RFI MEMO #014

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October 26, 2005

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To: RFI Group
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Subject: Interference temperature from model for power line noise.

The basic mechanism for power line noise generated by "loose" or corroded hardware which produce small sparks has been studied by William Beasley ("An investigation of radiated signals produced by small sparks on power lines," Ph.D. dissertation, Texas A&M. 1970). "Large" sparks, due to cracked insulators are generally obvious and quickly repaired by the power company whereas "small" sparks are subtle and not easily located.

RFI is from a spark which results from a breakdown between metal surfaces which have formed a poor contact due to the buildup of an insulating layer. The insulating layer is formed by corrosion or oxidation. Generally the insulating layer is a result of loose hardware and this hardware is often coupled to the high voltage through the capacitance of an insulator. Bell insulators which are coupled together by clevis pin joints are frequently a source of RFI.

The average radiated power from a spark is given by $i^2 z\,\tau / P$

Where i = current in the spark

z = impedance of antenna elements at terminals of spark gap

τ = spark current duration ~ few nanosec

P = pulse period ~ 16 ms

And the interference temperature, T, at a distance measured with an isotropic antenna is given by

$$T \sim i^2 z\tau\lambda^2 \Big/ \left(P \left(4\pi r \right)^2 k \right) \qquad (1)$$

where λ = wavelength
k = Boltzman's constant
r = distance from power line

The current duration is determined by the capacitance, c, of the insulator. For a typical capacitance of 30 pf and an impedance of 100 Ω the time constant which determines the pulse duration is about 3 ns. With this duration the RFI from the pulses will start to roll off above 100 MHz. In some cases there will be one pulse per 60 Hz period and in other cases there will be 2 pulses, one of each polarity. There can also be multiple pulses as a capacitance charges and discharges many times during the rising and falling portions of the sinusoidal waveform. If the breakdown occurs at 500 v across the capacitance the spark current will be limited to 5 amps for a radiation impedance 100 Ω.

For the following parameters:

i = 5 amp
z = 100 Ω
τ = 3 ns
λ = 3 ms
c = 30 *pf*
P = 16 ms
R = 1000 m

The interference temperature is about 6000 K at a distance of 1 km from the power line. The "small spark" mechanism is usually most active when the air is dry and disappears when it rains or the humidity is sufficient to provide a leakage current which prevents the small sparking.

Equation 1 can be rewritten in terms of the breakdown voltage, v and the number of pulses, N, in a 60 Hz period.

$$T \sim Nv^2c^2z\lambda^2 \Big/ \left(P\left(4\pi r\right)^2 k\right) \tag{2}$$

Power line noise causes: leaking insulators, poor connection on "slack span", microarcing in bell insulators. See Power-Line Noise Mitigation Handbook for Naval and Other Receiving Sites @ www.arrl.org