## Rectangular to Polar Coordinates

$a^2+b^2=c^2$ $c=\sqrt{a^2+b^2}$

$R^2+X^2=Z^2$ $Z=\sqrt{R^2+X^2}$

$\tan(\theta)=\frac{Opposite}{Adjacent}=(\frac{X}{R})$ $\theta=\arctan(\frac{Opposite}{Adjacent})=\arctan(\frac{X}{R})$

## Polar to Rectangular Coordinates

$\cos(\theta)=\frac{Adjacent}{Hypotenuse}=\frac{R}{Z}$ $R=Hypotenuse\cdot\cos(\theta)=Z\cdot\cos(\theta)$

$\sin(\theta)=\frac{Opposite}{Hypotenuse}=\frac{X}{Z}$ $X=Hypotenuse\cdot\sin(\theta)=Z\cdot\sin(\theta)$

## Example

$3+j4\,\Omega=5\,\Omega,53.1\,Degree\,Phase\,Angle$

## Complex Impedance Rules

$Admittance=\frac{1}{Impedance}=Y=\frac{1}{Z}$ Admittance,

$Conductivity=\frac{1}{Resistance}=G=\frac{1}{R}$ Conductivity,

$Susceptance=\frac{1}{Reactance}=B=\frac{1}{X}$ & Susceptance all have units of Siemens

- $X_L$ is Positive
- $X_C$ is Negative
- Impedances in Series Add Together
- Admittances in Parallel Add Together
- $\frac{1}{j}=-j$
- Voltage is the reference for Phase Angle Polarity
- Converting Phase Angles from Impedance to Admittance (and vice versa) changes the sign

## Time Constant

$$\tau = RC$$

## Capacitor Charging

$$V(t) = E\left(1 - e^{\frac{-t}{\tau}}\right)$$

## Capacitor Discharging

$$V(t) = E\left(e^{\frac{-t}{\tau}}\right)$$

## Inductive Reactance

$$X_L = 2\pi fL$$

## Capacitive Reactance

$$X_C = \frac{1}{2\pi fC}$$

## Power

$P = I^2 R$ for Series Circuits

$P = E^2 R$ for Parallel Ciruits

## Power Factor

$$PF = \frac{P_{Real}}{P_{Apparent}} = \cos(Phase\ Angle)$$

## Circuit Q

$$Q = \frac{X}{R}$$

## Resonant Frequency

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

## Half Power Bandwidth

$$\Delta f = \frac{f_r}{Q}$$

## Op Amp Gain

$$|A_V| = \frac{R_F}{R_1}$$

## RMS Voltage

$$V_{RMS} = \frac{\sqrt{2}}{2} \cdot V_{Peak}$$

$$V_{Peak} = \sqrt{2} \cdot V_{Peak}$$

$$V_{(P-P)} = 2 \cdot V_{Peak}$$

## RMS Power

$$P_{AVG} = \frac{V^2_{RMS}}{Z}$$

## Peak Envelope Power

$$PEP = \frac{(0.707 \cdot PEV)^2}{R_{Load}}$$

## FM Deviation Ratio

$$Deviation\,Ratio = \frac{Deviation_{MAX}}{ModulatingFreqency_{MAX}}$$

## FM Modulation Index

$$Modulation\,Index = \frac{Deviation_{MAX}}{ModulatingFrequency_{Instant}}$$

## Isotropic & Dipole Antenna Gain

$$dB_{dipole} = dB_{isotropic} - 2.15\,dB \qquad dB_{isotropic} = dB_{dipole} + 2.15\,dB$$

## Antenna Efficiency

$$Efficiency = \left(\frac{R_{Radiation}}{R_{Total}}\right) \cdot 100 = \left(\frac{R_{Radiation}}{R_{Radiation} + R_{Ohmic}}\right) \cdot 100$$

## Effective Radiated Power

$$ERP = TPO \cdot SystemGain = TransmitterPowerOutput \cdot 10^{\frac{Gain_{dB}}{10}}$$

Note: **SystemGain** is in Watts

## Velocity Factor

$$VF = \frac{Velocity_{WaveConductor}}{Velocity_{LightVacuum}}$$

## Power Measurement

$$P_{Load} = P_{Forward} - P_{Reflected}$$