

## 2016 – 2020 Amateur Extra Question Pool Study Guide

Arranged by Jim Gallacher

### Subelement E1 - Commission's Rules

Group E1A - Operating Standards: frequency privileges; emission standards; automatic message forwarding; frequency sharing; stations aboard ships or aircraft

E1A01: When using a transceiver that displays the carrier frequency of phone signals, which of the following displayed frequencies represents the highest frequency at which a properly adjusted USB emission will be totally within the band?

#### **3 kHz below the upper band edge**

E1A02: When using a transceiver that displays the carrier frequency of phone signals, which of the following displayed frequencies represents the lowest frequency at which a properly adjusted LSB emission will be totally within the band?

#### **3 kHz above the lower band edge**

E1A03: With your transceiver displaying the carrier frequency of phone signals, you hear a station calling CQ on 14.349 MHz USB. Is it legal to return the call using upper sideband on the same frequency?

#### **No, the sideband will extend beyond the band edge**

E1A04: With your transceiver displaying the carrier frequency of phone signals, you hear a DX station calling CQ on 3.601 MHz LSB. Is it legal to return the call using lower sideband on the same frequency?

#### **No, the sideband will extend beyond the edge of the phone band segment**

E1A05: What is the maximum power output permitted on the 60 meter band?

#### **100 watts PEP effective radiated power relative to the gain of a half-wave dipole**

E1A06: Where must the carrier frequency of a CW signal be set to comply with FCC rules for 60 meter operation?

#### **At the center frequency of the channel**

E1A07: Which amateur band requires transmission on specific channels rather than on a range of frequencies?

#### **60 meter band**

E1A08: If a station in a message forwarding system inadvertently forwards a message that is in violation of FCC rules, who is primarily accountable for the rules violation?

#### **The control operator of the originating station**

E1A09: What is the first action you should take if your digital message forwarding station inadvertently forwards a communication that violates FCC rules?

#### **Discontinue forwarding the communication as soon as you become aware of it**

E1A10: If an amateur station is installed aboard a ship or aircraft, what condition must be met before the station is operated?

#### **Its operation must be approved by the master of the ship or the pilot in command of the aircraft**

E1A11: Which of the following describes authorization or licensing required when operating an amateur station aboard a U.S.-registered vessel in international waters?

#### **Any FCC-issued amateur license**

E1A12: With your transceiver displaying the carrier frequency of CW signals, you hear a DX station's CQ on 3.500 MHz. Is it legal to return the call using CW on the same frequency?

#### **No, one of the sidebands of the CW signal will be out of the band**

E1A13: Who must be in physical control of the station apparatus of an amateur station aboard any vessel or craft that is documented or registered in the United States?

#### **Any person holding an FCC issued amateur license or who is authorized for alien reciprocal operation**

E1A14: What is the maximum bandwidth for a data emission on 60 meters?

#### **2.8 kHz**

Group E1B - Station restrictions and special operations: restrictions on station location; general operating restrictions, spurious emissions, control operator reimbursement; antenna structure restrictions; RACES operations

E1B01: Which of the following constitutes a spurious emission?

#### **An emission outside its necessary bandwidth that can be reduced or eliminated without affecting the information transmitted**

E1B02: Which of the following factors might cause the physical location of an amateur station apparatus or antenna structure to be restricted?

#### **The location is of environmental importance or significant in American history, architecture, or culture**

E1B03: Within what distance must an amateur station protect an FCC monitoring facility from harmful interference?

#### **1 mile**

E1B04: What must be done before placing an amateur station within an officially designated wilderness area or wildlife preserve, or an area listed in the National Register of Historical Places?

#### **An Environmental Assessment must be submitted to the FCC**

E1B05: What is the National Radio Quiet Zone?

**An area surrounding the National Radio Astronomy Observatory**

E1B06: Which of the following additional rules apply if you are installing an amateur station antenna at a site at or near a public use airport?

**You may have to notify the Federal Aviation Administration and register it with the FCC as required by Part 17 of FCC rules**

E1B07: What is the highest modulation index permitted at the highest modulation frequency for angle modulation below 29.0 MHz?

**1.0**

E1B08: What limitations may the FCC place on an amateur station if its signal causes interference to domestic broadcast reception, assuming that the receivers involved are of good engineering design?

**The amateur station must avoid transmitting during certain hours on frequencies that cause the interference**

E1B09: Which amateur stations may be operated under RACES rules?

**Any FCC-licensed amateur station certified by the responsible civil defense organization for the area served**

E1B10: What frequencies are authorized to an amateur station operating under RACES rules?

**All amateur service frequencies authorized to the control operator**

E1B11: What is the permitted mean power of any spurious emission relative to the mean power of the fundamental emission from a station transmitter or external RF amplifier installed after January 1, 2003 and transmitting on a frequency below 30 MHz?

**At least 43 dB below**

Group E1C - Station control: definitions and restrictions pertaining to local, automatic and remote control operation; control operator responsibilities for remote and automatically controlled stations

E1C01: What is a remotely controlled station?

**A station controlled indirectly through a control link**

E1C02: What is meant by automatic control of a station?

**The use of devices and procedures for control so that the control operator does not have to be present at a control point**

E1C03: How do the control operator responsibilities of a station under automatic control differ from one under local control?

**Under automatic control the control operator is not required to be present at the control point**

E1C04: What is meant by IARP?

**An international amateur radio permit that allows U.S. amateurs to operate in certain countries of the Americas**

E1C05: When may an automatically controlled station originate third party communications?

**Never**

E1C06: Which of the following statements concerning remotely controlled amateur stations is true?

**A control operator must be present at the control point**

E1C07: What is meant by local control?

**Direct manipulation of the transmitter by a control operator**

E1C08: What is the maximum permissible duration of a remotely controlled station's transmissions if its control link malfunctions?

**3 minutes**

E1C09: Which of these ranges of frequencies is available for an automatically controlled repeater operating below 30 MHz?

**29.500 MHz - 29.700 MHz**

E1C10: What types of amateur stations may automatically retransmit the radio signals of other amateur stations?

**Only auxiliary, repeater or space stations**

E1C11: Which of the following operating arrangements allows an FCC-licensed U.S. citizen to operate in many European countries, and alien amateurs from many European countries to operate in the U.S.?

**CEPT agreement**

E1C12: What types of communications may be transmitted to amateur stations in foreign countries?

**Communications incidental to the purpose of the amateur service and remarks of a personal nature**

E1C13: Which of the following is required in order to operate in accordance with CEPT rules in foreign countries where permitted?

**You must bring a copy of FCC Public Notice DA 11-221**

Group E1D - Amateur Satellite service: definitions and purpose; license requirements for space stations; available frequencies and bands; telecommand and telemetry operations; restrictions, and special provisions; notification requirements

E1D01: What is the definition of the term telemetry?

**One-way transmission of measurements at a distance from the measuring instrument**

E1D02: What is the amateur satellite service?

**A radio communications service using amateur radio stations on satellites**

E1D03: What is a telecommand station in the amateur satellite service?

**An amateur station that transmits communications to initiate, modify or terminate functions of a space station**

E1D04: What is an Earth station in the amateur satellite service?

**An amateur station within 50 km of the Earth's surface intended for communications with amateur stations by means of objects in space**

E1D05: What class of licensee is authorized to be the control operator of a space station?

**Any class with appropriate operator privileges**

E1D06: Which of the following is a requirement of a space station?

**The space station must be capable of terminating transmissions by telecommand when directed by the FCC**

E1D07: Which amateur service HF bands have frequencies authorized for space stations?

**Only the 40 m, 20 m, 17 m, 15 m, 12 m and 10 m bands**

E1D08: Which VHF amateur service bands have frequencies available for space stations?

**2 meters**

E1D09: Which UHF amateur service bands have frequencies available for a space station?

**70 cm and 13 cm**

E1D10: Which amateur stations are eligible to be telecommand stations?

**Any amateur station so designated by the space station licensee, subject to the privileges of the class of operator license held by the control operator**

E1D11: Which amateur stations are eligible to operate as Earth stations?

**Any amateur station, subject to the privileges of the class of operator license held by the control operator**

Group E1E - Volunteer examiner program: definitions, qualifications, preparation and administration of exams; accreditation; question pools; documentation requirements

E1E01: What is the minimum number of qualified VEs required to administer an Element 4 amateur operator license examination?

**3**

E1E02: Where are the questions for all written U.S. amateur license examinations listed?

**In a question pool maintained by all the VECs**

E1E03: What is a Volunteer Examiner Coordinator?

**An organization that has entered into an agreement with the FCC to coordinate amateur operator license examinations**

E1E04: Which of the following best describes the Volunteer Examiner accreditation process?

**The procedure by which a VEC confirms that the VE applicant meets FCC requirements to serve as an examiner**

E1E05: What is the minimum passing score on amateur operator license examinations?

**Minimum passing score of 74%**

E1E06: Who is responsible for the proper conduct and necessary supervision during an amateur operator license examination session?

**Each administering VE**

E1E07: What should a VE do if a candidate fails to comply with the examiner's instructions during an amateur operator license examination?

**Immediately terminate the candidate's examination**

E1E08: To which of the following examinees may a VE not administer an examination?

**Relatives of the VE as listed in the FCC rules**

E1E09: What may be the penalty for a VE who fraudulently administers or certifies an examination?

**Revocation of the VE's amateur station license grant and the suspension of the VE's amateur operator license grant**

E1E10: What must the administering VEs do after the administration of a successful examination for an amateur operator license?

**They must submit the application document to the coordinating VEC according to the coordinating VEC instructions**

E1E11: What must the VE team do if an examinee scores a passing grade on all examination elements needed for an upgrade or new license?

**Three VEs must certify that the examinee is qualified for the license grant and that they have complied with the administering VE requirements**

E1E12: What must the VE team do with the application form if the examinee does not pass the exam?

**Return the application document to the examinee**

E1E13: Which of these choices is an acceptable method for monitoring the applicants if a VEC opts to conduct an exam session remotely?

**Use a real-time video link and the Internet to connect the exam session to the observing VEs**

E1E14: For which types of out-of-pocket expenses do the Part 97 rules state that VEs and VECs may be reimbursed?

**Preparing, processing, administering and coordinating an examination for an amateur radio license**

Group E1F - Miscellaneous rules: external RF power amplifiers; national quiet zone; business communications; compensated communications; spread spectrum; auxiliary stations; reciprocal operating privileges; IARP and CEPT licenses; third party communications with for

E1F01: On what frequencies are spread spectrum transmissions permitted?

**Only on amateur frequencies above 222 MHz**

E1F02: What privileges are authorized in the U.S. to persons holding an amateur service license granted by the Government of Canada?

**The operating terms and conditions of the Canadian amateur service license, not to exceed U.S. Extra Class privileges**

E1F03: Under what circumstances may a dealer sell an external RF power amplifier capable of operation below 144 MHz if it has not been granted FCC certification?

**It was purchased in used condition from an amateur operator and is sold to another amateur operator for use at that operator's station**

E1F04: Which of the following geographic descriptions approximately describes "Line A"?

**A line roughly parallel to and south of the U.S.-Canadian border**

E1F05: Amateur stations may not transmit in which of the following frequency segments if they are located in the contiguous 48 states and north of Line A?

**420 MHz - 430 MHz**

E1F06: Under what circumstances might the FCC issue a Special Temporary Authority (STA) to an amateur station?

**To provide for experimental amateur communications**

E1F07: When may an amateur station send a message to a business?

**When neither the amateur nor his or her employer has a pecuniary interest in the communications**

E1F08: Which of the following types of amateur station communications are prohibited?

**Communications transmitted for hire or material compensation, except as otherwise provided in the rules**

E1F09: Which of the following conditions apply when transmitting spread spectrum emission?

**All of these choices are correct**

A station transmitting SS emission must not cause harmful interference to other stations employing other authorized emissions

The transmitting station must be in an area regulated by the FCC or in a country that permits SS emission

The transmission must not be used to obscure the meaning of any communication

E1F10: What is the maximum permitted transmitter peak envelope power for an amateur station transmitting spread spectrum communications?

**10 W**

E1F11: Which of the following best describes one of the standards that must be met by an external RF power amplifier if it is to qualify for a grant of FCC certification?

**It must satisfy the FCC's spurious emission standards when operated at the lesser of 1500 watts or its full output power**

E1F12: Who may be the control operator of an auxiliary station?

**Only Technician, General, Advanced or Amateur Extra Class operators**

Subelement E2 - Operating Procedures

Group E2A - Amateur radio in space: amateur satellites; orbital mechanics; frequencies and modes; satellite hardware; satellite operations

E2A01: What is the direction of an ascending pass for an amateur satellite?

**From south to north**

E2A02: What is the direction of a descending pass for an amateur satellite?

**From north to south**

E2A03: What is the orbital period of an Earth satellite?

**The time it takes for a satellite to complete one revolution around the Earth**

E2A04: What is meant by the term mode as applied to an amateur radio satellite?

**The satellite's uplink and downlink frequency bands**

E2A05: What do the letters in a satellite's mode designator specify?

**The uplink and downlink frequency ranges**

E2A06: On what band would a satellite receive signals if it were operating in mode U/V?

**435 MHz - 438 MHz**

E2A07: Which of the following types of signals can be relayed through a linear transponder?

**All of these choices are correct**

FM and CW

SSB and SSTV

PSK and Packet

E2A08: Why should effective radiated power to a satellite which uses a linear transponder be limited?

**To avoid reducing the downlink power to all other users**

E2A09: What do the terms L band and S band specify with regard to satellite communications?

**The 23 centimeter and 13 centimeter bands**

E2A10: Why may the received signal from an amateur satellite exhibit a rapidly repeating fading effect?

**Because the satellite is spinning**

E2A11: What type of antenna can be used to minimize the effects of spin modulation and Faraday rotation?

**A circularly polarized antenna**

E2A12: What is one way to predict the location of a satellite at a given time?

**By calculations using the Keplerian elements for the specified satellite**

E2A13: What type of satellite appears to stay in one position in the sky?

**Geostationary**

E2A14: What technology is used to track, in real time, balloons carrying amateur radio transmitters?

**APRS**

Group E2B - Television practices: fast scan television standards and techniques; slow scan television standards and techniques

E2B01: How many times per second is a new frame transmitted in a fast-scan (NTSC) television system?

**30**

E2B02: How many horizontal lines make up a fast-scan (NTSC) television frame?

**525**

E2B03: How is an interlaced scanning pattern generated in a fast-scan (NTSC) television system?

**By scanning odd numbered lines in one field and even numbered lines in the next**

E2B04: What is blanking in a video signal?

**Turning off the scanning beam while it is traveling from right to left or from bottom to top**

E2B05: Which of the following is an advantage of using vestigial sideband for standard fast-scan TV transmissions?

**Vestigial sideband reduces bandwidth while allowing for simple video detector circuitry**

E2B06: What is vestigial sideband modulation?

**Amplitude modulation in which one complete sideband and a portion of the other are transmitted**

E2B07: What is the name of the signal component that carries color information in NTSC video?

**Chroma**

E2B08: Which of the following is a common method of transmitting accompanying audio with amateur fast-scan television?

**All of these choices are correct**

Frequency-modulated sub-carrier

A separate VHF or UHF audio link

Frequency modulation of the video carrier

E2B09: What hardware, other than a receiver with SSB capability and a suitable computer, is needed to decode SSTV using Digital Radio Mondiale (DRM)?

**No other hardware is needed**

E2B10: Which of the following is an acceptable bandwidth for Digital Radio Mondiale (DRM) based voice or SSTV digital transmissions made on the HF amateur bands?

**3 KHz**

E2B11: What is the function of the Vertical Interval Signaling (VIS) code sent as part of an SSTV transmission?

**To identify the SSTV mode being used**

E2B12: How are analog SSTV images typically transmitted on the HF bands?

**Varying tone frequencies representing the video are transmitted using single sideband**

E2B13: How many lines are commonly used in each frame of an amateur slow-scan color television picture?

**128 or 256**

E2B14: What aspect of an amateur slow-scan television signal encodes the brightness of the picture?

**Tone frequency**

E2B15: What signals SSTV receiving equipment to begin a new picture line?

**Specific tone frequencies**

E2B16: Which is a video standard used by North American Fast Scan ATV stations?

**NTSC**

E2B17: What is the approximate bandwidth of a slow-scan TV signal?

**3 kHz**

E2B18: On which of the following frequencies is one likely to find FM ATV transmissions?

**1255 MHz**

E2B19: What special operating frequency restrictions are imposed on slow scan TV transmissions?

**They are restricted to phone band segments and their bandwidth can be no greater than that of a voice signal of the same modulation type**

Group E2C - Operating methods: contest and DX operating; spread-spectrum transmissions; selecting an operating frequency

E2C01: Which of the following is true about contest operating?

**Operators are permitted to make contacts even if they do not submit a log**

E2C02: Which of the following best describes the term self-spotting in regards to HF contest operating?

**The generally prohibited practice of posting one's own call sign and frequency on a spotting network**

E2C03: From which of the following bands is amateur radio contesting generally excluded?

**30 m**

E2C04: What type of transmission is most often used for a ham radio mesh network?

**Spread spectrum in the 2.4 GHz band**

E2C05: What is the function of a DX QSL Manager?

**To handle the receiving and sending of confirmation cards for a DX station**

E2C06: During a VHF/UHF contest, in which band segment would you expect to find the highest level of activity?

**In the weak signal segment of the band, with most of the activity near the calling frequency**

E2C07: What is the Cabrillo format?

**A standard for submission of electronic contest logs**

E2C08: Which of the following contacts may be confirmed through the U.S. QSL bureau system?

**Contacts between a U.S. station and a non-U.S. station**

E2C09: What type of equipment is commonly used to implement a ham radio mesh network?

**A standard wireless router running custom software**

E2C10: Why might a DX station state that they are listening on another frequency?

**All of these choices are correct**

Because the DX station may be transmitting on a frequency that is prohibited to some responding stations

To separate the calling stations from the DX station  
To improve operating efficiency by reducing interference

E2C11: How should you generally identify your station when attempting to contact a DX station during a contest or in a pileup?

**Send your full call sign once or twice**

E2C12: What might help to restore contact when DX signals become too weak to copy across an entire HF band a few hours after sunset?

**Switch to a lower frequency HF band**

E2C13: What indicator is required to be used by U.S.-licensed operators when operating a station via remote control where the transmitter is located in the U.S.?

**No additional indicator is required**

Group E2D - Operating methods: VHF and UHF digital modes; APRS

E2D01: Which of the following digital modes is especially designed for use for meteor scatter signals?

**FSK441**

E2D02: Which of the following is a good technique for making meteor scatter contacts?

**All of these choices are correct**

15 second timed transmission sequences with stations alternating based on location

Use of high speed CW or digital modes

Short transmission with rapidly repeated call signs and signal reports

E2D03: Which of the following digital modes is especially useful for EME communications?

**JT65**

E2D04: What is the purpose of digital store-and-forward functions on an Amateur Radio satellite?

**To store digital messages in the satellite for later download by other stations**

E2D05: Which of the following techniques is normally used by low Earth orbiting digital satellites to relay messages around the world?

**Store-and-forward**

E2D06: Which of the following describes a method of establishing EME contacts?

**Time synchronous transmissions alternately from each station**

E2D07: What digital protocol is used by APRS?

**AX.25**

E2D08: What type of packet frame is used to transmit APRS beacon data?

**Unnumbered Information**

E2D09: Which of these digital modes has the fastest data throughput under clear communication conditions?

**300 baud packet**

E2D10: How can an APRS station be used to help support a public service communications activity?

**An APRS station with a GPS unit can automatically transmit information to show a mobile station's position during the event**

E2D11: Which of the following data are used by the APRS network to communicate your location?

**Latitude and longitude**

E2D12: How does JT65 improve EME communications?

**It can decode signals many dB below the noise floor using FEC**

E2D13: What type of modulation is used for JT65 contacts?

**Multi-tone AFSK**

E2D14: What is one advantage of using JT65 coding?

**The ability to decode signals which have a very low signal to noise ratio**

Group E2E - Operating methods: operating HF digital modes; error correction

E2E01: Which type of modulation is common for data emissions below 30 MHz?

**FSK**

E2E02: What do the letters FEC mean as they relate to digital operation?

**Forward Error Correction**

E2E03: How is the timing of JT65 contacts organized?

**Alternating transmissions at 1 minute intervals**

E2E04: What is indicated when one of the ellipses in an FSK crossed-ellipse display suddenly disappears?

**Selective fading has occurred**

E2E05: Which type of digital mode does not support keyboard-to-keyboard operation?

**Winlink**

E2E06: What is the most common data rate used for HF packet?

**300 baud**

E2E07: What is the typical bandwidth of a properly modulated MFSK16 signal?

**316 Hz**

E2E08: Which of the following HF digital modes can be used to transfer binary files?

**PACTOR**

E2E09: Which of the following HF digital modes uses variable-length coding for bandwidth efficiency?

**PSK31**

E2E10: Which of these digital modes has the narrowest bandwidth?

**PSK31**

E2E11: What is the difference between direct FSK and audio FSK?

**Direct FSK applies the data signal to the transmitter VFO**

E2E12: Which type of control is used by stations using the Automatic Link Enable (ALE) protocol?

**Automatic**

E2E13: Which of the following is a possible reason that attempts to initiate contact with a digital station on a clear frequency are unsuccessful?

**All of these choices are correct**

Your transmit frequency is incorrect

The protocol version you are using is not the supported by the digital station

Another station you are unable to hear is using the frequency

Subelement E3 - Radio Wave Propagation  
Group E3A - Propagation and technique, Earth-Moon-Earth communications; meteor scatter

E3A01: What is the approximate maximum separation measured along the surface of the Earth between two stations communicating by Moon bounce?

**12,000 miles, if the Moon is visible by both stations**

E3A02: What characterizes libration fading of an EME signal?

**A fluttery irregular fading**

E3A03: When scheduling EME contacts, which of these conditions will generally result in the least path loss?

**When the Moon is at perigee**

E3A04: What do Hepburn maps predict?

**Probability of tropospheric propagation**

E3A05: Tropospheric propagation of microwave signals often occurs along what weather related structure?

**Warm and cold fronts**

E3A06: Which of the following is required for microwave propagation via rain scatter?

**The rain must be within radio range of both stations**

E3A07: Atmospheric ducts capable of propagating microwave signals often form over what geographic feature?

**Bodies of water**

E3A08: When a meteor strikes the Earth's atmosphere, a cylindrical region of free electrons is formed at what layer of the ionosphere?

**The E layer**

E3A09: Which of the following frequency range is most suited for meteor scatter communications?

**28 MHz - 148 MHz**

E3A10: Which type of atmospheric structure can create a path for microwave propagation?

**Temperature inversion**

E3A11: What is a typical range for tropospheric propagation of microwave signals?

**100 miles to 300 miles**

E3A12: What is the cause of auroral activity?

**The interaction in the E layer of charged particles from the Sun with the Earth's magnetic field**

E3A13: Which emission mode is best for aurora propagation?

**CW**

E3A14: From the contiguous 48 states, in which approximate direction should an antenna be pointed to take maximum advantage of aurora propagation?

**North**

E3A15: What is an electromagnetic wave?

**A wave consisting of an electric field and a magnetic field oscillating at right angles to each other**

E3A16: Which of the following best describes electromagnetic waves traveling in free space?

**Changing electric and magnetic fields propagate the energy**

E3A17: What is meant by circularly polarized electromagnetic waves?

**Waves with a rotating electric field**

Group E3B - Propagation and technique, trans-equatorial; long path; gray-line; multi-path propagation

E3B01: What is transequatorial propagation?  
**Propagation between two mid-latitude points at approximately the same distance north and south of the magnetic equator**

E3B02: What is the approximate maximum range for signals using transequatorial propagation?  
**5000 miles**

E3B03: What is the best time of day for transequatorial propagation?

**Afternoon or early evening**

E3B04: What is meant by the terms extraordinary and ordinary waves?

**Independent waves created in the ionosphere that are elliptically polarized**

E3B05: Which amateur bands typically support long-path propagation?

**160 meters to 10 meters**

E3B06: Which of the following amateur bands most frequently provides long-path propagation?

**20 meters**

E3B07: Which of the following could account for hearing an echo on the received signal of a distant station?

**Receipt of a signal by more than one path**

E3B08: What type of HF propagation is probably occurring if radio signals travel along the terminator between daylight and darkness?

**Gray-line**

E3B09: At what time of year is Sporadic E propagation most likely to occur?

**Around the solstices, especially the summer solstice**

E3B10: What is the cause of gray-line propagation?

**At twilight and sunrise, D-layer absorption is low while E-layer and F-layer propagation remains high**

E3B11: At what time of day is Sporadic-E propagation most likely to occur?

**Any time**

E3B12: What is the primary characteristic of chordal hop propagation?

**Successive ionospheric reflections without an intermediate reflection from the ground**

E3B13: Why is chordal hop propagation desirable?

**The signal experiences less loss along the path compared to normal skip propagation**

E3B14: What happens to linearly polarized radio waves that split into ordinary and extraordinary waves in the ionosphere?

**They become elliptically polarized**

Group E3C - Propagation and technique, Aurora propagation; selective fading; radio-path horizon; take-off angle over flat or sloping terrain; effects of ground on propagation; less common propagation modes

E3C01: What does the term ray tracing describe in regard to radio communications?

**Modeling a radio wave's path through the ionosphere**

E3C02: What is indicated by a rising A or K index?

**Increasing disruption of the geomagnetic field**

E3C03: Which of the following signal paths is most likely to experience high levels of absorption when the A index or K index is elevated?

**Polar paths**

E3C04: What does the value of B<sub>z</sub> (B sub Z) represent?

**Direction and strength of the interplanetary magnetic field**

E3C05: What orientation of B<sub>z</sub> (B sub z) increases the likelihood that incoming particles from the Sun will cause disturbed conditions?

**Southward**

E3C06: By how much does the VHF/UHF radio horizon distance exceed the geometric horizon?

**By approximately 15 percent of the distance**

E3C07: Which of the following descriptors indicates the greatest solar flare intensity?

**Class X**

E3C08: What does the space weather term G5 mean?

**An extreme geomagnetic storm**

E3C09: How does the intensity of an X3 flare compare to that of an X2 flare?

**Twice as great**

E3C10: What does the 304A solar parameter measure?

**UV emissions at 304 angstroms, correlated to solar flux index**

E3C11: What does VOACAP software model?

**HF propagation**

E3C12: How does the maximum distance of ground-wave propagation change when the signal frequency is increased?

**It decreases**

E3C13: What type of polarization is best for ground-wave propagation?

**Vertical**

E3C14: Why does the radio-path horizon distance exceed the geometric horizon?

**Downward bending due to density variations in the atmosphere**

E3C15: What might a sudden rise in radio background noise indicate?

**A solar flare has occurred**

Subelement E4 - Amateur Practices

Group E4A - Test equipment: analog and digital instruments; spectrum and network analyzers, antenna analyzers; oscilloscopes; testing transistors; RF measurements

E4A01: Which of the following parameter determines the bandwidth of a digital or computer-based oscilloscope?

**Sampling rate**

E4A02: Which of the following parameters would a spectrum analyzer display on the vertical and horizontal axes?

**RF amplitude and frequency**

E4A03: Which of the following test instrument is used to display spurious signals and/or intermodulation distortion products in an SSB transmitter?

**A spectrum analyzer**

E4A04: What determines the upper frequency limit for a computer soundcard-based oscilloscope program?

**Analog-to-digital conversion speed of the soundcard**

E4A05: What might be an advantage of a digital vs an analog oscilloscope?

**All of these choices are correct**

Automatic amplitude and frequency numerical readout

Storage of traces for future reference

Manipulation of time base after trace capture

E4A06: What is the effect of aliasing in a digital or computer-based oscilloscope?

**False signals are displayed**

E4A07: Which of the following is an advantage of using an antenna analyzer compared to an SWR bridge to measure antenna SWR?

**Antenna analyzers do not need an external RF source**

E4A08: Which of the following instrument would be best for measuring the SWR of a beam antenna?

**An antenna analyzer**

E4A09: When using a computer's soundcard input to digitize signals, what is the highest frequency signal that can be digitized without aliasing?

**One-half the sample rate**

E4A10: Which of the following displays multiple digital signal states simultaneously?

**Logic analyzer**

E4A11: Which of the following is good practice when using an oscilloscope probe?

**Keep the signal ground connection of the probe as short as possible**

E4A12: Which of the following procedures is an important precaution to follow when connecting a spectrum analyzer to a transmitter output?

**Attenuate the transmitter output going to the spectrum analyzer**

E4A13: How is the compensation of an oscilloscope probe typically adjusted?

**A square wave is displayed and the probe is adjusted until the horizontal portions of the displayed wave are as nearly flat as possible**

E4A14: What is the purpose of the prescaler function on a frequency counter?

**It divides a higher frequency signal so a low-frequency counter can display the input frequency**

E4A15: What is an advantage of a period-measuring frequency counter over a direct-count type?

**It provides improved resolution of low-frequency signals within a comparable time period**

Group E4B - Measurement technique and limitations: instrument accuracy and performance limitations; probes; techniques to minimize errors; measurement of "Q"; instrument calibration

E4B01: Which of the following factors most affects the accuracy of a frequency counter?

**Time base accuracy**

E4B02: What is an advantage of using a bridge circuit to measure impedance?

**It is very precise in obtaining a signal null**

E4B03: If a frequency counter with a specified accuracy of +/- 1.0 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?

**146.52 Hz**

E4B04: If a frequency counter with a specified accuracy of +/- 0.1 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?

**14.652 Hz**

E4B05: If a frequency counter with a specified accuracy of +/- 10 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading?

**1465.20 Hz**

E4B06: How much power is being absorbed by the load when a directional power meter connected between a transmitter and a terminating load reads 100 watts forward power and 25 watts reflected power?

**75 watts**

E4B07: What do the subscripts of S parameters represent?

**The port or ports at which measurements are made**

E4B08: Which of the following is a characteristic of a good DC voltmeter?

**High impedance input**

E4B09: What is indicated if the current reading on an RF ammeter placed in series with the antenna feed line of a transmitter increases as the transmitter is tuned to resonance?

**There is more power going into the antenna**

E4B10: Which of the following describes a method to measure intermodulation distortion in an SSB transmitter?

**Modulate the transmitter with two non-harmonically related audio frequencies and observe the RF output with a spectrum analyzer**

E4B11: How should an antenna analyzer be connected when measuring antenna resonance and feed point impedance?

**Connect the antenna feed line directly to the analyzer's connector**

E4B12: What is the significance of voltmeter sensitivity expressed in ohms per volt?

**The full scale reading of the voltmeter multiplied by its ohms per volt rating will indicate the input impedance of the voltmeter**

E4B13: Which S parameter is equivalent to forward gain?

**S21**

E4B14: What happens if a dip meter is too tightly coupled to a tuned circuit being checked?

**A less accurate reading results**

E4B15: Which of the following can be used as a relative measurement of the Q for a series-tuned circuit?

**The bandwidth of the circuit's frequency response**

E4B16: Which S parameter represents return loss or SWR?

**S11**

E4B17: What three test loads are used to calibrate a standard RF vector network analyzer?

**Short circuit, open circuit, and 50 ohms**

Group E4C - Receiver performance characteristics, phase noise, capture effect, noise floor, image rejection, MDS, signal-to-noise-ratio; selectivity

E4C01: What is an effect of excessive phase noise in the local oscillator section of a receiver?

**It can cause strong signals on nearby frequencies to interfere with reception of weak signals**

E4C02: Which of the following portions of a receiver can be effective in eliminating image signal interference?

**A front-end filter or pre-selector**

E4C03: What is the term for the blocking of one FM phone signal by another, stronger FM phone signal?

**Capture effect**

E4C04: How is the noise figure of a receiver defined?

**The ratio in dB of the noise generated by the receiver to the theoretical minimum noise**

E4C05: What does a value of -174 dBm/Hz represent with regard to the noise floor of a receiver?

**The theoretical noise at the input of a perfect receiver at room temperature**

E4C06: A CW receiver with the AGC off has an equivalent input noise power density of -174 dBm/Hz. What would be the level of an unmodulated carrier input to this receiver that would yield an audio output SNR of 0 dB in a 400 Hz noise bandwidth?

**-148 dBm**

E4C07: What does the MDS of a receiver represent?

**The minimum discernible signal**

E4C08: An SDR receiver is overloaded when input signals exceed what level?

**The maximum count value of the analog-to-digital converter**

E4C09: Which of the following choices is a good reason for selecting a high frequency for the design of the IF in a conventional HF or VHF communications receiver?

**Easier for front-end circuitry to eliminate image responses**

E4C10: Which of the following is a desirable amount of selectivity for an amateur RTTY HF receiver?

**300 Hz**

E4C11: Which of the following is a desirable amount of selectivity for an amateur SSB phone receiver?

**2.4 kHz**

E4C12: What is an undesirable effect of using too wide a filter bandwidth in the IF section of a receiver?

**Undesired signals may be heard**

E4C13: How does a narrow-band roofing filter affect receiver performance?

**It improves dynamic range by attenuating strong signals near the receive frequency**

E4C14: What transmit frequency might generate an image response signal in a receiver tuned to 14.300 MHz and which uses a 455 kHz IF frequency?

**15.210 MHz**

E4C15: What is usually the primary source of noise that is heard from an HF receiver with an antenna connected?

**Atmospheric noise**

E4C16: Which of the following is caused by missing codes in an SDR receiver's analog-to-digital converter?

**Distortion**

E4C17: Which of the following has the largest effect on an SDR receiver's linearity?

**Analog-to-digital converter sample width in bits**

Group E4D - Receiver performance characteristics, blocking dynamic range, intermodulation and cross-modulation interference; 3rd order intercept; desensitization; preselection

E4D01: What is meant by the blocking dynamic range of a receiver?

**The difference in dB between the noise floor and the level of an incoming signal which will cause 1 dB of gain compression**

E4D02: Which of the following describes two problems caused by poor dynamic range in a communications receiver?

**Cross-modulation of the desired signal and desensitization from strong adjacent signals**

E4D03: How can intermodulation interference between two repeaters occur?

**When the repeaters are in close proximity and the signals mix in the final amplifier of one or both transmitters**

E4D04: Which of the following may reduce or eliminate intermodulation interference in a repeater caused by another transmitter operating in close proximity?

**A properly terminated circulator at the output of the transmitter**

E4D05: What transmitter frequencies would cause an intermodulation-product signal in a receiver tuned to 146.70 MHz when a nearby station transmits on 146.52 MHz?

**146.34 MHz and 146.61 MHz**

E4D06: What is the term for unwanted signals generated by the mixing of two or more signals?

**Intermodulation interference**

E4D07: Which describes the most significant effect of an off-frequency signal when it is causing cross-modulation interference to a desired signal?

**The off-frequency unwanted signal is heard in addition to the desired signal**

E4D08: What causes intermodulation in an electronic circuit?

**Nonlinear circuits or devices**

E4D09: What is the purpose of the preselector in a communications receiver?

**To increase rejection of unwanted signals**

E4D10: What does a third-order intercept level of 40 dBm mean with respect to receiver performance?

**A pair of 40 dBm signals will theoretically generate a third-order intermodulation product with the same level as the input signals**

E4D11: Why are third-order intermodulation products created within a receiver of particular interest compared to other products?

**The third-order product of two signals which are in the band of interest is also likely to be within the band**

E4D12: What is the term for the reduction in receiver sensitivity caused by a strong signal near the received frequency?

**Desensitization**

E4D13: Which of the following can cause receiver desensitization?

**Strong adjacent channel signals**

E4D14: Which of the following is a way to reduce the likelihood of receiver desensitization?

**Decrease the RF bandwidth of the receiver**

Group E4E - Noise suppression: system noise; electrical appliance noise; line noise; locating noise sources; DSP noise reduction; noise blankers

E4E01: Which of the following types of receiver noise can often be reduced by use of a receiver noise blanker?

**Ignition noise**

E4E02: Which of the following types of receiver noise can often be reduced with a DSP noise filter?

**All of these choices are correct**

Broadband white noise

Ignition noise

Power line noise

E4E03: Which of the following signals might a receiver noise blanker be able to remove from desired signals?

**Signals which appear across a wide bandwidth**

E4E04: How can conducted and radiated noise caused by an automobile alternator be suppressed?

**By connecting the radio's power leads directly to the battery and by installing coaxial capacitors in line with the alternator leads**

E4E05: How can noise from an electric motor be suppressed?

**By installing a brute-force AC-line filter in series with the motor leads**

E4E06: What is a major cause of atmospheric static?

**Thunderstorms**

E4E07: How can you determine if line noise interference is being generated within your home?

**By turning off the AC power line main circuit breaker and listening on a battery operated radio**

E4E08: What type of signal is picked up by electrical wiring near a radio antenna?

**A common-mode signal at the frequency of the radio transmitter**

E4E09: What undesirable effect can occur when using an IF noise blanker?

**Nearby signals may appear to be excessively wide even if they meet emission standards**

E4E10: What is a common characteristic of interference caused by a touch controlled electrical device?

**All of these choices are correct**

The interfering signal sounds like AC hum on an AM receiver or a carrier modulated by 60 Hz hum on a SSB or CW receiver

The interfering signal may drift slowly across the HF spectrum

The interfering signal can be several kHz in width and usually repeats at regular

E4E11: Which is the most likely cause if you are hearing combinations of local AM broadcast signals within one or more of the MF or HF ham bands?

**Nearby corroded metal joints are mixing and re-radiating the broadcast signals**

E4E12: What is one disadvantage of using some types of automatic DSP notch-filters when attempting to copy CW signals?

**A DSP filter can remove the desired signal at the same time as it removes interfering signals**

E4E13: What might be the cause of a loud roaring or buzzing AC line interference that comes and goes at intervals?

**All of these choices are correct**

Arcing contacts in a thermostatically controlled device

A defective doorbell or doorbell transformer inside a nearby residence

A malfunctioning illuminated advertising display

E4E14: What is one type of electrical interference that might be caused by the operation of a nearby personal computer?

**The appearance of unstable modulated or unmodulated signals at specific frequencies**

E4E15: Which of the following can cause shielded cables to radiate or receive interference?

**Common mode currents on the shield and conductors**

E4E16: What current flows equally on all conductors of an unshielded multi-conductor cable?

**Common-mode current**

Subelement E5 - Electrical Principles

Group E5A - Resonance and Q: characteristics of resonant circuits: series and parallel resonance; Q; half-power bandwidth; phase relationships in reactive circuits

E5A01: What can cause the voltage across reactances in series to be larger than the voltage applied to them?

**Resonance**

E5A02: What is resonance in an electrical circuit?

**The frequency at which the capacitive reactance equals the inductive reactance**

E5A03: What is the magnitude of the impedance of a series RLC circuit at resonance?

**Approximately equal to circuit resistance**

E5A04: What is the magnitude of the impedance of a circuit with a resistor, an inductor and a capacitor all in parallel, at resonance?

**Approximately equal to circuit resistance**

E5A05: What is the magnitude of the current at the input of a series RLC circuit as the frequency goes through resonance?

**Maximum**

E5A06: What is the magnitude of the circulating current within the components of a parallel LC circuit at resonance?

**It is at a maximum**

E5A07: What is the magnitude of the current at the input of a parallel RLC circuit at resonance?

**Minimum**

E5A08: What is the phase relationship between the current through and the voltage across a series resonant circuit at resonance?

**The voltage and current are in phase**

E5A09: How is the Q of an RLC parallel resonant circuit calculated?

**Resistance divided by the reactance of either the inductance or capacitance**

E5A10: How is the Q of an RLC series resonant circuit calculated?

**Reactance of either the inductance or capacitance divided by the resistance**

E5A11: What is the half-power bandwidth of a parallel resonant circuit that has a resonant frequency of 7.1 MHz and a Q of 150?

**47.3 kHz**

E5A12: What is the half-power bandwidth of a parallel resonant circuit that has a resonant frequency of 3.7 MHz and a Q of 118?

**31.4 kHz**

E5A13: What is an effect of increasing Q in a resonant circuit?

**Internal voltages and circulating currents increase**

E5A14: What is the resonant frequency of a series RLC circuit if R is 22 ohms, L is 50 microhenrys and C is 40 picofarads?

**3.56 MHz**

E5A15: Which of the following can increase Q for inductors and capacitors?

**Lower losses**

E5A16: What is the resonant frequency of a parallel RLC circuit if R is 33 ohms, L is 50 microhenrys and C is 10 picofarads?

**7.12 MHz**

E5A17: What is the result of increasing the Q of an impedance-matching circuit?

**Matching bandwidth is decreased**

Group E5B - Time constants and phase relationships: RLC time constants: definition; time constants in RL and RC circuits; phase angle between voltage and current; phase angles of series and parallel circuits

E5B01: What is the term for the time required for the capacitor in an RC circuit to be charged to 63.2% of the applied voltage?

**One time constant**

E5B02: What is the term for the time it takes for a charged capacitor in an RC circuit to discharge to 36.8% of its initial voltage?

**One time constant**

E5B03: What happens to the phase angle of a reactance when it is converted to a susceptance?

**The sign is reversed**

E5B04: What is the time constant of a circuit having two 220 microfarad capacitors and two 1 megohm resistors, all in parallel?

**220 seconds**

E5B05: What happens to the magnitude of a reactance when it is converted to a susceptance?

**The magnitude of the susceptance is the reciprocal of the magnitude of the reactance**

E5B06: What is susceptance?

**The inverse of reactance**

E5B07: What is the phase angle between the voltage across and the current through a series RLC circuit if  $X_C$  is 500 ohms,  $R$  is 1 kilohm, and  $X_L$  is 250 ohms?

**14.0 degrees with the voltage lagging the current**

E5B08: What is the phase angle between the voltage across and the current through a series RLC circuit if  $X_C$  is 100 ohms,  $R$  is 100 ohms, and  $X_L$  is 75 ohms?

**14 degrees with the voltage lagging the current**

E5B09: What is the relationship between the current through a capacitor and the voltage across a capacitor?

**Current leads voltage by 90 degrees**

E5B10: What is the relationship between the current through an inductor and the voltage across an inductor?

**Voltage leads current by 90 degrees**

E5B11: What is the phase angle between the voltage across and the current through a series RLC circuit if  $X_C$  is 25 ohms,  $R$  is 100 ohms, and  $X_L$  is 50 ohms?

**14 degrees with the voltage leading the current**

E5B12: What is admittance?

**The inverse of impedance**

E5B13: What letter is commonly used to represent susceptance?

**B**

Group E5C - Impedance plots and coordinate systems: plotting impedances in polar coordinates; rectangular coordinates

E5C01: Which of the following represents a capacitive reactance in rectangular notation?

**-jX**

E5C02: How are impedances described in polar coordinates?

**By phase angle and amplitude**

E5C03: Which of the following represents an inductive reactance in polar coordinates?

**A positive phase angle**

E5C04: Which of the following represents a capacitive reactance in polar coordinates?

**A negative phase angle**

E5C05: What is the name of the diagram used to show the phase relationship between impedances at a given frequency?

**Phasor diagram**

E5C06: What does the impedance  $50-j25$  represent?

**50 ohms resistance in series with 25 ohms capacitive reactance**

E5C07: What is a vector?

**A quantity with both magnitude and an angular component**

E5C08: What coordinate system is often used to display the phase angle of a circuit containing resistance, inductive and/or capacitive reactance?

**Polar coordinates**

E5C09: When using rectangular coordinates to graph the impedance of a circuit, what does the horizontal axis represent?

**Resistive component**

E5C10: When using rectangular coordinates to graph the impedance of a circuit, what does the vertical axis represent?

**Reactive component**

E5C11: What do the two numbers that are used to define a point on a graph using rectangular coordinates represent?

**The coordinate values along the horizontal and vertical axes**

E5C12: If you plot the impedance of a circuit using the rectangular coordinate system and find the impedance point falls on the right side of the graph on the horizontal axis, what do you know about the circuit?

**It is equivalent to a pure resistance**

E5C13: What coordinate system is often used to display the resistive, inductive, and/or capacitive reactance components of impedance?

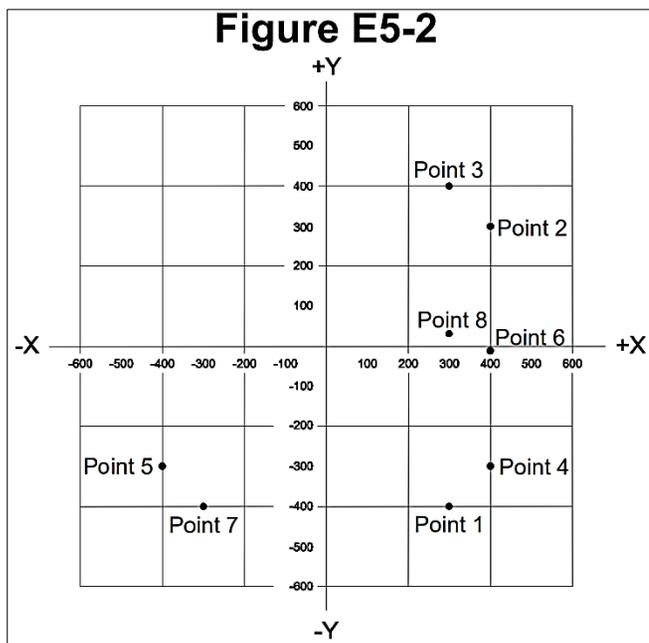
**Rectangular coordinates**

E5C14: Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 400 ohm resistor and a 38 picofarad capacitor at 14 MHz?

**Point 4**

E5C15: Which point in Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor and an 18 microhenry inductor at 3.505 MHz?

**Point 3**



E5C16: Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor and a 19 picofarad capacitor at 21.200 MHz?

**Point 1**

E5C17: Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor, a 0.64-microhenry inductor and an 85-picofarad capacitor at 24.900 MHz?

**Point 8**

Group E5D - AC and RF energy in real circuits: skin effect; electrostatic and electromagnetic fields; reactive power; power factor; coordinate systems

E5D01: What is the result of skin effect?

**As frequency increases, RF current flows in a thinner layer of the conductor, closer to the surface**

E5D02: Why is it important to keep lead lengths short for components used in circuits for VHF and above?

**To avoid unwanted inductive reactance**

E5D03: What is microstrip?

**Precision printed circuit conductors above a ground plane that provide constant impedance interconnects at microwave frequencies**

E5D04: Why are short connections necessary at microwave frequencies?

**To reduce phase shift along the connection**

E5D05: Which parasitic characteristic increases with conductor length?

**Inductance**

E5D06: In what direction is the magnetic field oriented about a conductor in relation to the direction of electron flow?

**In a direction determined by the left-hand rule**

E5D07: What determines the strength of the magnetic field around a conductor?

**The amount of current flowing through the conductor**

E5D08: What type of energy is stored in an electromagnetic or electrostatic field?

**Potential energy**

E5D09: What happens to reactive power in an AC circuit that has both ideal inductors and ideal capacitors?

**It is repeatedly exchanged between the associated magnetic and electric fields, but is not dissipated**

E5D10: How can the true power be determined in an AC circuit where the voltage and current are out of phase?

**By multiplying the apparent power times the power factor**

E5D11: What is the power factor of an R-L circuit having a 60 degree phase angle between the voltage and the current?

**0.5**

E5D12: How many watts are consumed in a circuit having a power factor of 0.2 if the input is 100-VAC at 4 amperes?

**80 watts**

E5D13: How much power is consumed in a circuit consisting of a 100 ohm resistor in series with a 100 ohm inductive reactance drawing 1 ampere?

**100 Watts**

E5D14: What is reactive power?

**Wattless, nonproductive power**

E5D15: What is the power factor of an R-L circuit having a 45 degree phase angle between the voltage and the current?

**0.707**

E5D16: What is the power factor of an R-L circuit having a 30 degree phase angle between the voltage and the current?

**0.866**

E5D17: How many watts are consumed in a circuit having a power factor of 0.6 if the input is 200VAC at 5 amperes?

**600 watts**

E5D18: How many watts are consumed in a circuit having a power factor of 0.71 if the apparent power is 500VA?

**355 W**

Subelement E6 - Circuit Components

Group E6A - Semiconductor materials and devices: semiconductor materials germanium, silicon, P-type, N-type; transistor types: NPN, PNP, junction, field-effect transistors: enhancement mode; depletion mode; MOS; CMOS; N-channel; P-channel

E6A01: In what application is gallium arsenide used as a semiconductor material in preference to germanium or silicon?

**In microwave circuits**

E6A02: Which of the following semiconductor materials contains excess free electrons?

**N-type**

E6A03: Why does a PN-junction diode not conduct current when reverse biased?

**Holes in P-type material and electrons in the N-type material are separated by the applied voltage, widening the depletion region**

E6A04: What is the name given to an impurity atom that adds holes to a semiconductor crystal structure?

**Acceptor impurity**

E6A05: What is the alpha of a bipolar junction transistor?

**The change of collector current with respect to emitter current**

E6A06: What is the beta of a bipolar junction transistor?

**The change in collector current with respect to base current**

E6A07: Which of the following indicates that a silicon NPN junction transistor is biased on?

**Base-to-emitter voltage of approximately 0.6 to 0.7 volts**

E6A08: What term indicates the frequency at which the grounded-base current gain of a transistor has decreased to 0.7 of the gain obtainable at 1 kHz?

**Alpha cutoff frequency**

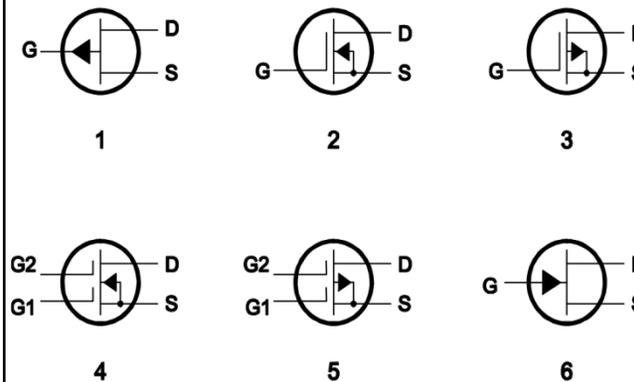
E6A09: What is a depletion-mode FET?

**An FET that exhibits a current flow between source and drain when no gate voltage is applied**

E6A10: In Figure E6-2, what is the schematic symbol for an N-channel dual-gate MOSFET?

4

Figure E6-2



E6A11: In Figure E6-2, what is the schematic symbol for a P-channel junction FET?

1

E6A12: Why do many MOSFET devices have internally connected Zener diodes on the gates?  
**To reduce the chance of the gate insulation being punctured by static discharges or excessive voltages**

E6A13: What do the initials CMOS stand for?  
**Complementary Metal-Oxide Semiconductor**

E6A14: How does DC input impedance at the gate of a field-effect transistor compare with the DC input impedance of a bipolar transistor?

**An FET has high input impedance; a bipolar transistor has low input impedance**

E6A15: Which semiconductor material contains excess holes in the outer shell of electrons?

**P-type**

E6A16: What are the majority charge carriers in N-type semiconductor material?

**Free electrons**

E6A17: What are the names of the three terminals of a field-effect transistor?

**Gate, drain, source**

Group E6B - Semiconductor diodes

E6B01: What is the most useful characteristic of a Zener diode?

**A constant voltage drop under conditions of varying current**

E6B02: What is an important characteristic of a Schottky diode as compared to an ordinary silicon diode when used as a power supply rectifier?

**Less forward voltage drop**

E6B03: What special type of diode is capable of both amplification and oscillation?

**Tunnel**

E6B04: What type of semiconductor device is designed for use as a voltage-controlled capacitor?

**Varactor diode**

E6B05: What characteristic of a PIN diode makes it useful as an RF switch or attenuator?

**A large region of intrinsic material**

E6B06: Which of the following is a common use of a hot-carrier diode?

**As a VHF/UHF mixer or detector**

E6B07: What is the failure mechanism when a junction diode fails due to excessive current?

**Excessive junction temperature**

E6B08: Which of the following describes a type of semiconductor diode?

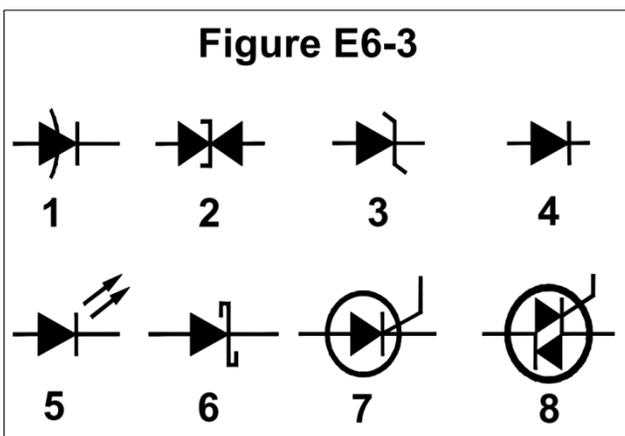
**Metal-semiconductor junction**

E6B09: What is a common use for point contact diodes?

**As an RF detector**

E6B10: In Figure E6-3, what is the schematic symbol for a light-emitting diode?

5



E6B11: What is used to control the attenuation of RF signals by a PIN diode?

**Forward DC bias current**

E6B12: What is one common use for PIN diodes?

**As an RF switch**

E6B13: What type of bias is required for an LED to emit light?

**Forward bias**

Group E6C - Integrated circuits: TTL digital integrated circuits; CMOS digital integrated circuits; gates

E6C01: What is the function of hysteresis in a comparator?

**To prevent input noise from causing unstable output signals**

E6C02: What happens when the level of a comparator's input signal crosses the threshold?

**The comparator changes its output state**

E6C03: What is tri-state logic?

**Logic devices with 0, 1, and high impedance output states**

E6C04: What is the primary advantage of tri-state logic?

**Ability to connect many device outputs to a common bus**

E6C05: What is an advantage of CMOS logic devices over TTL devices?

**Lower power consumption**

E6C06: Why do CMOS digital integrated circuits have high immunity to noise on the input signal or power supply?

**The input switching threshold is about one-half the power supply voltage**

E6C07: What best describes a pull-up or pull-down resistor?

**A resistor connected to the positive or negative supply line used to establish a voltage when an input or output is an open circuit**

E6C08: In Figure E6-5, what is the schematic symbol for a NAND gate?

2

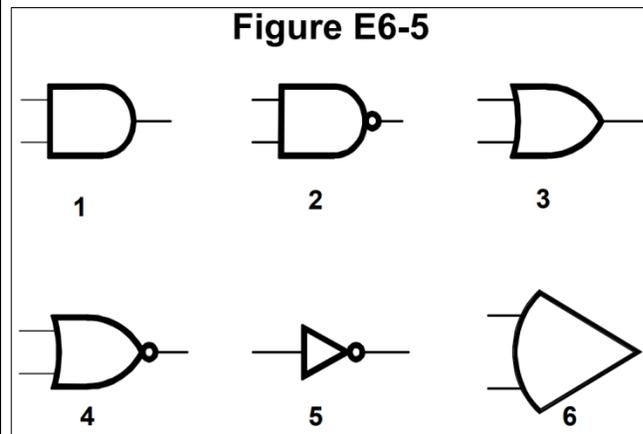
E6C09: What is a Programmable Logic Device (PLD)?

**A programmable collection of logic gates and circuits in a single integrated circuit**

E6C10: In Figure E6-5, what is the schematic symbol for a NOR gate?

4

E6C11: In Figure E6-5, what is the schematic



symbol for the NOT operation (inverter)?

5

E6C12: What is BiCMOS logic?

**An integrated circuit logic family using both bipolar and CMOS transistors**

E6C13: Which of the following is an advantage of BiCMOS logic?

**It has the high input impedance of CMOS and the low output impedance of bipolar transistors**

E6C14: What is the primary advantage of using a Programmable Gate Array (PGA) in a logic circuit?

**Complex logic functions can be created in a single integrated circuit**

Group E6D - Optical devices and toroids: cathode-ray tube devices; charge-coupled devices (CCDs); liquid crystal displays (LCDs); toroids: permeability, core material, selecting, winding

E6D01: How many turns will be required to produce a 5-microhenry inductor using a powdered-iron toroidal core that has an inductance index (A L) value of 40 microhenrys/100 turns?

35 turns

E6D02: What is the equivalent circuit of a quartz crystal?

**Motional capacitance, motional inductance, and loss resistance in series, all in parallel with a shunt capacitor representing electrode and stray capacitance**

E6D03: Which of the following is an aspect of the piezoelectric effect?

**Mechanical deformation of material by the application of a voltage**

E6D04: Which materials are commonly used as a slug core in a variable inductor?

**Ferrite and brass**

E6D05: What is one reason for using ferrite cores rather than powdered-iron in an inductor?

**Ferrite toroids generally require fewer turns to produce a given inductance value**

E6D06: What core material property determines the inductance of a toroidal inductor?

**Permeability**

E6D07: What is the usable frequency range of inductors that use toroidal cores, assuming a correct selection of core material for the frequency being used?

**From less than 20 Hz to approximately 300 MHz**

E6D08: What is one reason for using powdered-iron cores rather than ferrite cores in an inductor?

**Powdered-iron cores generally maintain their characteristics at higher currents**

E6D09: What devices are commonly used as VHF and UHF parasitic suppressors at the input and output terminals of a transistor HF amplifier?

**Ferrite beads**

E6D10: What is a primary advantage of using a toroidal core instead of a solenoidal core in an inductor?

**Toroidal cores confine most of the magnetic field within the core material**

E6D11: How many turns will be required to produce a 1-mH inductor using a core that has an inductance index (A L) value of 523 millihenrys/1000 turns?

**43 turns**

E6D12: What is the definition of saturation in a ferrite core inductor?

**The ability of the inductor's core to store magnetic energy has been exceeded**

E6D13: What is the primary cause of inductor self-resonance?

**Inter-turn capacitance**

E6D14: Which type of slug material decreases inductance when inserted into a coil?

**Brass**

E6D15: What is current in the primary winding of a transformer called if no load is attached to the secondary?

**Magnetizing current**

E6D16: What is the common name for a capacitor connected across a transformer secondary that is used to absorb transient voltage spikes?

**Snubber capacitor**

E6D17: Why should core saturation of a conventional impedance matching transformer be avoided?

**Harmonics and distortion could result**

Group E6E - Piezoelectric crystals and MMICs: quartz crystals; crystal oscillators and filters; monolithic amplifiers

E6E01: Which of the following is true of a charge-coupled device (CCD)?

**It samples an analog signal and passes it in stages from the input to the output**

E6E02: Which of the following device packages is a through-hole type?

**DIP**

E6E03: Which of the following materials is likely to provide the highest frequency of operation when used in MMICs?

**Gallium nitride**

E6E04: Which is the most common input and output impedance of circuits that use MMICs?

**50 ohms**

E6E05: Which of the following noise figure values is typical of a low-noise UHF preamplifier?

**2 dB**

E6E06: What characteristics of the MMIC make it a popular choice for VHF through microwave circuits?

**Controlled gain, low noise figure, and constant input and output impedance over the specified frequency range**

E6E07: Which of the following is typically used to construct a MMIC-based microwave amplifier?

**Microstrip construction**

E6E08: How is voltage from a power supply normally furnished to the most common type of monolithic microwave integrated circuit (MMIC)?

**Through a resistor and/or RF choke connected to the amplifier output lead**

E6E09: Which of the following component package types would be most suitable for use at frequencies above the HF range?

**Surface mount**

E6E10: What is the packaging technique in which leadless components are soldered directly to circuit boards?

**Surface mount**

E6E11: What is a characteristic of DIP packaging used for integrated circuits?

**A total of two rows of connecting pins placed on opposite sides of the package (Dual In-line Package)**

E6E12: Why are high-power RF amplifier ICs and transistors sometimes mounted in ceramic packages?

**Better dissipation of heat**

Group E6F - Optical components and power systems: photoconductive principles and effects, photovoltaic systems, optical couplers, optical sensors, and optoisolators

E6F01: What is photoconductivity?

**The increased conductivity of an illuminated semiconductor**

E6F02: What happens to the conductivity of a photoconductive material when light shines on it?

**It increases**

E6F03: What is the most common configuration of an optoisolator or optocoupler?

**An LED and a phototransistor**

E6F04: What is the photovoltaic effect?

**The conversion of light to electrical energy**

E6F05: Which describes an optical shaft encoder?

**A device which detects rotation of a control by interrupting a light source with a patterned wheel**

E6F06: Which of these materials is affected the most by photoconductivity?

**A crystalline semiconductor**

E6F07: What is a solid state relay?

**A device that uses semiconductors to implement the functions of an electromechanical relay**

E6F08: Why are optoisolators often used in conjunction with solid state circuits when switching 120VAC?

**Optoisolators provide a very high degree of electrical isolation between a control circuit and the circuit being switched**

E6F09: What is the efficiency of a photovoltaic cell?

**The relative fraction of light that is converted to current**

E6F10: What is the most common type of photovoltaic cell used for electrical power generation?

**Silicon**

E6F11: What is the approximate open-circuit voltage produced by a fully-illuminated silicon photovoltaic cell?

**0.5 V**

E6F12: What absorbs the energy from light falling on a photovoltaic cell?

**Electrons**

E6F13: What is a liquid crystal display (LCD)?

**A display utilizing a crystalline liquid and polarizing filters which becomes opaque when voltage is applied**

E6F14: Which of the following is true of LCD displays?

**They may be hard view through polarized lenses**

Subelement E7 - Practical Circuits

Group E7A - Digital circuits: digital circuit principles and logic circuits: classes of logic elements; positive and negative logic; frequency dividers; truth tables

E7A01: Which is a bi-stable circuit?

**A flip-flop**

E7A02: What is the function of a decade counter digital IC?

**It produces one output pulse for every ten input pulses**

E7A03: Which of the following can divide the frequency of a pulse train by 2?

**A flip-flop**

E7A04: How many flip-flops are required to divide a signal frequency by 4?

**2**

E7A05: Which of the following is a circuit that continuously alternates between two states without an external clock?

**Astable multivibrator**

E7A06: What is a characteristic of a monostable multivibrator?

**It switches momentarily to the opposite binary state and then returns to its original state after a set time**

E7A07: What logical operation does a NAND gate perform?

**It produces logic "0" at its output only when all inputs are logic "1"**

E7A08: What logical operation does an OR gate perform?

**It produces logic "1" at its output if any or all inputs are logic "1"**

E7A09: What logical operation is performed by an exclusive NOR gate?

**It produces logic "0" at its output if any single input is logic "1"**

E7A10: What is a truth table?

**A list of inputs and corresponding outputs for a digital device**

E7A11: What type of logic defines "1" as a high voltage?

**Positive Logic**

E7A12: What type of logic defines "0" as a high voltage?

**Negative logic**

Group E7B - Amplifiers: Class of operation; vacuum tube and solid-state circuits; distortion and intermodulation; spurious and parasitic suppression; microwave amplifiers

E7B01: For what portion of a signal cycle does a Class AB amplifier operate?

**More than 180 degrees but less than 360 degrees**

E7B02: What is a Class D amplifier?

**A type of amplifier that uses switching technology to achieve high efficiency**

E7B03: Which of the following components form the output of a class D amplifier circuit?

**A low-pass filter to remove switching signal components**

E7B04: Where on the load line of a Class A common emitter amplifier would bias normally be set?

**Approximately half-way between saturation and cutoff**

E7B05: What can be done to prevent unwanted oscillations in an RF power amplifier?

**Install parasitic suppressors and/or neutralize the stage**

E7B06: Which of the following amplifier types reduces or eliminates even order harmonics?

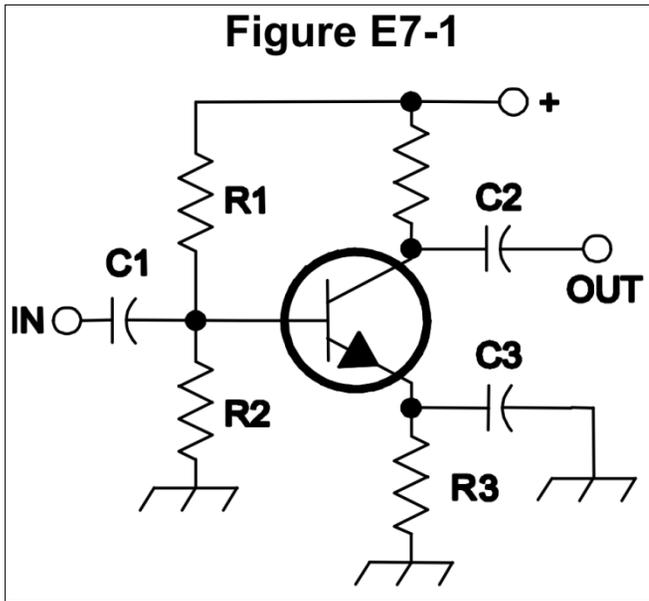
**Push-pull**

E7B07: Which of the following is a likely result when a Class C amplifier is used to amplify a single-sideband phone signal?

**Signal distortion and excessive bandwidth**

E7B08: How can an RF power amplifier be neutralized?

**By feeding a 180-degree out-of-phase portion of the output back to the input**



**Figure E7-1**

E7B09: Which of the following describes how the loading and tuning capacitors are to be adjusted when tuning a vacuum tube RF power amplifier that employs a Pi-network output circuit?

**The tuning capacitor is adjusted for minimum plate current, and the loading capacitor is adjusted for maximum permissible plate current**

E7B10: In Figure E7-1, what is the purpose of R1 and R2?

**Fixed bias**

E7B11: In Figure E7-1, what is the purpose of R3?

**Self bias**

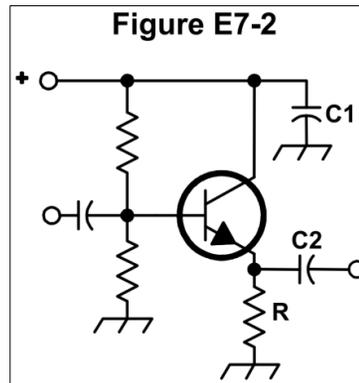
E7B12: What type of amplifier circuit is shown in Figure E7-1?

**Common emitter**

E7B13: In Figure E7-2, what is the purpose of R?

**Emitter load**

E7B14: Why are switching amplifiers more efficient than linear amplifiers?



**Figure E7-2**

**The power transistor is at saturation or cut off most of the time, resulting in low power dissipation**

E7B15: What is one way to prevent thermal runaway in a bipolar transistor amplifier?

**Use a resistor in series with the emitter**

E7B16: What is the effect of intermodulation products in a linear power amplifier?

**Transmission of spurious signals**

E7B17: Why are odd-order rather than even-order intermodulation distortion products of concern in linear power amplifiers?

**Because they are relatively close in frequency to the desired signal**

E7B18: What is a characteristic of a grounded-grid amplifier?

**Low input impedance**

Group E7C - Filters and matching networks: filters and impedance matching networks: types of networks; types of filters; filter applications; filter characteristics; impedance matching; DSP filtering

E7C01: How are the capacitors and inductors of a low-pass filter Pi-network arranged between the network's input and output?

**A capacitor is connected between the input and ground, another capacitor is connected between the output and ground, and an inductor is connected between input and output**

E7C02: Which of the following is a property of a T-network with series capacitors and a parallel shunt inductor?

**It is a high-pass filter**

E7C03: What advantage does a Pi-L-network have over a regular Pi-network for impedance matching between the final amplifier of a vacuum-tube transmitter and an antenna?

**Greater harmonic suppression**

E7C04: How does an impedance-matching circuit transform a complex impedance to a resistive impedance?

**It cancels the reactive part of the impedance and changes the resistive part to a desired value**

E7C05: Which filter type is described as having ripple in the passband and a sharp cutoff?

**A Chebyshev filter**

E7C06: What are the distinguishing features of an elliptical filter?

**Extremely sharp cutoff with one or more notches in the stop band**

E7C07: What kind of filter would you use to attenuate an interfering carrier signal while receiving an SSB transmission?

**A notch filter**

E7C08: Which of the following factors has the greatest effect in helping determine the bandwidth and response shape of a crystal ladder filter?

**The relative frequencies of the individual crystals**

E7C09: What is a Jones filter as used as part of an HF receiver IF stage?

**A variable bandwidth crystal lattice filter**

E7C10: Which of the following filters would be the best choice for use in a 2 meter repeater duplexer?

**A cavity filter**

E7C11: Which of the following is the common name for a filter network which is equivalent to two L-networks connected back-to-back with the two inductors in series and the capacitors in shunt at the input and output?

**Pi**

E7C12: Which describes a Pi-L-network used for matching a vacuum tube final amplifier to a 50 ohm unbalanced output?

**A Pi-network with an additional series inductor on the output**

E7C13: What is one advantage of a Pi-matching network over an L-matching network consisting of a single inductor and a single capacitor?

**The Q of Pi-networks can be varied depending on the component values chosen**

E7C14: Which mode is most affected by non-linear phase response in a receiver IF filter?

**Digital**

E7C15: What is a crystal lattice filter?

**A filter with narrow bandwidth and steep skirts made using quartz crystals**

Group E7D - Power supplies and voltage regulators

E7D01: What is one characteristic of a linear electronic voltage regulator?

**The conduction of a control element is varied to maintain a constant output voltage**

E7D02: What is one characteristic of a switching electronic voltage regulator?

**The controlled device's duty cycle is changed to produce a constant average output voltage**

E7D03: What device is typically used as a stable reference voltage in a linear voltage regulator?

**A Zener diode**

E7D04: Which of the following types of linear voltage regulator usually make the most efficient use of the primary power source?

**A series regulator**

E7D05: Which of the following types of linear voltage regulator places a constant load on the unregulated voltage source?

**A shunt regulator**

E7D06: What is the purpose of Q1 in the circuit shown in Figure E7-3?

**It increases the current-handling capability of the regulator**

E7D07: What is the purpose of C2 in the circuit shown in Figure E7-3?

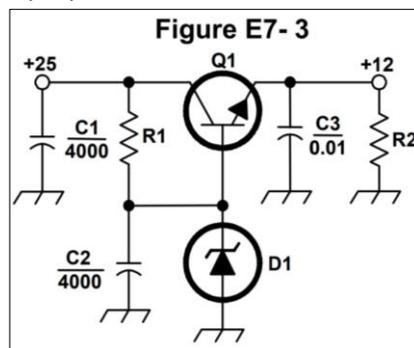
**It bypasses hum around D1**

E7D08: What type of circuit is shown in Figure E7-3?

**Linear voltage regulator**

E7D09: What is the main reason to use a charge controller with a solar power system?

**Prevention of battery damage due to overcharge**



E7D10: What is the primary reason that a high-frequency switching type high voltage power supply can be both less expensive and lighter in weight than a conventional power supply?

**The high frequency inverter design uses much smaller transformers and filter components for an equivalent power output**

E7D11: What circuit element is controlled by a series analog voltage regulator to maintain a constant output voltage?

**Pass transistor**

E7D12: What is the drop-out voltage of an analog voltage regulator?

**Minimum input-to-output voltage required to maintain regulation**

E7D13: What is the equation for calculating power dissipation by a series connected linear voltage regulator?

**Voltage difference from input to output multiplied by output current**

E7D14: What is one purpose of a "bleeder" resistor in a conventional unregulated power supply?

**To improve output voltage regulation**

E7D15: What is the purpose of a "step-start" circuit in a high voltage power supply?

**To allow the filter capacitors to charge gradually**

E7D16: When several electrolytic filter capacitors are connected in series to increase the operating voltage of a power supply filter circuit, why should resistors be connected across each capacitor?

**All of these choices are correct**

To equalize, as much as possible, the voltage drop across each capacitor

To provide a safety bleeder to discharge the capacitors when the supply is off

To provide a minimum load current to reduce voltage excursions at light loads

Group E7E - Modulation and demodulation: reactance, phase and balanced modulators; detectors; mixer stages; DSP modulation and demodulation; software defined radio systems

E7E01: Which of the following can be used to generate FM phone emissions?

**A reactance modulator on the oscillator**

E7E02: What is the function of a reactance modulator?

**To produce PM signals by using an electrically variable inductance or capacitance**

E7E03: How does an analog phase modulator function?

**By varying the tuning of an amplifier tank circuit to produce PM signals**

E7E04: What is one way a single-sideband phone signal can be generated?

**By using a balanced modulator followed by a filter**

E7E05: What circuit is added to an FM transmitter to boost the higher audio frequencies?

**A pre-emphasis network**

E7E06: Why is de-emphasis commonly used in FM communications receivers?

**For compatibility with transmitters using phase modulation**

E7E07: What is meant by the term baseband in radio communications?

**The frequency components present in the modulating signal**

E7E08: What are the principal frequencies that appear at the output of a mixer circuit?

**The two input frequencies along with their sum and difference frequencies**

E7E09: What occurs when an excessive amount of signal energy reaches a mixer circuit?

**Spurious mixer products are generated**

E7E10: How does a diode detector function?

**By rectification and filtering of RF signals**

E7E11: Which type of detector is used for demodulating SSB signals?

**Product detector**

E7E12: What is a frequency discriminator stage in a FM receiver?

**A circuit for detecting FM signals**

Group E7F - Frequency markers and counters: frequency divider circuits; frequency marker generators; frequency counters

E7F01: What is meant by direct digital conversion as applied to software defined radios?

**Incoming RF is digitized by an analog-to-digital converter without being mixed with a local oscillator signal**

E7F02: What kind of digital signal processing audio filter is used to remove unwanted noise from a received SSB signal?

**An adaptive filter**

E7F03: What type of digital signal processing filter is used to generate an SSB signal?

**A Hilbert-transform filter**

E7F04: What is a common method of generating an SSB signal using digital signal processing?

**Combine signals with a quadrature phase relationship**

E7F05: How frequently must an analog signal be sampled by an analog-to-digital converter so that the signal can be accurately reproduced?

**At twice the rate of the highest frequency component of the signal**

E7F06: What is the minimum number of bits required for an analog-to-digital converter to sample a signal with a range of 1 volt at a resolution of 1 millivolt?

**10 bits**

E7F07: What function can a Fast Fourier Transform perform?

**Converting digital signals from the time domain to the frequency domain**

E7F08: What is the function of decimation with regard to digital filters?

**Reducing the effective sample rate by removing samples**

E7F09: Why is an anti-aliasing digital filter required in a digital decimator?

**It removes high-frequency signal components which would otherwise be reproduced as lower frequency components**

E7F10: What aspect of receiver analog-to-digital conversion determines the maximum receive bandwidth of a Direct Digital Conversion SDR?

**Sample rate**

E7F11: What sets the minimum detectable signal level for an SDR in the absence of atmospheric or thermal noise?

**Reference voltage level and sample width in bits**

E7F12: What digital process is applied to I and Q signals in order to recover the baseband modulation information?

**Fast Fourier Transform**

E7F13: What is the function of taps in a digital signal processing filter?

**Provide incremental signal delays for filter algorithms**

E7F14: Which of the following would allow a digital signal processing filter to create a sharper filter response?

**More taps**

E7F15: Which of the following is an advantage of a Finite Impulse Response (FIR) filter vs an Infinite Impulse Response (IIR) digital filter?

**FIR filters delay all frequency components of the signal by the same amount**

E7F16: How might the sampling rate of an existing digital signal be adjusted by a factor of 3/4?

**Interpolate by a factor of three, then decimate by a factor of four**

E7F17: What do the letters I and Q in I/Q Modulation represent?

### In-phase and Quadrature

Group E7G - Active filters and op-amps: active audio filters; characteristics; basic circuit design; operational amplifiers

E7G01: What is the typical output impedance of an integrated circuit op-amp?

#### Very low

E7G02: What is the effect of ringing in a filter?

#### Undesired oscillations added to the desired signal

E7G03: What is the typical input impedance of an integrated circuit op-amp?

#### Very high

E7G04: What is meant by the term op-amp input offset voltage?

#### The differential input voltage needed to bring the open loop output voltage to zero

E7G05: How can unwanted ringing and audio instability be prevented in a multi-section op-amp RC audio filter circuit?

#### Restrict both gain and Q

E7G06: Which of the following is the most appropriate use of an op-amp active filter?

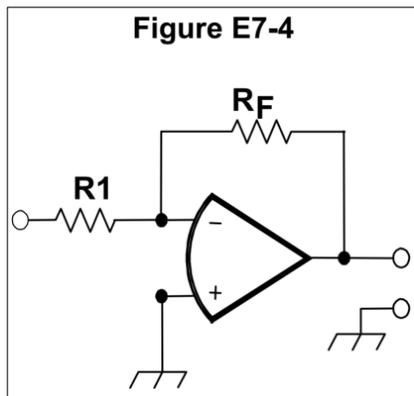
#### As an audio filter in a receiver

E7G07: What magnitude of voltage gain can be expected from the circuit in Figure E7-4 when R1 is 10 ohms and RF is 470 ohms?

#### 47

E7G08: How does the gain of an ideal operational amplifier vary with frequency?

**It does not vary with frequency**



E7G09: What will be the output voltage of the circuit shown in Figure E7-4 if R1 is 1000 ohms, RF is 10,000 ohms, and 0.23 volts DC is applied to the input?

#### -2.3 volts

E7G10: What absolute voltage gain can be expected from the circuit in Figure E7-4 when R1 is 1800 ohms and RF is 68 kilohms?

#### 38

E7G11: What absolute voltage gain can be expected from the circuit in Figure E7-4 when R1 is 3300 ohms and RF is 47 kilohms?

#### 14

E7G12: What is an integrated circuit operational amplifier?

#### A high-gain, direct-coupled differential amplifier with very high input impedance and very low output impedance

Group E7H - Oscillators and signal sources: types of oscillators; synthesizers and phase-locked loops; direct digital synthesizers

E7H01: What are three oscillator circuits used in Amateur Radio equipment?

#### Colpitts, Hartley and Pierce

E7H02: Which describes a microphonic?

#### Changes in oscillator frequency due to mechanical vibration

E7H03: How is positive feedback supplied in a Hartley oscillator?

#### Through a tapped coil

E7H04: How is positive feedback supplied in a Colpitts oscillator?

#### Through a capacitive divider

E7H05: How is positive feedback supplied in a Pierce oscillator?

#### Through a quartz crystal

E7H06: Which of the following oscillator circuits are commonly used in VFOs?

#### Colpitts and Hartley

E7H07: How can an oscillator's microphonic responses be reduced?

#### Mechanically isolating the oscillator circuitry from its enclosure

E7H08: Which of the following components can be used to reduce thermal drift in crystal oscillators?

#### NPO capacitors

E7H09: What type of frequency synthesizer circuit uses a phase accumulator, lookup table, digital to analog converter, and a low-pass anti-alias filter?

#### A direct digital synthesizer

E7H10: What information is contained in the lookup table of a direct digital frequency synthesizer?

#### The amplitude values that represent a sine-wave output

E7H11: What are the major spectral impurity components of direct digital synthesizers?

#### Spurious signals at discrete frequencies

E7H12: Which of the following must be done to insure that a crystal oscillator provides the frequency specified by the crystal manufacturer?

#### Provide the crystal with a specified parallel capacitance

E7H13: Which of the following is a technique for providing highly accurate and stable oscillators needed for microwave transmission and reception?

#### All of these choices are correct

Use a GPS signal reference

Use a rubidium stabilized reference oscillator

Use a temperature-controlled high Q dielectric resonator

E7H14: What is a phase-locked loop circuit?

#### An electronic servo loop consisting of a phase detector, a low-pass filter, a voltage-controlled oscillator, and a stable reference oscillator

E7H15: Which of these functions can be performed by a phase-locked loop?

**Frequency synthesis, FM demodulation**

Subelement E8 - Signals And Emissions  
Group E8A - AC waveforms: sine, square, sawtooth and irregular waveforms; AC measurements; average and PEP of RF signals; pulse and digital signal waveforms

E8A01: What is the name of the process that shows that a square wave is made up of a sine wave plus all of its odd harmonics?

**Fourier analysis**

E8A02: What type of wave has a rise time significantly faster than its fall time (or vice versa)?

**A sawtooth wave**

E8A03: What type of wave does a Fourier analysis show to be made up of sine waves of a given fundamental frequency plus all of its harmonics?

**A sawtooth wave**

E8A04: What is "dither" with respect to analog to digital converters?

**A small amount of noise added to the input signal to allow more precise representation of a signal over time**

E8A05: What would be the most accurate way of measuring the RMS voltage of a complex waveform?

**By measuring the heating effect in a known resistor**

E8A06: What is the approximate ratio of PEP-to-average power in a typical single-sideband phone signal?

**2.5 to 1**

E8A07: What determines the PEP-to-average power ratio of a single-sideband phone signal?

**The characteristics of the modulating signal**

E8A08: Why would a direct or flash conversion analog-to-digital converter be useful for a software defined radio?

**Very high speed allows digitizing high frequencies**

E8A09: How many levels can an analog-to-digital converter with 8 bit resolution encode?

**256**

E8A10: What is the purpose of a low pass filter used in conjunction with a digital-to-analog converter?

**Remove harmonics from the output caused by the discrete analog levels generated**

E8A11: What type of information can be conveyed using digital waveforms?

**All of these choices are correct**

Human speech

Video signals

Data

E8A12: What is an advantage of using digital signals instead of analog signals to convey the same information?

**Digital signals can be regenerated multiple times without error**

E8A13: Which of these methods is commonly used to convert analog signals to digital signals?

**Sequential sampling**

Group E8B - Modulation and demodulation: modulation methods; modulation index and deviation ratio; pulse modulation; frequency and time division multiplexing

E8B01: What is the term for the ratio between the frequency deviation of an RF carrier wave and the modulating frequency of its corresponding FM-phone signal?

**Modulation index**

E8B02: How does the modulation index of a phase-modulated emission vary with RF carrier frequency (the modulated frequency)?

**It does not depend on the RF carrier frequency**

E8B03: What is the modulation index of an FM-phone signal having a maximum frequency deviation of 3000 Hz either side of the carrier frequency when the modulating frequency is 1000 Hz?

**3**

E8B04: What is the modulation index of an FM-phone signal having a maximum carrier deviation of plus or minus 6 kHz when modulated with a 2 kHz modulating frequency?

**3**

E8B05: What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz when the maximum modulation frequency is 3 kHz?

**1.67**

E8B06: What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus or minus 7.5 kHz when the maximum modulation frequency is 3.5 kHz?

**2.14**

E8B07: Orthogonal Frequency Division Multiplexing is a technique used for which type of amateur communication?

**High speed digital modes**

E8B08: What describes Orthogonal Frequency Division Multiplexing?

**A digital modulation technique using subcarriers at frequencies chosen to avoid intersymbol interference**

E8B09: What is meant by deviation ratio?

**The ratio of the maximum carrier frequency deviation to the highest audio modulating frequency**

E8B10: What describes frequency division multiplexing?

**Two or more information streams are merged into a baseband, which then modulates the transmitter**

E8B11: What is digital time division multiplexing?  
**Two or more signals are arranged to share discrete time slots of a data transmission**

Group E8C - Digital signals: digital communications modes; CW; information rate vs. bandwidth; spread-spectrum communications; modulation methods

E8C01: How is Forward Error Correction implemented?

**By transmitting extra data that may be used to detect and correct transmission errors**

E8C02: What is the definition of symbol rate in a digital transmission?

**The rate at which the waveform of a transmitted signal changes to convey information**

E8C03: When performing phase shift keying, why is it advantageous to shift phase precisely at the zero crossing of the RF carrier?

**This results in the least possible transmitted bandwidth for the particular mode**

E8C04: What technique is used to minimize the bandwidth requirements of a PSK31 signal?

**Use of sinusoidal data pulses**

E8C05: What is the necessary bandwidth of a 13-WPM international Morse code transmission?

**Approximately 52 Hz**

E8C06: What is the necessary bandwidth of a 170-hertz shift, 300-baud ASCII transmission?

**0.5 kHz**

E8C07: What is the necessary bandwidth of a 4800-Hz frequency shift, 9600-baud ASCII FM transmission?

**15.36 kHz**

E8C08: How does ARQ accomplish error correction?

**If errors are detected, a retransmission is requested**

E8C09: Which is the name of a digital code where each preceding or following character changes by only one bit?

**Gray code**

E8C10: What is an advantage of Gray code in digital communications where symbols are transmitted as multiple bits?

**It facilitates error detection**

E8C11: What is the relationship between symbol rate and baud?

**They are the same**

Group E8D - Waves, measurements, and RF grounding: peak-to-peak values, polarization; RF grounding

E8D01: Why are received spread spectrum signals resistant to interference?

**Signals not using the spread spectrum algorithm are suppressed in the receiver**

E8D02: What spread spectrum communications technique uses a high speed binary bit stream to shift the phase of an RF carrier?

**Direct sequence**

E8D03: How does the spread spectrum technique of frequency hopping work?

**The frequency of the transmitted signal is changed very rapidly according to a particular sequence also used by the receiving station**

E8D04: What is the primary effect of extremely short rise or fall time on a CW signal?

**The generation of key clicks**

E8D05: What is the most common method of reducing key clicks?

**Increase keying waveform rise and fall times**

E8D06: Which of the following indicates likely overmodulation of an AFSK signal such as PSK or MFSK?

**Strong ALC action**

E8D07: What is a common cause of overmodulation of AFSK signals?

**Excessive transmit audio levels**

E8D08: What parameter might indicate that excessively high input levels are causing distortion in an AFSK signal?

**Intermodulation Distortion (IMD)**

E8D09: What is considered a good minimum IMD level for an idling PSK signal?

**-30 dB**

E8D10: What are some of the differences between the Baudot digital code and ASCII?

**Baudot uses 5 data bits per character, ASCII uses 7 or 8; Baudot uses 2 characters as letters/figures shift codes, ASCII has no letters/figures shift code**

E8D11: What is one advantage of using ASCII code for data communications?

**It is possible to transmit both upper and lower case text**

E8D12: What is the advantage of including a parity bit with an ASCII character stream?

**Some types of errors can be detected**

Subelement E9 - Antennas And Transmission Lines  
Group E9A - Isotropic and gain antennas: definition; used as a standard for comparison; radiation pattern; basic antenna parameters: radiation resistance and reactance, gain, beamwidth, efficiency

E9A01: What describes an isotropic antenna?

**A theoretical antenna used as a reference for antenna gain**

E9A02: What antenna has no gain in any direction?

**Isotropic antenna**

E9A03: Why would one need to know the feed point impedance of an antenna?

**To match impedances in order to minimize standing wave ratio on the transmission line**

E9A04: Which of the following factors may affect the feed point impedance of an antenna?

**Antenna height, conductor length/diameter ratio and location of nearby conductive objects**

E9A05: What is included in the total resistance of an antenna system?

**Radiation resistance plus ohmic resistance**

E9A06: How does the beamwidth of an antenna vary as the gain is increased?

**It decreases**

E9A07: What is meant by antenna gain?

**The ratio of the radiated signal strength of an antenna in the direction of maximum radiation to that of a reference antenna**

E9A08: What is meant by antenna bandwidth?

**The frequency range over which an antenna satisfies a performance requirement**

E9A09: How is antenna efficiency calculated?

**(radiation resistance / total resistance) x 100 per cent**

E9A10: Which of the following choices is a way to improve the efficiency of a ground-mounted quarter-wave vertical antenna?

**Install a good radial system**

E9A11: Which of the following factors determines ground losses for a ground-mounted vertical antenna operating in the 3 MHz to 30 MHz range?

**Soil conductivity**

E9A12: How much gain does an antenna have compared to a 1/2-wavelength dipole when it has 6 dB gain over an isotropic antenna?

**3.85 dB**

E9A13: How much gain does an antenna have compared to a 1/2-wavelength dipole when it has 12 dB gain over an isotropic antenna?

**9.85 dB**

E9A14: What is meant by the radiation resistance of an antenna?

**The value of a resistance that would dissipate the same amount of power as that radiated from an antenna**

E9A15: What is the effective radiated power relative to a dipole of a repeater station with 150 watts transmitter power output, 2 dB feed line loss, 2.2 dB duplexer loss, and 7 dBd antenna gain?

**286 watts**

E9A16: What is the effective radiated power relative to a dipole of a repeater station with 200 watts transmitter power output, 4 dB feed line loss, 3.2 dB duplexer loss, 0.8 dB circulator loss, and 10 dBd antenna gain?

**317 watts**

E9A17: What is the effective radiated power of a repeater station with 200 watts transmitter power output, 2 dB feed line loss, 2.8 dB duplexer loss, 1.2 dB circulator loss, and 7 dBi antenna gain?

**252 watts**

E9A18: What term describes station output, taking into account all gains and losses?

**Effective radiated power**

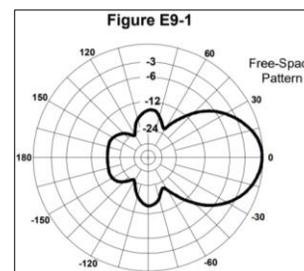
Group E9B - Antenna patterns: E and H plane patterns; gain as a function of pattern; antenna design; Yagi antennas

E9B01: In the antenna radiation pattern shown in Figure E9-1, what is the 3 dB beam-width?

**50 degrees**

E9B02: In the antenna radiation pattern shown in Figure E9-1, what is the front-to-back ratio?

**18 dB**



E9B03: In the antenna radiation pattern shown in Figure E9-1, what is the front-to-side ratio?

**14 dB**

E9B04: What may occur when a directional antenna is operated at different frequencies within the band for which it was designed?

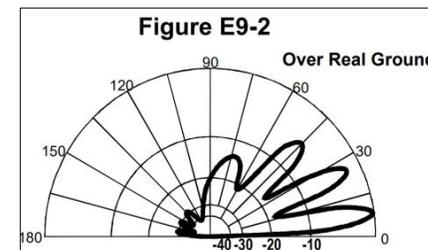
**The gain may change depending on frequency**

E9B05: What type of antenna pattern over real ground is shown in Figure E9-2?

**Elevation**

E9B06: What

is the elevation angle of peak response in the



antenna radiation pattern shown in Figure E9-2?

**7.5 degrees**

E9B07: How does the total amount of radiation emitted by a directional gain antenna compare with the total amount of radiation emitted from an isotropic antenna, assuming each is driven by the same amount of power?

**They are the same**

E9B08: How can the approximate beam-width in a given plane of a directional antenna be determined?

**Note the two points where the signal strength of the antenna is 3 dB less than maximum and compute the angular difference**

E9B09: What type of computer program technique is commonly used for modeling antennas?

**Method of Moments**

E9B10: What is the principle of a Method of Moments analysis?

**A wire is modeled as a series of segments, each having a uniform value of current**

E9B11: What is a disadvantage of decreasing the number of wire segments in an antenna model below the guideline of 10 segments per half-wavelength?

**The computed feed point impedance may be incorrect**

E9B12: What is the far field of an antenna?

**The region where the shape of the antenna pattern is independent of distance**

E9B13: What does the abbreviation NEC stand for when applied to antenna modeling programs?

**Numerical Electromagnetic Code**

E9B14: What type of information can be obtained by submitting the details of a proposed new antenna to a modeling program?

**All of these choices are correct**

SWR vs frequency charts

Polar plots of the far field elevation and azimuth patterns

Antenna gain

E9B15: What is the front-to-back ratio of the radiation pattern shown in Figure E9-2?

**28 dB**

E9B16: How many elevation lobes appear in the forward direction of the antenna radiation pattern shown in Figure E9-2?

**4**

Group E9C - Wire and phased vertical antennas: beverage antennas; terminated and resonant rhombic antennas; elevation above real ground; ground effects as related to polarization; take-off angles

E9C01: What is the radiation pattern of two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed 180 degrees out of phase?

**A figure-8 oriented along the axis of the array**

E9C02: What is the radiation pattern of two 1/4 wavelength vertical antennas spaced 1/4 wavelength apart and fed 90 degrees out of phase?

**Cardioid**

E9C03: What is the radiation pattern of two 1/4 wavelength vertical antennas spaced a 1/2 wavelength apart and fed in phase?

**A Figure-8 broadside to the axis of the array**

E9C04: What happens to the radiation pattern of an unterminated long wire antenna as the wire length is increased?

**The lobes align more in the direction of the wire**

E9C05: What is an OCFD antenna?

**A dipole feed approximately 1/3 the way from one end with a 4:1 balun to provide multiband operation**

E9C06: What is the effect of a terminating resistor on a rhombic antenna?

**It changes the radiation pattern from bidirectional to unidirectional**

E9C07: What is the approximate feed point impedance at the center of a two-wire folded dipole antenna?

**300 ohms**

E9C08: What is a folded dipole antenna?

**A dipole consisting of one wavelength of wire forming a very thin loop**

E9C09: What is a G5RV antenna?

**A multi-band dipole antenna fed with coax and a balun through a selected length of open wire transmission line**

E9C10: Which of the following describes a Zepp antenna?

**An end fed dipole antenna**

E9C11: How is the far-field elevation pattern of a vertically polarized antenna affected by being mounted over seawater versus rocky ground?

**The low-angle radiation increases**

E9C12: Which of the following describes an extended double Zepp antenna?

**A center fed 1.25 wavelength antenna (two 5/8 wave elements in phase)**

E9C13: What is the main effect of placing a vertical antenna over an imperfect ground?

**It reduces low-angle radiation**

E9C14: How does the performance of a horizontally polarized antenna mounted on the side of a hill compare with the same antenna mounted on flat ground?

**The main lobe takeoff angle decreases in the downhill direction**

E9C15: How does the radiation pattern of a horizontally polarized 3-element beam antenna vary with its height above ground?

**The main lobe takeoff angle decreases with increasing height**

Group E9D - Directional antennas: gain; satellite antennas; antenna beamwidth; losses; SWR bandwidth; antenna efficiency; shortened and mobile antennas; grounding

E9D01: How does the gain of an ideal parabolic dish antenna change when the operating frequency is doubled?

**Gain increases by 6 dB**

E9D02: How can linearly polarized Yagi antennas be used to produce circular polarization?

**Arrange two Yagis perpendicular to each other with the driven elements at the same point on the boom fed 90 degrees out of phase**

E9D03: Where should a high Q loading coil be placed to minimize losses in a shortened vertical antenna?

**Near the center of the vertical radiator**

E9D04: Why should an HF mobile antenna loading coil have a high ratio of reactance to resistance?

**To minimize losses**

E9D05: What is a disadvantage of using a multiband trapped antenna?

**It might radiate harmonics**

E9D06: What happens to the bandwidth of an antenna as it is shortened through the use of loading coils?

**It is decreased**

E9D07: What is an advantage of using top loading in a shortened HF vertical antenna?

**Improved radiation efficiency**

E9D08: What happens as the Q of an antenna increases?

**SWR bandwidth decreases**

E9D09: What is the function of a loading coil used as part of an HF mobile antenna?

**To cancel capacitive reactance**

E9D10: What happens to feed point impedance at the base of a fixed length HF mobile antenna as the frequency of operation is lowered?

**The radiation resistance decreases and the capacitive reactance increases**

E9D11: Which of the following types of conductors would be best for minimizing losses in a station's RF ground system?

**A wide flat copper strap**

E9D12: Which of the following would provide the best RF ground for your station?

**An electrically short connection to 3 or 4 interconnected ground rods driven into the Earth**

E9D13: What usually occurs if a Yagi antenna is designed solely for maximum forward gain?

**The front-to-back ratio decreases**

Group E9E - Matching: matching antennas to feed lines; power dividers

E9E01: What system matches a higher impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center?

**The delta matching system**

E9E02: What is the name of an antenna matching system that matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element and at a fraction of a wavelength to one side of center?

**The gamma match**

E9E03: What is the name of the matching system that uses a section of transmission line connected in parallel with the feed line at or near the feed point?

**The stub match**

E9E04: What is the purpose of the series capacitor in a gamma-type antenna matching network?

**To cancel the inductive reactance of the matching network**

E9E05: How must the driven element in a 3-element Yagi be tuned to use a hairpin matching system?

**The driven element reactance must be capacitive**

E9E06: What is the equivalent lumped-constant network for a hairpin matching system of a 3-element Yagi?

**A shunt inductor**

E9E07: What term best describes the interactions at the load end of a mismatched transmission line?

**Reflection coefficient**

E9E08: Which of the following measurements is characteristic of a mismatched transmission line?

**An SWR greater than 1:1**

E9E09: Which of these matching systems is an effective method of connecting a 50 ohm coaxial cable feed line to a grounded tower so it can be used as a vertical antenna?

**Gamma match**

E9E10: Which of these choices is an effective way to match an antenna with a 100 ohm feed point impedance to a 50 ohm coaxial cable feed line?

**Insert a 1/4-wavelength piece of 75 ohm coaxial cable transmission line in series between the antenna terminals and the 50 ohm feed cable**

E9E11: What is an effective way of matching a feed line to a VHF or UHF antenna when the impedances of both the antenna and feed line are unknown?

**Use the universal stub matching technique**

E9E12: What is the primary purpose of a phasing line when used with an antenna having multiple driven elements?

**It ensures that each driven element operates in concert with the others to create the desired antenna pattern**

E9E13: What is a use for a Wilkinson divider?

**It is used to divide power equally between two 50 ohm loads while maintaining 50 ohm input impedance**

Group E9F - Transmission lines: characteristics of open and shorted feed lines: 1/8 wavelength; 1/4 wavelength; 1/2 wavelength; feed lines: coax versus open-wire; velocity factor; electrical length; transformation characteristics of line terminated in impedance not

E9F01: What is the velocity factor of a transmission line?

**The velocity of the wave in the transmission line divided by the velocity of light in a vacuum**

E9F02: Which of the following determines the velocity factor of a transmission line?

**Dielectric materials used in the line**

E9F03: Why is the physical length of a coaxial cable transmission line shorter than its electrical length?

**Electrical signals move more slowly in a coaxial cable than in air**

E9F04: What is the typical velocity factor for a coaxial cable with solid polyethylene dielectric?

**0.66**

E9F05: What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz?

**3.5 meters**

E9F06: What is the approximate physical length of an air-insulated, parallel conductor transmission line that is electrically one-half wavelength long at 14.10 MHz?

**10 meters**

E9F07: How does ladder line compare to small-diameter coaxial cable such as RG-58 at 50 MHz?

**Lower loss**

E9F08: What is the term for the ratio of the actual speed at which a signal travels through a transmission line to the speed of light in a vacuum?

**Velocity factor**

E9F09: What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 7.2 MHz?

**6.9 meters**

E9F10: What impedance does a 1/8 wavelength transmission line present to a generator when the line is shorted at the far end?

**An inductive reactance**

E9F11: What impedance does a 1/8 wavelength transmission line present to a generator when the line is open at the far end?

**A capacitive reactance**

E9F12: What impedance does a 1/4 wavelength transmission line present to a generator when the line is open at the far end?

**Very low impedance**

E9F13: What impedance does a 1/4 wavelength transmission line present to a generator when the line is shorted at the far end?

**Very high impedance**

E9F14: What impedance does a 1/2 wavelength transmission line present to a generator when the line is shorted at the far end?

**Very low impedance**

E9F15: What impedance does a 1/2 wavelength transmission line present to a generator when the line is open at the far end?

**Very high impedance**

E9F16: Which of the following is a significant difference between foam dielectric coaxial cable and solid dielectric cable, assuming all other parameters are the same?

**All of these choices are correct**

Foam dielectric has lower safe operating voltage limits

Foam dielectric has lower loss per unit of length

Foam dielectric has higher velocity factor

**Group E9G - The Smith chart**

E9G01: Which of the following can be calculated using a Smith chart?

**Impedance along transmission lines**

E9G02: What type of coordinate system is used in a Smith chart?

**Resistance circles and reactance arcs**

E9G03: Which of the following is often determined using a Smith chart?

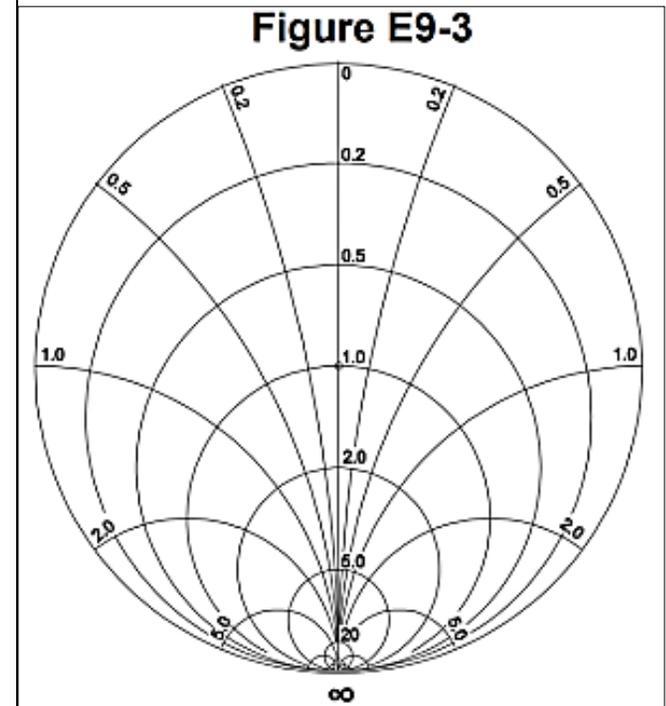
**Impedance and SWR values in transmission lines**

E9G04: What are the two families of circles and arcs that make up a Smith chart?

**Resistance and reactance**

E9G05: What type of chart is shown in Figure E9-3?

**Smith chart**



E9G06: On the Smith chart shown in Figure E9-3, what is the name for the large outer circle on which the reactance arcs terminate?

**Reactance axis**

E9G07: On the Smith chart shown in Figure E9-3, what is the only straight line shown?

**The resistance axis**

E9G08: What is the process of normalization with regard to a Smith chart?

**Reassigning impedance values with regard to the prime center**

E9G09: What third family of circles is often added to a Smith chart during the process of solving problems?

**Standing wave ratio circles**

E9G10: What do the arcs on a Smith chart represent?

**Points with constant reactance**

E9G11: How are the wavelength scales on a Smith chart calibrated?

**In fractions of transmission line electrical wavelength**

Group E9H - Effective radiated power; system gains and losses; radio direction finding antennas

E9H01: When constructing a Beverage antenna, which of the following factors should be included in the design to achieve good performance at the desired frequency?

**It should be one or more wavelengths long**

E9H02: Which is generally true for low band (160 meter and 80 meter) receiving antennas?

**Atmospheric noise is so high that gain over a dipole is not important**

E9H04: What is an advantage of using a shielded loop antenna for direction finding?

**It is electro statically balanced against ground, giving better nulls**

E9H05: What is the main drawback of a wire-loop antenna for direction finding?

**It has a bidirectional pattern**

E9H06: What is the triangulation method of direction finding?

**Antenna headings from several different receiving locations are used to locate the signal source**

E9H07: Why is it advisable to use an RF attenuator on a receiver being used for direction finding?

**It prevents receiver overload which could make it difficult to determine peaks or nulls**

E9H08: What is the function of a sense antenna?

**It modifies the pattern of a DF antenna array to provide a null in one direction**

E9H09: Which of the following describes the construction of a receiving loop antenna?

**One or more turns of wire wound in the shape of a large open coil**

E9H10: How can the output voltage of a multiple turn receiving loop antenna be increased?

**By increasing either the number of wire turns in the loop or the area of the loop structure or both**

E9H11: What characteristic of a cardioid pattern antenna is useful for direction finding?

**A very sharp single null**

Subelement E0 - Safety

Group E0A - Safety: amateur radio safety practices; RF radiation hazards; hazardous materials

E0A01: What is the primary function of an external earth connection or ground rod?

**Lightning protection**

E0A02: When evaluating RF exposure levels from your station at a neighbor's home, what must you do?

**Make sure signals from your station are less than the uncontrolled MPE limits**

E0A03: Which of the following would be a practical way to estimate whether the RF fields produced by an amateur radio station are within permissible MPE limits?

**Use an antenna modeling program to calculate field strength at accessible locations**

E0A04: When evaluating a site with multiple transmitters operating at the same time, the operators and licensees of which transmitters are responsible for mitigating over-exposure situations?

**Each transmitter that produces 5 percent or more of its MPE limit at accessible locations**

E0A05: What is one of the potential hazards of using microwaves in the amateur radio bands?

**The high gain antennas commonly used can result in high exposure levels**

E0A06: Why are there separate electric (E) and magnetic (H) field MPE limits?

**All of these choices are correct**

The body reacts to electromagnetic radiation from both the E and H fields

Ground reflections and scattering make the field impedance vary with location

E field and H field radiation intensity peaks can occur at different locations

E0A07: How may dangerous levels of carbon monoxide from an emergency generator be detected?

**Only with a carbon monoxide detector**

E0A08: What does SAR measure?

**The rate at which RF energy is absorbed by the body**

E0A09: Which insulating material commonly used as a thermal conductor for some types of electronic devices is extremely toxic if broken or crushed and the particles are accidentally inhaled?

**Beryllium Oxide**

E0A10: What toxic material may be present in some electronic components such as high voltage capacitors and transformers?

**Polychlorinated Biphenyls**

E0A11: Which of the following injuries can result from using high-power UHF or microwave transmitters?

**Localized heating of the body from RF exposure in excess of the MPE limits**