible, an attempt is made to clearly show the leading and trailing edges of the radar pulse as well as the complete pulse.

3. RADAR MEASUREMENTS

The ASR-8 uses two klystron amplifiers in a diplex mode, each output providing 1 MW peak power, frequency separated by 70 MHz. In addition to the general measurement techniques described in section two, some special techniques were employed to make measurements before and after the diplexer filter. The RSMS Van was moved to the radar transmitter site and directly coupled to the radar as illustrated in Figure 3.1. Low loss flexible heliax cable was used for the connections and was moved between the waveguide coupled outputs located before and after the diplexer filter. These outputs had a coupling factor of approximately 55 dB and reduced the 90 dBm peak power output of the radar to approximately 35 dBm peak power. Additionally a notch filter, was used to decrease the dynamic range of the radar signal at the center frequency. Although not normally used, this filter was added because the rapid fall off of the ASR-8 spectrum permitted center frequency energy to be present within the measurement system preselector bandwidth, effectively desensitizing the system, for measurements made within a few MHz of the center frequency. The insertion loss of the filter is compensated by the automatic system calibration routine to give a correct center frequency power measurement for the radar spectra. Figure 3.2. illustrates the insertion characteristics of the filter when it was tuned to the 2845 MHz operating frequency of the radar.

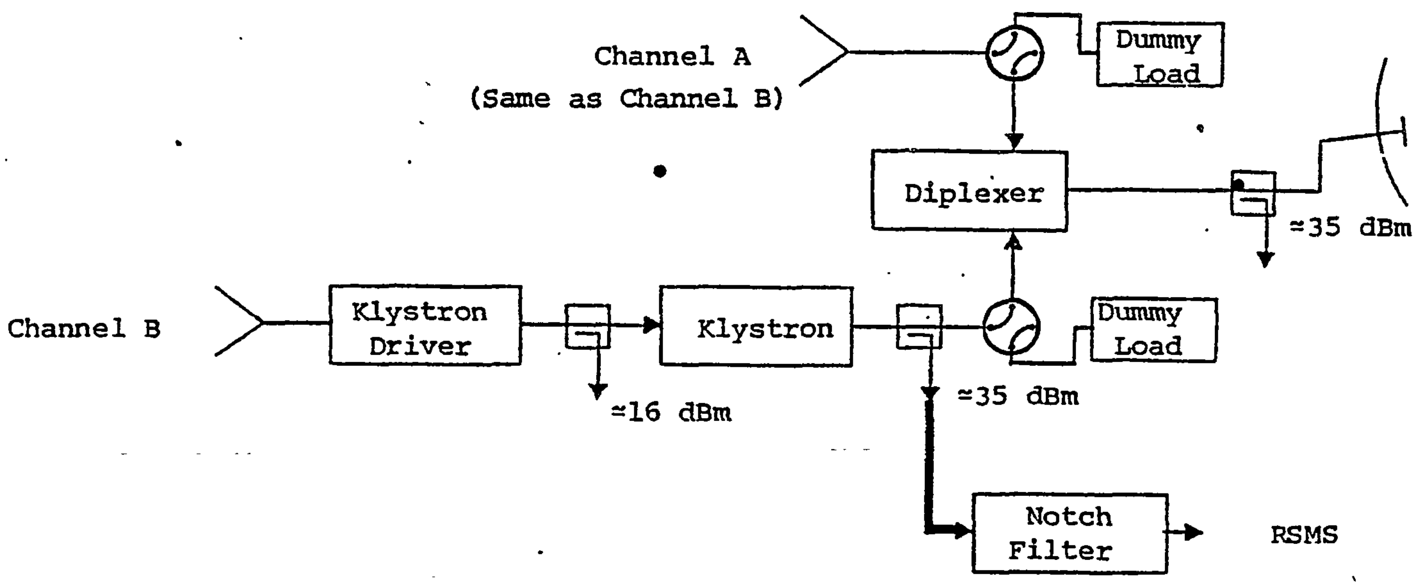


Figure 3.1. Partial block diagram of ASR-8 showing couplers and connection to RSMS.

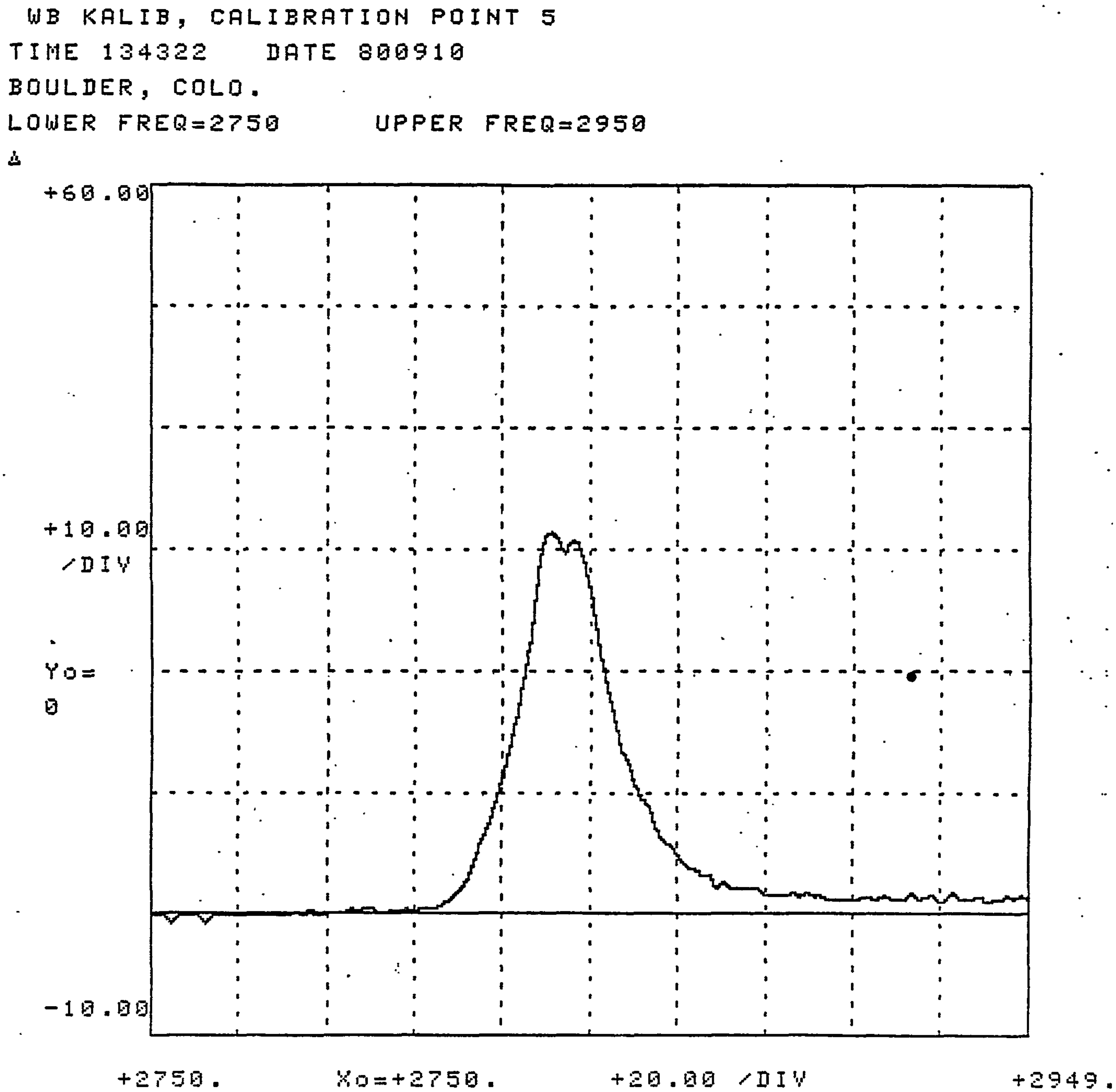


Figure 3.2. Calibration characteristics of notch filter when tuned to 2845 MHz.

3.1. Emission Spectra Measurements

Two locations were used for the emission spectra measurements. First, the far field measurements (Figure 3.3d. and 3.4d.) were made with the RSMS van positioned about one kilometer from the radar. The measurement techniques described in section two were used except that 250 measurement "steps" were selected and the notch filter was added to the measurement system input. When the far field measurements were completed, the RSMS van was relocated at the radar site for the before diplex (Figure 3.3a. and 3.4a.) and after diplex (Figure 3.3c. and 3.4c.) measurements as previously described (Figure 3.1.). The responses at 30 MHz and 60 MHz, before and after the fundamental frequency, (Figure 3.3b. and 3.4b.) are caused by the synchronizing coherent oscillator (COHO).

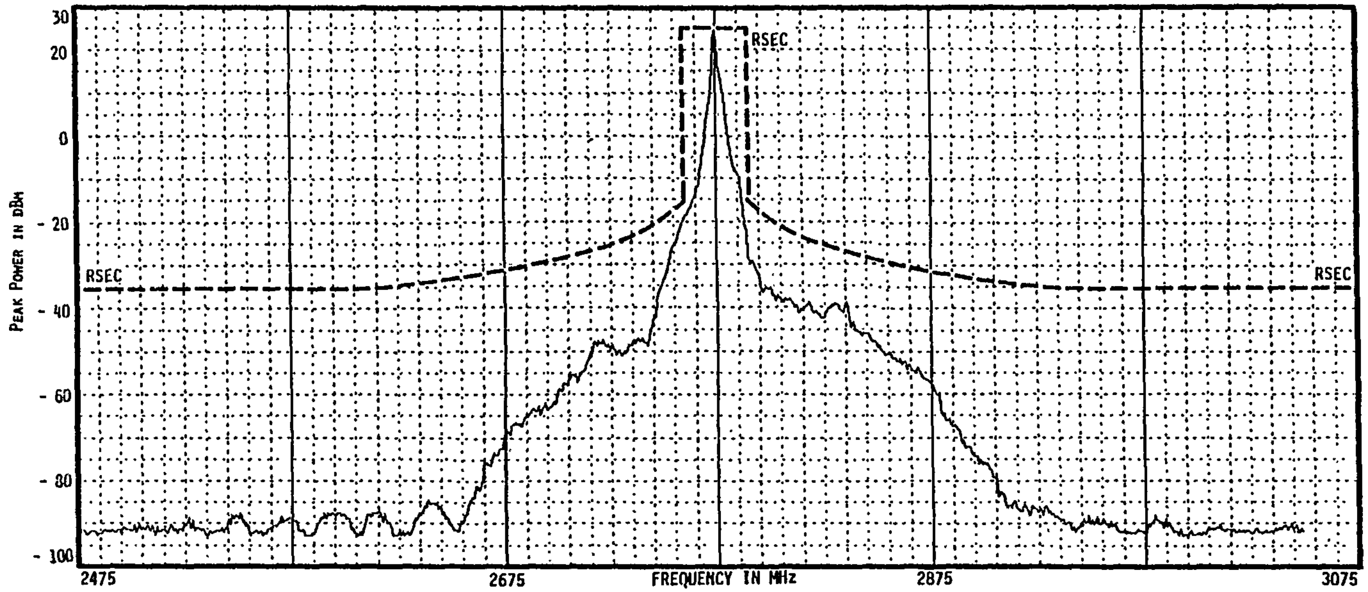
The dashed lines on the spectra figures represent the Radar Spectrum Engineering Criteria (RSEC), as defined in the Manual of Regulations and Procedures for Federal Radio Frequency Management, Chapter five. These criteria have been established to ensure an acceptable degree of electromagnetic compatibility among radar systems. As indicated by the figures, the ASR-8 with its klystron amplifiers, drive pulse shaping, and diplex filter, represents excellent emission spectrum characteristics, considerably better than that required in the RSEC. Table 3.1. lists the ASR-8 parameters used for the RSEC computations. The pulse width and pulse risetime for the Long Beach ASR-8 were measured, however, the nominal ASR-8 values were used for the RSEC computation so that future ASR-8 measurements could be more readily compared.

Table 3.1. ASR-8 Parameters

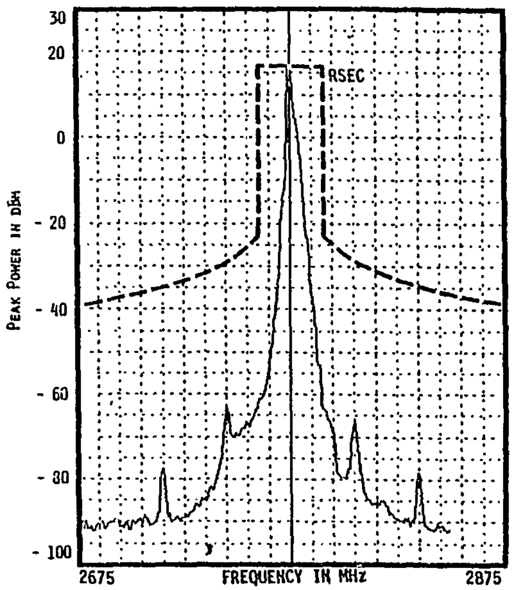
Parameter	Channel A	Channel B
Center Frequency (MHz)	2845	2775
Pulse Repetition Rate (PPS)	1000*	1000*
Peak Power (dBm)	90	90
Pulse Width (μs)	.6 (.62)**	.6 (.66)**
Pulse Rise Time (ns)	100 (90)**	100 (100)**
Measurement Bandwidth (kHz)	1000	1000

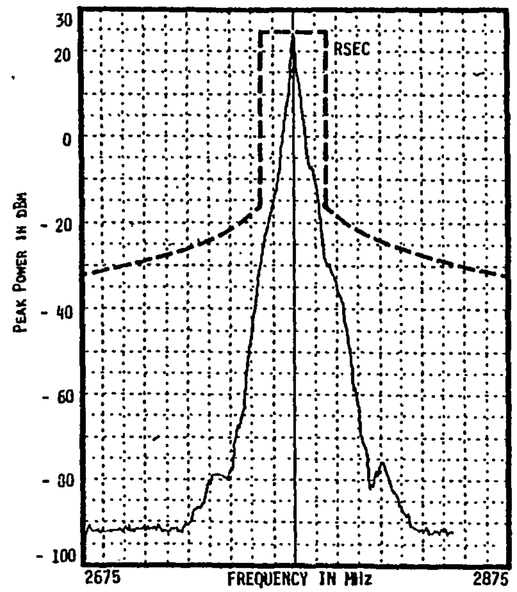
*ASR-8 uses 4X stagger, RSEC computed from average value.

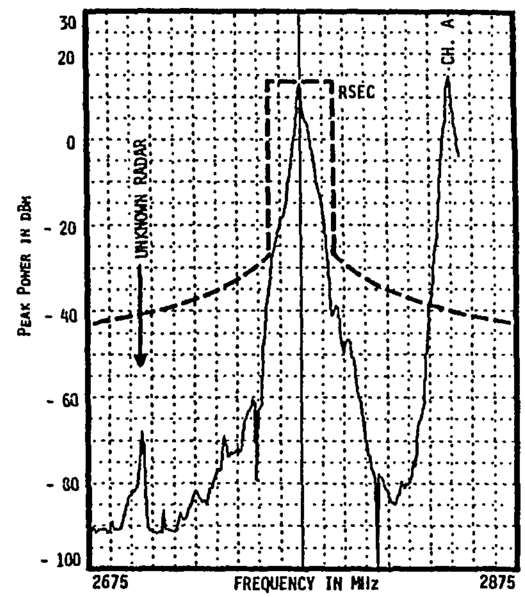
**Measured values in parenthesis. RSEC computed from nominal values.



a. Before diplexer (Direct Coupled)





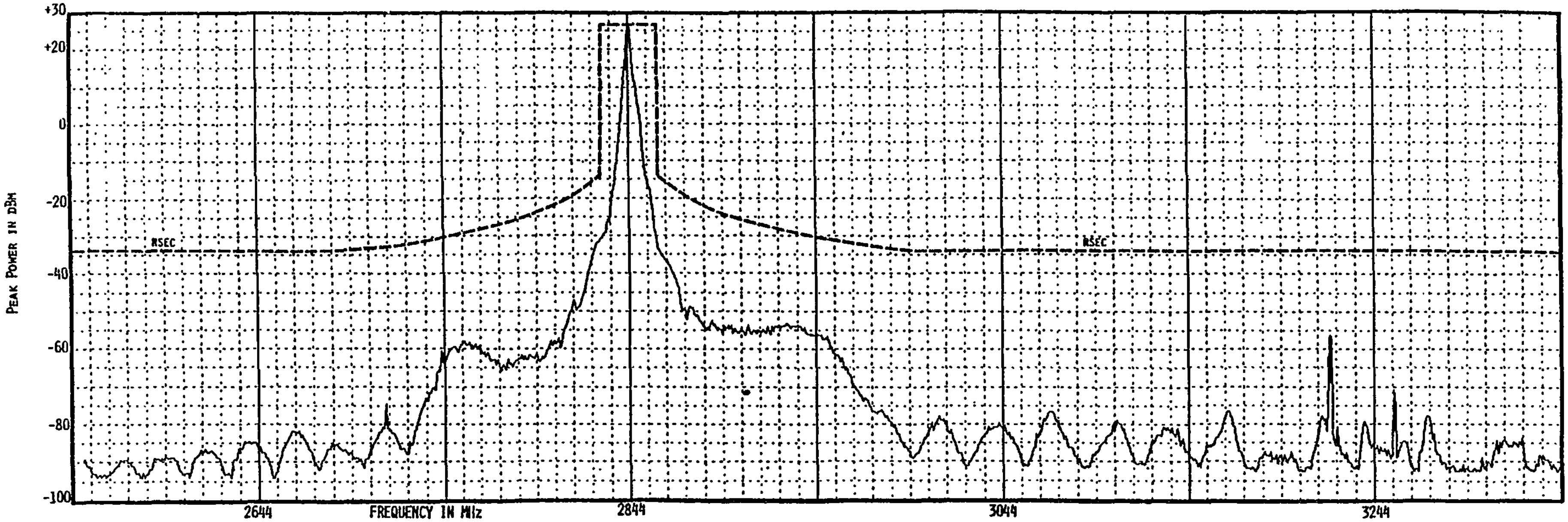


b. Klystron Input

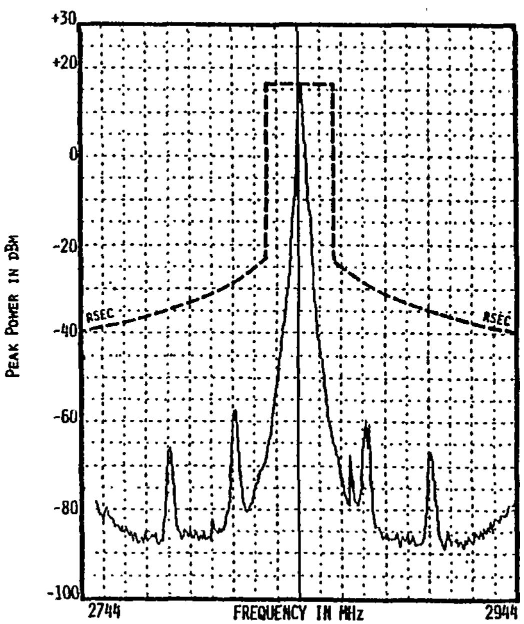
c. After diplexer (Direct Coupled)

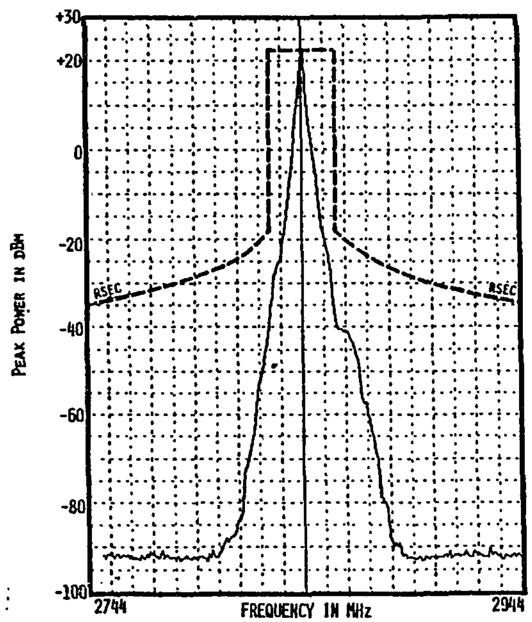
d. Far field (approx 1 kilometer)

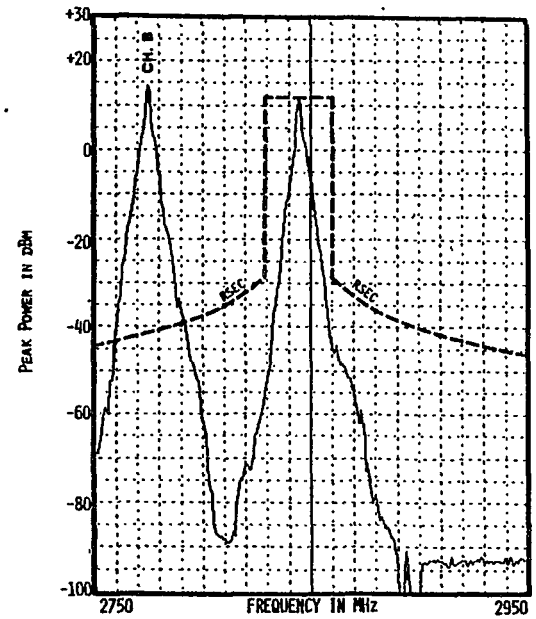
Figure 3.3. ASR-8 (Channel A) Radar Emission Spectra



a. Before diplexer (Direct Coupled)







b. Klystron Input

c. After Diplexer (Direct Coupled)

d. Far Field (approx. 1 kilometer)

Figure 3.4. ASR-8 (Channel B) Radar Emission Spectra

3.2. Pulse Shape Characteristics

The pulse shape photographs (Figure 3.6.) were made by coupling from the radar as illustrated in the block diagram (Figure 3.5.). The coupling port located after the diplexer is used for the illustration, and the measurement time base (ns/div) is displayed on the face of each photograph (Figure 3.6.). The coupled signal was detected with an AEL broadband detector utilizing internal limiters to protect against detector burnout. A 6 dB attenuator on the detector output was used to preserve the detector rise and fall times in the 50 Ω transmission line to the oscilloscope. A Tektronix R7623A oscilloscope, with a 7A26 amplifier and a 7853A time base, was used with an attached C-53 Tektronix scope camera to record the oscilloscope trace.

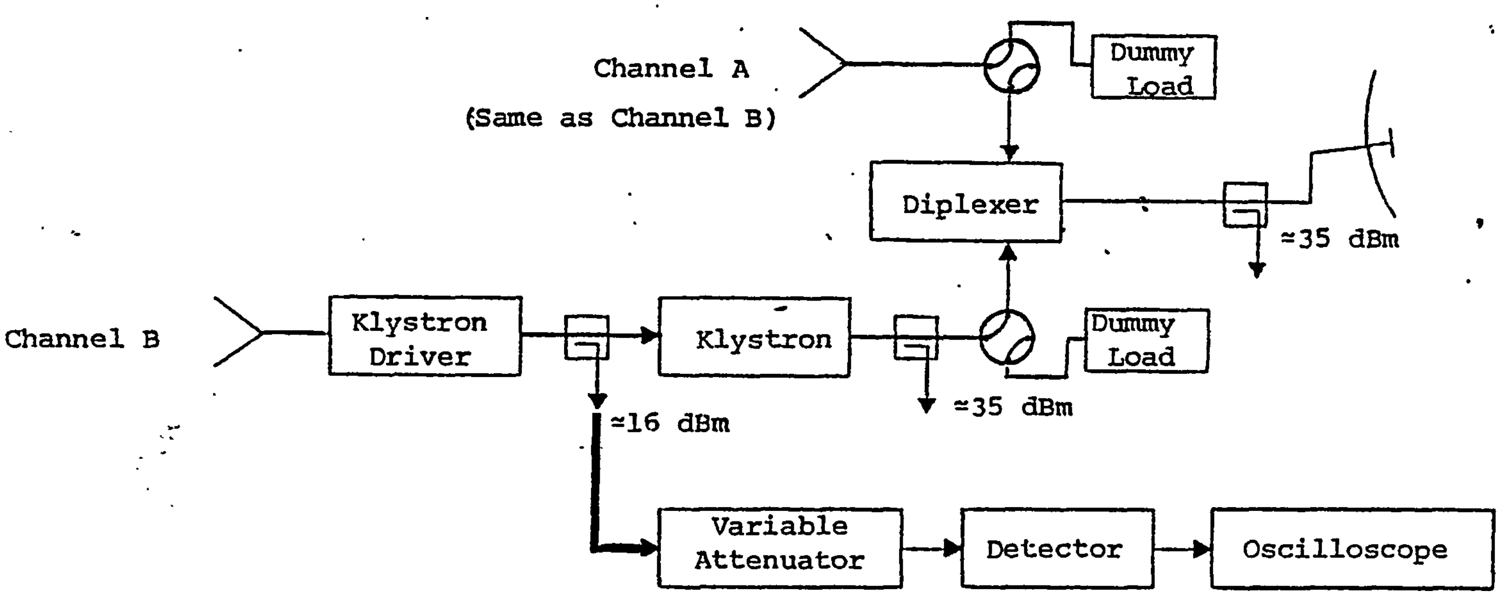
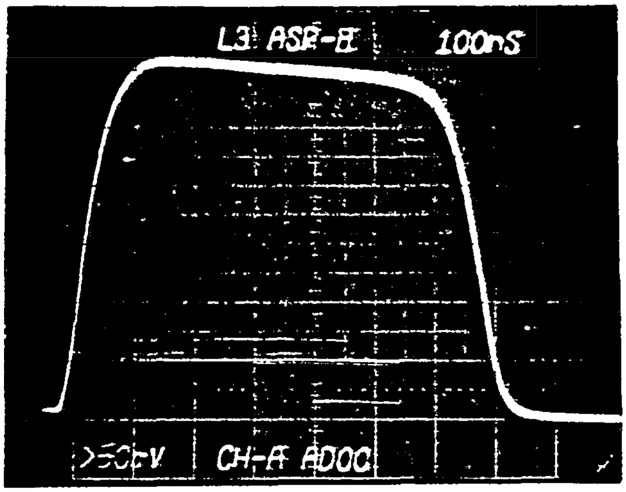
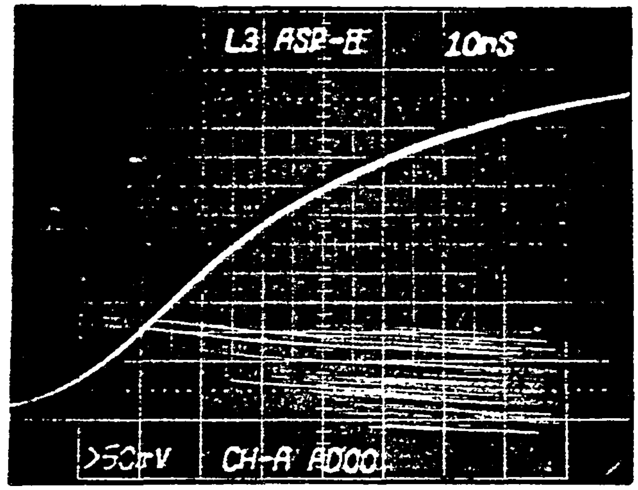


Figure 3.5. ASR-8 partial block diagram showing couplers and connection for pulse shape measurements.

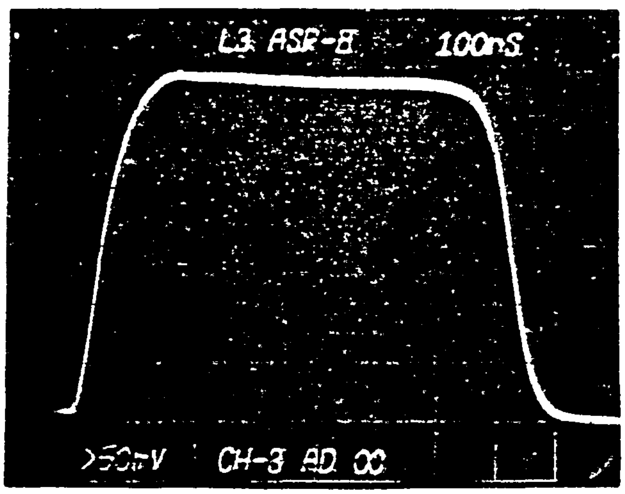


Full Pulse

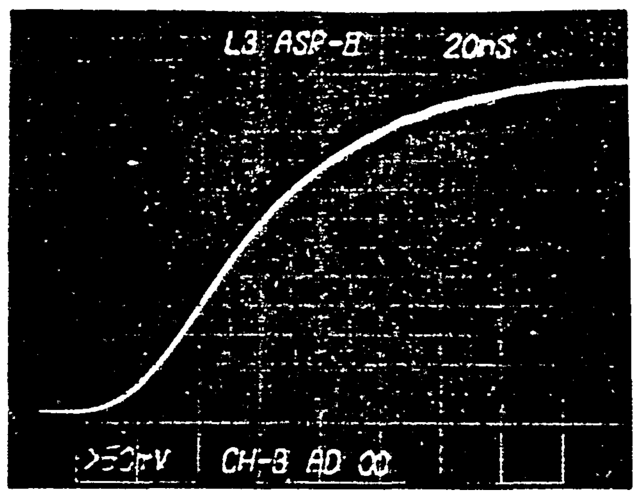


Extended to Show Risetime

a. Channel A (After Diplexer)



Full Pulse



Extended to Show Risetime

b. Channel B (After Diplexer)

Figure 3.6. ASR-8 Radar Pulse Shape

4. REFERENCES

Manual of Regulations and Procedures for Federal Radio Frequency Management, January, 1980 (revised edition), Chapter 5.

Matheson, R. J. (1980), The office of telecommunications radio spectrum measurement system, IEEE 1976 International Symposium on Electromagnetic Compatibility, July 13-15, pp. 1-5.

Radio Spectrum Measurement System (RSMS) Operations Manual, April 1977 (revised edition), Office of Telecommunications, Boulder, CO.

For additional information:

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