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SIMPLIFIED PROCEDURE FOR OBSERVATION OF BANDPASS OF S-BAND KLYSTRON POWER AMPLIFIER

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GODDARD SPACE FLIGHT CENTER
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ABSTRACT

In order to inspect the bandpass of the S-Band Klystron Power Amplifier with present techniques, it is necessary to carry an oscilloscope, a sweep generator, a TWT amplifier, a frequency meter, and auxiliary equipment to the site of the Klystron. This paper discusses an alternative technique which simply utilizes the frequency synthesizer, already built into the exciter circuit, and a simple transistor sweep circuit. Included in this report are the schematic diagram of the sweep circuit, a detailed schematic diagram of how this technique can permanently be built into the exciter circuit, the result of experimentation already performed at the Goddard Apollo Station and the estimated cost of the project.

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INTRODUCTION

At the Apollo tracking stations, it is periodically necessary to inspect the bandpass of the S-Band Klystron Power Amplifier. Present techniques require carrying an oscilloscope, a sweep generator, a TWT amplifier, a frequency meter, and auxiliary equipment to the site of the Klystron and this is exceedingly difficult especially in the 85 foot dish stations where the Klystron is located in the wheelhouse. This paper discusses an alternative technique which simply utilizes the frequency synthesizer, already built into the exciter circuit, and a simple transistor sweep circuit. With this technique, a sweep width of 30 MHz is obtained and the center frequency may be varied continuously from 2090 to 2120 MHz. This sweep width and range of center frequencies is ideal for inspecting the bandpass of the Klystron. Because the frequency sweep is linear, every cm on the oscilloscope display represents a specific number of MHz and therefore the frequency to which the Klystron is tuned can be read directly off of the oscilloscope display eliminating the requirement for a frequency meter.

Note that the procedure outlined in this paper is set up for a center frequency of 2105 MHz with a sweep in frequency from 2090 to 2120 MHz. As pointed out above, a center frequency continuously variable from 2090 to 2120 MHz can be obtained.

INSTRUMENTATION

A block diagram of the Unified S-Band exciter is shown in Figure 1. The modifications to the exciter circuit which will produce the desired frequency are indicated by dashed lines. The conversion can be made quite simply. First, drive the remote search control of the frequency synthesizer with a sawtooth waveform so that the synthesizer will produce a linear sweep in frequency from 21.77 MHz to 22.08 MHz at approximately a 150 Hz rate. Secondly, bypass the VCO and connect the synthesizer directly to the X96 multiplication chain so that a linear sweep in frequency from 2090 MHz to 2120 MHz is produced at the exciter output. This can be accomplished by running a cable from the back of the synthesizer to the X3 frequency mult. and distribution amp, location 5U4A104, J1. Finally, connect a crystal detector at the output of the power amplifier directional coupler and extend a cable from the detector directly to the vertical plates of the oscilloscope in the control room. Since there is approximately

90 db loss in the line from the power amplifier to the control room, it is necessary to place the detector in the line immediately after the power amplifier. With these slight modifications to the exciter circuit, the bandpass of the power amplifier can be observed on the oscilloscope display in the control room. Also, because these modifications are of such a minor nature, they can be permanently built into the exciter circuit and by merely pressing a button on the panel in the control room, the sweep circuit can be activated and the bandpass immediately observed.

DERIVED CHARACTERISTICS OF SAWTOOTH WAVEFORM

The synthesizer is to produce a signal swept in frequency from 21.77 MHz to 22.08 MHz. Since the synthesizer can only sweep a 1 MHz range, one would expect to encounter difficulty in going from 21.77 MHz to 22.08 MHz in one continuous sweep. However, there is no drastic departure from linearity when the search mode is overdriven. A plot of voltage vs. frequency in the overdriven mode is given in Figure 10. In the search mode, the synthesizer can sweep over a 1 MHz range by varying the external search control voltage between -1 and -11 volts. In order to search from 21.77 MHz to 22.08 MHz, the sawtooth waveform must vary between -8.7 volts and -11.83 volts.

SAWTOOTH CIRCUIT

A circuit which will generate such a sawtooth waveform is indicated in Figure 2. The sawtooth waveform is obtained across the capacitor. The values of R_1, R_2, C, and V are such that there is a 3.13 volt peak to peak sawtooth at 150 Hz across the capacitor. The purpose of the bias battery V_B is to supply the negative voltage necessary to limit the sawtooth from -8.7 volts to -11.83 volts. The bias battery therefore controls the center frequency of the sweep. Table 1 gives the values of V_B which are necessary to obtain other center frequencies.

RESULTS OF EXPERIMENT

This technique was demonstrated at the Apollo Tracking Station located at Goddard Space Flight Center, Greenbelt, Maryland. Figures 4 through 8 are pictures of the bandpass observed during the experiment. Figure 4 is a photograph of the exciter response. The horizontal sweep is 30 MHz wide and the center frequency is 2105 MHz. Figures 5 through 8 are photographs of the bandpass of the exciter and Klystron circuit at 20 kw, 10 kw, 5 kw, and 1.25 kw respectively.

A linearity calibration was also made. The sweep width was 30 MHz wide and the display on the scope was 10 cm wide. Therefore, every cm on the scope corresponded to 3 MHz. A frequency meter was used to superimpose a marker on the display. The marker was placed at the center frequency and then centered on the oscilloscope face. It was then moved to the left and to the right of the center frequency in one cm steps and the corresponding frequency was recorded at each interval. The results of this linearity test, which are plotted in Figure 9, show satisfactory operation.

CONCLUSION

The experimentation performed at GSFC demonstrates that this technique is feasible. The entire circuit can be built into the exciter system very simply and a job which now requires several man hours to perform can be accomplished by merely pressing a button on the control panel of the exciter circuit.

The sawtooth circuit can be built into a blank panel in the vicinity of the exciter synthesizer. The layout of the system is indicated in Figure 3. One output from the sawtooth will go to the remote search input of the synthesizer and a second output will go to the horizontal plates of the oscilloscope. The output of the synthesizer can be connected to a coaxial switch which will select either the VCO or the X96 multiplier chain. Also a crystal detector must be connected to the directional coupler output of the Klystron power amplifier and a cable must be installed from the detector to the oscilloscope in the control room. A single push button could be installed in the exciter control panel which would control the entire tuning verification process. The cost of the modifications is only about $500.

ACKNOWLEDGEMENTS

The authors would like to acknowledge both the encouragement and assistance in scheduling these tests given by Mr. James P. Shaughnessy of the Manned Flight Planning and Analysis Division. Also the very able assistance in performing the tests given by Mr. Charles Renn, Jr., of the NTTF M&O staff, was greatly appreciated.

Table 1

Center Frequency Derived	V_B
2090 MHz	-8.70 V
2093 MHz	-9.01 V
2096 MHz	-9.32 V
2099 MHz	-9.63 V
2102 MHz	-9.95 V
2105 MHz	-10.26 V
2108 MHz	-10.57 V
2111 MHz	-10.88 V
2114 MHz	-11.22 V
2117 MHz	-11.51 V
2120 MHz	-11.82 V

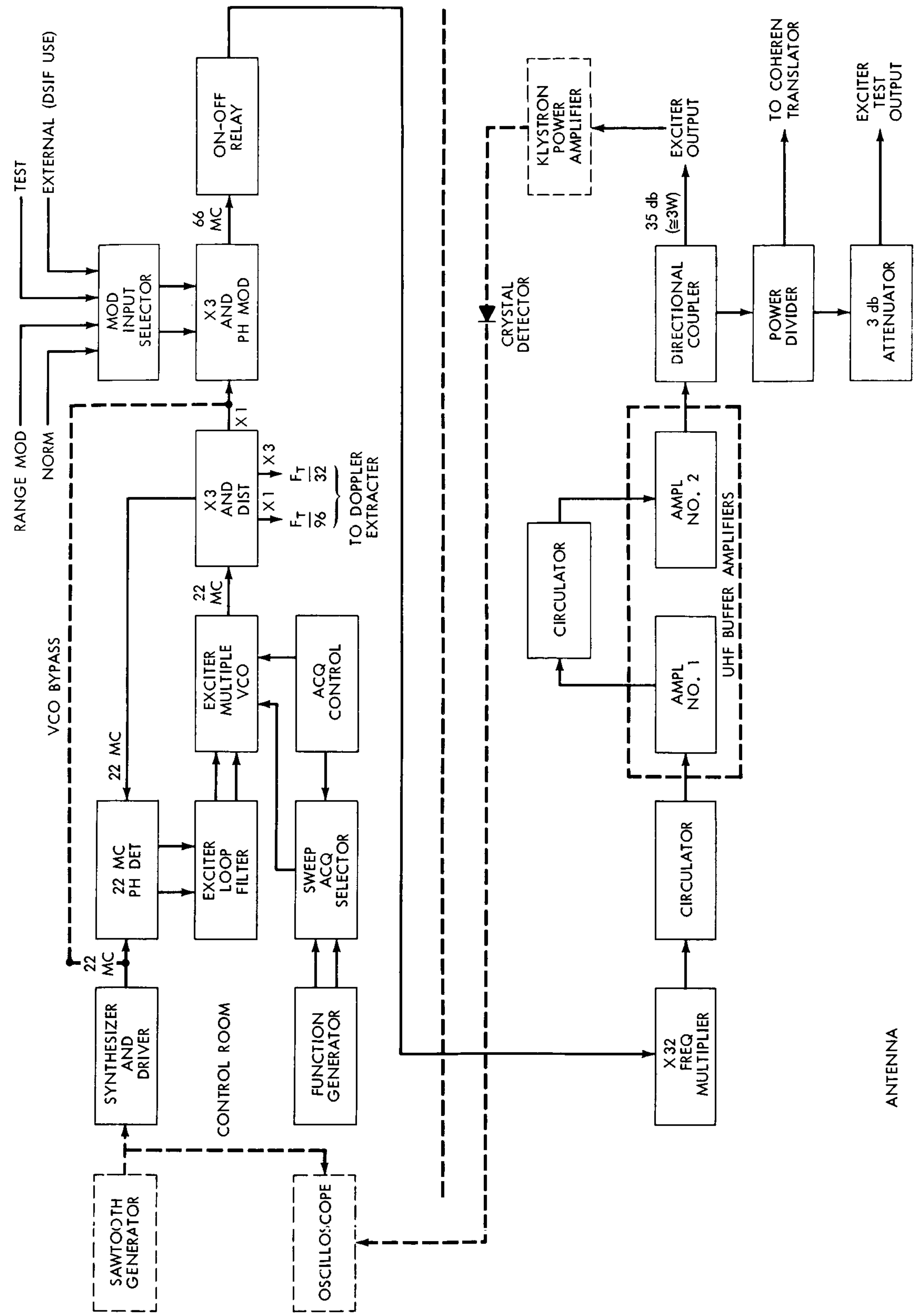
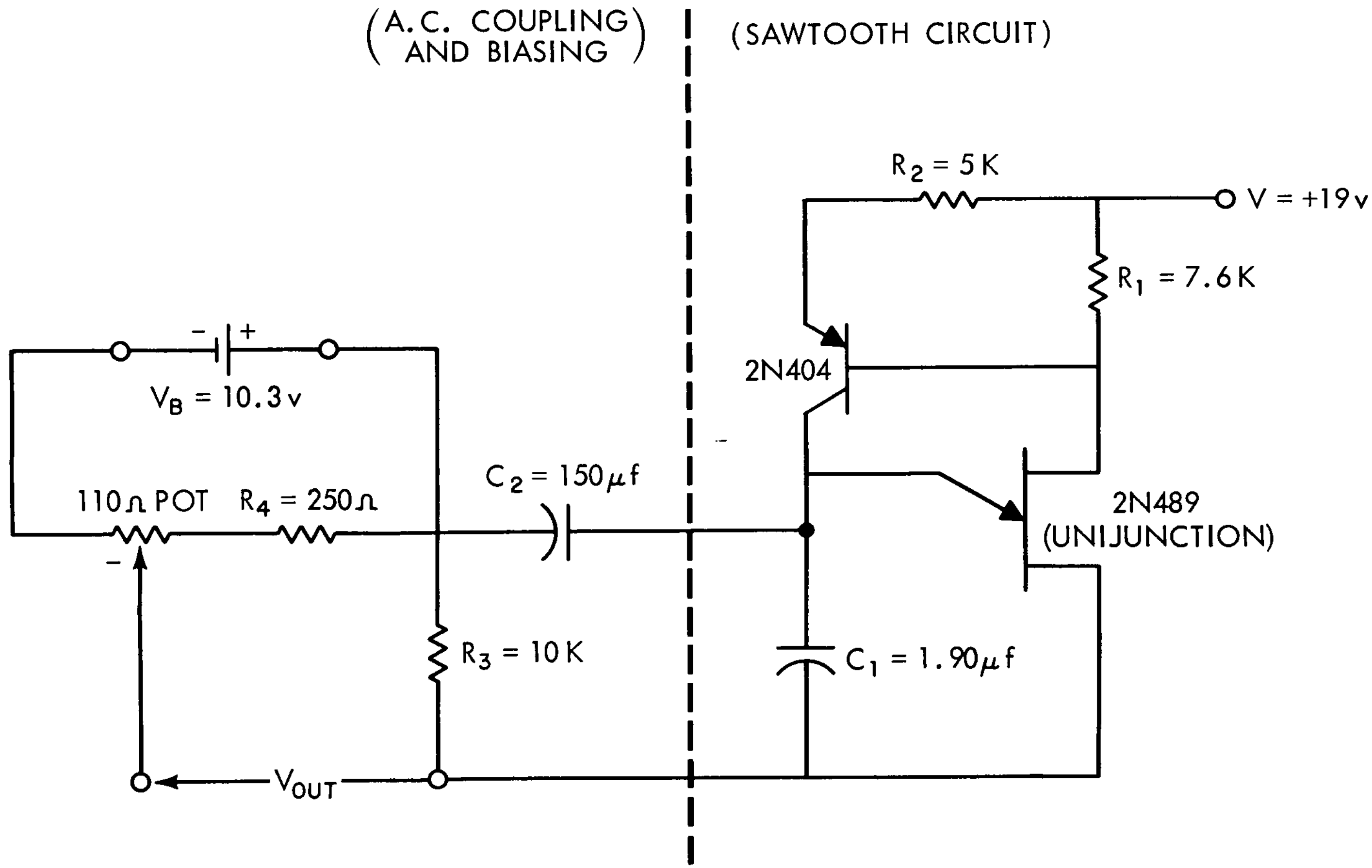


Figure 1. Modifications to the Exciter Circuit



NOTE: THE VOLTAGE DIVIDER AT THE OUTPUT PRODUCES THE VARIABLE CENTER FREQUENCY. TABLE 1 INDICATES WHAT BIAS VOLTAGES ARE NECESSARY FOR A SAMPLING OF CENTER FREQUENCIES.

Figure 2. Sawtooth Circuit

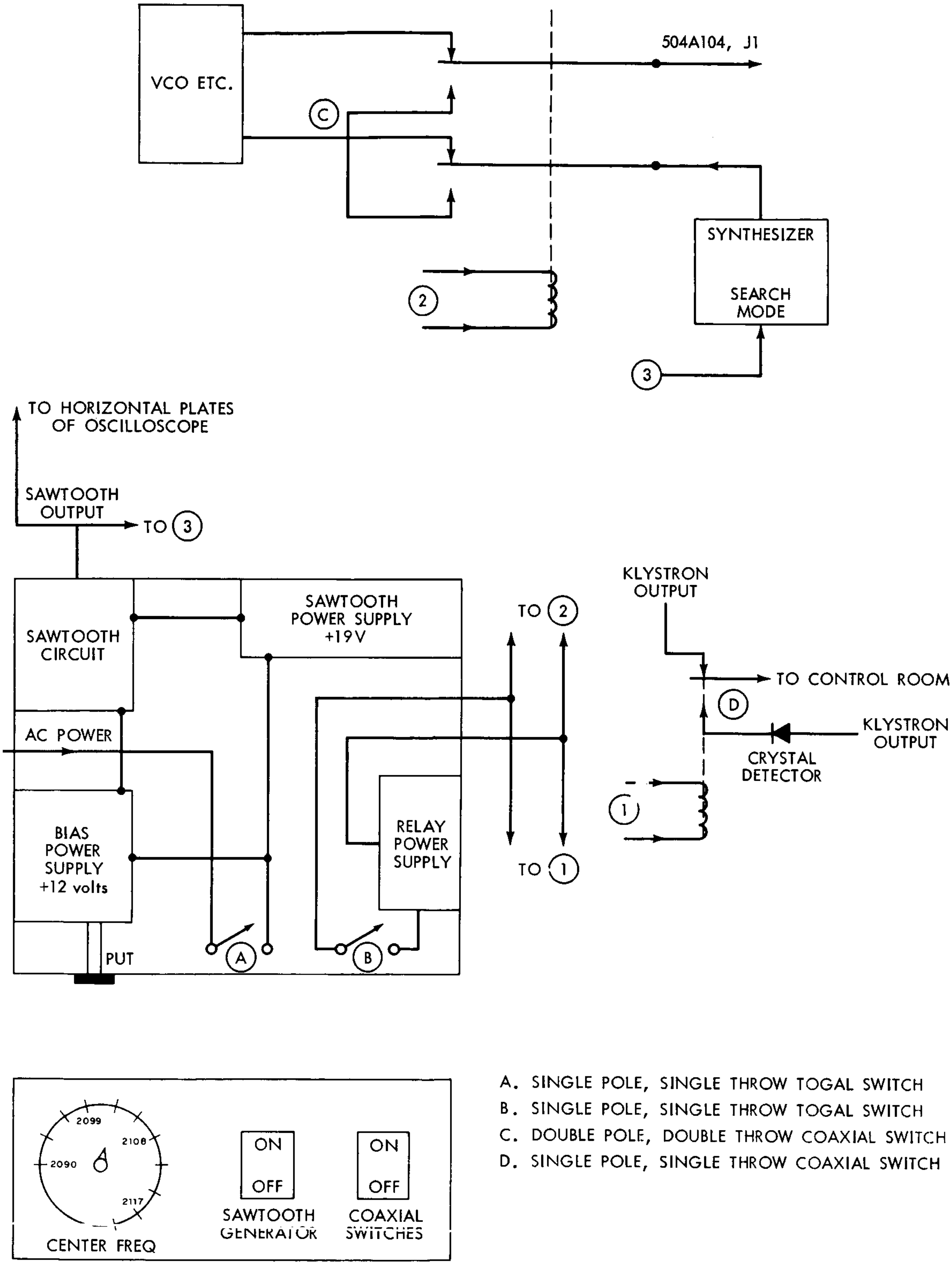


Figure 3. Schematic Diagram of System

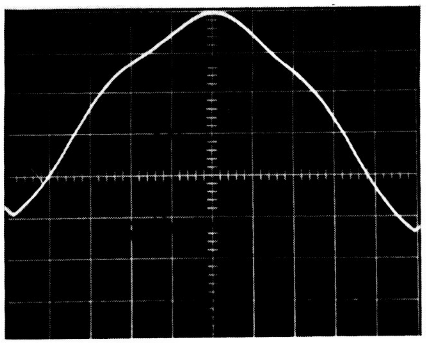


Figure 4.
Exciter Response

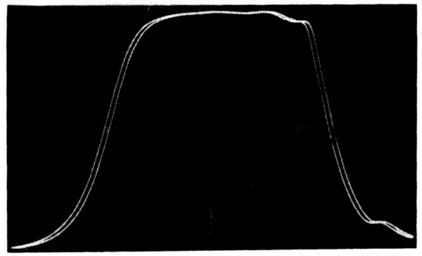


Figure 5. Bandpass of the
Exciter and Klystron at 20 Kw.

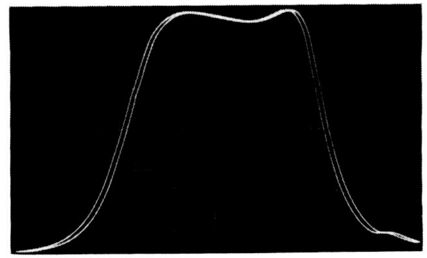


Figure 6. Bandpass of the
Exciter and Klystron at 10 Kw.

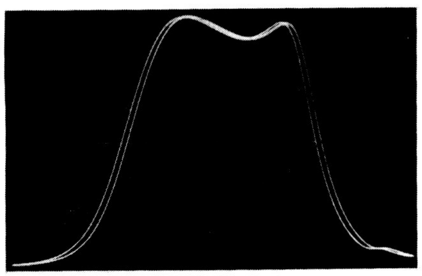


Figure 7. Bandpass of the
Exciter and Klystron at 5 Kw.

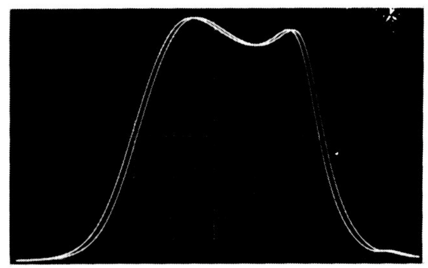


Figure 8. Bandpass of the
Exciter and Klystron at 1.25 Kw.

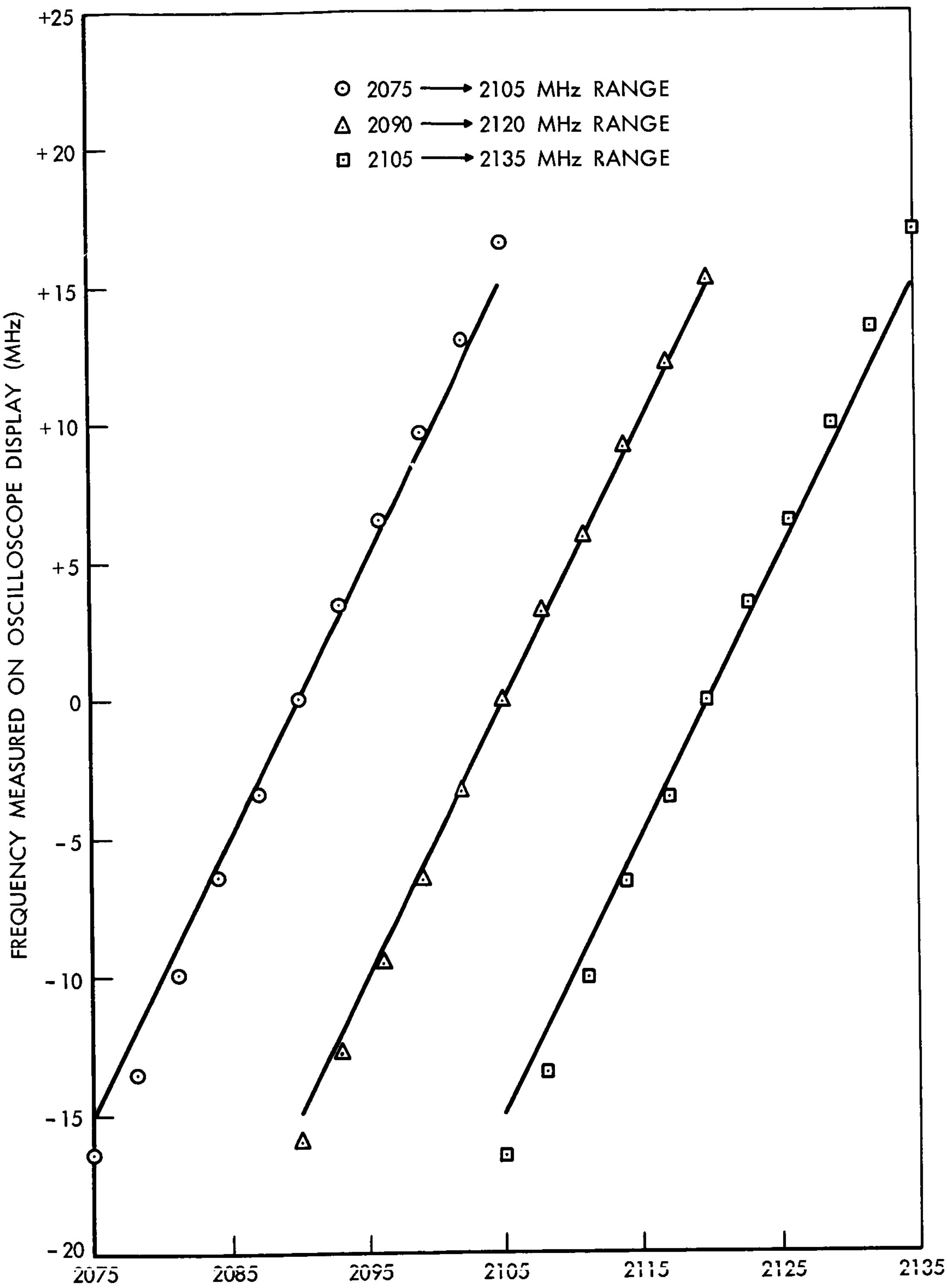


Figure 9. Plot of Linearity Tests

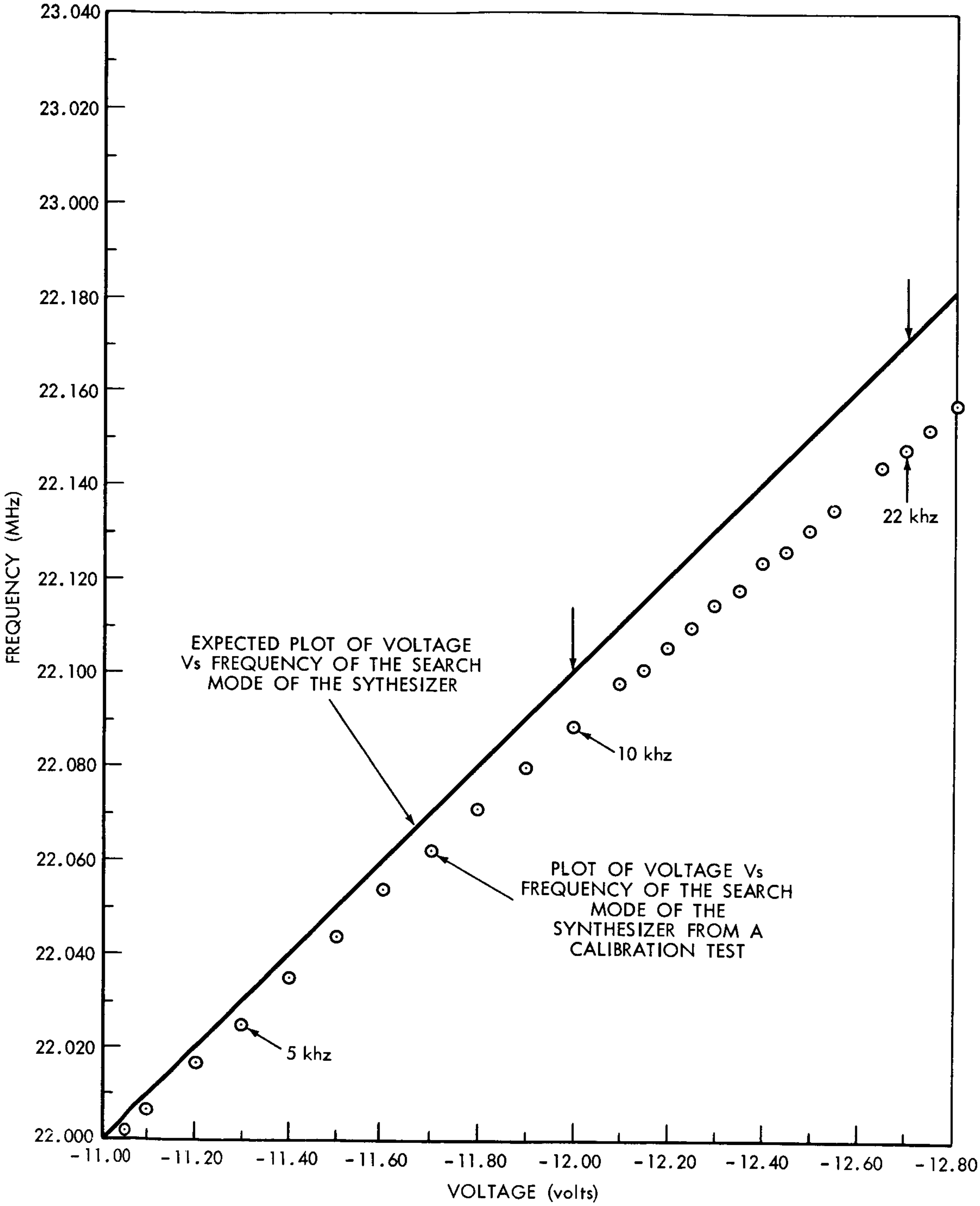


Figure 10. Plot of Synthesizer Response in Overdriven Mode