Preparing for the Extra class license exam

Author: Jack Tiley AD7FO

Revision: 1.06 **(July 1, 2012)**

Required For this class:

- Copy of ARRL Tenth Edition of the Extra Class License Manual or recent copy of the ARRL Handbook (both are available from ARRL or ham radio retailers).
- Scientific Calculator **that you can operate.** Available from stores like Wal-Mart and office supply stores for $15 or less.
  - Add, Subtract, Multiply and Divide
  - Base Ten Logarithms
  - Simple trigonometric functions
  - Squares, Square root
- A printed copy of this syllabus.
- Pencil/pen and note pad to take notes and work out problems
- Access to a computer with internet access at home or at a library to take practice exams.
- A desire to study, Learn and ask questions.

Amateur Radio Extra Class License Class Syllabus

Author: Jack Tiley AD7FO

This material is based on the July 1, 2012Extra Class Question Pool with additional information added to explain the answers. Questions are shown with the correct answer only, which in the authors 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 questions in the back of the manual to see the other answer choices and for the referenced page(s) in the License Manual that will provide further explanation of the subject.

It is not required, that you have your own copy of the ARRL (*American Radio Relay League*) Extra class license manual for the class which is available for purchase from ARRL publication sales on the ARRL web site and through amateur radio dealers. If you want more technical detail the author suggests you acquire a copy of a recent ARRL Handbook to help you understand the topics covered in this syllabus. Handbooks a few years old are fine and frequently available for reasonable prices at hamfests.

While every effort was made to insure the accuracy of the material herein, this material was prepared by an ordinary human, and there is always the possibility that a few typographical or other errors may remain. If you find any errors your feedback would be appreciated by the author who can be contacted at ad7fo@arrl.net .

Additional information and resources to help you study for the Extra Class License can be found on the ARRL web site at www.arrl.org/eclm . This site has articles and resources for reference materials on all aspects of the exam questions and links to math tutorials for those who have not used any algebra or trigonometry recently (the level of math required for the Extra Class License is not that difficult to master).

About the author

A retired Electrical Engineer with 44 yearsô experience ten years in the measurements/metrology field and thirty four years in the electronics and communications field with Hewlett Packard Test Instrument Group, now Agilent Technologies.

Author contact Information: **ad7fo@arrl.net**

Hobbies

- Amateur Radio, Test Equipment, Electronics in general
- Attending every hamfests I can, including Hamvention in Dayton Ohio
- Developing and presenting technical training for amateur radio.

Teaching and mentoring

- I Teach Technician, General and Extra License Classes (with training materials I have written)
- I wrote and taught Emcomm I training and have written training for the new 4th edition emcomm training course.
- I have written 20+ other training presentations for amateur radio. Contact the author if you are interested in using them for your local amateur radio meetings.
- ARRL Eastern Washington Technical Coordinator and Spokane County Technical specialist.
- Technical training for the Spokane County ARES/RACES Group and the Inland Empire VHF Club

Inland Empire VHF Club **www.vhfclub.org**

- Director 2009 thru 2012
- President 2012- current

Other ARRL Appointments:

- ARRL VE (Volunteer Examiner)
- ARRL Registered Instructor
- ARRL Certified EMCOMM instructor

Guide to using this syllabus.

Each question from the license manual is shown in bold type----- **E1A04**
The first two characters are the license class sub element number ---**E1**A04 ---for **E**xtra class subelement **1**.
The next letter identifies the group in the sub element ---E1**A**04 -- and the groups are in alphabetical order.
The last two characters are the question number in the group -- E1A**04**-- in numerical order starting with **01**.
If the question number is followed by another number in brackets, like 1A12 **[97.301, 97.305]**, the number in Brackets refers to a specific regulation in part 97 0f the FCC rules governing amateur radio.

This Syllabus was written to teach the material not just teach the answers, although it can be used that way. When the Author teaches this class it includes equipment and theory demonstrations and ñchalk Talkò. If you plan to teach classes using this syllabus visit the Inland Empire VHF Club website at **www.vhfclub.org** contact the author for a copy of the instructors guide.

The author offers additional explanations and graphics when felt that it would aid in understanding. These explanations and comments and explanations are shown in bold blue italicized text as shown below:

Telemetry is a technology that allows the remote measurement ……………………….

In problems involving math solutions are shown with precision that may be greater than the test answers (they may be rounded up or down) to allow you to verify your own solution to the problem. The following is an example:

$Z = SQR(X^2 + (X_L - X_C)^2)$ or $Z = SQR(400^2 + (0 - 300)^2)$ or $Z = SQR(250{,}000)$ or $Z = 500\ \Omega$
Angle is arc tan (reactance/resistance) or arc tan (300/400) or arc tan (.75) or 36.86°

The author suggests you look at the number of questions in each sub element and if there is one element you find particularly difficult consider concentrating on those areas you find easier to learn. Keep in mind you need a 74% passing score on the 50 question exam (you can get 13 wrong and still pass).

If you can, find a local Ham to ñElmerò you on the difficult areas or locate a formal class in your area (check ARRL web site and local club web sites for listings). You can also check the ARRL Web Site or ARRL Section Web Sites for a volunteer Technical Specialist in your area who may be able provide some ñElmeringò as well.

While studying take the online exams that are available from a number of sites to check your progress and for review:

http://aa9pw.com/radio/
http://www.eham.net/exams/
http://www.qrz.com/ham/

Check with the author at Ad7f0@arrl.netor the www.vhfclub.org web site if you are using this syllabus to make sure you have the latest revision.

SYLLABUS

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

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

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

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

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

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

E1F Miscellaneous rules: external RF power amplifiers; national quiet zone; business communications; compensated communications; spread spectrum; auxiliary stations; reciprocal operating privileges; IARP and CEPT licenses; third party communications with foreign countries; special temporary authority

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

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

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

E2D Operating methods: VHF and UHF digital modes; APRS

E2E Operating methods: operating HF digital modes; error correction

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

E3A Propagation and technique, Earth-Moon-Earth communications; meteor scatter

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

E6B Semiconductor diodes

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

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

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

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

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

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

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

E7D Power supplies and voltage regulators

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

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

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

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

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

E8A AC waveforms: sine, square, sawtooth and irregular waveforms; AC measurements; average and PEP of RF signals; pulse and digital signal waveforms

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

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

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

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

E9A Isotropic and gain antennas: definition; used as a standard for comparison; radiation pattern; basic antenna parameters: radiation resistance and reactance, gain, beam width, efficiency

E9B Antenna patterns: E and H plane patterns; gain as a function of pattern; antenna design; Yagi antennas

E9C Wire and phased vertical antennas: beverage antennas; terminated and resonant rhombic antennas; elevation above real ground; ground effects as related to polarization; take-off angles

E9D Directional antennas: gain; satellite antennas; antenna beamwidth; losses; SWR bandwidth; antenna efficiency; shortened and mobile antennas; grounding

E9E Matching: matching antennas to feed lines; power dividers

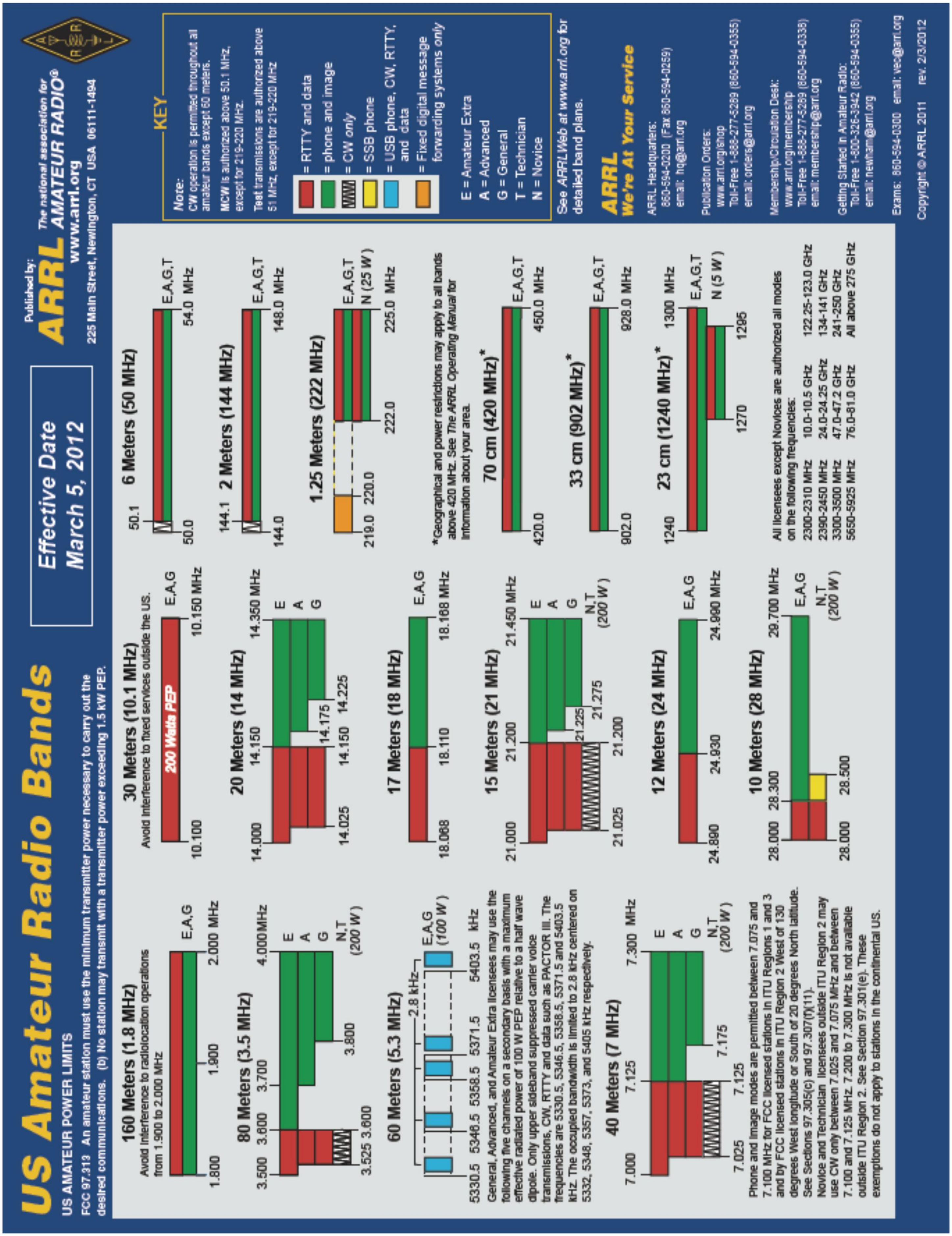
E9F Transmission lines: characteristics of open and shorted feed lines: 1/8 wavelength; 1/4 wavelength; 1/2 wavelength; feed lines: coax versus open-wire; velocity factor; electrical length; transformation characteristics of line terminated in impedance not equal to characteristic impedance

E9G The Smith chart

E9H Effective radiated power; system gains and losses; radio direction finding antennas

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

E0A Safety: amateur radio safety practices; RF radiation hazards; hazardous materials


US Amateur Radio Bands
Effective Date March 5, 2012
Published by: ARRL The national association for AMATEUR RADIO®
www.arrl.org
225 Main Street, Newington, CT USA 06111-1494
US AMATEUR POWER LIMITS
FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.
160 Meters (1.8 MHz)
Avoid interference to radiolocation operations from 1.900 to 2.000 MHz
1.800 1.900 2.000 MHz E,A,G
80 Meters (3.5 MHz)
3.500 3.600 3.700 4.000 MHz 3.525 3.600 3.800 E A G N,T (200 W)
60 Meters (5.3 MHz)
2.8 kHz E,A,G (100 W)
5330.5 5346.5 5358.5 5371.5 5403.5 kHz
General, Advanced, and Amateur Extra licensees may use the following five channels on a secondary basis with a maximum effective radiated power of 100 W PEP relative to a half wave dipole. Only upper sideband suppressed carrier voice transmissions, CW, RTTY and data such as PACTOR III. The frequencies are 5330.5, 5346.5, 5358.5, 5371.5 and 5403.5 kHz. The occupied bandwidth is limited to 2.8 kHz centered on 5332, 5348, 5357, 5373, and 5405 kHz respectively.
40 Meters (7 MHz)
7.000 7.125 7.300 MHz 7.025 7.125 7.175 E A G N,T (200 W)
Phone and image modes are permitted between 7.075 and 7.100 MHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11). Novice and Technician licensees outside ITU Region 2 may use CW only between 7.025 and 7.075 MHz and between 7.100 and 7.125 MHz. 7.200 to 7.300 MHz is not available outside ITU Region 2. See Section 97.301(e). These exemptions do not apply to stations in the continental US.
30 Meters (10.1 MHz)
Avoid interference to fixed services outside the US.
200 Watts PEP
10.100 10.150 MHz E,A,G
20 Meters (14 MHz)
14.000 14.150 14.350 MHz 14.025 14.150 14.175 14.225 E A G
17 Meters (18 MHz)
18.068 18.110 18.168 MHz E,A,G
15 Meters (21 MHz)
21.000 21.200 21.450 MHz 21.025 21.200 21.225 21.275 E A G N,T (200 W)
12 Meters (24 MHz)
24.890 24.930 24.990 MHz E,A,G
10 Meters (28 MHz)
28.000 28.300 29.700 MHz 28.000 28.500 E,A,G N,T (200 W)
6 Meters (50 MHz)
50.1 50.0 54.0 MHz E,A,G,T
2 Meters (144 MHz)
144.1 144.0 148.0 MHz E,A,G,T
1.25 Meters (222 MHz)
219.0 220.0 222.0 225.0 MHz E,A,G,T N (25 W)
*Geographical and power restrictions may apply to all bands above 420 MHz. See The ARRL Operating Manual for information about your area.
70 cm (420 MHz)*
420.0 450.0 MHz E,A,G,T
33 cm (902 MHz)*
902.0 928.0 MHz E,A,G,T
23 cm (1240 MHz)*
1240 1270 1295 1300 MHz E,A,G,T N (5 W)
All licensees except Novices are authorized all modes on the following frequencies:
2300-2310 MHz 10.0-10.5 GHz 122.25-123.0 GHz
2390-2450 MHz 24.0-24.25 GHz 134-141 GHz
3300-3500 MHz 47.0-47.2 GHz 241-250 GHz
5650-5925 MHz 76.0-81.0 GHz All above 275 GHz
KEY
Note:
CW operation is permitted throughout all amateur bands except 60 meters.
MCW is authorized above 50.1 MHz, except for 219-220 MHz.
Test transmissions are authorized above 51 MHz, except for 219-220 MHz
= RTTY and data
= phone and image
= CW only
= SSB phone
= USB phone, CW, RTTY, and data
= Fixed digital message forwarding systems only
E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice
See ARRLWeb at www.arrl.org for detailed band plans.
ARRL We're At Your Service
ARRL Headquarters:
860-594-0200 (Fax 860-594-0259)
email: hq@arrl.org
Publication Orders:
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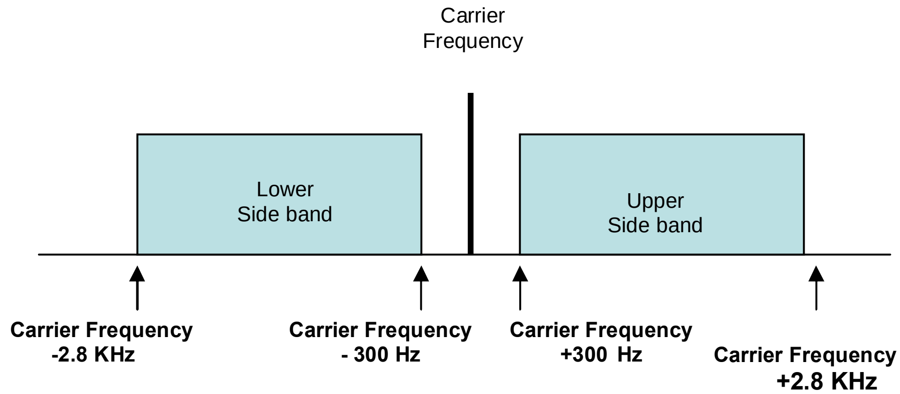
SUBELEMENT E1 - COMMISSION'S RULES [6 Exam Questions - 6 Groups]

E1A Operating Standards: frequency privileges; emission standards; automatic message forwarding; frequency sharing; stations aboard ships or aircraft message forwarding; frequency sharing; FCC license actions; stations aboard ships or aircraft



E1A01 [97.301, 97.305]
When using a transceiver that displays the carrier frequency of phone signals, which of the following displayed frequencies represents the highest frequency at which a properly adjusted USB emission will be totally within the band?

3 kHz below the upper band edge

In an upper sideband transmission the modulation will be up to 3 KHz above the carrier frequency set on the transmitter frequency display, therefore the carrier frequency must be 3 KHz below the band edge to insure you do not transmit sidebands out of band.

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

In a lower sideband transmission the modulation side band will be 300 Hz to 3 KHz below the carrier frequency set on the transmitter frequency dial, therefore the carrier frequency must be 3 KHz above the band edge to insure you do not transmit out of band.

E1A03 [97.301, 97.305]
With your transceiver displaying the carrier frequency of phone signals, you hear a DX station's CQ on 14.349 MHz USB. Is it legal to return the call using upper sideband on the same frequency?

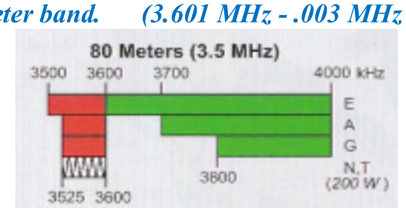
No, my sidebands will extend beyond the band edge

The 20 meter band is from 14.000 MHz to 14.350 MHz. When SSB modulation is applied to a carrier of 14.349 it would generate a sideband up to 14.379 which exceeds the 14.350 MHz upper frequency limit.

E1A04 [97.301, 97.305]
With your transceiver displaying the carrier frequency of phone signals, you hear a DX station calling CQ on 3.601 MHz LSB. Is it legal to return the call using lower sideband on the same frequency?

No, my sidebands will extend beyond the edge of the phone band segment

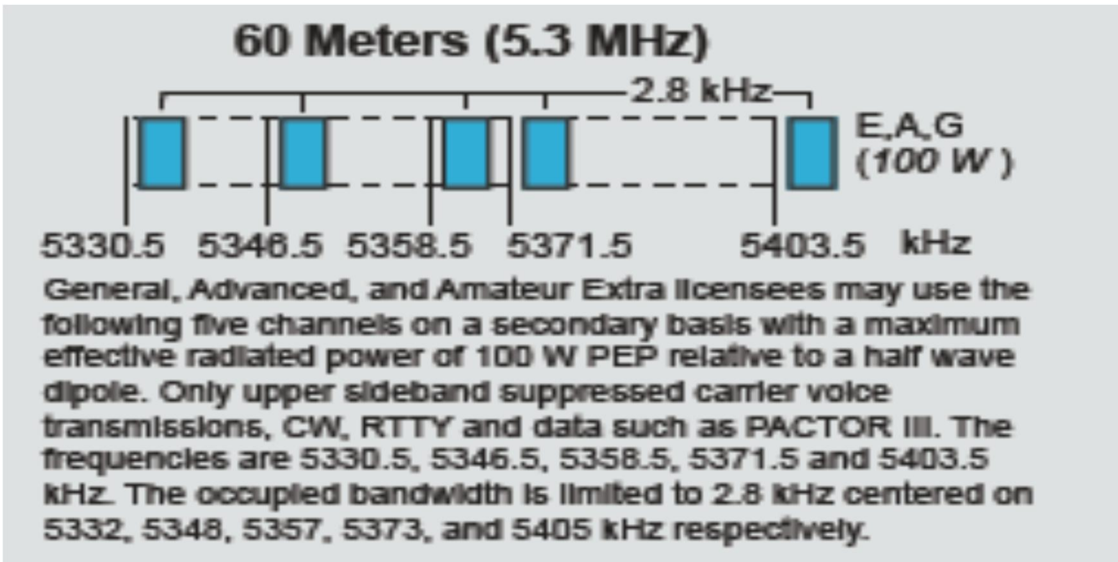
Adding the - 3 KHz for the modulation sideband would yield a lower frequency of 3.598 which places it in the RTTY and CW segment of the 80 meter band. (3.601 MHz - .003 MHz = 3.598 MHz)



E1A05 [97.313]
What is the maximum power output permitted on the 60 meter band?
100 watts PEP effective radiated power relative to the gain of a half-wave dipole

Effective radiated power is equal to the transmitter output power – the feed line loss + the antenna gain relative to a dipole (if you are not using a dipole). For example a station with 200 watts of output power and 3 dB transmission line loss using a dipole antenna would be legal. Remember that a 3 dB loss =0.5 times and a 3dB gain is 2 times. (With 200 watts of transmit power times the line loss which is 0.5 would leave 100 watts PEP with a dipole)

E1A06 [97.303]
Which of the following describes the rules for operation on the 60 meter band?
Operation is restricted to specific emission types and specific channels

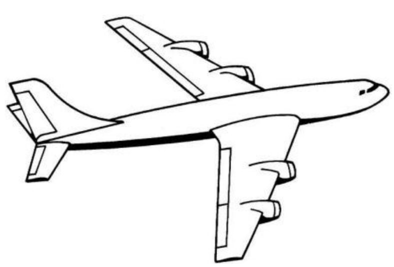


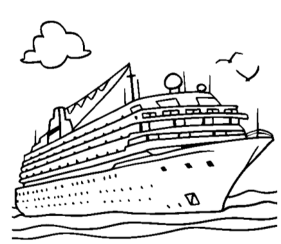
E1A07 [97.303]
What is the only amateur band where transmission on specific channels rather than a range of frequencies is permitted?
60 meter band

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 [97.219]
What is the first action you should take if your digital message forwarding station inadvertently forwards a communication that violates FCC rules?
Discontinue forwarding the communication as soon as you become aware of it

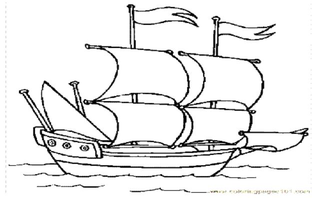
E1A10 [97.11]
If an amateur station is installed aboard a ship or aircraft, what condition must be met before the station is operated?
Its operation must be approved by the master of the ship or the pilot in command of the aircraft





E1A11 [97.5]
What authorization or licensing is required when operating an amateur station aboard a US-registered vessel in international waters?

Any FCC-issued amateur license or a reciprocal permit for an alien amateur licensee



E1A12 [97.301, 97.305]
With your transceiver displaying the carrier frequency of CW signals, you hear a DX station's CQ on 3.500 MHz. Is it legal to return the call using CW on the same frequency?

No, sidebands from the CW signal will be out of the band.

The CW portion of the 80 meter band extends from 3.50 to 3.60. A signal at 3.50 MHz would have sidebands that would be out of band

E1A13 [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

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

E1B01 [97.3]
Which of the following constitutes a spurious emission?

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

E1B02 [97.13]
Which of the following factors might cause the physical location of an amateur station apparatus or antenna structure to be restricted?

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

E1B03 [97.13]
Within what distance must an amateur station protect an FCC monitoring facility from harmful interference?

1 mile

E1B04 [97.13, 1.1305-1.1319]
What must be done before placing an amateur station within an officially designated wilderness area or wildlife preserve, or an area listed in the National Register of Historical Places?

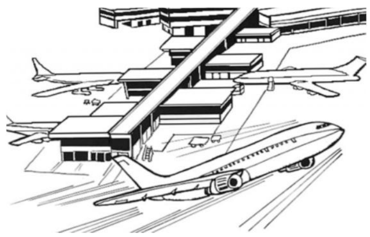
An Environmental Assessment must be submitted to the FCC

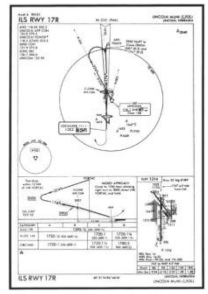
E1B05 [97.303]
What is the maximum bandwidth for a data emission on 60 meters?

2.8 kHz

E1B06 [97.15]
Which of the following additional rules apply if you are installing an amateur station antenna at a site at or near a public use airport?

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





E1B07 [97.15]
Where must the carrier frequency of a CW signal be set to comply with FCC rules for 60 meter operation?

At the center frequency of the channel

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 receiver(s) involved are of good engineering design?

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

"The amateur station shall not be operated during the hours of 8 p.m., local time to 10:30 p.m. local time and on Sunday for an additional period of 1:30 a.m. and 1 p.m., local time upon the frequency or frequencies used when interference is created".

E1B09 [97.407]
Which amateur stations may be operated in RACES?

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

E1B10 [97.407]
What frequencies are authorized to an amateur station participating in RACES?

All amateur service frequencies authorized to the control operator

E1B11 [97.307]
What is the permitted mean power of any spurious emission relative to the mean power of the fundamental emission from a station transmitter or external RF amplifier installed after January 1, 2003, and transmitting on a frequency below 30 MHZ?

At least 43 dB below

E1B12 [97.307]
What is the highest modulation index permitted at the highest modulation frequency for angle modulation?

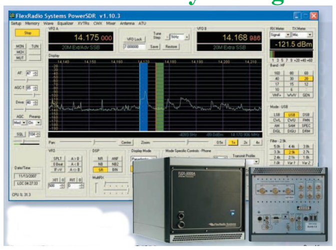
1.0

Modulation index is equal to the peak deviation divided by the modulation rate (frequency). For example a signal with a peak deviation of 5 KHz and a 1 KHz modulation frequency would have a modulation index of 5 KHz/1 KHz or 5.

Therefore a 2.8 KHz Maximum audio frequency could not have more than 2.8 KHz of peak deviation in order to meet the mode index of 1 requirement.

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

E1C01 [97.3]
What is a remotely controlled station?
A station controlled indirectly through a control link

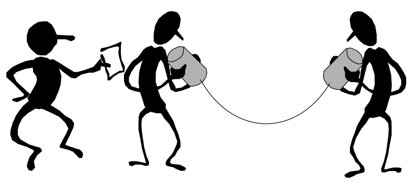


E1C02 [97.3, 97.109]
What is meant by automatic control of a station?
The use of devices and procedures for control so that the control operator does not have to be present at a control point

E1C03 [97.3, 97.109]
How do the control operator responsibilities of a station under automatic control differ from one under local control?
Under automatic control the control operator is not required to be present at the control point

E1C04 [97.109]
When may an automatically controlled station retransmit third party communications?
Only when transmitting RTTY or data emissions

E1C05 [97.109]
When may an automatically controlled station originate third party communications?
Never



EC106
Which of the following statements concerning remotely controlled amateur stations is true?
A control operator must be present at the control point

E1C07 [97.3]
What is meant by local control?
Direct manipulation of the transmitter by a control operator

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

E1C09 [97.205]
Which of these frequencies are available for an automatically controlled repeater operating below 30 MHz?
29.500 - 29.700 MHz

E1C10 [97.113]
What types of amateur stations may automatically retransmit the radio signals of other amateur stations?
Only auxiliary, repeater or space stations

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

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

E1D02 [97.3]
What is the amateur satellite service?

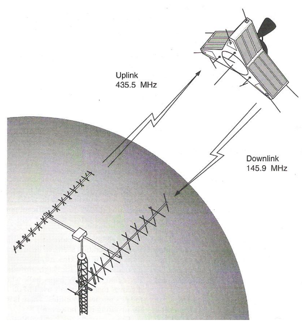
A radio communications service using amateur radio stations on satellites

E1D03 [97.3]
What is a telecommand station in the amateur satellite service?

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

E1D04 [97.3]
What is an Earth station in the amateur satellite service?

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



E1D05 [97.207]
What class of licensee is authorized to be the control operator of a space station?

All classes

Assuming the space station emissions are in a band authorized by that class of operator

E1D06 [97.207]
Which of the following special provisions must a space station incorporate in order to comply with space station requirements?

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

E1D07 [97.207]
Which amateur service HF bands have frequencies authorized to space stations?

Only 40m, 20m, 17m, 15m, 12m and 10m

Not on the 80m, 60m, 30m

E1D08 [97.207]
Which VHF amateur service bands have frequencies available for space stations?

2 meters

Note: this question specifically asks for frequencies authorized in the VHF Band. There are no frequencies available on the 6 meter or 1.25 meter bands, some other choices shown are authorized but are not in the VHF band.

E1D09 [97.207] THIS QUESTION HAS BEEN REMOVED FROM THE QUESTIPON POOL
Which amateur service UHF bands have frequencies available for a space station?

70 cm, 23 cm, 13 cm

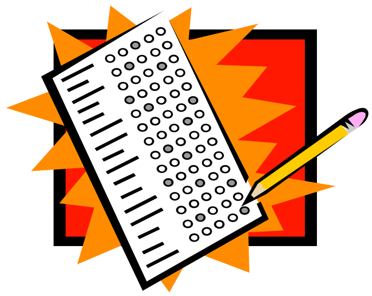
E1D10 [97.211]
Which amateur stations are eligible to be telecommand stations?

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

E1D11 [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

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

E1E01 [97.509]
What is the minimum number of qualified VEs required to administer an Element 4 amateur operator license examination?
Three

E1E02 [97.523]
Where are the questions for all written US amateur license examinations listed?
In a question pool maintained by all the VECs

E1E03 [97.521]
What is a Volunteer Examiner Coordinator?
An organization that has entered into an agreement with the FCC to coordinate amateur operator license examinations
***The* two groups authorized are ARRL VEC and W5YI Group**

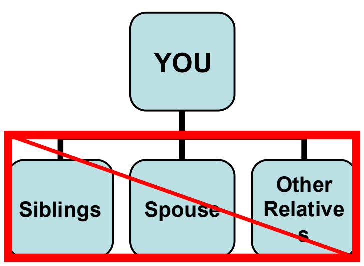
E1E04 [97.509, 97.525]
Which of the following best describes the Volunteer Examiner accreditation process?
The procedure by which a VEC confirms that the VE applicant meets FCC requirements to serve as an examiner

E1E05 [97.503]
What is the minimum passing score on amateur operator license examinations?
Minimum passing score of 74%

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]
What should a VE do if a candidate fails to comply with the examinerǒs 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

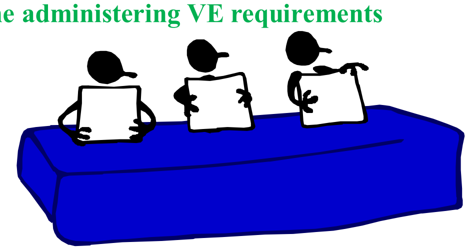
All those testing in a fraudulently administered exam must retest for their license.

E1E10 [97.509]
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]
What must the VE team do if an examinee scores a passing grade on all examination elements needed for an upgrade or new license?

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



E1E12 [97.509]
What must the VE team do with the application form if the examinee does not pass the exam?

Return the application document to the examinee

E1E13 [97.519]
What are the consequences of failing to appear for re-administration of an examination when so directed by the FCC?

The licensee's license will be cancelled

E1E14 [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 license

E1F Miscellaneous rules: external RF power amplifiers; national quiet zone; business communications; compensated communications; spread spectrum; auxiliary stations; reciprocal operating privileges; IARP and CEPT licenses; third party communications with foreign countries; special temporary authority

E1F01 [97.305]
On what frequencies are spread spectrum transmissions permitted?

Only on amateur frequencies above 222 MHz

E1F02 [97.5]
Which of the following operating arrangements allows an FCC-licensed US citizen to operate in many European countries, and alien amateurs from many European countries to operate in the US?

CEPT agreement

European Conference of Postal and Telecommunications Administrations
- 48 European countries cooperating to regulate posts, radio spectrum and communications networks

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 US-Canadian border

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 - 430 MHz

The 70 cm band covers from 420 MHz thru 450 MHz. Most voice communication takes place between 440 MHz and 450 MHz.

E1F06 [97.3]
What is the National Radio Quiet Zone?

An area surrounding the National Radio Astronomy Observatory

The National Radio Astronomy Observatory sites are located in Green Bank West Virginia, Socorro New Mexico, and Charlottesville NC.


E1F07 [97.113]
When may an amateur station send a message to a business?

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

E1F08 [97.113]
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 [97.311]
Which of the following conditions apply when transmitting spread spectrum emission?

A. A station transmitting SS emission must not cause harmful interference to other stations employing other authorized emissions
B. The transmitting station must be in an area regulated by the FCC or in a country that permits SS emissions
C. The transmission must not be used to obscure the meaning of any communication
D. All of these choices are correct

E1F10 [97.313]
What is the maximum transmitter power for an amateur station transmitting spread spectrum communications?

10 W

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

E1F12 [97.201]
Who may be the control operator of an auxiliary station?

Only Technician, General, Advanced or Amateur Extra Class operators

E1F13 [97.117]
What types of communications may be transmitted to amateur stations in foreign countries?

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

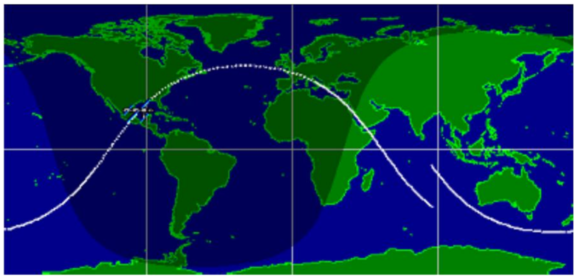
E1F14 [1.931]
Under what circumstances might the FCC issue a "Special Temporary Authority" (STA) to an amateur station?

To provide for experimental amateur communications

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
What is the direction of a descending pass for an amateur satellite?
From north to south

E2A03
What is the orbital period of an Earth satellite?
The time it takes for a satellite to complete one revolution around the Earth

E2A04
What is meant by the term mode as applied to an amateur radio satellite?
The satellite's uplink and downlink frequency bands

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

The following table summarizes the mode designators:

Mode	Satellite Receiving	Satellite Transmitting
V/H	VHF	HF
U/V	UHF	VHF
V/U	VHF	UHF
L/U	L-Band	UHF

E2A06
On what band would a satellite receive signals if it were operating in mode U/V?
435-438 MHz

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 of these choices are correct

E2A08
Why should effective radiated power to a satellite which uses a linear transponder be limited?
To avoid reducing the downlink power to all other users

In a linear transponder the largest received signal sets the transponder output power. Signals less than the larger signal are attenuated and therefore are re-sent at a lower power than the larger signal. Using the minimum power needed to access the transponder will allow more users to have access to the transponder.

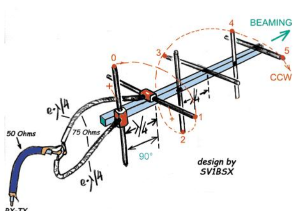
E2A09
What do the terms L band and S band specify with regard to satellite communications?
The 23 centimeter and 13 centimeter bands

Wave Guide Band Designator	*Frequency Range*
L	*~ 1 GHz to 2 GHz*
S	*~2 GHz to 4 GHz*
G	*3.95 GHz to 5.85 GHz*
C	*4.9 GHz to 7.o5 GHz*
H	*7.05 GHz to 10 GHz*
X	*8.2 GHZ to 12.4 GHz*
KU	*12.4 GHz to 18 GHz*
K	*18 GHz to 26.5 GHz*
KA	*26.5 GHz to 40 GHz*

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

Satellite designers often spin the satellite to improve its pointing stability so a rapid fading effect can be due to satellite rotation

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



E2A12
What is one way to predict the location of a satellite at a given time?
By calculations using the Keplerian elements for the specified satellite

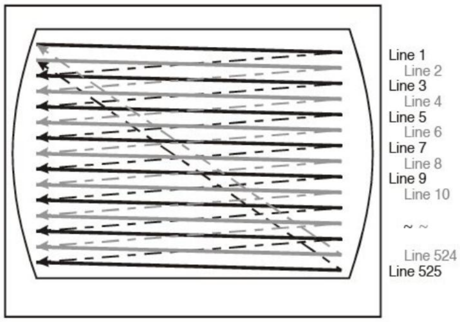
Example Keplerian Data from monthly ARRL report
Satellite AO-07
1 07530U 74089B 12030.76241720 -.00000027 +00000-0 +10000-3 0 02940
2 07530 101.3983 033.3460 0011821 193.4266 166.6489 12.53587393702707
Satellite AO-16
1 20439U 90005D 12030.88295038 +.00000148 +00000-0 +70839-4 0 04002
2 20439 098.4139 338.2452 0010117 206.4703 153.5962 14.32012962150202
Satellite AO-27
1 22825U 93061C 12030.93151253 +.00000113 +00000-0 +61456-4 0 00344
2 22825 098.5601 336.0086 0008243 332.3578 027.7165 14.29425966956729

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

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

E2B01
How many times per second is a new frame transmitted in a fast-scan (NTSC) television system?
30

E2B02
How many horizontal lines make up a fast-scan (NTSC) television frame?
525



E2B03
How is an interlaced scanning pattern generated in a fast-scan (NTSC) television system?
By scanning odd numbered lines in one field and even numbered ones in the next

It takes two frames to generate a complete picture. This interleaving makes the transition from one complete frame to another appear smoother.

E2B04
What is blanking in a video signal?
Turning off the scanning beam while it is traveling from right to left or from bottom to top

See graphic from question E2B02

E2B05
Which of the following is an advantage of using vestigial sideband for standard fast- scan TV transmissions?
Vestigial sideband reduces bandwidth while allowing for simple video detector circuitry

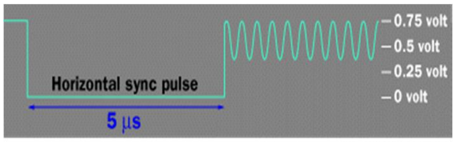
Vestigial sideband (VSB) is a type of amplitude modulation (AM) technique (sometimes called VSB-AM) that encodes data by varying the amplitude of a single carrier frequency . Portions of one of the redundant sidebands are removed to form a vestigial sideband signal - so-called because a vestige of the sideband remains.

VSB transmission is similar to single-sideband (SSB) transmission, where one of the sidebands is completely removed. In a VSB transmission, however, the second sideband is not completely removed, but is filtered to remove all but the desired range of frequencies . This technology achieves much of the bandwidth reduction goal of SSB but the technology required to demodulate the signal is much simpler than that needed for pure SSB.

E2B06
What is vestigial sideband modulation?
Amplitude modulation in which one complete sideband and a portion of the other are transmitted

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

A color TV signal starts off looking just like a black-and-white signal. An extra chrominance signal is added by superimposing a 3.579545 MHz sine wave onto the standard black-and-white signal following the horizontal sync pulse consisting of eight cycles of the 3.579545 MHz sine wave called the color burst



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Following these eight cycles, a phase shift in the chrominance signal indicates the color to display. The amplitude of the signal determines the saturation. The following table shows you the relationship between color and phase:

Color	Phase
Burst	0 degrees
Yellow	15 degrees
Red	75 degrees
Magenta	135 degrees
Blue	195 degrees
Cyan	255 degrees
Green	315 degrees

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

A. Frequency-modulated sub-carrier
B. A separate VHF or UHF audio link
C. Frequency modulation of the video carrier
D. All of these choices are correct

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

No other hardware is needed

DRM can deliver FM-comparable sound quality on frequencies below 30 MHz (long wave, medium wave and short wave), which allow for very-long-distance signal propagation. DRM is robust against the fading and interference which often plague conventional communication in these frequency ranges.

The encoding and decoding can be performed with digital signal processing, so that a cheap embedded computer with a conventional transmitter and receiver can perform the rather complex encoding and decoding.

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

3 KHz

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

To identify the SSTV mode being used

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

Varying tone frequencies representing the video are transmitted using single sideband

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

128 or 256

By comparison Fast scan TV uses 525 lines for each frame. See illustration for question E2B02

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

Tone frequency

E2B15
What signals SSTV receiving equipment to begin a new picture line?
Specific tone frequencies

E2B16
Which of the following is the video standard used by North American Fast Scan ATV stations?
NTSC

NTSC is an abbreviation for the National Television System Committee. This is the old analog television system that is used in most of North America, and still used for full motion amateur Television.

Most countries using the NTSC standard are switching to newer digital television standards, of which at least four different ones are in use around the world.

The first NTSC standard was developed in 1941 and had no provision for color television. In 1953 a second modified version of the NTSC standard was adopted, which allowed color television broadcasting compatible with the existing stock of black-and-white receivers. NTSC was the first widely adopted broadcast color system and remained dominant where it had been adopted until the first decade of the 21st century, when it was replaced with digital ATSC.

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

E2B18
On which of the following frequencies is one likely to find FM ATV transmissions?
1,255 MHz

E2B19
What special operating frequency restrictions are imposed on slow scan TV transmissions?
They are restricted to phone band segments and their bandwidth can be no greater than that of a voice signal of the same modulation type

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

E2C01
Which of the following is true about contest operating?
Operators are permitted to make contacts even if they do not submit a log

E2C02
Which of the following best describes the term ñself-spottingò in regards to contest operating?
The generally prohibited practice of posting one's own call sign and frequency on a call sign spotting network

DX operators use a web site to list DX stations they hear and work along with the band/frequency to help others make new and rare DX contacts. Is inappropriate list your own call and frequency on the DX spotting web site in order to gain more contacts by having operators come to you.

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

The 30 meter band is only 50 KHz wide (10.100 MHz to 10.150 MHz and operators must avoid interference to fixed radio services outside the US.

E2C04
On which of the following frequencies is an amateur radio contest contact generally discouraged?
146.52 MHz

This is because 146.52 is the national calling frequency for 2 meters.

E2C05
What is the function of a DX QSL Manager?

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

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

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

CW and weak signal:	***144.000 to 144.100***
	222.000 to 223.400
	432.000 to 432.125
	902.000 to 902.400
National calling frequencies:	***144.200 SSB and 146.52 FM***
	222.100 SSB and 223.500 FM
	432.100 SSB and 446.000 FM
	902.100 SSB

E2C07
What is the Cabrillo format?

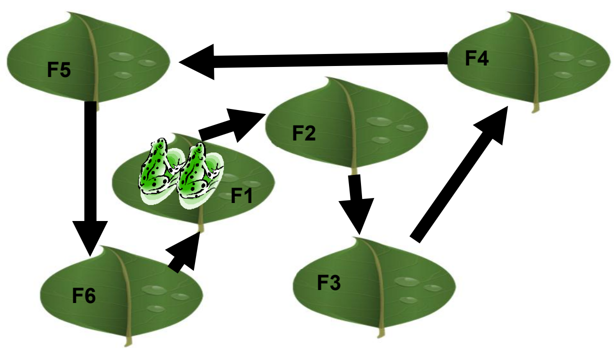
A standard for submission of electronic contest logs

E2C08
Why are received spread-spectrum signals resistant to interference?

Signals not using the spectrum-spreading algorithm are suppressed in the receiver

E2C09
How does the spread-spectrum technique of frequency hopping work?

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



In a frequency hopping spread spectrum communication system the sender and receiver agree to change frequencies in a predetermined sequence. Sort of like the two frogs who are talking to each other as the hop in unison from one lily pad to another. If they hop together they can carry on a continuous conversation. In addition to knowing the frequency hopping sequence, the sender and receiver need to have a common starting time reference.

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

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 reduce interference, thereby improving operating efficiency
D. All of these choices are correct

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

Send your full call sign once or twice

E2C12
What might help to restore contact when DX signals become too weak to copy across an entire HF band a few hours after sunset?
Wait 90 minutes or so for the signal degradation to pass

E2D Operating methods: VHF and UHF digital modes; APRS

E2D01
Which of the following digital modes is especially designed for use for meteor scatter signals?
FSK441

E2D02
What is the definition of baud?
The number of data symbols transmitted per second.

The baud rate can be higher than the bit rate if more than one parameter of the signal is changed during transmission, such as amplitude, width, or phase. If it takes ten bits to represent a single symbol then the bit rate will be 10 times the baud rate.

E2D03
Which of the following digital modes is especially useful for EME communications?
JT65

JT65 is also a low-power mode, even more so than PSK31. On the upper HF bands, you'll often run 5W-10W or so. On the lower bands, 5W-10W will often do the trick, but for DX you might crank it up to 30W-40W if really needed. Some JT65-HF users are committed to 5W max, period. It is important not to crank up the power too much because it will make it hard or impossible for others to hear weaker signals, just like on PSK31. In most cases, 10W will be sufficient. This is an extremely efficient weak-signal mode

E2D04
What is the purpose of digital store-and-forward functions on an Amateur Radio satellite?
To store digital messages in the satellite for later download by other stations

Sort of like a post office box you can send a message to and the recipient will go to that mailbox to retrieve your message.

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

E2D06
Which of the following is a commonly used 2-meter APRS frequency?
144.39 MHz

E2D07
Which of the following digital protocols is used by APRS?
AX.25

While there is no generally accepted formal definition of "protocol" but it is a set of agreed upon procedures to be followed when communicating digital data.

E2D08
Which of the following types of packet frames is used to transmit APRS beacon data?
Unnumbered Information

E2D09
Under clear communications conditions, which of these digital communications modes has the fastest data throughput?
300-baud packet

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

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

E2D11
Which of the following data are used by the APRS network communicate your location?
Latitude and longitude

E2D12
How does JT65 improve EME communications?
It can decode signals many dB below the noise floor using FEC

See explanation of JT65 for question E2D03 above

E2E Operating methods: operating HF digital modes; error correction

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

FSK is a digital method of transmission using Marks and spaces which are transmitted as one of two different frequencies of the transmitter carrier. FSK is true Frequency Shift Keying of the transmitter's carrier. This shift can be applied to any of the transmitter oscillators.

Audio Frequency Shift Keying is generated by shifting the frequency of an audio oscillator that is fed into the transmitter's normal transmit audio input. Unlike FSK, AFSK can be used for FM modulation.

E2E02
What do the letters FEC mean as they relate to digital operation?
Forward Error Correction

Forward error correction (FEC) is a method of obtaining error control in data transmission in which the source (transmitter) sends redundant data and the destination (receiver) recognizes only the portion of the data that contains no apparent errors. Because FEC does not require handshaking between the source and the destination, it can be used for broadcasting of data to many destinations simultaneously from a single source.

Simple FEC is one of two modes used by radio amateurs in a self-correcting digital mode called AMTOR Mode B (an abbreviation for amateur teleprinting over radio).

E2E03
How is Forward Error Correction implemented?
By transmitting extra data that may be used to detect and correct transmission errors

E2E04
What is indicated when one of the ellipses in an FSK crossed-ellipse display suddenly disappears?
Selective fading has occurred

In any radio transmission, the channel spectral response is not flat. It has dips or fades in the response due to reflections causing cancellation of certain frequencies at the receiver. Reflections off near-by objects (e.g. ground, buildings, trees, etc.) can lead to multipath signals of similar signal power as the direct signal. This can result in deep nulls in the received signal power due to destructive interference. For narrow bandwidth transmissions if the null in the frequency response occurs at the transmission frequency then the entire signal can be lost.

E2E05
How does ARQ accomplish error correction?
If errors are detected, a retransmission is requested

E2E06
What is the most common data rate used for HF packet communications?
300 baud

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

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

E2E09
Which of the following HF digital modes uses variable-length coding for bandwidth efficiency?
PSK31

Like Morse Code where a character or letter can be represented by variable length bit streams from one to 5 bits of data. E is a single dit, I is two dits, S is 3 dits and H is 4 dits and the number 5 is represented by 5 dits.

E2E10
Which of these digital communications modes has the narrowest bandwidth?
PSK31
2E11
What is the difference between direct FSK and audio FSK?
Direct FSK applies the data signal to the transmitter VFO

E2E12
Which type of digital communication does not support keyboard-to-keyboard operation?
Winlink

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

E3A Propagation and technique: Earth-Moon-Earth communications (EME), meteor scatter

E3A01
What is the approximate maximum separation measured along the surface of the Earth between two stations communicating by Moon bounce?
12,000 miles, as long as both can "see" the Moon

E3A02
What characterizes libration fading of an Earth-Moon-Earth 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

The moon is the closest to earth when it is at perigee most distant from earth it is at apogee.

E3A04
What type of receiving system is desirable for EME communications?
Equipment with very low noise figures

Noise figure describes how much noise is added to the theoretical noise in dB for a given receiver band width. The theoretical noise of a perfect resistor at room temperature is approximately -174 dBm in a 1 Hertz bandwidth. The lower the noise figure of the receiver front end the better it can hear weak signals. A noise figure of around 0.25 dB for VHF and UHF is desired.

E3A05
Which of the following describes a method of establishing EME contacts?
Time synchronous transmissions with each station alternating

When attempting an EME contact on 432 MHz two-and-one-half minute time sequences are used, where one station transmits for a full 2.5 minutes and then receives for the following 2.5 minutes.

E3A06
What frequency range would you normally tune to find EME signals in the 2 meter band?
144.000 - 144.100 MHz

E3A07
What frequency range would you normally tune to find EME signals in the 70 cm band?
432.000 - 432.100 MHz

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

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

E3A10
Which of the following is a good technique for making meteor-scatter contacts?
A. 15 second timed transmission sequences with stations alternating based on location
B. Use of high speed CW or digital modes
C. Short transmission with rapidly repeated call signs and signal reports

D. All of these choices are correct

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

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

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

E3B03
What is the best time of day for transequatorial propagation?
Afternoon or early evening

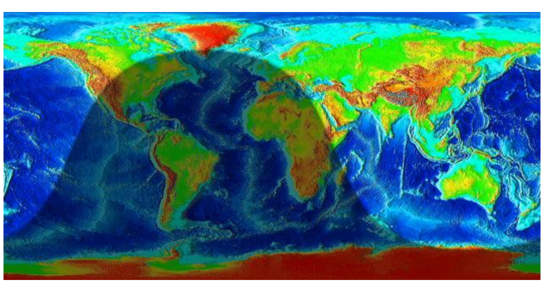
E3B04
What type of propagation is probably occurring if an HF beam antenna must be pointed in a direction 180 degrees away from a station to receive the strongest signals?
Long-path

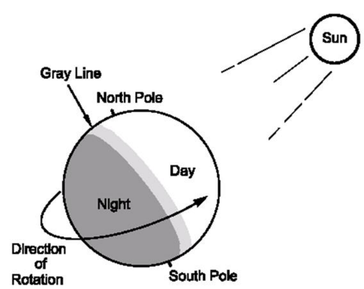
E3B05
Which amateur bands typically support long-path propagation?
160 to 10 meters

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

E3B07
Which of the following could account for hearing an echo on the received signal of a distant station?
Receipt of a signal by more than one path

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





E3B09
At what time of day is gray-line propagation most likely to occur?
At sunrise and sunset

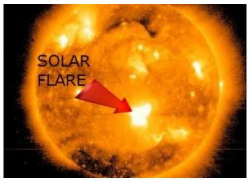
E3B10
What is the cause of gray-line propagation?
At twilight, D-layer absorption drops while E-layer and F-layer propagation remain strong

E3B11
Which of the following describes gray-line propagation?
Long distance communications at twilight on frequencies less than 15 MHz

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

E3C01
Which of the following effects does Aurora activity have on radio communications?
A. SSB signals are raspy
B. Signals propagating through the Aurora are fluttery
C. CW signals appear to be modulated by white noise
D. All of these choices are correct

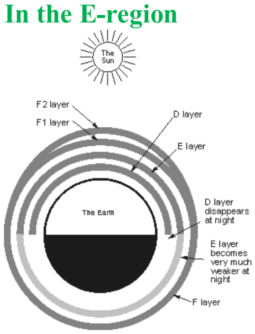
E3C02
What is the cause of Aurora activity?
The interaction of charged particles from the Sun with the Earth's magnetic field and the ionosphere



A solar flare propels charged particles into space through the solar wind. As the solar wind interacts with the earth's magnetic field it can produce the northern lights and provide and charge the ionosphere which allow long distance propagation for our HF signals.

We haven't seen the northern lights much or had good propagation in recent years because the sun has been inactive. We plunged into a solar minimum in 2007 and have slowly begun to rebound out of it. The solar cycle from maximum to minimum and back takes 11 years.

E3C03
Where in the ionosphere does Aurora activity occur?
In the E-region



E3C04
Which emission mode is best for Aurora propagation?
CW

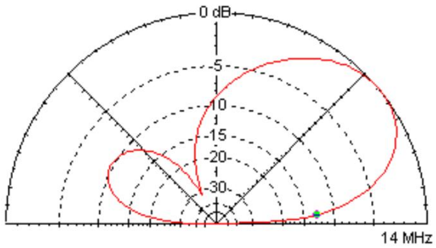
E3C05
Which of the following describes selective fading?
Partial cancellation of some frequencies within the received pass band

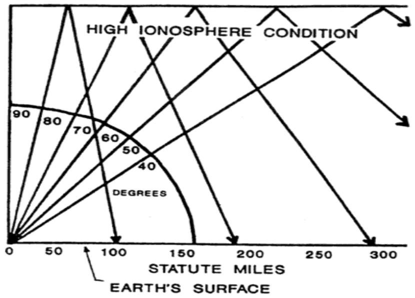
E3C06
By how much does the VHF/UHF radio-path horizon distance exceed the geometric horizon?
By approximately +15% of the distance

E3C07

How does the radiation pattern of a horizontally polarized 3-element beam antenna vary with its height above ground?

The main lobe takeoff angle decreases with increasing height

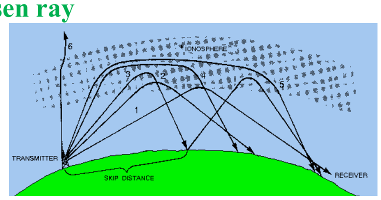




E3C08

What is the name of the high-angle wave in HF propagation that travels for some distance within the F2 region?

Pedersen ray



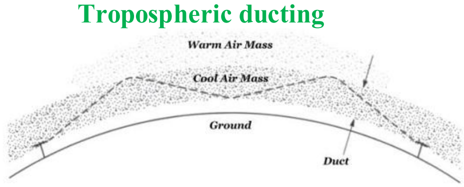
Paths 4 and 5 shown above are Pedersen rays or high-angle rays. These rays are not refracted sufficiently to return directly to the earth but don't have a high enough angle to penetrate (like ray 6). They get trapped in the ionosphere often exiting where there is a big gradient in electron density (at dusk and dawn). The plots below are the result of both high and low angle rays being present at the same time. An effect that we are normally unaware of!

Given this model, we might reasonably expect to see four components on an oblique path as it fades out: o and x wave from the low angle path and o and x waves from the high angle path. Each with different Doppler shifts.

E3C09

Which of the following is usually responsible for causing VHF signals to propagate for hundreds of miles?

Tropospheric ducting



The troposphere consists of atmospheric regions close to the Earth's surface. Slight bending of radio waves occur in the troposphere, causing signals to return to Earth beyond the geometric horizon, and allows you to contact stations that are farther away than would otherwise be possible. This radio path horizon is generally about 15% farther away than the visible horizon.

During the spring, summer, and fall months, it is possible to make VHF and UHF contacts over long distances up to 1,000 miles or more. This occurs during certain weather conditions that cause tropospheric enhancement and tropospheric ducting. It is most useful in the VHF/UHF region. When such "tropo" openings occur, the VHF and UHF bands are filled with excited operators eager to work DX. The troposphere is the layer of the atmosphere just below the stratosphere. It extends upward approximately 7 to 10 miles. In this region clouds form and temperature decreases rapidly with altitude.

E3C10

How does the performance of a horizontally polarized antenna mounted on the side of a hill compare with the same antenna mounted on flat ground?

The main lobe takeoff angle decreases in the downhill direction

E3C11
From the contiguous 48 states, in which approximate direction should an antenna be pointed to take maximum advantage of aurora propagation?

North

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

It decreases

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

Vertical

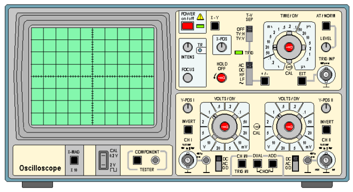
E3C14
Why does the radio-path horizon distance exceed the geometric horizon?

Downward bending due to density variations in the atmosphere

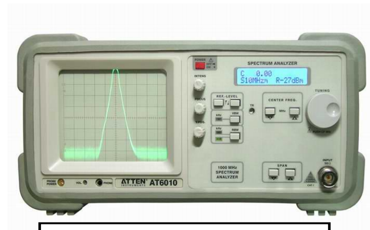
See illustration for E3C09

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

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

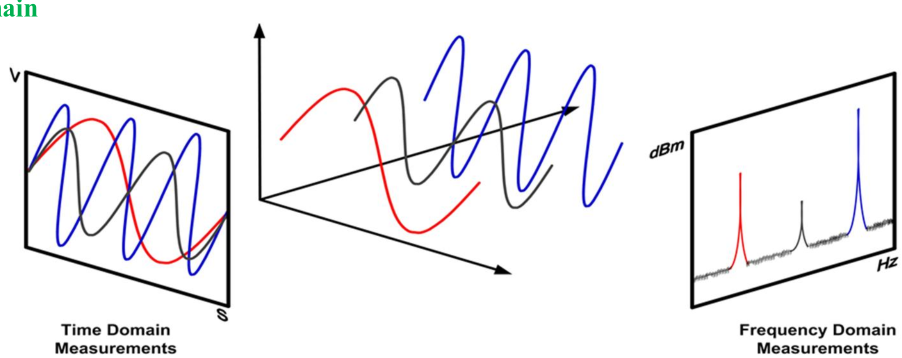


Oscilloscope

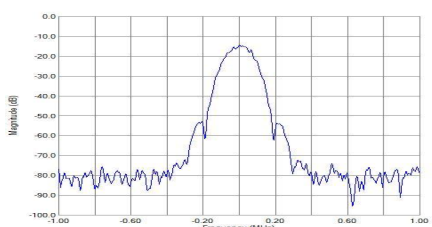


Spectrum Analyzer

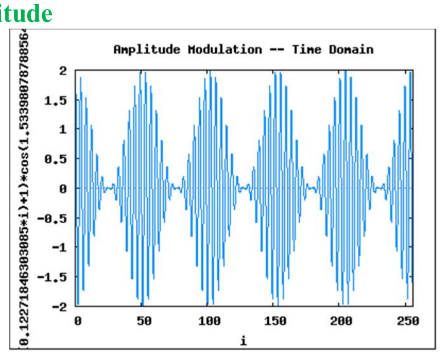
E4A01
How does a spectrum analyzer differ from an oscilloscope?
A spectrum analyzer displays signals in the frequency domain; an oscilloscope displays signals in the time domain



E4A02
Which of the following parameters would a spectrum analyzer display on the horizontal axis?
Frequency



E4A03
Which of the following parameters would a spectrum analyzer display on the vertical axis?
Amplitude

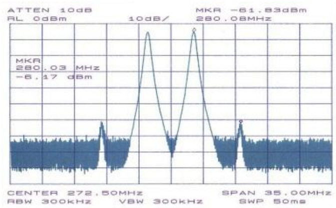


E4A04
Which of the following test instruments is used to display spurious signals from a radio transmitter?
A spectrum analyzer

E4A05
Which of the following test instruments is used to display intermodulation distortion products in an SSB transmission?

A spectrum analyzer

If two separate (non-harmonically related) audio tones are applied to the the microphone input of a SSB transmitter we would expect to see only two signals in the RF output (Carrier ± tone 1 and the carrier ±tone2). In the illustration below you can see that there two smaller signals about 55dB bellow the two RF signals. These are intermodulation distortion products.



E4A06
Which of the following could be determined with a spectrum analyzer?

A. The degree of isolation between the input and output ports of a 2 meter duplexer
B. Whether a crystal is operating on its fundamental or overtone frequency
C. The spectral output of a transmitter
D. <u>All of these choices are correct</u>

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

Antenna analyzers do not need an external RF source

These are some common antenna analyzers. The one the far left is made by MFJ and is the most commonly used by amateur radio operator.

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

An antenna analyzer

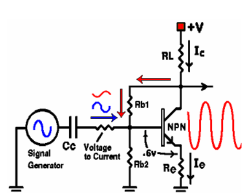
E4A09
Which of the following describes a good method for measuring the intermodulation distortion of your own PSK signal?

Transmit into a dummy load, receive the signal on a second receiver, and feed the audio into the sound card of a computer running an appropriate PSK program

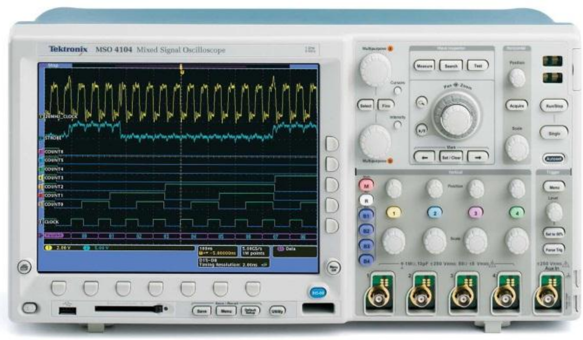
This is actually observing your own PSK Transmission. You should see only a single line on the waterfall display. Multiple signals mean you are driving the transmitter too hard and generating spurious intermodulation signal that would interfere with others.

E4A10
Which of the following tests establishes that a silicon NPN junction transistor is biased on?

Measure base-to-emitter voltage with a voltmeter; it should be approximately 0.6 to 0.7 volts



E4A11
Which of these instruments could be used for detailed analysis of digital signals?
Oscilloscope

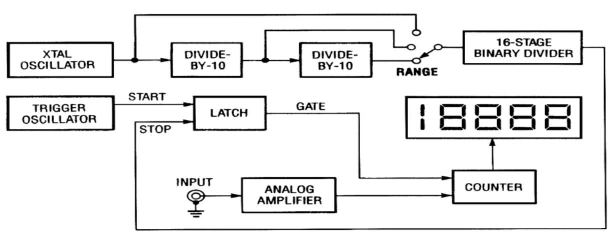


E4A12
Which of the following procedures is an important precaution to follow when connecting a spectrum analyzer to a transmitter output?
Attenuate the transmitter output going to the spectrum analyzer

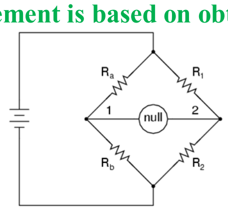
The attenuator acts as a dummy load for the transmitter and must handle the fill transmit output power while reducing the signal at its output to around 10 mW. For a 100 watt transmitter this would require 40dB of attenuation.

E4B Measurement techniques: Instrument accuracy and performance limitations; probes; techniques to minimize errors; measurement of Q; instrument calibration

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



E4B02
What is an advantage of using a bridge circuit to measure impedance?
The measurement is based on obtaining a signal null, which can be done very precisely



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

Parts per million can be expressed as hertz per MHz, for 146.52 Mhzsignal the error with a 1 ppm accuracy would be 146.52 times 1 Hz or ± 146.52 Hz

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

14.652 Hz

Parts per million can be expressed as hertz per MHz, for 14.652 Mhzsignal the error with a 0.1 ppm accuracy would be 14.562 times .01 Hz or ± 14.652 Hz

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

1465.20 Hz

Parts per million can be expressed as hertz per MHz, for 146.52 Mhzsignal the error with a 0.1 ppm accuracy would be 146.52 times 10 Hz or ± 1465.2 Hz

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

75 watts

The forward power is the power being accepted or absorbed by the load the 25 watts of reflected power is reflected back to the transmitter output circuit

E4B07
Which of the following is good practice when using an oscilloscope probe?

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

Long ground leads may look like an inductor and therefore a high impedance to ground at rf and VHF frequencies.

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

High impedance input

The higher the input impedance of the voltmeter the less it will load the circuit and influence the measurement.

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

There is more power going into the antenna

This is what you want to happen

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

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

E4B11
How should a portable antenna analyzer be connected when measuring antenna resonance and feed point impedance?

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

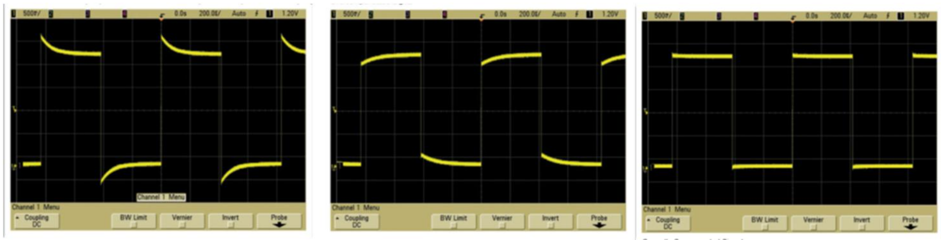
Never connect an antenna analyzer to a transmitter or measure an antenna in close proximity to an active transmitting antenna. This could destroy the antenna analyzer.

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

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

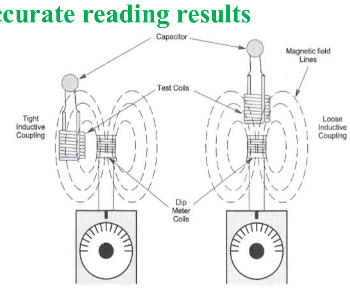
E4B13
How is the compensation of an oscilloscope probe typically adjusted?

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



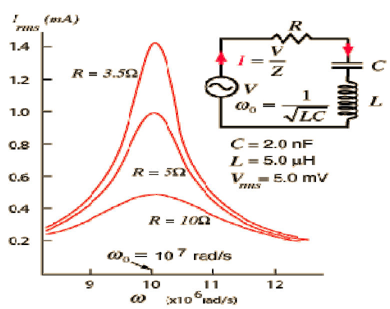
E4B14
What happens if a dip meter is too tightly coupled to a tuned circuit being checked?

A less accurate reading results



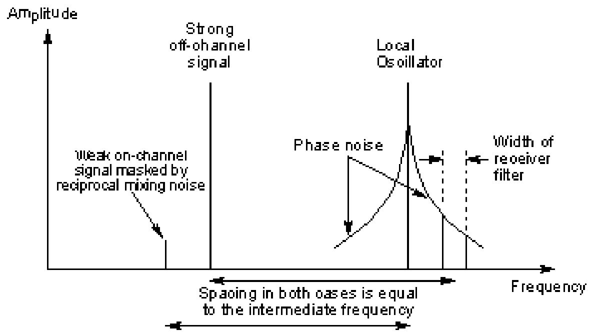
E4B15
Which of the following can be used as a relative measurement of the Q for a series-tuned circuit?

The bandwidth of the circuit's frequency response



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

E4C01
What is an effect of excessive phase noise in the local oscillator section of a receiver?
It can cause strong signals on nearby frequencies to interfere with reception of weak signals



E4C02
Which of the following portions of a receiver can be effective in eliminating image signal interference?
A front-end filter or pre-selector

Pre-selectors can be external and tunable or fixed as shown above. High performance receivers will have pre-selectors designed into the radio.

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

FM receivers exhibit what I called the capture effect when a strong FM signal overpowers and eliminates a weaker FM signal on the same frequency.

E4C04
What is the definition of the noise figure of a receiver?
The ratio in dB of the noise generated by the receiver compared to the theoretical minimum noise

The noise figure is a way of describing the amount of noise generated in a receiver, amp, transmission line, antenna system, or other component. The noise figure of a component or system is defined as the signal-to-noise ratio at the input divided by the signal-to-noise ratio at the output, with the input noise equal to the noise available from a matched resistance at a temperature of T_0=290 Kelvin.

E4C05
What does a value of -174 dBm/Hz represent with regard to the noise floor of a receiver?
The theoretical noise at the input of a perfect receiver at room temperature *(290° Kelvin)*

This noise floor will be higher as the receiver bandwidth is increased. A receiver with a 10 KHz bandwidth will have 10,000 times more noise or an additional 40dB of noise bringing the noise floor up to – 174dBm + 40 dB or -134 dBm.

E4C06
A CW receiver with the AGC off has an equivalent input noise power density of -174 dBm/Hz. What would be the level of an un-modulated carrier input to this receiver that would yield an audio output SNR of 0 dB in a 400 Hz noise bandwidth?
-148 dBm

This noise floor will be higher as the receiver bandwidth is increased. A receiver with a 400 KHz bandwidth will have 4 00 times more noise or an additional 26 dB of noise bringing the noise floor up to – 174dBm + 26 dB or -148 dBm.

dB= 10(log bw2/bw1) or dB= 10(log 400/1) dB= 10 (2.602) or dB=26

Therefore the new noise floor will be -174 +26 or -148dBm

E4C07
What does the MDS of a receiver represent?
The minimum discernible signal

E4C08
How might lowering the noise figure affect receiver performance?
It would improve weak signal sensitivity

E4C09
Which of the following choices is a good reason for selecting a high frequency for the design of the IF in a conventional HF or VHF communications receiver?
Easier for front-end circuitry to eliminate image responses

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

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

E4C12
What is an undesirable effect of using too wide a filter bandwidth in the IF section of a receiver?
Undesired signals may be heard

E4C13
How does a narrow-band roofing filter affect receiver performance?
It improves dynamic range by attenuating strong signals near the receive frequency

Roofing filters are band-pass filters installed before or in the early stage of a receivers IF amplifier

E4C14
On which of the following frequencies might a signal be transmitting which is generating a spurious image signal in a receiver tuned to 14.300 MHz and which uses a 455 kHz IF frequency?
15.210 MHz

When a local oscillator signal is mixed with an incoming signal in generates the sum and the difference of the two signals. If we assume High side mix (the LO is higher than the tuned frequency then the LO will be the tuned frequency + 455KHz. A signal 455 KHz above the LO would also generate a 455 KHz IF spurious or image signal. So taking the receive frequency of 14.300 MHz and 2 times the IF frequency of 0.455 MHz (14.300 – (2x.455) we get 15.210 MHz.

E4C15
What is the primary source of noise that can be heard from an HF receiver with an antenna connected?
Atmospheric noise

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

E4D01
What is meant by the blocking dynamic range of a receiver?
The difference in dB between the noise floor and the level of an incoming signal which will cause 1 dB of gain compression

E4D02
Which of the following describes two problems caused by poor dynamic range in a communications receiver?
Cross-modulation of the desired signal and desensitization from strong adjacent signals

E4D03
How can intermodulation interference between two repeaters occur?
When the repeaters are in close proximity and the signals mix in the final amplifier of one or both transmitters

E4D04
Which of the following may reduce or eliminate intermodulation interference in a repeater caused by another transmitter operating in close proximity?
A properly terminated circulator at the output of the transmitter

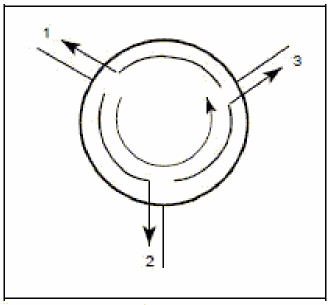


Figure 1. Symbolic Expression for a Y-Junction Circulator

E4D05
What transmitter frequencies would cause an intermodulation-product signal in a receiver tuned to 146.70 MHz when a nearby station transmits on 146.52 MHz?
146.34 MHz and 146.61 MHz

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

E4D07
Which of the following describes the most significant effect of an off-frequency signal when it is causing cross-modulation interference to a desired signal?
The off-frequency unwanted signal is heard in addition to the desired signal

E4D08
What causes intermodulation in an electronic circuit?
Nonlinear circuits or devices

E4D09
What is the purpose of the preselector in a communications receiver?
To increase rejection of unwanted signals

E4D10
What does a third-order intercept level of 40 dBm mean with respect to receiver performance?
A pair of 40 dBm signals will theoretically generate a third-order intermodulation product with the same level as the input signals

E4D11
Why are third-order intermodulation products created within a receiver of particular interest compared to other products?
The third-order product of two signals which are in the band of interest is also likely to be within the band

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

E4D13
Which of the following can cause receiver desensitization?
Strong adjacent-channel signals

E4D14
Which of the following is a way to reduce the likelihood of receiver desensitization?
Decrease the RF bandwidth of the receiver

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

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

E4E02
Which of the following types of receiver noise can often be reduced with a DSP noise filter?
A. Broadband white noise
B. Ignition noise
C. Power line noise
D. <u>All of these choices are correct</u>

E4E03
Which of the following signals might a receiver noise blanker be able to remove from desired signals?
Signals which appear across a wide bandwidth

E4E04
How can conducted and radiated noise caused by an automobile alternator be suppressed?
By connecting the radio's power leads directly to the battery and by installing coaxial capacitors in line with the alternator leads

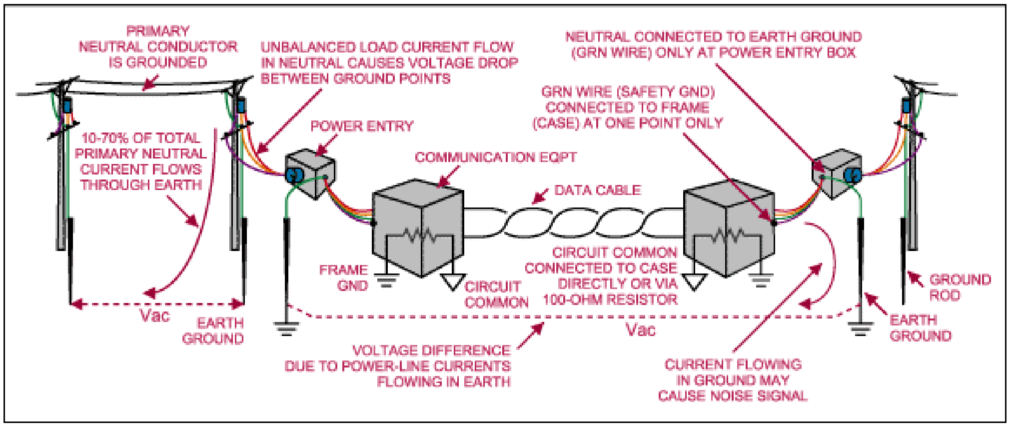
E4E05
How can noise from an electric motor be suppressed?
By installing a brute-force AC-line filter in series with the motor leads


E4E06
What is a major cause of atmospheric static?
Thunderstorms

E4E07
How can you determine if line noise interference is being generated within your home?
By turning off the AC power line main circuit breaker and listening on a battery operated radio

E4E08
What type of signal is picked up by electrical wiring near a radio antenna?
A common-mode signal at the frequency of the radio transmitter

The principal aim of any data-transmission system is to send data from one location to another, whether within a single box or enclosure, between boxes within an enclosure, between enclosures within a building or defined area, or between buildings. Figure 1 illustrates an RS-485 signaling situation in which the **buildings are supplied from different power circuits.**



E4E09
What undesirable effect can occur when using an IF noise blanker?
Nearby signals may appear to be excessively wide even if they meet emission standards

This is because a peak portion of the signal is removed and the broader lower section is only received. The observed 3 dB bandwidth of the blanked signal would appear to be much wider than if referred to the original peak signal level.

E4E10
What is a common characteristic of interference caused by a touch controlled electrical device?
A. The interfering signal sounds like AC hum on an AM receiver or a carrier modulated by 60 Hz hum on a SSB or CW receiver
B. The interfering signal may drift slowly across the HF spectrum
C. The interfering signal can be several kHz in width and usually repeats at regular intervals across a HF band
D. <u>All of these choices are correct</u>

E4E11
Which of the following is the most likely cause if you are hearing combinations of local AM broadcast signals within one or more of the MF or HF ham bands?
Nearby corroded metal joints are mixing and re-radiating the broadcast signals

Corroded joints act like diodes and then function as a mixer generating sum and difference frequencies from nearby strong signals.

E4E12
What is one disadvantage of using some types of automatic DSP notch-filters when attempting to copy CW signals?
The DSP filter can remove the desired signal at the same time as it removes interfering signals

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

E4E14
What is one type of electrical interference that might be caused by the operation of a nearby personal computer?
The appearance of unstable modulated or unmodulated signals at specific frequencies

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

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

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

Resonance is when the inductive reactance and capacitive reactance are equal. In this condition the current flowing in the circuit is limited only by the circuit resistance.

E5A02
What is resonance in an electrical circuit?
The frequency at which the capacitive reactance equals the inductive reactance

E5A03
What is the magnitude of the impedance of a series RLC circuit at resonance?
Approximately equal to circuit resistance

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

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

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

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

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

E5A09
What is the phase relationship between the current through and the voltage across a parallel resonant circuit at resonance?
The voltage and current are in phase

E5A10
What is the half-power bandwidth of a parallel resonant circuit that has a resonant frequency of 1.8 MHz and a Q of 95?
18.9 kHz
BW= Frequency / Q or 1,800 KHz/95 or 18.94 KHz

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

BW= Frequency / Q or 7,100 KHz/150 or 47.3 KHz

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

BW= Frequency / Q or 3,700 KHz/118 or 31.36 KHz

E5A13
What is the half-power bandwidth of a parallel resonant circuit that has a resonant frequency of 14.25 MHz and a Q of 187?
76.2 kHz

BW= Frequency / Q or 14,250 KHz/187 or 76.20 KHz

E5A14
What is the resonant frequency of a series RLC circuit if R is 22 ohms, L is 50 micro-henrys and C is 40 picofarads?
3.56 MHz

For frequency in MHz, Inductance in micro-henries and capacitance in picofarads: $F_{(resonance)} = 1{,}000 / (2\pi\sqrt{L \times C})$

$F_{(resonance)} = 1{,}000 / (2\pi\sqrt{L \times C}) = 1{,}000 / (6.28\sqrt{50 \times 40}) = 3.56$ MHz

E5A15
What is the resonant frequency of a series RLC circuit if R is 56 ohms, L is 40 micro-henrys and C is 200 picofarads?
1.78 MHz

$F_{(resonance)} = 1{,}000 / (2\pi\sqrt{L \times C}) = 1{,}000 / (6.28\sqrt{40 \times 200}) = 1.78$ MHz

E5A16
What is the resonant frequency of a parallel RLC circuit if R is 33 ohms, L is 50 micro-henrys and C is 10 pico-farads?
7.12 MHz

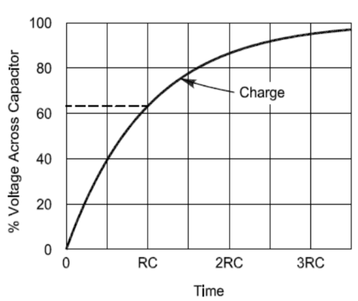
$F_{(resonance)} = 1{,}000 / (2\pi\sqrt{L \times C}) = 1 / (6.28\sqrt{50 \times 10}) = 7.121$ MHz

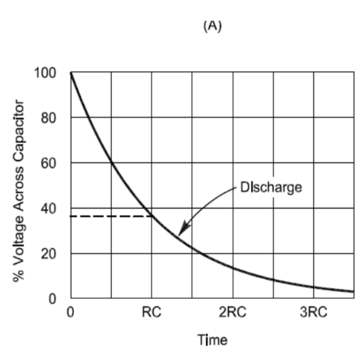
E5A17
What is the resonant frequency of a parallel RLC circuit if R is 47 ohms, L is 25 micro-henrys and C is 10 picofarads?
10.1 MHz

$F_{(resonance)} = 1{,}000 / (2\pi\sqrt{L \times C}) = 1 / (6.28\sqrt{25 \times 10}) = 10.1$ MHz

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

Time Constants Tutorial
When a voltage is applied to a capacitor through a resistance (all circuits have resistance) it takes time for the voltage across the capacitor to reach the applied voltage. At the instant the voltage is applied the current in the circuit is at a maximum limited only by the circuit resistance. As time passes the voltage across the capacitor rises and the current decreases until the capacitor charge reaches the applied voltage at which point the current goes to zero.





The voltage across the capacitor will rise to 63.2 % of the applied voltage in one time constant. The time constant in seconds is calculated by multiplying the resistance in megohms by the capacitance in microfarads.

TC= R(ohms) x C(farads) or in terms of more common values --TC= R (megohms) x C(microfarads)

For example, 100 volts applied to 1µF capacitor with a series one megohm resistor will charge to 63.2 volts in one second. Remember that TC= R (megohms) x C(microfarads) or TC= 1x1 or 1 second and the charge after 1 time constant will be 63.2% of the applied 100 volts, or 63.2 volts

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

Time Constants	*Charge % of applied voltage*	*Discharge % of starting voltage*
1	*63.2%*	*36.8%*
2	*86.5%*	*13.5 %*
3	*95.0%*	*5%*
4	*98.2%*	*1.8%*
5	*99.3%*	*.7%*

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

One time constant discharge would be 100% - 63.2% or 36.8%

E5B03
The capacitor in an RC circuit is discharged to what percentage of the starting voltage after two time constants?
13.5%

%= (100-((100 x .632)) – (100 – (100 x.632) x .632)) or 100+(- 63.2 – 23.25) or 13.54%

E5B04
What is the time constant of a circuit having two 220-microfarad capacitors and two 1-megohm resistors, all in parallel?
220 seconds
TC (seconds) = R (megohms) x C (microfarads)
TC =(1/2) x (220 x 2)
TC= 0.5 x 440
TC= 220 seconds

Remember that capacitors in parallel add and resistors of equal value in parallel are equal to one resistor divided by the number of resistors.

E5B05
How long does it take for an initial charge of 20 V DC to decrease to 7.36 V DC in a 0.01-microfarad capacitor when a 2-megohm resistor is connected across it?
0.02 seconds

To discharge to 7.36 VDC would take one time constant with an initial charge of 20V – (.632 x 20V) or 7.36 Volts

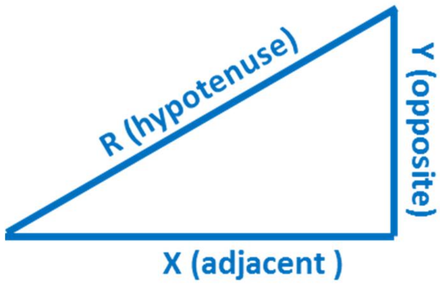
TC = 2 x .01
TC= 0 .02 seconds
TC= 20 milliseconds

E5B06
How long does it take for an initial charge of 800 V DC to decrease to 294 V DC in a 450-microfarad capacitor when a 1-megohm resistor is connected across it?
450 seconds

To discharge to 294 VDC would take one time constant
800V – (.632 x 800V) = 294.4V
TC = 1 x 450 or 450 seconds

Trigonometry Tutorial

For a number of problems associated with electronics involving series circuits of resistance and reactance and the Extra class Exam you will need a basic understanding of trigonometry. The problems center on a right triangle (that is a triangle that has one angle that is 90° and the sum of the remaining two angles is equal to 90°). Using trigonometric functions if we know two sides, or an angle (other than the 90°angle) and one side of the triangle we can calculate the remaining angles and dimensions.



Examples:
If X=3 and Y=4 then R=5 and θ = 53.1°

If X=50 and Y=100 then R=11.18 and θ = 63.4°

If X=5 and Y=10 then R=8.66 and θ = 63.1°

If X=153 and Y=52 then R=161.6 and θ = 18.7°

The sides of the triangle are given names from the rectangular coordinate system with the horizontal side called X (also called the Adjacent side) and the vertical side is called Y (also called the opposite side) and the side connecting the X and Y sides is called the Hypotenuse called R in this example If two of the three sides are known the third side can be found using the following equation:

Hypotenuse² = X² + Y² or as commonly expressed $R = \sqrt{(X^2+Y^2)}$

There are 6 trigonometric functions that can be used to calculate the angle between X and R and between Y and R. We will focus on three of these functions; Sine, Cosine and Tangent to solve for the angle between the X side and the R side (θ).

Sine of θ = Y / R	***Secant = R/Y***
Cosine of θ = X / R	***Cosecant = R/X***
Tangent of θ = Y / X	***Cotangent = X/Y***

<u>Example 1:</u>
To find the angle, θ for a triangle with side X value of 3 and a side Y value of 6:

Tangent of θ = 6 / 3 or 2.00. To find the angle enter 2 into your calculator and press the Arc Tan key which will show you the angle represented by the tangent value, in this case 2.00. The Arc Tan of 2 is 63.43°.

<u>Example 2:</u>
To find the angle, θ for a triangle with a side X value of 3 and a side Y value of 4:

Tangent of θ = 4 / 3 or 1.333 To find the angle enter 1.333 into your calculator and press the Arc Tan(or Tan^-1 on some calculators) key which will show you 53.03°

<u>Example 3:</u>
To find the angle, θ for a triangle with a side X value of 12 and a side Y value of 12

Tangent of θ = 12/12 or 1 To find the angle enter 1 into your calculator and press the Arc Tan key which will show you 45.0°

<u>Reactance (AC resistance of capacitors and inductors)</u>
Capacitors and inductors exhibit a resistance to current flow much like a resistor but with values that change with the frequency of the applied circuit.

The AC resistance of a capacitor is called capacitive reactance (X_C) and is calculated using the formula:

Xc= 1/(2π x F x C) with C in μF and F in MHz

Examples:

Find the capacitive reactance of a 1 µf capacitor at 200 Hz

$X_C = 1/(2\pi \times F \times C)$ or $X_C = 1/(6.28 \times .0002 \times 1)$ or $X_C = 796\ \Omega$

Find the Capacitive reactance of a 10 PF capacitor at 7 MHz

$X_C = 1/(2\pi \times F \times C)$ or $X_C = 1/(6.28 \times 7.0 \times 10^{-6})$ or $X_C = 2{,}275\ \Omega$

The AC resistance of an Inductor is called Inductive reactance (X_L) and is calculated using the formula:

$X_L = 2\pi \times F \times L$ *with L in µH and F in MHz*

Examples:

Find the inductive reactance of a 1 µH inductor at 100 MHz

$X_L = 2\pi \times F \times L$ or $X_L = 6.28 \times 100 \times 1$ or $X_L = 628\ \Omega$

Find the inductive reactance of a 100 µH inductor at 7 MHz

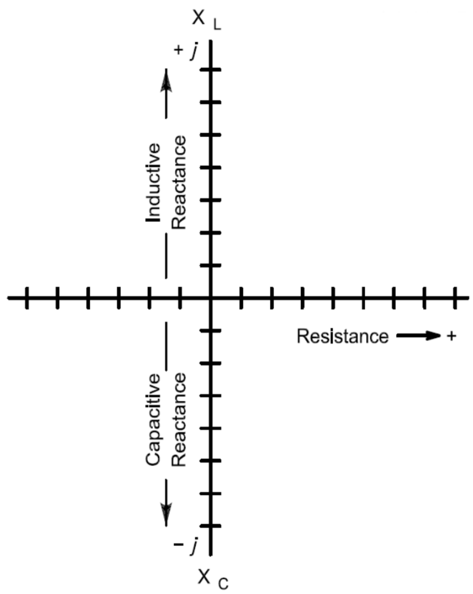
$X_L = 2\pi \times F \times L$ or $X_L = 6.28 \times 7 \times 100$ or $X_L = 4{,}396\ \Omega$

Circuit Impedance

The term Impedance refers to the equivalent circuit resistance in ohms for a circuit consisting of resistance and capacitive reactance and / or inductive reactance. To solve these problems for series circuits we use a rectangular coordinate graph and basic algebra and trigonometry. When working with complex circuits containing resistance and reactance, the reactive components are shown with a lower case j prefix. Inductive reactance is shown with a +j prefix and capacitive reactance with a –j prefix.

Rectangular Coordinate System

When solving problems involving impedance and phase angle of AC series circuits we show the circuit element values in a rectangular format. The rectangular format consists of a horizontal line intersected at 90° by a vertical line. Values on the horizontal or X axis are positive to the right of the vertical line and negative to the left. Values on the vertical or Y axis are positive above the X axis and Negative below the X axis.



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 = 250 / 1000 or Tangent of θ = .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 100 ohms, R is 100 ohms, and XL is 75 ohms?

14 degrees with the voltage lagging the current

Tangent of θ = Y / X or Tangent of θ = (75-100)/100 or Tangent of θ = -.25 or θ = -14.04°

Rules for calculating impedances and phase angles

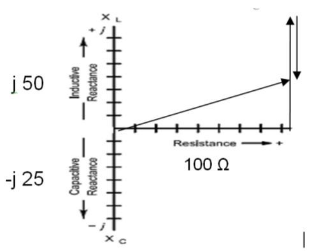
1. ***Impedances in series add together***
2. ***Admittance is the reciprocal of Impedance (admittance = 1/impedance)***
3. ***Admittances in parallel add together***
4. ***Inductive and capacitive reactance in series cancel***
5. ***1/j is equal to – j***

E5B09
What is the relationship between the current through a capacitor and the voltage across a capacitor?
Current leads voltage by 90 degrees

E5B10
What is the relationship between the current through an inductor and the voltage across an inductor?
Voltage leads current by 90 degrees

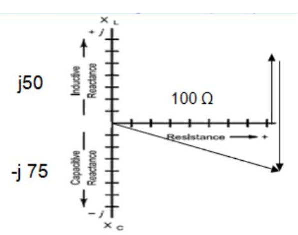
E5B11
What is the phase angle between the voltage across and the current through a series RLC circuit if XC is 25 ohms, R is 100 ohms, and XL is 50 ohms?
14 degrees with the voltage leading the current

Tangent of θ = Y / X or Tangent of θ = (50-25)/100 or Tangent of θ = -.25 or θ = 14.04°



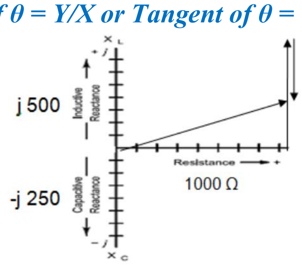
E5B12
What is the phase angle between the voltage across and the current through a series RLC circuit if XC is 75 ohms, R is 100 ohms, and XL is 50 ohms?
14 degrees with the voltage lagging the current

Tangent of θ = Y / X or Tangent of θ = (50-75)/100 or Tangent of θ = -.25 or θ = -14.04°



E5B13
What is the phase angle between the voltage across and the current through a series RLC circuit if XC is 250 ohms, R is 1 kilohm, and XL is 500 ohms?
14.04 degrees with the voltage leading the current

Tangent of θ = Y/X or Tangent of θ = (X_L - X_C)/I or θ = (500-250)/1000 or Tangent of θ = 0.25 or θ = 14.036°

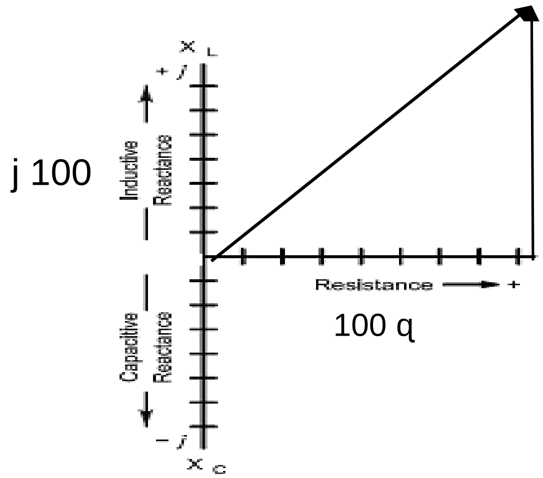


E5C Impedance plots and coordinate systems: plotting impedances in polar coordinates; rectangular coordinates

E5C01
In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance inductor in series with a 100-ohm resistor?

141 ohms at an angle of 45 degrees

$Z = \sqrt{X^2 + Y^2}$ or $Z = \sqrt{100^2 + 100^2}$ or $Z = \sqrt{20{,}000}$ or $Z = 141.42\ \Omega$
θ = arc tan (reactance/resistance) or arc tan 100/100 or arc tan 1 or 45°

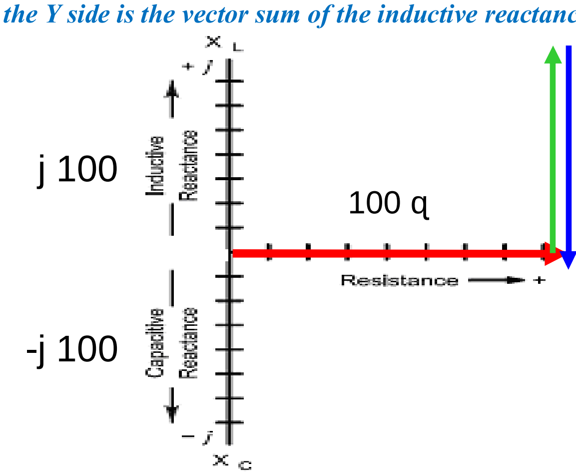


E5C02
In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance inductor, a 100-ohm-reactance capacitor, and a 100-ohm resistor, all connected in series?

100 ohms at an angle of 0 degrees

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ or $Z = \sqrt{100^2 + (100-100)^2}$ or $Z = \sqrt{10{,}000}$ or $Z = 100\ \Omega$
θ = arc tan (reactance/resistance) or arc tan 0/100 or arc tan 0 or 0°

Note- the Y side is the vector sum of the inductive reactance and capacitive reactance or $(X_L - X_C)$

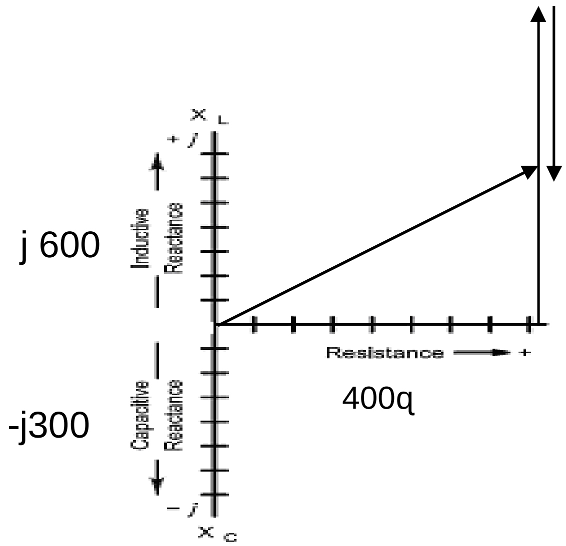


E5C03
In polar coordinates, what is the impedance of a network consisting of a 300-ohm-reactance capacitor, a 600-ohm-reactance inductor, and a 400-ohm resistor, all connected in series?

500 ohms at an angle of 37 degrees

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ or $Z = \sqrt{400^2 + (600-300)^2}$ or $Z = \sqrt{250{,}000}$ or $Z = 500\ \Omega$

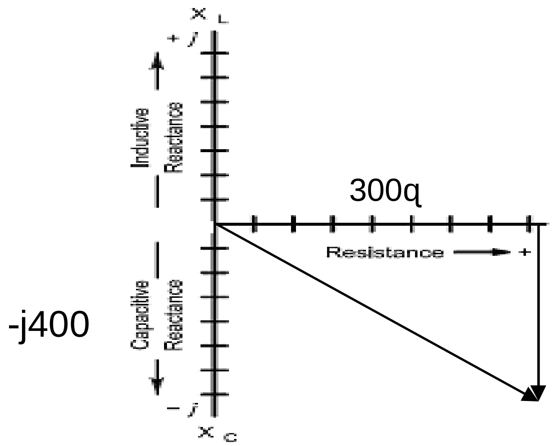
θ = arc tan (reactance/resistance) or 300/400 or arc tan .75 or 36.9°



E5C04
In polar coordinates, what is the impedance of a network consisting of a 400-ohm-reactance capacitor in series with a 300-ohm resistor?

D. 500 ohms at an angle of -53.1 degrees

$Z = \sqrt{X^2 + (X_L - X_C)^2}$ or $Z = \sqrt{300^2 + (0-400)^2}$ or $Z = \sqrt{250{,}000}$ or $Z = 500\ \Omega$
θ = arc tan (reactance/resistance) or arc tan (-400/300) or arc tan (0/100 or arc tan (- 1.33) or -53.13°



E5C05
In polar coordinates, what is the impedance of a network consisting of a 400-ohm-reactance inductor in parallel with a 300-ohm resistor?

240 ohms at an angle of 36.9 degrees

Impedance (Z) = $(R \times X_L) / \sqrt{R^2 + X_L^2} = (300 \times 400) / \sqrt{300^2 + 400^2} = 120{,}000 / 500 = 240\ \Omega$

θ = arctan 1/ (Reactance/Resistance) or θ= arctan 1/ (400 / 300) or θ= arctan 1/ 1.333 or arctan =.750 or θ =36.87°

E5C06
In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance capacitor in series with a 100-ohm resistor?

141 ohms at an angle of -45 degrees

$Z = \sqrt{X^2 + (X_L - X_C)^2}$ or $Z = \sqrt{100^2 + (-100)^2}$ or $Z = \sqrt{20{,}000}$ or $Z = 141.4\ \Omega$
Angle is arctan 1/ (reactance/resistance) or arctan 1/ (100/100) or arc tan (- 1) or -45°

E5C07
In polar coordinates, what is the impedance of a network comprised of a 100-ohm-reactance capacitor in parallel with a 100-ohm resistor?

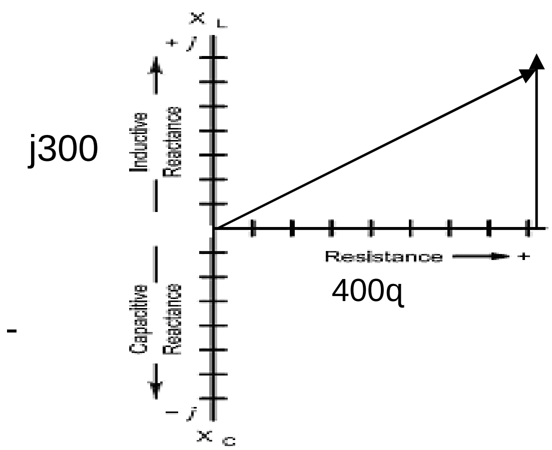
71 ohms at an angle of -45 degrees

Admittance = $1/100 + (-j/100)$ or $0.01 + j\,0.01$ Angle =arc tan .01/.01 or 45° (-45° in polar coordinates)
Impedance = $1/(\sqrt{(.01)^2 \times (.01)^2})$ or $1/(.0141)$ or 70.71 Ω

E5C08
In polar coordinates, what is the impedance of a network comprised of a 300-ohm-reactance inductor in series with a 400-ohm resistor?

500 ohms at an angle of 37 degrees

$Z = \sqrt{X^2 + (X_L - X_C)^2}$ or $Z = \sqrt{400^2 + (0-300)^2}$ or $Z = \sqrt{250{,}000}$ or $Z = 500\ \Omega$
Angle is arc tan (reactance/resistance) or arc tan (300/400) or arc tan (.75) or 36.86°



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

Resistive component

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

Reactive component

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

The coordinate values along the horizontal and vertical axes

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

It is equivalent to a pure resistance

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

Rectangular coordinates

E5C14
What coordinate system is often used to display the phase angle of a circuit containing resistance, inductive and/or capacitive reactance?

Polar coordinates

E5C15
In polar coordinates, what is the impedance of a circuit of 100 -j100 ohms impedance?
141 ohms at an angle of -45 degrees

Z= $\sqrt{}$(X^2 + (X_L –Xc)^2) or Z= $\sqrt{}$(100^2 + (-100)^2) or Z= $\sqrt{}$(20,000) or Z= 141.42 Ω
Angle is arc tan (reactance/resistance) or arc tan (-100/100) or arc tan (-1) or -45°

Parallel circuit solutions Tutorial

Solving for parallel circuits for ac circuits is similar to the way we solved resistance parallel circuits. Remember the Equation:

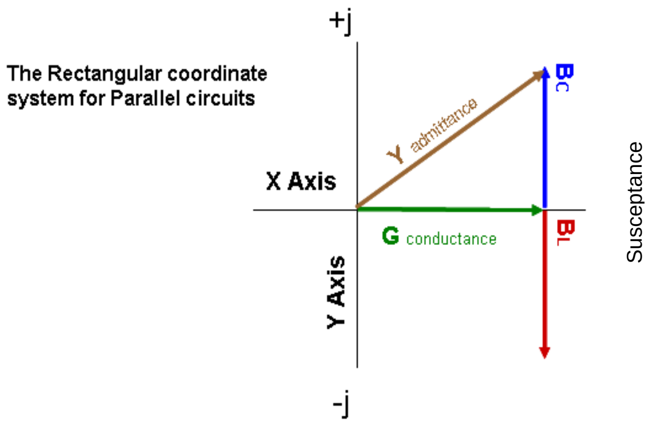
$R_{(total)} = 1 / ((1/R_1) + (1/R_2) + (1/R_3))$

The solution involved finding the conductance (G) of each leg by dividing the resistances into 1 and summing them. This gave the total circuit conductance in Siemens. The Mho was the term previously used for Seimen.

$G = (1/R_1) + (1/R_2) + (1/R_3)$

To find the resistance we divided the conductance into 1 and ended up with the parallel circuit resistance.

We do the same thing to find the impedance of parallel ac circuits. The names of the circuit references change- Impedance becomes admittance, "Y", (1/impedance). Resistance becomes conductance, "G", (1/resistance) and susceptance , "B" (1/reactance) We start by finding the "conductance of the resistive and reactive components and just add them as we did in the resistance solution (remember we will be summing resistive (real) and reactive (imaginary) conductance. The rectangular coordinates for parallel circuit solutions are shown below. Note that the reactive axis direction is opposite that of the series circuit solutions in that that reactive conductance is + for capacity and – for inductance.



E5C16
In polar coordinates, what is the impedance of a circuit that has an admittance of 7.09 millisiemens at 45 degrees?
141 ohms at an angle of -45 degrees

Polar Impedance (Z) =1/admittance or Z= 1/.00709 or Z= 141.04Ω
Polar angle = 1 / j (admittance angle) = 1/j(45°) or -j45°

E5C17
In rectangular coordinates, what is the impedance of a circuit that has an admittance of 5 millisiemens at -30 degrees?
173 +j100 ohms

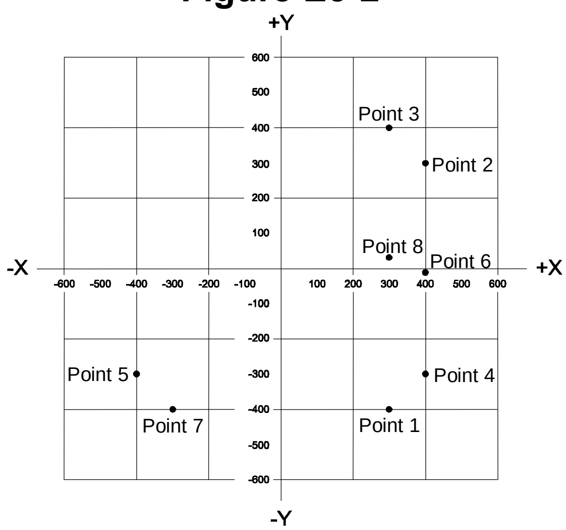
Polar Impedance (Z) =1/admittance or Z= 1/.005 or Z= 200Ω
Polar angle = 1/amdittance angle = 1/- 30° or +30°

Cos θ= resistance (R) / Impedance (Z) or R = 200Ω x Cosine 30° or R = 200Ω x .866 or 173.2 Ω
Sin θ= reactance (j) / Impedance (Z) or j = 200 x Sine 30° or j = 200Ω x .50 or j100Ω

E5C18
In polar coordinates, what is the impedance of a series circuit consisting of a resistance of 4 ohms, an inductive reactance of 4 ohms, and a capacitive reactance of 1 ohm?
5 ohms at an angle of 37 degrees

R=400 Ω
Xc= 1/ (2 π FC) or Xc= 1/(6.28 x 14 x .000038) or Xc= -300 Ω (remember capacitive reactance is negative).

Figure E5-2



E5C19
Which point on Figure E5-2 best represents that impedance of a series circuit consisting of a 400 ohm resistor and a 38 picofarad capacitor at 14 MHz?
Point 4

R=400 Ω
Xc= 1/ (2 π FC) or Xc= 1/(6.28 x 14 x .000038) or Xc= -300 Ω (remember capacitive reactance is negative).

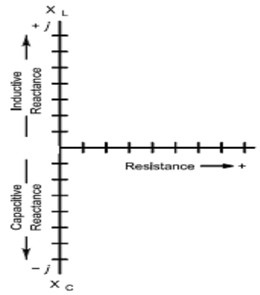
E5C20
Which point in Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor and an 18 microhenry inductor at 3.505 MHz?
Point 3

R=300 Ω
X_L= (2 π FL) or X_L = (6.28 x 3.505 x 18) or X_L = 396.4 Ω (remember inductive reactance is positive)
Answer is 300 Ω + j 395 Ω

E5C21
Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300 ohm resistor and a 19 picofarad capacitor at 21.200 MHz?
Point 1

E5C22
In rectangular coordinates, what is the impedance of a network consisting of a 10-microhenry inductor in series with a 40-ohm resistor at 500 MHz?
40 + j31,400

R=40 Ω
X_L= (2 π F x L) or X_L = (6.28 x 500 x 10) or X_L = 31,416 Ω (remember inductive reactance is positive)
Answer is 40 Ω + j 31,400



E5C23
Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300-ohm resistor, a 0.64-microhenry inductor and an 85-picofarad capacitor at 24.900 MHz?

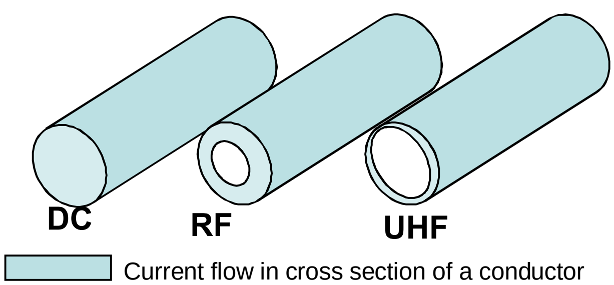
Point 8

R=300 Ω
Xc= 1/ (2 π F x C) or Xc= 1/(6.28 x 24.9 x .000085) or Xc= -75.19 Ω (remember capacitive reactance is negative) X_L= (2 π FL) or X_L = (6.28 x 24.9 x .64) or X_L = 100.12 Ω (remember inductive reactance is positive)
Net reactance is the sum of Xc and X_L or -75.19 + 100.12 or +24.9
Answer is 300 Ω + j 24.9

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

E5D01
What is the result of skin effect?

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



E5D02
Why is the resistance of a conductor different for RF currents than for direct currents?

Because of skin effect

E5D03
What device is used to store electrical energy in an electrostatic field?

A capacitor

E5D04
What unit measures electrical energy stored in an electrostatic field?

Joule

A Joule is defined as a quantity of energy equal to one Newton of force acting over 1 meter.

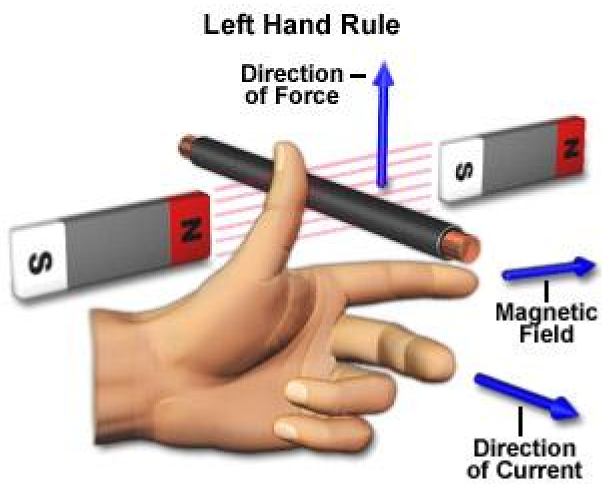
The newton is the SI unit for force; it is equal to the amount of net force required to accelerate a mass of one kilogram at a rate of one meter per second squared.

E5D05
Which of the following creates a magnetic field?

Electric current

E5D06
In what direction is the magnetic field oriented about a conductor in relation to the direction of electron flow?
In a direction determined by the left-hand rule

*The **Left Hand Rule** shows what happens when charged particles (such as electrons in a current) enter a magnetic field. You need to contort your hand in an unnatural position for this rule, illustrated below. As you can see, if your index finger points in the direction of a magnetic field, and your middle finger, at a 90 degree angle to your index, points in the direction of the charged particle (as in an electrical current), then your extended thumb (forming an L with your index) points in the direction of the force exerted upon that particle. This rule is also called Fleming's Left Hand Rule, after English electronics pioneer John Ambrose Fleming, who came up with it.*



E5D07
What determines the strength of a magnetic field around a conductor?
The amount of current

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

E5D09
What happens to reactive power in an AC circuit that has both ideal inductors and ideal capacitors?
It is repeatedly exchanged between the associated magnetic and electric fields, but is not dissipated

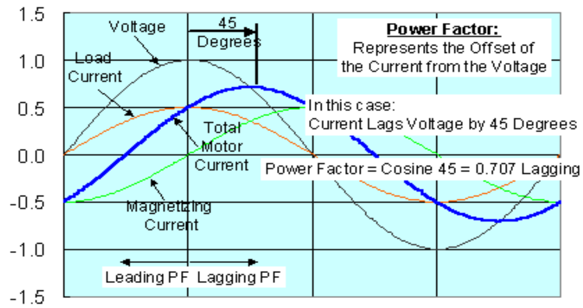
E5D10
How can the true power be determined in an AC circuit where the voltage and current are out of phase?
By multiplying the apparent power times the power factor

Understanding the Power Factor explanation

The components of motor (or other inductive load) current are load current and magnetizing current (adding those instantaneous values yields the total circuit current). Also, because load current is in phase with voltage and magnetizing current lags voltage by 90 degrees, their sum will be a sine wave that peaks somewhere between 0 and 90 degrees lagging which is the inductive current's offset (in time) from voltage.

There are negative effects associated with increased offset and that's part of the power factor explanation.

Power Factor represents the offset in time between voltage and the total current and is defined as the cosine of that offset. So when you look at the example in the graphic below, Total Current lags the voltage by 45 degrees. That is the offset. The cosine of 45 degrees is 0.707, and we call it "lagging" because the current lags behind the voltage



If the offset was 0 degrees (voltage and current in phase), the power factor would be 1.0 (cosine 0 = 1) and if the offset were a full 90 degrees (this would be all magnetizing current), the power factor would be 0.0 (cosine 90 = 0). So big deal....why is this offset so important?

In a motor (or Inductive load), the component of load current is the current associated with doing work (i.e. pumping fluid, compressing gas, running your Kilowatt rig, etc.) and the magnetizing current is not doing work. I know without the magnetic field the things like motors wouldn't work. This is true, however, as stated earlier; the magnetic field takes some energy to get built up in one half cycle and then returns that energy to the system in the next half cycle, so its net effect is that it uses no energy.

But if we consider the cable that delivers power to the circuit; when we add the magnetizing current to the load current, the cable's total current flow becomes larger. We, however, really just want to drive the load. If we could find a way to supply the magnetizing current without sending it down the cable, then the cable would only need to deliver the load current. This can be done by adding a capacitor across the inductive load which stores and releases energy for use by the inductive load locally at the motor-end of the cable delivering power.

E5D11
What is the power factor of an R-L circuit having a 60 degree phase angle between the voltage and the current?
0.5

PF is the cosine function of the voltage to current angle ►PF =cosine of 60° or PF= 0.5

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

Power Consumed = V x I x PF or 100 x 4 x .2 or 80 watts

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

$Power_{(real)} = I^2 \times R$ or $Power_{(real)} = (1)^2 \times 100$ or 100 watts. (Only the circuit resistance consumes power)

E5D14
What is reactive power?
Wattless, nonproductive power

E5D15
What is the power factor of an RL circuit having a 45 degree phase angle between the voltage and the current?
0.707
PF = Cosine of 45° or PF = 0.707

E5D16
What is the power factor of an RL circuit having a 30 degree phase angle between the voltage and the current?
0.866

PF Cosine of 30° or PF = 0.866

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

Power Consumed = V x I x PF or 200 x 5 x .6 or 600 watts

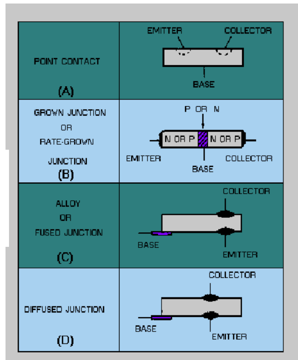
E5D18
How many watts are consumed in a circuit having a power factor of 0.71 if the apparent power is 500 VA?
355 W

Power Consumed = Apparent power x PF or 500 x .71 or 355 watts

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

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

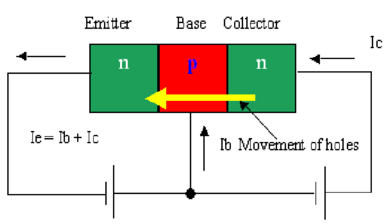
Transistor Construction



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

E6A02
Which of the following semiconductor materials contains excess free electrons?
N-type

E6A03
What are the majority charge carriers in P-type semiconductor material?
Holes

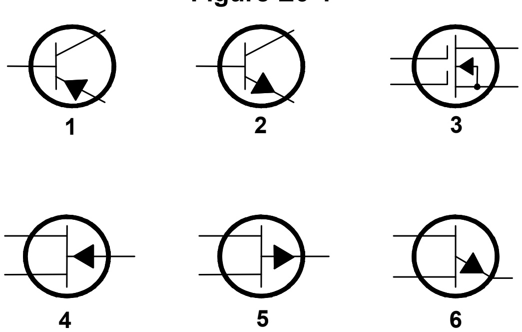


E6A04
What is the name given to an impurity atom that adds holes to a semiconductor crystal structure?
Acceptor impurity

E6A05
What is the alpha of a bipolar junction transistor?
The change of collector current with respect to emitter current

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

Figure E6-1

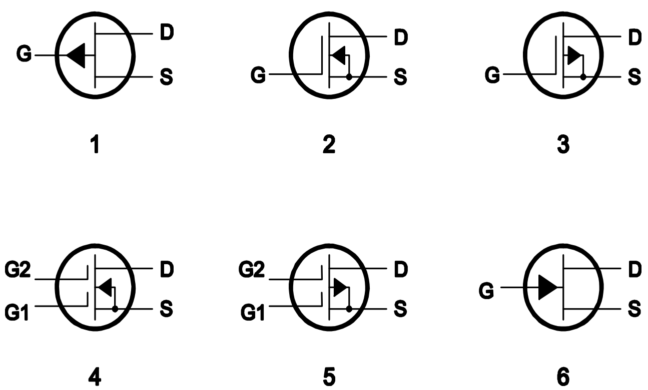


E6A07
In Figure E6-1, what is the schematic symbol for a PNP transistor?
1 (one)

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

E6A09
What is a depletion-mode FET?
An FET that exhibits a current flow between source and drain when no gate voltage is applied

Figure E6-2



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

E6A11
In Figure E6-2, what is the schematic symbol for a P-channel junction FET?
1 (one)

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

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

E6A14
How does DC input impedance at the gate of a field-effect transistor compare with the DC input impedance of a bipolar transistor?
An FET has high input impedance; a bipolar transistor has low input impedance

E6A15
Which of the following semiconductor materials contains an excess of holes in the outer shell of electrons?
P-type

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

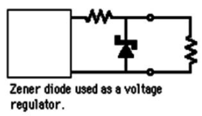
E6A17
What are the names of the three terminals of a field-effect transistor?
Gate, drain, source

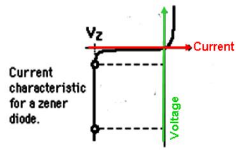
E6B Semiconductor diodes

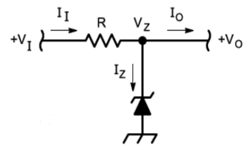
E6B01
What is the most useful characteristic of a Zener diode?

A constant voltage drop under conditions of varying current

The Zener diode symbol is number 3 in figure E6-3. Once the Zener voltage is reached increasing +V_I will not cause Vo to increase only the current will increase creating a larger voltage drop across R, up to the maximum current rating for the Zener diode.







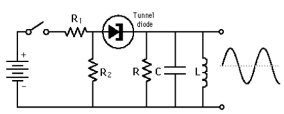
E6B02
What is an important characteristic of a Schottky diode as compared to an ordinary silicon diode when used as a power supply rectifier?

Less forward voltage drop

The Schottky diode or Schottky barrier diode is an electronic component that is widely used for radio frequency (RF) application as a mixer or detector diode. The Schottky diode is also used in power applications as a rectifier because of its low forward voltage drop. Although normally called the Schottky diode these days it is also sometimes referred to as the surface barrier diode, hot carrier or even electron diode.

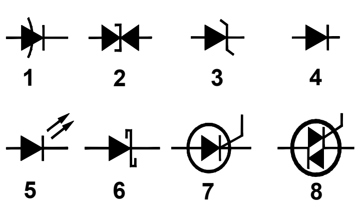
E6B03
What special type of diode is capable of both amplification and oscillation?

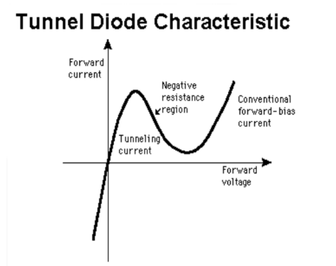
Tunnel Diode



The tunnel diode symbol is number 2 in figure E6-3.

Figure E6-3

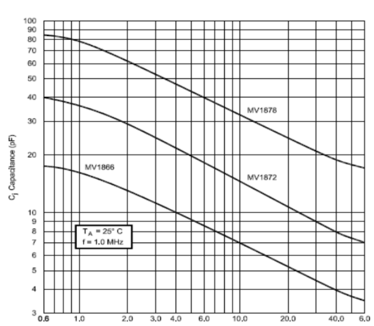


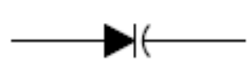


E6B04
What type of semiconductor device is designed for use as a voltage-controlled capacitor?

Varactor diode

The Varactor diode symbol is number 1 in figure E6-3 and as shown to the right of the graphic below.





E6B05
What characteristic of a PIN diode makes it useful as an RF switch or attenuator?
A large region of intrinsic material

E6B06
Which of the following is a common use of a hot-carrier diode?
As a VHF / UHF mixer or detector

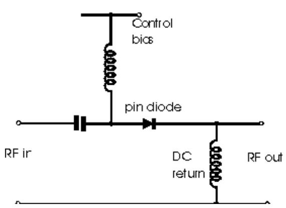
E6B07
What is the failure mechanism when a junction diode fails due to excessive current?
Excessive junction temperature

E6B08
Which of the following describes a type of semiconductor diode?
Metal-semiconductor junction

E6B09
What is a common use for point contact diodes?
As an RF detector

E6B10
In Figure E6-3, what is the schematic symbol for a light-emitting diode?
5 (five)

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



E6B12
What is one common use for PIN diodes?
As an RF switch

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

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

E6C01
What is the recommended power supply voltage for TTL series integrated circuits?
5 volts

E6C02
What logic state do the inputs of a TTL device assume if they are left open?
A logic-high state

E6C03
Which of the following describes tri-state logic?
Logic devices with 0, 1, and high impedance output states

E6C04
Which of the following is the primary advantage of tri-state logic?
Ability to connect many device outputs to a common bus

E6C05

Which of the following is an advantage of CMOS logic devices over TTL devices?

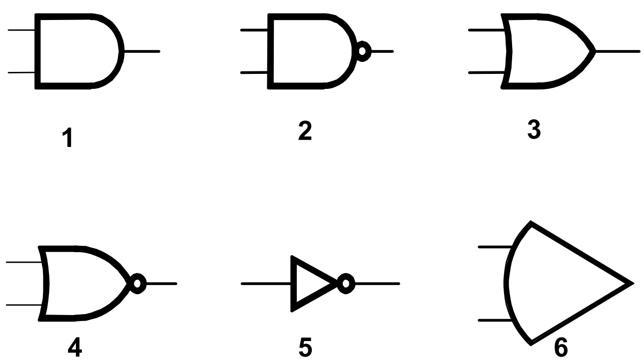
Lower power consumption

E6C06

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

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

Figure E6-5



E6C07

In Figure E6-5, what is the schematic symbol for an AND gate?

1(one)

If inputs A and B are 1 then the output is 1.

Input A	*Input B*	*output*
0	*0*	*0*
0	*1*	*0*
1	*0*	*0*
1	*1*	*1*

E6C08

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

2 (two)

If not A and B are 1 then the output is 1.

Input A	*Input B*	*output*
0	*0*	*1*
0	*1*	*1*
1	*0*	*1*
1	*1*	*0*

E6C09

In Figure E6-5, what is the schematic symbol for an OR gate?

3 (three)

If either A or B input are 1 then the output is 1.

Input A	*Input B*	*output*
0	*0*	*0*
0	*1*	*1*
1	*0*	*1*
1	*1*	*1*

E6C10

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

4 (four)

If neither A or B are 1 then the output will be 1.

Input A	*Input B*	*output*
0	*0*	*1*
0	*1*	*0*
1	*0*	*0*
1	*1*	*0*

E6C11
In Figure E6-5, what is the schematic symbol for the NOT operation (inverter)?
5 (five)

If the input is high the output is low, if the input is low the output will be high.

Input	*Output*
0	*1*
1	*0*

E6C12
What is BiCMOS logic?
An integrated circuit logic family using both bipolar and CMOS transistors

E6C13
Which of the following is an advantage of BiCMOS logic?
It has the high input impedance of CMOS and the low output impedance of bipolar transistors

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

E6D01
What is cathode ray tube (CRT) persistence?
The length of time the image remains on the screen after the beam is turned off

E6D02
Exceeding what design rating can cause a cathode ray tube (CRT) to generate X-rays?
The anode voltage

E6D03
Which of the following is true of a charge-coupled device (CCD)?
It samples an analog signal and passes it in stages from the input to the output

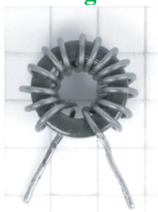
E6D04
What function does a charge-coupled device (CCD) serve in a modern video camera?
It stores photogenerated charges as signals corresponding to pixels

E6D05
What is a liquid-crystal display (LCD)?
A display using a crystalline liquid which, in conjunction with polarizing filters, becomes opaque when voltage is applied

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

E6D07
What is the usable frequency range of inductors that use toroidal cores, assuming a correct selection of core material for the frequency being used?
From less than 20 Hz to approximately 300 MHz

E6D08
What is one important reason for using powdered-iron toroids rather than ferrite toroids in an inductor?
Powdered-iron toroids generally maintain their characteristics at higher currents



E6D09
What devices are commonly used as VHF and UHF parasitic suppressors at the input and output terminals of transistorized HF amplifiers?
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

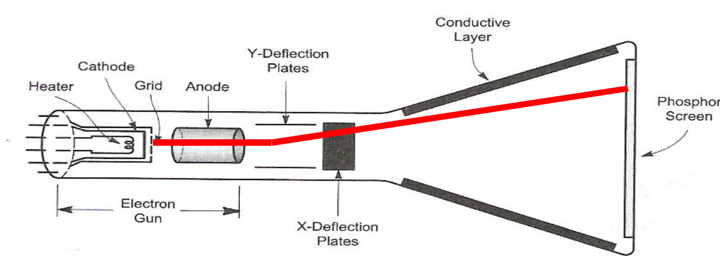
Applications for powdered Iron toroids would be oscillator and filter circuits where inductance stability with temperature is important.

E6D11
How many turns will be required to produce a 1-mH inductor using a ferrite toroidal core that has an inductance index (A L) value of 523 millihenrys/1000 turns?
43 turns
N turns = 1000 x (√ (L / A_L)) or N turns = 1000 x (√ (1 / 523)) or 43.7 turns

E6D12
How many turns will be required to produce a 5-microhenry inductor using a powdered-iron toroidal core that has an inductance index (A L) value of 40 microhenrys/100 turns?
35 turns

N_{turns} = 100 x (√ (L / A_L)) or N_{turns} = 100 x (√ (5 / 40)) or 35.35 turns

E6D13
What type of CRT deflection is better when high-frequency waveforms are to be displayed on the screen?
Electrostatic



E6D14
Which is NOT true of a charge-coupled device (CCD)?
It is commonly used as an analog-to-digital converter

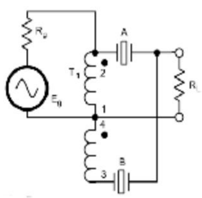
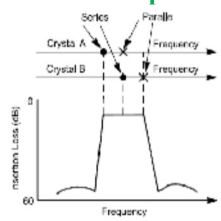
E6D15
What is the principle advantage of liquid-crystal display (LCD) devices over other types of display devices?
They consume less power

E6D16
What is one reason for using ferrite toroids rather than powdered-iron toroids in an inductor?
Ferrite toroids generally require fewer turns to produce a given inductance value

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

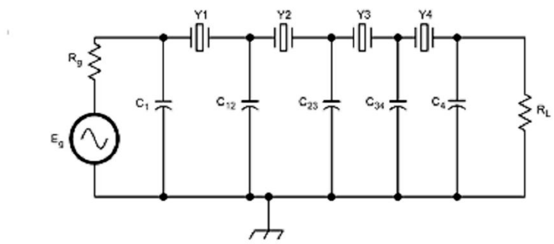
E6E01
What is a crystal lattice filter?

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

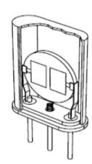
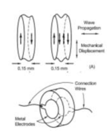
E6E02
Which of the following factors has the greatest effect in helping determine the bandwidth and response shape of a crystal ladder filter?

The relative frequencies of the individual crystals



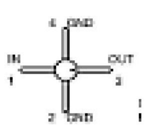
E6E03
What is one aspect of the piezoelectric effect?

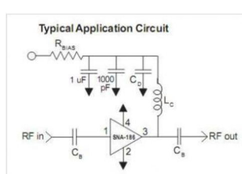
Physical deformation of a crystal by the application of a voltage

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

50 ohms





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

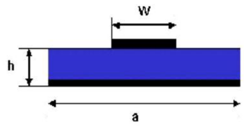
2 dB

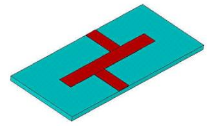
E6E06
What characteristics of the MMIC make it a popular choice for VHF through microwave circuits?

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

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

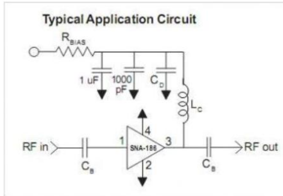
Microstrip construction





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

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



E6E09
Which of the following must be done to insure that a crystal oscillator provides the frequency specified by the crystal manufacturer?

Provide the crystal with a specified parallel capacitance

E6E10 **THIS QUESTION HAS BEEN REMOVED FROM THE QUESTION POOL**
What is the equivalent circuit of a quartz crystal?

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

E6E11
Which of the following materials is likely to provide the highest frequency of operation when used in MMICs?

Gallium nitride

E6E12
What is a "Jones filter" as used as part of a HF receiver IF stage?

A variable bandwidth crystal lattice filter

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

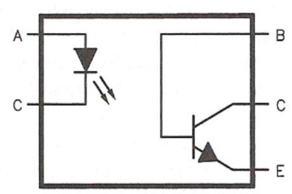
E6F01
What is photoconductivity?
The increased conductivity of an illuminated semiconductor

In other words the resistance decreases when light shines on it

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

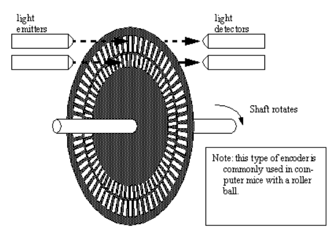
In other words the resistance decreases

E6F03
What is the most common configuration of an optoisolator or optocoupler?
An LED and a phototransistor



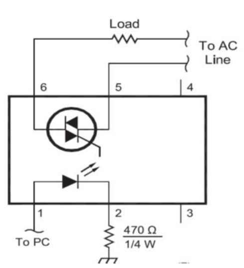
E6F04
What is the photovoltaic effect?
The conversion of light to electrical energy

E6F05
Which of the following describes an optical shaft encoder?
A device which detects rotation of a control by interrupting a light source with a patterned wheel



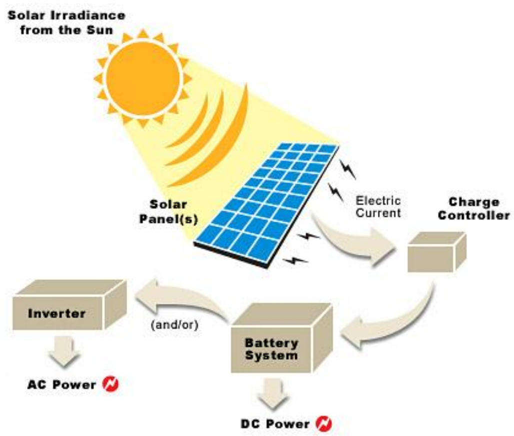
E6F06
Which of these materials is affected the most by photoconductivity?
A crystalline semiconductor

E6F07
What is a solid state relay?
A device that uses semiconductor devices to implement the functions of an electromechanical relay



E6F08
Why are optoisolators often used in conjunction with solid state circuits when switching 120 VAC?
Optoisolators provide a very high degree of electrical isolation between a control circuit and the circuit being switched

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



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

E6F11
Which of the following is the approximate open-circuit voltage produced by a fully-illuminated silicon photovoltaic cell?
0.5 V

Twenty seven cells would be required to produce 13.5 volts for charging a 12 volt battery.

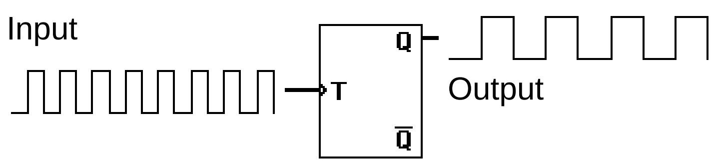
E6F12
What absorbs the energy from light falling on a photovoltaic cell?
Electrons

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

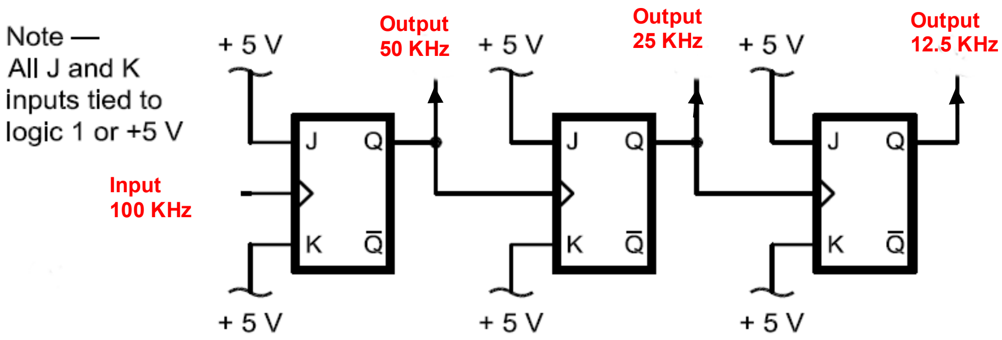
E7A01
Which of the following is a bistable circuit?
A flip-flop

E7A02
How many output level changes are obtained for every two trigger pulses applied to the input of a T flip-flop circuit?
Two

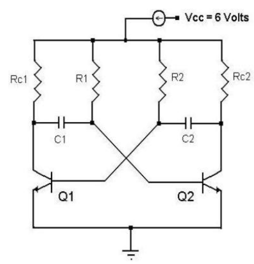


E7A03
Which of the following can divide the frequency of a pulse train by 2?
A flip-flop

E7A04
How many flip-flops are required to divide a signal frequency by 4?
2 (two)



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



E7A06
What is a characteristic of a monostable multivibrator?
It switches momentarily to the opposite binary state and then returns, after a set time, to its original state

E7A07
What logical operation does a NAND gate perform?
It produces a logic "0" at its output only when all inputs are logic "1"

Input A	Input B	output
0	0	1
0	1	1
1	0	1
1	1	0

E7A08
What logical operation does an OR gate perform?
It produces a logic "1" at its output if any or all inputs are logic "1"

Input A	Input B	output
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 logic "0" at its output if any single input is a logic "1"

Input A	Input B	output
0	0	1
0	1	0
1	0	0
1	1	1

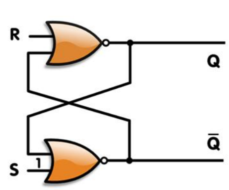
E7A10
What is a truth table?
A list of inputs and corresponding outputs for a digital device

Input A	Input B	output
0	0	1
0	1	0
1	0	0
1	1	0

E7A11
What is the name for logic which represents a logic "1" as a high voltage?
Positive Logic

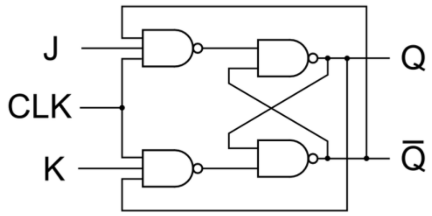
E7A12
What is the name for logic which represents a logic "0" as a high voltage?
Negative logic

E7A13
What is an SR or RS flip-flop?
A set/reset flip-flop whose output is low when R is high and S is low, high when S is high and R is low, and unchanged when both inputs are low



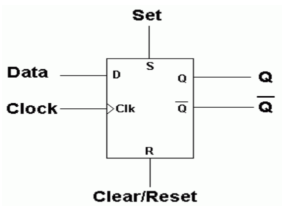
E7A14
What is a JK flip-flop?

A flip-flop similar to an RS except that it toggles when both J and K are high



E7A15
(What is a D flip-flop?

A flip-flop whose output takes on the state of the D input when the clock signal transition



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

Amplifier classes: Power amplifiers are classified primarily by the design of the output stage. Classification is based on the amount of time the output device(s) operate during each cycle of the input signal.

Class A operation is where the tube conducts continuously for the entire cycle of the input signal, or a bias current flows in the output devices at all times. The key ingredient of class A operation is that the output is always on. Conversely the output device is never turned off. Because of this, class A amplifiers are single-ended designs. Class A is the most inefficient of all power amplifier designs, averaging only around 20%. Because of this, class A amplifiers are large, heavy and run very hot. On the positive side, class A designs are inherently the most linear, and have the least amount of distortion.

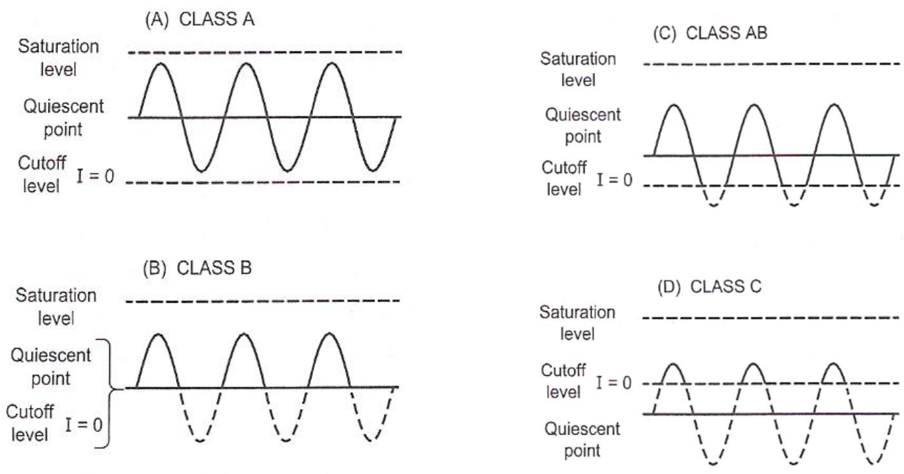
When driving an A class amplifier care should be taken to insure the peak to peak input voltage stays within the linear range of the amplifier.

Class B has conduction occurring for only for ½ of the input cycle. Class B amplifiers typically have dual output devices operating 180º out of phase with each other in a push / pull configuration to allow the full cycle of the input to be amplified. Both output devices are never allowed to be on at the same time, bias is set so that current flow in a specific output device is zero without an input signal. Current only flows in each of the push / pull amplifier output amplifiers for one half cycle. Thus each output amplifier is only on for ½ of a complete sinusoidal signal cycle. Class B push pull designs show high efficiency but poor linearity around the 0 voltage crossover region. This is due to the time it takes to turn one device off and the other device on, which translates into extreme crossover distortion. Thus restricting class B designs to power consumption critical applications, e.g., battery operated equipment. Class B push / pull transmitter power amplifiers reduce or prevent even order harmonics in the output signal.

Class AB operation allows both devices to be on at the same time (like in class A), but just barely. The output bias is set so that current flows in a specific output device appreciably more than a half cycle but less than the entire cycle. That is, only a small amount of current is allowed to flow through both devices, unlike the complete load current of class A designs, but enough to keep each device operating so they respond instantly to input voltage demands. Thus the inherent non-linearity of class B designs is eliminated, without the gross inefficiencies of the class A design. It is this combination of good efficiency (around 50%) with excellent linearity that makes class AB the most popular audio amplifier design.

Class C operation allows current flows for less than one half cycle of the input signal. The class C operation is achieved by reverse biasing the amplifier to point below cutoff and allows only the portion of the input signal that overcomes the reverse

bias to cause current flow. The class C operated amplifier is used as a radio-frequency amplifier in frequency modulated or CW transmitters.



E7B01
For what portion of a signal cycle does a Class AB amplifier operate?
More than 180 degrees but less than 360 degrees

E7B02
What is a Class D amplifier?
A type of amplifier that uses switching technology to achieve high efficiency

E7B03
Which of the following forms the output of a class D amplifier circuit?
A low-pass filter to remove switching signal components

E7B04
Where on the load line of a Class A common emitter amplifier would bias normally be set?
Approximately half-way between saturation and cutoff

E7B05
What can be done to prevent unwanted oscillations in an RF power amplifier?
Install parasitic suppressors and/or neutralize the stage

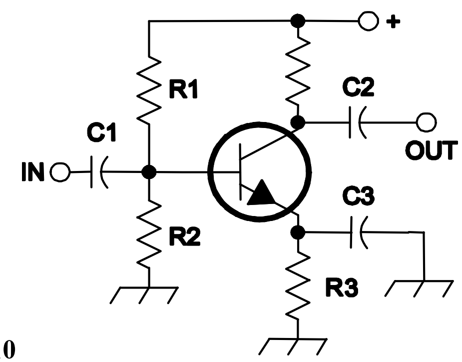
E7B06
Which of the following amplifier types reduces or eliminates even-order harmonics?
Push-pull

E7B07
Which of the following is a likely result when a Class C amplifier is used to amplify a single-sideband phone signal?
Signal distortion and excessive bandwidth

E7B08
How can an RF power amplifier be neutralized?
By feeding a 180-degree out-of-phase portion of the output back to the input

E7B09
Which of the following describes how the loading and tuning capacitors are to be adjusted when tuning a vacuum tube RF power amplifier that employs a pi-network output circuit?
The tuning capacitor is adjusted for minimum plate current, while the loading capacitor is adjusted for maximum permissible plate current

Figure E7-1



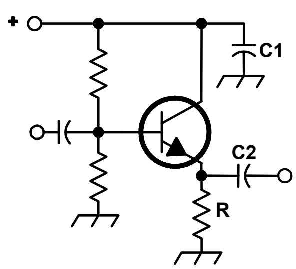
E7B10
In Figure E7-1, what is the purpose of R1 and R2?
Fixed bias

Base Bias voltage point is set by the voltage division ratio of R1 and R2 based on the Vcc (+ in the schematic)

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

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

Figure E7-2



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

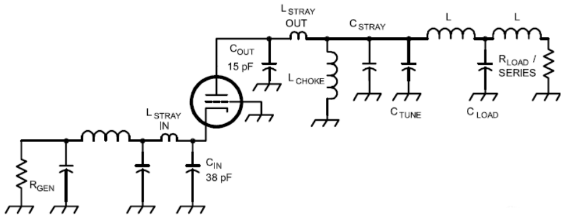
E7B14
In Figure E7-2, what is the purpose of C2?
Output coupling

E7B15
What is one way to prevent thermal runaway in a bipolar transistor amplifier?
Use a resistor in series with the emitter

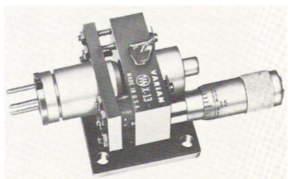
E7B16
What is the effect of intermodulation products in a linear power amplifier?
Transmission of spurious signals

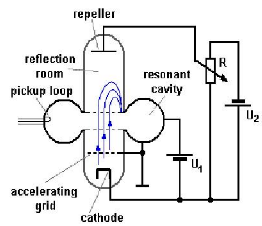
E7B17
Why are third-order intermodulation distortion products of particular concern in linear power amplifiers?
Because they are relatively close in frequency to the desired signal

E7B18
Which of the following is a characteristic of a grounded-grid amplifier?
Low input impedance

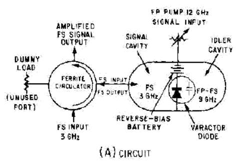


E7B19
What is a klystron?
A VHF, UHF, or microwave vacuum tube that uses velocity modulation



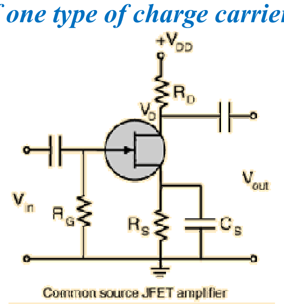


E7B20
What is a parametric amplifier?
A low-noise VHF or UHF amplifier relying on varying reactance for amplification



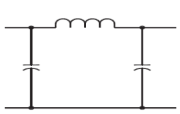
E7B21
Which of the following devices is generally best suited for UHF or microwave power amplifier applications?
Field effect transistor

The field-effect transistor (FET) is a transistor that relies on an electric field to control the shape and hence the conductivity of a channel of one type of charge carrier in a semiconductor material.

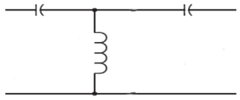


E7C Filters and matching networks: types of networks; types of filters; filter applications; filter characteristics; impedance matching; DSP filtering

E7C01
How are the capacitors and inductors of a low-pass filter Pi-network arranged between the network's input and output?
A capacitor is connected between the input and ground, another capacitor is connected between the output and ground, and an inductor is connected between input and output

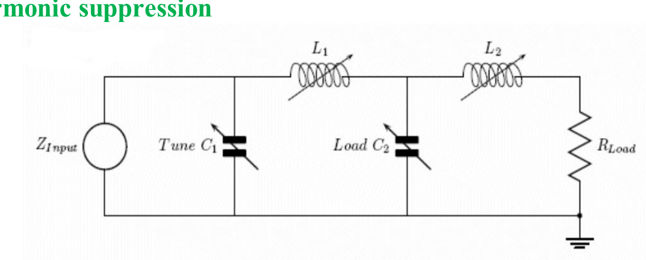


E7C02
A T-network with series capacitors and a parallel shunt inductor has which of the following properties?
It is a high-pass filter



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

Greater harmonic suppression

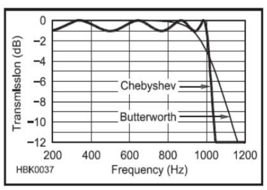


E7C04
How does an impedance-matching circuit transform a complex impedance to a resistive impedance?

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

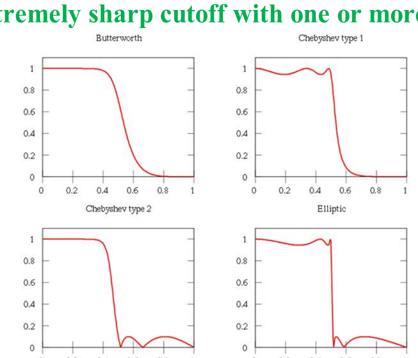
E7C05
Which filter type is described as having ripple in the passband and a sharp cutoff?

A Chebyshev filter



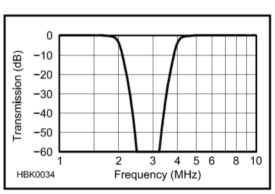
E7C06
What are the distinguishing features of an elliptical filter?

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



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

A notch filter



E7C08
What kind of digital signal processing audio filter might be used to remove unwanted noise from a received SSB signal?

An adaptive filter

An adaptive filter is a filter that self-adjusts its transfer function according to an optimization algorithm driven by an error signal. Because of the complexity of the optimization algorithms, most adaptive filters are digital filters.

The adaptive filter uses feedback in the form of an error signal to refine its transfer function to match the changing parameters.

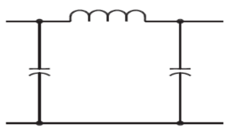
E7C09
What type of digital signal processing filter might be used to generate an SSB signal?
A Hilbert-transform filter

The Hilbert transform is a linear operator in mathematics and in signal processing.

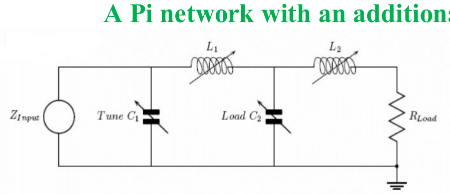
E7C10
Which of the following filters would be the best choice for use in a 2 meter repeater duplexer?
A cavity filter



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



E7C12
Which of the following describes a Pi-L network used for matching a vacuum-tube final amplifier to a 50-ohm unbalanced output?
A Pi network with an additional series inductor on the output

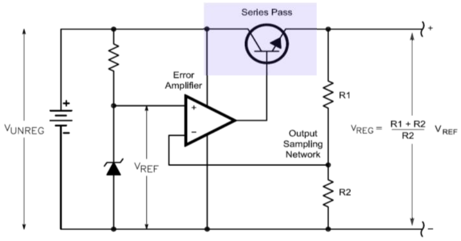


E7C13
What is one advantage of a Pi matching network over an L matching network consisting of a single inductor and a single capacitor?
The Q of Pi networks can be varied depending on the component values chosen

E7C14
Which of these modes is most affected by non-linear phase response in a receiver IF filter?
Digital

E7D Power supplies and voltage regulators

E7D01
What is one characteristic of a linear electronic voltage regulator?
The conduction of a control element is varied to maintain a constant output voltage



E7D02
What is one characteristic of a switching electronic voltage regulator?
The control device's duty cycle is controlled to produce a constant average output voltage

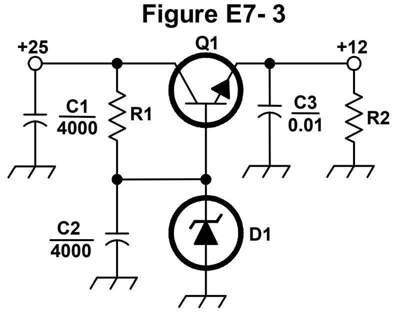
E7D03
What device is typically used as a stable reference voltage in a linear voltage regulator?
A Zener diode

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

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

E7D06
What is the purpose of Q1 in the circuit shown in Figure E7-3?
It increases the current-handling capability of the regulator

Figure E7- 3



E7D07
What is the purpose of C2 in the circuit shown in Figure E7-3?
It bypasses hum around D1

E7D08
What type of circuit is shown in Figure E7-3?
Linear voltage regulator

E7D09
What is the purpose of C1 in the circuit shown in Figure E7-3?
It filters the supply voltage

E7D10
What is the purpose of C3 in the circuit shown in Figure E7-3?
It prevents self-oscillation

E7D11
What is the purpose of R1 in the circuit shown in Figure E7-3?
It supplies current to D1

E7D12
What is the purpose of R2 in the circuit shown in Figure E7-3?

It provides a constant minimum load for Q1

E7D13
What is the purpose of D1 in the circuit shown in Figure E7-3?

To provide a voltage reference

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

To improve output voltage regulation

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

To allow the filter capacitors to charge gradually

This consists of inserting a resistor in the primary side of the transformer to limit the charge current on the capacitors at initial turn on. The series resistor is switched out after a few seconds of operation.

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

A. To equalize, as much as possible, the voltage drop across each capacitor
B. To provide a safety bleeder to discharge the capacitors when the supply is off
C. To provide a minimum load current to reduce voltage excursions at light loads
D. All of these choices are correct

E7D17
What is the primary reason that a high-frequency inverter type high-voltage power supply can be both less expensive and lighter in weight than a conventional power supply?

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

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

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

A reactance modulator on the oscillator

E7E02
What is the function of a reactance modulator?

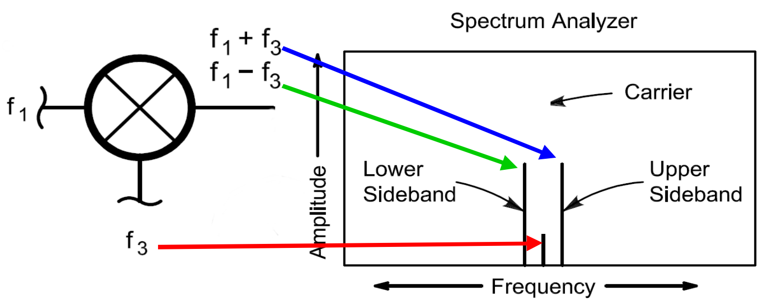
To produce PM signals by using an electrically variable inductance or capacitance

E7E03
How does an analog phase modulator function?

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

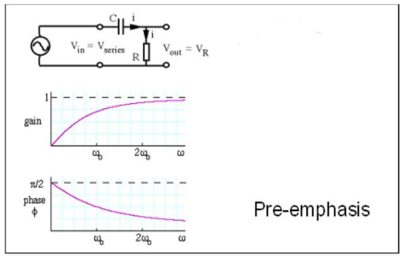
E7E04
What is one way a single-sideband phone signal can be generated?

By using a balanced modulator followed by a filter

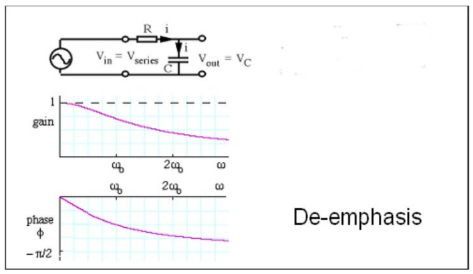


A balanced mixer will output the sum and difference of the two signals applied (Carrier and SSB audio) and the carrier, suppressed by passing the modulator output through a filter so that the upper or lower sideband can be filtered leaving only one of the sideband signals.

E7E05
What circuit is added to an FM transmitter to boost the higher audio frequencies?
A pre-emphasis network

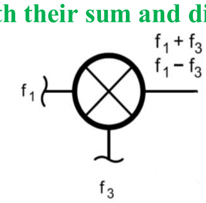


E7E06
Why is de-emphasis commonly used in FM communications receivers?
For compatibility with transmitters using phase modulation



E7E07
What is meant by the term baseband in radio communications?
The frequency components present in the modulating signal

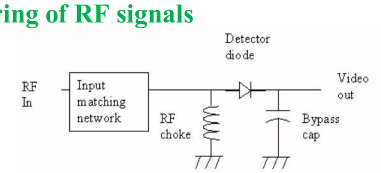
E7E08
What are the principal frequencies that appear at the output of a mixer circuit?
The two input frequencies along with their sum and difference frequencies



If F1 is 10 MHz and F2 is 9 MHz the output from the mixer will be 1 MHz (the Difference) and 19 MHz (the sum).

E7E09
What occurs when an excessive amount of signal energy reaches a mixer circuit?
Spurious mixer products are generated

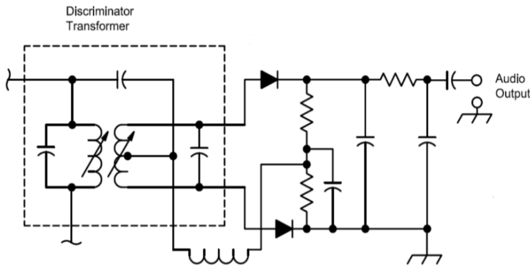
E7E10
How does a diode detector function?
By rectification and filtering of RF signals

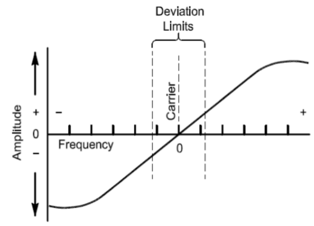


Basic detector circuit

E7E11
Which of the following types of detector is well suited for demodulating SSB signals?
Product detector

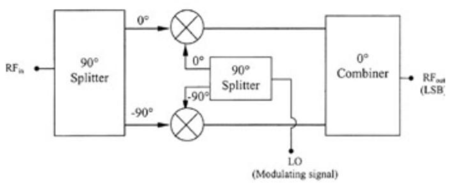
E7E12
What is a frequency discriminator stage in a FM receiver?
A circuit for detecting FM signals





E7E13
Which of the following describes a common means of generating an SSB signal when using digital signal processing?

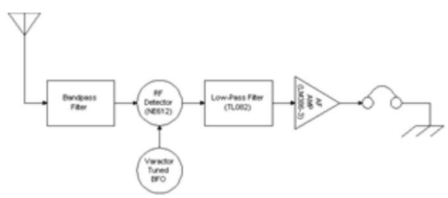
The quadrature method



Quadrature modulation uses two data channels denoted I (in phase) and Q (quadrature phase) displaced by 90^o with respect to each other. It may seem somewhat paradoxical, that although these two channels are combined prior to transmission, they do not interfere with each other.

E7E14
What is meant by direct conversion when referring to a software defined receiver?

Incoming RF is mixed to "baseband" for analog-to-digital conversion and subsequent processing



The incoming signal is mixed with a signal at the same carrier frequency. The result will be a signal at twice the receive signal and another at zero frequency. This zero RF frequency will have only the modulation contained in the incoming signal and can be directly fed into an audio stage.

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

E7F01
What is the purpose of a prescaler circuit?

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

In a pre-scaled counter the input frequency would be divided by 10 or 100 or another multiple of 10. Therefore our counter that measures a non-pre-scaled frequency of 10 MHz with 1Hz of resolution would measure the same frequency in the ÷10 prescale mode with 10 Hz resolution using the same counter gate time.

E7F02
Which of the following would be used to reduce a signalȏs frequency by a factor of ten?

Prescaler

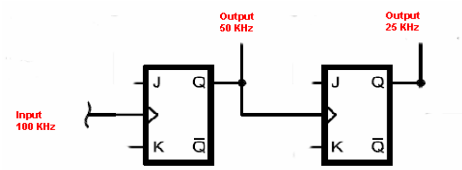
E7F03
What is the function of a decade counter digital IC?

It produces one output pulse for every ten input pulses

A decade counter (divider) can be used as a prescaler for a counter (assuming it works high enough in frequency) to increase the counters frequency range by a factor of 10 (allowing a 10 MHz counter to have an extended frequency range to100 MHz). A circuit with 2 decade dividers in series would divide the input by 100, extending the range of our 10 MHz counter to 1,000 MHz

E7F04
What additional circuitry must be added to a 100-kHz crystal-controlled marker generator so as to provide markers at 50 and 25 kHz?

Two flip-flops



E7F05
Which of the following is a technique for providing high stability 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. <u>All of these choices are correct</u>

E7F06
What is one purpose of a marker generator?

To provide a means of calibrating a receiver's frequency settings

E7F07
What determines the accuracy of a frequency counter?

The accuracy of the time base

E7F08
Which of the following is performed by a frequency counter?

Counting the number of input pulses occurring within a specific period of time

E7F09
What is the purpose of a frequency counter?

To provide a digital representation of the frequency of a signal

E7F10
What alternate method of determining frequency, other than by directly counting input pulses, is used by some counters?

Period measurement plus mathematical computation

A period measurement is the measurement of the time it takes for one or a number of cycles of the input signal and then converting the period measurement back to frequency.

F = 1/ period for a 1 millisecond period the frequency would be F=1/.001 or F=1000

E7F11
What is an advantage of a period-measuring frequency counter over a direct-count type?

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

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

Operational amplifier tutorial

An operational amplifier, or op amp, is one of the most useful linear devices that have been developed with integrated circuitry. While it is possible to build an op amp with discrete components, the symmetry of this circuit requires a close match of many components and is more effective, and much easier, to implement in integrated circuitry. Fig 5.43 shows a basic op-amp circuit. The op amp approaches a perfect analog circuit building block.

Ideally, an op amp has infinite input impedance (Zi), zero output impedance (Zo) and an open loop voltage gain (Av) of infinity. Obviously, practical op amps do not meet these specifications, but they do come closer than most other types of amplifiers.

The gain of an op amp is the function of the input resistor and the feed back resistor. Gain in calculated by dividing the input resistor R1 value into the feedback resistor Rf. In figure E7-4 if the input resistor,R1, is 10,000 ohms and the feedback resistor ,Rf, 1s 1,000,000 ohms the gain would be 1,000,0000 / 10,000 or a gain of 100. The output is inverted in this configuration when the signal is feed into the – pin of the op amp. This is the most commonly used configuration. The op amp can be configured in a non inverting mode so the out put signal is the same polarity as the input signal

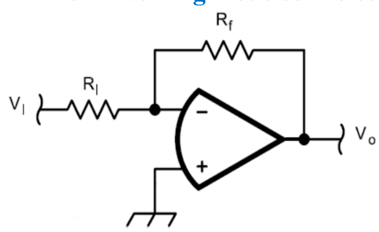
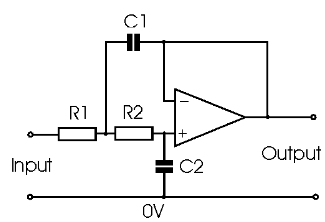


Figure E7-4

The Ideal/perfect operational amplifier has Infinite gain, infinite frequency response , infinite input impedance and very low output impedance.

E7G01
What primarily determines the gain and frequency characteristics of an op-amp RC active filter?
The values of capacitors and resistors external to the op-amp



E7G02
What is the effect of ringing in a filter?
Undesired oscillations added to the desired signal

E7G03
Which of the following is an advantage of using an op-amp instead of LC elements in an audio filter?
Op-amps exhibit gain rather than insertion loss

E7G04
Which of the following is a type of capacitor best suited for use in high-stability op-amp RC active filter circuits?
Polystyrene

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

E7G06
Which of the following is the most appropriate use of an op-amp active filter?
As an audio filter in a receiver

E7G07
What magnitude of voltage gain can be expected from the circuit in Figure E7-4 when R1 is 10 ohms and RF is 470 ohms?
47

E7G08
How does the gain of an ideal operational amplifier vary with frequency?
It does not vary with frequency

E7G09
What will be the output voltage of the circuit shown in Figure E7-4 if R1 is 1000 ohms, RF is 10,000 ohms, and 0.23 volts dc is applied to the input?
-2.3 volts

Gain = RF/ R1Or Gain = 10,000/1000 or Gain = 10
Output = input x Gain = .23 x 10 or - 2.3 volts. ***(Note the output is negative because it is an inverting amplifier)***

E7G10
What absolute voltage gain can be expected from the circuit in Figure E7-4 when R1 is 1800 ohms and RF is 68 kilohms?
38

Gain = RF/ R1 or Gain = 68,000/1,800 or Gain = 37.778

E7G11
What absolute voltage gain can be expected from the circuit in Figure E7-4 when R1 is 3300 ohms and RF is 47 kilohms?
14

Gain = RF/ R1 or Gain = 47,000/3,30000 or Gain = 14.242

E7G12
What is an integrated circuit operational amplifier?
A high-gain, direct-coupled differential amplifier with very high input and very low output impedance

E7G13
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

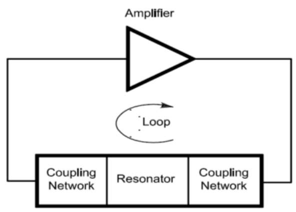
E7G14
What is the typical input impedance of an integrated circuit op-amp?
Very high

E7G15
What is the typical output impedance of an integrated circuit op-amp?
Very low

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

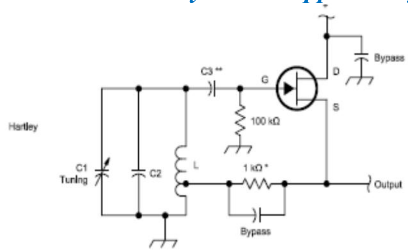
E7H01
What are three oscillator circuits used in Amateur Radio equipment?
Colpitts, Hartley and Pierce

E7H02
What condition must exist for a circuit to oscillate?
It must have positive feedback with a gain greater than 1



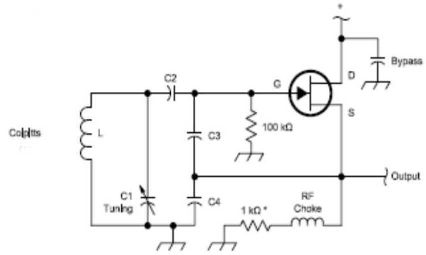
E7H03
How is positive feedback supplied in a Hartley oscillator?
Through a tapped coil

Remember Hartley uses a tapped coil for feedback. Henry is the measure of inductance of the coil in a Hartley oscillator.



E7H04
How is positive feedback supplied in a Colpitts oscillator?
Through a capacitive divider

Remember C for Colpitts and capacitive divider

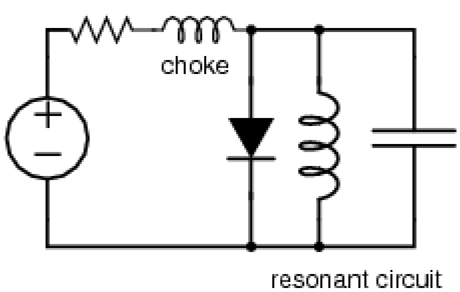


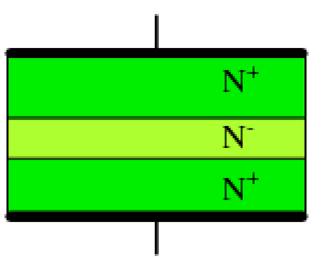
E7H05
How is positive feedback supplied in a Pierce oscillator?
Through a quartz crystal

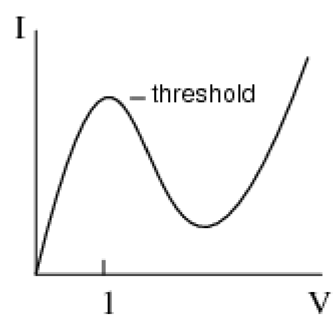
E7H06
Which of the following oscillator circuits are commonly used in VFOs?
Colpitts and Hartley

E7H07
What is a magnetron oscillator?
A UHF or microwave oscillator consisting of a diode vacuum tube with a specially shaped anode, surrounded by an external magnet

E7H08
What is a Gunn diode oscillator?
An oscillator based on the negative resistance properties of properly-doped semiconductors







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 syntheses is a method of producing an analog waveform, usually a sine wave, by generating a time varying signal in digital form and then performing a digital-to-analog conversion. Because operations in a DDS 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 frequency synthesizer?

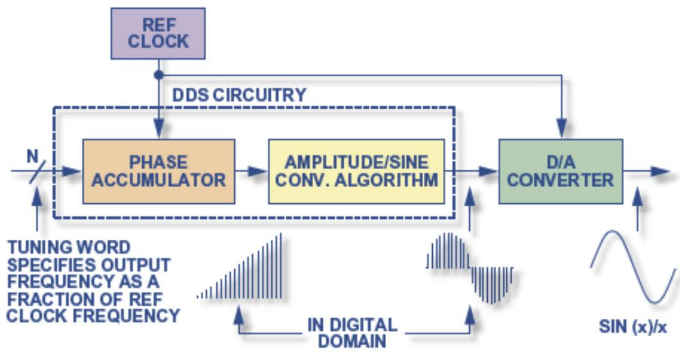
The amplitude values that represent a sine-wave output

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

Spurious signals at discrete frequencies

E7H12
Which of the following is a principal component of a direct digital synthesizer (DDS)?

Phase accumulator

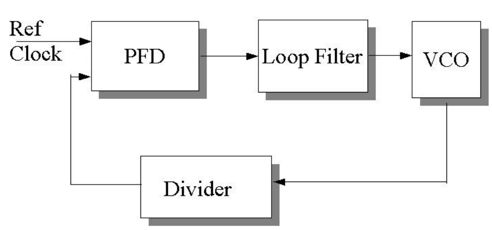


E7H13
What is the capture range of a phase-locked loop circuit?

The frequency range over which the circuit can lock

E7H14
What is a phase-locked loop circuit?

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



PLL Block Diagram

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

Frequency synthesis, FM demodulation

E7H16
Why is the short-term stability of the reference oscillator important in the design of a phase locked loop (PLL) frequency synthesizer?

Any phase variations in the reference oscillator signal will produce phase noise in the synthesizer output

E7H17
Why is a phase-locked loop often used as part of a variable frequency synthesizer for receivers and transmitters?

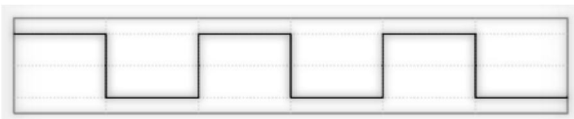
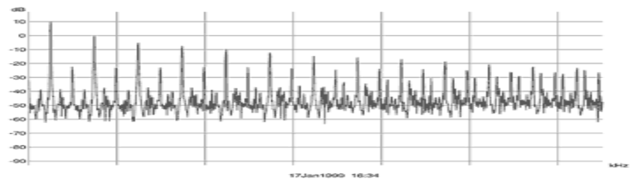
It makes it possible for a VFO to have the same degree of frequency stability as a crystal oscillator

E7H18
What are the major spectral impurity components of phase-locked loop synthesizers?
Phase noise

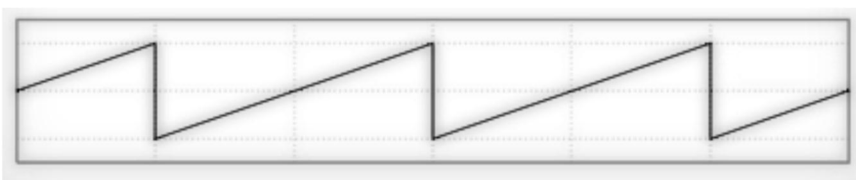
SUBELEMENT E8 - SIGNALS AND EMISSIONS [4 Exam Questions - 4 Groups]

E8A AC waveforms: sine, square, sawtooth and irregular waveforms; AC measurements; average and PEP of RF signals; pulse and digital signal waveforms

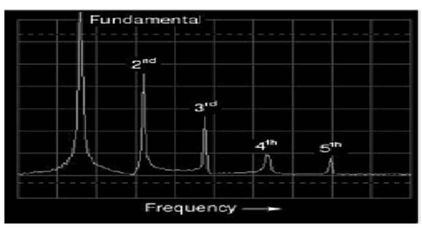
E8A01
What type of wave is made up of a sine wave plus all of its odd harmonics?
A square wave

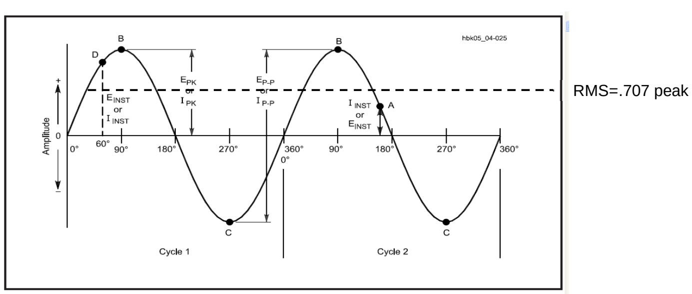
E8A02
What type of wave has a rise time significantly faster than its fall time (or vice versa)?
A sawtooth wave



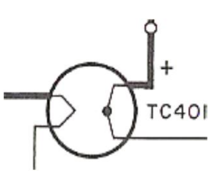
E8A03
What type of wave is made up of sine waves of a given fundamental frequency plus all its harmonics?
A sawtooth wave



E8A04
What is equivalent to the root-mean-square value of an AC voltage?
The DC voltage causing the same amount of heating in a resistor as the corresponding RMS AC voltage



E8A05
What would be the most accurate way of measuring the RMS voltage of a complex waveform?
By measuring the heating effect in a known resistor

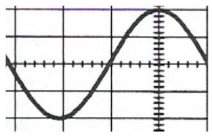


In precision measuring instruments a filament is heated with a current from an AC circuit and its temperature is measured by the voltage generated in a thermocouple attached to it. Then a DC current is applied to generate the same thermocouple voltage output. This dc current is then equal to the AC RMS current.

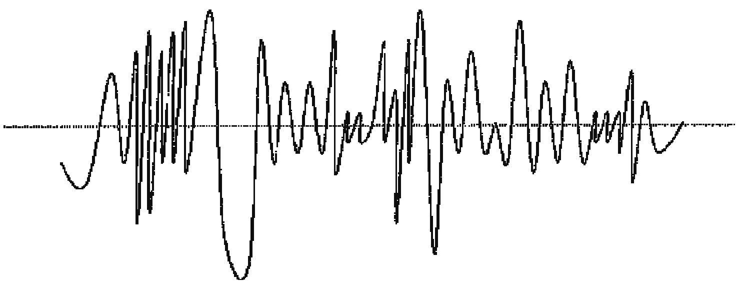
E8A06
What is the approximate ratio of PEP-to-average power in a typical single-sideband phone signal?
2.5 to 1

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

E8A08
What is the period of a wave?
The time required to complete one cycle

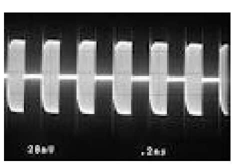


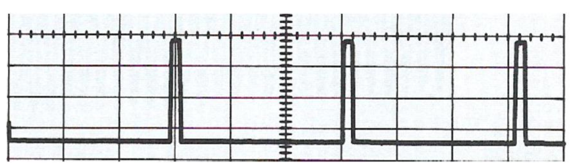
E8A09
What type of waveform is produced by human speech?
Irregular



This is because human speech is complex and contains many frequencies.

E8A10
Which of the following is a distinguishing characteristic of a pulse waveform?
Narrow bursts of energy separated by periods of no signal



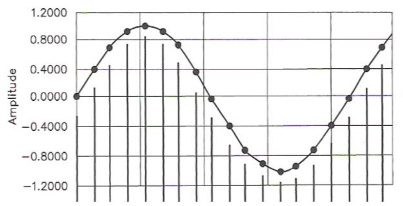


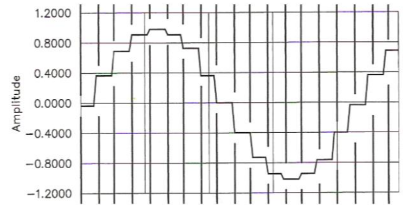
E8A11
What is one use for a pulse modulated signal?
Digital data transmission

E8A12
What type of information can be conveyed using digital waveforms?
Data

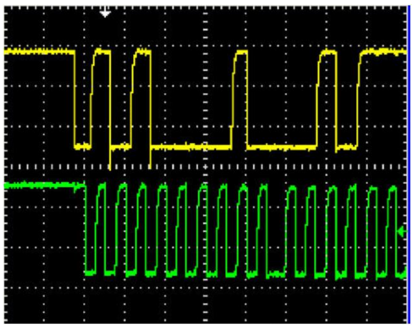
E8A13
What is an advantage of using digital signals instead of analog signals to convey the same information?
Digital signals can be regenerated multiple times without error

E8A14
Which of these methods is commonly used to convert analog signals to digital signals?
Sequential sampling





E8A15
What would the waveform of a stream of digital data bits look like on a conventional oscilloscope?
A series of pulses with varying patterns



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

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

E8B02
How does the modulation index of a phase-modulated emission vary with RF carrier frequency (the modulated frequency)?
It does not depend on the RF carrier frequency

Modulation index = Deviation / Modulation frequency

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

Modulation index = Deviation / Modulation frequency or 3000/1000 or 3.0

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

Modulation index = Deviation / Modulation frequency or 6000/2000 or 3.0

E8B05
What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz when the maximum modulation frequency is 3 kHz?
1.67

Deviation Ratio = Max Deviation / Max Modulation frequency or 5000/3000 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 when the maximum modulation frequency is 3.5 kHz?
2.14

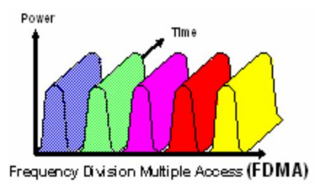
Deviation Ratio = Max Deviation / Max Modulation frequency or 7500/3500 or 2.142

E8B07
When using a pulse-width modulation system, why is the transmitter's peak power greater than its average power?
The signal duty cycle is less than 100%

E8B08
What parameter does the modulating signal vary in a pulse-position modulation system?
The time at which each pulse occurs

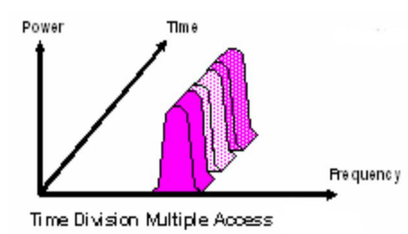
E8B09
What is meant by deviation ratio?
The ratio of the maximum carrier frequency deviation to the highest audio modulating frequency
Deviation Ratio = maximum carrier deviation / highest modulating frequency

E8B10
Which of these methods can be used to combine several separate analog information streams into a single analog radio frequency signal?
Frequency division multiplexing



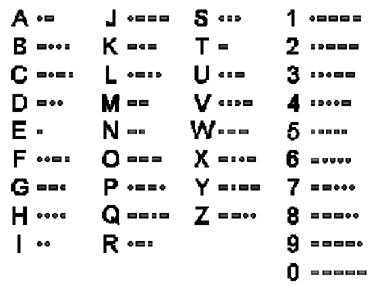
E8B11
Which of the following describes frequency division multiplexing?
Two or more information streams are merged into a "baseband", which then modulates the transmitter

E8B12
What is digital time division multiplexing?
Two or more signals are arranged to share discrete time slots of a data transmission



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

E8C01
Which one of the following digital codes consists of elements having unequal length?
Morse code



E8C02
What are some of the differences between the Baudot digital code and ASCII?
Baudot uses five data bits per character, ASCII uses seven or eight; Baudot uses two characters as shift codes, ASCII has no shift code

E8C03
What is one advantage of using the ASCII code for data communications?
It is possible to transmit both upper and lower case text

E8C04
What technique is used to minimize the bandwidth requirements of a PSK31 signal?
Use of sinusoidal data pulses

In PSK31 (1's) are represented by a tone with no phase shift compared to the previous bit and (0's) are tone with a 180 degree phase shift relative to the phase of the previous bit. The phase shift occurs during the zero level modulation to minimize bandwidth. When the modulation level returns, the positions of the sine wave top and bottom are reversed from the previous bit. Thus the phase changes by 180 degrees while the frequency remains constant.

E8C05
What is the necessary bandwidth of a 13-WPM international Morse code transmission?
Approximately 52 Hz

Required bandwidth = 4 times the character rate or 4 x13 = 52

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

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

E8C08
What term describes a wide-bandwidth communications system in which the transmitted carrier frequency varies according to some predetermined sequence?
Spread-spectrum communication

E8C09
Which of these techniques causes a digital signal to appear as wide-band noise to a conventional receiver?
Spread-spectrum

E8C10
What spread-spectrum communications technique alters the center frequency of a conventional carrier many times per second in accordance with a pseudo-random list of channels?
Frequency hopping

E8C11
What spread-spectrum communications technique uses a high speed binary bit stream to shift the phase of an RF carrier?

Direct sequence

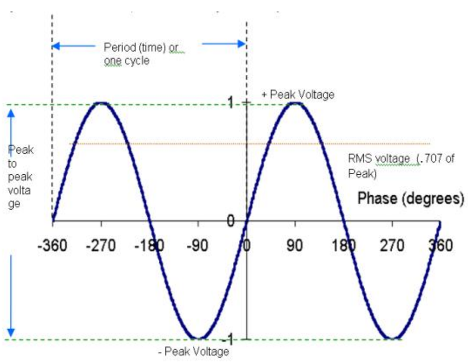
E8C12
What is the advantage of including a parity bit with an ASCII character stream?
Some types of errors can be detected

E8C13
What is one advantage of using JT-65 coding?
The ability to decode signals which have a very low signal to noise ratio

JT65 is a digital protocol intended for Amateur Radio communication with extremely weak signals. It was designed to optimize Earth-Moon-Earth (EME) contacts on the VHF bands, and conforms efficiently to the established standards and procedures for such QSOs.

E8D Waveforms: measurement, peak-to-peak, RMS, average; Electromagnetic Waves: definition, characteristics, polarization

E8D01
Which of the following is the easiest voltage amplitude parameter to measure when viewing a pure sine wave signal on an analog oscilloscope?
Peak-to-peak voltage



E8D02
What is the relationship between the peak-to-peak voltage and the peak voltage amplitude of a symmetrical waveform?
2:1

The peak to peak includes both the positive and negative excursions of the sine wave, therefore it is twice the value of only the peak voltage.

E8D03
What input-amplitude parameter is valuable in evaluating the signal-handling capability of a Class A amplifier?
Peak voltage

E8D04
What is the PEP output of a transmitter that develops a peak voltage of 30 volts into a 50-ohm load?
9 watts

Step 1 - RMS= .707 x Peak or RMS = .707 x 30 or RMS = 21.21 Volts
Step 2 – Power = (RMS)^2 / Resistance or P = (21.21)^2 / 50 or P = 449.86 / 50 or P = 8.997 Watts

E8D05
If an RMS-reading AC voltmeter reads 65 volts on a sinusoidal waveform, what is the peak-to-peak voltage?
184 volts

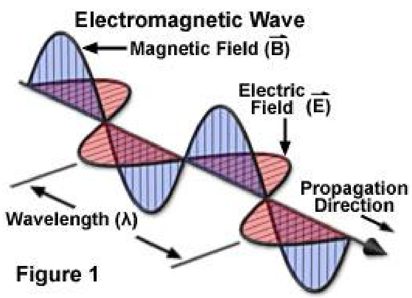
Peak to Peak = 2(RMS x 1.414) or PP = 2(65 x 1.414) or PP = 2 x 91.91 or PP 183.82 Volts

E8D06
What is the advantage of using a peak-reading wattmeter to monitor the output of a SSB phone transmitter?

It gives a more accurate display of the PEP output when modulation is present

E8D07
What is an electromagnetic wave?

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

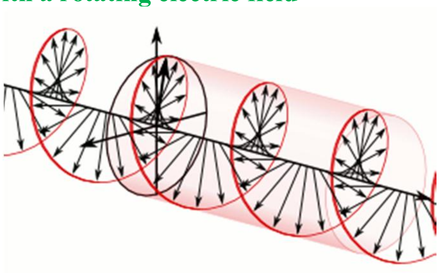


E8D08
Which of the following best describes electromagnetic waves traveling in free space?

Changing electric and magnetic fields propagate the energy

E8D09
What is meant by circularly polarized electromagnetic waves?

Waves with a rotating electric field



E8D10
What type of meter should be used to monitor the output signal of a voice-modulated single-sideband transmitter to ensure you do not exceed the maximum allowable power?

A peak-reading wattmeter

E8D11
What is the average power dissipated by a 50-ohm resistive load during one complete RF cycle having a peak voltage of 35 volts?

12.2 watts

Step 1 - RMS= .707 x Peak or RMS = .707 x 35 or RMS = 24.74 Volts
Step 2 – Power = (RMS)^2 / Resistance or P = (24.74)^2 / 50 or P = 612.31 / 50 or P = 12.24 Watts

E8D12
What is the peak voltage of a sinusoidal waveform if an RMS-reading voltmeter reads 34 volts?

48 volts

Peak = 1.414 x RMS or Peak = 1.414 x 34 or peak = 48.07 volts

E8D13
Which of the following is a typical value for the peak voltage at a standard U.S. household electrical outlet?

170 volts

Peak = 1.414 x RMS or Peak = 1.414 x 120 or peak = 169.68 volts

8D14
Which of the following is a typical value for the peak-to-peak voltage at a standard U.S. household electrical outlet?
340 volts

Peak to Peak= 2 (1.414 x RMS) or PP = 2 (1.414 x 120) or PP = 2 x 169.68 or PP = 339.36 volts

E8D15
Which of the following is a typical value for the RMS voltage at a standard U.S. household electrical power outlet?
120V AC

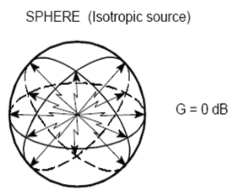
E8D16
What is the RMS value of a 340-volt peak-to-peak pure sine wave?
120V AC

RMS= (peak to Peak/2) / 1.414 or RMS= (340/2) / 1.414 or RMS= 170 / 1.414 or RMS = 120.22 volts

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

E9A Isotropic and gain antennas: definitions; uses; radiation patterns; Basic antenna parameters: radiation resistance and reactance, gain, beamwidth, efficiency

E9A01
Which of the following describes an isotropic antenna?
A theoretical antenna used as a reference for antenna gain



E9A02
How much gain does a 1/2-wavelength dipole in free space have compared to an isotropic antenna?
2.15 dB

Actually 2.14 dB gain, the test question answer is rounded to 2.15 dB

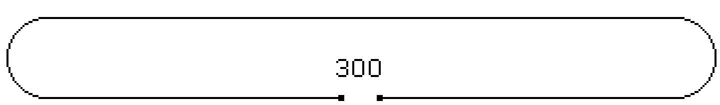
E9A03
Which of the following antennas has no **(zero)** gain in any direction?
Isotropic antenna

E9A04
Why would one need to know the feed point impedance of an antenna?
To match impedances in order to minimize standing wave ratio on the transmission line

E9A05
Which of the following factors may affect the feed point impedance of an antenna?
Antenna height, conductor length/diameter ratio and location of nearby conductive objects

E9A06
What is included in the total resistance of an antenna system?
Radiation resistance plus ohmic resistance

E9A07
What is a folded dipole antenna?
A dipole constructed from one wavelength of wire forming a very thin loop



E9A08
What is meant by antenna gain?
The ratio relating the radiated signal strength of an antenna in the direction of maximum radiation to that of a reference antenna

Gain is generally expressed in dB relative to either an Isotropic source or a dipole.

E9A09
What is meant by antenna bandwidth?
The frequency range over which an antenna satisfies a performance requirement

Performance examples would be – Gain - SWR or impedance - Beam width – etc.

E9A10
How is antenna efficiency calculated?
(radiation resistance / total resistance) x 100%

Can also be calculated by the equation: Efficiency = (Radiated Power / Input power x 100%

E9A11
Which of the following choices is a way to improve the efficiency of a ground-mounted quarter-wave vertical antenna?
Install a good radial system

E9A12
Which of the following factors determines ground losses for a ground-mounted vertical antenna operating in the 3-30 MHz range?
Soil conductivity

E9A13
How much gain does an antenna have compared to a 1/2-wavelength dipole when it has 6 dB gain over an isotropic antenna?
3.85 dB

The gain over isotropic source for an antenna with a 3.85 dB gain over a dipole antenna would be an additional 2.14 dB of gain. Remember dipole gain over an isotropic source is 2.14 dB or 3.85 dB +1.14dB or 5.99dB

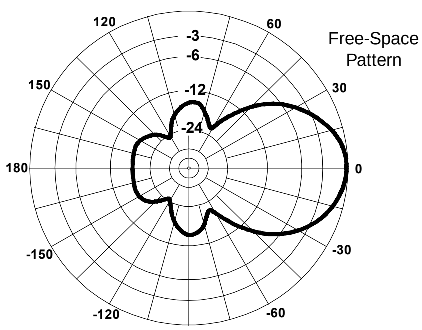
E9A14
How much gain does an antenna have compared to a 1/2-wavelength dipole when it has 12 dB gain over an isotropic antenna?
9.85 dB

Remember that a dipole has 2.14 dB of gain as referenced to an isotropic antenna.
12 dB -2.14 dB or gain =9.86dB

E9A15
What is meant by the radiation resistance of an antenna?
The value of a resistance that would dissipate the same amount of power as that radiated from an antenna

E9B Antenna patterns: E and H plane patterns; gain as a function of pattern; antenna design (computer modeling of antennas); Yagi antennas

Figure E9-1



E9B01
In the antenna radiation pattern shown in Figure E9-1, what is the 3-dB beamwidth?
50 degrees

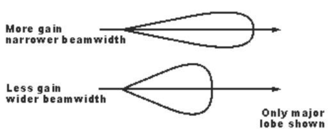
E9B02
In the antenna radiation pattern shown in Figure E9-1, what is the front-to-back ratio?

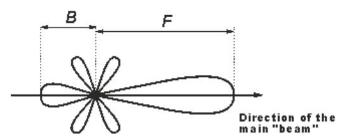
18 dB

E9B03
In the antenna radiation pattern shown in Figure E9-1, what is the front-to-side ratio?
14 dB

E9B04
What may occur when a directional antenna is operated at different frequencies within the band for which it was designed?
The gain may change depending on frequency

E9B05
What usually occurs if a Yagi antenna is designed solely for maximum forward gain?
The front-to-back ratio decreases





The front to back ratio is important in circumstances where interference or coverage in the reverse direction needs to be minimised. Unfortunately the conditions within the antenna mean that optimisation has to be undertaken for either front to back ratio, or maximum forward gain. Conditions for both features do not coincide, but the front to back ratio can normally be maximised for a small degradation of the forward gain.

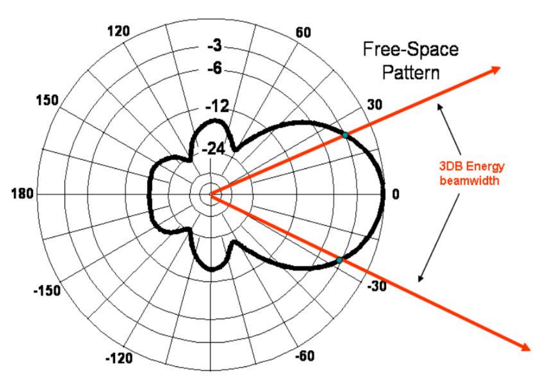
E9B06
If the boom of a Yagi antenna is lengthened and the elements are properly retuned, what usually occurs?
The gain increases

E9B07
How does the total amount of radiation emitted by a directional gain antenna compare with the total amount of radiation emitted from an isotropic antenna, assuming each is driven by the same amount of power?
They are the same

Remember the key word is total power. In an isotropic antenna power is equally radiated in all directions. In a gain antenna the power is focused in one direction so in that direction it is stronger but in other directions it is weaker. Total power is the sum of all power in all directions assuming both antennas are 100% efficient.

E9B08
How can the approximate beamwidth in a given plane of a directional antenna be determined?
Note the two points where the signal strength of the antenna is 3 dB less than maximum and compute the angular difference

Figure E9-1



E9B09
What type of computer program technique is commonly used for modeling antennas?**Method of Moments**

E9B10
What is the principle of a Method of Moments analysis?
A wire is modeled as a series of segments, each having a uniform value of current

E9B11
What is a disadvantage of decreasing the number of wire segments in an antenna model below the guideline of 10 segments per half-wavelength?
The computed feed point impedance may be incorrect

E9B12
What is the far-field of an antenna?
The region where the shape of the antenna pattern is independent of distance

E9B13
What does the abbreviation NEC stand for when applied to antenna modeling programs?
Numerical Electromagnetics Code

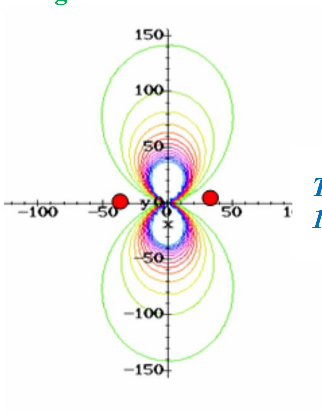
E9B14
What type of information can be obtained by submitting the details of a proposed new antenna to a modeling program?
A. SWR vs. frequency charts
B. Polar plots of the far-field elevation and azimuth patterns
C. Antenna gain
D. All of these choices are correct

E9C Wire and phased vertical antennas: beverage antennas; rhombic antennas; elevation above real ground; ground effects as related to polarization; take-off angles

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

E9C02
What is the radiation pattern of two 1/4-wavelength vertical antennas spaced 1/4-wavelength apart and fed 90 degrees out of phase?
A cardioid

E9C03
What is the radiation pattern of two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed in phase?
A Figure-8 broadside to the axis of the array

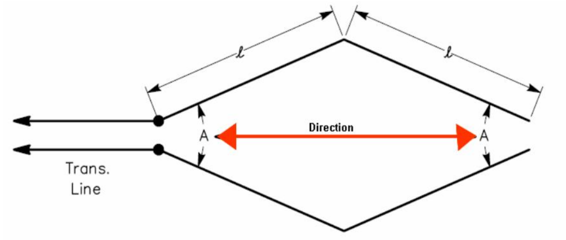


Two 1/4 wavelength verticals
1/2 wavelength apart, fed in phase

E9C04

Which of the following describes a basic unterminated rhombic antenna?

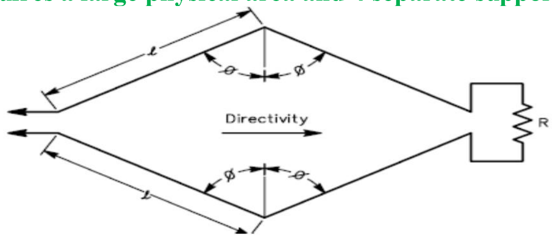
Bidirectional; four-sides, each side one or more wavelengths long; open at the end opposite the transmission line connection



E9C05

What are the disadvantages of a terminated rhombic antenna for the HF bands?

The antenna requires a large physical area and 4 separate supports

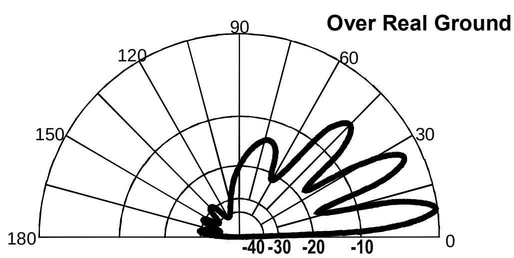


E9C06

What is the effect of a terminating resistor on a rhombic antenna?

It changes the radiation pattern from horizontal to vertical polarization

Figure E9-2



E9C07

What type of antenna pattern over real ground is shown in Figure E9-2?

Elevation

E9C08

What is the elevation angle of peak response in the antenna radiation pattern shown in Figure E9-2?

7.5 degrees

E9C09

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

28 dB

E9C10

How many elevation lobes appear in the forward direction of the antenna radiation pattern shown in Figure E9-2?

4 (four)

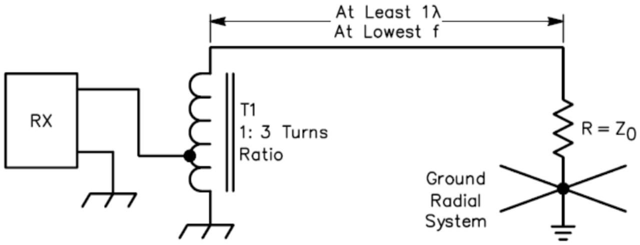
E9C11

How is the far-field elevation pattern of a vertically polarized antenna affected by being mounted over seawater versus rocky ground?

The low-angle radiation increases

E9C12
When constructing a Beverage antenna, which of the following factors should be included in the design to achieve good performance at the desired frequency?

It should be one or more wavelengths long



E9C13
What is the main effect of placing a vertical antenna over an imperfect ground?

It reduces low-angle radiation

E9D Directional antennas: gain; satellite antennas; antenna beamwidth; stacking antennas; antenna efficiency; traps; folded dipoles; shortened and mobile antennas; grounding

E9D01
How does the gain of an ideal parabolic dish antenna change when the operating frequency is doubled?

Gain increases by 6 dB

E9D02
How can linearly polarized Yagi antennas be used to produce circular polarization?

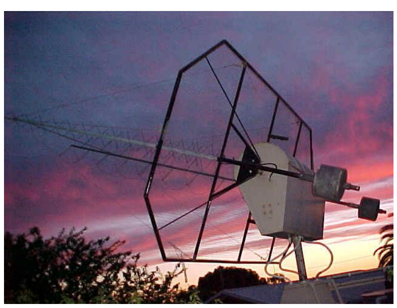
Arrange two Yagis perpendicular to each other with the driven elements at the same point on the boom and fed 90 degrees

E9D03
How does the beamwidth of an antenna vary as the gain is increased?

It decreases

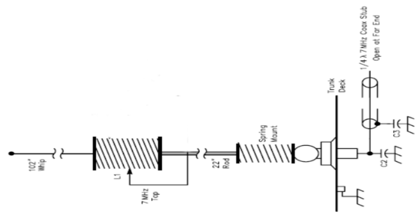
E9D04
Why is it desirable for a ground-mounted satellite communications antenna system to be able to move in both azimuth and elevation?

In order to track the satellite as it orbits the Earth



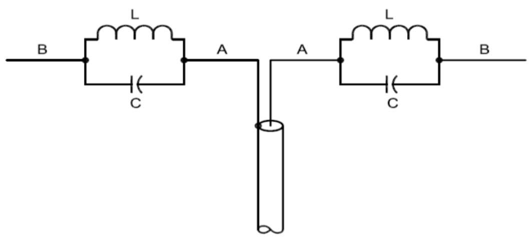
E9D05
Where should a high-Q loading coil be placed to minimize losses in a shortened vertical antenna?

Near the center of the vertical radiator



E9D06
Why should an HF mobile antenna loading coil have a high ratio of reactance to resistance?
To minimize losses

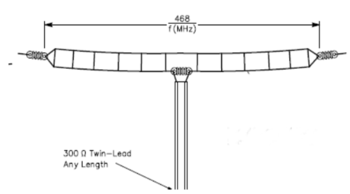
E9D07
What is a disadvantage of using a multiband trapped antenna?
It might radiate harmonics



E9D08
What happens to the bandwidth of an antenna as it is shortened through the use of loading coils?
It is decreased

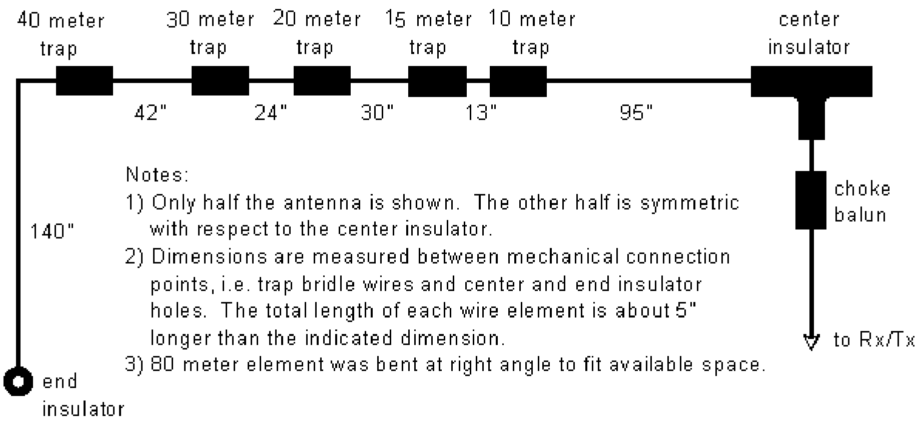
E9D09
What is an advantage of using top loading in a shortened HF vertical antenna?
Improved radiation efficiency

E9D10
What is the approximate feed point impedance at the center of a two-wire folded dipole antenna?
300 ohms



E9D11
What is the function of a loading coil as used with an HF mobile antenna?
To cancel capacitive reactance

E9D12
What is one advantage of using a trapped antenna?
It may be used for multiband operation



E9D13
What happens to feed point impedance at the base of a fixed-length HF mobile antenna as the frequency of operation is lowered?

The radiation resistance decreases and the capacitive reactance increases

E9D14
Which of the following types of conductor would be best for minimizing losses in a station's RF ground system?

A wide flat copper strap

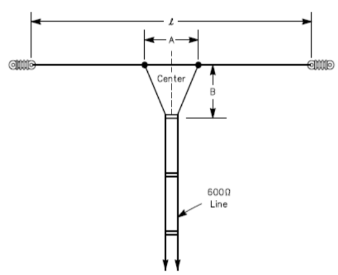
E9D15
Which of the following would provide the best RF ground for your station?

An electrically-short connection to 3 or 4 interconnected ground rods driven into the Earth

E9E Matching: matching antennas to feed lines; power dividers

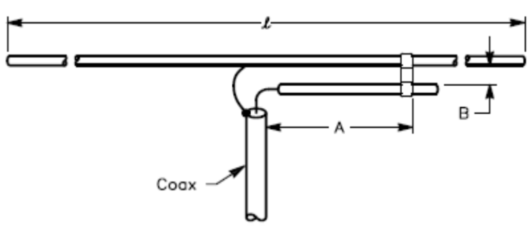
E9E01
What system matches a high-impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center?

The delta matching system

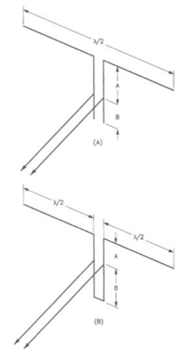


E9E02
What is the name of an antenna matching system that matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element and at a fraction of a wavelength to one side of center?

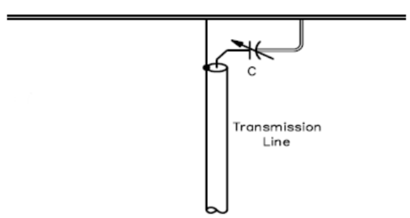
The gamma match



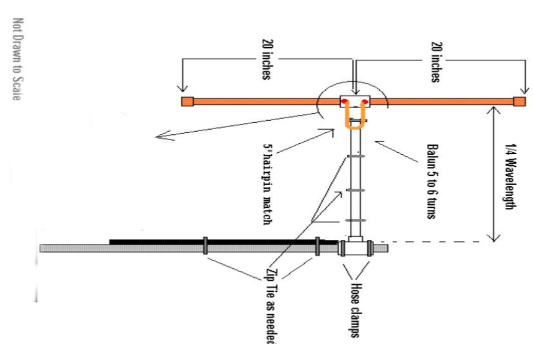
E9E03
What is the name of the matching system that uses a section of transmission line connected in parallel with the feed line at or near the feed point?
The stub match



E9E04
What is the purpose of the series capacitor in a gamma-type antenna matching network?
To cancel the inductive reactance of the matching network



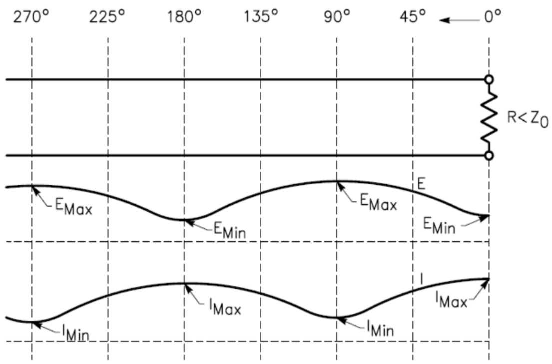
E9E05
How must the driven element in a 3-element Yagi be tuned to use a hairpin matching system?
The driven element reactance must be capacitive



E9E06
What is the equivalent lumped-constant network for a hairpin matching system on a 3-element Yagi?
L network

E9E07
What term best describes the interactions at the load end of a mismatched transmission line?
Reflection coefficient

E9E08
Which of the following measurements is characteristic of a mismatched transmission line?
An SWR greater than 1:1

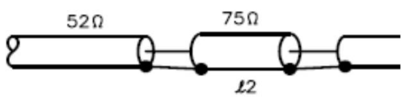


E9E09
Which of these matching systems is an effective method of connecting a 50-ohm coaxial cable feed line to a grounded tower so it can be used as a vertical antenna?

Gamma match

E9E10
Which of these choices is an effective way to match an antenna with a 100-ohm feed point impedance to a 50-ohm coaxial cable feed line?

Insert a 1/4-wavelength piece of 75-ohm coaxial cable transmission line in series between the antenna terminals and the 50-ohm feed cable



E9E11
What is an effective way of matching a feed line to a VHF or UHF antenna when the impedances of both the antenna and feed line are unknown?

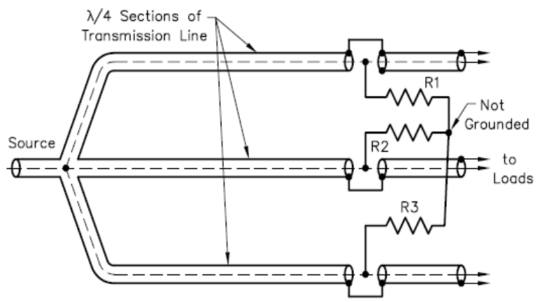
Use the universal stub matching technique

E9E12
What is the primary purpose of a phasing line when used with an antenna having multiple driven elements?

It ensures that each driven element operates in concert with the others to create the desired antenna pattern

E9E13
What is the purpose of a Wilkinson divider?

It divides power equally among multiple loads while preventing changes in one load from disturbing power flow to the others



E9F Transmission lines: characteristics of open and shorted feed lines; 1/8 wavelength; 1/4 wavelength; 1/2 wavelength; feed lines: coax versus open-wire; velocity factor; electrical length; coaxial cable dielectrics; velocity factor

E9F01
What is the velocity factor of a transmission line?
The velocity of the wave in the transmission line divided by the velocity of light in a vacuum

E9F02
Which of the following determines the velocity factor of a transmission line?
Dielectric materials used in the line

Velocity Factor = Velocity of wave in Transmission line / Velocity of light

E9F03
Why is the physical length of a coaxial cable transmission line shorter than its electrical length?
Electrical signals move more slowly in a coaxial cable than in air

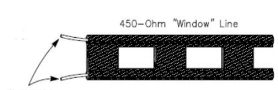
E9F04
What is the typical velocity factor for a coaxial cable with solid polyethylene dielectric?
0.66

E9F05
What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz? ***(Assuming a velocity factor of 0.66)***
3.5 meters
¼ Wavelength (in Transmission line) = (300/F(MHz)) / 4 x Velocity Factor
¼ Wavelength (in Transmission line) =(300/14.1 x .66) / 4 or 14.04/4 or 3.51 meters

E9F06
What is the approximate physical length of an air-insulated, parallel conductor transmission line that is electrically one-half wavelength long at 14.10 MHz? ***(Assuming a velocity factor of 0.95)***
10 meters

½ Wavelength (in Transmission line) = (300/F(MHz))/2 x Velocity Factor
½ Wavelength (in Transmission line) = (300/14.1 x .95)/2 or 20.21/2 or 10.10 meters

E9F07
How does ladder line compare to small-diameter coaxial cable such as RG-58 at 50 MHz?
Lower loss



E9F08
What is the term for the ratio of the actual speed at which a signal travels through a transmission line to the speed of light in a vacuum?
Velocity factor

E9F09
What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 7.2 MHz? ***(Assuming a velocity factor of 0.66)***

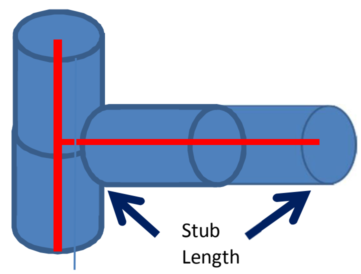
6.9 meters

¼ Wavelength(in Transmission line) = (300/F(MHz))/4 x Velocity Factor
¼ Wavelength(in Transmission line) =(300/7.2 x..66)/4 or 27.50/4 or 6.87 meters

E9F10
What impedance does a 1/8-wavelength transmission line present to a generator when the line is shorted at the far end?

An inductive reactance

Impedance of coaxial stubs		
Wavelength	**Open Stub**	**Shorted Stub**
1/8	Capacitive	Inductive
1/4	Low imp.	High imp.
1/2	High imp	Low imp



E9F11
What impedance does a 1/8-wavelength transmission line present to a generator when the line is open at the far end?

A capacitive reactance

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

Very low impedance

E9F13
What impedance does a 1/4-wavelength transmission line present to a generator when the line is shorted at the far end?

Very high impedance

E9F14
What impedance does a 1/2-wavelength transmission line present to a generator when the line is shorted at the far end?

Very low impedance

E9F15
What impedance does a 1/2-wavelength transmission line present to a generator when the line is open at the far end?

Very high impedance

E9F16
Which of the following is a significant difference between foam-dielectric coaxial cable and solid-dielectric cable, assuming all other parameters are the same?

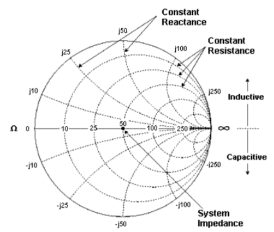
A. Reduced safe operating voltage limits
B. Reduced losses per unit of length
C. Higher velocity factor
D. All of these choices are correct

E9G The Smith chart

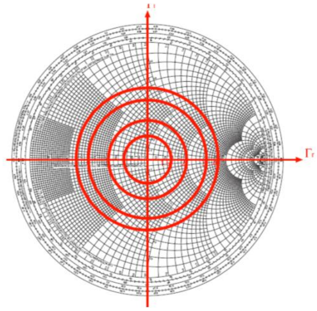
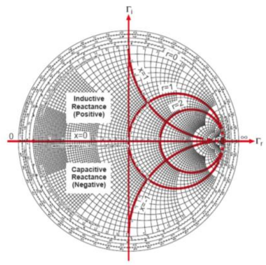
For a tutorial on smith charts go to http://www.maxim-ic.com/app-notes/index.mvp/id/742

E9G01
Which of the following can be calculated using a Smith chart?

Impedance along transmission lines



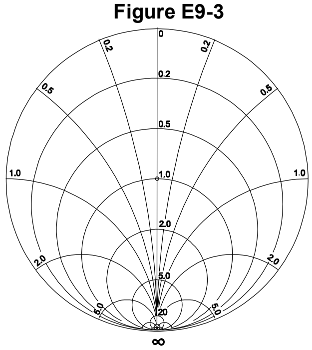
E9G02
What type of coordinate system is used in a Smith chart?
Resistance circles and reactance arcs

E9G03
Which of the following is often determined using a Smith chart?
Impedance and SWR values in transmission lines

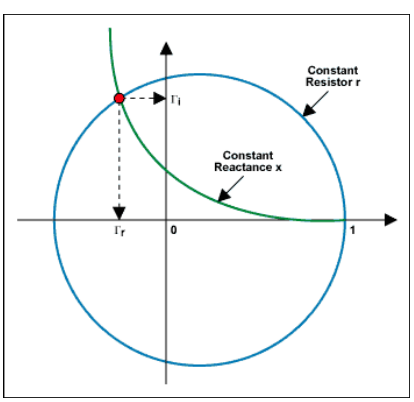
E9G04
What are the two families of circles and arcs that make up a Smith chart?
Resistance and reactance

Figure E9-3



E9G05
What type of chart is shown in Figure E9-3?
Smith chart

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



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

E9G08
What is the process of normalization with regard to a Smith chart?
Reassigning impedance values with regard to the prime center

E9G09
What third family of circles is often added to a Smith chart during the process of solving problems?
Standing-wave ratio circles

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

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

E9H Effective radiated power; system gains and losses; radio direction finding antennas

E9H01
What is the effective radiated power relative to a dipole of a repeater station with 150 watts transmitter power output, 2-dB feed line loss, 2.2-dB duplexer loss and 7-dBd antenna gain?
286 watts

ERP = Power + gain(s) – Loss(es)
ERP= 150 watts + (7 dB) – (2 dB + 2.2 dB) or 150 watts + 2.8 dB
Gain/loss ratio = 10^(dB/10)or 10^(2.8/10) or 10^.28 or 1.905
ERP = 150 watts x 1.905(the overall db gain/loss ratio) or 285.8 watts

E9H02
What is the effective radiated power relative to a dipole of a repeater station with 200 watts transmitter power output, 4-dB feed line loss, 3.2-dB duplexer loss, 0.8-dB circulator loss and 10-dBd antenna gain?
317 watts

ERP = Power + gain(s) – Loss(es)
ERP= 150 watts + (10 dB) – (4 dB + 3.2 dB +0.8 dB) or 150 watts + 2 dB
Gain/loss ratio = 10^(dB/10)or 10^(2.0/10) or 10^.20 or 1.584
ERP = 200 watts x 1.584(the overall db gain/loss ratio) or 316.9 watts

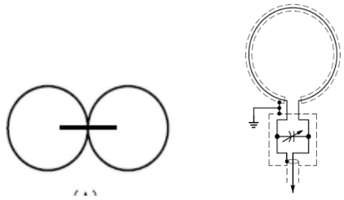
E9H03
What is the effective isotropic radiated power of a repeater station with 200 watts transmitter power output, 2-dB feed line loss, 2.8-dB duplexer loss, 1.2-dB circulator loss and 7-dBi antenna gain?
252 watts

ERP = Power + gain(s) – Loss(es)
ERP= 200 watts + (7 dB) – (2 dB + 2.8 dB +1.2 dB) or ERP = 200 watts + 1 dB
Gain/loss ratio = 10^(dB/10) or 10^(1/10) or 10^.1 or 1.258
ERP = 200 watts x 1.258 (the overall db gain/loss ratio) or 251.7 watts

E9H04
What term describes station output, including the transmitter, antenna and everything in between, when considering transmitter power and system gains and losses?
Effective radiated power

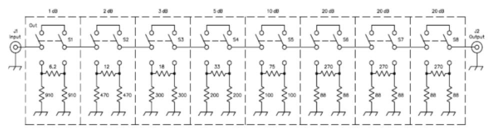
E9H05
What is the main drawback of a wire-loop antenna for direction finding?

It has a bidirectional pattern

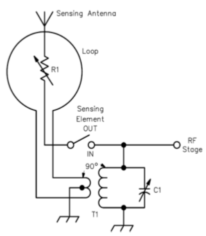


E9H06
What is the triangulation method of direction finding?
Antenna headings from several different receiving locations are used to locate the signal source

E9H07
Why is it advisable to use an RF attenuator on a receiver being used for direction finding?
It prevents receiver overload which could make it difficult to determine peaks or nulls



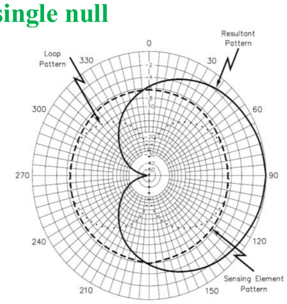
E9H08
What is the function of a sense antenna?
It modifies the pattern of a DF antenna array to provide a null in one direction

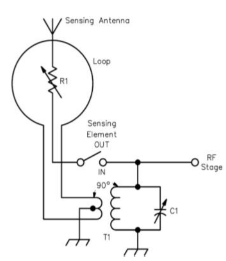


E9H09
Which of the following describes the construction of a receiving loop antenna?
One or more turns of wire wound in the shape of a large open coil

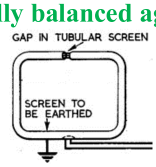
E9H10
How can the output voltage of a multi-turn receiving loop antenna be increased?
By increasing either the number of wire turns in the loop or the area of the loop structure or both

E9H11
What characteristic of a cardioid-pattern antenna is useful for direction finding?
A very sharp single null





E9H12
What is an advantage of using a shielded loop antenna for direction finding?
It is electro-statically balanced against ground, giving better nulls



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

E0A Safety: amateur radio safety practices; RF radiation hazards; hazardous materials

E0A01
What, if any, are the differences between the radiation produced by radioactive materials and the electromagnetic energy radiated by an antenna?

Radioactive materials emit ionizing radiation, while RF signals have less energy and can only cause heating

E0A02
When evaluating RF exposure levels from your station at a neighborؘs home, what must you do?

Make sure signals from your station are less than the uncontrolled MPE limits

E0A03
Which of the following would be a practical way to estimate whether the RF fields produced by an amateur radio station are within permissible MPE limits?

Use an antenna modeling program to calculate field strength at accessible locations

E0A04
When evaluating a site with multiple transmitters operating at the same time, the operators and licensees of which transmitters are responsible for mitigating over-exposure situations?

Each transmitter that produces 5% or more of its MPE exposure limit at accessible locations

E0A05
What is one of the potential hazards of using microwaves in the amateur radio bands?

The high gain antennas commonly used can result in high exposure levels

For example a transmitter at 2.5 GHz with a power output of 100 watts and an antenna gain of 12 dB would be the equivalent of 800 watts in the direction the antenna is pointing. Your home microwave oven operates at about this frequency with a power output of around 600 watts. Would you stand in front of your microwave oven with the door open and operating?

E0A06
Why are there separate electric (E) and magnetic (H) field MPE limits?

A. The body reacts to electromagnetic radiation from both the E and H fields
B. Ground reflections and scattering make the field impedance vary with location
C. E field and H field radiation intensity peaks can occur at different locations
D. All of these choices are correct

E0A07
How may dangerous levels of carbon monoxide from an emergency generator be detected?

Only with a carbon monoxide detector

E0A08
What does SAR measure?

The rate at which RF energy is absorbed by the body

SAR is short for Specific Absorption Rate

E0A09
Which insulating material commonly used as a thermal conductor for some types of electronic devices is extremely toxic if broken or crushed and the particles are accidentally inhaled?

Beryllium Oxide

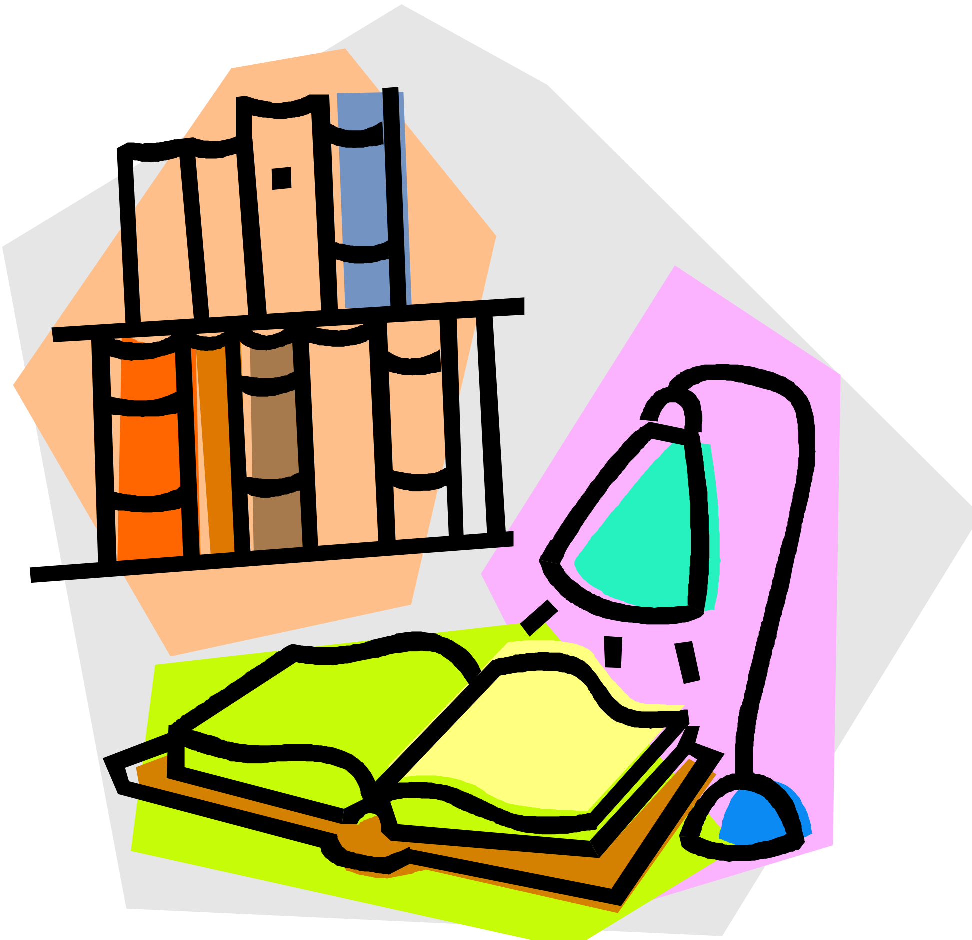
E0A10
What material found in some electronic components such as high-voltage capacitors and transformers is considered toxic?

Polychlorinated biphenyls (PCB's)

E0A11
Which of the following injuries can result from using high-power UHF or microwave transmitters?

Localized heating of the body from RF exposure in excess of the MPE limits

Reference materials



International System of Units (SI)—Metric Units

Prefix	Symbol ð ð ð ð	Multiplication Factorð ð ð	
exe	E	10+18	1,000,000 000,000,000,000
peta	P	10+15	1,000 000,000,000,000
tera	T	10+12	1,000,000,000,000
giga	G	10+9	1,000,000,000
mega	M	10+6	1,000,000
kilo	k	10+3	1,000
hecto	h	10+2	100
deca	da	10+1	10
(unit)		10+0	1
deci	d	10-1	0.1
centi	c	10-2	0.01
milli	m	10-3	0.001
micro	ε	10-6	0.000001
nano	n	10-9	0.000000001
pico	p	10-12	0.000000000001
femto	f	10-15	0.000000000000001
atto	a	10-18	0.000000000000000001

Scientific Notation to component values

Milli	m= .001 or	1x 10^-3
Micro	µ = .000,001 or	1x 10^-6
Nano	n= .000,000,001 or	1 x 10^-9
Pico	p= .000,000,000,001 or	1 x 10^-12
Fempto	f= .000,000,000,000,001 or	1 x 10^-15

Ohms Law

I=E/R R=E/I E=I * R (Amperes ï Volts-Ohms)

P=E * I P= E^2 /R I= P/E (amperes-volts-ohms-watts)

Series connected Resistors

R = R1 + R2 + R3 + Rx

Parallel connected Resistors

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_x}}$$

Series inductors

Total Inductance = $L_1 + L_2 + L_3 + L_x$

Parallel inductors

$$L = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots \frac{1}{L_x}}$$

Capicators in parallel

$C = C_1 + C_2 + C_3 + C_x$

Capacitors in series

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \text{é ..} \frac{1}{C_x}}$$

Reactance

Reactance is the equivalent AC resistance of a capacitor or inductor at a given frequency

For an inductor, X_L =2´ FL

X_L =2´ FL frequency is in Hertz and Inductance is in Henries. or Mili-Henries and Kilo-Hertz or Micro-Henries and Megahertz

Example 20 mH inductor at 3.5 KHz
XL =2´ FL = 6.28 x .02 x 3,500 = 6.28x 70 = 439.8 Ý
OR
XL =2´ FL = 6.28 x 20 x 3.5 = 6.28x 70 = 439.8 Ý
OR
XL =2´ FL = 6.28 x 20,000 x .0035 = 6.28x 70 = 439.8 Ý

For a capacitor
Reactance (Xc) is equal to 1/ (2π FC) frequency is in Hertz and Capacitance is in Farads. or Microfarads and Megahertz

Example 20 µF Capacitor at 3.5 KHz
Xc =1/(2πFC) = 1/(6.28 x .000,020 x 3,500) = 1/(6.28x .07) = 2.27 Ý
OR
Xc =1/(2πFC) = 1/(6.28 x 20 x .0035) = 1/(6.28 x .7) = 1/.44 = 2.27 Ý

RC Time Constant

TC = C * R farads - ohms or microfarads ï megohms

Charge vs number of time constants

Time Constant	% Charge / Discharge
1	63.2
2	86.5
3	95
4	98.2
5	99.3

dB Calculations

Power dB = 10 * LOG (P1/P2) P1 andP2 must be the same i.e.: µWatts. Miliwatts or Watts
Voltage - dB = 20 * LOG (V1/V2) V1 and V2 must be the same i.e.: µvolts. Milivolts or Volts

The following table will allow you to quickly estimate dB gain or loss. The one and two dB values are close enough to get you to the correct answer in the test.

Gain (+)	dB	Loss (-)
x 1.2	1	**80%**
x 1.6	2	**63%**
x 2	3	**50%**
x 4	6	**25%**
x 10	10	**10%**

Noise Figure vs Sensitivity

Noise figure is what the front end amplifier adds to the theoretical noise floor

Theoretical noise floor is -174dBm in a 1HZ bandwidth. For a 500 HZ receiver bandwidth this would be:

Noise Floor

Noise Floor = -174 + 10*Log (500/1) dB or -174dBm +27dB or -147 dBm

If in the Previous example our receiver has a noise figure of 8dB then the smallest signal you could possibly receive would need to be 8 dB larger. :

Noise floor would be -147 dBm + 8 dB or -139 dBm or about .03µV

Blocking dynamic range

The blocking dynamic range of a receiver that has an 8 db noise figure and an IF bandwidth of 500 Hz and a -1 dB compression point of -20dBm is 119 db

Theoretical noise floor for 500 Hz bandwidth is -147dBm

Noise Floor = -174 dBm + (10 log (1/500)))dB
Noise floor = - 174 dBm +(10 log (.002))dB
Noise floor = - 174 dBm +27dB
Noise floor = - 147 dBm

Add the +8 db Noise figure to the noise floor and get the actual noise floor of -139 dBm.

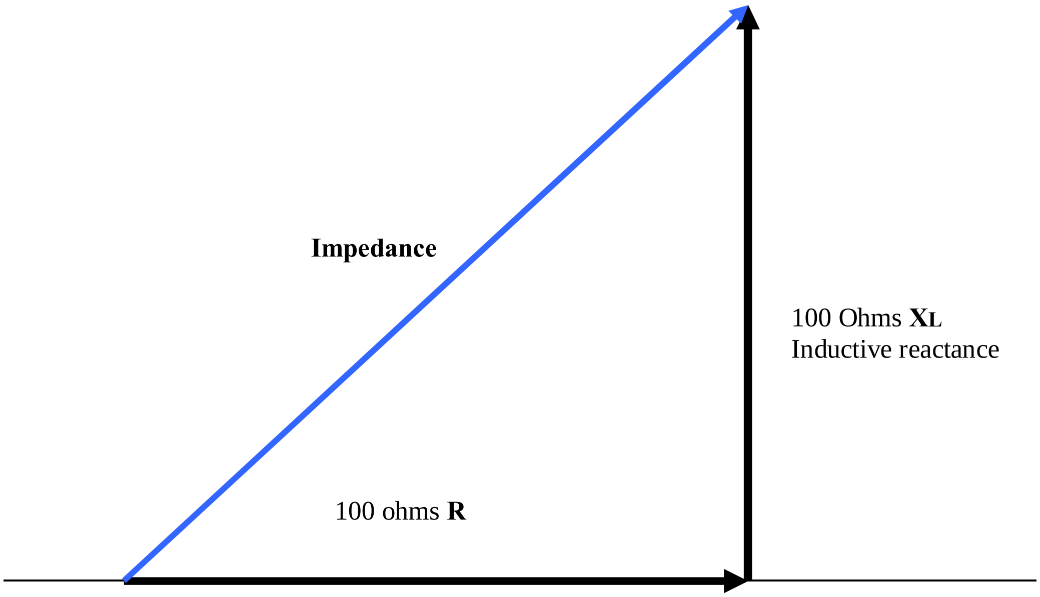
Receiver Noise floor = theoretical noise floor plus noise figure
Receiver Noise floor = -147dBm + 8dB = -139 dBm

Subtracting the – 20 dBm compression point gives us a difference of 119dB which is the Blocking dynamic range.

Blocking Dynamic range = Receiver Noise floor – 1 dBCompression point
Blocking Dynamic range = -139 –(– 20 dB) = -119 dB
Blocking Dynamic range is expressed as a positive number so the answer is 119 dB

For a 2.8 KHz wide receiver the theoretical noise floor with a 5 dB noise figure would be
-174dBm + 10 * LOG (2800/1) + 5 Or -174 + 34.5 + 5 or – 134.5 dB

Impedance of complex series circuits



Series circuit Impedance = $\sqrt{(resistance^2 + reactance^2)} = \sqrt{(10{,}000+10{,}000)} = \sqrt{20{,}000} = 141.4$ ***Ohms***

Angle = arc tangent =Opposite/Adjacent or arc tangent =100/100 or Arc tangent (1.00) = 45 °

The equation for calculating Impedance given resistance and inductive and/or capacitive reactance is:

Impedance (Z) = $\sqrt{(R^2 + Reactance^2)}$

For a circuit with 53 Ohms of resistance and 25 ohms of reactance (either Inductive or capacitive) it would be:

$$Z = \sqrt{[(53)^2 + (15)^2)]} = \sqrt{3034} = 55\Omega$$

For a circuit with 35 Ohms resistance, 38 Ohms Inductive reactance 50 Ohms Capacitive Reactance. The resistor value in this problem is 35 ohms and the reactance is 38 (inductance is +) + (- 50ohms) (capacitive reactance is -) or a total reactive value of -12 ohms (capacitive)

$$Z = \sqrt{[(35)^2 + (38-50)^2]} = \sqrt{[(35)^2 + (12)^2]} = \sqrt{1369} = 37\ \Omega$$

Remember that Impedance is never less than the resistance in the circuit.

Component Q

The Q of a capacitor or inductor can be calculated from the following equations:

Capacitor Q= Capacitive Reactance/ resistance
Inductor Q= Inductive Reactance/ resistance

The Q of a parallel RLC network with a 8.2 µH inductor, R of 1000 Ý with a resonant frequency of 7.125 MHz is 0.23:

$$Q = R/Reactance = R/(2\pi FL) = 220/(6.28*3.625*42) = 220/956.6 = 0.230$$

The Q of a parallel RLC network with a 42 µH inductor, R of 220 Ý with a resonant frequency of 7.125 MHz is 2.72:

$$Q = R/Reactance = R/(2\pi FL) = 1000/(6.28*7.125*8.2) = 1000/367.09 = 2.724$$

Effective Radiated Power

Lets take an example with the following characteristics:

- Power output from radio = **50 watts**
- Feed line loss = **- 4dB**
- Duplexer loss = **-2 dB**
- Circulator loss = **- 1dB**
- Antenna Gain =**+ 4 dB**

First we calculate the overall ERP as follows:

ERP=Transmitter Power Out = +((-4)+(-2)+(-=1)+(+4)) = 50 - 3 dB or 25 watts

Resonant circuits

- In any resonant circuit the X L is equal to the XC at resonance
- In a series resonant circuit the impedance at the resonant frequency is zero
- In a parallel resonant circuit the impedance at resonance is Ð
- In a parallel resonant circuit with perfect components once the circuit is energized it will continue to oscillate forever with the capacitor charging the inductor then the inductor charging the capacitor. Since our components are not perfect this will not happen.

Series resonant circuits

Series Resonant Circuits look like a short to the signal source (assuming ideal components) with the only limit on current being the resistance of the components and any external resistance added in series

Series Resonant Frequency is determined by the following equation with Frequency in Hertz, Inductance in Henries and Capacity in farads. (or frequency in kHz, inductance in mH and capacity in µ Henries and µH)

$$FR = \frac{1}{2\pi\sqrt{(LC)}}$$

For a circuit with an inductance of 50 µH and 40 pF

FR = 1/ (2π√(LC)) = 1/(6.28 √(.000050 x .000,000,000,040) = 3,558,812 Hz

or

FR = 1/ (2π√(LC)) = 1/(6.28 √(50 x . 000,040) = 3.559 kHz

Parallel Resonant circuits

Has high output voltage and looks like a high resistance (or in a perfect circuit an open circuit) to the signal source.

Calculating resonant frequency for a parallel inductor and capacitor circuit:

Resonant frequency = 1/ (2π √ (LC))

Letǿs calculate the resonant frequency for a circuit a circuit with a 10 µH inductor and 300 pf capacitor. Remember that this equation requires the inductance to be in Henries and capacitance in Farads, the resonant frequency answer will be in Hz.

F = 1/ (2π √ (LC)) = 1/ (2 π √ ((10 ↑-6) * (300 ↑-12)) = 1/ (2 π √(30↑-16))
F= 2,900,000 Hz or 2.9 MHz

If you need to determine which L or C component is needed to resonate at a specific frequency, the following equations can be used:

L= 1/((2 π F)² C) **or** ***C= 1/((2 π F)² L)***

Calculating Component values for resonance

At a specific frequency Capacity in Farads, Inductance in Henries, and Frequency in Hertz (or *frequency in MHz, Inductance in µH and capacity in µF*):

$$C = \frac{1}{(2\pi FR)^2 L} \qquad L = \frac{1}{(2\pi FR)^2 C}$$

Find the capacitor value for:
A resonant frequency of F=3,600,000 Hz (3.6 MHz)
A 20µH (.000,020 H) inductor:

C= 1/(6.28 x 3,600,000)² x 000020 = 1/(.000516) x 20 = 1/ 10,23 = 97.7 ^-12F or 98 pF

Or

C = 1/(6.28 x 3.6)² x 20 = 1/(511.6 x 20) = 1/ 10.23 = 97.7 ^-6 µ F or 98 pF

For 7.3 MHz and 19µH
C = 1/(6.28 x 7.3)² x 19 = 25pF

For 21 MHz and 3 µH
C = 1/(6.28 x 21)² x 3 = 19.1 pF

Finding an Inductor value
For a resonant frequency of 10 MHz with a capacitor of 10 pF

L = 1/(6.28 x 10)² x .000,010 = 1/(39.44 x .000,010 = 1/ .39.44 = 25µH

A resonant frequency of 21 MHz with a capacitor of 7 pF

L = 1/(6.28 x 21)² x .000,007 = 8.21µH

A resonant frequency of 7.3 MHz with a capacitor of 25 pF

L = 1/(6.28 x 7.3)² x .000,025 = 19µH

Resonant Circuit Q
Q for a resonant circuit is a function of the circuit resistance vs the reactance at a given frequency.

For a series circuit Q = XL /R
Example- a circuit with 1000 ohms of inductive reactance and 100 ohms of resistance would be Q = 1000 / 100 or 10

For a parallel circuit Q = Resistance /Reactance
Example a circuit with 500 ohms of Inductive reactance and 100 Ohms
And 10,000 ohms of parallel resistance would be Q = 10,000 / 500 or 20

The bandwidth of the resonant circuit

The 3 dB bandwidth of a resonant circuit is equal to:
Bandwidth = Resonant Frequency / Q
A circuit resonant at 3.5 MHz with a Q of 50 would have a bandwidth of **3,500,000 / 50 or 70 kHz**

A circuit resonant at 25 MHz with a Q of 85 would have a bandwidth of **25,000,000 / 85 or 294 kHz**

A circuit resonant at 7.25 MHz with a Q of 180 would have a bandwidth of **7,250,000 / 180 or 40.3 kHz**

Power Factor

Power Factor is the Cosine of the impedance angle this a number between 1 and 0 and represents a ratio between the real and the apparent power in the circuit

If you know the magnitude of the resistance and Reactance you can determine power factor and real power from their angle as a tangent function (Opposite over Adjacent sides of a right triangle), then determine the cosine function of that angle, this will be the circuit ó***power factor'***

Example 1 - For a circuit with resistance of 50 ohms and a reactance of 19 ohms, you would calculate the power factor as follows:

- Find the tangent function -tangent = opposite/ adjacent = 10 / 50 = .2
- Using a calculator find the angle whose tangent is .2 = 11°
- Using a calculator find the cosine of 11° = .982

Example 2 - For a circuit with resistance of 30 ohms and a reactance of 17 ohms, you would calculate the power factor as follows:

- Find the tangent function -tangent = opposite/ adjacent = 17 / 30 = .567
- Using a calculator find the angle whose tangent is .567 = 29.5°
- Using a calculator find the cosine of 29.5° = .87

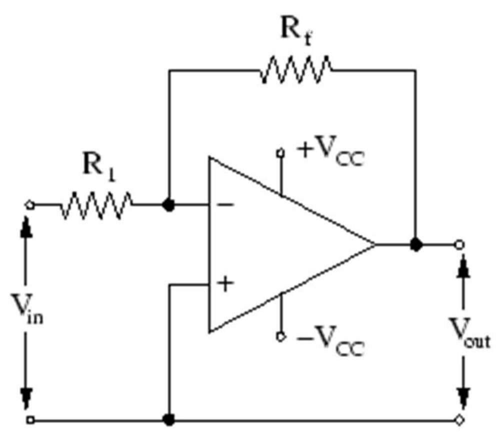
If you know the real and the apparent power you can calculate the power factor directly using the equation:

Power Factor = P real / P apparent

For a circuit with an apparent power of 120VA and a real power of 100 watts the power factor would be 100/120 or .833.

For a circuit with an apparent power of 400VA and a power factor of .2 the real power would be 400 x .2 or 80 Watts

Operational Amplifiers



Gain = R(feedback) /R(input)

If the feedback resistor was 100,000 Ý and the input resistor was 1,000 Ý the **gain would be 100,000/1,000 or 100.** Since the input impedance is very high there is no current flowing through Rinput, and the voltage applied is accurately amplified.

AC Voltage Calculations

The RMS (Root Mean Square) value for a sine wave is the value of an equivalent DC voltage required to generate the same amount of power or heat in a resistive load

For a pure sine wave the equivalent **RMS value is .707 times the peak value**. Conversely the **peak voltage can be calculated as 1.414 times the RMS Value.**

The peak voltage for standard 120V RMS AC line voltage is
Peak Voltage = 1.414 x 120V or ~170 volts peak.

The peak to peak would be two times the peak voltage
Voltage Peak to peak = 2 x 170 or 340 Volts pp

An AC voltage that reads 65 volts on an RMS meter will have a peak to peak voltage of **Peak to Peak = 65 x 1.414 x 2 or** ***~184 Volts.***

The average power dissipated by a 50 ohm resistor during one cycle of voltage with a peak voltage of 35 volts is 12.2 Watts.

$P(avge) = E^2 (avge) / R = (.707 \times 35)^2 / 50 = 12.2$ Watts

FM Modulation

Modulation Index

M index = Deviation /Modulating Frequency

The Modulation Index for a FM phone signal with 3 KHz deviation and a 1 KHz tone would be:

M Index = 3,000/1,000 = 3

From the above equation you can see that Modulation index is independent of the carrier frequency

Deviation Ratio
Deviation Ratio = Maximum Deviation / Maximum modulating frequency

For a FM phone transmission with a ± 5 KHz deviation and a 3 KHz maximum modulating tone the deviation ration would be:

Deviation ratio= 5,000/3,000 = 1.67
Deviation ratio describes a maximum event (max deviations and max audio frequency, while **modulation index describes an instantaneous set of conditions**

Transmitter Power Measurements

The PEP power output for a transmitter with an observed 30 volt peak envelope voltage (as seen on an oscilloscope) would be 9 watts. To determent the PEP power we take the peak voltage and multiply it by >707 to get the Peak RMS voltage then using the Peak RMS voltage we calculate power using the equation $P(watts) = V(RMS)^2 / R (load)$

$PEP (watts) = [V(peak) \times .707]^2 / \text{Load Resistance}$

$PEP (watts) = [V(peak) \times .707]^2 / 50 = (21.2)^2 / 50 = 449 / 50 = 9$

Amplifier efficiency
Amplifier efficiency is the ratio of power divided by power input times 100%.

Efficiency = P(out) / P(input) x 100

A typical 1500 Watt PEP class B amplifier will require 2500 watts of DC input power (assume 60% efficiency). A typical class A amplifier will be typically 25 to 35% efficient.

P(input) = P(output) / Efficiently = 1500 Watts/.60 = 2500Watts

Transmission lines

The Velocity Factor of a cable is calculated as the Velocity of the wave in the transmission line (coaxial cable) divided by the velocity of light (which is the velocity of the electrical wave in a vacuum).

VF = V (transmission line) / V (light)

Since energy moves slower in a coaxial cable its electrical length will be shorter than the electrical length. A typical velocity for common coaxial cable with a polyethylene dielectric is about .66

The physical length of a typical transmission line (VF= .66) one quarter wavelength long at 14. 1 MHz would be 3.5 Meters.

Physical length (PL)= [Wavelength/4] x Velocity Factor

PL= [((300/14.1))/4] x .66 = [5.32] x .66 = 3.5 meters

Coaxial Stubs

Stub Length	¼ wave length	½ wave length
Shorted at far end	High Impedance	Low impedance
Open at far end	Low Impedance	High impedance

Think about it as moving around the Smith Chart which is 1/2 a wavelength all the way around (180 degrees). If we move 90° on the smith chart our transmission line does the opposite of our input, so a short at 90° will appear as an open to the generator (transmitter input) end and an open will look like a short. Moving to ½ wavelength or 180° brings us back to the starting point so there is no opposite transformation, therefore a short at the output will look like a short at the input and an open will look like an open. For partial wavelengths the impedance between 0 and ¼ wavelength the line will look like an inductive reactance and for a ¼ to ½ wavelength the line will look like a capacitive reactance depending on the actual fractional wavelength.