

# **BASIC ELECTRICITY AND ELECTRONICS 3**

**JIM PYTEL**

Open Oregon Educational Resources



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This course is the 3rd installment in a three part series intended to support the flipped classroom approach for traditional basic electronics classes. Basic Electronics 3 covers apparent, real, and reactive power and power factor, power factor correction, ideal and non-ideal transformers, and transformer connection diagrams, AC circuit analysis techniques and theorems like source conversion, the AC superposition theorem, AC Thevenin's Theorem, and the AC Maximum Power Transfer Theorem, 3 phase AC systems including balanced and unbalanced 4 wire Y configurations, 3 wire Y configurations, and delta configurations, the single wattmeter method and the two wattmeter method. These resources are meant to accompany a hands on lab with the guidance of an instructor.





# UNIT 1: AC POWER

**Objective:** Demonstrate understanding of real, reactive, and apparent power. Determine individual and total real, reactive, and apparent power for elements in series, parallel, and series-parallel AC circuits.



# AC POWER



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## AC Power Study Guide

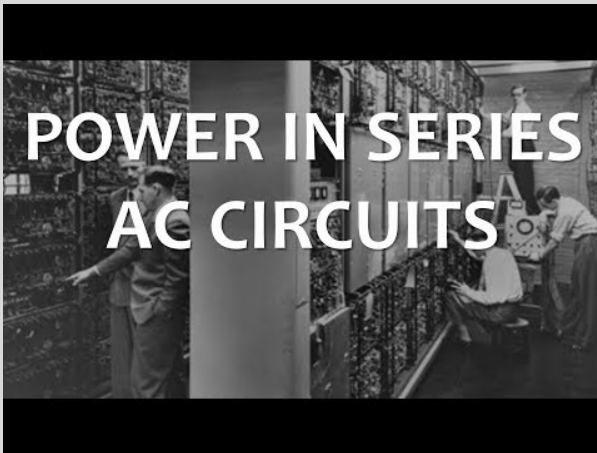
# AC POWER EXAMPLES



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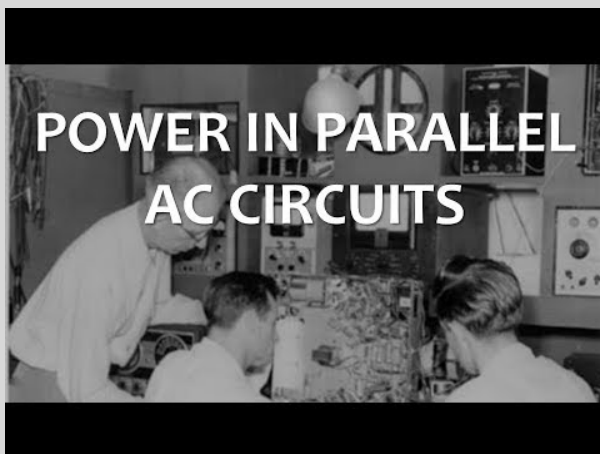
AC Power Examples Study Guide

# POWER IN SERIES AC CIRCUITS



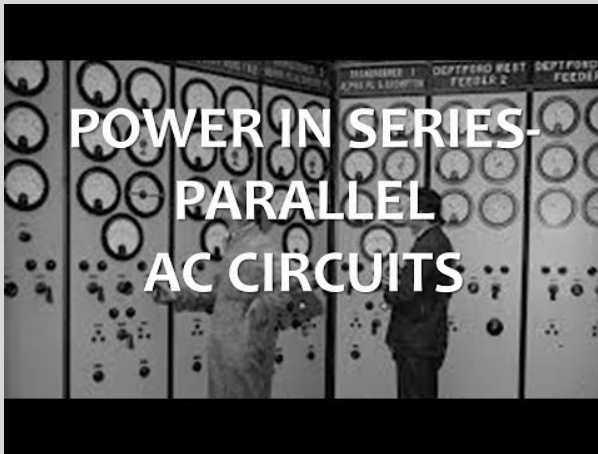
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# POWER IN PARALLEL AC CIRCUITS



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# POWER IN SERIES-PARALLEL AC CIRCUITS



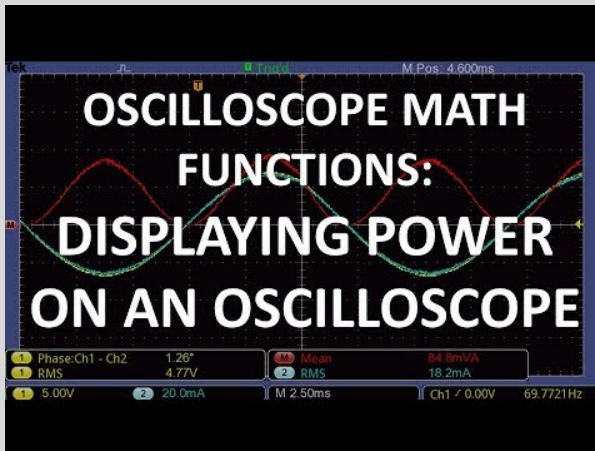
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## Power in Series Parallel AC Circuits Study Guide



# OSCILLOSCOPE MATH FUNCTIONS: MEASURING POWER ON AN OSCILLOSCOPE



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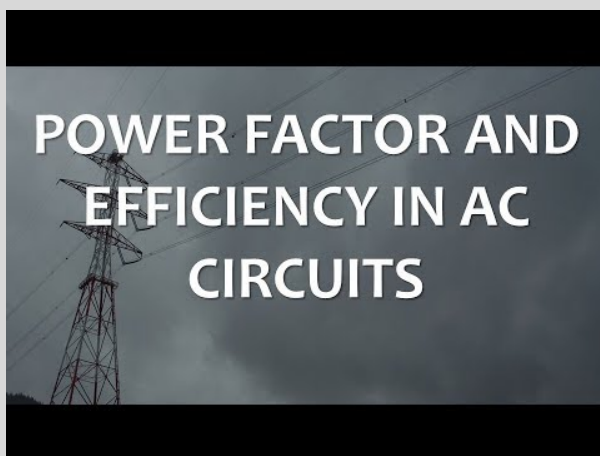
## Oscilloscope MATH Functions Measuring Power with an Oscilloscope Study Guide

# UNIT 2 POWER FACTOR CORRECTION

**Objective:** Demonstrate understanding of power factor and efficiency. Power factor correct a system. Identify characteristics of non-power factor corrected and power factor corrected systems.



# POWER FACTOR AND EFFICIENCY IN AC CIRCUITS



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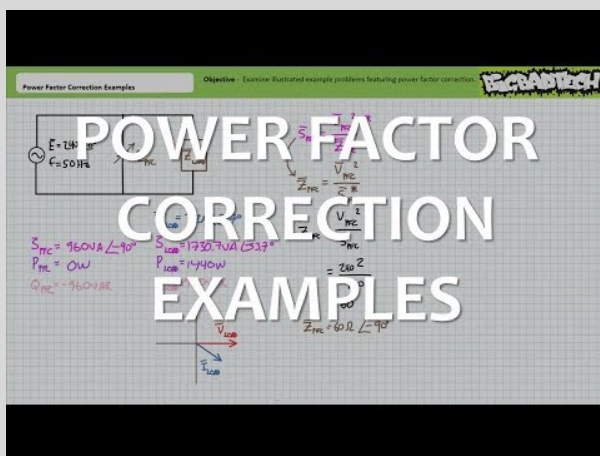


# POWER FACTOR CORRECTION



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# POWER FACTOR CORRECTION EXAMPLES



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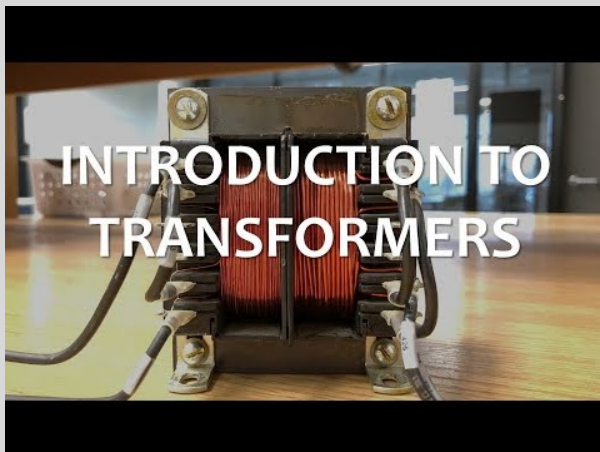
# UNIT 3:

# TRANSFORMERS

**Objectives:** Demonstrate understanding of the theory of operation and construction of transformers. Demonstrate understanding of turns ratio, voltage, current, and power transformation in transformers. Demonstrate understanding of transformer connection diagrams, transformer ratings, phase dot notation, parallel connections of transformer windings, series aiding connections of transformer windings, and series opposing connections of transformer windings. Demonstrate understanding of copper losses, iron losses (hysteresis and eddy currents), and magnetizing current. Demonstrate understanding of transformer efficiency and voltage regulation.



# TRANSFORMERS



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## Introduction to Transformers Study Guide

# TRANSFORMER CONNECTION DIAGRAMS



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Transformer Connection Diagrams Study Guides

# NON-IDEAL TRANSFORMERS



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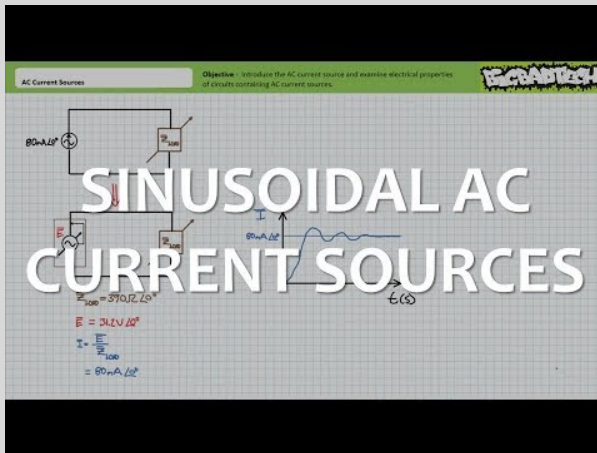
# UNIT 4: AC CIRCUIT ANALYSIS TECHNIQUES

**Objectives:** Demonstrate understanding of current sources, source conversions, and delta/Y conversions using complex impedances.





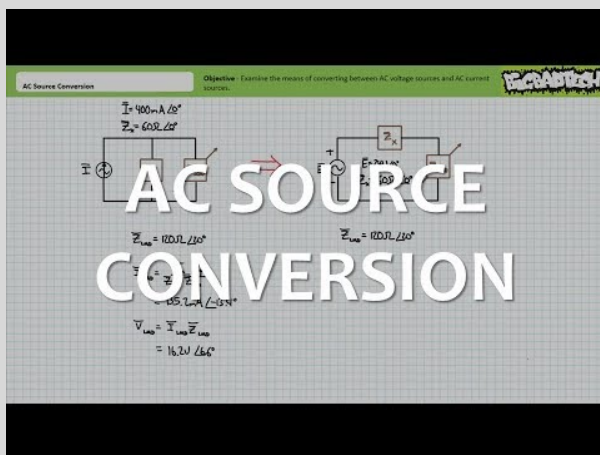
# AC CURRENT SOURCES



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<https://openoregon.pressbooks.pub/electronics3/?p=114>

## AC Current Sources Study Guide

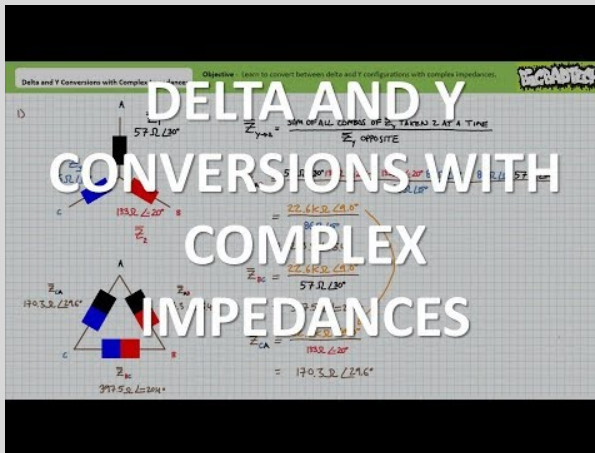
# AC SOURCE CONVERSION



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## AC Source Conversion Study Guide

# DELTA AND Y CONVERSIONS WITH COMPLEX IMPEDANCES



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## Impedance Delta Y Conversion Study Guide

# **UNIT 5: AC CIRCUIT ANALYSIS THEOREMS**

**Objectives:** Demonstrate understanding of the Superposition Theorem, Thevenin's Theorem, Norton's Theorem, and the Maximum Power Transfer Theorem as applied to AC circuits. Demonstrate understanding of impedance matching transformers. Demonstrate understanding of bridge circuit analysis.



# AC SUPERPOSITION THEOREM



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# AC SUPERPOSITION THEOREM EXAMPLES

**AC Superposition Theorem Examples** Objective - Examine several illustrated examples of the Superposition Theorem applied to AC circuits. **EXAMPLES!**

**$E_1$  ONLY:**

$V_1 = 40 \angle 0^\circ \uparrow$

$I_1 = 25 \angle 0^\circ \uparrow$

$I_2 = 12.5 \angle 0^\circ \downarrow$

$V_3 = 20 \angle 0^\circ \downarrow$

$I_3 = 4 \angle 0^\circ \downarrow$

**$E_2$  ONLY:**

$V_1 = 25 \angle 90^\circ \downarrow$

$I_1 = 5 \angle 90^\circ \downarrow$

$V_3 = 10 \angle 90^\circ \downarrow$

$I_3 = 669.7 \angle 90^\circ \uparrow$

**$E_3$  &  $E_4$ :**

$V_1 = 22.1 \angle -36.5^\circ \downarrow$

$I_1 = 1412.8 \angle -36.5^\circ \downarrow$

$V_3 = 11 \angle 0^\circ \downarrow$

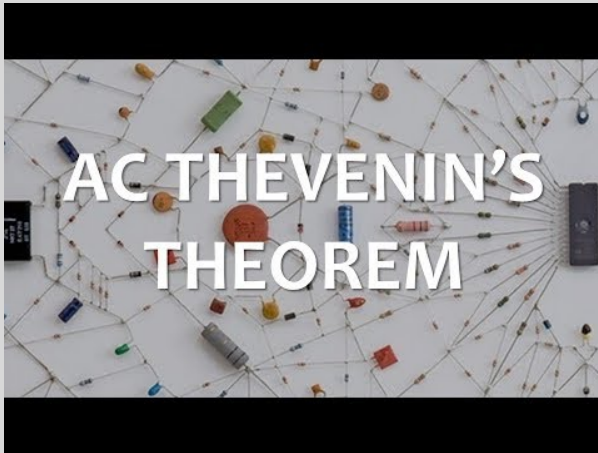
$I_3 = 545.4 \angle 0^\circ \uparrow$

**AC SUPERPOSITION THEOREM EXAMPLES**

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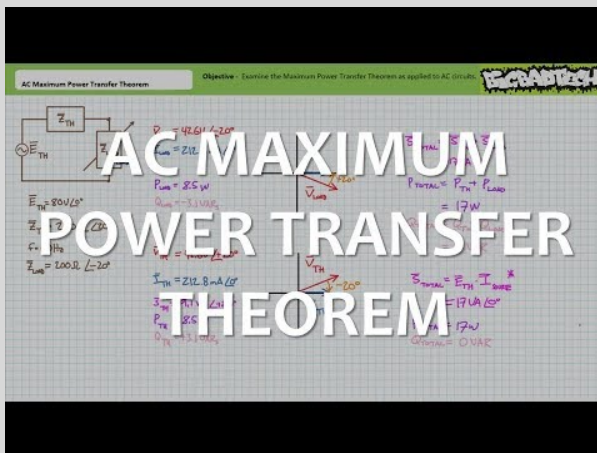
# AC THEVENIN'S THEOREM



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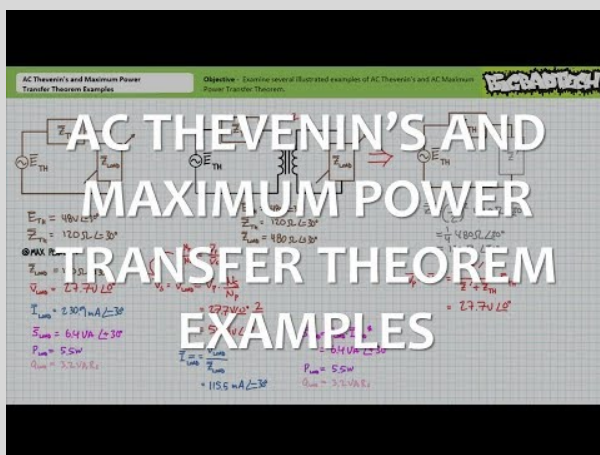
## AC Thevenins Theorem Study Guide

# AC MAXIMUM POWER TRANSFER THEOREM



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# AC THEVENIN'S THEOREM AND AC MAXIMUM POWER TRANSFER THEOREM EXAMPLES

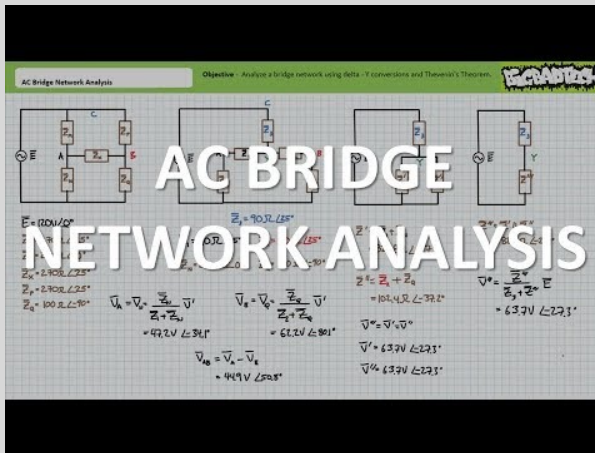


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## AC Thevenins Theorem and Maximum Power Transfer Theorem Examples Study Guide

# AC BRIDGE NETWORK ANALYSIS



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# UNIT 6: 3 PHASE AC CIRCUIT ANALYSIS

**Objectives:** Demonstrate understanding of line to neutral voltage and line to line voltage. Analyze balanced and unbalanced 4 and 3 wire Y and delta configured loads in 3 phase AC systems. Examine the 3 wattmeter, single wattmeter, and two wattmeter method in 3 phase AC systems.

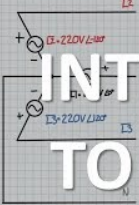






Introduction to 3 Phase AC

**Objective** - Examine 3 phase AC systems. Determine phase voltage and line voltage for 3 phase AC systems.

**ECADLAB**







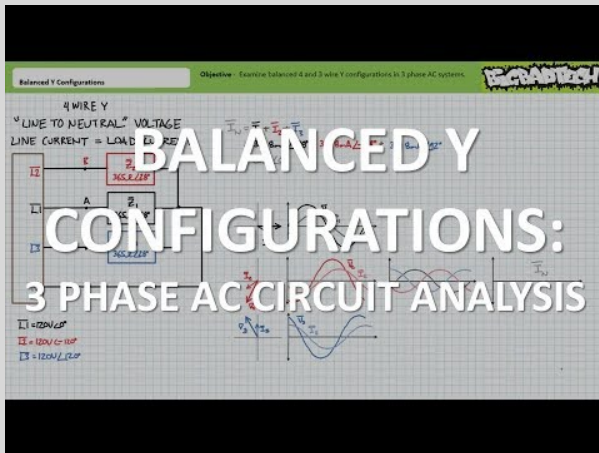
$V_{max} = 578V$   
 $V_{rms} = 380V$   
 $\phi_1 = 0^\circ$   
 $\phi_2 = 120^\circ$   
 $\phi_3 = 240^\circ$   
 $V_{line} = 578V$   
 $V_{line} = 380V$   
 $\phi = 150^\circ$

# INTRODUCTION TO 3 PHASE AC

$V_{max} = 311V$   
 $V_{rms} = 220V$   
 $T = 20ms$   
 $f = 50Hz$

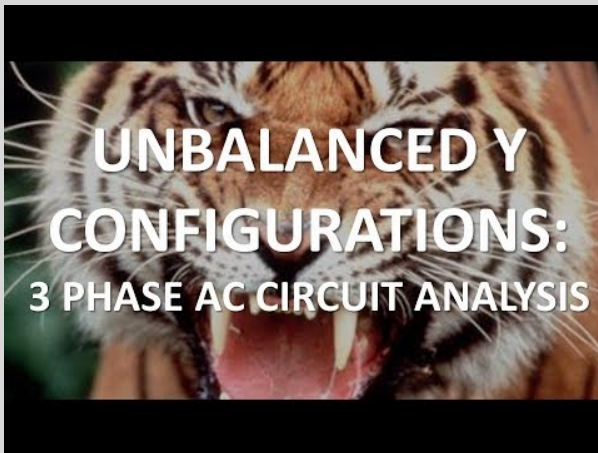
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# BALANCED Y CONFIGURATIONS



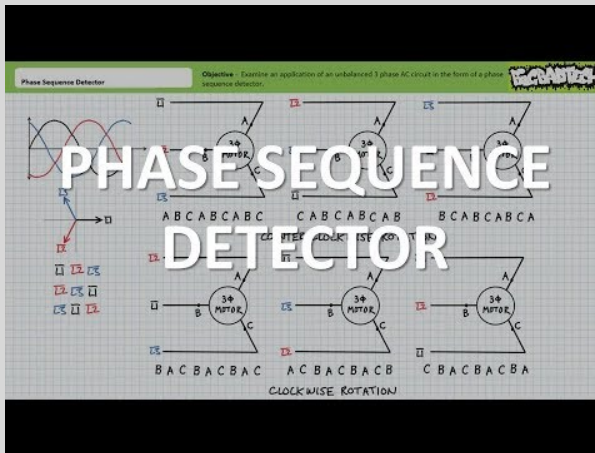
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# UNBALANCED Y CONFIGURATIONS



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# PHASE SEQUENCE AND PHASE SEQUENCE DETECTION

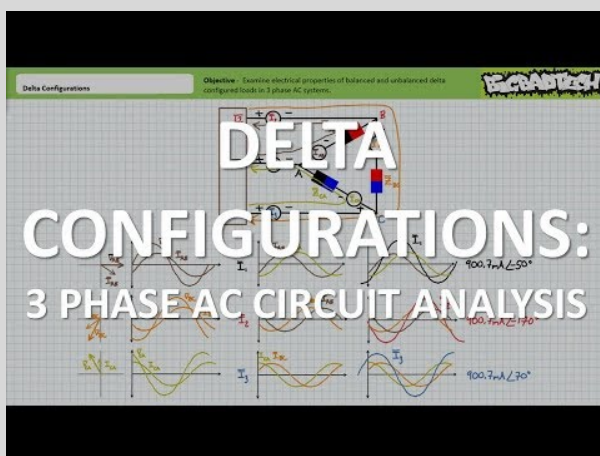


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## Phase Sequence Detector Study Guide

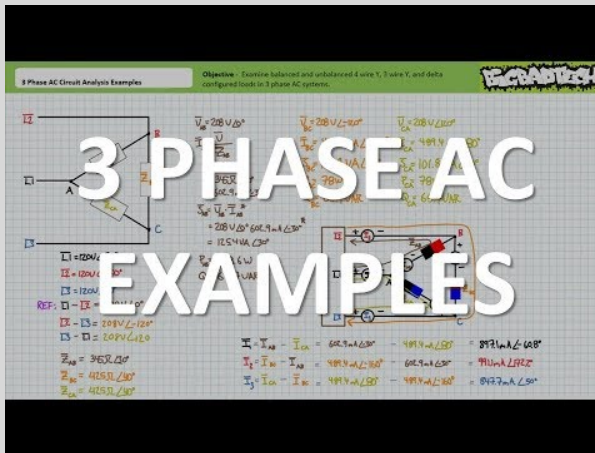
# DELTA CONFIGURATIONS



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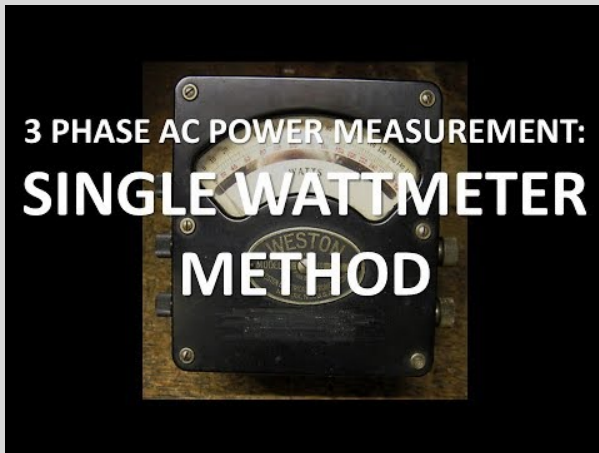
## Delta Configurations Study Guide

# 3 PHASE AC CIRCUIT ANALYSIS EXAMPLES



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# SINGLE WATTMETER METHOD



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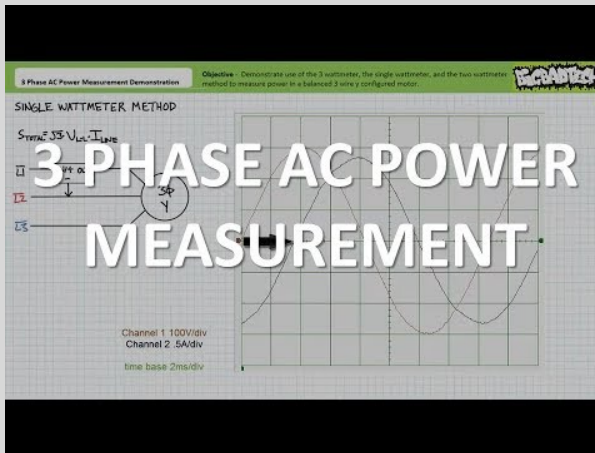
# TWO WATTMETER METHOD



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## 2 Wattmeter Method Study Guide

# 3 PHASE AC POWER MEASUREMENT EXAMPLES



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### 3 Phase AC Power Measurement Application Study Guide

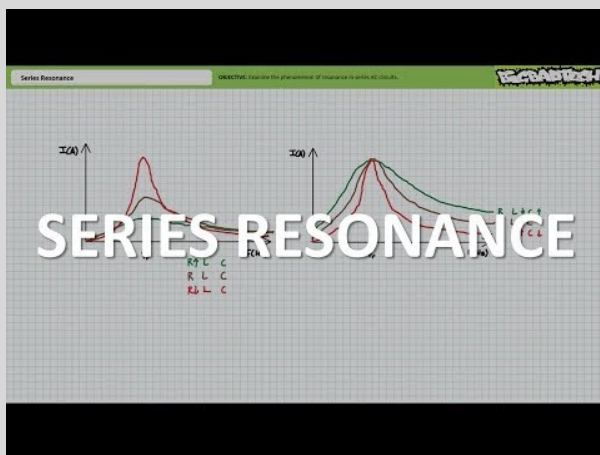


# UNIT 7: RESONANCE AND FILTERS

**Objectives:** Determine the resonant frequency of a series AC circuit. Evaluate electrical properties of series AC circuit at resonant and at other than resonant conditions. Determine bandwidth and quality factor of a resonant circuit. Calculate common logarithms. Use semi-log plots. Calculate gain in unit of decibels (dB). Determine the critical frequency for an RC filter. Evaluate electrical properties of RC filters below, at, and above the critical frequency. Differentiate between low and high pass RC filters.



# SERIES RESONANCE




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## Series Resonance Study Guide

# SERIES RESONANT CIRCUIT EXAMPLES

Series Resonant Circuit Example
OBJECTIVE: Analyze resonance in series AC circuits by way of an illustrated example.
PRACTICE



$Q_F = \frac{Z_L}{Z_C} = \frac{628.5}{50} = 12.57$

$Q_C = \frac{Z_L}{Z_R} = \frac{628.5}{50} = 12.57$

$f_c = 459.4 \text{ Hz} \rightarrow 33.8 \text{ kHz} = 442.9 \text{ Hz}$

$f_c = 440 \text{ μH} \rightarrow 33.8 \text{ kHz} = 33.8 \text{ kHz}$

$Z = 50 \Omega$

$I_{\text{max}} = \frac{V}{Z} = \frac{120 \text{ V}}{50 \Omega} = 2.4 \text{ A}$

$V_L = 120 \text{ V}$

$V_C = 2.4 \text{ V}$

$P_L = 2.9 \text{ W}$

$Q_C = 0.4 \text{ A}$

# SERIES RESONANT CIRCUIT EXAMPLES

$Z_C = \frac{1}{2\pi f C} = 628.5 \Omega$

$Z_L = 628.5 \Omega$

$Z = 237 \angle 0^\circ$

$L = \frac{Z_C}{2\pi f} = 240 \text{ mH}$

$I_{\text{max}} = \frac{V}{Z} = \frac{120 \text{ V}}{50 \Omega} = 2.4 \text{ A}$

$V_L = 120 \text{ V}$

$V_C = 2.4 \text{ V}$

$P_L = 2.9 \text{ W}$

$Q_C = 0.4 \text{ A}$

$V_L = Q_F \cdot E = 166.5 \text{ V}$

$V_C = Q_F \cdot E = 166.5 \text{ V}$

$V_L = 166.5 \text{ V} \angle 90^\circ$

$V_C = 166.5 \text{ V} \angle -90^\circ$

$Q_F = \frac{\text{REACTIVE}}{\text{REAL}} \rightarrow \frac{\text{REAL} \cdot Q_F = \text{REACTIVE}}{2.9 \text{ W} \cdot 12.57 = 37.9 \text{ VAR}}$

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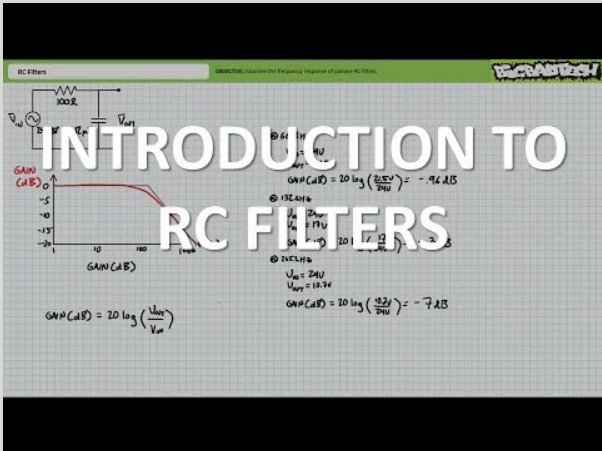


# LOGARITHMS AND DECIBELS



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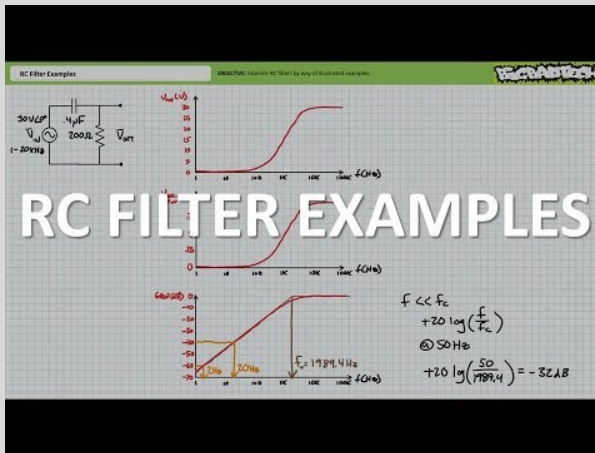
# RC FILTERS



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# RC Filters Study Guide

# RC FILTER EXAMPLES



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## RC Filter Examples Study Guide



This is where you can add appendices or other back matter.

## **ABOUT THE AUTHOR**

Jim Pytel is currently an instructor at Columbia Gorge Community College's Electro-Mechanical Technology program where he teaches basic electronics, hydraulics and pneumatics, motor control, PLCs, digital logic, and power generation and transmission. He is a former Captain in the US Army and has worked in the semiconductor manufacturing and wind power generation industries. To see more of his online content check out his YouTube channel at: <https://www.youtube.com/user/bigbadtech>