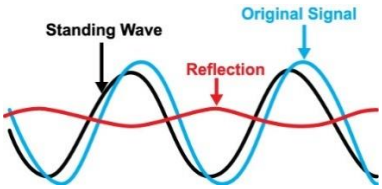
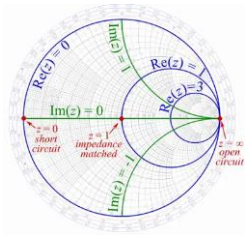
Amateur Radio Extra Class License Class Syllabus

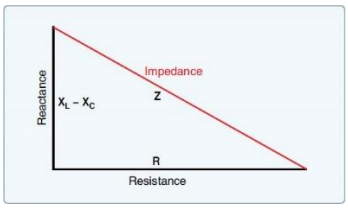
Valid for license exams given July 1, 2024 thru June 30, 2028

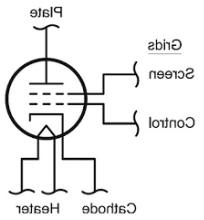
Revision Final 2 March 23, 2024

Based on Public Release of the 2024 Amateur Extra License Question Pool









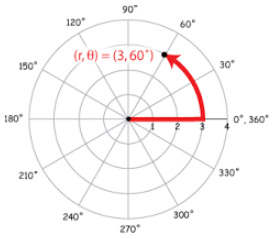
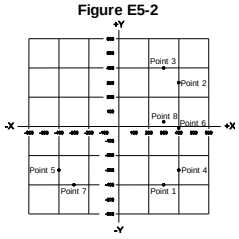


Figure E5-2



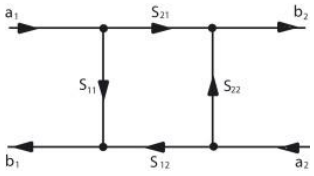
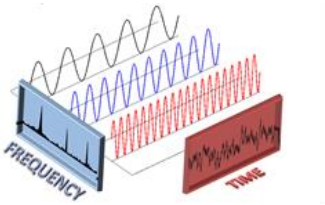
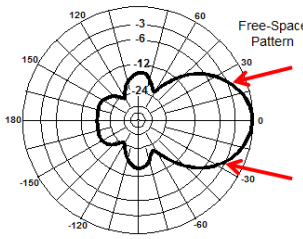
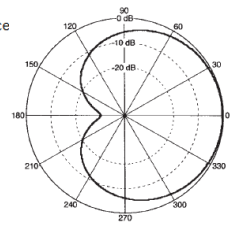
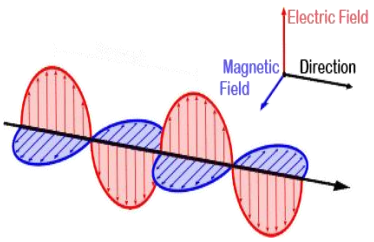


Figure E9-1









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Check authors web site www.ad7fo.com to confirm you have the latest revision of this Syllabus

Table of contents

Overview

All questions in this syllabus are shown exactly as they will appear in the License exam, with only the correct answer shown **(in green bold text)**. This in the author's view makes it easier when you see the other choices in your exam to identify the correct answer. Question numbers have been included so you can go to the ARRL Extra Class License Manual, or the question pool itself to see the additional choices in the exam for each question. The actual July 1, 2024, license question pool with all the answer choices can be found at **http://www.ncvec.org/downloads/2020ExtraClassPoolJan22.txt**

This material is based on the above published 2024 Extra Class License question pool. Additional information added by the author (***in bold italicized blue text***).

You do not need a copy of the current ARRL Extra Class License Manual or any other License Study Guide. All the questions that could possibly be in the exam are contained in this syllabus. Additional information is in the authors "***Reference Materials for FCC Amateur Extra License Study***" on his web site www.ad7fo.com . It is suggested for more in-depth explanations of the technical areas that you acquire a copy of the ARRL Handbook available for the ARRL at www.arrl.org or book sellers like Amazon and Barnes and Noble.

Frequently, used ARRL Handbooks are available at hamfests for significantly less than a new one. The Handbook will serve as a useful technical reference to help you understand the technical areas covered in this syllabus and for Ham Radio in general. You do not need the latest edition of the ARRL Handbook, any edition within the past few years is adequate since the technical content changes very little from year to year.

The electronic file of this syllabus is too large to be e-mailed so an alternate form of distribution such as color printed or electronic means such as thumb drives will be required. It is recommended that Syllabus not be posted on another web site instead that the downloads will be the latest revision.

While every effort was made to ensure the accuracy of the material herein, this material was prepared by an ordinary human being and it is likely that some typographical, spelling, or other errors remain. The author can be contacted at *ad7fo@arrl.net*. Corrections are always welcome and appreciated.

Additional information and resources to help you study for the Extra Class License can be found on the ARRL web site www.arrl.org . The ARRL site has articles and resources for reference materials on all aspects of the exam questions and Amateur Radio in general.

There are on-line sites with practice exams you can take with real exam questions. Listed below are some sites where you can find practice exams, Many more can be found by searching the internet.

https://hamradioprep.com/free-ham-radio-practice-tests
https://arrlexamreview.appspot.com
http://www.hamstudy.org http://www.hamradiolicenseexam.com

About the Author

Education:
Electrical Engineering, Pennsylvania State University

Work Experience:
Hewlett Packard Company: Thirty-four years filling various positions (retired in 2004)

RF Products Division in Spokane WA :1981 to 2004

- New Product Introduction planning
- Product Management
- Systems Development
- Worldwide Sales Management
- Military program sales development
- Regional Sales Support

Field Sales Office in Valley Forge PA : 1969 until 1981

- Engineering Technical Support
- Technical Customer Training
- Field Sales Engineer

American Electronics Laboratories (AEL) in Colmar PA :1961 to 1970

- Working in and managing a Metrology (Calibration Standards) laboratory responsible for maintaining electronic test instruments and other standards and their calibration accuracy traceable to the National Bureau of Standards (NBS) now called the National Institute of Standards and Technology (NIST)

Jerrold Electronics, Hatboro PA: 1959 to 1961

- Technician in the R&D Laboratory working on Cable TV system products and Cable TV RF test equipment

Hobbies:

- Amateur Radio
- Test Equipment
- Electronics in general

Amateur Radio Activities:

- Teaching amateur radio Technician, General and Extra License classes with training materials I have developed. Over 50 classes taught, and 431 new hams licensed.
- Writing and presenting 30 to 60-minute technical talks on Amateur Radio topics for local clubs. They are available for others to use and are on my web site www.ad7fo.com
- Attending as many hamfests as I can: Mike and Key Hamfest in Puyal
- lup WA, Yakima WA Hamfest, KARS Hamfest Post Falls ID, Spokane Hamfest, Spokane WA
- In the past attending Hamvention in Dayton, Ohio every year from 1992 to 2014

ARRL Appointments:

- ARRL Technical Specialist
- ARRL VE (Volunteer Examiner)
- ARRL Registered Instructor

Other:

- Member of the Inland Empire VHF Club (past President)
- Member of the Spokane County ARES/RACES (past AEC)

2020-2024 Extra Class Outline
FCC Element 4 Question Pool Syllabus
Effective July 1, 2024

SUBELEMENT E1 — COMMISSION RULES [***6 Exam Questions — 6 Groups***]
75 Questions

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

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

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

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

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

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

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

SUBELEMENT E9 - ANTENNAS AND TRANSMISSION LINES [***8 Exam Questions - 8 Groups***] 96 Questions

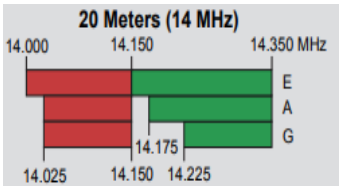
SUBELEMENT E0 – SAFETY [***1 exam question – 1 group***]
11 Questions

There are 50 questions in the Amateur Extra Exam from 50 sub element groups, only one question will come from each sub-element group. You must have 37 correct answers to pass your extra class license exam.

SUBELEMENT E1 - COMMISSION RULES [6 Exam Questions - 6 Groups]

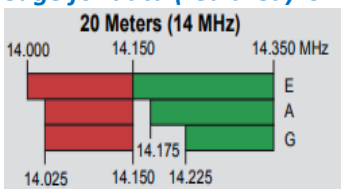
E1A Frequency privileges; signal frequency range; automatic message forwarding; stations aboard ships or aircraft; power restriction on 630- and 2200-meter bands

E1A01 [97.305, 97.307(b)]
Why is it not legal to transmit a 3 kHz bandwidth USB signal with a carrier frequency of 14.348 MHz?
The upper 1 kHz of the signal is outside the 20-meter band
An Upper Sideband transmission would be 14.351 and 1 KHz above the 14.350 MHz upper band limit.

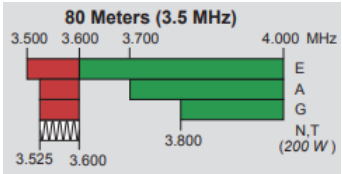


E1A02 [97.301, 97.305]
When using a transceiver that displays the carrier frequency of phone signals, which of the following displayed frequencies represents the lowest frequency at which a properly adjusted LSB emission will be totally within the band? **3 kHz above the lower band edge**

E1A03 [97.305, 97.307(b)]
What is the highest legal carrier frequency on the 20-meter band for transmitting a 2.8 kHz wide USB data signal? **14.1472 MHz**
The upper band edge for data (red area) is 14.150 MHz. 14.150 MHz - .0028 MHz = 14.1472 MHz

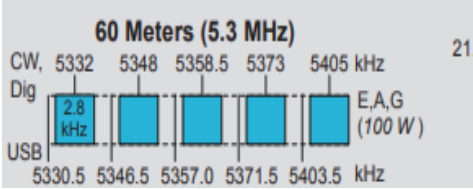


E1A04 [97.301, 97.305]
May an Extra class operator answer the CQ of a station on 3.601 MHz LSB phone?
No, the sideband components will extend beyond the edge of the phone band segment
A 3.601 LSB signal will occupy a 3 KHz bandwidth (3.598 to 3.601 MHz). This is 2 kHz below the lower edge of the phone band.

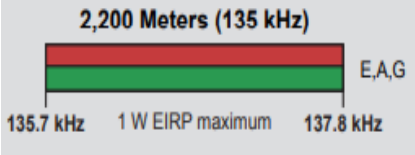


E1A05 [97.5]
Who must be in physical control of the station apparatus of an amateur station aboard any vessel or craft that is documented or registered in the United States?
Any person holding an FCC issued amateur license or who is authorized for alien reciprocal operation

E1A06 [97.303(h)(1)]
What is the required transmit frequency of a CW signal for channelized 60 meter operation?
At the center frequency of the channel



E1A07 [97.313(k)]
What is the maximum power permitted on the 2200-meter band?
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, who is primarily accountable for the rules violation?
The control operator of the originating station

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

E1A10 [97.11]
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 [97.5]
What licensing is required when operating an amateur station aboard a US-registered vessel in international waters? **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]
Which of the following constitutes a spurious emission?
An emission outside the signal's necessary bandwidth that can be reduced or eliminated without affecting the information transmitted

E1B02 [97.307(f)(2)]
Which of the following is an acceptable bandwidth for digital voice or slow-scan TV transmissions made on the HF amateur bands? **3 kHz**

E1B03 [97.13]
Within what distance must an amateur station protect an FCC monitoring facility from harmful interference? **1 mile**
US FCC Monitoring stations are located in Allegan, Michigan; Belfast, Maine; Canandaigua, New York; Douglas, Arizona; Ferndale, Washington; Grand Island, Nebraska; Kenai, Alaska; Kingsville, Texas; Laurel, Maryland; Livermore, California; Powder Springs; Santa Isabel, Puerto Rico; Vero Beach, Florida; Waipahu, Hawaii.

E1B04 [97.303(b)]
What must the control operator of a repeater operating in the 70-centimeter band do if a radiolocation system experiences interference from that repeater?
Cease operation or make changes to the repeater that mitigate the interference
***Radiolocation, also known as radiolocating, is* the process of finding the location of something through the use of radio waves.**

E1B05 [97.3]
What is the National Radio Quiet Zone?
An area surrounding the National Radio Astronomy Observatory
The National Radio Astronomy Observatory is located at the University of Virginia in Charlottesville, VA.

E1B06 [97.15]
Which of the following additional rules apply 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]
To what type of regulations does PRB-1 apply? **State and local zoning**

E1B08 [97.121]
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 [97.407]
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 [97.407]
What frequencies are authorized to an amateur station operating under RACES rules?
All amateur service frequencies authorized to the control operator

E1B11 [97.15]
What does PRB-1 require of state and local regulations affecting amateur radio antenna size and structures? **Reasonable accommodations of amateur radio must be made**

If you live in an area where you agreed to or joined an HOA (Home-Owners Association) this might not apply.

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]
What is the maximum bandwidth for a data emission on 60 meters? **2.8 kHz**

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

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

E1C04
What is an IARP? **A permit that allows US amateurs to operate in certain countries of the Americas**

E1C05 [97.221(c)(1), 97.115(c)]
Under what situation may a station transmit third party communications while being automatically controlled? **Only when transmitting RTTY or Data Emissions**

E1C06
Which of the following is required 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**
Go to https://docs.fcc.gov/public/attachments/DA-16-1048A1.pdf ***to see and print a copy***

E1C07 [97.303(g)]
What notifications must be given 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

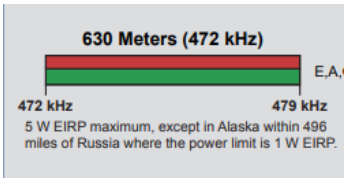
E1C08 [97.213]
What is the maximum permissible duration of a remotely controlled station's transmissions if its control link malfunctions? **3 minutes**

E1C09 [97.307]
What is the highest modulation index permitted at the highest modulation frequency for angle modulation below 29.0 MHz? **1.0**
Calculating the modulation index is relatively straightforward for simple modulation schemes like AM, FM, and PM. In AM, the modulation index (denoted as 'm') can be computed as m = (Amax – Amin) / (Amax + Amin), where Amax and Amin are the maximum and minimum amplitudes of the modulated signal, respectively.

E1C10 [97.307]
What is the maximum mean power level for a spurious emission below 30 MHz with respect to the fundamental emission? **- 43 dB**
For a 1,000 wat transmission the spurious signals may not exceed 50 milliwatts. 1,000(!0^(-43/10) or 1,000(10^(-4.3)) or 1,0000 (0.000,05) or .05 watts

E1C11 [97.5]
Which of the following operating arrangements allows an FCC-licensed US citizen to operate in many European countries, and amateurs from many European countries to operate in the US? **CEPT**
The European Conference of Postal and Telecommunications Administrations (CEPT) was established on June 26, 1959, by nineteen European states in Montreux, Switzerland, as a coordinating body for European state telecommunications and postal organization. They set standards for RF communication.

E1C12 [97.305(c)]
In what portion of the 630-meter band are phone emissions permitted? **The entire band**



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

E1D01 [97.3]
What is the definition of telemetry?
One-way transmission of measurements at a distance from the measuring instrument

E1D02 [97.211(b)]
Which of the following may transmit encrypted messages?
Telecommand signals from a space telecommand station

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

E1D04 [97.119(a)]
Which of the following is required in the identification transmissions from a balloon-borne telemetry station? **Call sign**

E1D05 [97.213(d)]

What must be posted at the location of a station being operated by telecommand on or within 50 kilometers of the Earth's surface?
A. A photocopy of the station license
B. A label with the name, address, and telephone number of the station licensee
C. A label with the name, address, and telephone number of the control operator
D. **All these choices are correct**

E1D06 [97.215(c)]
What is the maximum permitted transmitter output power when operating a model craft by telecommand? **1 watt**
You cannot operate your "Drone" or model from miles away or out of sight.

E1D07 [97.207]
Which group of HF amateur bands include allocations for space stations?
40 meters, 20 meters, 15 meters, and 10 meters

E1D08 [97.207]
Which VHF amateur bands have frequencies authorized for space stations? **2 meters**

E1D09 [97.207]
Which UHF amateur bands have frequencies authorized for space stations?
70 centimeters and 13 centimeters

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

E1D11 [97.209]
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

E1D12 [97.207(e), 97.203(g)]
Which of the following amateur stations may transmit one-way communications?
A space station, beacon station, or telecommand station

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

E1E01 [97.527]
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 operator license

E1E02 [97.523]
Who is tasked by Part 97 with maintaining the pools of questions for all US amateur license examinations? **The VECs**

E1E03 [97.521]
What is a Volunteer Examiner Coordinator?
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]
What is required 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)]
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

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

E1E07 [97.509, 97.511]
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 [97.509]
To which of the following examinees may a VE not administer an examination?
Relatives of the VE as listed in the FCC rules

E1E09 [97.509]
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 [97.509(h)]
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 [97.509(m)]
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

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]
On what frequencies are spread spectrum transmissions permitted?
Only on amateur frequencies above 222 MHz

E1F02 [97.107]
What privileges are authorized in the US 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 US Amateur Extra class license privileges

E1F03 [97.315]
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 [97.3]
Which of the following geographic descriptions approximately describes "Line A"?
A line roughly parallel to and south of the border between the US and Canada

E1F05 [97.303]
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 [1.931]
Under what circumstances might the FCC issue a Special Temporary Authority (STA) to an amateur station? **To provide for experimental amateur communications**

E1F07 [97.113]
When may an amateur station send a message to a business?
When neither the amateur nor their employer has a pecuniary interest in the communications

E1F08 [97.113(c)]
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 [FCC Part 97.113(a)(4)]
Which of the following cannot be transmitted over an amateur radio mesh network?
Messages encoded to obscure their meaning

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

E1F11 [97.317]
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

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
What is the direction of an ascending pass for an amateur satellite? **From south to north**

E2A02
Which of the following is characteristic of an inverting linear transponder?
A. Doppler shift is reduced because the uplink and downlink shifts are in opposite directions
B. Signal position in the band is reversed
C. Upper sideband on the uplink becomes lower sideband on the downlink, and vice versa
D. **All these choices are correct**

E2A03
How is an upload signal processed by an inverting linear transponder?
The signal is mixed with a local oscillator signal and the difference product is transmitted
An inverted linear transponder reverses the ordering of frequencies between input and output. The Doppler shift shifts the input and output frequencies the same way, and so there is some cancellation due to the reversing effect of the transponder. USB and LSB signals are likewise swapped, as is signal position.

E2A04
What is meant by the "mode" of an amateur radio satellite?
The satellite's uplink and downlink frequency bands
Uplink and downlink designations use sets of paired letters following the structure X/Y where X is the uplink band and Y is the downlink band. A U/V satellite will have a UHF uplink and VHF downlink.

E2A05
What do the letters in a satellite's mode designator specify?
The uplink and downlink frequency ranges
See previous answer.

E2A06
What are Keplerian elements? **Parameters that define the orbit of a satellite**
The traditional orbital elements are the six Keplerian elements, after Johannes Kepler and his laws of planetary motion.

E2A07
Which of the following types of signals can be relayed through a linear transponder?
A. FM and CW
B. SSB and SSTV
C. PSK and packet
D. **All these choices are correct**

A linear transponder acts much like a repeater, except that it relays an entire group of signals, not just one signal at a time.

E2A08
Why should effective radiated power (ERP) be limited to a satellite that uses a linear transponder?
To avoid reducing the downlink power to all other users
Satellite transponders are power-sharing. If one signal received at the satellite is stronger than the others, all other retransmitted signals will get a smaller portion of the available power.

E2A09
What do the terms "L band" and "S band" specify?
The 23- and 13-centimeter bands

L band 1 to 2 GHz	***15 cm to 30 cm***
S band 2 to 4 GHz	***7.5 cm to 15 cm***
C band 4 to 8 GHz	***3.75 cm to 7.5 cm***
X band 8 to 12 GHz2	***5 mm to 37.5 mm***

E2A10
What type of satellite appears to stay in one position in the sky? **Geostationary**
Examples would be Satellite Radio satellites and GPS Satellites.

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 the purpose of digital store-and-forward functions on an amateur radio satellite?
To hold digital messages in the satellite for later download
Being able to upload a message that is stored by the satellite when it is covering one area of the globe and downloaded when the satellite is covering another area of the globe.

E2A13 (B)
Which of the following techniques is used by digital satellites to relay messages?
Store-and-forward

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

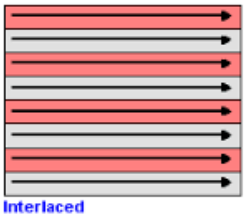
E2B01
In digital television, what does a coding rate of 3/4 mean?
25% of the data sent is forward error correction data
In a case where bandwidth isn't really an issue and If you make shorter symbols, you can have more of them. Each symbol would be noisier, but with more symbols more of them can be used for error correction.

E2B02
How many horizontal lines make up a fast-scan (NTSC) television frame? **525**
NTSC is National Television Standards Committee (the old Analog TV standard).

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

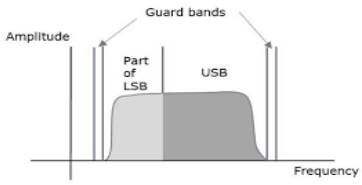
How is color information sent in analog SSTV? **Color lines are sent sequentially**

Slow Scan Television or SSTV is essentially a derivative of the old analog wideband broadcast television system. The fundamental principles of SSTV signal structure and modulation are fairly similar to that of analog TV. However, the primary difference lies in the fact that while the regular commercial television displays motion pictures along with synchronized sound, the SSTV protocol only allows for still pictures to be transmitted over a radio channel.

2B05

Which of the following describes the use of vestigial sideband in analog fast-scan TV transmissions?

Vestigial sideband reduces the bandwidth while increasing the fidelity of low frequency video components



E2B06

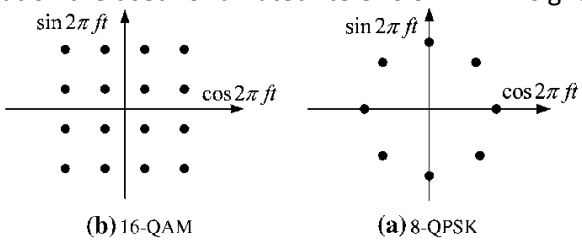
What is vestigial sideband modulation?

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

See Graphic for E2B05 above.

E2B07

Which types of modulation are used for amateur television DVB-T signals. **QAM and QPSK**



The conventional channel-optimized vector quantization is very powerful in the protection of vector quantization data over noisy channels

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

E2B09
What kind of receiver can be used to receive and decode SSTV using the Digital Radio Mondiale (DRM) protocol? **SSB**
Digital Radio Mondiale (DRM) is the universal, openly standardized digital broadcasting system for all broadcasting frequencies up to 300 MHz. Apart from the ability of DRM to fit in with existing spectrum requirements, the DRM system is an open system where all manufacturers and interested parties have free access to the complete technical standards and are able to design and manufacture equipment on an equitable basis.

E2B10
What aspect of an analog slow-scan television signal encodes the brightness of the picture?
Tone frequency
By up or down frequency shifts.

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

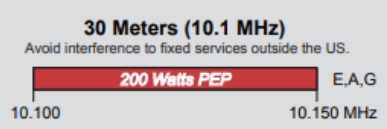
E2B12
What signals SSTV receiving software to begin a new picture line? **Specific tone frequencies**

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

E2C01
What 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?
No additional indicator is required

E2C02
Which of the following file formats is used for exchanging amateur radio log data? **ADIF**
Audio Data Interchange Format (ADIF), a file format to exchange Advanced Audio Coding (AAC) data; see Advanced Audio Coding § Container formats. AAC is short for "Advanced Audio Coding", which is a standard audio format for compressed digital audio and data.

E2C03
From which of the following bands is amateur radio contesting generally excluded? **30 meters**



E2C04

Which of the following frequencies can be used for amateur radio mesh networks?

Frequencies shared with various unlicensed wireless data services

AREDN (Amateur Radio Emergency Data Network) has evolved over the past 10-12 years from its first implementation by Broadband Hamnet (BBHN). Over the years the AREDN Project has developed software support for nearly 70 commercial wireless routers---moving them from their Part 15 allocation into adjacent Part 97 allocations in the 0.9, 2, 3, and 5 GHz bands providing an inexpensive and easy way for hams to implement high-speed (up to 144 Mbps) data networks in support of Emergency Operations Centers (EOCs), Non-governmental Agencies (NGOs) and first responders.

E2C05

What is the function of a DX QSL Manager?

Handle the receiving and sending of confirmations for a DX station

To avoid poor postal systems and cut postage expenses, many DX stations and DXpeditions use a QSL manager. The manager is located in a country with reliable, secure postal service. This method results in a nearly 100 percent return rate. QSLing via a manager is just like direct QSLing. If you don't include return postage and an envelope to a manager for a DX station, you'll likely get your card back via the QSL bureau, which takes a few months at minimum.

E2C06

During a VHF/UHF contest, in which band segment would you expect 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

What is the Cabrillo format? **A standard for submission of electronic contest logs**

```
START-OF-LOG: 2.0
ARRL-SECTION: SCV
CALLSIGN: K6MM
CLUB: Northern California Contest Club
CONTEST: CA-QSO-PARTY
CATEGORY: SINGLE-OP ALL HIGH MIXED
CLAIMED-SCORE: 174249
OPERATORS: K6MM
NAME: John Miller
ADDRESS: 6349 Slida Drive
ADDRESS: San Jose, CA 95129
ADDRESS: USA
CREATED-BY: N1MM Logger V10.9.5
QSO: 14047 CW 2010-10-02 1600 K6MM          0001 CA    K6KQV         0001 SCLA
QSO: 14047 CW 2010-10-02 1602 K6MM          0002 CA    W7DM          0005 WA
QSO: 14047 CW 2010-10-02 1603 K6MM          0003 CA    N0AC          0004 CO
QSO: 14047 CW 2010-10-02 1604 K6MM          0004 CA    N4CD          0003 TX
QSO: 14047 CW 2010-10-02 1604 K6MM          0005 CA    K9EN          0002 WI
```

E2C08

Which of the following contacts may be confirmed through the Logbook of The World (LoTW)?

A. Special event contacts between stations in the US

B. Contacts between a US station and a non-US station

C. Contacts for Worked All States credit

D. **All these choices are correct**

***Logbook of The World* (*LoTW*) is a tool to confirm ham radio contacts and use the confirmations as credit toward awards.**

E2C09

What type of equipment is commonly used to implement an amateur radio mesh network?

A wireless router running custom firmware

E2C10
Why do DX stations often transmit and receive on different frequencies?
A. Because the DX station may be transmitting on a frequency that is prohibited to some responding stations
B. To separate the calling stations from the DX station
C. To improve operating efficiency by reducing interference
D. **All these choices are correct**

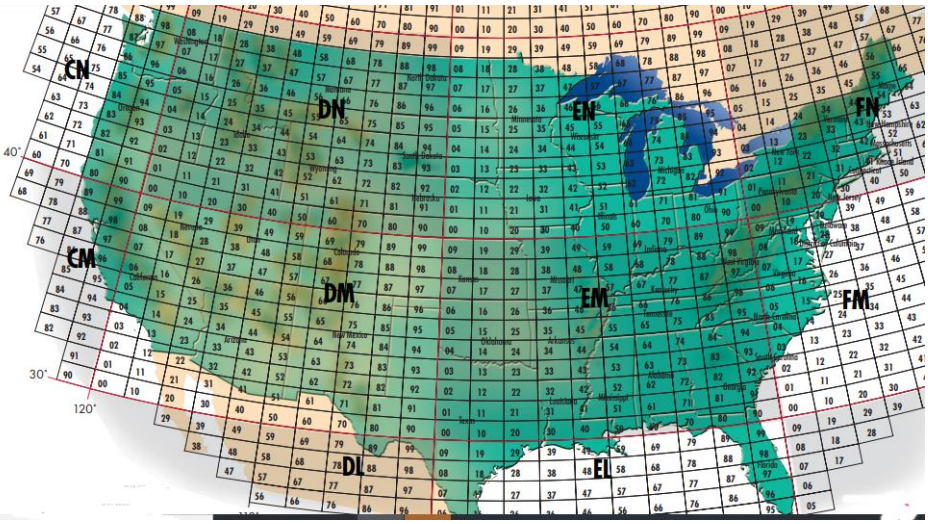
E2C11
How should you generally identify your station when attempting to contact a DX station during a contest or in a pileup? **Send your full call sign once or twice**

E2C12
What indicates the delay between a control operator action and the corresponding change in the transmitted signal? **Latency**
Network latency is the delay in network communication. It shows the time that data takes to transfer across the network. Networks with a longer delay or lag have high latency, while those with fast response times have low latency.

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

E2D01
Which of the following digital modes is designed for meteor scatter communications? **MSK144**

E2D02
What information replaces signal-to-noise ratio when using the FT8 or FT4 modes in a VHF contest?
Grid square
Grid Squares are rectangles and are just a way of dividing up the surface of the Earth. Grid squares are a shorthand means of describing your general location anywhere on the Earth in a manner that is easy to communicate over the air.



E2D03
Which of the following digital modes is designed for EME communications? **Q65**
Q65 uses a 65-tone frequency-shift keying modulation mode. It has a sync tone for both time and frequency synchronization. Q65 is particularly effective for tropospheric scatter, rain scatter, ionospheric scatter, TEP, and EME on VHF and higher bands, as well as other fast-fading signals.

E2D04
What technology is used for real-time tracking of balloons carrying amateur radio transmitters? **APRS**
Automatic Packet Reporting System (APRS) is an amateur radio-based system for real time digital communications of information of immediate value in the local area. Data can include object Global Positioning System (GPS) coordinates, weather station telemetry, text messages, announcements, queries, and other telemetry.

E2D05
What is the characteristic of the JT65 mode? **Decodes signals with a very low signal-to-noise ratio**
JT65 is a weak signal digital mode that uses precisely timed transmit- receive sequences. You transmit for about one minute and listen for one minute.

E2D06
Which of the following is a method for establishing EME contacts?
Time-synchronous transmissions alternating between stations
Earth–Moon–Earth communication (EME), also known as Moon bounce, is a radio communications technique that relies on the propagation of radio waves from an Earth-based transmitter directed via reflection from the surface of the Moon back to an Earth-based receiver.

E2D07
What digital protocol is used by APRS? **AX.25**
AX.25 (Amateur X.25) is* a data link layer protocol originally derived *from layer 2 (Data link layer) of the X.25 protocol suite and designed for use by amateur radio operators.

E2D08
What type of packet frame is used to transmit APRS beacon data? **Unnumbered Information**

E2D09
What type of modulation is used by JT65? **Multitone AFSK**
AFSK is an acronym for Audio frequency-shift keying. AFSK is a modulation technique by which digital data is represented by changes in the frequency (pitch) of an audio tone, yielding an encoded signal suitable for transmission via radio.

E2D10
What does the packet path WIDE3-1 designate?
Three digipeater hops are requested with one remaining
Mobile stations will use a path of Wide1-1 for the first position and Wide2-2 for the 2nd. That gives your mobile's packet three hops out. Mobile and portable stations use Wide1-1, Wide2-2. Keep your path to 2 or 3 hops. Anything more will create congestion in the system.

E2D11
How do APRS stations relay data? **By packet digipeaters**
Digipeater is the term used to describe a packet radio digital repeater. Unlike the FM voice repeaters, most digipeaters operate on simplex and do not receive and transmit simultaneously.

E2E Operating methods: digital modes and procedures for HF

E2E01
Which of the following types of modulation is used for data emissions below 30 MHz? **FSK**
Frequency-shift keying (FSK) is a method of transmitting digital signals using discrete signals. The two binary states, logic 0 (low) and 1 (high) in a binary frequency-shift key mechanism and are each represented by an analog waveform.

E2E02
Which of the following synchronizes WSJT-X digital mode transmit/receive timing?
Synchronization of computer clocks ***by using an accurate time standard***

E2E03
To what does the "4" in FT4 refer? **Four-tone continuous-phase frequency shift keying**

E2E04
Which of the following is characteristic of the FST4 mode?
A. Four-tone Gaussian frequency shift keying
B. Variable transmit/receive periods
C. Seven different tone spacings
D**. All these choices are correct**
FST4 is optimized for two-way QSOs, while FST4W is for quasi-beacon transmissions of WSPR-style messages. FST4 and FST4W do not require the strict, independent time synchronization and phase locking of modes like EbNaut. The new modes use 4-GFSK modulation and share common software for encoding and decoding messages.

E2E05
Which of these digital modes does not support keyboard-to-keyboard operation? **WSPR**
WSPR (pronounced "whisper") is an acronym for Weak Signal Propagation Reporter. It is a protocol, implemented in a computer program, used for weak-signal radio communication between amateur radio operators. The protocol was designed, and a program written initially, by Joe Taylor, K1JT. The software code is now open source and is developed by a small team. The program is designed for sending and receiving low-power transmissions to test propagation paths on the MF and HF bands.

E2E06
What is the length of an FT8 transmission cycle? **15 seconds**
FT8 sends 77 information bits in 15-second cycles with 12.64 seconds of transmission time and 2.36 seconds of decode time for a user data rate of 6.09 bits/sec. Source encoding gives an effective throughput of about 5 words per minute.

E2E07
How does Q65 differ from JT65? **Multiple receive cycles are averaged**

E2E08
Which of the following HF digital modes can be used to transfer binary files? **PACTOR**
PACTOR is a radio modulation mode used by amateur radio operators, marine radio stations, military or government radio stations in isolated areas to send and receive digital information via radio.

E2E09
Which of the following HF digital modes uses variable-length character coding? **PSK31**
PSK31 or "Phase Shift Keying, 31 Baud", also BPSK31 and QPSK31, is a popular computer-sound card-generated radioteletype mode, used primarily by amateur radio operators to conduct real-time keyboard-to-keyboard chat, most often using frequencies in the high frequency amateur radio bands.

E2E10
Which of these digital modes has the narrowest bandwidth? **FT8**
FT8 is a digital mode used in amateur radio that is designed for efficient and reliable communication in weak signal conditions.

E2E11
What is the difference between direct FSK and audio FSK? **Direct FSK modulates the transmitter VFO**
Audio FSK does not change the RF transmit frequency, instead it changes the frequency of an audio tone.

E2E12
How do ALE stations establish contact?
ALE constantly scans a list of frequencies, activating the radio when the designated call sign is received
ALE (Automatic Link Establishment) is a feature in an HF communications radio transceiver system that enables the radio station to make contact, or initiate a circuit, between itself and another HF radio station or network of stations.

E2E13
Which of these digital modes has the highest data throughput under clear communication conditions?
PACTOR IV
PACTOR-IV is at least twice as fast as PACTOR-3 with the same power and bandwidth of PACTOR 3. Pactor IV modems are very expensive (around $2,000 US).

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

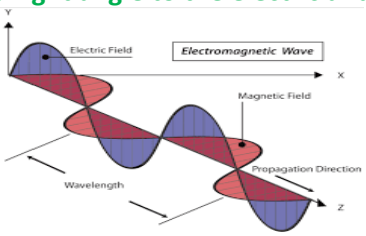
E3A Electromagnetic Waves and Specialized Propagation: Earth-Moon-Earth (EME) communications; meteor scatter; microwave tropospheric and scatter propagation; auroral propagation; daily variation of ionospheric propagation; circular polarization

E3A01
What is the approximate maximum separation measured along the surface of the Earth between two stations communicating by EME? **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
Perigee is the point in the orbit of the moon at which it is closest to earth. The average distance from the earth to the moon is 238,900 miles(384,400 kilometers) from Earth..

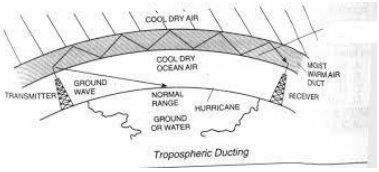
E3A04
In what direction does an electromagnetic wave travel?
It travels at a right angle to the electric and magnetic fields



E3A05
How are the component fields of an electromagnetic wave oriented? **They are at right angles**

E3A06
What should be done to continue a long-distance contact when the MUF for that path decreases due to darkness? **Switch to a lower frequency HF band**

E3A07
Atmospheric ducts capable of propagating microwave signals often form over what geographic feature?
Large bodies of water



E3A08
When a meteor strikes the Earth's atmosphere, a linear ionized region is formed at what region of the ionosphere? **The E region**

E3A09
Which of the following frequency ranges is most suited for meteor-scatter communications?
28 MHz - 148 MHz

E3A10
What determines the speed of electromagnetic waves through a medium? **The index of refraction**
Atmospheric refraction is the deviation electromagnetic waves from a straight line as they pass through the Ionosphere.

E3A11
What is a typical range for tropospheric duct propagation of microwave signals?
100 miles to 300 miles

E3A12
What is most likely to result in auroral propagation? **Severe geomagnetic storms**
Visible auroras are a sign of a disturbance occurring in the upper reaches of the Earth's atmosphere. This can result in significant changes to radio propagation conditions. HF radio communications via the ionosphere can be blacked out, but it is possible at VHF to use the ionization around the poles for communication.

E3A13
Which of these emission modes is best for auroral propagation? **CW**

E3A14
What are circularly polarized electromagnetic waves? **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
Where is transequatorial propagation (TEP) most likely to occur?
Between points separated by 2,000 miles to 3,000 - 5,000 miles over a path perpendicular to the geomagnetic equator
Transequatorial propagation supports communications over distances of approximately 1,500 and 3,000 miles. These paths occur across the equator in a north south or south north direction. Transequatorial propagation generally occurs in the late afternoon or early evening. Signals propagated using this mode tended to suffer some distortion as a result of multipath effects., but despite this, modes like single sideband, SSB are usable.

E3B02
What is the approximate maximum range for signals using transequatorial propagation? **5,000 miles**

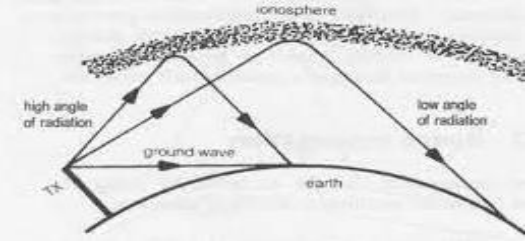
E3B03
At what time of day is transequatorial propagation most likely to occur? **Afternoon or early evening**

E3B04
What are “extraordinary” and “ordinary” waves?
Independently propagating, elliptically polarized waves created in the ionosphere
The wave which obeys the law and laws of refraction is called ordinary wave. The wave which does not obey the laws of refraction is called extra ordinary wave.

E3B05
Which of the following paths is most likely to support long-distance propagation on 160 meters?
A path entirely in darkness

E3B06
On which of the following amateur bands is long-path propagation most frequent?
40 meters and 20 meters

E3B07
What effect does lowering a signal’s transmitted elevation angle have on ionospheric HF skip propagation? **The distance covered by each hop increases**



E3B08
How does the maximum range of ground-wave propagation change when the signal frequency is increased? **It decreases**

E3B09
At what time of year is sporadic-E propagation most likely to occur?
Around the solstices, especially the summer solstice
The word solstice is derived from the Latin sol ("sun") and sistere ("to stand still"), because at the solstices, the Sun's declination appears to "stand still"; that is, the seasonal movement of the Sun's daily path (as seen from Earth) pauses at a northern or southern limit before reversing direction.

E3B10
What is the effect of chordal-hop propagation?
The signal experiences less loss compared to multi-hop propagation, which uses Earth as a reflector
Chordal hop propagation occurs when a radio wave is refracted by the ionosphere such that the refracted wave hits the ionosphere and is refracted a second or third time before hitting the ground.

E3B11
At what time of day is sporadic-E propagation most likely to occur? **Between sunrise and sunset**

E3B12
What is chordal-hop propagation?
Successive ionospheric refractions without an intermediate reflection from the ground
The refracting strength of the ionosphere on the night side of earth bends signals in a shallow angle that allows multiple skips without returning to earth. The stronger daylight side ionosphere bends the signals more steeply, returning them to the surface.

E3B13
What type of polarization is supported by ground-wave propagation? **Vertical**

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

E3C01
What is the cause of short-term radio blackouts? **Solar flares**
A Solar flare is defined as a sudden, rapid, and intense variation in brightness. A solar flare occurs when magnetic energy that has built up in the solar atmosphere is suddenly released. Radiation is emitted across virtually the entire electromagnetic spectrum. The amount of energy released is the equivalent of millions of 100-megaton hydrogen bombs exploding at the same time! The first solar flare recorded in astronomical literature was on September 1, 1859. Two scientists, Richard C. Carrington and Richard Hodgson, were independently observing sunspots at the time, when they viewed a large flare in white light. This event has been referred to as the Carrington Event.

E3C02
What is indicated by a rising A-index or K-index? **Increasing disturbance of the geomagnetic field**
The A Index: It's simply an index of geomagnetic activity derived from a scaled average of the previous 24 hours K-index readings. You should use this as a reference for general conditions on the bands. Lower A index means better conditions for propagation.

The K-Index (or Boulder K): The K index is a gauge of geomagnetic activity relative to an assumed quiet-day. Falling numbers mean improving conditions and better propagation particularly in northern latitudes and areas where aurora activity can occur.

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? **Through the auroral oval**
The auroral oval is the footprint in the atmosphere of the boundary between the highly stretched field lines of the polar cap and the more normal field lines at lower latitudes.

E3C04
What does the value of Bz (B sub z) represent?
North-South strength of the interplanetary magnetic field

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

E3C06
How does the VHF/UHF radio horizon compare to the geographic horizon?
It is approximately 15 percent farther
Radio waves will travel about 15% further than line of Site

E3C07
Which of the following indicates the greatest solar flare intensity? **Class X**
X-class solar flares can create radiation storms which have the potential to not only harm satellites but also give small doses of radiation to the people flying in airplanes at the time! Moreover, these devastating flares can disrupt global communications and bring down the power grids to create blackouts.

E3C08
Which of the following is the space-weather term for an extreme geomagnetic storm? **G5**
The NOAA Geomagnetic Storm Scale indicates the severity of geomagnetic storms. It is denoted by a G followed by a number from 1 to 5, with 1 being a minor event, and 5 being an extreme event.

E3C09
What type of data is reported by amateur radio propagation reporting networks?
Digital-mode and CW signals
Radio amateurs have voluntarily built networks which monitor transionospheric radio links in real time and report these observations back to central servers.

E3C10
What does the 304A solar parameter measure?
UV emissions at 304 angstroms, correlated to the solar flux index
The angstrom (˚A) is an internationally recognized unit of length equal to 1×10−10m. It is another way to express extremely short wavelengths.

E3C11
What does VOACAP software model? **HF propagation**
VOACAP is free professional high-frequency (3-30 MHz) propagation prediction software originally developed for Voice of America (VOA).

E3C12

Which of the following is indicated by a sudden rise in radio background noise across a large portion of the HF spectrum? **A coronal mass ejection impact or a solar flare has occurred**

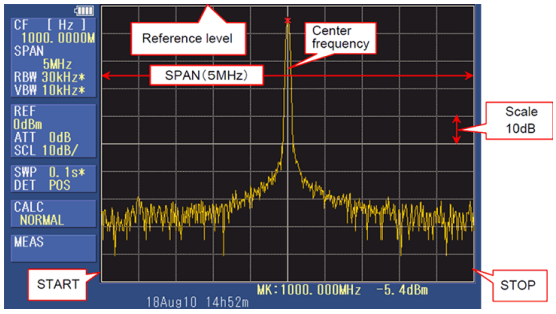
A coronal mass ejection (CME) is an explosive outburst of plasma from the Sun. The blast of a CME carries about a billion tons of material out from the Sun at very high speeds of hundreds of kilometers per second

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

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

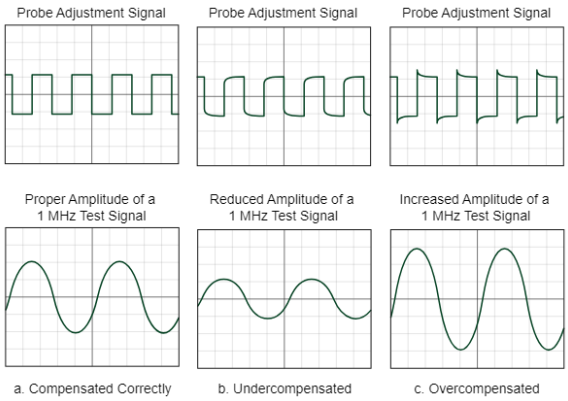
E4A01
Which of the following limits the highest frequency signal that can be accurately displayed on a digital oscilloscope? **Sampling rate of the analog-to-digital converter**

E4A02
Which of the following parameters does a spectrum analyzer display on the vertical and horizontal axes?
Signal amplitude and frequency



E4A03
Which of the following test instruments is used to display spurious signals and/or intermodulation distortion products generated by an SSB transmitter? **Spectrum analyzer**

E4A04
How is compensation of an oscilloscope probe performed?
A square wave is displayed, and the probe is adjusted until the horizontal portions of the displayed wave are as nearly flat as possible



E4A05
What is the purpose of using a prescaler with a frequency counter?
Reduce the signal frequency to within the counter's operating range
Prescaler is a frequency divider to reduce an input signal to a range the frequency counter can handle. For example a divide by ten frequency scaler would allow a 10 MHz counter to count up to a 100 MHz signal.

E4A06
What is the effect of aliasing on a digital oscilloscope when displaying a waveform?
A false, jittery low-frequency version of the waveform is displayed
Aliasing is basically a form of under sampling. The under sampled waveform is constructed to look like a slower frequency waveform or a flat line when the sample rate is the same as the frequency of your signal.

E4A07
Which of the following is an advantage of using an antenna analyzer compared to an SWR bridge?
Antenna analyzers compute SWR and impedance automatically

E4A08
Which of the following is used to measure SWR?
A. Directional wattmeter
B. Vector network analyzer
C. Antenna analyzer
D**. All these choices are correct**



E4A09
Which of the following is good practice when using an oscilloscope probe?
Minimize the length of the probe's ground connection
At higher frequencies the ground lead may have high inductive reactance.

E4A10
Which trigger mode is most effective when using an oscilloscope to measure a linear power supply's output ripple? **Line**
This is because the power supplies ripple will be usually at the power line frequency or a multiple of it.

E4A11
Which of the following can be measured with an antenna analyzer?
A. Velocity factor
B. Cable length
C. Resonant frequency of a tuned circuit
D**. All these choices are correct**

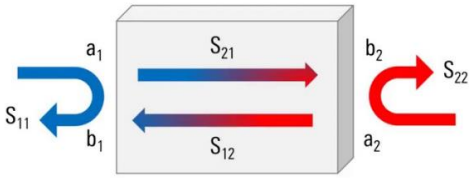
E4B Measurement technique and limitations: instrument accuracy and performance limitations; probes; techniques to minimize errors; measurement of Q; instrument calibration; S parameters; vector network analyzers; RF signals

E4B01
Which of the following factors most affects the accuracy of a frequency counter? **Time base accuracy**
Since the time base is what controls the period of time over which the frequency counting is accumulated the accuracy of the count is dependent on the accuracy of the measurement period of time.

E4B02
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 is the input impedance of the voltmeter
The lower the ohms per volt the higher the load is on the circuit being measured.

E4B03
Which S parameter is equivalent to forward gain? **S21**

E4B04
Which S parameter represents input port return loss or reflection coefficient (equivalent to VSWR)?
S11



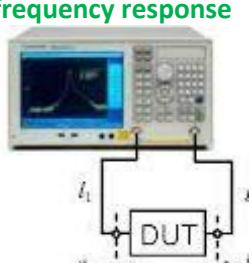
E4B05
What three test loads are used to calibrate an RF vector network analyzer?
Short circuit, open circuit, and 50 ohms

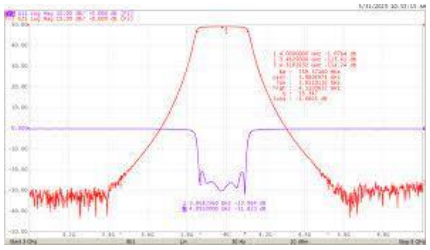
E4B06
How much power is being absorbed by the load when a directional power meter connected between a transmitter and a terminating load reads 100 watts forward power and 25 watts reflected power?
75 watts

E4B07
What do the subscripts of S parameters represent?
The port or ports at which measurements are made
S11 is the input impedance, S22 is the output impedance, S21 is the output vs the input(gain), and S12 is the input vs the output (loss).

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

E4B09
Which of the following can be measured by a two-port vector network analyzer?
Filter frequency response





E4B10
Which of the following methods measures intermodulation distortion in an SSB transmitter?
Modulate the transmitter using two AF signals having non-harmonically related frequencies and observe the RF output with a spectrum analyzer

E4B11
Which of the following can be measured with a vector network analyzer?
A. Input impedance
B. Output impedance
C. Reflection coefficient
D. **All these choices are correct**

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
What is an effect of excessive phase noise in an SDR receiver's master clock oscillator?
It can combine with strong signals on nearby frequencies to generate interference

E4C02
Which of the following receiver circuits can be effective in eliminating interference from strong out-of-band signals? **A front-end filter or preselector**
***This is a fixed or tunable filter before the receiver input circuitry*.**

E4C03
What is the term for the suppression in an FM receiver of one signal by another stronger signal on the same frequency? **Capture effect**
The capture effect relates the ability of the receiver demodulator to recover the message of the dominant carrier when two or more FM carriers of unequal power level are present.

E4C04
What is the noise figure of a receiver?
The ratio in dB of the noise generated by the receiver to the theoretical minimum noise
The lower the noise figure the smaller the signal that can be and be detected.

E4C05
What does a receiver noise floor of -174 dBm represent?
The theoretical noise in a 1 Hz bandwidth at the input of a perfect receiver at room temperature
Theoretical Noise power is a function of temperature and receiver bandwidth at 290° Kelvin (62° Fahrenheit) the theoretical noise floor is -174 dBm in a 1 Hz bandwidth. This means a perfect receiver would not be able to receive a signal below this value. A receiver with a 3 KHz bandwidth (a 34.7 dB wider bandwidth than 1 Hz) would have a theoretical noise floor of
– 139 dBm (.02 µV).

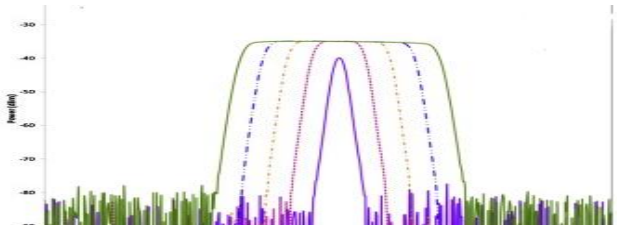
E4C06
How much does increasing a receiver's bandwidth from 50 Hz to 1,000 Hz increase the receiver's noise floor? **13 dB**
dB=10(log(1000/50)) or =(log(20)) or =10 (1.301) or =13.01dB

E4C07
What does the MDS of a receiver represent? **The minimum discernible signal**
The Minimum Discernible Signal is defined as a signal that achieves a 3dB audio voltage gain over the internally generated noise from within the receiver alone.

E4C08
An SDR receiver is overloaded when input signals exceed what level?
The reference voltage of the analog-to-digital converter
ADCs convert analog inputs that can vary from zero volts up to a maximum voltage level that is called the reference voltage. The reference voltage that determines the ceiling of what the Analog to Digital Converter can convert.

E4C09
Which of the following choices is a good reason for selecting a high IF for a superheterodyne HF or VHF communications receiver? **Easier for front-end circuitry to eliminate image responses**
The mixer products are further apart and easier to filter out the unwanted image frequency. Receiving a 30 MHz signal with a 455KHz IF the two input mixer products are 30.455 MHz and 29.545 MHz a separation of 0.910 MHz. with a 10 MHz IF the two input mixer products are 20 MHz and 40 MHz a separation of 20 MHz.

E4C10
What is an advantage of having a variety of receiver bandwidths from which to select?
Receive bandwidth can be set to match the modulation bandwidth, maximizing signal-to-noise ratio and minimizing interference
The ability to adapt the receiver's bandwidth to the width of the signal to be received reduces extraneous noise that is received thus reducing interference from other nearby signals and improving the signal-to-noise ratio.



E4C11
Why does input attenuation reduce receiver overload on the lower frequency HF bands with little or no impact on signal-to-noise ratio?
Atmospheric noise is generally greater than internally generated noise even after attenuation

E4C12
How does a narrow-band roofing filter affect receiver performance?
It improves blocking dynamic range by attenuating strong signals near the receive frequency
A Roofing filter is a type of filter used in an HF radio receiver. It is usually found after the first receiver mixer. The goal of a roofing filter is to limit the passband of the first intermediate frequency (IF) stage. Additional filters for specific modulation types follow the roofing filter stage.

E4C13
What is reciprocal mixing?
Local oscillator phase noise mixing with adjacent strong signals to create interference to desired signals

E4C14
What is the purpose of the receiver IF Shift control?
To reduce interference from stations transmitting on adjacent frequencies

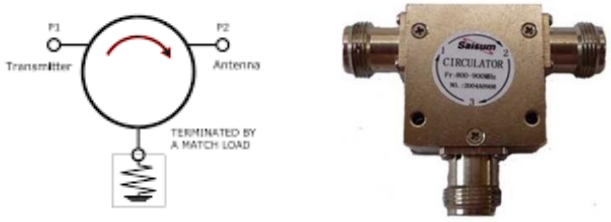
E4D Receiver performance characteristcs: dynamic range; intermodulation and cross-modulation interference; third-order intercept; desensitization; preselector; sensitivity; link margin

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 that will cause 1 dB of gain compression

E4D02
Which of the following describes problems caused by poor dynamic range in a receiver?
Spurious signals caused by cross modulation and desensitization from strong adjacent signals
***Cross Modulation. Cross-modulation* is an effect in which amplitude modulation (AM) from a strong undesired signal is transferred to a weaker desired signal.**
Desensitization is the term for the reduction in receiver sensitivity caused by a strong signal near the received frequency is desensitization. This is caused by RF energy from a strong signal near the receive frequency entering pass-band of the receiver.

E4D03
What creates intermodulation interference between two repeaters in close proximity?
The output signals mix in the final amplifier of one or both transmitters
Placing a circulator in the transmitter output will prevent signals from coming back from the antenna into the transmitter output. Adding a circulator as a one way path for the transmit signal can prevent this. .

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



E4D05
What transmitter frequencies would create 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**
IM interference = ((145.52)(2)) – (146.70) or (293.04) - (146.70) or 146.34 also
IM interference = ((146.70 + 146.52) ÷ (2)) or (293.220) ÷ (2) or 146.61

E4D06
What is the term for the reduction in receiver sensitivity caused by a strong signal near the received frequency? **Desensitization**
See added note in answer for E4D02

E4D07
Which of the following reduces the likelihood of receiver desensitization?
Insert attenuation before the first RF stage
Desensitization of a receiver is caused by overload to the receiver from strong nearby transmitters. Lower input signal level may help to prevent desensitization. .

E4D08
What causes intermodulation in an electronic circuit? **Nonlinear circuits or devices**
Intermodulation (IM) or intermodulation distortion (IMD) is the amplitude modulation of signals containing two or more different frequencies, caused by nonlinearities or time variance in a system. The intermodulation between frequency components will form additional components at frequencies that are not just at harmonic frequencies (integer multiples) of either, like harmonic distortion, but also at the sum and difference frequencies of the original frequencies and at sums and differences of multiples of those frequencies.

E4D09
What is the purpose of the preselector in a communications receiver?
To increase the rejection of signals outside the band being received
A preselector is an electronic device that connects between a radio antenna and a radio receiver. The preselector is a band-pass filter that blocks troublesome frequencies from passing through from the antenna into the radio receiver.

E4D10
What does a third-order intercept level of 40 dBm mean with respect to receiver performance?
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
Why are odd-order intermodulation products, created within a receiver, of particular interest compared to other products?
Odd-order products of two signals in the band being received are also likely to be within the band

E4D12
What is the link margin in a system with a transmit power level of 100 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? **+8dB**
Available power= Tx power + ant Gain + cable loss + path loss or 40 +10 - 3 – 136 or -89 dBm
Needed power = Receiver MDS + required s/n or -103 + 6 or -97
Link Margin = Available power – needed power or -89 - (-97) or 8 dBm

E4D13
What is the received signal level with a transmit power of 100 W (+40 dBm), a transmit antenna gain of 6 dBi, a receive antenna gain of 3 dBi, and a path loss of 100 dB? **-51 dBm**
Tx power + Tx ant gain + rec. antenna gain – path loss or + 40dBm + 6dB +3 dB -100 dB or -51dbm

E4D14
What power level does a receiver minimum discernible signal of -100 dBm represent? **0.1 picowatts**
Watts -
Milliwatts - .001 watts -30 dBm
Microwatts - .000 001 watts -60 dBm
Picowatts - .000 000 000,001 watts - 90 dBm
A tenth of a Pico Watt would be 10 dB more -100 dBm

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

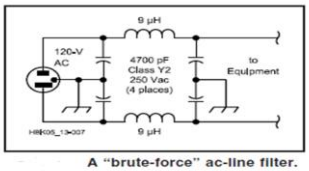
E4E01
What problem can occur when using an automatic notch filter (ANF) to remove interfering carriers while receiving CW signals? **Removal of the CW signal as well as the interfering carrier**

E4E02
Which of the following types of noise can often be reduced by a digital noise reduction?
A. Broadband white noise
B. Ignition noise
C. Power line noise
D. **All these choices are correct**

E4E03
Which of the following types of noise are removed by a noise blanker? **Impulse noise**
In radio receivers, a noise blanker is a circuit intended to reduce the effect of certain kinds of radio noise on a received signal. It is often used on shortwave receivers or communications receivers The noise blanker is only effective on impulse-type noise such as from lightning or from automotive ignition systems, and cannot improve performance on wideband noise.

E4E04
How can conducted noise from an automobile battery charging system be suppressed?
By installing ferrite chokes on the charging system leads
The noise caused by the charging system comes from the alternator rectifier diodes.

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



A "brute-force" ac-line filter.

E4E06
What type of electrical interference can be caused by computer network equipment?
The appearance of unstable modulated or unmodulated signals at specific frequencies

E4E07
Which of the following can cause shielded cables to radiate or receive interference?
Common-mode currents on the shield and conductors
Common mode currents are generally a problem* because they flow through parasitic, unintended paths*. One example is on the outside of coaxial cable shields.

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

E4E09
What undesirable effect can occur when using a noise blanker?
Strong signals may be distorted and appear to cause spurious emissions
To detect sharp noise pulses, the nose blanker must detect signals over a wide bandwidth and therefore cannot be protected by narrow receive filters. The noise blanker can be fooled by strong signals as if they were noise pulses causing the receiver to shut down. This can cause distortion of the desired signals even if no noise was present. This might sound as if the strong signal is very wide with lots of spurious signals.

E4E10
Which of the following can create intermittent loud roaring or buzzing AC line interference?
A. Arcing contacts in a thermostatically controlled device
B. A defective doorbell or doorbell transformer inside a nearby residence
C. A malfunctioning illuminated advertising display
D. **All these choices are correct**

E4E11
What could be the cause of local AM broadcast band signals combining to generate spurious signals on the MF or HF bands?
Nearby corroded metal connections are mixing and reradiating the broadcast signals
The corroded joints act as a diode causing the mixing of signals and generation of harmonics and mixing products

E4E12
What causes interference received as a series of carriers at regular intervals across a wide frequency range? **Switch-mode power supplies**
Switch mode power supplies immediately rectify the incoming AC Line voltage then switch it on and off at a higher frequency (Typically around 20 KHz or higher). Unless carefully shielded and filtered the output can have the switching frequency and harmonics being radiated or on the output,

E4E13
Where should a station AC surge protector be installed? **On the single point ground panel**
A true single point ground system means just that, everything is referenced to a single point and that is where everything within your shack is tied to the external earth ground system. The single point is truly a single point, typically a single bus bar or equal that is 4 or 6 inches by 24 inches. All system grounds terminate to this single bus bar connecting point. In reality each component and external source is effectively bonded to a single point, which is then bonded to the external ground system.

E4E14

What is the purpose of a single point ground panel?

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
What can cause the voltage across reactances in a series RLC circuit to be higher than the voltage applied to the entire circuit? **Resonance**
Resonance occurs when the capacitive reactance and inductive reactance of components in parallel or series have equal values of reactance.

E5A02
What is the resonant frequency of an RLC circuit if R is 22 ohms, L is 50 microhenries, and C is 40 picofarads? **3.56 MHz**
Resonant Frequency (MHz)= 1 ÷ ((2 π)(√)((L micro Henries)(C micro-farads)) or
F_{MHz} = 1 / ((2 π)(√(50)(.000,040)) or 1 ÷ ((2 π)(√(.002)) or 1 / (2 π)(.0447) or 1 ÷ .2809)) or 3.560
Note: Resistance does not enter into the calculation for resonant frequency, only applies when calculating the Q of the circuit.

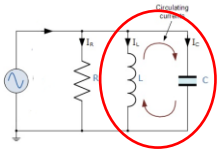
E5A03
What is the magnitude of the impedance of a series RLC circuit at resonance?
Approximately equal to circuit resistance
Capacitive reactance and Inductive reactance are equal, they cancel each other out and circuit is only resistive.

E5A04
What is the magnitude of the impedance of a parallel RLC circuit at resonance?
Approximately equal to circuit resistance

E5A05
What is the result of increasing the Q of an impedance-matching circuit?
Matching bandwidth is decreased

E5A06
What is the magnitude of the circulating current within the components of a parallel LC circuit at resonance? **It is at a maximum**
Circulating current is the exchange of energy between the capacitor and the inductor. Since they cancel each other out the current flowing is only limited by the circuit resistance.

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



The circulating current is the exchange of energy between the capacitor and the inductor. With ideal capacitors and inductors no power is taken from the input signal and the current continues indefinitely. .

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
What is the resonant frequency of an RLC circuit if R is 33 ohms, L is 50 microhenries, and C is 10 picofarads? **7.12 MHz**
Resonant Frequency (MHz)= 1 ÷ ((2 π)(√(L micro Henries)(C micro-farads))or
F(MHz) = 1 / ((2 π)(√(50)(.000,010)) or 1 ÷ ((2 π)(√(.002)) or 1 / (2 π)(.0224) or 1 ÷ .1404)) or 7.121

E5A11
What is the half-power bandwidth of a resonant circuit that has a resonant frequency of 7.1 MHz and a Q of 150? **47.3 kHz**
Bandwidth = Frequency ÷ Q or 7,100,000 kHz ÷ 150 or 47.3 kHz

E5A12
What is the half-power bandwidth of a resonant circuit that has a resonant frequency of 3.7 MHz and a Q of 118? **31.4 kHz**
Bandwidth = Frequency ÷ Q or 3,700,000 Hz ÷ 118 or 31.356 kHz

E5A13
What is an effect of increasing Q in a series resonant circuit? **Internal voltages increase**

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

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 or to discharge to 36.8% of its initial voltage? **One time constant**
One Time constant (τ) in seconds = R x C with capacity in µF and R in Megohms.
For example, for a 1 meg ohm resistor connected to a 10 µF capacitor:
τ = 1 x 10 or10 Seconds.

E5B02
What letter is commonly used to represent susceptance? **B**

E5B03
How is impedance in polar form converted to an equivalent admittance?
Take the reciprocal of the magnitude and change the sign of the angle
An impedance of 5 Ω at 37° would be an admittance of 0.2 at -37°

E5B04

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

$\tau_{(time\ constant)}$ = (1 megohm ÷ 2) (220) (2) or τ = (.5) (440) or τ =220 seconds

E5B05

What is the effect on the magnitude of pure reactance when it is converted to susceptance?

It is replaced by its reciprocal

A positive reactance becomes a negative susceptance and a negative reactance becomes a positive susceptance.

E5B06

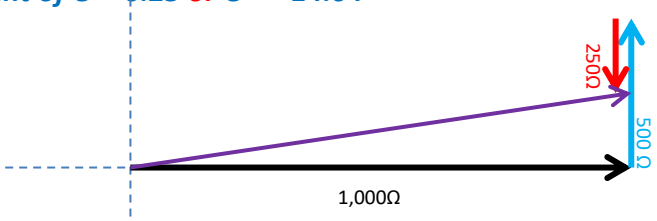
What is susceptance? **The imaginary part of admittance**

Susceptance is one divided by the reactance.

E5B07

What is 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? **14.0 degrees with the voltage lagging the current**

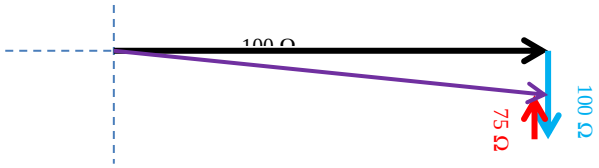
Tangent of Θ = Y ÷ X or Tangent of Θ = (500 - 250) ÷ 1000 or Tangent= 250 ÷ 1000 or Tangent of Θ= 0.25 or Θ = +14.04°



E5B08

What is 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? **63 degrees with the voltage lagging the current**

Tangent of Θ = Y ÷ X or Tangent of Θ = (-100 +75) ÷ 100 or arc Tangent of Θ = -25÷100 or arc Tangent of Θ = -0 .25 or Θ = -14.04°



E5B09

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

Current leads voltage by 90 degrees

Because initially the capacitor looks like a very low impedance.

E5B10

What is the relationship between the AC current through an inductor and the voltage across an inductor? **Voltage leads current by 90 degrees**

Because Initially the inductor looks like a very High impedance.

E5B11

What is 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? **27 degrees with the voltage leading the current**

Tangent of Θ = Xc ÷ R or Tangent of Θ = (25 - 75) ÷ 100 or arc Tangent of Θ = -50 ÷ 100 or arc Tangent of Θ = 0 .50 or Θ = -26.56°

E5B12

What is admittance? **The inverse of impedance**

Admittance is 1÷impedance and is measured in the unit of Siemens, and its symbol is "Y". Like impedance, admittance is a complex quantity rather than a scalar (X,Y value).

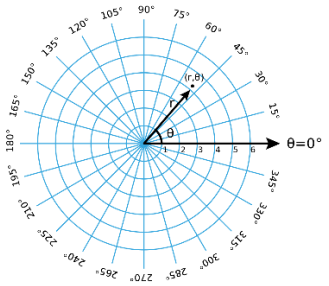
E5C Coordinate systems and phasors in electronics: rectangular coordinates; polar coordinates; phasors; logarithmic axes

E5C01

Which of the following represents pure capacitive reactance of 100 ohms in rectangular notation?
0 - j100

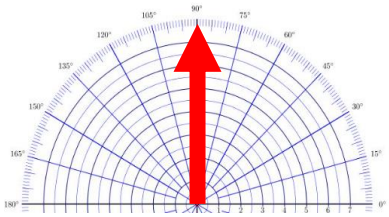
E5C02

How are impedances described in polar coordinates? **By magnitude and phase angle**



E5C03

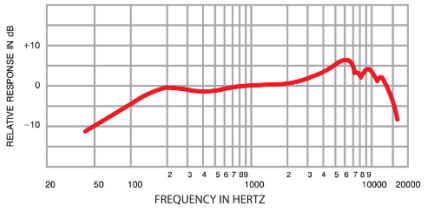
Which of the following represents a pure inductive reactance in polar coordinates?
A positive 90 degree phase angle



E5C04

What type of Y-axis scale is most often used for graphs of circuit frequency response?

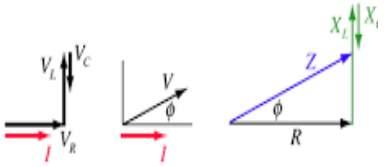
Logarithmic



E5C05

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

Phasor diagram



Phasor Diagrams

E5C06

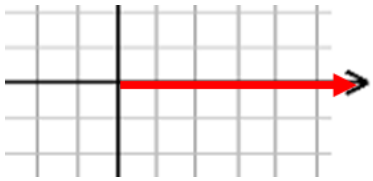
What does the impedance 50 - j25 ohms represent?

50 ohms resistance in series with 25 ohms capacitive reactance

E5C07

Where is the impedance of a pure resistance plotted on rectangular coordinates?

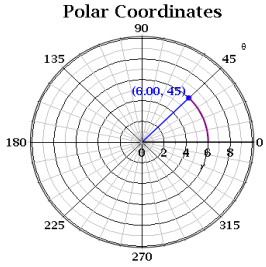
On the horizontal axis



E5C08

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

Polar coordinates

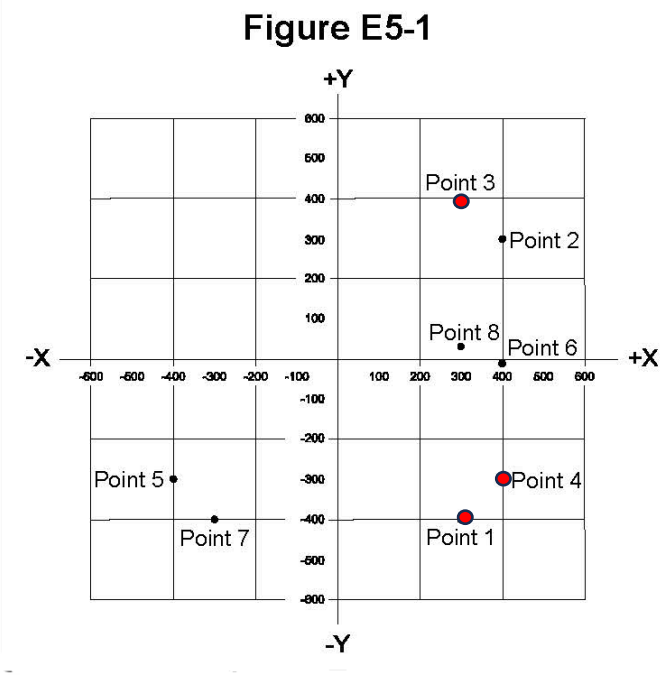


E5C09

When using rectangular coordinates to graph the impedance of a circuit, what do the axes represent?

The X axis represents the resistive component, and the Y axis represents the reactive component

Figure E5-1



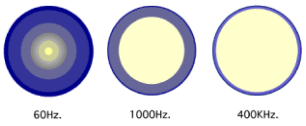
E5C10
Which point on Figure E5-1 best represents the impedance of a series circuit consisting of a 400-ohm resistor and a 38-picofarad capacitor at 14 MHz? **Point 4**
Xc = 1 ÷ ((2)(π)(F)(C)) or Xc = 1 ÷ ((6.28)(14)(0.000038)) or Xc = -299 Ω
In rectangular coordinates 400Ω (X Axis) and -299 Ω (Y axis) or 400, -j299

E5C11
Which point 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? **Point 3**
XL = (2)(π)(F)(C) or Xc = (6.28) (3.505) (18) or Xc = 396 Ω
In rectangular coordinates 300 Ω (X Axis) and 396 Ω (Y axis) or 300, j396

E5C12
Which point 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? **Point 1**
Xc = 1 ÷ (2)(π)(F)(C) or Xc = 1 ÷ (6.28) (21.2) (0.000019) or Xc = -395 Ω
In rectangular coordinates 300Ω (X Axis) and -395 Ω (Y axis) or 300, -j395

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

E5D01
What is the result of conductor skin effect?
Resistance increases as frequency increases because RF current flows closer to the surface



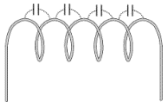
E5D02
Why is it important to keep lead lengths short for components used in circuits for VHF and above?
To minimize inductive reactance

E5D03
What is the phase relationship between current and voltage for reactive power?
They are 90 degrees out of phase

E5D04
Why are short connections used at microwave frequencies?
To reduce phase shift along the connection
One wavelength at 10 GHz would be 3cm (1.180 inches). A 0,032 inch lead would have 10° of phase change.

E5D05
What parasitic characteristic causes electrolytic capacitors to be unsuitable for use at RF?
Inductance
Electrolytic capacitors are a poor choice for high frequencies because they basically consist of two sheets of metal foil separated by sheets dielectric and formed into a roll. This kind of structure has considerable self-inductance and acts more like an inductor than a capacitor at Higher frequencies.

E5D06
What parasitic characteristic creates an inductor's self-resonance?
Inter-turn capacitance



E5D07
What combines to create the self-resonance of a component?
The component's nominal and parasitic reactance

E5D08
What is the primary cause of loss in film capacitors at RF? **Skin effect**

E5D09
What happens to reactive power in **ideal** inductors and capacitors?
Energy is stored in magnetic or electric fields, but power is not dissipated

E5D10
As a conductor's diameter increases, what is the effect on its electrical length? **It increases**
As the ratio of the diameter of a conductor to wavelength increases, the capacitance increases, so the node occurs farther beyond the end, and the electrical length of the element increases.

E5D11

How much real 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**

In a circuit consisting of a 100 ohm resistor in series with a 100 ohm inductive reactance drawing 1 ampere, the power consumed is 100 Watts. $P = I^2 \times R = 1A^2 \times 100$ ohms = 100 W

E5D12

What is reactive power? **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 what application is gallium arsenide used as a semiconductor material? **In microwave circuits**
GaAs, or Gallium Arsenide, is a compound semiconductor material that is widely used in the field of microwave devices. It is a crystalline material that has a high electron mobility and excellent properties of direct bandgap, which make it a great option for high-frequency applications.

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
The depletion region is the layer where the flow of charges decreases. This region acts as the barrier that opposes the flow of electrons from the n-side to the p-side of the semiconductor diode.

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

E6A05
How does DC input impedance at the gate of a field-effect transistor (FET) compare with that of a bipolar transistor? **An FET has higher input impedance**

E6A06
What is the beta of a bipolar junction transistor?
The change in collector current with respect to base current
This is the current gain of the transistor. A transistors current gain is given the Greek symbol beta (β).

E6A07
Which of the following indicates that a silicon NPN junction transistor is biased on?
Base-to-emitter voltage of approximately 0.6 volts to 0.7 volts
This is the normal silicon diode junction forward voltage drop which is approx. 0.7 volts.

E6A08

What 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? **Alpha cutoff frequency**

Transistor alpha(α) is the gain of a transistor, ß, at a higher frequency compared to the ß of the transistor at 1 kHz, then increasing the frequency till ß is 0.7 of the 1 kHZ ß. This is the Alpha(α) cut off frequency.

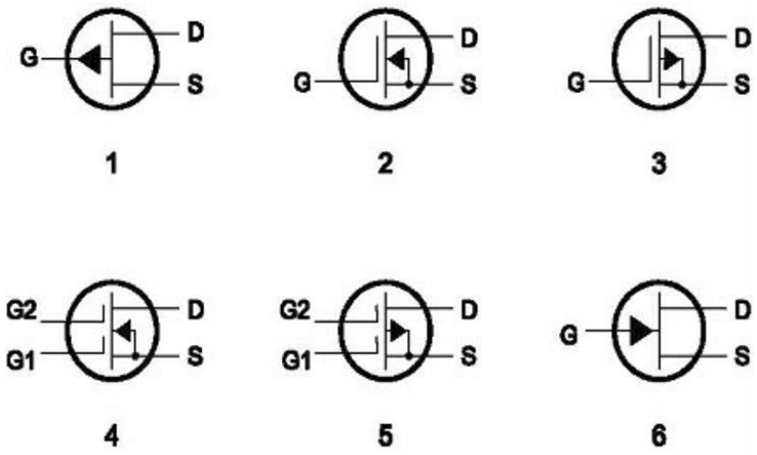
E6A09

What is a depletion-mode field-effect transistor (FET)?

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

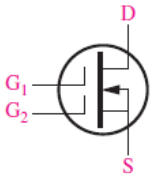
This device requires a bias voltage to stop the current flow, opposite of a normal FET where a bias voltage is required to cause current to flow.

Figure E6-1



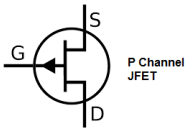
E6A10

In Figure E6-1, which is the schematic symbol for an N-channel dual-gate MOSFET? **4**



E6A11

In Figure E6-1, which is the schematic symbol for a P-channel junction FET? **1**



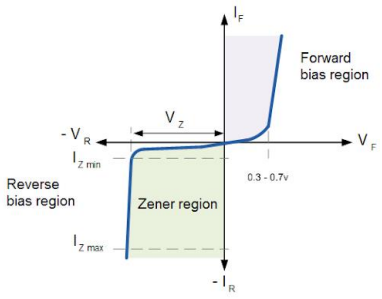
E6A12

What is the purpose of connecting Zener diodes between a MOSFET gate and its source or drain?

To protect the gate from static damage

E6B Diodes

E6B01
What is the most useful characteristic of a Zener diode?
A constant voltage drop under conditions of varying current

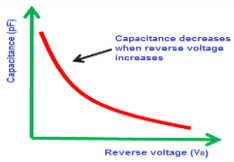


A Zener diode is a diode that when reverse biased will have a constant breakdown voltage vs current flow over a wide range of current. The current must be limited in the Zener region to prevent too much current from flowing which would result in failure of the diode.

E6B02
Which characteristic of a Schottky diode makes it a better choice than a silicon junction diode for use as a power supply rectifier? **Lower forward voltage drop**

E6B03
What property of an LED's semiconductor material determines its forward voltage drop?
Band gap
Light-emitting diodes (LEDs) produce light) by the recombination of electrons and electron holes in a semiconductor, a process called "electroluminescence". The wavelength (Color) of the light produced depends on the energy band gap.

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?
Low junction capacitance
If the forward current through the PIN diode is near the maximum the diode is designed for, it typically has an RF resistance of only 0.1 ohm, and thus acts as a closed switch. Thus, for RF, the PIN diode acts as a closed switch if it is forward biased with the near maximum DC bias current.

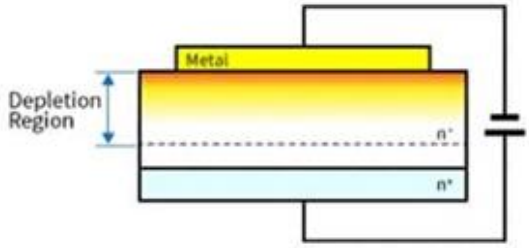
E6B06
Which of the following is a common use of a Schottky diode? **As a VHF/UHF mixer or detector**
A Schottky diode is a type of metal – semiconductor junction diode, which is also known as hot-carrier diode. The Schottky diode is formed by the junction of a semiconductor with a metal. Schottky diodes offers fast switching action and have a low forward voltage drop.

E6B07
What causes a junction diode to fail from excessive current? **Excessive junction temperature**

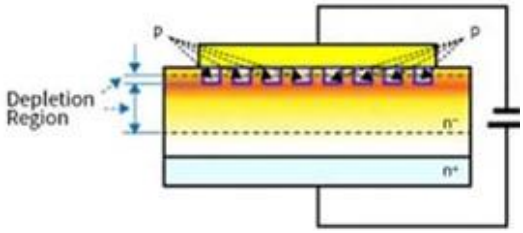
E6B08

Which of the following is a Schottky barrier diode? **Metal-semiconductor junction**

Schottky Barrier Diodes (SBDs) generally have the advantages of very short reverse recovery time and low forward voltage drop.



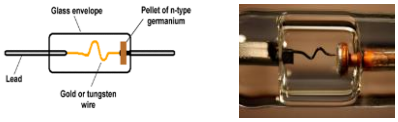
Conventional SBD Structure



Junction Barrier SBD structure

E6B09

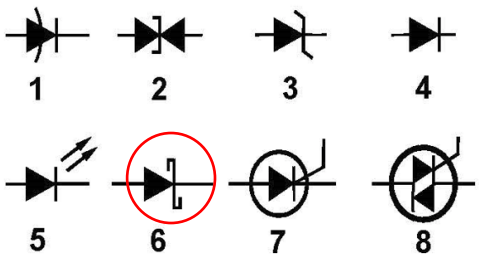
What is a common use for point-contact diodes? **As an RF detector**



E6B10

In Figure E6-2, which is the schematic symbol for a Schottky diode? **6**

Figure E6-2



E6B11

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

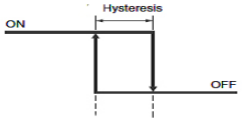
Forward DC bias current

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

E6C01

What is the function of hysteresis in a comparator?

To prevent input noise from causing unstable output signals



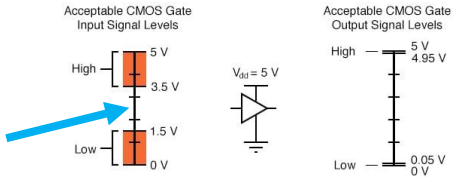
E6C02
What happens when the level of a comparator's input signal crosses the threshold voltage?
The comparator changes its output state

E6C03
What is tri-state logic? **Logic devices with 0, 1, and high-impedance output states**
The basic concept of the third state, high impedance (Hi-Z), is to effectively remove the device's influence from the rest of the circuit. If more than one device is electrically connected to another device, putting an output into the Hi-Z state is often used to prevent one device driving high (logical 1) against another device driving low (logical 0).

E6C04
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

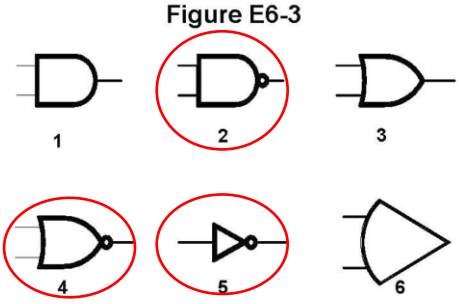
E6C05
Which of the following digital logic families has the lowest power consumption? **CMOS**

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 half the power supply voltage**

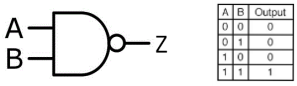


E6C07
What best describes a pull-up or pull-down resistor?
A resistor connected to the positive or negative supply used to establish a voltage when an input or output is an open circuit

Figure E6-3



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

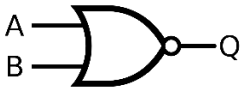


A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

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

E6C10

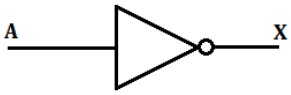
In Figure E6-3, which is the schematic symbol for a NOR gate? **4**



A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

E6C11

In Figure E6-3, which is the schematic symbol for the NOT operation (inversion)? **5**



Input	Output
0	1
1	0

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

E6D01

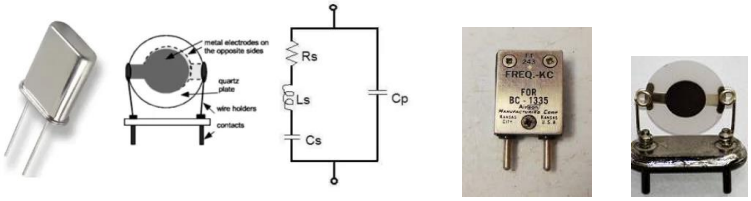
What is piezoelectricity?

A characteristic of materials that generate a voltage when stressed and that flex when a voltage is applied

E6D02

What is the equivalent circuit of a quartz crystal?

Series RLC in parallel with a shunt C representing electrode and stray capacitance



E6D03

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

Mechanical deformation of material due to the application of a voltage

E6D04

Why are cores of inductors and transformers sometimes constructed of thin layers?

To reduce power loss from eddy currents in the core

Eddy currents occur when the magnetic field around a stationary conductor changes. In other words, eddy currents are produced by anything that causes a change in the intensity or direction of a magnetic field in a conductor.

E6D05

How do ferrite and powdered iron compare for use in an inductor core?

Ferrite cores generally require fewer turns to produce a given inductance value

Iron core inductors have a maximum current at zero frequency, while ferrite core inductors have a minimum current at zero frequency. This helps iron core inductors to transfer more energy but decreases the Q factor. Ferrite cores are able to transfer less energy but have a higher Q factor at higher frequencies

E6D06
What core material property determines the inductance of an inductor? **Permeability**
Permeability is the measure of the resistance of a material against the formation of a magnetic field. Hence, it is the degree of magnetization that a material obtains in response to an applied magnetic field.

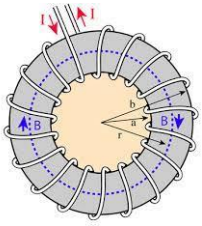
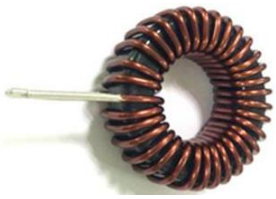
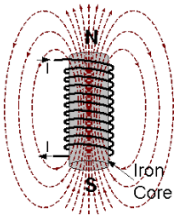
E6D07
What is the current that flows in the primary winding of a transformer when there is no load on the secondary winding? **Magnetizing current**

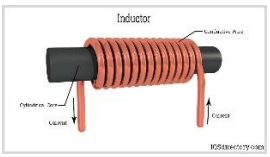
E6D08
Which of the following materials has the highest temperature stability of its magnetic characteristics?
Powdered iron

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



Toroidal Core **Solenoidal Core**

E6D11
Which type of core material decreases inductance when inserted into a coil? **Brass**

E6D12
What causes inductor saturation? **Operation at excessive magnetic flux**

E6E Semiconductor materials and packages for RF use

E6E01

Why is gallium arsenide (GaAs) useful for semiconductor devices operating at UHF and higher frequencies? **Higher electron mobility**

Gallium arsenide is a type of semiconductor, with high electron mobility and a high saturated electron velocity compared to silicon, enabling transistors made of gallium arsenide to function at frequencies into the microwave region.

E6E02

Which of the following device packages is a through-hole type? **DIP**

DIP = Dual in line Package (or pins)

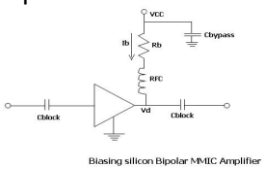
E6E03

Which of the following materials supports the highest frequency of operation when used in MMICs?
Gallium nitride

Monolithic microwave integrated circuit, or MMIC (sometimes pronounced "mimic"), is a type of integrated circuit (IC) device that operates at Microwave frequencies up to 300 GHz).

E6E04

Which is the most common input and output impedance of MMICs? **50 ohms**



Biasing silicon Bipolar MMIC Amplifier

E6E05

Which of the following noise figure values is typical of a low-noise UHF preamplifier? **0.5 dB**

The noise factor (figure) is defined as the ratio of the output noise power of a device to the portion thereof attributable to thermal noise in the input termination at standard noise temperature T_0 (usually 290 K (16° C). The noise factor is the ratio of actual output noise to that which would remain if the device itself did not introduce noise, or the ratio of input SNR (Signal to Noise Ratio) to output SNR. The noise figure is simply the noise factor expressed in decibels (dB).

E6E06

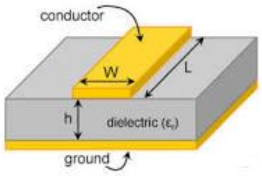
What characteristics of MMICs make them a popular choice for VHF through microwave circuits?
Controlled gain, low noise figure, and constant input and output impedance over the specified frequency range

And in addition they are inexpensive, around $1 each in small quantities.

E6E07

What type of transmission line is often used for connections to MMICs? **Microstrip**

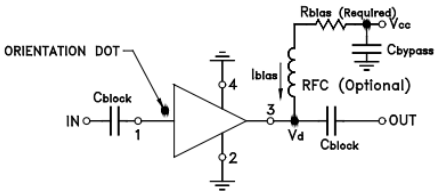
Microstrip is a type of electrical transmission line which can be fabricated using printed circuit board technology and is used to convey microwave-frequency signals. It consists of a conducting strip separated from a ground plane by a dielectric layer known as the substrate. The impedance is a function of conductor width and distance above the ground plane.



E6E08

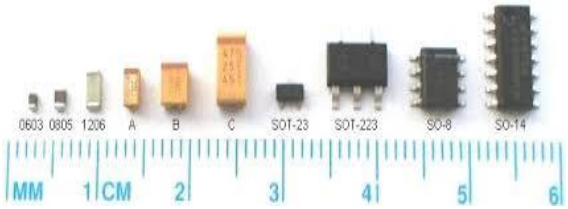
How is power supplied to the most common type of MMIC?

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



E6E09

Which of the following component package types have the least parasitic effects at frequencies above the HF range? **Surface mount**



E6E10

What advantage does surface-mount technology offer at RF compared to using through-hole components?

A. Smaller circuit area

B. Shorter circuit board traces

C. Components have less parasitic inductance and capacitance

D**. All these choices are correct**

E6E11

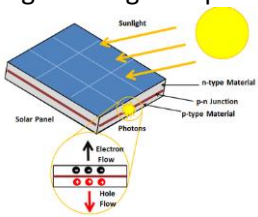
What is a characteristic of DIP packaging used for integrated circuits?

Two rows of connecting pins on opposite sides of package (dual in-line package)

E6E12
Why are DIP through-hole package ICs not typically used at UHF and higher frequencies?
Excessive lead length

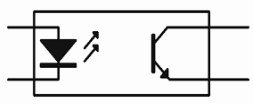
E6F Electro-optical technology: photoconductivity; photovoltaic devices; optical sensors and encoders; optically isolated switching

E6F01
What absorbs the energy from light falling on a photovoltaic cell? **Electrons**



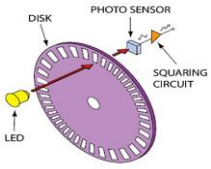
E6F02
What happens to photoconductive material when light shines on it? **Resistance decreases**

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 of the following describes an optical shaft encoder?
A device that detects rotation by interrupting a light source with a patterned wheel



E6F06
Which of these materials is most commonly used to create photoconductive devices?
Crystalline semiconductor
A crystalline semiconductor uses a* silicon *or gallium arsenide substrate composed of a single* crystal*. Its atomic structure is the same throughout the material.

E6F07

What is a solid-state relay?

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

Solid State Relays are used to provide isolated switching of AC or DC Circuits.

E6F08

Why are opto-isolators often used in conjunction with solid-state circuits that control 120 VAC circuits?

Optoisolators provide an 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 material used in power-generating photovoltaic cells? **Silicon**

E6F11

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

0.5 volts

It takes 24 Silicon Solar Cells in serries to produce 12 volts DC.

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

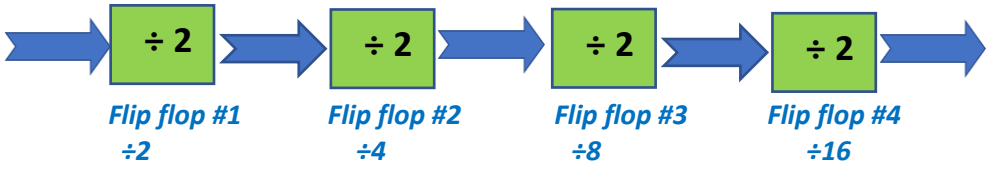
E7A Digital circuits: digital circuit principles and logic circuits; classes of logic elements; positive and negative logic; frequency dividers; truth tables

E7A01
Which circuit is bistable? **A flip-flop**
The bistable multivibrator can be switched over from one stable state to the other by the application of an external trigger pulse thus, it requires a second external trigger pulse to return to its original state.

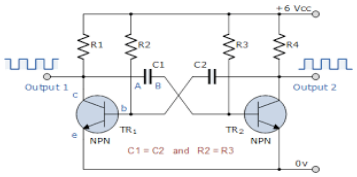
E7A02
What is the function of a decade counter? **It produces one output pulse for every 10 input pulses**
It divides an input frequency by 10.

E7A03
Which of the following can divide the frequency of a pulse train by 2? **A flip-flop**

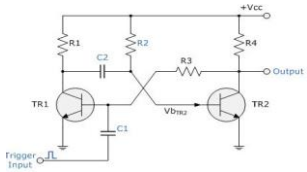
E7A04
How many flip-flops are required to divide a signal frequency by 16? **4**



E7A05
Which of the following circuits continuously alternates between two states without an external clock signal? **Astable multivibrator**



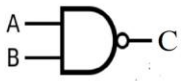
E7A06
What is a characteristic of a monostable multivibrator?
It switches temporarily to an alternate state for a set time



E7A07

What logical operation does a NAND gate perform? **It produces a 0 at its output only if all inputs are 1**

NAND GATE



Truth Table

INPUT		OUTPUT
A	B	A NAND B
0	0	1
0	1	1
1	0	1
1	1	0

E7A08

What logical operation does an OR gate perform? **It produces a 1 at its output if any input is 1**

OR Gate

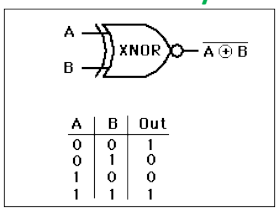
TRUTH TABLE

INPUT		OUTPUT
A	B	A OR B
0	0	0
0	1	1
1	0	1
1	1	1

E7A09

What logical operation is performed by a two-input exclusive NOR gate?

It produces a 0 at its output if one and only one of its inputs is 1



E7A10

What is a truth table? **A list of inputs and corresponding outputs for a digital device**

As shown in explanations EA07, EA08 and EA09

E7A11

What does "positive logic" mean in reference to logic devices?

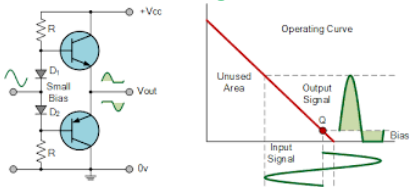
High voltage represents a 1, low voltage a 0

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

E7B01

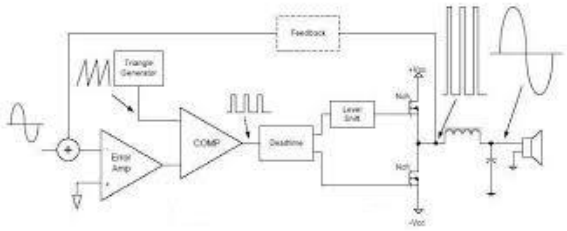
For what portion of the signal cycle does each active element in a push-pull, Class AB amplifier conduct?

More than 180 degrees but less than 360 degrees



E7B02

What is a Class D amplifier? **An amplifier that uses switching technology to achieve high efficiency**



E7B03

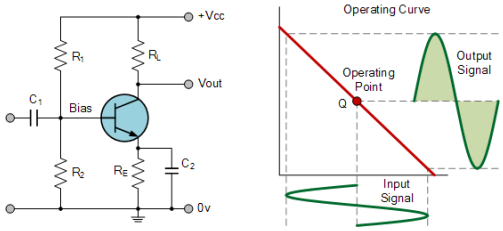
What circuit is required at the output of an RF switching amplifier?

A filter to remove harmonic content

E7B04

What is the operating point of a Class A common emitter amplifier?

Approximately halfway between saturation and cutoff



E7B05

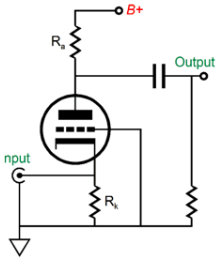
What can be done to prevent unwanted oscillations in an RF power amplifier?

Install parasitic suppressors and/or neutralize the stage

Parasitic oscillations can be eliminated in a power amplifier by neutralization. Neutralization is where a 180-degree out-of-phase portion of the output is feed back to the input.

E7B06

What is a characteristic of a grounded-grid amplifier? **Low input impedance**



E7B07

Which of the following is the likely result of using a Class C amplifier to amplify a single-sideband phone signal? **Signal distortion and excessive bandwidth**

E7B08

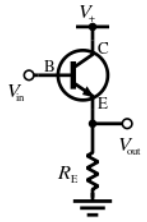
Why are switching amplifiers more efficient than linear amplifiers?

The switching device is at saturation or cutoff most of the time

E7B09

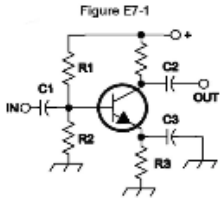
What is characteristic of an emitter follower (or common collector) amplifier?

Input and output signals in-phase



E7B10

In Figure E7-1, what is the purpose of R1 and R2? **Voltage divider bias**



E7B11

In Figure E7-1, what is the purpose of R3? **Self bias**

E7B12

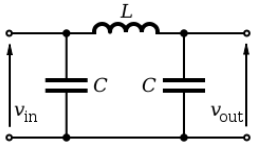
What type of amplifier circuit is shown in Figure E7-1? **Common emitter**

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

E7C01

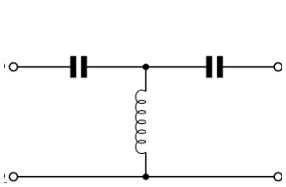
How are the capacitors and inductors of a low-pass filter Pi-network arranged between the network's input and output?

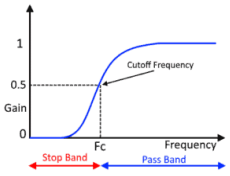
A capacitor is connected between the input and ground, another capacitor is connected between the output and ground, and an inductor is connected between the input and output



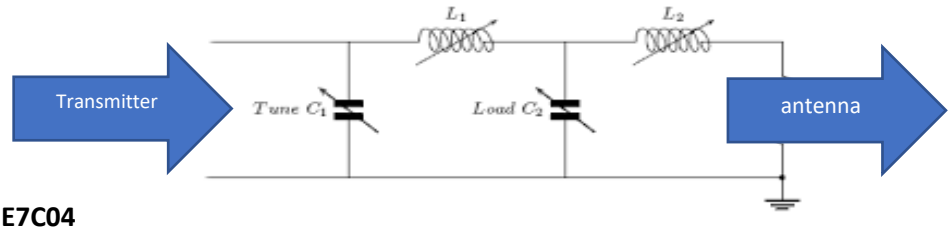
E7C02

What is the frequency response of a T-network with series capacitors and a shunt inductor? **High-pass**



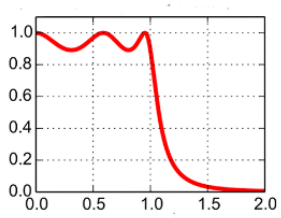


E7C03
What is the purpose of adding an inductor to a Pi-network to create a Pi-L-network?
Greater harmonic suppression

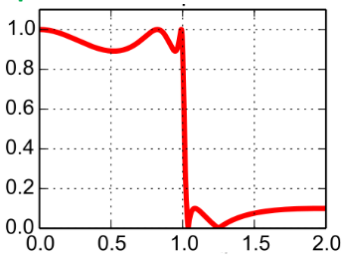


E7C04
How does an impedance-matching circuit transform a complex impedance to a resistive impedance?
It cancels the reactive part of the impedance and changes the resistive part to the desired value

E7C05
Which filter type has ripple in the passband and a sharp cutoff? **Chebyshev filter**

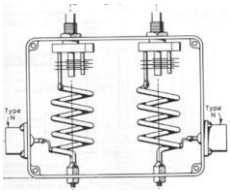


E7C06
What are the characteristics of an elliptical filter?
Extremely sharp cutoff with one or more notches in the stop band



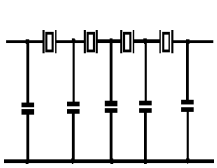
E7C07
Which describes a Pi-L network? **A Pi-network with an additional output series inductor**
See graphic for E7C03

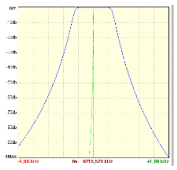
E7C08
Which of the following is most frequently used as a band-pass or notch filter in VHF and UHF transceivers? **A helical filter**



E7C09

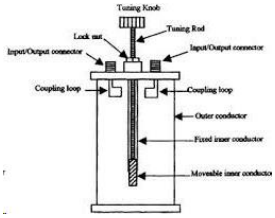
What is a crystal lattice filter? **A filter for low-level signals made using quartz crystals**





E7C10

Which of the following filters is used in a 2-meter band repeater duplexer? **A cavity filter**



E7C11

Which of the following measures a filter's ability to reject signals in adjacent channels? **Shape factor**

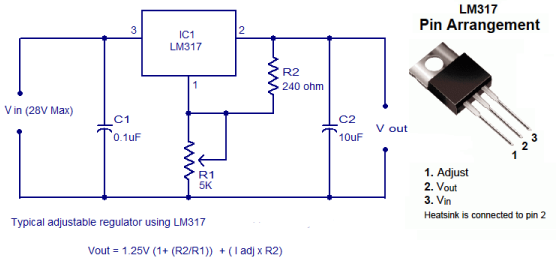
The sharper the filter (narrower with steep skirts) the better it can reject nearby signals.

E7D Power supplies and voltage regulators; solar array charge controllers

E7D01

How does a linear electronic voltage regulator work?

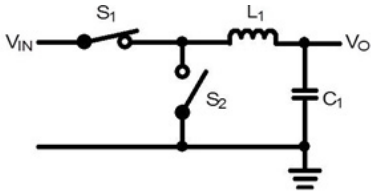
The conduction of a control element is varied to maintain a constant output voltage



E7D02

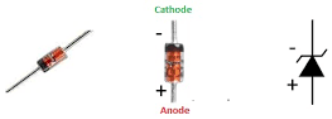
How does a switchmode voltage regulator work? **By varying the duty cycle of pulses input to a filter**

Switching regulator can convert input direct current (DC) voltage to the desired direct current (DC) voltage. In an electronic or other device, a switching regulator takes the role of converting the voltage from a power source to the output voltage required by controlling the on time for the input pulse to a charge capacitor.



E7D03

What device is used as a stable voltage reference? **A Zener diode**



Zener diodes are widely used as voltage references and as shunt regulators to regulate the voltage across small circuits. When connected in parallel with a variable voltage source so that it is reverse biased, a Zener diode conducts when the voltage reaches the diode's reverse breakdown voltage and maintains that voltage over a varying current range.

E7D04

Which of the following describes a three-terminal voltage regulator? **A series regulator**

A 3-terminal regulator is an integrated circuit that provides a constant regulated output voltage, regardless of changes in the input voltage or load conditions. It typically has three terminals: input, output, and ground.

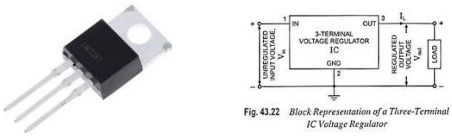


Fig. 43.22 *Block Representation of a Three-Terminal IC Voltage Regulator*

E7D05

Which of the following types of linear voltage regulator operates by loading the unregulated voltage source? **A shunt regulator**

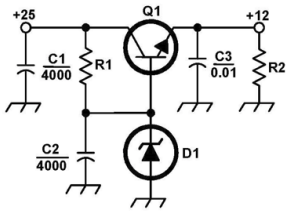
A shunt regulator regulates the output voltage by applying a variable load to the input to provide a constant output independent of the load. Because there is always power being drawn whether the load is high or low it is an inefficient regulator especially for higher current.

E7D06

What is the purpose of Q1 in the circuit shown in Figure E7-2?

It controls the current to keep the output voltage constant

Figure E7-2



E7D07

What is the purpose of C2 in the circuit shown in Figure E7-2?

It bypasses rectifier output ripple around D1

E7D08

What type of circuit is shown in Figure E7-2? **Linear voltage regulator**

E7D09

How is battery operating time calculated? **Capacity in amp-hours divided by average current**

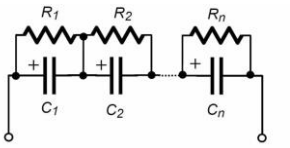
E7D10
Why is a switching type power supply less expensive and lighter than an equivalent linear power supply?
The high frequency inverter design uses much smaller transformers and filter components for an equivalent power output

E7D11
What is the purpose of an inverter connected to a solar panel output?
Convert the panel's output from DC to AC

E7D12
What is the dropout voltage of a linear voltage regulator?
Minimum input-to-output voltage required to maintain regulation

E7D13
Which of the following calculates power dissipated by a series linear voltage regulator?
Voltage difference from input to output multiplied by output current

E7D14
What is the purpose of connecting equal-value resistors across power supply filter capacitors connected in series?
A. Equalize the voltage across each capacitor
B. Discharge the capacitors when voltage is removed
C. Provide a minimum load on the supply
D. **All these choices are correct**



E7D15
What is the purpose of a step-start circuit in a high-voltage power supply?
To allow the filter capacitors to charge gradually
A "step-start" circuit in a high voltage power supply gradually increases the voltage in steps applied to filter capacitors. The reason to use this circuit is to avoid putting the full voltage (and high charging current) on the capacitors all at once.

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

E7E01
Which of the following can be used to generate FM phone signals?
Reactance modulation of a local oscillator
In the oscillator circuit the output frequency is changed using the modulation signal to change the reactance of the oscillator inductor or capacitor to change its frequency or phase (FM or PM).

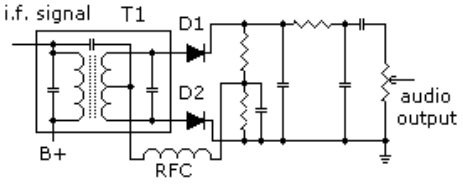
E7E02

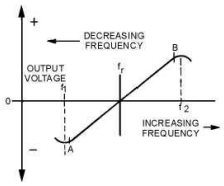
What is the function of a reactance modulator?

Produce PM or FM signals by varying a capacitance

E7E03

What is a frequency discriminator? **A circuit for detecting FM signals**





E7E04

What is one way to produce a single-sideband phone signal?

Use a balanced modulator followed by a filter

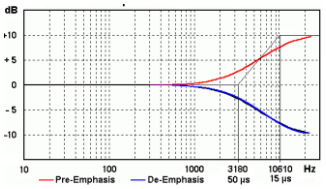
The output of a balanced modulator would be the carrier and both the upper and lower sidebands. A band pass filter can be used to select only one sideband and block the carrier and the other sideband

E7E05

What is added to an FM speech channel to boost the higher audio frequencies?

A pre-emphasis network

Pre-emphasis is the first part of a noise reduction technique in which a signal's weaker, audio higher frequencies are boosted before they are transmitted. The receiver uses a de-emphasis filter to the audio to reverse the process and restore normal sounding voice.



E7E06

Why is de-emphasis used in FM communications receivers?

For compatibility with transmitters using phase modulation

FM transmitters use Phase modulation to generate the RF signal and the Phase modulation process pre-emphasis the modulation signal and therefore to demodulate it you need to de-emphasis the signal.

E7E07

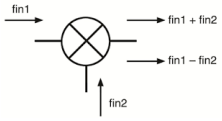
What is meant by the term “baseband” in radio communications?

The frequency range occupied by a message signal prior to modulation

E7E08

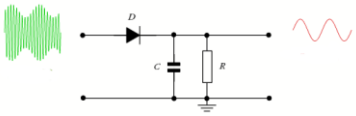
What are the principal frequencies that appear at the output of a mixer?

The two input frequencies along with their sum and difference frequencies



E7E09
What occurs when the input signal levels to a mixer are too high?
Spurious mixer products are generated

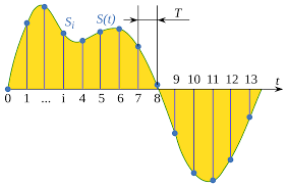
E7E10
How does a diode envelope detector function? **By rectification and filtering of RF signals**



E7E11
Which type of detector is used for demodulating SSB signals? **Product detector**
A *product detector* is a type of demodulator used for AM and *SSB* signals. Rather than converting the envelope of the signal into the decoded waveform like an envelope *detector*, the *product detector* uses the *product* of the modulated signal and a local oscillator, hence the name. A *product detector* is basically a frequency mixer.

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

E7F01
What is meant by "direct sampling" in 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**
The term adaptive filter implies changing the characteristic of a filter in some automated fashion to obtain the best possible signal quality despite changing signal/system conditions. Adaptive filters are usually associated with the broader topic of statistical signal processing.

E7F03
What type of digital signal processing filter is used to generate an SSB signal? **A Hilbert-transform filter**
Digital Hilbert filters are a special class of digital filter whose characteristic is to introduce a π/2 radians phase shift of the input signal. In the ideal Hilbert transformer all the positive frequency components are shifted by –π/2 radians and all the negative frequency components are shifted by π/2 radians.

E7F04
Which method generates an SSB signal using digital signal processing?
Signals are combined in quadrature phase relationship
"Quadrature" refers to two sinusoids that have the same frequency and are 90° out of phase.

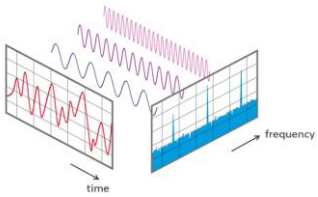
E7F05
How frequently must an analog signal be sampled to be accurately reproduced?
At least twice the rate of the highest frequency component of the signal
For a 10 MHz signal the sampling rate would need to be at least 20 MHz.

E7F06
What is the minimum number of bits required to sample a signal with a range of 1 volt at a resolution of 1 millivolt? **10 bits**

Resolution would be 2^10 or 1024

Bits	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
resolution	*1*	*2*	*4*	*8*	*16*	*32*	*64*	*128*	*256*	*512*	*1024*

E7F07
What function is performed by a Fast Fourier Transform?
Converting signals from the time domain to the frequency domain



E7F08
What is the function of decimation? **Reducing the effective sample rate by removing samples**

E7F09
Why is an anti-aliasing filter required in a decimator?
It removes high-frequency signal components that 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-sampling software defined radio (SDR)? **Sample rate**

E7F11
What sets the minimum detectable signal level for a direct-sampling software defined receiver in the absence of atmospheric or thermal noise? **Reference voltage level and sample width in bits**

E7F12
Which of the following is generally true of Finite Impulse Response (FIR) filters?
FIR filters can delay all frequency components of the signal by the same amount
A finite impulse response (FIR) filter is a filter whose impulse response is of finite duration, because it decays to zero in finite time. This is in contrast to infinite impulse response (IIR) filters, which continue to respond indefinitely.

E7F13
What is the function of taps in a digital signal processing filter?
Provide incremental signal delays for filter algorithms

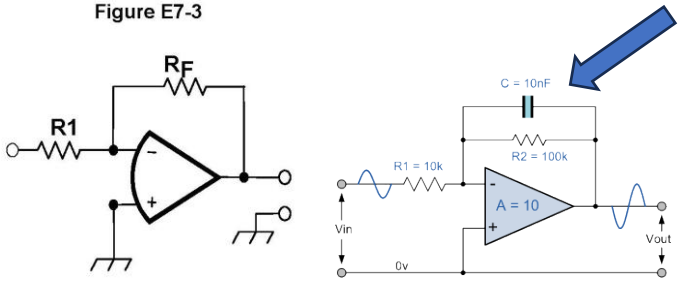
E7F14
Which of the following would allow a digital signal processing filter to create a sharper filter response?
More taps

E7G Operational amplifiers: characteristics and applications

E7G01
What is the typical output impedance of an op-amp? **Very low**

E7G02
What is the frequency response of the circuit in E7-3 if a capacitor is added across the feedback resistor?
Low-pass filter

Figure E7-3

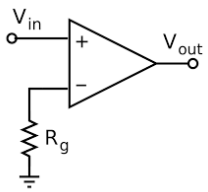


E7G03
What is the typical input impedance of an op-amp? **Very high**

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 an op-amp audio filter?
Restrict both gain and Q

E7G06
What is the gain-bandwidth of an operational amplifier?
The frequency at which the open-loop gain of the amplifier equals one
Open loop gain is the gain of the amplifier without a feedback resistor or path.



E7G07
What voltage gain can be expected from the circuit in Figure E7-3 when R1 is 10 ohms and RF is 470 ohms? **47**
Gain = feedback resistor ÷ input resistor or Gain = 470 ÷ 10 or 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 E7-3 if R1 is 1,000 ohms, RF is 10,000 ohms, and 0.23 volts DC is applied to the input? **Minus 2.3 volts**
Output = (feedback resistor ÷ input resistor) (input voltage)(-1) or
(0.23V) (10,000 ÷ 1,000)(-1) or (0.23 v) (10) (-1) or – 2.3 volts

The multiply by (-1) is because this an inverting amplifier. If the input is positive, then the output will be negative and if the input is negative the output will be positive.

E7G10
What absolute voltage gain can be expected from the circuit in Figure E7-3 when R1 is 1,800 ohms and RF is 68 kilohms? **38**
Gain = feedback resistor ÷ input resistor or 68,000 ÷ 1,800 or 37.78

E7G11
What absolute voltage gain can be expected from the circuit in Figure E7-3 when R1 is 3,300 ohms and RF is 47 kilohms? **14**
Gain = feedback resistor ÷ input resistor or 47,000 ÷ 3300 or 14.24

E7G12
What is an operational amplifier?
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

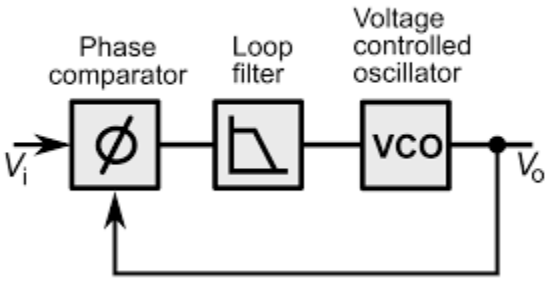
E7H01
What are three common oscillator circuits? **Colpitts, Hartley, and Pierce**

E7H02
What is a microphonic? **Changes in oscillator frequency caused by mechanical vibration**

E7H03

What is a phase-locked loop?

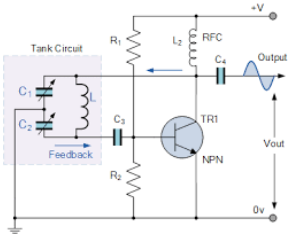
An electronic servo loop consisting of a phase detector, a low-pass filter, a voltage-controlled oscillator, and a stable reference oscillator



E7H04

How is positive feedback supplied in a Colpitts oscillator? **Through a capacitive divider**

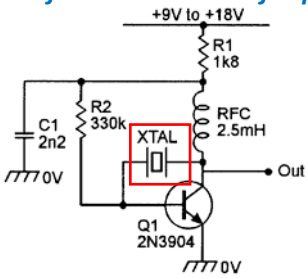
When you think of Colpitts think "C" for capacitor



E7H05

How is positive feedback supplied in a Pierce oscillator? **Through a quartz crystal**

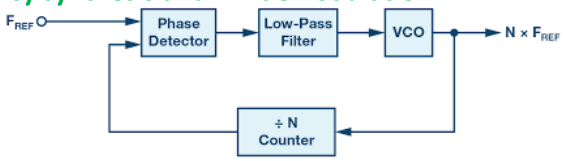
When you think of Peirce think "P" for piezoelectric (quartz crystal)



E7H06

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

Frequency synthesis and FM demodulation



E7H07

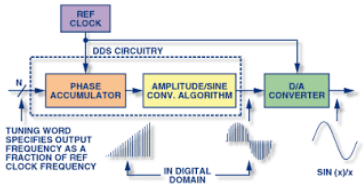
How can an oscillator's microphonic responses be reduced?

Mechanically isolate the oscillator circuitry from its enclosure

Microphonics are caused by mechanical movement of frequency determining element of an oscillator (Quartz Crystal, adjustable capacitors or inductors)

E7H08
Which of the following components can be used to reduce thermal drift in crystal oscillators?
NP0 capacitors
NPO is a type of ceramic capacitor that has excellent temperature stability. That is, its capacitance value changes very little as temperature changes.

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**
Direct digital synthesis (DDS) is a method of producing an analog waveform by generating a time-varying signal in digital form and then performing a digital-to-analog conversion. Operations within a DDS device are primarily digital, it can offer fast switching between output frequencies, fine frequency resolution, and operation over a broad spectrum of frequencies.



E7H10
What information is contained in the lookup table of a direct digital synthesizer (DDS)?
Amplitude values that represent the desired waveform

E7H11
What are the major spectral impurity components of direct digital synthesizers?
Spurious signals at discrete frequencies

E7H12
Which of the following ensures that a crystal oscillator operates on the frequency specified by the crystal manufacturer? **Provide the crystal with a specified parallel capacitance**

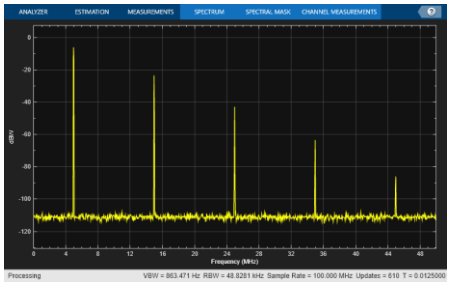
E7H13
Which of the following is a technique for providing highly accurate and stable oscillators needed for microwave transmission and reception?
A. Use a GPS signal reference
B. Use a rubidium stabilized reference oscillator
C. Use a temperature-controlled high Q dielectric resonator
D. **All these choices are correct**
A rubidium reference is based on the molecular resonant frequency of a capsule of Rubidium gas which is precisely 6,834.682,610.904 Hz. This frequency is typically translated to a 10 MHz reference.

A dielectric resonator is a piece of dielectric (nonconductive) material, usually ceramic, that is designed to function as a resonator for radio waves.

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
What technique shows that a square wave is made up of a sine wave and its odd harmonics?
Fourier analysis
This an FFT (fast Frequency Fourier Transform) of a 1 KHz square wave showing it is made up of a fundamental and odd harmonics. This can be seen in the Spectrum analyzer display below.



E8A02
Which of the following is a type of analog-to-digital conversion? **Successive approximation**
A successive approximation ADC is a type of analog-to-digital converter that converts analog voltage level into a digital value by a binary search through all possible quantization levels in decreasing values before finally converging on a digital output representing the input level. The A/D first compares the input voltage the most significant digit in 0.1 steps of the reference voltage. Let's say it was between 2.0 and 2.9. we have the first digit a 2. The A/D then compares the input to a reference in 0.01 increments between 2.0 and 2.9 again let's say it was between 2.8 and 2.9. We now have the second digit 8. This process continues in increasingly smaller steps until the desired resolution is obtained.

E8A03
Which of the following describes a signal in the time domain? **Amplitude at different times**
This is what you see on an oscilloscope.

E8A04
What is "dither" with respect to analog-to-digital converters?
A small amount of noise added to the input signal to reduce quantization noise
Dithering can be defined as intentional, deliberate adding of some noise to signal to prevent large-scale / low resolution errors that come from quantization or under sampling.

E8A05
What is the benefit of making voltage measurements with a true-RMS calculating meter?
RMS is measured for both sinusoidal and non-sinusoidal signals

E8A06
What is the approximate ratio of PEP-to-average power in an unprocessed single-sideband phone signal? **2.5 to 1**
This means a 100 watt PEP SSB signal will have and average power of 40 watts
100 watts ÷ 2.5 = 40 watts, the peak to average power for a digital modulated signal is near 100%.

E8A07
What determines the PEP-to-average power ratio of an unprocessed single-sideband phone signal?
Speech characteristics

E8A08
Why are direct or flash conversion analog-to-digital converters used for a software defined radio?
Very high speed allows digitizing high frequencies

E8A09
How many different input levels can be encoded by an analog-to-digital converter with 8-bit resolution?
256
2^8 is 256

E8A10
What is the purpose of a low-pass filter used at the output of a digital-to-analog converter?
Remove spurious sampling artifacts from the output signal

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

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

E8B01
What is the modulation index of an FM signal?
The ratio of frequency deviation to modulating signal frequency
Modulation index is the deviation ÷ modulating frequency. For an FM signal with a deviation of 5 kHz and a modulation frequency of 2.5 kHz the modulation index would be: 5,000 ÷ 2, 500 or 2.0

E8B02
How does the modulation index of a phase-modulated emission vary with RF carrier frequency?
It does not depend on the RF carrier frequency
See answer for E8B01 – Since modulation index is the deviation divided by the Modulation rate the carrier frequency is not part of the equation. Only deviation and modulation rate are in the calculation.

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 if the highest modulating frequency is 1000 Hz? **3**
Modulation index is the frequency deviation ÷ modulating frequency or 3,000 ÷ 1,000 or 3

E8B04
What is 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? **3**
Modulation index is the frequency deviation ÷ modulating frequency or 6,000 ÷ 2,000 or 3

E8B05
What is 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? **1.67**
Deviation ratio is the ratio of the maximum carrier frequency deviation to the highest audio modulating frequency. 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:
Deviation Ratio = the Max Deviation ÷ Max. Modulating Frequency or 5,000 ÷ 3,000 or 1.666

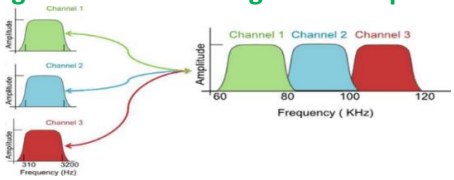
E8B06
What is the deviation ratio of an FM phone signal having a maximum frequency swing of plus or minus 7.5 kHz if the highest modulation frequency is 3.5 kHz? **2.14**
Deviation Ratio = the Max Deviation ÷ Max. Modulating Frequency or 7,500 ÷ 3,500 or 2.14

E8B07
Orthogonal frequency-division multiplexing (OFDM) is a technique used for which types of amateur communication? **Digital modes**

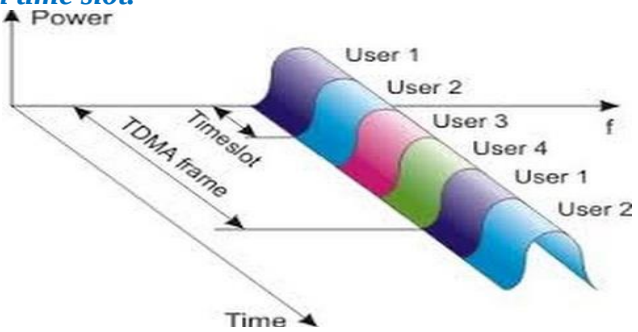
E8B08
What describes orthogonal frequency-division multiplexing (OFDM)?
A digital modulation technique using subcarriers at frequencies chosen to avoid intersymbol interference
OFDM is a frequency division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. In OFDM, multiple closely spaced orthogonal (at 90°) subcarrier signals with overlapping spectra are transmitted to carry data in parallel. Demodulation is based on Fast Fourier Transform algorithms. Each subcarrier (signal) is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase shift keying) at a low symbol rate. This maintains total data rates like conventional single-carrier modulation schemes

E8B09
What is deviation ratio?
The ratio of the maximum carrier frequency deviation to the highest audio modulating frequency
Deviation Ratio = the Maximum Deviation ÷ Maximum Modulating Frequency
The deviation ratio for a signal with 5 KHz of peak deviation at a max. 3 KHz rate would be 5 ÷ 3 or 1.33

E8B10
What is frequency division multiplexing (FDM)?
Dividing the transmitted signal into separate frequency bands that each carry a different data stream



E8B11
What is digital time division multiplexing?
Two or more signals are arranged to share discrete time slots of a data transmission
Time-division multiple access (TDMA) is a channel access method for shared-medium networks. It allows several users to share the same frequency channel by dividing the signal into different time slots. The users transmit in rapid succession, one after the other, each using its own time slot.



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

E8C01
What is Quadrature Amplitude Modulation or QAM?
Transmission of data by modulating the amplitude of two carriers of the same frequency but 90 degrees out of phase

E8C02
What is the definition of symbol rate in a digital transmission?
The rate at which the waveform changes to convey information

E8C03
Why should the phase of a PSK signal be changed at the zero crossing of the RF signal?
To minimize bandwidth

E8C04
What technique minimizes the bandwidth of a PSK31 signal? **Use of sinusoidal data pulses**

E8C05
What is the approximate bandwidth of a 13-WPM International Morse Code transmission? **52 Hz**
Approximate CW bandwidth for 13 WPM: BW = (WPM) (4Hz) or (4 Hz)(13) or 52 Hz.

If the CW Rate was 20 WPM: Approximate CW bandwidth for 20 WPM: BW = (WPM) (4Hz) or (4 Hz) (20) or 80 Hz

E8C06
What is the bandwidth of an FT8 signal? **50 Hz**

E8C07
What is the bandwidth of a 4,800-Hz frequency shift, 9,600-baud ASCII FM transmission? **15.36 kHz**
Bandwidth = (1.2 (frequency shift))+ (baud rate) or Bandwidth = (1.2) (4800) + (9600) or (5760) + (9600) or 15,360 Hz or 15.36 KHz

E8C08
How does ARQ accomplish error correction? **If errors are detected, a retransmission is requested**

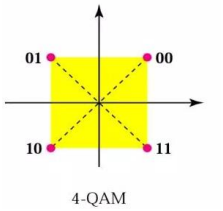
E8C09
Which digital code allows only one bit to change between sequential code values? **Gray code**
The Gray code is an ordering of the Binary numerical system such that two successive values differ in only one bit (binary digit). Today, Gray codes are widely used to facilitate error correction in digital communications.

E8C10
How can data rate be increased without increasing bandwidth?
Using a more efficient digital code

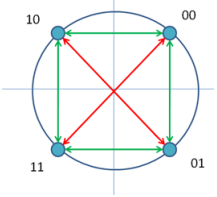
E8C11
What is the relationship between symbol rate and baud? **They are the same**
Binary has two symbols, one for each bit 0 or 1, that represent voltage levels. In this case, the baud or symbol rate is the same as the bit rate.

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

E8C13
What is described by the constellation diagram of a QAM or QPSK signal?
The possible phase and amplitude states for each symbol



4-QAM



E8C14
What type of addresses do nodes have in a mesh network? **Internet Protocol (IP)**

E8C15
What technique do individual nodes use to form a mesh network?
Discovery and link establishment protocols

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

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**

Direct-sequence spread spectrum (DSSS) is a spread-spectrum modulation technique primarily used to reduce overall signal interference. The direct-sequence modulation makes the transmitted signal wider in bandwidth than the information bandwidth. DSSS can also be used as a multiple access technique, whereby several different pseudo random spreading codes are being used simultaneously. This multiple access technique is better known as Direct Sequence CDMA (Code Division Multiple Access).

E8D03

Which describes spread spectrum frequency hopping?

Rapidly varying the frequency of a transmitted signal according to a pseudorandom sequence

Both the transmitter and receiver change frequency rapidly in a using a pseudo-random sequence. If you do not know the sequence and do not have the ability to accurately time synchronize the transmitter and the receiver you will not be able to recover the transmitted signal.

E8D04

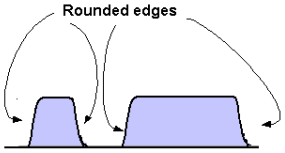
What is the primary effect of extremely short rise or fall time on a CW signal?

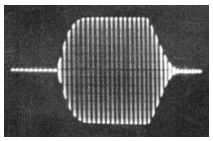
The generation of key clicks

E8D05

What is the most common method of reducing key clicks?

Increase keying waveform rise and fall times





E8D06

What is the advantage of including parity bits in ASCII characters?

Some types of errors can be detected

E8D07

What is a common cause of overmodulation of AFSK signals? **Excessive transmit audio levels**

AFSK is Audio Frequency Shift Keying:

E8D08

What parameter evaluates distortion of an AFSK signal caused by excessive input audio levels?

Intermodulation Distortion (IMD)

E8D09

What is considered an acceptable maximum IMD level for an idling PSK signal? **-30 dB**

A very good IMD report for an idling signal is around -30\:\text{dB}, a poor report around -20\:\text{dB} with the worst possible at -10\:\text{dB}. This value means the spurious emissions

from the PSK transmitter are 1000 times weaker than the main PSK signal. Lower numbers indicate a cleaner signal.

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

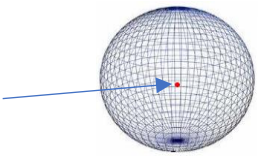
What is one advantage of using ASCII code for data communications?

It is possible to transmit both 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
What is an isotropic radiator?
A hypothetical, lossless antenna having equal radiation intensity in all directions used as a reference for antenna gain



An isotropic source can be thought of a theoretical single point source with equal power being radiated in all directions. A dipole has + 2.15 dB gain over a theoretical isotropic source.

E9A02
What is 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? **286 watts**
ERP = Tx power – feed line loss - duplexer loss = Antenna Gain or
150 watts -2dB – 2.2 dB + 7dB or 150 watts + 2,8 dB or 150 (log (2.8 ÷ 10)) or 150 (1.90) or
285.8 watts

E9A03
What term describing total radiated power takes into account all gains and losses?
Effective radiated power

E9A04
Which of the following factors affect the feed point impedance of an antenna? **Antenna height**

E9A05
What does the term “ground gain” mean?
An increase in signal strength from ground reflections in the environment of the antenna

E9A06
What is 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?
317 watts
The ERP is equal to the transmitter output and the sum of the gains and losses.
ERP = 200 watts +((-4 dB) + (-3.2 dB) + (-0.8) + (+10 DB)) or 200 watts -8 dB +10 dB or
200 watts +2.0 dB

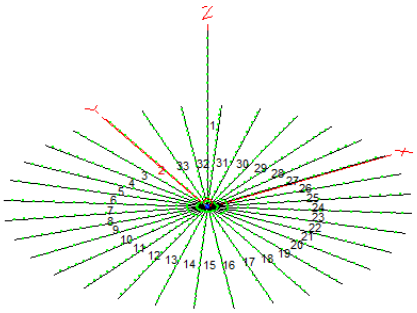
ERP = (transmit power) (2 dB power ratio) or ERP = (200) ((=10^ (dB ÷ 10)) or
ERP (200) ((10^(2÷10)) or 10^0.20 or 1.585.
The power out = transmitter power (power ratio) or (200) (1.585 watts) or 316.9 watts

E9A07
What is 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?
252 watts
The ERP is equal to the transmitter output and the sum of the gains and losses.
ERP = 200 watts -2 dB - 2.8 dB -1.2 dB + 7 DB or 200 watts +1 dB
ERP= (200) (1 dB power ratio) or ERP =200 ((10^ (1 ÷ 10)) or ERP = (200) (10^0.1) or
ERP = (200) (1.259) or power out = transmitter power (power ratio) or (200 watts) (1.259) or
251.7 watts

E9A08
Which frequency band has the smallest first Fresnel zone? **5.8 GHz**
The first Fresnel zone is defined as a series of imaginary rings surrounding the centerline of the direct path such that the distance from the transmitting antenna to each ring plus the distance from the ring to the receiving antenna is equal to one-half wavelength more than the direct path between the antennas.
The size of the calculated Fresnel zone at any particular distance from the transmitter and receiver can help to predict whether obstructions or discontinuities along the path will cause significant interference.

E9A09
What is antenna efficiency? **Radiation resistance divided by total resistance**

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



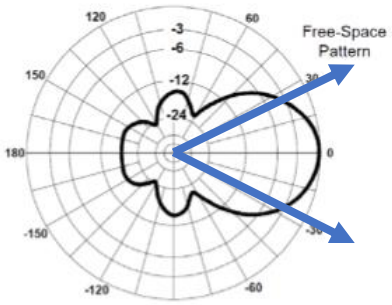
E9A11
Which of the following determines ground losses for a ground-mounted vertical antenna operating on HF? **Soil conductivity**

E9A12
How much gain does an antenna have compared to a half-wavelength dipole if it has 6 dB gain over an isotropic radiator? **3.85 dB**
Gain = antenna gain – dipole Isotropic Gain or 6 dB – 2.15 or 3.85dB

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

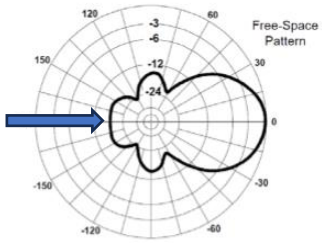
E9B01
What is the 3 dB beamwidth of the antenna radiation pattern shown in Figure E9-1? **50 degrees**

Figure E9-1



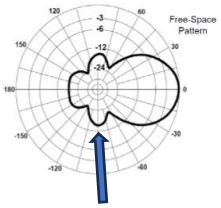
E9B02
What is the front-to-back ratio of the antenna radiation pattern shown in Figure E9-1? **18 dB**

Figure E9-1



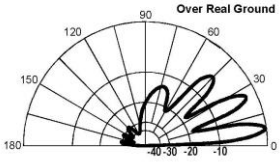
E9B03
What is the front-to-side ratio of the antenna radiation pattern shown in Figure E9-1? **14 dB**

Figure E9-1



E9B04
What is the front-to-back ratio of the radiation pattern shown in Figure E9-2? **28 dB**

Figure E9-2



E9B05
What type of antenna pattern 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
What is the difference in radiated power between a lossless antenna with gain and an isotropic radiator driven by the same power? **They are the same**
The directional antenna is simply directing the total energy of the isotropic omnidirectional antenna into a focused narrower beam of radiation.

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

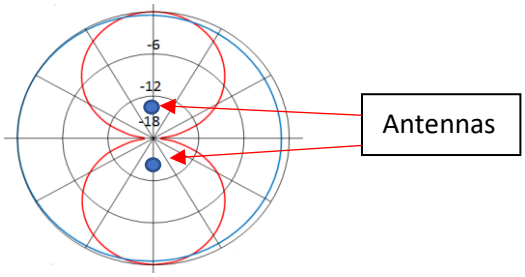
E9B09
What type of analysis is commonly used for modeling antennas? **Method of Moments**
The Method of Moments involves breaking the antenna structure of the conductors into "segments" so the current on each segment can be determined. The moment is numerically the size of the current and the vector describing the segment.

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 10 segments per half-wavelength? **The computed feed point impedance may be incorrect**

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

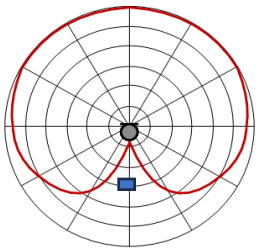
E9C01
What type of radiation pattern is created by two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed 180 degrees out of phase?
A figure-eight oriented along the axis of the array
The radiation pattern of two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed 180 degrees out of phase is a figure-8 oriented along the axis of the array.



E9C02

What type of radiation pattern is created by two 1/4-wavelength vertical antennas spaced 1/4-wavelength apart and fed 90 degrees out of phase? **Cardioid**

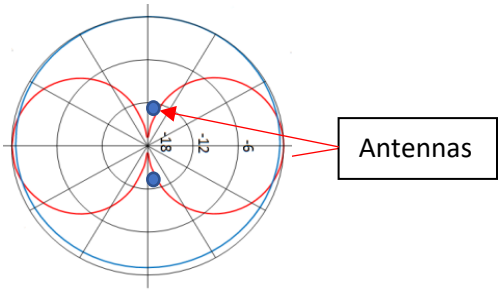
The radiation pattern of two 1/4-wavelength vertical antennas spaced 1/4-wavelength apart and fed 90 degrees out of phase is a cardioid.



E9C03

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

The radiation pattern of two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed in phase is a Figure-8 broadside to the axis of the array.



E9C04

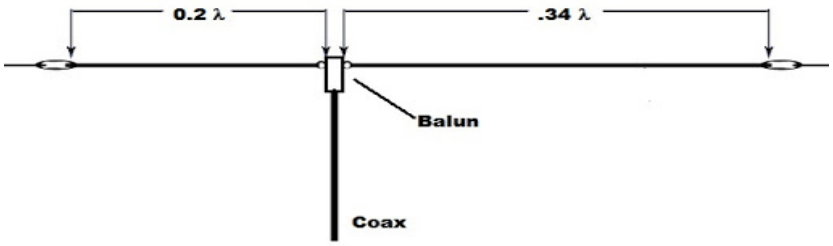
What happens to the radiation pattern of an unterminated long wire antenna as the wire length is increased?

Additional lobes form with major lobes increasingly aligned with the axis of the antenna

E9C05

What is the purpose of feeding an off-center-fed dipole (OCFD) between the center and one end instead of at the midpoint? **To create a similar feed point impedance on multiple bands**

OCFD Antenna is an Off Center Fed Dipole

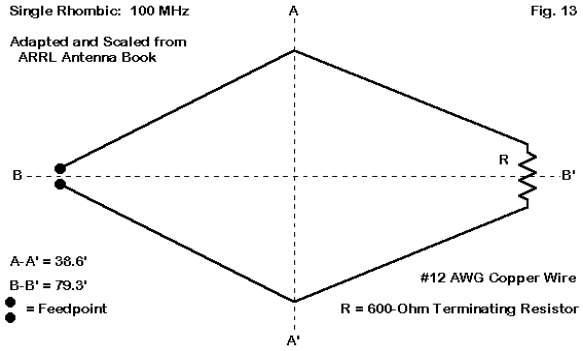


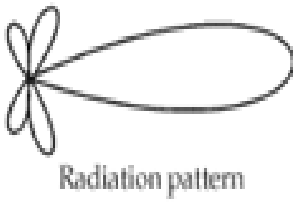
E9C06

What is the effect of adding a terminating resistor to a rhombic or long-wire antenna?

It changes the radiation pattern from bidirectional to unidirectional

A rhombic antenna consists of one to several parallel wires suspended above the ground in a "rhombus" (diamond) shape. Long versions are typically supported by a pole or tower at each vertex to which the wires are attached by insulators. Each of the four sides is the same length. If the sections are joined by a resistor the antenna will receive from and transmit to only the direction the end with the resistor points at. This antenna has high forward gain and wide frequency bandwidth.





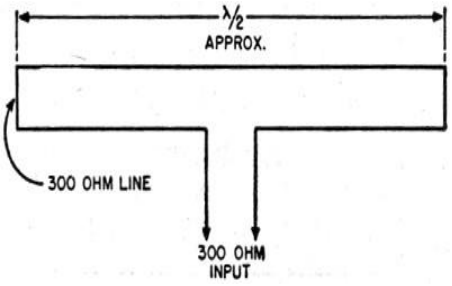
E9C07

What is the approximate feed point impedance at the center of a two-wire half-wave folded dipole antenna? **300 ohms**

E9C08

What is a folded dipole antenna?

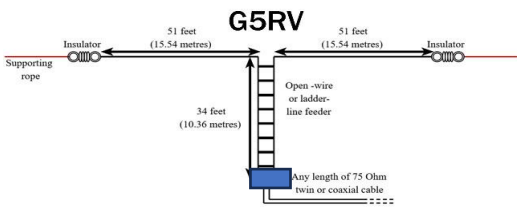
A half-wave dipole with an additional parallel wire connecting its two ends



E9C09

Which of the following describes a G5RV antenna?

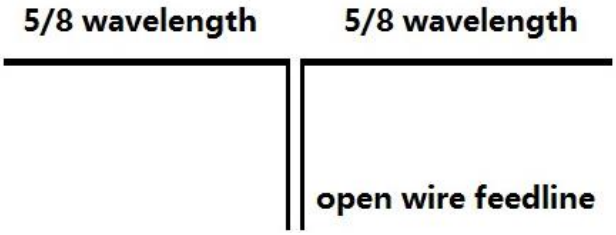
A wire antenna center-fed through a specific length of open-wire line connected to a balun and coaxial feed line



E9C10
Which of the following describes a Zepp antenna? **An end-fed half-wavelength dipole**

E9C11
How is the far-field elevation pattern of a vertically polarized antenna affected by being mounted over seawater versus soil? **Radiation at low angles increases**
Better for long distance DX

E9C12
Which of the following describes an extended double Zepp antenna?
A center-fed 1.25-wavelength dipole antenna
This antenna is constructed much like an ordinary Dipole antenna but with 5/8 Wavelength Elements matched with an added Impedance Matching Section of balanced feed line. The Matching Section is 450 Ohm Open Wire Feedline and is a compromise impedance between the 5/8 Wave antenna elements and the feed point, a 4:1 Current Balun is used to match the feedline.

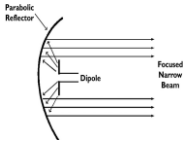


E9C13
How does the radiation pattern of a horizontally polarized antenna vary with increasing height above ground? **The takeoff angle of the lowest elevation lobe decreases**

E9C14
How does the radiation pattern of a horizontally-polarized antenna mounted above a long slope compare with the same antenna mounted above flat ground?
The main lobe takeoff angle decreases in the downhill direction

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

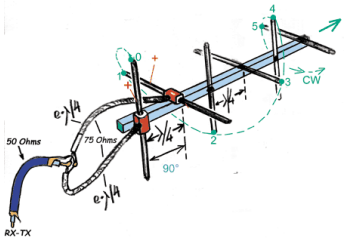
E9D01
How much does the gain of an ideal parabolic reflector antenna increase when the operating frequency is doubled? **6 dB**



E9D02

How can two linearly polarized Yagi antennas be used to produce circular polarization?

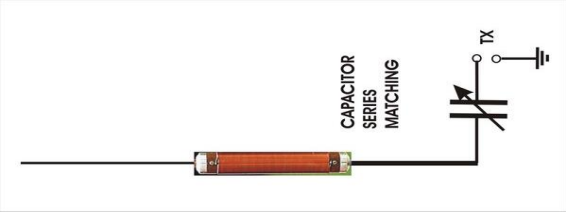
Arrange two Yagis on the same axis and perpendicular to each other with the driven elements at the same point on the boom and fed 90 degrees out of phase



E9D03

What is the most efficient location for a loading coil on an electrically short whip?

Near the center of the vertical radiator



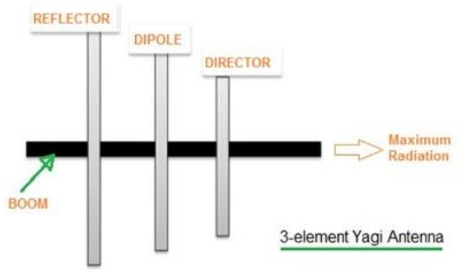
E9D04

Why should antenna loading coils have a high ratio of reactance to resistance? **To maximize efficiency**

E9D05

Approximately how long is a Yagi's driven element? **1/2 wavelength**

The driven element is ½ wavelength long, the reflector is about 5% longer than the driven element and the director(s) are about 5% shorter than the driven element



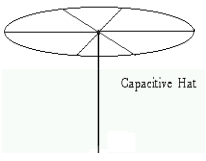
E9D06

What happens to SWR bandwidth when one or more loading coils are used to resonate an electrically short antenna? **It is decreased**

E9D07

What is an advantage of top loading an electrically short 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 in an electrically short antenna?
To resonate the antenna by cancelling the capacitive reactance

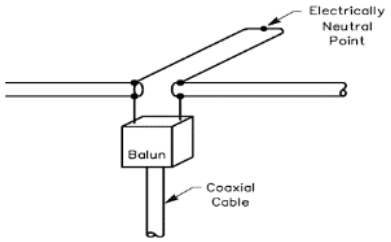
E9D10
How does radiation resistance of a base-fed whip antenna change below its resonant frequency?
Radiation resistance decreases

E9D11
Why do most two-element Yagis with normal spacing have a reflector instead of a director?
Higher gain

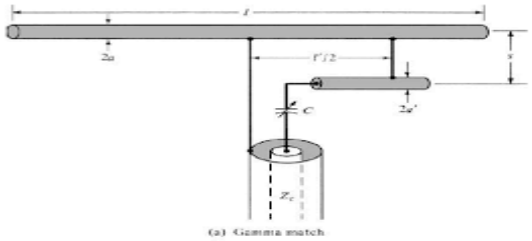
E9D12
What is the purpose of making a Yagi's parasitic elements either longer or shorter than resonance?
Control of phase shift

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

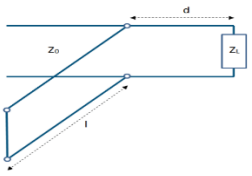
E9E01
Which matching system for Yagi antennas requires the driven element to be insulated from the boom?
Beta or hairpin
The Beta or Hairpin Match is a simple and robust form of matching a lower impedance Yagi to the transmission line. This diagram above from the ARRL Antenna Handbook shows a Beta Match in the center of a Yagi Driven Element.



E9E02
What antenna 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? **Gamma match**



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



Stub matches are widely used to match any complex load to a transmission line. They consist of shorted or opened segments of the line, connected in parallel to a line at appropriate distances from the load. The single stub match is a widely used matching circuit.

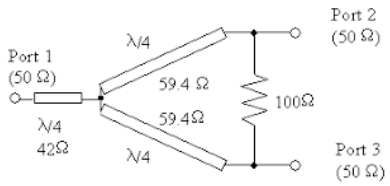
E9E04
What is the purpose of the series capacitor in a gamma match?
To cancel unwanted inductive reactance

E9E05
What Yagi driven element feed point impedance is required to use a beta or hairpin matching system?
Capacitive (driven element electrically shorter than 1/2 wavelength)

E9E06
Which of these transmission line impedances would be suitable for constructing a quarter-wave Q-section for matching a 100-ohm feed point impedance to a 50-ohm transmission line? **75 ohms**

E9E07
What parameter describes the interaction of a load and transmission line? **Reflection coefficient**
Reflection coefficient is a parameter that describes how much of an electromagnetic wave is reflected by an impedance discontinuity in the transmission medium. It is equal to the ratio of the amplitude of the reflected wave to the incident wave. It is another way of expressing the match between the source and the load.

E9E08
What is a use for a Wilkinson divider?
To divide power equally between two 50-ohm loads while maintaining 50-ohm input impedance
The Wilkinson Power Divider is a specific class of power divider circuit that can achieve isolation between the output ports while maintaining a matched condition on all ports.



E9E09
Which of the following is used to shunt feed a grounded tower at its base? **Gamma match**

E9E10
Which matching system places an inductance across the feed point of a vertical monopole antenna?
Beta or hairpin

E9E11
What is the purpose of using multiple driven elements connected through phasing lines?
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
What is the velocity factor of a transmission line?
The velocity of a wave in the transmission line divided by the velocity of light in a vacuum
Velocity Factor is a measure of how much the radio waves (RF) are slowed from their free space velocity, the speed of light. Physical Wavelength in coaxial cable will be shorter than in free space.

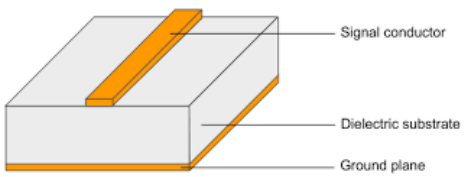
E9F02
Which of the following has the biggest effect on the velocity factor of a transmission line?
The insulating dielectric material

E9F03
Why is the electrical length of a coaxial cable longer than its physical length?
Electromagnetic waves move more slowly in a coaxial cable than in air
If the wavelength in free space for a frequency is approximately 2 meters, then the wavelength in a coaxial cable with a velocity factor of 0.66 would be (2 meters) (0.66) or 1.32 Meters.

E9F04
What impedance does a 1/2-wavelength transmission line present to an RF generator when the line is shorted at the far end? **Very low impedance**
Every ¼ λ (wavelength) the stub looks like the opposite of the previous ¼ λ. For example, this is what Stubs look like at different wavelengths.

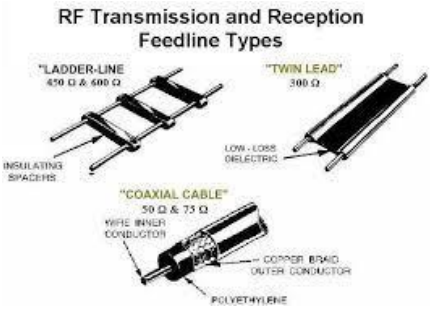
	¼ λ	½ λ	¾ λ	1 λ	1-¼ λ
Shorted Stub	open	short	open	short	open
Open Stub	short	open	short	open	Short

E9F05
What is microstrip?
Precision printed circuit conductors above a ground plane that provide constant impedance interconnects at microwave frequencies



E9F06
What is the approximate physical length of an air-insulated, parallel conductor transmission line that is electrically 1/2 wavelength long at 14.10 MHz? **10.6 meters**
A Half wavelength at 14.1 MHz in free space would be (300 ÷ 14.1) ÷ (2) or (21.277) ÷ (2) or 10.613 Meters. Since air insulated transmission line has very little loss a wavelength in the transmission line would be near the free space length.

E9F07
How does parallel conductor transmission line compare to coaxial cable with a plastic dielectric?
Lower loss



E9F08
Which of the following is a significant difference between foam dielectric coaxial cable and solid dielectric coaxial cable, assuming all other parameters are the same?
A. Foam dielectric coaxial cable has lower safe maximum operating voltage
B. Foam dielectric coaxial cable has lower loss per unit of length
C. Foam dielectric coaxial cable has higher velocity factor
D. **All these choices are correct**

E9F09
What impedance does a 1/4-wavelength transmission line present to an RF generator when the line is shorted at the far end? **Very high impedance**

	¼ λ	½ λ	¾ λ	1 λ	1-¼ λ
Shorted Stub	open	short	open	short	open
Open Stub	short	open	short	open	Short

E9F10
What impedance does a 1/8-wavelength transmission line present to an RF generator when the line is shorted at the far end? **An inductive reactance**

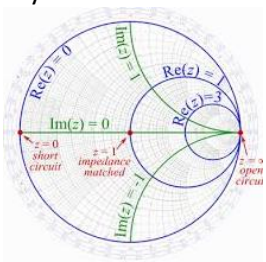
E9F11
What impedance does a 1/8-wavelength transmission line present to an RF generator when the line is open at the far end? **A capacitive reactance**

E9F12
What impedance does a 1/4-wavelength transmission line present to an RF generator when the line is open at the far end? **Very low impedance**

E9G The Smith chart

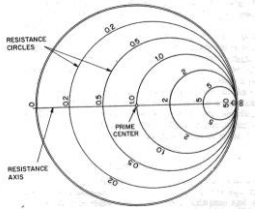
E9G01
Which of the following can be calculated using a Smith chart? **Impedance along transmission lines**

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

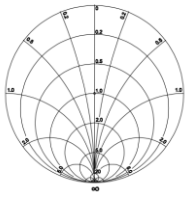
E9G04
What are the two families of circles and arcs that make up a Smith chart? **Resistance and reactance**



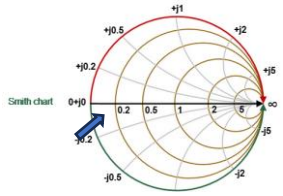
E9G05
Which of the following is a common use for a Smith chart?
Determine the length and position of an impedance matching stub

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**

Figure E9-3

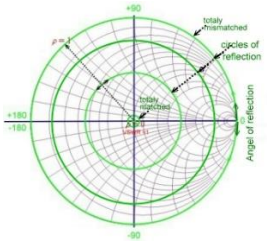


E9G07
On the Smith chart shown in Figure E9-3, what is the only straight line shown? **The resistance axis**

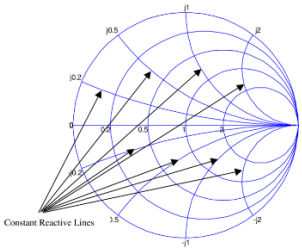


E9G08
How is a Smith chart normalized? **Reassign the prime center's impedance value**

E9G09
What third family of circles is often added to a Smith chart during the process of designing impedance matching networks? **Constant-SWR circles**



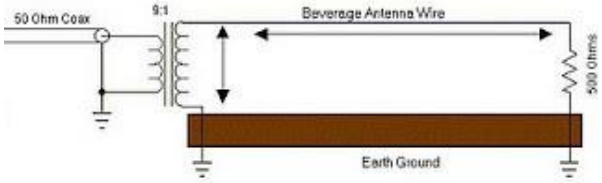
E9G10
What do the arcs on a Smith chart represent? **Points with constant reactance**



E9G11
In what units are the wavelength scales on a Smith chart calibrated?
In fractions of transmission line electrical wavelength

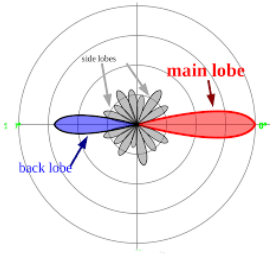
E9H Receiving antennas: radio direction finding (RDF) techniques; Beverage antennas; single- and multiple-turn loops

E9H01
When constructing a Beverage antenna, which of the following factors should be included in the design to achieve good performance at the desired frequency? **It should be at least one wavelength long**
Beverage antennas are typically used as receiving antennas rather than transmitting antennas due to their design and characteristics. Beverage antennas are long wire antennas that are typically several wavelengths long and are directional, providing high gain in one direction and low gain in the opposite direction.

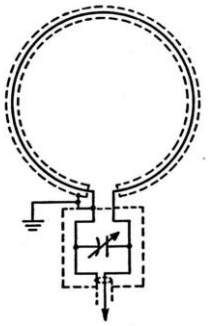


E9H02
Which is generally true for 160- and 80-meter receiving antennas?
Atmospheric noise is so high that directivity is much more important than losses

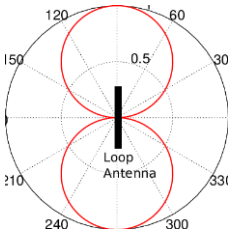
E9H03
What is receiving directivity factor (RDF)?
Peak antenna gain compared to average gain over the hemisphere around and above the antenna
Receiving Directivity Factor (RDF) is a figure of merit for radio receiving antennas. It is the antenna gain in the forward direction divided by the gain in all other directions.



E9H04
What is the purpose of placing an electrostatic shield around a small-loop direction-finding antenna?
It eliminates unbalanced capacitive coupling to the antenna's surroundings, improving the depth of its nulls



E9H05
What challenge is presented by a small wire-loop antenna for direction finding?
It has a bidirectional null pattern



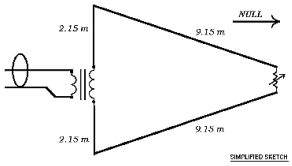
E9H06
What indicates the correct value of terminating resistance for a Beverage antenna?
Minimum variation in SWR over the desired frequency range

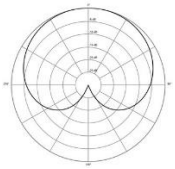
E9H07

What is the function of a Beverage antenna's termination resistor?
Absorb signals from the reverse direction

E9H08
What is the function of a sense antenna?
It modifies the pattern of a DF antenna to provide a null in only one direction

E9H09
What type of radiation pattern is created by a single-turn, terminated loop such as a pennant antenna?
Cardioid





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

E9H11
What feature of a cardioid pattern antenna makes it useful for direction-finding antennas?
A single null

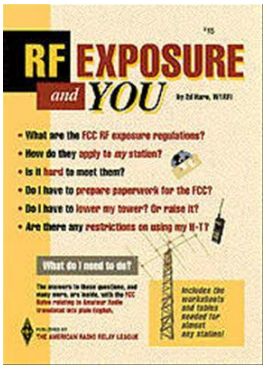
SUBELEMENT E0 - SAFETY - [1 exam question - 1 group]

E0A Safety: RF radiation hazards; hazardous materials; grounding

E0A01
What is the primary function of an external earth connection or ground rod?
Lightning charge dissipation

E0A02
When evaluating RF exposure levels from your station at a neighbor's home, what must you do?
Ensure signals from your station are less than the uncontrolled maximum permissible exposure (MPE) limits
These are the MPE limits (Effective Radiated Power), above which a station MPE evaluation is required

Band	Power (W) into Antenna
160-meters	500
80-meters	500
40-meters	500
30-meters	425
20-meters	225
17-meters	125
15-meters	100
12-meters	75
10-meters	50
6-meters	50
2-meters	50
1.25-meters	50
70-centimeters	70



A Radio Frequency power density calculator can be found on line at
http://hintlink.com/power_density.htm

E0A03
Over what range of frequencies are the FCC human body RF exposure limits most restrictive?
30 - 300 MHz
That would be the 10 meter through the 1.25 meter bands from the chart in the previous question

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 in areas where the total MPE limit is exceeded

E0A05
What hazard is created by operating at microwave frequencies?
The high gain antennas commonly used can result in high exposure levels
A transmitter with 50 watts into an antenna with 10 dB 0f gain would have a power level of 500 watts in the direction is aimed

E0A06
Why are there separate electric (E) and magnetic (H) MPE limits at frequencies below 300 MHz?
A. The body reacts to electromagnetic radiation from both the E and H fields
B. Ground reflections and scattering cause the field strength to vary with location
C. E field and H field radiation intensity peaks can occur at different locations
D. **All these choices are correct**

E0A07
What is meant by "100% tie-off" regarding tower safety?
At least one lanyard attached to the tower at all times

E0A08
What does SAR measure?
The rate at which RF energy is absorbed by the body

E0A09
Which of the following types of equipment are exempt from RF exposure evaluations?
Hand-held transceivers sold before May 3, 2021
The FCC introduced new RF exposure rules for amateur radio in 2021. Hams used to have special exemptions, now we need to do RF exposure evaluations for all uses. SAR (Specific Absorption Rate) is a measure of the rate of RF (radiofrequency) energy absorption by the body from the source such as a Handheld. Even though devices sold before the new rules effective date are exempt but still should be thought of in connection with the new limits. A 5 Watt HT on 2 m is quite safe. It would need to put out 20+ Watts to reach the SAR exposure limit. A 5 Watt 70 cm HT is safe, but probably just under the SAR exposure limit. Higher-powered HTs, like the newer 8 Watt models, are probably over the safe exposure limit on the 70 cm band.

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

E0A11
To what should lanyards be attached while climbing?
Tower legs

E0A12
Where should a shock-absorbing lanyard be attached to a tower when working above ground?
Above the climber's head level