Lesson 3: Electronics & Circuits

Preparation for Amateur Radio Technician Class Exam

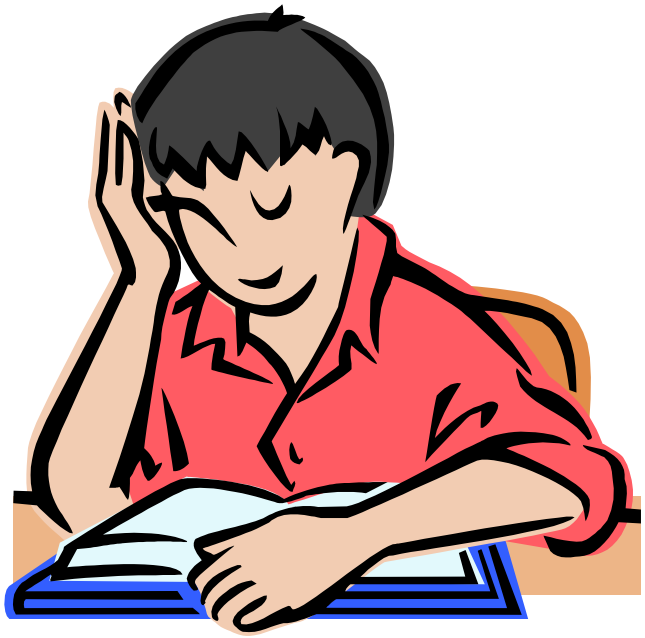
Topics

- Review
- Ohm's Law
- Energy & Power
- Circuits
- Inductors & Inductance
- Capacitors & Capacitance
- Analog vs Digital
- Exam Questions for this section

Reading

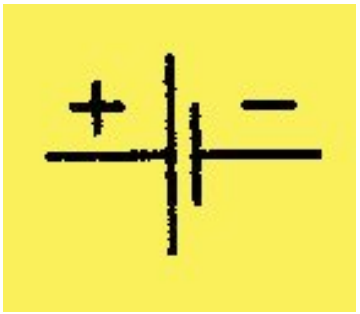
- Chapter 7 – 7.11-7.25

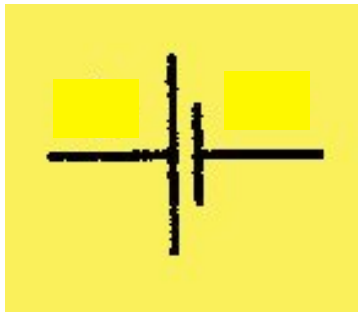
A Quick Review!



Electricity

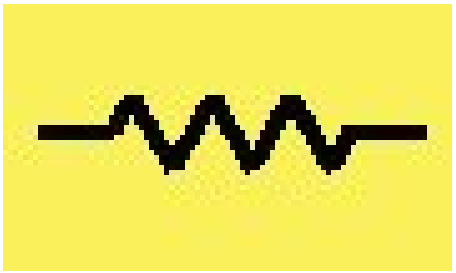
- We can diagram electrical circuits using symbols
- A single cell battery, such as a small hearing aid or watch battery, has this symbol on an electrical diagram:



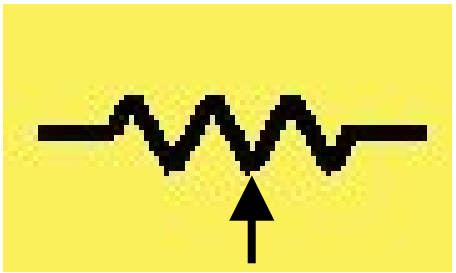


Resistance

- Since a resistor is a part of an electrical circuit, we can diagram it. Here is a fixed and 2 versions of variable resistors:



Fixed

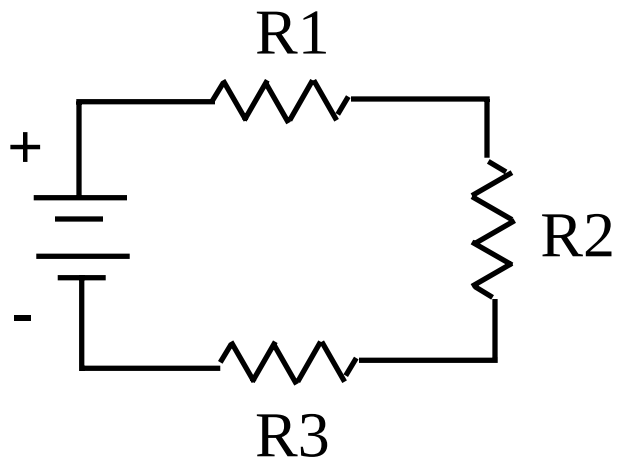


Variable resistors or pots

Series & Parallel Circuits

- Series – the parts are connected in a line and the current flows through each part in turn
- In a series circuit, add all the resistor values together, as if it were one large resister, rather than several smaller ones
- Total resistance is the sum of the values of the resistors:

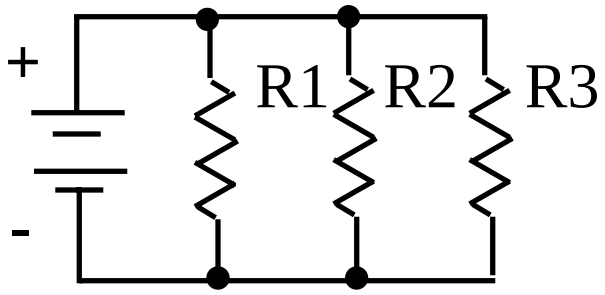
$$R_{total} = R1 + R2 + R3$$



Series & Parallel Circuits

- Parallel – the parts are connected so that current flows through all the parts at the same time
- This reduces the effect of each individual resistor, so the combination appears to have a smaller value
- Total resistance is one over the sum of the inverse of the values of the resistors:

$$R_{total} = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}}$$



Electricity

- We learned that electricity is measured by current, which is the flow of electrons
  - Current is measured in amps
  - Amps are measured with an ammeter or amp meter
- Current or Amps in electricity is analogous to current in a river

Electricity

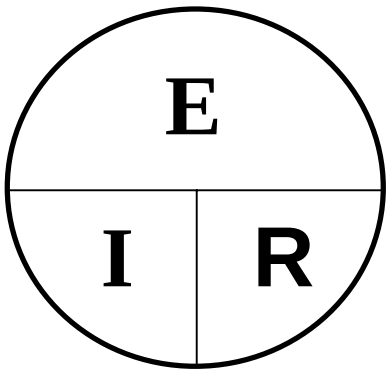
- It takes force to make the electrons move
- This is called the Electromotive force
  - It is measured in volts (V)
  - Volts are measured with a voltmeter
- Force or Volts in electricity is analogous to a waterfall
  - The height of the waterfall determines the force when the water hits the bottom
  - The volts in electricity determine the force pushing the current

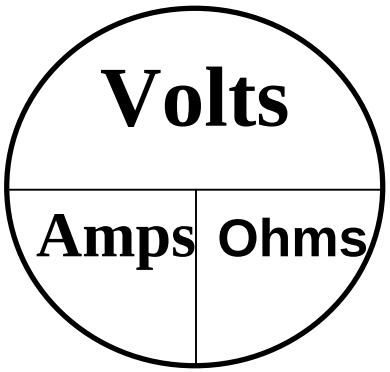
Resistance

- Resistance is what prevents electricity from moving through an electrical circuit
  - Think of water flowing through a pipe
  - The smaller you make the pipe, the more resistance there is to water going through, so the less water goes through
  - Or think of a small pebble stuck in the pipe, preventing some amount of the water from getting through

Ohm's Law

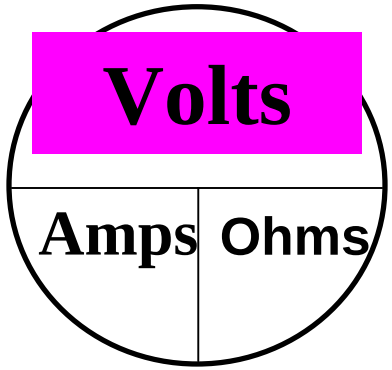
- Ohm's law relates the electrical current to the voltage and resistance
  - E = Electromotive force that is measured in Volts
  - I = Intensité (current) measured in amps
  - R = Resistance measured in Ohms (written Ω)





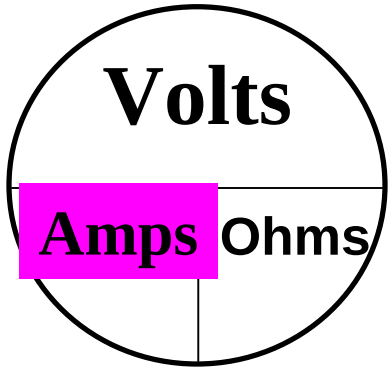
Ohm's Law

- Given current and resistance, you can find force
  - Volts = amps * Ohms
  - If a current of 2 amperes flows through a 50-ohm resistor, what is the voltage across the resistor?
  - 100 Volts = 2 amps * 50 Ω



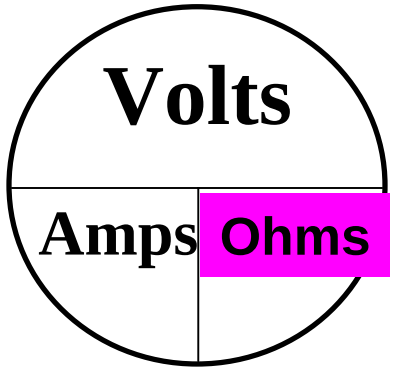
Ohm's Law

- Given resistance and force, you can find current
  - amps = Volts / Ohms
  - If a 100-ohm resistor is connected to 200 volts, what is the current through the resistor?
  - 2 amps = 200 volts / 100 Ω



Ohm's Law

- Given current and force, you can find resistance
  - Ohms = Volts / amps
  - If a current of 3 amperes flows through a resistor connected to 90 volts, what is the resistance?
  - 30 Ω = 90 volts / 3 amps



Energy & Power

- Energy is the ability to do work
- Power is the rate of energy consumption
- We measure electrical power in Watts
- Decibels (dB) are used to compare power levels
  - Note that dB is not an absolute value, but a comparison of two values
  - dB = log (new watts / original watts) * 10
- This can indicate an increase or decrease in power

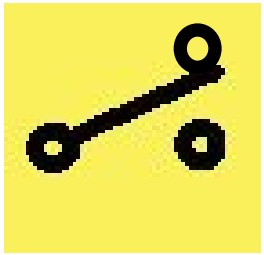
Energy & Power

- Increase your power output from 5 watts to 10 watts – what is the dB change?
  - dB = log (new watts / original watts) * 10
  - dB = log (10 / 5) * 10 = (0.3) * 10 = 3 dB

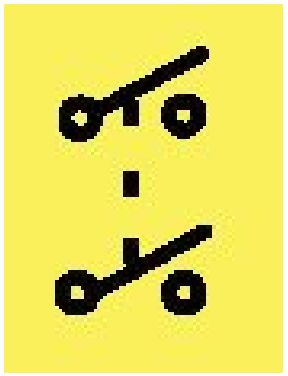
Circuits

- Switch
  - Controls a circuit
  - A switch is open or closed (off or on)
- There are several kinds of switches, each with their own symbol

Single-pole, double-throw

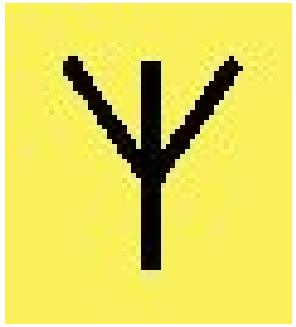


Double-pole, single-throw



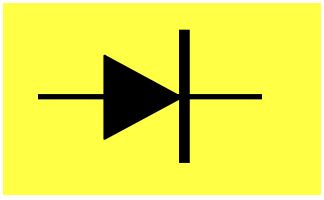
Circuits

- Antenna
  - Moves RF from the air to the receiver and from the transmitter to the air
- This is the symbol for an antenna:



Circuits

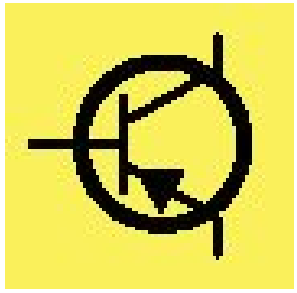
- Diodes
  - Allow current to flow in only one direction through the circuit
  - Can be used to change an alternating current signal into a varying direct current signal – called rectifying the signal, so sometimes a diode is called a rectifier
- This is the symbol for a diode:



Circuits

- Transistor
  - Amplifies a small signal
  - Uses low voltage
    - By contrast a vacuum tube amplifies a small signal, but uses high voltage to do so
  - Come in two main types : PNP, NPN
- The symbols for transistors are:

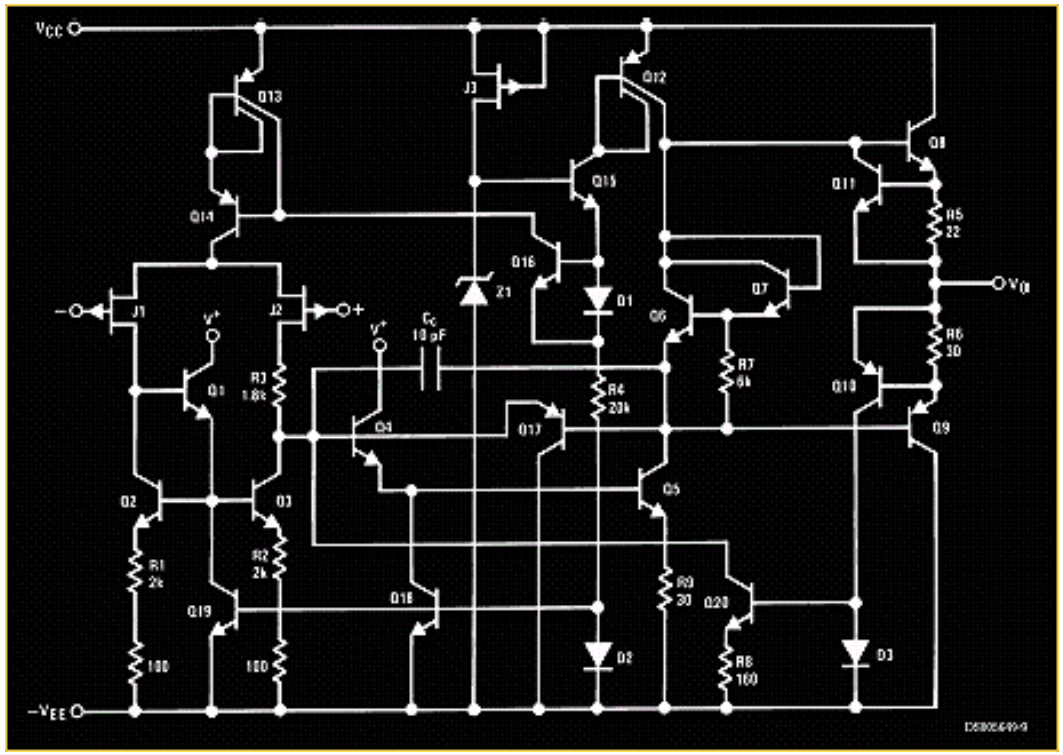
PNP
Points in proudly



NPN
Not pointing in

Circuits

- Integrated Circuits
  - Combine several circuit functions in one package

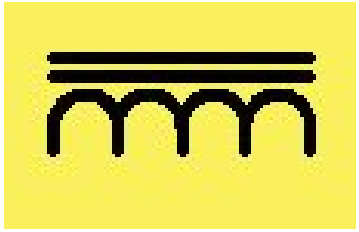


Inductors & Inductance

- Inductor
  - Stores energy in an electro-magnetic field
    - The flow of electricity through a wire creates a magnetic field around the wire
    - An inductor is a coil of wire that has a magnetic field when electricity is applied to it
    - Some also have an iron or ferrite core
  - An inductor resists changes in current, evening out the flow of electricity through the circuit
  - Inductance is measured in Henry's

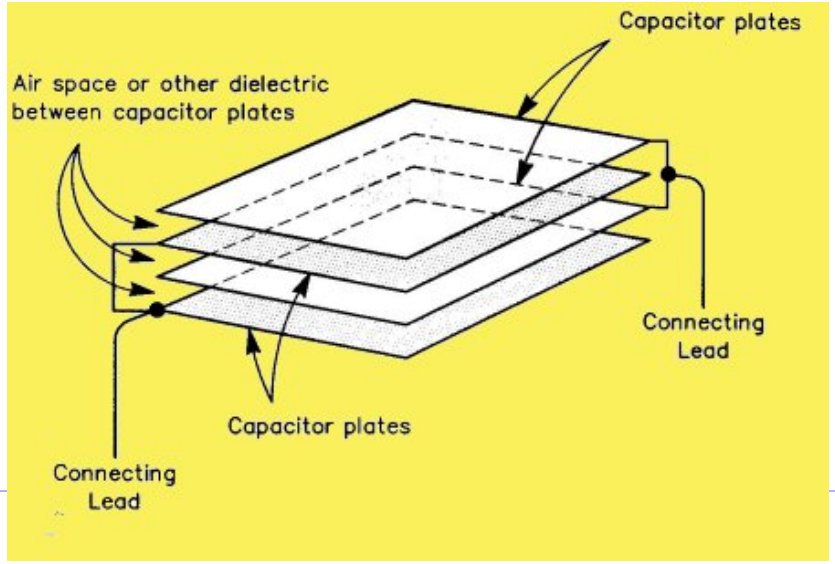
Inductors & Inductance

- Inductors can have fixed or variable values, an air core, iron core, or other kind of core
- The symbol for a fixed value iron core inductor is this:



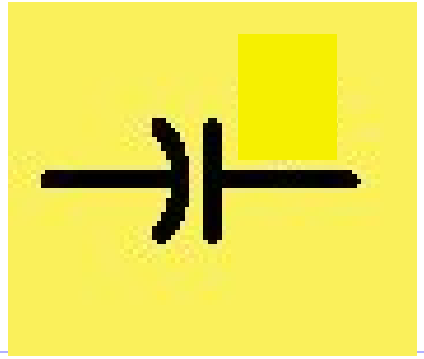
Capacitors & Capacitance

- Capacitor
  - Blocks the flow of direct current, but allows alternating current to pass
  - Stores energy in an electrostatic field and opposes a change in voltage
  - Capacitance is measured in farads



Capacitors & Capacitance

- Capacitor
  - Some capacitors have fixed values, others are variable
    - Variable capacitors are: two sets of rotating conducting plates separated by an insulator, which can be varied in surface area exposed to each other
- The symbol for a fixed value capacitor is:



Capacitors & Capacitance

- Capacitors can be connected in series or parallel, in the same way that resistors can be connected in series or parallel
  - When ***resistors*** are connected in ***series***, we sum their values
  - When ***capacitors*** are connected in ***parallel***, we sum their values
    - So 2 equal valued capacitors connected in parallel have twice the capacitance of one

Analog vs Digital

- Analog signals have voltage or current values that vary continuously over some range
- Examples of analog communication signals include:
  - FM voice
  - SSB voice
  - SSTV
  - ATV

Analog vs Digital

- Digital signals have voltage or current in specified steps over some range
  - Typically only two steps, on and off
- Examples of digital signals include:
  - RTTY
  - Packet
  - Morse code

Exam Questions

- The following slides contain questions from the exam pool that are covered in this section of the notes

T7A12

- T7A12 What formula shows how voltage, current and resistance relate to each other in an electric circuit?
  - A. Ohm's Law
  - B. Kirchhoff's Law
  - C. Ampere's Law
  - D. Tesla's Law

T7A13

- T7A13 If a current of 2 amperes flows through a 50-ohm resistor, what is the voltage across the resistor?
  - A. 25 volts
  - B. 52 volts
  - C. 100 volts
  - D. 200 volts

T7A14

- T7A14 If a 100-ohm resistor is connected to 200 volts, what is the current through the resistor?
  - A. 1 ampere
  - B. 2 amperes
  - C. 300 amperes
  - D. 20,000 amperes

T7A15

- T7A15 If a current of 3 amperes flows through a resistor connected to 90 volts, what is the resistance?
  - A. 3 ohms
  - B. 30 ohms
  - C. 93 ohms
  - D. 270 ohms

T7A04

- T7A04 What is the basic unit of electrical power?
  - A. The ohm
  - B. The watt
  - C. The volt
  - D. The ampere

T7A16

- T7A16 If you increase your transmitter output power from 5 watts to 10 watts, what decibel (dB) increase does that represent?
  - A. 2 dB
  - B. 3 dB
  - C. 5 dB
  - D. 10 dB

T7A11

- T7A11 Which of the following circuits changes an alternating current signal into a varying direct current signal?
  - A. Transformer
  - B. Rectifier
  - C. Amplifier
  - D. Director

T7B10

- T7B10 Which component can amplify a small signal using low voltages?
  - A. A PNP transistor
  - B. A variable resistor
  - C. An electrolytic capacitor
  - D. A multiple-cell battery

T7B11

- T7B11 Which component can amplify a small signal but normally uses high voltages?
  - A. A transistor
  - B. An electrolytic capacitor
  - C. A vacuum tube
  - D. A multiple-cell battery

T7C09

- T7C09 What component controls current to flow in one direction only?
  - A. A fixed resistor
  - B. A signal generator
  - C. A diode
  - D. A fuse

T7C10

- T7C10 What is one advantage of using ICs (integrated circuits) instead of vacuum tubes in a circuit?
  - A. ICs usually combine several functions into one package
  - B. ICs can handle high-power input signals
  - C. ICs can handle much higher voltages
  - D. ICs can handle much higher temperatures

T7C14

- T7C14 In Figure T7-1, which symbol represents an NPN transistor?
  - A. Symbol 2
  - B. Symbol 4
  - C. Symbol 10
  - D. Symbol 12

T7C16

- T7C16 In Figure T7-1, which symbol represents an antenna?
  - A. Symbol 5
  - B. Symbol 7
  - C. Symbol 8
  - D. Symbol 14

T7C18

- T7C18 In Figure T7-2, which symbol represents a single-pole, double-throw switch?
  - A. Symbol 1
  - B. Symbol 2
  - C. Symbol 3
  - D. Symbol 4

T7C19

- T7C19 In Figure T7-2, which symbol represents a double-pole, single-throw switch?
  - A. Symbol 1
  - B. Symbol 2
  - C. Symbol 3
  - D. Symbol 4

T7A09

- T7A09 What is the basic unit of inductance?
  - A. The coulomb
  - B. The farad
  - C. The henry
  - D. The ohm

T7C08

- T7C08 What does an inductor do?
  - A. It stores energy electrostatically and opposes a change in voltage
  - B. It stores energy electrochemically and opposes a change in current
  - C. It stores energy electromagnetically and opposes a change in current
  - D. It stores energy electromechanically and opposes a change in voltage

T7C17

- T7C17 In Figure T7-1, which symbol represents a fixed-value iron-core inductor?
  - A. Symbol 6
  - B. Symbol 9
  - C. Symbol 11
  - D. Symbol 12

T7A10

- T7A10 What is the basic unit of capacitance?
  - A. The farad
  - B. The ohm
  - C. The volt
  - D. The henry

T7C04

- T7C04 What is one reason capacitors are used in electronic circuits?
  - A. To block the flow of direct current while allowing alternating current to pass
  - B. To block the flow of alternating current while allowing direct current to pass
  - C. To change the time constant of the applied voltage
  - D. To change alternating current to direct current

T7C05

- T7C05 If two equal-value capacitors are connected in parallel, what is their total capacitance?
  - A. Twice the value of one capacitor
  - B. Half the value of one capacitor
  - C. The same as the value of either capacitor
  - D. The value of one capacitor times the value of the other

T7C06

- T7C06 What does a capacitor do?
  - A. It stores energy electrochemically and opposes a change in current
  - B. It stores energy electrostatically and opposes a change in voltage
  - C. It stores energy electromagnetically and opposes a change in current
  - D. It stores energy electromechanically and opposes a change in voltage

T7C07

- T7C07 Which of the following best describes a variable capacitor?
  - A. A set of fixed capacitors whose connections can be varied
  - B. Two sets of insulating plates separated by a conductor, which can be varied in distance from each other
  - C. A set of capacitors connected in a series-parallel circuit
  - D. Two sets of rotating conducting plates separated by an insulator, which can be varied in surface area exposed to each other

T7C15

- T7C15 Which symbol of Figure T7-1 represents a fixed-value capacitor?
  - A. Symbol 1
  - B. Symbol 3
  - C. Symbol 5
  - D. Symbol 13

T7B01

- T7B01 What type of electric circuit uses signals that can vary continuously over a certain range of voltage or current values?
  - A. An analog circuit
  - B. A digital circuit
  - C. A continuous circuit
  - D. A pulsed modulator circuit

T7B02

- T7B02 What type of electric circuit uses signals that have voltage or current values only in specific steps over a certain range?
  - A. An analog circuit
  - B. A digital circuit
  - C. A step modulator circuit
  - D. None of these choices is correct

T7B03

- T7B03 Which of the following is an example of an analog communications method?
  - A. Morse code (CW)
  - B. Packet Radio
  - C. Frequency-modulated (FM) voice
  - D. PSK31

T7B04

- T7B04 Which of the following is an example of a digital communications method?
  - A. Single-sideband (SSB) voice
  - B. Amateur Television (ATV)
  - C. FM voice
  - D. Radioteletype (RTTY)