NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA ELECTRONICS MEMORANDUM NO. 4

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A TEST SET FOR VLA CORRELATOR DESIGN STUDIES

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1. Introduction

To facilitate design studies a test set was built to simulate the IF signals from two radio telescopes of an interferometer. The amount of correlation between the signals may be adjusted to simulate the presence of a radio source of arbitrary magnitude. A block diagram of the test set is shown in Figure 1 below. Here N_A and N_B represent the random noise associated with the noise temperature of the antenna and the receiver front end while S represents the source. Details of the test set circuitry are shown in Figures 2 through 5.

2. Characteristics

2.1 Output Signals: The output consists of white noise with rectangular power spectra between 2 and 50 MHz and a frequency response of about ± 4 dB. Maximum output of any noise source is greater than 0 dBm into a 50 Ω load.

2.2 Output Monitors: Each monitor consists of a 100-0-100 μA null meter which indicates a null with an output of 0 dBm into 50 ohms; ± 75 μA corresponds to about ± 1 dBm. Calibration potentiometers are located at the rear of the chassis.

2.3 Isolation Between Uncorrelated Noise Sources, N_A and N_B: The fraction of N_A leaking into N_B or vice-versa is better than 60 dB down.

CORRELATOR T[illegible]T SET BLOCK DIA[illegible]AM

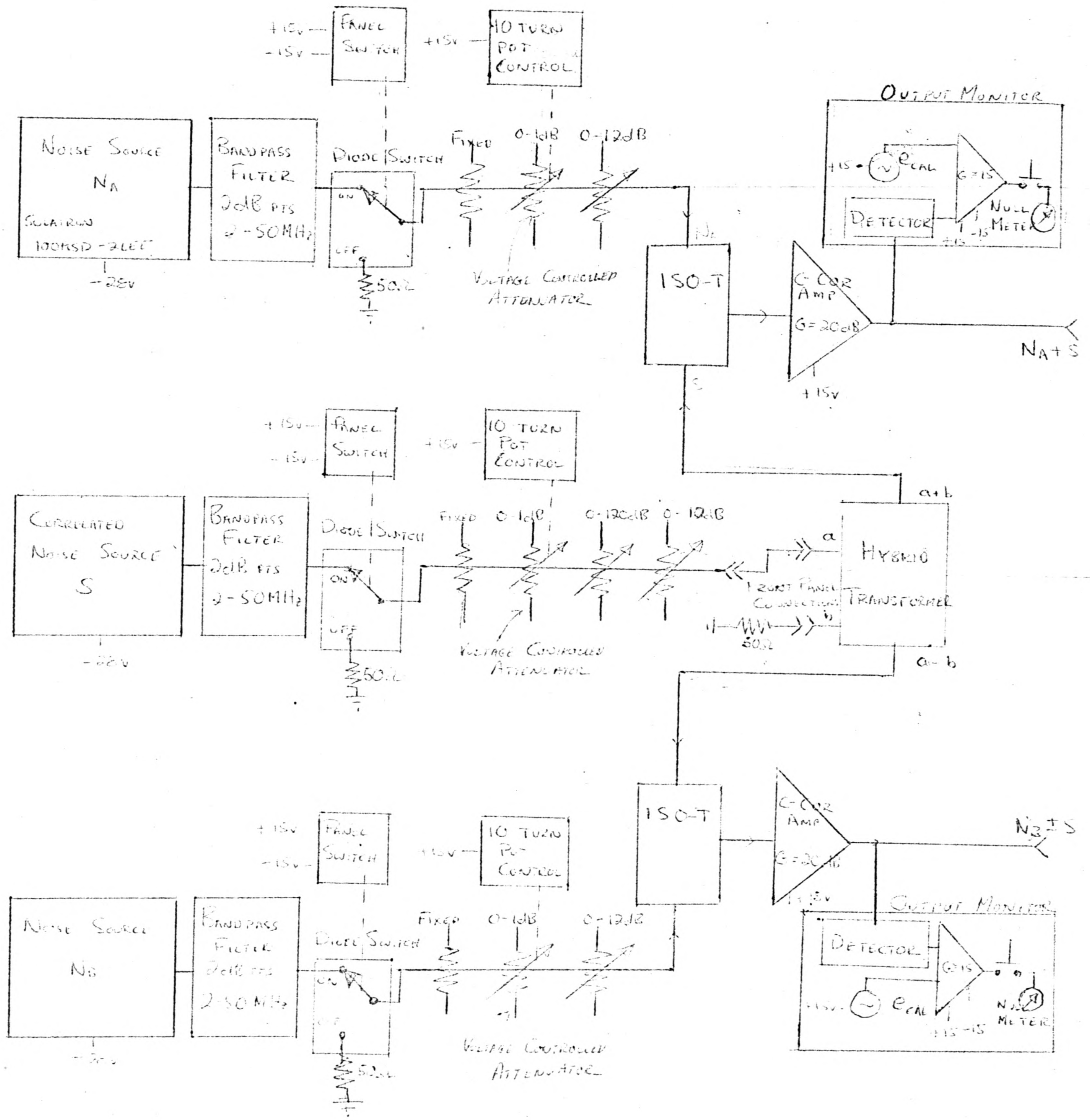


Fig 1.

Bandpass Filter Design

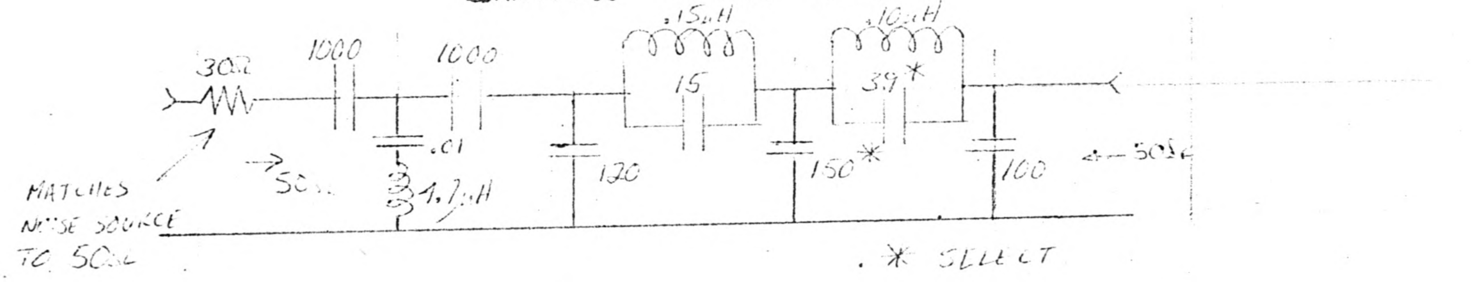


Fig 2

See Fig 2.A for response curve on p. 4

Diode Switch Circuitry

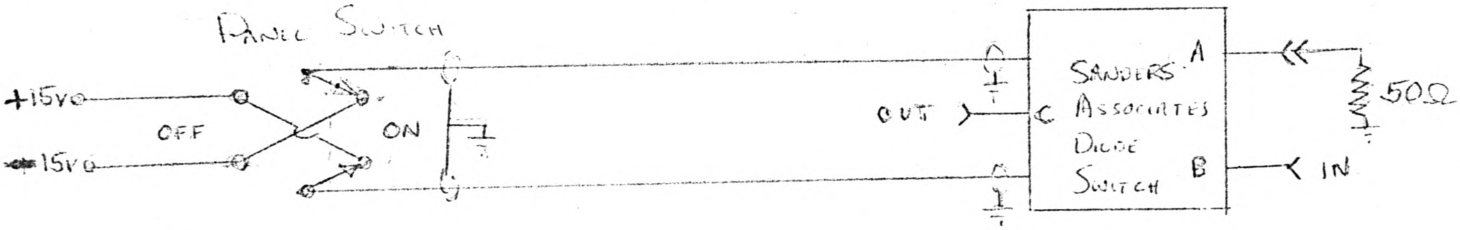
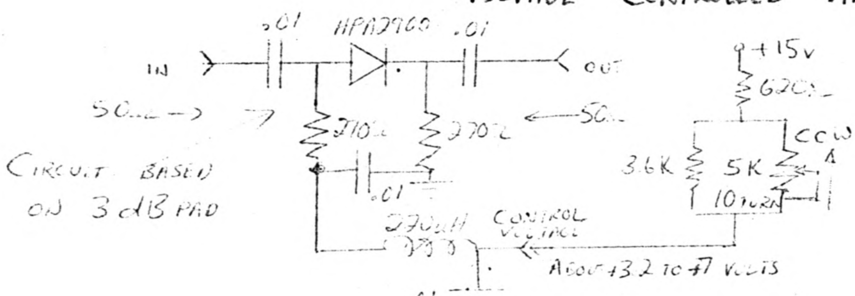


Fig. 3.

Voltage Controlled Attenuator



Range: 2.5 to 3.5 dB
Ripple: ±0.5 dB, 2 to 30 MHz
Control Linearity: ± 10%
VSWR: < 1.2

Fig. 4.

Output Monitor Circuit

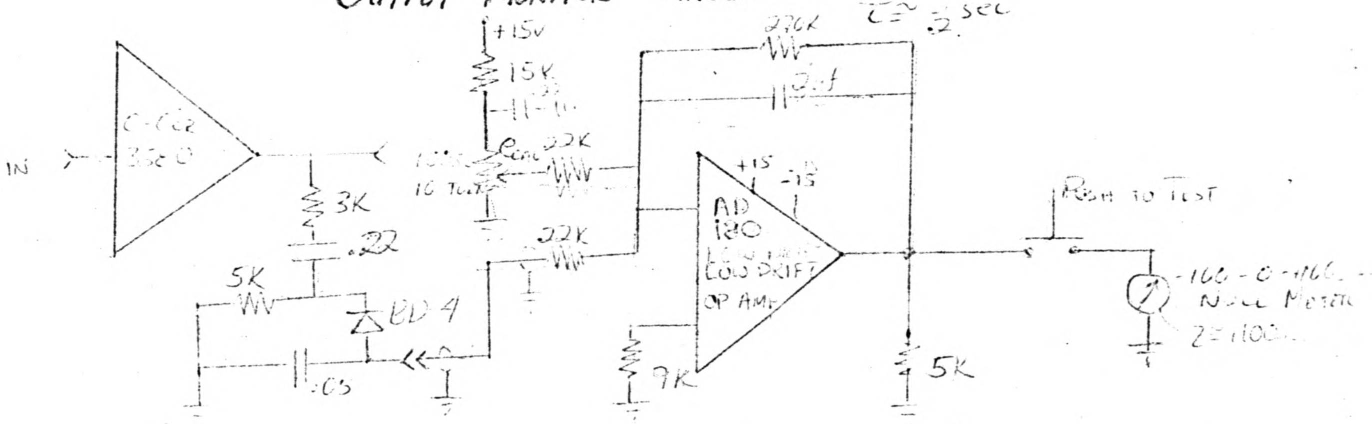
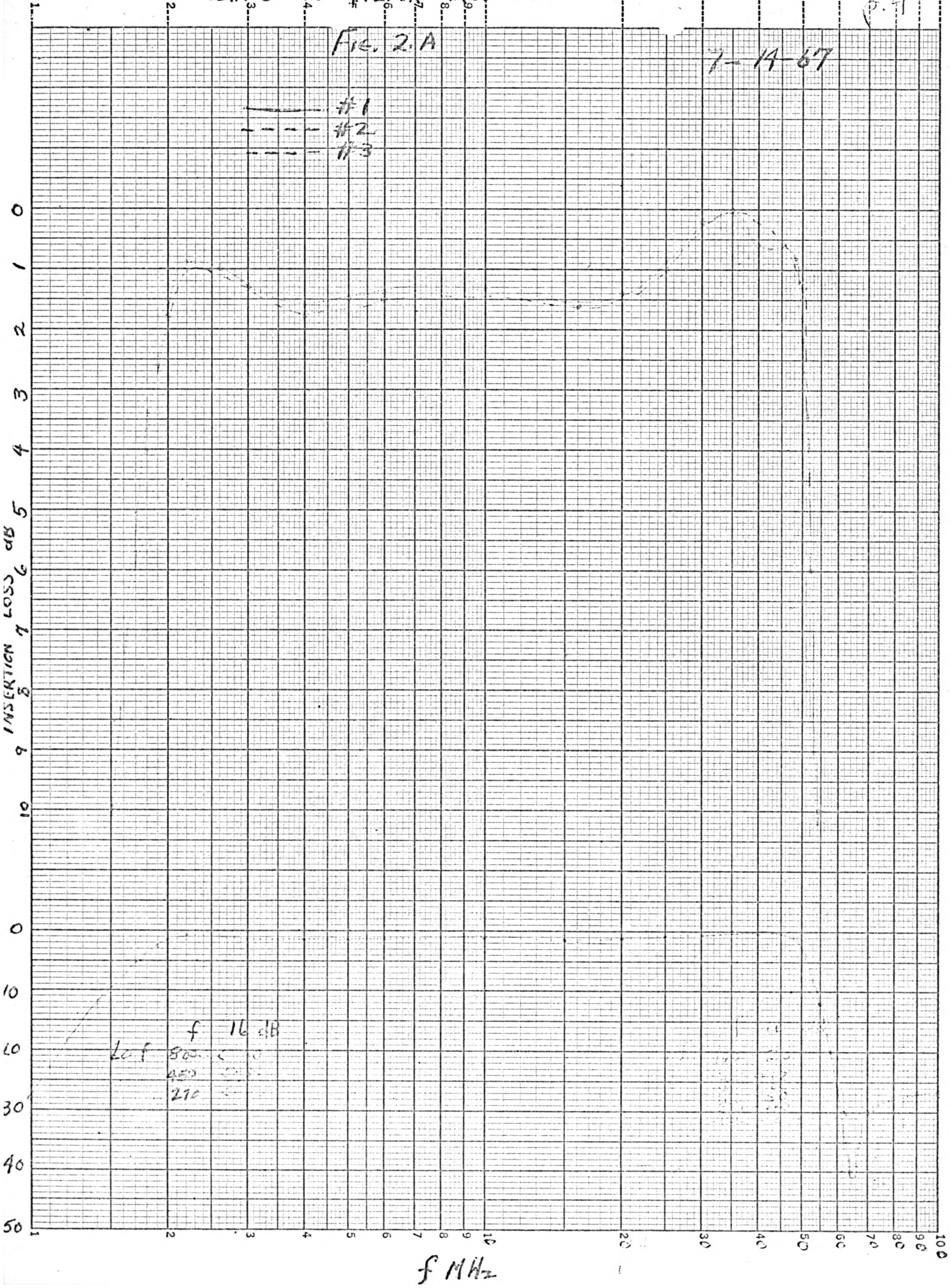


Fig 5.

BAND PASS FILTER RESPONSE



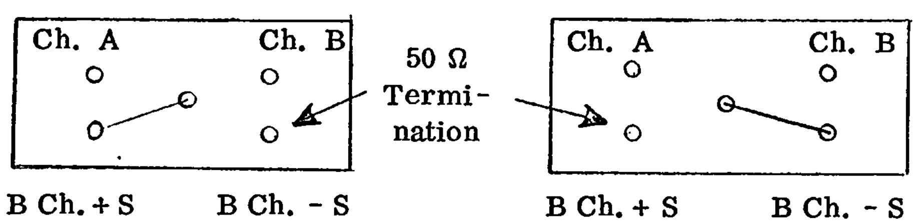
K+E SEMI-LOGARITHMIC 358-64
KEUFFEL & ESSER CO. MADE IN U.S.A.
2 CYCLES X 200 DIVISIONS

2. (continued):

2.4 Attenuation Controls: Output of uncorrelated noise sources N_A or N_B is continuously adjustable from greater than zero to -12 dBm. The amount of power from the correlated noise source S is continuously adjustable from greater than zero to -130 dBm. Each source may be turned off (effective attenuation of 80 dB) by a switch on the front panel.

2.5 Correlation of Output Signals: The level of the correlated component of the output in either channel is the same ± 0.05 dB. The correlated component in channel B may either be in phase or 180 degrees out of phase with the component in channel A depending on the connections on the front panel. See Figure 6.

Correlator Test Set



Correlator component in Channel B in phase with component A.

Correlator component in Channel B 180 out of phase with component A.

Figure 6

2.6 Regulated Power Supplies: Regulated voltages of +15, -15, and -28 V DC are available at the front panel to supply power for correlator circuitry.

2.7 Warm-up Time: Warm-up time for the diode noise sources is a few hours. During this period the output of a noise source drops about 1 dB. Further drift is on the order of ± 0.1 dB/24 hours.

3. Operating Instructions

3.1 Measurement of Correlator Accuracy: The output of an ideal correlator should be proportional to the average product of the input signals. Since the correlated component S is nearly the same in both channels, the DC voltage at the output of the correlator e_o should be proportional to the amount of correlated power P_{corr} in either channel; i.e., a plot of e_o vs. P_{corr} should be a straight line. Since most radio sources have a noise temperature less than the system temperature it is desirable the output be most linear up to $P_{corr} = -3$ dBm for 0 dBm total output.

a. With all noise sources off, adjust the trimming pot in the op amp in the correlator for $e_o = 0$ V; this cancels the offset in the op amp.

b. With the correlator noise source S off and both N_A and N_B on, adjust the attenuation controls until the output power into each port of the correlator is 0 dBm as indicated by a null reading on the output monitor. Then balance the correlator (if possible) or record the offset.

c. Turn N_A and N_B off and turn S on. Adjust the S attenuation controls until the output of both channels is 0 dBm. (Since the levels of the correlated components are different in different channels, it may be necessary to have the output in channel A slightly above 0 dBm and the output in channel B slightly below 0 dBm.) This step calibrates the level of P_{corr}. Do not adjust the fine attenuation control after this step. Now increase the coarse attenuation controls of S to about -40 dBm and turn N_A and N_B on.

3.1 (continued):

d. The attenuation of S should now correspond to the amount of correlated power into each port of the correlator. It is usually convenient to take measurements every 3 dB from about -30 dBm to 0 dBm. When the output is nonlinear, it may be desirable to take measurements every 1 dB. Note that when P_{corr} is greater than -20 dBm it may be necessary to readjust the attenuation controls of the uncorrelated noise sources so the total power out is 0 dBm at all times. (This is equivalent to the ALC function.)

3.2 Uncorrelated Power Sensitivity: A true correlator should not be sensitive to changes in the uncorrelated component of the input to the correlator. Since the nonlinear elements used in correlators are neither perfect square law devices nor precisely matched, all practical correlators are somewhat sensitive to uncorrelated power. Although the sensitivity may be measured with any level of correlated power, it is usually convenient to use either uncorrelated or half correlated power (P_{corr} = -3 dBm).

Note: It is possible to use sinusoids to test correlator response. Simply connect the generator to the A port of the appropriate diode switch in Figure 1 and Figure 3.

4. Suggested Modifications

4.1 Incorporation of an ALC Loop: It should be relatively easy to modify the instrument so the ALC function described in 3.1.d is performed automatically as null type monitor circuits and voltage controlled attenuators are already contained in the test set.

4. (continued):

4.2 Unequal Correlated Power Levels: By placing attenuators between the hybrid and iso-T in Figure 1 it is possible to test correlator response to correlated signals with unequal levels. This modification is strongly suggested.

4.3 Delay Line Tests: It is possible to test delay lines with no modification to the instrument. The delay may simply be placed between the output of the correlator test set and the correlator.

5. Calibration

The instrument should be calibrated with a good RMS sensing voltmeter or power meter with flat response from 2 to 50 MHz. A suggested method is the following: Turn the correlated noise source S off. Then adjust the attenuation controls of N_A and N_B so that each channel has an output of 0 dBm as measured on the voltmeter or power meter. Then with accurate 50 ohm terminations at the test set outputs adjust the calibration potentiometers at the rear of chassis for a null reading on the monitor meters. This completes the calibration procedure.