EDGES MEMO #119

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Subject: Thermal Control of EDGES front-end box

In the future deployment of EDGES-2 it is proposed that the "front-end" box with the 3-positioned switch, LNA and post amplification be located under the ground plane near the antenna. In the early concept of an EDGES system the advantages of locating the antenna at ground level were considered and it was proposed the electronics be located in an underground vault deep enough to maintain a constant temperature. Recent plans for deployment are proposed in memo #108 in which the front-end box is about 2 feet below the surface in a plastic NEMA box containing the LNA box maintained at a constant temperature using a thermoelectric element with a controller. The thermoelectric unit can heat or cool the LNA by reversing the polarity of the current.

The excess heat of the whole system is removed by drawing in outside air. The problem with using outside air is that it is difficult to filter the air to avoid drawing in dirt and insects. The installation diagram in Figure 6 of memo #116 shows the NEMA box without ventilation in the hope that the approximately 10 watts of excess heat could be thermally conducted away through the ground. Some simple tests and calculations now show that this will not work well enough to keep the box wall temperature below about 40 C. In order to improve that heat conduction into the ground it now proposed to add an underground pipe to remove the hot air from the box and return it at a lower temperature via the heat conduction loss into the ground. The heat loss from a buried pipe (from webwormcpt.blogspot.com)

$$Q = S \times km \times \Delta T$$

Where Q = heat loss in watts

S = shape factor m

km = soil conductivity

= 0.1 W/m-K for dry soil

ΔT = temperature difference between pipe and soil

$$S = 2\pi L / \log(4d/D)$$

Where L= length of pipe m

d = depth of pipe m

D = diameter of pipe m

For 10 m of 0.025 m diameter pipe buried 1 meter below the surface the temperature rise for 10 W is 8 K. The temperature difference can be ensured by moving 10 cfm $\left(5\times10^{-3}\ m^3/s\right)$ of air which limits the difference in air temperature between the input and the output for 10 w to under 2 K. since the air capacity is about $10^3 J/m^3/K$. A quick test in regular soil using a 75 w lamp as a heat source with a 3m long pipe and 26 cfm fan kept the box temperature rise under 10 K. The reason the pipe takes away more heat than the box for the same surface area is because the temperature field from the pipe decays radially instead of spherically in the case of the box alone.

Figure 1. Photo of the test of heat exchange with ground.