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INSTRUCTION MATERIAL

For

SINGLE SIDEBAND UNIT

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May 12, 1954

DOC 2 REV DATE 24 APR 1980 BY 064540
ORIG COMP 056 OPI 56 TYPE 30
ORIG CLASS C PAGES 20 REV CLASS C
JUST 22 NEXT REV 2010 AUTH: HR 70-2

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SINGLE SIDEBAND UNIT

SPECIFICATIONS

EXCITER UNIT:

Chassis:	rack mounting	19 in. wide by 12¼ in. high
Finish:	grey	
Input:	audio	1 volt @ 10,000 ohms
	ext. HFO	3 volts @ 100 ohms
Output:	audio	0.5 volts @ 600 ohms
		2.5 volts @ 2000 ohms
	r.f.	15 volts @ 100 ohms
Power Requirements:	115 volts, 60 cps, 135 watts	

POWER SUPPLY UNIT: (Model P-1)

Chassis:	rack mounting	19 in. wide by 5¼ in. high
Finish:	grey	
Type:	regulated	
Power Requirements:	115 volts, 60 cps, 45 watts	

CONTROLS AND THEIR FUNCTION

1. R101---Audio gain
2. R102---Vary from square law to sine wave audio output
3. R103---Phase modulator adjust
4. R104---Square law adjust
5. R105---Phase modulator bias control
6. R106---Balance pot to minimize HFO component
7. C101---Main tuning condenser

Frequency Range (in kilocycles)

Band	Output Frequency		
A	125	to	250
B	250	to	500
C	500	to	1000
D	1000	to	2000
E	2000	to	4000
F	4000	to	8000

Mixer Frequency is 1/2 Output Frequency.

8. C102---Vernier, fine tuning

9. S1 ---Sideband selector

10. S2 ---To obtain correct sense of envelope when using square law.

11. S3 ---External-Internal HFO switch

12. S4 ---Meter Selector

13. S5 ---Range Selector

    A. Mixer output
    B. Doubler output
    C. Ouput plate tank circuit
    D. RF output

14. J1 ---RF output (output of 15 to 20 volts @ 100 ohms impedance)

15. J2 ---Ext. HFO (required input of 2 volts min. @ 200 ohms impedance)

16. TB1 ---Audio input and output terminal strip

Output Data

2.5 volts @ 2000 ohms
0.5 volts @ 600 ohms

DESCRIPTION

The Single Sideband Unit equipment provides excitation for a class C plate modulated transmitter enabling it to radiate single sideband plus carrier. Switch positions are provided which permit Phase Modulated operation as well as Amplitude Modulated operation.

A block diagram of the equipment is shown in Figure 5. Theory of Operation is outlined in the following Section.

The use of a fixed oscillator permits phase modulation at one frequency. This eliminates tuning critical phase modulator circuits in covering the wide range of output frequencies. A balanced mixer balances out the fundamental beating oscillator component. This prevents the oscillator voltage in the mixer plate circuit from predominating over the signal voltage. When driving a doubler, it is desirable that the component which is to be doubled should predominate. The doubler stage is incorporated to minimize feedback from the output to earlier stages. The output stage provides 15 to 20 volts rms at 100 ohms impedance for feeding a low level r-f stage in the transmitter.

The audio input is amplified, then passed through an audio phaser which has quadrature output voltages as required for phase shift single sideband generation. Upper and lower sidebands are selected by reversing phase of one of the outputs as shown. This phaser holds the 90 degree relationship between outputs within 1.5 degrees from 100 cps to 3500 cps. Relative audio phase also should be this precise as measured between the phase modulator grid and at the amplitude modulator plate. To insure this condition these points are inspected using an oscilloscope and the phase is equalized ahead of the p-m audio amplifier as required. A square law circuit is incorporated in the a-m line to decrease distortion of the received signal on a single sideband receiver. For minimum receiver distortion using a linear or diode detector on the other hand, "normal" output is maintained as outlined below. The phase inverter and sense switch provide for applying the square law characteristic in the correct sense to the signal envelope. This switch has no effect when the "normal" output is used. The output amplifier audio provides sufficient output to feed a low impedance line. This output feeds the modulation input circuit of the auxiliary transmitter.

To obtain a given output frequency from this unit, a crystal or an external input voltage must be provided for the HFO circuit. The correct HFO frequency is (Output Freq. /2) + 2.5 mc. Maximum output frequency available is 8 mc. Normally there will be frequency multiplying in the transmitter to cover the higher output frequencies. For adjusting and monitoring transmitter output it is desirable to have a single sideband receiver, however, it is possible to use a communications receiver with selective crystal filter. Initial adjustment sets amplitude modulation level to 80%. It is necessary to use steady tone of about 2000 cps for this adjustment. The receiver then is tuned to the rejected sideband and the phase modulation level control on the back of the chassis is set for minimum output from the receiver. The "square-law-normal" control should be set in "normal" position for maximum rejection. Where a single sideband receiver is available this adjustment may be made on program material. Adjustment of the vernier tuning control will have some effect upon rejection of the unwanted sideband, as will transmitter tuning and loading adjustments.

THEORY OF OPERATION

This system is basically the well known arrangement of Figure 1. This is a phase shift system method in generation of single sideband signals. The present system is shown in basic form in Figure 2. It should be noted that V2 in Figure 2 is not a balanced form of modulator, and that its r-f input consists of the carrier shifted 90 degrees plus the modulation products generated in V1. This arrangement of V1 and V2 leads to the generation of higher order sidebands which are not present in the arrangement of Figure 1.

In practice, V1 balanced modulator and the reinserted 90 degree r-f components are replaced by a phase modulator stage which achieves the same end-result and at the same time eliminates two adjustments (balance control on the modulator and the phase control).

Vectors showing various components arising in the process of phase modulation (V1) and amplitude modulation (V2) are shown in Figure 3. The signal at the input to the limiter of Figure 2 is made up of the carrier plus upper p-m (6) and lower p-m (5) components. The resultant scalar magnitude is greater than the value when modulation is not present. This magnitude varies during the modulation cycle, the result being amplitude modulation at twice the modulating frequency. While this amplitude modulation is chiefly second harmonic, small amounts of other even harmonics also are present. Now as this wave is passed through a limiter stage, which removes any amplitude modulation present, the scalar magnitude of the carrier will remain constant. This means that additional sidebands (components 6, 7, and some others not shown) have been created to cancel the amplitude component. Limiting is not essential to the creation of single sideband signals and the limiter could be left out of Figure 2. However, limiting will occur when passing a signal through class C amplifier stages, therefore an accurate representation of the system must incorporate the limiter.

Whem amplitude modulation is applied to a signal consisting of carrier (1) plus phase modulation components (4, 5, 6, 7) sidebands due to the amplitude modulation process are generated on all components present. New sidebands 2 and 3 are associated with 1 (carrier: 8 and 9 are associated with 4; 10 and 11 are associated with 5; and lesser sidebands not shown are associated with 6 and 7.) Now when the amplitude modulation is at the same frequency as the phase modulation but removed 90 degrees in phase, relationships exist as shown in Figure 3. Certain of the components are at identical frequency and add or subtract as shown in Figure 4. Laboratory tests indicate that the level of a-m sidebands generated on components other than the carrier is not determined directly by the a-m modulation index, but is reduced in the ratio of the component level to carrier level. This factor was used in arriving at the component levels indicated in Figures 3 and 4. As a result of this reduction factor, single sideband performance becomes better at lower modulation levels.

A square law characteristic imposed on the a-m audio will cause cancellation of components shown as 6 and 7 in Figure 3. This reduces the second order sideband on the accept side. The db relationship shown in Figure 4 becomes:

- △f			Carrier	+ △f		
-9KC	-6KC	-3KC	0	+ 3KC	+6KC	+9KC
-46DB	-19DB	-1.9DB	0	-Inf.	-19DB	-46DB

Theoretical rejection at high modulation level as outlined above is 25 db (Intermodulation in this case is 12 db). The optimum performance may be degraded by audio distortion, phase shift of individual r-f sidebands due to Q of tuned circuits, and excessive audio phase shift in amplitude modulator stages in the transmitter.

Detailed function of stages shown in the block diagram is as follows:

Block 1. Oscillator-V1 -6AU6. This is an oven controlled crystal oscillator which provides a stable frequency for phase modulation.

Block 2. Phase Modulator-V2 -6AC7. This stage varies the phase of the r-f input in accordance with the audio input.

Block 3. Balanced Mixer-V3, V4-6BE6, 6AU6. The balanced mixer combines the phase modulated wave from V2 with the signal from the high frequency oscillator (HFO) to give a resultant difference frequency.

Block 4. Doubler-V5-6AU6. The doubler multiplies the input frequency by two, and amplifies it.

Block 5. Power Output-V6-6AQ5. This stage provides sufficient power to feed a low impedance line (3 watts at 100 ohms).

Block 6. High Frequency Oscillator-V7-6AC7. This stage is used as a crystal controlled oscillator, and as an amplifier for an external HFO input, where that is desired.

Block 7. Audio Amplifier-½V8-12AU7. This stage amplifies the audio input to the required level.

Block 8. Audio Phaser Unit-(4) 12AU7's. The audio phaser is a subassembly which gives a 90° phase difference between the two cathode or plate output terminals. (Millen 90° phase shift network, Part/Dwg. No. K75011).

Block 9. Audio Amplifier-½V10-12AU7. This stage provides the required amount of audio for the phase modulator.

Block 10. Phase Equalizer. This is circuitry inserted to insure correct phase between the audio and p-m line, compensating for phase shift in the transmitter amplifiers.

Block 11. Square Law circuit-V9-12AU7. This circuit permits a square law characteristic to be imposed upon the audio signal where desired (see Theory of Operation)

Block 12. Phase Splitter-½V10-12AU7. The phase splitter has a gain of about 0.9 at both the cathode and plate, which are 180° out of phase. A switch permits choosing the proper phase when using the square law circuit. This phase depends upon the input to output phase relationship in the transmitter to be used.

Block 13. Output Amplifier-V11, V12-12AU7, 6AQ5. The output amplifier stages employ negative feedback to minimize distortion and provide low output impedance.

PROCEDURE FOR SETTING UP SINGLE SIDEBAND UNIT

1. Connect Power Supply Unit to the Exciter Unit.
2. Connect the Single Sideband Exciter to the Transmitter.
   a. The r-f ouput (J1) is fed to a low level r-f stage of the transmitter.
   b. Audio output is fed to the audio input jack of the transmitter. The 600 ohm output should be used unless the transmitter input is high impedance.
3. Determine HFO Frequency.

To determine the HFO frequency, divide the desired output frequency by the number of multiplication stages used in the overall system, including the doubler stage in the Exciter, and add 2.5 mc to the resultant frequency. Example: desired output frequency is 8 mc. The r-f voltage is doubled twice in the transmitter. Divide 8 mc by 4 = 2 mc. Now 2 mc + 2.5 mc = 4.5 mc which is the required HFO input required at the HFO input jack.

4. Set Band Selector on desired frequency.

NOTE: Band Selector frequencies are as follows:

Band	Output Freq.
A	125 to 250 kc
B	250 to 500 kc
C	500 to 1000 kc
D	1000 to 2000 kc
E	2000 to 4000 kc
F	4000 to 8000 kc

Mixer Frequency is ½ Output Frequency.

5. Turn on Equipment.

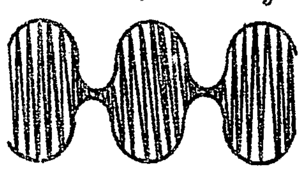
6. Tune Exciter.

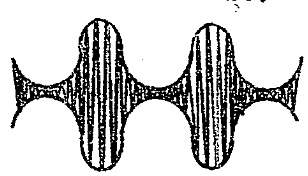
Set the meter selector switch on "Output", then adjust the main tuning mechanism and vernier for maximum deflection on the meter.

7. Determine Type of Envelope to be Used.

"Normal" operation should be used for least intermodulation distortion on a standard receiver, "square law" operation should be used for least distortion on a single-sideband receiver. Adjust R102 for the characteristic desired.

NOTE: To adjust the Square Law Circuit, use an oscilloscope to monitor the audio output. Turn R102 completely to the Square Law end as marked on the chassis, and adjust R104 for best Square Law wave characteristic. This varies with amplitude of audio output. Input to the exciter should be set at the optimum level, and that level should correspond to 100% modulation of the transmitter by adjustment of the transmitter audio gain control. When using the Square Law characteristic it is necessary to see that the transmitted signal envelope is in the correct sense as shown. S2 may be used to obtain the correct sense.


Correct Sense


Incorrect Sense

8. Set Audio Gain Control for Desired Degree of Modulation.

Apply an audio frequency of about 2000 cycles to the audio input terminal (TB1-1), then with the meter selector switch on modulation, determine the 100% modulation point, and reduce the level as desired. CAUTION: once the audio level is set initially, do not use the gain control of the transmitter. Make all audio adjustments with the exciter gain control

9A. Adjust for Single Sideband Performance.

a. Using the input meter of a monitoring receiver, tune for the first order sideband to be rejected (the receiver should be in sharp crystal selectivity; keep input from transmitter below 40 db as indicated on the receiver meter, be sure r-f coupling is all from transmitter output and none is direct from the Exciter Unit).

b. Set the sideband selector switch of the Exciter for the desired accept sideband.

c. Adjust R103 for null.

d. Tune the vernier for a null.

e. Make final adjustments using both R103 and the vernier control for optimum null.

9B. Using Single Sideband Receiver for Monitoring:

A single sideband receiver has at least three different accept positions.

upper sideband
lower sideband
normal reception

a. Using the normal position, tune to the transmitter frequency.

b. Switch to the accept sideband and adjust the gain control of receiver for maximum audio output.

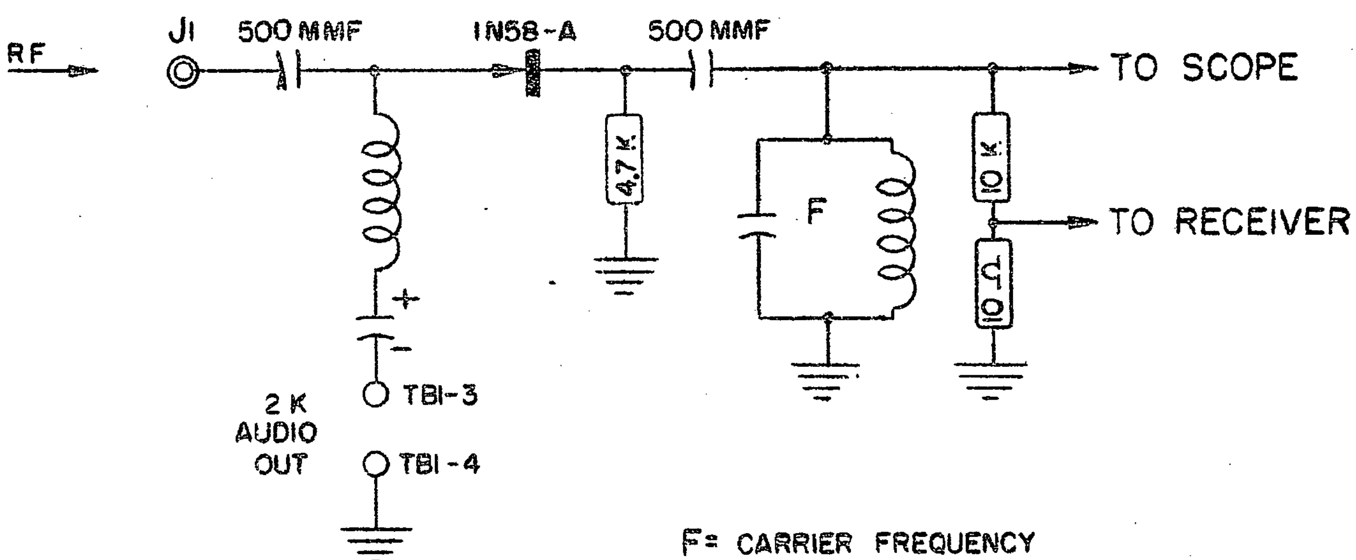
c. Switch to the reject sideband and adjust the Exciter for minimum, (a null on the audio output meter of the receiver). NOTE: To tune the Exciter for a null adjust R103 and the vernier the same as step 9Ac.

ALTERNATE PROCEDURE USING A DIODE (LINEAR) MODULATOR

Since a diode modulator approximates an almost perfect device and can be constructed readily and inexpensively, it becomes a very useful instrument for setting up and trouble shooting the Exciter. In using the diode modulator, the tuning of the Exciter becomes simplified since the transmitter does not have to be used in the setting up procedure. This eliminates possible errors due to slight misadjustments of it.

When using a diode modulator, such as the one shown below, follow the same procedure as outlined for standard transmitters, replacing the transmitter with the diode modulator.

CIRCUIT DIAGRAM OF DIODE MODULATOR



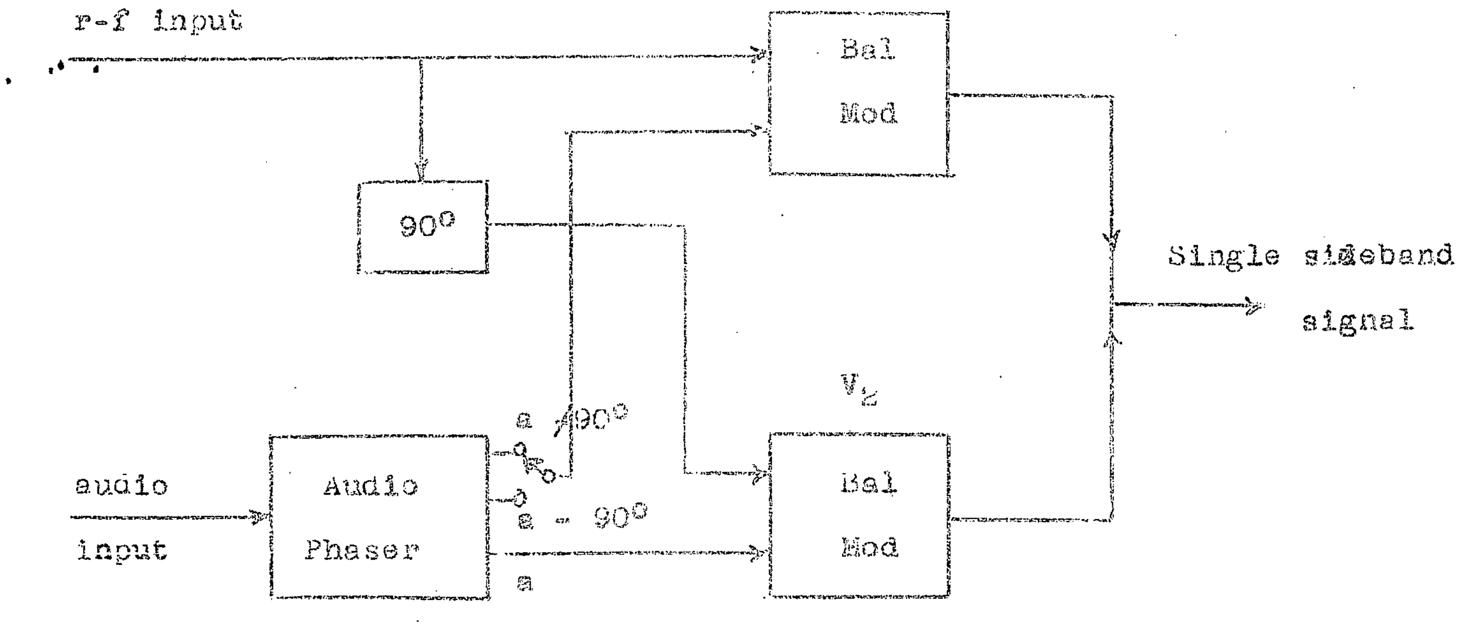


Figure 1. Phase Shift System for Single Sideband Generation

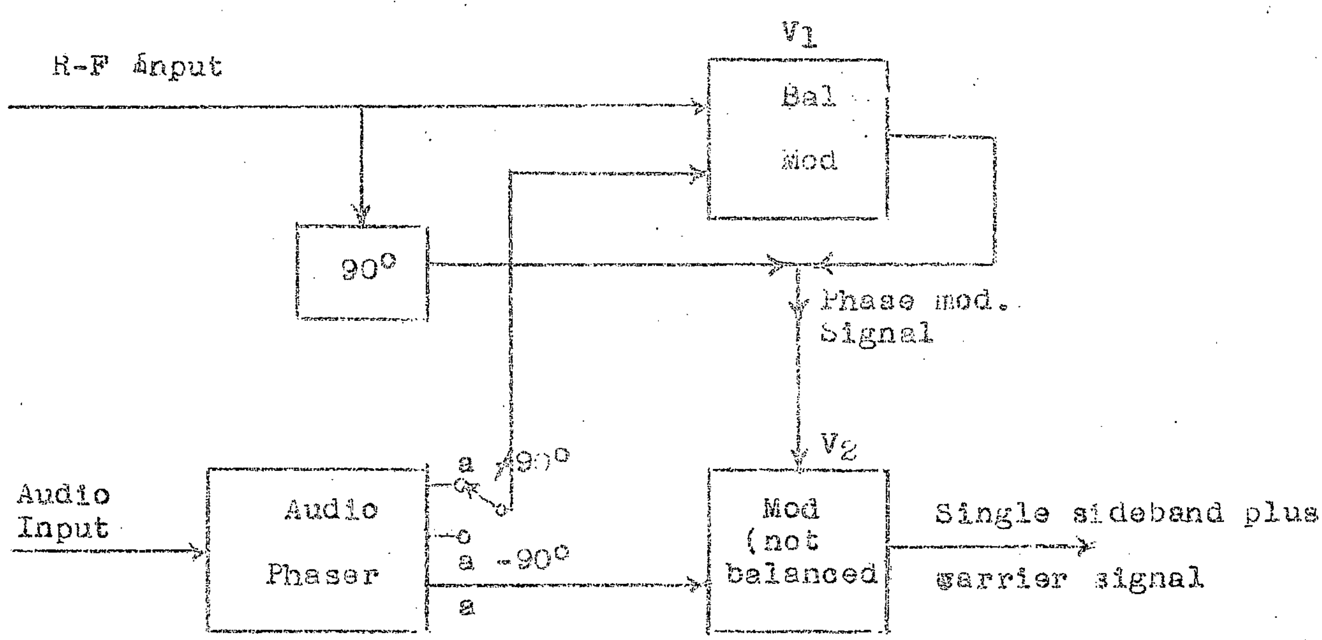


Figure 2. Variation of Phase Shift System of Single Sideband Generation.

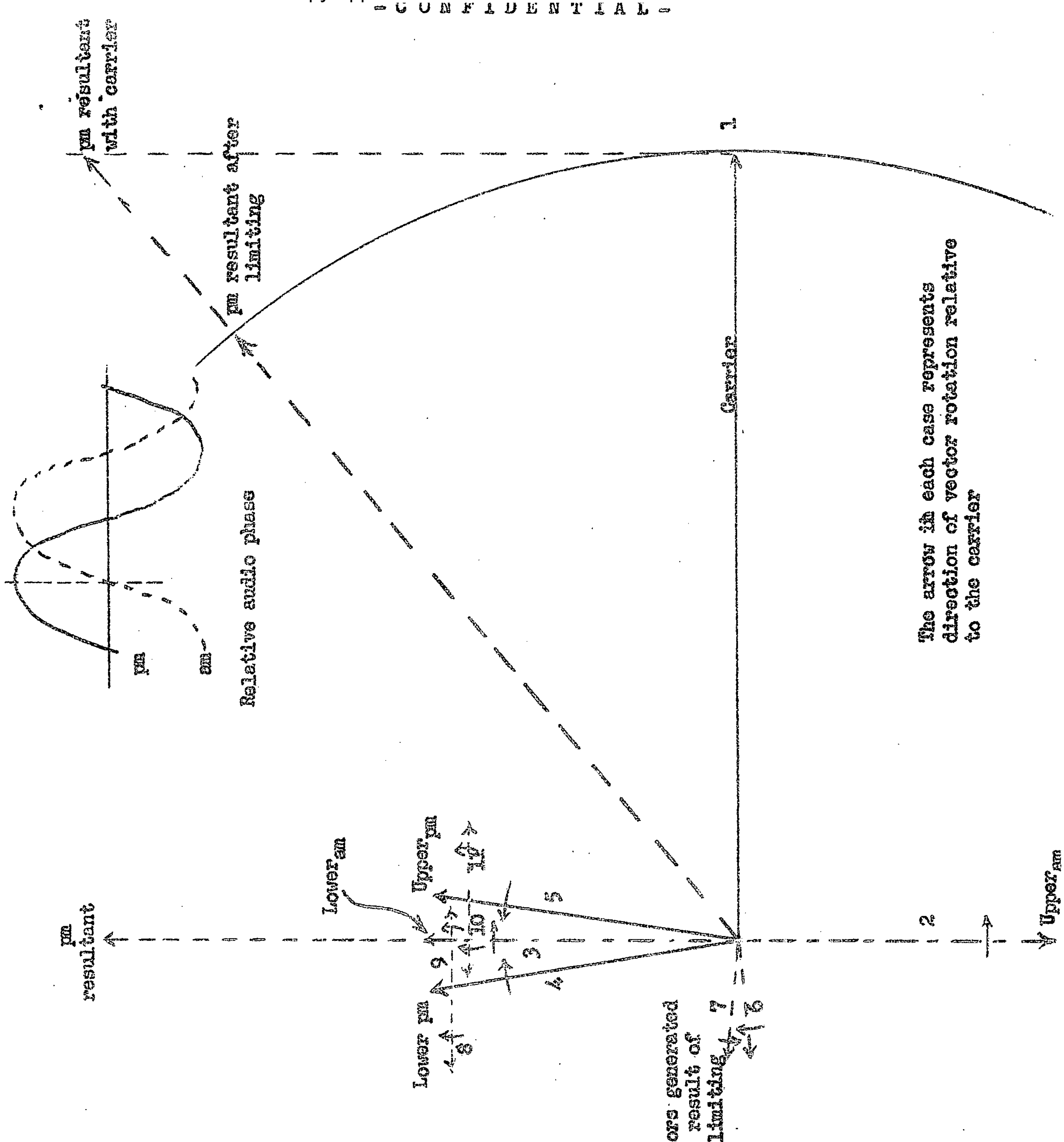
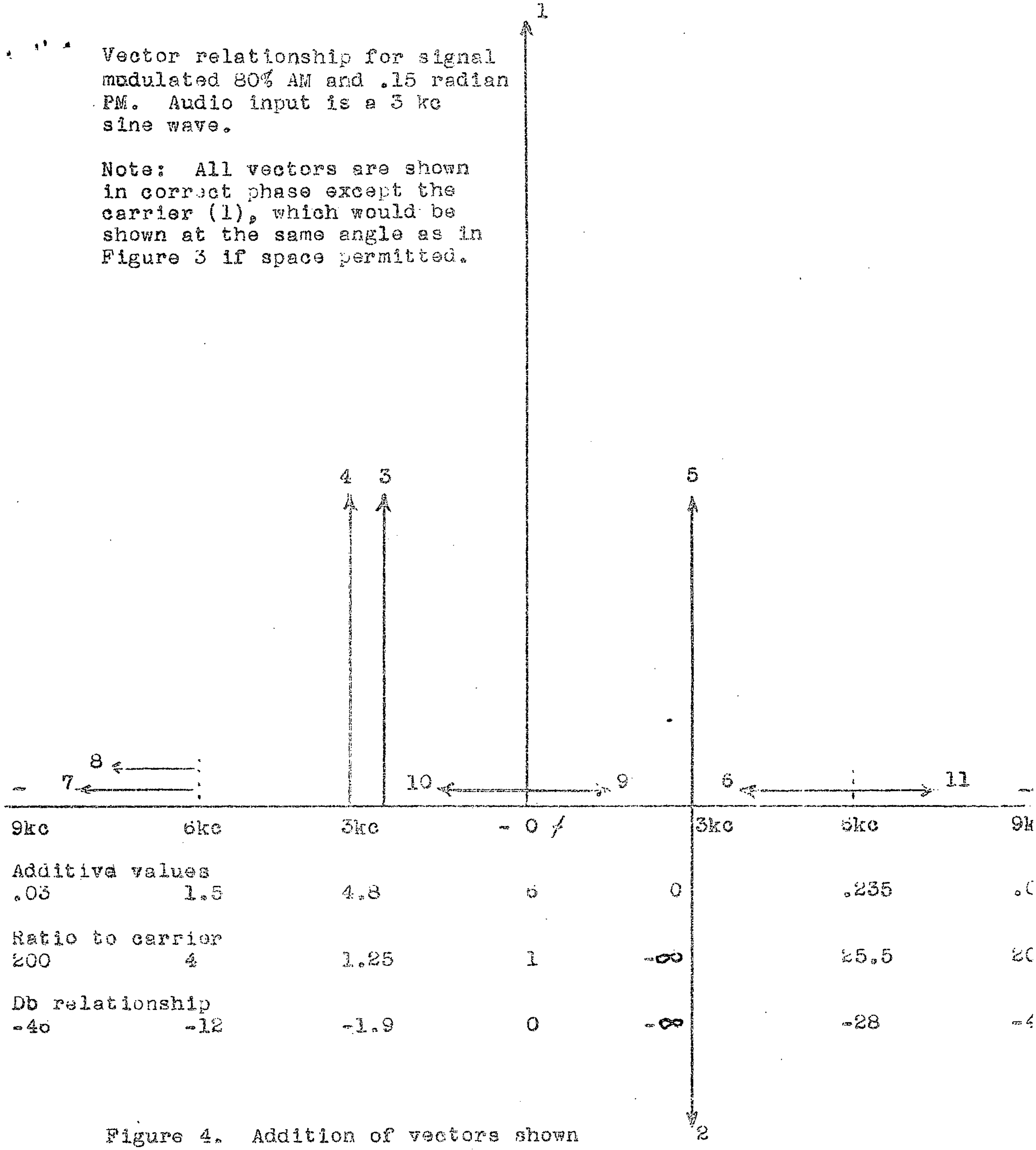


Figure 3. Vector Relationship
for Single Tone Modulation

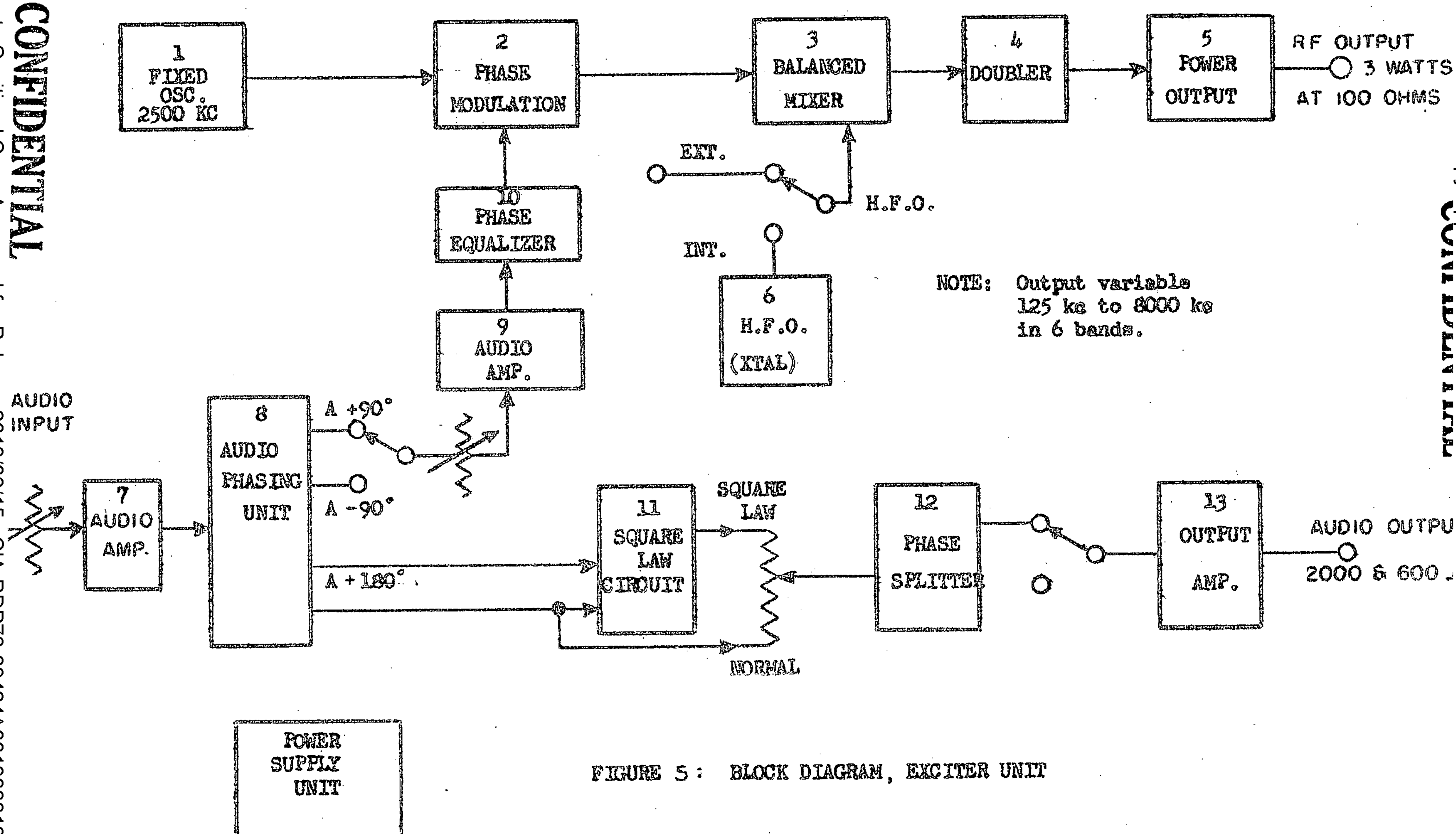
Vector relationship for signal modulated 80% AM and .15 radian PM. Audio input is a 3 kc sine wave.

Note: All vectors are shown in correct phase except the carrier (1), which would be shown at the same angle as in Figure 3 if space permitted.



	9kc	6kc	3kc	0		3kc	6kc	9k
Additive values	.03	1.5	4.8	6	0		.235	.(
Ratio to carrier	200	4	1.25	1	-∞		25.5	2(
Db relationship	-46	-12	-1.9	0	-∞		-28	-4

Figure 4. Addition of vectors shown in Figure 3.



NOTE: Output variable
125 kc to 8000 kc
in 6 bands.

FIGURE 5: BLOCK DIAGRAM, EXCITER UNIT

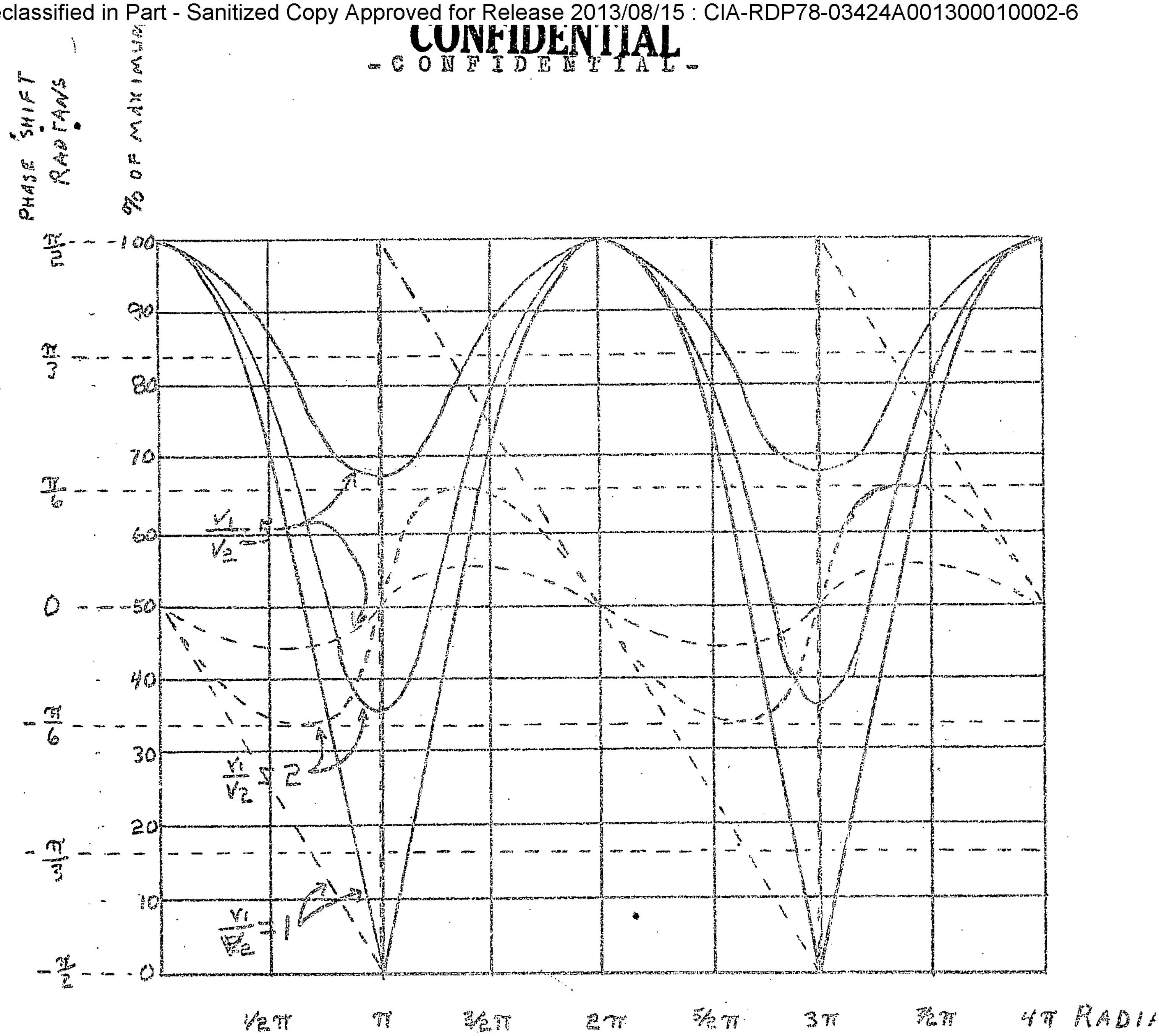
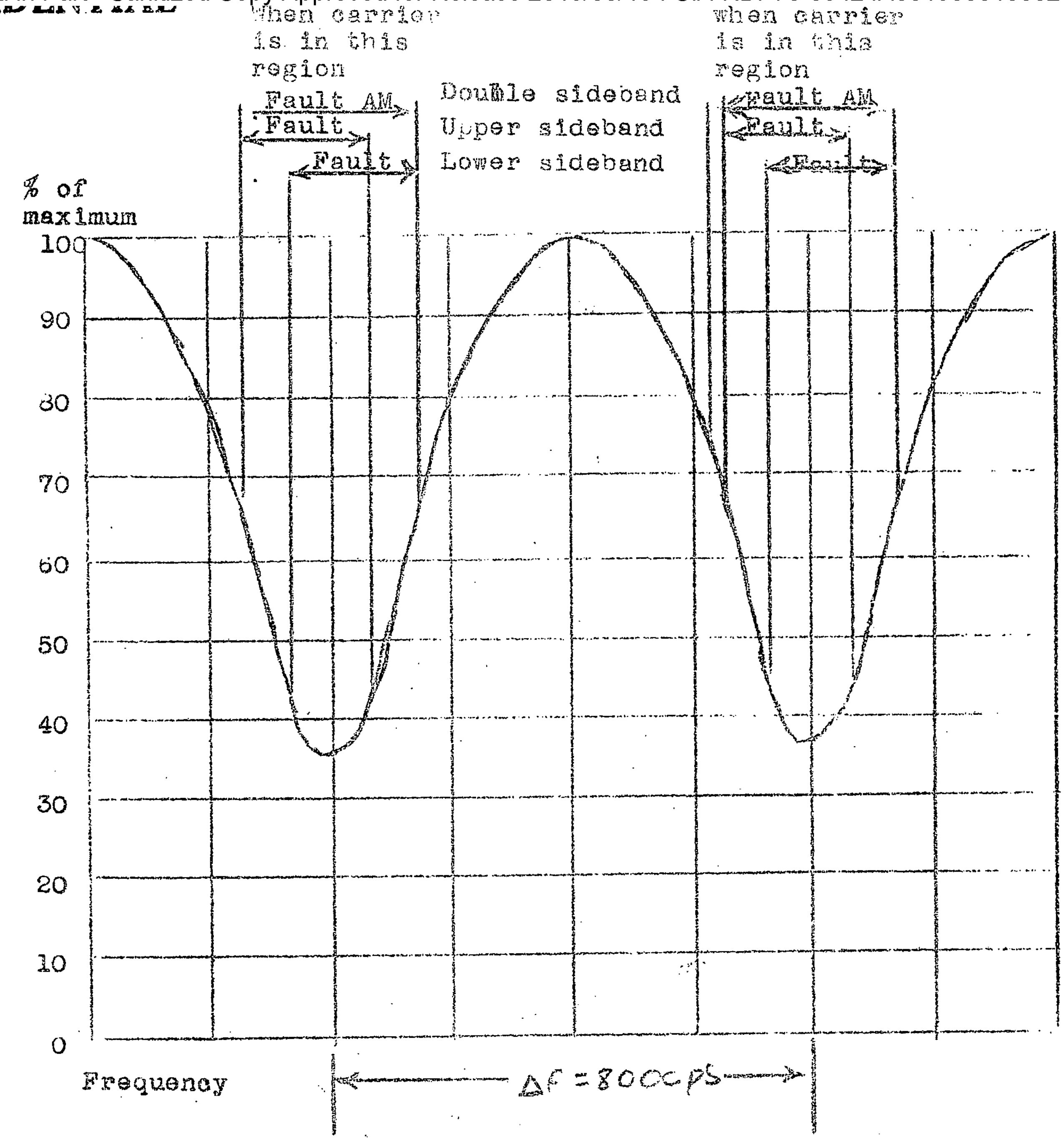


Fig. 6 Solid graph shows signal amplitude.

Dotted graph shows signal phase.



Conditions:

1. $V_1/V_2 = 2$ V_1 and V_2 are components from separate paths.
2. $\Delta f = 800$ cps
3. Modulation is 200 cps in each case
4. AM signal is modulated 100%. SSB is modulated so the sideband is .707 of carrier.
5. Fault is defined as condition where the sum of sideband amplitudes is greater than the carrier.

Figure 7 Region of faults as transmission minimums move relative to carrier frequency.

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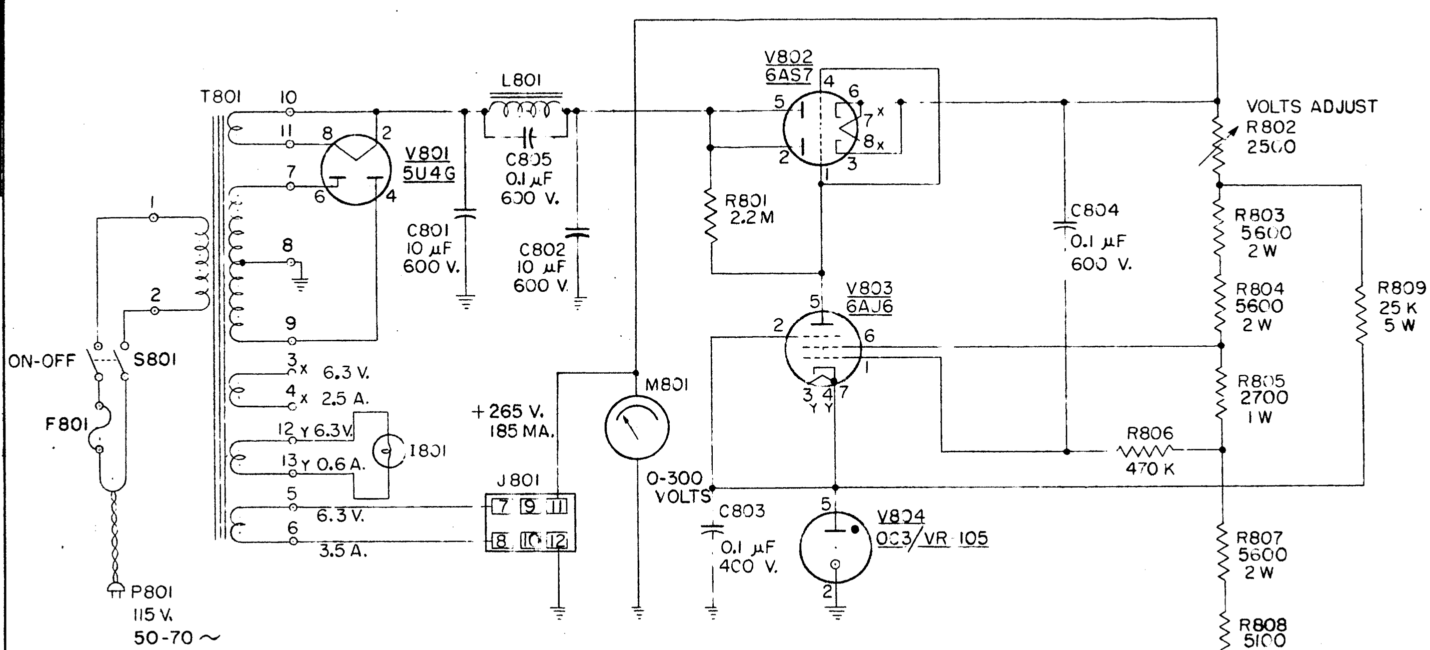

FIGURE 8
CIRCUIT DIAGRAM
POWER SUPPLY UNIT
MODEL P-1

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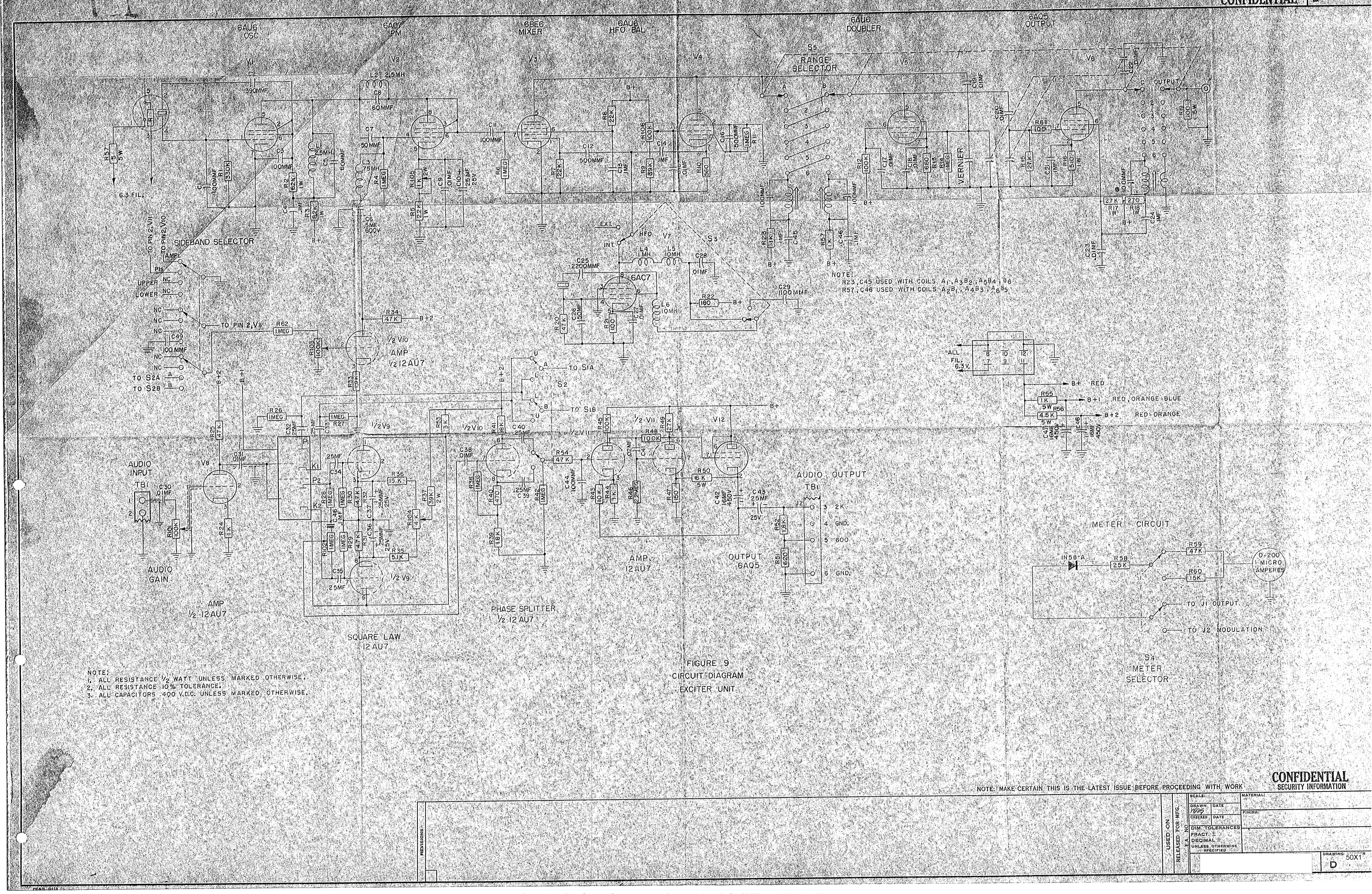

FIGURE 9
CIRCUIT DIAGRAM
EXCITER UNIT

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