RF System Formulas

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$Noise\_Floor_{[dBm]} = -174 + 10*LOG(BW_{[Hz]}) + Noise\_Figure_{[dB]} + Gain_{[dB]}$

$Minimum\_Detectable\_Signal_{[dBm]} = [-174 + 3_{dB}] + 10*LOG(BW_{[Hz]}) + Noise\_Figure_{[dB]}$

$Spurious\_Free\_Dynamic\_Range_{[dB]\ ord\ 2} = (1/2) * [174 + IIP2_{[dBm]} - Noise\_Figure_{[dB]} - 10*LOG(BW_{[Hz]})]$

$Spurious\_Free\_Dynamic\_Range_{[dB]\ ord\ 3} = (2/3) * [174 + IIP3_{[dBm]} - Noise\_Figure_{(dB)} - 10*LOG(BW_{[Hz]})]$

$Noise\_Figure_{[dB]} = 174 + RX\_Sensitivity_{[dBm]} - 10*LOG(BW_{[Hz]}) - Signal/Noise_{[dB]}$

$RX\_Sensitivity_{[dBm]} = -174 + 10*LOG(BW_{[Hz]}) + Noise\_Figure_{[dB]} + Signal/Noise_{[dB]}$

$Signal/Noise_{[dB]} = 174 + RX\_Sensitivity_{[dBm]} - 10*LOG(BW_{[Hz]}) - Noise\_Figure_{[dB]}$

$RX\_Dynamic\_Range_{[dB]} = RX\_Sensitivity_{[dBm]} - P1dB_{[dBm]}$

$Blocking\_Dynamic\_Range_{[dB]} = P1dB_{[dBm]} - Noise\_Floor_{[dBm]} - Signal/Noise_{[dB]}$

$Co\text{-}channel\_rejection_{[dB]} = Co\text{-}channel\_interferer_{[dBm]} - RX\_Sensitivity_{[dBm]}$

$RX\_selectivity_{[dB]} = - Co\text{-}ch\_rejection_{[dB]} - 10*LOG[10^{(-IF\_filter\_rej[dB]/10)} + 10^{(-LO\_spur[dBc]/10)} + IF\_BW_{[Hz]} * 10^{(SB\_Noise[dBc/Hz]/10)}]$

$Image\_frequency_{[MHz]} = RF\_frequency_{[MHz]} \pm 2*IF\_frequency_{[MHz]}$

$Half\_IF_{[MHz]} = RF\_frequency_{[MHz]} \pm IF\_frequency_{[MHz]} / 2$

$Half\_IF_{[dBm]} = [OIP2_{[dBm]} - RX\_Sensitivity_{[dBm]} - Co\text{-}channel\_rejection_{[dB]}] / 2$

$IM\_rejection_{[dB]} = [2*IIP3_{[dBm]} - 2* RX\_Sensitivity_{[dBm]} - Co\text{-}Channel\_rejection_{[dB]}] / 3$

$IIP3_{[dBm]} = Interferer\_level_{[dBm]} + [Interferer\_level_{[dBm]} - RX\_level_{[dBm]} + Signal/Noise_{[dB]}] / 2$

$OIP3_{[dBm]} = Pout_{[dBm]} + [IM3_{[dBc]} / 2] = Pout_{[dBm]} + [Pout_{[dBm]} - IM3_{[dBm]}] / 2$

$IM3_{[dBm]} = 3* Pout_{[dBm]} - 2*OIP3_{[dBm]}$

$IM3_{out}\ unequal\_input\_levels(left\_side)_{[dBm]} = Pout\_Left_{[dBm]} - 2*[OIP3_{[dBm]} - Pout\_Right_{[dBm]}]$

$OIP2_{[dBm]} = Pout_{[dBm]} + IM2_{[dBc]} = 2 * Pout_{[dBm]} - IM2_{[dBm]}$

$IM2_{[dBm]} = 2 * Pout_{[dBm]} - OIP2_{[dBm]}$

$IIP2(cascaded\_stages)_{[dBm]} = IIP2_{last\ stage[dBm]} - Gain_{total[dB]} + Selectivity\ @\ 1/2\ IF_{[dB]}$

$IIP2(Direct\_Conversion\_Receiver)_{[dBm]} \geq 2*AM\_Interferer_{[dBm]} - Noise\_Floor_{[dBm]}$

$Full\_Duplex\_Noise@RX\_inp_{[dBm]} = -174 - TX\_Noise@RX\_band_{[dBm/Hz]} - Duplexer\_rejection_{[dB]}$

$Crest\_Factor_{[dB]} = 10*LOG[Peak\_Power_{(w)} / Average\_Power_{[w]}] = Peak\_Power_{[dBm]} - Average\_Power_{[dBm]}$

$MultiCarrier\_Peak\_to\_Average\_Ratio_{[dB]} = 10*LOG(Number\_of\_Carriers)$

$MultiCarrier\_Total\_Power_{[dBm]} = 10*LOG(Number\_of\_Carriers) + Carrier\_Power_{[dBm]}$

$Processing\_Gain_{[dB]} = 10*LOG[BW_{[Hz]} / Data\_Rate_{[Hz]}]$

$Eb/No_{[dB]} = S/N_{[dB]} + 10*LOG[BW_{[Hz]} / Data\_Rate_{[Hz]}]$

$RX\_Input\_Noise\_Power\_max_{[dBm]} = Sensitivity_{[dBm]} + Processing\_Gain_{[dB]} - Eb/No_{[dB]}$

$Carrier\_Noise\_Ratio_{[dB]} = 10*LOG[Eb/No] + 10*LOG[Bit\_Rate_{[bps]} / BW_{[Hz]}]$

$Bandwidth\_Efficiency_{[bps/Hz]} = Bit\_Rate_{[bps]} / BW_{[Hz]}$

$Integer\_PLL\_freq\_out_{[MHz]} = [N_{(VCO\_divider)} / R_{(Ref\_divider)}] * Reference\_frequency_{[MHz]}$

$Required\_LO\_PhaseNoise_{[dBc/Hz]} = RX\_level_{[dBm]} – Blocking\_level_{[dBm]} – Signal/Noise_{[dB]} – 10*LOG(BW_{[Hz]})$

$PLL\_PhaseNoise_{[dBc/Hz]} = 1Hz\_Normalized\_PhaiseNoise_{[dBc/Hz]} + 10*LOG(Comparison\ Frequency_{[Hz]}) + 20*LOG(N)$

$PLL\_Lock\_Time_{[usec]} = [400 / Loop\_BW_{[kHz]}] * [1-10*LOG(Frequency\_tolerance_{[Hz]} / Frequency\_jump_{[Hz]})]$

$PLL\_Switching\_Time_{[usec]} = 50 / F\_comparison_{[MHz]} = 2.5 / Loop\_Bandwidth_{[MHz]}$

$PhaseNoise\_on\_SpectrumAnalyzer_{[dBc/Hz]} = Carrier\_Power_{[dBm]} – Noise\_Power@Freq\_offset_{[dBm]} – 10*LOG(RBW_{[Hz]})$

$PLL\_Phase\_Error_{RMS\ [°]} = 107 * 10^{(PhaseNoise[dBc/Hz] / 20)} * \sqrt{Loop\_BW[Hz]}$

$PLL\_Jitter_{[seconds]} = PLL\_Phase\_Error_{RMS\ [°]} / (360*Frequency_{[Hz]})$

$EVM_{RMS\ [\%]} = 1.74 * PLL\_Phase\_Error_{RMS\ [°]}$

$TX\_PhaseNoise\_limit_{[dBc/Hz]} = Power\_limit@Offset\_from\_carrier_{[dBc]} + 10*LOG(BW_{[Hz]})$

$ACLR_{[dBc]} = 20.75 + 1.6*Crest\_Factor_{[dB]} + 2*[Input\_Power_{[dBm]} – PA\_IIP3_{[dBm]\ sine}]$

$EVM_{[\%]} = [10^{(-Signal/Noise[dB] / 20)}]*100 \Leftrightarrow EVM_{[dB]} = 20*LOG(EVM_{[\%]} / 100)$

$Signal/Noise_{[dB]} = 20*LOG(EVM_{[\%]} / 100)$

$Corrected\_EVM_{[\%]} = \sqrt{Residual\_EVM[\%] * Measured\_EVM[\%]}$

$ADC\_SNR_{[dB]} = (Nr\_of\_Bits*6.02) + 1.76 + 10*LOG(Sampling\_Frequency_{[Hz]} / 2*BW_{[Hz]})$

$ADC\_Nyquist\_frequency_{[Hz]} = Sampling\_Frequency_{[Hz]} / 2$

$ADC\_NoiseFigure_{[dB]} = Full\_Scale\_Pin_{[dBm]} – SNR_{[dB]} – 10*LOG(FS\_sampling\_rate / 2) – Thermal\_Noise_{[dBm/Hz]}$

$ADC\_NoiseFloor_{[dBFS]} = SNR_{[dB]} + 10*LOG(FS\_sampling\_rate / 2)$

$ADC\_Spurious\_Free\_Dynamic\_Range_{[dB]} = Desired\_Input\_Signal_{[0dB]} – Highest\_Amplitude\_Spurious_{[dB]}$

$ADC\_Input\_Dynamic\_Range_{[dB]} = 20*LOG(2^{Nr\_of\_Bits} -1)$

$VSWR = (1+\Gamma) / (1– \Gamma) = (Vinc + Vref) / (Vinc – Vref) = (Z_L – Zo) / (Z_L + Zo)$

$Reflection\_Coefficient\ \Gamma = (VSWR – 1) / (VSWR + 1) = Vref / Vinc$

$Return\_Loss_{[dB]} = - 20*LOG(\Gamma)$

$Missmatch\_Loss_{[dB]} = - 10*LOG [1 – \Gamma^2]$

$Reflected\_Power_{[W]} = Incident\_Power_{[W]} * \Gamma^2$

$Power\_Absorbed\_by\_the\_Load_{[W]} = 4 * Incident\_Power_{[W]} * [VSWR/(1+VSWR^2)]$

Characteristic_Impedance $Zo = \sqrt{L / C}$

$Resonant\_Frequency_{[Hz]} = 1 / [2*\Pi*\sqrt{L*C}\,]$

$L = Xs / \omega$; $C = 1 / (\omega*Xp)$; $\omega = 1 / \sqrt{L*C}$; $Q_{(series\ LC)} = Xs / Rs$; $Q_{(parallel\ LC)} = Rp / Xp$

$Free\_Space\_Path\_Loss_{[dB]} = 27.6 – 20*LOG[Frequency_{[MHz]}] – 20*LOG[Distance_{[m]}]$

$RX\_inp\_level_{[dBm]} = TX\_Power_{[dBm]} + TX\_Ant\_Gain_{[dB]} – Free\_Space\_Path\_Loss_{[dB]} – Cable\_loss_{[dB]} + Rx\_Ant\_Gain_{[dB]}$

$Antenna\_Polarization\_Mismatch\_Loss_{[dB]} = 20*LOG(\cos \varphi)$ [for linear polarized antennas]

$$Antenna\_Factor_{[dB]} = 20*LOG[(12.56 / \lambda_{[m]}) * \sqrt{\frac{30}{R\_load[ohms]*10\wedge(Antenna\_Gain[dBi]/10)}}\,]$$

$EIRP_{[W]} = Power_{[W]} * 10^{(Antenna\_Factor[dB] / 10)}$

$Antenna\_Near\_Field_{[m]} = 2 * Antenna\_Dimension^2_{[m]} / \lambda_{[m]}$

$Te = (Noise\ Factor_{[lin]} – 1) * To_{[290K]}$

$ENR(Excess\_Noise\_Ratio) = 10*LOG\ [(T_{ENR} – To_{[290K]}) / To_{[290K]}\,]$

$Noise\_Figure\_Test(Y\_Factor\_Method)_{[dB]} = 10*LOG[(10^{(ENR/10)})/(10^{(Y/10)})]$; $Y = NF_{out} - NF_{inp}$

RMS Noise Voltage across a Resistor $_{(V)} = \sqrt{[4*R[ohms]*k[Boltzman]*Temp[K]*BW[Hz]]}$

IP3 (all linear) – Cascaded Stages

$$IP3_{INPUT} = 10\log\left(\frac{1}{\frac{1}{IP_1}+\frac{1}{IP_2}+\cdots\frac{1}{IP_N}}\right)$$

$IP3_{INPUT}$: equivalent system input intercept point (dBm)

$IP1$: IP3 of first stage transferred to input (mW)

IP_N : IP3 of last stage transferred to input (mW)

$$IP3_{TOTAL} = \frac{1}{\frac{1}{IP3_1}+\frac{G_1}{IP3_2}+\frac{G_1G_2}{IP3_3}+\frac{G_1G_2G_3}{IP3_4}+....}$$

$$IIP3 = -10\log(10^{-\frac{OIP3_1-G_1}{10}}+10^{-\frac{OIP3_2-G_2-G_1}{10}}+10^{-\frac{OIP3_3-G_3-G_2-G_1}{10}})$$

Noise Factor (all linear) - Cascaded Stages

$$F_{IN} = F_1 + \frac{F_2-1}{G_1} + \frac{F_3-1}{G_1G_2} + ..$$

$Noise\_Figure_{[dB]} = 10*LOG(F)$

Noise Factor (all linear) – Identical Cascaded Stages

$$F_{tot} = 1 + \frac{F-1}{1-\frac{1}{G_a}}$$

Noise Temperature – Cascaded Stages

$$T_{eq} = T_1 + \frac{T_2}{G_1} + \frac{T_3}{G_1G_2} + \cdots$$

$T_{(1,2,3\ldots n)} = (Noise\ Factor_{[lin]} – 1) * To_{[290K]}$

$NF_{[dB]} = 10*LOG\ (1 + Teq / To_{[290K]})$

$$AM\_Modulation\_Index = \frac{V\max[Vpp]-V\min[Vpp]}{V\max[Vpp]+V\min[Vpp]} = 2 * \sqrt{\frac{Power\_sideband(usb\_lsb)[W]}{Power\_carrier[W]}}$$

$AM\_Total\_Power_{[W]} = Power\_carrier_{[W]} * [(1+AM\_Modulation\_Index^2) / 2]$

$AM\_Bandwidth_{[Hz]} = 2 * Highest\_Modulation\_Frequency_{[Hz]}$

$FM\_Modulation\_Index = Max\_Frequency\_Deviation_{[Hz]} / Max\_Modulation\_Frequency_{[Hz]}$

$FM\_Bandwidth_{[Hz]} = 2 * Max\_Modulation\_Frequency_{[Hz]} * [1+ FM\_Modulation\_Index]$

Term Conversion in 50 Ω Environment

Log

dBµV to dBm	$dBm = dB\mu V - 107$
dBµA to dBm	$dBm = dB\mu A - 73$
dBm to dBµV	$dB\mu V = dBm + 107$
dBµA to dBµV	$dB\mu V = dB\mu A + 34$
dBm to dBµA	$dB\mu A = dBm + 73$
dBµV to dBµA	$dB\mu A = dB\mu V - 34$

Log ⇦ Linear

Volts to dBm	$dBm = 20 \bullet Log(Volts) + 13$
Amps to dBm	$dBm = 20 \bullet Log(Amps) + 47$
Watts to dBµV	$dB\mu V = 10 \bullet Log(watts) + 137$
Amps to dBµV	$dB\mu V = 20 \bullet Log(Amps) + 154$
Watts to dBµA	$dB\mu A = 10 \bullet Log(Watts) + 103$
Volts to dBµA	$dB\mu A = 20 \bullet Log(Volts) + 86$

Log ⇨ Linear

dBµV to Watts	$Watts = 10^{\left(\frac{dB\mu V - 137}{10}\right)}$
dBµA to Watts	$Watts = 10^{\left(\frac{dB\mu A - 103}{10}\right)}$
dBm to Volts	$Volts = 10^{\left(\frac{dBm - 13}{20}\right)}$
dBµA to Volts	$Volts = 10^{\left(\frac{dB\mu A - 86}{20}\right)}$
dBm to Amps	$Amps = 10^{\left(\frac{dBm - 47}{20}\right)}$
dBµV to Amps	$Amps = 10^{\left(\frac{dB\mu V - 154}{20}\right)}$

Linear

Volts to Watts	$Watts = \frac{Volts^2}{50}$
Amps to Watts	$Watts = Amps^2 \bullet 50$
Watts to Volts	$Volts = \sqrt{Watts \bullet 50}$
Amps to Volts	$Volts = Amps \bullet 50$
Watts to Amps	$Amps = \sqrt{\frac{Watts}{50}}$
Volts to Amps	$Amps = \frac{Volts}{50}$

Unit Conversion

Log ⇦ Linear

Watts to dBm	$dBm = 10 \bullet Log(Watts) + 30$
Volts to dBµV	$dB\mu V = 20 \bullet \log(Volts) + 120$
Amps to dBµA	$dB\mu A = 20 \bullet \log(Amps) + 120$
Ω to dBΩ	$d B\Omega = 20 \bullet \log(\Omega)$

Used for the conversion of Voltage & Current

Log ⇨ Linear

dBm to Watts	$Watts = 10^{\left(\frac{dBm - 30}{10}\right)}$
dBµV to Volts	$Volts = 10^{\left(\frac{dB\mu V - 120}{20}\right)}$
dBµA to Amps	$Amps = 10^{\left(\frac{dB\mu A - 120}{20}\right)}$
dBΩ to Ω	$\Omega = 10^{\left(\frac{dB\Omega}{20}\right)}$

Term Conversion/Ohms Law

Log

dBµV to dBm	$dBm = dB\mu V - 10 \bullet Log(\Omega) - 90$
dBµA to dBm	$dBm = dB\mu A + 10 \bullet Log(\Omega) - 90$
dBm to dBµV	$dB\mu V = dBm + 10 \bullet Log(\Omega) + 90$
dBµA to dBµV	$dB\mu V = dB\mu A + 20 \bullet Log(\Omega)$
dBm to dBµA	$dB\mu A = dBm - 10 \bullet Log(\Omega) + 90$
dBµV to dBµA	$dB\mu A = dB\mu V - 20 \bullet Log(\Omega)$

Linear

Find Watts $Watts = Amps^2 \bullet \Omega$, $Watts = \frac{Volts^2}{\Omega}$

Find Volts $Volts = Amps \bullet \Omega$, $Volts = \sqrt{Watts \bullet \Omega}$

Find Amps $Amps = \sqrt{\frac{Watts}{\Omega}}$, $Amps = \frac{Volts}{\Omega}$

dB Calculations

dB Δ Watts $dB = 10Log\left(\frac{Watts_1}{Watts_2}\right)$

dB Δ Volts $dB = 20Log\left(\frac{Volts_1}{Volts_2}\right)$

dB Δ Amps $dB = 20Log\left(\frac{Amps_1}{Amps_2}\right)$

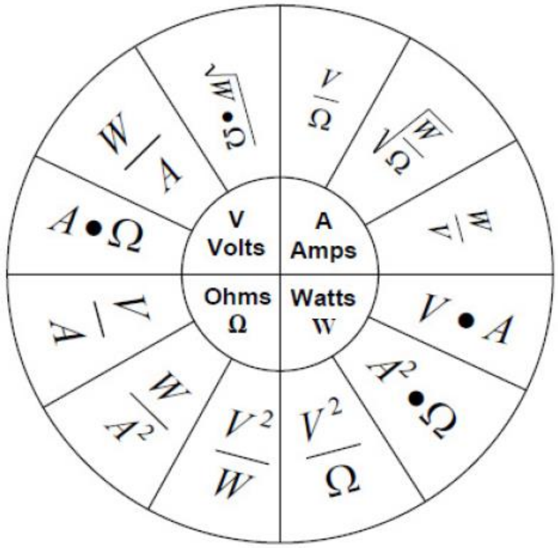
New Watts w/dB Δ $Watts_{New} = 10^{\left(\frac{dB\Delta + 10 \bullet Log(Watts_{start})}{10}\right)}$

New Volts w/dB Δ $Volts_{New} = 10^{\left(\frac{dB\Delta + 20 \bullet Log(Volts_{start})}{20}\right)}$

New Amps w/dB Δ $Amps_{New} = 10^{\left(\frac{dB\Delta + 20 \bullet Log(Amps_{start})}{20}\right)}$

dB Correction for distance change (antenna far field)

$$dB = 20 \bullet Log\left(\frac{\text{distance}_2}{\text{distance}_1}\right)$$



Sine Wave

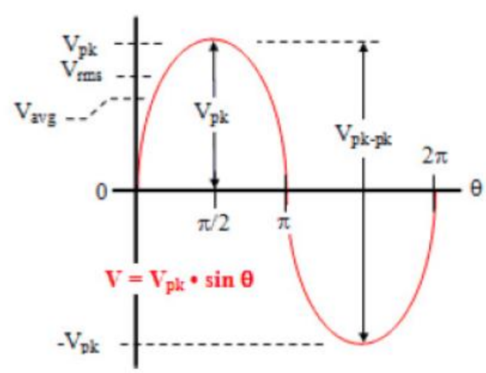
Voltage levels for a sine wave

$$Volts_{peak} = \sqrt{2} \bullet Volts_{rms} = \frac{\pi}{2} \bullet Volts_{Avg}$$

$$Volts_{rms} = \frac{Volts_{peak}}{\sqrt{2}} = \frac{\pi}{2 \bullet \sqrt{2}} \bullet Volts_{Avg}$$

$$Volts_{avg} = \frac{2}{\pi} \bullet Volts_{peak} = \frac{2 \bullet \sqrt{2}}{\pi} \bullet Volts_{Avg}$$

$$Volts_{peak-peak} = 2 \bullet Volts_{peak}$$



w/ Impedance of air = 377 Ω

dBµV/m to dBm/m² $dBm/m^2 = dB\mu V/m - 115.8$

dBm/m² to dBµV/m $dB\mu V/m = dBm/m^2 + 115.8$

dBµA/m to dBµV/m $dB\mu V/m = dB\mu A/m + 51.5$

dBµV/m to dBµA/m $dB\mu A/m = dB\mu V/m - 51.5$

dBµA/m to dBpT $dBpT = dB\mu A/m + 2$

dBpT to dBµA/m $dB\mu A/m = dBpT - 2$

Watts/m² to V/m $V/m = \sqrt{Watts/m^2 \bullet 377}$

V/m to Watts/m² $Watts/m^2 = \frac{V/m^2}{377}$

Radiated Field

dBµV/m to V/m $V/m = 10^{\left(\frac{dB\mu V/m - 120}{20}\right)}$

V/m to dBµV/m $dB\mu V/m = 20 \bullet Log(V/m) + 120$

New V/m with dBΔ

$$V/m_{new} = 10^{\left(\frac{dB\Delta + 20 \bullet Log(V/m_{start})}{20}\right)}$$

Interpolation values on a graph w/ Log of frequency
This equation works for finding all points on a test curve where test limit is sloping (i.e. DO 160F BCI testing)

$$value_{new} = \frac{Log\left(\frac{freq_{new}}{freq_{lower}}\right)}{Log\left(\frac{freq_{upper}}{freq_{lower}}\right)} \bullet \left(value_{upper} - value_{lower}\right) + Value_{lower}$$

Current Injection

Power needed for BCI probe (50Ω) for given Insertion loss (IL(dB))

$$Watts = 10^{\left(\frac{IL + 10 \bullet LOG\left(Volts^2/50\right)}{10}\right)}$$

$$Watts = 10^{\left(\frac{IL + 10 \bullet LOG\left(Amps^2 \bullet 50\right)}{10}\right)}$$

$$Watts = 10^{\left(\frac{IL + dB\mu A - 73}{10}\right)}$$

Power needed for BCI probe or EM Clamp (150Ω) for given Insertion loss (IL(dB))

$$Watts = 10^{\left(\frac{IL + 10 \bullet LOG\left(Volts^2/150\right)}{10}\right)}$$

$$Watts = 10^{\left(\frac{IL + 10 \bullet LOG\left(Amps^2 \bullet 150\right)}{10}\right)}$$

Conducted current measurement using a current probe. Where reading is in dBµV and probe factor is dBΩ or Ω

$$dB\mu A = dB\mu V - dB\Omega$$

$$dB\mu A = dB\mu V - 20 \bullet Log(\Omega)$$

Power needed for TEM Cell

$$Watts = \frac{\left(V/m \bullet Height \bullet 0.5\right)^2}{Z_{(50\Omega)}}$$

Power needed for GTEM Cell

$$Watts = \frac{\left(V/m \bullet SpectrualHeight\right)^2}{Z_{(50\Omega)}} \bullet 1.08$$

Wave length (λ)

$$\lambda[meters] = \frac{300}{MHz} \quad 1/4\,\lambda[meters] = \frac{75}{MHz}$$

Period

$$Time(s)=\frac{1}{Hz} \qquad Hz=\frac{1}{Time(s)}$$

VSWR

VSWR given Fwd/Rev power

$$VSWR=\frac{1+\sqrt{\frac{Watts_{rev}}{Watts_{fwd}}}}{1-\sqrt{\frac{Watts_{rev}}{Watts_{fwd}}}}$$

VSWR given Return Loss (RL)

$$VSWR=\frac{1+10^{\left(\frac{-RL(dB)}{20}\right)}}{1-10^{\left(\frac{-RL(dB)}{20}\right)}}$$

VSWR Given Impedance (Z)

$Z_O > Z_L$ $$VSWR=\frac{Z_O}{Z_L}$$

$Z_L > Z_O$ $$VSWR=\frac{Z_L}{Z_O}$$

VSWR given reflection coefficient (Γ)

$$VSWR=\frac{1+\Gamma}{1-\Gamma}$$

Reflection Coefficient (Γ)

$$\Gamma=\sqrt{\frac{Watts_{Rev}}{Watts_{Fwd}}}$$

$$\Gamma=\left|\frac{Z_{load}-Z_{Amp}}{Z_{load}+Z_{Amp}}\right|$$

$$\Gamma=\frac{VSWR-1}{VSWR+1}$$

$$\Gamma=10^{\left(\frac{-RL(dB)}{20}\right)}$$

Return Loss (RL) in dB

$$RL(dB)=-20\bullet Log\left(\frac{VSWR-1}{VSWR+1}\right)$$

$$RL(dB)=10\bullet Log\left(\frac{Watts_{fwd}}{Watts_{rev}}\right)$$

$$RL(dB)=-20\bullet Log(\Gamma)$$

Transmission Loss (TL) in dB

$$TL(dB)=10\bullet Log\left(\frac{Watts_{fwd}}{Watts_{fwd}-Watts_{rev}}\right)$$

$$TL(dB)=-10\bullet Log\left(1-\Gamma^2\right)$$

$$TL(dB)=-10\bullet Log\left(1-\left(10^{\left(\frac{-RL(dB)}{20}\right)}\right)^2\right)$$

$$TL(dB)=-10\bullet Log\left(1-\left(\frac{VSWR-1}{VSWR+1}\right)^2\right)$$

Antenna Equations

Far Field Distance

Dipole & Log-periodic antenna

$$FarField = \frac{\lambda}{2 \bullet \pi}$$

Horn antenna $$FarField = \frac{2 \bullet apeture^2}{\lambda}$$

Far Field Equations

Gain over isotropic $Gain_{Numeric} = 10^{\left(\frac{Gain_{dBi}}{10}\right)}$

$$Gain_{dBi} = 10 \bullet Log(Gain_{numeric})$$

$$Gain_{Numeric} = \frac{(Meters \bullet V/_m)^2}{30 \bullet Watts}$$

$$Gain_{dBi} = 10 \bullet Log\left(\frac{(Meters \bullet V/_m)^2}{30 \bullet Watts}\right)$$

$$Gain_{dBi} = 20 \bullet Log(MHz) - AF - 29.79$$

Antenna Factor (AF)

$$AF = 20 \bullet Log(MHz) - Gain_{dBi} - 29.79$$

$$AF = 20 \bullet Log(MHz) - 10 \bullet Log(Gain_{numeric}) - 29.79$$

Find Antenna Spot size, Beam Width and Distance

$$Spot_{meters} = 2 \bullet \text{Distance}_{meters} \tan\left[\frac{Angle_{3dB}}{2}\right]$$

$$\text{Distance}_{meters} = \frac{Spot_{meters}}{2 \bullet \tan\left(Angle_{3dB}/_2\right)}$$

$$Angle_{3dB} = 2 \bullet \tan^{-1}\left[\frac{Spot_{meters}}{2 \bullet \text{Distance}}\right]$$

Field Strength

$$V/m = \frac{\sqrt{30 \bullet Watts \bullet Gain_{numeric}}}{Meters}$$

$$V/m = \frac{\sqrt{30 \bullet Watts \bullet 10^{\left(\frac{Gain_{dBi}}{10}\right)}}}{Meters}$$

$$Watts = \frac{(V/_m \bullet meters)^2}{30 \bullet Gain_{numeric}}$$

$$Watts = \frac{(V/_m \bullet meters)^2}{30 \bullet 10^{\left(\frac{Gain_{dBi}}{10}\right)}}$$

Power needed if gain remains constant (in Far Field) using same antenna and changing field level or test distance.

For Field Change $$Watts_{New} = Watts_{Old} \frac{(V/_{m\,New})^2}{(V/_{m\,Old})^2}$$

For Distance Change

$$Watts_{New} = Watts_{Old} \frac{(Meters_{New})^2}{(Meters_{Old})^2}$$

Power for given Amplitude Modulation %

$$Watts_{peak} = Watts_{CW} \bullet (1 + (\% \bullet 0.01))^2$$

$$Watts_{avg} = \frac{Watts_{CW} \bullet \left(2 + (\% \bullet 0.01)^2\right)}{2}$$

$$Watts_{avg} = \frac{Watts_{peak} \bullet \left(2 + (\% \bullet 0.01)^2\right)}{2 \bullet (1 + (\% \bullet 0.01))^2}$$

Power for given Pulse Modulation Duty Cycle %

$$Watts_{peak} = \frac{Watts_{avg}}{\% \bullet 0.01}$$