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APPENDIX K

( TEST PLAN AND TEST INSTRUMENTATION )

Submitted as part of the Final Report

for RF Test Console on JPL

Contract No. 950144

MAS 7-100

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DATE: August, 1964

WESTINGHOUSE DEFENSE AND SPACE CENTER

SURFACE DIVISION

ADVANCED DEVELOPMENT ENGINEERING

TEST EQUIPMENT

|                                    |    |
|------------------------------------|----|
| A. Commercial Test Instrumentation | 1  |
| B. Special Test Instrumentation    | 10 |

## TEST EQUIPMENT

## A. Commercial Test Instrumentation

A survey of commercial test instrumentation was made to determine those instruments which would most suitably meet the requirements of the R.F. Test Console. The results of this survey are summarized in Tables 1 to 8. In these tables the instruments of various manufacturers are compared with regard to what are felt to be the most important characteristics. The recommended instruments are given below with the reasons for selection.

## 1. Frequency Counter

The Hewlett Packard #245L frequency counter is recommended because of its superior stability and accuracy.

## 2. Sine Wave Oscillator

The Hewlett Packard #651A sine wave oscillator is recommended because of its low distortion, stability and flexibility.

## 3. Function Generator

The Wavetek #103 function generator is recommended because of its low distortion, range and flexibility.

## 4. Oscilloscope

The Tektronix #585 oscilloscope with a Type #2 plug-in is recommended because of its frequency response, sensitivity and availability of plug-in units.

## 5. Digital Voltmeter

The Hewlett Packard #3440A digital voltmeter is a good general purpose meter at a reasonable price.

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TABLE 1

FILAMENTARY COUNTER (ref. 3.5.5.1) a digital freq. counter up to 50mc

| Model                             | Manufacturer                         | Model                             | Manufacturer                         | Model                        | Manufacturer                     |
|-----------------------------------|--------------------------------------|-----------------------------------|--------------------------------------|------------------------------|----------------------------------|
| 5245 L                            | Hewlett Packard<br>Palo Alto, Calif. | 5244 L                            | Hewlett Packard<br>Palo Alto, Calif. | 1037                         | Syston Donner<br>Concord, Calif. |
| 0 to 50mc                         |                                      | 0 to 50mc                         |                                      | 0 to 50mc                    |                                  |
| + 1 count + time<br>base accuracy |                                      | + 1 count + time<br>base accuracy |                                      | + 1 count<br>+ time base     |                                  |
| + 3 parts in $10^9$ /day          |                                      | + 2 parts in $10^7$ /mo.          |                                      | + 3 parts in<br>$10^9$ /days |                                  |
| * after 72 hrs                    |                                      | 1 hr                              |                                      | after 10 days                |                                  |
| 100mv rms                         |                                      | 100mv rms                         |                                      | 100mv rms                    |                                  |
| 10K, 40pf, 0.1V range             |                                      | 10K, 40pf, 0.1V                   |                                      | 1m ± 50pf                    |                                  |
| 1u sec to 10 sec                  |                                      | 1u sec to 10 sec                  |                                      | 1u sec 10 sec                |                                  |
| 0.2 sec to 00                     |                                      | 0.1 sec to 00                     |                                      | .2 sec to 00                 |                                  |
| 8 DIGITS                          |                                      | 7 DIGITS                          |                                      | 8 DIGITS                     |                                  |
| KC 0.1MC w/decimal<br>point       |                                      | KC 0.1MC w/decimal<br>point       |                                      | KC, KC, MC                   |                                  |
| Available                         |                                      | None                              |                                      | Available                    |                                  |
| 90 watts                          |                                      | 80 watts                          |                                      | 100 watts                    |                                  |
| 16 5/16 x 5 1/2 x<br>1 3/8        |                                      |                                   |                                      | 75 watts                     |                                  |
| \$2000                            |                                      | \$2225                            |                                      | \$3010 w/902A                |                                  |
|                                   |                                      |                                   |                                      | \$2625                       |                                  |

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TABIE 2

SINE WAVE OSCILLATOR (ref 3.5.5.2) to 1.5 mc

| SPECIFICATION | Hewlett Packard<br>Palo Alto, Calif. | Wayne Kerr<br>Philadelphia, Pa. | Wave Forms<br>New York, N. Y. |
|---------------|--------------------------------------|---------------------------------|-------------------------------|
|---------------|--------------------------------------|---------------------------------|-------------------------------|

|                         |  |                                   |   |
|-------------------------|--|-----------------------------------|---|
| Model                   | 651A   | 0-22A                             | 402A                                    |
| Frequency Range         | 10 cps to 10mc   | 10KC to 10mc                      | 10cps to 15mc                           |
| Output Impedance        | 50 and 600 ohms<br>75 ohms on request                                  | 75 ohms                           | 600                                     |
| Output Level            | 16mm(3.16 <sup>v</sup> ) into 600<br>200mm(3.16 <sup>v</sup> ) into 50 | 2v into 10K<br>160mm, 75          | 10mw into 600                           |
| Distortion              | 1% to 5mc, 2% @ 10mc   | 1%                                | 10%                                     |
| Stability               | 10 parts in 10 <sup>6</sup> for<br>60 sec.                             | 1 part in 10 <sup>3</sup> hr      | + 5 parts in 10 <sup>5</sup> short term |
| Output Monitor Accuracy | + 2% of full scale<br>+ 1% to 10 mc                                    | + .5db                            | Output monitor                          |
| Output Attenuator       | 90db   | 60db                              | 100db                                   |
| Miscellaneous           |  | 50 output<br>optionally available |   |
| Power                   | 20 watts   |                                   | 60 watts                                |
| Size and Weight         | 5 7/32H x 16 3/4 D   |                                   | 8 x 6 x 10 <sup>1/2</sup> , 12#         |
| Price                   | \$590  | \$780                             | \$350                                   |

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TABLE 3

FUNCTION GENERATOR (ref 3.5.5.3) Low-Frequency sine, square, & triangular waveforms

| SPECIFICATION                           | Hewlett Packard<br>Palo Alto, Calif.                     | Wavetek<br>San Diego, Calif.   |
|---|--|--|
| Model                                   | 202A   | 103  |
| Frequency Range                         | .001 to 1200 cps   | .008 to 1 MC   |
| Wave Forms                              | sine, square, triangular                                 | sine, square, triangular   |
| Output Impedance                        | 40 ohms  | 50 ohms & 600 ohms   |
| Output Level                            | 30 <sup>v</sup> P-P across 4000                          | 30 <sup>v</sup> P-P into 600   |
| Amplitude Stability                     | 1%   | 1% long term .1% short term  |
| Frequency Stability                     | 1%   | 1% long term .1% short term  |
| Distortion sine<br>triangular<br>square | 1% on x .01, x.1x1, x10 freq. range<br>2% on x 100 range | 1% to 10KC, 2% to 100 KC<br>1% for harmonics 1 mc<br>tilt .1% overshoot<br>ringing |
| Power                                   | 150 watts  | 5 watts  |
| Weight                                  | 37#  | 8#   |
| Size                                    | 19W x 10 15/32H x 13"D                                   | 7 3/4W x 5 1/8H x 7 1/2D   |
| Price                                   | \$535  | \$595  |

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TABLE 4

C301 LOGSCOP (ref. 3.5.5.4) capable of directly viewing any signal generated

| SPECIFICATION               | Hewlett Packard<br>Palo Alto, Calif.           | Tektronix<br>Portland, Oregon      | Fairchild<br>Clifton, N.J.                 |
|-----------------------------|--|------------------------------------|--|
| Model                       | 175A   | 585                                | 757A/F                                     |
| Sweep Generator<br>range    | w/1780A time unit<br>.1u sec/cm to 5 sec       | .05u sec/cm to 2sec/cm.            | w/74-03 time base<br>.05u sec/div to 2 sec |
| accuracy                    | + 3%   | 3%                                 | 3%   |
| triggering                  | AC, DC, Int, Ext, Line                         | AC, DC, Int, Ext, Line             | AC, DC, Int, Ext, Line                     |
| external triggering         | .5v PPI 550 mc                                 | .2v PTP                            | .25v lmc                                   |
| sensitivity                 |  | 2 parts in 10 <sup>4</sup>         |  |
| jitter                      |  |                                    |  |
| Vertical Amplifier          | w/1750F dual trace                             | w/type 82 dual trace               | w/79-02A dual trace                        |
| rise time                   | 7 sec  | 4.2 sec                            | 3.5 sec                                    |
| pass band                   | 50 mc  | 85 mc                              | 100 mc                                     |
| sensitivity                 | .05v/cm to 20v/cm                              | .01v/cm to 20v/cm                  | .01v/div to 20v/div                        |
| impedance (no probe)        | 1M & 23pf                                      | 1M & 12pf                          | 1M & 14pf                                  |
| Cathode Ray Tube & Phosphor | 6 x 10 cm display<br>P31 aluminumized phosphor | 4 x 10 cm<br>P31                   | 6 x 10" cm<br>P31                          |
| Graticle                    | internal                                       | external                           | external (internal optional)               |
| Plug In Capability          | yes  | yes                                | yes  |
| Miscellaneous               | requires time base<br>plug-in 1780A P25        | 582 plug in<br>at \$50.00          | requires time base<br>unit 74-03A \$245.00 |
| Power                       | 425 watt max.                                  | 630 watt max.                      | 200 watt                                   |
| Size weight                 | 16 3/4" x 12 1/4" x<br>24 2/8" 70#             | 16 7/8" x 13 1/8" x<br>23 7/8" 67# | 7" H x 20" D x 19" 27#                     |
| Price                       | \$1675 + 25 = \$1700.00                        | 1725 + 650 = 2375                  | 1970 + 345 = 2315                          |



## DIGITAL VOLTMMETER (ref 3.5.5.5) digital dc voltmeter w/limited AC capabilities

| Model                          | Hewlett Packard<br>Palo Alto, Calif.                        | Hewlett Packard<br>Palo Alto, Calif.                      | Cubic<br>San Diego, Calif.  | Cimron<br>San Diego, Calif.                  |
|--------------------------------|---|---|---|--|
| 3440A<br>w/3442A plug-in       | 405BR   | 15-250  | 7200A   |  |
| Display                        | 4 Digits  | 3 Digits  | 5 Digits + range<br>+ polarity  | 5 Digits                                     |
| Accuracy                       | $\pm .05\% \pm 1$ digit                                     | $\pm .02\% \pm 1$ digit                                   | $\pm .001\% \pm 1$ digit<br>.005%/month                                   | $\pm .01\% \pm 1$ digit                      |
| Stability                      |   |   |   |  |
| Ranges                         | 3 ranges up to 999.9  | 3 ranges up to 999  | 3 up to 1000  | 3 to 999.99                                  |
| Sample Rate                    | 5 ranges/sec  | 4 or 5 per sec  |   |  |
| Input Impedance                | 10.2 M  | 10 M  | DC  | 1000M on 9.9999 range<br>11M 99.999 & 999.99 |
| Response Time                  | 450ms to a step<br>function                                 | 1sec to a step<br>function                                | .2sec max.  |  |
| Common Mode<br>Rejection       |   | 130db DC<br>100db 60 cps                                  |   | 100 mv                                       |
| Sensitivity                    |   |   |   | 1200   |
| A-C Capability<br>to frequency | 457 AC to DC converter<br>50 cps to 500 KC<br>(\$395)       | w/457AC to DC<br>converter<br>50 cps to 500 KC<br>(\$395) | w/PN 86-7100<br>35 cps to 5KC<br>can measure<br>ohms, remote<br>operation |  |
| Power                          | 20 watt   | 180 watt  |   |  |
| Size & weight                  | 5 $\frac{1}{4}$ " x 16 3/4" W<br>x 11 $\frac{1}{2}$ " D 20# | 7" H x 19" W<br>x 13 7/8" D 31#                           |   |  |
| Price                          | 1295 + 395 = 1690.00  | \$890 + 395 = 1285  | 3990 + conv   | 3400 + 1200 = 4600                           |

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TABLE 6. Comparison of two types of (ref. 3.5.5.6) measure phase noise variance C/H

| SPECIFICATION       | Hewlett Packard<br>Palo Alto, Calif.                                | Keithley<br>Cleveland, Ohio   | Fluke<br>Seattle, Wash.                      |
|---------------------|---|---|--|
| Model               | 3400A   | 121   | 910A   |
| Frequency range     | 10 cps to 3 mc  | 15 cps to 50 mc   | 10 cps to 7 mc                               |
| Range               | 100 uv to 300 v   | 100 uv to 300 v   | 10 uv to 300 v                               |
| Accuracy            | ± 1% 50 cps to 3 mc<br>± 2% 10 cps to 3 mc                          | ± 1% 20 cps to 10 mc<br>± 3% 10 cps to 20 mc  | ± 1% 50 cps to 300 KC<br>± 2% 20 cps to 2 mc |
| Meter response time | 2 sec   | 1 second  |  |
| Crest factor        | 3 to 10 full scale<br>16 to 10 <sup>2</sup>                         | 3 to 10 full scale 120db  | 3 to 10 full scale                           |
| Input Impedance     | 10M & 25 pf   | 1M & 20 pf  | 10M & 30 pf                                  |
| Meter               | 2 linear and scales<br>0 to 3 & 0 to 10<br>1 log db scale -12 to +2 | 2 linear and scales<br>0 to 3 & 0 to 10<br>1 log db scale -12 to +2   | 3 scales                                     |
| Miscellaneous       |   | AC output .100 mv rms<br>6 rise time<br>DC output 100 mv<br>Cathode Follower probe<br>available 10 meg, 15 pf |  |
| Power               | 5 watts   | 50 watts  |  |
| Size & weight       | 5 1/2" x 5 1/2" x 11" D<br>7 1/2"                                   | 11 1/2" x 7 1/4" x 13 1/30 17 1/2"  | 10 1/2" x 5 1/2" x 13 1/2"                   |
| Price               | \$525   | \$970   | \$545  |

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SPECTRUM ANALYZER (ref. 3.5.1.2 & 3.5.5.7) measuring spectral components - possible to translate the spectrum

| SPECIFICATION             | Hewlett Packard<br>Palo Alto, Calif.   | Airmec<br>England           | Singer-Metrics<br>Bridgeport, Conn.  |
|---------------------------|--|-----------------------------|--|
| Model                     | 310  | 853                         | Panalyzer SD-12  |
| Frequency Range           | 100 to 1.5mc w/200 cps B.W.<br>500 to 1.5mc w/100 B.W.<br>10MC to 1.5mc w/300 B.W. | 30KC to 30mc                | 500 KC center frequency  |
| Sensitivity               | 10 uv  | 1 uv                        | 200 uv w/.3V rms conversion sig  |
| Selectivity               | 3dB 600cps w/200cps B.W.   |                             | as low as 10 cps   |
| Frequency Accuracy        | + (1% + 300 cps) A.F.O<br>linear grid w/1 div/200cps                               | + 1%                        | marker at 5KC intervals  |
| Voltage Accuracy          | + 6%   | calibration charts supplied | + 5% bandpass flatness   |
| Dynamic Range             | 75 db  | 70 db                       | 60 db  |
| Input Impedance           | 10K  | 75                          |  |
| Spurious & Noise Response | -75db  |                             |  |
| Accessories               | sweep drive  | probe                       |  |
| Miscellaneous             |  |                             | scale-log linear<br>sweep rate 0.1 to 30 cps<br>requires external frequency<br>converting local oscillator |
| Power                     | 10 watts   | 70 watts                    | 180 watts  |
| Size & Weight             | 16 3/4" x 10 1/2" x 18 3/8"<br>44lb  | 19" W x 16" H x 8 1/2" D    | 18 1/2" x 19" W x 11 1/2" D  |
| Price                     | \$2200   | \$650                       | \$1875   |

C 2 0 0 0 0 0 0 0 0 0 0 0

TABLE 8

SPECTRUM DISPLAY (ref. 3.5.4.2 &amp; 3.5.5.7) display transmitted spectrum 50 + 1.5 mc

| SPECIFICATION | Hewlett Packard<br>Palo Alto, Calif. | Singer Metrics<br>Bridgeport, Connecticut | Singer Metrics<br>Bridgeport, Conn. |
|---------------|--------------------------------------|---|-------------------------------------|
|---------------|--------------------------------------|---|-------------------------------------|

|       |            |                                 |        |
|-------|------------|---------------------------------|--------|
| Model | 951A/9551A | Panalyzer SE - 8BZ type T100000 | SPA-3a |
|-------|------------|---------------------------------|--------|

|                 |               |                       |             |
|-----------------|---------------|-----------------------|-------------|
| Frequency range | 10mc to 10 GC | 30mc center frequency | 1KC to 15mc |
|-----------------|---------------|-----------------------|-------------|

|                |             |                        |              |
|----------------|-------------|------------------------|--------------|
| Scanning Modes | linear + 5% | linear, line, external | linear, line |
|----------------|-------------|------------------------|--------------|

|              |              |           |          |
|--------------|--------------|-----------|----------|
| Sweep widths | 100KJ to 2GC | 0 to 10mc | 0 to 3mc |
|--------------|--------------|-----------|----------|

|            |            |             |                 |
|------------|------------|-------------|-----------------|
| Resolution | 1KC to 1mc | 9KC to 30KC | 200 cps to 20KC |
|------------|------------|-------------|-----------------|

|                      |  |      |        |
|----------------------|--|------|--------|
| frequency Separation |  | 35KC | 2.2 KC |
|----------------------|--|------|--------|

|             |         |                                   |               |
|-------------|---------|-----------------------------------|---------------|
| Sensitivity | -55 dbm | 100mv w/.1V rms conversion signal | 25 uv to 1.4v |
|-------------|---------|-----------------------------------|---------------|

|                 |                               |                               |             |
|-----------------|-------------------------------|-------------------------------|-------------|
| Amplitude Scale | log, linear, & square (power) | log, linear, % square (power) | log, linear |
|-----------------|-------------------------------|-------------------------------|-------------|

|                    |                       |       |                         |
|--------------------|-----------------------|-------|-------------------------|
| Amplitude Response | + 1db any 200 mc B.W. | + 15% | + 15% to max cent freq. |
|--------------------|-----------------------|-------|-------------------------|

|                 |  |  |         |
|-----------------|--|--|---------|
| Input Impedance |  |  | 75 , 50 |
|-----------------|--|--|---------|

|                       |                       |                   |             |
|-----------------------|-----------------------|-------------------|-------------|
| Sweep Repetition Rate | 3m sec/cm to 1 sec/cm | 1 to 60 sweep/sec | 1 to 60/sec |
|-----------------------|-----------------------|-------------------|-------------|

|                 |  |  |                   |
|-----------------|--|--|-------------------|
| Internal Marker |  |  | 50KC & 500KC xtal |
|-----------------|--|--|-------------------|

|     |  |          |       |
|-----|--|----------|-------|
| CAT | P2 (others optional)<br>internal graticule | 5" 5ADP7 | 5ADP7 |
|-----|--|----------|-------|

|       |                |                        |                              |
|-------|----------------|------------------------|------------------------------|
| Misc. | complete as is | w/ external oscillator | requires external oscillator |
|-------|----------------|------------------------|------------------------------|

|       |           |     |     |
|-------|-----------|-----|-----|
| Power | 275 watts | 150 | 180 |
|-------|-----------|-----|-----|

|                      |                               |  |                      |
|----------------------|-------------------------------|--|----------------------|
| Size & Weight (loth) | 18 3/8D x 16 3/4W x 20"H 130# |  | 21 1/2 x 19" x 21" D |
|----------------------|-------------------------------|--|----------------------|

|       |        |        |        |
|-------|--------|--------|--------|
| Price | \$9500 | \$1500 | \$3400 |
|-------|--------|--------|--------|

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#### 6. True RMS Voltmeter

The Keithley 121 True RMS Voltmeter is recommended because of its frequency range and accuracy.

#### 7. Spectrum Analyzer

The Hewlett Packard 310 Spectrum Analyzer has adequate frequency range coupled with good resolution, sensitivity and low spurious response.

#### 8. Spectrum Display

Although the Singer-Metric SPA-3a requires an external oscillator and mixer to down-convert the 50 mc signal to 15 mc, it has the advantages of good resolution, bandwidth and sensitivity.

If no test equipment other than that specified will be available for use with the R.F. Test Console, consideration should be given to the procurement of some additional items, such as a recorder for the frequency counter, a camera for use with the oscilloscope and spectrum display, an r.f. signal generator, a power meter, and r.f. millivoltmeter, a differential voltmeter, a communications receiver and miscellaneous test equipment such as multimeters, bridges, etc.

#### P. Special Test Instrumentation

At present, it appears that very little special test instrumentation will be required. The major items will be mixers for up-converting and down-converting the 50 mc signal and at least one external frequency source. These items and their application are summarized below:

1. A mixer for up-converting the 50 mc signal to 70 mc so that the Marconi Modem Test Set MQ-26A can be used as a standard demodulator for checking the transmitters. A local oscillator source of 120 mc is also

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required but it is felt that a commercial signal generator can be used for this application since the mixer is required only for unit tests.

2. A down-converter and local oscillator will be required for use with the Spectrum Display. For the down-converter, it appears that the General Radio 874-MR is satisfactory and will meet the requirements of this application. A 65 mc local oscillator will be required.

3. In addition to the above, there may be some items which will be required for special test setups, such as directional couplers, power dividers and etc.

Addendum to Test Equipment

9. Power Meter

The General Microwave 450 A Power Meter is recommended because of its scale resolution. High resolution is required in setting up the linear S/N summer. Table 9 summarizes the characteristics of the instruments surveyed.

TABLE 9  
POWER METER

| SPECIFICATION       | HEWLETT PACKARD<br>Palo Alto, Calif.  | FXR<br>Woodside, N. Y.  | GENERAL MICROWAVE<br>Farmingdale, Long Island, N. Y.  |
|---------------------|---|---|---|
| Model               | 431 B   | B833A   | 450A<br>454A  |
| Range               | 7 ranges<br>Full scale readings, 10<br>microwatt to 10 MW<br>(-20dbm to + 10 dbm) | 4 ranges<br>Full scale readings,<br>10 microwatt to 10MW<br>(-20dbm to + 10dbm)                           | 5 ranges<br>.100 MW to 10 MW<br>(-10dbm to 10dbm)<br>13 ranges<br>*.3 W to 300 MW<br>(-45dbm to +25dbm) |
| Accuracy            | 3%(20-35°C); 5%(0-55°C)   | 3% (15-35°C); 5% (0-50°C)   | 1%  |
| Thermal Drift       |   | 2 W/°C  | .1%/°C  |
| Zero Carryover      | 1% of full scale when<br>zeroed on most sensitive<br>range                        | Yes   | Yes   |
| Operating Impedance | 100 or 200 ohms, negative   |   | 100 ohm negative  |
| VSWR                | 1.3   | 1.5   | 1.5   |
| Drift               | 25mc - 10gc   | 1.5 10MC-12.4 gc  | .01-10 gc<br>1.5 nanowatts  |
| Scale Resolution    |   |   | .1% of full scale   |
| Miscellaneous       | Recorder/Voltmeter Output<br>Requires 478A thermistor<br>mount                    | Provision for external<br>potentiometer devices,<br>recorder output<br>Requires N218C Thermistor<br>mount | Recorder/voltmeter<br>output<br>Requires Thermist<br>mount  |
| Power               | 2.5 W, 115/230 V + 10%,<br>50 to 1000 cps.  | 12 W, 115/230 V + 10%<br>50 - 60 cps.   | 55 W, 115/230 V±10%<br>50-1000 cps.<br>30W, 115/230 V<br>60 cps.  |
| Size & Weight       | 7 25<br>32 "W x 12 1/2" L x 6 5/8"H; 8#   | 13"W x 8 1/4" L x 6"H; 15#  | 7 1/2" W x 14" L x 11 1/2" H; 19#<br>18#  |
| Price               | 425. + 145 = \$570.00   |   | \$495 + 150 = \$645<br>\$475 + 175 = \$650  |

\* With N420 Thermistor mount,  
3 W to 30 MW



Outline For  
Test Plan For R.F. Test Console

- A. GENERAL
- B. FREQUENCY SYNTHESIZER
  - 1. Short Term Stability Test
  - 2. Long Term Stability Test
- C. PM TRANSMITTER/RECEIVER
  - 1. PM Transmitter
    - a. General
      - (1) Frequency
      - (2) Power Output
      - (3) Frequency Multipliers & Reference Output
      - (4) Bandwidth
    - b. Phase Modulator
      - (1) Frequency Response
      - (2) Phase Deviation
      - (3) Deviation Linearity
      - (4) Incidental AM
    - c. Amplitude Modulator
      - (1) Frequency Response
      - (2) Percent Modulation
      - (3) Modulation Linearity
      - (4) Incidental FM & PM

- 2. PM Receiver
  - a. General
  - b.\* Input amplifier
    - (1) Bandwidth
    - (2) Phase linearity
  - c.\* Voltage Controlled Oscillator
    - (1) Frequency
    - (2) Stability
    - (3) Manual Tuning
    - (4) Locked Condition
  - d.\* Balanced Modulators
    - (1) Spurious & Carrier rejection
  - e.\* IF Amplifiers
    - (1) Frequency response
    - (2) Phase response
  - f.\* Reference Oscillator
    - (1) Frequency & Phase Stability
  - g. Phase Detectors
    - (1) Bandwidth
    - (2) Fidelity
    - (3) Gain Constant
    - (4) Phase Adjustment
  - h. Phase Loop
    - (1) Gain
      - (a) Static Phase Error

(b) Gain Stability

(2) Filter Bandwidth and Response

i. Amplitude Detectors

(1) Bandwidth

(2) Linearity

(3) Phase adjustment & manual gain control

j. AGC

(1) Loop Gain

(2) Filters

k. Offset Frequency

l. DC & AC Isolation amplifiers & PM predetection playback

3. PM Transmitter/Receiver Pair

a. Phase Stability

b. Fidelity

4. Phase Noise Instrumentation

D. FM TRANSMITTER/RECEIVER

1. FM Transmitter

a. General

(1) Transmitter Center Frequency

(2) Power Output

(3) Frequency Multipliers & Reference Output

(4) AFC Operation

(5) Bandwidth

b. Frequency Modulator

(1) Response & Sensitivity

(2) Frequency deviation

- (3) Deviation Linearity
  - (4) Incidental AM
  - c. Amplitude Modulator
2. FM Receiver
- a. General
  - b. Input Filter
    - (1) Bandwidths
    - (2) Amplitude Characteristics
    - (3) Linearity
  - c. Limiter
    - (1) Dynamic Range
    - (2) Waveform
  - d. Conventional FM detector
  - e. Phase Lock FM Detector
    - (1) Voltage controlled oscillator
    - (2) Phase detector
    - (3) Loop gain
    - (4) Loop filter
  - f. \*Output filter
    - (1) Response and Bandwidth
  - g. Offset Frequency
  - h.\* Balanced Modulator
  - i.\* DC & AC Isolation amplifiers & FM predetection playback
3. FM Transmitter/Receiver Pair
- a. Frequency Stability

- b. Static Linearity
- c. Dynamic Linearity

**E. LINEAR S/N ADDER (Section IV)**

**F. MISCELLANEOUS**

- 1. Purchased Instrumentation
- 2. Console Assembly Equipment
- 3. Interference

TEST PLAN

A. General

This test plan describes the type of tests and the test measurements to provide performance data of the completed assemblies. In some cases, two types of tests will be used for comparison purposes. Tests of the individual items for bandwidth, response and etc., will be made and documented by the designer of the specific components, using the test setups needed to achieve the level of performance. This will require comparison methods and use of a calibrated reference, such as the Weinschel Engineering high precision attenuators and dual channel measuring setup. In some of the steps, a meter is shown as the indicator. If this is not accurate enough, the meter will be used only as a detector and the Weinschel dual channel system will be used as the method for comparison.

Those tests which are starred (\*) are appropriately unit tests and they are listed for completeness.

B. Frequency Synthesizer

Since a number of the frequencies which are used throughout the console are derived in the frequency synthesizer, the determination of stability of the reference as well as the multiplied frequencies is of the greatest importance.

1. Short Term Stability Test

The short term stability of a crystal oscillator is, at the longer averaging times, predominantly controlled by oscillator defects and, for very short averaging times, approaches the limits set by the

thermal noise of the crystal. It has shown that the frequency deviation

$$\frac{\Delta f}{f} = \frac{2\pi}{\pi f_0} \sqrt{\frac{4KT B}{P}} \quad (1)$$

where

- $\tau$  = averaging time
- $f_0$  = oscillator frequency
- $K$  = Boltzman's constant
- $T$  = absolute temperature
- $B$  = bandwidth of network
- $P$  = crystal driving power

As can be seen the frequency deviation is inversely proportional to the averaging time. Although no accepted standards exist for the specification of short term stability, the method most suitable for the evaluation of the oscillator performance is to specify the standard deviation,  $\sigma$ , for a specified confidence level. Phase deviation can be computed from the frequency deviation by the relation

$$\Delta \phi (\text{radians}) = (2\pi f) \left( \frac{\Delta f}{f} \right) \tau \quad (2)$$

Short term stability tests have already been made. The method, repeated here, was covered in the May 1964 Monthly Status Letter.

#### LMC Frequency Standard and X5, X2, X2 Frequency Multipliers

The short term stability of the LMC standard was measured as indicated in figure 1.

1. E. Hafner "Stability of Crystal Oscillators", Proc. 14th Annual Symposium on Frequency Control, 1960 p. 192-199.

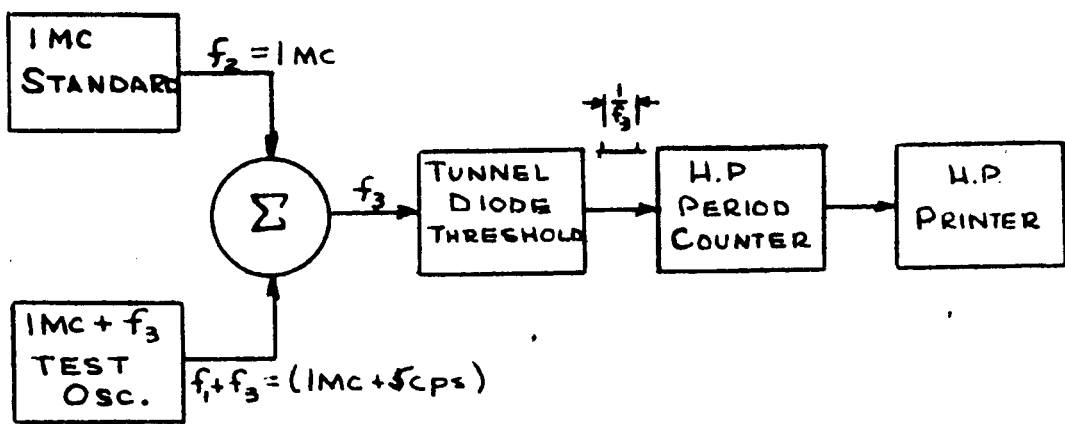


Figure 1. Oscillator Short Term Stability Test Set

The oscillator under test,  $f_1$ , is offset from a lmc standard,  $f_2$ , with known short term stability characteristics by an arbitrary frequency,  $f_3$ . The two oscillator outputs are linearly summed, envelope detected and the resultant threshold-detected with a low noise tunnel diode. The difference frequency ( $f_3$ ) is converted to an impulse whose pulse repetition time (PRT) is  $\frac{1}{f_3}$  plus the oscillator's short term instabilities.

The period counter counts the time between pulses,  $\frac{1}{f_3}$ . The variation in count is a dimensionless number which is a measure of the oscillator's short term instabilities as expressed by:

$$\frac{\Delta \text{ count}}{\text{counter capacity}} \times \frac{f_3}{f_1}$$
 For example, if  $f_3 = 5 \text{ cps}$ , counter capacity = 6 place and  $\Delta \text{ count} = 4$ , then, the short term stability =  $\frac{4}{200,000} \cdot \frac{5}{10^6} = 1 \text{ part in } 10^{-10}$ .



The  $\Delta$  count is printed for alternate 200,000 usec periods and may be read out as peak  $\Delta$  count or computed as RMS. One hundred printed samples were taken to enhance the confidence level in either the peak or RMS  $\Delta$  count levels.

This technique yielded a short term stability of 1.6 parts in  $10^{-11}$  (RMS) referred to 1 sec integration time. The 1 second integration time was chosen, as a loop with 2 BLO of 3 cps will perform virtually no correction on a 1 cps input. The relationship of the dimensionless number of 1.6 parts in  $10^{-11}$  (RMS) to degrees of phase jitter ( $\Delta\phi$ ) at 50 mc is outlined as follows:

$$\begin{aligned} \Delta\phi \text{ (degrees)} &= (2\pi f) \left( \frac{\Delta f}{f} \right) \times \pi \times 57.3 \\ &= (2\pi \times 50 \times 10^6) (1.6 \times 10^{-11}) (1 \text{ second}) \times 57.3 \\ &= .288^\circ \text{ rms phase jitter} \end{aligned}$$

This technique may be of interest but it does not provide an easily interpreted measure of performance when compared to the JPL spec.: namely, 3 degrees peak phase error in a noise free coherent receiver with 2BL of 3.0 cps. Therefore, 1-H(S)  $\left[ \frac{e(s)}{\theta_e(s)} \right]$  was mechanized on the analog computer as follows:

$$\frac{e(s)}{\theta_e(s)} = \frac{s^2}{s^2 + \sqrt{2} B_0 s + B_0^2}$$

or 
$$e(s) = \theta_i(s) - \frac{e(s)}{s} \sqrt{2} B_0 - \frac{e(s)}{s^2} B_0^2$$

scaling:  $2BL_0 = 3 = 6.6 f_0, f_0 = \frac{B_0}{2\pi}$   
 $B_0 = \frac{3 \times 2\pi}{6.6} = 2.86 \text{ RAD/SEC}$   
 $B_0^2 = 8.21 \text{ [RAD/SEC]}^2$   
 $\sqrt{2} B_0 = 4.05 \text{ [RAD/SEC]}$

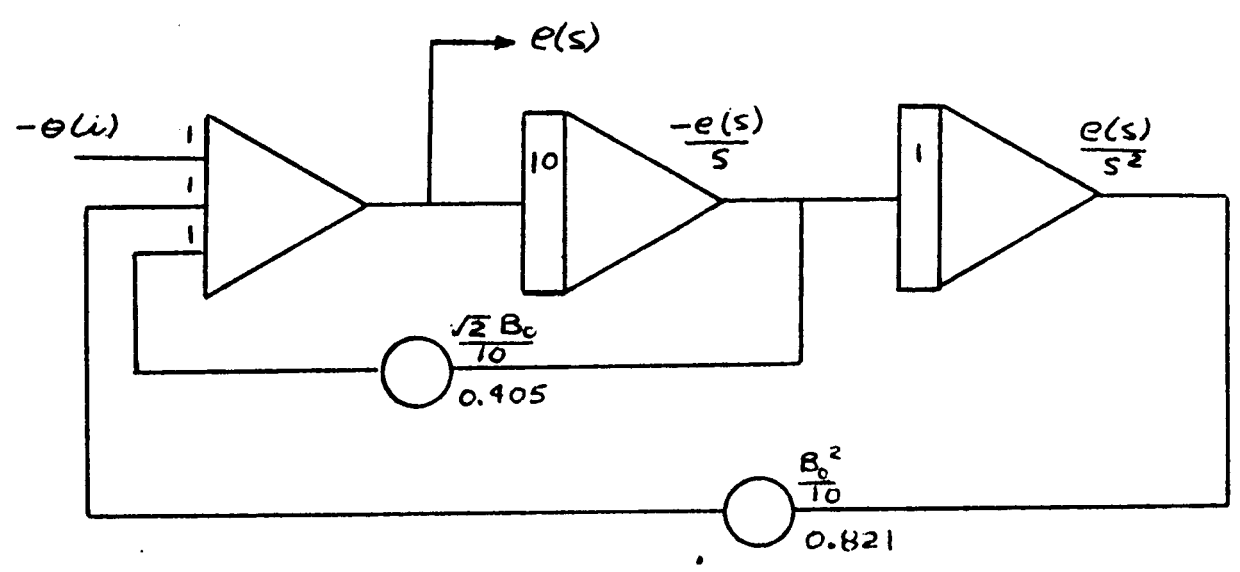


Figure 2. Analog Computer Simulation

Further, the oscillators (test and standard) were organized as follows:

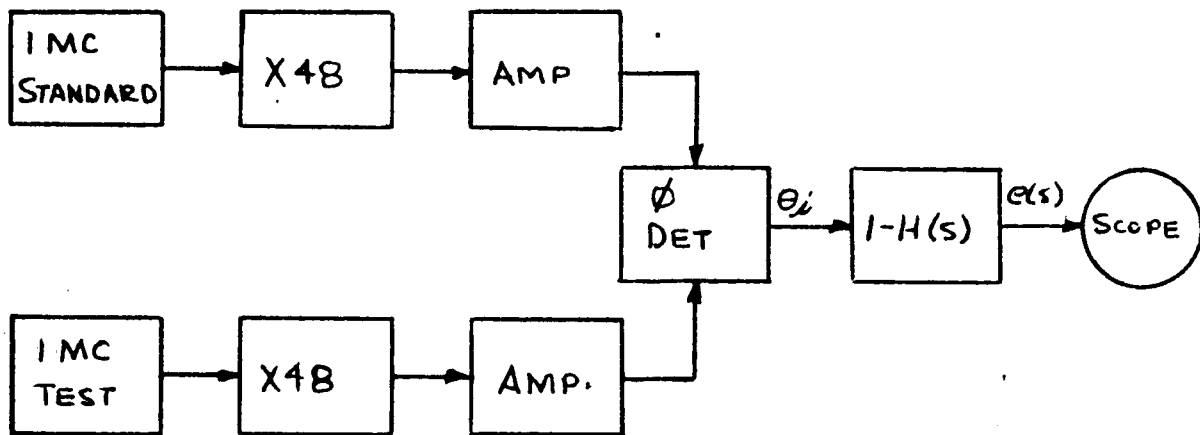


Figure 3. Oscillator Short Term Stability Test with Simulated  $2RL_0 = 3.0$  cps

Initially, the oscillators were offset to calibrate the scope in  $\frac{\text{volts}}{\text{radian}}$ .

The oscillators were tuned to zero beat and the phase noise in  $2RL_0$  of 3 cps measured on the scope as 1.43 degrees peak i.e. truly, "peak" is meaningless in a statistical sense as pointed out by Mr. Frank Charles; however, this was the "grass level" viewed on the scope. Secondly, the system was connected as follows:

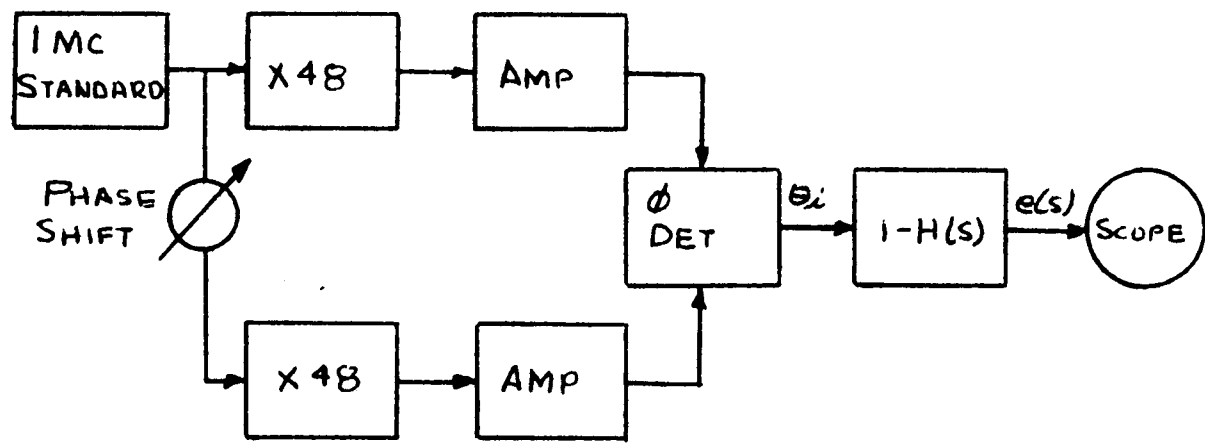


Figure 4. Multiplier, Amplifier, Phase Detector Short Term Stability Test

$J_0(\beta)$ , as seen on the spectrum analyzer disappears. (This can also be monitored by the carrier suppression measurement equipment if available). This represents the first carrier null and occurs for a modulation index  $\beta = 2.4048$ . Data is then taken of the voltage needed to null the carrier as a function of modulating frequency. A curve is then plotted as shown in figure 6. For phase modulation,  $\beta = \Delta\theta$  and so changes in modulating frequency will only spread the sidebands and not change the level or their number, since  $\Delta\theta$  is not being changed. Response will also be checked for other deviations, such as  $\beta = 3.8$  for the first sideband null.

At deviations below 2.4048, the response should be good and there should be no tendency to clip off the sidebands. Consequently, if the response is good at 2.4, it should be good at lower B's, and,

$$\frac{\beta_x}{\beta_{2.4}} = \frac{V_x}{V_{2.4}}$$

A check of the response at modulation indices less than 2.4 will be made by means of a spectrum analyzer. Since the carrier and first sideband amplitudes are functions of  $\beta$ , their ratio is a measure of the modulation index. As the  $\beta$  is reduced, the ratio can be measured and the modulation index found from tables or curves. The measurement will be made by means of a reference generator and a precision attenuator in which its output level is matched to the levels of the carrier and sidebands.

C. PM Transmitter/Receiver

1. PM Transmitter

a. General

Input-output characteristics of the transmitter, such as impedances and levels will be measured. The impedances will be measured with an RF bridge such as the General Radio 1606A or the Founton 250A IM Meter. Measurements with these instruments can be made to accuracies within 2-3% at 50 mc. Levels will be measured with a power meter, the Hewlett Packard 431B. This is a very stable instrument and measurement accuracies of 3% are attainable.

(1) Transmitter Center Frequency

This is a demonstration of capability and will be verified with a frequency counter such as the HP5245L. A measurement accuracy of  $\pm 1$  count  $\pm 3$  parts in  $10^9$  per day can be obtained with this instrument.

(2) Power Output (covered above)

(3) Frequency Multipliers and Reference Output

This was covered in Section E.

(4) Bandwidth

Bandwidth and frequency response will be determined by the setup shown in Figure 6. An audio oscillator is used to modulate the phase modulator and a spectrum analyzer or a narrow band receiver is used to monitor the output.

With the modulating frequency of the oscillator at a low value, the output voltage  $V$  of the oscillator is adjusted until the carrier,

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$J_0(\beta)$ , as seen on the spectrum analyzer disappears. (This can also be monitored by the carrier suppression measurement equipment if available). This represents the first carrier null and occurs for a modulation index  $\beta = 2.4048$ . Data is then taken of the voltage needed to null the carrier as a function of modulating frequency. A curve is then plotted as shown in figure 6. For phase modulation,  $\beta = \Delta\theta$  and so changes in modulating frequency will only spread the sidebands and not change the level or their number, since  $\Delta\theta$  is not being changed. Response will also be checked for other deviations, such as  $\beta = 3.8$  for the first sideband null.

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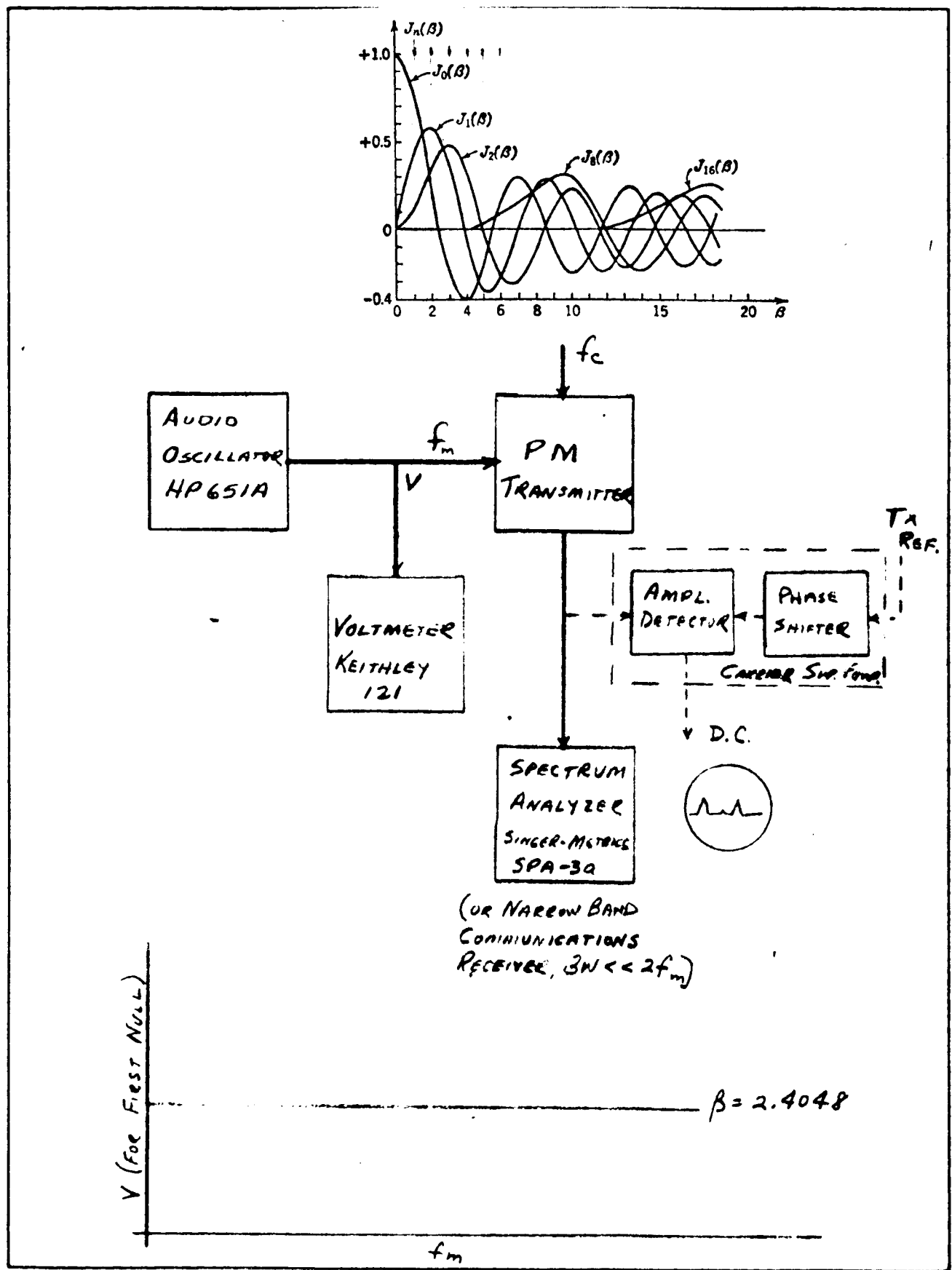


Figure 6. Test Setup for Frequency Response & Sensitivity

For this method to give accurate results, the incidental AM must be low as incidental AM on a PM spectrum increases the amplitude of one sideband and decreases the amplitude of the other.

For this reason, these tests will also be made with an available standard demodulator, the Marconi Modem Test Set, NQ-26A. This demodulator is sufficiently accurate\* to determine if the transmitter meets the required performance. For this test a conversion to the frequency of the test set (70 mc) is required. When the standard demodulator is used, its output is the modulating frequency plus any distortion products at a level proportional to  $\beta$ .

b. Phase Modulator

- (1) Frequency Response
- (2) Phase Deviation

Both of these items are checked in Cla(4).

- (3) Deviation Linearity

A qualitative measure of the distortion will be obtained by use of the arrangement in figure 6. This shows up as a greater number of sidebands than should be there. However, this will only show distortion which is rather bad, say 5-10%.

A more accurate measure of distortion is by use of the two tone test. In this test, figure 7, the transmitter will be modulated with two tones, each within the bandwidth, and the output observed by means of the standard demodulator and spectrum analyzer (or a spectrum display).

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• Specifications on this set are itemized at the end of this section.



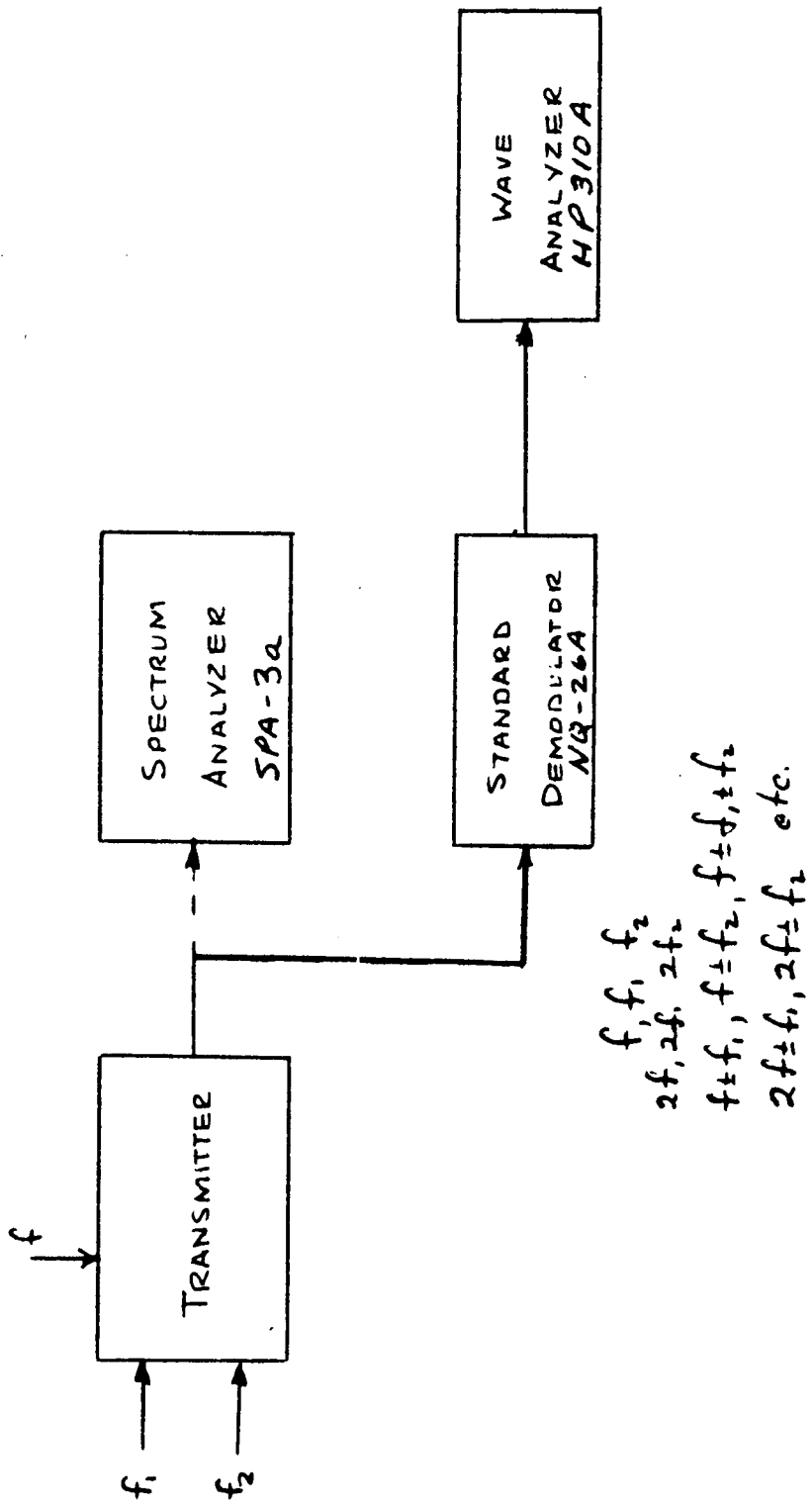


Figure 7. Deviation Linearity

All intermodulation components produced by the two tones can be seen and evaluated in terms of the amplitude of the undesired signal required to give a specified output compared with the amplitude of the desired signal to give the same amplitude. Thus, if an image voltage must be 100 times as strong as the desired signal to produce a given output, then the image discrimination is 40db.

With respect to the phase modulator, the goal of this measurement is to determine if the intermodulation and spurious products are down -46db (as noted in the PI modulator design). Using the Hewlett Packard 310 Spectrum Analyzer, a measurement accuracy of 1.0db appears practical. It will be necessary to do the two tone test with two or three pair of tones and for two or three different modulation indices in order to obtain a good measure of distortion.

(L) Incidental AM

Incidental AM will be checked by observation of the output of the transmitter on a scope (figure 3) for several deviations and modulating frequencies. Other methods, such as a spectrum analyzer and envelope detector will also be used as a check. These methods will give an indication of the presence of incidental AM with about 2% resolution. If a more accurate indication is required, an AM receiver calibrated for definite amplitude modulations will be used.

c. Amplitude Modulator

1. Frequency Response

Response of the modulator will be measured by putting known tones into the modulator and envelope detecting the output of the transmitter,

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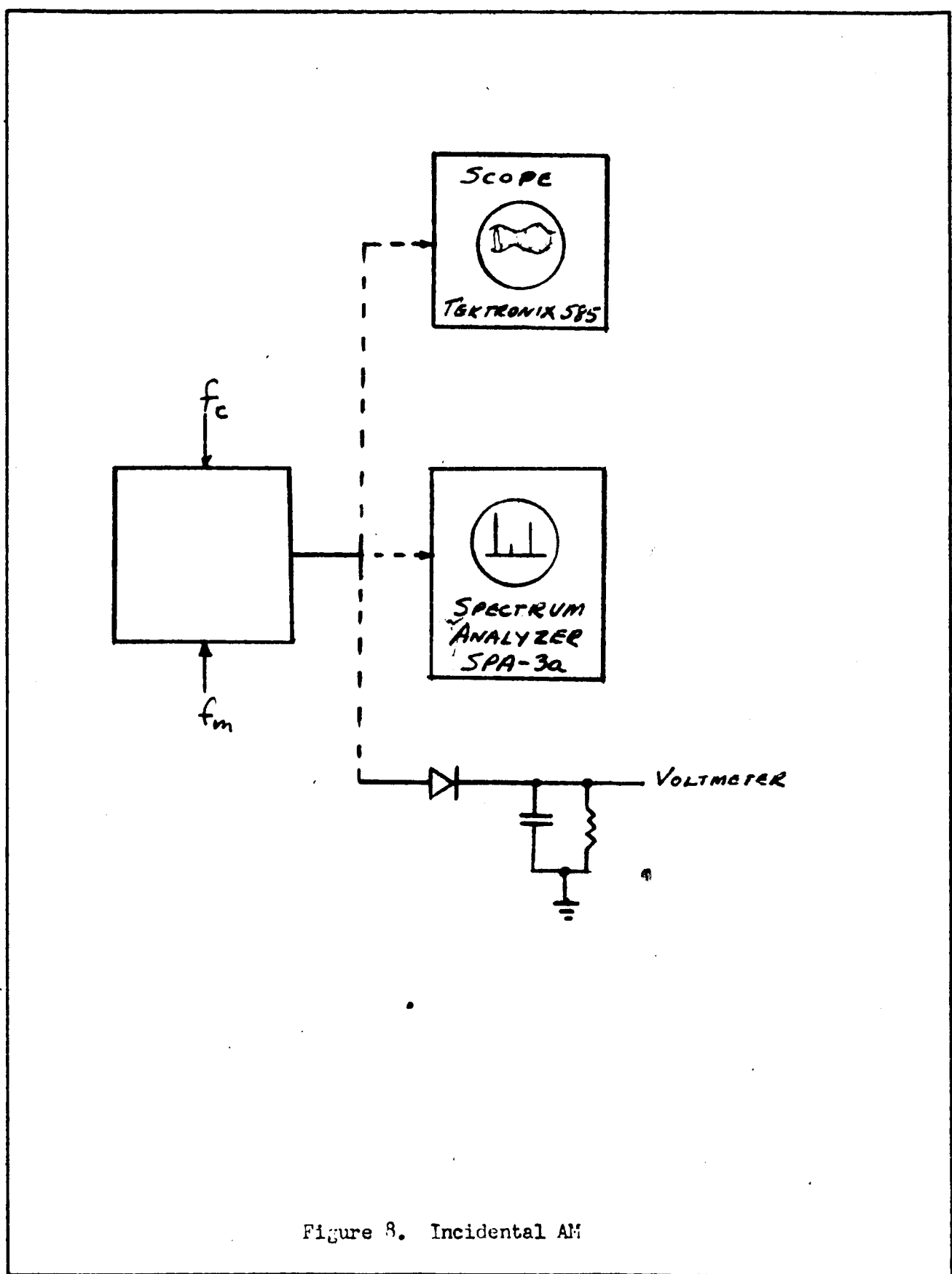


Figure 8. Incidental AM

figure 9. As  $f$  is varied, with  $V_1$  being fixed, the change of  $V_2$  with  $f$  gives a measure of response. This will be done for various modulations up to 50%. With this, method, it is, of course, necessary to know the characteristics of the envelope detector. Data supplied by General Radio on the 874VQ indicate that its response is flat at these frequencies. However, a spot calibration will be made by injection of known frequencies and levels and measurement of the output with a voltmeter.

## 2. Per Cent Modulation

The degree of modulation will be determined by the setup shown in figure 10. Changes in the level of  $V_1$  change the percent modulation. With this type of measurement, an accuracy of 10% is probable.

### (3) Modulator Linearity

Linearity will be determined by the two tone test already discussed.

### (4) Incidental FM & PM

Incidental FM and PM will be determined by monitoring the output of the transmitter with the standard demodulator, figure 11. The presence of an output and the frequency at which it occurs is a measure of incidental angle modulation.

## 2. PM Receiver

### a. General

Once the PM transmitter has been fully tested, it will be used as a test set for checking out the PM receiver. As with the transmitter, input/output impedances and levels will be measured.

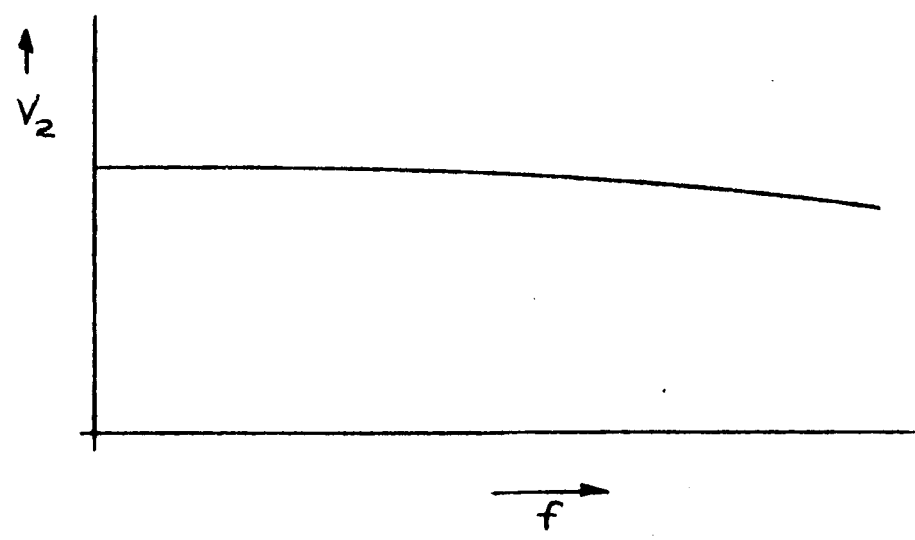
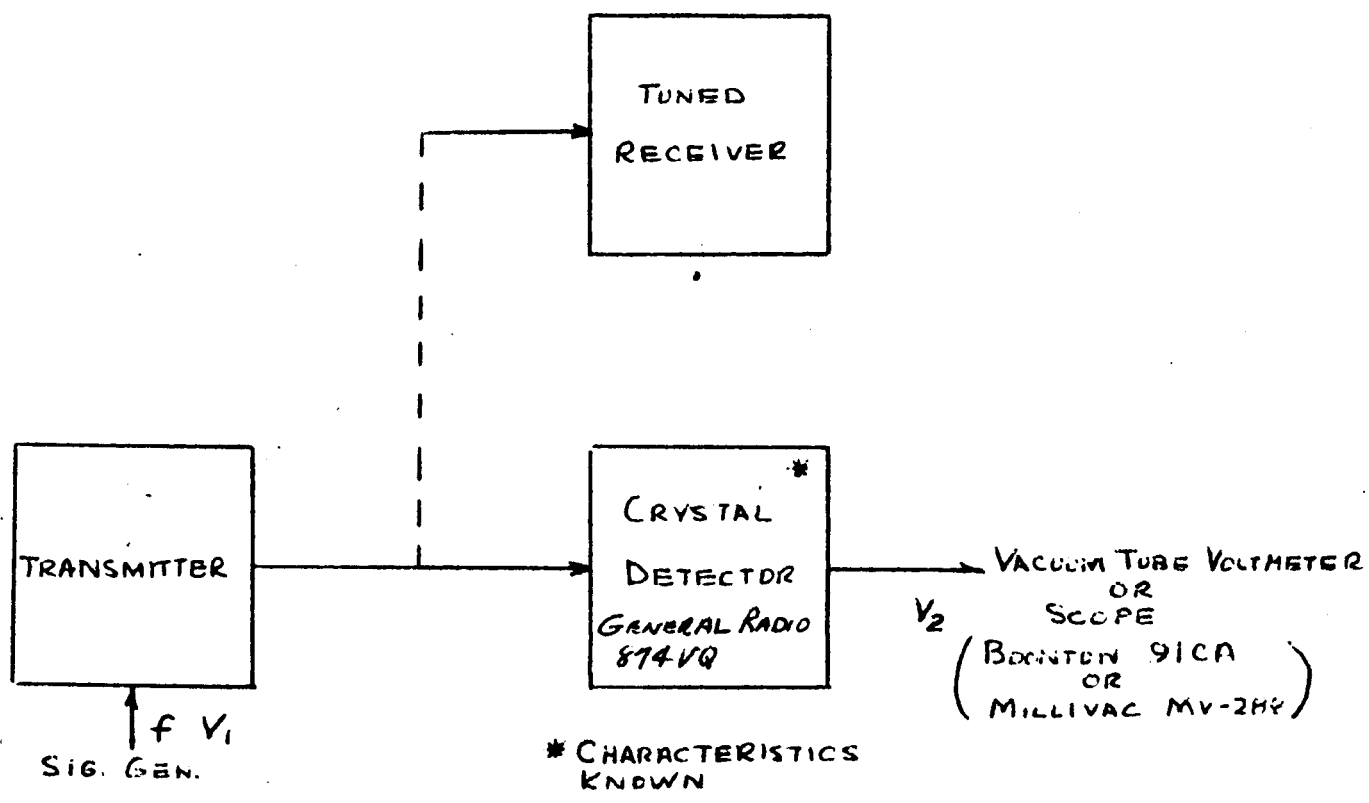
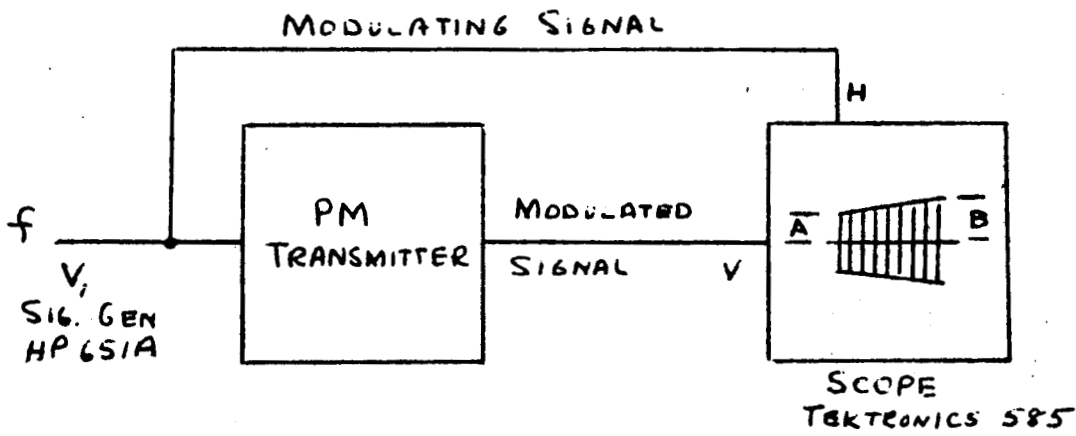


Figure 9. Frequency Response



AMPLITUDE MODULATION  $m = \frac{B-A}{B+A}$

Figure 10. Percent Modulation

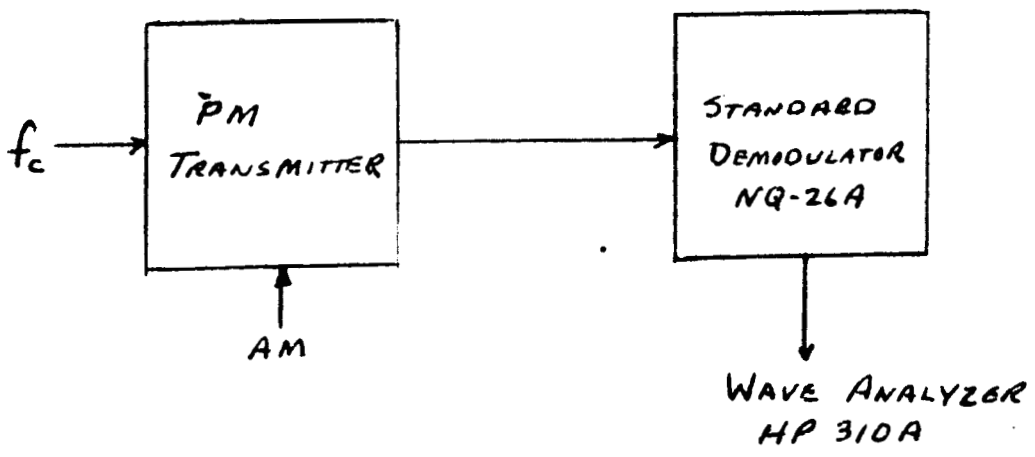


Figure 11. Incidental FM and PM

b. Input Amplifier

(1) Bandwidth

An initial measurement of the response will be made with swept frequency techniques. Final measurement of response will be made by injecting known frequencies across the band and measuring the output with the Weinschel dual channel setup as shown in figure 12. As shown, the rf signal is divided into two channels and the detected outputs of both channels are amplified and balanced to zero in the Synchronous Differential Null Detector (ND-2). When the amplifier to be tested is inserted, audio attenuation is changed in the BA-5 to keep the signal levels at the ND-2 balanced and constant. The attenuation is then equal to the difference in the BA-5 settings. Measurement accuracies well within the specified requirements of  $\pm .25\text{db}$  can be obtained with this method.

(2) Phase Linearity

This will be tested as part of the receiver fidelity test. However, a preliminary check of linearity will be made by means of the two tone test.

c.\* Voltage Controlled Oscillator

(1) Frequency

The frequency will be verified with a counter to an accuracy of  $\pm 1$  count  $\pm 3$  parts in  $10^9$ /day with the HP5245L.

(2) Stability

The stability will be checked as part of the overall stability of the pair. A preliminary check of stability will be obtained by use of the HP5245L counter and operation for an 8 hour period.



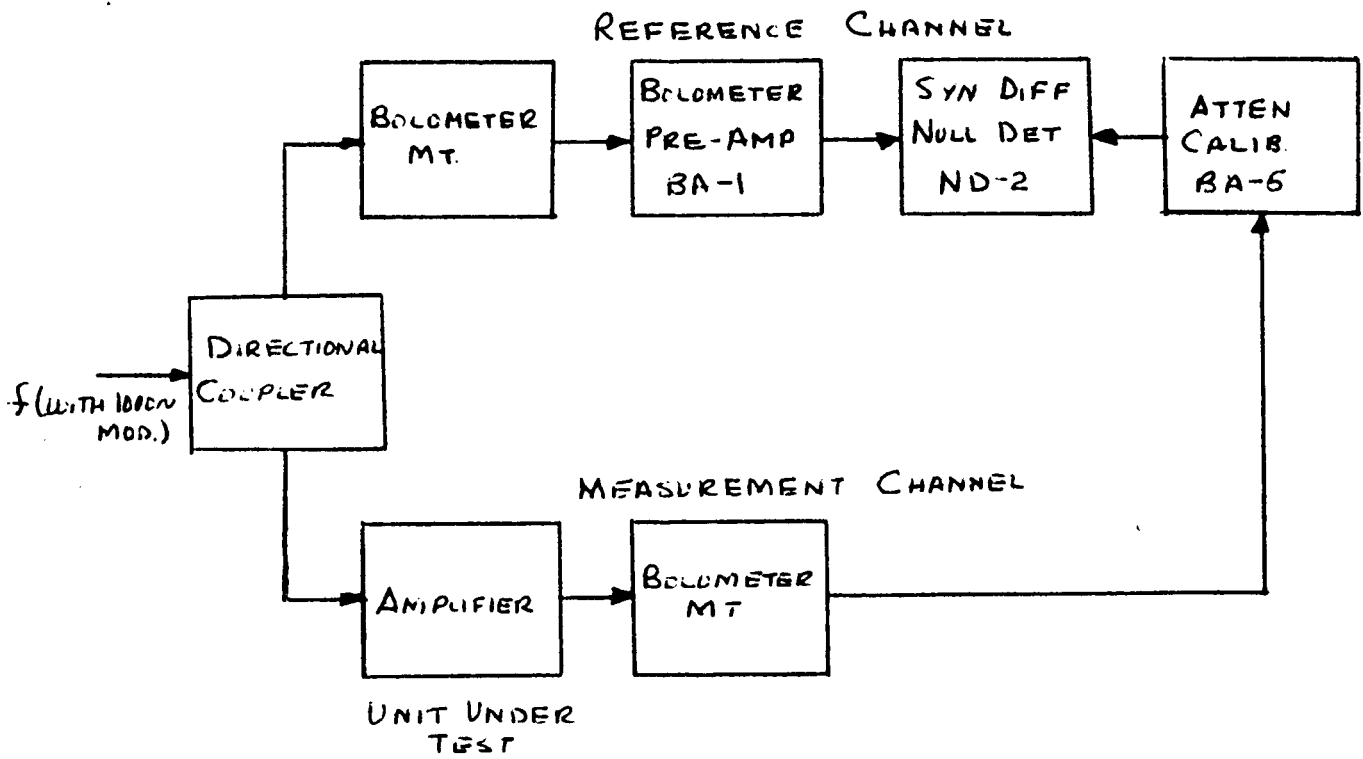


Figure 11. Input Amplifier Response

- (3) Manual Tuning - demonstration of a capability
- (4) Locked Condition - demonstration of a capability

d.\* Balanced Modulator

- (1) Carrier and spurious rejection

Carrier and spurious rejection will be determined (figure 13) by feeding the carrier and a known tone  $f$  into the modulator and observing the output of the modulator with a spectrum analyzer with a resolution greater than  $2f$ . An amplitude accuracy of 1db is probable. Since the output frequencies will bear simple integral relationships with the input frequencies, the frequency accuracy is that of the input frequencies. A search will be made for other spurious outputs. In this case, the HP5245L counter can be used to check any marker frequencies.

e.\* IF Amplifiers

- (1) Frequency response

The response will be checked with the Weinschel Dual channel setup as shown in figure 12.

- (2) Phase response

Phase response will be measured by use of one of the 10mc phase detectors which will be built and whose phase response (volts/degree) will be known, figure 14.

f.\* Reference Oscillator

- (1) Frequency and phase stability

This will be checked as part of the stability tests of the transmitter/receiver pair. Preliminary tests will be made with the HP5245L frequency counter.

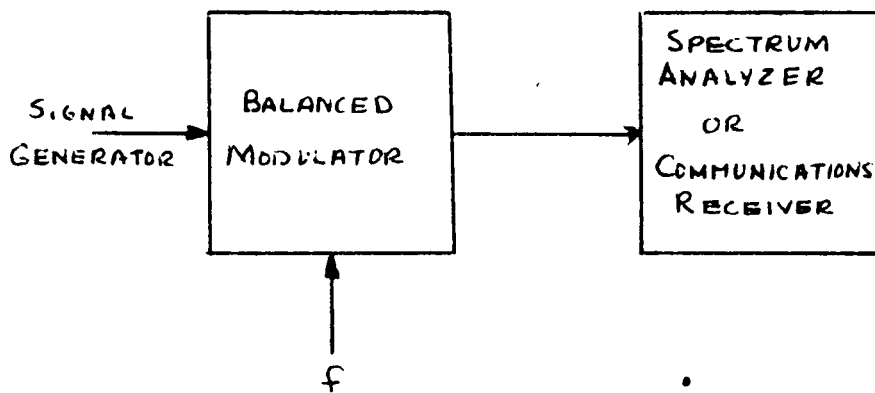


Figure 13. Balanced Modulator

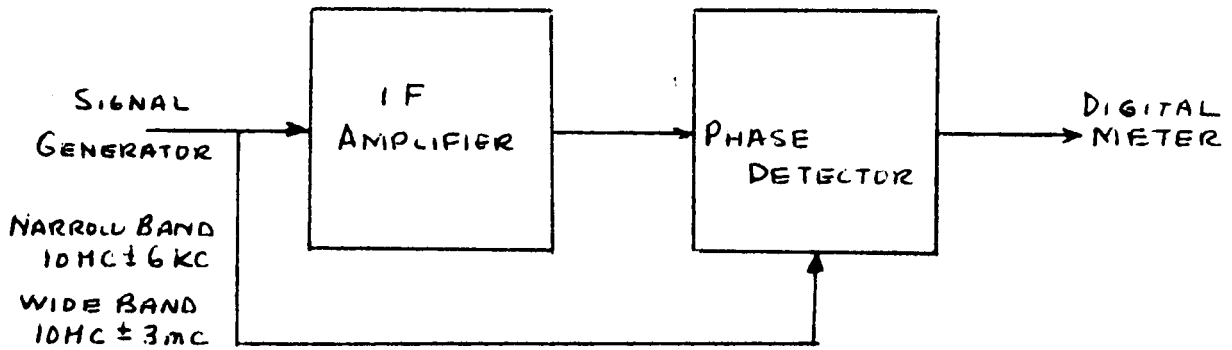


Figure 14. Phase Response of IF Amplifiers

g. Phase Detectors

(1) Bandwidth (Figure 15)

Open the phase loop, vary the input frequency and measure the output of the phase detector as a function of the difference between the input frequency and the VCO ~~present~~ frequency. The beat frequency will be measured with a counter, the amplitude with true r.m.s. voltmeter or scope. Forecast measurement accuracy, 2%.

(2) Fidelity

Fidelity will be checked as part of the transmitter/receiver pair test. A measure of fidelity will be obtained from the response data.

(3) Gain constant (volts/radians)

The gain constant will be determined from the response data taken.

(4) Phase adjustment - demonstration of a capability

h. Phase Loop

(1) Gain

The gain of the individual loop parameters will be determined and then the loop gain calculated ( $GAIN_{AT} / RAD / SEC = K_A K_{VCO} K_{OD}$ ). In addition, the loop gain will be measured by the method shown in figure 16. An error signal is introduced into the loop with a low frequency function generator and  $e_0, e_1$  and  $e_2$  measured with a scope. Then

$\frac{error}{e_1} = \frac{e_2}{e_1} = \frac{1}{1+G(s)}$  can be plotted as a function of frequency. Then  $\frac{1}{1+G(s)} \approx G(s)$  for  $G(s) \gg 1$

(a) Static Phase Error (figure 17)

The static phase error will be measured by measuring

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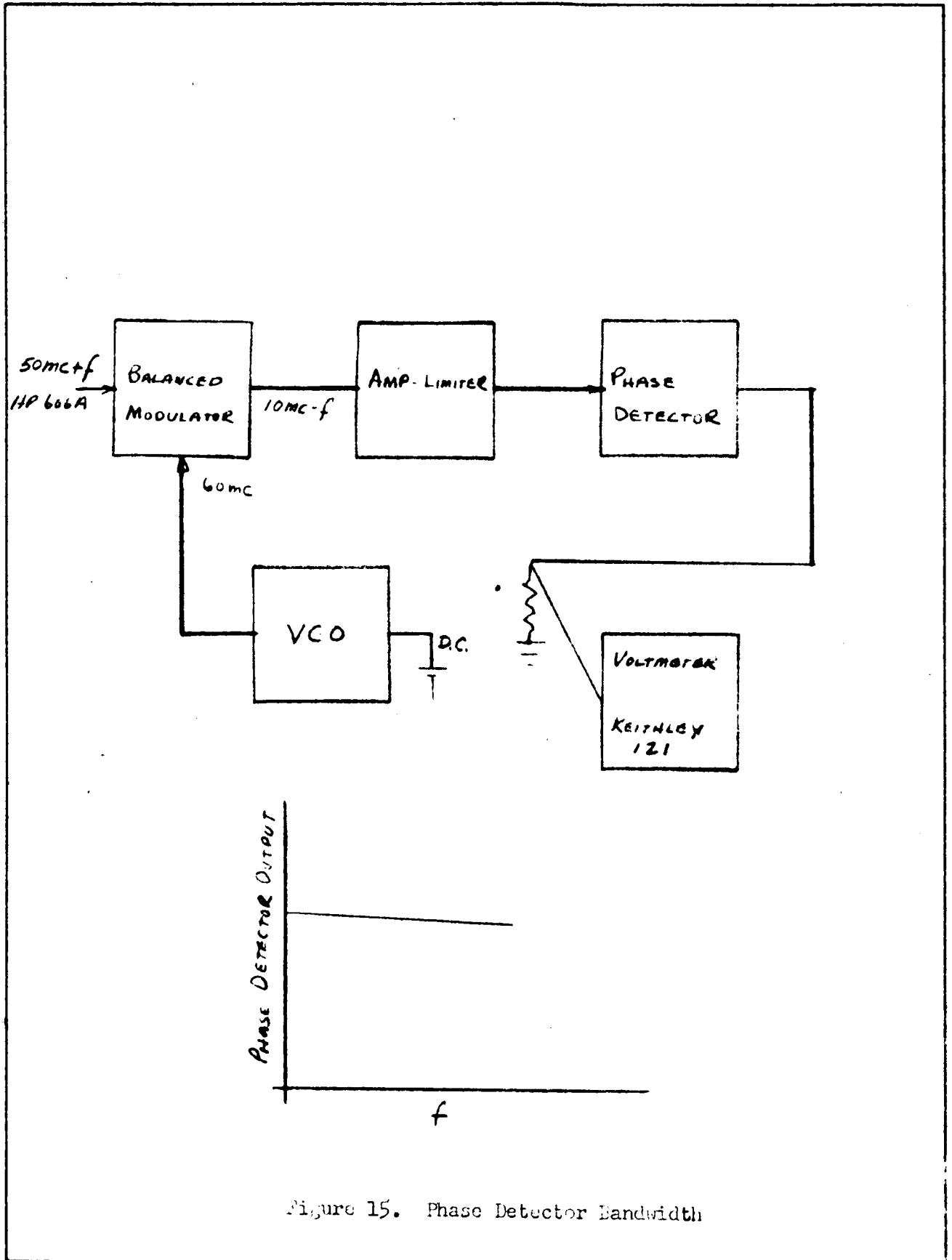
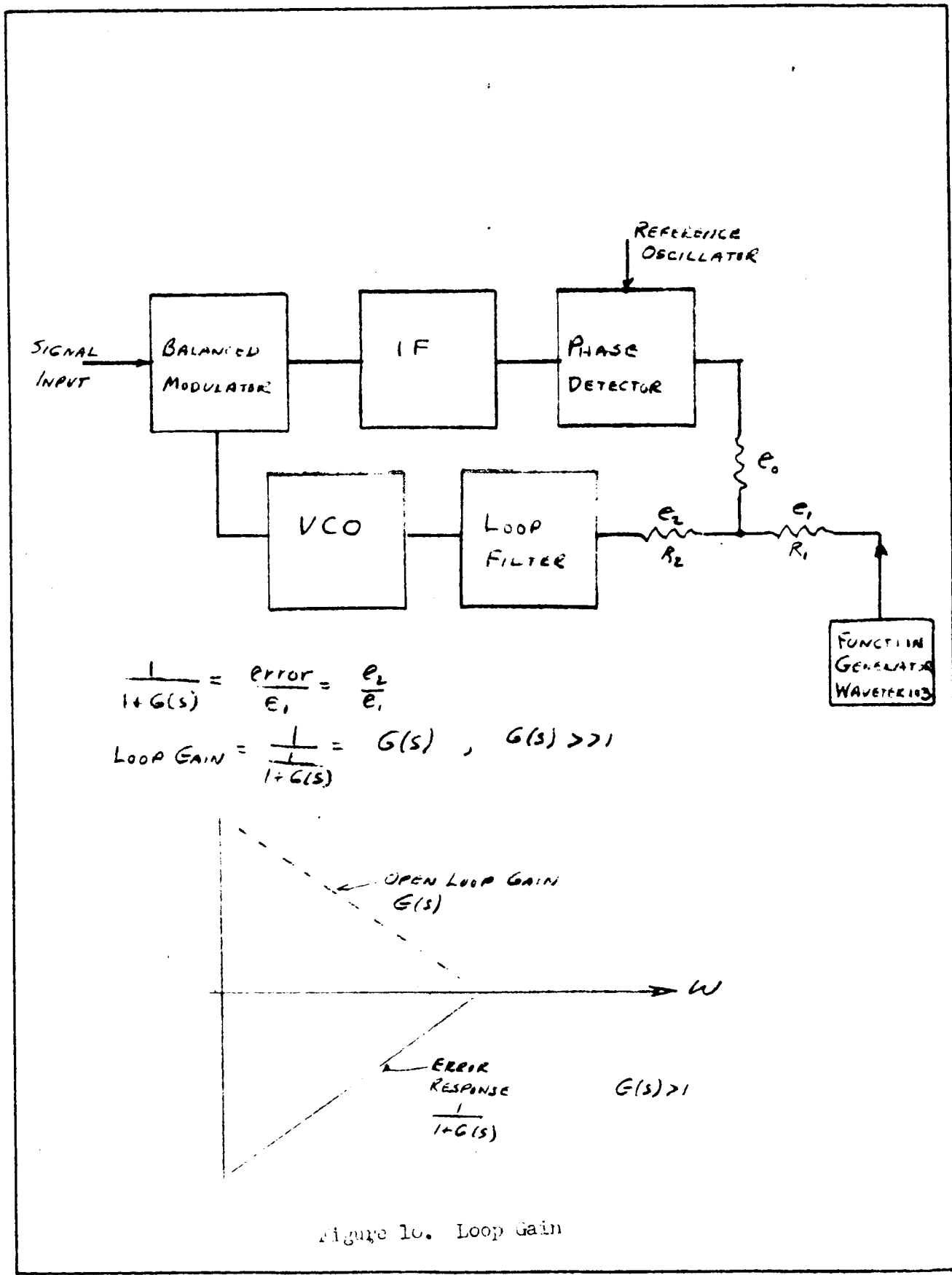


Figure 15. Phase Detector Bandwidth

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$$\frac{1}{1+G(s)} = \frac{\text{error}}{e_1} = \frac{e_2}{e_1}$$

$$\text{LOOP GAIN} = \frac{1}{\frac{1}{1+G(s)}} = G(s), \quad G(s) \gg 1$$

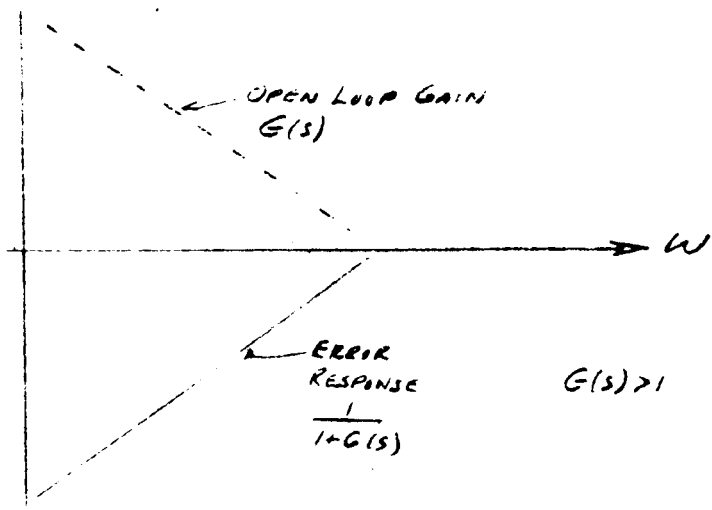


Figure 10. Loop Gain

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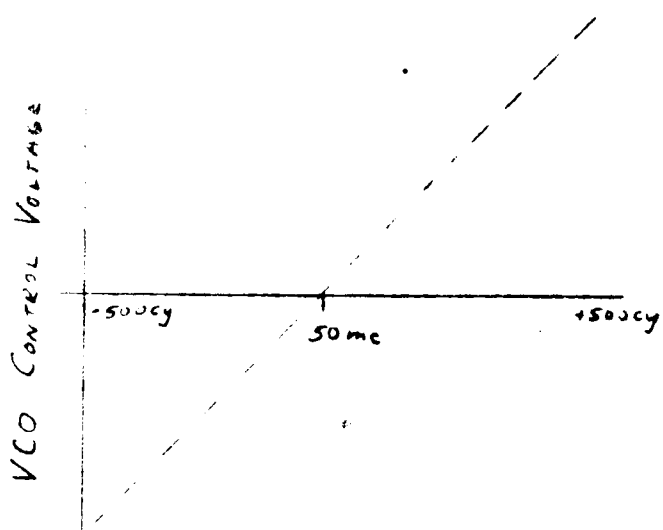
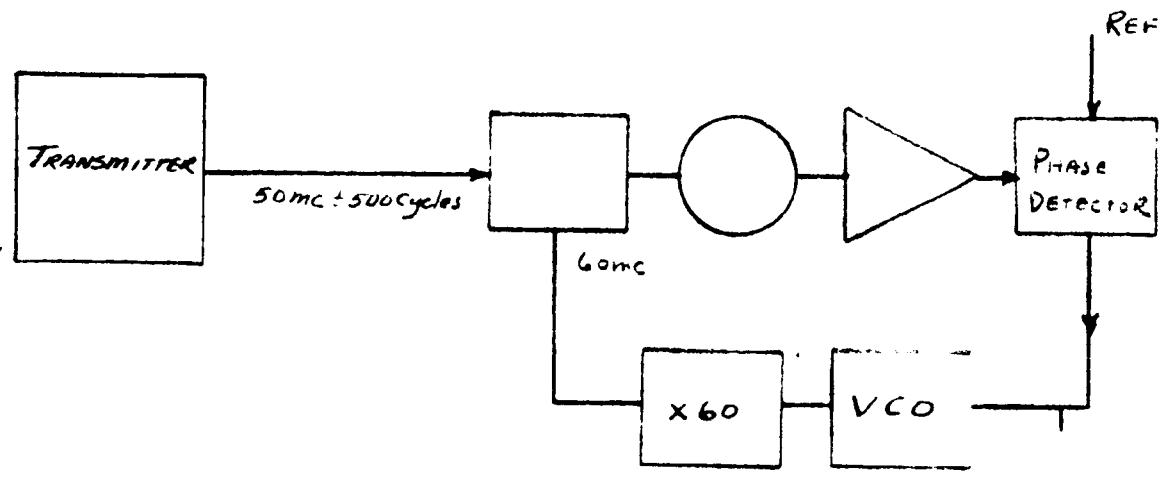


Figure 17. Static Phase Error Gain Stability

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at the output of the phase detector as the transmitter frequency is adjusted over the 500 cycle-tuning range.

(b) Gain Stability

Will be determined by measuring the VCO control voltage as a function of the change of the transmitter frequency. The nearest straight line is the nominal. Since this voltage can be measured with a digital voltmeter, an accuracy of 1% is probable.

(2) Filter Bandwidths

Filter bandwidths will be measured by the setup shown in Figure 16.

i. Amplitude Detectors

(1) Bandwidth

The bandwidth will be checked by feeding known signals into the detector and noting any change in level, with changes in frequency. This will be done at several input levels. See Figure 18.

(2) Linearity

(a) Static

Static linearity will be determined by connecting the transmitter to the receiver with the AGC disabled, varying the transmitter carrier level and measuring the change with a d.c. meter on the output of the AM detector (Figure 19a). The measurement accuracy depends on the accuracy of the attenuator and the digital voltmeter. In this case, the Weinschel attenuators and the HP3400A digital voltmeter will be used. The attenuators are accurate to a .1db while the digital

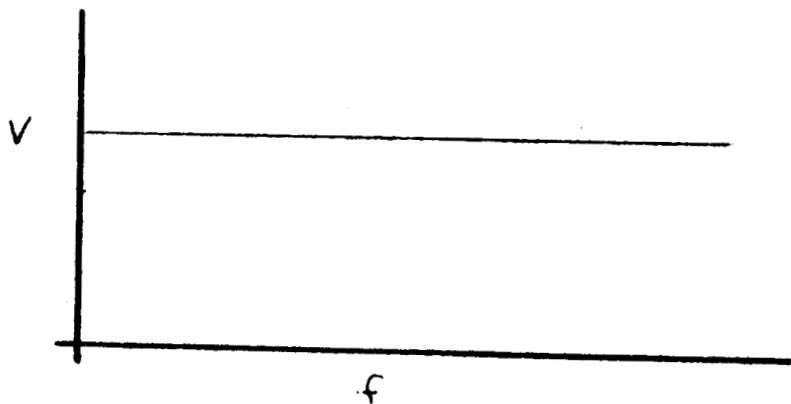
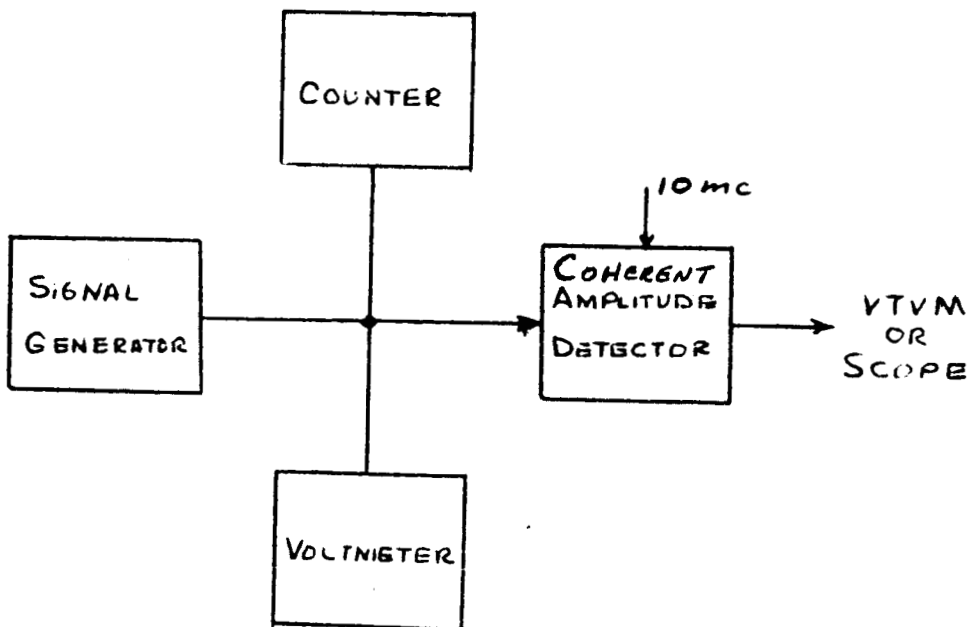


Figure 14. Amplitude Detector Bandwidth

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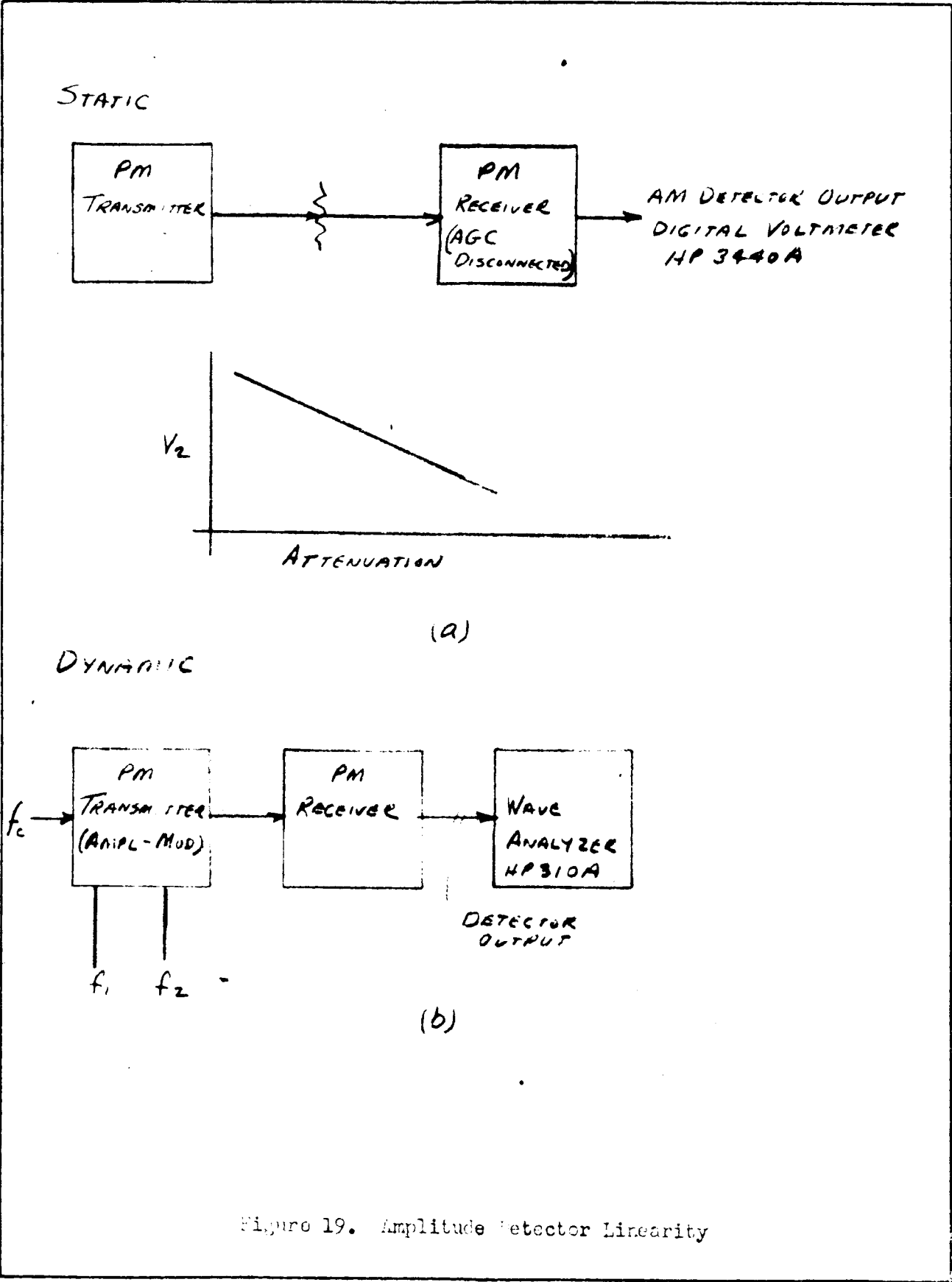


Figure 19. Amplitude Detector Linearity

voltmeter is accurate to .05%. On this basis, a measurement accuracy of less than 1% is probable.

(b) Dynamic

Dynamic linearity (figure 19b) will be determined by the two tone test previously explained. Probable accuracy, 1db.

(3) Phase adjustment and manual gain control

This is a demonstration of capability.

j. AGC

(1) Loop Gain (figure 20)

Vary the input level of receiver by means of precision attenuator. Measure output of narrowband IF amplifier with true rms voltmeter and scope. Measurement accuracy, probably less than 5%.

(2) Filters will be measured by the setup shown in figure 16.

k. Offset Frequency

The offset frequency will be checked with the HP5245L frequency counter.

1. DC & AC Isolation Amplifiers & Predetection Playback

This is a demonstration of capability.

3. PM Transmitter/Receiver Pair

a. Phase Stability

Phase stability will be measured as outlined in the synthesizer test, Section B1 (figure 3 & 4). With an unmodulated carrier input, a scope is used to observe the jitter on the output of the phase detector.

b. Fidelity

Fidelity will be determined by means of the two tone test previously described for checking the transmitter only. Here, the transmitter/receiver pair will be used instead of the individual item.

L. Phase Noise Instrumentation - This is covered in another section of the report.

D. FM Transmitter/Receiver

1. F.M. Transmitter

a. General

In a number of cases the same tests performed on the FM transmitter will be used to check out the FM transmitter. In those cases where this can be done, the appropriate section is noted.

(1) Transmitter Center Frequency

This is a demonstration of capability and will be verified with the HP52,5L frequency counter to the accuracy of the counter.

(2) Power Output

The power output will be checked with a power meter.

(3) Frequency Multipliers and Reference Output

These are covered in section B.

(4) AFC Operation

This is a demonstration of capability.

(5) Bandwidth

This will be measured in the same way as for the FM transmitter. See Section C1a(4). In this case, (figure 21), a change in modulation frequency,  $f_m$ , requires a corresponding change in the deviation,  $\Delta f$ , in order to maintain the same B (for FM,  $\beta = \frac{\Delta f}{f_m}$ ).

The response curve should accordingly be a line with a constant slope,

$$\frac{\Delta V}{\Delta f_m} = C.$$

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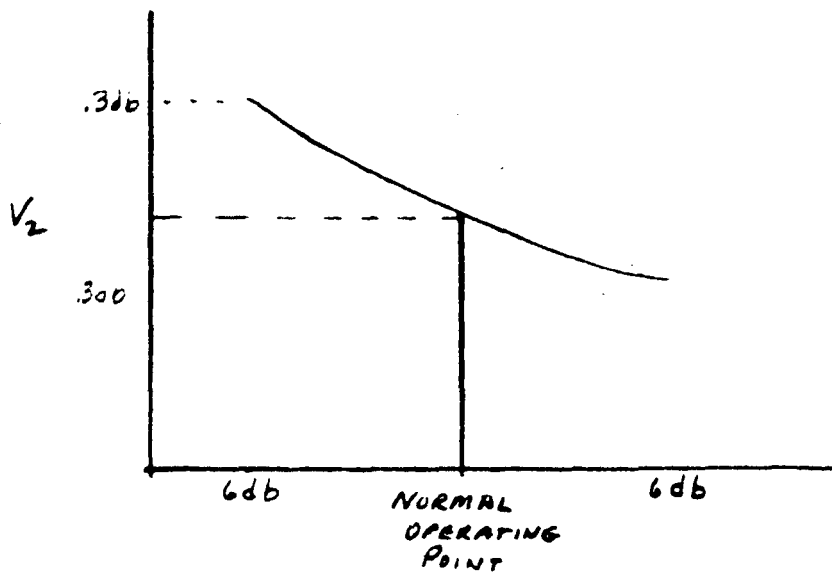
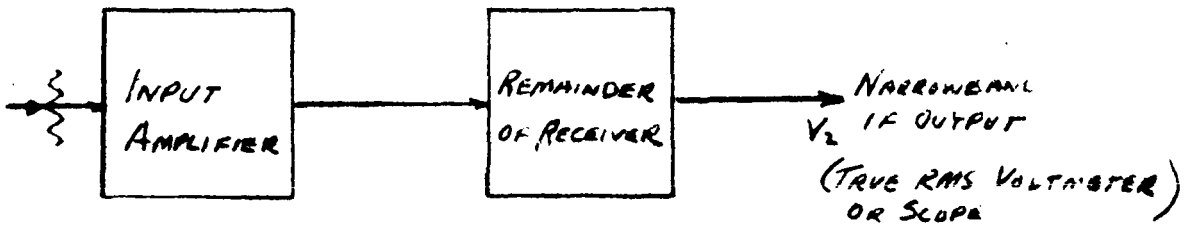


Figure 20. AGC Loop Gain

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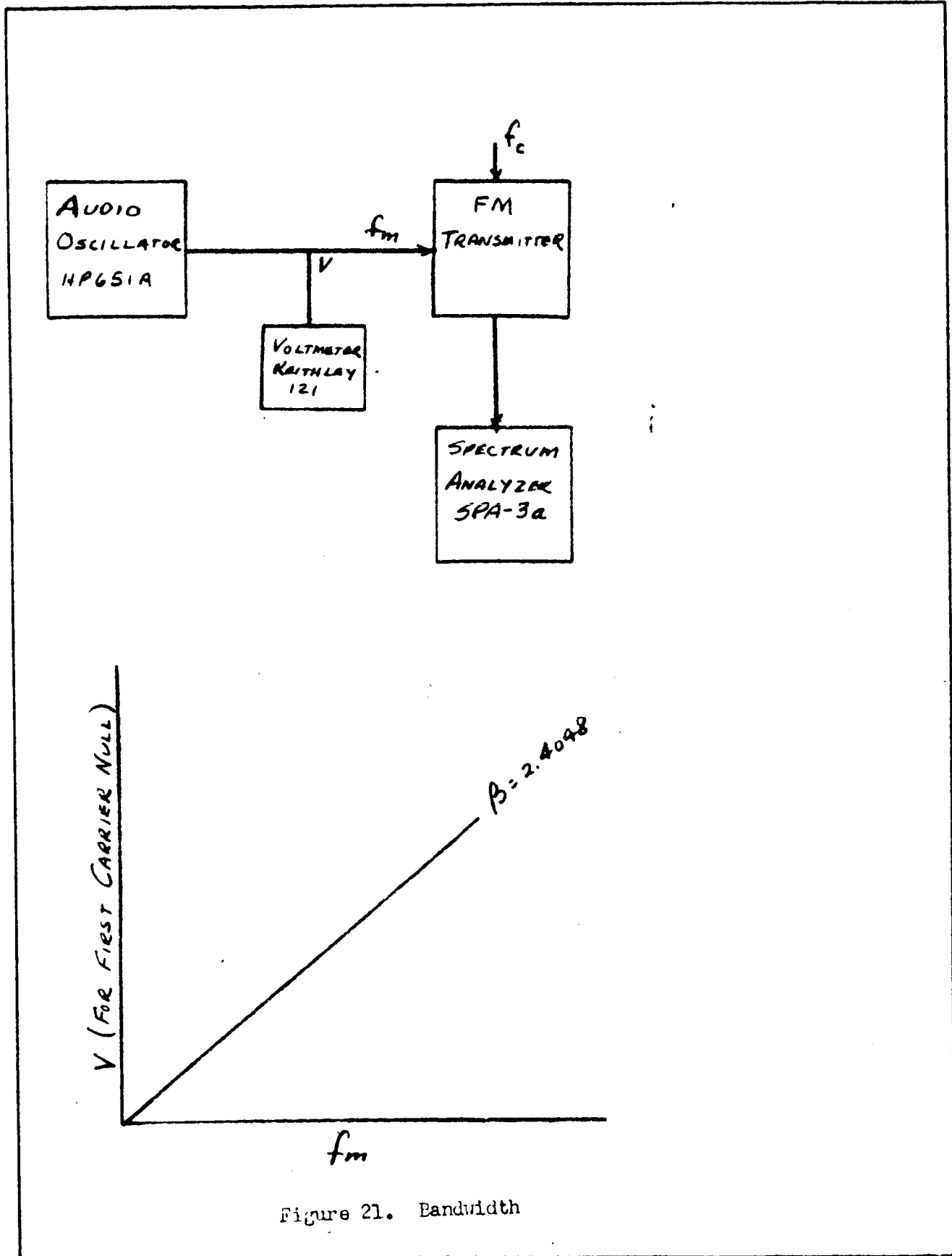


Figure 21. Bandwidth

## b. Frequency Modulator

- (1) Response and Sensitivity
- (2) Frequency Deviation
- (3) Deviation Linearity
- (4) Incidental AM

The same test procedure will be used here as for the Phase Modulator in the PM Transmitter.

## c. Amplitude Modulator

The same test procedure will be used here as for the amplitude modulator in the PM Transmitter.

## d. FM Receivers

## a. General

Much the same condition for the FM receiver applies as for the FM transmitter in that a number of the tests used for the PM receiver will also be used for the FM receiver.

## b.\* Input Filter

- (1) Bandwidth

The bandwidth will be determined by the method covered in C2b.

- (2) Amplitude Characteristics

The amplitude characteristics will be determined during the bandwidth test.

- (3) Phase Linearity

The phase linearity will be checked as part of the pair test.

## c.\* Limiter

- (1) Dynamic Range



The static range of the limiter will be measured by the setup shown in figure 22. The output voltage is monitored as a function of input voltage. The dynamic range will be checked as part of the pair tests by observation of the response of the receiver to AM at different signal levels.

(2) Output Waveform

The output waveform will be examined by means of the Tektronics #585 scope.

d. Conventional FM Detector

This will be tested as part of the pair test. However, a preliminary two tone test will be made on it.

e. Phase Lock FM Detector

(1) Voltage Controlled Oscillator

The frequency of the voltage controlled oscillator will be checked with the HP52452 counter. The deviation capability will be verified by use of varying d.c. levels and measurement of the frequency excursion of the oscillator by means of the counter. The other characteristics will be verified in the test of the Tx/Rx pair.

(2) Phase Detector

Phase detector will be tested as in C2g.

(3) Loop Gain

Same as C2h(1)

(4) Loop Filter

Same as C2h(2)

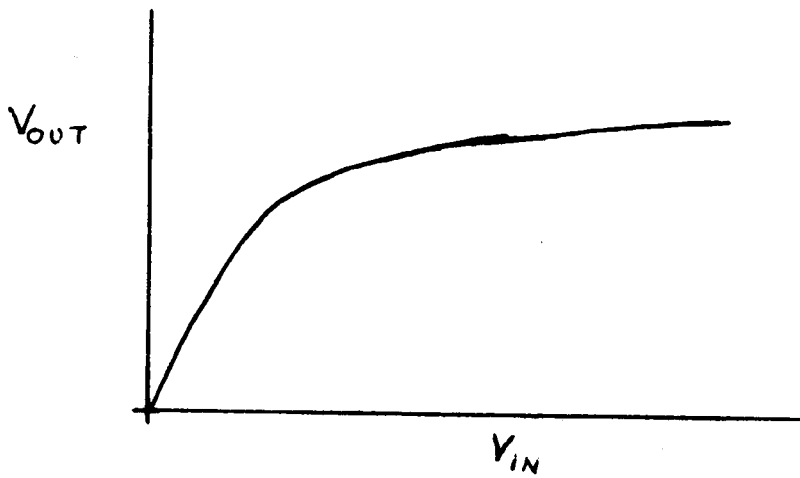
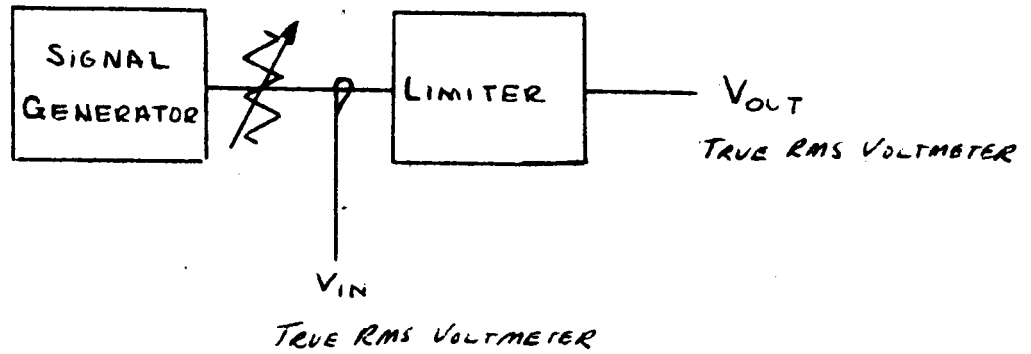


Figure 22. Limiter Static Range

## f. Output Filter

## (1) Bandwidth

Bandwidth will be checked by monitoring output vs. input.

## g. Offset Frequency

This will be verified with the HP52452 frequency counter.

## h. Balanced Modulator

This will be checked as in C2d.

## i. D.C. and A.C. Isolation Amplifiers and FM Predetection Playback

Demonstration of capability.

## 3. FM Transmitter/Receiver Pair

## a. Frequency Stability

The method for measuring the residual FM characteristics of the transmitter-receiver pair is illustrated in figure 23. For a certain  $f_m$ , adjust the level until a  $\beta$  of 2.4048 is attained. At this point, no energy exists in the carrier. Record the value of  $V_2$ . The rms deviation corresponding to  $V_2$  is  $.707 \times 2.4048 \times f_m$ . Then, remove the modulating-frequency by opening the switch. Record the resulting value of  $V_2$  and call it  $V_2'$ . Then

$$\Delta f_n = \frac{V_2'}{V_2} \times .707 \times 2.4048 \times f_m$$

$$\text{If } f_m = 50\text{Kc, then } \Delta f_n = \frac{V_2'}{V_2} \times 85010$$

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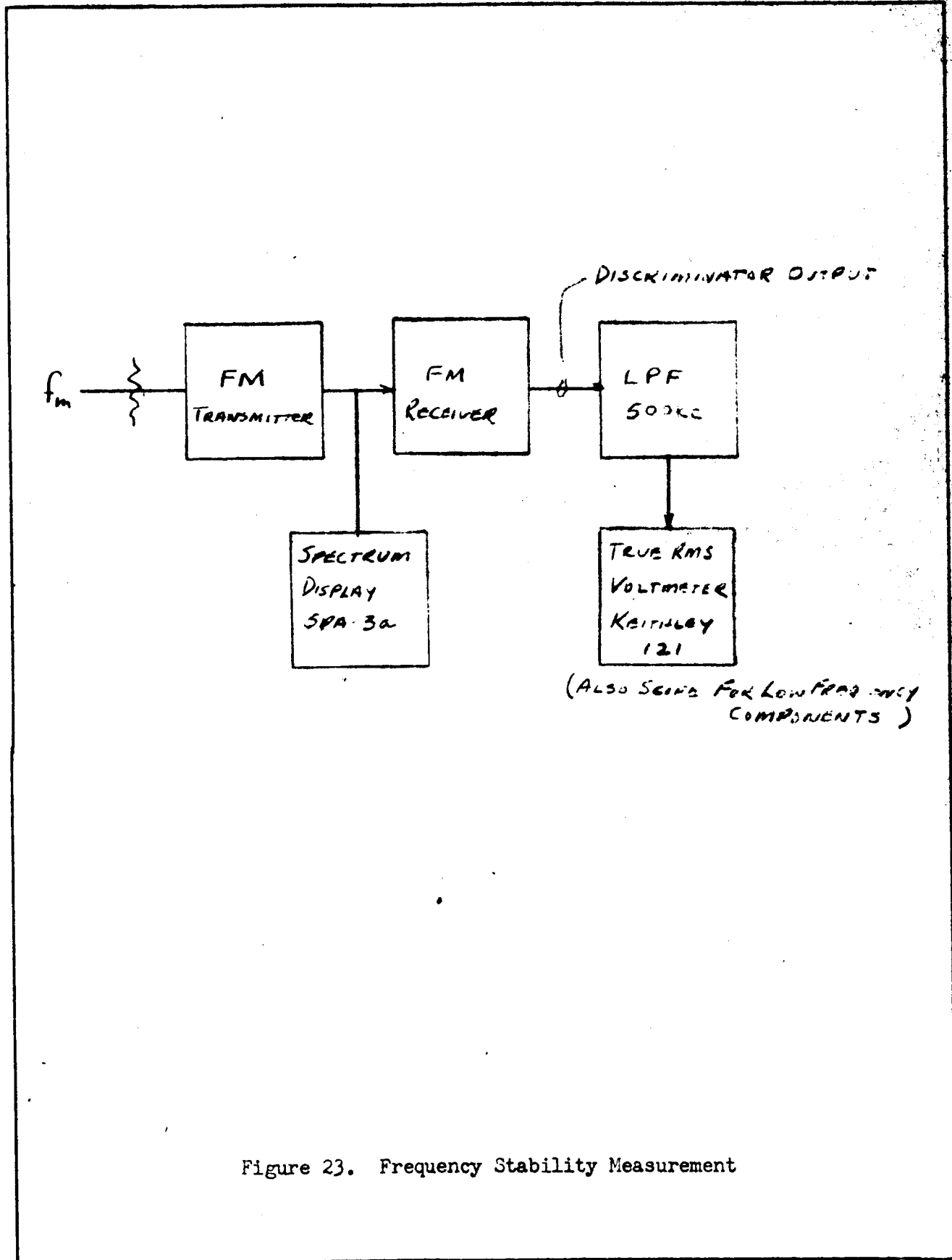


Figure 23. Frequency Stability Measurement

This test will be made in the AFC and non AFC mode. Probable measurement accuracy, 10%. It is worthwhile noting that it is anticipated that the 20 cps rms residual FM requirement in the non-AFC mode can be met for only a short time interval of a second.

(2) Static Linearity

The static linearity characteristics of the transmitter-receiver pair will be obtained by feeding a series of d.c. voltages into the transmitter and recording their values at the output of the receiver figure 24. Since this measurement is made in the non-AFC mode, drift may be a problem. Consequently, the zero reading will be checked after each reading. Probable accuracy using Fluke 801B Differential Voltimeter is less than 1%.

(c) Dynamic Linearity

The amount of harmonic distortion in the output signal is a direct measure of the degree of dynamic linearity. The two tone test as previously described will be used to check linearity. The Hewlett Packard 310A spectrum analyzer will be used to observe the output of the receiver and compare it to the modulation input to the transmitter.

E. Linear S/N Summer — This is covered in Section IV of the report.

F. Miscellaneous

1. Purchased Instrumentation

The purchased instrumentation will be tested sufficiently to indicate compliance with published data. This will be done by the Product Reliability Department - it is well equipped for this work as it has been set up to handle all calibration and standards certification for the Surface Division.

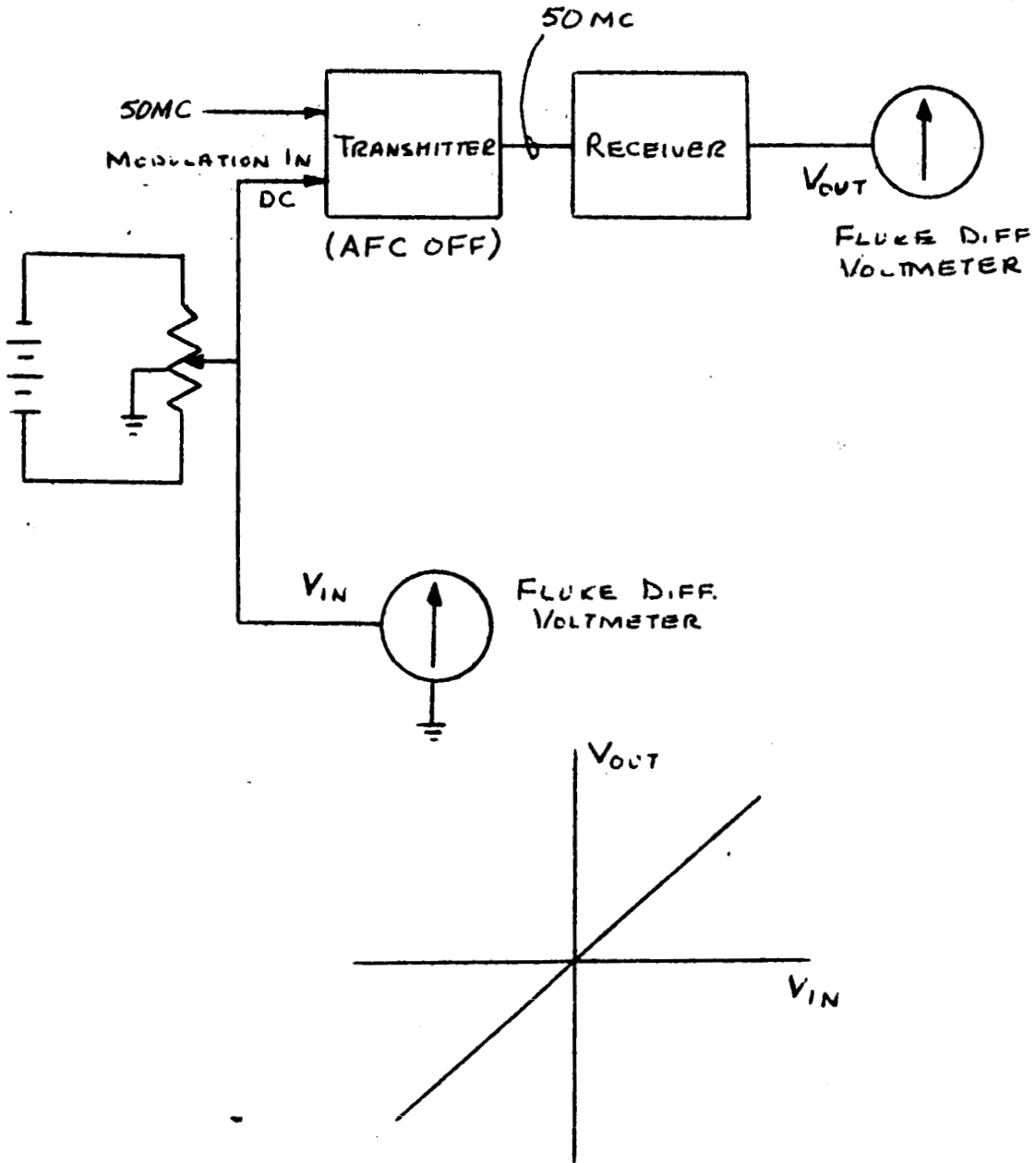


Figure 24 Static Linearity

## 2. Console Assembly Equipment

Bench tests of the power supplies and routine checks of the power distribution will be made during the course of assembly of the individual items in the console.

## 3. Interference

### a. Coherent

It is assumed that coherent interference is referring to those signals existing in various parts of the system which are coherent with the desired signals and which, due to proximity or radiation, cause interference with the desired signal. Positioning of the parts and use of shielded assemblies and double shielded cables in critical areas will help considerably in eliminating this problem. Since the components will be tested prior to installation in the console, an indication of coherent interference will be obtained if results are different from that obtained prior to installation.

### b. Spurious

Responses to spuriously generated internal signals will be determined as part of the normal tests on the transmitters and receivers for intermodulation and spurious. Tests for responses within the console to externally generated spurious signals cannot be made unless one has a knowledge of the environment in which the test console will work. As part of the design, shielded power line filters over the frequency range of operation will be installed in the incoming lines. Also a completely shielded enclosure with double shielded cables will be used. However, tests for the effect of externally generated radiation will have to be conducted at the time of installation of the equipment.

### c. Radiated

It is assumed that the radiated interference figure of -150dbm

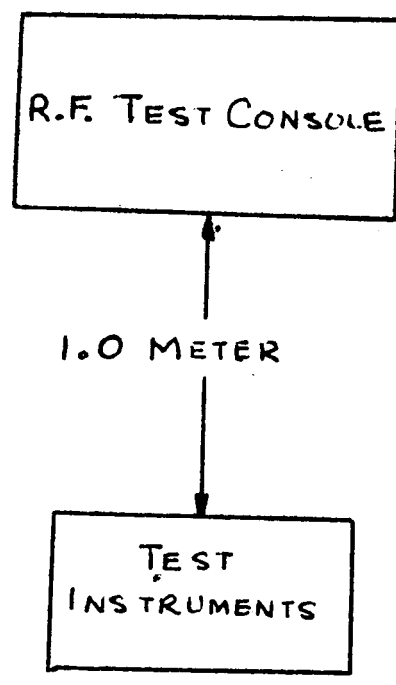


Figure 25. Radiated Interference Test



is -150 dbm per square centimeter as this is within the measurement range of presently available interference measuring equipment. The equipment (figure 25) is energized and adjusted for normal operation. Interference measuring instruments (Studdart or Polarad) will be located in a position of maximum RF pickup at a distance of one meter from the console. Measurements will cover the range from 10 KC to 1.0 Gc. The entire band will be scanned by continuously tuned interference measuring sets and interference peaks, if any, will be measured and recorded. In addition, specific frequencies, namely those intentionally generated inside the console will be measured and recorded.

PERFORMANCE SPECIFICATION  
CANADIAN MARCONI COMPANY  
NQ-26A MODEM TEST SET

#163-915 DEMODULATOR

In the demodulator, a series of limiter-amplifier stages provides gain stability and removes amplitude modulating noise components prior to demodulation in a frequency discriminator. The final demodulator stage is a discriminator feeding baseband information to the demodulator output unit.

## Demodulator Unit

| Item                        | Value or Description   |
|-----------------------------|--|
| <b>Limiters</b>             |  |
| Centre Frequency            | 70 mc  |
| Bandwidth                   | + 10 mc within + 0.25 db   |
| Input Level                 | + 3 dbm nominal  |
| Input Impedance             | 75 ohms  |
| Input Return Loss           | Greater than 26 db + 5 mc<br>Greater than 20 db + 10 mc<br>Amplitude compression of a 70 mc carrier with 10% amplitude modulation is greater than 30 db for modulating frequencies 30 kc to 5 mc for nominal input level |
| <b>Discriminator</b>        |  |
| Derivative                  | Within + 0.1 db over + 5 mc<br>Within + 1.0 db over + 9 mc   |
| Sensitivity                 | 100 mv/mc + 3 db   |
| Sense                       | Type A - Increase in i-f frequency produces a positive going baseband output voltage<br>Type B - Increase in i-f frequency produces a negative going baseband output voltage   |
| Linearity (2 Tone Test)     | 60 db  |
| Noise Power Ratio           | 55 db (60 kc to 2.5 mc)  |
| <b>Complete Unit</b>        |  |
| Baseband Frequency Response | 0.5 cps to 5 mc within + 1 db  |
| Baseband Output             | Matched to 1000 ohm resistive input of demodulator output unit.  |
| Power Consumption           | + 160 vdc, regulated, at 75 ma<br>+ 160 vdc, unregulated, at 90 ma<br>12.6 vac at 0.9 amp<br>6.3 vdc at 1.5 amp  |
| Mechanical                  | Standard printed board chassis<br>Width: 4-1/2 inches<br>Length: 16-1/2 inches<br>Height: 2-1/2 inches (with tubes)  |
| Tube Complement             | 11 7737  |

Demodulator Output Unit

Traffic Amplifier

|                    |  |
|--------------------|--|
| Output Level       | -7 dbm/channel   |
| Maximum Gain       | 19 db $\pm$ 2 db   |
| Frequency Response | High Frequency: within $\pm$ 0.1 db up to 6 mc<br>Low Frequency: within $\pm$ 1 db up to 8 mc;<br>less than 1% droop on a 60 cps square wave |
| Input Impedance    | 1000 ohms resistive  |
| Output Impedance   | 75 ohms  |
| Output Return Loss | Greater than 26 db up to 5 mc<br>Greater than 20 db up to 7 mc<br>Greater than 17 db up to 8 mc  |