Element 4 Study Guide - Preliminary

2024-2028 FCC Element 4 Question Pool
Effective for VEC Examinations on
July 1, 2024 thru June 30, 2028

SUBELEMENT E1 – COMMISSION’S RULES - [6 Exam Questions - 6 Groups] 57 Questions

E1A – Frequency privileges; signal frequency range; automatic message forwarding; stations aboard ships or aircraft; power restriction on 630- and 2200-meter bands

E1A01 [97.305, 97.307(b)]
It is not legal to transmit a 3 kHz bandwidth USB signal with a carrier frequency of 14.348 MHz because the upper 1 kHz of the signal is outside the 20-meter band.

E1A02 [97.301, 97.305]
When using a transceiver that displays the carrier frequency of phone signals, the lowest frequency at which a properly adjusted LSB emission will be totally within the band is 3 kHz above the lower band edge.

E1A03 [97.305, 97.307(b)]
The highest legal carrier frequency on the 20-meter band for transmitting a 2.8 kHz wide USB data signal is 14.1472 MHz.

E1A04 [97.301, 97.305]
An Extra class operator may not answer the CQ of a station on 3.601 MHz LSB phone because the sideband components will extend beyond the edge of the phone band segment.

E1A05 [97.5]
Any person holding an FCC issued amateur license or who is authorized for alien reciprocal operation 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.

E1A06 [97.303(h)(1)]
For channelized 60 meter operation the required transmit frequency of a CW signal is at the center frequency of the channel.

E1A07 [97.313(k)]
The maximum power permitted on the 2200-meter band is 1 watt EIRP (equivalent isotropic radiated power).

E1A08 [97.219]
If a station in a message forwarding system inadvertently forwards a message that is in violation of FCC rules, the control operator of the originating station is primarily accountable for the rules violation.

E1A09 [97.313(l)]
Except in some parts of Alaska, the maximum power permitted on the 630-meter band is 5 watts EIRP (equivalent isotropic radiated power).

E1A10 [97.11]
If an amateur station is installed aboard a ship or aircraft, before the station is operated its (the station's) operation must be approved by the master of the ship or the pilot in command of the aircraft.

E1A11 [97.5]
When operating an amateur station aboard a US-registered vessel in international waters the operator must hold any FCC-issued amateur license.

E1B Station restrictions and special operations: restrictions on station location; general operating restrictions; spurious emissions; antenna structure restrictions; RACES operations

E1B01 [97.3]
An emission outside the signal’s necessary bandwidth that can be reduced or eliminated without affecting the information transmitted constitutes a spurious emission.

E1B02 [97.307(f)(2)]
3 kHz is an acceptable bandwidth for digital voice or slow-scan TV transmissions made on the HF amateur bands anything wider is unacceptable.

E1B03 [97.13]
An amateur station must protect an FCC monitoring facility within 1 mile distance from harmful interference.

E1B04 [97.303(b)]
If a radiolocation system experiences interference from a repeater operating in the 70-centimeter band, the control operator of a repeater must cease operation or make changes to the repeater that mitigate the interference.

E1B05 [97.3]
The National Radio Quiet Zone is an area surrounding the National Radio Astronomy Observatory.

E1B06 [97.15]
If you are erecting an amateur station antenna structure 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 the FCC rules.

E1B07 [97.15]
PRB-1 applies to state and local zoning regulations.

E1B08 [97.121]
If an amateur station's signal causes interference to domestic broadcast reception, assuming that the receivers involved are of good engineering design, the FCC may require the amateur station to avoid transmitting during certain hours on frequencies that cause the interference.

E1B09 [97.407]
Any FCC-licensed amateur station certified by the responsible civil defense organization for the area served may be operated under RACES rules.

E1B10 [97.407]
All amateur service frequencies authorized to the control operator are authorized to an amateur station operating under RACES rules.

E1B11 [97.15]
PRB-1 requires state and local regulations affecting amateur radio antenna size and structures to provide reasonable accommodations to amateur radio.

E1C Automatic and remote control; band-specific regulations; operating in and communicating with foreign countries; spurious emission standards; HF modulation index limit; band-specific rules

E1C01 [97.303]
The maximum bandwidth for a data emission on 60 meters is 2.8 kHz.

E1C02 [97.117]
Communications transmitted to amateur stations in foreign countries must be limited to those incidental to the purpose of the amateur service and remarks of a personal nature.

E1C03 [97.303(g)]
An operator may operate on the 2200-meter or 630-meter band 30 days after filing a notification with the Utilities Technology Council (UTC), providing they have not been told that their station is within 1 kilometer of PLC systems using those frequencies.

E1C04
An IARP (International Amateur Radio Permit) is a permit that allows US amateurs to operate in certain countries of the Americas.

E1C05 [97.221(c)(1), 97.115(c)]
A station may transmit third party communications while being automatically controlled only when transmitting RTTY or data emissions.

E1C06
In order to operate in accordance with CEPT rules in foreign countries where permitted, you must have a copy of FCC Public Notice DA 16-1048.

E1C07 [97.303(g)]
Before transmitting on the 630- or 2200-meter bands, operators must inform the Utilities Technology Council (UTC) of their call sign and coordinates of the station.

E1C08 [97.213]
If a remotely controlled station's control link malfunctions the maximum permissible duration of its transmissions is 3 minutes.

E1C09 [97.307]
The highest modulation index permitted at the highest modulation frequency for angle modulation below 29.0 MHz is 1.0.

E1C10 [97.307]
The maximum mean power level for a spurious emission below 30 MHz with respect to the fundamental emission is -43dB.

E1C11 [97.5]
CEPT (European Conference of Postal and Telecommunications Administrations) is an operating arrangement allowing an FCC-licensed US citizen to operate in many European countries, and amateurs from many European countries to operate in the US.

E1C12 [97.305(c)]
Phone emissions are permitted on the entire 630-meter band.

E1D Amateur Space and Earth stations; telemetry and telecommand rules; identification of balloon transmissions; one-way communications

E1D01 [97.3]
Telemetry is defined as one-way transmission of measurements at a distance from the measuring instrument.

E1D02 [97.211(b)]
Telecommand signals from a space telecommand station may be encrypted; telecommand signals to terrestrial repeaters, auxiliary relay links carrying repeater audio, or mesh network backbone nodes may not.

E1D03 [97.3(a)(45)]
A space telecommand station is an amateur station that transmits communications to initiate, modify, or terminate functions of a space station.

E1D04 [97.119(a)]
A call sign is required in the identification transmissions from a balloon-borne telemetry station.

E1D05 [97.213(d)]
A station being operated by telecommand on or within 50 kilometers of the Earth’s surface must have a photocopy of the station license, a label with the name, address, and telephone number of the station licensee, and a label with the name, address, and telephone number of the control operator posted at the location of the station.

E1D06 [97.215(c)]
The maximum permitted transmitter output power when operating a model craft by telecommand is 1 watt.

E1D07 [97.207]
The amateur HF 40 meter, 20 meter, 15 meter, and 10 meter bands include allocations for space stations.

E1D08 [97.207]
The VHF 2 meter amateur band has frequencies authorized for space stations.

E1D09 [97.207]
The UHF 70 centimeter and 13 centimeter amateur bands have frequencies authorized for space stations.

E1D10 [97.211]
Any amateur station so designated by the space station licensee is eligible to be telecommand station of space stations, subject to the privileges of the class of operator license held by the control operator of the station.

E1D11 [97.209]
Any amateur station, subject to the privileges of the class of operator license held by the control operator is eligible to operate as Earth stations.

E1D12 [97.207(e), 97.203(g)]
A space station, beacon station, or telecommand station may transmit one-way communications.

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

E1E01 [97.527]
Part 97 rules state that VEs (Volunteer Examiners) and VECs (Volunteer Examiner Coordinators) may be reimbursed for expenses preparing, processing, administering, and coordinating an examination for an amateur radio operator license.

E1E02 [97.523]
The VECs (Volunteer Examiner Coordinators) are tasked by Part 97 with maintaining the pools of questions for all US amateur license examinations.

E1E03 [97.521]
A Volunteer Examiner Coordinator (VEC) an organization that has entered into an agreement with the FCC to coordinate, prepare, and administer amateur operator license examinations.

E1E04 [97.509, 97.525]
To be accredited as a Volunteer Examiner a VEC must confirm that the VE applicant meets FCC requirements to serve as an examiner.

E1E05 [97.509(j)]
If an examinee does not pass the exam the VE team must return the application document to the examinee.

E1E06 [97.509]
Each administering VE is responsible for the proper conduct and necessary supervision during an amateur operator license examination session.

E1E07 [97.509, 97.511]
If a candidate fails to comply with the examiner’s instructions during an amateur operator license examination the VEs should immediately terminate the candidate’s examination.

E1E08 [97.509]
A VE may not administer an examination to relatives of the VE as listed in the FCC rules.

E1E09 [97.509]
A VE who fraudulently administers or certifies an examination may be subject to revocation of the VE’s amateur station license grant and the suspension of the VE’s amateur operator license grant.

E1E10 [97.509(m)]
After the administration of a successful examination for an amateur operator license, the administering VEs must submit the application document to the coordinating VEC according to the coordinating VEC instructions.

E1E11 [97.509(i)]
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.

E1F Miscellaneous rules: external RF power amplifiers; prohibited communications; spread spectrum; auxiliary stations; Canadian amateurs operating in the US; special temporary authority

E1F01 [97.305]
Spread spectrum transmissions permitted only on amateur frequencies above 222 MHz.

E1F02 [97.107]
Persons holding an amateur service license granted by the government of Canada are authorized privileges according to the operating terms and conditions of the Canadian amateur service license, not to exceed US Amateur Extra class license privileges.

E1F03 [97.315]
A dealer may sell an external RF power amplifier capable of operation below 144 MHz if it has not been granted FCC certification if the amplifier is constructed or modified by an amateur radio operator for use at an amateur station.

E1F04 [97.3]
"Line A" is geographically described as a line roughly parallel to and south of the border between the US and Canada.

E1F05 [97.303]
Amateur stations may not transmit in the 420 MHz - 430 MHz frequency segments if they are located in the contiguous 48 states and north of Line A.

E1F06 [1.931]
The FCC may issue a Special Temporary Authority (STA) to an amateur station to provide for experimental amateur communications.

E1F07 [97.113]
An amateur station send a message to a business only when neither the amateur nor their employer has a pecuniary interest in the communications.

E1F08 [97.113(c)]
Communications transmitted for hire or material compensation, except as otherwise provided in the rules, are prohibited.

E1F09 [FCC Part 97.113(a)(4)]
Messages encoded to obscure their meaning cannot be transmitted over an amateur radio mesh network.

E1F10 [97.201]
Only Technician, General, Advanced, or Amateur Extra class operators may be the control operator of an auxiliary station.

E1F11 [97.317]
To qualify for a grant of FCC certification one of the standards that must be met by an external RF power amplifier is it must satisfy the FCC’s spurious emission standards when operated at the lesser of 1500 watts or its full output power

SUBELEMENT E2 - OPERATING PROCEDURES [5 Exam Questions - 5 Groups]

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

E2A01
The direction of an ascending pass for an amateur satellite is from south to north.

E2A02
An inverting linear transponder will have reduced doppler shift because the uplink and downlink shifts are in opposite directions, signal position in the band will be reversed, and upper sideband on the uplink will become lower sideband on the downlink, and vice versa.

E2A03
An inverting linear transponder mixes the upload signal with a local oscillator signal and transmits the difference product.

E2A04
The “mode” of an amateur radio satellite means the satellite’s uplink and downlink frequency bands.

E2A05
The letters in a satellite’s mode designator specify the uplink and downlink frequency ranges.

E2A06
Keplerian elements are parameters that define the orbit of a satellite.

E2A07
FM, CW, SSB, SSTV, PSK and packet signals can be relayed through a linear transponder.

E2A08
Effective radiated power (ERP) should be limited to a satellite that uses a linear transponder to avoid reducing the downlink power to all other users.

E2A09
The terms “L band” and “S band” specify the 23- and 13-centimeter bands.

E2A10
Geostationary satellite appears to stay in one position in the sky.

E2A11
A circularly polarized antenna can be used to minimize the effects of spin modulation and Faraday rotation.

E2A12
The purpose of digital store-and-forward functions on an amateur radio satellite is to hold digital messages in the satellite for later download.

E2A13
Store-and-forward is a technique used by digital satellites to relay messages.

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

E2B01
In digital television, a coding rate of 3/4 means 25% of the data sent is forward error correction data.

E2B02
525 horizontal lines make up a fast-scan (NTSC) television frame.

E2B03
An interlaced scanning pattern is generated in a fast-scan (NTSC) television system by scanning odd-numbered lines in one field and even-numbered lines in the next.

E2B04
Color lines are sent sequentially in analog SSTV (Slow-Scan TeleVision).

E2B05
In analog fast-scan TV transmissions vestigial sideband reduces the bandwidth while increasing the fidelity of low frequency video components.

E2B06
Vestigial sideband modulation is amplitude modulation in which one complete sideband and a portion of the other are transmitted.

E2B07
QAM (Quadrature Amplitude Modulation) and QPSK (Quadrature Phase-Shift Keying)
are used for amateur television DVB-T (Digital Video Broadcasting – Terrestrial) signals

E2B08
Transmitting on channels shared with cable TV allows commercial analog TV receivers to be used for fast-scan TV operations on the 70-centimeter band.

E2B09
SSB receivers can be used to receive and decode SSTV using the Digital Radio Mondiale (DRM) protocol.

E2B10
The tone frequency of an analog slow-scan television signal encodes the brightness of the picture

E2B11
The function of the vertical interval signaling (VIS) code sent as part of an SSTV transmission is to identify the SSTV mode being used.

E2B12
Specific tone frequencies signal SSTV receiving software to begin a new picture line.

E2C Contest and DX operating; remote operation techniques; log data format; contact confirmation; RF network systems

E2C01
No additional indicator is required to be used by US-licensed operators when operating a station via remote control and the remote transmitter is located in the US.

E2C02
ADIF file format is used for exchanging amateur radio log data, NEC, ARLD, and OCF are not.

E2C03
Amateur radio contesting is generally excluded from the 30-meter band.

E2C04
Amateur radio mesh networks can be used on frequencies shared with various unlicensed wireless data services but not on HF frequencies where digital communications are permitted, cable TV channels 41-43, or the 60-meter band channel centered on 5373 kHz.

E2C05
The function of a DX QSL Manager is to handle the receiving and sending of confirmations for a DX station.

E2C06
During a VHF/UHF contest, you wouldexpect to find the highest level of SSB or CW activity in the weak signal segment of the band, with most of the activity near the calling frequency.

E2C07
The Cabrillo format is a standard for submission of electronic contest logs.

E2C08
Special event contacts between stations in the US, contacts between a US station and a non-US station, and contacts for Worked All States credit may be confirmed through the Logbook of The World (LoTW).

E2C09
A wireless router running custom firmware is commonly used to implement an amateur radio mesh network.

E2C10
DX stations often transmit and receive on different frequencies 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, and to improve operating efficiency by reducing interference.

E2C11
When attempting to contact a DX station during a contest or in a pileup you should generally identify your station by sending your full call sign once or twice.

E2C12 (C)
Latency is the delay between a control operator action and the corresponding change in the transmitted signal.

E2D Operating methods: digital modes and procedures for VHF and UHF; APRS; EME procedures; meteor scatter procedures

E2D01
MSK144 is the digital mode designed for meteor scatter communications.

E2D02
Grid square information replaces signal-to-noise ratio when using the FT8 or FT4 modes in a VHF contest.

E2D03
Q65 is a digital mode designed for EME communications.

E2D04
APRS technology is used for real-time tracking of balloons carrying amateur radio transmitters.

E2D05
The characteristic of the JT65 mode is it 65 baud symbol rate.

E2D06
Time-synchronous transmissions alternating between stations is a method for establishing EME contacts.

E2D07
APRS uses the AX.25 digital protocol.

E2D08
APRS beacon data is transmitted by unnumbered Information packet frame.

E2D09
JT65 uses Multitone AFSK modulation.

E2D10
The packet path WIDE3-1 designates three digipeater hops are requested with one remaining.

E2D11
APRS stations relay data using packet digipeaters.

E2E Operating methods: digital modes and procedures for HF

E2E01
FSK (Frequency-Shift Keying) modulation is used for data emissions below 30 MHz, DTMF tones modulating an FM signal, Pulse modulation, and spread spectrum are not.

E2E02
Synchronization of computer clocks synchronizes WSJT-X digital mode transmit/receive timing; alignment of frequency shifts, sync-field transmission, and sync-pulse timing are not.

E2E03
The "4" in FT4 refers to four-tone continuous-phase frequency shift keying.

E2E04
Four-tone Gaussian frequency shift keying, variable transmit/receive periods, and seven different tone spacings are characteristic of the FST4 mode.

E2E05
WSPR is a digital mode which does not support keyboard-to-keyboard operation; RTTY, PSK31, and MFSK16 do.

E2E06
The length of an FT8 transmission cycle is 15 seconds.

E2E07 (C)
Q65 differs from JT65 in that Q65 averages multiple receive cycles.

E2E08
PACTOR is an HF digital mode which can be used to transfer binary files; PSK31, RTTY, and AMTOR can not.

E2E09
PSK31is an HF digital mode using variable-length character coding; RTTY, PACTOR, and MT63 do not.

E2E10
FT8 has narrower bandwidth than MFSK16; 170 Hz shift, 45-baud RTTY; or PACTOR IV.

E2E11
The difference between direct FSK and audio FSK is that direct FSK modulates the transmitter VFO.

E2E12
ALE stations establish contact by constantly scanning a list of frequencies, activating the radio when the designated call sign is received.

E2E13
Under clear communication conditions, PACTOR IV has higher data throughput than MFSK16; 170 Hz shift, 45 baud RTTY; or FT8.

SUBELEMENT E3 - RADIO WAVE PROPAGATION [3 Exam Questions - 3 Groups]

E3A Electromagnetic Waves and Specialized Propagation: Earth-Moon-Earth (EME) communications; meteor scatter; microwave tropospheric and scatter propagation; auroral propagation; daily variation of ionospheric propagation; circular polarization

E3A01
The approximate maximum separation measured along the surface of the Earth between two stations communicating by EME is 12,000 miles, if the moon is “visible” by both stations.

E3A02
Libration fading of an EME signal is characterized by a fluttery, irregular fading.

E3A03
Scheduling EME contacts when the Moon is at perigee, will generally result in the least path loss compared to when the Moon is full, when the Moon is at apogee, or when the MUF is above 30 MHz.

E3A04
An electromagnetic wave travels at a right angle to the electric and magnetic fields.

E3A05
The component fields of an electromagnetic wave oriented are at right angles.

E3A06
When the MUF for that path decreases due to darkness, to continue a long-distance contact, switch to a lower frequency HF band.

E3A07
Atmospheric ducts capable of propagating microwave signals often form over large bodies of water.

E3A08
When a meteor strikes the Earth’s atmosphere, a linear ionized region is formed at the E region of the ionosphere.

E3A09
The frequency ranges 28 MHz - 148 MHz are most suited for meteor-scatter communications when compared to the ranges 1.8 MHz - 1.9 MHz, 10 MHz - 14 MHz, and 220 MHz - 450 MHz.

E3A10
The index of refraction determines the speed of electromagnetic waves through a medium.

E3A11
A typical range for tropospheric duct propagation of microwave signals is 100 miles to 300 miles.

E3A12
Severe geomagnetic storms are most likely to result in auroral propagation.

E3A13
The CW emission mode is best for auroral propagation when compared to SSB, FM, or RTTY.

E3A14
Circularly polarized electromagnetic waves are waves with rotating electric and magnetic fields.

E3B Transequatorial propagation; long-path propagation; ordinary and extraordinary waves; chordal hop; sporadic-E mechanisms; ground-wave propagation

E3B01
Transequatorial propagation (TEP) are most likely to occur between points separated by 2,000 miles to 3,000 miles over a path perpendicular to the geomagnetic equator.

E3B02
The approximate maximum range for signals using transequatorial propagation is 5,000 miles.

E3B03
Transequatorial propagation is most likely to occur in the afternoon or early evening.

E3B04
“Extraordinary” and “ordinary” waves are independently propagating, elliptically polarized waves created in the ionosphere.

E3B05
A path entirely in darkness is more likely to support long-distance propagation on 160 meters than a path entirely in sunlight, paths at high latitudes, or a direct north-south path.

E3B06
Long-path propagation most frequent on the 40 and 20 meter bands compared to 160 meters and 80 meters, 10 meters and 6 meters, or 6 meters and 2 meters.

E3B07
Lowering a signal’s transmitted elevation angle on ionospheric HF skip will increase the distance covered by each hop.

E3B08
When the signal frequency is increased the maximum range of ground-wave propagation decreases.

E3B09
Sporadic-E propagation is most likely to occur around the solstices, especially the summer solstice.

E3B10
Chordal-hop propagation results in a signal experiencing less loss compared to multi-hop propagation, which uses Earth as a reflector.

E3B11
Sporadic-E propagation is most likely to occur between sunrise and sunset.

E3B12
Chordal-hop propagation is successive ionospheric refractions without an intermediate reflection from the ground.

E3B13
Vertical polarization is supported by ground-wave propagation.

E3C Propagation prediction and reporting: radio horizon; effects of space-weather phenomena

E3C01
Solar flares can cause of short-term radio blackouts.

E3C02
A rising A-index or K-index indicates an increasing disturbance of the geomagnetic field.

E3C03
Signal paths through the auroral oval are most likely to experience high levels of absorption when the A-index or K-index is elevated.

E3C04
The value of Bz (B sub z) represents the north-south strength of the interplanetary magnetic field.

E3C05
Southward orientation of Bz (B sub z) increases the likelihood that charged particles from the Sun will cause disturbed conditions.

E3C06
The VHF/UHF radio horizon is approximately 15 percent farther than the geographic horizon.

E3C07
Class X indicates the greatest solar flare intensity.

E3C08
G5 is the space-weather term for an extreme geomagnetic storm.

E3C09
Digital-mode and CW signals are reported by amateur radio propagation reporting networks.

E3C10
The 304A solar parameter measures UV emissions at 304 angstroms, correlated to the solar flux index.

E3C11
VOACAP software models HF propagation

E3C12
A sudden rise in radio background noise across a large portion of the HF spectrum indicates a coronal mass ejection impact or a solar flare has occurred.

SUBELEMENT E4 - AMATEUR PRACTICES [5 Exam Questions - 5 Groups]

E4A Test equipment: analog and digital instruments; spectrum analyzers; antenna analyzers; oscilloscopes; RF measurements

E4A01
The sampling rate of the analog-to-digital converter limits the highest frequency signal that can be accurately displayed on a digital oscilloscope.

E4A02
A spectrum analyzer displays signal amplitude and frequency on the vertical and horizontal axes.

E4A03
A spectrum analyzer is used to display spurious signals and/or intermodulation distortion products generated by an SSB transmitter.

E4A04
Compensation of an oscilloscope probe is performed by displaying a square wave, and adjusting the probe until the horizontal portions of the displayed wave are as nearly flat as possible.

E4A05
The purpose of using a prescaler with a frequency counter is to reduce the signal frequency to within the counter's operating range.

E4A06
When displaying a waveform on a digital oscilloscope aliasing will result in a false, jittery low-frequency version of the waveform being displayed.

E4A07
An advantage of using an antenna analyzer compared to an SWR bridge is antenna analyzers compute SWR and impedance automatically.

E4A08
SWR can be measured by a directional wattmeter, a vector network analyzer, or an antenna analyzer.

E4A09
Minimizing the length of the probe's ground connection is good practice when using an oscilloscope probe.

E4A10
Line trigger mode is most effective when using an oscilloscope to measure a linear power supply’s output ripple.

E4A11
An antenna analyzer can measure velocity factor, cable length, and resonant frequency of a tuned circuit.

E4B Measurement technique and limitations: instrument accuracy and performance limitations; probes; techniques to minimize errors; measurement of Q; instrument calibration; S parameters; vector network analyzers; RF signals

E4B01
Time base accuracy has more effect on the accuracy of a frequency counter than input attenuator accuracy, decade divider accuracy, or temperature coefficient of the logic.

E4B02
The significance of voltmeter sensitivity expressed in ohms per volt is the full scale reading of the voltmeter multiplied by its ohms per volt rating providing the input impedance of the voltmeter.

E4B03
The S21 parameter is equivalent to forward gain.

E4B04
The S11 parameter represents input port return loss or reflection coefficient (equivalent to VSWR).

E4B05
The three test loads used to calibrate an RF vector network analyzer are short circuit, open circuit, and 50 ohms.

E4B06
75 watts of 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 (100W - 25W = 75W).

E4B07
The subscripts of S parameters represent the port or ports at which measurements are made.

E4B08
The bandwidth of the circuit's frequency response can be used to determine the Q of a series-tuned circuit.

E4B09
Filter frequency response can be measured by a two-port vector network analyzer.

E4B10
Intermodulation distortion in an SSB transmitter can be measured by modulating the transmitter using two AF signals having non-harmonically related frequencies and observing the RF output with a spectrum analyzer.

E4B11
A vector network analyzer can measure input impedance, output impedance, and reflection coefficient.

E4C Receiver performance: phase noise, noise floor, image rejection, minimum detectable signal (MDS), increasing signal-to-noise ratio and dynamic range, noise figure, reciprocal mixing; selectivity; SDR non-linearity; use of attenuators at low frequencies

E4C01
Excessive phase noise in an SDR receiver’s master clock oscillator can combine with strong signals on nearby frequencies to generate interference.

E4C02
A front-end filter or preselector can be effective in eliminating interference from strong out-of-band signals.

E4C03
Capture effect is the term for the suppression in an FM receiver of one signal by another stronger signal on the same frequency.

E4C04
The noise figure of a receiver is the ratio in dB of the noise generated by the receiver to the theoretical minimum noise.

E4C05
A receiver noise floor of -174 dBm represents the theoretical noise in a 1 Hz bandwidth at the input of a perfect receiver at room temperature.

E4C06
Increasing a receiver’s bandwidth from 50 Hz to 1,000 Hz increases the receiver’s noise floor 13 dB.

E4C07
The MDS of a receiver represents the minimum discernible signal.

E4C08
An SDR receiver is overloaded when input signals exceeds the reference voltage of the analog-to-digital converter.

E4C09
Making it easier for front-end circuitry to eliminate image responses is a good reason for selecting a high IF for a superheterodyne HF or VHF communications receiver.

E4C10
An advantage of having a variety of receiver bandwidths from which to select is receive bandwidth can be set to match the modulation bandwidth, maximizing signal-to-noise ratio and minimizing interference.

E4C11
Input attenuation reduces receiver overload on the lower frequency HF bands with little or no impact on signal-to-noise ratio because atmospheric noise is generally greater than internally generated noise even after attenuation.

E4C12
A narrow-band roofing filter affects receiver performance because it improves blocking dynamic range by attenuating strong signals near the receive frequency.

E4C13
Reciprocal mixing is local oscillator phase noise mixing with adjacent strong signals to create interference to desired signals.

E4C14
The purpose of the receiver IF Shift control is to reduce interference from stations transmitting on adjacent frequencies.

E4D Receiver performance characteristics: dynamic range; intermodulation and cross-modulation interference; third-order intercept; desensitization; preselector; sensitivity; link margin

E4D01
The blocking dynamic range of a receiver is the difference in dB between the noise floor and the level of an incoming signal that will cause 1 dB of gain compression.

E4D02
Poor dynamic range in a receiver can result in signals caused by cross modulation and desensitization from strong adjacent signals.

E4D03
The output signals mixing in the final amplifier of one or both transmitters creates intermodulation interference between two repeaters in close proximity.

E4D04
A properly terminated circulator at the output of the repeater's transmitter is used to reduce or eliminate intermodulation interference in a repeater caused by a nearby transmitter.

E4D05
Transmitter frequencies 146.34 MHz and 146.61 MHz would create an intermodulation-product signal in a receiver tuned to 146.70 MHz when a nearby station transmits on 146.52 MHz.

E4D06
Desensitization is the term for the reduction in receiver sensitivity caused by a strong signal near the received frequency.

E4D07
Inserting attenuation before the first RF stage reduces the likelihood of receiver desensitization.

E4D08
Nonlinear circuits or devices cause intermodulation in an electronic circuit.

E4D09
The purpose of the preselector in a communications receiver is to increase the rejection of signals outside the band being received.

E4D10
With respect to receiver performance a third-order intercept level of 40 dBm means a pair of 40 dBm input signals will theoretically generate a third-order intermodulation product that has the same output amplitude as either of the input signals.

E4D11
Odd-order intermodulation products, created within a receiver, are of particular interest compared to other products because odd-order products of two signals in the band being received are also likely to be within the band.

E4D12
In a system with a transmit power level of 10 W (+40 dBm), a system antenna gain of 10 dBi, a cable loss of 3 dB, a path loss of 136 dB, a receiver minimum discernable signal of -103 dBm, and a required signal-to-noise ratio of 6 dB, the link margin is +8dB.

E4D13
With a transmit power of 10 W (+40 dBm), a transmit antenna gain of 6 dBi, a receive antenna gain of 3 dBi, and a path loss of 100 dB, the received signal level is -51 dBm.

E4D14
A receiver minimum discernible signal of -100 dBm represents a power level of 0.1 picowatts.

E4E Noise and interference: external RF interference; electrical and computer noise; line noise; DSP filtering and noise reduction; common-mode current; surge protectors; single point ground panel

E4E01
Using an automatic notch filter (ANF) to remove interfering carriers while receiving CW signals can result in removal of the CW signal as well as the interfering carrier.

E4E02
Broadband white noise, ignition noise, and power line noise can often be reduced by a digital noise reduction.

E4E03
Impulse noiseis removed by a noise blanker.

E4E04
Conducted noise from an automobile battery charging system be suppressed by installing ferrite chokes on the charging system leads.

E4E05
A brute-force AC-line filter in series with the motor’s power leads is used to suppress radio frequency interference from a line-driven AC motor.

E4E06
Computer network equipment can cause the appearance of unstable modulated or unmodulated signals at specific frequencies.

E4E07
Common-mode currents on the shield and conductors can cause shielded cables to radiate or receive interference.

E4E08
Common-mode current flows equally on all conductors of an unshielded multiconductor cable.

E4E09
An undesirable effect of using a noise blanker, is strong signals may be distorted and appear to cause spurious emissions.

E4E10
Arcing contacts in a thermostatically controlled device, a defective doorbell or doorbell transformer inside a nearby residence, or a malfunctioning illuminated advertising display can create intermittent loud roaring or buzzing AC line interference.

E4E11
Nearby corroded metal connections mixing and reradiating the broadcast signals could be the cause of local AM broadcast band signals combining to generate spurious signals on the MF or HF bands.

E4E12
Switch-mode power supplies can cause interference received as a series of carriers at regular intervals across a wide frequency range.

E4E13
A station AC surge protector should be installed on the single point ground panel.

E4E14
The purpose of a single point ground panel is to ensure all lightning protectors activate at the same time.

SUBELEMENT E5 - ELECTRICAL PRINCIPLES [4 Exam Questions - 4 Groups]

E5A Resonance and Q: characteristics of resonant circuits; series and parallel resonance; definitions and effects of Q; half-power bandwidth

E5A01
Resonance can cause the voltage across reactances in a series RLC circuit to be higher than the voltage applied to the entire circuit.

E5A02
The resonant frequency of an RLC circuit if R is 22 ohms, L is 50 microhenries, and C is 40 picofarads is 3.56 MHz.

E5A03
The magnitude of the impedance of a series RLC circuit at resonance is approximately equal to circuit resistance.

E5A04
The magnitude of the impedance of a parallel RLC circuit at resonance is approximately equal to circuit resistance.

E5A05
The result of increasing the Q of an impedance-matching circuit is the matching bandwidth is decreased.

E5A06
The magnitude of the circulating current within the components of a parallel LC circuit at resonance is at a maximum.

E5A07
The magnitude of the current at the input of a parallel RLC circuit at resonance is minimum.

E5A08 (C)
The current through and the voltage are in phase across a series resonant circuit at resonance.

E5A09
The Q of an RLC parallel resonant circuit is calculated by dividing resistance by the reactance of either the inductance or capacitance.

E5A10
The resonant frequency of an RLC circuit if R is 33 ohms, L is 50 microhenries, and C is 10 picofarads is 7.12 MHz.

E5A11
The half-power bandwidth of a resonant circuit having a resonant frequency of 7.1 MHz and a Q of 150 is 47.3 kHz.

E5A12
The half-power bandwidth of a resonant circuit having a resonant frequency of 3.7 MHz and a Q of 118 is 31.4 kHz.

E5A13
An effect of increasing Q in a series resonant circuit is increasing internal voltages.

E5B Time constants and phase relationships: RL and RC time constants; phase angle in reactive circuits and components; admittance and susceptance

E5B01
One time constant is the term for the time required for the capacitor in an RC circuit to be charged to 63.2% of the applied voltage or to discharge to 36.8% of its initial voltage.

E5B02
The letter B is commonly used to represent susceptance.

E5B03
Impedance in polar form is converted to an equivalent admittance by taking the reciprocal of the magnitude and changing the sign of the angle.

E5B04
The time constant of a circuit having two 220-microfarad capacitors and two 1-megohm resistors, all in parallel is 220 seconds.

E5B05
When it is converted to susceptance the magnitude of pure reactance is replaced by its reciprocal.

E5B06
Susceptance is the imaginary part of admittance.

E5B07
The phase angle between the voltage across and the current through a series RLC circuit if XC is 500 ohms, R is 1 kilohm, and XL is 250 ohms will be 14.0 degrees with the voltage lagging the current.

E5B08
The phase angle between the voltage across and the current through a series RLC circuit if XC is 300 ohms, R is 100 ohms, and XL is 100 ohms will be 63 degrees with the voltage lagging the current.

E5B09
The AC current through a capacitor will lead the voltage across a capacitor by 90 degrees.

E5B10
The AC current through an inductor will lag 90 degrees behind the voltage across an inductor.

E5B11
The phase angle between the voltage across and the current through a series RLC circuit if XC is 25 ohms, R is 100 ohms, and XL is 75 ohms will be 27 degrees with the voltage leading the current.

E5B12
Admittance is the inverse of impedance.

E5C Coordinate systems and phasors in electronics: rectangular coordinates; polar coordinates; phasors; logarithmic axes

E5C01
0 - j100 represents a pure capacitive reactance of 100 ohms in rectangular notation.

E5C02
Impedances are described in polar coordinates by magnitude and phase angle.

E5C03
A positive 90 degree phase angle represents a pure inductive reactance in polar coordinates.

E5C04
A logarithmic Y-axis scale is most often used for graphs of circuit frequency response.

E5C05
A phasor diagram is used to show the phase relationship between impedances at a given frequency.

E5C06
The impedance 50 - j25 ohms represents a 50 ohm resistance in series with 25 ohms capacitive reactance.

E5C07
On rectangular coordinates, the impedance of a pure resistance is plotted on the horizontal axis.

E5C08
A polar coordinate system is often used to display the phase angle of a circuit containing resistance, inductive, and/or capacitive reactance.

E5C09
When using rectangular coordinates to graph the impedance of a circuit, the X axis represents the resistive component, and the Y axis represents the reactive component.

E5C10
On Figure E5-1, Point 4 best represents the impedance of a series circuit consisting of a 400-ohm resistor and a 38-picofarad capacitor at 14 MHz

E5C11
Point 3 in Figure E5-1 best represents the impedance of a series circuit consisting of a 300-ohm resistor and an 18-microhenry inductor at 3.505 MHz.

E5C12
Point 1 on Figure E5-1 best represents the impedance of a series circuit consisting of a 300-ohm resistor and a 19-picofarad capacitor at 21.200 MHz.

E5D RF effects in components and circuits: skin effect; real and reactive power; electrical length of conductors

E5D01
The result of conductor skin effect is resistance increases as frequency increases because RF current flows closer to the surface.

E5D02
It is important to keep lead lengths short for components used in circuits for VHF and above to minimize inductive reactance.

E5D03
The current and voltage for reactive power are 90 degrees out of phase.

E5D04
Short connections used at microwave frequencies to reduce phase shift along the connection.

E5D05
Electrolytic capacitors are unsuitable for use at RF due to the parasitic characteristic of inductance.

E5D06
Inter-turn capacitance is a parasitic characteristic creating an inductor’s self-resonance.

E5D07
A component’s nominal and parasitic reactance combine to create the self-resonance of a component.

E5D08
The primary cause of loss in film capacitors at RF is skin effect.

E5D09
Reactive power in ideal inductors and capacitors is energy is stored in magnetic or electric fields, but power is not dissipated.

E5D10
As a conductor’s diameter increases, its electrical length increases.

E5D11
100 watts of real power is consumed in a circuit consisting of a 100-ohm resistor in series with a 100-ohm inductive reactance drawing 1 ampere.

E5D12
Reactive power is wattless, nonproductive power.

SUBELEMENT E6 - CIRCUIT COMPONENTS [6 Exam Questions - 6 Groups]

E6A Semiconductor materials and devices: semiconductor materials; bipolar junction transistors; operation and types of field-effect transistors

E6A01
In microwave circuits gallium arsenide is used as a semiconductor material

E6A02
N-type semiconductor materials contains excess free electrons.

E6A03
A PN-junction diode not conduct current when reverse biased because holes in P-type material and electrons in the N-type material are separated by the applied voltage, widening the depletion region.

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

E6A05
DC input impedance at the gate of a field-effect transistor (FET) is higher than that of a bipolar transistor.

E6A06
The beta of a bipolar junction transistor is the change in collector current with respect to the change in base current.

E6A07
A base-to-emitter voltage of approximately 0.6 volts to 0.7 volts indicates that a silicon NPN junction transistor is biased on.

E6A08
Alpha cutoff frequency is the term for the frequency at which the grounded-base current gain of a bipolar junction transistor has decreased to 0.7 of the gain obtainable at 1 kHz.

E6A09
A depletion-mode field-effect transistor (FET) is an FET that exhibits a current flow between source and drain when no gate voltage is applied.

E6A10
In Figure E6-1, symbol 4 is the schematic symbol for an N-channel dual-gate MOSFET.

E6A11
In Figure E6-1, symbol 1 is the schematic symbol for a P-channel junction FET.

E6A12
The purpose of connecting Zener diodes between a MOSFET gate and its source or drain is to protect the gate from static damage.

E6B Diodes

E6B01
The most useful characteristic of a Zener diode is its constant voltage drop under conditions of varying current.

E6B02
Its lower forward voltage drop is the characteristic of a Schottky diode making it a better choice than a silicon junction diode for use as a power supply rectifier.

E6B03
Band gap of an LED's semiconductor material determines its forward voltage drop.

E6B04
A varactor diode is a type of semiconductor device designed for use as a voltage-controlled capacitor.

E6B05
The low junction capacitance of a PIN diode makes it useful as an RF switch.

E6B06
A common use of a Schottky diode is as a VHF/UHF mixer or detector.

E6B07
Excessive junction temperature causes a junction diode to fail from excessive current.

E6B08
A Schottky barrier diode has a metal-semiconductor junction.

E6B09
A common use for point-contact diodes is as an RF detector.

E6B10
In Figure E6-2, symbol 6 is the schematic symbol for a Schottky diode.

E6B11
Forward DC bias current is used to control the attenuation of RF signals by a PIN diode.

E6C Digital ICs: families of digital ICs; gates; programmable logic devices

E6C01
The function of hysteresis in a comparator is to prevent input noise from causing unstable output signals.

E6C02
When the level of a comparator’s input signal crosses the threshold voltage the comparator changes its output state.

E6C03
Tri-state logic devices have 0, 1, and high-impedance output states.

E6C04
An advantage of BiCMOS logic is it has the high input impedance of CMOS and the low output impedance of bipolar transistors.

E6C05
CMOS digital logic families have the lowest power consumption compared to TTL, ECL, and NMOS.

E6C06
CMOS digital integrated circuits have high immunity to noise on the input signal or power supply because the input switching threshold is about half the power supply voltage.

E6C07
A pull-up or pull-down resistor is best described as a resistor connected to the positive or negative supply used to establish a voltage when an input or output is an open circuit.

E6C08
In Figure E6-3, symbol 2 is the schematic symbol for a NAND gate.

E6C09
Hardware description language (HDL) is used to design the configuration of a field-programmable gate array (FPGA).

E6C10
In Figure E6-3, symbol 4 is the schematic symbol for a NOR gate.

E6C11
In Figure E6-3, symbol 5 is the schematic symbol for the NOT operation (inversion).

E6D Inductors and piezoelectricity: permeability, core material and configuration; transformers; piezoelectric devices

E6D01
Piezoelectricity is a characteristic of materials that generate a voltage when stressed and that flex when a voltage is applied.

E6D02
The equivalent circuit of a quartz crystal is a series RLC in parallel with a shunt C representing electrode and stray capacitance.

E6D03
An aspect of the piezoelectric effect is mechanical deformation of material due to the application of a voltage.

E6D04
Cores of inductors and transformers are sometimes constructed of thin layers to reduce power loss from eddy currents in the core.

E6D05
Ferrite cores generally require fewer turns than powdered iron to produce a given inductance value.

E6D06
Permeability of the core material property determines the inductance of an inductor?

E6D07
Magnetizing current is the current that flows in the primary winding of a transformer when there is no load on the secondary winding.

E6D08
Powdered iron has the highest temperature stability of its magnetic characteristics when compared to Brass, Ferrite, or Aluminum.

E6D09
Ferrite beads are commonly used as VHF and UHF parasitic suppressors at the input and output terminals of a transistor HF amplifier.

E6D10
A primary advantage of using a toroidal core instead of a solenoidal core in an inductor is toroidal cores confine most of the magnetic field within the core material.

E6D11
Brass core material decreases inductance when inserted into a coil.

E6D12
Operation at excessive magnetic flux causes inductor saturation.

E6E Semiconductor materials and packages for RF use

E6E01
Gallium arsenide (GaAs) is useful for semiconductor devices operating at UHF and higher frequencies because it has higher electron mobility.

E6E02
DIP device packages are a through-hole type, PLCC, BGA, and SOT are not.

E6E03
Gallium nitride materials supports the highest frequency of operation when used in MMICs compared to silicon, silicon nitride, and silicon dioxide.

E6E04
50 ohms is the most common input and output impedance of MMICs.

E6E05
A 0.5 dB noise figure values is typical of a low-noise UHF preamplifier.

E6E06
Controlled gain, low noise figure, and constant input and output impedance over the specified frequency range are characteristics of MMICs which make them a popular choice for VHF through microwave circuits.

E6E07
Microstrip transmission line is often used for connections to MMICs.

E6E08
Power supplied to the most common type of MMIC through a resistor and/or RF choke connected to the amplifier output lead.

E6E09
Surface mount component package types have the least parasitic effects at frequencies above the HF range when compared to TO-220, axial lead, or radial lead.

E6E10
At RF surface-mount technology offers the following advantages compared to through-hole: smaller circuit area, shorter circuit board traces, and components have less parasitic inductance and capacitance.

E6E11
A characteristic of DIP packaging used for integrated circuits is two rows of connecting pins on opposite sides of package (dual in-line package)

E6E12
DIP through-hole package ICs are not typically used at UHF and higher frequencies because of excessive lead length.

E6F Electro-optical technology: photoconductivity; photovoltaic devices; optical sensors and encoders; optically isolated switching

E6F01
Electrons absorb the energy from light falling on a photovoltaic cell.

E6F02
When light shines on photoconductive material its resistance decreases.

E6F03
The most common configuration of an optoisolator or optocoupler is an LED and a phototransistor.

E6F04
The photovoltaic effect is the conversion of light to electrical energy.

E6F05
An optical shaft encoder is a device that detects rotation by interrupting a light source with a patterned wheel.

E6F06
Crystalline semiconductor is most commonly used to create photoconductive devices.

E6F07
A solid-state relay is a device that uses semiconductors to implement the functions of an electromechanical relay.

E6F08
Optoisolators are often used in conjunction with solid-state circuits that control 120 VAC circuits because optoisolators provide an electrical isolation between a control circuit and the circuit being switched.

E6F09
The efficiency of a photovoltaic cell is the relative fraction of light that is converted to current.

E6F10
The most common material used in power-generating photovoltaic cells is silicon.

E6F11
The approximate open-circuit voltage produced by a fully illuminated silicon photovoltaic cell is 0.5 volts.

SUBELEMENT E7 - PRACTICAL CIRCUITS [8 Exam Questions - 8 Groups]

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

E7A01
A flip-flop circuit is bistable.

E7A02
A decade counter produces one output pulse for every 10 input pulses.

E7A03
A flip-flop can divide the frequency of a pulse train by 2.

E7A04
4 flip-flops are required to divide a signal frequency by 16.

E7A05
An astable multivibrator circuit continuously alternates between two states without an external clock signal.

E7A06
A monostable multivibrator switches temporarily to an alternate state for a set time.

E7A07
A NAND gate produces a 0 at its output only if all inputs are 1.

E7A08
An OR gate produces a 1 at its output if any input is 1.

E7A09
A two-input exclusive NOR gate produces a 0 at its output if one and only one of its inputs is 1.

E7A10
A truth table is a list of inputs and corresponding outputs for a digital device.

E7A11
In reference to logic devices “positive logic” means high voltage represents a 1, low voltage a 0.

E7B Amplifiers: class of operation; vacuum tube and solid-state circuits; distortion and intermodulation; spurious and parasitic suppression; switching-type amplifiers

E7B01
Each element of a Class AB amplifier conducts for more than 180 degrees but less than 360 degrees of the signal cycle.

E7B02
A Class D amplifier is an amplifier that uses switching technology to achieve high efficiency.

E7B03
A filter circuit is required at the output of an RF switching amplifier to remove harmonic content.

E7B04
The operating point of a Class A common emitter amplifier is approximately halfway between saturation and cutoff.

E7B05
To prevent unwanted oscillations in an RF power amplifier install parasitic suppressors and/or neutralize the stage.

E7B06
One characteristic of a grounded-grid amplifier is low input impedance.

E7B07
Signal distortion and excessive bandwidth is the likely result of using a Class C amplifier to amplify a single-sideband phone signal.

E7B08
Switching amplifiers are more efficient than linear amplifiers because the switching device is at saturation or cutoff most of the time.

E7B09
One characteristic of an emitter follower (or common collector) amplifier is the input and output signals in-phase.

E7B10
In Figure E7-1, R1 and R2 provide voltage divider bias.

E7B11
In Figure E7-1, R3 provides self bias.

E7B12
Figure E7-1 shows a common emitter amplifier.

E7C Filters and matching networks: types of networks; types of filters; filter applications; filter characteristics; impedance matching

E7C01
A low-pass filter Pi-network will have a capacitor connected between the input and ground, another capacitor connected between the output and ground, and an inductor connected between the input and output.

E7C02
The frequency response of a T-network with series capacitors and a shunt inductor will be high-pass.

E7C03
The purpose of adding an inductor to a Pi-network to create a Pi-L-network is greater harmonic suppression.

E7C04
An impedance-matching circuit transforms a complex impedance to a resistive impedance by canceling the reactive part of the impedance and changes the resistive part to the desired value.

E7C05
A Chebyshev filter has ripple in the passband and a sharp cutoff.

E7C06
An elliptical filter will have an extremely sharp cutoff with one or more notches in the stop band.

E7C07
A Pi-L network is a Pi-network with an additional output series inductor.

E7C08
A helical filter is most frequently used as a band-pass or notch filter in VHF and UHF transceivers.

E7C09
A crystal lattice filter is a filter for low-level signals made using quartz crystals.

E7C10
A cavity filter is used in a 2-meter band repeater duplexer.

E7C11
Shape factor measures a filter’s ability to reject signals in adjacent channels.

E7D Power supplies and voltage regulators; solar array charge controllers

E7D01
A linear electronic voltage regulator works by varying the conduction of a control element to maintain a constant output voltage.

E7D02
A switchmode voltage regulator works by varying the duty cycle of pulses input to a filter.

E7D03
A Zener diode is used as a stable voltage reference.

E7D04
A series regulator describes a three-terminal voltage regulator.

E7D05
A shunt regulator is a linear voltage regulator which operates by loading the unregulated voltage source.

E7D06
The purpose of Q1 in the circuit shown in Figure E7-2 is to control the current to keep the output voltage constant.

E7D07
The purpose of C2 in the circuit shown in Figure E7-2 is to bypass rectifier output ripple around D1.

E7D08
Figure E7-2 shows the circuit for a linear voltage regulator.

E7D09
A battery’s operating time is calculated by dividing the capacity in amp-hours by average current.

E7D10
A switching type power supply is less expensive and lighter than an equivalent linear power supply because the high frequency inverter design uses much smaller transformers and filter components for an equivalent power output.

E7D11
The purpose of an inverter connected to a solar panel output is to convert the panel's output from DC to AC.

E7D12
The dropout voltage of a linear voltage regulator is the minimum input-to-output voltage required to maintain regulation.

E7D13
Multiplying the voltage difference from input to output by output current calculates power dissipated by a series linear voltage regulator.

E7D14
The purpose of connecting equal-value resistors across power supply filter capacitors connected in series equalize the voltage across each capacitor, discharge the capacitors when voltage is removed, and provide a minimum load on the supply.

E7D15
The purpose of a step-start circuit in a high-voltage power supply is to allow the filter capacitors to charge gradually.

E7E Modulation and demodulation: reactance, phase, and balanced modulators; detectors; mixers

E7E01
Reactance modulation of a local oscillator can be used to generate FM phone signals.

E7E02
A reactance modulator produces PM or FM signals by varying a capacitance.

E7E03
A frequency discriminator is a circuit for detecting FM signals.

E7E04
One way to produce a single-sideband phone signal is to use a balanced modulator followed by a filter.

E7E05
A pre-emphasis network is added to an FM speech channel to boost the higher audio frequencies.

E7E06
De-emphasis used in FM communications receivers for compatibility with transmitters using phase modulation.

E7E07
The term "baseband" in radio communications refers to the frequency range occupied by a message signal prior to modulation.

E7E08
The principal frequencies that appear at the output of a mixer are the two input frequencies along with their sum and difference frequencies.

E7E09
When the input signal levels to a mixer are too high spurious mixer products are generated.

E7E10
A diode envelope detector functions by rectification and filtering of RF signals.

E7E11
A product detector is used for demodulating SSB signals.

E7F Software defined radio fundamentals: digital signal processing (DSP) filtering, modulation, and demodulation; analog-digital conversion; digital filters

E7F01
“Direct sampling” in software defined radios means the incoming RF is digitized by an analog-to-digital converter without being mixed with a local oscillator signal.

E7F02
An adaptive filter is a digital signal processing audio filter used to remove unwanted noise from a received SSB signal.

E7F03
A Hilbert-transform filter is a type of digital signal processing filter used to generate an SSB signal.

E7F04
Combining signals in quadrature phase relationship generates an SSB signal using digital signal processing.

E7F05
To be accurately reproduced an analog signal be sampled at least twice the rate of the highest frequency component of the signal.

E7F06
A minimum of 10 bits is required to sample a signal with a range of 1 volt at a resolution of 1 millivolt.

E7F07
A Fast Fourier Transform converts signals from the time domain to the frequency domain.

E7F08
Decimation reduces the effective sample rate by removing samples.

E7F09
An anti-aliasing filter is required in a decimator to remove high-frequency signal components that would otherwise be reproduced as lower frequency components.

E7F10
A receiver’s analog-to-digital sample rate determines the maximum receive bandwidth of a direct-sampling software defined radio (SDR).

E7F11
The reference voltage level and sample width in bits sets the minimum detectable signal level for a direct-sampling software defined receiver in the absence of atmospheric or thermal noise.

E7F12
FIR filters can generally delay all frequency components of the signal by the same amount

E7F13
In a digital signal processing filter taps provide incremental signal delays for filter algorithms.

E7F14
More taps would allow a digital signal processing filter to create a sharper filter response.

E7G Operational amplifiers: characteristics and applications

E7G01
The typical output impedance of an op-amp is very low.

E7G02
In the circuit in E7-3, if a capacitor is added across the feedback resistor the frequency response would be that of a low-pass filter.

E7G03
The typical input impedance of an op-amp is very high.

E7G04
The term “op-amp input offset voltage” means the differential input voltage needed to bring the open loop output voltage to zero.

E7G05
Unwanted ringing and audio instability can be prevented in an op-amp audio filter by restricting both gain and Q.

E7G06
The gain-bandwidth of an operational amplifier is the frequency at which the open-loop gain of the amplifier equals one.

E7G07
In Figure E7-3, when R1 is 10 ohms and RF is 470 ohms, the voltage gain can be expected to be 47.

E7G08
The gain of an ideal operational amplifier will not vary with frequency.

E7G09
In the circuit shown in Figure E7-3, if R1 is 1,000 ohms, RF is 10,000 ohms, and 0.23 volts DC is applied to the input the output voltage will be -2.3 volts.

E7G10
An absolute voltage gain can be expected to be 38 from the circuit in Figure E7-3 when R1 is 1,800 ohms and RF is 68 kilohms.

E7G11
An absolute voltage gain of 14 can be expected from the circuit in Figure E7-3 when R1 is 3,300 ohms and RF is 47 kilohms.

E7G12
An operational amplifier is a high-gain, direct-coupled differential amplifier with very high input impedance and very low output impedance.

E7H Oscillators and signal sources: types of oscillators; synthesizers and phase-locked loops; direct digital synthesizers; stabilizing thermal drift; microphonics; high-accuracy oscillators

E7H01
Three common oscillator circuits are Colpitts, Hartley, and Pierce.

E7H02
A microphonic is changes in oscillator frequency caused by mechanical vibration.

E7H03
A phase-locked loop is an electronic servo loop consisting of a phase detector, a low-pass filter, a voltage-controlled oscillator, and a stable reference oscillator.

E7H04
Positive feedback is supplied in a Colpitts oscillator through a capacitive divider.

E7H05
Positive feedback is supplied in a Pierce oscillator through a quartz crystal.

E7H06
Frequency synthesis and FM demodulation are functions which can be performed by a phase-locked loop.

E7H07
An oscillator’s microphonic responses be reduced by mechanically isolating the oscillator circuitry from its enclosure.

E7H08
NP0 capacitors can be used to reduce thermal drift in crystal oscillators.

E7H09
A direct digital synthesizer circuit uses a phase accumulator, lookup table, digital-to-analog converter, and a low-pass anti-alias filter.

E7H10
The lookup table of a direct digital synthesizer (DDS) contains amplitude values that represent the desired waveform.

E7H11
The major spectral impurity components of direct digital synthesizers are spurious signals at discrete frequencies.

E7H12
Providing a crystal with a specified parallel capacitance ensures that a crystal oscillator operates on the frequency specified by the crystal manufacturer.

E7H13
Using a GPS signal reference, using a rubidium stabilized reference oscillator, or using a temperature-controlled high Q dielectric resonator are techniques for providing highly accurate and stable oscillators needed for microwave transmission and reception.

SUBELEMENT E8 - SIGNALS AND EMISSIONS [4 Exam Questions - 4 Groups]

E8A Fourier analysis; RMS measurements; average RF power and peak envelope power (PEP); analog/digital conversion

E8A01
Fourier analysis shows that a square wave is made up of a sine wave and its odd harmonics.

E8A02
Successive approximation is a type of analog-to-digital conversion.

E8A03
Amplitude at different times describes a signal in the time domain.

E8A04
“Dither”, with respect to analog-to-digital converters, is a small amount of noise added to the input signal to reduce quantization noise.

E8A05
The benefit of making voltage measurements with a true-RMS calculating meter is that RMS is measured for both sinusoidal and non-sinusoidal signals.

E8A06
The approximate ratio of PEP-to-average power in an unprocessed single-sideband phone signal is 2.5 to 1.

E8A07
Speech characteristics determine the PEP-to-average power ratio of an unprocessed single-sideband phone signal.

E8A08
Direct or flash conversion analog-to-digital converters are used for a software defined radio because their very high speed allows digitizing high frequencies.

E8A09
256 different input levels can be encoded by an analog-to-digital converter with 8-bit resolution.

E8A10
The purpose of a low-pass filter used at the output of a digital-to-analog converter is to remove spurious sampling artifacts from the output signal.

E8A11
Total harmonic distortion is a measure of the quality of an analog-to-digital converter

E8B Modulation and demodulation: modulation methods; modulation index and deviation ratio; frequency- and time-division multiplexing; orthogonal frequency-division multiplexing (OFDM)

E8B01
The modulation index of an FM signal is the ratio of frequency deviation to modulating signal frequency.

E8B02
The modulation index of a phase-modulated emission does not depend on the RF carrier frequency.

E8B03
The modulation index of an FM phone signal having a maximum frequency deviation of 3000 Hz either side of the carrier frequency if the highest modulating frequency is 1000 Hz is 3.

E8B04
The modulation index of an FM phone signal having a maximum carrier deviation of plus or minus 6 kHz if the highest modulating frequency is 2 kHz is 3.

E8B05
The deviation ratio of an FM phone signal having a maximum frequency swing of plus or minus 5 kHz if the highest modulation frequency is 3 kHz is 1.67.

E8B06
The deviation ratio of an FM phone signal having a maximum frequency swing of plus or minus 7.5 kHz if the highest modulation frequency is 3.5 kHz is 2.14.

E8B07
Orthogonal frequency-division multiplexing (OFDM) is a technique used for digital modes of amateur communication.

E8B08
Orthogonal frequency-division multiplexing (OFDM) is a digital modulation technique using subcarriers at frequencies chosen to avoid intersymbol interference.

E8B09
Deviation ratio is the ratio of the maximum carrier frequency deviation to the highest audio modulating frequency.

E8B10
Frequency division multiplexing (FDM) is dividing the transmitted signal into separate frequency bands that each carry a different data stream.

E8B11
Digital time division multiplexing means arranging two or more signals to share discrete time slots of a data transmission.

E8C Digital signals: digital communication modes; information rate vs. bandwidth; error correction; constellation diagrams

E8C01
Quadrature Amplitude Modulation or QAM means transmission of data by modulating the amplitude of two carriers of the same frequency but 90 degrees out of phase.

E8C02
The symbol rate in a digital transmission is the rate at which the waveform changes to convey information.

E8C03
The phase of a PSK signal should be changed at the zero crossing of the RF signal to minimize bandwidth.

E8C04
Use of sinusoidal data pulses minimizes the bandwidth of a PSK31 signal.

E8C05
The approximate bandwidth of a 13-WPM International Morse Code transmission is 52 Hz.

E8C06
The bandwidth of an FT8 signal is 50 Hz.

E8C07
The bandwidth of a 4,800-Hz frequency shift, 9,600-baud ASCII FM transmission is 15.36 kHz.

E8C08
ARQ accomplishes error correction by requesting a retransmission if errors are detected.

E8C09
Gray code is a digital code allowing only one bit to change between sequential code values.

E8C10
Data rate be increased without increasing bandwidth by using a more efficient digital code.

E8C11
Symbol rate and baud are the same.

E8C12
Keying speed and shape factor (rise and fall time) are factors which affect the bandwidth of a transmitted CW signal.

E8C13
The constellation diagram of a QAM or QPSK signal describes the possible phase and amplitude states for each symbol.

E8C14
In a mesh network nodes have Internet Protocol (IP) addresses.

E8C15
Individual nodes use discovery and link establishment protocols to form a mesh network.

E8D Keying defects and overmodulation of digital signals; digital codes; spread spectrum

E8D01
Spread spectrum signals are resistant to interference because signals not using the spread spectrum algorithm are suppressed in the receiver.

E8D02
Direct sequence spread spectrum communications technique use a high-speed binary bit stream to shift the phase of an RF carrier.

E8D03
Spread spectrum frequency hopping is described as rapidly varying the frequency of a transmitted signal according to a pseudorandom sequence.

E8D04
The primary effect of extremely short rise or fall time on a CW signal is the generation of key clicks.

E8D05
The most common method of reducing key clicks is increase keying waveform rise and fall times.

E8D06
The advantage of including parity bits in ASCII characters is some types of errors can be detected.

E8D07
A common cause of overmodulation of AFSK signals is excessive transmit audio levels.

E8D08
The Intermodulation Distortion (IMD) parameter evaluates distortion of an AFSK signal caused by excessive input audio levels.

E8D09
-30 dB is considered an acceptable maximum IMD level for an idling PSK signal.

E8D10
Some of the differences between the Baudot digital code and ASCII are 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
One advantage of using ASCII code for data communications is the possibility of transmitting both uppercase and lowercase text.

SUBELEMENT E9 - ANTENNAS AND TRANSMISSION LINES [8 Exam Questions - 8 Groups]

E9A Basic antenna parameters: radiation resistance, gain, beamwidth, efficiency; effective radiated power (ERP) and effective isotropic radiated power (EIRP)

E9A01
An isotropic radiator is a hypothetical, lossless antenna having equal radiation intensity in all directions used as a reference for antenna gain.

E9A02
The effective radiated power (ERP) 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 is 286 watts.

E9A03
Effective radiated power is the term describing total radiated power which takes into account all gains and losses.

E9A04
Antenna height is a factor affecting the feed point impedance of an antenna.

E9A05
The term “ground gain” means an increase in signal strength from ground reflections in the environment of the antenna.

E9A06
The effective radiated power (ERP) 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 is 317 watts.

E9A07
The effective isotropic radiated power (EIRP) 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 is 252 watts.

E9A08
The 5.8 GHz frequency band has the smallest first Fresnel zone.

E9A09
Antenna efficiency is the radiation resistance divided by total resistance.

E9A10
Installing a ground radial system improves the efficiency of a ground-mounted quarter-wave vertical antenna.

E9A11
Soil conductivity determines ground losses for a ground-mounted vertical antenna operating on HF.

E9A12
An antenna will have a gain of 3.85 dB of gain compared to a half-wavelength dipole if it has 6 dB gain over an isotropic radiator.

E9B Antenna patterns and designs: azimuth and elevation patterns; gain as a function of pattern; antenna modeling

E9B01
The 3 dB beamwidth of the antenna radiation pattern shown in Figure E9-1 is 50 degrees.

E9B02
The front-to-back ratio of the antenna radiation pattern shown in Figure E9-1 is 18 dB.

E9B03
The front-to-side ratio of the antenna radiation pattern shown in Figure E9-1 is 14 dB.

E9B04
The front-to-back ratio of the radiation pattern shown in Figure E9-2 is 28 dB.

E9B05
Figure E9-2 shows an elevation antenna pattern.

E9B06
The elevation angle of peak response in the antenna radiation pattern shown in Figure E9-2 is 7.5 degrees.

E9B07
The radiated power from a lossless antenna with gain will be the same as from an isotropic radiator driven by the same power.

E9B08
The far field of an antenna is the region where the shape of the radiation pattern no longer varies with distance.

E9B09
A Method of Moments analysis is commonly used for modeling antennas.

E9B10
The principle of a Method of Moments analysis is modeling a wire as a series of segments, each having a uniform value of current.

E9B11
A disadvantage of decreasing the number of wire segments in an antenna model below 10 segments per half-wavelength is the computed feed point impedance may be incorrect.

E9C Practical wire antennas; folded dipoles; phased arrays; effects of ground near antennas

E9C01
Two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed 180 degrees out of phase will create a figure-eight oriented along the axis of the array.

E9C02
A cardioid radiation pattern is created by two 1/4-wavelength vertical antennas spaced 1/4-wavelength apart and fed 90 degrees out of phase.

E9C03
A figure-eight pattern broadside to the axis of the array is created by two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed in phase.

E9C04
As the wire length of an unterminated long wire antenna is increased additional lobes form with major lobes increasingly aligned with the axis of the antenna.

E9C05
The purpose of feeding an off-center-fed dipole (OCFD) between the center and one end instead of at the midpoint is to create a similar feed point impedance on multiple bands.

E9C06
The effect of adding a terminating resistor to a rhombic or long-wire antenna is to change the radiation pattern from bidirectional to unidirectional.

E9C07
The approximate feed point impedance at the center of a two-wire half-wave folded dipole antenna is 300 ohms.

E9C08
A folded dipole antenna is a half-wave dipole with an additional parallel wire connecting its two ends.

E9C09
A G5RV antenna is a wire antenna center-fed through a specific length of open-wire line connected to a balun and coaxial feed line.

E9C10
A Zepp antenna is an end-fed half-wavelength dipole.

E9C11
Mounting a vertically polarized antenna over seawater versus soil increases radiation at low angles.

E9C12
An extended double Zepp antenna is a center-fed 1.25-wavelength dipole antenna.

E9C13
Increasing height above ground of a horizontally polarized antenna decreases the takeoff angle of the lowest elevation lobe.

E9C14
Mounting a horizontally-polarized antenna above a long slope will result in decreasing the takeoff angle in the downhill direction versus over flat ground.

E9D Yagi antennas; parabolic reflectors; feed point impedance and loading of electrically short antennas; antenna Q; RF grounding

E9D01
When the operating frequency of an ideal parabolic reflector antenna is doubled the gain will increase by 6dB.

E9D02
Two linearly polarized Yagi antennas can be used to produce circular polarization by arranging the two Yagis on the same axis and perpendicular to each other with the driven elements at the same point on the boom and feeding them 90 degrees out of phase.

E9D03
The most efficient location for a loading coil on an electrically short whip is near the center of the vertical radiator.

E9D04
Antenna loading coils should have a high ratio of reactance to resistance to maximize efficiency.

E9D05
A Yagi's driven element is approximately 1/2 wavelength.

E9D06
When one or more loading coils are used to resonate an electrically short antenna the SWR bandwidth decreases.

E9D07
An advantage of top loading an electrically short HF vertical antenna is improved radiation efficiency.

E9D08
As the Q of an antenna increases SWR bandwidth decreases.

E9D09
The function of a loading coil in an electrically short antenna is to resonate the antenna by cancelling the capacitive reactance.

E9D10
Radiation resistance of a base-fed whip antenna decreases below its resonant frequency

E9D11
Most two-element Yagis with normal spacing have a reflector instead of a director for higher gain.

E9D12
The purpose of making a Yagi's parasitic elements either longer or shorter than resonance is to control phase shift.

E9E Impedance matching: matching antennas to feed lines; phasing lines; power dividers

E9E01
Beta or hairpin matching systems for Yagi antennas requires the driven element to be insulated from the boom.

E9E02
Gamma match matching system matches coaxial cable to an antenna by connecting the shield to the center of the antenna and the conductor a fraction of a wavelength to one side.

E9E03
Stub match matching system uses a short length of transmission line connected in parallel with the feed line at or near the feed point.

E9E04
The purpose of the series capacitor in a gamma match is to cancel unwanted inductive reactance.

E9E05
A Yagi driven element feed point impedance is required be capacitive (driven element electrically shorter than 1/2 wavelength) to use a beta or hairpin matching system.

E9E06
75 ohm transmission line impedance would be suitable for constructing a quarter-wave Q-section for matching a 100-ohm feed point impedance to a 50-ohm transmission line.

E9E07
Reflection coefficient describes the interaction of a load and transmission line.

E9E08
A Wilkinson divider can be used to divide power equally between two 50-ohm loads while maintaining 50-ohm input impedance.

E9E09
A gamma match is used to shunt feed a grounded tower at its base.

E9E10 Question Deleted (section not renumbered)

E9E11
the purpose of using multiple driven elements connected through phasing lines is to control the antenna’s radiation pattern.

E9F Transmission lines: characteristics of open and shorted feed lines; coax versus open wire; velocity factor; electrical length; coaxial cable dielectrics; microstrip

E9F01
the velocity factor of a transmission line is the velocity of a wave in the transmission line divided by the velocity of light in a vacuum.

E9F02
The insulating dielectric material has the biggest effect on the velocity factor of a transmission line compared to the characteristic impedance, the transmission line length, the center conductor resistivity.

E9F03
The electrical length of a coaxial cable longer than its physical length because electromagnetic waves move more slowly in a coaxial cable than in air.

E9F04
A 1/2-wavelength transmission line presents a very low impedance to an RF generator when the line is shorted at the far end.

E9F05
Microstrip is precision printed circuit conductors above a ground plane that provide constant impedance interconnects at microwave frequencies.

E9F06
The approximate physical length of an air-insulated, parallel conductor transmission line that is electrically 1/2 wavelength long at 14.10 MHz is 10.6 meters.

E9F07
Parallel conductor transmission line has lower loss compared to coaxial cable with a plastic dielectric.

E9F08
Significant differences between foam dielectric coaxial cable and solid dielectric coaxial cable, assuming all other parameters are the same are foam dielectric coaxial cable has lower safe maximum operating voltage, foam dielectric coaxial cable has lower loss per unit of length, and foam dielectric coaxial cable has higher velocity factor.

E9F09
A 1/4-wavelength transmission line presents a very high impedance to an RF generator when the line is shorted at the far end.

E9F10
A 1/8-wavelength transmission line presents an inductive reactance to an RF generator when the line is shorted at the far end.

E9F11
A 1/8-wavelength transmission line presents a capacitive reactance to an RF generator when the line is open at the far end.

E9F12
A 1/4-wavelength transmission line presents a very low impedance to an RF generator when the line is open at the far end.

E9G The Smith chart

E9G01
Impedance along transmission lines can be calculated using a Smith chart, but radiation resistance, an antenna radiation pattern, and radio propagation can not.

E9G02
A Smith chart uses a coordinate system consisting of resistance circles and reactance arcs.

E9G03
Impedance and SWR values in transmission lines are often determined using a Smith chart, but beam headings and radiation patterns, satellite azimuth and elevation bearings, point-to-point propagation reliability as a function of frequency are not.

E9G04
Resistance and reactance are the two families of circles and arcs that make up a Smith chart

E9G05
A common use for a Smith chart is to determine the length and position of an impedance matching stub.

E9G06
On the Smith chart shown in Figure E9-3, the name for the large outer circle on which the reactance arcs terminate is the reactance axis.

E9G07
On the Smith chart shown in Figure E9-3, the only straight line shown is the resistance axis.

E9G08
A Smith chart is normalized by reassigning the prime center’s impedance value.

E9G09
Constant-SWR circles are a third family of circles often added to a Smith chart during the process of designing impedance matching networks.

E9G10
The arcs on a Smith chart represent points with constant reactance.

E9G11
The wavelength scales on a Smith chart are calibrated in fractions of transmission line electrical wavelength.

E9H Receiving antennas: radio direction finding (RDF) techniques; Beverage antennas; single- and multiple-turn loops

E9H01
When constructing a Beverage antenna, a factor which should be included to achieve good performance is the antenna should be at least one wavelength long.

E9H02
Atmospheric noise is so high that directivity is generally much more important than losses for 160- and 80-meter receiving antennas.

E9H03
Receiving directivity factor (RDF) is peak antenna gain compared to average gain over the hemisphere around and above the antenna.

E9H04
The purpose of placing an electrostatic shield around a small-loop direction-finding antenna is to eliminate unbalanced capacitive coupling to the antenna’s surroundings, improving the depth of its nulls.

E9H05
A challenge presented by a small wire-loop antenna for direction finding is it has a bidirectional null pattern.

E9H06
Minimum variation in SWR over the desired frequency range indicates the correct value of terminating resistance for a Beverage antenna.

E9H07
The function of a Beverage antenna’s termination resistor is to absorb signals from the reverse direction.

E9H08
The function of a sense antenna is to modify the pattern of a DF antenna to provide a null in only one direction.

E9H09
A single-turn, terminated loop such as a pennant antenna creates a cardioid radiation pattern.

E9H10
The output voltage of a multiple-turn receiving loop antenna can be increased by increasing the number of turns and/or the area enclosed by the loop.

E9H11
A feature of a cardioid pattern antenna making it useful for direction-finding antennas is a single null.

SUBELEMENT E0 - SAFETY - [1 exam question - 1 group]

E0A Safety: RF radiation hazards; hazardous materials; grounding

E0A01
The primary function of an external earth connection or ground rod is lightning charge dissipation.

E0A02
When evaluating RF exposure levels from your station at a neighbor’s home, you must ensure signals from your station are less than the uncontrolled maximum permissible exposure (MPE) limits.

E0A03
The FCC human body RF exposure limits are most restrictive over the 30 – MHz range of frequencies.

E0A04
When evaluating a site with multiple transmitters operating at the same time, the operators and licensees of each transmitter that produces 5 percent or more of its MPE limit in areas where the total MPE limit is exceeded are responsible for mitigating over-exposure situations.

E0A05
A hazard created by operating at microwave frequencies is the high gain antennas commonly used can result in high exposure levels.

E0A06
Below 300 MHz there separate electric (E) and magnetic (H) MPE limits because the body reacts to electromagnetic radiation from both the E and H fields, ground reflections and scattering cause the field strength to vary with location, and E field and H field radiation intensity peaks can occur at different locations.

E0A07
“100% tie-off”, regarding tower safety, means at least one lanyard attached to the tower at all times.

E0A08
SAR measures the rate at which RF energy is absorbed by the body.

E0A09
Hand-held transceivers sold before May 3, 2021 are exempt from RF exposure evaluations.

E0A10
An RF exposure evaluation must always be performed on an amateur station operating on 80 meters.

E0A11
While climbing, lanyards should be attached to tower legs.

E0A12
A shock-absorbing lanyard be attached to a tower above the climber’s head level when working above ground.

End of Questions

The graphics required for certain questions in sections E5, E6, E7, and E9 are included below and on the following pages.

Figure E5-1

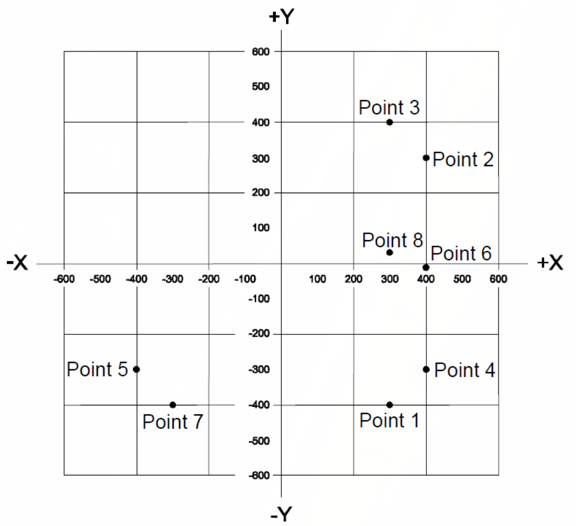

Figure E6-1

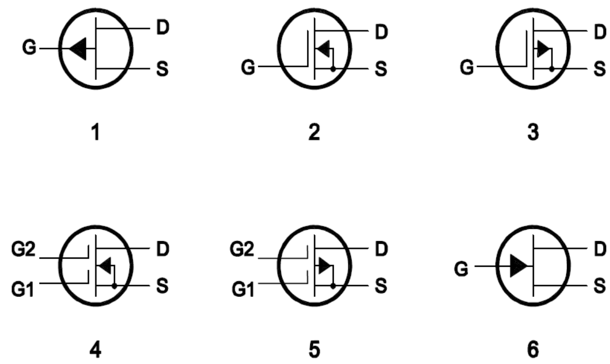

Figure E6-2

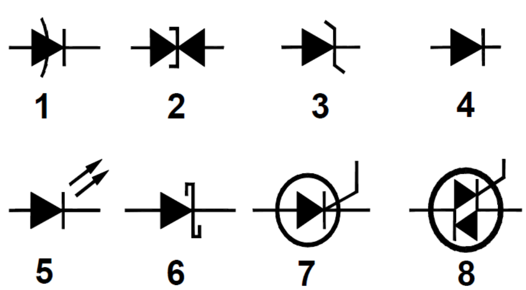

Figure E6-3

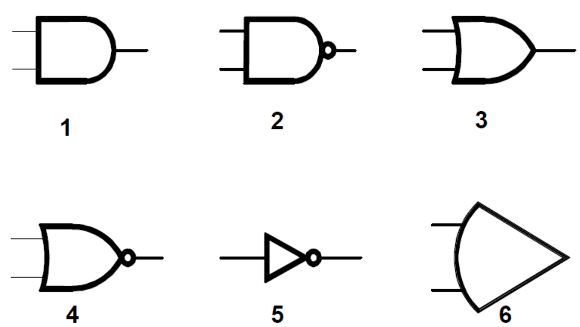

Figure E7-1

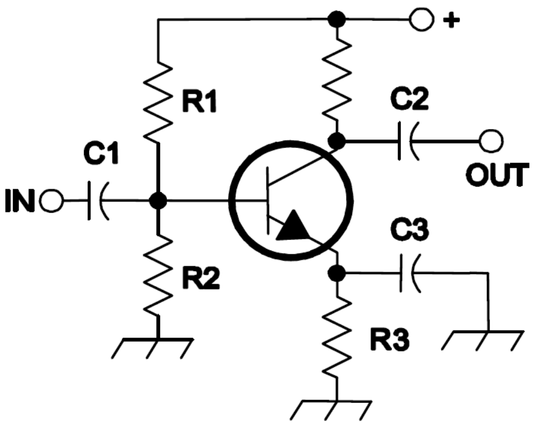

Figure E7-2

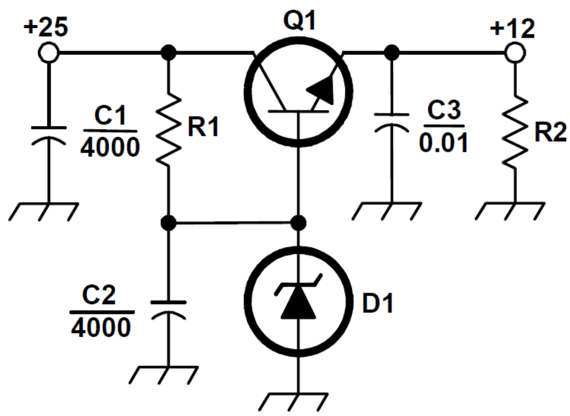

Figure E7-3

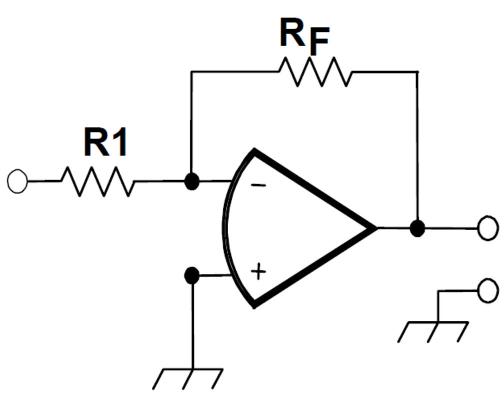

Figure E9-1

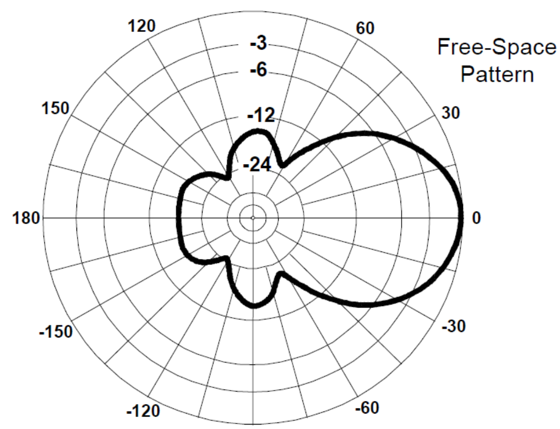

Figure E9-2

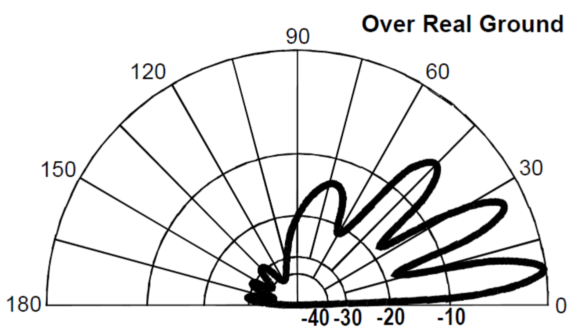

Figure E9-3