RADIO ENGINEERING
POINT-TO-POINT RADIO
RECEIVER NOISE MEASUREMENTS

1. GENERAL

1.01 This section describes a method of evaluating "site noise" at VHF or UHF radio receiving locations, providing a means of obtaining quantitative information with a minimum of test equipment.

1.02 Performance of radio systems is limited by the ratio of undesired noise to desired signal. Computation of path loss and of power input to the radio receiver can usually be accurate within a few dB. Site noise at 150 MHz on the other hand may vary from a value near thermal to perhaps 40 or 50 dB greater, depending upon the particular site and time. Average noise levels at 450 MHz will probably be about 10 dB lower than at 150 MHz, while noise levels can be expected to increase rapidly at frequencies below 150 MHz.

1.03 Information in this section was formerly covered in Section 940-102-103.

2. BASIS OF TEST

2.01 Part 5 of BSP Section 940-250-100 gives the method of computing the radio receiver input power required to obtain a specified channel noise performance at the radio receiver output. Based upon that computation it can be shown that an input signal power of −99 dBm to the radio receiver will result in a noise level of 34 dBa at the 0TLP (zero transmission level point), assuming the following conditions:

(a) Single-channel operation without compandor.

(b) Thermal noise controlling.

(c) Receiver noise figure of 8 dB (typical for 150 MHz).

(d) Channel bandwidth 3000 hertz.

(e) Modulation adjusted to ±15 kHz with 0 dBm of 1000-Hz tone applied at the transmitting 0TLP.

This is a theoretical value rather than an actual one but is used as the basis for Fig. 1 in which radio receiver noise output power is related to radio receiver input power. It is useful in this test since it provides a measure of receiver performance with thermal noise controlling.

2.02 Figure 2 of this section provides practical curves showing the relation between receiver input and channel noise. These curves are derived from Fig. 1, but include necessary allowances as indicated.

2.03 Channel noise power in the radio receiver output is related both to the signal and the effective noise power acting at the receiver input. The relationship can be expressed:

$$\frac{C}{N_{rf} + N_s} = \frac{S}{82 - N_{dBa}} + I \qquad (1)$$

or, in dB,

$$C - (N_{rf} + N_s) = S - (82 - N_{dBa}) + I \qquad (2)$$

Where: C = the value of carrier at the receiver input (expressed in dBm).

N_{rf} = equivalent noise power at the receiver input due to the radio equipment (expressed in dBm).

N_s = equivalent noise power at the receiver input due to all other causes (expressed in dBm).

S = the level of signal at the transmitting 0TLP which is required to ***fully*** modulate the transmitter (expressed in dBm).

N_{dBa} = the channel noise at the receiver output expressed in dBa equated to the receiving 0TLP. (82 is the conversion factor between weighted noise power expressed in dBm and the same power expressed in dBa.)

I = the FM or PM improvement factor expressed in dB.

As indicated, the ratio of channel noise to signal will depend upon the effective sum of the site noise and receiver noise as it relates to the received carrier power. Accordingly, an increase in site noise can be compensated for by an increase in received carrier power. This relation makes possible an evaluation of site noise at a proposed receiving location using as a signal source only an unmodulated RF carrier in a simple "AB" test. This test made at any point of Fig. 1 will provide quantitative information concerning the ratio of ambient noise to set noise. From this it is possible to plot curves showing channel noise versus carrier input for any particular location. This is done by plotting a parallel curve separated horizontally from the appropriate curve of Fig. 2 by the amount established in the "AB" test.

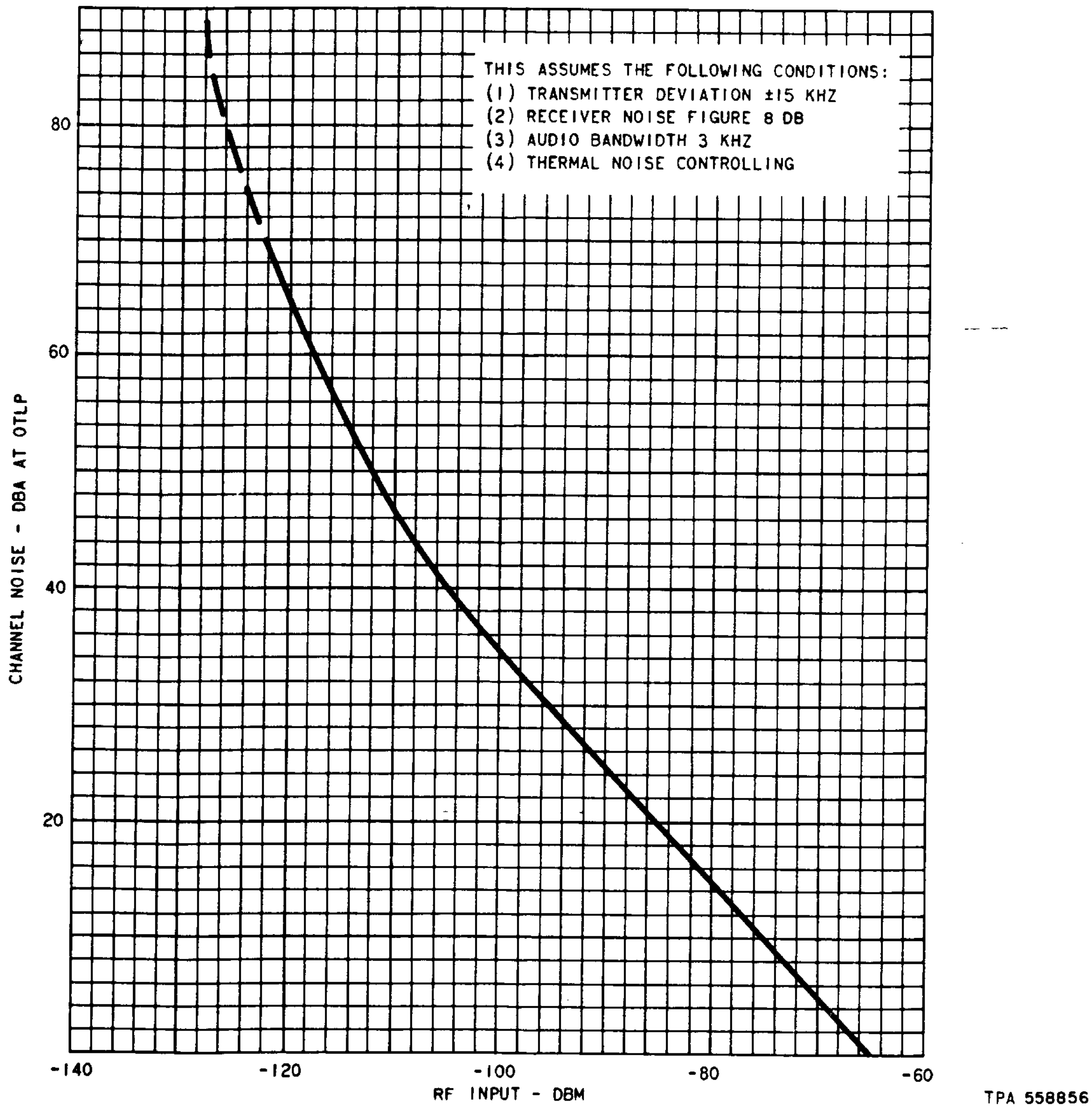
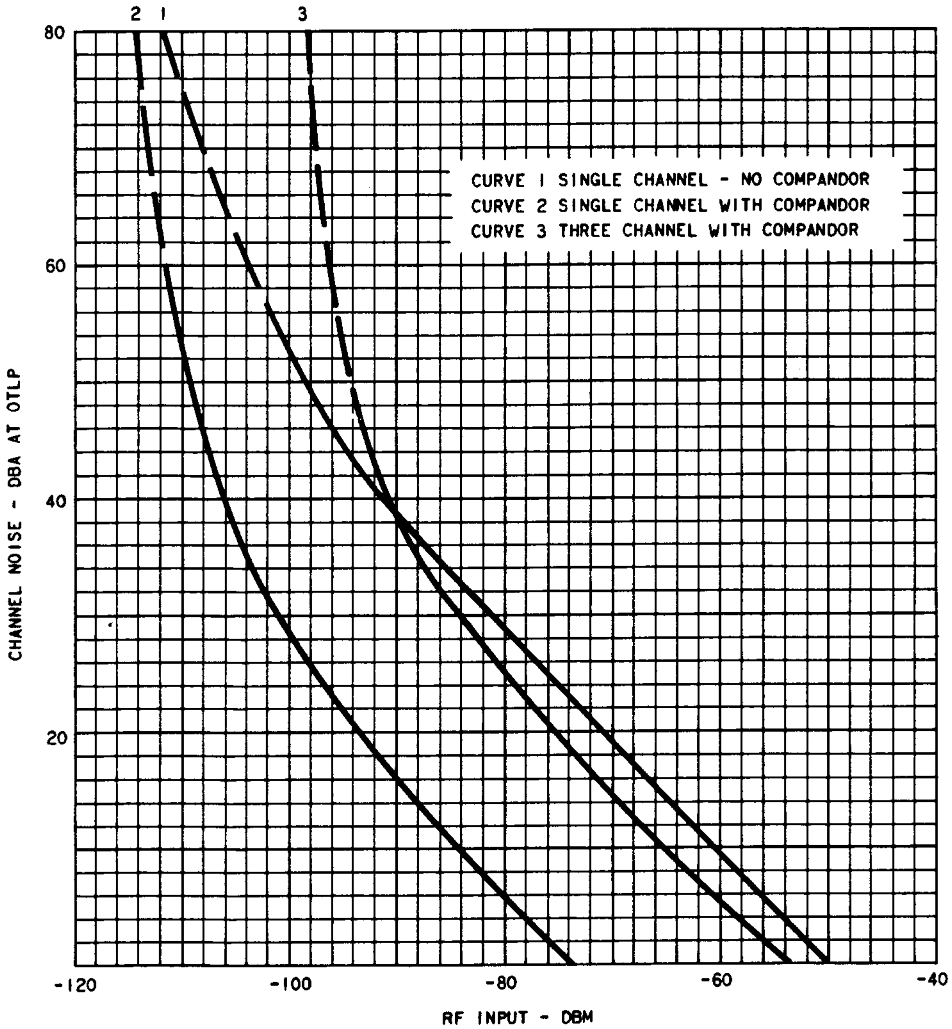


Fig. 1—Channel Noise Related to Radio Receiver Input—Theoretical Value



CURVES ARE BASED ON THE ASSUMPTION THAT THERMAL NOISE CONTROLS SYSTEM PERFORMANCE, AND THAT OTHER SYSTEM PARAMETERS ARE AS FOLLOWS:

	CURVE 1	CURVE 2	CURVE 3
LOAD CAPACITY ALLOWANCE	-9 DB	-9 DB	-6 DB
MAINTENANCE FACTOR	-5 DB	-5 DB	-5 DB
RECEIVER NOISE FIGURE	-8 DB	-8 DB	-8 DB
CHANNEL BANDWIDTH	3 KHZ	3 KHZ	3 KHZ
PEAK DEVIATION	±15 KHZ	±15 KHZ	±15 KHZ
FM IMPROVEMENT	+19 DB	+19 DB	+3.5 DB
COMPANDOR ADVANTAGE (WHERE APPLICABLE)		+23 DB	+23 DB

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Fig. 2—Channel Noise Related to Radio Receiver Input—Practical Systems

3. EQUIPMENT REQUIRED

3.01 Equipment required for this test includes the following items:

(a) A radio receiver similar to that proposed for the installation, preferably tuned to the operating frequency or, if this is not available, then a receiver tuned to a nearby frequency (approximately ± 3 MHz).

(b) A signal generator capable of good frequency stability and equipped with an accurate output indicator and attenuator. (For 150 MHz, Measurements Corp. Model 80 equipped with the

Measurements Corp. 6 dB pad or an equivalent signal generator; for 450 MHz, Measurements Corp. Model 80R or M500 equipped with 6 dB pad or an equivalent signal generator.)

(c) A 2B noise measuring set.

(d) An antenna similar to that proposed for the system, preferably mounted at the proposed location.

(e) A bridging pad as shown in Fig. 3.

(f) A termination (noninductive) having a resistance near the impedance of the test antenna (47 or 72 ohms as appropriate). This is shown as part of Fig. 3.

(g) Suitable interconnecting cables as required.

(h) A dc microammeter to permit checking of receiver limiter currents and of discriminator for "on frequency" indication.

4. PROCEDURE

4.01

(a) Connect the equipment as shown in Fig. 4.

(b) Disable the receiver "squelch" circuit, either by removing the noise amplifier tube or by turning the control to the "off" position.

(c) With the signal generator detuned, adjust level of unsquelched noise at the receiver output to a value well below the receiver audio overload point. (90 dBa will usually be convenient.) Measure and record this level which is the audio reference level.

(d) Connect the antenna termination to the antenna tap of the bridging pad; tune the signal generator to the frequency of the radio receiver, checking for the "on frequency" indication at the discriminator test point.

(e) Connect the meter to the first limiter circuit of the receiver; reduce the signal generator output until the receiver input is sufficiently low to avoid first limiter saturation. Tune the antenna circuit of the receiver for resonance.

(f) Adjust the RF signal input until the receiver noise output is 20 dB lower than the audio reference level measured in (c) above. Record the signal generator output. This is a measure of the carrier input to the bridging pad required to produce 20 dB of receiver quieting with set noise controlling.

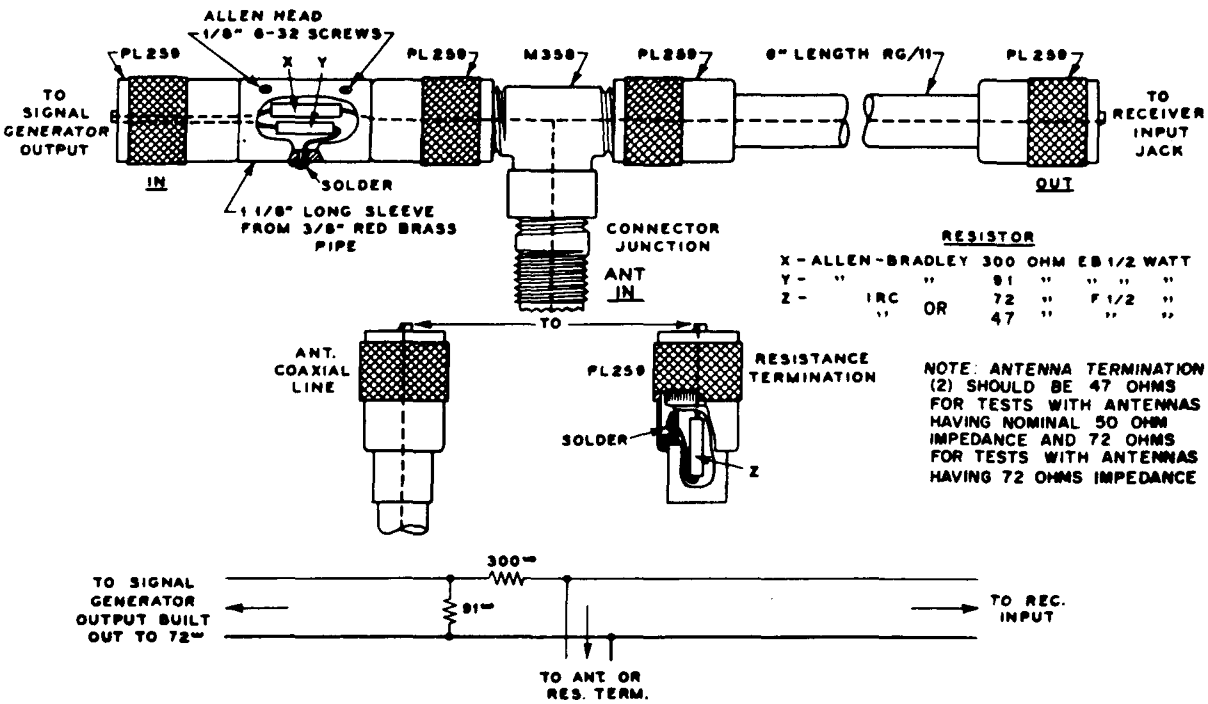

Fig. 3—Construction of Test Pad and Terminating Resistor

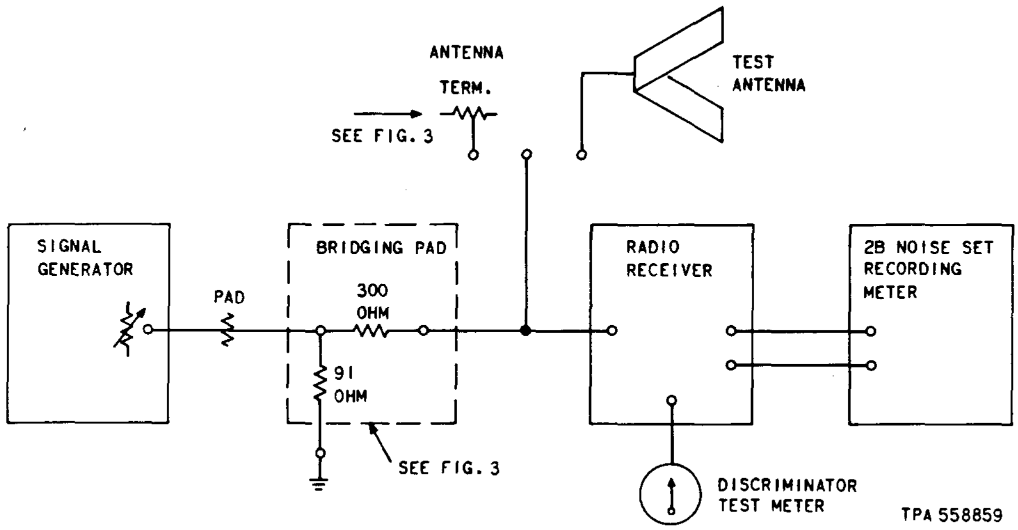

Fig. 4—Equipment Arrangement for Site Noise Tests

(g) Remove the antenna termination from the bridging pad; connect the transmission line from the antenna in its place. Orient the antenna in the approximate direction of the proposed transmitting station. Check receiver antenna tuning to assure that first limiter current is still at maximum. Repeat the measurement of (f) above. Record the signal generator output. This is a measure of the carrier input to the bridging pad which will provide 20 dB quieting of receiver noise plus site noise.

(h) The difference in signal generator output between tests (f) and (g) expressed in dB (20 log of the voltage ratio) is equal to the circuit noise contribution of the site noise factor (N_s) of equations (1) and (2). It represents the amount by which the indicated receiver input power for the appropriate curve of Fig. 2 must be increased in order to provide a given channel noise when using the test antenna.

5. EVALUATION OF DATA

5.01 Tests of Part 4 are useful in obtaining a good approximation of receiving site noise. Noise at any particular location may vary widely from time to time, and accordingly tests will have greatest usefulness if they are repeated at several times during the day and night or if they are taken on a continuous basis. When a sampling only is taken, the times at which tests are made should be chosen to cover representative periods of activity. Apparently busy and idle hours in the particular location should be chosen.

5.02 Where possible, it may be desirable to install the measuring equipment as described, setting levels and proceeding as shown in Part 4, paragraphs (f) and (g), except that the 2B noise measuring set should be replaced by a recording arrangement such as a General Electric Company level recording meter or by an Esterline Angus recorder connected to the radio receiver through a locally designed rectifier circuit. Assuming a constant output from the signal generator, the channel noise at the receiver output will vary directly with the noise input to the receiver. Thus, by recording noise level at the receiver output, it becomes possible to obtain a continuous record of site noise with a minimum of effort. Since stability of equipment is necessary for optimum results, it may be desirable to supply power to the signal generator and the radio receiver through a voltage regulating transformer unless power supply regulation is known to be extremely good. Precautions should also be taken to avoid any large temperature changes which might affect the equipment during the tests.

5.03 The antenna used in the tests should be similar electrically to the antenna proposed for the permanent installation. Its location and orientation during the test should be such that it will receive from approximately the same potential noise field as would the permanent antenna. During the course of the tests, the antenna should be placed in several locations, moving it in both the horizontal and vertical planes. In addition to assisting in determining the most favorable location for the antenna, this may help to locate nearby noise sources which may be suppressed at the source as discussed in Section 940-250-100. Also, where high noise levels are encountered, listening tests may frequently help in the identification of the noise source by revealing the nature of the disturbance.

5.04 Under some conditions, it may be practicable to reduce the effect of known noise sources by orienting the receiving antenna in such a way as to take maximum advantage of "nulls" in the antenna radiation pattern as it relates to the noise source while impairing the reception of the desired signal to a smaller degree.

5.05 Some noise sources may be found which emit a signal having predominantly horizontal or vertical polarization of output. In these cases, proper selection of antenna polarization may provide useful performance improvements.