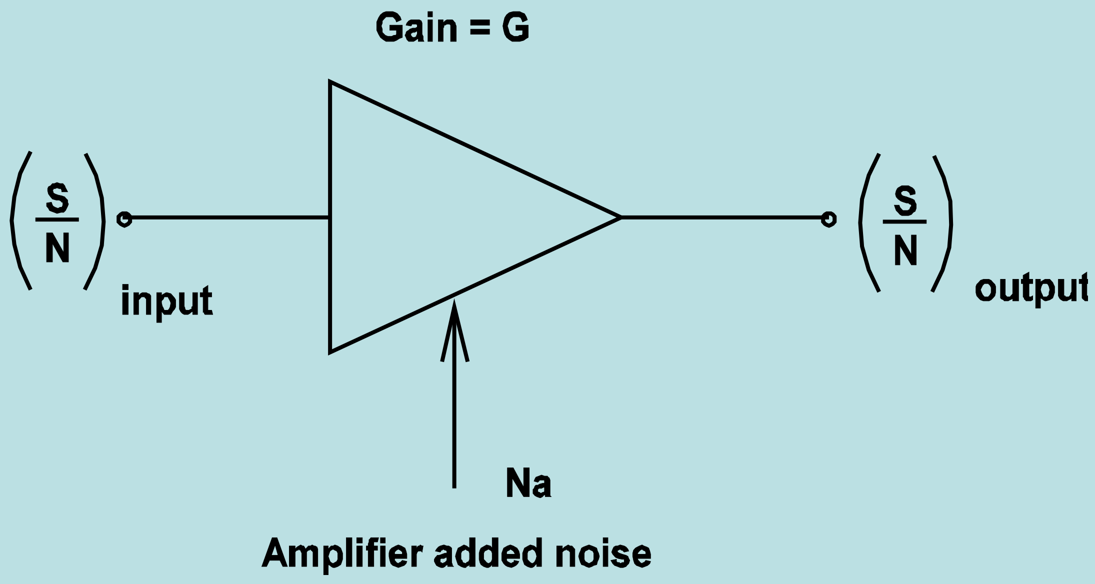
Noise Figure Measurement using Natural Noise Sources

Receiver sensitivity

- Generally want best possible sensitivity
- Important at UHF/microwave frequencies where background noise levels are low
- Weak signals such as beacons can be useful

Noise figure definition

$$F = \frac{\left(\frac{signal}{noise}\right)_{input}}{\left(\frac{signal}{noise}\right)_{output}}$$



Thermal Noise

N = KTB

N = Noise power

K = Boltzmann's constant

T = Absolute temperature

B = Bandwidth

Thermal noise

- All bodies at a finite temperature emit noise
- Noise due to random motion of electrons
- As temperature increases random motion increases.
- As temperature increases noise increases

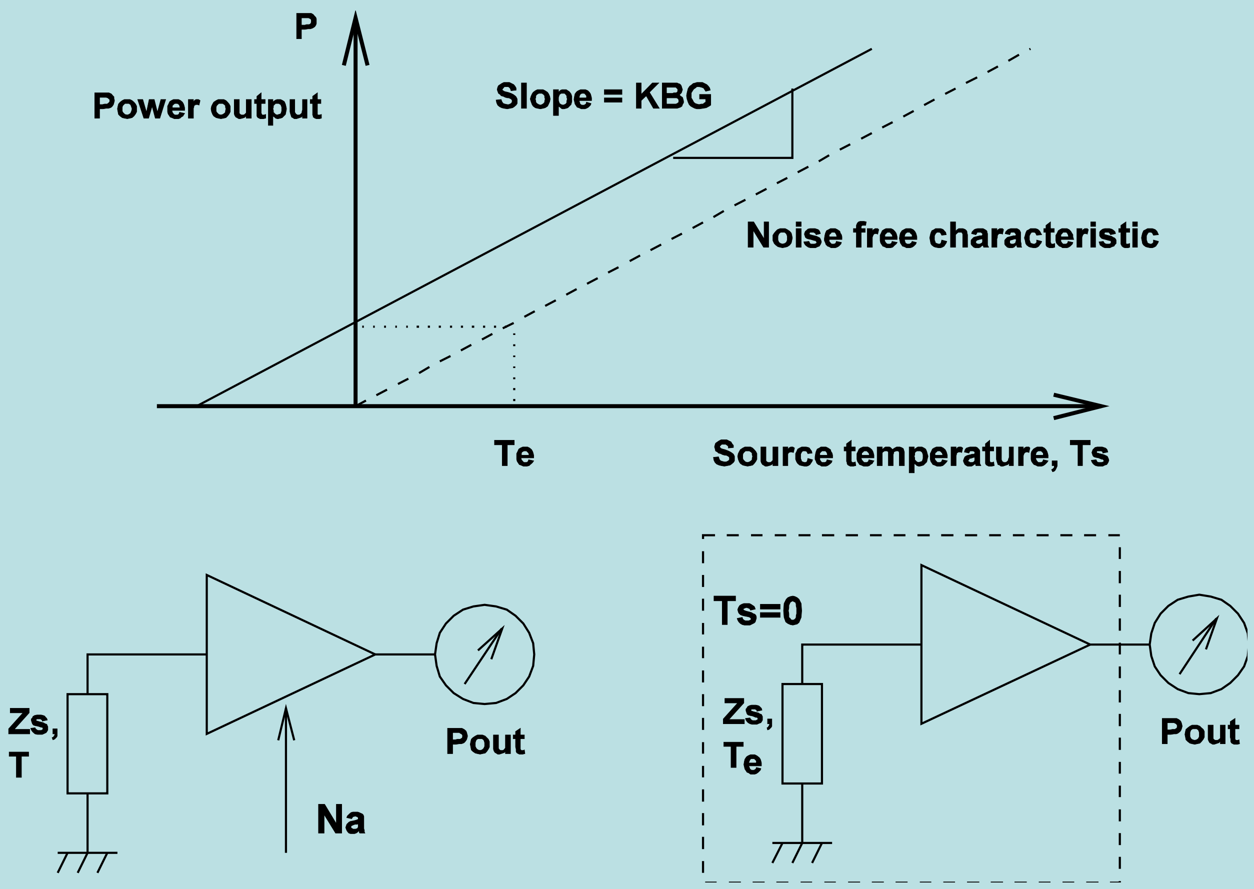
Noise power

- Noise power from a matched load at the input of a receiver = KTB Watts
- Noise is proportional to temperature.

Noise temperature

- Noise temperature is defined as the temperature of an input termination to a “perfect noiseless amplifier” that would give the same noise output power as with the real amplifier.

Noise Temperature



Conversion from noise figure to noise temperature.

$$NF_{dB} = 10\log_{10}\left(\frac{T_e}{290} + 1\right)$$

Conversion from NF to Te

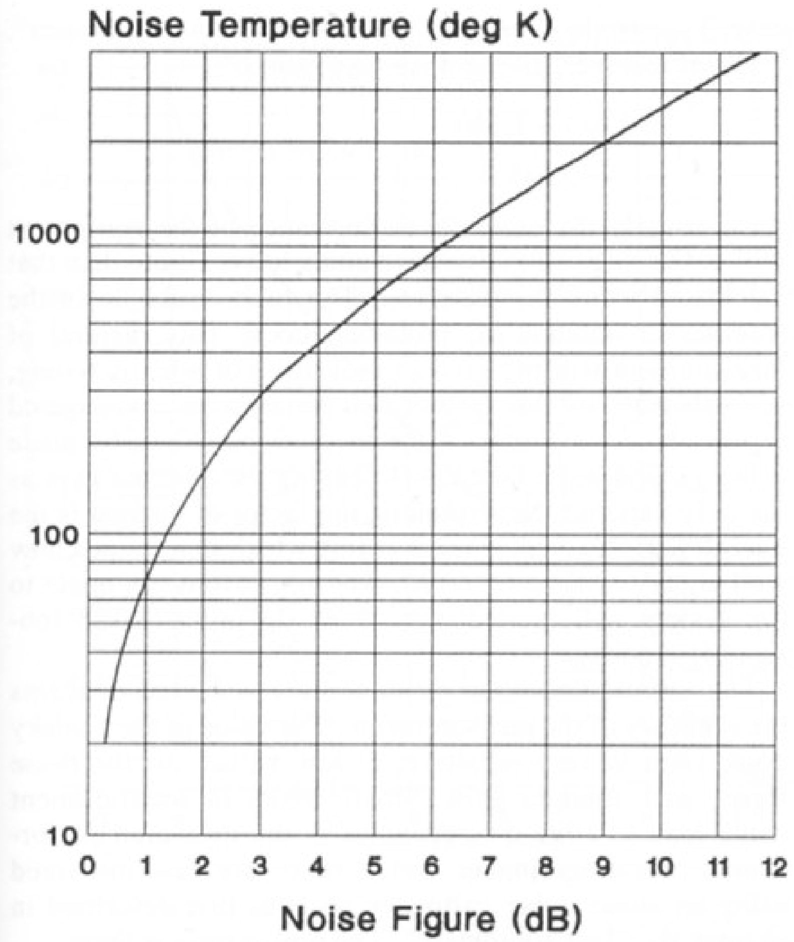


Fig A1.1. Graph of noise temperature (in kelvin) vs. receiver noise figure in decibels

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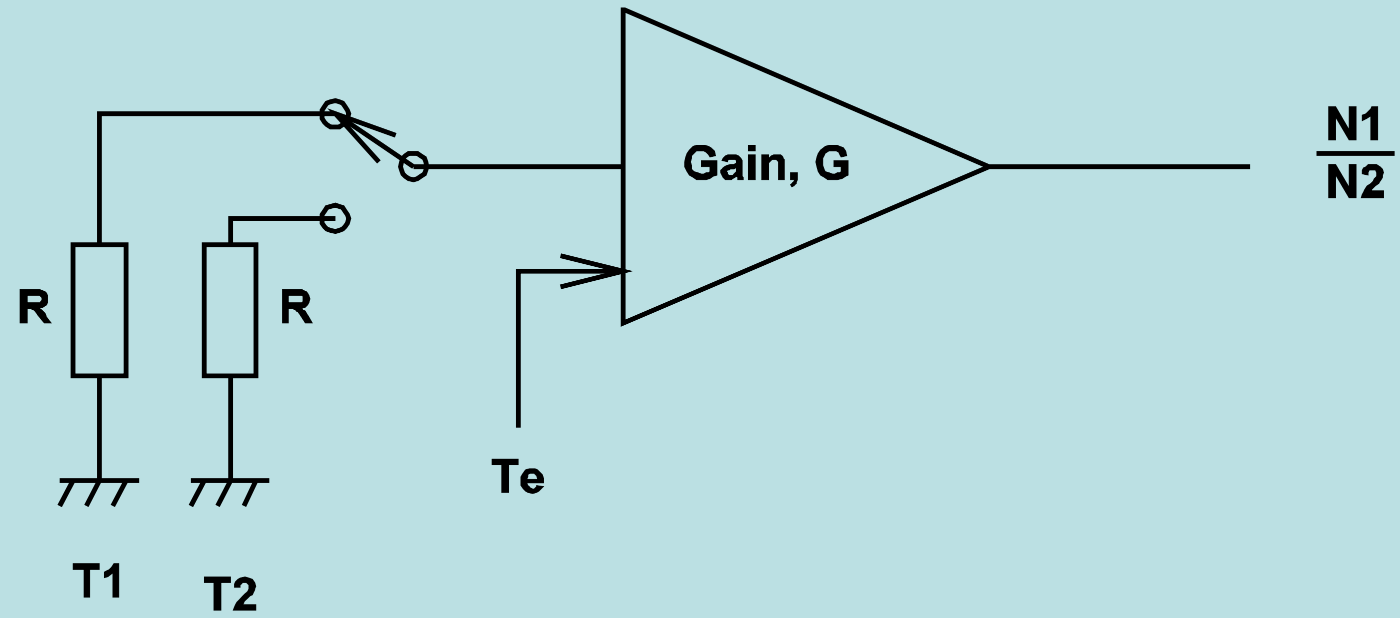
Measurement of Noise Temperature



$$\frac{N_1}{N_2} = \frac{T_1 + T_e}{T_2 + T_e}$$

Hot and Cold load method

- Can make use of this relationship
- Use resistors at different temperatures
- PROBLEM:
- Need to cool to low temperatures for accurate results – liquid nitrogen!

Natural noise sources

- Ground is at about 300 kelvin
- Sky is electrically “cold” at about 20-30 kelvin
- Point antenna at sky and ground and observe difference at receiver output.

- The Sun?????

Ground – Sky Comparison

- Ground at Room temp – approx 290 K
- Sky is electrically cold – approx 0 K

$$\frac{N1}{N2} = \frac{Te + Tground}{Te}$$

$$\frac{N1}{N2} = \frac{Te + 290}{Te}$$

Ground – Sky noise Comparison

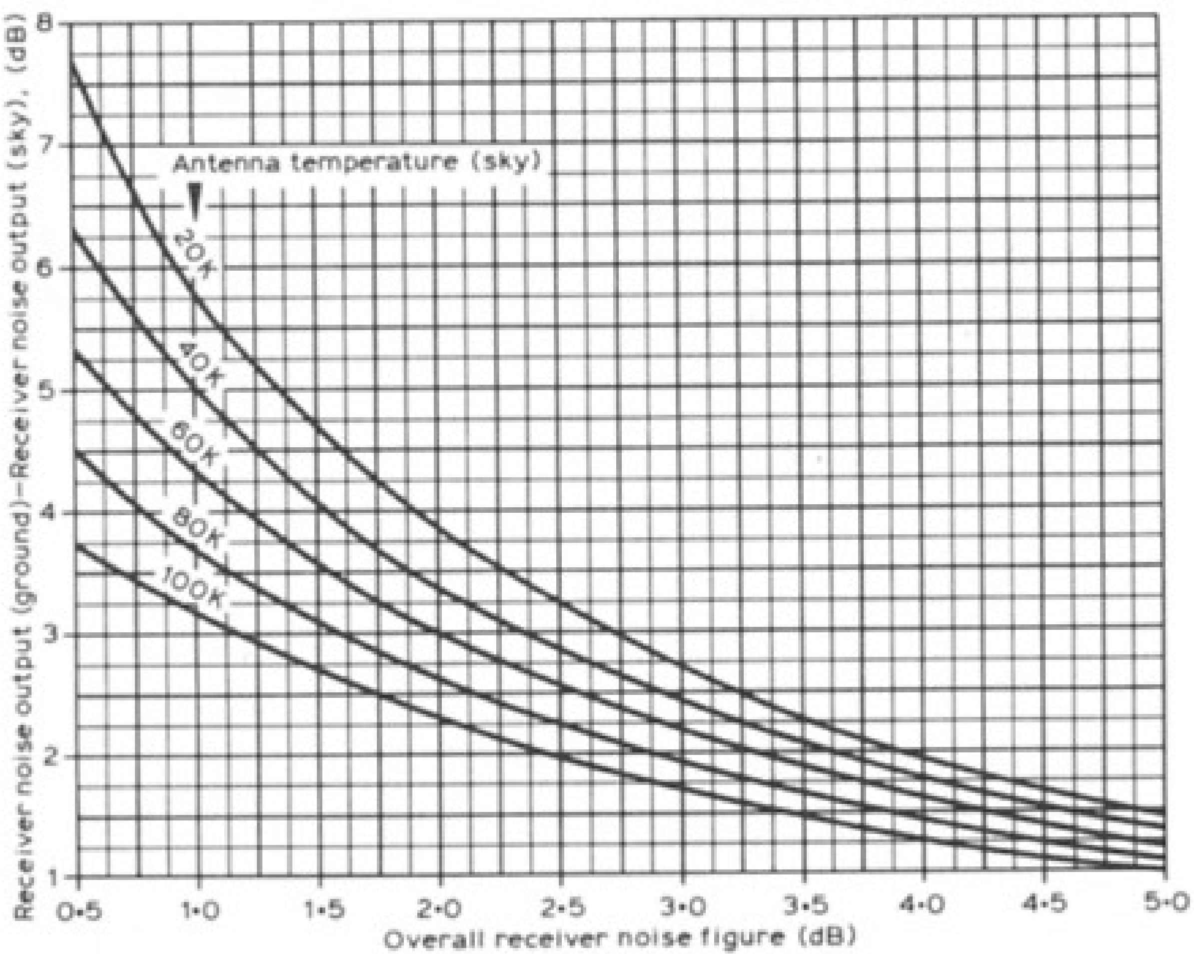


Fig A1.4. Graph of ground/sky noise differential (in dB) vs. overall receiver noise figure for different antenna temperatures (T_{ant} – see text)

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Solar Noise

- The sun varies but at “quiet times” it is a useful point source allowing the performance of antennas to be checked.
- If the NF of the system is known then it is possible to get a good estimate of an antenna gain from the sun noise.

Sun Noise

Table A1.1. Solar and lunar flux

Frequency	Solar Flux* (typ)	Solar Flux* (min)	Solar Flux* (max)	Lunar Flux** (typ)
1.3GHz	100	35	120	0.08
2.3GHz	110	50	210	0.25
3.4GHz	120	75	270	0.50
5.6GHz	150	130	290	1.50
10GHz	300	270	460	4.50
24GHz	1100	1050	1200	26.00

* 1 Solar flux unit (SFU) = 10^{-22} W/m^2/Hz^{-1}

** Lunar flux expressed in same units (SFU)

Minimum flux represents the noise level of the "quiet" sun. Typical flux represents the noise level of the "normal" sun. Maximum flux represents the noise level of the "active" sun.

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Sun Noise for Antenna Checks

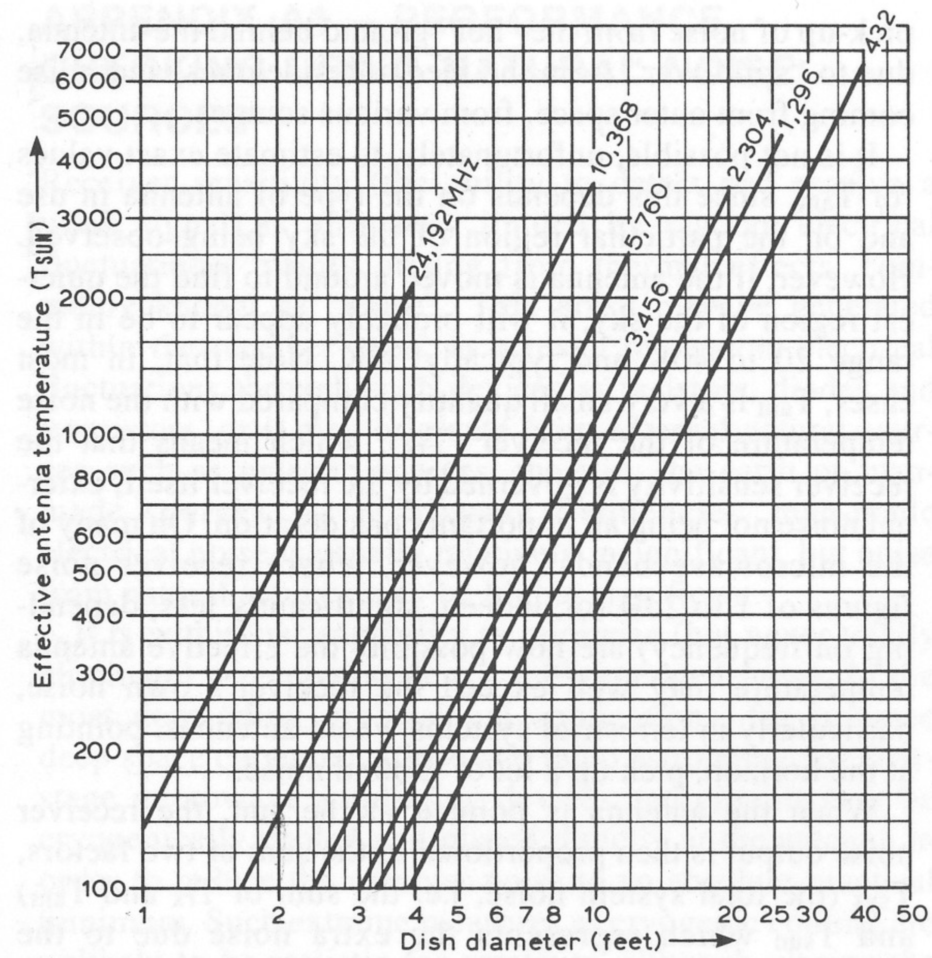

Fig A1.2. Graph of dish diameter (in feet) vs. effective antenna temperature (T_{sun} – see text) for the amateur bands from 432MHz to 24GHz

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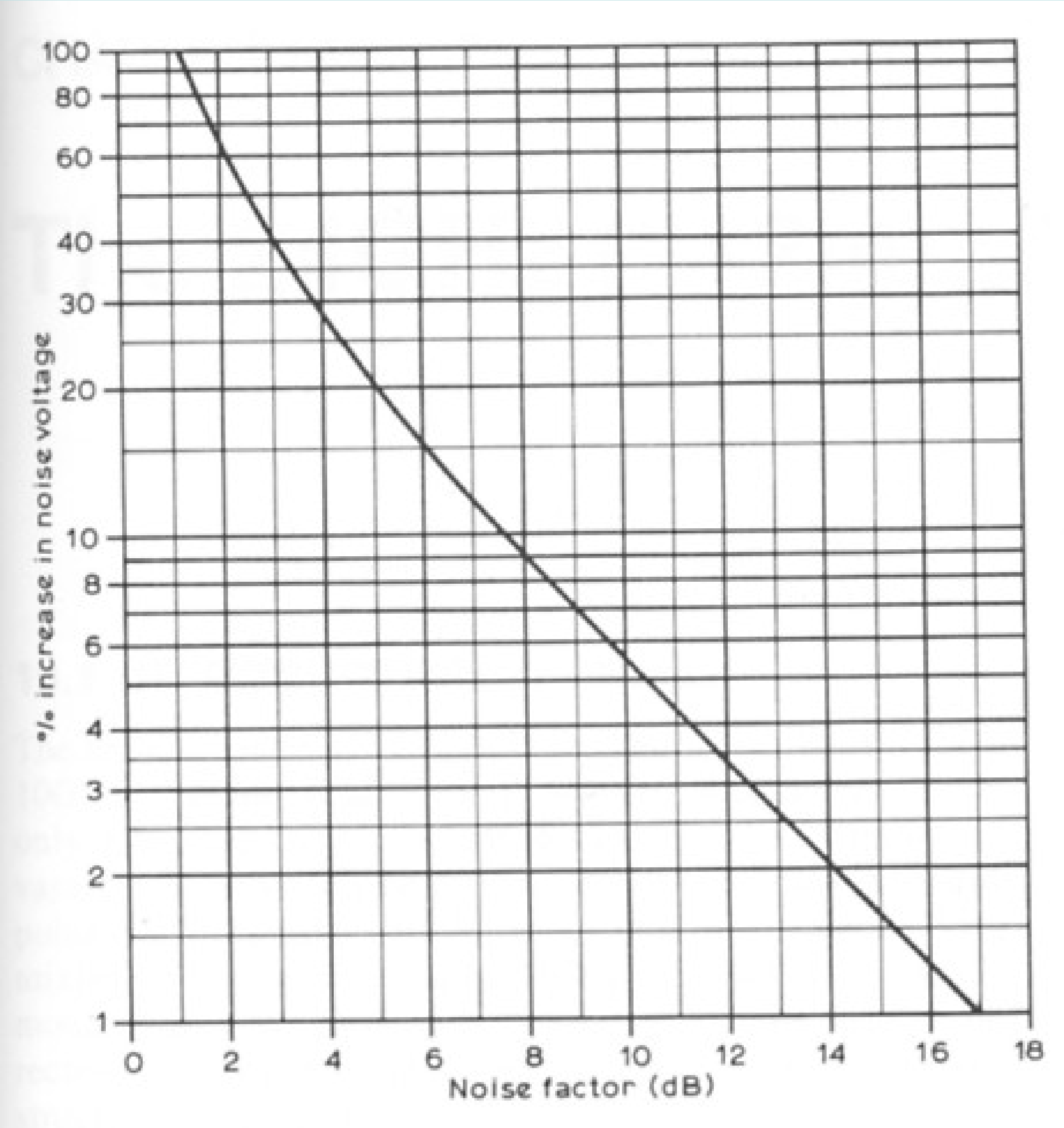
Noise measurement

- Can simple measure the audio noise output from a receiver.
- Make sure AGC is off
- PROBLEM – Fluctuation of readings due to narrow bandwidth.
- SOLUTION – Use a wideband receiver and a power meter.

Noise Voltage



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Demonstration of NF Measurement


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E7
Rail Star
WEST JAPAN
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