VSRT MEMO #044

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To: VSRT Group
From: Alan E.E. Rogers
Subject: Demonstration of microwave noise output from a heated resistor

A] Set-up

In this demonstration a left handed polarization (LCP) helix antenna is placed within 2" on the shortest possible baseline formed by 2 LNBFs. The set-up is illustrated in Figure 1 and Figure 2. When the LNBF interferometer is located inside the room contributes about 300 K of background noise which adds to the difficulty of observing the relative weak signal from a resistor. In order to increase the signal as much as possible the resistor is connected to a helix antenna with LCP to match the polarization of the LNBFs. In addition the helix is brought close and the baseline is made as short as possible.

B] Theory

The power output from a resistor due to the thermal motions of the electrons in the resistor is

$$kT \quad watts/Hz$$

where k is Boltzman's constant (1.38×10^{-23} $watts/Hz/K$) and the temperature is in Kelvin. If this power were to be coupled into each LNBF loss the power in each LNBF would be ½ kT. If we include the coupling factor, *c*, normalized correlation is

$$c\left(T_r/2\right)/\left(T_A+T_{LNA}\right)$$

where T_r = resistor temperature

T_A = ambient temperature

T_{LNA} = LNA noise temperature

c = coupling factor

In practice the coupling factor is only a few percent at best.

C] Measurements

Figure 3 shows of plot of the interferometer correlation as the switch is manually cycled on and off. The 18V battery provides 2.7 w to the 1/8 w resistor causing it to heat up the resistor to several hundred degrees above ambient. If the system has a simple single thermal time constant, τ, the temperature rises

$$T_{\max}\left(1-e^{-t/\tau}\right)$$

and delays exponentially

$T_{\max}\, e^{-t/\tau}$

from the plot the time constant is estimated to be about sec.

D] Comments

The purpose of this demonstration is to emphasize the nature of thermal radiation upon which much radio astronomy and radiometric remote sensing is based. Another important demonstration of thermal radiation is take a single LNBF outside and compare the total detected power (using a voltmeter connected to the diode square law detector) looking at the sky and the ground. This can also be done with the LNBF on a dish to obtain a 4 degree beam compared with the ~45 degree beam width of the LNBF. [The beamwidth of an antenna is approximately aperture diameter/wavelength.]

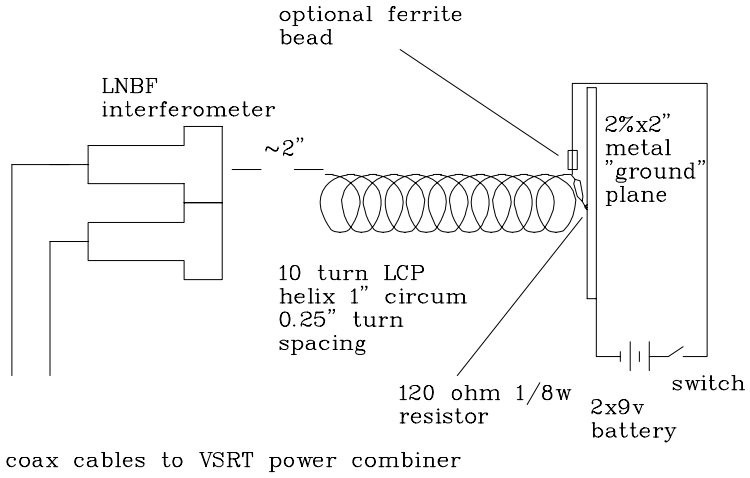

Figure 1.

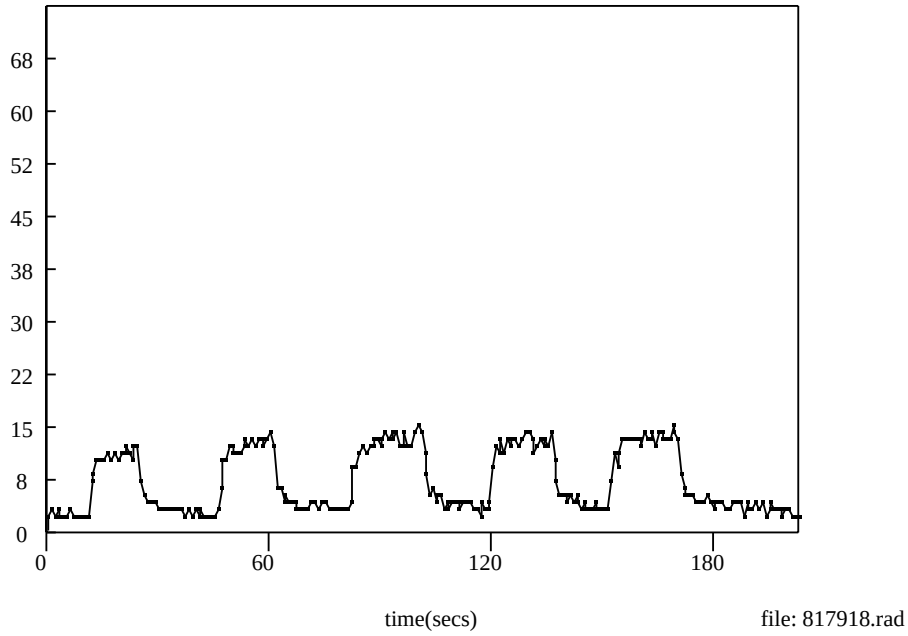

Figure 2.

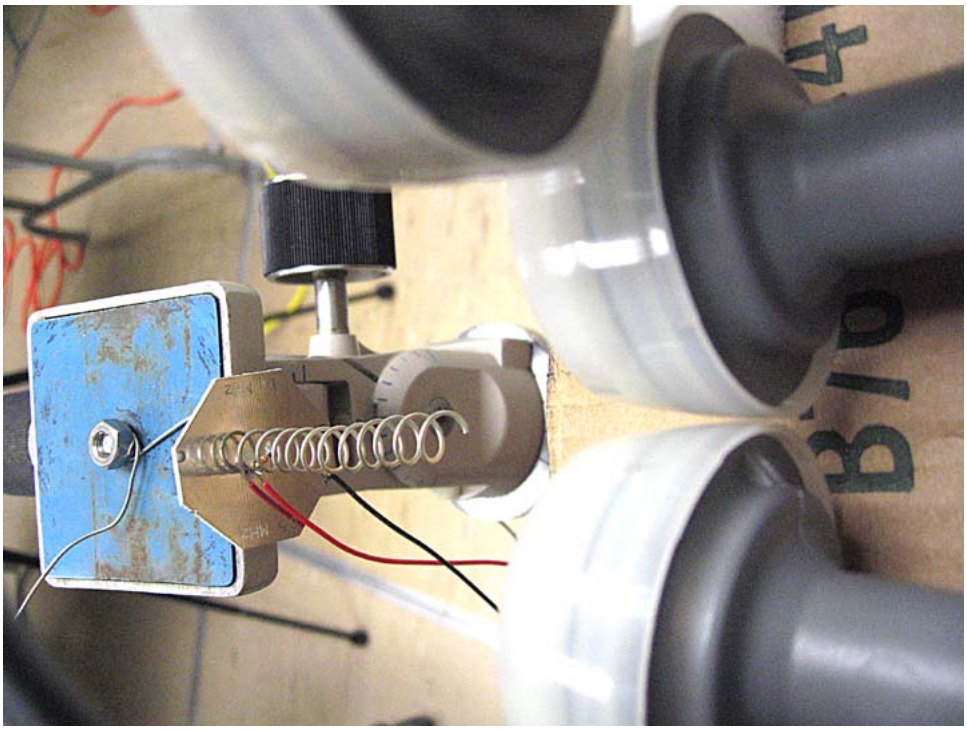

Figure 3.