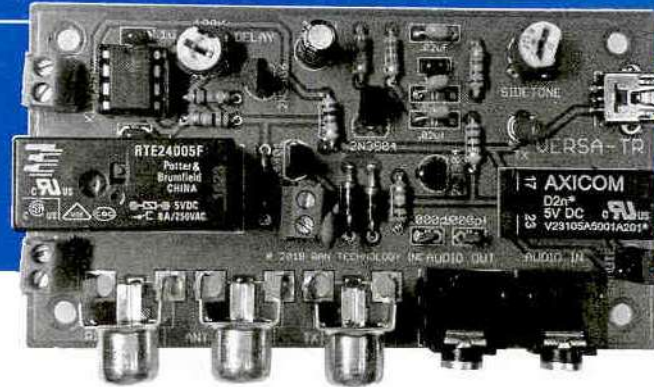




Chapter 4

Components and Circuits



General Class License 2025



George - WBØCNK

Chapter 4

Components and Circuits

4-1

We will cover these main topics today:

4.1 Power and Decibels

4.2 AC Power

4.3 Basic Components

Next Class:

4.4 Reactance, Impedance, and Resonance

4.5 Active Circuits

4.6 Practical Circuits

4.7 Basic Test Equipment²

Chapter 4

Components and Circuits

4-1

We will cover these main topics today:

4.1 Power and Decibels

4.2 AC Power

4.3 Basic Components

Next Class:

4.4 Reactance, Impedance, and Resonance

4.5 Active Circuits

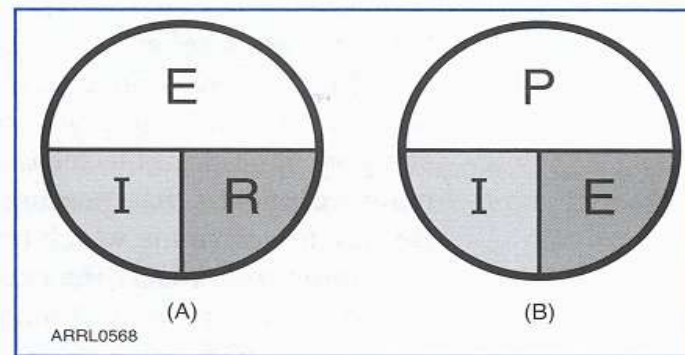
4.6 Practical Circuits

4.7 Basic Test Equipment³

4.1 Power and Decibels

EIR and PIE Diagrams

4-2



- **Cover** the unknown quantity you are needing
- The positions of the two remaining symbols show whether you multiply the remaining quantities (side by side) or divide them (one above the other).

4

4.1 Power and Decibels

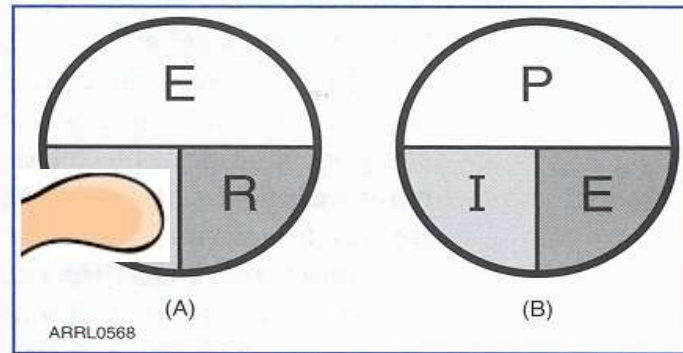
EIR and PIE Diagrams

4-2

A short review of topics from the Technician Class

EIR and PIE Diagrams:

If you need I (current):
Divide E(voltage) by R
 $I = E/R$



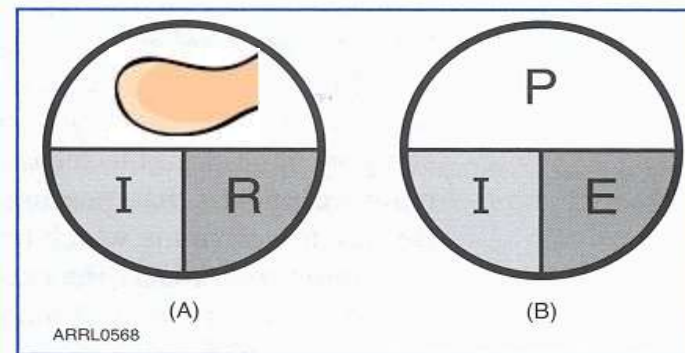
- Cover the unknown quantity you are needing
- The positions of the two remaining symbols show whether you multiply the remaining quantities (side by side) or divide them (one above the other).

4.1 Power and Decibels

EIR and PIE Diagrams

4-2

EIR and PIE Diagrams:



If you need
Voltage:
multiply $I \times R$

- Cover the unknown quantity you are needing
- The positions of the two remaining symbols show whether you multiply the remaining quantities (side by side) or divide them (one above the other).

4.1 Power and Decibels

EIR and PIE Diagrams

4-2

EIR and PIE Diagrams:

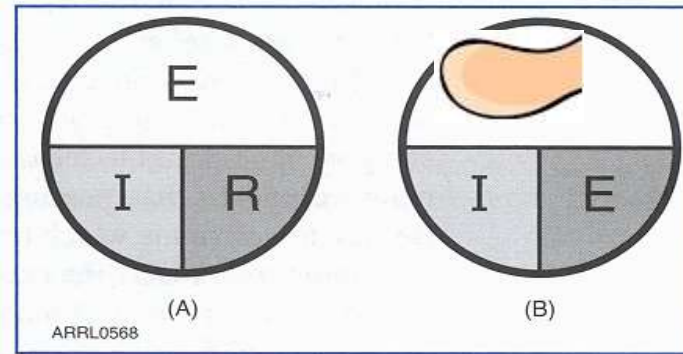
If you need **Power**:
multiply I x E

If you don't have I

We know that $I=E/R$

SO:

substitute E/R for I



To find out how many watts of electrical power are used if 400 V dc is supplied to an 800 ohm resistor:

$$P = I \times E = \frac{E}{R} \times E = \frac{E \times E}{R} = \frac{400 \times 400}{800} = \frac{16,0000}{800} = 200W \text{ [G5B03]}$$

7

4.1 Power and Decibels

Calculating a Power or Voltage Ratio from dB

4-2

Formulas for Power and Voltage ratios:

$$\text{Power Ratio} = \log^{-1} \left(\frac{\text{dB}}{10} \right)$$

$$\text{Voltage Ratio} = \log^{-1} \left(\frac{\text{dB}}{20} \right)$$

- Note that the inverse log (written as $\log 10^{-1}$ or just \log^{-1} is sometimes referred to as **antilog**.
- Most calculators use the inverse log notation.
- On scientific calculators it may be labeled **LOG⁻¹**, **ALOG** or **10^x**
- Some calculators require a two button sequence such as INV then LOG

4.1 Power and Decibels

Calculating a Power or Voltage Ratio from dB

4-2

Examples:

Example 1

$$\begin{aligned}\text{A power ratio of 9 dB} &= \log^{-1} (9/10) \\ &= \log^{-1} (0.9) \\ &= 8\end{aligned}$$

Example 2

$$\begin{aligned}\text{A voltage ratio of 32 dB} &= \log^{-1} (32/20) \\ &= \log^{-1} (1.6) \\ &= 40\end{aligned}$$

4.1 Power and Decibels

Calculating a Power or Voltage Ratio from dB

4-2

Useful to remember:

Any time you **double the power** or **cut it in half**, there is a 3 dB change. Two times increase or decrease in power is a gain or loss of 3dB. [G5B01]

$$\text{dB} = 10 \log_{10} \left(\frac{2}{1} \right) = 10 \log_{10} (2) = 10 \times (0.3) = 3 \text{dB}$$

$$\text{dB} = 10 \log_{10} \left(\frac{1}{2} \right) = 10 \log_{10} (0.5) = 10 \times (-0.3) = -3 \text{dB}$$

4.1 Power and Decibels

Converting dB to Percentage & Vice Versa

4-3

Converting dB to Percentage and Vice Versa

$$\text{dB} = 10 \log \left(\frac{\text{Percentage Power}}{100\%} \right)$$

$$\text{dB} = 20 \log \left(\frac{\text{Percentage Voltage}}{100\%} \right)$$

$$\text{Percentage Power} = 100\% \times \log^{-1} \left(\frac{\text{dB}}{10} \right)$$

$$\text{Percentage Voltage} = 100\% \times \log^{-1} \left(\frac{\text{dB}}{20} \right)$$

4.1 Power and Decibels

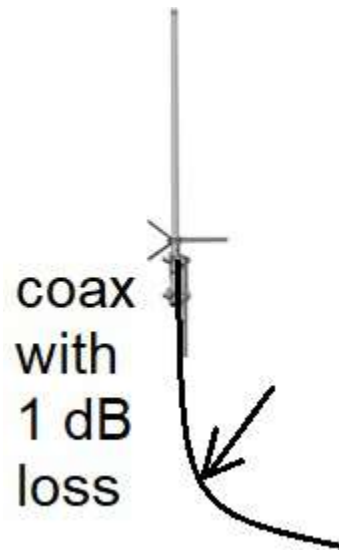
Converting dB to Percentage & Vice Versa

4-3

Practical application of Percentage power

Suppose you are using an antenna feed line that has a signal loss of 1 dB. You can calculate the amount of transmitter power that's actually reaching your antenna and how much is lost in the feed line.

$$\text{Percentage Power} = 100\% \times \log^{-1} \left(\frac{-1}{10} \right) = 100\% \times \log^{-1} (-0.1) = 79.4\% \quad [\text{G5B10}]$$



(More examples in the book page 4-3)

4.1 Power and Decibels

Reference Values for dB

4-3

These Reference Values for dB are typically used when the RF power is very small.

Typically when signals are **sampled** for measurements using Oscilloscopes, Network Analyzers and other very sensitive pieces of test equipment.



Reference Values for dB

There are several commonly used reference powers and voltages, such as 1 V or 1 mW. When a dB value uses such a reference, dB is followed with a letter. Here are the most common:

- ✓ dBV means dB with respect to 1 V ($V_{REF} = 1 \text{ V}$)
- ✓ dB μ V means dB with respect to 1 μ V ($V_{REF} = 1 \mu\text{V}$)
- ✓ dBm means dB with respect to 1 mW ($P_{REF} = 1 \text{ mW}$)

4.1 Power and Decibels

Reference Values for dB

4-3

4-4

The Manual shows

"For More Information – Electrical Review"
(a review from Technician Class)

---> Reacquaint yourself with the review material.

- Current, Voltage & Power
- Resistance and Ohms Law
- AC & DC Waveforms
- Frequency
- Wavelength
- Series and Parallel Circuits
- Decibels

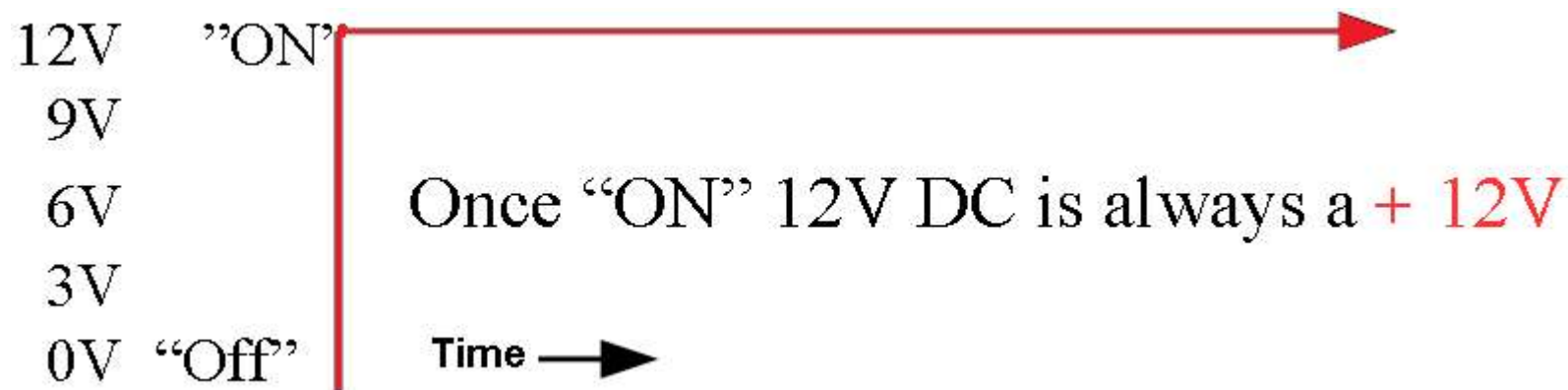
The next slides will concentrate on General Class Material

4.2 AC Power

1st let's recall what a **DC** waveform looks like

4-5

Recall that current that flows in one direction is DC (direct current)



- Understanding DC power is straight forward :

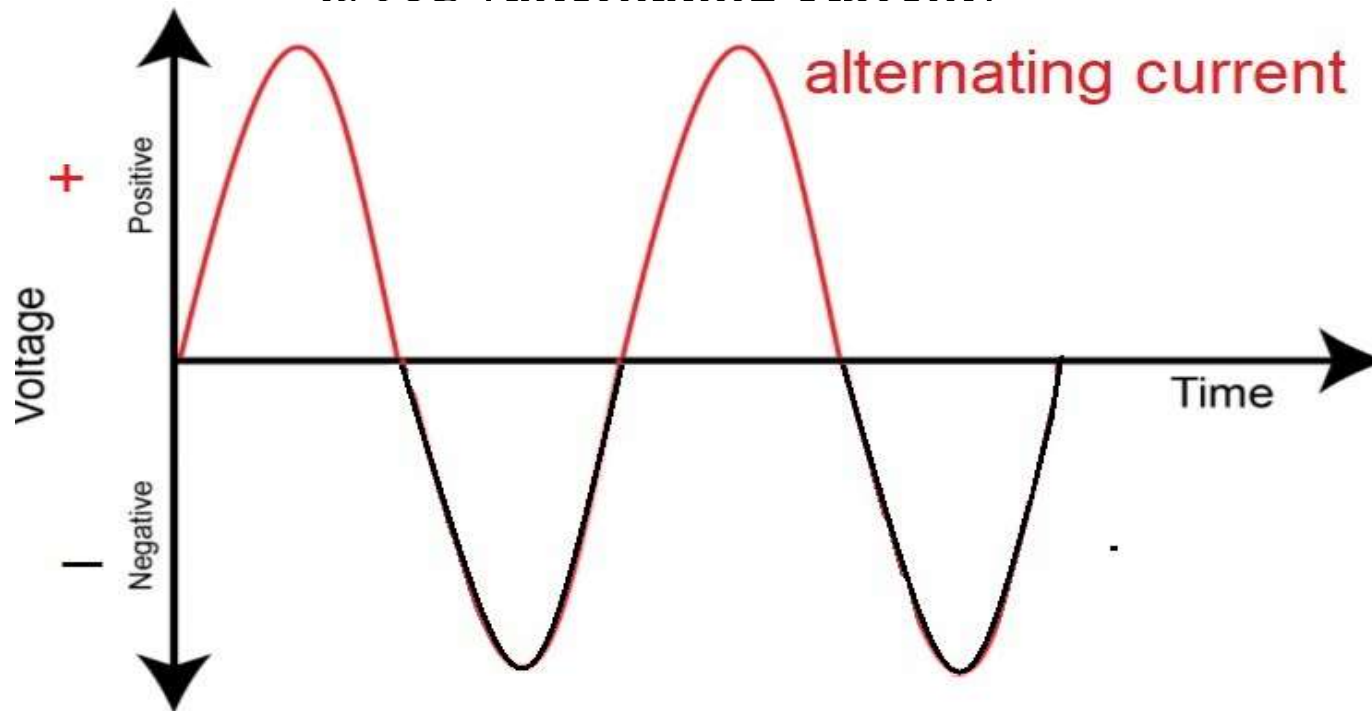
$$P = V \times I \quad \text{or} \quad P = \frac{V^2}{R} \quad (\text{etc.})$$

AC and DC Waveforms

4-5

AC

Recall current that reverses polarity (i.e. positive then negative) is AC (alternating current)

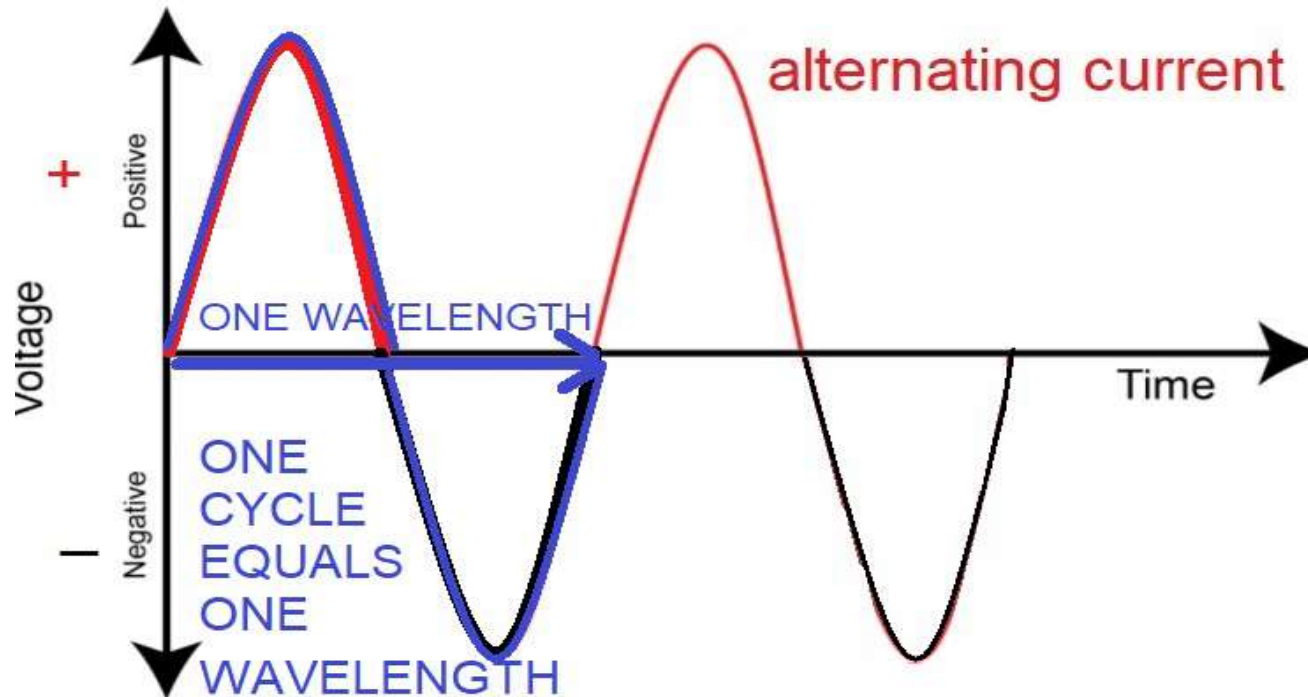


10

AC and DC Waveforms

4-5

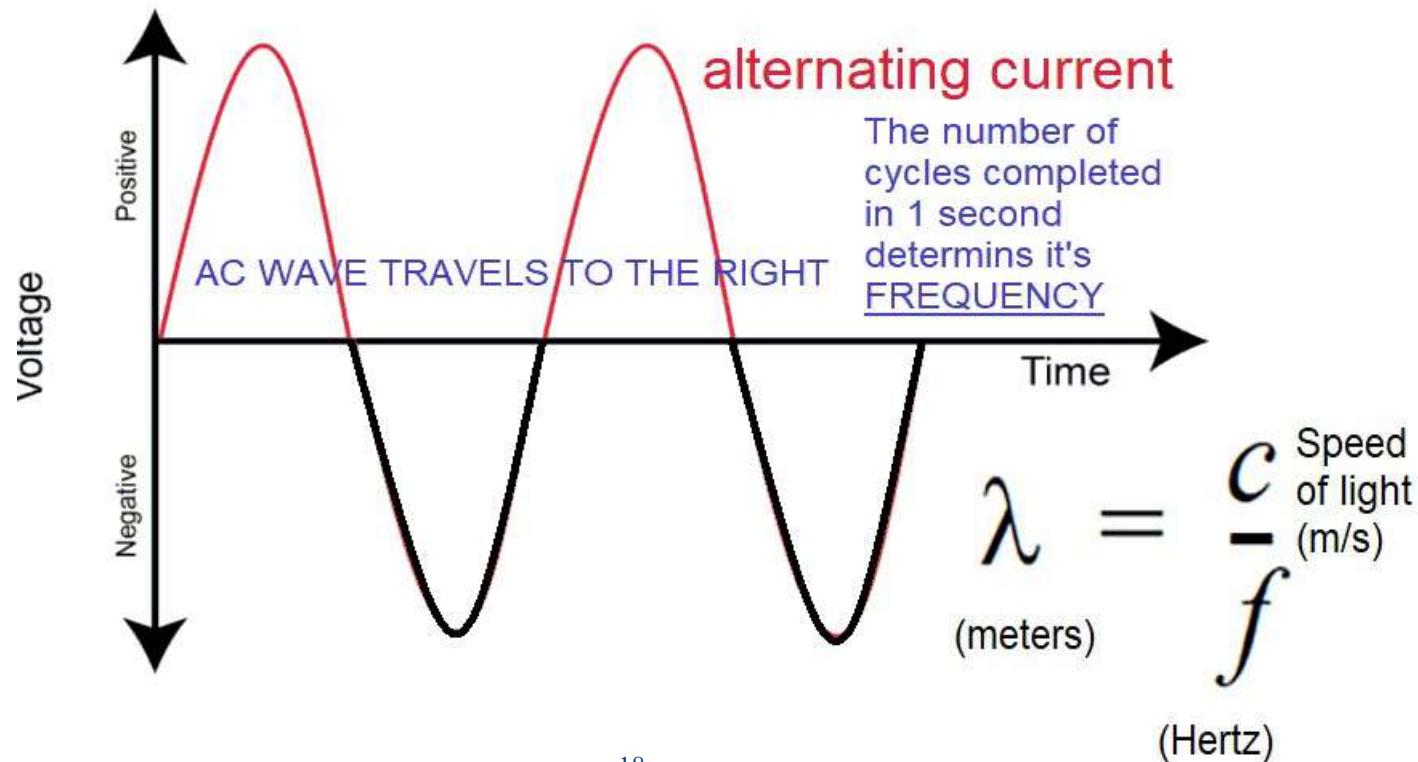
Recall that AC has a wavelength defined by 1 of it's cycles.



AC and DC Waveforms

4-5

Recall that the number of cycles the AC current completes in one second determines its **FREQUENCY**.

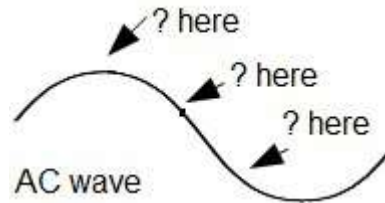


4.2 AC Power

RMS: Definition and Measurement

4-6

Finding power for DC is straight forward, but for AC power it is a bit more complicated since *the voltage is constantly changing.*



Where do you measure?
What voltage do you use?

It turns out that the voltage used for AC calculations is the root mean square (RMS) abbreviated: V_{RMS}

- ◆ It is the root of the average(mean) of the squares of the values of the signal voltages that are present.
- ◆ If RMS voltage is used in the equations for Power, the result for the signal is the same as for an unvarying DC voltage [G5B07]
- ◆ The RMS value for a sine wave is: 0.707 times the wave's peak voltage V_{pk}

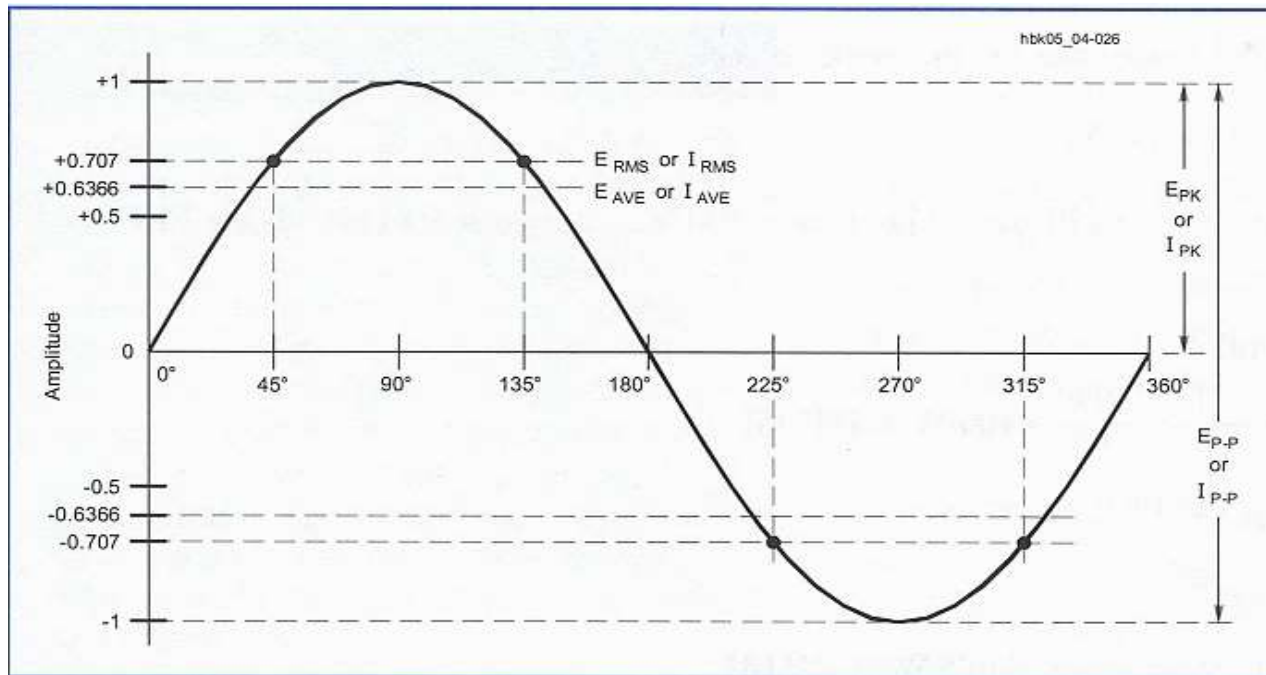
19

4.2 AC Power

RMS: Definition and Measurement

4-6

Figure 4.2 an AC waveform



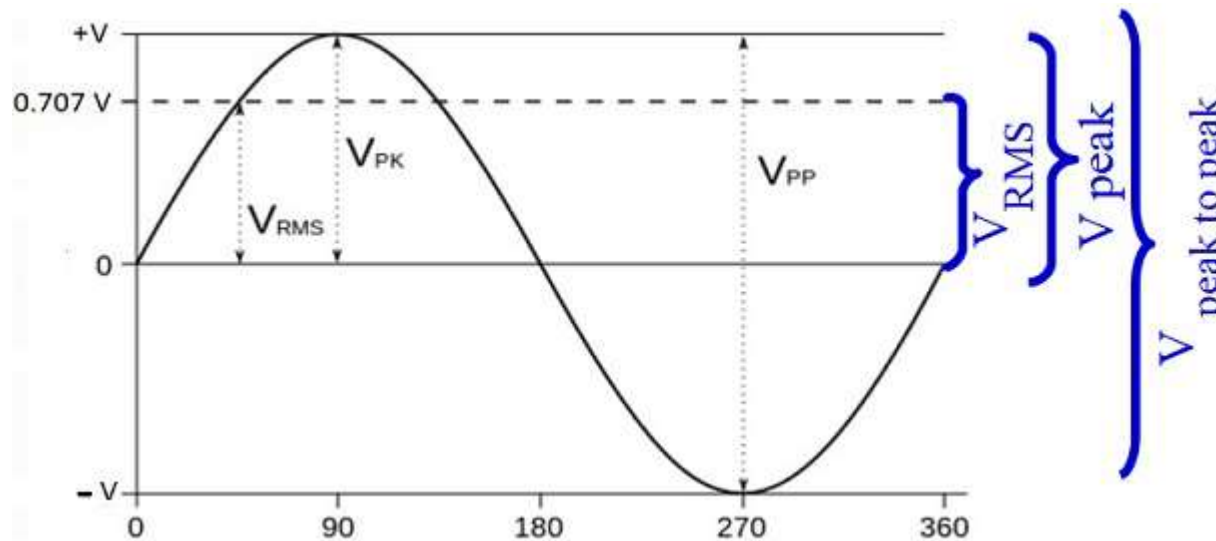
Shows the relationships between RMS, Average, Peak, and Peak to Peak values for an AC sine wave.

4.2 AC Power

RMS: Definition and Measurement

4-6

Relationships between RMS, peak & peak to peak



Pay attention to questions: Which value is provided ?
Which value is being requested ?
→ Use the formulas to convert from one to another.

4.2 AC Power

RMS: Definition and Measurement

4-6

Formulas for converting between V_{peak} , V_{RMS} & $V_{\text{peak to peak}}$

$$V_{\text{RMS}} = 0.707 \times V_{\text{peak}} = 0.707 \times \frac{V_{\text{P-P}}}{2}$$

$$V_{\text{peak}} = 1.414 \times V_{\text{RMS}}$$

$$V_{\text{P-P}} = 2 \times 1.414 \times V_{\text{RMS}} = 2.828 \times V_{\text{RMS}}$$

4.2 AC Power

RMS: Definition and Measurement

4-6

Example Calculations:

Example 7:

- A SIN wave with a peak voltage of 17V has an RMS value of :

$$V_{\text{RMS}} = 0.707 \times 17 = 12\text{V} \quad [\text{G5B09}]$$

Example 8:

- A SIN wave with a peak-to-peak voltage of 100V has an RMS value of:

$$V_{\text{RMS}} = 0.707 \times (100/2) = 35.4\text{V}$$

Example 9:

- A SIN wave with an RMS voltage of 120.0V has a peak-to-peak voltage of:

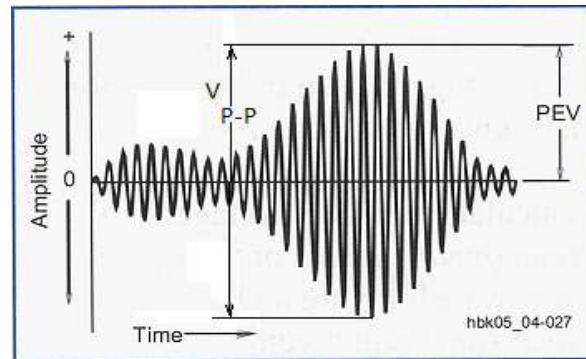
$$V_{\text{P-P}} = 2 \times 1.414 \times 120 = 2.828 \times 120 = 339.4\text{V} \quad [\text{G5B08}]$$

23

4.2 AC Power

PEP: Definition and Measurement

4-7

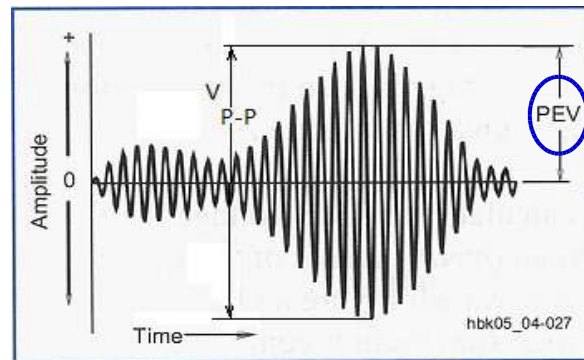


- PEP(or peak envelope power) is the average power of one complete RF cycle at the peak of the signal's envelope.
- PEP is used because it is a convenient way to measure or specify the maximum power of amplitude modulated signals.
- To calculate the average AC power you need the load impedance and RMS voltage

4.2 AC Power

PEP: Definition and Measurement

4-7



PEV
Peak Envelope Voltage

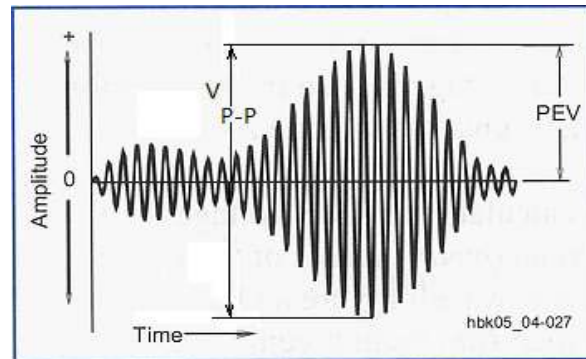
- Measure the RF voltage at the very peak of the modulated signal's envelope –this is the peak envelope voltage (**PEV**)
- **PEV** is equal to $\frac{1}{2}$ of the wave form's V_{P-P} .

$$\bullet \text{ PEP} = \frac{\left[\frac{0.707 \times V_{P-P}}{2} \right]^2}{R} = \frac{(\text{PEV} \times 0.707)^2}{R} = \frac{V_{RMS}^2}{R}$$

4.2 AC Power

PEP: Definition and Measurement

4-7



Examples:

Example 10: If PEV is 50 V across a 50-Ω load, the PEP power is

$$PEP = \frac{(50 \times 0.707)^2}{50} = 25 \text{ W}$$

Example 11: If a 50-Ω load is dissipating 1200 W PEP, the RMS voltage is

$$V_{RMS} = \sqrt{PEP \times R} = \sqrt{1200 \times 50} = 245 \text{ V [G5B12]}$$

Example 12: The peak voltage in example 11 is

$$V_{PK} = 245 \text{ V} \times 1.414 = 346 \text{ V}$$

4.2 AC Power

PEP: Definition and Measurement

4-7

Examples Continued:

Example 13: If an oscilloscope measures 200 V_{P-P} across a 50-Ω load, the PEP power is

$$\text{PEP} = \frac{\left[\frac{0.707 \times 200}{2} \right]^2}{50} = \frac{4999}{50} = 100 \text{ W [G5B06]}$$

For 500 VP-P, the PEP power is

$$\text{PEP} = \frac{\left[\frac{0.707 \times 500}{2} \right]^2}{50} = \frac{31241}{50} = 625 \text{ W [G5B14]}$$

- PEP is equal to the average power if an amplitude-modulated signal is not modulated. [G5B11]
- This is the case when modulation is removed from an AM signal (leaving just the carrier), or when CW is keyed.
FM is a constant power signal, so PEP is equal to average Power for FM signals.
- If an average-reading watt meter reads 1060W when you close the key on CW, your PEP output is also 1060W. [G5B13]

4.3 Basic Components

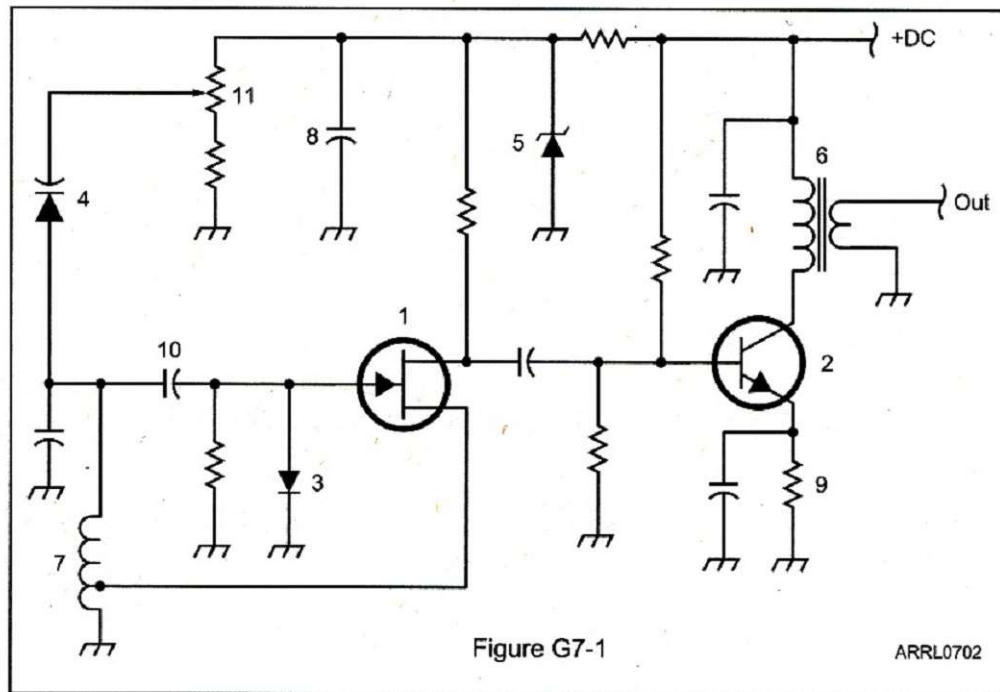
4-8

- Resistors & Resistance
- Inductors & Inductance
- Capacitors & Capacitance
- Transformers & Winding Ratios
- Components in:
 - ✓ Series Circuits
 - ✓ Parallel Circuits

4.3 Basic Components

In this section, you'll learn some basic characteristics of resistors, capacitors, inductors and transformers.

4-8



This circuit diagram show a variety of symbols for electrical components you should learn to recognize.

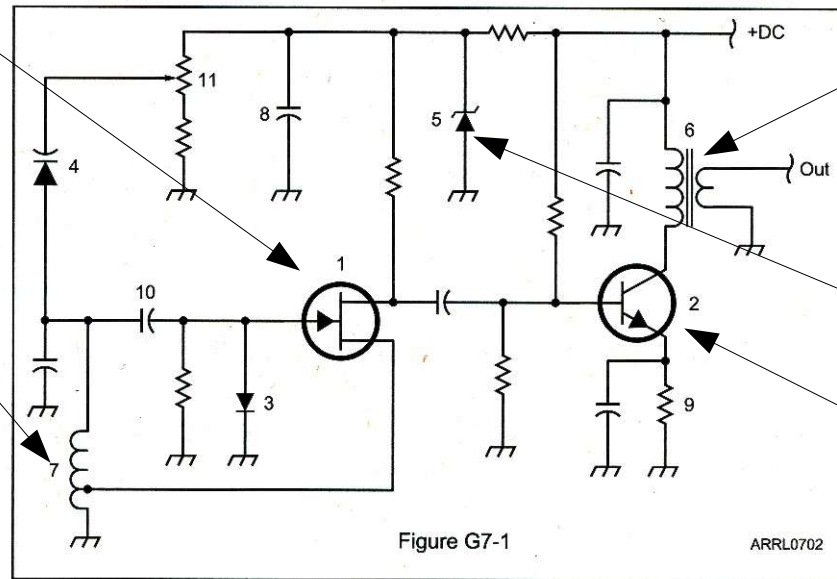
4.3 Basic Components

Conversion Between Values of Components

4-8

Field Effect Transistor
G7A09

Tapped Inductor
G7A13



Solid Core Transformer
G7A11

Zener Diode
G7A10

NPN Junction Transistor
G7A11

Conversions from one unit to another are common:

Divide by 1000:
to change:

- Pico to nano
- nano to micro
- micro to milli
- kilo to mega
- mega to gigia

Multiply by 1000:
To change:

- nano to pico
- micro to nano
- milli to micro
- mega to kilo
- gigia to mega

4.3 Basic Components

Conversion Between Values of Components

4-8

- Each electrical component is produced in a variety of values.
- These values are often marked*** (and advertised) using equivalent metric representations.
- Conversions from one representation to another are many times required:
- They all follow the same rules for metric measurements.

Most common changes are by a 1000 (thousand). The groups below show moving the decimal by 3 places, right or left, to adopt a different metric representation.

Divide by 1000:

Changes:

- Pico to nano
- nano to micro
- micro to milli
- kilo to mega
- mega to gigia

Multiply by 1000:

Changes:

- nano to pico
- micro to nano
- milli to micro
- mega to kilo
- gigia to mega

*** (Just FYI): For certain very small parts, the understood convention is to not mark the units symbol.

(See ARRL Handbooks)



Real small caps

Industry Convention:
pF is implied

4.3 Basic Components

Schematic Symbols for Electronic Components

4-9

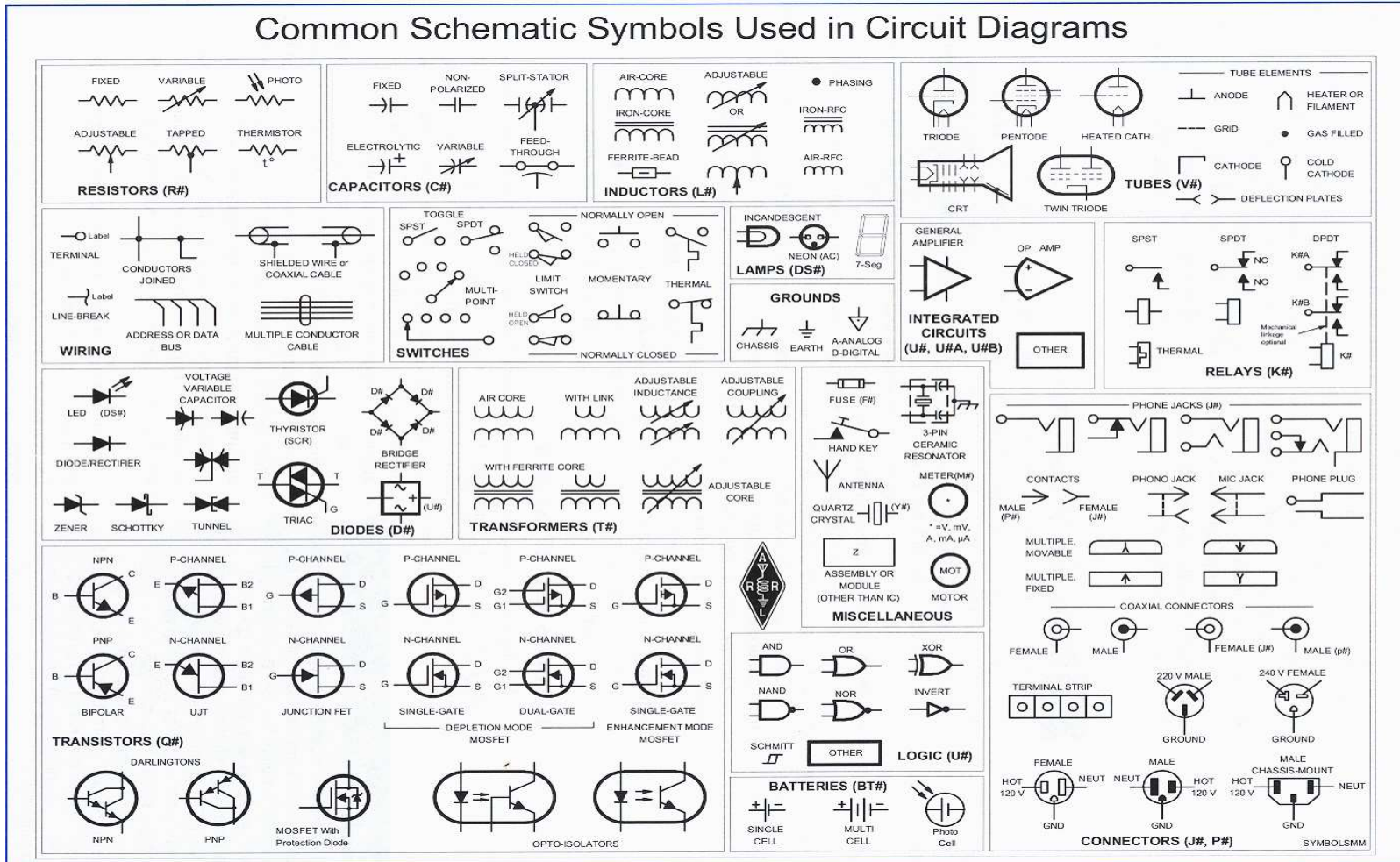


Figure 4-4 — These are the standard symbols used by the ARRL on schematic diagrams.

4.3 Basic Components

Types of Electronic Components

4-10

Components

The three most basic types of electronic components are resistors, capacitors and inductors (coils). Resistors, designated with an R, have a resistance specified in ohms (Ω), kilohms ($k\Omega$) or megohms ($M\Omega$). Capacitors, designated with a C, store electric energy and have values measured in picofarads (pF), nanofarads (nF) and microfarads (μF). Inductors, designated L, store magnetic energy and have values measured in nanohenrys (nH), microhenrys (μH), millihenrys (mH) and henrys (H).

The following terms apply to all components and may be important when selecting a component for a design or for repair.

✓ **Nominal value** – the quantity of a specific characteristic that the component is manufactured to exhibit, such as a 10 Ω resistor.

✓ **Tolerance** – the amount by which the actual value is allowed to vary from the nominal value, usually expressed in percent, such as a 5% tolerance resistor.

✓ **Temperature coefficient** – the variation of the component's actual value with temperature, such as 10 m Ω per degree Centigrade. Temperature coefficients (or "tempco") may be either positive (increasing value with temperature) or negative. For a positive temperature coefficient, as temperature increases so does resistance. Most components are available with several different values of tempco.

✓ **Power (or voltage or current) rating** – the rated ability of the component to withstand heat or dissipate power, such as a ¼ W resistor.

A more complete description of electronic components can be found in *The ARRL Handbook*, and the website for this book contains links to more information.

4.3 Basic Components

Types of Electronic Components

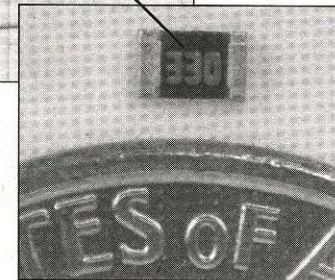
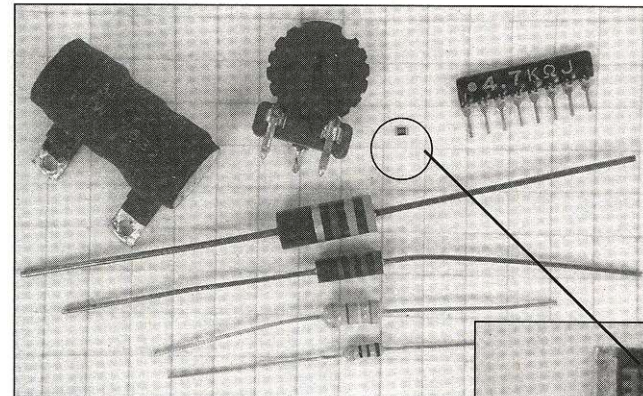
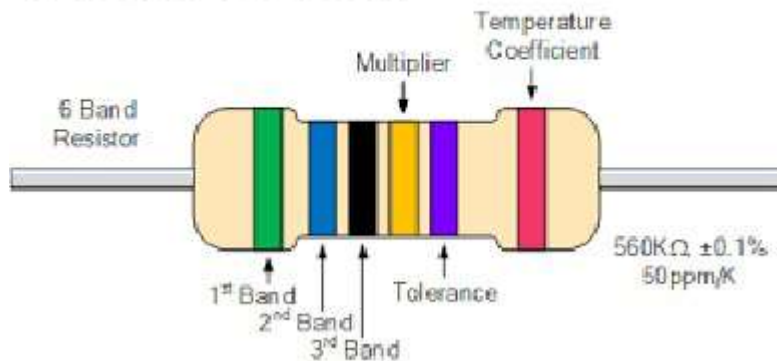
4-10

Resistors and Resistance

Fig 4.5 shows a variety of resistors ranging from surface mount technology (SMT) to large power resistors.

Resistors are available in a wide range of values (1Ω or less, to $1M\Omega$) and tolerances. Their value is printed on their body, or by use of color bands.

6 Band resistor



4.3 Basic Components

Resistors and Resistance

4-11

Table 4.1

Characteristics of Resistor Types

<i>Resistor Type</i>	<i>Power Ratings</i>	<i>Applications</i>
Carbon composition	$\frac{1}{8} - 2 \text{ W}$	General use, wire leads
Carbon film	$\frac{1}{10} - \frac{1}{2} \text{ W}$	General use, wire leads and SMT package
Metal film	$\frac{1}{10} - \frac{1}{2} \text{ W}$	Low-noise, wire leads and SMT package
Wirewound	1 W – 100 W or more	Power circuits
Metal oxide	$\frac{1}{2} - 10 \text{ W}$	Noninductive for RF applications

The most common units for resistors are ohms Ω , kilohms $\text{k}\Omega$, and megohms $\text{M}\Omega$

Use the following convention to convert between these units:

Ohms to kilohms divide by 1000, kilohms to ohms $\times 1000$, Megohms to ohms $\times 1,000,000$ etc.

Example 14: $150\Omega = 150/1000 = 0.15 \text{ k}\Omega$ and $150\Omega = 150/1,000,000 = 0.00015 \text{ M}\Omega$

Example 15: $4.7 \text{ k}\Omega = 4.7 \times 1,000 = 4,700\Omega$ and $4.7 \text{ k}\Omega = 4.7 / 1000 = 0.0047 \text{ M}\Omega$

Example 16: $2.2 \text{ M}\Omega = 2.2 \times 1,000,000 = 2,200,000\Omega$ and $2.2 \text{ M}\Omega = 2.2 \times 1,000 = 2,200 \text{ k}\Omega$

4.3 Basic Components

Inductors and Inductance

4-11

- Fig 4.6 shows several common inductors and their schematic symbols
- Double solid lines indicate a solid magnetic core(C)
- Air cores have dashed or no lines (A)
- Variable inductors have a diagonal arrow(B)
- Miniature inductors (not shown) have a style similar to resistors.



Open Air Inductor

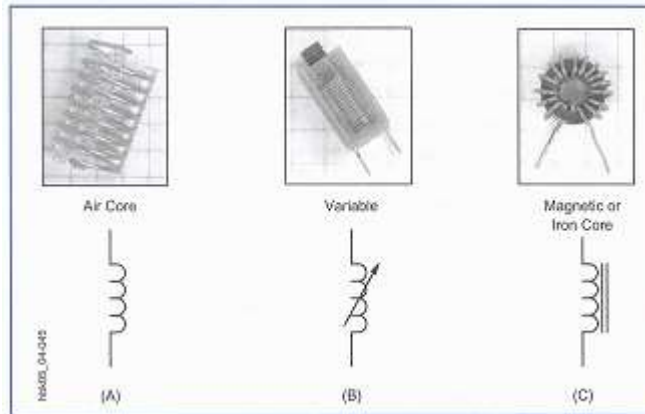
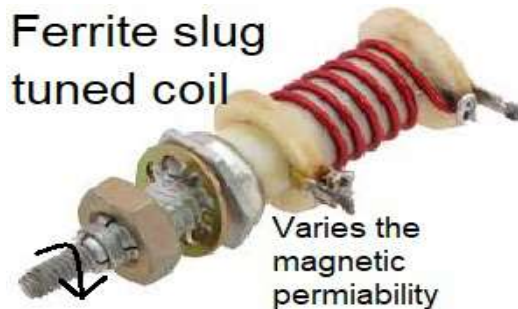


Figure 4-6 — Photos and schematic symbols for common inductors.



Toroide inductor



4.3 Basic Components

Inductors and Inductance

4-12

- Inductance:
 - Is the measure of an inductor's ability to store magnetic energy

 - Directly related to # turns and area enclosed by each turn.
 - A longer inductor without more turns or area has less inductance
 - *Permeability* is the inductor's ability to store energy
 - The type of core & winding are important for the type of circuit used in.
 - *Laminated iron core*: dc and ac power and filtering
 - *Powdered iron solenoid*: Power supplies, RF chokes, audio, low freq RF
 - *Powdered iron & ferrite toroids*: audio and radio
 - *Air Core*: RF transmitting.
 - Variable inductors are used in low power receiving and transmitting
 - Adjusted by moving the magnetic core in and out of the winding

4.3 Basic Components

Inductors and Inductance

4-12

- Inductance:
 - Common units are mH, microhenries μH and nanohenries nH
 - Conversion from nano(nH), Micro(μH), and Millihenries(mH) is similar to resistors and other conversions.
 - Nano to Micro: $\div 1,000$
 - Micro to Nano: $\times 1000$
 - Mill to Nano: $\times 1,000,000$
- Example 17: $330 \text{ nH} = 330 \div 1000 = 0.33\mu\text{H}$
 $330\mu\text{H} = 330 \div 1,000,000 = 0.00033\text{mH}$
- Example 18: $6.8\mu\text{H} = 6.8 \times 1,000 = 6,800\text{nH}$
 $6.8\mu\text{H} \div 1,000 = 0.0068\text{mH}$
- Example 19: $88\text{mH} = 88 \times 1,000,000 = 88,000,000 \text{ nH}$
 $88 \text{ mH} \times 1000 = 8,800 \mu\text{H}$

4.3 Basic Components

Inductors and Inductance

4-12

- Stored energy in inductors can go outside of their bodies. Their placement can cause their field to pass to another inductor (if desired) or must be oriented to not.

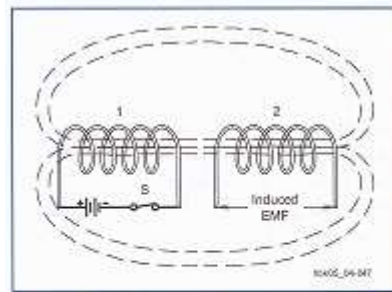
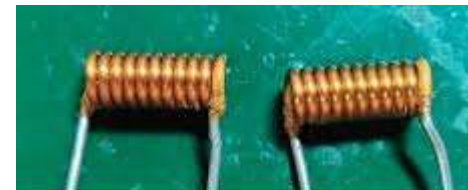


Figure 4-7 — When ac voltage is applied, current flows through coil number 1, setting up a shared magnetic field that causes a voltage to be induced in the turns of coil number 2.



2 Air Core Inductors may share their magnetic fields.

A toroidal winding, with a ring shaped core, contains nearly all of the inductor's field. They can be placed next to each other, making them ideal for RF circuits.



Magnetic or Iron Core



4.3 Basic Components

Inductors and Inductance

4-12

- Toroids may be wound on ferrite or powdered iron cores.
- These cores make it possible to obtain large values of inductance in a small package.
- The combination of materials (or "mix") used to make the core is selected so the inductor performs best over a specific range of frequencies.

[G6B01, G6B05]

PALOMAR ENGINEERS® Ferrite Toroid Comparison Table									
CORE SIZE	Parameters	Mix 31	Mix 43	Mix 61	Mix 75	Mix 77	SIZE	SIZE	SIZE
	Permeability (μ)	1500	850	125	5000	2000	A	B	C
	RFI Use (MHz)	1-300	20-300	200-2000	.15-10	.1-10	O.D.	I.D.	HT.
	Coil Use (MHz)	<30	.01-1	<25	<5	.01-5	in/mm	in/mm	in/mm
	Transformer Use (MHz)	.5-60	.5-60	1-200	.1-20	.1-20			
F400		✓					4/101.6	3/76.2	1/25.4
F350*		*		178			3.5/88.9	2/50.8	0.5/12.7
F290*		*	1300		8100	3740	2.9/73.65	1.53/38.85	.5/12.7
F240		✓	1240	173	6850	2740	2.4/61	1.4/35.55	0.5/12.7
F140			1060	140	5500	2250	1.4/35.55	0.9/23	0.5/12.7
F114A*			993	146		2340	1.14/29	0.75/19	0.55/13.85
F114			603	79		1270	1.14/29	0.75/19	0.3/7.5
F82*			557	73	2950	1170	0.825/21	0.52/13.2	0.25/6.35
F50B*			1140	150	6000	2400	0.5/12.7	0.31/7.9	0.5/12.7
F50A*			570	75		1200	0.5/12.7	0.31/7.9	0.25/6.35
F50*			523	68		1100	0.5/12.7	0.28/7.1	0.19/4.8
F37*			420	55		884	0.37/9.4	0.19/4.8	.12/3.05
F23*			188	25		396	0.23/5.84	.12/3.05	0.06/1.52

4.3 Basic Components

Capacitors and Capacitance

4-13

Many types of capacitors are used in radio electronics

- All have the same basic structure of two conducting surfaces
 - » Called electrodes
 - » Separated by a dielectric
 - » Stores energy-while preventing dc current flow between surfaces)
 - » Capacitance is increased by larger surface areas or bringing surfaces closer together or using dielectrics that Store more energy.

- Two types are optimized to store energy:

- Aluminum electrolytic capacitors: Metal foil and wet paste electrolyte
- Tantalum capacitors with special electrolyte and large surfaces create large capacitance in comparatively small volumes. [G6A04]



4.3 Basic Components

Capacitors and Capacitance

4-13

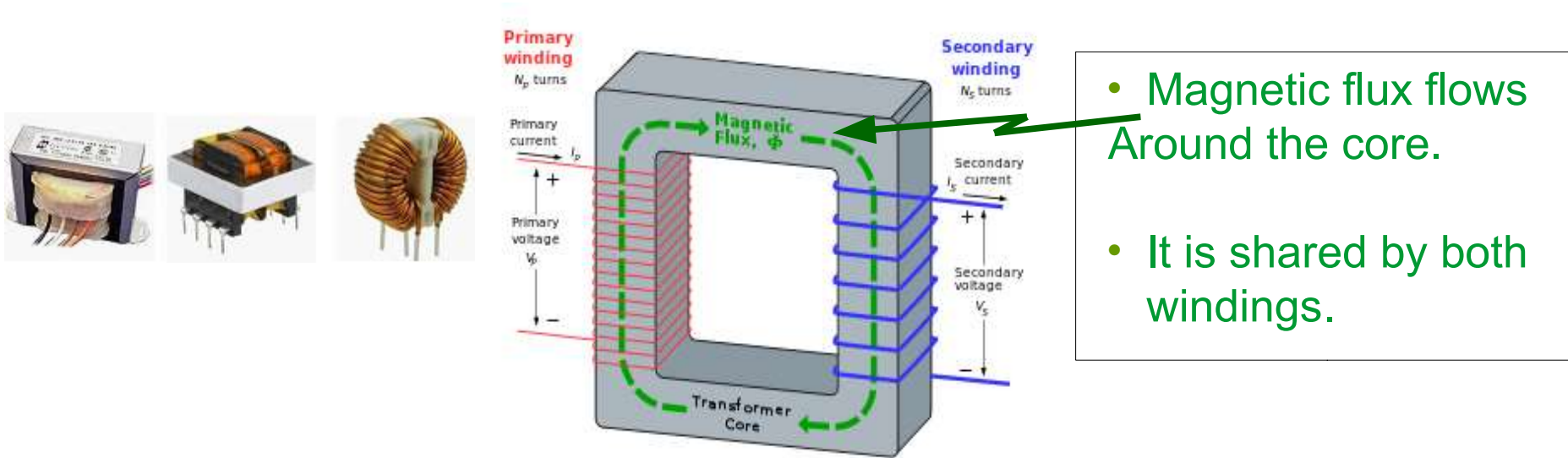
- Tantalum and electrolytic capacitors are polarized where the dc voltage may only be applied in one direction. If the voltage is applied reversed, the capacitor may be damaged or destroyed. Look for the polarity marking on the capacitor body to install it correctly
- An important rating is their Voltage rating. Above the limit the insulating dielectric between the layers breaks down and arc the conducting surfaces.
- There are many uses of capacitors in radio circuits. Each requires different characteristics and they vary by construction.
 - Ceramic – RF filtering, bypassing at hi freq, low cost [G6A08]
 - Plastic film – Circuits for audio and lower radio frequencies
 - Silvered mica – Highly stable, low loss: Used in RF circuits
 - Electrolytic and tantalum – power supplies and filter circuits
 - Air and vacuum dielectric – transmitting and RF circuits
 - Blocking caps pass AC signals while blocking DC.
 - Bypass caps provide low impedance path for AC signals around a hi impedance component
 - Tuning caps vary the frequency of a resonant circuit.
 - Conversions from Pico to Nano and Mico are as before (you don't see milli farad caps)

42

4.3 Basic Components

Transformers

4-14



Transformers use mutual inductance between their windings

- AC power is transferred between common windings on the core
- Primary winding has the power applied to it
- Secondary winding is where the power is provided to the next circuit
- When voltage is applied to the primary winding, mutual inductance causes voltage to appear across the secondary winding [G5C01]

43

4.3 Basic Components

Transformers

4-15

- Transformers work in either direction however construction is based on safety considerations for the different voltages and currents etc.
- A significant change in primary and secondary voltage requires a change in the size of wire between windings. In a step-up transformer the primary winding carries higher current and is wound with larger-diameter wire than the secondary.
[G5C05]
- Transformers work based upon the difference in the number of windings between Primary and Secondary
 - The ratio of the number of turns in the primary N_p to the number of turns in the secondary N_s determines how current and voltage are changed.

Formulas that reveal Secondary (S) and Primary(P) Voltages and Turns Ratios:

$$\frac{E_S}{E_P} = \frac{N_S}{N_P}$$

or

$$E_S = E_P \times \frac{N_S}{N_P}$$

44

4.3 Basic Components

Transformers

$$\frac{E_S}{E_P} = \frac{N_S}{N_P}$$

or

$$E_S = E_P \times \frac{N_S}{N_P}$$

4-15

Example 23: What is the voltage across a 1,500 turn secondary winding if 120V is applied across the 500 turn primary winding?

$$E_S = 120 \times \frac{1500}{500} = 360 \text{ Vac} \quad [\text{G5C06}]$$

Example 24: What would be the secondary to primary turns ratio to change 115Vac to 500Vac?

$$\frac{N_S}{N_P} = \frac{E_S}{E_P} = \frac{500}{115} = 4.35$$

Example 25:

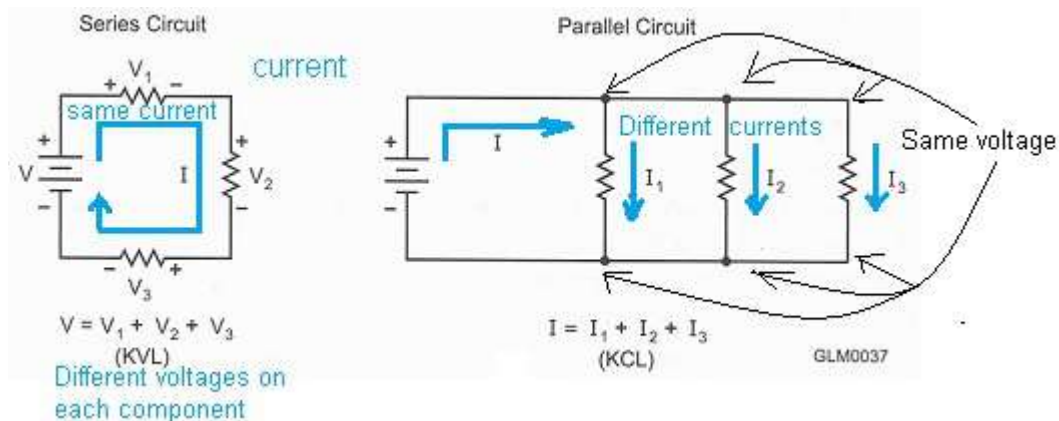
What happens if a signal is applied to the secondary winding of a 4:1 transformer instead of the primary? In the transformer equation

E_P and E_S are reversed. The resulting output voltage of the transformer is 4 times the input voltage [G5C02]

4.3 Basic Components

Components In Series and Parallel Circuits

4-16



- In a series circuit the current is the same in all components and the voltages are summed.
- In parallel circuits, voltage across all components is the same and the sum of currents into and out of junctions must be equal.
- Water Analogy between electricity water pressure and flow for Series Circuits:
 - Pump supplies pressure to a closed system, the pressure drops around the system must add up to equal the pressure supplied by pump. There is no "spare" or "leftover" pressure.
 - Around a series circuit – the voltages across the components must add up to be equal to the voltage applied to the circuit : Kirchhoff's Voltage Law (KVL)

4.3 Basic Components

Components In Series and Parallel Circuits

4-17

- Parallel circuits water analogy: Where pipes come together, the sum of water flows entering the junction must equal the sum of water flows leaving the junction
 - The sum of water flows entering and leaving the junction must equal zero.
 - Water in must equal water out. Electrical current works in just the same way:
 - The total current entering a circuit junction must equal the sum of currents leaving the junction. This is Kirchhoff's current Law (KCL) [G5B02]

- Components connected in series or parallel can be replaced with a single equivalent component. The rules for determining the equivalent components values are summarized in Table 4.2 and Table 4.3 (Fig. 4.10)

[G5C13, G5C14]

4.3 Basic Components

Components In Series and Parallel Circuits

4-17

- Components connected in series or parallel can be replaced with a single equivalent component. The rules for determining the equivalent components values are summarized in Table 4.2 and Table 4.3 (Fig. 4.10)

[G5C13, G5C14]

- **Really - only two formulas to remember:**

- Simple sum (add the values)
- Reciprocal of reciprocals

- When there are only two components: the reciprocals equation simplifies to a 3rd formula that can be used:

$$R_{\text{EQU}} = \frac{R1 \times R2}{R1 + R2}$$

Table 4.2

Calculating Series and Parallel Equivalent Values

<i>Component</i>	<i>In Series</i>
Resistor	Add values, R1 + R2 + R3 +...
Inductor	Add values, L1 + L2 + L3 +...
Capacitor	Reciprocal of reciprocals, 1/(1/C1 + 1/C2 + 1/C3 +...)

<i>Component</i>	<i>In Parallel</i>
Resistor	Reciprocal of reciprocals, 1/(1/R1 + 1/R2 + 1/R3 +...)
Inductor	Reciprocal of reciprocals, 1/(1/L1 + 1/L2 + 1/L3 +...)
Capacitor	Add values, C1+C2+C3+...

Table 4.3

Effect on Total Value of Adding Components in Series and Parallel

<i>Component</i>	<i>Adding In Series</i>	<i>Adding In Parallel</i>
Resistor	Increase	Decrease
Inductor	Increase	Decrease
Capacitor	Decrease	Increase

Example: What is the approximate total resistance of a 100 and 200 ohm resistor in parallel?

$$R_{\text{EQU}} = \frac{100 \times 200}{100 + 200} = \frac{20,000}{300} = 66.67 \Omega$$

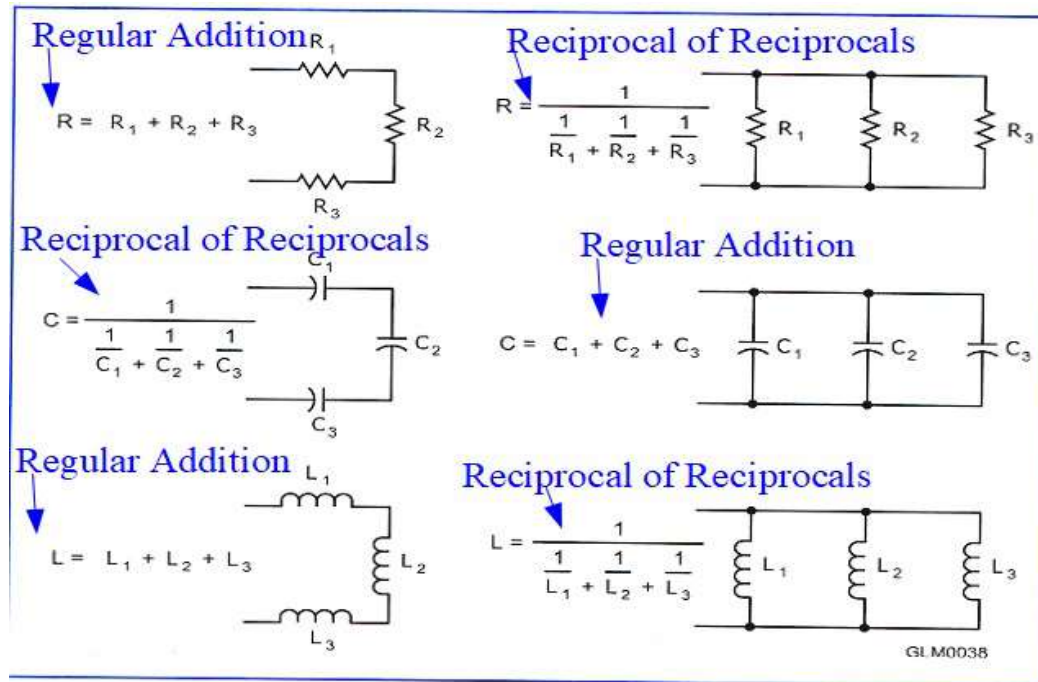
[G5C04]

4.3 Basic Components

Components In Series and Parallel Circuits

4-18

- Components connected in series or parallel can be replaced with a single equivalent component. The rules for determining the equivalent component's value are summarized in Table 4.2 and Table 4.3 and shown graphically in Fig. 4.10



4.3 Basic Components

Components In Series and Parallel Circuits

4-18

Example 27: What is the total capacitance of three 100 μF capacitors in series?

$$C_{\text{EQU}} = \frac{1}{\frac{1}{100} + \frac{1}{100} + \frac{1}{100}} = \frac{1}{\frac{3}{100}} = \frac{100}{3} = 33.3 \mu\text{F} \quad [\text{G5C09}]$$

In parallel?

$$C_{\text{EQU}} = 100 + 100 + 100 = 300 \mu\text{F}$$

Example 28: What is the total inductance of three 10 mH inductors in parallel?

$$L_{\text{EQU}} = \frac{1}{\frac{1}{10} + \frac{1}{10} + \frac{1}{10}} = \frac{10}{3} = 3.3 \text{ mH} \quad [\text{G5C10}]$$

In series?

$$L_{\text{EQU}} = 10 + 10 + 10 = 30 \text{ mH}$$

4.3 Basic Components

Components In Series and Parallel Circuits

4-18

Example 29 : What is the total inductance of a 20 mH and 50 mH inductor in series?

[G5C11]

$$L_{\text{EQU}} = 20 + 50 = 70 \text{ mH}$$

In parallel?

$$L_{\text{EQU}} = \frac{L1 \times L2}{L1 + L2} = \frac{20 \times 50}{20 + 50} = 14.29 \text{ mH}$$

4.3 Basic Components

Components In Series and Parallel Circuits

4-19

Example30: What is the total capacitance of a 20 μF and 50 μF capacitor in parallel?

$$C_{\text{EQU}} = 20 + 50 = 70 \mu\text{F}$$

[G5C12]

In series?

$$C_{\text{EQU}} = \frac{C1 \times C2}{C1 + C2} = \frac{20 \times 50}{20 + 50} = 14.29 \mu\text{F}$$

4.3 Basic Components

Components In Series and Parallel Circuits

4-19

Example 31: What is the total resistance of a 10 Ω , a 20 Ω and a 50 Ω resistor in series?

$$R_{\text{EQU}} = 10 + 20 + 50 = 80 \Omega$$

[G5C03]

In parallel?

$$R_{\text{EQU}} = \frac{1}{\frac{1}{10} + \frac{1}{20} + \frac{1}{50}} = 5.9 \Omega$$

4.3 Basic Components

Components In Series and Parallel Circuits

4-19

Example 32: What is the total capacitance of two 5 nF and one 750 pF capacitors in series?

First, convert 5 nF to pF: $5 \text{ nF} \times 1000 = 5000 \text{ pF}$.

$$C_{\text{EQU}} = \frac{1}{\frac{1}{5000} + \frac{1}{5000} + \frac{1}{750}} = 577 \text{ pF}$$

[G5C08]

In parallel?

$$C_{\text{EQU}} = 5000 + 750 = 10,750 \text{ pF} = 10.75 \text{ nF}$$

4.3 Basic Components

Components In Series and Parallel Circuits

4-19

Equivalent Values:

Knowing these equations for combinations of components can be used to create a specific **equivalent value**.

Example 33: What three equal-value resistors can be combined in series to create an equivalent value of 450Ω ? If R is the unknown value:

$$R_{\text{EQU}} = R + R + R = 3R = 450 \Omega$$

so

$$R = \frac{450}{3} = 150 \Omega$$

Ch 4.1 to 4.3 Questions

G5B01

What dB change represents a factor of two increase or decrease in power?

- A. Approximately 2 dB
- B. Approximately 3 dB
- C. Approximately 6 dB
- D. Approximately 12 dB

Ch 4.1 to 4.3 Questions

G5B01 (B)

What dB change represents a factor of two increase or decrease in power?

A. Approximately 2 dB

B. Approximately 3 dB

C. Approximately 6 dB

D. Approximately 12 dB

Ch 4.1 to 4.3 Questions

G5B03

How many watts of electrical power are used if 400 VDC is supplied to an 800 ohm load?

- A. 0.5 watts
- B. 200 watts
- C. 400 watts
- D. 3200 watts

Ch 4.1 to 4.3 Questions

G5B03 (B)

How many watts of electrical power are used if 400 VDC is supplied to an 800 ohm load?

A. 0.5 watts

B. 200 watts

C. 400 watts

D. 3200 watts

Ch 4.1 to 4.3 Questions

G5B04

How many watts of electrical power are used by a 12 VDC light bulb that draws 0.2 amperes?

- A. 2.4 watts
- B. 24 watts
- C. 6 watts
- D. 60 watts

Ch 4.1 to 4.3 Questions

G5B04 (A)

How many watts of electrical power are used by a 12 VDC light bulb that draws 0.2 amperes?

- A. 2.4 watts**
- B. 24 watts
- C. 6 watts
- D. 60 watts

Ch 4.1 to 4.3 Questions

G5B05

How many watts are dissipated when a current of 7.0 milliamperes flows through a 1.250 kiliohms resistance?

- A. Approximately 61 milliwatts
- B. Approximately 61 watts
- C. Approximately 11 milliwatts
- D. Approximately 11 watts

Ch 4.1 to 4.3 Questions

G5B05 (A)

How many watts are dissipated when a current of 7.0 milliamperes flows through a 1.250 kilohms resistance?

- A. Approximately 61 milliwatts**
- B. Approximately 61 watts
- C. Approximately 11 milliwatts
- D. Approximately 11 watts

Ch 4.1 to 4.3 Questions

G5B06

What is the output PEP from a transmitter if an oscilloscope measures 200 volts peak-to-peak across a 50 ohm dummy load connected to the transmitter output?

- A. 1.4 watts
- B. 100 watts
- C. 353.5 watts
- D. 400 watts

Ch 4.1 to 4.3 Questions

G5B06 (B)

What is the output PEP from a transmitter if an oscilloscope measures 200 volts peak-to-peak across a 50 ohm dummy load connected to the transmitter output?

- A. 1.4 watts
- B. 100 watts**
- C. 353.5 watts
- D. 400 watts

Ch 4.1 to 4.3 Questions

G5B07

What value of an AC signal produces the same power dissipation in a resistor as a DC voltage of the same value?

- A. The peak-to-peak value
- B. The peak value
- C. The RMS value
- D. The reciprocal of the RMS value

Ch 4.1 to 4.3 Questions

G5B07 (C)

What value of an AC signal produces the same power dissipation in a resistor as a DC voltage of the same value?

- A. The peak-to-peak value
- B. The peak value
- C. The RMS value**
- D. The reciprocal of the RMS value

Ch 4.1 to 4.3 Questions

G5B09

What is the RMS voltage of a sine wave with a value of 17 volts peak?

- A. 8.5 volts
- B. 12 volts
- C. 24 volts
- D. 34 volts

Ch 4.1 to 4.3 Questions

G5B09 (B)

What is the RMS voltage of a sine wave with a value of 17 volts peak?

A. 8.5 volts

B. 12 volts

C. 24 volts

D. 34 volts

Ch 4.1 to 4.3 Questions

G5B11

What is the ratio of peak envelope power to average power for an unmodulated carrier?

- A. 0.707
- B. 1.00
- C. 1.414
- D. 2.00

Ch 4.1 to 4.3 Questions

G5B11 (B)

What is the ratio of peak envelope power to average power for an unmodulated carrier?

A. 0.707

B. 1.00

C. 1.414

D. 2.00

Ch 4.1 to 4.3 Questions

G5B12

What would be the RMS voltage across a 50 ohm dummy load dissipating 1200 watts?

- A. 173 volts
- B. 245 volts
- C. 346 volts
- D. 692 volts

Ch 4.1 to 4.3 Questions

G5B12 (B)

What would be the RMS voltage across a 50 ohm dummy load dissipating 1200 watts?

A. 173 volts

B. 245 volts

C. 346 volts

D. 692 volts

Ch 4.1 to 4.3 Questions

G5B13

What is the output PEP of an unmodulated carrier if an average reading wattmeter connected to the transmitter output indicates 1060 watts?

- A. 530 watts
- B. 1060 watts
- C. 1500 watts
- D. 2120 watts

Ch 4.1 to 4.3 Questions

G5B13 (B)

What is the output PEP of an unmodulated carrier if an average reading wattmeter connected to the transmitter output indicates 1060 watts?

A. 530 watts

B. 1060 watts

C. 1500 watts

D. 2120 watts

Ch 4.1 to 4.3 Questions

G5B14

What is the output PEP from a transmitter if an oscilloscope measures 500 volts peak-to-peak across a 50 ohm resistive load connected to the transmitter output?

- A. 8.75 watts
- B. 625 watts
- C. 2500 watts
- D. 5000 watts

Ch 4.1 to 4.3 Questions

G5B14 (B)

What is the output PEP from a transmitter if an oscilloscope measures 500 volts peak-to-peak across a 50 ohm resistive load connected to the transmitter output?

- A. 8.75 watts
- B. 625 watts**
- C. 2500 watts
- D. 5000 watts

Ch 4.1 to 4.3 Questions

G5B02

How does the total current relate to the individual currents in each branch of a purely resistive parallel circuit?

- A. It equals the average of each branch current
- B. It decreases as more parallel branches are added to the circuit
- C. It equals the sum of the currents through each branch
- D. It is the sum of the reciprocal of each individual voltage drop

Ch 4.1 to 4.3 Questions

G5B02 (C)

How does the total current relate to the individual currents in each branch of a purely resistive parallel circuit?

- A. It equals the average of each branch current
- B. It decreases as more parallel branches are added to the circuit
- C. It equals the sum of the currents through each branch**
- D. It is the sum of the reciprocal of each individual voltage drop

Ch 4.1 to 4.3 Questions

G5C01

What causes a voltage to appear across the secondary winding of a transformer when an AC voltage source is connected across its primary winding?

- A. Capacitive coupling
- B. Displacement current coupling
- C. Mutual inductance
- D. Mutual capacitance

Ch 4.1 to 4.3 Questions

G5C01 (C)

What causes a voltage to appear across the secondary winding of a transformer when an AC voltage source is connected across its primary winding?

- A. Capacitive coupling
- B. Displacement current coupling
- C. Mutual inductance**
- D. Mutual capacitance

Ch 4.1 to 4.3 Questions

G5C02

What happens if a signal is applied to the secondary winding of a 4:1 voltage step-down transformer instead of the primary winding?

- A. The output voltage is multiplied by 4
- B. The output voltage is divided by 4
- C. Additional resistance must be added in series with the primary to prevent overload
- D. Additional resistance must be added in parallel with the secondary to prevent overload

Ch 4.1 to 4.3 Questions

G5C02 (A)

What happens if a signal is applied to the secondary winding of a 4:1 voltage step-down transformer instead of the primary winding?

A. The output voltage is multiplied by 4

B. The output voltage is divided by 4

C. Additional resistance must be added in series with the primary to prevent overload

D. Additional resistance must be added in parallel with the secondary to prevent overload

Ch 4.1 to 4.3 Questions

G5C08

What is the equivalent capacitance of two 5.0 nanofarad capacitors and one 750 picofarad capacitor connected in parallel?

- A. 576.9 nanofarads
- B. 1733 picofarads
- C. 3583 picofarads
- D. 10.750 nanofarads

Ch 4.1 to 4.3 Questions

G5C08 (D)

What is the equivalent capacitance of two 5.0 nanofarad capacitors and one 750 picofarad capacitor connected in parallel?

- A. 576.9 nanofarads
- B. 1733 picofarads
- C. 3583 picofarads
- D. 10.750 nanofarads**

Ch 4.1 to 4.3 Questions

G5C09

What is the capacitance of three 100 microfarad capacitors connected in series?

- A. 0.30 microfarads
- B. 0.33 microfarads
- C. 33.3 microfarads
- D. 300 microfarads

Ch 4.1 to 4.3 Questions

G5C09 (C)

What is the capacitance of three 100 microfarad capacitors connected in series?

- A. 0.30 microfarads
- B. 0.33 microfarads
- C. 33.3 microfarads
- D. 300 microfarads

Ch 4.1 to 4.3 Questions

G5C10

What is the inductance of three 10 millihenry inductors connected in parallel?

- A. 0.30 henries
- B. 3.3 henries
- C. 3.3 millihenries
- D. 30 millihenries

Ch 4.1 to 4.3 Questions

G5C10 (C)

What is the inductance of three 10 millihenry inductors connected in parallel?

- A. 0.30 henries
- B. 3.3 henries
- C. 3.3 millihenries**
- D. 30 millihenries

Ch 4.1 to 4.3 Questions

G5C11

What is the inductance of a 20 millihenry inductor connected in series with a 50 millihenry inductor?

- A. 0.07 millihenries
- B. 14.3 millihenries
- C. 70 millihenries
- D. 1000 millihenries

Ch 4.1 to 4.3 Questions

G5C11 (C)

What is the inductance of a 20 millihenry inductor connected in series with a 50 millihenry inductor?

- A. 0.07 millihenries
- B. 14.3 millihenries
- C. 70 millihenries**
- D. 1000 millihenries

Ch 4.1 to 4.3 Questions

G5C12

What is the capacitance of a 20 microfarad capacitor connected in series with a 50 microfarad capacitor?

- A. 0.07 microfarads
- B. 14.3 microfarads
- C. 70 microfarads
- D. 1000 microfarads

Ch 4.1 to 4.3 Questions

G5C12 (B)

What is the capacitance of a 20 microfarad capacitor connected in series with a 50 microfarad capacitor?

- A. 0.07 microfarads
- B. 14.3 microfarads**
- C. 70 microfarads
- D. 1000 microfarads

Ch 4.1 to 4.3 Questions

G5C13

Which of the following components should be added to a capacitor to increase the capacitance?

- A. An inductor in series
- B. A resistor in series
- C. A capacitor in parallel
- D. A capacitor in series

Ch 4.1 to 4.3 Questions

G5C13

Which of the following components should be added to a capacitor to increase the capacitance?

- A. An inductor in series
- B. A resistor in series
- C. A capacitor in parallel
- D. A capacitor in series

Ch 4.1 to 4.3 Questions

G5C13 (C)

Which of the following components should be added to a capacitor to increase the capacitance?

- A. An inductor in series
- B. A resistor in series
- C. A capacitor in parallel
- D. A capacitor in series

Ch 4.1 to 4.3 Questions

G5C14

Which of the following components should be added to an inductor to increase the inductance?

- A. A capacitor in series
- B. A resistor in parallel
- C. An inductor in parallel
- D. An inductor in series

Ch 4.1 to 4.3 Questions

G5C14 (D)

Which of the following components should be added to an inductor to increase the inductance?

- A. A capacitor in series
- B. A resistor in parallel
- C. An inductor in parallel
- D. An inductor in series**

Ch 4.1 to 4.3 Questions

Extra question – similar but not a test question -

What is the total resistance of a 10 ohm, a 20 ohm, and a 50 ohm resistor connected in parallel?

- A. 5.9 ohms
- B. 0.17 ohms
- C. 10000 ohms
- D. 80 ohms



Extra question – similar but not a test question -

What is the total resistance of a 10 ohm, a 20 ohm, and a 50 ohm resistor connected in parallel?

- A. 5.9 ohms**
- B. 0.17 ohms
- C. 10000 ohms
- D. 80 ohms

Credits:

ARRL Newington, CT. Website

ARRL Gneral Class License Manual for Ham Radio Tenth Edition

Prior Editions of ARRL License Manuals

ARRL Handbook (various editions)