

## COMMON FORMULAS AND RF POWER REQUIREMENTS FOR RADIATED IMMUNITY TESTING

### Important Factors

- Antenna Gain
- Antenna VSWR
- Cable Losses
- Linearity of the power amplifier
- Anechoic room field gradients (6dB maximum)
- Antenna gain vs. Frequency
- Transmit distance
- Amplitude modulation
- Amplifier harmonic levels at rated power

### Useful Formulas

Field Strength (far field)

$$E_o = (30P_i G_a)^{1/2} / d$$

Transmit power

$$P_i = [(E_o^2)(d^2)] / 30G_a$$

Peak Voltage on AM carrier

$$E_p = (E_{um})(1 + AM/100)$$

Peak envelope power (PEP) for 80% AM

$$= 3.24P_{(um)} \text{ and is obtained from } (1 + AM/100)^2 \text{ with } 20 \log (1 + AM/100)^2 = 5.1 \text{ dB}$$

$E_p/E_{(um)} = 20 \log (1 + AM/100) = 5.1 \text{ dB}$  for 80% AM (This is the power increase required to accommodate an 80% depth of amplitude modulation.)

Where

$E_o$  = field strength in volts/meter

$P_i$  = incident power at the antenna in watts

$G_a$  = numeric antenna gain ( $10^{(dbi/10)}$ )

$d$  = transmission distance in meters

$E_p$  = peak voltage of the modulated carrier

$E_{um}$  = unmodulated rf voltage

$P_{um}$  = unmodulated carrier power

AM = depth of modulation (%)

dBi = antenna gain referenced to an isotropic radiator (a theoretical

point source radiator with uniform spherical coverage and no losses)

### VSWR and Transmission Loss

Ratio of transmitted to incident power =  $P_t/P_i = 1 - \Gamma^2$

Transmission loss of dB =  $10 \log(1 - \Gamma^2)$

Where  $\Gamma$  = reflection coefficient =  $(s-1)/(s+1) = 4s/(s+1)^2$   
 $s$  = VSWR =  $(\Gamma + 1)/(\Gamma - 1)$   
 $P_i$  = incident power  
 $P_t$  = transmit power

Return Loss in dB is often a more useful expression than VSWR or reflected coefficient

Return Loss (RL) =  $20 \log \Gamma$

### Convert Antenna Factor to Antenna Gain in dBi

$G = 20 \log(f) = AF - 29.79$  dB

Where  $G$  = antenna gain in dBi  
 $AF$  = antenna factor in dB  
 $f$  = frequency in MHz

### Frequency and Wavelength

$\lambda = 300/f$

Where  $\lambda$  = wavelength in meters  
 $f$  = frequency in MHz