SCTE · ISBE
STANDARDS

Interface Practices Subcommittee

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Measurement Procedure for Noise Power Ratio

NOTICE

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1. Introduction

1.1. Executive Summary

Test procedure for Noise power ratio of active equipment.

1.2. Scope

This procedure defines a method of measurement for Noise Power Ratio (NPR) of active Cable Telecommunications equipment. It is intended for measurement of 75-ohm devices having type "F" or 5/8-24 KS connectors. See SCTE 96 2008 Cable Telecommunications Testing Guidelines for a discussion of proper testing techniques.

This procedure uses a spectrum analyzer to measure the noise power in a narrow frequency band. Other means of measurement such as a narrow band filter followed by a power meter may be used as long as the results can be shown to correlate to this method.

1.3. Benefits

A uniform procedure to measure the noise power ratio of active equipment

1.4. Intended Audience

Equipment manufacturers

1.5. Areas for Further Investigation or to be Added in Future Versions

None

2. Normative References

The following documents contain provisions, which, through reference in this text, constitute provisions of this document. At the time of Subcommittee approval, the editions indicated were valid. All documents are subject to revision; and while parties to any agreement based on this document are encouraged to investigate the possibility of applying the most recent editions of the documents listed below, they are reminded that newer editions of those documents might not be compatible with the referenced version.

2.1. SCTE References

- No normative references are applicable.

2.2. Standards from Other Organizations

- No normative references are applicable.

2.3. Published Materials

- No normative references are applicable.

3. Informative References

The following documents might provide valuable information to the reader but are not required when complying with this document.

3.1. SCTE References

- [SCTE 96] SCTE 96 2013, Cable Telecommunications Testing Guidelines

3.2. Standards from Other Organizations

- No informative references are applicable.

3.3. Published Materials

- No informative references are applicable.

4. Compliance Notation

shall	This word or the adjective "***required***" means that the item is an absolute requirement of this document.
shall not	This phrase means that the item is an absolute prohibition of this document.
forbidden	This word means the value specified shall never be used.
should	This word or the adjective "*recommended*" means that there may exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighted before choosing a different course.
should not	This phrase means that there may exist valid reasons in particular circumstances when the listed behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
may	This word or the adjective "*optional*" means that this item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.
deprecated	Use is permissible for legacy purposes only. Deprecated features may be removed from future versions of this document. Implementations should avoid use of deprecated features.

5. Definitions

Noise Power Ratio (NPR) Test	A test method that examines the amount of noise and intermodulation distortion in a channel. A test signal, comprised of flat Gaussian noise band limited to the frequency range of interest and with a narrow band (channel) of the noise deleted by a notch filter or other means, is injected into the Device Under Test (DUT). The NPR is measured at the output of the DUT as the test signal is swept across a power range. See Figure 1 for an example of an NPR test signal.

Noise Power Ratio	The ratio of the signal power density to the power density of the combined noise and intermodulation distortion in the channel. Essentially, NPR is the depth of notch. The signal power density is defined with the entire passband filled with energy. The power density of the noise and intermodulation distortion shall be measured by removing signal power from a range of frequencies with a notch filter while maintaining constant total signal power at the DUT input.
Signal	In an NPR measurement, the injected noise is referred to as the “signal.”
Noise Region	The range of input powers where the power in the notch is dominated by thermal noise, laser RIN, shot noise, and other noise contributors that do not change with signal level. The noise region is on the left side of a dynamic range plot. In the noise region, NPR increases approximately 1:1 with an increase in input power.
Intermodulation Region	The range of input powers where the power in the notch is dominated by intermodulation noise. In a dynamic range plot this is evidenced by a rounding of the top of the curve. The intermodulation region is between the noise and clipping regions. If the distortion performance of the DUT is extremely good, the NPR curve will transition from the noise region to the clipping region with a minimal or no intermodulation region present.
Clipping Region	The range of input powers where the power in the notch is dominated by high order intermodulation noise caused by clipping. Clipping occurs when RF or optical devices are driven into an operating region in which the input-to-output transfer function is quickly reduced. The clipping region is on the right side of a dynamic range plot. In the clipping region, NPR decreases rapidly with an increase in input power. See Figure 2 for an example of a DUT output in the clipping region.
Dynamic Range:	The range of input levels that produces a desired NPR.
Dynamic Range Plot:	A plot that shows the dynamic range of the DUT. Generally, the range of input or output powers is on the x-axis and the NPR is on the y-axis, with the noise region on the left and the clipping region on the right. See Figure 3 for an example of a dynamic range plot.
Peak NPR	The highest NPR reading.

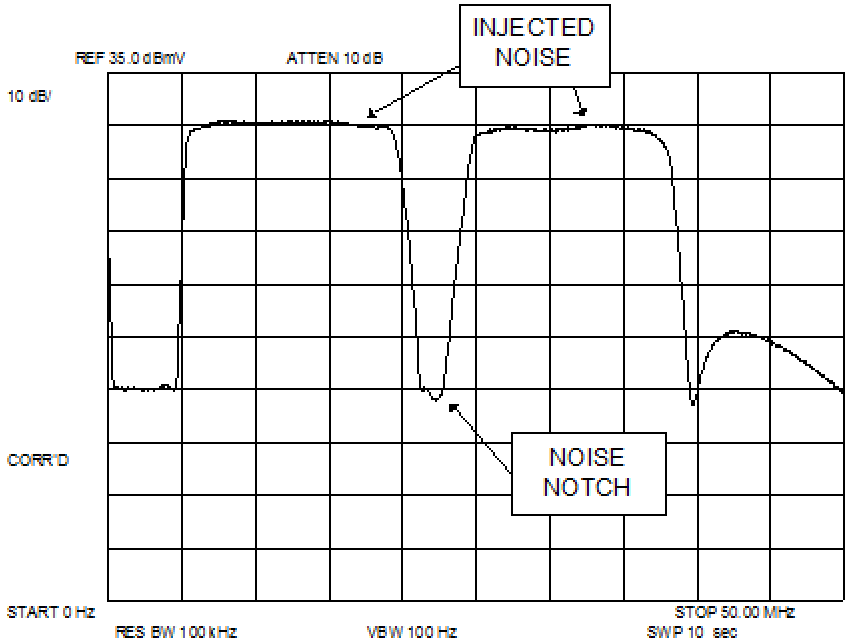

Figure 1 - Spectrum of Injected Signal

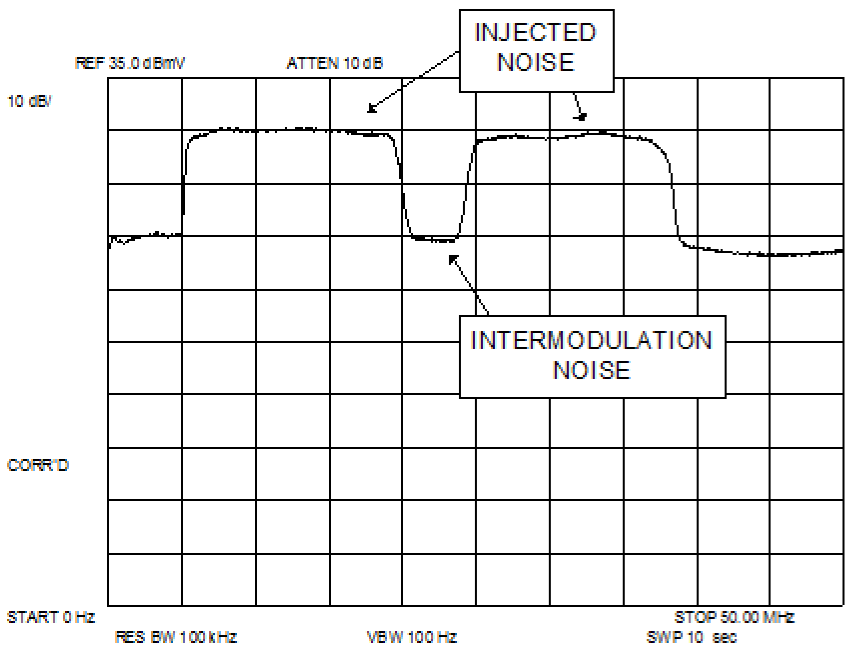

Figure 2 - Signal with Intermodulation and Clipping Distortion

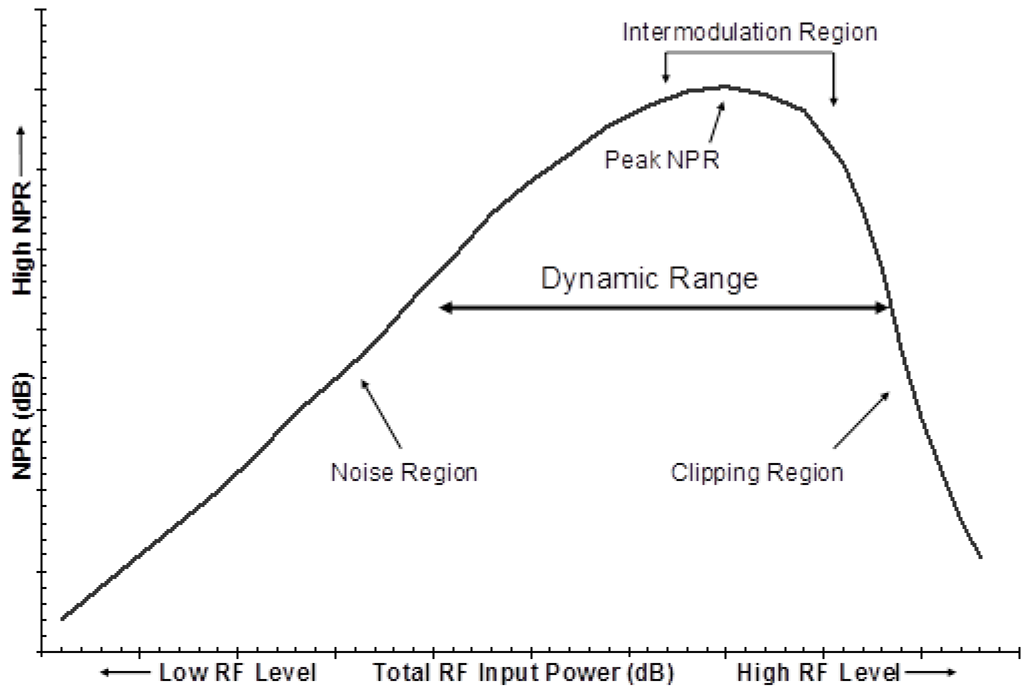

Figure 3 - NPR Dynamic Range Example

6. Equipment

Only equipment specific to this procedure is described in detail here. SCTE 96 should be consulted for further information on all other equipment.

6.1. Required Equipment

- Additive White Gaussian Noise (AWGN) source with a bandwidth at least as wide as the passband to be tested
- “Signal Shaping” bandpass filter equal to the passband to be tested
- Bandstop (notch) filter centered at the specified frequency (generally in the middle of the passband) with a depth at least 10 dB deeper than the desired maximum NPR measurement

NOTE: As an alternative to the first three items, a synthesized source may be used, provided that the output waveform is Gaussian (i.e., not clipped or compressed) and the programmed bandstop region has sufficient depth. If the bandstop depth is not sufficient, a filter may be added to the output of the synthesized source.

- 2 way signal splitter/combiner
- (2) Precision variable attenuators (0.5 or 1 dB step capable)
- Self terminating A/B switch
- RF power meter
- Spectrum analyzer with noise measurement mode (sometimes referred to as a noise marker or a noise normalization)
- Adapters, connectors, and cables as required

6.2. Optional Equipment

- Amplifier to obtain sufficient level at the DUT input
- Amplifier to obtain sufficient level at the spectrum analyzer input
- 1 dB step attenuator to adjust input level to spectrum analyzer
- Bandpass filter with a passband wider than the notch filter.

7. Setup

Following the equipment manufacturer's recommendations, perform the appropriate warm-up and calibration procedures.

Connect the equipment as shown in Figure 4. Be certain that the total power incident on the power meter does not exceed the maximum rating of the power meter.

Note: If an amplifier is required to obtain sufficient signal level, the amplifier should be placed between the bandpass and notch filters as shown in Figure 4. No amplifier should be used after the notch filter because its distortion will reduce the depth of the notch. Be certain that any amplifier used has sufficient capability to produce the required level without compression. Any amplifier that follows the filters can reduce the peak-to-average ratio of the injected noise, which could produce unrealistically “good” results.

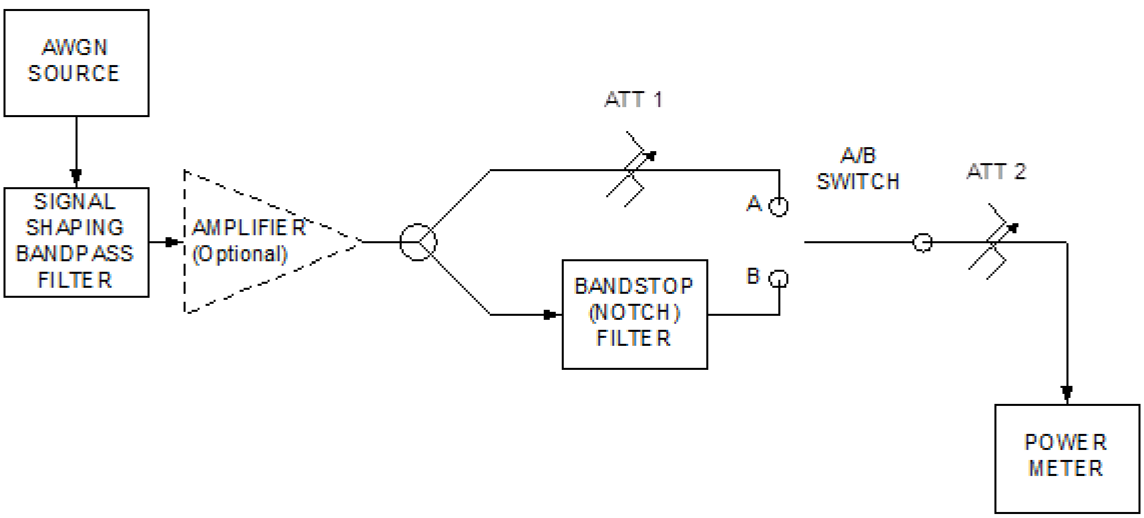

Figure 4 - Initial Setup

Put the A/B switch in position B and adjust ATT2 until the power at the power meter is within the power meter’s optimal range (do not overload the power meter). Adjust ATT1 so that the power when the switch is in position A is equal to the power in position B.

Adjust ATT2 until the power at the power meter is equal to the optimal (nominal) input level to the DUT. Record the setting of ATT2 and the measured power.

Replace the power meter with the spectrum analyzer and measure the flatness of the noise signal. The noise should be flat across the passband. A level variation less than 2 dB across the band is recommended.

8. Procedure

1. Connect the DUT as shown in Figure 5 and allow time for the DUT to warm up and stabilize before making measurements.

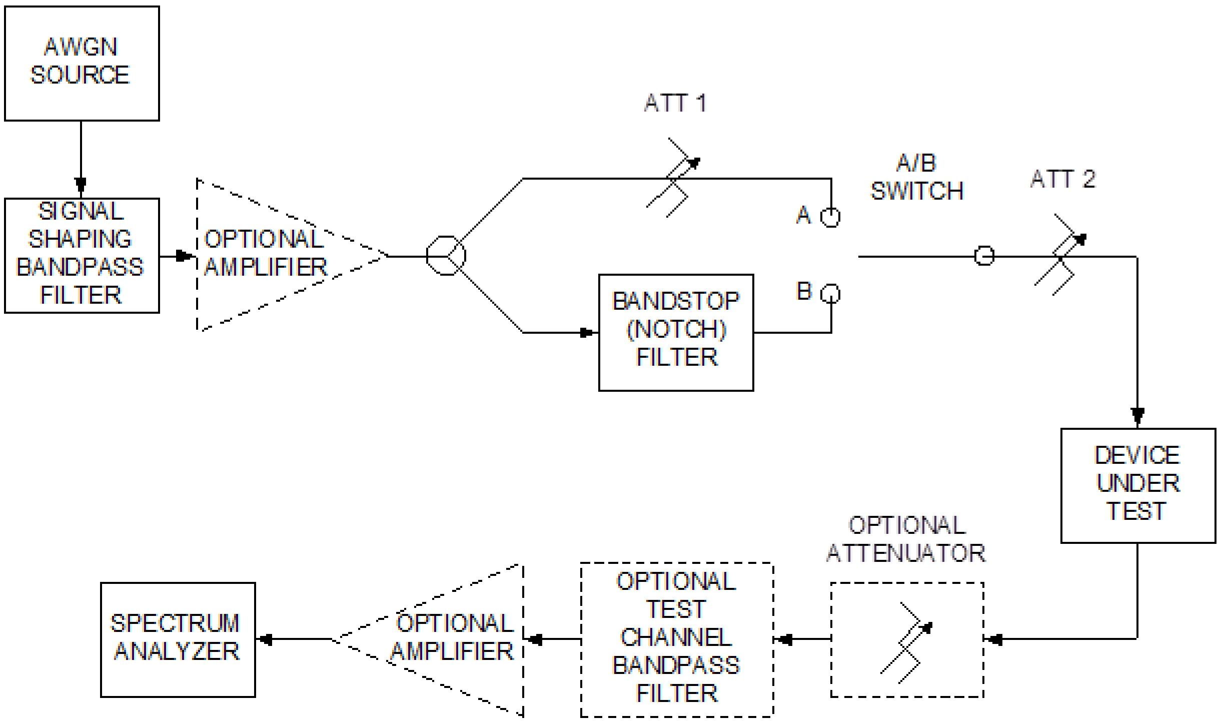

Figure 5 - Equipment Connection

2. Set the spectrum analyzer as follows:
   - Center Frequency: Center of notch
   - Frequency Span: Approx. 5 to 10 MHz (see text)
   - Amplitude Scale: 10 dB/div
   - IF Resolution Bandwidth: Approx. 30 to 100 kHz (see Note below)
   - Sweep Time: Automatic for calibrated measurement
   - Input Attn: As required (see steps below)
   - Marker Type: Noise Marker

Note: The width of the notch at the depth of interest must be at least as wide as the resolution BW setting on the analyzer. For instance, to use the recommended RBW of 100 kHz, the notch should be at least 100 kHz wide at the depth of interest.

3. Put the analyzer into the “sample” detection mode. (Note: On many analyzers, activating the noise measurement mode will automatically put the analyzer into the “sample” detection mode.)
4. Set the A/B Switch to position B.
5. Set the video filter to automatic (or off) and adjust the reference level so that the peaks of the noise never exceed the top of the display. The input attenuator should be in the automatic mode during this adjustment.
6. Measure the noise level by placing the marker in the center of the notch. If the marker reading is not stable, turn on video averaging or use a lower video bandwidth. (Note: On some spectrum analyzers, the noise marker reads all frequencies within about ±½ graticule of the marker

location. Therefore, if the notch is not at least one graticule wide, readjust the frequency span setting.)

7. Adjust the input attenuator of the spectrum analyzer high enough so that the analyzer does not cause additional intermodulation noise, and low enough so that the analyzer does not cause additional thermal noise. Do this by measuring the noise level in the bottom of the notch and adjusting the attenuator for a minimum reading. There should be at least a 10 dB range of attenuator values that has less than a 1 dB effect on the reading of the notch floor. If this cannot be obtained, the optional test channel bandpass filter (centered at the notch frequency) might be required to minimize spectrum analyzer distortion. Or, if the steps of the spectrum analyzer's attenuator are too coarse, the level can be adjusted with an optional 1 dB step attenuator in front of the analyzer. If the level into the spectrum analyzer is too low, the optional amplifier should be inserted in front of the spectrum analyzer.
8. Record the Noise Level.
9. Verify that the analyzer noise floor is sufficiently below the noise notch level by either externally attenuating the signal (at the analyzer input) by at least 30 dB or by disconnecting the signal and terminating the analyzer input. If the drop is less than 15 dB, optimize the dynamic range of the receiver by adding the optional test channel bandpass filter and/or optional amplifier as described in step 7 and repeat steps 8 and 9. If the drop is still less than 15 dB, calculate a Correction Factor by using Equation 1 or the noise-near-noise correction chart in Figure 6.

$$\text{Correction (dB)} = \left| 10\log\left(1 - 10^{\frac{\text{-Noise Drop}}{10}}\right) \right| \text{dB} \qquad (1)$$

Note: Corrections for any drops less than 2.0 dB are subject to significant potential errors. Therefore, it is recommended that, for noise deltas less than 2.0 dB, a 4.3 dB correction factor be used and the total NPR result be expressed as "greater than" (>) x dB.

10. Set the A/B Switch to position A and measure the Signal Level by placing the noise marker on the signal at the same frequency. If the marker reading is not stable, turn on video averaging or use a lower video bandwidth.
11. Calculate the NPR by subtracting the noise level (step 8) from the signal level (step 10) and adding the correction factor (step 9).

    NPR = Signal Level - Noise Level + Correction Factor (2)

Note: When measuring noise with a spectrum analyzer, correction factors are usually required to correct for bandwidth; however, since this measurement is a relative measurement of one noise level vs. another noise level, corrections are not required.

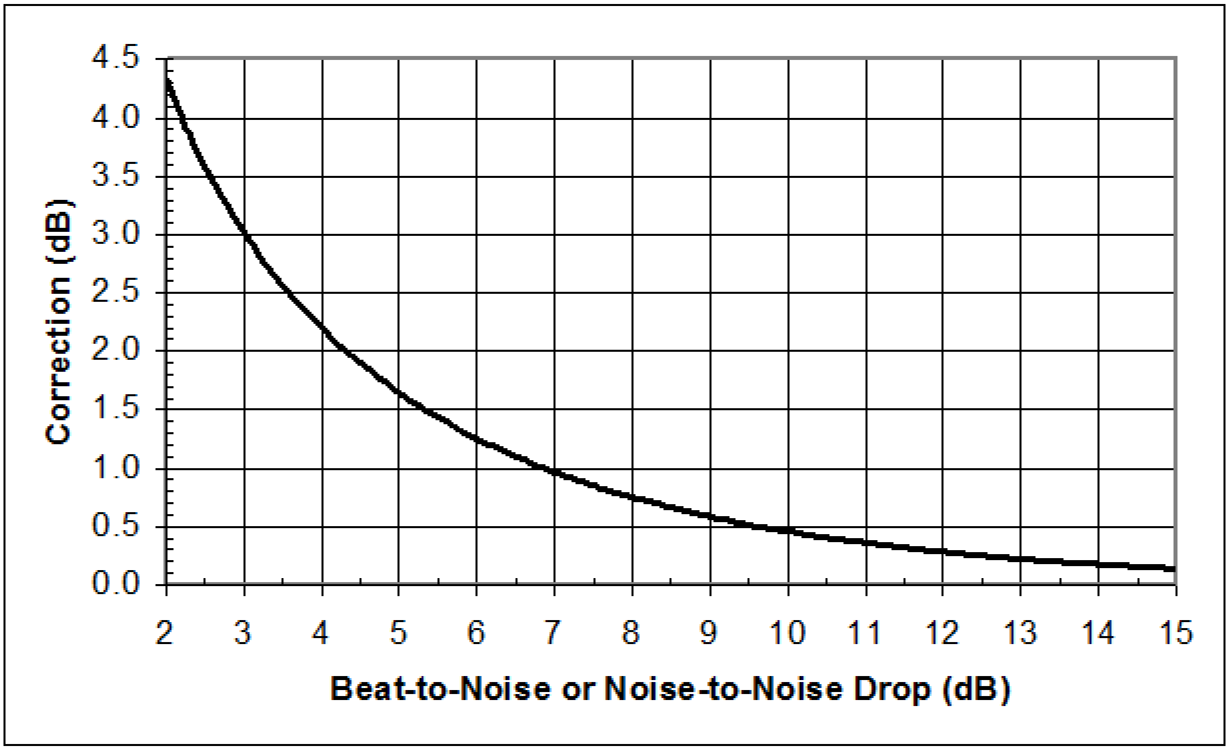

Figure 6 - Noise-Near-Noise Correction

12. Decrease ATT2 and repeat steps 4 through 11 to measure the clipping side of the dynamic range.
13. Return ATT2 to the initial level and then increase ATT2 settings and repeat steps 4 through 11 to measure the noise side of the dynamic range.
14. If a measurement of Peak NPR is desired, fine tune ATT2 and measure NPR until the highest NPR value is obtained.

9. Calculating Dynamic Range

Dynamic Range is the range of input levels that produces a desired NPR. If the required minimum NPR is "Q" dB, then the dynamic range is the range "R" of RF input powers over which the NPR is Q dB or higher. The calculation of dynamic range shall be performed as described in this section. See Figure 7 for reference.

The NPR shall be measured at any convenient interval of input power, but not greater than 1 dB. Then, the two input power levels that correspond to a NPR of Q shall be approximated by doing a linear interpolation of the two points on either side of Q, on both the ascending and descending parts of the curve. The dynamic range is the difference between the power at the intersection point on the ascending part of the curve and the power at the intersection point on the descending part of the curve. See Equations 3 through 5 and Figure 7 for the calculation.

$$P_{Ascending} = P1 + (Q - NPR1) \bullet \left(\frac{P2 - P1}{NPR2 - NPR1} \right) \quad (3)$$

$$P_{Descending} = P3 + (Q - NPR3) \bullet \left(\frac{P4 - P3}{NPR4 - NPR3} \right) \quad (4)$$

$$\text{Dynamic Range} = P_{Descending} - P_{Ascending} \quad (5)$$

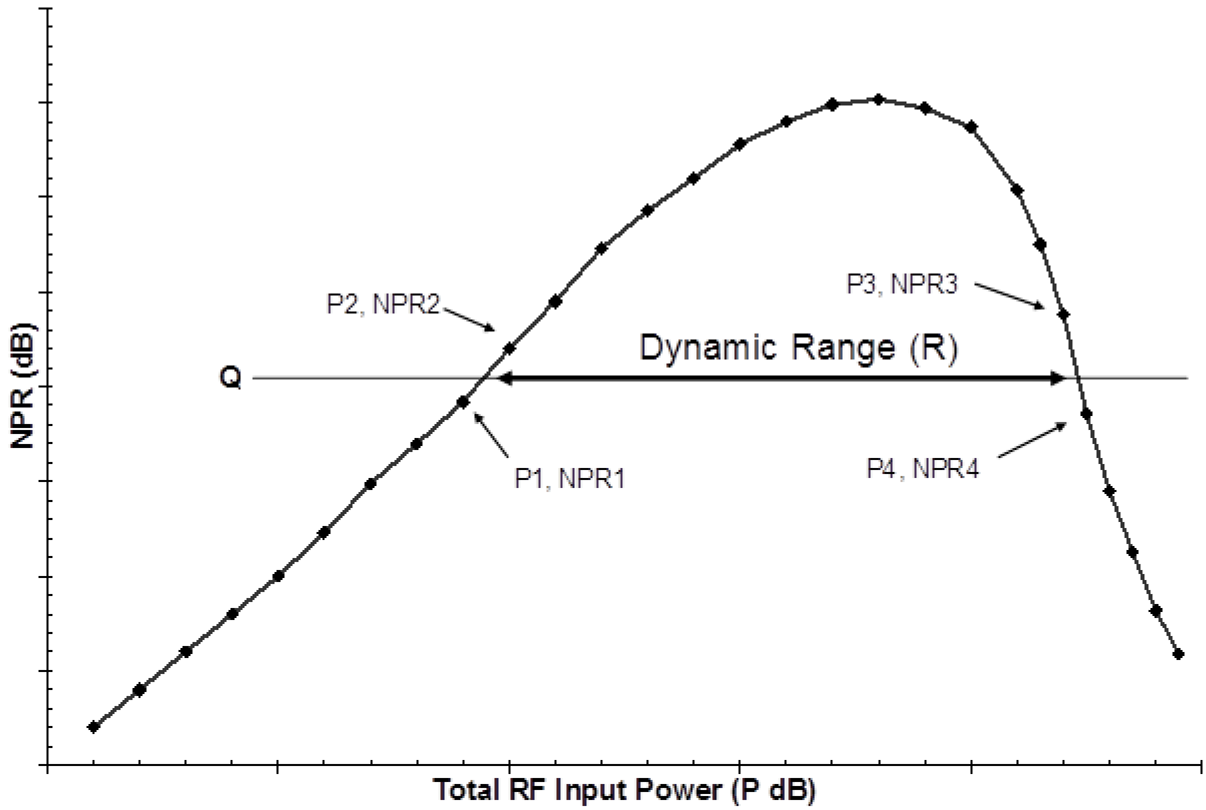

Figure 7 - NPR Dynamic Range Example

10. Notes

This NPR procedure measures the power density of a signal that fills the entire passband (without a notch). Some NPR measurement procedures use the notched noise signal for all measurements, with the NPR being measured by comparing the level adjacent to the notch to the level inside the notch. Such an alternative procedures is allowable only if it can be shown to correlate to the definitions given in this standard. Some issues that must be addressed when using the alternative procedure are mentioned below.

The result is dependent on the flatness of the system being measured and the selection of the RF frequency at which to make the level measurements. The frequencies used must be consistent from measurement to measurement and must be selected such that they are at average points within the flatness of the system.

The power density of the noise signal with the notch is higher than the power density of the noise signal with no notch. In order to use an alternative method, the amount of this error must be measured and subtracted from each NPR result.

Appendix A: Test Report

Device under test

Equipment Type:		Manufacturer:	
Model Number:		Serial number:	

Test equipment

Description	Manufacturer	Model Number	Serial Number	Calibration Date

Test Results

Passband Freq.:		Peak NPR:	
Notch Freq.:			

ATT 2 Setting	Input Level	Signal Level (step 5.10)	Noise Level (step 5.8)	Correction Factor (step 5.9)	NPR (step 5.11)

Dynamic Range Calculation

Required NPR:	
$P_{ascending}$:	
$P_{descending}$:	
Dynamic Range:	

Tested by	Date