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THERMAL NOISE AS ELECTROMAGNETIC POLUTAN IN WIRELESS COMMUNICATION SYSTEM

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ABSTRACT

In wireless communication system thermal noise is one of the noise that detected at the receiver. Thermal noise (Johnson Noise) exists in all resistors and results from the thermal agitation of free electrons therein by the temperature.This paper starts with an introduction onhow temperature appears on the receiver and thermal noise on thereceiver. The major contribution factor to thermal noise power and RMS voltage is also discussed analytically. The CDMA modem is used as a subject to study thermal noise in wireless communication system.

Keywords: thermal noise, electromagnetic pollutants, wireless communication.

INTRODUCTION

The performance of a telecommunication system depends on the signal-to noise ratio (SNR) at the receiver's input. However, the received signal power is meaningless unless comparedwith the power received from unwanted sources.Random noise appears in across the terminal of receiving antenna; this noise comes from two sources. Thermal noise generated in antenna's ohmic resistance and noise received from other source. The impedance measured at the terminals of a radio frequency communication antenna is real valued, the resistance that appears at the terminals is the sum of a radiation resistance and ohmic resistance. From transmitter, power supplied to an antenna is absorbed by this resistance, the power absorbed by the radiation resistance is radiated into space, and power that absorbed by the ohmic resistance is turned into heat. Often, the antenna noise is represented as though it were thermal noise generated in fictitious resistance equal to the radiation resistance, at the temperature that would account the actual delivered noise power.We can model the antenna as a warm resistor, with all parameter resistance equal to the antenna parameter, operated in some antennanoise temperature[1] degrees kelvin, so we can simulated the thermal noise that appear on the antenna.

Characteristic

The **equivalent input noise temperature receiver** (T_{eq}) on the receiver would equal the sum of two noise temperatures

$$T_{eq} = T_{ant} + T_{sys} \qquad (1)$$

Theantenna noise temperature (T_{ant}) gives the noise power seen at the output of the antenna, and the noise temperature system (T_{sys}), represents noise generated by noisy components inside the receiver [6].

The noise power given by the symbol P, in watts, = kTB where k is Boltzmann's constant in Joules per Kelvin, and B is the bandwidth in hertz. Thermal noise generates unwanted currents or voltages in an electronic component resulting from the agitation of electrons by heat [2].

Thermal noise is effectively white noise and extends over a very wide spectrum. The noise power is proportional to the bandwidth [5]. It is therefore possible to define a generalised equation for the noise voltage within a given bandwidth as below

$$V^2 = 4kT \int_{f1}^{f2} R\, df \qquad (2)$$

Where V is the integrated RMS voltage between frequenciesf1 and f2, Ris resistive component of the impedance (or resistance) Ω T is the temperature in degrees Kelvin, and f1 and f2 are lower and upper limits of required bandwidth. For most cases the resistive component of the impedance will remain constant over the required bandwidth. It therefore possible to simplify the thermal noise equation to:

$$V = \sqrt{4kTBR} \qquad (3)$$

Where **B** is bandwidth in hertz.It is possible to calculate the thermal noise levels for room temperature, 20°C or 290°K. This is most commonly calculated for a 1 Hz bandwidth as it is easy to scale from here as noise power is proportional to the bandwidth. The most common impedance is 50 Ω.

$$V = \sqrt{4(1.3803 \times 10^{-23}) \times 290 \times 50 \times 1} = 0.9\, nV$$

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While the thermal noise calculations above are expressed in terms of voltage, it is often more useful to express the thermal noise in terms of a power level. To model this it is necessary to consider the noisy resistor as an ideal resistor, R connected in series with a noise voltage source and connected to a matched load.

$$P = \frac{V^2}{4R} = \frac{\sqrt{4kTBR}}{4R} = kTB \qquad (4)$$

Where P is the thermal noise power in watts. Notice it can be seen that the noise power is independent of the resistance, only on the bandwidth.This figure is then normally expressed in terms of dBm.Thermal noise in a 50 Ω system at room temperature is -174 dBm. It isrelate this to the other bandwidth, because the power level is proportional to the bandwidth, twice the bandwidth level gives twice the power level (+3dB), and ten times the bandwidth gives ten times the power level (+10dB) it shows in Table-1 with various bandwidth applications [4].

Thermal noise factor analysis

The analytical using (2), (3) and (4) gave result that show in Figures 1 to 4. The factor that contribute to the thermal noise voltage and powerare temperature, bandwidth and resistance. The temperature is associated with thermal noise voltage; the bigger temperature gives bigger thermal noise voltage and power, Figures 1 and 4. And the resistance have a negative effect on thermal noise voltage, due to the heat release as consequence of energy loss, Figure-2. Also the factor that contribute to the thermal noise power is bandwidth, the channel that have bigger of bandwidth tend to produce higher thermal noise, Figure-3.

Table-1. The Thermal Noise Power in various communication application bands.

Bandwidth (Hz)	**Thermal Noise Power** (dBm)
1	-174
10	-164
100	-154
1k	-144
10k	-134
100k	-124
200k (GSM channel)	-121
1M (Bluetooth channel)	-114
5M (WCDMA channel)	-107
10M	-104
20M (wifi channel)	-101

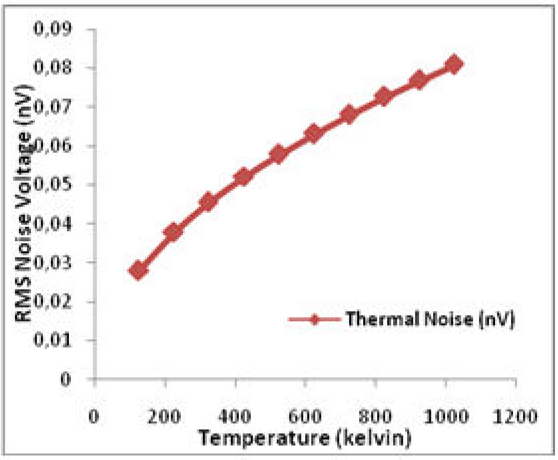

Figure-1. The raising of thermal noise voltage is associatedwith temperature increased.

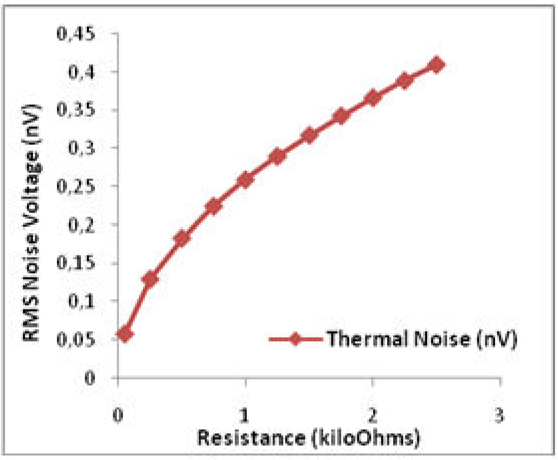

Figure-2. The increment of resistance will increase the RMS noise voltage.

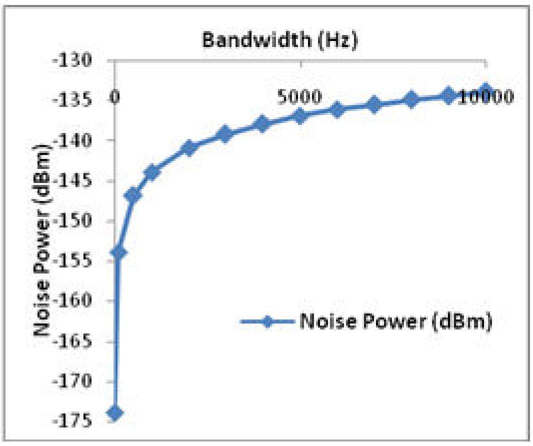

Figure-3. The signals with bigger bandwidth tend to produce higher thermal noise effect.

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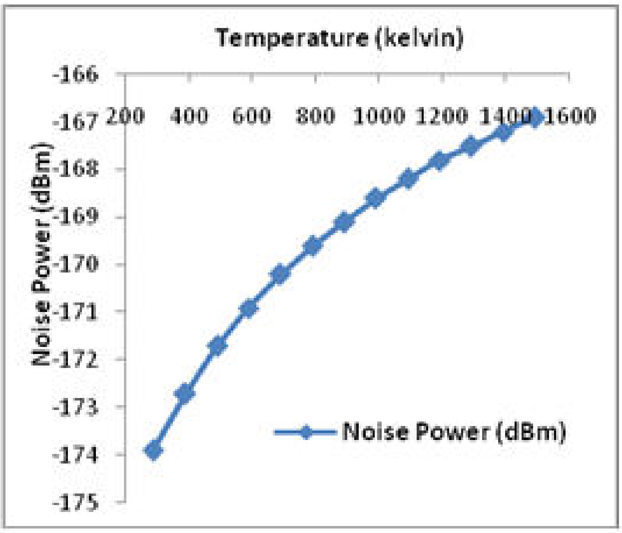

Figure-4. The exponentially rising of thermal noise power associated with temperature increased.

Then we conduct an experiments using a CDMA modem, we took pictures of the subject with a FLIR (forward looking Infra Red) camera to get the temperature of the modem.

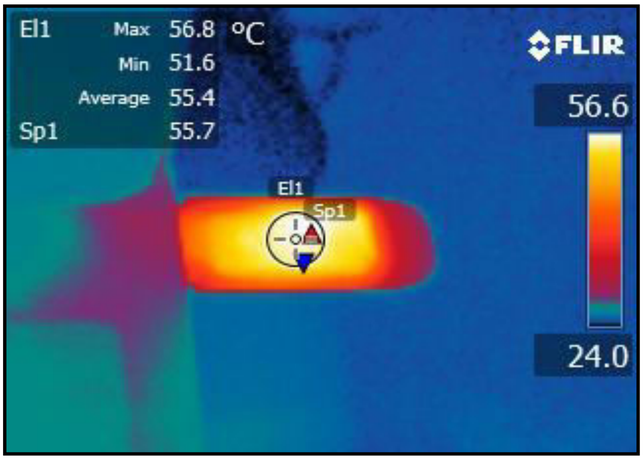

Figure-5.CDMA modem picture taken with the FLIR camera.

Data collection is done with an interval of 10 minutes for 60 minutes. The results obtained from the experiments related to the temperature and heat for the duration of 60 minutes can be seen in the Figure 6 to 7. Due to an increase in temperature, the heat on the modem also can be calculated. It can be seen that the heat also rise in line with the duration of use, it will certainly cause an increase in thermal noise. The noise voltage and noise power of the modem for 60 minutes duration can be seen in Figure-8.

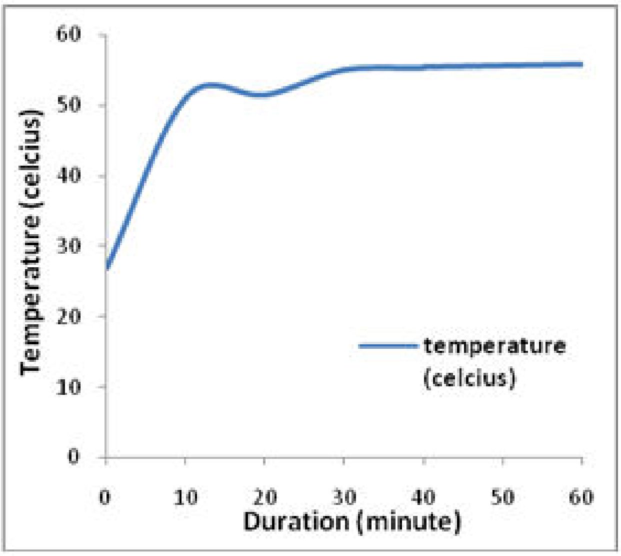

Figure-6. Temperature rise in line with the long duration.

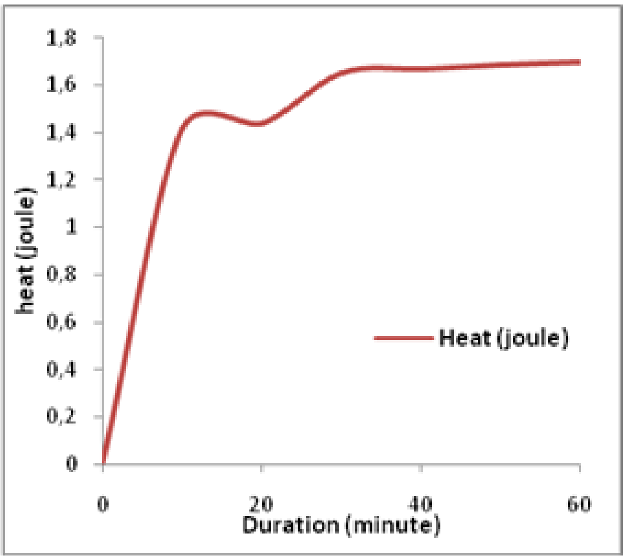

Figure-7. As well as heat, the longer duration of use the greater the heat. It was influenced by the temperature difference.

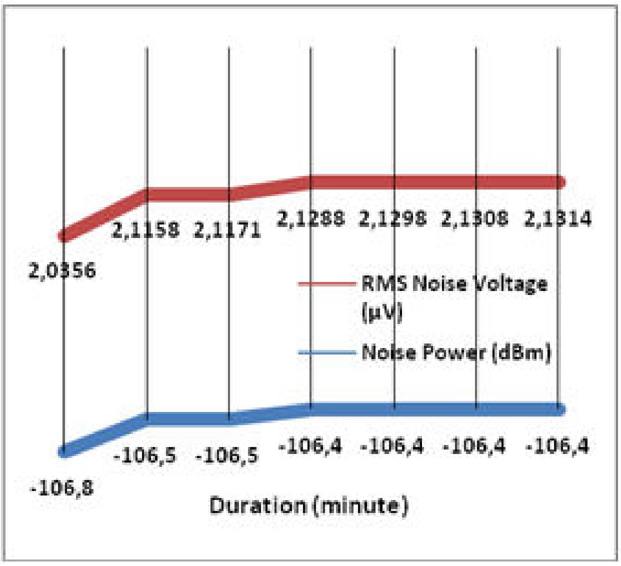

Figure-8. The increase noise voltage and noise power of the modem in duration of 60 minutes.

CONCLUSIONS

Our analysis reveals that there will always be small but significant noise thermal on the receivers; depend on the factors that contribute to the thermal noise power and voltages that we have discussed above.

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