Technician Licensing Class
“T5”

Presented by
Renton Emergency
Communication Service

July 1, 2010

Amateur Radio Technician Class
Element 2 Course Presentation

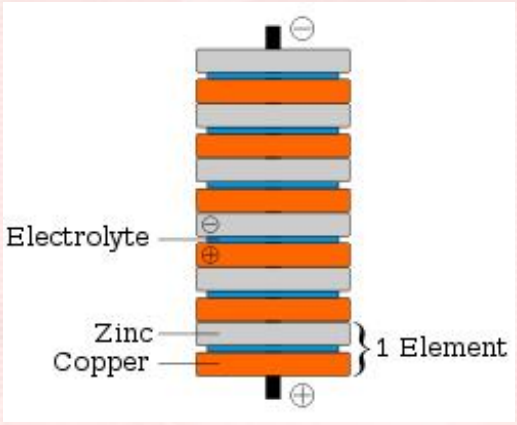
- **ELEMENT 2 SUB-ELEMENTS**
  - **T1 – FCC Rules & Responsibilities**
  - **T2 – Operating Procedures**
  - **T3 – Radio Wave Properties**
  - **T4 – Station Setup & Operation**
  - **T5 – Electrical Principles**
  - **T6 – Electrical Components**
  - **T7 – Station Equipment & Troubleshooting**
  - **T8 – Operating Modes**
  - **T9 – Antennas & Feedlines**
  - **T0 – Electrical and RF Safety**

Basic Electrical Units

- You don't have to be an electronics engineer to get a Technician Class license, but it does help to know the basics of electricity and and some of the units we use in electronics. The most important concepts are **voltage, current, resistance, power,** and **frequency**.

Names of electrical units: Voltage

- **Count Alessandro Giuseppe Antonio Anastasio Volta** (18 February 1745 – 5 March 1827) was an Italian physicist known especially for the development of the first electric cell in 1800.



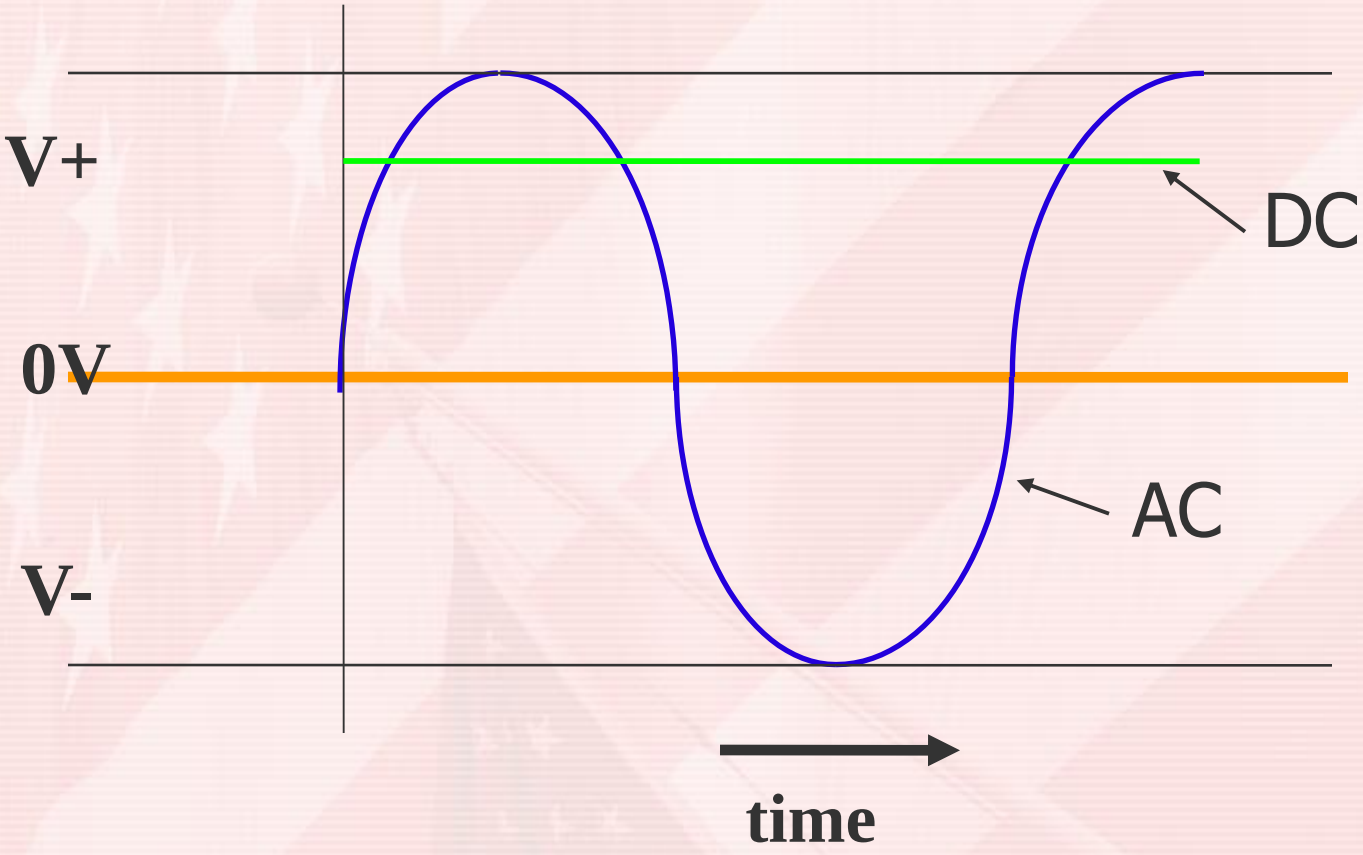
- **Voltage** is the electrical term for the electromotive force (EMF) that causes electron flow. (T5A05)
- **The volt** is the basic unit of electromotive force. (T5A11)
- You use **a voltmeter** to measure electric potential or electromotive force. (T7D01)
- **About 12 volts** is the amount of voltage that a mobile transceiver usually requires. (T5A06)

Names of electrical units: Current

- The **Ampere** is the unit of electric current. It is named after André-Marie Ampère (1775–1836), French mathematician and physicist, considered the father of electrodynamics. In practice, its name is often shortened to **Amp**.

- **Current** is the name for the flow of electrons in an electric circuit (T5A03).
- Electrical current is measured in **amperes** (T5A01).
- **An ammeter** is the instrument used to measure electric current (T7D04).
- **Direct current** is the name for a current that flows only in one direction (T5A04). Batteries supply direct current, or simply DC.
- **Alternating current** is the name for a current that reverses direction on a regular basis (T5A09). Alternating current, or AC, is what is available from your home's wall sockets. Power supplies convert the AC into DC, which is required for most modern amateur radio equipment.

Direct and Alternating Currents



Names of electrical units: Resistance

- **Georg Simon Ohm** (1789 – 1854) was a German physicist.
- **Resistance** is the term used to describe opposition to current flow in a circuit. The basic unit of resistance is named the **ohm**, in his honor. The Greek letter omega (Ω) is shorthand for ohms.
- **An ohmmeter** is the instrument used to measure resistance (T7D05).

- **Conductors** are materials that conduct electrical current well, or, in other words, have a low resistance. The copper wires that we use to connect a power supply to a radio are good conductors because **copper** is a good electrical conductor (T5A07).

- **Insulators** are materials that that have a high resistance. They do not conduct electrical current very well. Plastics and **glass**, for example, are good electrical insulators (T5A08).

Names of electrical units: Capacitance & Inductance

- **Michael Faraday**, (1791 – 1867) was an English chemist and physicist (or natural philosopher, in the terminology of the time) who contributed to the fields of electromagnetism and electrochemistry.

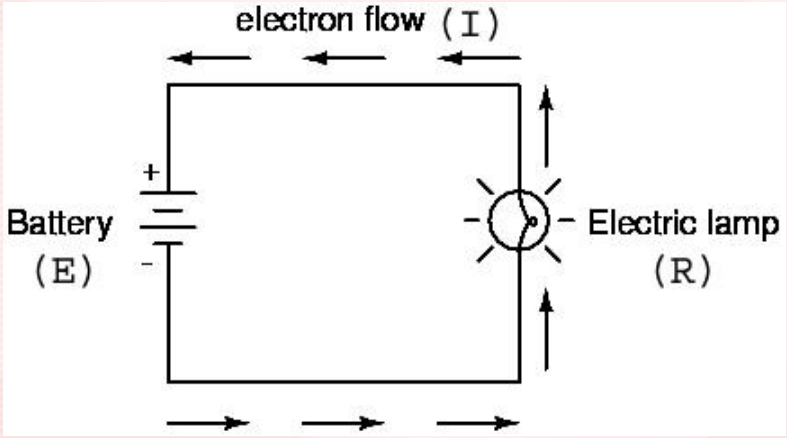
- **Capacitance** is the ability to store energy in an electric field. (T5C01)
- The basic unit of capacitance is the **farad** (T5C02).

- **Joseph Henry** (1797 – 1878) was an American scientist who served as the first Secretary of the Smithsonian Institution. While building electromagnets, Henry discovered the electromagnetic phenomenon of self-inductance. He also discovered mutual inductance independently of Michael Faraday. The unit of inductance, the henry, is named in his honor. Henry's work on the electromagnetic relay was the basis of the electrical telegraph, invented by Samuel Morse.

- **Inductance** is the ability to store energy in a magnetic field. (T5C03)
- The basic unit of inductance is the **henry** (T5C04).

Ohm's Law

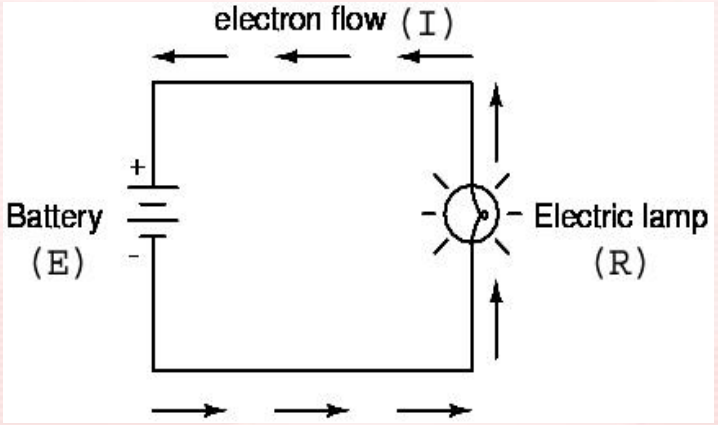
- As a high school teacher, Ohm began his research with the recently invented electrochemical cell, invented by Italian Count Alessandro Volta. Using equipment of his own creation, Ohm determined that there is a direct proportionality between the potential difference (voltage) applied across a conductor and the resultant electric current – now known as **Ohm's Law**.
- Using the results of his experiments, Ohm was able to define the fundamental relationship among voltage, current, and resistance, which represents the true beginning of electrical circuit analysis.



- **Ohm's Law** is the relationship between voltage, current, and the resistance in a DC circuit. When you know any two of these values, you can calculate the third.
- The most basic equation for Ohm's Law is **E = I * R.** The formula used to calculate voltage across the circuit is **voltage (E) equals current (I) multiplied by resistance (R)** (T5D02).
- The formula used to calculate resistance in a circuit is **resistance (R) equals voltage (E) divided by current (I)** (T5D03). **R = E / I**
- The formula used to calculate current in the circuit is **current (I) equals voltage (E) divided by resistance (R)** (T5D01). **I = E / R**

Ohm's Law

- **E = I * R**
  - The voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it is **1 volt** (T5D10).
  - The voltage across a 10-ohm resistor if a current of 1 ampere flows through it is **10 volts** (T5D11).
  - The voltage across a 10-ohm resistor if a current of 2 amperes flows through it is **20 volts** (T5D12).



- **I = E / R**
- The current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms is **1.5 amperes** (T5D07).
- The current flowing through a 100-ohm resistor connected across 200 volts is **2 amperes** (T5D08).
- The current flowing through a 24-ohm resistor connected across 240 volts is **10 amperes** (T5D09).
- **R = E / I**
- The resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts is **30 ohms** (T5D04).
- The resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes is **8 ohms** (T5D05).
- The resistance of a circuit that draws 4 amperes from a 12-volt source is **3 ohms** (T5D06).

Measurement Equipment

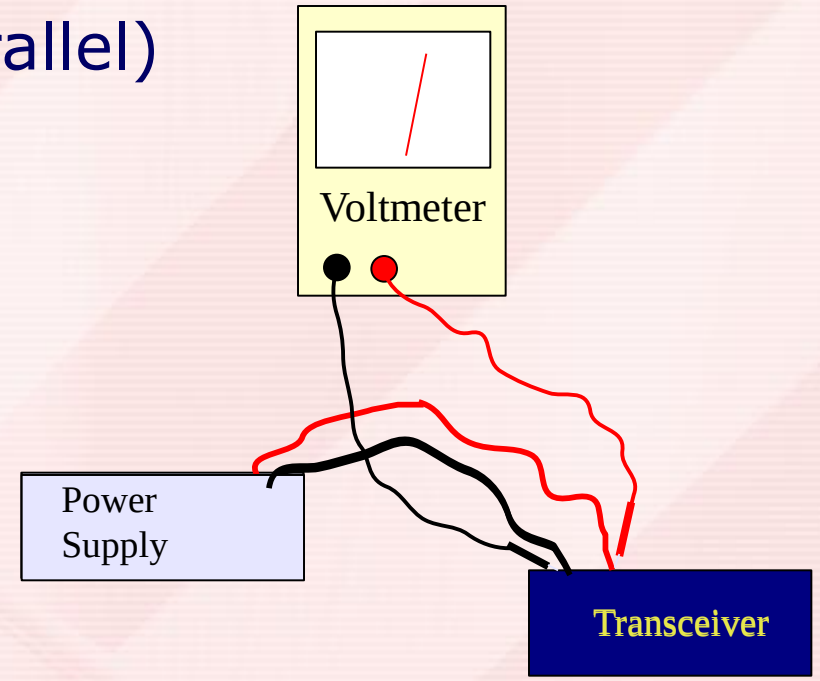
Multimeters will measure Voltage, Current and Resistance.

Be sure it is set properly to read what is being measured.

If it is set to the ohms setting and voltage is measured the meter could be damaged!

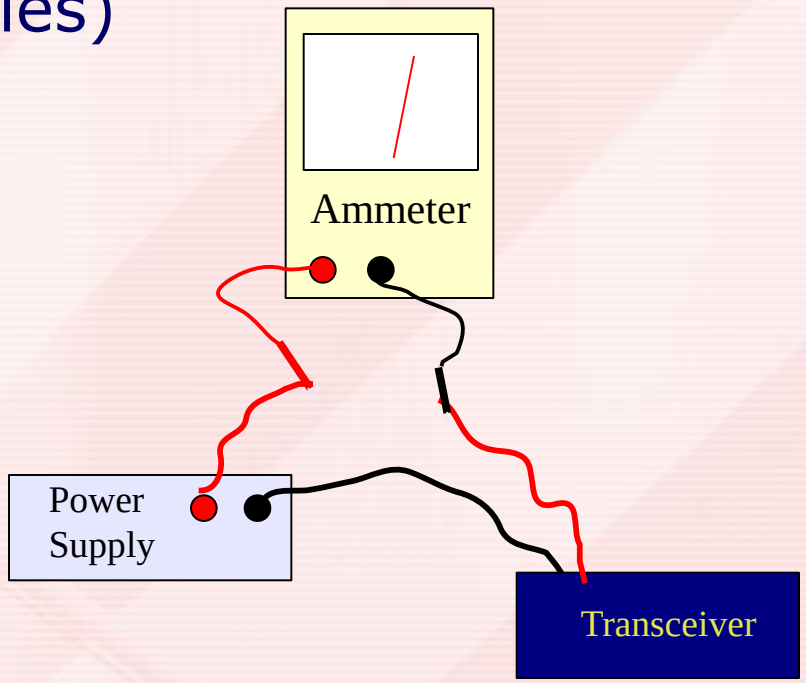
Measurement Equipment

- Measuring Voltage
- (always measured in parallel)



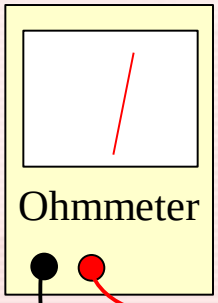
Measurement Equipment

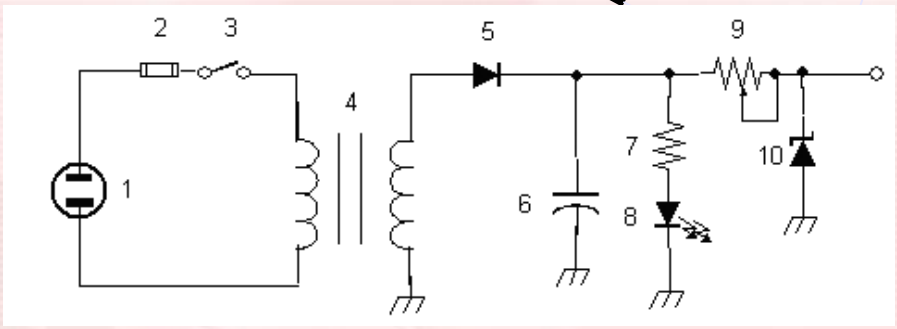
- Measuring Current
- (always measured in series)



Measurement Equipment

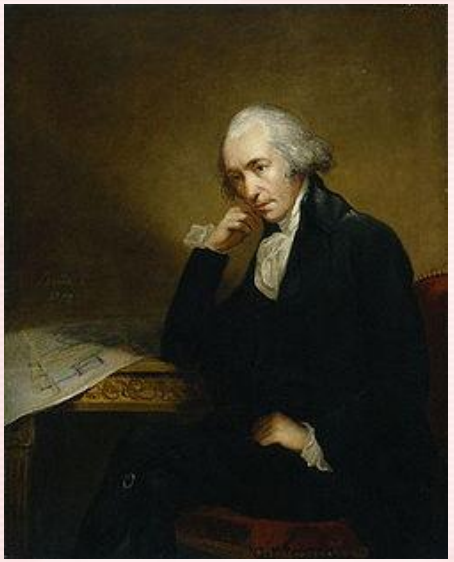
- Measuring Resistance
- (always measured with power off!)





➢ Names of electrical units: Power

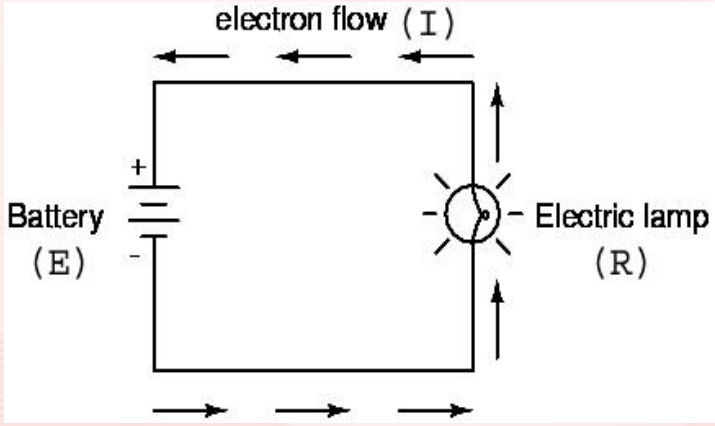
- **James Watt**, (19 January 1736 – 25 August 1819) was a Scottish inventor and mechanical engineer whose improvements to the Newcomen steam engine were fundamental to the changes brought by the Industrial Revolution in both the Kingdom of Great Britain and the world. The official unit of power, the **watt**, is named in his honor.



- The term that describes the rate at which electrical energy is used (or generated) is **power** (T5A10).
- Electrical power is measured in **watts** (T5A02).

DC Power Calculations

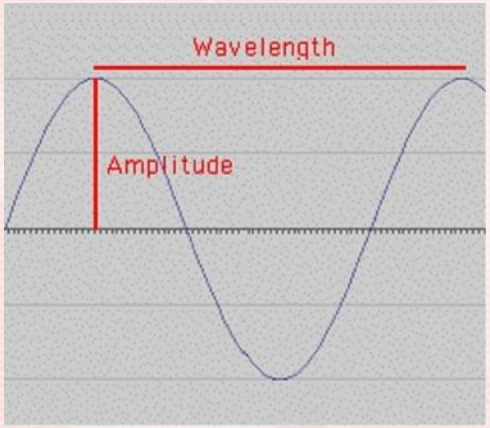
- Power is the rate at which electrical energy is generated or consumed. The formula used to calculate electrical power in a DC circuit is **power (P) equals voltage (E) multiplied by current (I)** (T5C08).



- **P = E * I**
- **138 watts** is the power being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes (T5C09).
- When the applied voltage in a circuit is 12 volts DC and the current is 2.5 amperes, the power being used is **30 watts** (T5C10).
- **I = P / E**
- For example, **10 amperes** are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts (T5C11).

Names of electrical units: Frequency

- **Heinrich Rudolf Hertz** (February 22, 1857 – January 1, 1894) was a German physicist who clarified and expanded the electromagnetic theory of light that had been put forth by Maxwell. He was the first to satisfactorily demonstrate the existence of electromagnetic waves by building an apparatus to produce and detect VHF or UHF radio waves. The unit of measurement for frequency was named in his honor.



- The unit of frequency is the **Hertz (Hz)** (T5C05). One Hz is one cycle per second.
- The usual name for electromagnetic waves that travel through space is **radio waves** (T5C07).
- **RF** is the abbreviation that refers to radio frequency signals of all types (T5C06).

Names of electrical units: Decibels

- When dealing with ratios—especially power ratios—we often use **decibels (dB).** The reason for this is that the decibel scale is a logarithmic scale, meaning that we can talk about large ratios with relatively small numbers. Devised by engineers of the Bell Telephone Laboratories in the 1920s, the decibel originates from methods used to quantify reductions in audio levels in telephone circuits. The base-10 logarithm of the power ratio as a standard unit was named the "bel" in honor of the Bell System's founder and telecommunications pioneer Alexander Graham Bell. A decibel is one-tenth of a bel.

- **3 dB** is the approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts (T5B09). This is a ratio of 2 to 1.
- **6 dB** is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts (T5B10). This is a ratio of 4 to 1.
- **10 dB** is the approximate amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts (T5B11). This is a ratio of 10 to 1.

Metric Measurements

- When dealing with electrical parameters, such as voltage, resistance, current, and power, we use a set of prefixes to denote various orders of magnitude:

Metric		Exponent	English
Tera	T	10^{12}	Trillion
Giga	G	10^{9}	Billion
Mega	M	10^{6}	**Million**
Kilo	k	10^{3}	**Thousand**
Centi	c	10^{-2}	Hundredth
Milli	m	10^{-3}	**Thousandth**
Micro	u	10^{-6}	**Millionth**
Nano	n	10^{-9}	Billionth
Pico	p	10^{-12}	Trillionth

Metric Measurements

- **Milli**- is the prefix we use to denote 1 one-thousandth of a quantity. A milliampere, for example, is 1 one-thousandth of an ampere, or .001 A. Often, the letter m is used instead of the prefix milli-. 1 milliampere is, therefore, **1 mA**.
- **Micro**- is the prefix we use to denote 1 millionth of a quantity. A microvolt, for example, is 1 millionth of a volt, or .000001 V. Often you will see the Greek letter mu, or μ, to denote the prefix micro-. 1 microvolt is, therefore, **1 μV**.
- **Pico**- is the prefix we use to denote 1 trillionth of a quantity. A picovolt is 1 trillionth of a volt, or **1 pV**.
- **Kilo**- is the prefix we use to denote 1 thousand of a quantity. A kilovolt, for example, is 1000 volts. Often, the letter k is used instead of the prefix kilo-. 1 kilovolt is, therefore, **1 kV**.
- **Mega**- is the prefix we use to denote 1 million of a quantity. A megahertz, for example, is 1 million Hertz. Often, the letter M is used instead of the prefix mega-. 1 megahertz is, therefore, **1 MHz**.

Metric Measurements

- **Examples of Metric conversions:**

- **1,500 milliamperes** is 1.5 amperes (T5B01).
- Another way to specify a radio signal frequency of 1,500,000 hertz is **1500 kHz** (T5B02).
- **One thousand volts** are equal to one kilovolt (T5B03).
- **One one-millionth of a volt** is equal to one microvolt (T5B04).
- If an ammeter calibrated in amperes is used to measure a 3000-milliampere current, the reading it would show would be **3 amperes** (T5B06).
- If a frequency readout calibrated in megahertz shows a reading of 3.525 MHz, it would show **3525 kHz** if it were calibrated in kilohertz (T5B07).
- **1 microfarad** is 1,000,000 picofarads (T5B08). Farad is the unit for capacitance.

Element 2 Technician Class Question Pool

T5 – Electrical Principles

Valid July 1, 2010

Through

June 30, 2014

T5A01 Electrical current is measured in which of the following units?

A. Volts
B. Watts
C. Ohms
D. Amperes

T5A02 Electrical Power is measured in which of the following units?

A. Volts
B. Watts
C. Ohms
D. Amperes

T5A03 What is the name for the flow of electrons in an electric circuit?

A. Voltage
B. Resistance
C. Capacitance
D. Current

T5A04 What is the name of a current that flows only in one direction?

A. Alternating current
B. Direct current
C. Normal current
D. Smooth current

T5A05 What is the electrical term for the electromotive force (EMF) that causes electron flow?

A. Voltage
B. Ampere-hours
C. Capacitance
D. Inductance

T5A06 How much voltage does a mobile transceiver usually require?

A. About 12 volts
B. About 30 volts
C. About 120 volts
D. About 240 volts

T5A07 Which of the following is a good electrical conductor?

A. Rubber
B. Wood
C. Glass
D. Copper

T5A08 Which of the following is a good electrical insulator?

A. Glass
B. Copper
C. Aluminum
D. Mercury

T5A09 What is the name for a current that reverses direction on a regular basis?

A. Direct Current
B. Circular Current
C. Alternating Current
D. Vertical Current

T5A10 Which term describes the rate at which electrical energy is used?

A. Resistance
B. Power
C. Current
D. Voltage

T5A11 What is the basic unit of electromotive force?

A. The Watt
B. The Volt
C. The Ampere
D. The Ohm

T5B01 How many milliamperes is 1.5 amperes?

A. 15 milliamperes
B. 150 milliamperes
C. 1,500 milliamperes
D. 15,000 milliamperes

T5B02 What is another way to specify a radio signal frequency of 1,500,000 hertz?

A. 1500 MHz
B. 1500 kHz
C. 15 GHz
D. 150 kHz

T5B03 How many volts are equal to one kilovolt?

A. One one-thousandth of a volt
B. One hundred volts
C. One thousand volts
D. One million volts

T5B04 How many volts are equal to one microvolt?

A. One million volts
B. One thousand kilovolts
C. One one-thousandth of a volt
D. One one-millionth of a volt

T5B05 Which of the following is equivalent to 500 milliwatts?

A. 0.02 watts
B. 0.5 watts
C. 5 watts
D. 50 watts

T5B06 If an ammeter calibrated in amperes is used to measure a 3000-milliampere current, what reading would it show?

A. 0.003 amperes
B. 0.3 amperes
C. 3 amperes
D. 3,000,000 amperes

T5B07 If a frequency readout calibrated in mega-hertz shows a reading of 3.525 MHz, what would it show if it were calibrated in kilohertz?

A. 3525 kHz

B. 35.25 kHz

C. 0.003525 kHz

D. 3,525,000 kHz

T5B08 How many microfarads are 1,000,000 picofarads?

A. 0.001 microfarads
B. 1 microfarad
C. 1000 microfarads
D. 1,000,000,000 microfarads

T5B09 What is the approximate amount of change, measured in decibels (dB), of a power increase from 5 watts to 10 watts?

A. 10 dB
B. 5 dB
C. 2 dB
D. 3 dB

T5B10 What is the approximate amount of change, measured in decibels (dB), of a power decrease from 12 watts to 3 watts?

A. 1 dB

B. 3 dB

C. 6 dB

D. 9 dB

T5B11 What is the approximate amount of change, measured in decibels (dB), of a power increase from 20 watts to 200 watts?

A. 10 dB

B. 12 dB

C. 18 dB

D. 28 dB

T5C01 What is the ability to store energy in an electric field called?

A. Capacitance
B. Tolerance
C. Resistance
D. Inductance

T5C02 What is the basic unit of capacitance?

A. The volt
B. The ohm
C. The henry
D. The farad

T5C03 What is the ability to store energy in a magnetic field called?

A. Admittance
B. Capacitance
C. Inductance
D. Resistance

T5C04 What is the basic unit of inductance?

A. The ohm
B. The henry
C. The farad
D. The coulomb

T5C05 What is the unit of frequency?

A. Hertz
B. Henry
C. Farad
D. Tesla

T5C06 What is the abbreviation that refers to radio frequency signals of all types?

A. RF
B. AF
C. HF
D. VHF

T5C07 What is a usual name for electromagnetic waves that travel through space?

A. Gravity waves
B. Sound waves
C. Radio waves
D. Pressure waves

T5C08 What is the formula used to calculate electrical power in a DC circuit?

A. Power (P) equals voltage (E) multiplied by current (I)

B. Power (P) equals voltage (E) divided by current (I)

C. Power (P) equals voltage (E) minus current (I)

D. Power (P) equals voltage (E) plus current (I)

T5C09 How much power is being used in a circuit when the applied voltage is 13.8 volts DC and the current is 10 amperes?

A. 0.7 watts

B. 3.8 watts

C. 23.8 watts

D. 138 watts

T5C10 How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes?

A. 4.8 watts

B. 30 watts

C. 14.5 watts

D. 0.208 watts

T5C11 How many amperes are flowing in a circuit when the applied voltage is 12 volts DC and the load is 120 watts?

A. 0.1 amperes
B. 10 amperes
C. 12 amperes
D. 132 amperes

T5D01 What formula is used to calculate current in a circuit?

A. Current (I) equals voltage (E) multiplied by resistance (R)

B. Current (I) equals voltage (E) divided by resistance (R)

C. Current (I) equals voltage (E) added to resistance (R)

D. Current (I) equals voltage (E) minus resistance (R)

T5D02 What formula is used to calculate voltage in a circuit?

A. Voltage (E) equals current (I) divided by resistance (R)

B. Voltage (E) equals current (I) multiplied by resistance (R)

C. Voltage (E) equals current (I) added to resistance (R)

D. Voltage (E) equals current (I) minus resistance (R)

T5D03 What formula is used to calculate resistance in a circuit?

A. Resistance (R) equals voltage (E) multiplied by current (I)

B. Resistance (R) equals voltage (E) divided by current (I)

C. Resistance (R) equals voltage (E) added to current (I)

D. Resistance (R) equals voltage (E) minus current (I)

T5D04 What is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts?

A. 30 ohms
B. 3 ohms
C. 93 ohms
D. 270 ohms

T5D05 What is the resistance of a circuit in which the applied voltage is 12 volts and the current flow is 1.5 amps?

A. 0.125 ohms

B. 8 ohms

C. 13.5 ohms

D. 18 ohms

T5D06 What is the resistance of a circuit that draws 4 amperes froma 12-volt source?

A. 8 ohms

B. 3 ohms

C. 16 ohms

D. 48 ohms

T5D07 What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?

A. 9600 amperes

B. 200 amperes

C. 1.5 amperes

D. 0.667 amperes

T5D08 What is the current flowing through a 100 ohm resistor connected across 200 volts?

A. 20,000 amperes

B. 100 amperes

C. 0.5 amperes

D. 2 amperes

T5D09 What is the current flowing through a 24 ohm resistor connected across 240 volts?

A. 10 amperes

B. 216 amperes

C. 24,000 ampers

D. 0.1 amperes

T5D10 What is the voltage across a 2-ohm resistor if a current of 0.5 amperes flows through it?

A. 1 volt
B. 0.25 volts
C. 2.5 volts
D. 1.5 volts

T5D11 What is the voltage across a 10-ohm resistor if a current of 1 ampere flows through it?

A. 10 volts

B. 11 volts

C. 9 volts

D. 1 volt

T5D12 What is the voltage across a 10-ohm resistor if a current of 2 ampere flows through it?

A. 0.2 volts

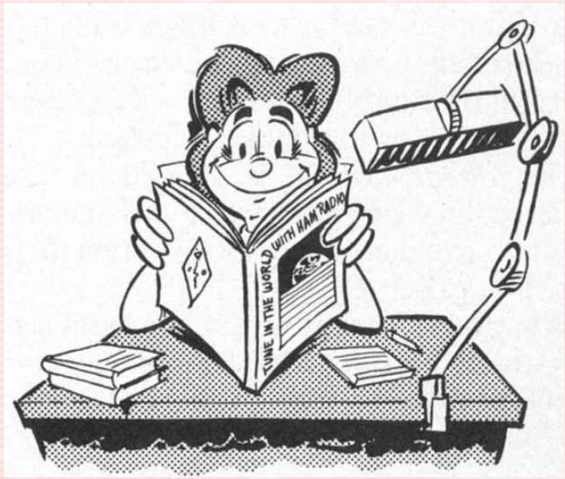
B. 8 volts

C. 20 volts

D. 12 volts

Element 2 Technician Class

Study for next time….



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