Technical Note

Multi-Channel Combining Analog & Digital Transmitters

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Combining consists of summing multiple channels together to feed onto a common cable. Low frequencies and higher frequencies will in time reach a peak voltage together of the same polarity. This voltage summation peak can have more peak power than the sum of their RMS powers.

Since gas tube protectors are voltage sensitive, they must be designed to handle combiner outputs or turn-on RF voltage peaks can result. This can cause major problems at other frequencies (intermod, spurs, interference, etc.). Each protector designed for combiners is listed with the total voltage peak (Vt) that it can withstand without gas tube turn-on. This total is the summation of all the voltage peaks for each channel being combined.

$Vt = Vp1 + Vp2 + Vp3 \ldots + Vpn$

where $Vp = 1.414 \cdot X^* \cdot \sqrt{Pch \cdot 50\ \text{Ohms}}$

(Pch = each channel power OUT OF COMBINER)

SWR.............X*

1.1 to 1 = 1.05

1.2 to 1 = 1.09

1.3 to 1 = 1.13

1.4 to 1 = 1.17

1.5 to 1 = 1.2

1.86 to 1= 1.3

Example:

100 watts each transmitter (into the combiner)

Possible 3 dB loss through combiner = 50 watts (one channel power out of combiner to an antenna with a 1.1:1 SWR);
1.414 . 1.05 . 50 = 74 Vp

5 channels . 74 Vp = 370 Vt

The peak voltage formula was used when there were more than one transmitter through a combiner. The protector was designed to be inserted at the output of the combiner and would be subjected to summed peak voltages of all transmitters after combiner insertion losses (1.5 - 3 dB). The formula assumes a continuous wave transmission (such as FM or PM) and sums the peak voltages of all transmitters. The theoretical maximum peak voltage occurs when all transmitters are on the same frequency and the rf output from the transmitters are precisely in phase. This cannot occur when transmitters are on different frequencies and under Frequency or Phase modulation. So the formula is not reality, but is a practical tool to estimate protector gas tube “turn on headroom” when phasing relationships between transmitters are close enough to be additive. This was important to estimate when we used a gas tube protector (like the obsolete IS-CT50HN) with FM / PM and high power (100 Watt RMS) transmitters to make sure the gas tube turned off after a strike and was not “kept alive” by peak transmitter voltages. Filter type protectors like the DSXZ do not use gas tubes and (within peak power limitations) not subject to voltage summing conditions.

A “300 Watt rms Average” rating of a newer protector takes into account various types of digital modulation with varying peak voltages and duty cycle (“power averaged over time”) and has a great deal to do with the operating temperature of the protector not necessarily the gas tube turn on value. Actual peak voltage for gas tube turn on would be difficult to accurately predict with the “GX” series since the gas tube has a dc protection circuit shunted across it and is biased by the operating dc voltage. The transmitter peak power will change with the applied modulation scheme and duty cycle. It can be very high.

Multi-Channel Combining Digital Transmitters

Combined digital transmitter Peak Envelope Powers (PEP) can be much higher than converting from average power to peak then summing all the transmitter peak powers. There are formulas available to make this calculation, but they are beyond the scope of this venue.

One way to quickly approximate the PEP of combined digital transmitters is to use a “Modulation Factor” that has been empirically determined to produce results reasonably close to a more complex calculation. For band limited $\pi/4$ QPSK modulation, the factor would be 2.18.

Example:

PEP = 2.18 x N 2 x avg pwr

Where: N 2 = number of carriers squared

Example; 12 carriers

Avg pwr = Average power of each carrier

Example; = 20 watts

2.18 x 144 x 20 = 6278.4 Watts PEP

2.18 x 144 x 25 watts = 7848 Watts PEP

Combiner losses from 1.2 to 3 dB will reduce the PEP output to the lightning protector.

Please contact us for questions or further information on this topic.

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