Extra Class Exam Study Guide

Workshop Course Book for March 2013

K4VRC

The Villages Amateur Radio Club
The Villages, Florida 32162
www.k4vrc.com

Introduction

Amateur radio has been around for a long time and has grown itself into a worldwide community of licensed hams on the airwaves with all sorts of communications technology. Ham radio attracts those who have never held a microphone as well as deep technical experts who grew up with a soldering iron and computer. Your United States Amateur Service license gives you the most powerful wireless communications capability available to any private citizen anywhere in the world. In the United States, amateur radio licensing is governed by the Federal Communications Commission (FCC) under strict federal regulations. Licenses to operate amateur stations for personal use are granted to individuals of any age once they demonstrate an understanding of both pertinent FCC regulations and knowledge of radio station operation and safety considerations. December 2012 marked one hundred years of amateur radio operator and station licensing by the United States government. Operator licenses are divided into different classes, each of which correlates to an increasing degree of knowledge and corresponding privileges. Over the years, the details of the classes have changed significantly, leading to the current system of three open classes and two grandfathered but closed to new applicants. The top US license class is Amateur Extra Class. The Extra Class license requires an applicant pass 35 of a 50 question multiple-choice theory exam. Those with Amateur Extra licenses are granted all privileges on all US amateur bands.

The ARRL Extra Class License description says it best; "General licensees may upgrade to Extra Class by passing a 50-question multiple-choice examination. No Morse code test is required. In addition to some of the more obscure regulations, the test covers specialized operating practices, advanced electronics theory and radio equipment design. Non-licensed individuals must pass Element 2, Element 3 and Element 4 written exams to earn an Extra License. The FCC grants exam element 3 credit to individuals that previously held certain older types of licenses. The HF bands can be awfully crowded, particularly at the top of the solar cycle. Once one earns HF privileges, one may quickly yearn for more room. The Extra Class license is the answer. Extra Class licensees are authorized to operate on all frequencies allocated to the Amateur Service."

The Extra Class workshop must cover a vast amount of material in six classes. This workshop will be conducted as peers sitting around a table discussing a technical topic. This is the format requested as specific technical topics not a rote review of the questions. The material in this study guide is formatted as abbreviated points or a quick reference format instead of slides. It is intended that the guide combined with the reference material supplied will have long-term value.

The workshop is specially presented for those with amateur radio experience who want to learn more. The workshop will primarily focus on technical aspects of the exam and regulatory questions are expected to be self-study. This is intended to help members advance in the hobby we love and give a little boost to those on the fence.

Looking forward to congratulating you in your advancement to Amateur Extra Class,

Rick

WD4JJI
Richard Silverston
President
The Villages Amateur Radio Club

How to best use this guide

This study guide is written to help you understand the radio theory with a practical slant, not just teach the answers, although the scope is limited to question pool topics due to the limited workshop time. This guide presents and explains the Extra Class License Exam questions by discussing each sub-group as an individual topic. There are fifty-four topics in this guide which represent approximately one for each of the fifty exam questions. This study guide is not intended to circumvent reading the assigned ARRL textbook chapter(s) but to support a better understanding of the radio theory.

Start by reading the next few pages to be sure you have all your supplies and look at the summary of the math required during the exam. This will give you time to order material without the last minute rush.

Everything is provided as a PDF format for your use. Determine how you want to read your personal copy of this guide and supporting material. In today's world an electronic reader may be the right choice or if you prefer paper you can print out the workshop material and place it in a three-ring binder. Do not wait until the weekend prior to the workshop to prepare.

Read the ARRL textbook completely before the workshops. You will not understand everything but it will help put everything into perspective during the workshops.

Take online practice tests prior to the workshops but don't worry about the score yet.

Online Practice Tests

http://aa9pw.com/radio/
www.eham.net/exams
http://kb0mga.net/exams/
www.radioexam.org

A few days before each workshop read the ARRL textbook chapter(s) assigned and work the problems. It is a good idea to work your problems in a notebook and bring it to class for your reference and help finding where that decimal point got lost.

Review the exam question group(s) assigned in this study guide to help focus on the key takeaways and scribble down questions to ask during the workshop.

Again, take the online practice tests and review the questions you failed in your ARRL textbook and this guide.

If you are still having trouble, review the technical references on the workshop CD ROM. These documents have much more detail and are explained in different ways from the book. You will find over a hundred technical references on the workshop CD ROM and you are not expected to have time to read all of them. The references are arranged by Question Pool Group Number; E0, E1, E2… E9 followed by a subject title and number (i.e.1,2,3). Start with title #1 and progress to the higher numbers as they increase in detail. If you have questions about decibels or just want more information read "E9-dB-1" before "E9-dB-2".

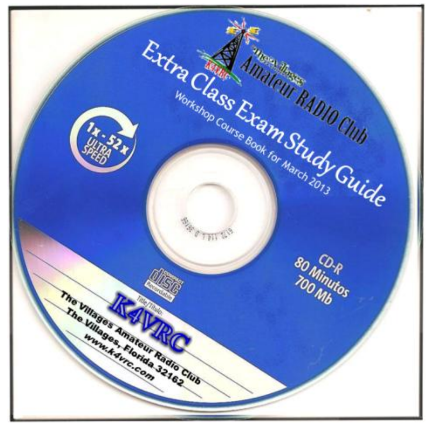
If you still are having difficulties with a question(s), the workshop discussion should clarify the problem. Do NOT be self-conscious if you are having trouble understanding; it is very likely the rest of the workshop is also not sure.

This will be a discussion group format so every workshop is intended to address your questions even if they are not part of assignment, just be considerate of the workshop's limited time.

The last workshop will be devoted to topic(s) as requested.

Supplies you will need

ARRL Tenth Edition of the Extra Class License Manual
ARRL Extra Class License Manual 10th Edition ISBN: 978-0-87259-517-0
for use July 1, 2012 to June 30, 2016
Available from ARRL, book stores or ham radio retailers



Pencil/pen and note pad to take notes and work out problems

The workshop CD-ROM

You will need access to a home computer to read the documents on the workshop CD-ROM and to take practice exams.

Scientific Calculator with the following functions;

- Add
- Subtract
- Divide
- Multiple
- Squares
- Square Roots
- Sine
- Cosine
- Arctan or tan-1 (Inverse Tangent)
- Base Ten Logarithms (10^x)

The formal test will require you to clear your memory so purchase a calculator with little or no memory. You want to use the same calculator during home study, practice tests, workshop exercises and the real test. Many points are lost to math errors so you want a calculator that you can operate with confidence.

SCIENTIFIC CALCULATOR

KEYS AND CONTROLS	
[ON/C]	Turns on your calculator / Clears display
[CE]	Clears the last entry
[OFF]	Turns off your calculator
[0] - [9]	Numerical Keys
[•]	Decimal Point
[%]	Percentage Key
[=]	Equal Key
[+] [-] [x] [÷]	Four Basic Function Keys
[M+]	Memory Plus Key
[RM]	Memory Recall
[+/-]	Changes the sign of the value entered.
[√]	Extraction of Square Root
[2nd F]	selects the 2nd functions which are above the keys
[DRG]	changes from degrees, radians, and grads

FUNCTIONS		
[+] [-] [x] [÷]	356 [+] 580 [=] 936 960 [-] 330 [=] 630	75 [x] 3 [=] 225 84 [÷] 4 [=] 21
Negatives	12 [x] 2 [+/-] [÷] 4 [=] -6	
Percentage	350 [x] 2 [2nd F] [%] [=] 7	
Ratio	250 [÷] 5 [2nd F] [%] [=] 5000	
Discount	450 [-] 6 [2nd F] [%] [=] 423	
Exponents	6 [x] [÷] 2 [=] 8	
Roots	144 [√] [÷] 4 [√] [=] 14	

Math you will need to use

Calculations

Add, Subtract, Divide & Multiple
Squares & Square Roots
Sine & Cosine
Arctan or tan-1 (Inverse Tangent)
Base Ten Logarithms (10^x)

International System of Units (SI)—Metric Units

Prefix	Symbol	Multiplication Factor	
exe	E	10+18	1,000,000 000,000,000,000
peta	P	10+15	1,000 000,000,000,000
tera	T	10+12	1,000,000,000,000
giga	G	10+9	1,000,000,000
mega	M	10+6	1,000,000
kilo	k	10+3	1,000
hecto	h	10+2	100
deca	da	10+1	10
(unit)		10+0	1
deci	d	10-1	0.1
centi	c	10-2	0.01
milli	m	10-3	0.001
micro	µ	10-6	0.000001
nano	n	10-9	0.000000001
pico	p	10-12	0.000000000001
femto	f	10-15	0.000000000000001
atto	a	10-18	0.000000000000000001

The workshop and license exam requires you to use a small amount of algebra and trigonometry to solve problems. Every equation you need to use is listed below. Working solving the example problems will help you be at ease with using the math. If you would like to learn a bit about trigonometry, or brush up on it, then you can but do not lose focus on the radio theory. These equations are more of an introduction and guide and the actual exam question calculations will be shown step by step during the workshop. For more help you should read the math reference material on your CD-ROM.

Conversions

dB to ratio >> **ratio = 10 ^ (dB/10)** > **Solve for 5.2 dB** > ? = 10 ^ (5.2dB / 10) = 10 ^ 0.52 = **3.311**
0dB = 1   3 dB = 1.995   6 dB = 3.981   9dB = 7.943   12dB = 15.849

ratio to dB >> **dB = 10 x log (ratio/10)** > **Solve for 800** > ? = 10 x log (800) = 10 X 2.9031= **29.031dB**
2 = 3dB   75 = 18.75dB   500 = 26.99dB   1500 = 31.76dB

Inductor Impedance >> **Ω = 2 π FL** = 2 x π x MHz x uH
Solve for 18 uH @ 3.505 MHz > ? = 3.505 x 18 = **396.41 Ω**

Capacitor Impedance >> **Ω = 1/ (2 π FC)** = 1/ (2 x π x MHz x uF)
Solve for 38 pF @ 14 MHz >
? = 1 / (2 x 3.14 x 14 x 0.000038) = 1 / 0.00334096 = **299.32 Ω**

Series RLC Impedance >> **Freq = 1/[2π√(LC)]** *Note the R drops out!*
Solve for 40 pF + 50 uH + 22 Ω >
? = 1/[6.28x√(0.00005x0.00000000004)] = 1/(2.808501379739736e-7) = 3560618 Hz = **3.56 MHz**

Parallel RLC Impedance >> **Freq = 1/[2π√(LC)]** *Note the R drops out and use same equation for resonance!*
Solve for 10 pF + 25 uH + 47 Ω >
? = 1/[6.28x√(0.000025x0.00000000001)] = 1/(9.929551852911e-8) = **10.070948 MHz**

RC Time Constant >> **TC (sec) = R (MΩ) x C (uF)** **Solve for 440 pF + 500K Ω** > ? = 0.5 x 440 = **220 Seconds**

Polar to Rectangular Coordinates >> Magnitude at an angle or a vector >> **X = M x Cos θ and Y = M x Sin θ**
Solve for 200 at 30° >
X = 200 x Cos 30° = **173.20**
Y = 200 x Sin 30° = **100**

Rectangular to Polar Coordinates >> **Magnitude = √[X^2 + Y^2]** and the **angle = tan^-1 [Y / X]**
Solve for X = 400 and Y = 300
M = √[400^{2+} 300^2] = √ 250,000 = **500**
θ = tan^-1 [300/400] = tan^-1 (0.75) = **36.87°**

TVARC 2013 Workshop Meeting Schedule

Class Date	ARRL Chap	Question Pool Group rev Dec 18, 2012	
		E1	**COMMISSION'S RULES**
Self Study	3	E1A	Operating Standards
Self Study	3	E1B	Station restrictions & special operations
Self Study	3	E1C	Station control
Self Study	3	E1D	Amateur Satellite service
Self Study	3	E1E	Volunteer examiner program
Self Study	3	E1F	Misc
		E5	**ELECTRICAL PRINCIPLES**
Mon 3/4	4	E5A	Resonance & Q: resonant circuits
Mon 3/4	4	E5B	Time constants & phase relationships
Mon 3/4	4	E5C	Impedance plots & coordinate systems
Mon 3/4	4	E5D	AC & RF in real circuits
		E6	**CIRCUIT COMPONENTS**
Wed 3/6	5	E6A	Semiconductors
Wed 3/6	5	E6B	Semiconductor diodes
Wed 3/6	5	E6C	Integrated circuits
Wed 3/6	4,5	E6D	Optical & Toroids
Wed 3/6	5,6	E6E	Piezoelectric crystals & MMICs
Wed 3/6	5	E6F	Optical
		E7	**PRACTICAL CIRCUITS**
Mon 3/11	5	E7A	Digital circuits
Mon 3/11	6	E7B	Amplifiers Classes
Mon 3/11	6	E7C	Filters & impedance matching networks
Mon 3/11	6	E7D	Power supplies & voltage regulators
Mon 3/11	6	E7E	Modulation & demodulation
Mon 3/11	5	E7F	Frequency markers & counters
Mon 3/11	6	E7G	Active filters & op-amps
Mon 3/11	6	E7H	Oscillators & signal sources
		E8	**SIGNALS & EMISSIONS**
Wed 3/13	7,8	E8A	AC waveforms
Wed 3/13	7	E8B	Modulation & demodulation methods
Wed 3/13	8	E8C	Digital signals: digital modes
Wed 3/13	7	E8D	Waves, measurements, RF grounding

TVARC 2013 Workshop Meeting Schedule

Class Date	ARRL Chap	Question Pool Group rev Dec 18, 2012	
		E2	**OPERATING PROCEDURES**
Wed 3/13	2	E2A	Amateur radio in space
Wed 3/13	8	E2B	Television practices
Wed 3/13	2	E2C	DX; spread-spectrum; Operating Frequency
Wed 3/13	2 & 8	E2D	VHF and UHF digital modes; APRS
Wed 3/13	8	E2E	HF digital modes
		E4	**AMATEUR PRACTICES**
Mon 3/18	7,8,9	E4A	Test equipment
Mon 3/18	7&9	E4B	Measurement limitations
Mon 3/18	8	E4C	Phase noise, image rejection, S/N
Mon 3/18	7&8	E4D	Dynamic range, IMD, 3rd order intercept
Mon 3/18	7	E4E	Noise suppression
		E9	**ANTENNAS & TRANSMISSION LINES**
Wed 3/20	9	E9A	Isotropic & gain antennas
Wed 3/20	9	E9B	Antenna patterns
Wed 3/20	9	E9C	Wire & phased antennas
Wed 3/20	9	E9D	Directional antennas
Wed 3/20	9	E9E	Matching
Wed 3/20	9	E9F	Transmission lines
Wed 3/20	9	E9G	Smith Charts
Wed 3/20	9	E9H	Effective radiated power
Wed 3/20	9	E9H	Radio Direction Finding Antennas
		E3	**RADIO WAVE PROPAGATION**
Self Study	10	E3A	Earth-Moon-Earth, meteor scatter
Self Study	10	E3B	Long path; gray-line; multi-path propagation
Self Study	10	E3C	Aurora, fading; radio horizon; take-off angle
		E0	**SAFETY**
Self Study	11	E0A	Amateur radio safety practices
Mon 3/25			Topic(s) determined by class requests
Wed 3/27			VEC Testing all Levels

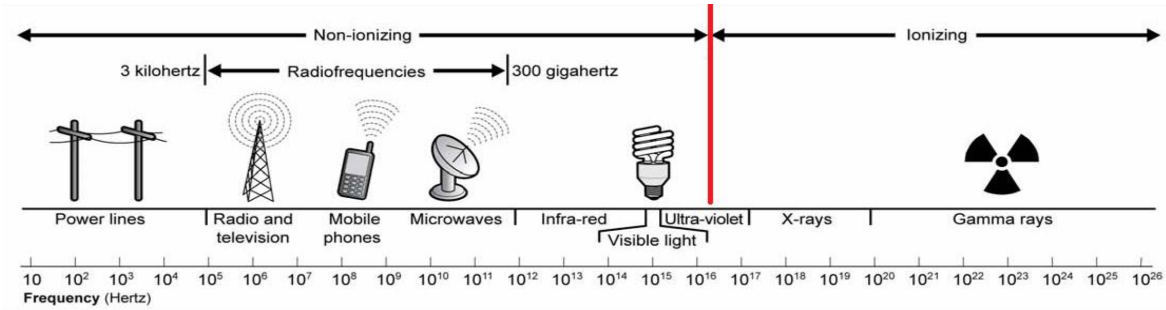
Table of Contents

Table of Contents

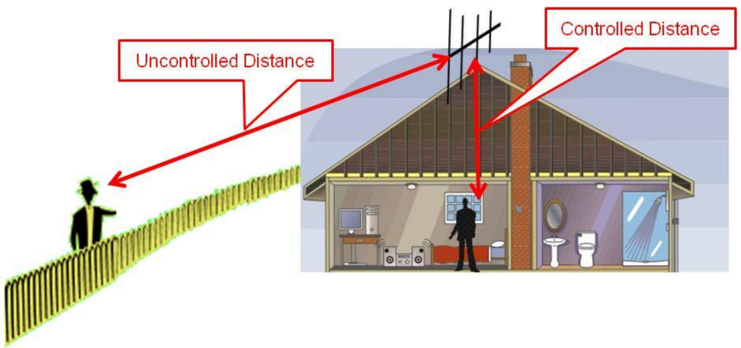
E0A Safety

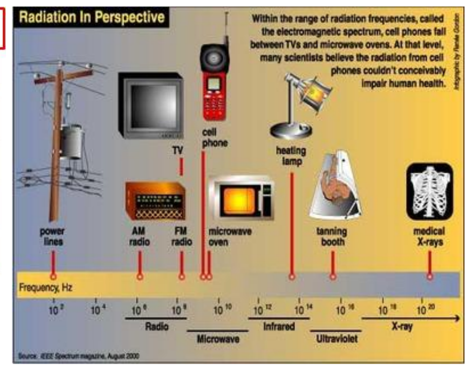
Chapters 11 of ARRL Extra Class License Manual Estimated 1 Exam Question

Radioactive materials emit ionizing radiation, while **RF signals have less energy and can only cause heating**

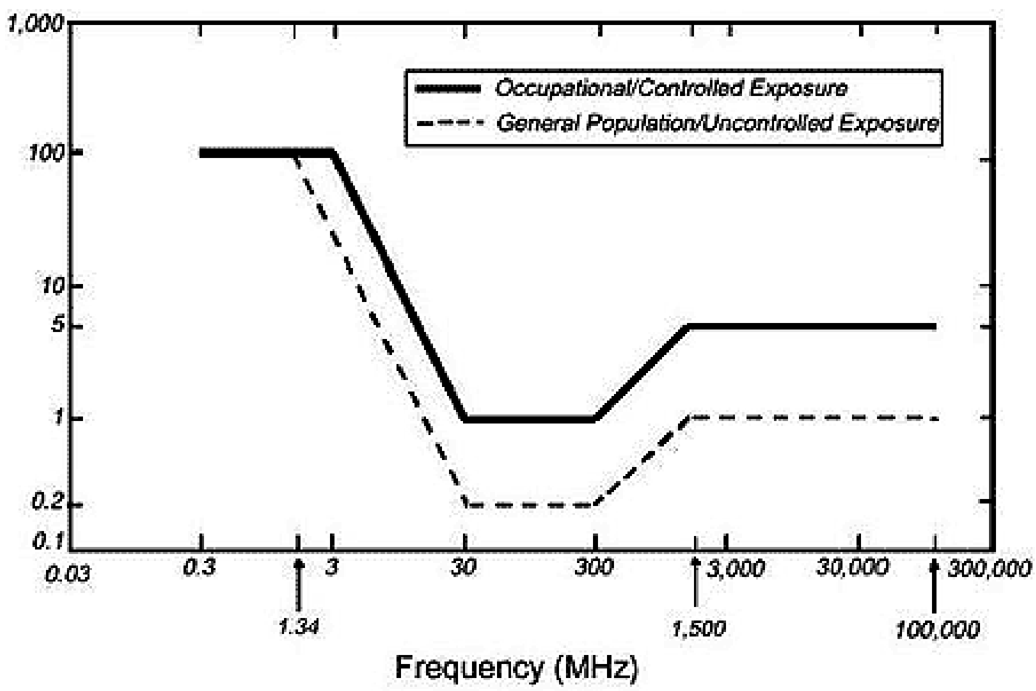


RF exposure levels at your station at a **neighbor's home** must be less than the **uncontrolled MPE limits**





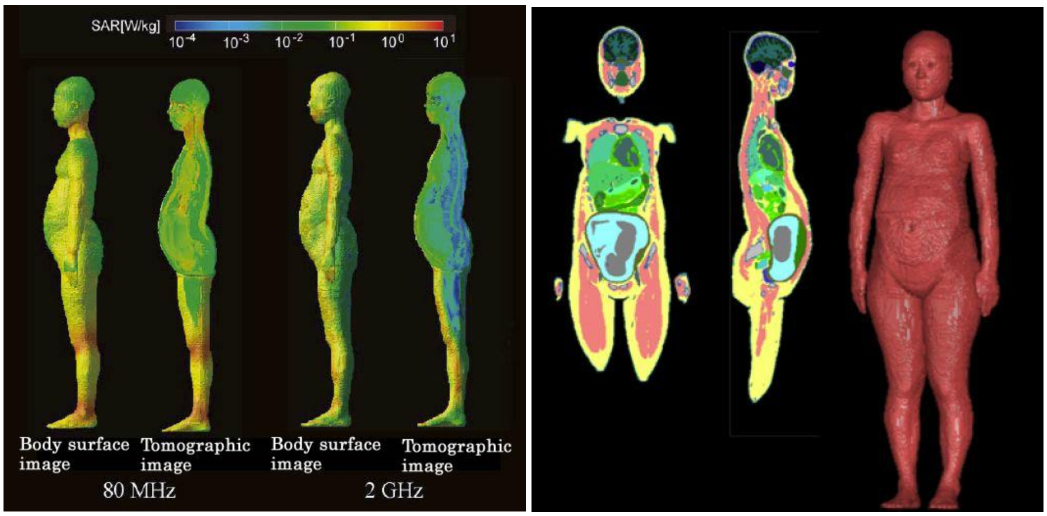
Using an **antenna modeling program to calculate field strength** is a practical way to estimate whether the RF fields produced by an amateur radio station are within **permissible MPE limits**



Every transmitter that produces 5% or more of its MPE exposure limit at accessible locations for multiple transmitters operating at the same time each of the operators and licensees of which transmitters **are responsible for mitigating over-exposure situations**

Localized heating of the body from RF exposure in excess of the MPE limits result from using high-power UHF or microwave transmitters

Editor's note: The body heating from RF exposure is analysis below is included to show how the body surface is heated by RF. This means the primary RF hazard in your shack is your skin and eyes.



The National Institute of Information and Communications Technology (NICT) disclosed a numerical model database of a whole-body Japanese pregnant woman. The database was jointly developed with Chiba University. Numerical Model Data of Pregnant Woman Disclosed for Electromagnetic Field Analysis   The distribution of the Specific Absorption Rate (SAR) per unit mass, at the time of frontal exposure to radio waves. Frequencies: 80MHz and 2GHz. Strength: 1mW/cm2), is shown by color.

SAR is the rate at which RF energy is absorbed by the body

The **high gain antennas** commonly used can **result in high RF exposure** levels using microwaves in the amateur radio bands

Why are there **separate electric (E) and magnetic (H) field MPE limits**?

A. The body reacts to electromagnetic radiation from both the E and H fields
B. Ground reflections and scattering make the field impedance vary with location
C. E field and H field radiation intensity peaks can occur at different locations
D. All of these choices are correct

Dangerous levels of **carbon monoxide from an emergency generator** can be detected with a carbon monoxide detector

Beryllium Oxide commonly used as a thermal conductor for some types of electronic devices is extremely toxic if broken or crushed and the particles are accidentally inhaled

Polychlorinated biphenyls found in some electronic components such as high-voltage capacitors and transformers is considered toxic

Remember this question from the General License Exam?

G0A03 | (D) How can you determine that your station complies with FCC RF exposure regulations?
- A. By calculation based on FCC OET Bulletin 65
- B. By calculation based on computer modeling
- C. By measurement of field strength using calibrated equipment
- D. All of these choices are correct

You will NOT see this on the Extra exam but you should have analysis on file like the one below!

RF Safety for your Flagpole Antenna:

This document details a typical TVARC member's Flagpole Antenna RF hazard calculations that predict the power density levels in occupied areas around the system antenna. This "worst case" estimate assumes the true average-radiated power from the antenna based on the maximum transmitter output for each band are compared to the Maximum Permissible Exposure (MPE). The results are expressed in power density at distance for far field determine a safe environment directly at the flagpole antenna.

Density Calculation:

Power density from an isotropic antenna

$$P_D = \frac{P_t}{4\pi R^2}$$

where: P_t = Average Transmitter Power
R = Range from Antenna (i.e. radius of sphere)

The power density at a distant point from an antenna gain of Gt is the antenna gain.

Power density equals;

$$P_D = \frac{P_t G_t}{4\pi R^2}$$

Assumptions:

Assumes; 100 W Transmitter, SSB, 100 Feet RG-8X, VSWR 1.5, 10 M

Watts	100	Steady State Transmitter Power in Watts (Example 100W SSB or 25W AM)
Factor	0.20	Modulation Factor (Am, FM, RTTY & Digital = 1, CW = 0.4, SSB = 0.2)

dB	0.3	Tuner or Duplexer Loss in dB
dB	1.5	Cable Loss in dB
dB	0.5	BALAN or Antenna Impedance Matching Loss in dB
dB	0.0	Antenna Gain in dBi (Vert = 0, Dipole = 2.1, Random Wire = 0, etc)

Feet	1	Distance in Feet from Antenna to your head (Controlled)
Feet	2	Distance in Feet from Antenna to your property line (Uncontrolled)

Exposure Limits:

The FCC Second Memorandum and Order dated August 27, 1997 adopted a sliding scale for categorical exemption to routine RF radiation compliance testing based on peak envelope power (PEP) at various Amateur Radio operating frequencies. While the RF radiation exposure compliance levels are based on average power, the categorical exemptions from the requirement for periodic station compliance testing are based upon peak envelope power (PEP). Stations operating at or below these respective PEP levels are categorically excluded from having to perform a routine RF radiation evaluation. However, all stations, regardless of power level, still must comply with the RF exposure limits. OST/OET Bulletin #65 sets the Maximum Permissible Exposure (MPE) to field levels.

Density Results:

The calculated maximum power density for this station is shown at the top of the respective controlled and uncontrolled columns in the table below. The maximum MPE allowable strength of the RF fields around this station are listed descending in each column for the maximum frequency in each amateur band listed.

	0.8338	Controlled Power Density mW/cm2						
		0.1907	Uncontrolled Power Density mW/cm2					
				Routine RF Radiation Evaluations Required				
	Max PD Allowed mW/cm2	Max PD Allowed mW/cm2		Min MHz	Max MHz	Watts Peak	Amateur Band	
OK	100.00	45.00	OK	1.80	2.00	500	160 M	
OK	56.26	11.26	OK	3.50	4.00	500	80 M	
OK	16.89	3.38	OK	7.00	7.30	500	40 M	
OK	8.66	1.74	OK	10.10	10.15	425	30 M	
OK	4.38	0.88	OK	14.00	14.35	225	20 M	
OK	2.37	0.55	OK	18.07	18.17	125	17 M	
OK	1.96	0.40	OK	21.00	21.45	100	15 M	
OK	3.71	0.29	OK	24.89	24.99	75	12 M	
OK	1.03	0.21	OK	28.00	29.70	50	10 M	
OK	1.00	0.20	OK	50	54	50	6 M	
OK	1.00	0.20	OK	144	148	50	2 M	
OK	1.00	0.20	OK	222	225	50	1.25 M	
OK	1.50	0.30	OK	420	450	70	70 cm	

Safety CONOPS: The practical answer is operations in a safe environment that can be used under normal operating conditions without burden to the station operator. It is recommended that access to the planter be restricted when RF radiation is permitted. No additional precautions are required for a residential station as the operator has control over maintenance workers as the owner of the yard and controls both access and transmitter emissions. In reviewing the station MPE levels it has been determined the operator and neighbors have full unrestricted use of the yard during transmitter operation by taking the following actions.

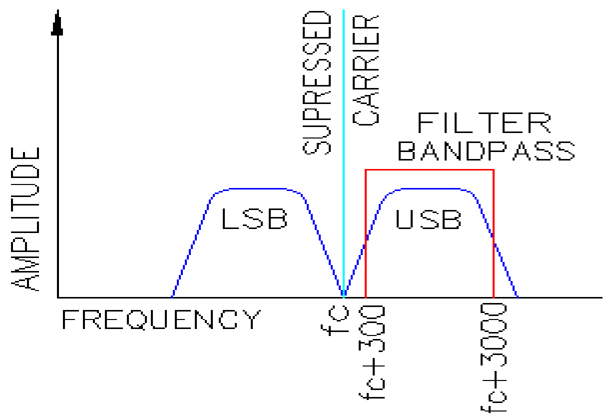
- Radiating element inside PVC pipe to prevent direct contact
- Control Zone established by planter
- Control Zone = 1+ Feet
- Uncontrolled Zone = 2+ Feet
- Operator monitors site during transmissions

E1A Operating Standards

Chapters 3 of ARRL Extra Class License Manual   Estimated 1 Exam Question

Upper Sideband (USB) emissions will be **3 kHz above** the carrier frequency

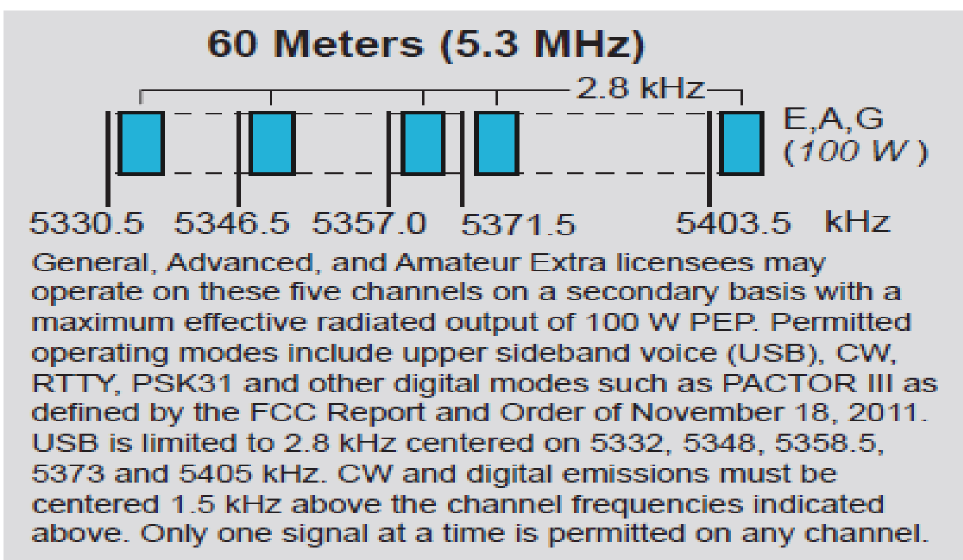
Lower Sideband (LSB) emissions will be **3 kHz below** the carrier frequency



With your transceiver displaying the carrier frequency of phone signals, you hear a DX station's CQ on **14.349 MHz USB it is NOT legal to return the call** using upper sideband on the same frequency

With your transceiver displaying the carrier frequency of phone signals, you hear a DX station calling CQ **on 3.601 MHz LSB it is NOT legal to return the call** using lower sideband on the same frequency

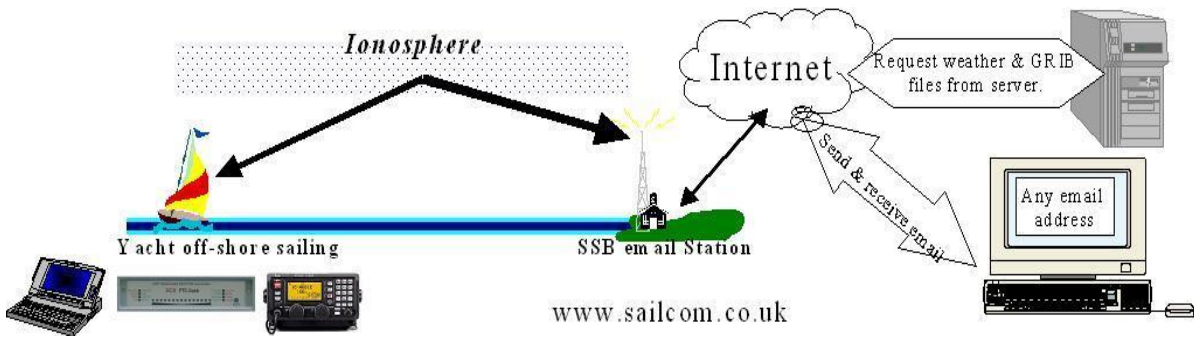
With your transceiver displaying the carrier frequency of CW signals, you hear a DX station's CQ on **3.500 MHz it is NOT legal to return the call** using CW on the same frequency



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

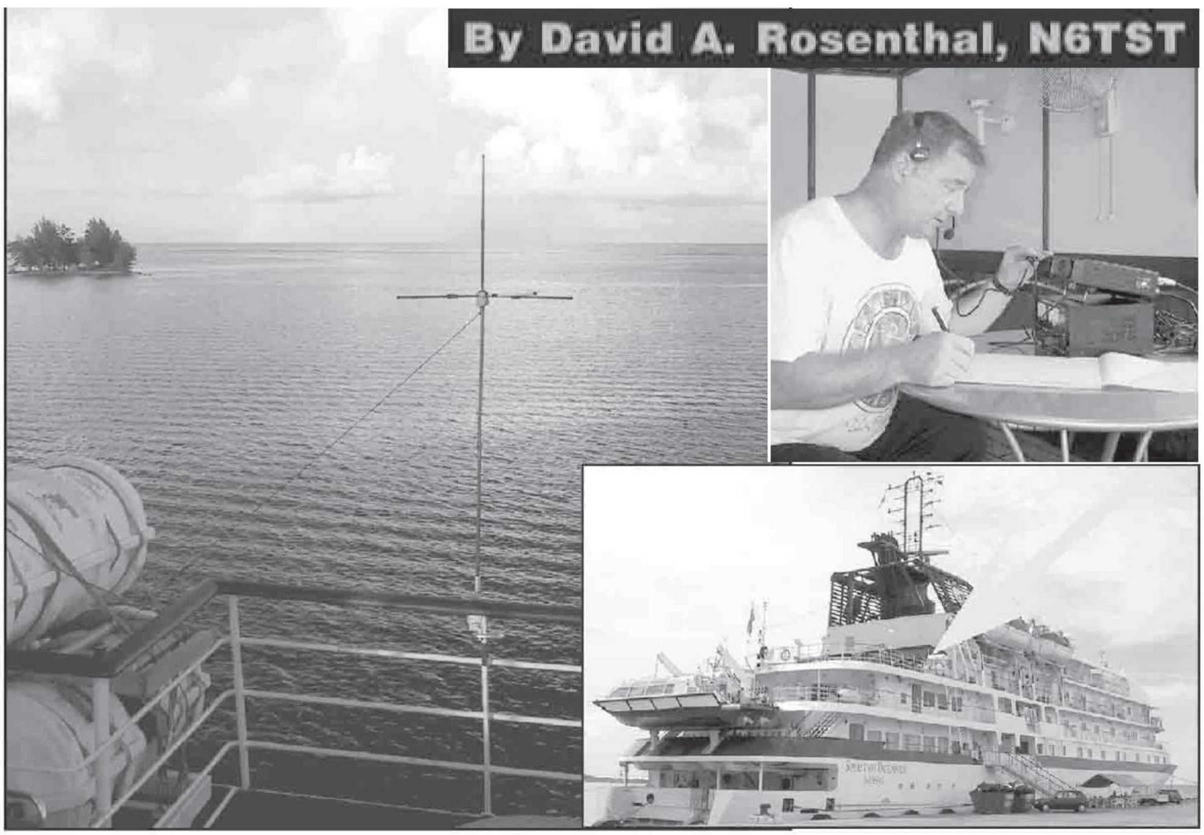
Operation is restricted to **specific emission types and specific channels** describes the rules for operation on the **60 meter band**

60 meter band is the only amateur band where transmission on specific channels rather than a range of frequencies is permitted



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

The first action you should take 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**



Operation of an amateur station is installed aboard a **ship or aircraft** must be **approved by the master** of the ship or the pilot in command of the aircraft

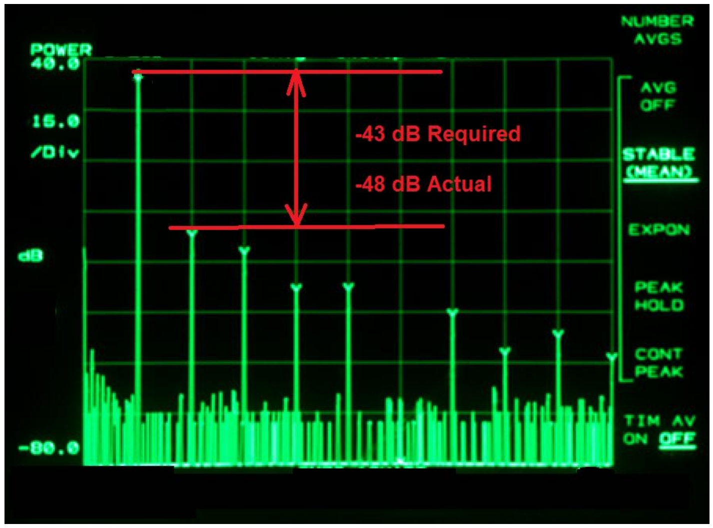
A FCC-issued amateur license or a reciprocal permit for an alien amateur licensee is required when operating an amateur station **aboard a US-registered vessel in international waters**

A FCC-issued amateur license or a reciprocal permit for an alien amateur licensee is required when operating an amateur station **aboard any vessel or craft that is documented or registered in the United States**

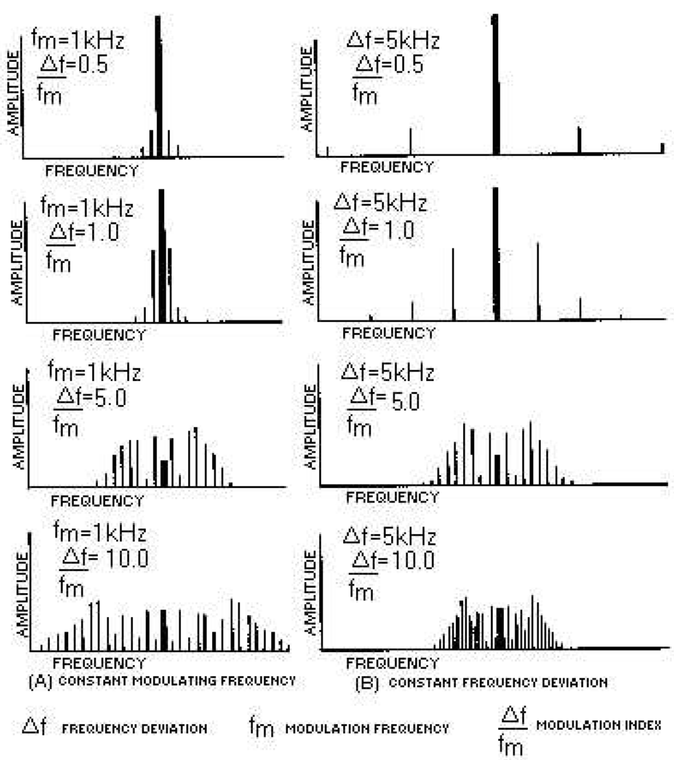
E1B Station restrictions & Special operations

Chapters 3 of ARRL Extra Class License Manual Estimated 1 Exam Question

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

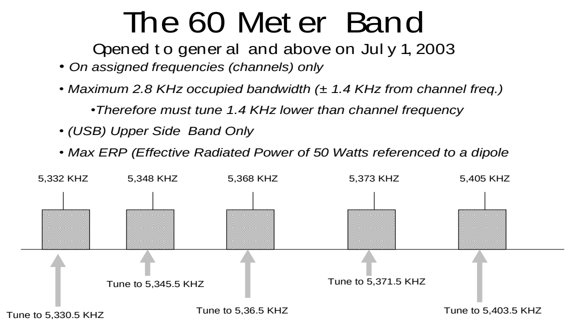


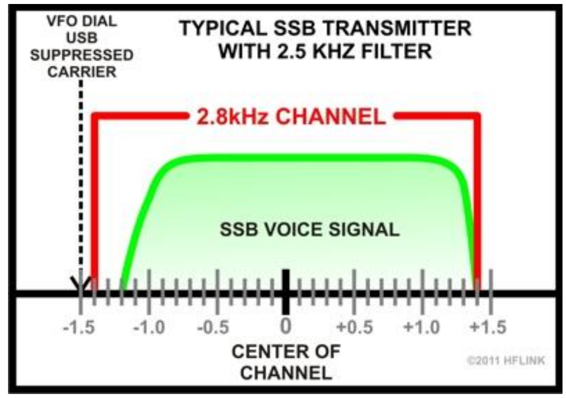
The mean power of **any spurious emission must be at least - 43 dB** relative to the mean power of the fundamental emission from a station transmitter or **external RF amplifier** installed after January 1, 2003, and transmitting on a frequency below 30 MHZ



1.0 is the highest modulation index permitted at the highest modulation frequency for angle modulation

Operating with a 2.5kHz filter, an Upper Sideband transmitter set at 1.5kHz below the center-of-channel frequency, with a typical voice bandpass of 300Hz to 2800Hz, the signal will just barely meet the requirements of the FCC rules for the 2.8kHz channel.





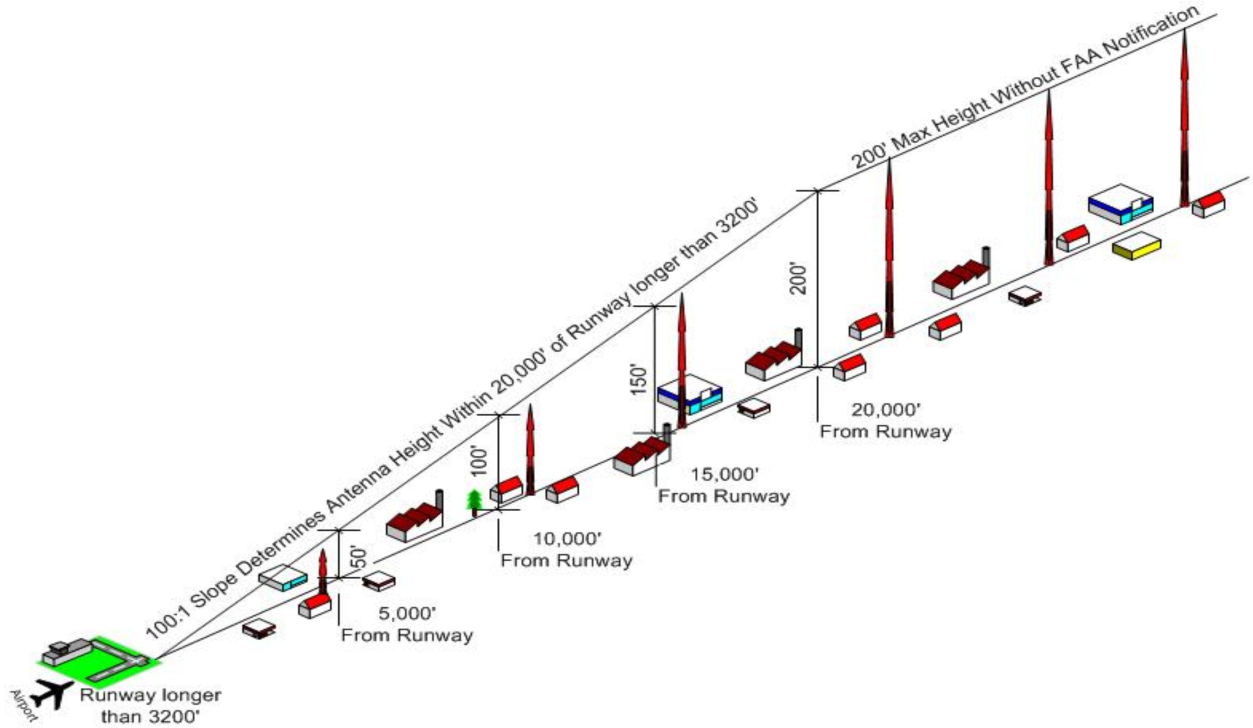
2.8 kHz is the maximum bandwidth for a data emission on **60 meters**

The carrier frequency of **a CW signal must be at the center frequency of the channel** to comply with FCC rules for **60 meter** operation

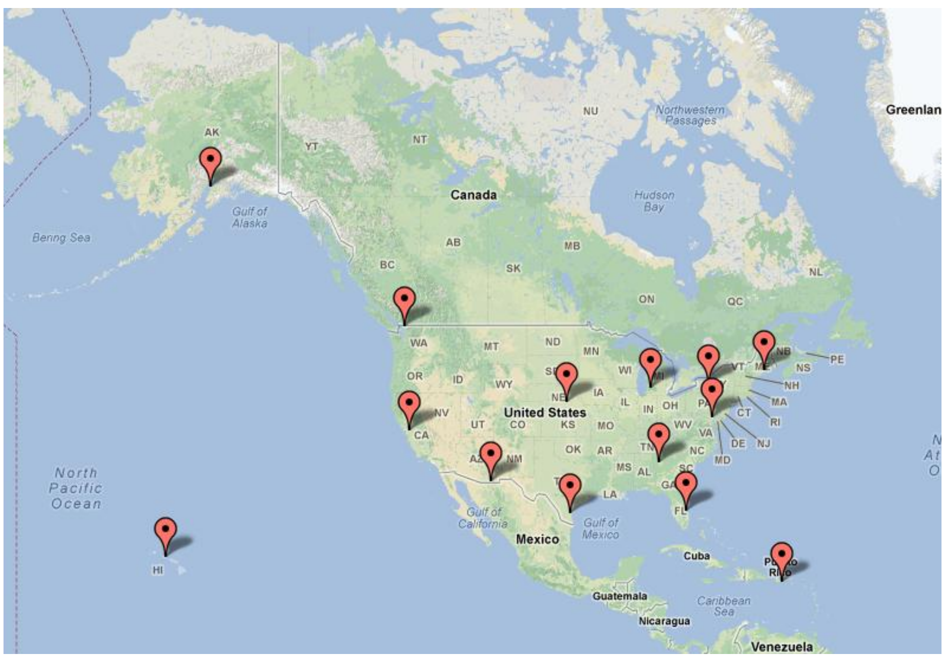
Locations of environmental importance or significant in American history, architecture, or culture might cause the physical location of **an amateur station apparatus or antenna structure to be restricted**

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 Historical Places

If you are installing an amateur station antenna at a site at or **near a public use airport** you may have to notify the **Federal Aviation Administration and register it with the FCC as required** by Part 17 of FCC rules



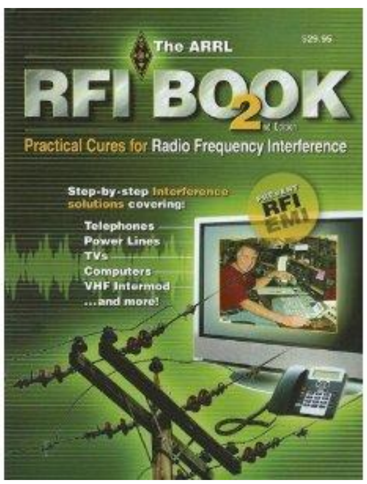
FCC monitoring facility must protect that facility from harmful interference. Failure to do so could result in imposition of operating restrictions upon the amateur station by an EIC pursuant to Sec. 97.121 of this part. Geographical coordinates of the facilities that require protection are listed in Sec. 0.121 (c) of this chapter. There are 14 such stations listed in 47 CFR 0.121(b) and are shown below.

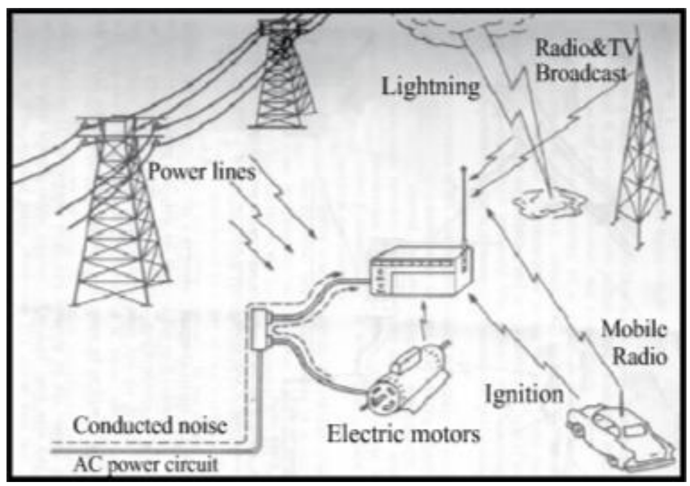


Within 1 mile an amateur station must protect an **FCC monitoring facility** from harmful interference

Any FCC-licensed amateur station certified by the responsible civil defense organization for the area served **may be operated in RACES**

All amateur service frequencies authorized to the control operator are authorized to an amateur station participating in **RACES**





An **amateur station could be required to avoid transmitting during certain hours on** frequencies that cause the interference if its signal causes interference to domestic broadcast reception, assuming that the receiver(s) involved are of good engineering design

E1C Station Control

Chapters 3 of ARRL Extra Class License Manual Estimated 1 Exam Question

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

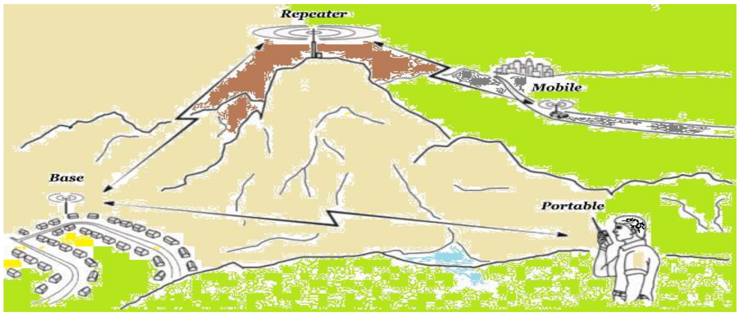
Under **automatic** control the control operator is **not required to be present** at the control point

An **automatically controlled station may retransmit third party** communications when transmitting **RTTY or data emissions**

An **automatically controlled** station **may NOT originate third party** communications

29.500 - 29.700 MHz are available for an **automatically controlled repeater** operation

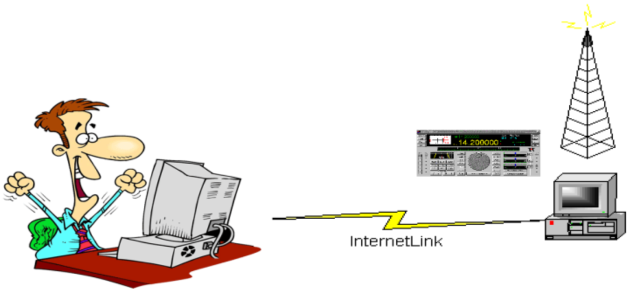
Only auxiliary, repeater or space stations may **automatically retransmit** the radio signals of other amateur stations



A **control operator must be present** at the control point of a **remotely controlled amateur station**

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

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

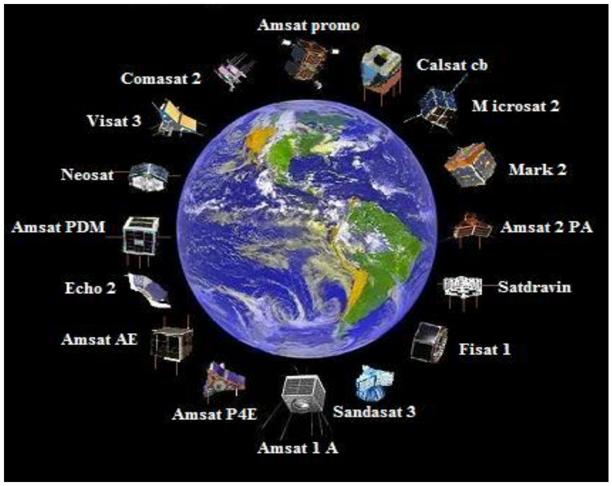


Direct manipulation of the transmitter by a control operator is meant by **local control**

E1D Amateur Satellite Service

Chapters 3 of ARRL Extra Class License Manual Estimated 1 Exam Question

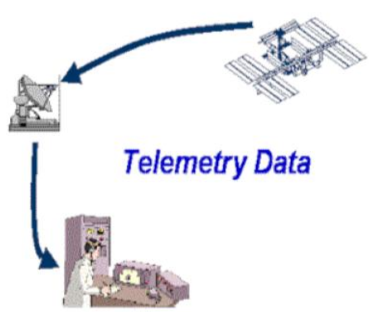
The **amateur satellite service** is a radio communications using amateur radio stations on satellites



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

A **telecommand station** is **designated** by the **space station licensee**, subject to the privileges of the class of operator license held by the control operator

A **space station** must **terminate transmissions by telecommand** when directed by the FCC



Telemetry is one-way transmission of measurements at a distance from the measuring instrument

40m, 20m, 17m, 15m, 12m and 10m bands have **HF frequencies** authorized to **space stations**

2M, 70 cm, 23 cm, 13 cm bands have **frequencies** authorized to **space stations**

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

An **Earth station** is any amateur station, subject to the privileges of the class of operator license held by the control operator

All classes of licensee is authorized to be the **control operator of a space station**

E1E Volunteer Examiner Program

Chapters 3 of ARRL Extra Class License Manual Estimated 1 Exam Question

A **Volunteer Examiner Coordinator (VEC)** is an organization that has entered into an agreement with the FCC to coordinate amateur operator license examinations

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

Three is the minimum number of qualified **VEs** required to administer an Element 4 amateur operator license examination

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

The questions for all written US amateur license examinations are listed in a **question pool maintained by all the VECs**

A **score of 74%** is the minimum passing score on amateur operator license examinations

Each administering VE is responsible for the proper conduct and necessary supervision during an amateur operator license examination session

Immediately terminate the candidate's examination if a candidate fails to comply with the examiner's instructions during an amateur operator license examination

A **VE not administer an examination to relatives of the VE** as listed in the FCC rules

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

The administering **VEs must submit the application document** to the coordinating VEC according to the coordinating VEC instructions after the administration of a successful examination for an amateur operator license

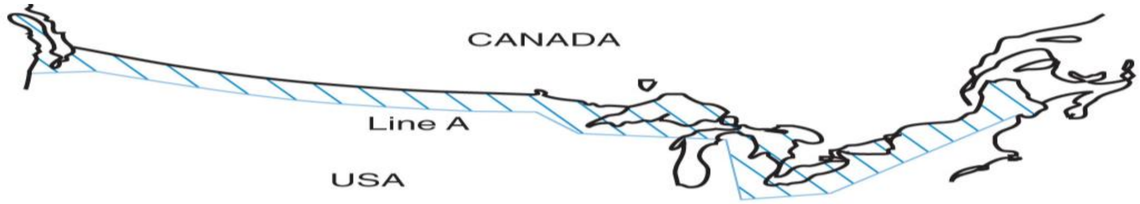
The VE team must **return the application document** to the examinee with the application form if the examinee does not pass the exam

Preparing, processing, administering and coordinating an examination for an amateur radio license are **out-of-pocket** expenses that may be reimbursed VEs and VECs

The licensee's license will be cancelled for **failing to appear for re-administration** of an examination when so directed by the FCC

E1F Miscellaneous Rules

Chapters 3 of ARRL Extra Class License Manual   Estimated 1 Exam Question

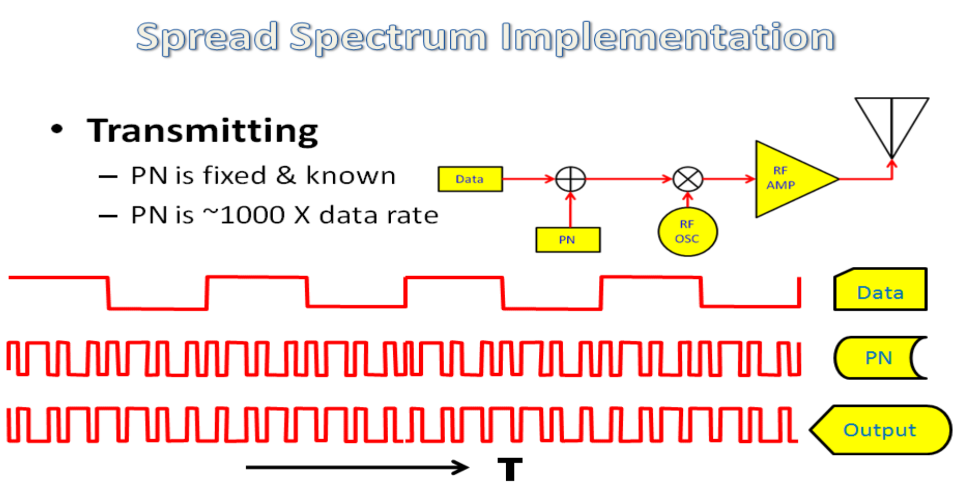


LINE A is an area roughly parallel to and about 75 miles south of the US-Canadian border

Amateur stations may not transmit on 420 - 430 MHz if they are located in the contiguous 48 states **and north of Line A**


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

The National Radio Quiet Zone is an area surrounding the **National Radio Astronomy Observatory**



Spread spectrum transmissions permitted on amateur frequencies **above 222 MHz**

10 W is the maximum transmitter power for an amateur station transmitting **spread spectrum**

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

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

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

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

D. All of these choices are correct

An **external RF power amplifier** if it is to qualify for a grant of FCC certification must satisfy the FCC's **spurious emission standards** when operated at the lesser of 1500 watts, or its **full output power**

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

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

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

CEPT agreement allows an FCC-licensed US citizen to operate in many European countries, and alien amateurs from many European countries to operate in the US

The FCC may issue a **"Special Temporary Authority" (STA**) to an amateur station to provide for experimental amateur communications

Only Technician, General, Advanced or Amateur Extra Class operators may be the **control operator of an auxiliary station** (no Novice!)

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 communications

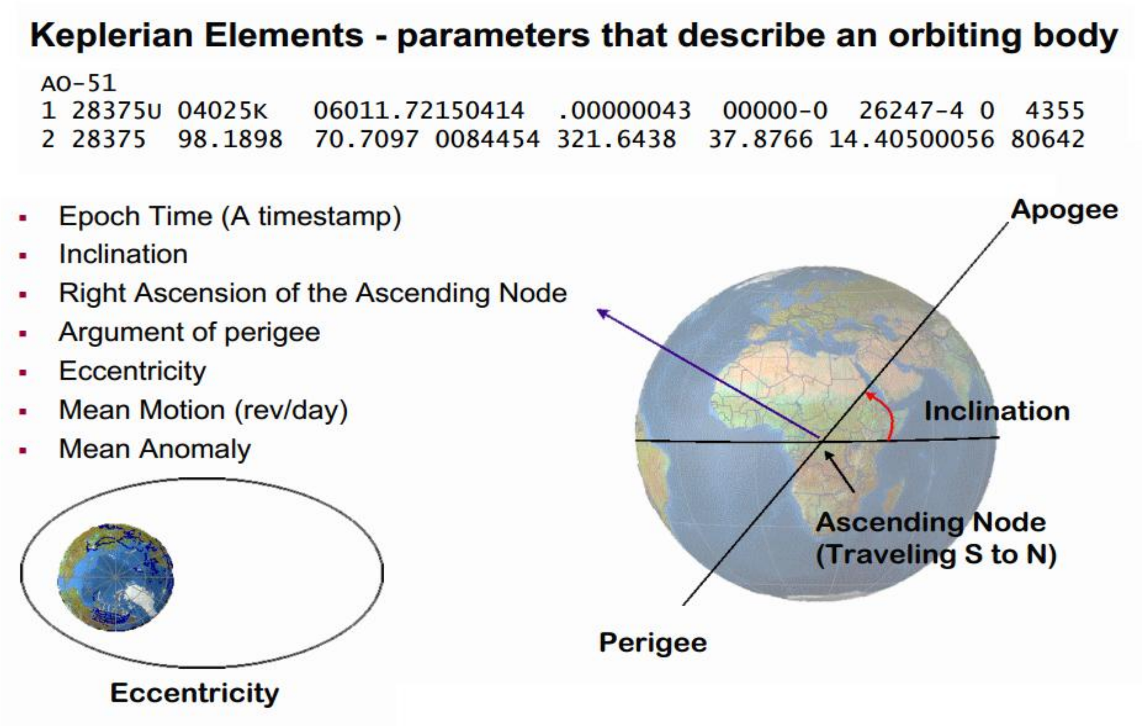
E2A Amateur Radio in Space

Chapters 2 of ARRL Extra Class License Manual Estimated 1 Exam Question

A **Geostationary** satellite appears to stay in one position in the sky

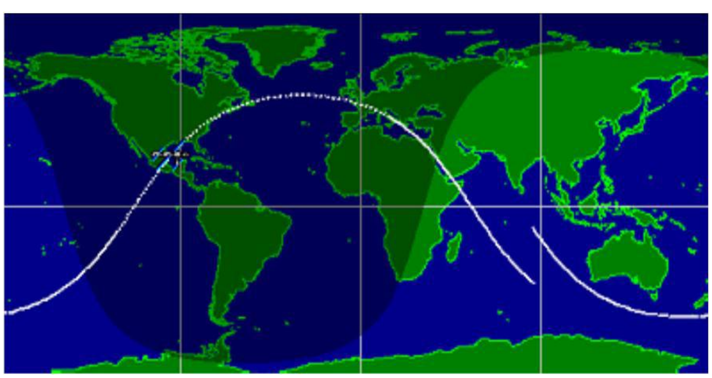
The **orbital period** is the time it takes for a satellite to complete **one revolution around the Earth**

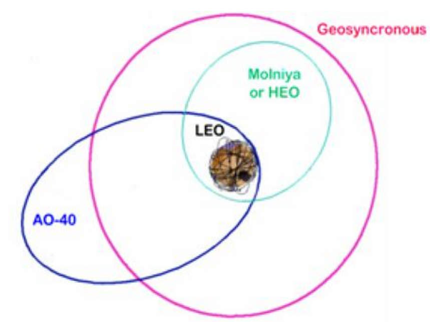
Calculations using **Keplerian Elements** for a satellite is one way to **predict the location** of a satellite



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

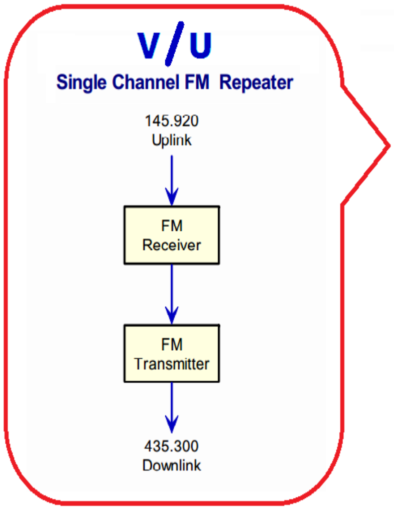
From north to south is the direction of a **descending pass** for an amateur satellite?





The term **mode** (as applied to an amateur radio satellite) is the **uplink and downlink** frequency bands

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



HF Bands	29.300 – 29.500	200 KHz	Primary	Uplink & Downlink
V Band	145.800 – 146.000	200 KHz	Primary	Uplink and Downlink
U Band	435.000 – 438.000	3 MHz	Secondary	Uplink and Downlink
L Band	1260 – 1270	10 MHz	Secondary	Uplink Only
S Band	2400 – 2450 3400 – 3410*	10 MHz 10 MHz	Secondary Secondary	Uplink and Downlink Uplink and Downlink
C Band	5650 – 5670 5830 – 5850	20 MHz 20 MHz	Secondary Secondary	Uplink Only Downlink Only
X Band	10.45 – 10.5 GHz	50 MHz	Secondary	Uplink and Downlink
K Band	24.0 – 24.05 GHz	50 MHz	Primary	Uplink and Downlink
Q Band	47.0 – 47.2 GHz	200 MHz	Primary	Uplink and Downlink
W Band	75.5 – 76.0 GHz	500 MHz	Primary	Uplink and Downlink

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

If the signal from an amateur satellite exhibit a **rapidly repeating fading** effect means the **satellite is spinning**

Limit YOUR power to a satellite which uses a **linear transponder** to avoid **reducing the downlink power** to others

In a linear transponder the largest received signal sets the transponder output power. Signals less than the larger signal are attenuated and therefore are re-sent at a lower power than the larger signal. Using the minimum power needed to access the transponder will allow more users to have access to the transponder. – AD7FO

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

A. FM and CW
B. SSB and SSTV
C. PSK and Packet
D. All of these choices are correct

E2B Television Practices

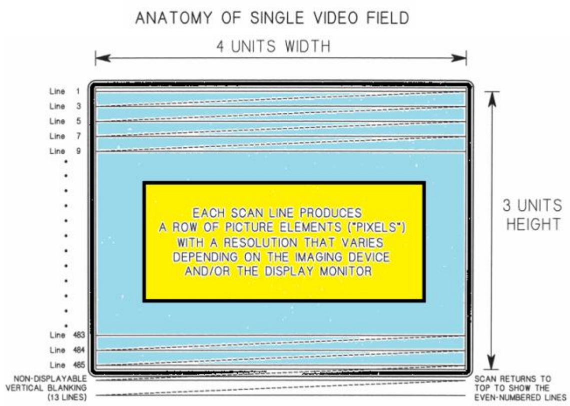
Chapters 8 of ARRL Extra Class License Manual Estimated 1 Exam Question

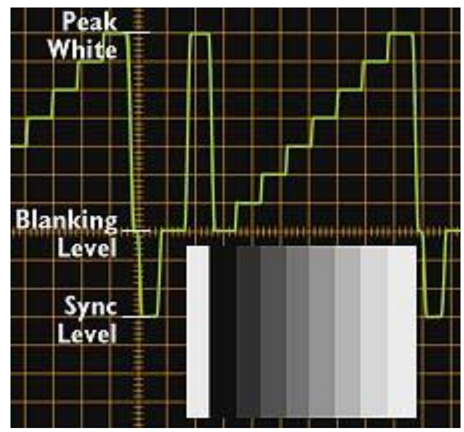
NTSC is the video standard used by North American Fast Scan ATV stations

30 frames per second are transmitted in a **fast-scan (NTSC) television** system

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

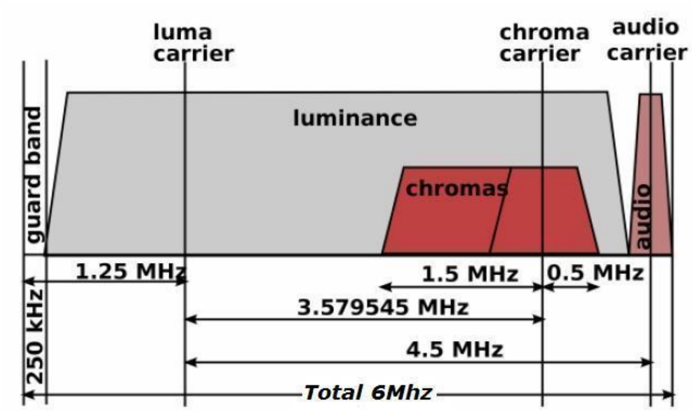
An **interlaced scanning** pattern generated by scanning odd numbered lines in one field and even numbered ones in the next in a fast-scan (NTSC) television system





Blanking in a video signal is turning off the scanning beam while it is traveling from right to left or from bottom to top

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



Vestigial sideband reduces bandwidth while allowing for simple video detector circuitry for standard fast- scan TV transmissions

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

1255 MHz is one likely to find FM ATV transmissions

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

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

Digital Radio Mondiale (DRM) can be decoded using a receiver with SSB capability and a suitable computer

Digital Radio Mondiale (DRM) based voice or SSTV digital transmissions made on the **HF amateur bands has a 3 KHz bandwidth**

3 kHz is the approximate bandwidth of a **slow-scan TV signal**

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

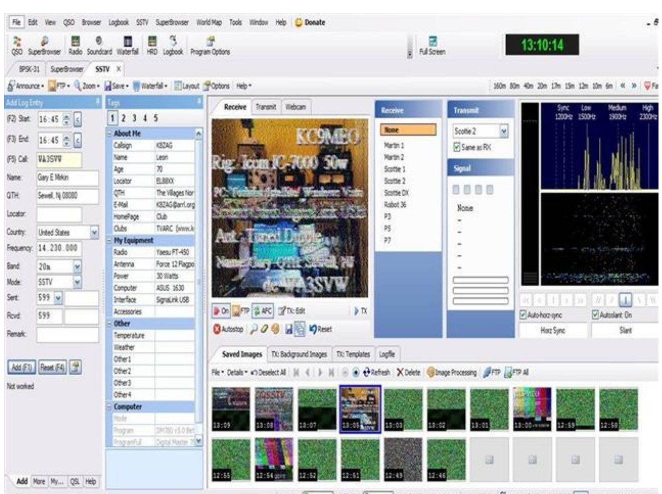
Analog SSTV images typically transmitted on the **HF bands by varying tone frequencies** representing the video are transmitted using single sideband

Tone frequency of an amateur slow-scan television signal **encodes the brightness** of the picture

128 or 256 lines are commonly used in each frame on an **amateur slow-scan color television** picture

Specific tone frequencies signal SSTV receiving equipment to **begin a new picture line**

The **Vertical Interval Signaling (VIS) code** transmitted as part of an SSTV transmission identifies the **SSTV Mode**



E2C Operating Frequency & DX

Chapters 2 of ARRL Extra Class License Manual Estimated 1 Exam Question

The Radio Amateur's Code

The Radio Amateur is

CONSIDERATE... He never knowingly operates in such a way as to lessen the pleasure of others.

LOYAL... He offers loyalty, encouragement and support to other amateurs, local clubs, the IARU Radio Society in his country, through which Amateur Radio in his country is represented nationally and internationally.

PROGRESSIVE... He keeps his station up to date. It is well-built and efficient. His ***operating practice*** is above reproach.

FRIENDLY... He operates slowly and patiently when requested; offers friendly advice and counsel to the beginner; kind assistance, cooperation and consideration for the interests of others. These are the marks of the amateur spirit.

BALANCED... Radio is a hobby, never interfering with duties owed to family, job, school or community.

PATRIOTIC... His station and skills are always ready for service to country and community.

*-- adapted from the original Amateur's Code, written by Paul M. Segal, W9EEA, in **1928**.*

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

"self-spotting" is the prohibited practice of posting one's own call sign and frequency on a call sign spotting network

146.52 MHz is a frequency that contest contact generally discouraged

30 meters bands is amateur radio contesting generally excluded

During a VHF/UHF contest the weak signal segment of the band, with most of the activity near the calling frequency would have the highest level of activity

Send your full call sign once or twice when attempting to contact a DX station working a **pileup** or in a contest

Switching to a lower frequency HF band might help to restore contact when DX signals become too weak to copy across an entire HF band a few hours after sunset

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

A. Because the DX station may be transmitting on a frequency that is prohibited to some responding stations
B. To separate the calling stations from the DX station
C. To reduce interference, thereby improving operating efficiency
D. All of these choices are correct

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

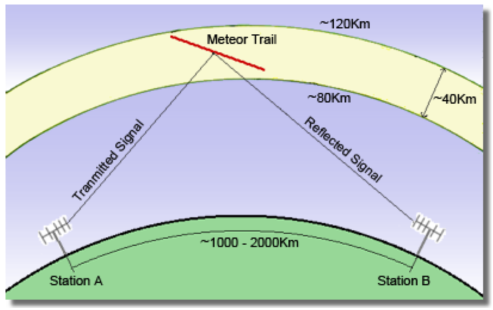
Cabrillo format is a standard for submission of electronic contest logs

Spread-spectrum signals resistant to interference because the spreading algorithm suppresses in the receiver

Spread-spectrum technique of frequency hopping works by the transmitted signal is changing very rapidly according to a particular sequence also used by the receiving station

E2D VHF and UHF digital modes

Chapters 2 & 8 of ARRL Extra Class License Manual Estimated 1 Exam Question



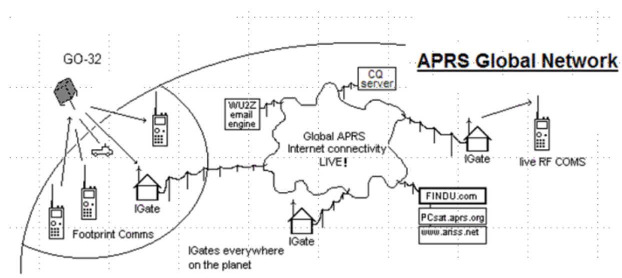
FSK441 is especially designed for use for **meteor scatter** signals

JT65 is especially useful for **EME** communications

JT65 is can decode signals many dB **below the noise floor using FEC**

The purpose of digital **store-and-forward** functions on an Amateur Radio satellite is to store digital messages in the satellite for later download by other stations

Store-and-forward is normally used by low Earth orbiting digital satellites to relay messages around the world



144.39 MHz is a commonly used 2-meter APRS frequency

AX.25 is the digital protocol is used by APRS

Unnumbered Information is used to transmit **APRS beacon data**

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

Latitude and longitude are used by the **APRS** network communicate your location

BAUD is the number of data symbols transmitted per second

E2E HF Digital Modes

Chapters 8 of ARRL Extra Class License Manual Estimated 1 Exam Question

300 baud is the most common data rate used for **HF packet** communications

Forward Error Correction (FEC) is implemented by transmitting extra data that may be used to detect and correct transmission errors

With **ARQ** if errors are detected, a **retransmission is requested**

FSK modulation is common for data emissions below 30 MHz

Selective fading has occurred when one of the ellipses in an FSK **crossed-ellipse display suddenly disappears**

Direct FSK applies the data signal to the transmitter VFO

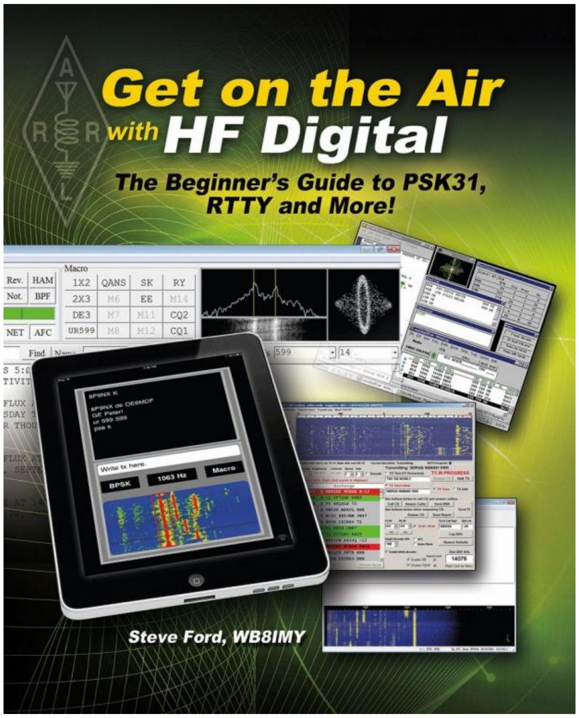
PACTOR can be used to transfer binary files

PSK31 uses variable-length coding for bandwidth efficiency

PSK31 uses has the narrowest bandwidth

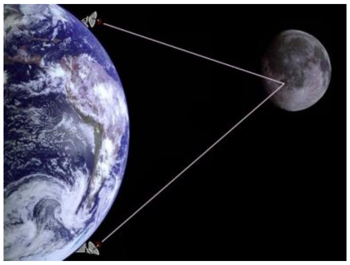
316 Hz is the typical **bandwidth** of a properly modulated **MFSK16 signal**

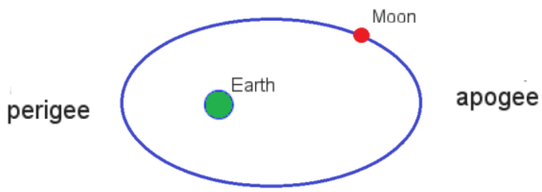
Winlink does not support keyboard-to-keyboard operation



E3A Earth-Moon-Earth Communications

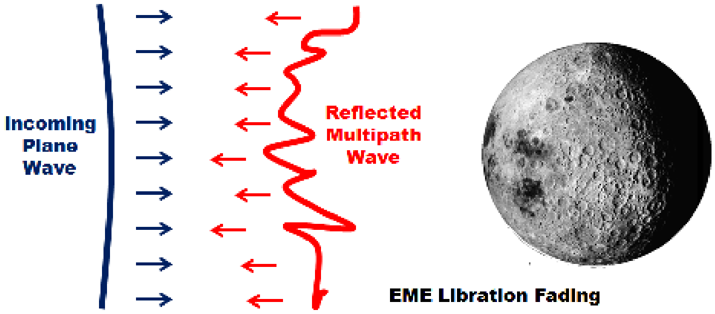
Chapters 10 of ARRL Extra Class License Manual Estimated 1 Exam Question





12,000 miles is the approximate **maximum** separation measured along the surface of the Earth between **two stations communicating by Moon bounce**

Scheduling EME contacts when the Moon is at **perigee** will generally result in the **least path loss**



A **fluttery irregular fading** characterizes **libration fading** of an Earth-Moon-Earth signal

Time synchronous transmissions with each station alternating describes a method of establishing EME contacts

The theoretical noise of a perfect resistor at room temperature is approximately -174 dBm / Hz. The lower the noise figure of the receiver front end the better it can hear weak signals. A noise figure of around 0.25 dB for VHF and UHF is desired. When attempting an EME contact on 432 MHz two-and-one-half minute time sequences are used, where one station transmits for a full 2.5 minutes and then receives for the following 2.5 minutes. – AD7FO

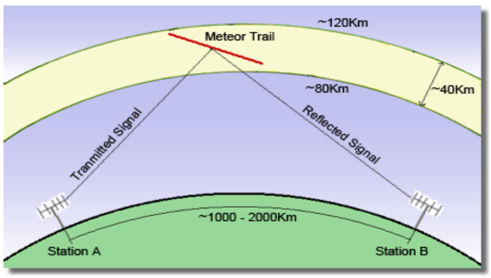
Receivers with very low noise figures is desirable for EME communications

144.000 - 144.100 MHz to find EME signals in the 2 meter band

432.000 - 432.100 MHz to find EME signals in the 70 cm band

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

A. 15 second timed transmission sequences with stations alternating based on location
B. Use of high speed CW or digital modes
C. Short transmission with rapidly repeated call signs and signal reports
D. All of these choices are correct



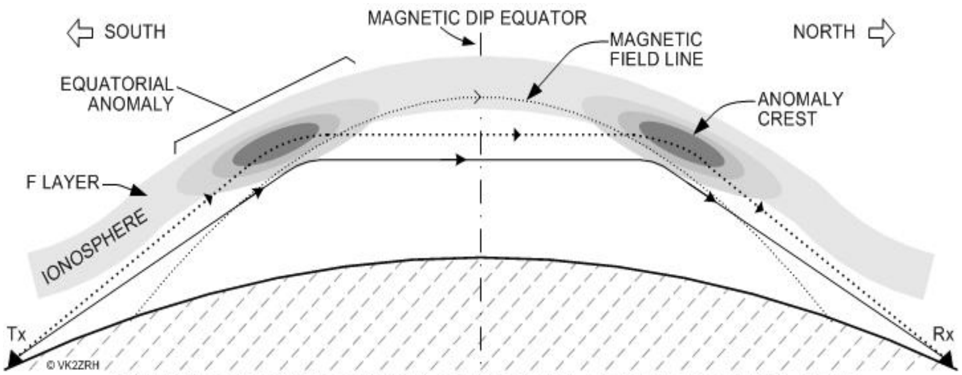
When a **meteor strikes** the Earth's atmosphere, a cylindrical region of free electrons is formed at the **E layer of the ionosphere**

28 - 148 MHz is well suited for meteor-scatter communications

E3B Long path, Gray-line, Multi-path Propagation

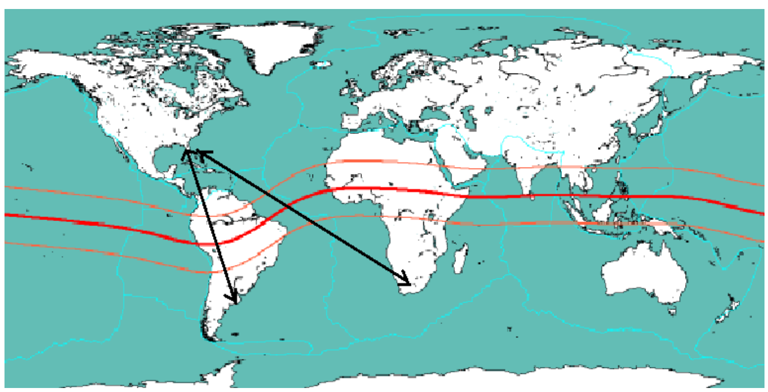
Chapters 10 of ARRL Extra Class License Manual   Estimated 1 Exam Question

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

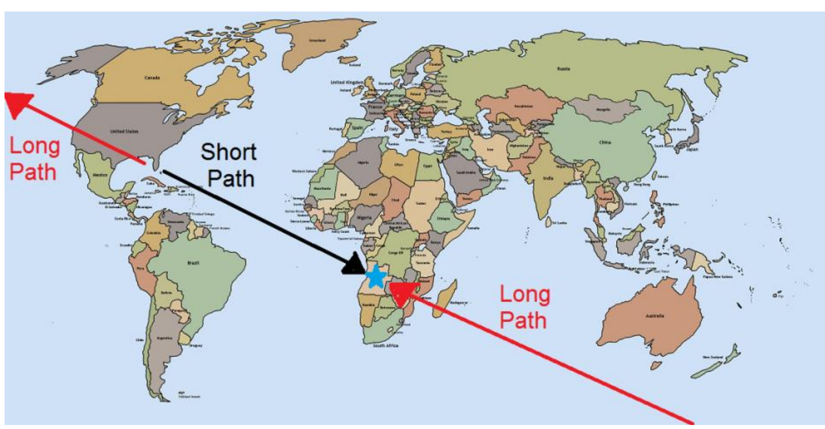


AFTERNOON TYPE TRANSEQUATORIAL PROPAGATION (aTEP)

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



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

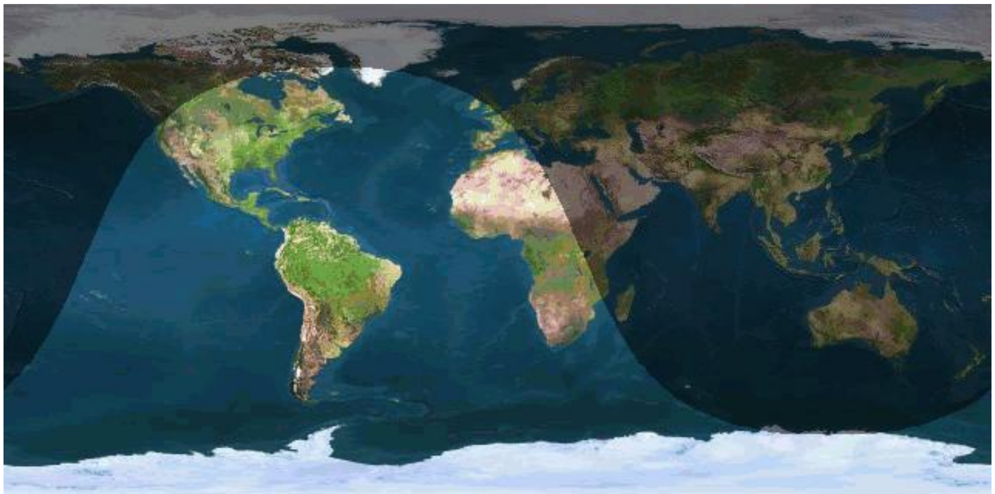


Long-path propagation is probably occurring if an HF beam antenna must be pointed in a direction 180 degrees away from a station to receive the strongest signals

160 to 10 meters typically support **long-path** propagation

20 meters most frequently provides **long-path** propagation?

Receipt of a signal by **more than one path** account for **hearing an echo** on the received signal of a distant station



Gray-line HF propagation is probably occurring if radio signals travel along the terminator between daylight and darkness

Gray-line propagation most likely to occur **sunrise and sunset**

At twilight, D-layer absorption drops while E-layer and F-layer propagation remain strong causing **Gray-line** propagation

Gray-line propagation is long distance communications **at twilight on frequencies less than 15 MHz**

E3C Aurora, Radio Horizon, Take-off Angle

Chapters 10 of ARRL Extra Class License Manual   Estimated 1 Exam Question

Aurora activity is the interaction of **charged particles from the Sun with the Earth's magnetic field** and the ionosphere

Aurora activity occurs in the **E-region of the ionosphere**

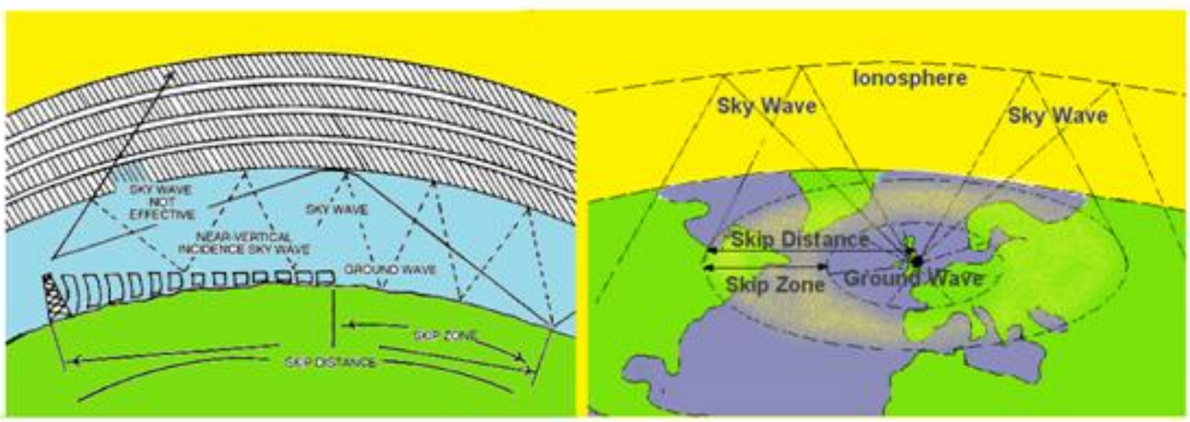
An antenna should be pointed **north** to take maximum advantage of **aurora propagation**

CW mode is best for **Aurora propagation**

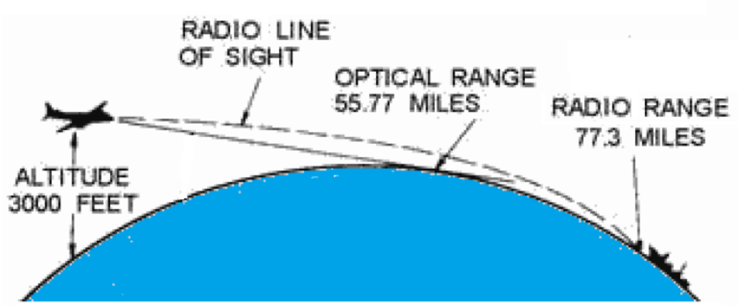
Which of the following effects does **Aurora activity** have on radio communications?

A. SSB signals are raspy
B. Signals propagating through the Aurora are fluttery
C. CW signals appear to be modulated by white noise
D. All of these choices are correct

Vertical polarization is **best for ground-wave** propagation

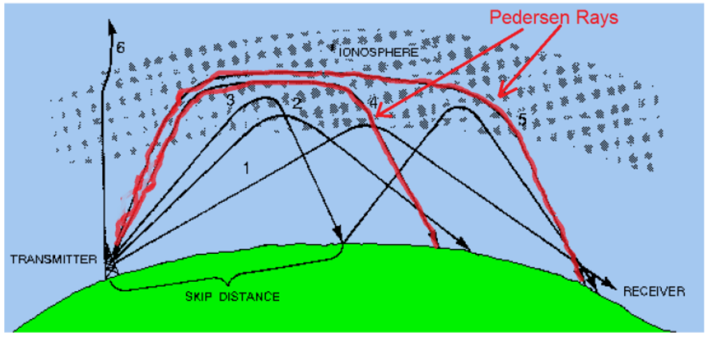


Ground-wave propagation decreases when the **signal frequency** is increased

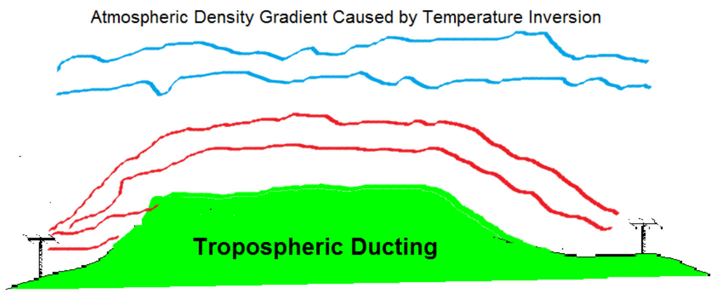


The VHF/UHF **radio-path horizon** distance exceed the geometric horizon by approximately **15%**

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



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



Tropospheric ducting is usually responsible for causing VHF signals to propagate for hundreds of miles

Figure 1 — *EZNEC* predicted elevation of ¼ wave monopole with four elevated radials at different heights above typical ground. The black trace is just above ground, the blue at 0.2 wavelengths and the red at 0.25. Note the increase in the higher lobe at the higher position. Any higher and it becomes the peak.

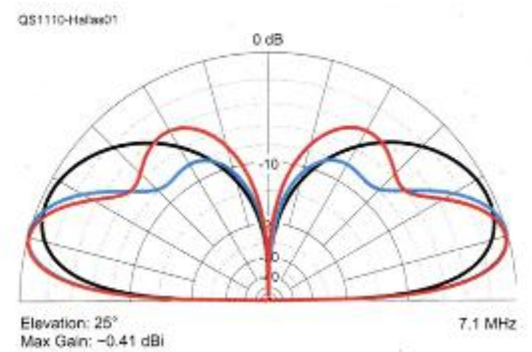
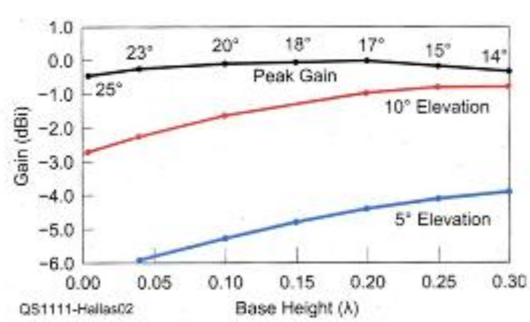


Figure 2 — Gain of a quarter wave monopole with elevated radials as a function of hight of base and radials above ground. The top curve is the peak gain with the peak elevation angle shown. The lower curves are the gain at 5 and 10° elevation, important for long haul work.



The **main lobe takeoff angle decreases with increasing height** of a horizontally polarized 3-element beam antenna vary with its height above ground

Selective fading is the **partial cancellation** of some frequencies within the pass band

E4A Test Equipment

Chapters 7, 8 & 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

An **oscilloscope** displays signals in the **time domain**

An **Oscilloscope** could be used for detailed **analysis of digital signals**

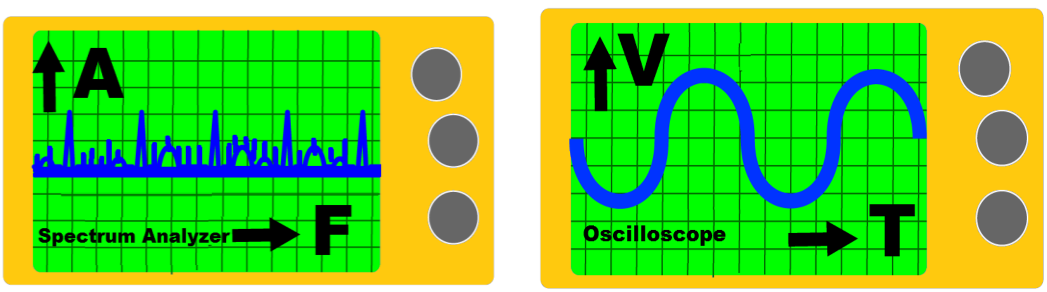
A **spectrum analyzer** displays signals in the **frequency domain**

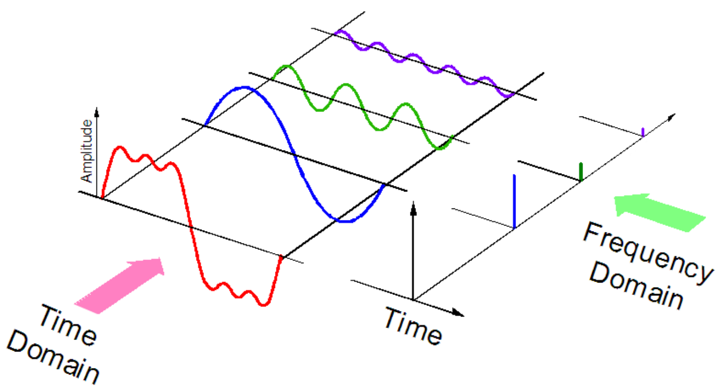
A spectrum analyzer displays **frequency on the horizontal axis**

A spectrum analyzer displays **amplitude on the vertical axis**

A spectrum analyzer is used to display **spurious signals** from a radio transmitter

A spectrum analyzer is used to display intermodulation distortion products in an SSB transmission?





Attenuate the transmitter output signal going to the spectrum analyzer

Transmit into a dummy load, receive the signal on a second receiver, and feed the audio into the sound card of a computer running an appropriate PSK program describes a good **method for measuring the intermodulation distortion** of your own PSK signal

The following could be determined with a spectrum analyzer;

A. The degree of isolation between the input and output ports of a 2 meter duplexer

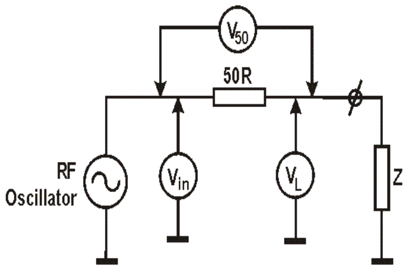
B. Whether a crystal is operating on its fundamental or overtone frequency

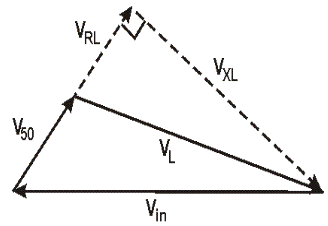
C. The spectral output of a transmitter

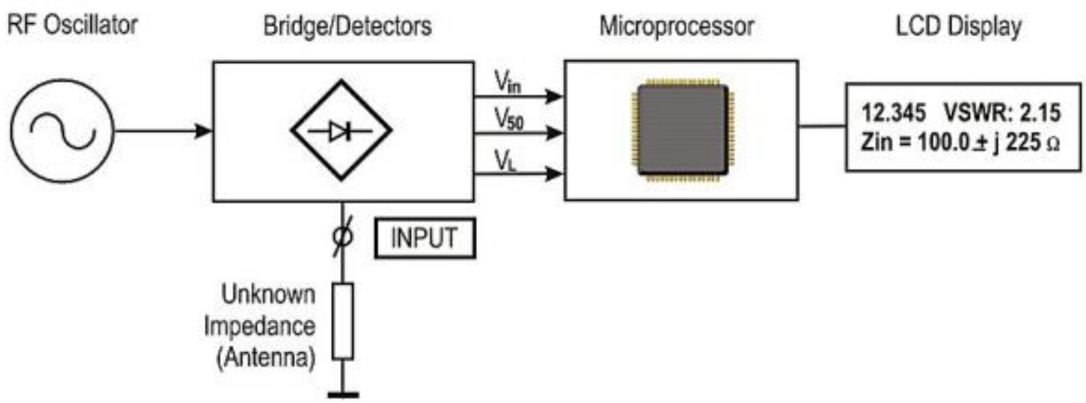
D. All of these choices are correct

Antenna analyzers have an internal **RF source**

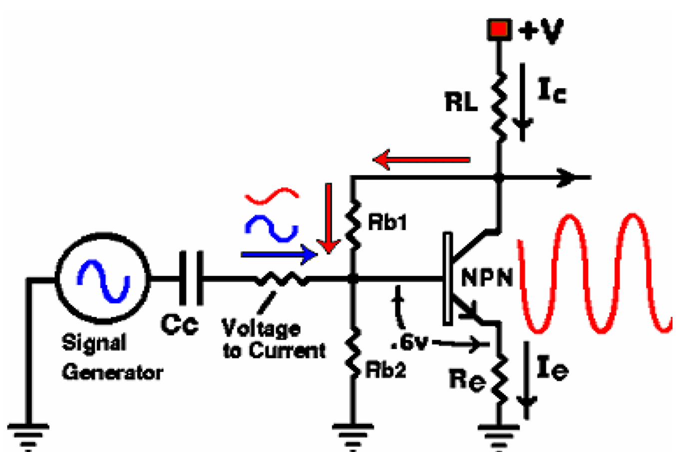
An **antenna analyzer** would be best for **measuring the SWR** of a beam antenna







A **silicon NPN** junction transistor is biased on **base-to-emitter voltage** is approximately **0.6 to 0.7 volts**



E4B Measurement Techniques

Chapter 7 & 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

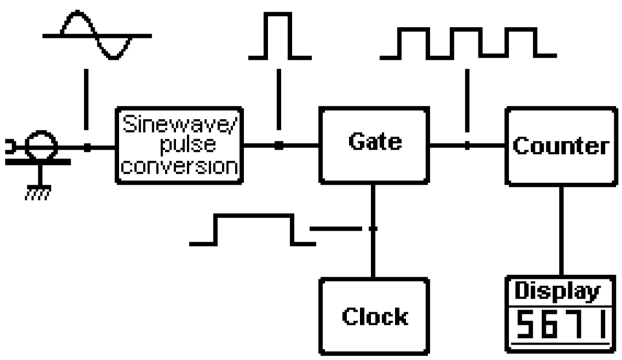
Time base accuracy most affects the **accuracy of a frequency counter**

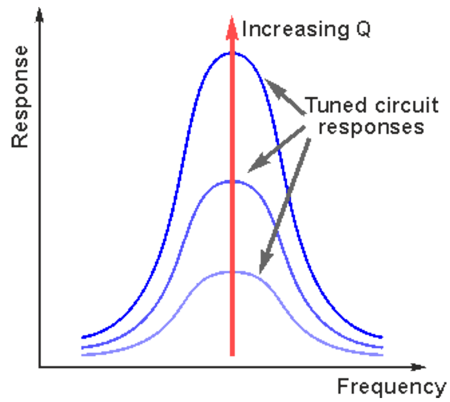
E4B03 If a frequency counter with a specified accuracy of +/- 1.0 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading? = C. 146.52 Hz

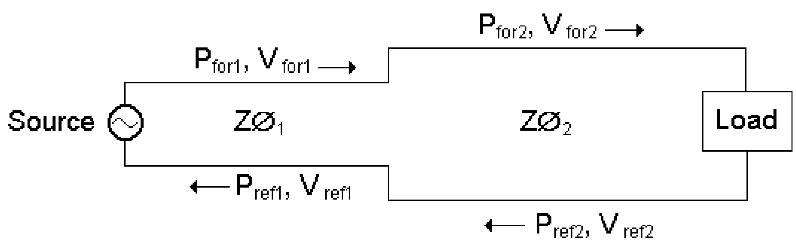
Error = Freq x Accuracy = (146.52 MHz) x (1 / 1,000,000) = **146.52 Hz**

E4B04 If a frequency counter with a specified accuracy of +/- 0.1 ppm reads 146,520,000 Hz, what is the most the actual frequency being measured could differ from the reading? = A. 14.652 Hz

Error = Freq x Accuracy = (146.52 MHz) x (10 / 1,000,000) = **1,465.20 Hz**







A **less accurate reading results** when a dip meter is **too tightly coupled** to a tuned circuit being checked

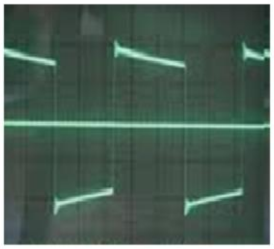
Bandwidth can be used as a relative **measurement of the Q** for a series-tuned circuit

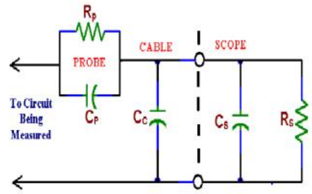
More power goes into the antenna when the current increases as the transmitter is **tuned to resonance**

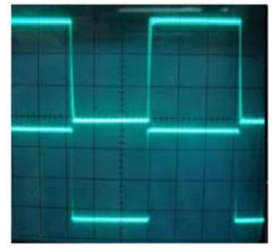
E4B06 How much power is being absorbed by the load when a directional power meter connected between a transmitter and a terminating load reads 100 watts forward power and 25 watts reflected power? = D. 75 watts

Load Power = TX Output – Power Reflected = 100W - 25W = 25W

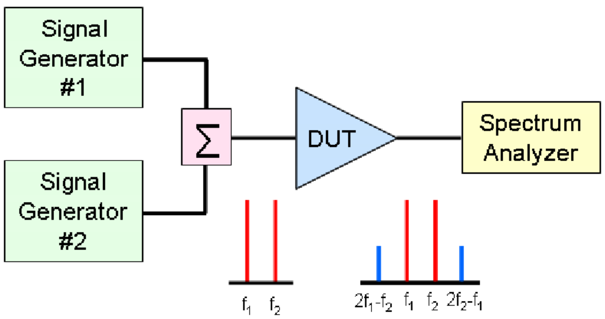
Keep the **oscilloscope probe ground** connection of the probe as **short as possible**

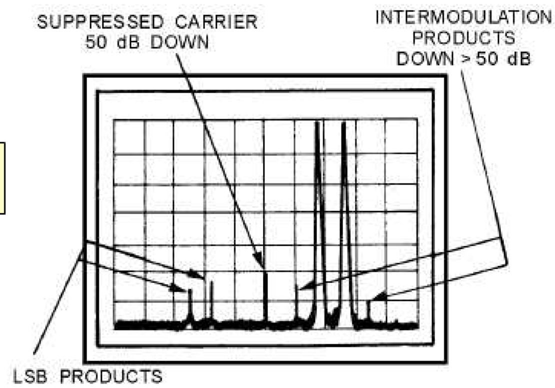






E4B13 How is the **compensation of an oscilloscope probe** typically adjusted? = A. A **square wave** is displayed and the probe is adjusted until the horizontal portions of the displayed wave are as nearly **flat as possible**



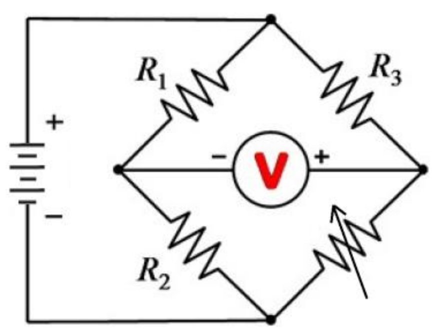


Intermodulation distortion (IMD) >> SSB TX non-harmonically **two tones** & observe RF on a spectrum analyzer

Antenna analyzer measures antenna **resonance** and **feed point impedance**

High impedance input is a characteristic of a **good DC voltmeter**

The (full scale voltmeter) x (ohms per volt rating) = **input impedance of the voltmeter**



The **bridge circuit** measurement is **based on obtaining a signal null**, which can be done very **precisely**

E4C Phase Noise, Image Rejection, Signal / Noise

Chapter 8 of ARRL Extra Class License Manual Estimated 1 Exam Question

Minimum discernible signal (MDS) represents the receiver minimum discernible signal

Lowering the receiver **noise figure improves weak signal sensitivity**

The **noise figure of a receiver** >> ratio in dB of the noise generated by the receiver vs. theoretical minimum noise

The **theoretical noise** at the input of a perfect receiver at room temperature = **-174 dBm/Hz**

Receiver **oscillator phase noise** causes nearby frequencies to **interfere with reception of weak signals**

Atmospheric noise is the primary source of noise that can be heard from receiver connected to an antenna

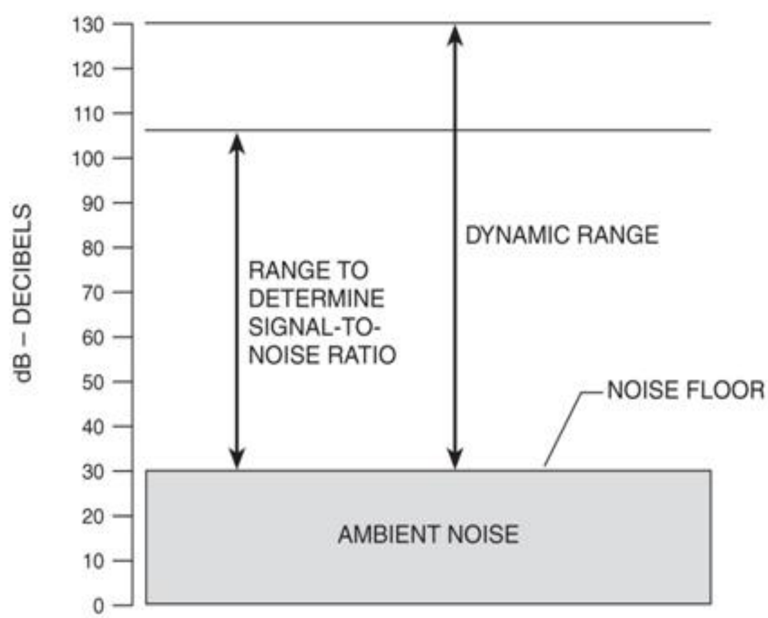
E4C06 A CW receiver with the AGC off has an equivalent input noise power density of -174 dBm/Hz. What would be the level of an unmodulated carrier input to this receiver that would yield an audio output SNR of 0 dB in a 400 Hz noise bandwidth? = D. -148 dBm

You are given the MDS for the receiver in Hz but you need to determine the MDS for 400 Hz

BW Ratio for 400 vs. 1 Hz >> 10 X log BW Factor = 10 X log (400 / 1) = 10 x 2.6 = 26 dB

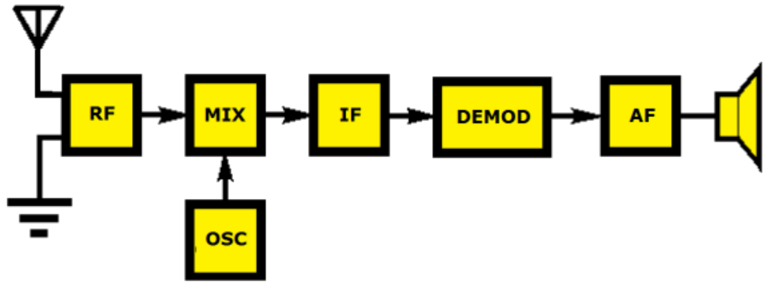
MDS for 400 Hz = MDS 1 Hz + BW Ratio = -174 + 26 = **-148 dBm**

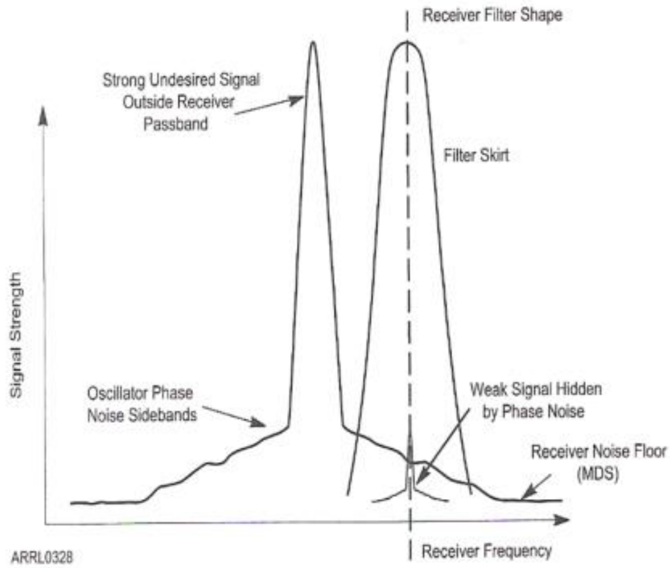
A **narrow-band roofing filter improves dynamic range** by attenuating strong signals near the receive frequency



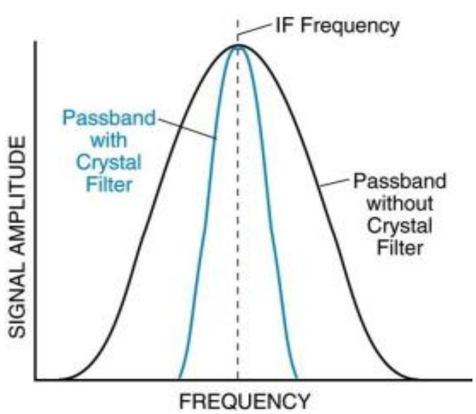
A **wide IF filter bandwidth** in a receiver causes **undesired signals** to be heard

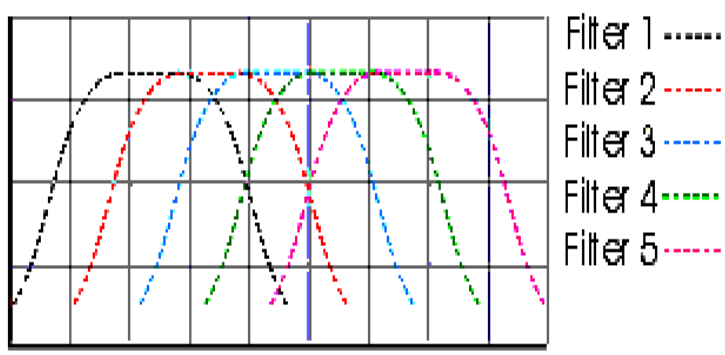
A **higher frequency IF** requires less for front-end circuitry to **eliminate image responses**





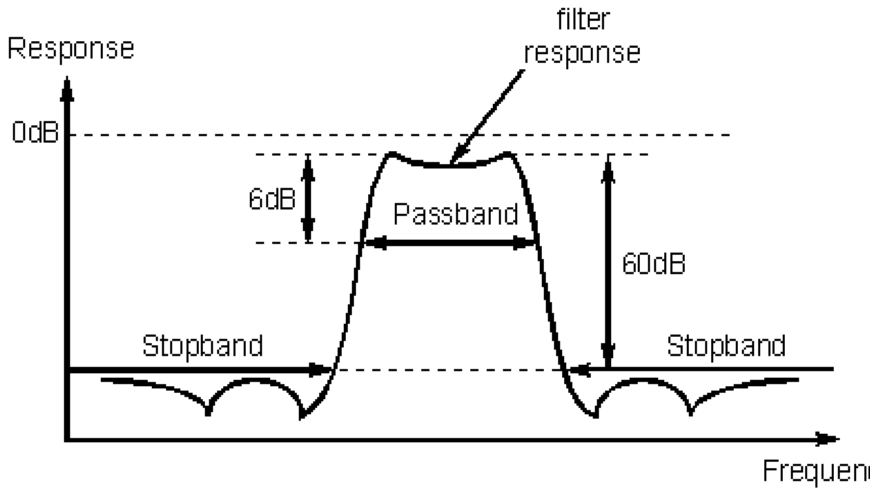
A **front-end filter or pre-selector** can be effective in **eliminating image signal interference**





300 Hz is a desirable amount of **selectivity** for an **RTTY** HF receiver

2400 Hz is a desirable amount of **selectivity** for an **SSB phone** receiver



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

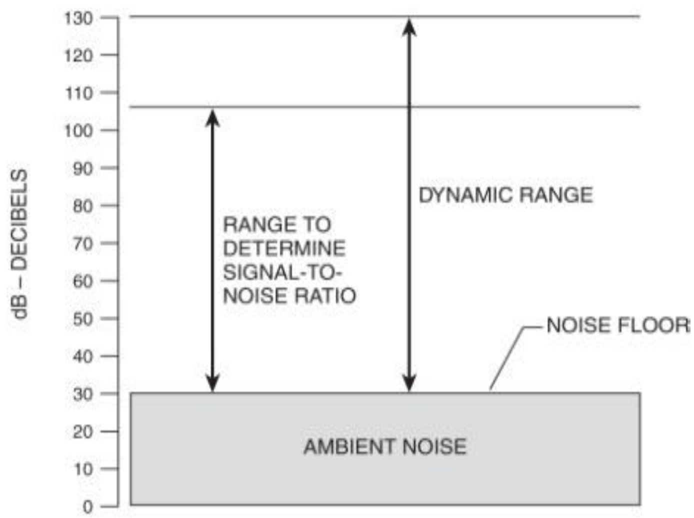
When a local oscillator signal is mixed with an incoming signal in generates the sum and the difference of the two signals. If we assume High side mix (the LO is higher than the tuned frequency then the LO will be the tuned frequency + 455KHz. A signal 455 KHz above the LO would also generate a 455 KHz IF spurious or image signal. So taking the receive frequency of 14.300 MHz and 2 times the IF frequency of 0.455 MHz (14.300 – (2x.455) we get 15.210 MHz – AD7FO.

CAPTURE EFFECT is the term for the blocking of one FM phone signal by another, stronger FM phone signal

E4D Dynamic Range, IMD, 3rd Order Intercept

Chapter 7 & 8 of ARRL Extra Class License Manual Estimated 1 Exam Question

The **BLOCKING DYNAMIC RANGE** of a receiver is the difference in dB between the noise floor and the level of an incoming signal which will cause 1 dB of gain compression.



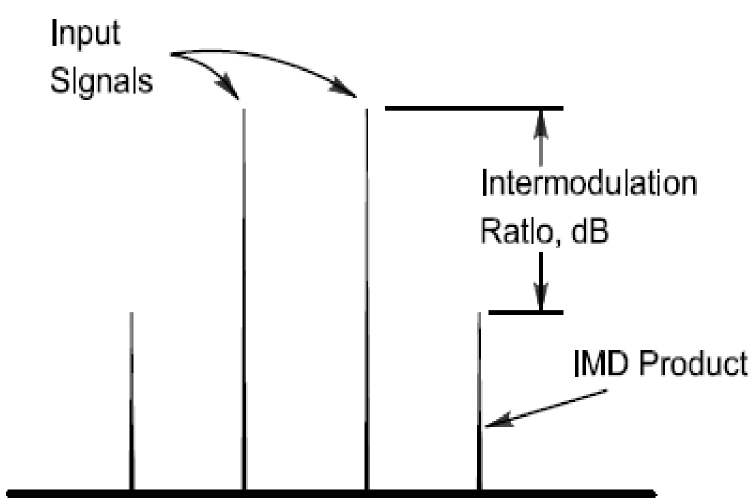
Nonlinear circuits or devices **cause intermodulation** in an electronic circuit

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

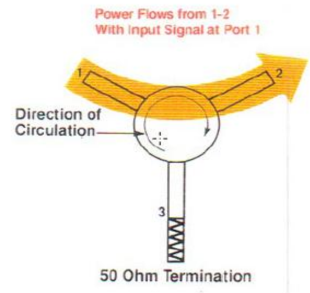
Intermodulation between repeaters occur when they are in close proximity and the signals mix in the final amplifier of one or both transmitters

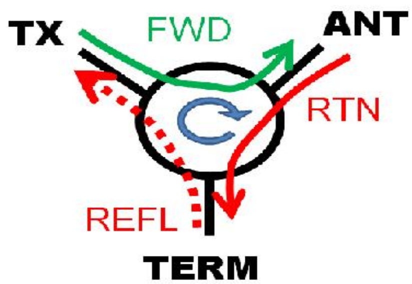
Cross-modulation interference >> the off-frequency unwanted signal is heard in addition to the desired signal

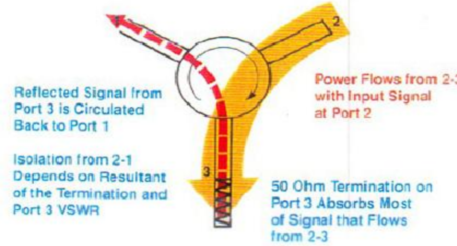
Cross-modulation and desensitization from strong adjacent signals are caused by **poor dynamic range**



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







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

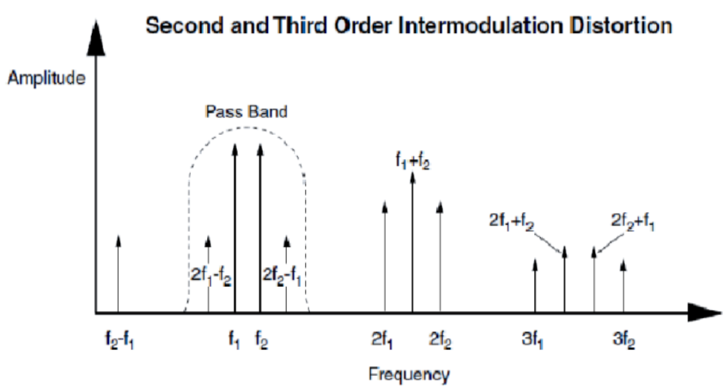
Strong adjacent-channel signals can cause receiver **desensitization**

Decreasing the RF bandwidth of a receiver **will reduce** the likelihood of receiver **desensitization**

A **PRESELECTOR** increases the rejection of unwanted signals

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

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



Intermod Product	Frequency
Second Order	$f_1 + f_2$
	$f_1 - f_2$
Third Order	$2f_1 + f_2$
	$2f_1 - f_2$
	$f_1 + 2f_2$
	$f_1 - 2f_2$

There are many possible IMD solutions; You know 146.70 MHz = F_{IMD} and you know transmitter A (TX_a) = 146.52 MHz you are being asked to find transmitter B!

#1) 2nd $F_{IMD} = TX_a + TX_b$ > too high for the receiver

#2) 2nd $F_{IMD} = TX_a - TX_b$ > too low for the receiver

#3) 3rd $F_{IMD} = 2TX_a + TX_b$ > too high for the receiver

#4) 3rd $F_{IMD} = 2TX_a - TX_b$ > 146.70= (2 x 146.52) - TX_b >> TX_b = (2 x 146.52) - 146.70 = (293.04) - 146.70 = **146.34 MHz**

#5) 3rd $F_{IMD} = 2TX_b + TX_a$ > too high for the receiver

#6) 3rd $F_{IMD} = 2TX_b - TX_a$ > 146.70 = (2 x TX_b) - 146.52 >> TX_b = (146.70 + 146.52) / 2 = (293.22) / 2 = **146.61 MHZ**

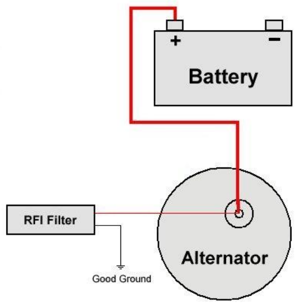
E4E Noise Suppression

Chapter 7 of ARRL Extra Class License Manual Estimated 1 Exam Question

Broadband white noise, ignition noise & power line noise can often be reduced with a **DSP noise filter**

A **noise blanker** may remove **signals which appear across a wide bandwidth**

Electric motor noise may be suppressed by installing a brute-force **AC-line filter in series with the motor leads**



Alternator noise may be suppressed by connecting the radio's power leads **directly to the battery** and by installing **coaxial capacitors in line with the alternator** leads

Ignition noise can often be reduced by use of a receiver **noise blanker**

Thunderstorms are the major cause of **atmospheric static**

You can determine if line noise interference is being generated within your home by **turning off the AC power line main circuit breaker** and listening on a battery operated radio

Common-mode signal at the frequency of the radio transmitter is picked up by electrical wiring near a radio antenna

An **IF noise blanker** makes **nearby signals may appear to be excessively wide** even if they meet emission standards

This is because a peak of the signal is removed and the broader lower section is only received. The observed 3 dB bandwidth of the blanked signal would appear to be much wider than if referred to the original peak signal level. - AD7FO

Interference caused by **a touch controlled electrical device** >> Rx **AC Hum** on SSB & CW, **slow drifting signal** or interfering **signal can be several kHz in width and usually repeats** at regular intervals across a HF band

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

Corroded joints act like diodes and then function as a mixer generating sum and difference frequencies from nearby strong signals. - AD7FO

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

Arcing thermostat contacts, defective **doorbell transformer** or a malfunctioning **illuminated advertising display** may cause a loud roaring or buzzing AC line interference that comes and goes at intervals

The appearance of unstable modulated or unmodulated signals at specific frequencies might be caused by the operation of a nearby **personal computer**

E5A Characteristics of Resonant Circuits

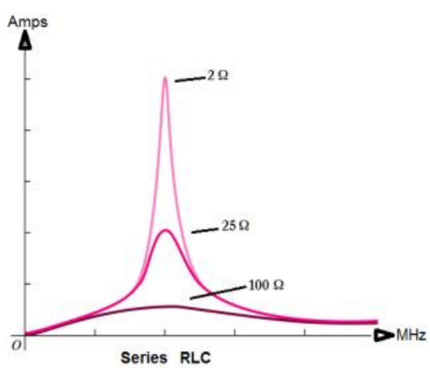
Chapter 4 of ARRL Extra Class License Manual Estimated 1 Exam Question

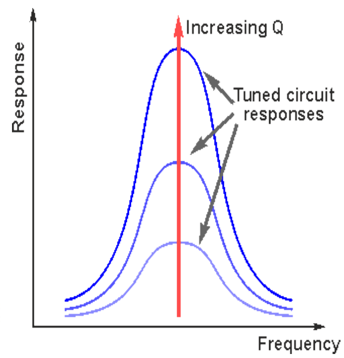
Resonance is the frequency at which the **capacitive reactance equals the inductive reactance**

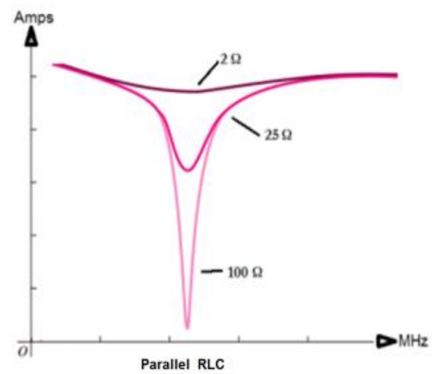
Resonance can cause the voltage across **reactances** in series to be **larger than the voltage applied to them**

The **voltage and current are in phase** across a **series resonant** circuit at resonance

The **voltage and current are in phase** across a **parallel resonant** circuit at resonance

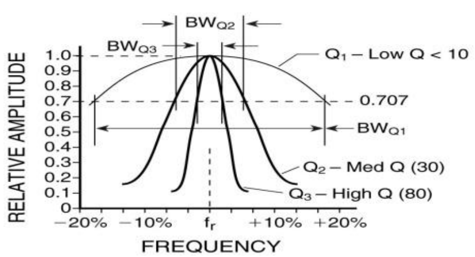






The impedance of a **series RLC circuit at resonance is equal to circuit resistance** (looks like R)

Maximum current is at the input of a **series RLC** circuit as the frequency is **resonance**

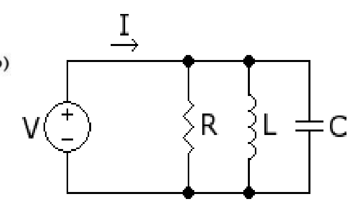


f_r = Resonant frequency in Hz

BW = Half-power Bandwidth (−3db)

$Q = \frac{f_r}{BW}$

$\therefore BW = \frac{f_r}{Q}$

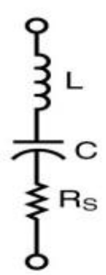


The impedance of a circuit with a **RLC all in parallel, at resonance is equal to circuit resistance** (looks like R)

The **maximum circulating current of a parallel LC circuit occurs at resonance** within the components

Minimum current is at the **input** of a **parallel RLC** circuit as the frequency is **resonance**

Series Resonant Circuit



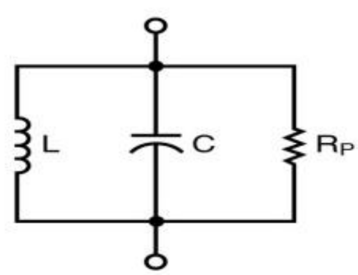
$$Q = \frac{X_L}{R_S} \text{ or } \frac{X_C}{R_S}$$

$$X_L = 2\pi f_r L$$

$$X_C = \frac{1}{2\pi f_r C}$$

$X_L = X_C$ at f_r, the resonant frequency

Parallel Resonant Circuit



$$Q = \frac{R_P}{X_L} \text{ or } \frac{R_P}{X_C}$$

E5A10 What is the half-power bandwidth of a parallel resonant circuit that has a resonant frequency of 1.8 MHz and a Q of 95? = A. 18.9 kHz

B/W = Freq/Q = 1.8 MHz / 95 = 18.9474 KHz

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

B/W = Freq/Q = 7.1 MHz / 150 = 47.3333 KHz

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

B/W = Freq/Q = 3.7 MHz / 118 = 31.3559 KHz

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

B/W = Freq/Q = 14.25 MHz / 187 = 76.2032 KHz

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

Freq = 1/[2π√(LC)] = 1/[6.28x√(0.00005x0.00000000004)] = 1/(2.808501379739736e-7) = 3560618 Hz = 3.56 MHz

E5A15 What is the resonant frequency of a series RLC circuit if R is 56 ohms, L is 40 microhenrys and C is 200 picofarads? = B. 1.78 MHz

Freq = 1/[2π√(LC)] = 1/[6.28x√(0.00004x0.0000000002)] = 1/(5.617002759479472e-7) = 1.780309 MHz

E5A16 What is the resonant frequency of a parallel RLC circuit if R is 33 ohms, L is 50 microhenrys and C is 10 picofarads? = D. 7.12 MHz

Freq = 1/[2π√(LC)] = 1/[6.28x√(0.00005x0.00000000001)] = 1/(1.404250689869868e-7) = 7.121236 MHz

E5A17 What is the resonant frequency of a parallel RLC circuit if R is 47 ohms, L is 25 microhenrys and C is 10 picofarads? = A. 10.1 MHz

Freq = 1/[2π√(LC)] = 1/[6.28x√(0.000025x0.00000000001)] = 1/(9.929551852928711e-8) = 10.070948 MHz

E5B Time Constants & Phase Angles

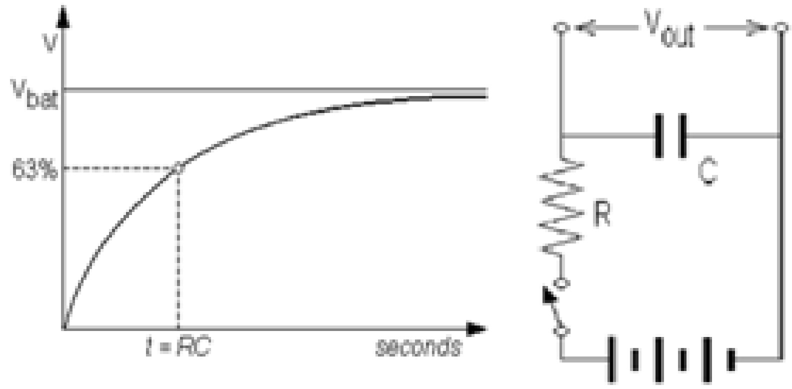
Chapter 4 of ARRL Extra Class License Manual   Estimated 1 Exam Question

One time constant is the time required for the capacitor in an RC circuit to **charge 63.2%**

One time constant is the time required for a charged capacitor in an RC circuit to **discharge to 36.8%**

The capacitor in an RC circuit is **discharged to 13.5%** of the starting voltage after **two time constants**

One time constant = **TC (sec) = R (MΩ) x C (uF)** *Check your decimal point!*



When a voltage is applied to a capacitor through a resistance (all circuits have resistance) it takes time for the voltage across the capacitor to reach the applied voltage. At the instant the voltage is applied the current in the circuit is at a maximum limited only by the circuit resistance. As time passes the voltage across the capacitor rises and the current decreases until the capacitor charge reaches the applied voltage at which point the current goes to zero. - AD7FO

E5B04 What is the time constant of a circuit having two 220-microfarad capacitors and two 1-megohm resistors, all in parallel? = D. 220 seconds

TC (sec) = R (MΩ) x C (uF) = 0.5 x 440 = 220 Sec

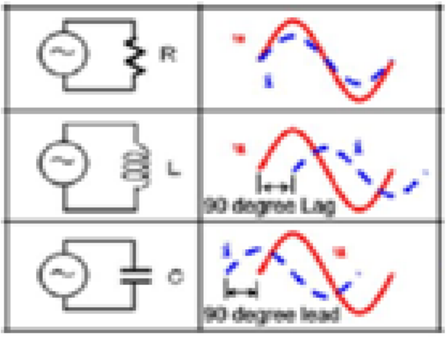
E5B05 How long does it take for an initial charge of 20 V DC to decrease to 7.36 V DC in a 0.01-microfarad capacitor when a 2-megohm resistor is connected across it? = A. 0.02 seconds

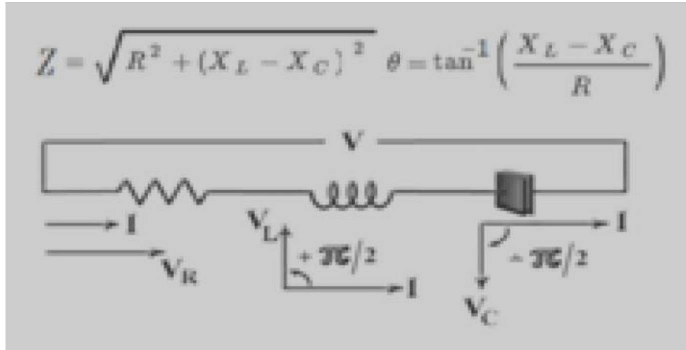
7.36/20 = 0.368 = 36.8% i.e. One Time Constant >> **TC (sec) = R (MΩ) x C (uF)** = 2 x .01 = .02 Sec

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

294/800 = 0.3675 = 36.8% i.e. One Time Constant >> **TC (sec) = R (MΩ) x C (uF)** = 1 x 450 = 450 Sec

XL > XC Voltage Leads Current **XC > XL Voltage Lags Current**





Voltage leads current by 90 deg through an **inductor**

Current leads voltage by 90 deg through **a capacitor**

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

Θ = tan^-1 [(250-500)/1000] = tan^-1 (-0.25) = -14.036° *(Negative Phase = Volt **Lags** Current)*

E5B08 What is the phase angle between the voltage across and the current through a series RLC circuit if XC is 100 ohms, R is 100 ohms, and XL is 75 ohms? = A. 14 degrees with the voltage lagging the current

Θ = tan^-1 [(75-100)/100] = tan^-1 (-0.25) = -14.036° *(Negative Phase = Volt **Lags** Current)*

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

Θ = tan^-1 [(50-25)/100] = tan^-1 (+0.25) = +14.036° *(Positive Phase = Volt **Leads** Current)*

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

Θ = tan^-1 [(50-75)/100] = tan^-1 (-0.25) = -14.036° *(Negative Phase = Volt **Lags** Current)*

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

Θ = tan^-1 [(500-250)/1000] = tan^-1 (+0.25) = +14.036° *(Positive Phase = Volt **Leads** Current)*

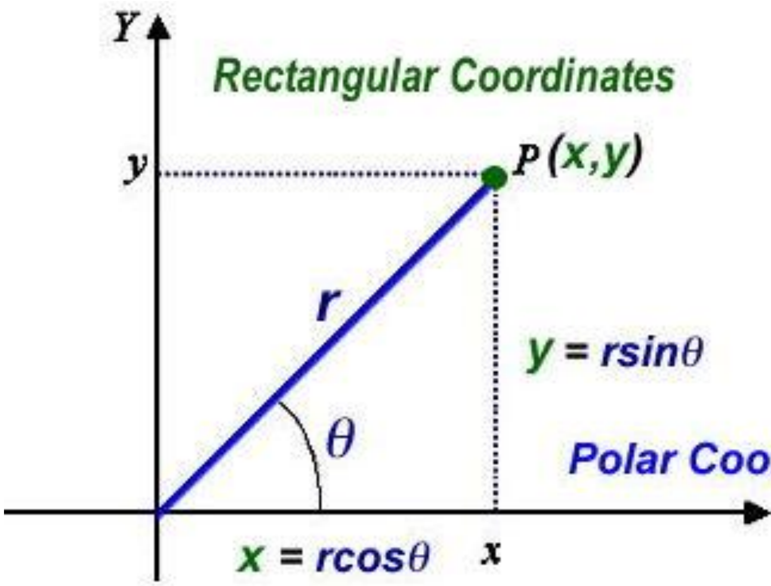
Editors Comment: Note ALL answers are 14 Degrees on exam. You must know:

XL > XC Voltage Leads Current **XC > XL Voltage Lags Current**

E5C Impedance Plots & Coordinate Systems

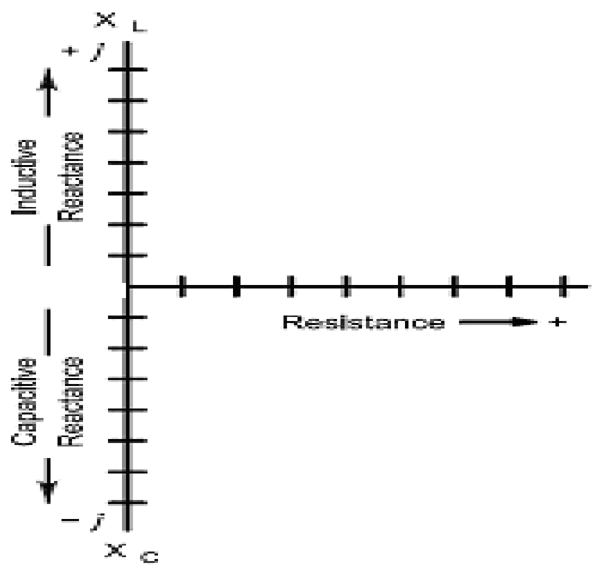
Chapter 4 of ARRL Extra Class License Manual Estimated 1 Exam Question

Polar coordinates display the phase angle of a circuit resistance, inductive and/or capacitive reactance **(# Ω at zz°)**



Rectangular coordinates to display the resistive, inductive, and/or capacitive reactance **(R+jX)**

The values along the horizontal and vertical axes **define a point on a graph** using rectangular coordinates



The **horizontal axis** represents the **resistive component**

The **vertical axis** represents the **reactive component**

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \qquad \theta = \tan^{-1}(X / R)$$

E5C01 In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance inductor in series with a 100-ohm resistor? = B. 141 ohms at an angle of 45 degrees

$$Z = \sqrt{[100^2 + 100^2]} = \sqrt{20{,}000} = 141.42\ \Omega \gg \Theta = \tan^{-1}[100/100] = \tan^{-1}(1) = 45°$$

E5C02 In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance inductor, a 100-ohm-reactance capacitor, and a 100-ohm resistor, all connected in series? = D. 100 ohms at an angle of 0 degrees

$$Z = \sqrt{[100^2 + 0^2]} = \sqrt{10{,}000} = 100\ \Omega \gg \Theta = \tan^{-1}[100-100/100] = \tan^{-1}(0) = 0°$$

E5C03 In polar coordinates, what is the impedance of a network consisting of a 300-ohm-reactance capacitor, a 600-ohm-reactance inductor, and a 400-ohm resistor, all connected in series? = A. 500 ohms at an angle of 37 degrees

$$Z = \sqrt{[400^2 + 300^2]} = \sqrt{250{,}000} = 500\ \Omega \gg \Theta = \tan^{-1}[600-300/400] = \tan^{-1}(0.75) = 36.87°$$

E5C04 In polar coordinates, what is the impedance of a network consisting of a 400-ohm-reactance capacitor in series with a 300-ohm resistor? = D. 500 ohms at an angle of -53.1 degrees

$$Z = \sqrt{[300^2 + 400^2]} = \sqrt{250{,}000} = 500\ \Omega \gg \Theta = \tan^{-1}[-400/300] = \tan^{-1}(-1.333) = -53.12°$$

E5C05 In polar coordinates, what is the impedance of a network consisting of a 400-ohm-reactance inductor in parallel with a 300-ohm resistor? = A. 240 ohms at an angle of 36.9 degrees

$$Z = 1/\sqrt{[(1/300)^2 + 1/(400)^2]} = 1/\sqrt{1.73611\text{e-}5} = 1/0.004166 = 240\ \Omega \gg \Theta = \tan^{-1}[1/400 / 1/300] = \tan^{-1}(0.75) = 36.87°$$

E5C06 In polar coordinates, what is the impedance of a network consisting of a 100-ohm-reactance capacitor in series with a 100-ohm resistor? = D. 141 ohms at an angle of -45 degrees

$$Z = \sqrt{[100^2 + 100^2]} = \sqrt{20{,}000} = 141.42\ \Omega \gg \Theta = \tan^{-1}[-100/100] = \tan^{-1}(-1) = -45°$$

E5C07 In polar coordinates, what is the impedance of a network comprised of a 100-ohm-reactance capacitor in parallel with a 100-ohm resistor? = C. 71 ohms at an angle of -45 degrees

$$Z = 1/\sqrt{[(1/100)^2 + 1/(100)^2]} = 1/\sqrt{0.0002} = 1/0.0141 = 70.71\ \Omega \gg \Theta = \tan^{-1}[1/-100 / 1/100] = \tan^{-1}(-1) = -45°$$

E5C08 In polar coordinates, what is the impedance of a network comprised of a 300-ohm-reactance inductor in series with a 400-ohm resistor? = B. 500 ohms at an angle of 37 degrees

$$Z = \sqrt{[400^2 + 300^2]} = \sqrt{250{,}000} = 500\ \Omega \gg \Theta = \tan^{-1}[300/400] = \tan^{-1}(0.75) = 36.87°$$

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

$$Z = \sqrt{[100^2 + 100^2]} = \sqrt{20,000} = 141.42\ \Omega \gg \Theta = \tan^{-1}[-100/100] = \tan^{-1}(-1) = -45°$$

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

$$Z = \sqrt{[4^2 + 3^2]} = \sqrt{25} = 5\ \Omega \gg \Theta = \tan^{-1}[3/4] = \tan^{-1}(0.75) = 36.87°$$

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

{Siemens = 1/R} so R = 1/0.00709 **Ω** = 141.044 **Ω** Polar angle = 1 / j (admittance angle) = 1/j(45°) = -45°

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

{Siemens = 1/R} so R = 1/0.005 **Ω** = 200 **Ω** Polar angle = 1 / j (admittance angle) = 1/j(-30°) = 30°

R = R X Cos θ = 200 X Cos 30° = 173.20 >> X = R X Sin θ = 200 X Sin 30° = 100

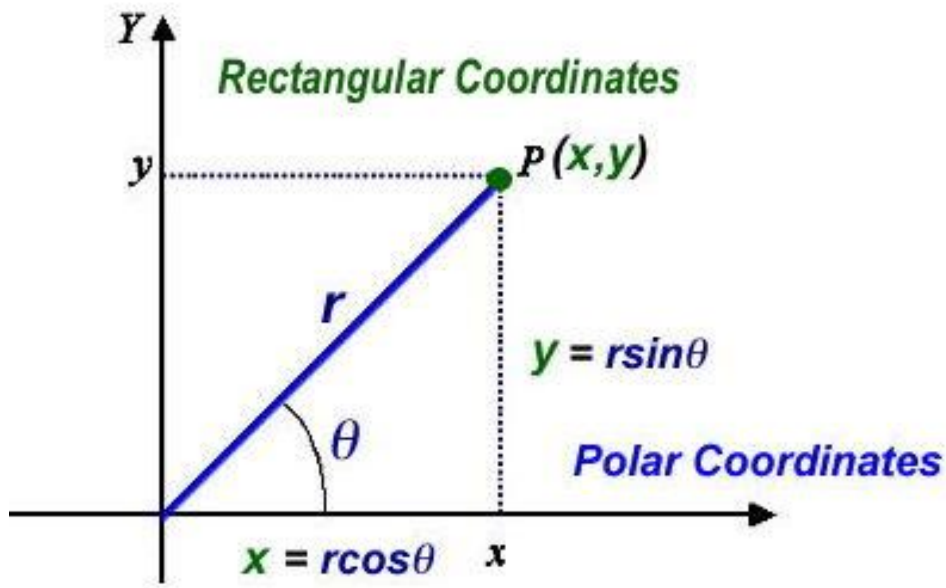
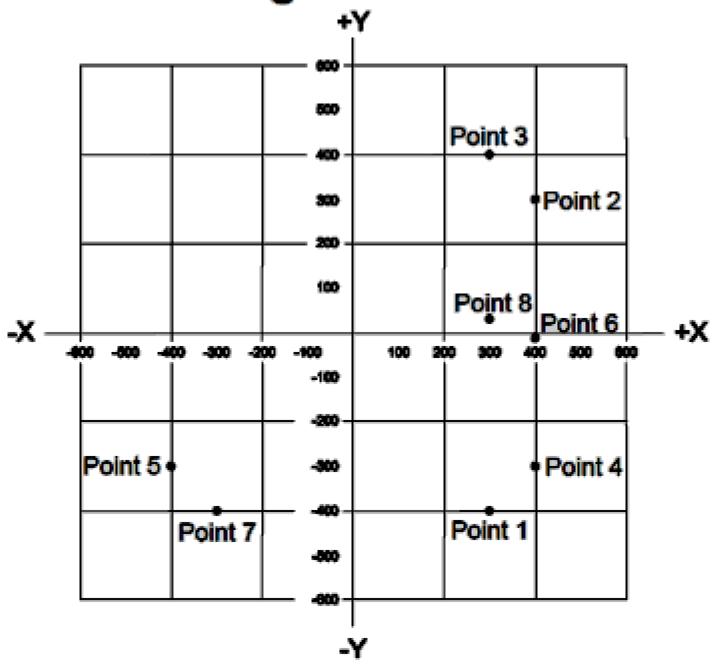


Figure E5-2



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

R = 400 >> X = 1/ (2 π FC) = X = 1/ (2 x π x MHz x uF) = 1/0.0033427 = -299.16 Ω **or 400 R – 300 j**

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

R = 300 >> X = 2 π FL = 2 x π x MHz x uH = 396.41 Ω **or 300 R + 400 j**

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

R = 300 >> X = 1/ (2 π FC) = 1/ 0.002531 = -395.12 Ω **or 300 R – 400 j**

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

R = 40 >> X = 2 π FL = 31415.93 Ω **or 40 R + 31,416 j**

E5C23 Which point on Figure E5-2 best represents the impedance of a series circuit consisting of a 300-ohm resistor, a 0.64-microhenry inductor and an 85-picofarad capacitor at 24.900 MHz? = D. Point 8

R = 300 >> XL = 2 π FL = 100.13 Ω >> XC = 1/ (2 π FC) = -75.20 Ω

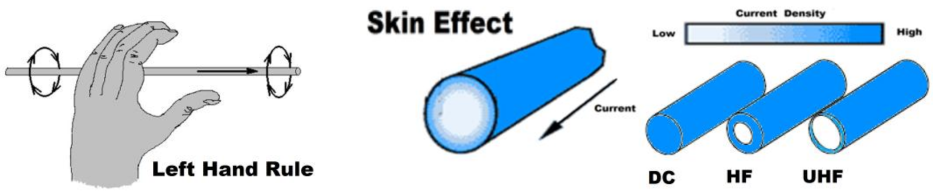
or 300 R + 100 j – 75 j **= 300 R + 25 j**

E5D AC and RF Energy in Circuits

Chapter 4 of ARRL Extra Class License Manual Estimated 1 Exam Question

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

SKIN EFFECT is why the resistance at RF currents is different at DC



Potential energy is stored in an electromagnetic or electrostatic field

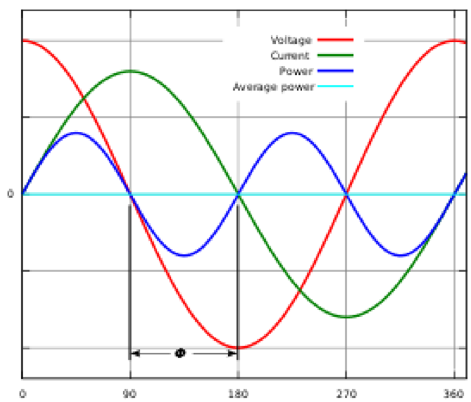
A **capacitor** stores electrical energy in an electrostatic field

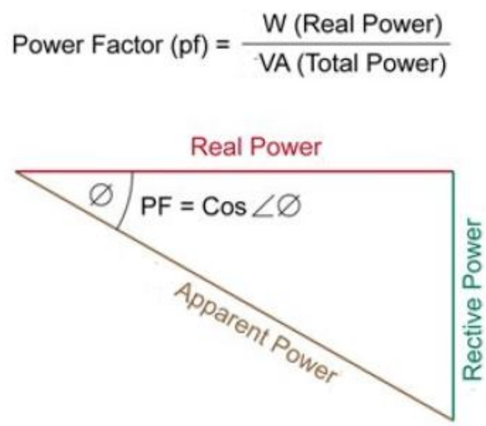
Joule >> Unit measures electrical energy stored in an electrostatic field

Electric current creates a magnetic field

MAGNETIC FIELD around a conductor is determined by the left-hand rule

Current determines the **strength** of a magnetic field around a conductor



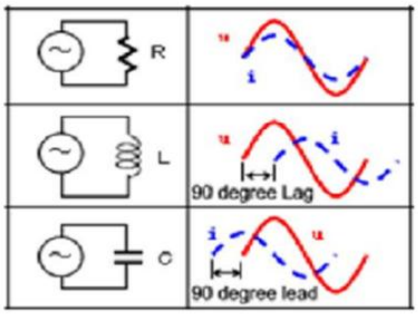


Wattless, nonproductive power is **REACTIVE POWER**

REACTIVE POWER in an AC circuit is exchanged between magnetic and electric fields, **but is not dissipated**

POWER FACTOR = Real Power (Watts) / Total Power (V x A)

POWER FACTOR = COS (Voltage to Current Phase



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

PF = COS (Voltage to Current Phase) = COS 60° = 0.5

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

PF = COS 60° = 0.5

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

PF = Real Pwr / Total Pwr >> therefore >> **Real Pwr = PF x Total Pwr** = 0.2 x VA = 0.2 x 400 = 80 W

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

Trick question Resistor has **Real Power** >> therefore W = I^2 R >> **Real Pwr** = 1^2 x 100 = 100 W

E5D15 What is the power factor of an RL circuit having a 45 deg phase between the voltage and the current? = D. 0.707

PF = COS 45° = 0.707

E5D16 What is the power factor of an RL circuit having a 30 deg phase between the voltage and the current? = C. 0.866

PF = COS 30° = 0.866

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

PF = Real Pwr / Total Pwr >> therefore >> **Real Pwr = PF x Total Pwr** = 0.6 x VA = 0.6 x 1000 = 600 W

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

PF = Real Pwr / Total Pwr >> therefore >> **Real Pwr = PF x Total Pwr** = 0.71 x VA = 0.71 x 500 = 355 W

E6A Semiconductor Materials & Devices

Chapter 5 of ARRL Extra Class License Manual Estimated 1 Exam Question

N-type semiconductor materials contains excess **free electrons**

Free electrons are the majority **charge carriers in N-type** semiconductor material

Holes are the majority **charge carriers in P-type** semiconductor material

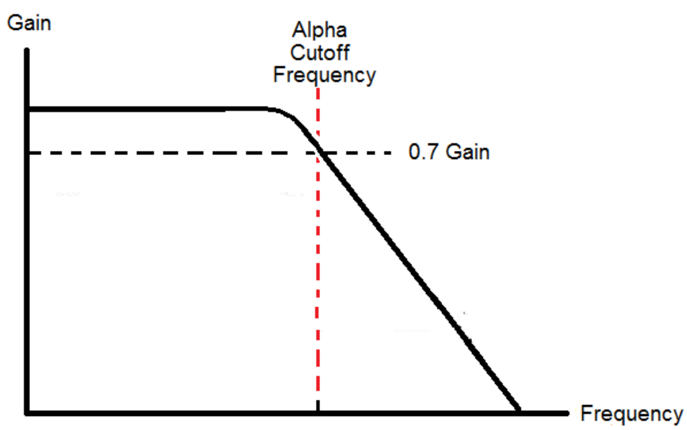
A **P-type** semiconductor materials contains an excess of **holes** in the outer shell of electrons

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

A **bipolar transistor has low input impedance**

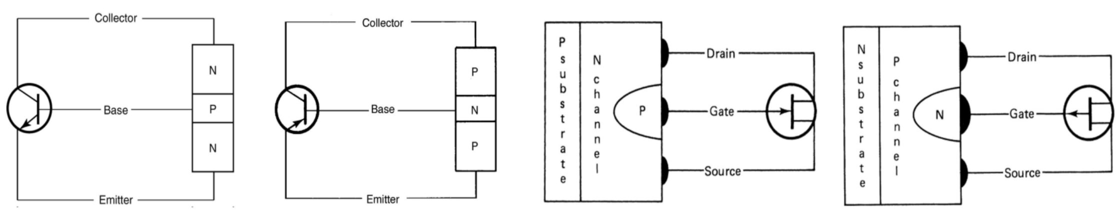
The change of **collector current with respect to emitter current** is the **alpha** of a bipolar junction transistor

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



Alpha cutoff is the frequency at which the gain of a transistor has decreased to **0.7 of the gain obtainable at 1 kHz**

At **microwave frequencies gallium arsenide** is used as a semiconductor material in preference to germanium or silicon



Complementary Metal-Oxide Semiconductor (CMOS)

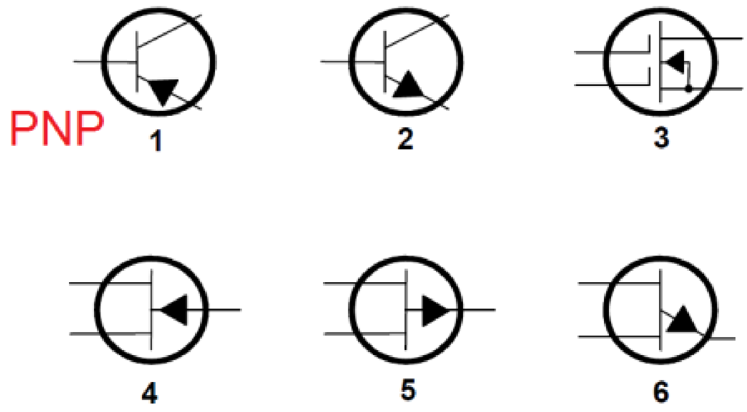
An **FET has high input impedance**

Gate, drain, source are the names of the three terminals of a **field-effect transistor**

Many **MOSFET** devices have internally connected **Zener diodes on the gates** to reduce the chance of the gate insulation being punctured by static discharges or excessive voltages

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

Figure E6-1

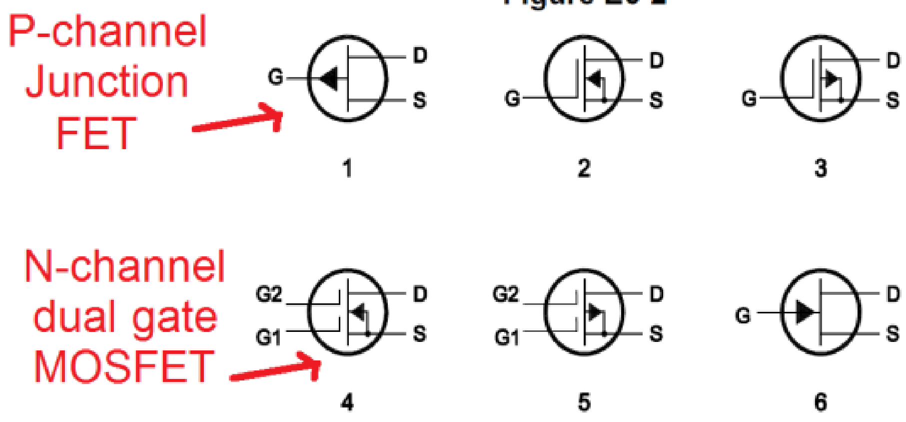


E6A07 In Figure E6-1, what is the schematic symbol for a PNP transistor? = A. 1

E6A10 In Figure E6-2, what is the schematic symbol for an N-channel dual-gate MOSFET? = B. 4

E6A11 In Figure E6-2, what is the schematic symbol for a P-channel junction FET? = A. 1

Figure E6-2



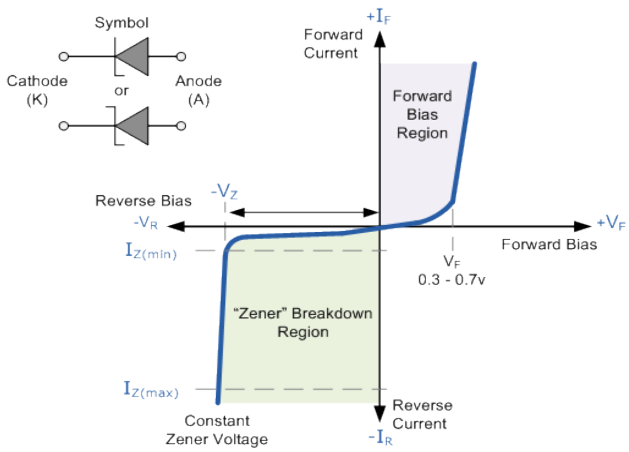
E6B Semiconductor Diodes

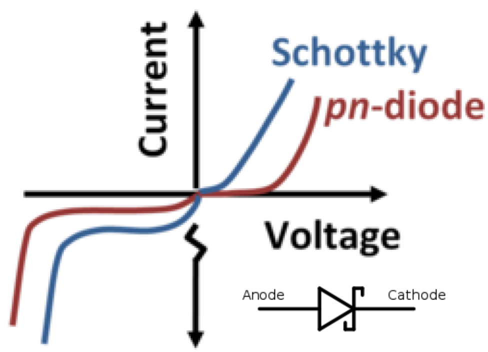
Chapter 5 of ARRL Extra Class License Manual Estimated 1 Exam Question

Metal-semiconductor junction describes a type of semiconductor diode

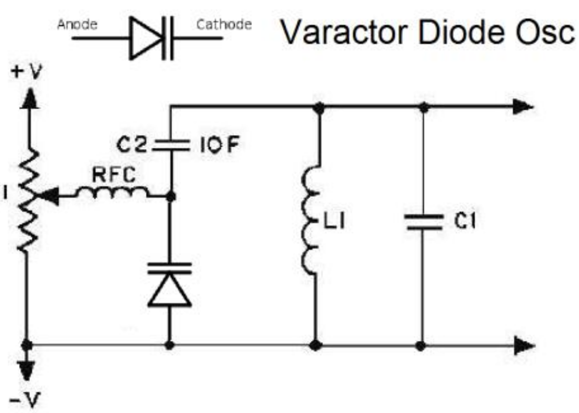
Excessive junction temperature is the failure mechanism when a **junction diode fails** due to excessive current

A **Zener diode** maintains a **constant voltage** drop under conditions of varying current

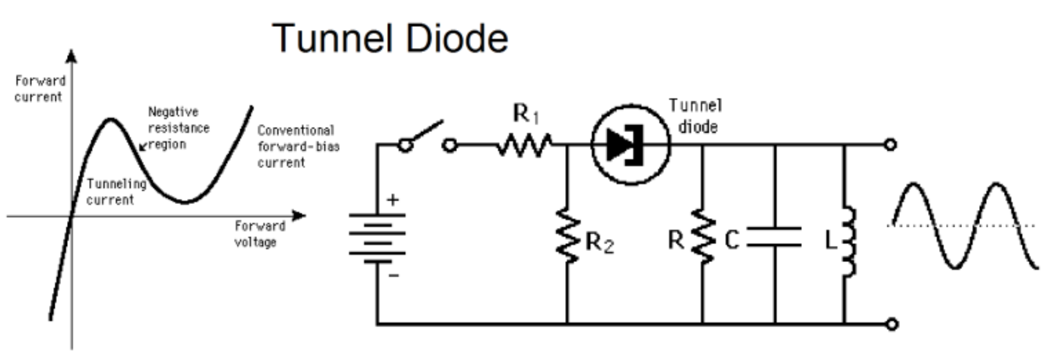




A **Schottky diode has less forward voltage drop** silicon diode when used as a power supply rectifier



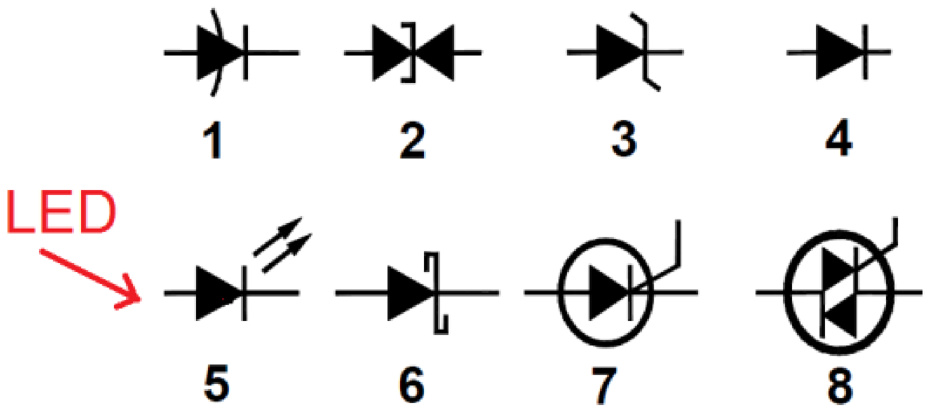
A **Varactor diode** is designed for use as a **voltage-controlled capacitor**



A **Tunnel diode** is capable of both **amplification and oscillation**

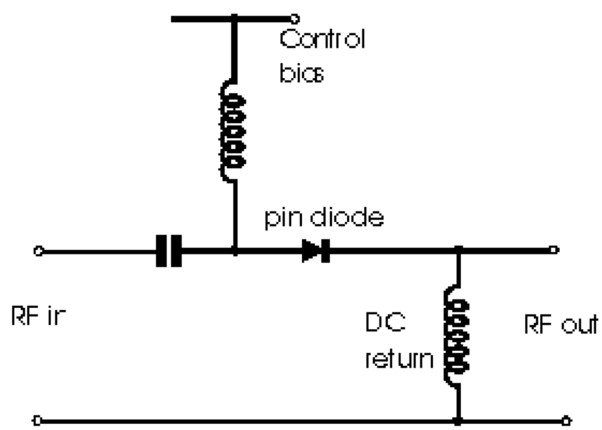
E6B10 In Figure E6-3, what is the schematic symbol for a light-emitting diode? = B. 5

Figure E6-3



A **VHF / UHF mixer or detector** is a common use of a **hot-carrier diode**

An **RF detector** is a common use for **point contact diodes**



A **PIN diode has a large region of intrinsic material** making it useful as an **RF switch or attenuator**

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

An **RF switch** is one common use for **PIN diodes**

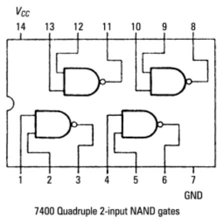
Forward bias is required for an **LED to emit light**

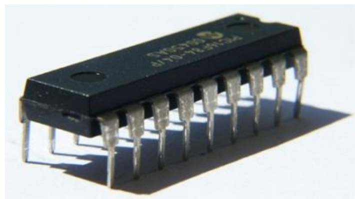
E6C Integrated Circuits

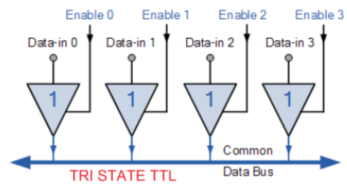
Chapter 5 of ARRL Extra Class License Manual Estimated 1 Exam Question

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

TTL device **assume logic-high state if they are left open**







A logic device with **0, 1, and high impedance output** states describes **tri-state logic**

Ability to connect many device outputs to a **common bus** is the primary advantage of **tri-state logic**

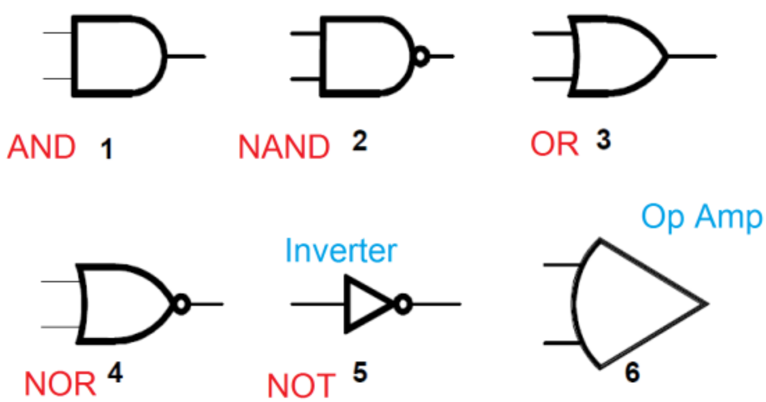
CMOS logic devices have lower power consumption compared to TTL devices

CMOS input switching threshold is about one-half the power supply **voltage** providing a **high immunity to noise**

BiCMOS is an integrated circuit logic family using **both bipolar and CMOS** transistors

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

Figure E6-5



E6C07 In Figure E6-5, what is the schematic symbol for an AND gate? = A. 1

E6C08 In Figure E6-5, what is the schematic symbol for a NAND gate? = B. 2

E6C09 In Figure E6-5, what is the schematic symbol for an OR gate? = B. 3

E6C10 In Figure E6-5, what is the schematic symbol for a NOR gate? = D. 4

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

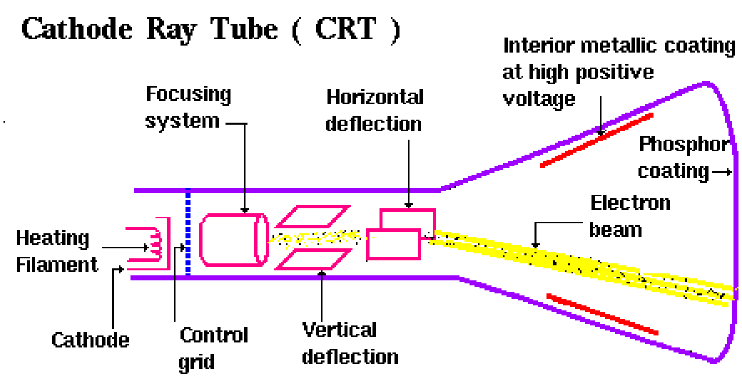
E6D Optical Devices & Toroids

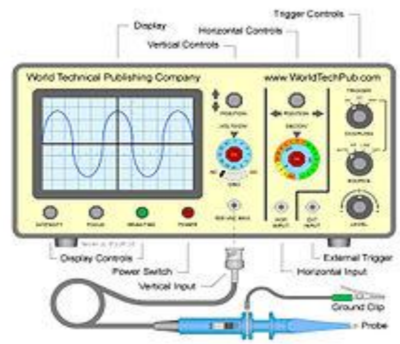
Chapter 4 & 5 of ARRL Extra Class License Manual   Estimated 1 Exam Question

Exceeding the anode voltage design rating can cause a **cathode ray tube (CRT)** to **generate X-rays**

CRT **persistence** is the length of **time the image remains on the screen** after the beam is turned off

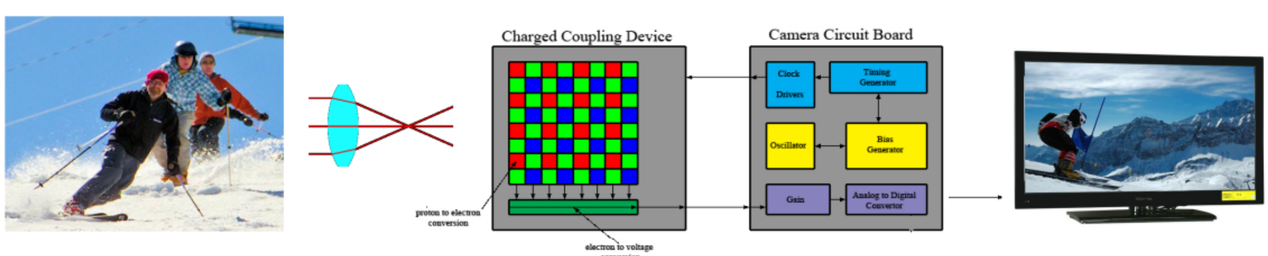
A **CRT uses electrostatic deflection** is better when high-frequency waveforms are to be displayed on the screen





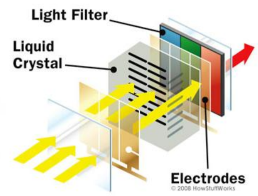
A **charge-coupled device (CCD) samples an analog signal** and passes it in stages from the input to the output

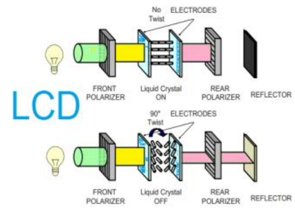
CCD in a modern video camera stores **photo-generated charges as signals corresponding to pixels**



A **liquid-crystal display (LCD)** uses **polarizing filters that become opaque when voltage is applied**

LCD devices consume less power than most other types of display devices



Permeability of the core material determines the **inductance** of a toroidal inductor

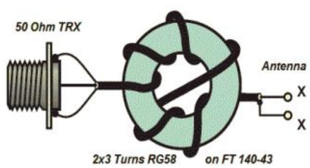
Powdered-iron toroids maintain their **characteristics at higher currents** rather than ferrite toroids

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

20 Hz to 300 MHz is the usable frequency range of **inductors that use toroidal cores**

Toroidal cores confine most of the magnetic field within the core material unlike a solenoidal

Ferrite beads are commonly used as VHF and UHF **parasitic suppressors** on HF amplifiers


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

N = required number of turns, L = desired inductance (in mH), AL = inductance index of the core (in mH/1000 turns)

$$N = 1000 \times \sqrt{(L / AL)} = 1000 \times \sqrt{(1/523)} = 1000 \times \sqrt{(0.001912)} = 1000 \times 0.043727 = \mathbf{43.727} \text{ Turns}$$

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

N = required number of turns, L = desired inductance (in mH), AL = inductance index of the core (in mH/1000 turns)

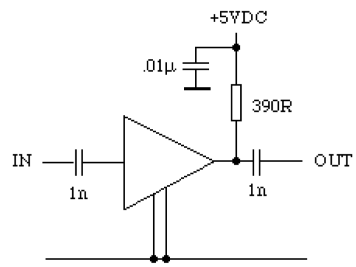
$$N = 100 \times \sqrt{(L / AL)} = 100 \times \sqrt{(5/40)} = 100 \times \sqrt{(0.125)} = 100 \times 0.\ 0.353553 = \mathbf{35.355} \text{ Turns}$$

E6E Piezoelectric Crystals & MMICs

Chapters 5 & 6 of ARRL Extra Class License Manual Estimated 1 Exam Question

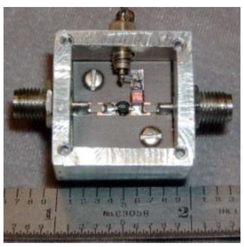
50 ohms is the most common input and output **impedance** of circuits that use **MMICs**

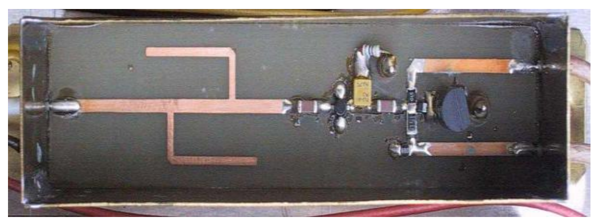
Controlled gain, low noise figure, constant impedance makes the **MMIC** good for VHF to microwave circuits



The B**+ supply is furnished through a resistor** and/or RF choke connected to the **MMIC output lead**

Microstrip construction is typically used to construct a **MMIC** based microwave amplifier



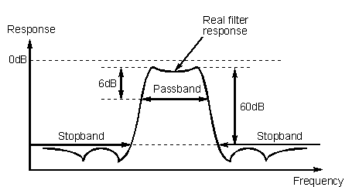


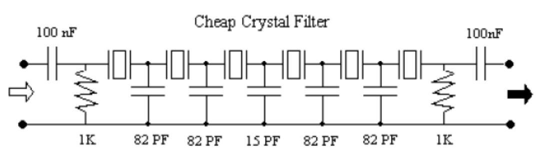
Gallium nitride is likely to provide the highest frequency of operation when used in MMICs

2 dB is a typical noise value of a low-noise **UHF preamplifier**

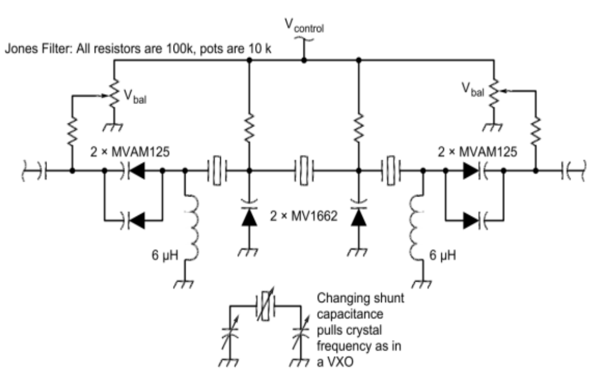
A **crystal lattice filter** is a filter with **narrow bandwidth and steep skirts** made using quartz crystals

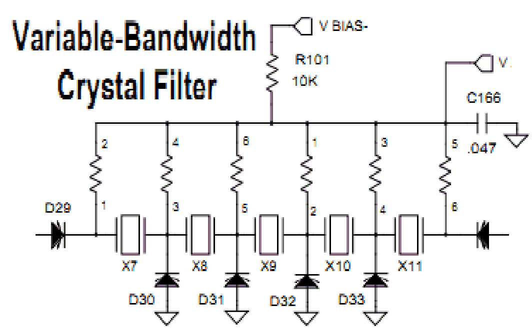
The **relative frequencies of the each crystal** determine the bandwidth and response shape of a **crystal ladder filter**





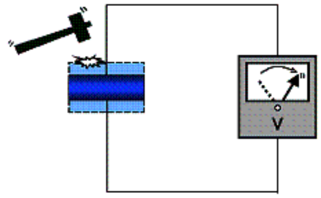
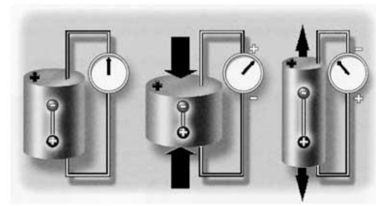
A **variable bandwidth crystal lattice filter** is a **"Jones filter"** as used as part of a HF receiver IF stage



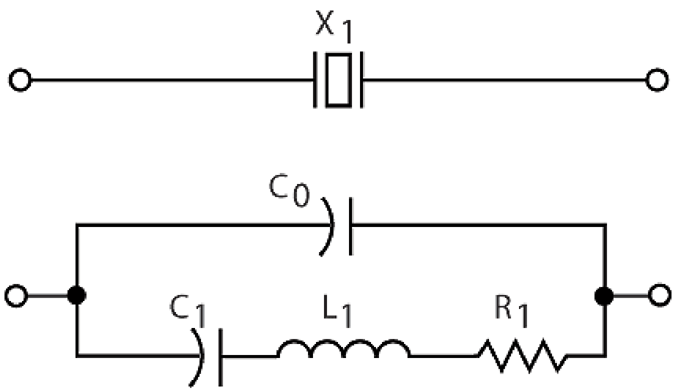


Physical deformation of a crystal by the application of a voltage is one aspect of the piezoelectric effect

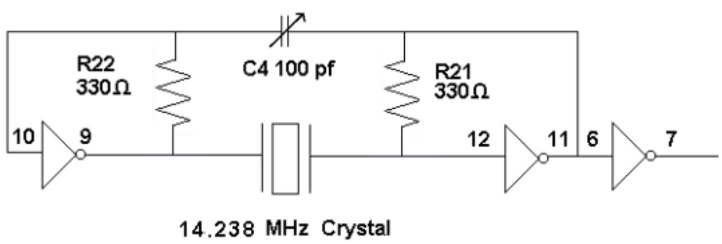


The **equivalent circuit of a quartz crystal** is motional capacitance, motional inductance and loss resistance in series, with a shunt capacitance representing electrode and stray capacitance



A **parallel capacitor** is added to insure a **crystal oscillator** provides the **frequency specified**



E6F Optical Components & Power Systems

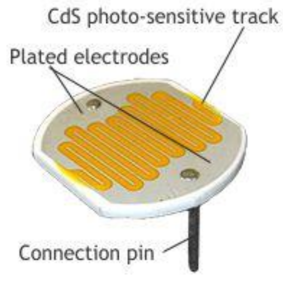
Chapters 5 of ARRL Extra Class License Manual Estimated 1 Exam Question

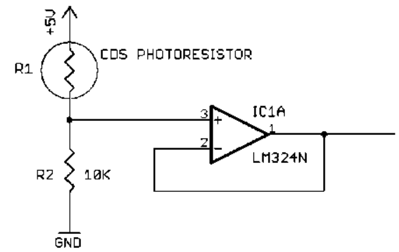
The **increased conductivity of an illuminated semiconductor** is **PHOTOCONDUCTIVITY**

The conversion of **LIGHT to ELECTRICAL** energy is the **photovoltaic effect**

A **crystalline semiconductor** is affected the most by photoconductivity

The **conductivity** of a photoconductive material increases **when light shines on it**



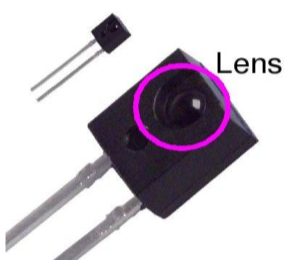



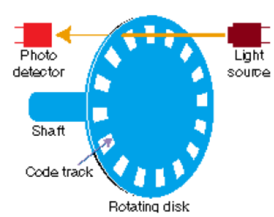
An **LED and a phototransistor** is the most common configuration of an **optoisolator** or optocoupler

A **solid state relay** uses semiconductor devices to implement the functions of an electromechanical relay

Optoisolators provide electrical isolation between a control circuit and the circuit being switched

An **optical shaft encoder** detects rotation of a control by **interrupting a light source** with a patterned wheel



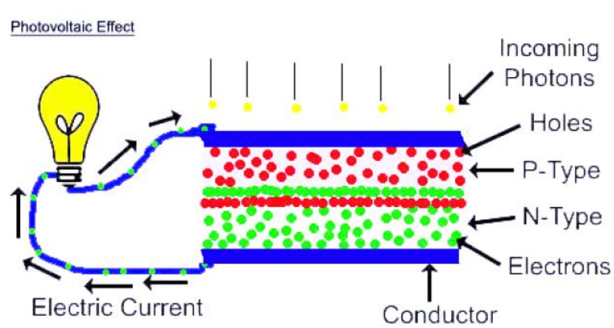



Electrons absorb the energy from light falling on a photovoltaic cell

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

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

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

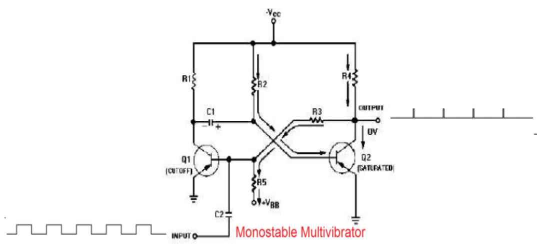



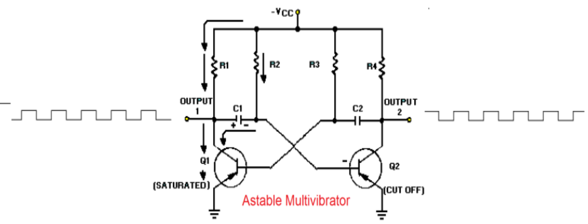
E7A Digital Circuits & Logic Circuits

Chapters 5 of ARRL Extra Class License Manual Estimated 1 Exam Question

Astable multivibrator is a circuit that continuously alternates between two states without an external clock

A **monostable multivibrator** switches momentarily to the opposite binary state and then returns, after a set time



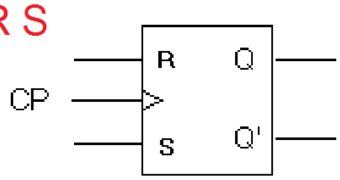


A **flip-flop** is a bistable circuit

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

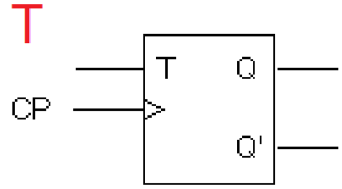
Two flip-flops are required to **divide** a signal frequency by **4**

R S



Q S R	Q(t+1)
0 0 0	0
0 0 1	0
0 1 0	1
0 1 1	indeterminate
1 0 0	1
1 0 1	0
1 1 0	1
1 1 1	indeterminate

T

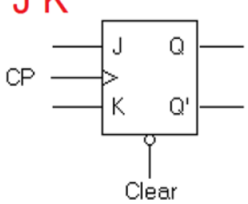


Q T	Q(t+1)
0 0	0
0 1	1
1 0	1
1 1	0

SR or RS flip-flop is a set/reset flip-flop whose output is low when R is high and S is low, high when S is high and R is low, and unchanged when both inputs are low

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

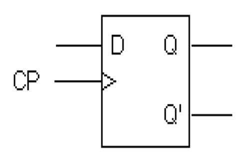
J K



Inputs				Outputs	
Clear	Clock	J	K	Q	Q'
0	x	x	x	0	1
1	0→1	0	0	No change	
1	0→1	0	1	0	1
1	0→1	1	0	1	0
1	0→1	1	1	Toggle	

J K Q	Q(t+1)
0 0 0	0
0 1 0	0
1 0 0	1
1 1 0	1
0 0 1	1
0 1 1	0
1 0 1	1
1 1 1	0

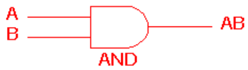
D



Q D	Q(t+1)
0 0	0
0 1	1
1 0	0
1 1	1

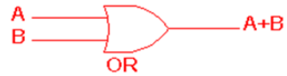
JK flip-flop is similar to an RS except that it toggles when both J and K are high

A **D flip-flop** output takes on the state of the D input when the clock signal transitions from low to high



2 Input AND gate		
A	B	A.B
0	0	0
0	1	0
1	0	0
1	1	1

2 Input NAND gate		
A	B	$\overline{A.B}$
0	0	1
0	1	1
1	0	1
1	1	0



2 Input OR gate		
A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

2 Input NOR gate		
A	B	$\overline{A+B}$
0	0	1
0	1	0
1	0	0
1	1	0

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

NAND gate produces a logic "0" at its output only when all inputs are logic "1"

OR gate produces a logic "1" at its output if any or all inputs are logic "1"

NOR gate produces a logic "0" at its output if any single input is a logic “1”

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

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

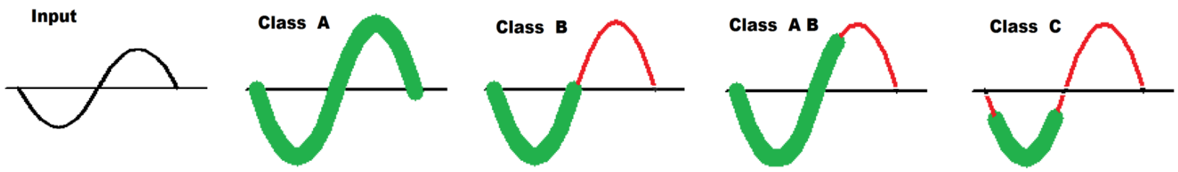
E7B Amplifiers

Chapters 6 of ARRL Extra Class License Manual   Estimated 1 Exam Question

A **Class A** common emitter amplifier would bias normally be set half-way between saturation and cutoff

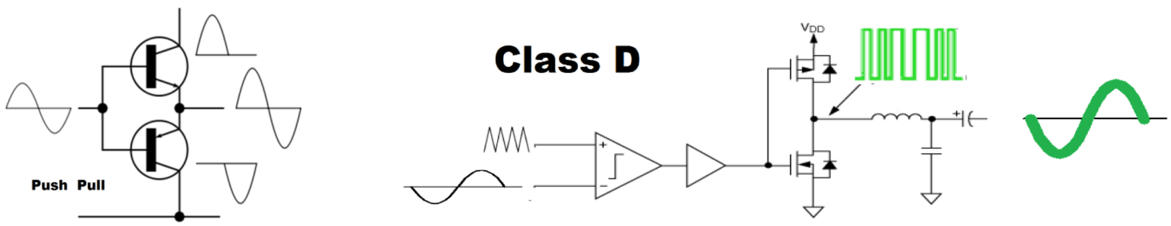
A **Class AB amplifier** operates more than 180 degrees but less than 360 degrees

Signal distortion and excessive bandwidth result when a **Class C** amplifier is used to amplify a SSB phone signal



A **Class D** amplifier that uses switching technology to achieve high efficiency

A class **D amplifier** uses **low-pass output filter** to remove switching signal components



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

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

Class B has conduction occurring for only for ½ of the input cycle. Class B amplifiers typically have dual output devices operating 180º out of phase with each other in a push / pull configuration to allow the full cycle of the input to be amplified. Both output devices are never allowed to be on at the same time, bias is set so that current flow in a specific output device is zero without an input signal. Current only flows in each of the push / pull amplifier output amplifiers for one half cycle. Thus each output amplifier is only on for ½ of a complete sinusoidal signal cycle. Class B push pull designs show high efficiency but poor linearity around the 0 voltage crossover region. This is due to the time it takes to turn one device off and

the other device on, which translates into extreme crossover distortion. Thus restricting class B designs to power consumption critical applications, e.g., battery operated equipment. Class B push / pull transmitter power amplifiers reduce or prevent even order harmonics in the output signal.

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

Class C operation allows current flows for less than one half cycle of the input signal. The class C operation is achieved by reverse biasing the amplifier to point below cutoff and allows only the portion of the input signal that overcomes the reverse bias to cause current flow. The class C operated amplifier is used as a radio-frequency amplifier in frequency modulated or CW transmitters. - AD7FO

Intermodulation products in a linear power amplifier result in transmission of **spurious signals**

Third-order intermodulation distortion products are relatively **close in frequency to the desired signal**

RF power amplifier be **neutralized b**y feeding **a 180-degree out-of-phase** portion of the **output back to the input**

Install **parasitic suppressors and/or neutralize** the stage prevent unwanted oscillations in an RF power amplifier

Push-pull amplifier types reduces or eliminates even-order harmonics

Use a **resistor in series with the emitter** to prevent **thermal runaway** in a bipolar transistor amplifier

Field effect transistor is generally best suited for UHF or microwave power amplifier applications

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

A **klystron** is a VHF, UHF, or microwave vacuum tube that uses **velocity modulation**

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

When tuning a vacuum tube RF power amplifier that employs **a pi-network output** circuit the **tuning capacitor is adjusted for minimum** plate current, while the **loading capacitor is adjusted for maximum** permissible plate current

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

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

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

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

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

Figure E7-1

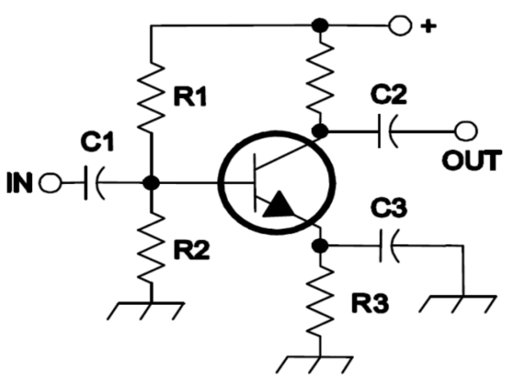
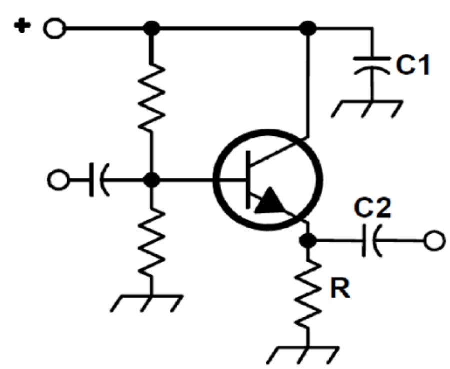


Figure E7-2



E7C Filters & Impedance Matching Networks

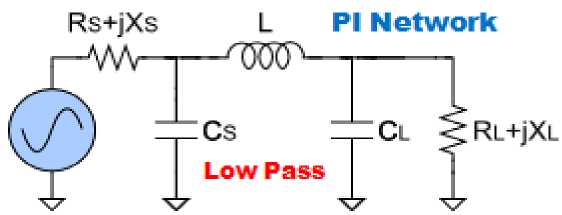
Chapters 6 of ARRL Extra Class License Manual Estimated 1 Exam Question

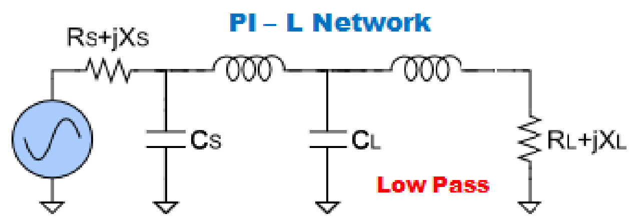
Pi Network is the common name for a filter network which is equivalent to two L networks connected back-to-back with the inductors in series and the capacitors in shunt at the input and output

A **low-pass filter Pi-network** has 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

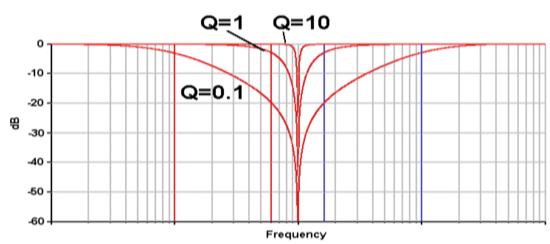
A **Pi-L network** with a series inductor on the output is used for matching a **vacuum-tube final** amp to 50-ohm output

An **impedance-matching** circuit transforms a complex impedance to a resistive impedance by **cancelling the reactive** part of the impedance and changes the resistive part to a desired value



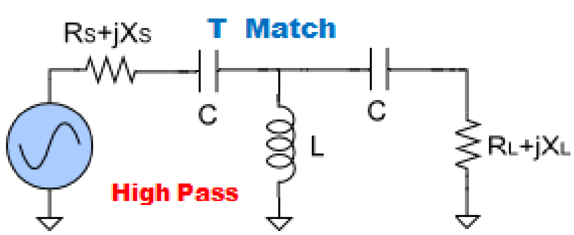


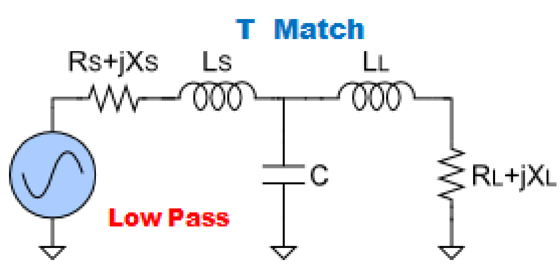
The **Q of Pi networks can be varied** depending on the component values chosen



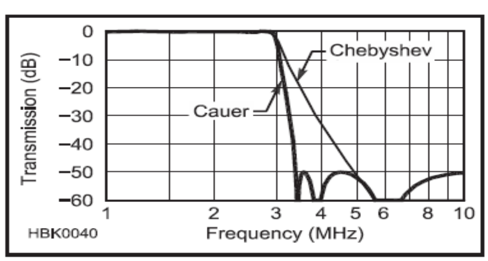
A **Pi-L-network** has **greater harmonic suppression** over a Pi-network for impedance matching between the final amplifier of a vacuum-tube transmitter and an antenna

A **T-network** with series capacitors and a parallel shunt inductor is a **high-pass filter**

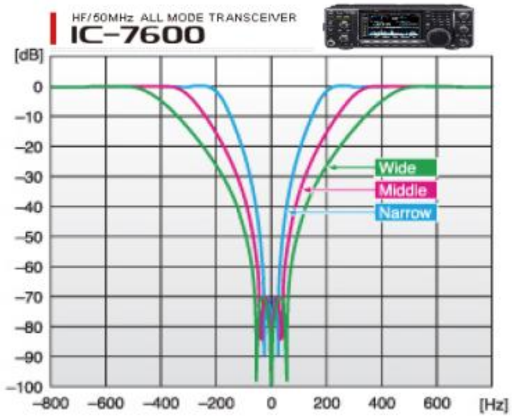




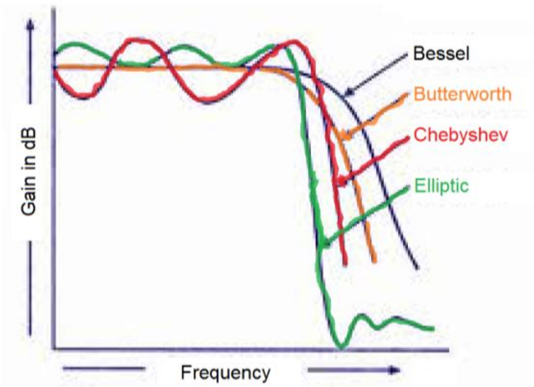
A **Chebyshev filter** is described as having ripple in the passband and a sharp cutoff?



A **notch filter** would be used to attenuate an interfering carrier signal while receiving an SSB transmission

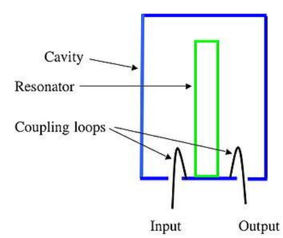


An **elliptical filter** has extremely sharp cutoff with one or more notches in the stop band



An **adaptive filter DSP** audio filter can be used to remove **unwanted noise from a received SSB** signal

A **Hilbert-transform is a DSP filter** might be used to generate an SSB signal



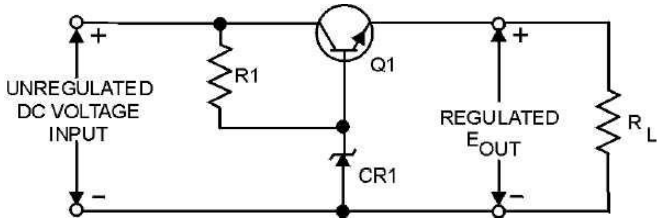
A **cavity filter** would be the best choice for use in a 2 meter repeater duplexer

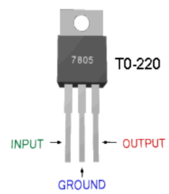
Digital modes are most affected by **non-linear phase response in a receiver IF filter**

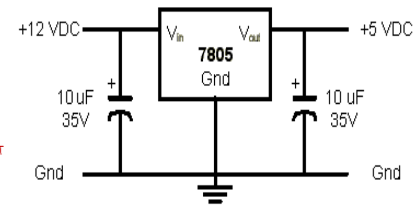
E7D Power Supplies & Voltage Regulators

Chapters 6 of ARRL Extra Class License Manual Estimated 1 Exam Question

The conduction of a control element is varied to **maintain a constant output voltage** in a **LINEAR** electronic voltage regulator



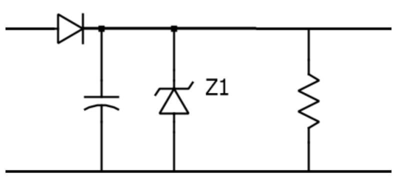


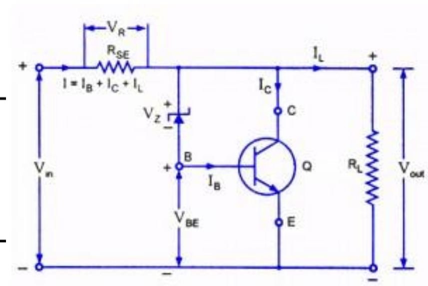


A **Zener diode** is typically used as a stable **reference voltage** in a linear voltage regulator?

Of the linear voltage regulators a **series regulator** usually makes the **most efficient use** of the primary power source

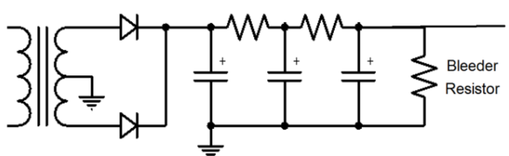
Editors Note: This is a trick question due to sentence structure > > Linear regulators are NOT efficient, so the correct answer is saying the series regulator is the best of the worst type (linear) for efficiency.



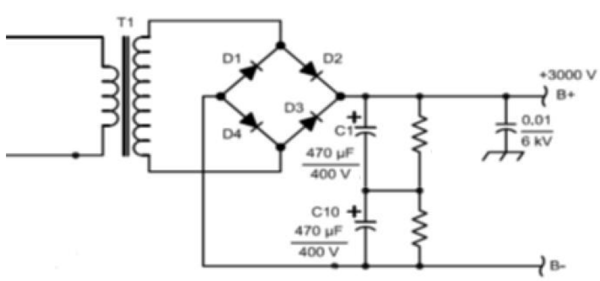


Transistor Shunt Voltage Regulator

A **shunt regulator** is a linear voltage regulator with a **constant load** on the unregulated voltage source

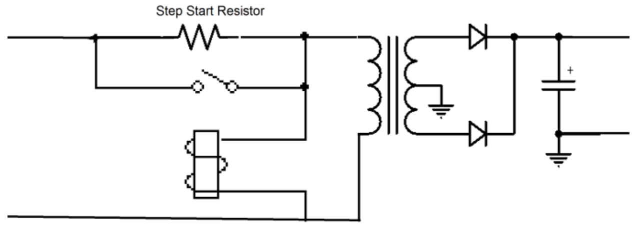


A **"bleeder" resistor** in a conventional (unregulated) power supply is used to improve output **voltage regulation**

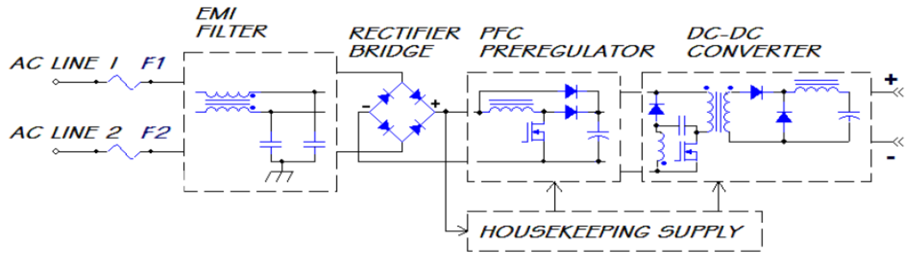


E7D16 When several electrolytic **filter capacitors are connected in series** to increase the operating voltage of a power supply filter circuit, why should resistors be connected across each capacitor?

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



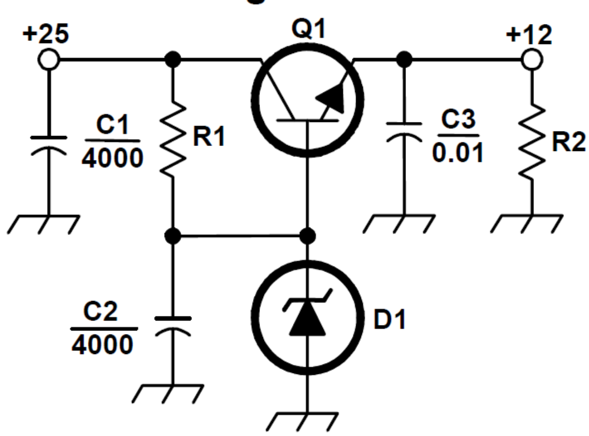
A **"step-start" circuit** in a high-voltage power supply allows the filter capacitors to charge gradually



The control device's duty **cycle is controlled to produce a constant average** output voltage in a **SWITCHING** electronic voltage regulator

The **high frequency inverter** design uses much smaller transformers and filter components for an equivalent power output making it both **less expensive and lighter in weight** than a conventional power supply

Figure E7- 3



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

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

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

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

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

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

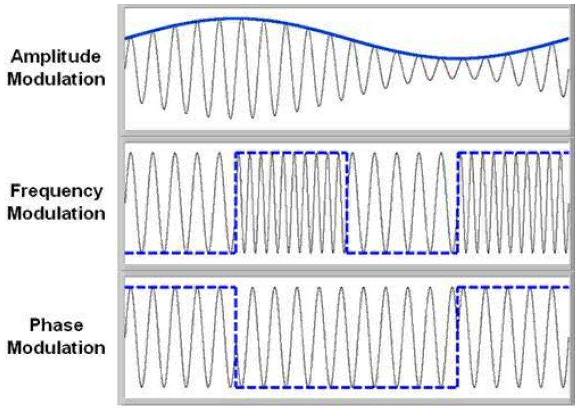
E7D12 What is the purpose of R2 in the circuit shown in Figure E7-3? = D. It provides **a constant minimum load** for Q1

E7D13 What is the purpose of D1 in the circuit shown in Figure E7-3? = B. To provide a **voltage reference**

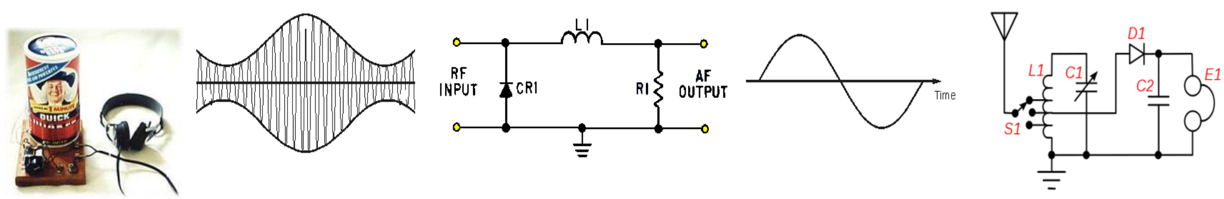
E7E Modulation and Demodulation

Chapters 6 of ARRL Extra Class License Manual   Estimated 1 Exam Question

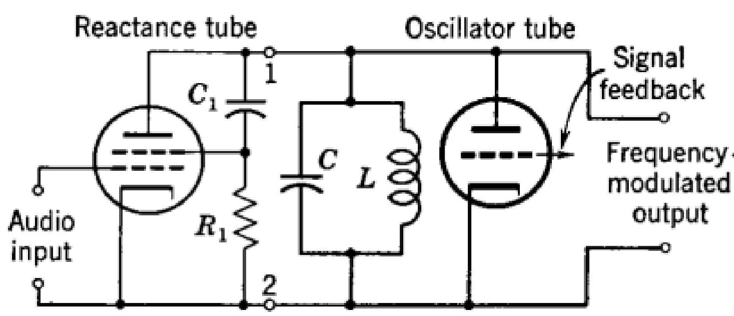
The frequency components present in **the modulating signal is called BASEBAND**



A **diode detector** functions by rectification and filtering of RF signals

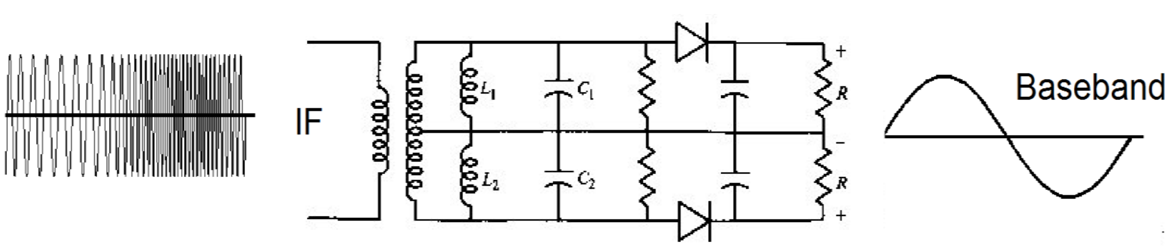


A **reactance modulator** on the oscillator can be used to generate **FM phone** emissions



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

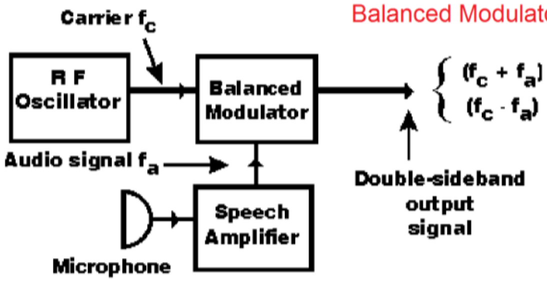
An analog **phase modulator** functions by varying the tuning of an amplifier tank circuit to **produce PM signals**

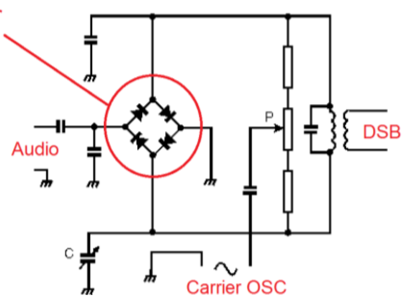


Balanced Frequency Discriminator

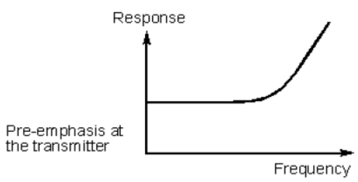
The **frequency DISCRIMINATOR** stage in a FM receiver is used for **detecting FM signals**

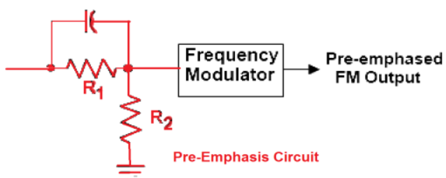
A **SSB phone** signal can be **generated** by using a **BALANCED modulator** followed by a filter

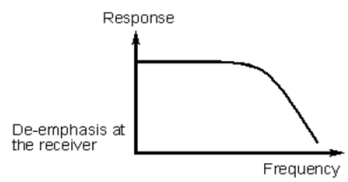




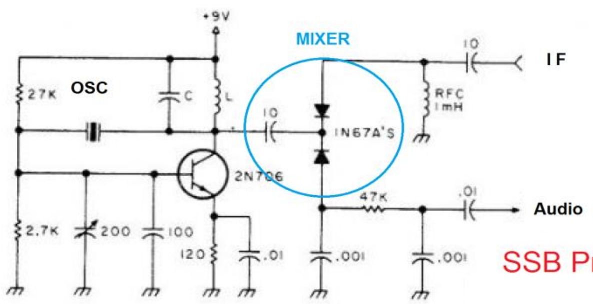
A **pre-emphasis** network circuit is added to an **FM transmitter** to **boost the higher audio** frequencies



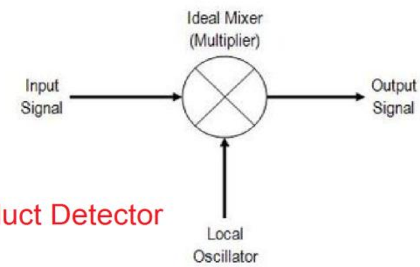




De-emphasis commonly used in FM communications receivers for compatibility with **transmitters using phase modulation**



SSB Product Detector

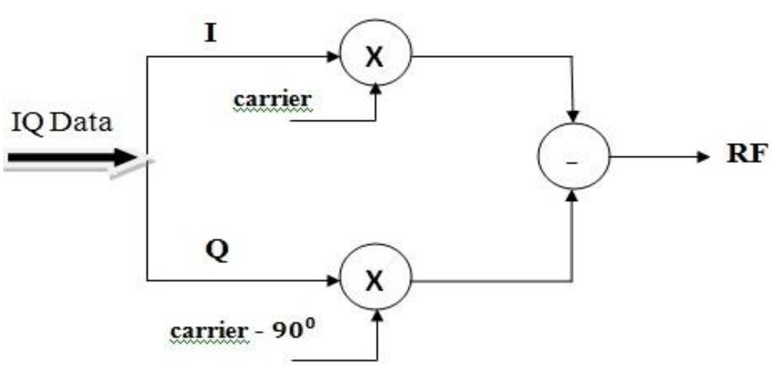


A **PRODUCT detector** is well suited for demodulating **SSB** signals

The **two input frequencies** along with their **sum and difference frequencies** appear at the output of a **MIXER CIRCUIT**

SPURIOUS MIXER PRODUCTS are generated when an **excessive amount of signal** energy reaches a mixer circuit

A means of **generating a SSB** signal when using **DSP** is **QUADRATURE**



SDR Direct conversion is when incoming **RF is mixed to "baseband" for analog-to-digital conversion** and subsequent processing

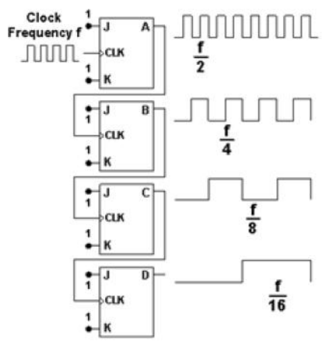
E7F Frequency Markers & Counters

Chapters 5 of ARRL Extra Class License Manual Estimated 1 Exam Question

A **PRESCALER** divides a high frequency signal so a low-frequency counter can display the input frequency

A **PRESCALER** would be used to reduce a signal's frequency by a factor of ten

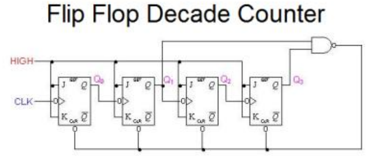
Two flip-flops must be added to a 100-kHz crystal-controlled marker generator so as to provide markers at 50 and 25 kHz



Flip Flop Marker Generator

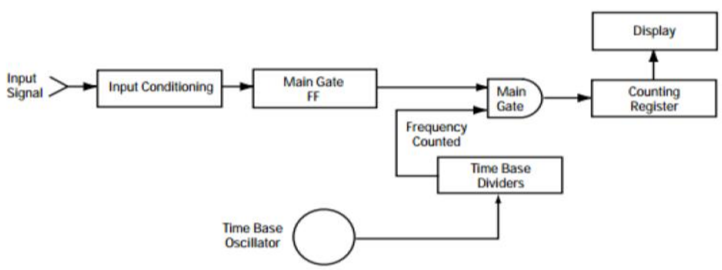
Clock Pulse	Q3	Q2	Q1	Q0
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Flip Flop Decade Counter



A **marker generator** provides a means of calibrating a receiver's frequency settings

A **decade counter** digital IC produces **one output pulse for every ten input** pulses



The accuracy of the **time base determines the accuracy** of a **frequency counter**

A **frequency counter** counts the **number of input pulses** occurring within a **specific period of time**

A **frequency counter** provides a digital representation of the frequency of a signal

Period measurement plus mathematical **computation** is used by some counters

Period measurement provides improved resolution of low-frequency signals

High stability oscillators needed for microwave transmission and reception

A. Use a GPS signal reference
B. Use a rubidium stabilized reference oscillator
C. Use a temperature-controlled high Q dielectric resonator
D. All of these choices are correct

E7G Active Filters & Operational Amplifiers

Chapters 6 of ARRL Extra Class License Manual Estimated 1 Exam Question

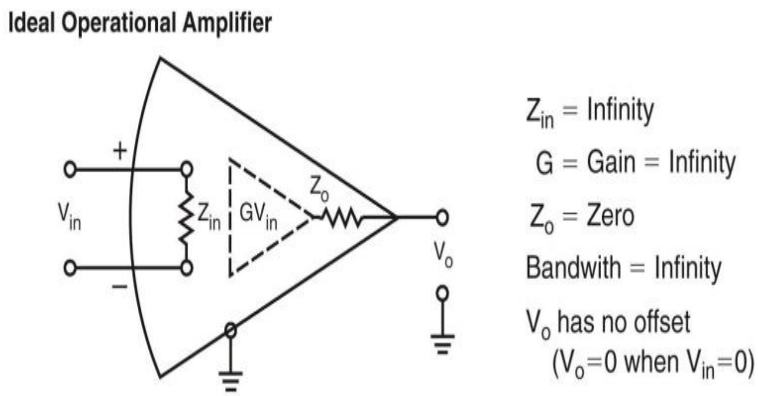
An integrated circuit operational amplifier is a **high-gain, direct-coupled differential amplifier** with very **high input** and very **low output** impedance

The typical **input impedance** of an integrated circuit **op-amp is very high**

The typical **output impedance** of an integrated circuit op-amp is **very low**

The **gain** of an ideal operational amplifier **does not vary with frequency**

The values of capacitors and resistors **external to the op-amp determines the gain** and frequency characteristics of an op-amp RC active filter



An operational amplifier is one of the most useful linear devices that have been developed with integrated circuitry. While it is possible to build an op amp with discrete components, the symmetry of this circuit requires a close match of many components and is more effective, and much easier, to implement in integrated circuitry. The op amp approaches a perfect analog circuit building block. Ideally, an op amp has infinite input impedance (Zi), zero output impedance (Zo) and an open loop voltage gain (Av) of infinity. Obviously, practical op amps do not meet these specifications, but they do come closer than most other types of amplifiers. The gain of an op amp is the function of the input resistor and the feedback resistor. Gain in calculated by dividing the input resistor R1 value into the feedback resistor Rf. In figure E7-4 if the input resistor,R1, is 10,000 ohms and the feedback resistor ,Rf, 1s 1,000,000 ohms the gain would be 1,000,0000 / 10,000 or a gain of 100. The output is inverted in this configuration when the signal is feed into the negative pin of the op amp. This is the most commonly used configuration. Op amp can be configured in a non-inverting so the output signal is the same polarity as the input signal. – AD7FO

Restrict both gain & Q to prevent ringing and audio instability in a multi-section op-amp RC audio filter

Undesired oscillations added to the desired signal is the effect of **ringing in a filter**

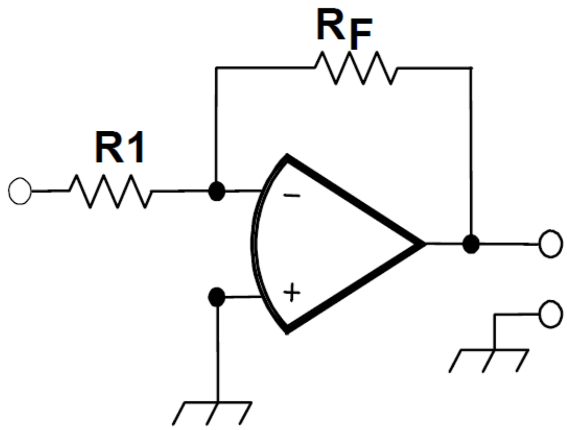
A **Polystyrene capacitor best** suited for use in high-stability op-amp RC active filter circuits?

As an audio filter in a receiver is an appropriate use of an **op-amp active filter**

Op-amps exhibit gain rather than insertion loss compared to LC elements for an audio filter

Op-amp **input-offset voltage** is the differential input voltage needed to **bring the open-loop output voltage to zero**

Figure E7-4



E7G07 What magnitude of voltage gain can be expected from the circuit in Figure E7-4 when R1 is 10 ohms and RF is 470 ohms? = C. 47

Gain = - RF /R1 = -470/10 = -47

E7G09 What will be the output voltage of the circuit shown in Figure E7-4 if R1 is 1000 ohms, RF is 10,000 ohms, and 0.23 volts dc is applied to the input? = D. -2.3 volts

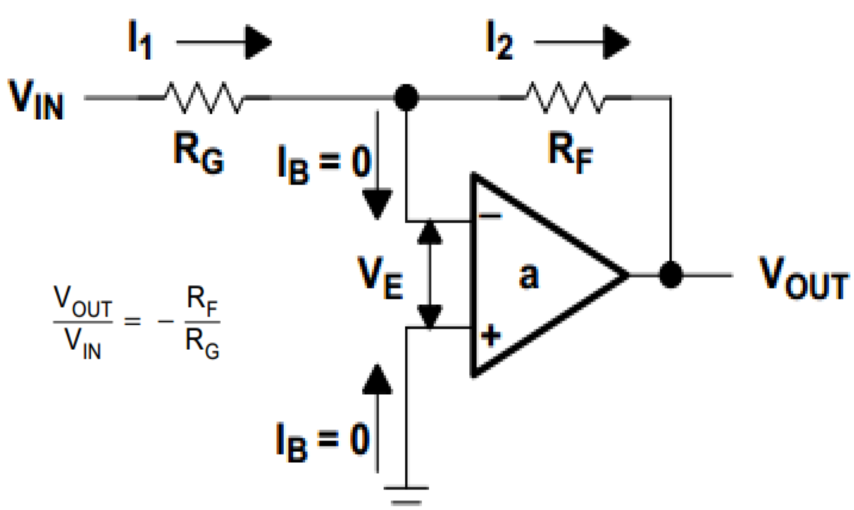
Vop = Input x Gain >> Gain = - RF /R1 = -10K/1K = -10 >> Vop = 0.23 x -10 = - 2.3 V

E7G10 What absolute voltage gain can be expected from the circuit in Figure E7-4 when R1 is 1800 ohms and RF is 68 kilohms? = C. 38

Gain = - RF /R1 = -68K/1800 = -37.78

E7G11 What absolute voltage gain can be expected from the circuit in Figure E7-4 when R1 is 3300 ohms and RF is 47 kilohms? = B. 14

Gain = - RF /R1 = -47K/3300 = -14.24



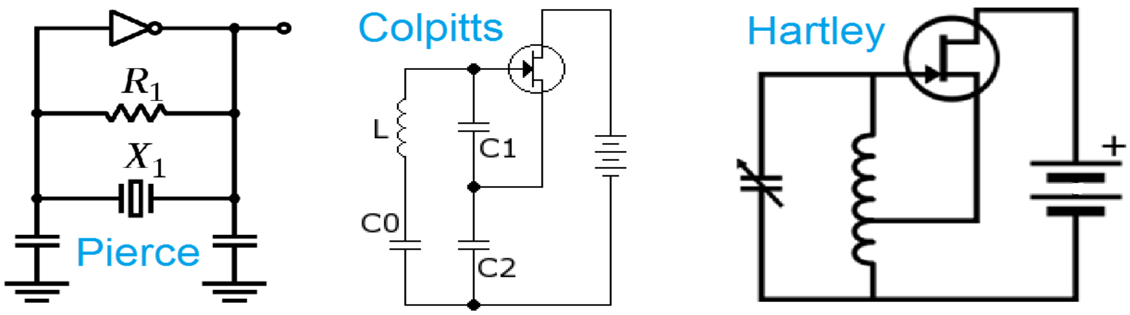
E7H Oscillators & Signal Sources

Chapters 6 of ARRL Extra Class License Manual   Estimated 1 Exam Question

Colpitts, Hartley and Pierce are three oscillator circuits used in Amateur Radio equipment

Colpitts and Hartley oscillator circuits are commonly used in VFOs

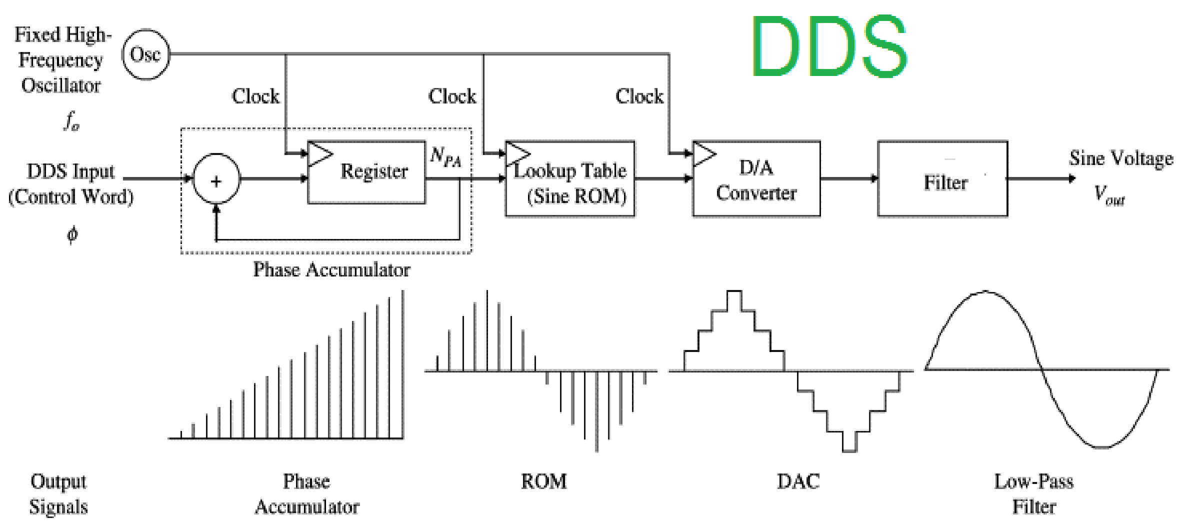
For a circuit to oscillate it must have **positive feedback with a gain greater than 1**



Positive feedback supplied in a **Hartley** oscillator through a **tapped coil**

Positive feedback supplied in a **Colpitts** oscillator through a **capacitive divider**

Positive feedback supplied in a **Pierce** oscillator through a **quartz crystal**



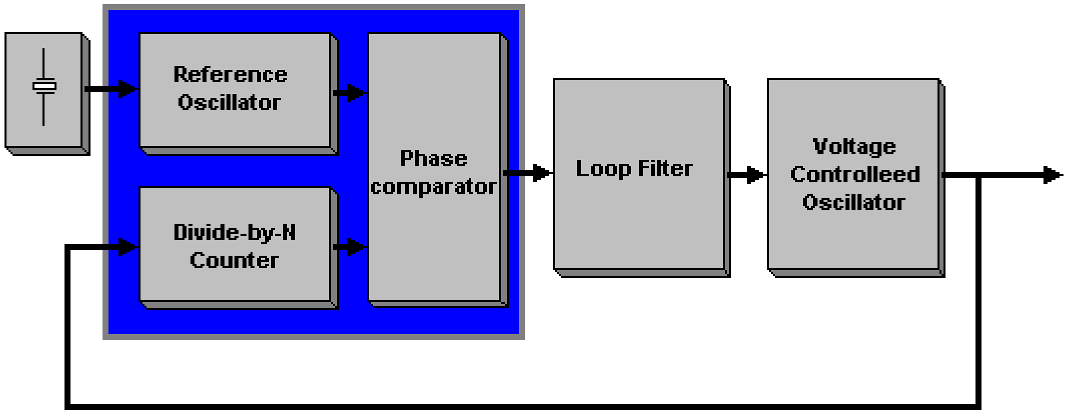
Phase accumulator is a principal component of a **Direct Digital Synthesizer (DDS)**

A **Direct Digital Synthesizer (DDS)** circuit uses a phase accumulator, lookup table, digital to analog converter and a low-pass anti-alias filter

The amplitude values that represent a sine-wave output is contained in the **lookup table of a DDS**

Spurious signals at discrete frequencies are the major spectral impurity components of **DDS**

A **Phase-Locked Loop (PPL)** circuit an electronic servo loop consisting of a phase detector, a low-pass filter, a voltage-controlled oscillator, and a stable reference oscillator



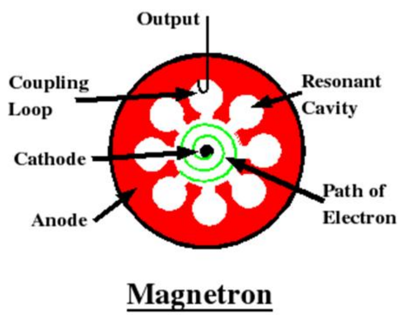
A **PLL is used as VFO** because it has the same degree of frequency **stability as a crystal oscillator**

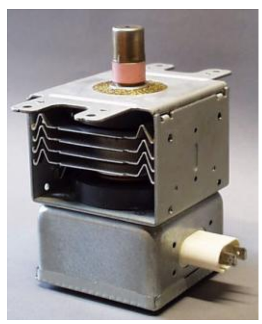
The **frequency range over which the circuit can lock** is the **capture range** of a **PLL** circuit

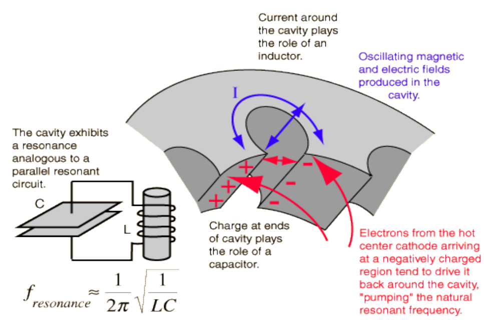
Frequency synthesis, FM demodulation can be performed by a **PLL**

Why is the **short-term stability of the reference oscillator important** in because any phase variations in the reference oscillator signal will **produce phase noise** in the synthesizer output in a PLL

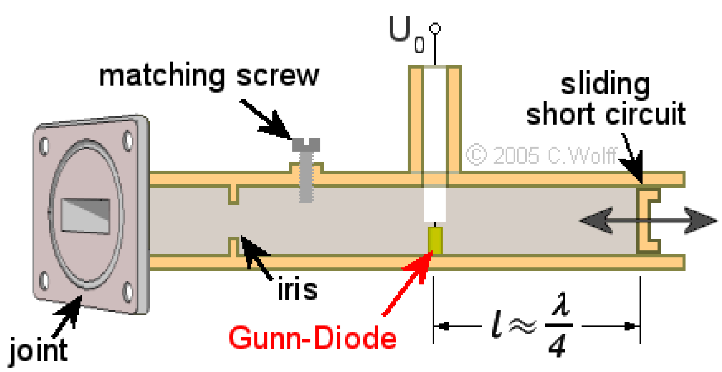
Phase noise is the major **spectral impurity** components of PLL







A **magnetron oscillator** is a UHF or microwave oscillator consisting of a diode vacuum tube with a specially shaped anode, surrounded by an external magnet

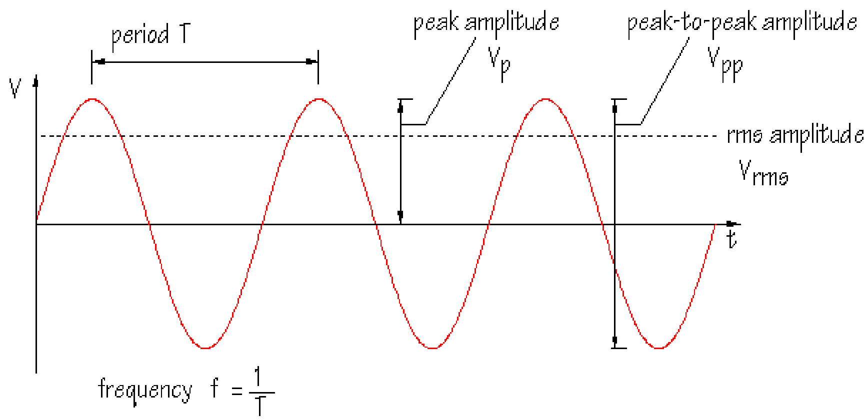


A **Gunn diode oscillator** is an oscillator based on the negative resistance properties of properly-doped semiconductors

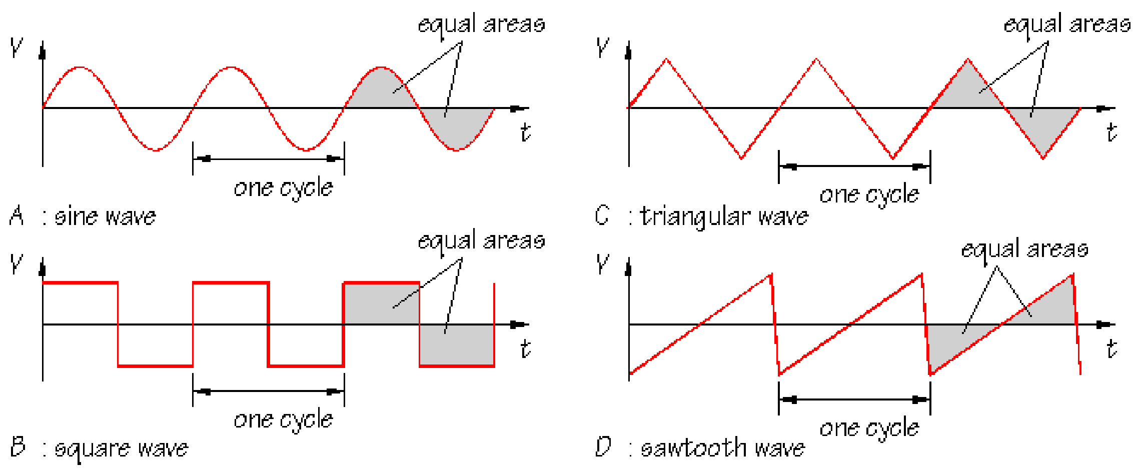
E8A AC Waveforms

Chapters 7 & 8 of ARRL Extra Class License Manual Estimated 1 Exam Question

The **time required to complete one cycle** is the **period** of a wave

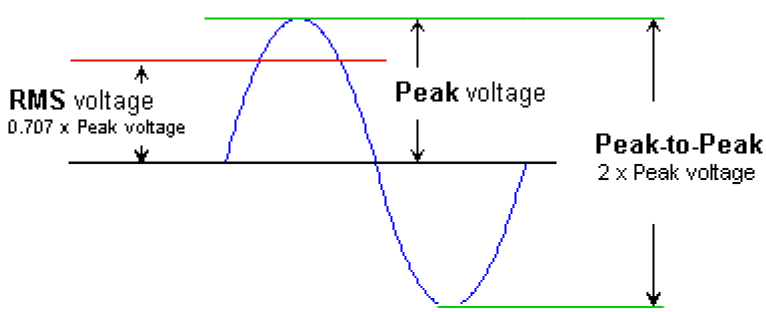


A **square wave** is made up of a sine wave plus **all of its ODD harmonics**



A **sawtooth** wave has a **rise time significantly faster** than its fall time (or vice versa)

A **sawtooth** wave is made up of sine waves of a given fundamental **frequency plus ALL ITS harmonics**



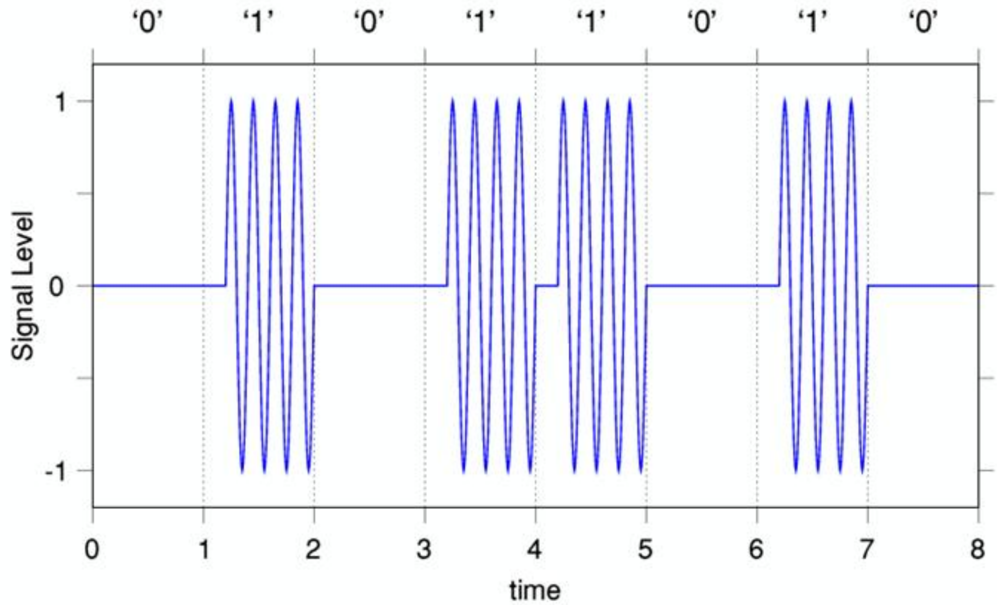
The **DC voltage** causing the same **amount of heating in a resistor** as the **RMS AC voltage**

Measuring the heating effect in a known resistor would be the most accurate way of measuring the **RMS voltage** of a complex waveform

2.5 to 1 is the approximate ratio of **PEP-to-average power** in a typical **SSB phone** signal

The **modulating signal determines** the **PEP-to-average** power ratio of a SSB phone signal

Irregular waveform is produced by **human speech**



Narrow bursts of energy separated by periods of no signal is a distinguishing characteristic of a **pulse waveform**

Digital signals can be regenerated multiple times without error is an advantage of using digital signals instead of analog signals to convey the same information

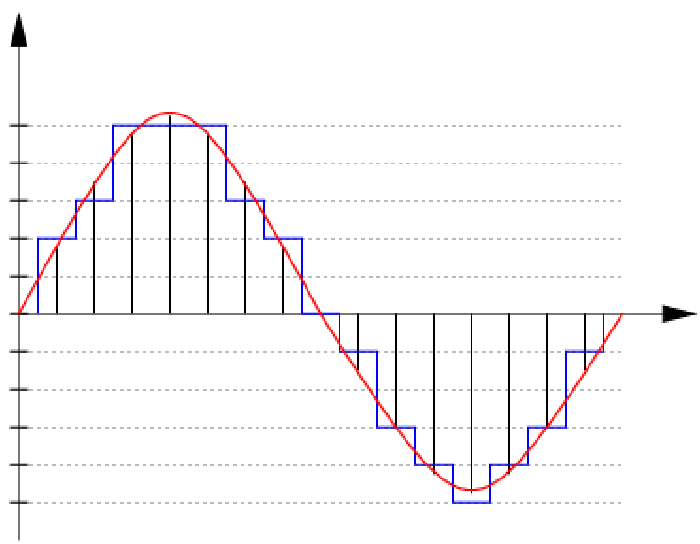
Digital data transmission is one use for a **pulse modulated** signal

Digital data bits would look like a **series of pulses with varying patterns** on a conventional oscilloscope

What type of information can be conveyed using digital waveforms?

A. Human speech
B. Video signals
C. Data
D. All of these choices are correct

Sequential sampling is commonly used to convert analog signals to digital signals



E8B Modulation & Demodulation

Chapters 7 of ARRL Extra Class License Manual Estimated 1 Exam Question

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

Modulation index is the term for the ratio between the frequency deviation of an RF carrier wave, and the modulating frequency of its corresponding FM-phone signal

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

E8B03 What is the modulation index of an FM-phone signal having a maximum frequency deviation of 3000 Hz either side of the carrier frequency, when the modulating frequency is 1000 Hz? = A. 3

Modulation index = Max Carrier Dev / Max Modulation Dev = 3000 / 1000 = 3

E8B04 What is the modulation index of an FM-phone signal having a maximum carrier deviation of plus or minus 6 kHz when modulated with a 2-kHz modulating frequency? = B. 3

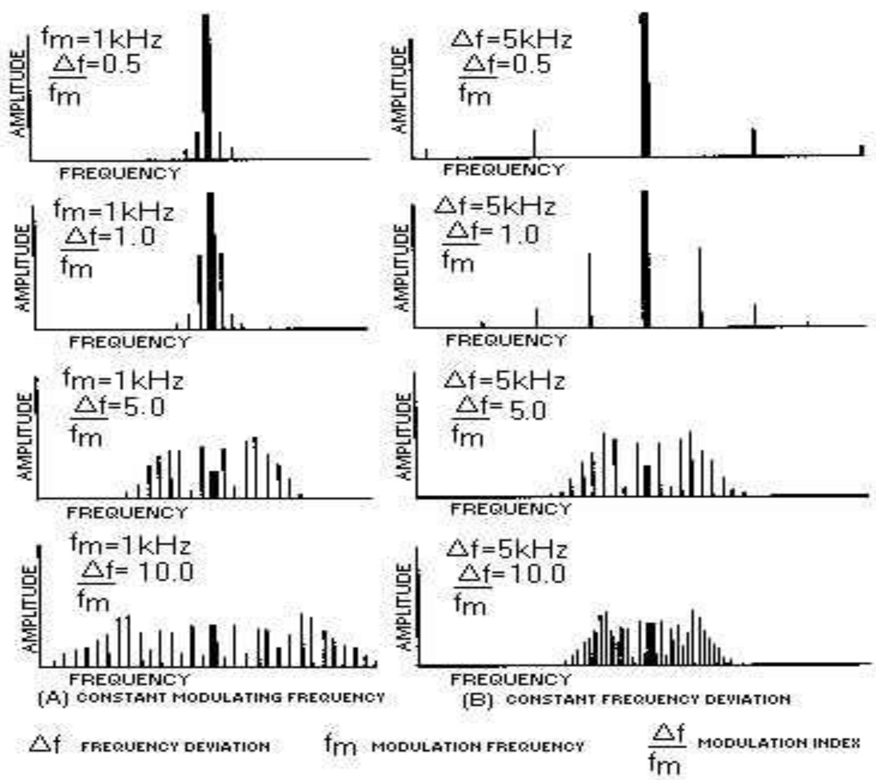
Modulation index = Max Carrier Dev / Max Modulation Dev = 6000 / 2000 = 3

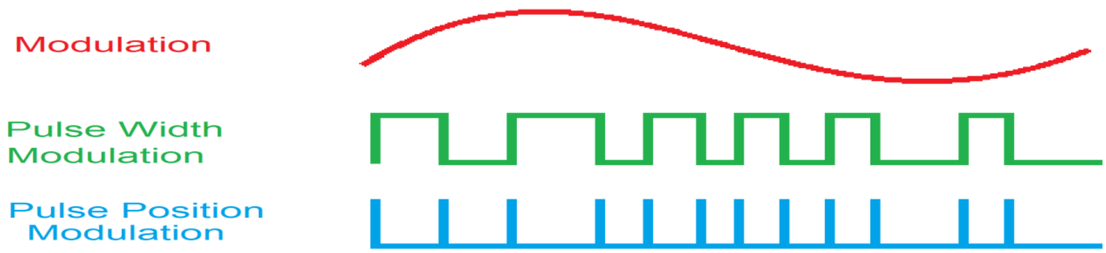
E8B05 What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus-or-minus 5 kHz when the maximum modulation frequency is 3 kHz? = D. 1.67

Modulation index = Max Carrier Dev / Max Modulation Dev = 5000 / 3000 = 1.6667

E8B06 What is the deviation ratio of an FM-phone signal having a maximum frequency swing of plus or minus 7.5 kHz when the maximum modulation frequency is 3.5 kHz? = A. 2.14

Modulation index = Max Carrier Dev / Max Modulation Dev = 7500 / 3500 = 2.1429

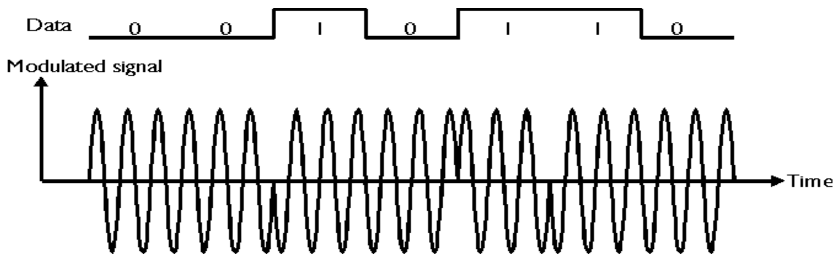




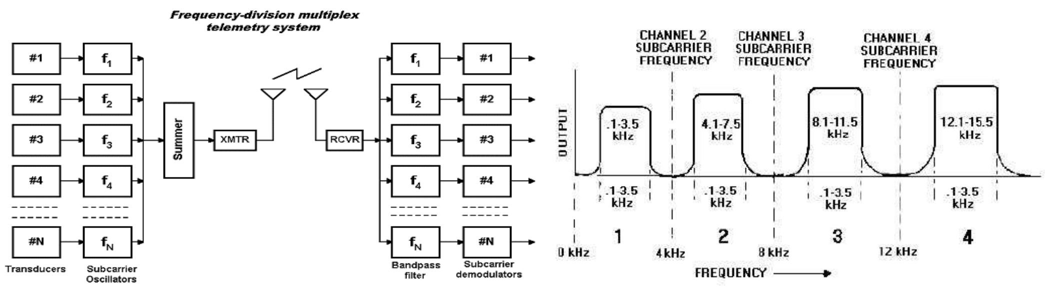
A **pulse-width modulation** system transmitter's peak power is greater than its average power or the signal **duty cycle is less than 100%**

The **time at which each pulse occurs** vary in a **pulse-position modulation** system

The **time at which each pulse occurs** vary in a **pulse-position modulation** system

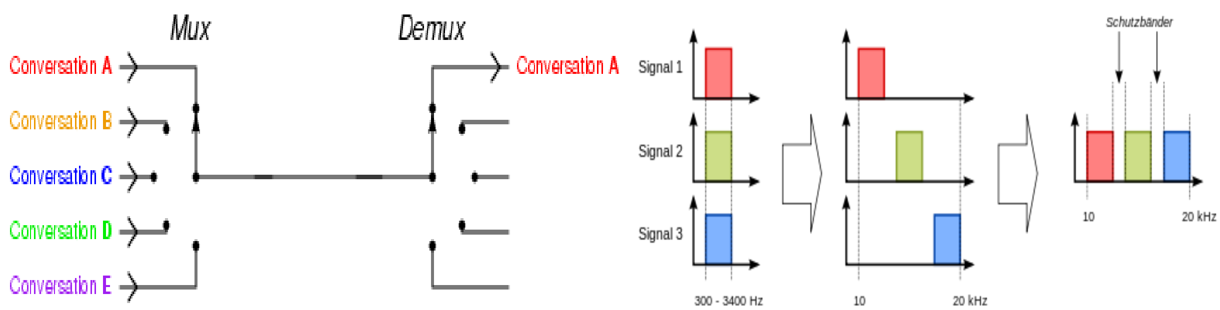


The modulation index of a **phase-modulated emission does not depend on the RF carrier frequency**



Frequency division multiplexing can be used to **combine several separate analog information streams** into a single analog radio frequency signal

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

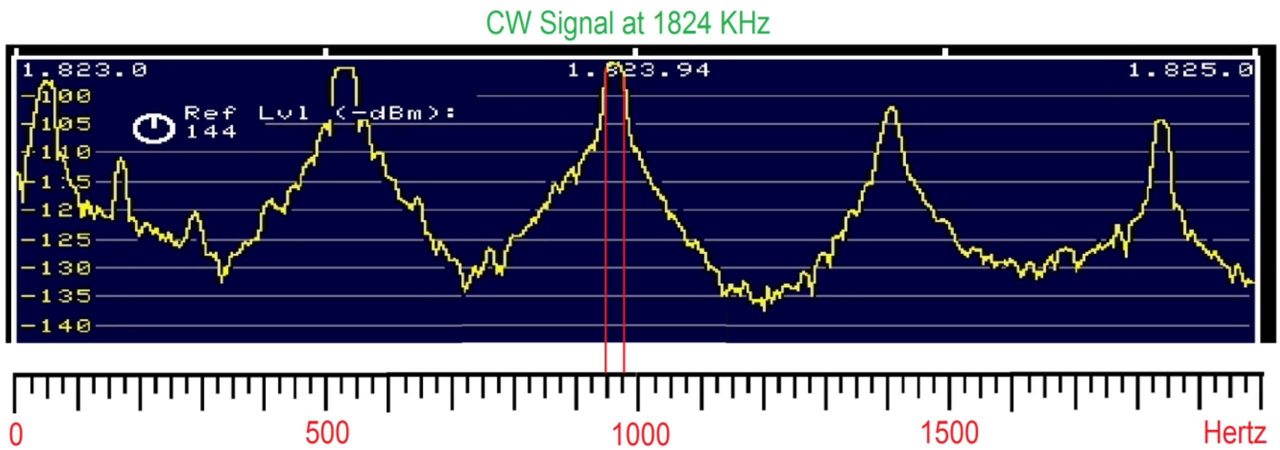


Digital **time division multiplexing** is two or more **signals are arranged to share discrete time slots** of a data transmission

E8C Digital Signals

Chapters 8 of ARRL Extra Class License Manual   Estimated 1 Exam Question

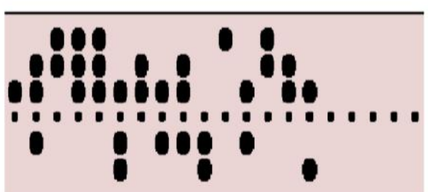
Morse code is a digital code consisting of **elements having unequal length**

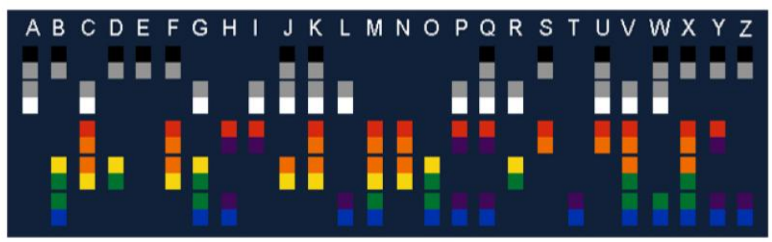


E8C05 What is the necessary bandwidth of a 13-WPM international Morse code transmission? = C. Approximately 52 Hz

BW = WPM x 4 = 13 x 4 = 52 Hz

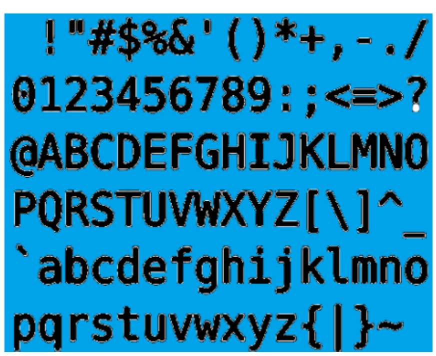
Baudot uses **five data bits** per character and uses two characters as shift codes





ASCII uses **seven or eight data bits** per character and no shift code

ASCII code has both **upper and lower case** text



7 Bits = 2^7 = 128 Characters

0	*NUL*	16	*DLE*	32	SPC	48	0	64	@	80	P	96	`	112	p
1	*SOH*	17	*DC1*	33	!	49	1	65	A	81	Q	97	a	113	q
2	*STX*	18	*DC2*	34	"	50	2	66	B	82	R	98	b	114	r
3	*ETX*	19	*DC3*	35	#	51	3	67	C	83	S	99	c	115	s
4	*EOT*	20	*DC4*	36	$	52	4	68	D	84	T	100	d	116	t
5	*ENQ*	21	*NAK*	37	%	53	5	69	E	85	U	101	e	117	u
6	*ACK*	22	*SYN*	38	&	54	6	70	F	86	V	102	f	118	v
7	*BEL*	23	*ETB*	39	'	55	7	71	G	87	W	103	g	119	w
8	*BS*	24	*CAN*	40	(	56	8	72	H	88	X	104	h	120	x
9	*HT*	25	*EM*	41	)	57	9	73	I	89	Y	105	i	121	y
10	*LF*	26	*SUB*	42	*	58	:	74	J	90	Z	106	j	122	z
11	*VT*	27	*ESC*	43	+	59	;	75	K	91	[	107	k	123	{
12	*FF*	28	*FS*	44	,	60	<	76	L	92	\	108	l	124	|
13	*CR*	29	*GS*	45	-	61	=	77	M	93	]	109	m	125	}
14	*SO*	30	*RS*	46	.	62	>	78	N	94	^	110	n	126	~
15	*SI*	31	*US*	47	/	63	?	79	O	95	_	111	o	127	DEL

*American Standard Code for Information Interchange (**ASCII**) is a digital code with the letters, numbers, and punctuation characters are represented by a 7 bit number.*

Some types of **errors can be detected** by including a **parity bit** with an **ASCII** character stream

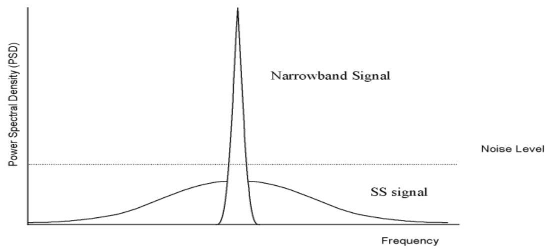
Editors Note: Narrow band two state or digital modulation requires a bandwidth (BW) = (Constant Factor multiplied by Frequency Shift) plus the Baud rate. The constant factor depends on how much signal distortion. The constant commonly used for audio rates and amateur HF digital communications is 1.2.

E8C06 What is the necessary bandwidth of a 170-hertz shift, 300-baud ASCII transmission? = C. 0.5 kHz

BW = (Constant Factor x Shift) + Baud = (1.2 X 170 Hz) + 300 = (204) + 300 = 504 Hz

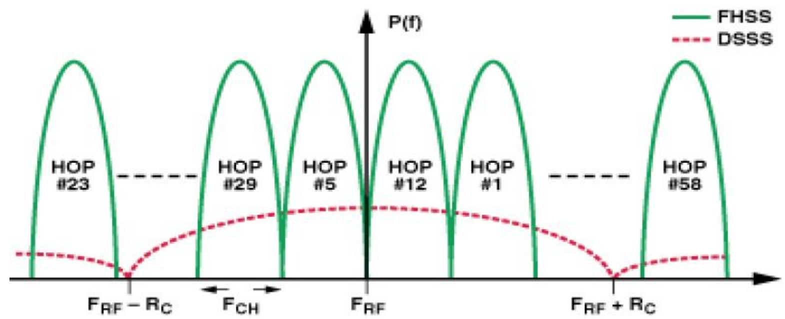
E8C07 What is the necessary bandwidth of a 4800-Hz frequency shift, 9600-baud ASCII FM transmission? = A. 15.36 kHz

BW = (Constant Factor x Shift) + Baud = (1.2 X 4800 Hz) + 9600 = (5760) + 9600 = 15,360 Hz



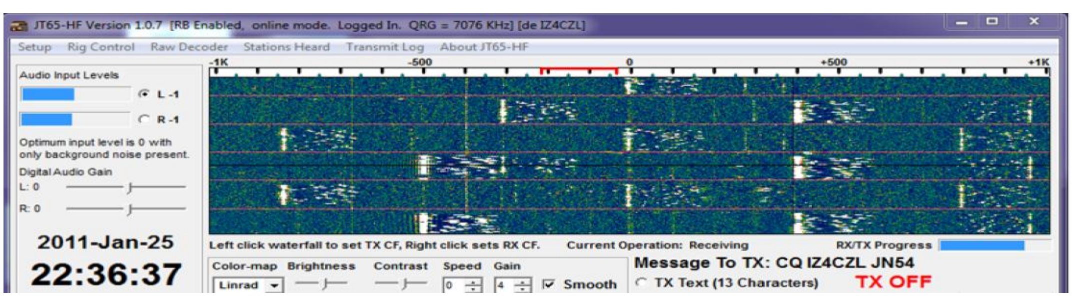
Spread-spectrum causes a digital signal to appear as wide-band noise to a conventional receiver

Direct sequence spread-spectrum (DSSS) communications technique uses a high speed binary bit stream to shift the phase of an RF carrier



Frequency hopping spread-spectrum (FHSS) communications technique alters the center frequency of a conventional carrier many times per second in accordance with a pseudo-random list of channels

Frequency hopping **Spread-spectrum (FHSS)** communication is a wide-bandwidth communications system in which the transmitted carrier frequency varies according to some predetermined sequence



JT-65 coding has the ability to decode signals which have a **very low signal to noise ratio**

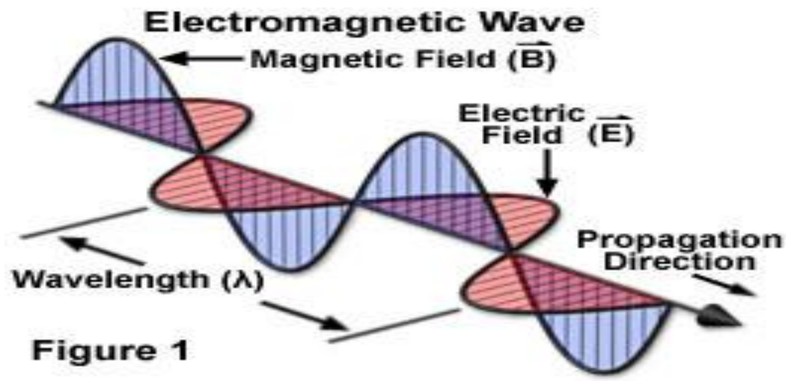
Sinusoidal data pulses are used to **minimize the bandwidth** requirements of a PSK31 signal

In PSK31 (1's) are represented by a tone with no phase shift compared to the previous bit and (0's) are tone with a 180 degree phase shift relative to the phase of the previous bit. The phase shift occurs during the zero level modulation to minimize bandwidth. When the modulation level returns, the positions of the sine wave top and bottom are reversed from the previous bit. Thus the phase changes by 180 degrees while the frequency remains constant. – AD7FO

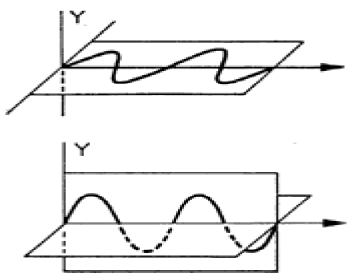
E8D Waveforms

Chapters 7 of ARRL Extra Class License Manual Estimated 1 Exam Question

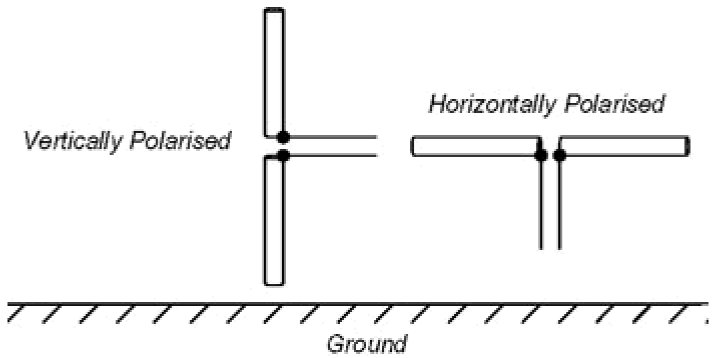
A wave consisting of an electric field and a magnetic field oscillating at right angles to each other is an **electromagnetic wave**



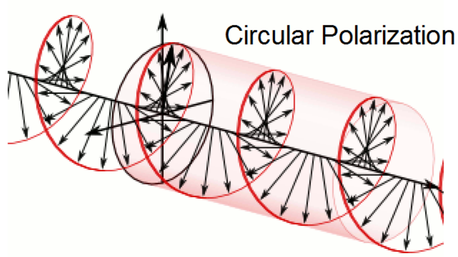
Changing electric and magnetic fields propagate the energy **electromagnetic waves traveling in free space**



Linear Polarized



Waves with a rotating electric field are **circularly polarized** electromagnetic waves

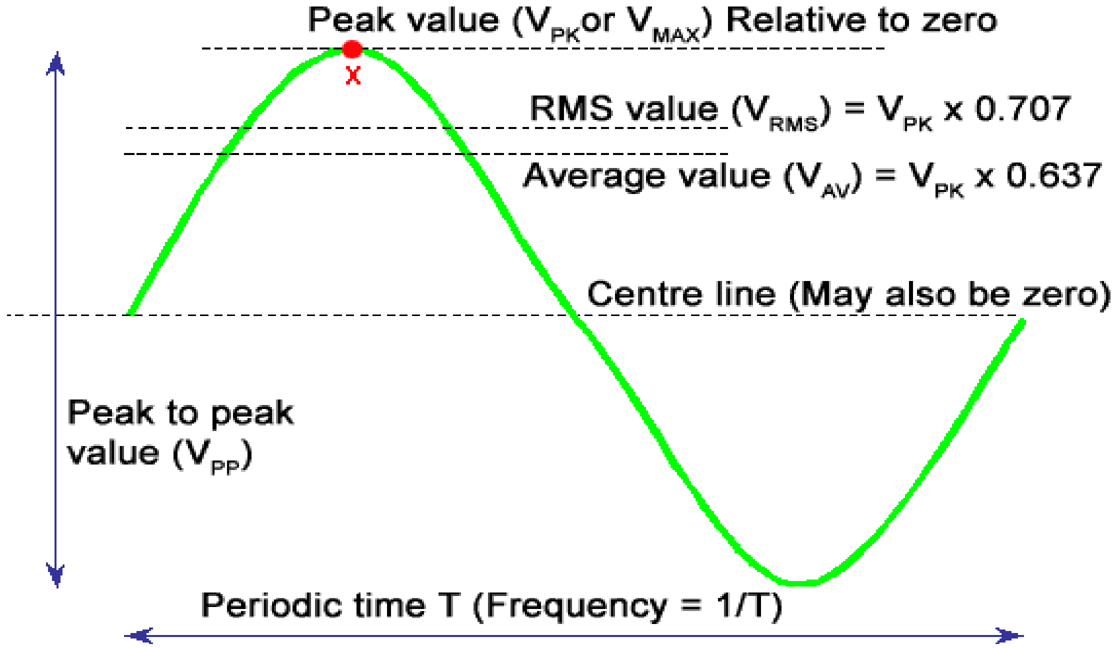


Peak-to-peak voltage is the easiest voltage amplitude parameter to measure when viewing a pure sine wave signal on an analog oscilloscope

Peak-to-peak voltage is the easiest voltage amplitude parameter to measure when viewing a pure sine wave signal on an analog oscilloscope

A **peak-reading wattmeter** gives a more accurate display of the **output of a SSB phone** transmitter

A **peak-reading wattmeter** should be used to monitor the output signal of a voice-modulated single-sideband transmitter to ensure you do not exceed the maximum allowable power



E8D02 What is the relationship between the peak-to-peak voltage and the peak voltage amplitude of a symmetrical waveform? = B. 2:1

Vpp = 2 x Vp

E8D04 What is the PEP output of a transmitter that develops a peak voltage of 30 volts into a 50-ohm load? = B. 9 watts

W = E x I >> E = RMS (30 Vp) = 21.21 V >> I = E/R = 21.21 / 50 = 0.4242 A

W = E x I = 21.21 x 0.4242 = 8.997 W

E8D05 If an RMS-reading AC voltmeter reads 65 volts on a sinusoidal waveform, what is the peak-to-peak voltage? = D. 184 volts

Vpp = 2 xVp = 2 x (Vrms / 0.707) = 2 x (65 /0.707) = 2 x (91.94) = 183.88 Vpp

E8D11 What is the average power dissipated by a 50-ohm resistive load during one complete RF cycle having a peak voltage of 35 volts? = A. 12.2 watts

W = E x I >> E = RMS (35 Vp) = 24.745 V >> I = E/R = 24.745 / 50 = 0.4949 A

W = E x I = 24.745 x 0.4949 = 12.246 W

E8D12 What is the peak voltage of a sinusoidal waveform if an RMS-reading voltmeter reads 34 volts? = D. 48 volts

Vp = Vrms / 0.707 = 34 / 0.707 = 48.091 Vp

The typical value for the **RMS voltage at a standard U.S. household** power outlet is **120V AC**

E8D13 Which of the following is a typical value for the peak voltage at a standard U.S. household electrical outlet? = B. 170 volts

Vp = Vrms / 0.707 = 120 / 0.707 = 169.731 Vp

E8D14 Which of the following is a typical value for the peak-to-peak voltage at a standard U.S. household electrical outlet? = C. 340 volts

Vpp = 2 xVp = 2 x (Vrms / 0.707) = 2 x (120 /0.707) = 2 x (169.731) = 339.463 Vpp

E8D16 What is the RMS value of a 340-volt peak-to-peak pure sine wave? = A. 120V AC

Vpp = 2 x Vp or Vp = Vpp / 2 = 340 / 2 = 170 Vp

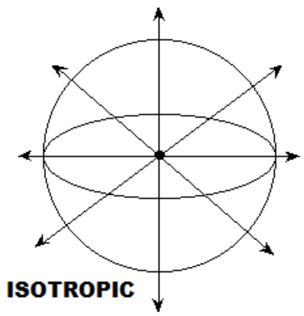
Vrms = Vp x 0.707 = 170 x 0.707 = 120.19 Vrms

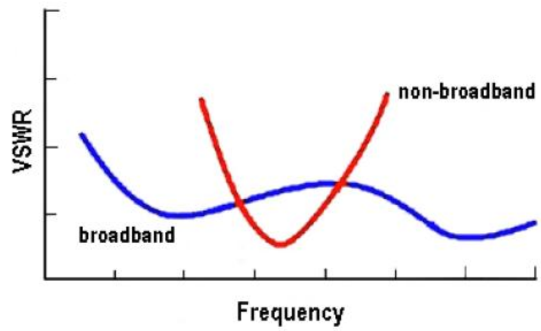
E9A Antennas & Parameters

Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

An **ISOTROPIC** antenna is a theoretical antenna used as a reference for antenna gain

An **ISOTROPIC** antenna has no gain in any direction



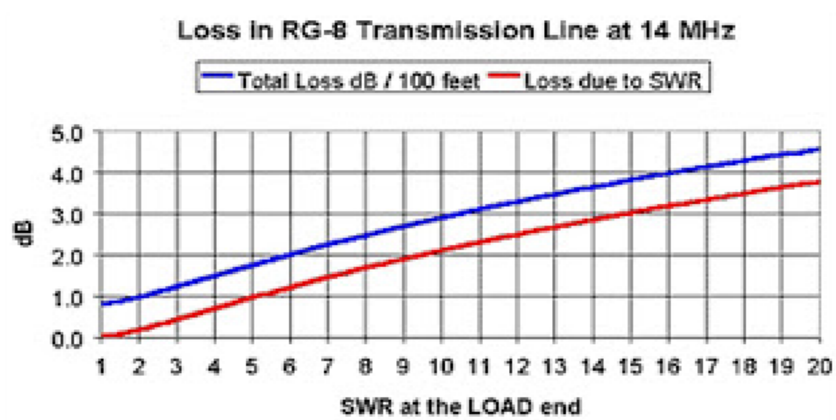


GAIN is the ratio of radiated signal strength in the direction of maximum radiation to a reference antenna

Radiation resistance + Ohmic resistance equal the total resistance of an antenna system

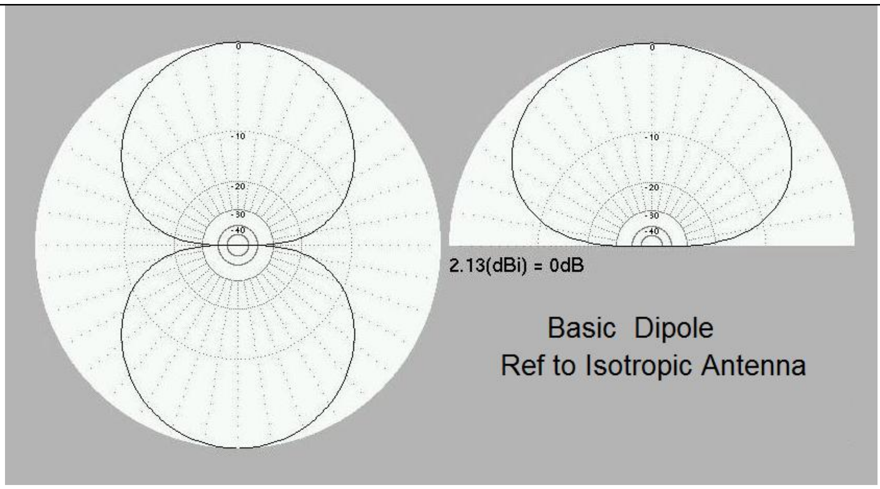
Antenna efficiency = (radiation resistance / total resistance) x 100%

Matching the feed point impedances minimize **SWR** on the transmission line



Antenna **height, length/diameter ratio & location of conductive objects** affect the feed point impedance

Antenna **BANDWIDTH** is the frequency range over which an antenna satisfies a performance requirement



A **folded dipole** constructed from one wavelength of wire forming a very thin loop

A 1/2-wavelength **dipole** in free space **2.15 dB Gain** over an isotropic antenna

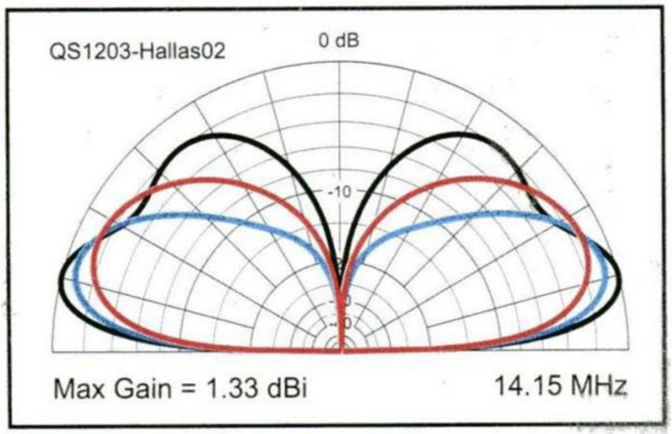


Figure 2 — *EZNEC* elevation pattern of ⅝ wave long ground mounted monopole on 20 meters above typical ground (black) compared to ¼ wave (red) and ½ wave (blue). The azimuth pattern for each is omnidirectional.

A **good radial system** is a way to **improve the efficiency** of a ground-mounted quarter-wave vertical antenna

Soil conductivity determines ground losses for a ground-mounted vertical antenna operating in the 3-30 MHz range

E9A13 How much gain does an antenna have compared to a 1/2-wavelength dipole when it has 6 dB gain over an isotropic antenna? = A. 3.85 dB

Unknown Ant Gain – DP Gain >> 6 dBi – 2.15 dBi = 3.85 dB

E9A14 How much gain does an antenna have compared to a 1/2-wavelength dipole when it has 12 dB gain over an isotropic antenna? = B. 9.85 dB

Unknown Ant Gain – DP Gain >> 12 dBi – 2.15 dBi = 9.85 dB

E9B Antenna Patterns

Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

Numerical Electromagnetics Code (NEC) >> antenna modeling programs

Method of Moments is a computer program technique is commonly used for modeling antennas

Antenna modeling program can provide; **Gain**, **SWR** vs. frequency, Polar plots of the far-field **Az & El patterns**

Method of Moments analysis is a wire modeled as a series of segments with the same current

Decreasing the wire segments **below 10 segments per half-wavelength** may result in **feed impedance errors**

FAR-FIELD is the region where the shape of the antenna **pattern is independent of distance**

BEAMWIDTH is the angle between two points where the signal strength of the antenna is 3 dB less than max

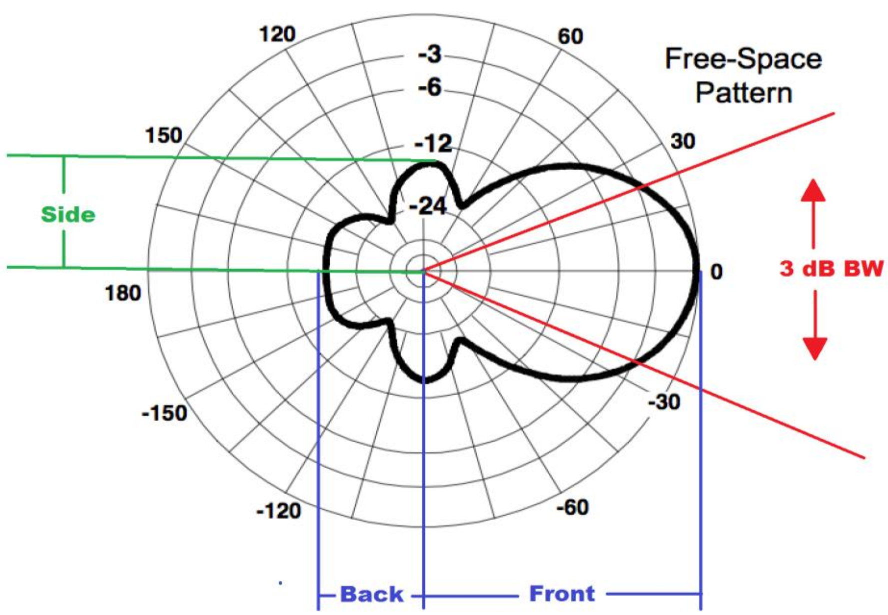
The **front-to-back ratio decreases** if a YAGI is designed **solely for maximum forward gain**

If the boom of a **YAGI is lengthened the gain increases**

A **directional antenna gain** may change depending on **frequency**

The total **radiation emitted by a directional gain antenna is the same as an isotropic** antenna

Figure E9-1



E9B01 In the antenna radiation pattern in Figure E9-1, what is the 3-dB beamwidth? = B. 50 degrees

3 dB from Max Gain are shown in red at +/- 25° = 50°

E9B02 In the antenna radiation pattern shown in Figure E9-1, what is the front-to-back ratio? = B. 18 dB

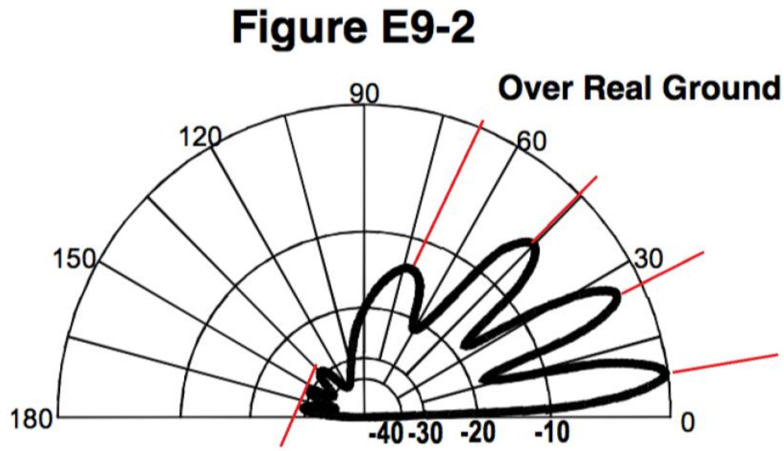
Back = -18 dB >> Front = 0 dB >> the difference is 18 dB

E9B03 In the antenna radiation pattern shown in Figure E9-1, what is the front-to-side ratio? = B. 14 dB

Side = -14 dB >> Front = 0 dB >> the difference is 14 dB

E9C Wire & Phased Vertical Antennas

Chapter 9 of ARRL Extra Class License Manual   Estimated 1 Exam Question



E9C07 What type of antenna pattern over real ground is shown in Figure E9-2? = A. Elevation

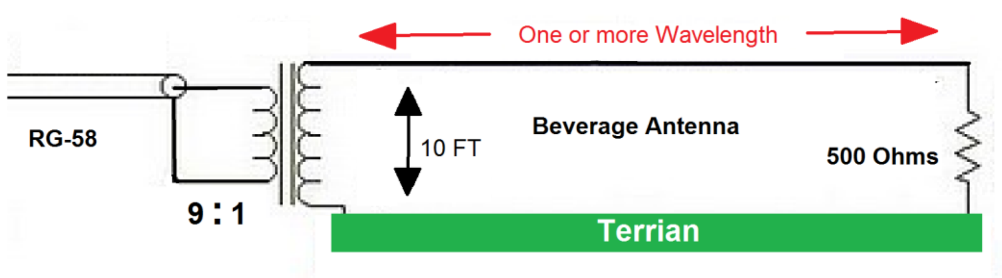
E9C08 What is the elevation angle of peak response in the radiation pattern shown in Figure E9-2? = C. 7.5 degrees

E9C09 What is the front-to-back ratio of the radiation pattern shown in Figure E9-2? = B. 28 dB

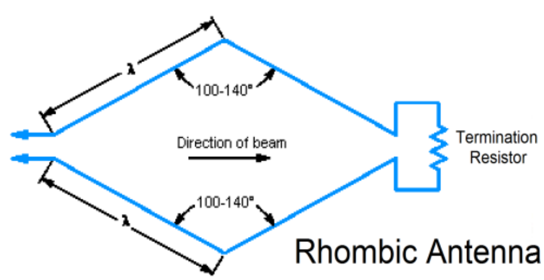
E9C10 How many elevation lobes appear in the forward direction of the radiation pattern shown in Figure E9-2? = A. 4

A vertically polarized antenna **low-angle radiation increases over seawater** versus rocky ground

Placing a vertical antenna over an **imperfect ground reduces low-angle radiation**



A **BEVERAGE** antenna should be **one or more wavelengths long**

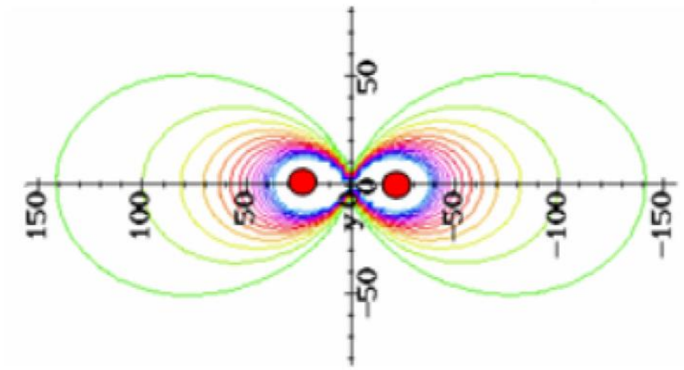


An **UNTERMINATED RHOMBIC** antenna is Bidirectional; four-sides, each WL long; open opposite the feed point

An HF **TERMINATED RHOMBIC** antenna requires a large physical area & 4 separate supports

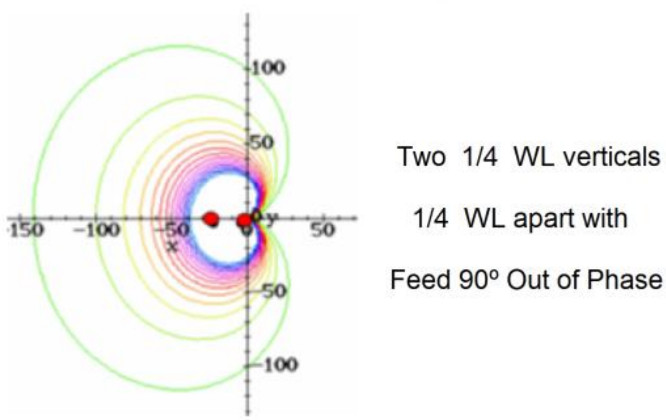
The **terminating resistor on a rhombic** antenna provides a **unidirectional radiation pattern**

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

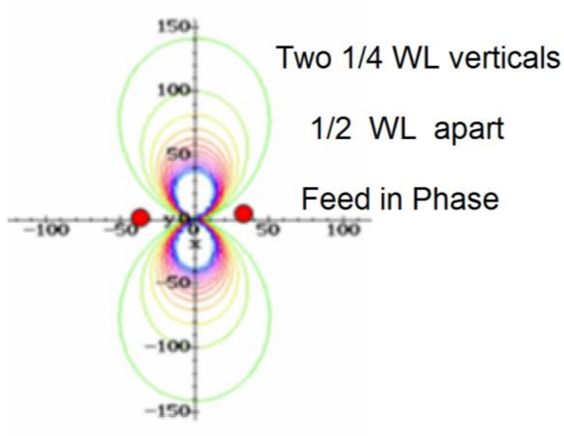


Two vertical ¼ WL antennas Feed points 180º out of phase

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



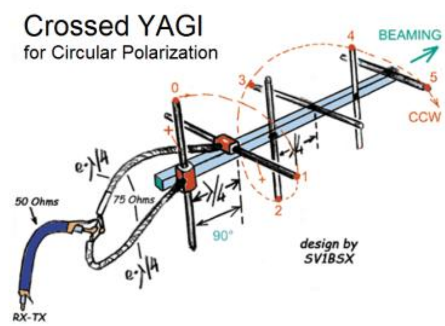
E9C03 What is the radiation pattern of two 1/4-wavelength vertical antennas spaced 1/2-wavelength apart and fed in phase? = C. A Figure-8 broadside to the axis of the array



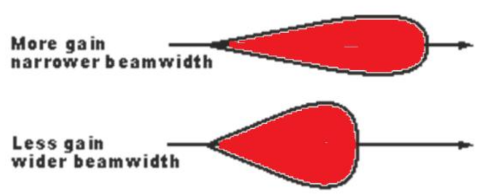
E9D Directional Antennas

Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

A linearly polarized **Yagi antennas** be used to produce **circular polarization** by arranging two Yagis perpendicular to each other with the driven elements at the same point on the boom and fed 90 degrees out of phase



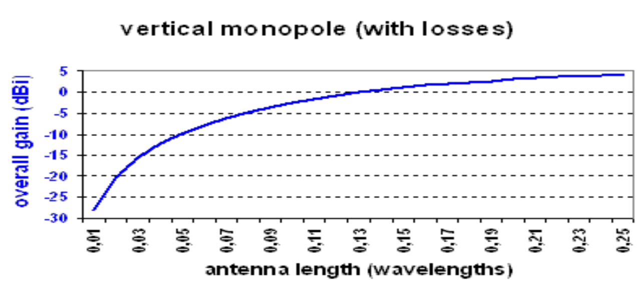
Antenna **beamwidth decreases** as the **gain increases**



Tracking a satellite in orbit the ground **antenna moves in both azimuth and elevation**

HF mobile antenna >> **Resistance decreases & Capacitive increases as the frequency decreases**

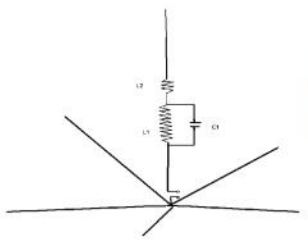
To minimize losses an HF mobile antenna loading coil have a **high ratio of reactance to resistance**

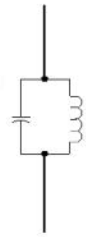


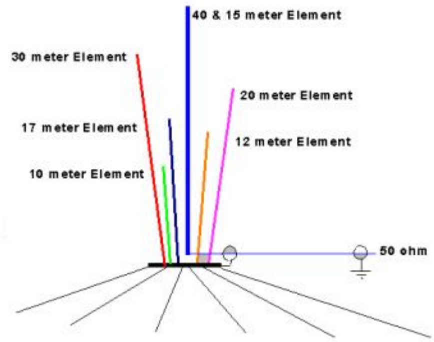
Place a **high-Q loading coil at center of the vertical radiator** to minimize losses in a shortened antenna

Multiband operation is an advantage of using a **trapped antenna**

A **multiband trapped antenna might radiate harmonics**



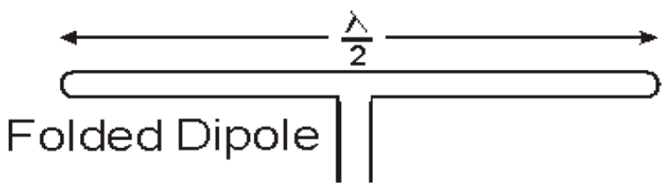




Loading coils used with an HF mobile antenna to **cancel capacitive reactance**

The **bandwidth decreases** in an antenna shortened through the use of **loading coils**

Top loading in a shortened HF vertical antenna **improves radiation efficiency**

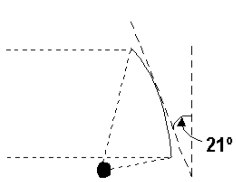


The feed point impedance of a **folded dipole antenna is 300 ohms**

Best RF station ground >> short connection to 3 or 4 interconnected ground rods driven into the Earth

A **wide flat copper strap** is best for minimizing losses in a station's RF ground system

Gain increases 6 dB on a parabolic dish antenna when the operating **frequency is doubled**



$$x = \frac{\pi d}{\lambda}\sin\varphi$$

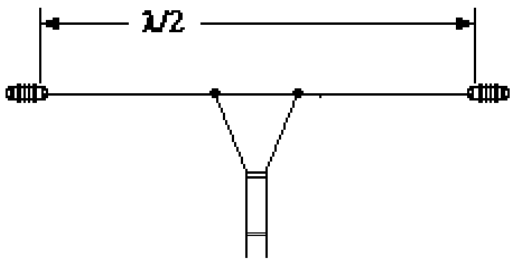
$$G_{Max} = \rho_e\left(\pi\frac{d}{\lambda}\right)^2$$

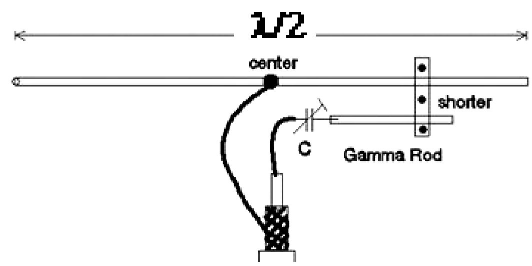
$$G(\varphi) = G_{Max}\left(\frac{2J_1(x)}{x}\right)^2$$

E9E Matching

Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

The **delta matching** system matches a high-impedance transmission line to a lower impedance antenna by connecting the line to the driven element in two places spaced a fraction of a wavelength each side of element center

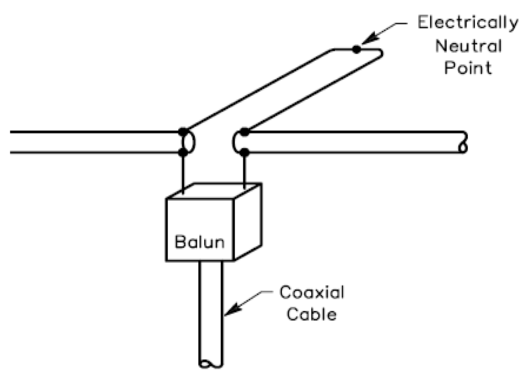




The **gamma match** that matches an unbalanced feed line to an antenna by feeding the driven element both at the center of the element and at a fraction of a wavelength to one side of center

A **Gamma match** is an **effective match** of a 50-ohm feed to a **grounded tower** so it can be a **vertical antenna**

The **series capacitor** in a **gamma matching** network **cancels the inductive reactance** of the matching network



The **stub match** uses a section of transmission line connected in parallel with the feed line at or near the feed point

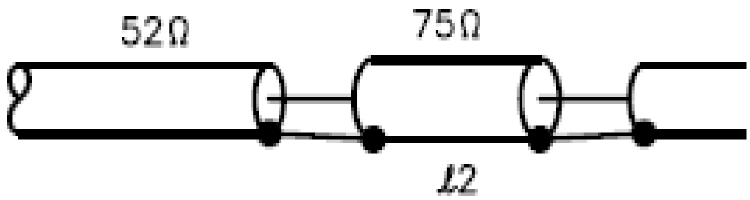
The ***universal stub matching*** technique is an effective way of matching a feed line to a VHF or UHF antenna when the impedances of both the antenna and feed line are unknown

The **driven element must be capacitive** in a 3-element Yagi be tuned **to use a hairpin matching** system

An **L network is the equivalent** network for a **hairpin matching** system on a 3-element Yagi

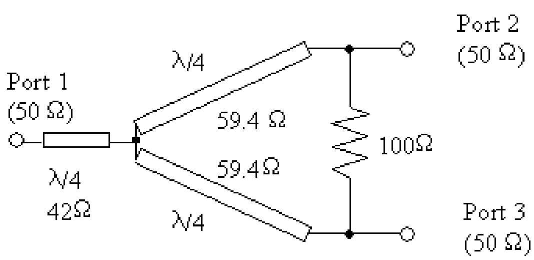
An **SWR greater** than 1:1 is a characteristic of a **mismatched transmission** line

Reflection coefficient describes the interactions at the load end of a **mismatched transmission line**



Insert a **1/4-wavelength piece of 75-ohm coaxial cable** transmission line in series between the antenna and the **50-ohm feed** cable to match an **antenna with 100-ohm** feed point impedance to a 50-ohm coaxial cable feed line

The primary **purpose of a phasing line** when used with an antenna having **multiple driven elements** is to ensure that each driven element operates in concert with the others to **create the desired antenna pattern**



A **Wilkinson divider** divides power equally among multiple loads while preventing changes in one load from disturbing power flow to the others

E9F Transmission Lines

Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

Velocity factor of a transmission line is the transmission line velocity divided by the velocity of light in a vacuum

VELOCITY FACTOR is the ratio of a signal speed through a transmission line to the speed of light in a vacuum

Dielectric determines the **velocity factor** of a transmission line

Electrical signals move more slowly in a coaxial cable than in air

The significant differences between **foam-dielectric** coaxial cable and **solid-dielectric** cable are; reduced safe operating **voltage** limits, reduced **losses** per unit of length and **higher velocity factor**

Coaxial cable with **solid polyethylene dielectric 0.66** is the typical velocity factor

Ladder line has lower loss than coaxial cable such as RG-58 at 50 MHz?

E9F05 What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 14.1 MHz? = C. 3.5 meters

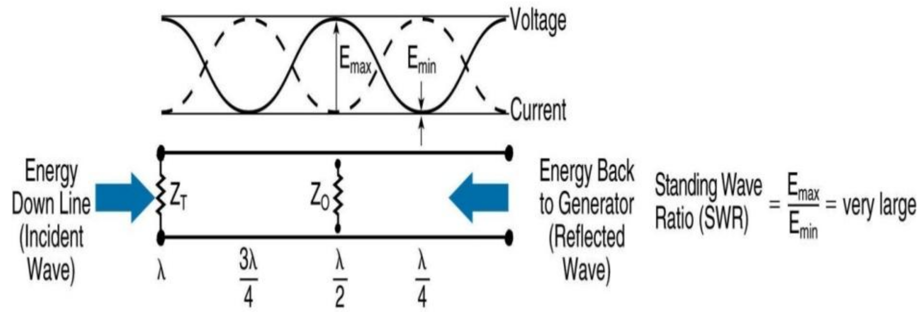
VF x WL/4 = 0.66 x (300 / 14.1) / 4 = 0.66 x (21.28 / 4) = 0.66 x 5.319 = 3.511 M

E9F06 What is the approximate physical length of an air-insulated, parallel conductor transmission line that is electrically one-half wavelength long at 14.10 MHz? = C. 10 meters

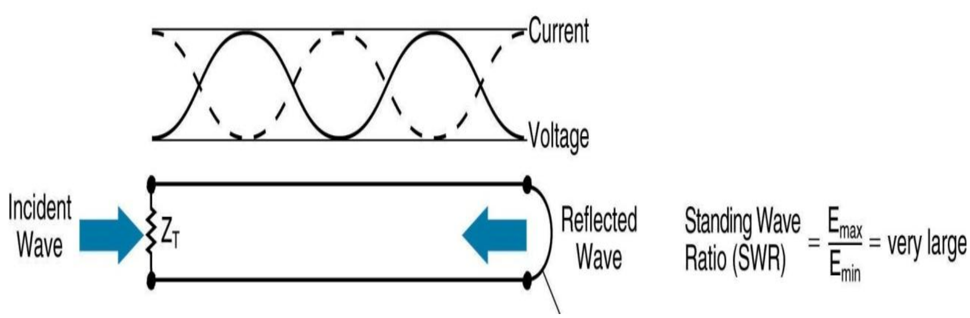
VF x WL/2 = 0.95 x (300 / 14.1) / 2 = 0.95 x (21.28 / 2) = 0.95 x 10.64 = 10.11 M

E9F09 What is the approximate physical length of a solid polyethylene dielectric coaxial transmission line that is electrically one-quarter wavelength long at 7.2 MHz? = B. 6.9 meters

VF x WL/4 = 0.66 x (300 / 7.2) / 4 = 0.66 x (41.66 / 4) = 0.66 x 10.417 = 6.875 M



Impedance of Coaxial Stubs		
Wavelength	**Open Stub**	**Shorted Stub**
1/8	Capacitive	Inductive
1/4	Low Imp.	High Imp.
1/2	High Imp.	Low Imp.



E9G Smith Charts

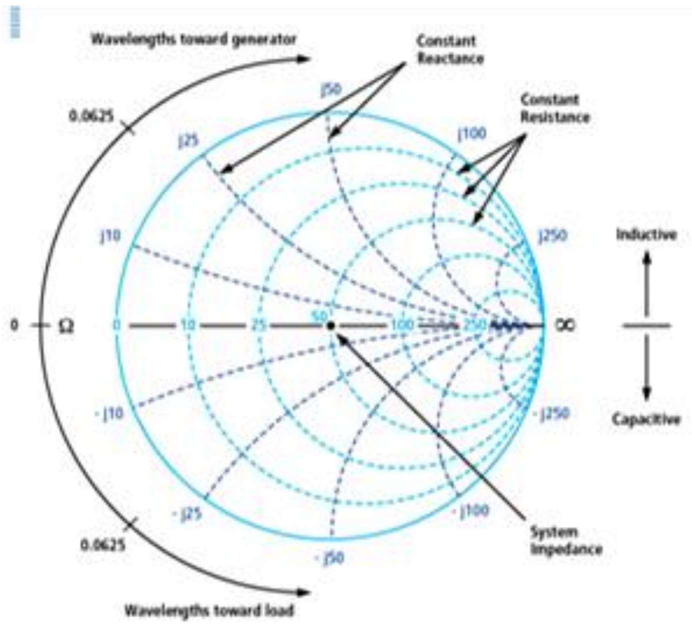
Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

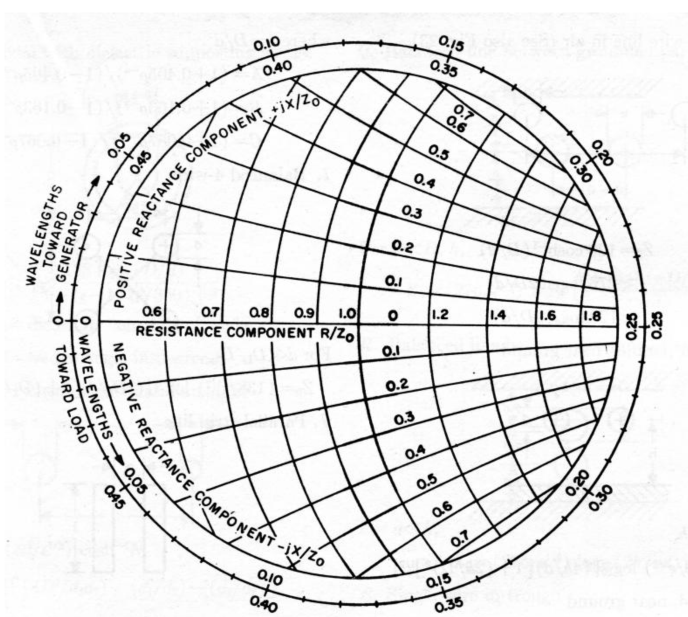
Impedance along transmission lines can be calculated using a Smith chart

Resistance circles and reactance arcs coordinate system is used in a Smith chart

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

The arcs on a Smith chart represent **Points with constant Reactance**

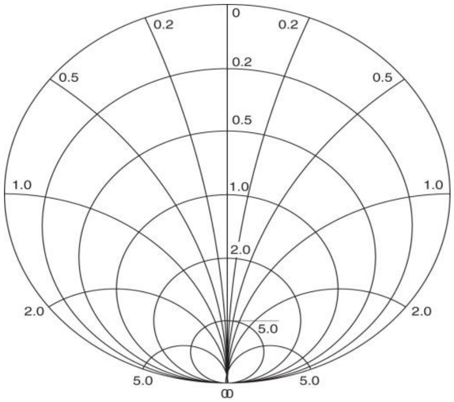




Impedance and SWR values in transmission lines are often determined using a Smith chart

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

Reassigning impedance values with regard to the prime center is the process of normalization on a Smith chart

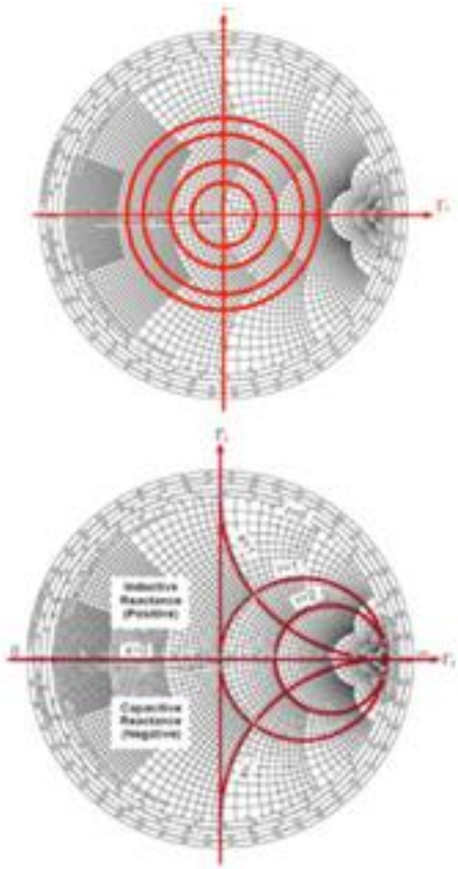


E9G06 On the Smith chart shown in Figure E9-3, what is the name for the large outer circle on which the reactance arcs terminate? = B. Reactance axis

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

< Figure E9-3

Standing-wave ratio circles is the third family of circles is often added to a Smith chart solving problems



Think about it as moving around the Smith Chart which is 1/2 a wavelength all the way around (180 degrees). If we move 90° on the smith chart our transmission line does the opposite of our input, so a short at 90º will appear as an open to the generator (transmitter input) end and an open will look like a short. Moving to ½ wavelength or 180º brings us back to the starting point so there is no opposite transformation, therefore a short at the output will look like a short at the input and an open will look like an open. For partial wavelengths the impedance between 0 and ¼ wavelength the line will look like an inductive reactance and for a ¼ to ½ wavelength the line will look like a capacitive reactance depending on the actual fractional wavelength. – AD7FO

E9H ERP, Gain, Loss

Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

Decibel (dB) is a ratio expressed as a log of 10 or Gain/loss ratio = 10^(dB/10)

Ratios e.g.,2 = 3db =10^(dB/10) = 10^(3/10) = 10^0.3 = 2 >> 0dB=1, 1dB=1.26, 2dB=1.58, 3dB=2, -6dB=1/4

Watts e.g., 1 milliwatt = −30 dBW, 1 watt = 0 dBW, 10 watts = 10 dBW, 100 watts = 20 dBW, and 1,000 W = 30 dBW dBi >> dB (isotropic) – the gain of an antenna compared with the hypothetical isotropic antenna

dBd >> dB (dipole) – the gain of an antenna compared with a half-wave dipole antenna. 0 dBd = 2.15 dBi

EFFECTIVE RADIATED POWER describes station output, including the transmitter, antenna and everything in between, when considering transmitter power and system gains and losses

E9H01 What is the effective radiated power relative to a dipole of a repeater station with 150 watts transmitter power output, 2-dB feed line loss, 2.2-dB duplexer loss and 7-dBd antenna gain? = D. 286 watts

ERP = Power X (Gain - Loss)

ERP = 150W X (7.0 - 2.0 - 2.2) dB

ERP = 150W X 2.8dB

Head math check 3dB is about 2 ratio so the answer is about 300W

2.8dB = Gain/loss ratio = 10^(dB/10)or 10^(2.8/10) or 10^.28 or 1.905

ERP = 150W X 1.905

ERP = 285.75W

E9H02 What is the effective radiated power relative to a dipole of a repeater station with 200 watts transmitter power output, 4-dB feed line loss, 3.2-dB duplexer loss, 0.8-dB circulator loss and 10-dBd antenna gain? = A. 317 watts

ERP = Power X (Gain - Loss)

ERP = 200W X (10.0 - 4.0 - 3.2 – 0.8) dB

ERP = 200W X 2.0dB

Head math check 2dB is about 1.5 ratio so the answer is about 300W

2.0dB = Gain/loss ratio = 10^(dB/10)or 10^(2.0/10) or 10^.20 or 1.584

ERP = 200W X 1.584

ERP = 316.80 W

E9H03 What is the effective isotropic radiated power of a repeater station with 200 watts transmitter power output, 2-dB feed line loss, 2.8-dB duplexer loss, 1.2-dB circulator loss and 7-dBi antenna gain? = B. 252 watts

ERP = Power X (Gain - Loss)

ERP = 200W X (7.0 - 2.0 - 2.8 – 1.2) dB

ERP = 200W X 1.0dB

Head math check 1dB is about 1.2 ratio so the answer is about 240W

1.0dB = Gain/loss ratio = 10^(dB/10)or 10^(1.0/10) or 10^.10 or 1.2589

ERP = 200W X 1.2589

ERP = 251.78 W

Editors Comment: There is another way to work these problems

by converting the transmitter power to dBW.

Here is the same problem as above in all dB math.

You will get the same answer, see if it is easier for you.

ERP = Power + Gain - Loss

ERP = (200W) + 7.0 - 2.0 - 2.8 – 1.2

ERP = 23.0103 dBw + 7.0 - 2.0 - 2.8 – 1.2

ERP = 24.0103 dBW

24.0103 dBW = 10^(dB/10)or 10^(24.0103/10) or 10^2.40103 or 251.7851 Watts

ERP = 251.78 W

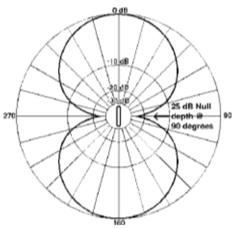
This method is good for complex transmission paths

you just add and subtract dBs and only convert at the TX end

E9H Direction Finding Antennas

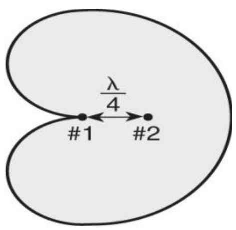
Chapter 9 of ARRL Extra Class License Manual Estimated 1 Exam Question

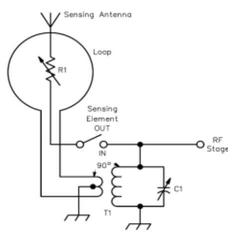
The main drawback of a **wire-loop antenna** for direction finding is the **bidirectional pattern**

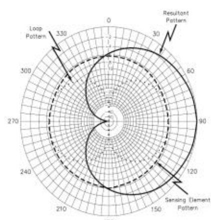



A **cardioid-pattern antenna** has a **very sharp single null** useful for direction finding

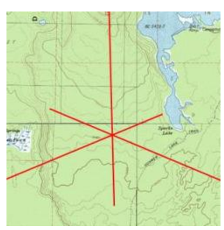
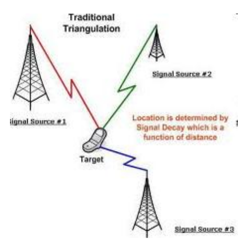
A **sense antenna** modifies the pattern of a DF antenna array to provide a null in one direction







The **triangulation** method uses headings from **several different receiving locations** to locate a signal

An **RF attenuator prevents receiver overload** making it difficult to determine peaks or nulls

RECEIVING LOOP ANTENNA >> One or more turns of wire wound in the shape of a large open coil

The **output loop antenna** be increased by **adding turns** in the loop or **add area** to the loop

Shielded loop antenna is electro-statically balanced against ground, giving better nulls

INDEX

S con't

T

U V

W X Y Z