# AMATEUR EXTRA License Class Guide 2024-2028

Instructor: Bill Kelly, NB1LL

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| E0 – Safety | 11 | 1 |
| Totals | 619 | 50 |

The following questions have been deleted from the question pool:
E2A13, E6D07, E9E10

# Subelement E1 – Commission Rules

| | |
|---|---|
| 1A – Operating Standards | |
| 1B – Station Restrictions | 6 sub sections |
| 1C – Definitions and Restrictions | 6 questions |
| 1D – Amateur Space and Earth Stations | |
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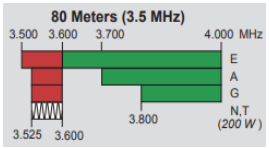
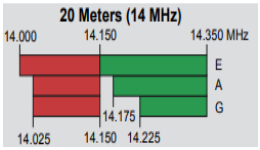
## 1A - Frequency Privileges

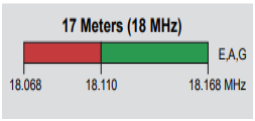
**3 kHz above the lower band edge** is the lowest frequency, of phone signals, at which a properly adjusted LSB emission will be totally within the band. E1A02



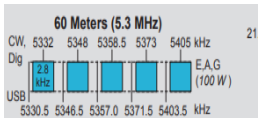

**No, the sideband will extend beyond the edge of the phone band segment** is the answer if your transceiver displays a carrier frequency of a phone signal from a DX station calling CQ on 3.601 MHz LSB. E1A04




**14.149 MHz** is the maximum legal carrier frequency on the 20-meter band for transmitting USB AFSK digital signals having a 1 kHz bandwidth. E1A03




**18.068 MHz** is a carrier frequency that is illegal for LSB AFSK emissions on the 17-meter band RTTY and data segment of 18.068 to 18.110 MHz. E1A01




The maximum power output permitted on the 60 meter band is **100 watts PEP effective radiated power relative to the gain of a half-wave dipole**. E1A05

To comply with FCC rules for 60 meter operation, the carrier frequency of a CW signal must be **at the center frequency of the channel**. E1A06

The special operating frequency restrictions that are imposed on slow-scan TV transmissions are **they are restricted to phone band segments**. E1A12

## 1A - Automatic Message Forwarding

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

The actions that should be taken if your digital message forwarding station inadvertently forwards a communication that violates FCC rules is to **discontinue forwarding the communication as soon as you become aware of it.** E1A09

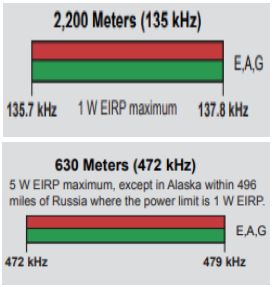
## 1A - Stations Aboard Ship or Aircraft

Before a station is installed or operated aboard a ship or aircraft, **its operation must be approved by the master of the ship or the pilot in command of the aircraft**. E1A10

**Any FCC-issued amateur license** is the authorization or licensing required when operating an amateur station aboard a U.S.-registered vessel in international water. E1A11

**Any person holding an FCC issued amateur license or who is authorized for alien reciprocal operation** must be in physical control of the station apparatus of an amateur station aboard any vessel or craft that is documented or registered in the United States. E1A13

## 1A – 630- & 2200-Meter Bands




The maximum power permitted on the 2200 meter band is **1 watt EIRP (Equivalent isotropic radiated power).** E1A07

**5 watts EIRP** is the maximum power permitted on the 630 meter band, except in some parts of Alaska. E1A14

## 1B - Station Restrictions

Limitations that the FCC can place on an amateur station if its signal causes interference to domestic broadcast reception, assuming the receivers involved are of good engineering design, are that **the amateur station must avoid transmitting during certain hours on frequencies that cause the interference**. E1B08

## 1B - Restrictions on Station Location

Within **1 mile** is the distance that an amateur station must protect an FCC monitoring facility from harmful interference. E1B03.

The FCC Monitoring stations in operation include Atlanta, Baltimore; Boston, Chicago; Dallas, Denver; Detroit, Kansas City, Los Angeles, New Orleans, New York, Philadelphia, San Diego, San Francisco, Seattle, and Tampa

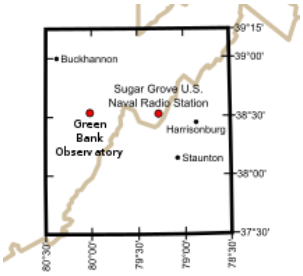
**An Environmental Assessment must be submitted to the FCC** before placing an amateur station within an officially designated wilderness area or wildlife preserve, or an area listed in the National Register of Historic Places. E1B04

## 1B – General Operating Restrictions

If operating a repeater on the 70 cm band and a radiolocation system experiences interference from that repeater, the control operator must **cease operation or make changes to the repeater to mitigate the interference**. E1B12

**3 kHz** is an acceptable bandwidth for Digital Radio Mondiale (DRM) based voice or SSTV digital transmissions made on the HF amateur bands. E1B02

The National Radio Quite Zone is **an area surrounding the National Radio Astronomy Observatory**. E1B05


The NRQZ includes portions of West Virginia, Virginia, and a small part of Maryland.

## 1B – Spurious Emissions

Spurious emissions are **an emission outside the signal's necessary bandwidth that can be reduced or eliminated without affecting the information transmitted**. E1B01

## 1B - Antenna Structures Restrictions

An additional rule that applies if you are installing an amateur station antenna at a site at or near a public use airport is **you may have to notify the Federal Aviation Administration and register it with the FCC as required by Part 17 of the FCC rules**. E1B06

PRB-1 applies to **state and local zoning**. E1B07

PRB-1 are FCC regulations requiring local government to make reasonable accommodations for amateur radio in land-use regulations

PRB-1 regulations affecting amateur radio require that **reasonable accommodations of amateur radio must be made**. E1B11

## 1B - RACES Operations

The amateur stations that may operate under RACES rules are **any FCC-licensed amateur station certified by the responsible civil defense organization for the area served**. E1B09

The frequencies that are authorized to an amateur station operating under RACES rules are **all amateur service frequencies authorized to the control operator**. E1B10

## 1C – Rules Pertaining to Automatic & Remote Control

The control operator responsibilities of a station under automatic control differs from one **under local control in that under automatic control the control operator is not required to be present at the control point**. E1C03

**3 minutes** is the maximum permissible duration of a remotely controlled station's transmission if its control link malfunctions. E1C08

## 1C – Band-specific Regulations

**2.8 kHz** is the maximum bandwidth for a data emission on 60 meters. E1C01

On the 630 band, phone emissions are permitted on **the entire band**. E1C12

Before transmitting on the 630 meter or 2200 meter bands, **operators must inform the Utilities Technology Council (UTC) of their call sign and coordinates of the station**. E1C13

After notifying the Utilities Technology Council (UTC) and before operating on the 2200 meter or 630 meter band, the **operator may operate after 30 days, providing they have not been told that their station is 1 km of PLC systems using those frequencies**. E1C14

PLC = Power line control

## 1C – Operating in, and Communicating with Foreign Countries

Only **communications incidental to the purpose of the amateur service and remarks of a personal nature** may be transmitted to amateur stations in foreign countries. E1C02

IARP is **an international amateur radio permit that allows U.S. amateurs to operate in certain countries of the Americas**. E1C04

CERT = The European Conference of Postal and Telecommunications Administration

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

A **CERT agreement** allows an FCC-licensed U.S. citizen to operate in many European countries, and alien amateurs from many European countries to operate in the U.S. E1C11

## 1C – Spurious Emissions Standards

**At least 43 dB below** 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. E1C10

## 1C – HF Modulation Index

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

## 1C – Bandwidth Definitions

According to FCC rules, **26 dB** is the level below a signal's mean power level is how the bandwidth is determined. E1C07

The signal becomes weaker above and below the central range as the sidebands become less powerful. The signals bandwidth is the difference between the frequencies at which the sideband strength is 26dB (400 times) lower than the mean signal power.

## 1D - Amateur Space & Earth Stations

**Any amateur station, subject to the privileges of the class of operator license held by the control operator** are amateur stations eligible to operate as Earth stations. E1D11

**Only the 40, 20, 17, 15, 12, and 10 meter bands** are the HF amateur bands that have frequencies authorized for space stations. E1D07

Only the **2 meters** band is the VHF amateur band that have frequencies authorized for space stations. E1D08

Only the **70 cm and 13 cm** bands are the UHF amateur bands that have frequencies authorized for space stations. E1D09

**Any amateur station so designated by the space station licensee** are amateur stations eligible to be telecommand stations of space stations (subject to the privileges of the class of operator license held by the control operator of the station). E1D10

## 1D – Telemetry & Telecommand Rules

The definition of telemetry is a **one-way transmission of measurements at a distance from the measuring instruments**. E1D01

**1 watt** is the maximum permitted transmitter output power when operating a model craft by telecommand. E1D06

The items that must be posted at the station location of a station being operated by telecommand on or within 50 km of the earth's surface is; E1D05

- A photocopy of the station license,
- A label with the name, address, and telephone number of the station licensee, and
- A label with the name, address, and telephone number of the control operator

**All these choices are correct**

**Telecommand signals from a space telecommand station** may transmit special codes intended to obscure the meaning of messages. E1D02

A telecommand station is **an amateur station that transmits communications to initiate, modify or terminate functions of a space station**. E1D03

## 1D – Identification of Balloon Transmissions

Only a **call sign** is required in the identification transmission from a balloon-borne telemetry station. E1D04

## 1D – One-way Communications

**A space station, beacon station, or telecommand station** are amateur stations that may transmit one-way communications. E1D12

## 1E - Volunteer Examiner Program

A Volunteer Examiner Coordinator is **an organization that has entered into an agreement with the FCC to coordinate, prepare, and administer amateur operator license examinations**. E1E03

The Volunteer Examiner accreditation process is **the procedure by which a VEC confirms that the VE applicant meets FCC requirements to serve as an examiner**. E1E04

VEC = Volunteer Examiner Coordinator

VE = Volunteer Examiner

**Preparing, processing, administering, and coordinating an examination for an amateur radio operator license** are the types of out-of-pocket expenses that the Part 97 rule states that VEs and VECs may be reimbursed. E1E01

A VE may not administer an examination for a **relative of the VE as listed in the FCC rules**. E1E08

A Volunteer Examiner (VE) may not administer an examination to his or her spouse, children, grandchildren, stepchildren, parents, grandparents, stepparents, brothers, sisters, stepbrothers, stepsisters, aunts, uncles, nieces, nephews, and in-laws.

## 1E – Question Pool

Part 97 tasks the maintaining the pools of questions for all U.S. amateur license examinations to **the VEC**. E1E02

## 1E – Preparation & Administration of Exams

**Each administrating VE** is responsible for the proper conduct and necessary supervision during an amateur operator license examination session. E1E06

If a candidate fails to comply with the examiner's instructions during an amateur operator license examination, the VE should **immediately terminate the candidate's examination**. E1E07

The penalty for a VE who fraudulently administers or certifies an examination is **revocation of the VE's amateur station license grant and the suspension of the VE's amateur operator license grant**. E1E09

The passing score on all amateur operator license examinations is a **minimum passing score of 74%**. E1E05

When an examinee scores a passing grade on all examination elements needed for an upgrade or new license, the administrating VE team must do the following; **three VEs must certify that the examinee is qualified for the license grant and that they have complied with the administering VE requirements**. E1E11

## 1E – Document Requirements

After the administration of a successful examination for an amateur operator license, the administering VEs must do the following; **they must submit the application document to the coordinating VEC according to the coordinating VEC instructions**. E1E10

If the examinee does not pass the exam, the VE team must **return the application document to the examinee**. E1E12

## 1F - External RF Power Amplifiers

The circumstances that a dealer may sell an external RF amplifier capable of operation below 144 MHz if it has not been granted FCC certification is when **it was purchased in used condition from an amateur operator and is sold to another amateur operator for use at that operator's station**. E1F03

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 is **it must satisfy the FCC's spurious emission standards when operated at the lesser of 1500 watts or its full output power**. E1F11

## 1F – Prohibited Communications

An amateur station may send a message to a business **when neither the amateur nor his or her employer has a pecuniary interest in the communication**. E1F07

Pecuniary interest means monetary interest

Amateur stations are prohibited from **communications transmitted for hire or material compensation, except as otherwise provided in the rules**. E1F08

An approximate geographic description of the "Line A" is a **line roughly parallel to and south of the border between the U.S. and Canada**. E1F04

Amateur stations may not transmit on the **420 MHz – 430 MHz** frequency segments if they are located in the continuous 48 states and north of Line A. E1F05


## 1F - Spread Spectrum

The following conditions apply when transmitting spread spectrum emissions? E1F09

- A station transmitting SS emission must not cause harmful interference to other stations employing other authorized emissions
- The transmitting station must be in an area regulated by the FCC or in a country that permits SS emissions
- The transmission must not be used to obscure the meaning of any communication

**All these choices are correct**

Spread spectrum transmissions are permitted **only on amateur frequencies above 222 MHz**. E1F01

## 1F – Auxiliary Stations

**Only Technician, General, Advanced or Amateur Extra Class operators** may be the control operator of an auxiliary station. E1F10

## 1F – Canadian Amateurs Operating in U.S.

The privileges authorized in the U.S. to persons holding an amateur service license granted by the government of Canada are that **the operating terms and conditions of the Canadian amateur service license, not to exceed U.S. Amateur Extra Class license privileges**. E1F02

## 1F - Special Temporary Authority

The circumstances that the FCC might issue a Special Temporary Authority (STA) to an amateur station is **to provide for experimental amateur communications**. E1F06

# Subelement E2 – Operating Procedures

| | |
|---|---|
| 2A – Amateur Radio in Space | |
| 2B – Television Practices | 5 sub-sections |
| 2C – Operating Methods (1) | 5 questions |
| 2D – Operating Methods (2) | |
| 2E – Operating Methods (3) | |

## 2A - Amateur Satellites

**From south to north** is the direction of an ascending pass for an amateur satellite. E2A01

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

## 2A - Satellite Operation

The following occurs when a satellite is using an inverting linear transponder: E2A02

- Doppler shift is reduced because the uplink and downlink shifts are in opposite direction
- Signal position in the band is reversed
- Upper sideband on the uplink becomes lower sideband on the downlink, and vice versa

**All these choices are correct**

An inverting linear transponder can invert the signal by **the signal is passed through a mixer and the difference rather than the sum is transmitted**. E2A03

**To avoid reducing the downlink power to all other users** is why the effective radiated power to a satellite that uses a linear transponder is limited. E2A08

The following are types of signals that can be relayed through a linear transponder: E2A07

- FM and CW
- SSB and SSTV
- PSK and packet

**All these choices are correct**

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

PACSAT: Packet radio store-and-forward systems in space

The meaning of the term "mode" as applied to an amateur radio satellite is **the satellite's uplink and downlink frequency bands**. E2A04.

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

| Band | Frequency |
|---|---|
| L | 1-2 GHz |
| S | 2-4 GHz |
| C | 4-8 GHz |
| X | 8-12 GHz |

In regard to satellite communications, the terms "L band" and "S band" specify **the 23 centimeter and 13 centimeter bands**. E2A09

The 23 band is the 1300 MHz, the 13 cm band is the 2300 MHz.

Microwave Frequency Bands are frequently designated by letters

## 2A – Orbital Mechanics

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

**Geostationary** is the type of satellite that appears to stay in one position in the sky. E2A10

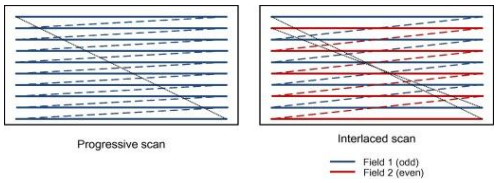
## 2B - Fast-Scan Television Standards & Techniques

**Transmitting on channels shared with cable TV** is a technique that allows commercial analog TV receivers to be used for fast-scan TV operation on the 70 cm band. E2B08

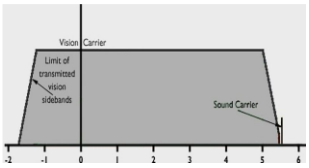
**30** times per second is a new frame transmitted in a fast-scan (NTSC) television system. E2B01

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

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



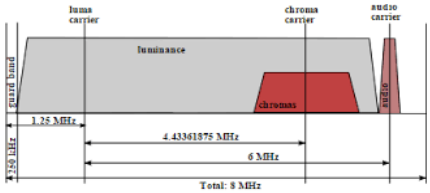

The use of vestigial sideband in analog fast-scan TV transmission can be described as **vestigial sideband reduces bandwidth while allowing for simple video detector circuitry**. E2B05




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

## 2B - Television Practices

**Chroma** is the name of the signal component that carries color information in NTSC video. E2B07



## 2B - Slow-Scan Television Standards & Techniques

**Color lines are sent sequentially** is how color information is sent in analog SSTV. E2B04

The aspect of an analog slow-scan television signal that encodes the brightness of the picture is **tone frequency**. E2B10

The function of the Vertical Interval Signaling (VIS) code sent as part of an SSTV transmission is **to identify the SSTV mode being used**. E2B11

**Specific tone frequencies** are what signals SSTV receiving software to begin a new picture line. E2B12

**No other hardware is needed** other than a receiver with SSB capacity and a suitable computer, is needed to decode SSTV using Digital Radio Mondiale (DRM). E2B09

## 2C – RF Network Connected Systems

**Frequencies shared with various unlicensed wireless data service**s are frequencies that are sometimes used for amateur radio mesh networks. E2C04

**A wireless router running custom firmware** is the type of equipment commonly used to implement an amateur radio mesh network. E2C09

The technique that individual nodes use to form a mesh network is **discovery and link establishment protocols**. E2C12

## 2C – Contesting & DX Operating

A DX station may state that they are listening on another frequency is: E2C10

- Because the DX station may be transmitting on a frequency that is prohibited to some responding stations
- To separate the calling stations from the DX station
- To improve operating efficiency by reducing interference

**All these choices are correct**

You should generally identify your station when attempting to contact a DX station during a contest or in a pileup by **send your full call sign once or twice**. E2C11

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

**Contacts between a U.S. station and a non-U.S. station** may be confirmed through the U.S. QSL bureau system. E2C08

Amateur radio contesting is generally excluded from the **30 meters** band. E2C03

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

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

The description that best describes the term "self-spotting" in connection with HF contest operating is **the often-prohibited practice of posting one's own call sign and frequency on a spotting network**. E2C02

## 2C - Remote Operation Techniques

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

## 2D – JT65

The type of modulation that is used for JT65 contacts is **multi-tone AFSK**. E2D09

## 2D - APRS

An APRS station can be used to help support a public service communications activity because **an APRS station with Global Positioning System unit can automatically transmit information to show a mobile station's position during the event**. E2D10


**APRS** is the technology used to tract, in real time, balloons carrying amateur radio transmitters. E2D04.

The digital protocol that is used by APRS is **AX.25**. E2D07

**Unnumbered Information** is the type of packet frame that is used to transmit APRS beacon data. E2D08

The data used by APRS network to communicate station location is **latitude and longitude**. E2D11

## 2D – EME Procedures

**JT65** is the digital mode that is especially useful for EME communications. E2D03.

One advantage of the JT65 mode is **the ability to decode signals which have a very low signal-to-noise ratio**. E2D05

**Time synchronous transmissions alternately from each station** describes a method of establishing EME contacts. E2D06

## 2D - Meteor Scatter Procedures

**MAK144** is the digital mode designed for meteor scatter communications. E2D01

A good technique for making meteor scatter contacts is: E2D02

- 15-second timed transmission sequences with stations alternating based on location
- Use of special digital modes
- Short transmissions with rapidly repeated call signs and signal reports

**All these choices are correct**

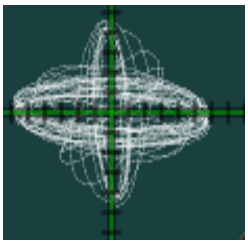
## 2E – Operating Methods

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

ALE = Automatic Link Establishment

**FSK** is a type of modulation that is common for data emissions below 30 MHz. E2E01

If one of the ellipses in an FSK cross-ellipse display suddenly disappears, it indicates **selective fading has occurred**. E2E04



The difference between direct FSK and audio FSK is that **direct FSK applies the data signal to the transmitter VFO, while AFSK transmits tones via phone**. E2E11

The possible reason that attempts to initiate contact with a digital station on a clear frequency are unsuccessful are: E2E07

- Your transmit frequency is incorrect
- The protocol version you are using is not supported by the digital station
- Another station you are unable to hear is using the frequency

**All these choices are correct**

As related to digital operation, FEC means **Forward Error Correction**. E2E02

## 2E - Operating HF Digital Modes

**PSK31** is the digital mode with the narrowest bandwidth. E2E10

**PSK31** is the HF digital mode that uses variable-length coding for bandwidth efficiency. E2E09

## 2E – Operating HF Digital Modes

The most common data rate used for HF Packet is **300 baud**. E2E06

**300 baud packet** is the digital mode that has the fastest data throughput under clear communication conditions. E2E13

**PACTOR** is the digital mode that does not support keyboard-to-keyboard operation. E2E05

**PACTOR** is the HF digital mode that can be used to transfer binary files. E2E08

The timing of FT4 contacts is organized by **alternating transmissions at 7.5 second intervals**. E2E03

# **Subelement** E3 – Radio Wave Propagation

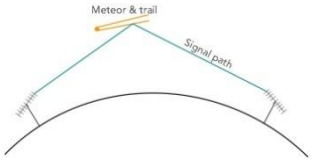
| | |
|---|---|
| 3A – Electromagnetic Waves | |
| 3B – Propagation | 3 sub sections |
| 3C – Radio Horizon | 3 questions |

## 3A - Auroral Propagation

**The interaction in the E layer of charged particles from the Sun with the Earth's magnetic field** is what causes auroral activity. E3A12

**CW** is the best emission mode for auroral propagation. E3A13

## 3A - Meteor Scatter



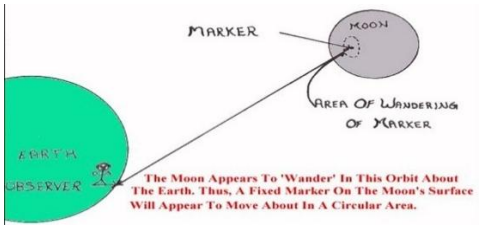

When a meteor strikes the Earth's atmosphere, a cylindrical region of free electrons is formed at **the E layer** of the atmosphere. E3A08

**28 MHz – 148 MHz** is the frequency range most suited for meteor scatter communications. E3A09

## 3A - Earth-Moon-Earth Communications

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

**A fluttery irregular fading** characterizes libration fading of an EME signal. E3A02

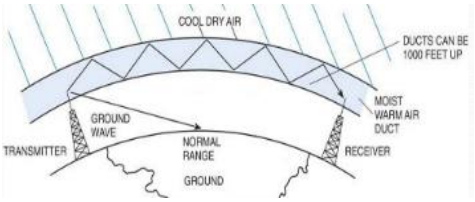



When scheduling EME contacts, a condition that will generally result in the least path loss is **when the moon is at perigee**. E3A03

## 3A – Ionospheric Propagation Changes Over the Day

If you **switch to a lower frequency HF band**, this might help to restore contact when DX signals become too weak to copy across an entire HF band a few hours after sunset. E3A06

## 3A – Microwave Tropospheric & Scatter Propagation

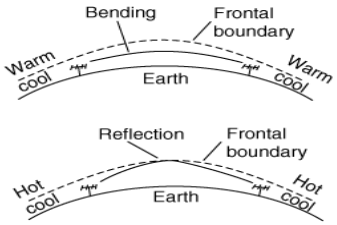



The geographic feature over which atmospheric ducts form and are capable of propagating microwave signals is **over bodies of water**. E3A07

Hepburn maps predict the **probability of tropospheric propagation**. E3A04

Tropospheric propagation of microwave signals often occurs in association with the phenomenon of **warm and cold fronts**. E3A05

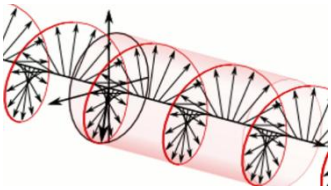
A typical range for tropospheric propagation of microwave signals is **100 miles to 300 miles**. E3A11




**Temperature inversion** is a type of atmospheric structure that can create a path for microwave propagation. E3A10

## 3A – Circular Polarization

A circularly polarized electromagnetic wave are **waves with a rotating electric field**. E3A14

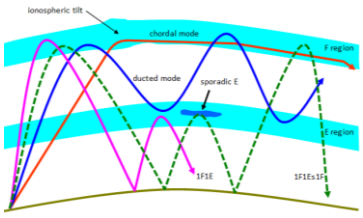


## 3B - Long-Path

The amateur bands that typically support long-path propagation are the **160 meters and 10 meters**. E3B05

The amateur band that most frequently provides long-path propagation is **20 meters**. E3B06

## 3B – Chordal Hop




Chordal hop propagation is desirable because **the signal experiences less loss compared to multi-hop using Earth as a reflector**. E3B10

The primary characteristic of chordal hop propagation is the **successive ionospheric refractions without an intermediate reflection from the ground**. E3B12

## 3B - Ordinary and Extraordinary Waves

The terms “extraordinary” and “ordinary” waves mean **independent waves created in the ionosphere that are elliptically polarized**. E3B04

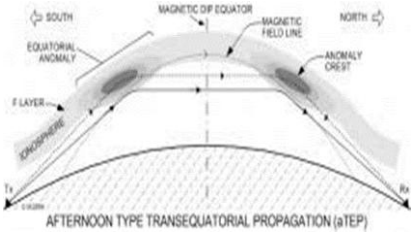
When linearly polarized radio waves are split into ordinary and extraordinary waves in the ionosphere, **they become elliptically polarized**. E3B07

## 3B - Sporadic E Mechanisms

**Around the solstices, especially the summer solstice** is the time of year when sporadic E propagation is most likely to occur. E3B09

At **any time** of the day, sporadic E propagation can occur. E3B11

## 3B - Transequatorial Propagation




Transequatorial propagation is **propagation between two mid-latitude points at approximately the same distance north and south of the magnetic equator**. E3B01

**5000 miles** is the approximate maximum range for signals using transequatorial propagation. E3B02

**Afternoon or early evening** is the best time of day for transequatorial propagation. E3B03

## 3C - Radio Horizon

The VHF/UHF radio horizon distance exceeds the geometric horizon **by approximately 15 percent of the distance**. E3C06

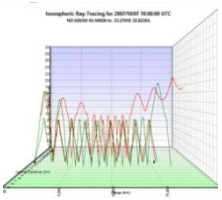
The radio-path horizon distance exceeds the geometric horizon because the **downward bending due to density variations in the atmosphere**. E3C14

## 3C – Ground Wave

**Vertical** is the type of polarization best for ground-wave propagation. E3C13

The maximum range of ground-wave propagation changes, **it decreases**, when the signal frequency is increased. E3C12

## 3C – Propagation Prediction Techniques & Modeling



The radio communication term “ray tracing” describes **modeling a radio wave’s path through the ionosphere**. E3C01

VOACAP software models **HF propagation**. E3C11

VOACAP = Voice of America Coverage Analysis Program

## 3C – Effects of Space Weather on Propagation

A **polar** signal path is most likely to experience high levels of absorption when the A index or K index is elevated. E3C03

A sudden rise in radio background noise across a large portion of the HF spectrum might indicate **a solar flare has occurred**. E3C15

The **Class X** descriptor indicates the greatest solar flare intensity. E3C07

The intensity of an X3 flare is **50 percent greater** when compared to that of an X2 flare. E3C09

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

A rising A or K index indicates an **increasing disruption of the geomagnetic field**. E3C02

The value of Bz (B sub Z) represents the **direction and strength of the interplanetary magnetic field**. E3C04

A **Southward** orientation of Bz (B sub Z) increases the likelihood that incoming particles from the sun will cause disturbed conditions. E3C05

The space weather term "G5" means **an extreme geomagnetic storm**. E3C08

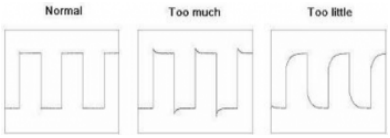
# Subelement E4 – Amateur Practice

| | |
|---|---|
| 4A – Test Equipment | |
| 4B – Measurement Technique | 5 sub sections |
| 4C – Receiver Performance (1) | 5 questions |
| 4D – Receiver Performance (2) | |
| 4E – Noise Suppression and Interference | |

## 4A – RF Measurements

The purpose of the prescaler function on a frequency counter is that **it divides a higher frequency signal so a low-frequency counter can display the input frequency**. E4A05

## 4A - Oscilloscopes

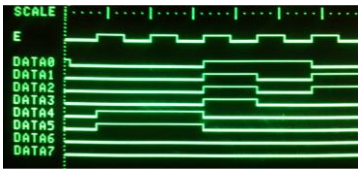



Compensating of an oscilloscope probe is typically adjusted by **a square wave is displayed and the probe is adjusted until the horizontal portions of the display wave are as nearly flat as possible**. E4A04

A good practice when using an oscilloscope probe is to **keep the signal ground connection of the probe as short as possible**. E4A09

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

The effect of aliasing on a digital oscilloscope caused by setting the time base too slow is **a false, jittery low-frequency version of the signal is displayed**. E4A06




The **logic analyzer** displays multiple digital signal states simultaneously. E4A10

## 4A - Spectrum Analyzers

**RF amplitude and frequency** are the parameters that a spectrum analyzer displays on the vertical and horizontal axes. E4A02

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

## 4A - Antenna and Network Analyzers


**An antenna analyzer** measures SWR. E4A08

An advantage to using an antenna analyzer compared to an SWR bridge to measure antenna SWR is **antenna analyzers do not need an external RF source**. E4A07

**Connect the antenna feed line directly to the analyzer's connector** is how an antenna analyzer should be connected when measuring antenna resonance and feed point impedance. E4A11

The following can be measured with a vector network analyzer: E4B11

- Input impedance
- Output impedance
- Reflection coefficient

**All these choices are correct**

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

A method that measures intermodulation distortion in an SSB transmitter is to **modulate the transmitter using two AF signals having non-harmonically related frequencies and observe the RF output with a spectrum analyzer**. E4B10

## 4B - Instruments Accuracy and Performance Limitations

**Time base accuracy** is a factor that most affects the accuracy of a frequency counter. E4B01

The significance of voltage sensitivity expressed in ohms per volts is **the full scale reading of the voltmeter multiplied by its ohms per volt rating will indicate the input impedance of the voltmeter.** E4B02

## 4B - Power Measurement

**75 watts** is 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. E4B06

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, this indicates **there is more power going into the antenna**. E4B09

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

"Q" is the ratio of reactance to resistance or the ratio of how much energy is stored to how much energy is dissipated.

## 4B - Scattering (S) Parameters

The S parameter that is the equivalent to forward gain is **S21**. E4B03

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

VSWR = Voltage Standing Wave Ratio

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

## 4C - MDS

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

An attenuator can be used to reduce receiver overload on the lower frequency HF bands with little or no impact on signal-to-noise ratio because **atmospheric noise is generally greater than internally generated noise even after attenuation**. E4C11

## 4C - Noise Figure

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

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

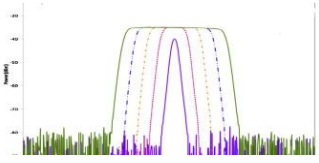
In a CW receiver with AGC off and has an equivalent input noise power density of -174 dBm/Hz, **-148 dBm** would be the level of an unmodulated carrier input to this receiver that would yield an audio output SNR of 0 dB in a 400 Hz noise bandwidth. E4C06

## 4C - Selectivity

**A front-end filter or pre-selector** receiver circuit can be effective in eliminating interference from strong out-of-band signals. E4C02

A good reason for selecting a high frequency for the design of the IF in a superheterodyne HF or VHF communications receiver is its **easier for front-end circuitry to eliminate image responses**. E4C09

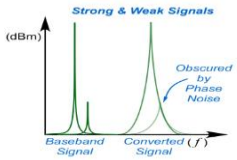
An advantage of having a variety of receiver IF bandwidths from which to select is the **receive bandwidth can be set to match the modulation bandwidth, maximizing signal-to-noise ratio and minimum interference**. E4C10



A narrow-band roofing filter affects receiver performance because **it improves dynamic range by attenuating strong signals near the receive frequency**. E4C13

A transmit frequency of **15.210 MHz** might generate an image response signal in a receiver tuned to 14.300 MHz and that uses a 455 kHz IF frequency. E4C14

## 4C - Phase Noise




The effect of excessive phase noise in a receiver's local oscillator is that **it can combine with strong signals on nearby frequencies to generate interference.** E4C01

The term reciprocal mixing is when a **local oscillator phase noise mixing with adjacent strong signals to create interference to desired signals**. E4C15

## 4C - Capture Effect

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

## 4C – Effects of SDR Receiver Non-linearity

An SDR receiver will become overloaded if the level of the input signal exceeds **the reference voltage of the analog-to-digital converter**. E4C08

**An analog-to-digital converter sample width in bits** has the largest effect on an SDR receiver's dynamic range. E4C12

## 4D - Desensitization

**Desensitization** is the reduction in receiver sensitivity caused by a strong signal near the receiver frequency. E4D12

## 4D - Preselector

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

## 4D - Blocking Dynamic Range

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

**Decrease the RF bandwidth of the receiver** will likely reduce the receiver desensitization. E4D07

## 4D – Third-order Intercept

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

## 4D - Intermodulation and Cross-modulation Interference

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

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

**Spurious signals caused by cross-modulation and desensitization from strong adjacent signals** describes problems caused by poor range in a receiver. E4D02

The term **intermodulation** means spurious signals generated by the combination of two or more signals in a non-linear device or circuit. E4D06

Intermodulation in an electronic circuit is caused by **nonlinear circuits or devices**. E4D08

Intermodulation interference between two repeaters can occur **when the repeaters are in close proximity and the signals mix in the final amplifier of one or both transmitters**. E4D03

**A properly terminated circulator at the output of the repeater's transmitter** may reduce or eliminate intermodulation interference in a repeater caused by another transmitter operating in close proximity. E4D04

## 4E – System Noise

A cause for local AM broadcast band signals to combine to generate spurious signals in the MF or HF bands is that **nearby corroded metal joints are mixing and re-radiating the broadcast signals**. E4E11

Radio frequency interference from an AC motor can be suppressed **by installing a brute- force AC-line filter in series with the motor leads**. E4E05

The cause of a loud roaring or buzzing AC line interference that comes and goes at intervals might be caused by: E4E10.

- Arcing contacts in a thermostatically controlled device
- A defective doorbell or doorbell transformer inside a nearby residence
- A malfunctioning illuminated advertising display

**All these choices are correct**

## 4E - Common-mode currents

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

The current that flows equally on all conductors of an unshielded multi-conductor cable is **common-mode current**. E4E08

## 4E - Electrical Appliance Noise

A type of electrical interference that might be caused by a nearby personal computer is **the appearance of unstable modulated or unmodulated signals at specific frequencies**. E4E06

## 4E – System Noise

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

## 4E - Noise Blankers

Signals that a receiver noise blanker might be able to remove from a desired signals are **signals that appear across a wide bandwidth**. E4E03

An undesirable effect that can occur when using an IF noise blanker is **nearby signals may appear to be excessively wide even if they meet emission standards**. E4E09

## 4E - DSP Noise Reduction

A problem that can occur when using an automatic notch filter (ANF) to remove interfering carriers while receiving CW signals is the **removal of the CW signal as well as the interfering carrier**. E4E01

The following types of noise can be reduced with a digital signal processing noise filter: E4E02.

- Broadband white noise
- Ignition noise
- Power line noise

**All these choices are correct**

# Subelement E5 – Electrical Principles

| | |
|---|---|
| 5A – Resonance and Q | |
| 5B – Time Constants and Phase | 4 sub sections |
| 5C – Coordinate Systems and Phasors | 4 questions |
| 5D – AC and RF Energy in Real Circuits | |

## 5A – Characteristics of Resonant Circuits

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

The resonance in an LC or RLC circuit is **the frequency at which the capacitive reactance equals the inductive reactive**. E5A02

The resonant frequency of an RLC circuit if R is 22 ohms,
L is 50 microhenries and C is 40 picofarads is **3.56 MHz**. E5A14

The resonant frequency of an RLC circuit if R is 33 ohms,
L is 50 microhenries and C is 10 picofarads is **7.12 MHz**. E5A16

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

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

## 5A – Characteristics of Resonant Circuits

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

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

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

## 5A – Definitions and Effects of Q

"Q" is the ratio of reactance to resistance or the ratio of how much energy is stored to how much energy is dissipated.

The effect of increasing Q in a series resonant circuit is **internal voltages increase**. E5A13

**Lower losses** increases Q for inductors and capacitors. E5A15

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

The Q of an RLC series resonant circuit is calculated by the **reactance of either the inductance or capacitance divided by the resistance**. E5A10

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

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

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

## 5B - Time Constants and Phase Relationships

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

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

## 5B - Admittance and Susception

**B** is the letter commonly used to represent susceptance. E5B02

The mathematical symbol of susceptance is the letter “B”

The magnitude of a pure reactance when it is converted to a susceptance is **it becomes the reciprocal**. E5B05

**Susceptance** is the imaginary part of admittance. E5B06

Admittance is **the inverse of impedance**. E5B12

Impedance in a polar form is converted to an equivalent admittance when you **take the reciprocal of the magnitude and change the sign of the angle**. E5B03

## 5B - Phase Angle in Reactive Circuits and Components

The relationship between the AC current through a capacitor and the voltage across a capacitor is the **current leads voltage by 90 degrees**. E5B09

The relationship between the AC current through an inductor and the voltage across an inductor is the **voltage leads current by 90 degrees**. E5B10

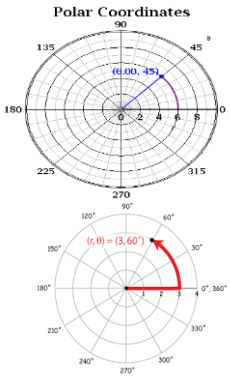
## 5B - Admittance and Susception

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

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 is **14 degrees with the voltage leading the current**. E5B11

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 is **14 degrees with the voltage lagging the current**. E5B08

## 5C - Polar coordinates



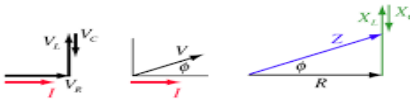

**Polar coordinates** is the coordinate system often used to display the phase angle of a circuit containing resistance. E5C08

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

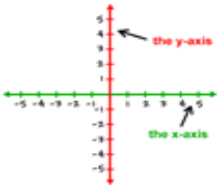
**A positive phase angle** represents an inductive reactance in polar coordinates. E5C03

## 5C – Phasors

A **phasor diagram** is the name of the diagram used to show the phase relationship between impedance at a given frequency. E5C05



## 5C – Rectangular Coordinates




**Rectangular coordinates** is the coordinate system often used to display the resistive, inductive, and/or capacitive reactance components of impedance. E5C04

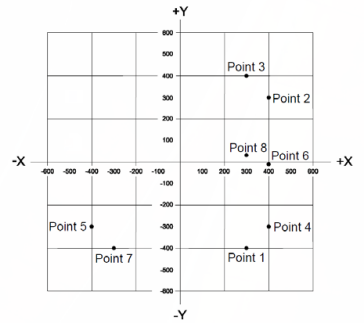
**-jX** represents capacitive reactance in rectangular notation. E5C01

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

The impedance of a pure resistance plotted on a rectangular coordinates is **on the horizontal axis**. E5C07

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

Figure E5-1




**Point 4** best represents the impedance of a series circuit consisting of a 400-ohm resistor and a 38-picofarad capacitor at 14 MHz. E5C10

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

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

## 5D - Reactive Power

Reactive power is **wattless, nonproductive power**. E5D14

When reactive power in an AC circuit that has both ideal inductors and ideal capacitors is **it is repeatedly exchanged between the associated magnetic and electrical fields, but is not dissipated**. E5D09

The power factor of an RL circuit having a 30-degree phase angle between the voltage and the current is **0.866**. E5D05

The power factor of an RL circuit having a 45-degree phase angle between the voltage and the current is **0.707**. E5D15

The power factor of an RL circuit having a 60-degree phase angle between the voltage and the current is **0.5**. E5D11

**355 w** are the watts consumed in a circuit having a power factor of 0.71 if the apparent power is 500 VA. E5D07

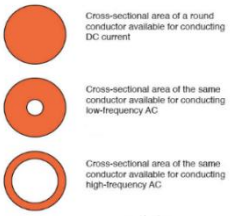
**100 w** are the watts consumed in a circuit consisting of a 100-ohm resistor in series with a 100-ohm inductive reactance drawing 1 ampere. E5D13

**600 w** are the watts consumed in a circuit having a power factor of 0.6 if the input is 200 VAC at 5 amperes. E5D08

**80 w** are the watts consumed in a circuit having a power factor of 0.2 if the input is 100 VAC at 4 amperes. E5D12

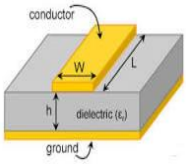
The true power can be determined in an AC circuit where the voltage and current are out of phase **by multiplying the apparent power by the power factor**. E5D10

## 5D - Skin Effect




Skin effect has the result of **as frequency increases, RF current flows in a tinner layer of the conductor, closer to the surface**. E5D01

## 5D - Microstrip



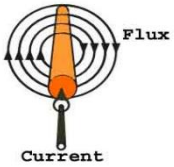

A microstrip is a **precision printed circuit conductors above a ground plane that provide constant impedance interconnects at microwave frequencies**. E5D03

## 5D – Electrical length of Conductors at UHF and Microwave Frequencies

It is important to keep lengths short for components used in circuits for VHF and above **to avoid unwanted inductive reactance**. E5D02

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

## 5D – Electromagnetic Fields




The direction of the magnetic field oriented about a conductor in relation to the direction of electron flow is **in a circle around the conductor**. E5D06

# Subelement E6 – Circuit Components

6A – Semiconductor Materials and Devices
6B – Diodes — 6 sub sections
6C – Digital IC's — 6 questions
6D – Toroidal and Solenoidal Inductors
6E – Analog IC's
6F – Electro-Optical Technology

## 6A - Semiconductor Materials

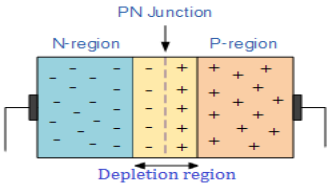
Gallium arsenide is used as a semiconductor material **in microwave circuits**. E6A01

The **N-type** semiconductor material that contains excessive free electrons. E6A02

The **acceptor impurity** is the name of the impurity atom that adds holes to a semiconductor crystal structure. E6A04

## 6A - Semiconductor Devices

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



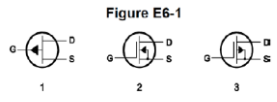

A **base-to-emitter voltage of approximately 0.6 to 0.7 volts** indicates that a silicon NPN junction transistor is biased on. E6A07

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

**Alpha cutoff frequency** is the term that indicates the frequency at which the ground-base current gain of a transistor has decreased to 0.7 of the gain obtainable a 1 kHz. E6A08

When the DC input impedance at the gate of a field-effect transistor is compared with the DC input impedance of a bipolar transistor, **an FET has higher input impedance**. E6A05

The schematic symbol for a P-channel junction FET is symbol number **1**. E6A11




The schematic symbol for a N-channel dual-gate MOSFET is symbol number **4**. E6A10

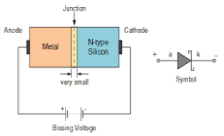
A depletion-mode FET is **an FET that exhibits a current flow between source and drain when no gate voltage is applied**. E6A09

Many MOSFET devices have internally connected Zener diodes on the gate **to reduce the chance of static damage to the gate**. E6A12

## 6B - Diodes

**Less forward voltage drop** is an important characteristic of a Schottky diode as compared to an ordinary silicon diode when used as a power supply rectifier. E6B02

A **metal-semiconductor junction** is a Schottky barrier diode. E6B08




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

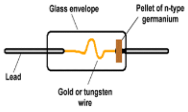
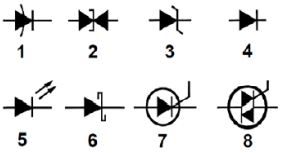



Figure E6-2

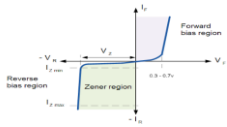
**Forward bias** is required for an LED to emit light. E6B03

LED – Light Emitting Diode

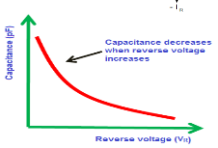
The schematic symbol for a light-emitting diode is symbol number **5**. E6B10




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




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


**Low junction capacitance** is a characteristic that makes a PIN diode useful as an RF switch. E6B05

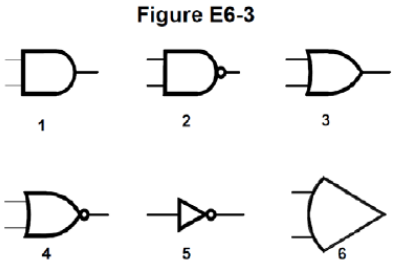
The failure mechanism when a junction diode fails due to **excessive current is excessive junction temperature**. E6B07

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

Logic Basics

| Logic Gate | Symbol | Description | Boolean |
|---|---|---|---|
| AND | | Output is at logic 1 when, and only when all its inputs are at logic 1,otherwise the output is at logic 0. | X = A•B |
| OR | | Output is at logic 1 when one or more are at logic 1.If all inputs are at logic 0,output is at logic 0. | X = A+B |
| NAND | | Output is at logic 0 when,and only when all its inputs are at logic 1,otherwise the output is at logic 1 | $X = \overline{A \cdot B}$ |
| NOR | | Output is at logic 0 when one or more of its inputs are at logic 1.If all the inputs are at logic 0,the output is at logic 1. | $X = \overline{A+B}$ |
| XOR | | Output is at logic 1 when one and Only one of its inputs is at logic 1. Otherwise is it logic 0. | $X = A \oplus B$ |
| XNOR | | Output is at logic 0 when one and only one of its inputs is at logic1.Otherwise it is logic 1. Similar to XOR but inverted. | $X = \overline{A \oplus B}$ |
| NOT | | Output is at logic 0 when its only input is at logic 1, and at logic 1 when its only input is at logic 0.That's why it is called and INVERTER | $X = \overline{A}$ |

## 6C - Digital Logic




The schematic symbol for the NOT operation (inverter) is symbol number **5**. E6C11

The schematic symbol for the NAND gate is symbol number **2**. E6C08

The schematic symbol for the NOR gate is symbol number **4**. E6C10

Tri-state logic are **logic devices with 0, 1, and high-impedance output states**. E6C03

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

## 6C - Logic Families

An advantage of CMOS logic devices over TTL devices is **lower power consumption**. E6C05

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

An advantage of BICMOS Logic is **it has the high input impedance of CMOS and the low output impedance of bipolar transistors**. E6C04

## 6C - Programmable Logic Devices (PLDs)

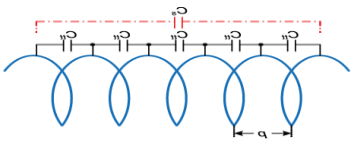
A Programmable Logic Device (PLD) is **a programmable collection of logic gates and circuits in a single integrated circuit**. E6C09

## 6C - Comparators

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

When toe level of a comparator's input signal crosses the threshold, **the comparator changes its output state**. E6C02

## 6D - Self Resonance



The primary cause of inductor self-resonance is **inter-turn capacitance**. E6D13

## 6D – Core Material

Core saturation of an impedance matching transformer should be avoided because **harmonics and distortion could result**. E6D01

Materials commonly used as a core in an inductor are **ferrite and brass**. E6D04

**Brass** is the type of core material that decreases inductance when inserted into a coil. E6D11

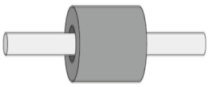
One reason for using ferrite cores rather than powdered iron in an inductor is **ferrite toroids generally requires fewer turns to produce a given inductance value**. E6D05

**Permeability** is the core material property that determines the inductance of an inductor. E6D06

One reason for using powdered-iron cores rather than ferrite cores in an inductor is **powdered-iron cores generally maintain their characteristics at higher currents**. E6D08

Inductor saturation is **the ability of the inductor's core to store magnetic energy has been exceeded**. E6D12

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



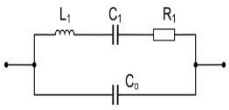
The primary advantage of using a toroidal core instead of a solenoidal core in an inductor is **toroidal cores confine most of the magnetic field within the core material**. E6D10

Toroidal

Solenoidal

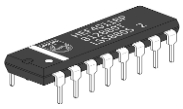
## 6D - Crystals and Oscillators

An equivalent circuit of a quartz crystal is a circuit with **motional capacitance, motional inductance, and loss resistance in series, all in parallel with a shunt capacitor representing electrode and stray capacitance**. E6D02




An aspect of the piezoelectric effect is the **mechanical deformation of material by the application of a voltage**. E6D03

## 6E – IC Packaging Characteristics



**DIP** is a device package that is a through-hole type. E6E02

DIP = dual in-line package, an integrated circuit (IC) with two parallel rows of pins

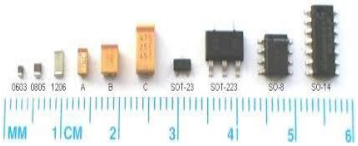
A characteristic of DIP packaging used for integrated circuits is **a total of two rows of connecting pins placed on opposite sides of the package (Dual in-line Package)**. E6E11

DIP through-hole package IC's is not typically used at UHF and higher frequencies due to **excessive lead length**. E6E12

### 6E - Principles of Circuits

Components at RF and Microwave Frequencies Effects of Component Packaging at RF

**Surface mount** is a component package type that would be most suitable for use at frequencies above HF range. E6E09




## 6E - IC Packaging Characteristics

The advantages that surface-mount technology offers at RF as compared to using through-hole components is: E6E10

- Smaller circuit area
- Shorter circuit-board traces
- Components have less parasitic inductance and capacitance

**All these choices are correct**

## 6E - MMIC

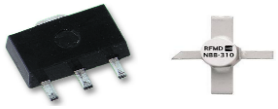
The characteristics of a MMIC that make it popular choice for VHF through microwave circuits are **controlled gain, low noise figure, and constant input and output impedance over the specified frequency range**. E6E06

MMIC = Monolithic Microwave Integrated Circuit

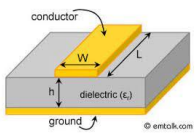
Gallium arsenide (GaAs) is useful for semiconductor devices operating at UHF and higher frequencies because of **higher electron mobility**. E6E01

The most common input and output impedance of circuits that use MMIC are **50 ohms**. E6E04

**Gallium nitride** is likely to provide the highest frequency of operation when used in MMICs. E6E03



**Microstrip** is the type of transmission line used for connections to MMICs. E6E07

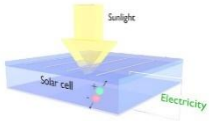


For the most common type of MMIC, the power is supplied **through a resistor and/or RF cable connected to the amplifier output lead**. E6E08

## 6E – Noise Figure

**2 dB** is the typical noise figure of a low-noise UHF preamplifier. E6E05

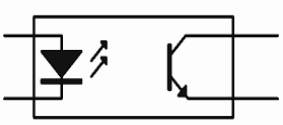
## 6F - Photoconductivity



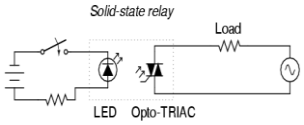

When light shines on photoconductive material, **it increases** the conductivity. E6F02

**A crystalline semiconductor** material is the most commonly used to create photoconductive devices. E6F06

## 6F – Optical Sensors and Encoders



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

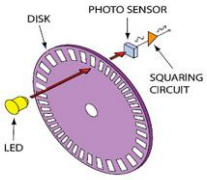




A solid-state relay is a device that uses semiconductors to implement the functions of **an electromechanical relay**. E6F07

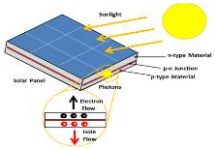
Optoisolators are often used in conjunction with solid-state circuits when switching 120 VAC because **optoisolators provide a very high degree of electrical isolation between a control circuit and the circuit being switched**. E6F08

## 6F – Optical Sensors and Encoders




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

## 6F - Photovoltaic Cells



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

Photovoltaic effect is **the conversion of light to electrical energy**. E6F04

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

**Silicon** is the most common type of photovoltaic cell used for electrical power generation. E6F10

**0.5 V** is the approximate open-circuit voltage produced by a fully illuminated silicon photovoltaic cell. E6F11

# Subelement E7 – Practical Circuits

7A – Digital Circuits
7B – Amplifiers
7C – Filters and Matching Networks
7D – Power Supplies
7E – Modulation and Demodulation
7F – DSP Filtering
7G – Active Filters and Op-amp Circuits
7H – Oscillators and Signal Sources

8 sub sections
8 questions

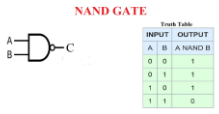
## 7A – Truth Tables

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

Truth Table

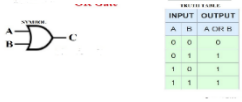
| Name | NOT | AND | NAND | OR | NOR | XOR | XNOR |
|---|---|---|---|---|---|---|---|
| Alg. Expr. | $\overline{A}$ | $AB$ | $\overline{AB}$ | $A+B$ | $\overline{A+B}$ | $A \oplus B$ | $\overline{A \oplus B}$ |
| Symbol |  |  |  |  |  |  |  |
| Truth Table | A X<br>0 1<br>1 0 | B A X<br>0 0 0<br>0 1 0<br>1 0 0<br>1 1 1 | B A X<br>0 0 1<br>0 1 1<br>1 0 1<br>1 1 0 | B A X<br>0 0 0<br>0 1 1<br>1 0 1<br>1 1 1 | B A X<br>0 0 1<br>0 1 0<br>1 0 0<br>1 1 0 | B A X<br>0 0 0<br>0 1 1<br>1 0 1<br>1 1 0 | B A X<br>0 0 1<br>0 1 0<br>1 0 0<br>1 1 1 |

In an OR gate logical operation, **it produces logic 1 at its output if any or all inputs are logic 1**. E7A08




In a NAND gate logical operation, **it produces logic 0 at its output only when all inputs are logic 1**. E7A07


In an exclusive NOR gate logical operation, **it produces logic 0 at its output if only one input is logic 1**. E7A09




## 7A – Positive and Negative Logic

**Positive Logic** is the type of logic that defines "1" as a high voltage. E7A11

## 7A - Flip-Flops

A **flip-flop** circuit is bistable. E7A01

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

**2** flip flops are required to divide a signal frequency by 4. E7A04

## 7A - Digital Logic

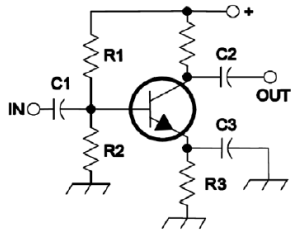
The function of a decade counter is **it produces one output pulse for every 10 input pulses**. E7A02

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

A characteristic of a monostable multivibrator is **it switches momentarily to the opposite binary state and then returns to its original state after a set time**. E7A06

## 7B - Amplifiers

Figure E7-1




The purpose of R1 and R2 is a **voltage divider bias**. E7B10

The purpose of R3 is a **self bias**. E7B11

The type of amplifier circuit shown is called a **common emitter**. E7B12

An emitter follower (or common collector) amplifier is **an amplifier with a low impedance output that follows the base input voltage**. E7B13

One way to prevent thermal runaway in a bipolar transistor amplifier is to **use a resistor in series with the emitter**. E7B15

A characteristic of a ground-grid amplifier is **low input impedance**. E7B18

## 7B - Impedance Matching

**The tuning capacitor is adjusted for minimum plate current, and the loading capacitor is adjusted for maximum permissible plate current** is how to describe 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. E7B09

## 7B - Classes of Operation

On the load line of a Class A common amplifier, the bias normally will be set at **approximately halfway between saturation and cutoff**. E7B04

The amplifier type that reduces even-order harmonics is a **push-pull**. E7B06

The portion of the signal cycle that each active element in a push-pull Class AB amplifier conducts is **more than 180 degrees but less than 360 degrees**. E7B01

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

Switching amplifiers are more efficient than linear amplifiers because **the power transistor is at saturation or cutoff most of the time**. E7B14

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

**A low-pass filter to remove switching signal components** form the output of a class D amplifier circuit. E7B03

## 7B - Distortion and Intermodulation

The effect of intermodulation products in a linear power amplifier are the **transmission of spurious signals**. E7B16

Odd-order rather than even-order intermodulation distortion products are of concern in linear power amplifiers **because they are relatively close in frequency to the desired signal**. E7B17

## 7B - Signal Processing

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

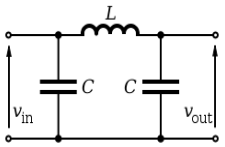
An RF power amplifier can be neutralized **by feeding a 180-degree out-of-phase portion of the output back to the input**. E7B08

## 7C - Impedance Matching

An impedance-matching circuit transforms a complex impedance to a resistive impedance when **it cancels the reactive part of the impedance and changes the resistive part to a desired value**. E7C04

## 7C - Pi and Pi-L Networks

The arrangement of capacitors and inductors of a low-pass filter Pi-network between the network's input and output are **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**. E7C01



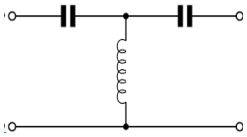

The advantage a series-L Pi-L-network has over a series-L Pi-network for impedance matching between the final amplifier of a vacuum-tube transmitter and an antenna is **greater harmonic suppression**. E7C03

One advantage of a Pi-matching network over an L-matching network consisting of a single inductor and a single capacitor is **the Q of Pi-networks can be controlled**. E7C12

A description of a Pi-L-network used for matching a vacuum tube final amplifier to a 50-ohm unbalanced output is **a Pi-network with an additional series inductor on the output**. E7C07

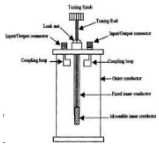
## 7C – T Networks

A property of a T-network with series capacitors and a parallel shunt inductor is **it is a high-pass filter**. E7C02



T

## 7C - Passive and Active Filters



**A cavity filter** would be the best choice for use in a 2 meter band repeater duplex. E7C10

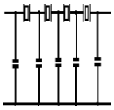
## 7C - Filter Design

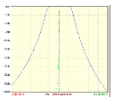
The filter type described as having ripple in the passband and a sharp cutoff is **a Chebyshev filter**. E7C05

A distinguishing feature of an elliptical filter is an **extremely sharp cutoff with one or more notches in the stop band**. E7C06

A **shape factor** describes a receiving filter's ability to reject signals occupying an adjacent channel. E7C11

## 7C - Crystal Filters





A crystal ladder filter is **a filter with narrow bandwidth and steep skirts made using quartz crystals**. E7C09

**The relative frequencies of the individual crystals** is the factor that has the greatest effect on the bandwidth and response shape of a crystal ladder filter. E7C08

## 7D - Linear Voltage Regulators

A linear electronic voltage regulator works when **the conduction of a control element is varied to maintain a constant output voltage**. E7D01

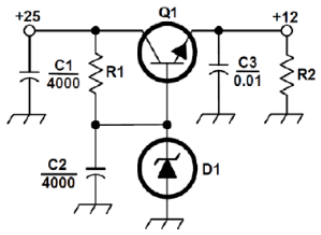
**A Zener diode** is a device that is typically used as a stable voltage reference in a linear voltage regulator. E7D03

**A shunt regulator** is a type of linear voltage regulator that places a constant load on the unregulated voltage source. E7D05

## 7D - Linear Voltage Regulators

The purpose of Q1 is **it controls the current supplied to the load**. E7D06

Figure E7-2




The purpose of C2 is **it bypasses rectifier output ripple and D1**. E7D07

## 7D - Linear Voltage Regulators

The type of circuit shown is a **linear voltage regulator**. E7D08

The function of the pass transistor in a linear voltage regulator circuit is to **maintain nearly constant voltage over a wide range of load current**. E7D11

The dropout voltage of an analog voltage regulator is the **minimum input-to-output voltage required to maintain regulation**. E7D12

## 7D - Efficiency and Power Dissipation

**A series regulator** is a type of linear voltage regulator that usually makes the most efficient use of the primary power source. E7D04

The equation for calculating power dissipated by a series linear voltage regulator is the **voltage difference from input to output multiplied by output current**. E7D13

## 7D - Battery Charging Regulators

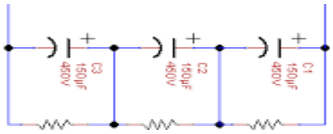
The main reason to use a charge controller with a solar power system is the **prevention of battery damage due to overcharging**. E7D09

## 7D – Switching Regulators

A characteristic of a switching electronic voltage regulator is **the controlled device's duty cycle is changed to produce a constant average output voltage**. E7D02

The primary reason that a high-frequency switching type high-voltage power supply can be both less expensive and lighter in weight than a conventional power supply is **the high frequency inverter design uses much smaller transformers and filter components for an equivalent power output**. E7D10

## 7D - High Voltage Techniques



The purpose of connecting equal-value resistors across power supply filter capacitors connected in series is: E7D14

- Equalize the voltage across each capacitor
- Discharge the capacitors when voltage is removed
- Provide a minimum load on the supply

**All these choices are correct**

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

## 7E - Mixers

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

When an excessive amount of signal energy reaches a mixer circuit **spurious mixer products are generated**. E7E09

## 7E - Modulators

The term “baseband” in radio communication means **the frequency range occupied by a message signal prior to modulation**. E7E07

## 7E - Signal Processing

One way a single-sideband phone signal can be generated is **by using a balanced modulator followed by a filter.** E7E04

**A reactance modulator on the oscillator** can be used to generate FM phone emissions. E7E01

The function of a reactance modulator is **to produce PM or FM signals by using an electrically variable inductance or capacitance**. E7E02

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

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

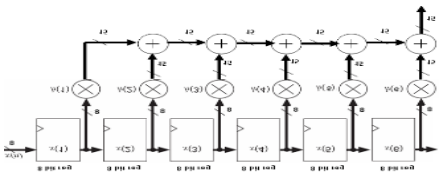
The frequency discriminator stage in a FM receiver is **a circuit for detecting FM signals**. E7E03

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

A **product detector** is the type of detector circuit used for demodulating SSB signals. E7E11

## 7F - Digital Signal Processing (DSP) Filters

**An adaptive filter** is the kind of digital signal processing filter used to remove unwanted noise from a received SSB signal. E7F02



The function of taps in a digital signal processing filter is to **provide incremental signal delays for filter algorithms**. E7F13

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

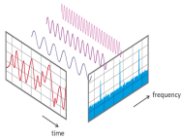
An advantage of a Finite Impulse Response (FIR) filter vs an Infinite Impulse Response (IIR) digital filter is the **FIR filters can delay all frequency components of the signal by the same amount**. E7F12

## 7F - Digital Signal Processing (DDS)

A frequency must be **at least twice the rate of the highest frequency component of the signal** for an analog signal to be sampled by an analog-to-digital converter so that the signal cab be accurately reproduced. E7F05

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

A **reference voltage level and sample width in bits** is what sets the minimum detectable signal level for a direct-sampling SDR receiver in the absence of atmospheric or thermal noise. E7F11




**Converting digital signals from the time domain to the frequency domain** is the function performed by a Fast Fourier Transform. E7F07

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

An anti-aliasing digital filter is required in a digital decimator because **it removes high-frequency signal components that would otherwise be reproduced as lower frequency components**. E7F09

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

A common method of generating an SSB signal using digital signal processing is when **signals are combined in quadrature phase relationship**. E7F04

## 7F - Software Defined Radio (SDR)

Direct digital conversion as applied to software defined radio means **incoming RF is digitized by an analog-to-digital converter without being mixed with a local oscillator signal**. E7F01

**Sample rate** is the aspect of receiver analog-to-digital conversion that determines the maximum receive bandwidth of a Direct Digital Conversion SDR. E7F10

## 7G – Op Amp Amplifiers

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

## 7G - Op Amp Characteristics

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

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

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

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

How does the gain of an ideal operational amplifier vary with frequency, **it does not vary with frequency**. E7G08

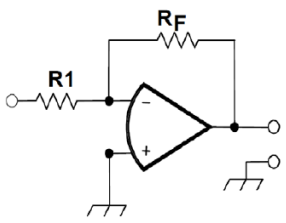
Trick question

## 7G - Basic Amplifier Circuits

When R1 is 10 ohms and RF is 470 ohms, the magnitude of voltage gain that can be expected is **47**. E7G07

When R1 is 1000 ohms and RF is 10,000 ohms, and 0.23 volts DC is applied to the input, the output voltage of the circuit would be **-2.3 volts**. E7G09

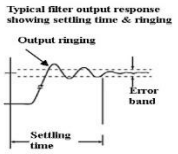
Figure E7-3




When R1 is 1800 ohms and RF is 68 kilohms, the absolute voltage gain that can be expected from the circuit is **38**. E7G10

When R1 is 3300 ohms and RF is 47 ohms, the absolute voltage gain that can be expected from the circuit is **14**. E7G11

## 7G - Filters




Ringing in a filter is the **undesired oscillations added to the desired signal**. E7G02

You can prevent the unwanted ringing and audio instability in an op-amp RC audio filter circuit when you **restrict both gain and Q**. E7G05

## 7H - RF Oscillations

**Colpitts, Hartley and Pierce** are the three oscillator circuits used in amateur radio equipment. E7H01

A positive feedback is supplied in a Hartley oscillator **through a tapped coil**. E7H03

A positive feedback is supplied in a Colpitts oscillator **through a capacitive divider**. E7H04

A positive feedback is supplied in a Pierce oscillator **through a quartz crystal**. E7H05

## 7H - Basic Amplifier Circuits

A technique for providing highly accurate and stable oscillators needed for microwave transmissions and reception is: E7H13

- Use a GPS signal reference
- Use a rubidium stabilized reference oscillator
- Use a temperature-controlled high Q dielectric resonator

**All these choices are correct**

**Colpitts and Hartley** are oscillator circuits commonly used in VFO's. E7H06

## 7H - Microphonics and Thermal Drift

A microphonic is **changes an oscillation frequency due to mechanical vibration**. E7H02

An oscillator's microphonic responses can be reduced by **mechanically isolate the oscillator circuitry from its enclosure**. E7H07

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

NPO = negative-positive zero temperature coefficients

## 7H - Direct Digital Synthesizers (DDS)

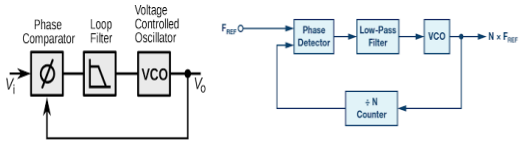
**A direct digital synthesizer** is the type of frequency synthesizer circuit that uses a phase accumulator, lookup table, digital to analog converter, and a low-pass anti-alias filter. E7H09

Information contained in the lookup table of a direct digital synthesizer (DDS) is **amplitude values that represent the desired waveform**. E7H10

The major special impurity components of direct digital synthesizers is **spurious signals at discrete frequencies**. E7H11

## 7H - Phase-Locked Loops (PLL)

A phase-locked loop circuit is **an electronic servo loop consisting of a phase detector, a low-pass filter, a voltage-controlled oscillator, and a stable reference oscillator**. E7H14




A phase-locked loop can perform the function of **frequency synthesis, FM demodulation**. E7H15

## 7H - Crystals and Oscillators

To ensure that a crystal oscillator provides the frequency specified by the crystal manufacturer, you must **provide the crystal with a specified parallel capacitance**. E7H12

# Subelement E8 – Signals and Emissions

| | |
|---|---|
| 8A – AC Waveforms | |
| 8B – Modulation and Demodulation | 4 sub sections |
| 8C – Digital Signals | 4 questions |
| 8D – Keying Defects and Overmodulation | |

## 8A – Signals and Emissions

With respect to analog-to-digital converters, a "dither" is **a small amount of noise added to the input signal to allow more precise representation of a signal over time**. E8A04

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

The purpose of a low-pass filter used with a digital-to-analog converter is to **remove harmonics from the output caused by the discrete analog levels generated**. E8A10

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

## 8A - Analog-to-Digital Conversion

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

A direct or flash conversion analog-to-digital converter would be useful for a software defined radio because **very high speed allows digitizing high frequencies**. E8A08

## 8A - RMS Measurements

**A true-RMS calculating meter** would be the most accurate for measuring the RMS voltage of a complex waveform. E8A05

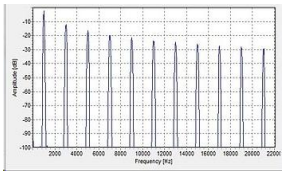
RMS – Root-mean-square

## 8A - RF Wattmeters

The approximate ratio of PEP-to-average power in a typical single-sideband phone signal is **2.5 to 1**. E8A06

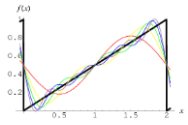
**Speech characteristics** determine the PEP-to-average power ratio of a single-sideband phone signal. E8A07

## 8A - The Spectrum Analyzer



The name of the process that shows that a square wave is made up of a sine wave plus all its odd harmonics is called **Fourier analysis**. E8A01

A Fourier analysis of **a sawtooth wave** shows it to be made up of sine waves of a given fundamental frequency plus all its harmonics. E8A03



## 8B - Deviation Ratio

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

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 is **1.67**. E8B05

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 is **2.14**. E8B06

## 8B - Modulation Index

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

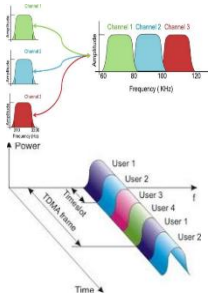
The modulation index of a phase-modulated emission varies with RF carrier frequency in that **it does not depend on the RF carrier frequency**. E8B02

Trick question

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 is **3**. E8B03

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 is **3**. E8B04

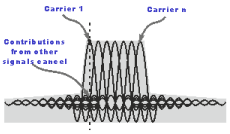
## 8B - Multiplexing




Frequency division multiplexing is **two or more information streams are merged into a baseband, which then modulates the transmitter**. E8B10

Digital time division multiplexing is **two or more signals are arranged to share discrete time slots of a data transmission**. E8B11

## 8B - OFDM Modulation




Orthogonal Frequency Division Multiplexing is described as **A digital modulation technique using subcarriers at frequencies chosen to avoid intersymbol interference**. E8B08

**High-speed digital modes** is the type of amateur communication where the technique of Orthogonal Frequency Division Multiplexing is used. E8B07

## 8C - Error Detection and Correction

Forward Error Correction is implemented **by transmitting extra data that may be used to detect and correct transmission errors**. E8C01

The way ARQ accomplishes error correction is **if errors are detected, a retransmission is requested**. E8C08

## 8C - Symbol Rate, Data Rate, and Bandwidth

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

The relationship between symbol rate and baud is **they are the same**. E8C11

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

## 8C - Protocols and Codes

The **Gray code** is the digital code that allows only one bit to change between sequential code values. E8C09

## 8C - Digital Modes

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

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

The bandwidth of a 170-hertz shift, 300-baud ASCII transmission is **0.5 kHz**. E8C06

The bandwidth of a 4800-Hz frequency shift, 9600-baud ASCII FM transmission is **15.36 kHz**. E8C07

Phase-shifting of a PSK signal should be done at the zero crossing of the RF signal **to minimize bandwidth**. E8C03

The **use of sinusoidal data pulses** is a technique that minimizes the bandwidth of a PSK31 signal. E8C04

## 8D - Digital Protocols and Modes

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

An advantage of using ASCII code for data communications is **it is possible to transmit both upper and lower case text**. E8D11

Some of the differences between the Baudot digital code and ASCII are **Baudot uses 5 data bits per character, ASCII uses 7 or 8; Baudot uses 2 characters as letters/figures shift codes, ASCII has no letters/figures shift code**. E8D10

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

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

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

AFSK is Audio Frequency Shift Keying

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

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

## 8D - Spread Spectrum Techniques

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

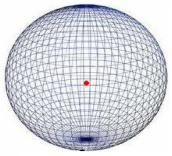
The way the spread spectrum technique of frequency hopping works is the **frequency of the transmitted signal is changed very rapidly according to a pseudorandom sequence also used by the receiving station**. E8D03

The spread spectrum communications technique that uses a high-speed binary bit stream to shift the phase of an RF carrier is **direct sequence**. E8D02

# Subelement E9 – Antennas & Transmission Lines

| | |
|---|---|
| 9A – Basic Antenna Parameters | |
| 9B – Antenna Patterns and Designs | 8 sub sections |
| 9C – Practical Wire Antennas | 8 questions |
| 9D – Yagi Antennas | |
| 9E – Matching | |
| 9F – Transmission Lines | |
| 9G – The Smith Chart | |
| 9H – Receiving Antennas | |

## 9A - Antenna Gain



An isotropic antenna is a **theoretical, omnidirectional antenna used as a reference for antenna gain**. E9A01

**3.85 dB** is the gain an antenna has compared to a ½-wavelength dipole when it has a 6 dB gain over an isotropic antenna. E9A12

## 9A - Radiation Resistance

The radiation resistance of an antenna is **the value of a resistance that would dissipate the same amount of power as that radiated from an antenna**. E9A03

The total resistance of an antenna system includes the **radiation resistance plus loss resistance**. E9A05

## 9A - Feed Point Impedance

A factor that affects the feed point impedance of an antenna is **antenna height**. E9A04

## 9A - Antenna Efficiency

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

## 9A - Bandwidth

Antenna bandwidth is **the frequency range over which an antenna satisfies a performance requirement**. E9A08

## 9A - Effects of Ground and Ground System

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

**Soil conductivity** is a factor that determines ground losses for a ground-mounted vertical antenna in the 3 MHz to 30 MHz range. E9A11

## 9A - Effective Radiated Power

The term that describes station output, taking into account all gains and losses is **effective radiated power**. E9A13

**286 watts** 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 dB antenna gain. E9A02

**317 watts** 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. E9A06

**252 watts** is the effective isotropic radiated power of a dipole 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. E9A07

## 9B - Antenna Modeling and Design

**Method of Moments** is a type of computer program technique commonly used for modeling antennas. E9B09

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

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

## 9B - Antenna Radiation Patterns

The far field of an antenna is **the region where the shape of the antenna pattern is independent of distance**. E9B08

## 9B - Antenna Gain

When the total amount of radiation emitted by a directional gain antenna is compared with the total amount of radiation emitted from a theoretical isotropic antenna, assuming each is driven by the same amount of power, **they are the same**. E9B07

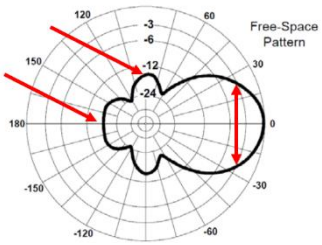
## 9B - Beamwidth and Pattern Ratios

Beamwidth is measured where the main lobe crosses the -3 dB circle.

Front-to-back ratio is read where the exact opposite of the main lobe is at the 180-degree mark.

Front-to-side ratio is read where the main lobe is at the 90-degree mark

Figure E9-1



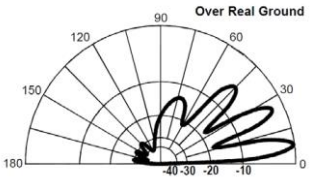

The beamwidth is **50 degrees**. E9B01

The front-to-back ratio is **18 dB**. E9B02

The front-to-side ratio is **14 dB**. E9B03

## 9B - Antenna Pattern Types

Figure E9-2




This type of antenna pattern is called an **elevation**. E9B05

The front-to-back ratio is **28 dB**. E9B04

The elevation angle of peak response is **7.5 degrees**. E9B06

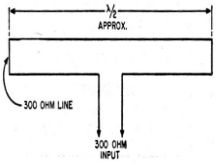
## 9C - Effects of Ground and Ground System

The affect on the far-field elevation pattern of a vertically polarized antenna when mounted over seawater verses soil is **the low-angle radiation increases**. E9C11

When you increase the height above ground of a horizontally polarized 3-element beam antenna, the radiation pattern will vary, **the takeoff angle of the lowest elevation lobe decreases**. E9C13

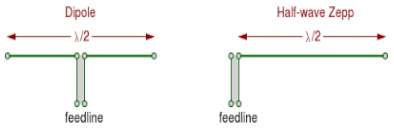
The performance of a horizontally polarized antenna mounted on the side of a hill as compared to the same antenna mounted on flat ground is **the main lobe takeoff angle decreases in the downhill direction**. E9C14

## 9C - Dipole Variations

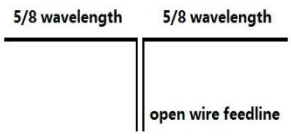



A folded dipole antenna is **a half-wave dipole with an additional parallel wire connecting its two ends**. E9C08

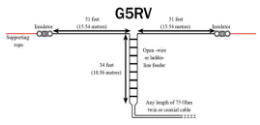
The approximate feed point impedance at the center of a two-wire folded dipole antenna is **300 ohms**. E9C07




A Zepp antenna can be described as **an end-fed dipole antenna**. E9C10

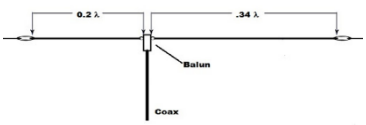



An Extended Double Zepp antenna can be described as **a center-fed 1.25-wavelength antenna (two 5/8-wave elements in phase)**. E9C12




A G5RV antenna can be described as **a multi-band dipole antenna fed with coax and a balun through a selected length of open wire transmission line**. E9C09

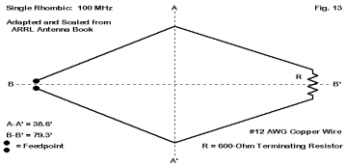
**A dipole fed approximately 1/3 the way from one end with a 4:1 balun to provide multiband operation** is a type of OCFD antenna. E9C05

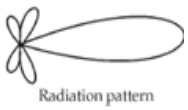



## 9C - Traveling Wave Antennas

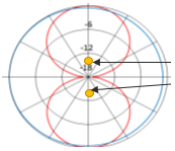
**The lobes align more in the direction of the wire** is what happens to the radiation pattern of an unterminated long wire antenna as the wire length is increased. E9C04

The effect of adding a terminating resistor to a rhombic antenna is **it changes the radiation pattern from bidirectional to unidirectional**. E9C06

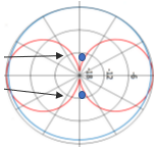


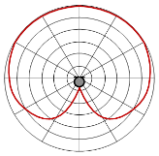

## 9C - Phased Arrays



The radiation pattern of two ¼-wavelength vertical antennas spaced ½-wavelength apart and fed 180 degrees out of phase is **a figure-8 oriented along the axis of the array**. E9C01



The radiation pattern of two ¼-wavelength vertical antennas spaced ½-wavelength apart and fed in phase is **a figure-8 broadside to the axis of the array**. E9C03



The radiation pattern of two ¼-wavelength vertical antennas spaced 1/4-wavelength apart and fed 90 degrees out of phase is **cardioid.** E9C02

## 9D - Design Tradeoffs and Optimization

If a Yagi antenna is designed solely for maximum forward gain, what usually occurs is **the front-to-back ratio decreases**. E9D05

## 9D - Bandwidth

Q = the energy stored in the fields around the antenna divided by the power it radiates.

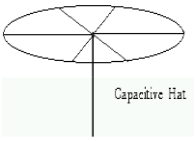
As the Q of an antenna increases, the **SWR bandwidth decreases**. E9D08

## 9D - Loaded Whips

A high Q loading coil should be placed **near the center of the vertical radiator** to minimize losses in a shortened vertical antenna. E9D03

An HF mobile antenna loading coil should have a high ratio of reactance to resistance, **to minimize losses**. E9D04

When one or more loading coils are used to resonate an electrically short antenna, the change to the SWR bandwidth is **it is decreased**. E9D06



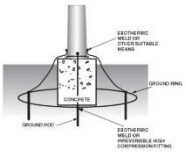

An advantage of using top loading in a shortened HF vertical antenna is **improved radiation efficiency**. E9D07

The function of a loading coil used as part of an HF mobile antenna is **to cancel capacitive reactance**. E9D09

**The radiation resistance decreases and the capacitive reactance increases** is what happens to feed-point impedance at the base of a fixed length HF mobile antenna when operated below its resonant frequency. E9D10

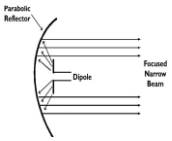
## 9D - Ground Connection

**Wide flat copper strap** would be the conductor best for minimizing losses in a station's RF ground system. E9D11

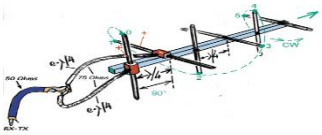


**An electrically short connection to 3 or 4 interconnected ground rods driven into the Earth** would provide the best RF ground for your station. E9D12

## 9D - Antennas for Space Communications

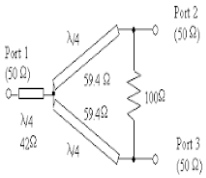



The gain of an ideal parabolic dish antenna changes **6 dB** when the operating frequency is doubled. E9D01



Linearly polarized Yagi antennas can be used to produce circular polarization when you **arrange two Yagis perpendicular to each other with the driven elements at the same point on the boom fed 90 degrees out of phase**. E9D02

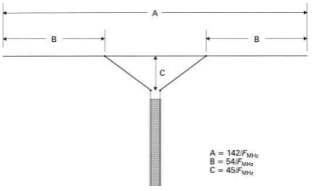
## 9E - Phased Arrays




A use for a Wilkinson divider is **it is used to divide equally between two 50-ohm loads while maintaining 50-ohm input impedance**. E9E08

The primary purpose of phasing lines when used with an antenna having multiple driven elements is **it ensures that each driven element operates in concert with the others to create the desired antenna pattern**. E9E11

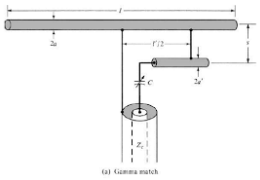
## 9E - Impedance Matching




**The delta matching system** matches a higher-impedance transmission line to a lower-impedance antenna by connecting the

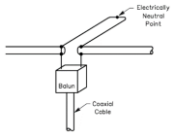
line to the driven element in two places spaced a fraction of a wavelength each side of element center. E9E01

**Gamma match** is used to shunt-feed a grounded tower at its base. E9E09

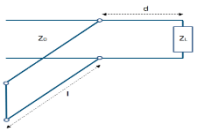


**The gamma match** is the antenna matching system that matches an unbalanced feed line to an antenna by feeding the driver element both at the center of the element and at a fraction of a wavelength to one side of center. E9E02

The purpose of the series capacitor in a gamma-type antenna matching network is **to cancel the inductive reactance of the matching network**. E9E04




To tune an antenna's driven element to use a hairpin matching system, **the driven element reactance must be capacitive**. E9E05



**The stub match** is the matching system that uses a section of transmission line connected in parallel with the feed line at or near the feed point. E9E03

## 9E - Transmission Lines

A **75 ohms** feed line impedance would be suitable for constructing a quarter-wave Q-section for matching a 100-ohm loop to 50-ohm feed line. E9E06

**Reflection coefficient** is the parameter that describes the interactions at the load end of a mismatched transmission line. E9E07

## 9F - Transmission Lines

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

**Dielectric materials used in the line** has the biggest effect on the velocity factor of a transmission line. E9F02

The physical length of a coaxial cable transmission line is shorter than its electrical length because **electrical signals move more slowly in a coaxial cable than in air**. E9F03

**3.5 meters** is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically 1/4 wavelength long at 14.1 MHz. E9F05

**8.3 meters** is the approximate physical length of a foam polyethylene dielectric coaxial transmission line that is electrically 1/4 wavelength long at 7.2 MHz. E9F09

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

Ladder line has **lower loss** as compared to small-diameter coaxial cable such as RG-58 at 50 MHz. E9F07

A significant difference between foam dielectric coaxial cable and solid dielectric cable, assuming all other parameters are the same is: E9F08

- Foam dielectric has lower safe operating voltage limits
- Foam dielectric has lower loss per unit of length
- Foam dielectric has higher velocity factor

**All these choices are correct**

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

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

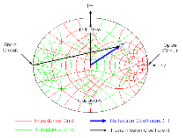
A 1/8-wavelength transmission line presents **a capacitive reactance** to a generator when the line is open at the far end. E9F11

## 9F - Transmission Lines

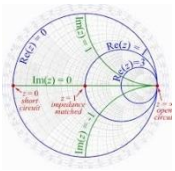
A 1/4-wavelength transmission line presents **very low impedance** to a generator when the line is open at the far end. E9F12

A 1/4-wavelength transmission line presents **very high impedance** to a generator when the line is shorted at the far end. E9F13

## 9G - Smith Chart



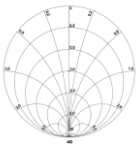
**Impedance along transmission lines** can be calculated using a Smith chart. E9G01



The coordinate system used in a Smith chart is **resistance circles and reactance arcs**. E9G02

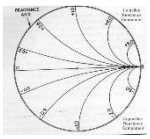
The two families of circles and arcs that make up a Smith chart are **resistance and reactance**. E9G04

Figure E9-3

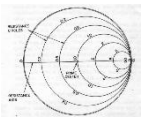


The name of the large outer circle on which the reactance arcs terminate is the **reactance axis**. E9G06

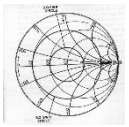
The only straight line shown is **the resistance axis**. E9G07



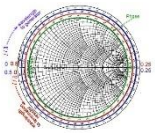
The arcs on a Smith chart represent the **points with constant reactance**. E9G10



The process of normalization with regard to a Smith chart is **reassigning impedance values with regard to the prime center**. E9G08



**Standing wave ratio circles** is the third family of circles often added to a Smith chart during the process of solving problems. E9G09



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

**Impedance and SWR values in transmission lines** is often determined using a Smith chart. E9G03

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

## 9H - Receiving Antennas

When constructing a Beverage antenna, **it should be one or more wavelengths long**, is a factor that should be included in the design to achieve good performance at the desired frequency. E9H01

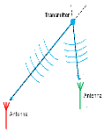
It is generally true for low band (160 meter and 80 meter) receiving antennas that **atmospheric noise is so high that gain over a dipole is not important**. E9H02

Receiving Directivity Factor (RDF) is the **forward gain compared to average gain over the entire hemisphere**. E9H03

RDF = the gain in forward direction divided by the gain in all other directions

An advantage of placing a grounded electrostatic shield around a small loop direction-finding antenna is **it eliminates unbalanced capacitive coupling to the surroundings, improving the nulls**. E9H04

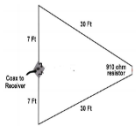
The main drawback of a small wire-loop antenna for direction finding is **it has a bidirectional pattern**. E9H05



Triangulation method of direction finding is **antenna headings from several different receiving locations are used to locate the signal source**. E9H06

RF attenuation is used when direction finding **to prevent receiver overload which reduces pattern nulls**. E9H07

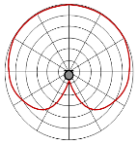
The function of a sense antenna is **it modifies the pattern of a DF antenna array to provide a null in one direction**. E9H08




A Pennant antenna is **a small, vertically oriented receiving antenna consisting of a triangular loop terminated in approximately 900 ohms**. E9H09

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

A feature of a cardioid pattern antenna that makes it useful for direction finding is **a very sharp single null**. E9H11



# Subelement E0 – Safety

| | |
|---|---|
| 0A – Safety | 1 sub section<br>1 question |

## 0A - RF Exposure

When evaluating RF exposure levels from your station at a neighbor's home, you must **ensure signals from your station are less than the uncontrolled Maximum Permitted Exposure (MPE) limits**. E0A02

The **30 to 300 MHz** range of frequencies is where the FCC human body RF exposure limits most restrictive. E0A03

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

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

One of the potential hazards of operating in the amateur radio microwave bands is **the high gain antennas commonly used can result in high exposure levels**. E0A05

The reason that there are separate electric € and magnetic (H) field MPE limits is: E0A06

- The body reacts to electromagnetic radiation from both the E and H fields
- Ground reflections and scattering make the field strength vary with location
- E and H field radiation intensity peaks can occur at different locations

**All these choices are correct**

Injuries that can result form using high power UHF or microwave transmitters is **localized heating of the body from RF exposure in excess of the MPE limits**. E0A11

## 0A - Hazardous Materials

Dangerous levels of carbon monoxide from an emergency generator ca be detected **only with a carbon monoxide detector**. E0A07

**Beryllium Oxide** is an 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 accidently inhaled. E0A09

**Polychlorinated biphenyls** is a toxic material that may be present in some electronic components such as high volage capacitors and transformers. E0A10

## 0A - Grounding

The primary function of an external earth connection or ground rod is **lightning protection**. E0A01