Noise Figure Measurement Using Natural (Free) Noise Sources

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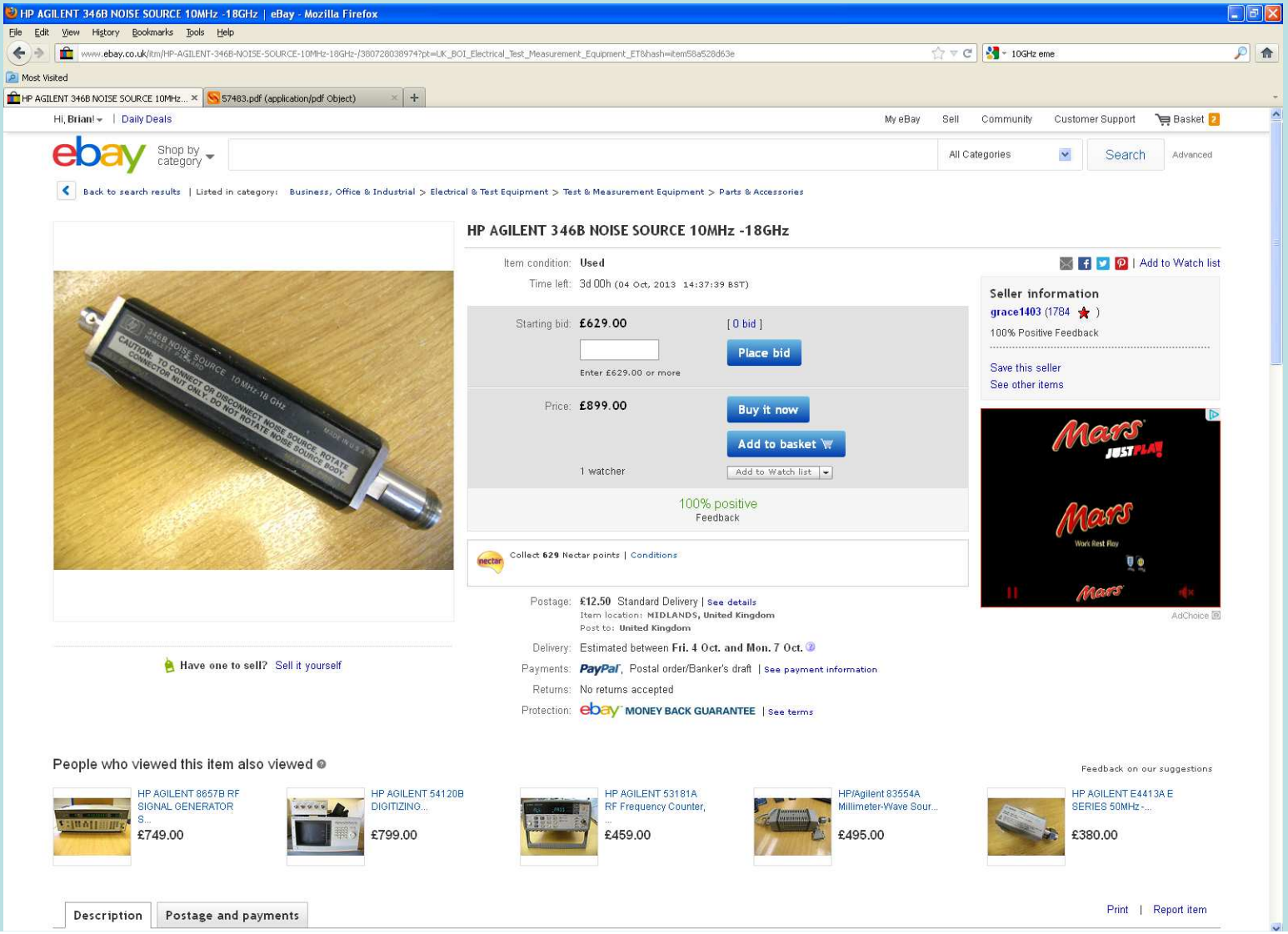
Noise figure measurement is expensive!



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 – often variable
- Useful to be able to verify receiver performance

A Bit About 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

Thermal Noise Power from a Matched Load

$$P = KTB$$

P = Noise power

K = Boltzmann’s constant

T = Absolute temperature

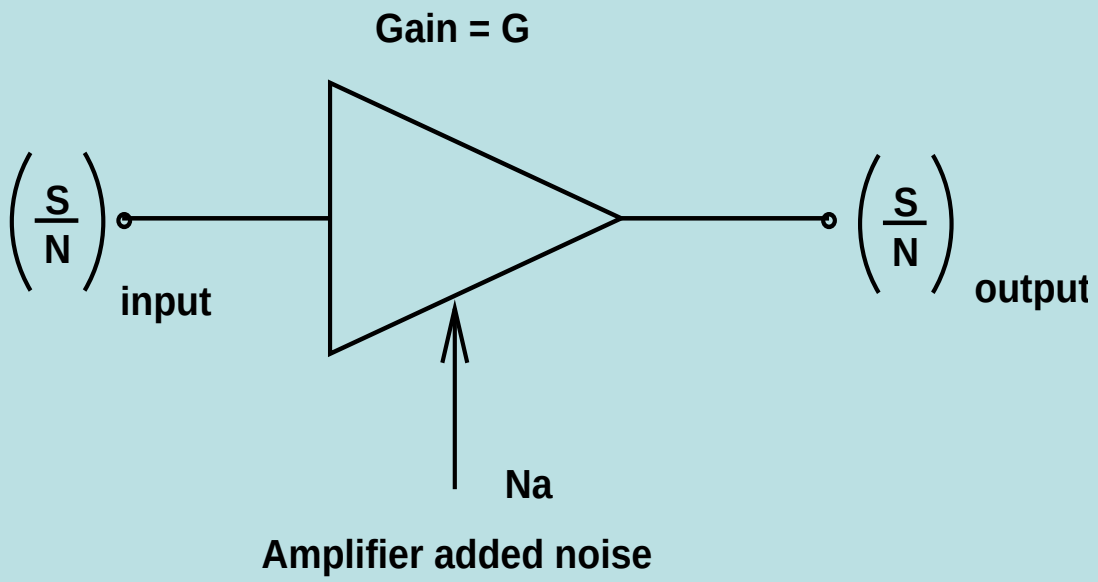
B = Bandwidth

Noise power

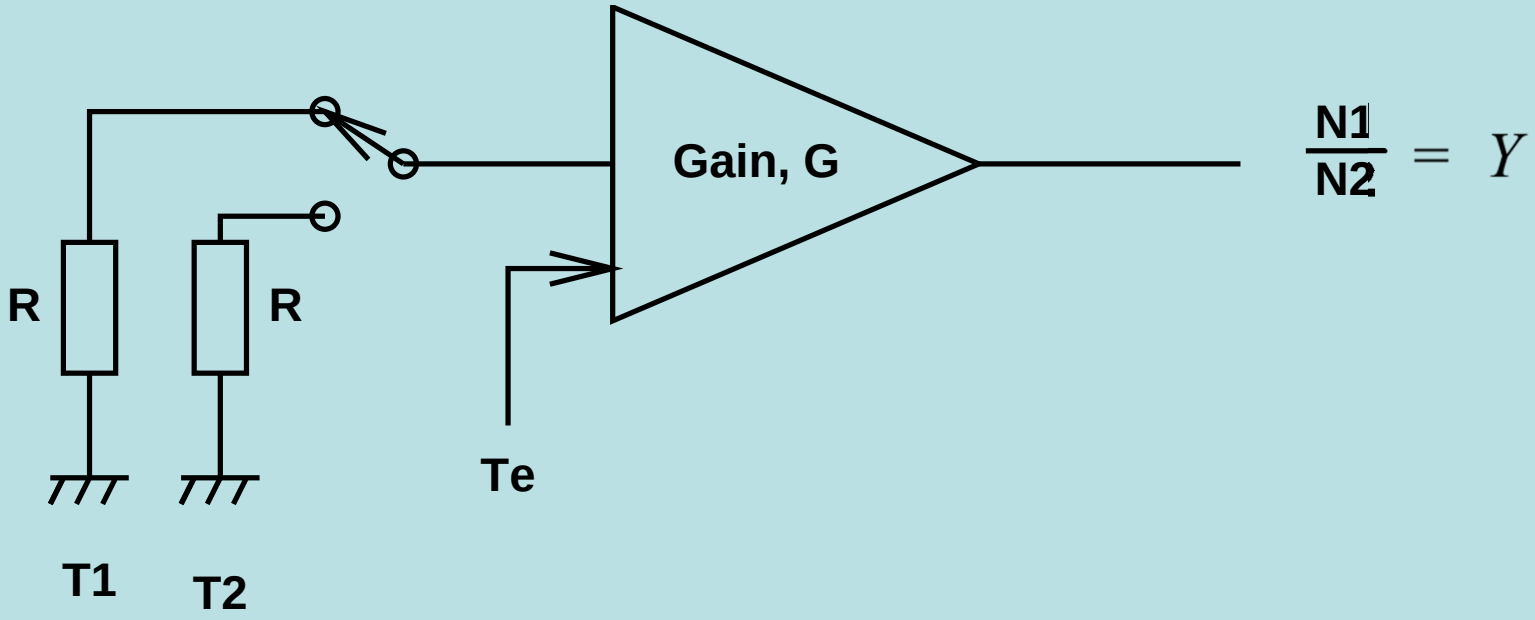
- Noise power from a matched load at the input of a receiver = KTB Watts
- Noise is proportional to temperature
- Temperature can be used to describe the noise power

Noise figure definition

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



Measurement of Noise Temperature

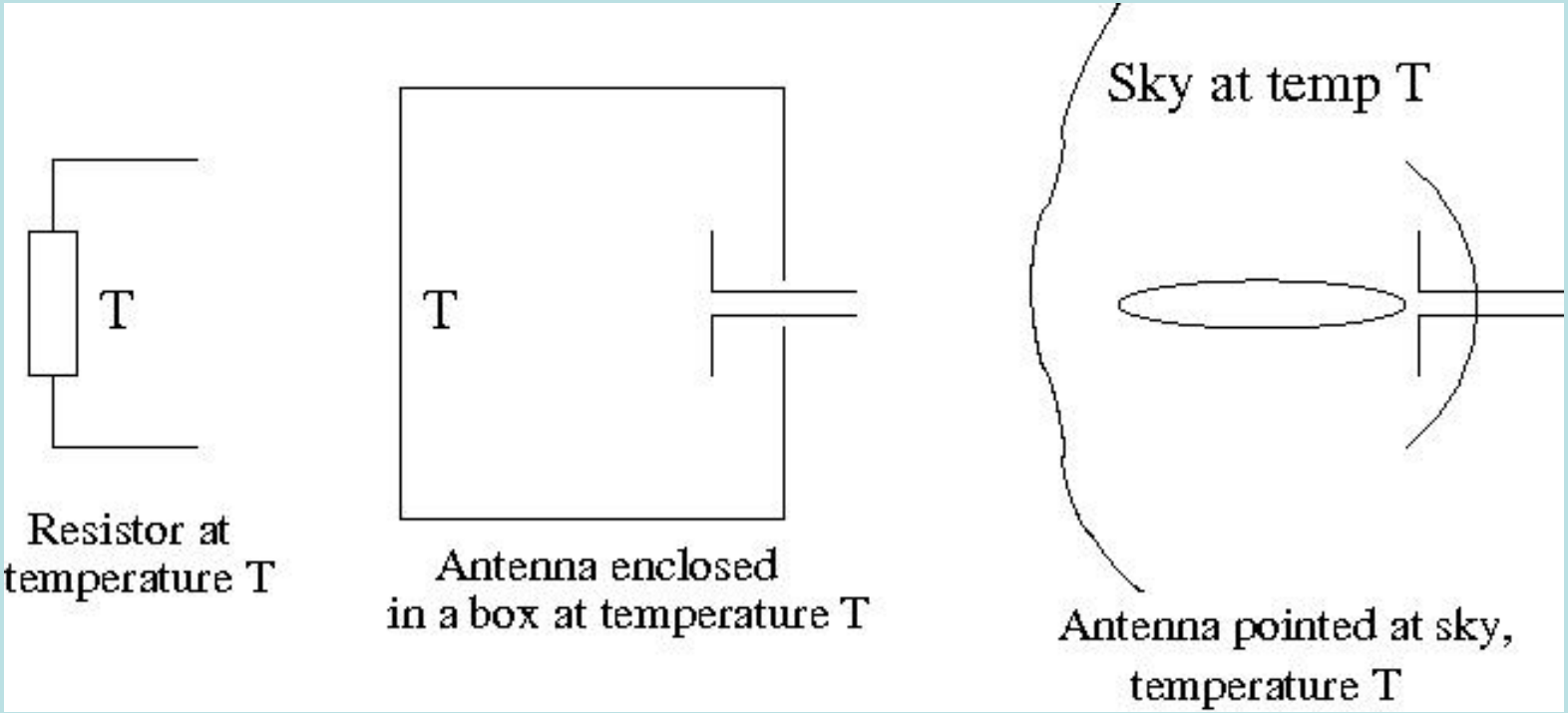


$$\frac{N_1}{N_2} = \frac{T_1 + T_e}{T_2 + T_e} = Y$$

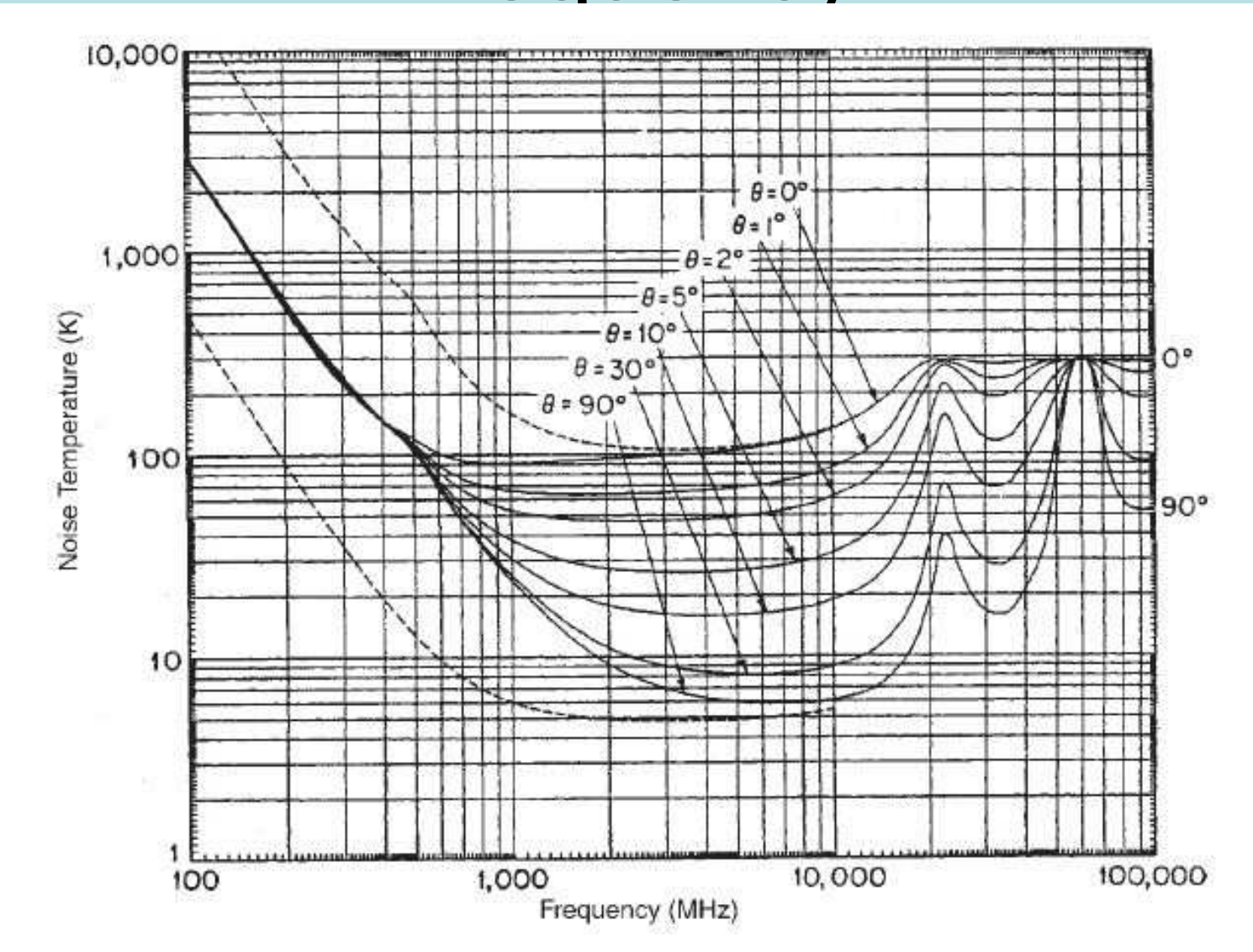
Hot and Cold Load Method

- Can make use of this relationship
- Use resistors at different temperatures
- PROBLEM:
- Need to cool to low temperatures for accurate results – liquid nitrogen!
- Where to get a “cold” load ????

Antenna Noise Temperature



Sky Noise Temperature vs Frequency



Natural noise sources

- Ground is at about 290 kelvin
- Sky is electrically “cold” at about 20 kelvin
- Point antenna at sky and ground and observe difference at receiver output.

Taking it to Extremes at RW3BP

Ground – Sky Comparison

- Ground at room temp – approx 290 K
- Sky is electrically cold – approx 20 K

$$\frac{N_1}{N_2} = \frac{T_e + T_{Ground}}{T_e + T_{Sky}}$$

$$\frac{N_1}{N_2} = \frac{T_e + 290}{T_e + 20} = Y$$

$$T_e = \frac{290 - 20Y}{Y - 1}$$

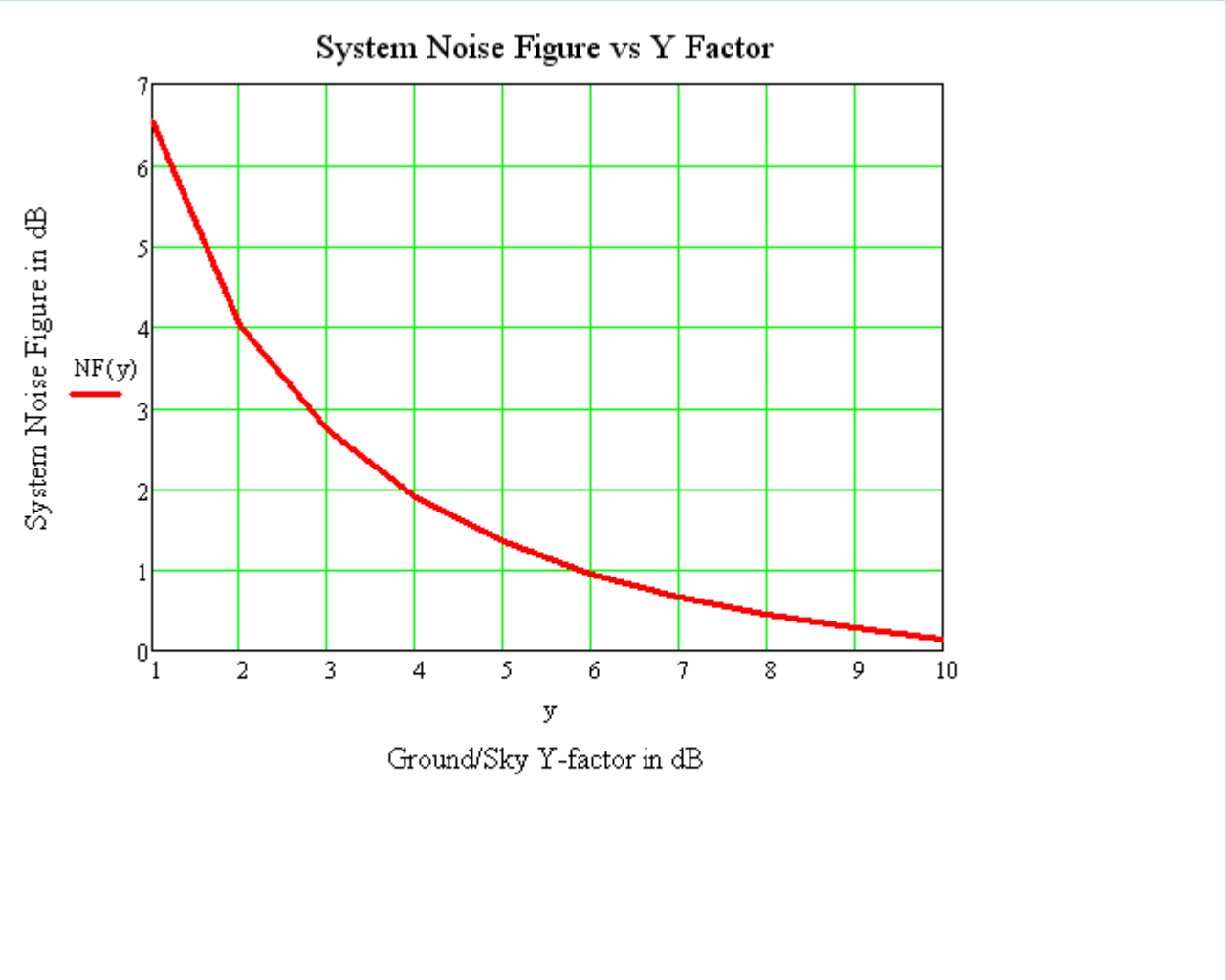
Conversion from Effective Temperature Te to Noise Figure

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

$$NF_{dB} = 10\log_{10}\left(\frac{\left(\frac{290 - 20Y}{Y - 1}\right)}{290} + 1\right)$$

Plot NF_{dB} versus Y-factor in dB

Ground – Sky noise Comparison



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.

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 Receivers/Meters
Ailtech 75

Noise meters:
HP 400 rms Voltmeter

HP432/HP435 + noise amplifier

Pros andCons of Sky/Gound Noise Method

- Noise levels are accurately known
- Not subject to changing input impedance
- Difficult for tweaking – Noise meter better
- Good for low NF – NF meter uncertain
- Most of all SIMPLE!

Questions ?