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NOISE FIGURE TESTING OF RF AMPLIFIER TUBES

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NOISE FIGURE TESTING OF RF AMPLIFIER TUBES

Preface

This publication describes in considerable detail a method for measuring noise figure of RF amplifier tubes in the receiving tube class.

This method is intended for use in obtaining noise figure values for inclusion on JEDEC data sheets.

- 1 -



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NOISE FIGURE TESTING OF RF AMPLIFIER TUBES

1.0 EQUIPMENT SPECIFICATIONS

- 1.1** Basically the equipment for making noise figure measurements of RF amplifier tubes consists of a noise source, test jig in which the tube under test can be operated under the specified conditions of voltage and circuitry, post amplifier, and noise figure meter.

Block diagrams showing set-up for neutralization (Figure 1A), gain and bandwidth check (Figure 1B), and noise figure (Figure 1C) are shown on page 5.

- 1.1.1** Noise Source - Hewlett-Packard No. 343A or equivalent.

- 1.1.2** Tube-Under-Test Jig - Circuit specifications:

- 1) 200 megacycles center frequency.
- 2) 3 db bandwidth of 10 ± 2 megacycles.
- 3) Pi input circuit adjustable to noise matched conditions.
- 4) Pi output circuit tunable to 50 ohms output impedance.
- 5) Single frequency neutralization for triodes, including the grounded cathode section of cascode tubes.

- 1.1.3** Post Amplifier - The general specifications for the post amplifier are as follows:

- 1) 200-megacycle center frequency at input.
- 2) Maximum bandwidth of 5 megacycles at 3 db points.
- 3) Sufficient gain in conjunction with the noise figure meter to read the noise figure of the unit itself.
- 4) Maximum noise figure of 6 db.
- 5) 50-ohm input constant over the pass band.
- 6) 50-ohm output.

The post amplifier can assume several configurations. A 200-megacycle amplifier, modified if necessary to provide an undetected output, can be used. Frequency conversion to an IF frequency can be used. In this case, a standard VHF tuner with its input modified to 50 ohms unbalanced can be coupled to a standard 44-megacycle IF amplifier. Experience has shown that the total gain of the post amplifier should be approximately 75 db. A gain control capable of reducing the gain by 20 db should be incorporated.

- 1.1.4** Noise Figure Meter - Hewlett-Packard No. 342A or equivalent. The noise figure meter must be equipped with a 200 mc input or 44 mc input corresponding to the amplifier output frequency and must be capable of monitoring the noise figure.

- 1.2** Additional equipment needed in the tests:

- 1.2.1 Suitable sources of heater and dc power for the tube under test.
- 1.2.2 For neutralization (Figure 1A) an AM RF signal generator tunable through the 200 mc range, a 50-ohm detector, and a vacuum tube voltmeter are required.
- 1.2.3 For gain and bandwidth measurements (Figure 1B), the same equipment as for neutralization is used.

2.0 MEASUREMENT PROCEDURES

2.1 The block diagrams of Figure 1 illustrate the equipment set-up for neutralization, gain, bandwidth, and noise figure measurements. The gain and bandwidth measurements serve two purposes:

- 1) The bandwidth indicates that the specified loading for the tube under test is present in the circuit so as to meet the specification of 10 ± 2 megacycles.
- 2) The gain measurement is used as a check on jig operation and to compute the correction for second stage noise figure.

2.2 Neutralization

2.2.1 For single triodes and the grounded cathode section of cascode tubes, neutralization is required. Single frequency coil neutralization is used. The procedure for neutralization is as follows:

- 1) With the equipment set up as shown in Figure 1A, turn off the B+ to the tube-under-test jig.
- 2) Amplitude modulate the signal generator 30%.
- 3) Increase the signal input to obtain an indication on the VTVM.
- 4) Tune the neutralization coil for a null (minimum feedthrough).

2.3 Gain and Bandwidth

2.3.1 A check should be made on the gain and bandwidth of the tube-under-test jig before proceeding with noise measurements. With the equipment set up as shown in Figure 1B, proceed as follows:

- 1) Apply rated voltages to the tube.
- 2) Tune all adjustments on the input and output Pi networks and the plate circuit tuning for a maximum indication on the VTVM.
- 3) Tune the signal generator to the 3 db points either side of the center frequency to obtain the bandwidth. (Note: The characteristic of the crystal detector should be checked to determine what the 3 db reduction represents in terms of scale readings on the VTVM.)
- 4) Read the signal generator output voltage " V_1 " for a reference point "P" on the VTVM.
- 5) Remove the tube-under-test jig from the circuit, and increase the signal generator output to obtain the same reference point "P" on the VTVM.

- 6) Read the signal generator output voltage " V_2 ."
- 7) Db gain = $20 \log \frac{V_2}{V_1}$.

2.4 Noise Figure

2.4.1 For the noise figure measurement, the equipment should be set up as indicated in Figure 1C, and the following procedure observed:

- 1) With the tube-under-test jig tuned as indicated under gain measurements, paragraph 2.3.1, adjust the gain of the post amplifier so that the total gain of the TUT jig and the post amplifier is approximately 75 db.
- 2) Follow the manufacturer's manual for setting up the noise figure meter.
- 3) Adjust the input Pi network of the tube-under-test jig for a minimum noise figure " N_{12} ."
- 4) Remove the tube-under-test jig, and read the noise figure of the post amplifier " N_2 ."
- 5) Without retuning the input Pi, read the noise matched gain " G_1 " as outlined in Steps 4 through 7, paragraph 2.3.1.
- 6) Use the formula $N_1 = N_{12} - \frac{N_2 - 1}{G_1}$ (expressed as power ratios) to obtain the corrected noise figure " N_1 " of the tube under test.

2.4.2 Step 4 would be required only once in any series of measurements. With sufficient gain and a low noise second stage, Steps 5 and 6 may not be necessary.

2.4.3 Good engineering practice in setting up the equipment and taking the measurements is dictated by the nature of the noise figure measurement. In most locations a screen room will be required.

2.4.4 An example of a tube-under-test jig constructed for testing a double triode in cascode circuit configuration is given on the following pages.

2.4.5 A sample data sheet for the Type 6BQ7A incorporating the noise figure ratings is attached as Appendix A.