Technician and General Class Amateur Radio & Satellite Stuff

Anthony Odenthal, KE7OSN Amateur Extra

January 30, 2014

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The goals are:

- To introduce you to Amateur Radio
- Prepare you to take (and pass) the technician and general exams
- Introduce you to satellite communications.

A little about myeself

- Passed Tech Sept 2007
- Passed Gen Oct 2007
- Joined Benton County ARES April 2012
- Passed Extra April 2012
- Became a VE in June 2012

What is Amateur Radio?

Amateur radio are people and activities that are regulated and encouraged, in the US and abroad, that allow licensed individuals to play around with radio waves, electronics, software, techniques, practices, and equipment to do all sorts of really cool stuff. Radio Amateurs are some of the least restricted users of radio spectrum, and with that freedom they have proven time and time again their worth. The term Amateur refers to someone who does something as a pastime rather than a profession.

Some useful tools

Some things you may want to look into as useful for studying

- AA9PW practice exams http://aa9pw.com
- ARRL license Manuals http://www.arrl.org/shop/Licensing-Education-and-Training/

About the test

- 35 questions

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- 396 questions in the tech pool, 457 in the general
- Need a 75% to pass

Shal we begin?

Remember if I go too fast or you have questions, let me know.

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Who's In charge

International Telecommunications Union (ITU)

- Worldwide, treaty-based organization that allocates frequencies for specific uses.
- Primary Users - first "rights" to a frequency
- Secondary Users - permitted to use a frequency but must not interfere with a primary user
- World divided into 3 regions, US is in Region 2
- Creates "bands" - sections of spectrum allocated for amateur radio use.

Who's In Charge

Federal Comunications Commission (FCC)

- Promulgates rules for non-federal radio users within ITU spec
- Divides amateur bands into mode-specific sub-bands
- Rules for telecommunications are in the Code of Federal Regulations, Chapter 47
- Rules for amateur radio are in Part 97 of Chapter 47 (47 CFR 97)

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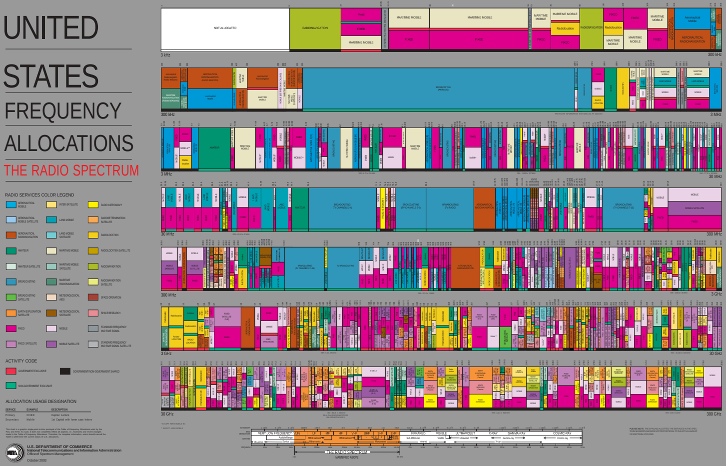
- Voluntary rules unless there is interference, then the coordinated user "wins"
- Gentleman's agreement

FCC allocations



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The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

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E Continuation and extension of the amateur's unique ability to enhance international goodwill.

Keyphrase

...a voluntary noncommercial communications service...

This phrase sums up almost every rule and tenant of amateur radio.

A voluntary noncommercial communications service

Noncommercial means no "pecuniary interest". It is illegal to profit from the use of amateur radio.

As with almost any rule there are exceptions"

- Teachers may use ham radio in the classroom as a teaching aid
- "Code practice" transmissions
- Disaster Drills

More basic rules

- No Music - expect transmission or re-transmission of a signal from a space station
- No Broadcasting
- No commercial traffic
- No profanity
- No codes or ciphers intended to hid content
- No international third party traffic unless treaty-approved

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Licenses

A license is valid for ten years, with a two year grace period. Upgrades don't count as renewals. Basic renewals are free! There are five classes.

- *Novice
- Technician
- General
- *Advanced
- Extra

Licenses

There are four kinds of licenses, Individual hams hold both a "Station" and "Operator"

- Station
- Operator
- Club - W7OSU, K7CVO, W1AW
- Special Event - A7W

Clubs can get a "club callsign", and events can get an event callsign.

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Callsigns

- US callsigns start with A,K,N, or W
- The format is one or two letters, a number, and one to three letters.
- New callsigns are assigned in sequential order - number indicates the region in the US
- Shorter callsigns are reserved for higher license classes
- 1X1 for special events only

Callsigns

- KE7OSN
- N8GFO

Callsigns

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- N8GFO -Yep

Callsigns

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Callsigns

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Operator

Who "operates" an amateur station?

Operator

Who "operates" an amateur station?
The control operator, who is designated by the station licensee, and determines the privileges of operation.
e.g. if you are at a radio that can operate outside your privileges, you still can only use what you are licensed to.

Your Callsign

A station must transmit it's callsign at least every ten minutes and at the end of every communication.
Special situations have special rules

- Control operator working outside of a station licensee privileges.
- Special event station control operator
- Control operator using new privileges prior to FCC database update

The Uniform Licensing System

The ULS is an online database of FCC license information. A new licensee may use their privileges as soon as their information appears in the ULS. When you upgrade you may use your new privileges as soon as you pass the test.

Typical uses of a callsign

- W7OSU This is KE7OSN

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- Net Control This is KE7OSN

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- This is KF7FGE stroke (/) KE7OSN

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- CQ CQ CQ this is KE7OSN
- KE7OSN monitoring
- This is KF7FGE stroke (/) KE7OSN
- Hey Bob, you around?

Hey bob, you around

Hey bob you around?
Legal?

Hey bob, you around

Hey bob you around?
Legal?
Yes, as long as you keep to the every ten minutes and the end of every communication.

Hey bob, you around

Hey bob you around?
Legal?
Yes, as long as you keep to the every ten minutes and the end of every communication.
What if Bob isn't there?

Hey bob, you around

Hey bob you around?
Legal?
Yes, as long as you keep to the every ten minutes and the end of every communication.
What if Bob isn't there?
KE7OSN clear

Types of stations

- Club – at least four people, one of which accepts responsibility and is the "trustee".
- Space – at least 50km above the surface.
- Beacon – transmits a low-level signal for propagation studies
- Repeater – retransmits a signal heard on one frequency on another frequency.
- Auxillary – a secondary receiver that feeds a repeater station.

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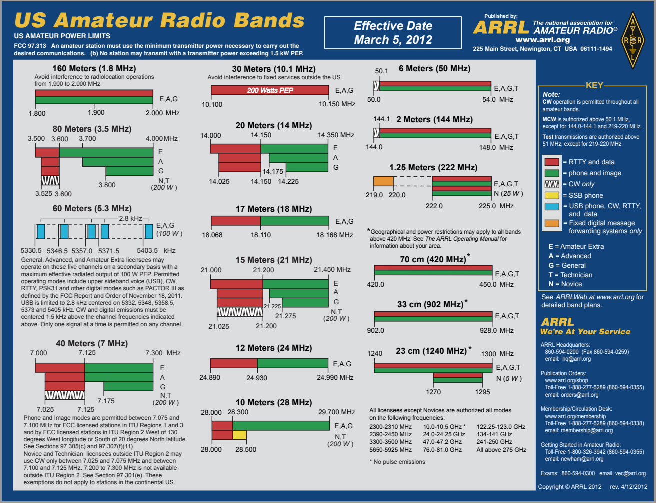
Band Plan



US Amateur Radio Bands
US AMATEUR POWER LIMITS
FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.
Effective Date March 5, 2012
Published by: ARRL The national association for AMATEUR RADIO® www.arrl.org
225 Main Street, Newington, CT USA 06111-1494
160 Meters (1.8 MHz)
Avoid interference to radiolocation operations from 1.900 to 2.000 MHz
1.800 1.900 2.000 MHz E,A,G
80 Meters (3.5 MHz)
3.500 3.600 3.700 4.000 MHz
E A G N,T (200 W)
3.525 3.600 3.800
60 Meters (5.3 MHz)
2.8 kHz E,A,G (100 W)
5330.5 5346.5 5357.0 5371.5 5403.5 kHz
General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated output of 100 W PEP. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III as defined by the FCC Report and Order of November 18, 2011. USB is limited to 2.8 kHz centered on 5332, 5348, 5358.5, 5373 and 5405 kHz. CW and digital emissions must be centered 1.5 kHz above the channel frequencies indicated above. Only one signal at a time is permitted on any channel.
40 Meters (7 MHz)
7.000 7.125 7.300 MHz
E A G N,T (200 W)
7.025 7.125 7.175
Phone and Image modes are permitted between 7.075 and 7.100 MHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11). Novice and Technician licensees outside ITU Region 2 may use CW only between 7.025 and 7.075 MHz and between 7.100 and 7.125 MHz. 7.200 to 7.300 MHz is not available outside ITU Region 2. See Section 97.301(e). These exemptions do not apply to stations in the continental US.
30 Meters (10.1 MHz)
Avoid interference to fixed services outside the US.
200 Watts PEP E,A,G
10.100 10.150 MHz
20 Meters (14 MHz)
14.000 14.150 14.350 MHz
E A G
14.025 14.150 14.175 14.225
17 Meters (18 MHz)
18.068 18.110 18.168 MHz E,A,G
15 Meters (21 MHz)
21.000 21.200 21.450 MHz
E A G N,T (200 W)
21.025 21.200 21.225 21.275
12 Meters (24 MHz)
24.890 24.930 24.990 MHz E,A,G
10 Meters (28 MHz)
28.000 28.300 29.700 MHz
E,A,G N,T (200 W)
28.000 28.500
6 Meters (50 MHz)
50.1 50.0 54.0 MHz E,A,G,T
2 Meters (144 MHz)
144.1 144.0 148.0 MHz E,A,G,T
1.25 Meters (222 MHz)
219.0 220.0 222.0 225.0 MHz E,A,G,T N (25 W)
*Geographical and power restrictions may apply to all bands above 420 MHz. See The ARRL Operating Manual for information about your area.
70 cm (420 MHz)*
420.0 450.0 MHz E,A,G,T
33 cm (902 MHz)*
902.0 928.0 MHz E,A,G,T
23 cm (1240 MHz)*
1240 1300 MHz E,A,G,T N (5 W)
1270 1295
All licensees except Novices are authorized all modes on the following frequencies:
2300-2310 MHz 10.0-10.5 GHz * 122.25-123.0 GHz
2390-2450 MHz 24.0-24.25 GHz 134-141 GHz
3300-3500 MHz 47.0-47.2 GHz 241-250 GHz
5650-5925 MHz 76.0-81.0 GHz All above 275 GHz
* No pulse emissions
KEY
Note:
CW operation is permitted throughout all amateur bands.
MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.
Test transmissions are authorized above 51 MHz, except for 219-220 MHz
= RTTY and data
= phone and image
= CW only
= SSB phone
= USB phone, CW, RTTY, and data
= Fixed digital message forwarding systems only
E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice
See ARRLWeb at www.arrl.org for detailed band plans.
ARRL We're At Your Service
ARRL Headquarters: 860-594-0200 (Fax 860-594-0259) email: hq@arrl.org
Publication Orders: www.arrl.org/shop Toll-Free 1-888-277-5289 (860-594-0355) email: orders@arrl.org
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Exams: 860-594-0300 email: vec@arrl.org
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ITU Band Names

- MF - Medium Frequency 300KHz to 3MHz
- HF - High Frequency 3MHz to 30 MHz
- VHF - Very High Frequency 30MHz to 300MHz
- UHF - Ultra High Frequency 300MHz to 3GHz
- SHF - Super High Frequency 3GHz to 30GHz
- EFE - Extremely High Frequency - 30GHz to 300GHz
- THF - Tremendously High Frequency - 300GHZ to 3THz

HF 3-30MHz

- 80 Meters
  - 3.525-3.600MHz: CW Only
- 40 Meters
  - 7.025-7.125MHz: CW Only
- 15 Meters
  - 21.025-21.200MHz: CW Only
- 10 Meters
  - 28.000-28.300MHz: CW, RTTY/Data 200 watts PEP max
  - 28.300-28.500MHz: CW, Phone 200 watts PEP max

VHF 30-300MHz

- 6 Meters
  - 50.0-50.1MHz CW Only
  - 50.1-54.0MHz All modes
- 2 Meters
  - 144.0-144.1MHz CW Only
  - 144.1-148.0MHz All modes
- 1.25 Meters
  - 222.00-225.00MHz All modes

UHF 300-3000MHz (3GHz)

- 70 Centimeters
  - 420.0-450.0MHz All Modes
- 33 Centimeters
  - 902.0-928.0MHz All Modes
- 23 Centimeters
  - 1240-1300MHz All Modes
- 2.4GHz
  - 2.3-2.31GHz
  - 2.39-2.45GHz *

2.4GHz

We share the 2390-2450MHz band with: 802.11 networks, cordless phones, video cameras, zigbee, etc.
We are PRIMARY users. We have first "rights". Secondary users must not cause us interference and must accept interference from our operations.

SHF 3GHz-30GHz and up

- 3.3-3.5GHz
- 5.65-5.925GHz
- 10.0-10.5GHz
- 24.0-24.25GHz
- 47.0-47.2GHz
- 76.0-81.9GHz
- 119.98-120.02GHz
- 142-149GHz
- 241-250GHz
- Everything above 300GHz

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  D. Persons who are interested in radio technique solely with a personal aim and without pecuniary interest

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  A. A station in an Amateur Radio Service consisting of the apparatus necessary for carrying on radio communications

T1A 6 Questions from T1

- **T1A01 For whom is the Amateur Radio Service intended?**
  D. Persons who are interested in radio technique solely with a personal aim and without pecuniary interest
- **T1A02 What agency regulates and enforces the rules for the Amateur Radio Service in the United States?**
  C. The FCC
- **T1A03 Which part of the FCC rules contains the rules and regulations governing the Amateur Radio Service?**
  D. Part 97
- **T1A04 Which of the following meets the FCC definition of harmful interference?**
  C. That which seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with the Radio Regulations
- **T1A05 What is the FCC Part 97 definition of a space station?**
  D. An amateur station located more than 50 km above the Earth's surface
- **T1A06 What is the FCC Part 97 definition of telecommand?**
  C. A one-way transmission to initiate, modify or terminate functions of a device at a distance
- **T1A07 What is the FCC Part 97 definition of telemetry?**
  C. A one-way transmission of measurements at a distance from the measuring instrument
- **T1A08 Which of the following entities recommends transmit/receive channels and other parameters for auxiliary and repeater stations?**
  B. Frequency Coordinator
- **T1A09 Who selects a Frequency Coordinator?**
  C. Amateur operators in a local or regional area whose stations are eligible to be auxiliary or repeater stations
- **T1A10 What is the FCC Part 97 definition of an amateur station?**
  A. A station in an Amateur Radio Service consisting of the apparatus necessary for carrying on radio communications
- **T1A11 Which of the following stations transmits signals over the air from a remotereceive site to a repeater for retransmission?**
  C. Auxiliary station

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T1B 6 Questions from T1

- **T1B01 What is the ITU?**
  B. A United Nations agency for information and communication technology issues

T1B 6 Questions from T1

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- **T1B03 Which frequency is within the 6 meter band?**
  B. 52.525 MHz

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  B. So that modulation sidebands do not extend beyond the band edge
  C. To allow for transmitter frequency drift
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- **T1B11 What emission modes are permitted in the mode-restricted sub-bands at 50.0 to 50.1 MHz and 144.0 to 144.1 MHz?**
  A. CW only

T1C 6 Questions from T1

- **T1C01 Which type of call sign has a single letter in both the prefix and suffix?**
  C. Special event

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- **T1C08 What is the normal term for an FCC-issued primary station/operator license grant?**
  C. Ten years

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  C. As soon as your name and call sign appear in the FCC s ULS database

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- **T1C11 If your license has expired and is still within the allowable grace period, may you continue to operate a transmitter on amateur service frequencies?**
  A. No, transmitting is not allowed until the ULS database shows that the license has been renewed

T1D 6 Questions from T1

Anthony Odenthal, KE7OSN Amateur Extra

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  A. Any country whose administration has notified the ITU that it objects to such communications

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- **T1D10 What is the meaning of the term broadcasting in the FCC rules for the amateur services?**
  D. Transmissions intended for reception by the general public

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  A. Only where such communications directly relate to the immediate safety of human life or protection of property
- **T1D10 What is the meaning of the term broadcasting in the FCC rules for the amateur services?**
  D. Transmissions intended for reception by the general public
- **T1D11 Which of the following types of communications are permitted in the Amateur Radio Service?**
  A. Brief transmissions to make station adjustments

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T1E 6 Questions from T1

- **T1E01 When must an amateur station have a control operator?**
  A. Only when the station is transmitting

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  D. The station licensee

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  B. Any time upon request by an FCC representative

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97.403 Safety of life and protection of property

No provision of these rules prevents the use by an amateur station of any means of radio communication at its disposal to provide essential communication needs in connection with the immediate safety of human life and immediate protection of property when normal communication systems are not available.

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ARES

ARES – **A**mateur **R**adio **E**mergency **S**ervice

- Organized and run by ARRL
- Supports governmental and NGO groups.
- Most groups are organized at the county level
- "EC" – Emergency Coordinator

RACES

RACES – **R**adio **A**mateur **C**ivil **E**mergency **S**ervice

- Defined by the FCC
- Supports governmental agencies ONLY.
- Operators are registered with the controlling agency.
- RACES Officer
- Activated by federal declaration of emergency.
- In Oregon, ARES members are also registered in RACES

Table of Contents

Disaster == Organized Chaos

To keep some organization to the use of frequencies and communications, groups are organized into "nets".
A "net" is a group of stations that are cooperating in the use of a frequency. The "net control" is responsible for deciding who gets to talk.

Disaster == Organized Chaos

There are two kinds of nets:

Directed - the net control is strict in controlling who talks to whom. Stations tell net control they have a message for another station, and the net control directs them to call that station and pass the message.

Free - the net control allows stations to contact each other as they need to.

Disaster == Organized Chaos

There are three types of messages

Formal - written messages.

Informal - unwritten messages.

Administrative - station to station housekeeping.

Written Messages – Formal Traffic

ARES and RACES have adopted the NIMS/ICS system for written traffic. I.e., ICS-213 message forms, in either digital or transcribed versions.

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The TEST doesn't ask you about that. The TEST deals with the National Traffic System message form.

Written Messages – Formal Traffic

The National Traffic System (NTS) is a system organized by ARRL to transmit messages in a standard format, usually concerning "Health and Welfare". For example: "Aunt Martha arrived home safely. Have a happy birthday." Or "welcome to Ham radio". These messages use the NTS RadioGram form. The process is described in depth in the Message Processing Guidelines (MPG).

NTS RadioGram Form

The American Radio Relay League
RADIOGRAM
Via Amateur Radio

Number	Precedence	HX	Station of Origin	Check	Place of Origin	Time Filed	Date

To:

This Radio Message was received at:

Amateur Station____________ Date_____
Name______________________________
Street Address____________________
City, State, Zip__________________

Telephone Number:

	From	Date	Time		To	Date	Time
REC'D				SENT			

A licensed Amateur Radio Operator, whose address is shown above, handled this message free of charge. As such messages are handled solely for the pleasure of operating, a "Ham" Operator can accept no compensation. A return message may be filed with the "Ham" delivering this message to you. Further information on Amateur Radio may be obtained from ARRL Headquarters, 225, Main Street, Newington, CT 06111.

The American Radio Relay League, Inc. is the National Membership Society of licensed radio amateurs and the publisher of *QST* Magazine. One of its functions is promotion of public service communication among Amateur Operators. To that end, The League has organized the National Traffic System for daily nationwide message handling.

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Types of radio short-hand

Amateur radio has its own codes, and slang. Much like 1337 or txt, this "shared language" makes it easier to communicate quickly, and efficently. Much of it comes from the days of telegraph and Morse Code.

- **Q Codes** - Three letter codes beginning with Q
- **Number codes** - Codes sent as numbers, we really only us 73
- **Pro-words** - Standardized ways of saying things in a clear and concise fashion
- **Phonetics** - Words for letters, try saying BCDEZGT five times fast.

Q-Codes

Q codes are three letter codes that begin with Q and not QU and can be sent as either a question or a response. Really useful when using Morse Code as the codes are much shorter than what they represent. Some common Q codes are listed below.

QSY	Change frequency
QRT	Stop transmitting
QRZ	I'm calling
QRM	Man made interference
QRN	Natural interference or Noise
QSL	Acknowledge
QST	Message to all amateurs

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Pro-words

Pro or Professional words are used as shorthand, and because they prevent confusion. Yea and Nah kinda sound the same.

Roger	Received
WilCO	Will Comply
Over	I'm done talking for now
Out	I'm done talking to you
This Is	I'm going to say my callsign now
Wait	Hold on for a while
Affirmative	Yes
Negative	No

Phonetics

In amateur radio we use ITU phonetics, this helps us reduce the potential of confusion over letters that sound the same

A - Alfa "AL-FAH"	N - November "NO-VEM-BER"	0 "ZEE-RO"
B - Bravo "BRAH-VOH"	O - Oscar "OSS-CAH"	1 "WUN"
C - Charlie "CHAR-LEE"	P - Papa "PAH-PAH"	2 "TOO"
D - Delta "DELL-TAH"	Q - Quebec "KEH-BECK"	3 "TH-UH-REE"
E - Echo "ECK-OH"	R - Romeo "ROW-ME-OH	4 "FOW-ER"
F - Foxtrot "FOKS-TROT"	S - Sierra "SEE-AIR-RAH"	5 "FI-IV" OR "FIFE"
G - Golf "GOLF"	T - Tango "TANG-GO"	6 "SIX"
H - Hotel "HOH-TELL"	U - Uniform "YOU-NEE-FORM"	7 "SEV-EN"
I - India "IN-DEE-AH"	V - Victor "VIK-TAH"	8 "ATE"
J - Juliett "JEW-LEE-ETT	W - Whiskey "WISS-KEY"	9 "NIN-ER"
K - Kilo "KEE-LOH"	X - X-Ray "ECKS-RAY"	
L - Lima "LEE-MAH	Y - Yankee "YANG-KEY"	
M - Mike "MIKE"	Z - Zulu "ZOO-LOO"	

W7QH becomes "Whiskey 7 Quebec Hotel"

CQ and 73

There are two other special cases.

- CQ is the standard calling call. Think of it as Seek You, though no one really knows where it comes from. It is common to add extra stuff depending on the situation. You might hear CQ JOTA, CQ Field Day, CQ Contest, CQ DX, CQ Oregon. This lets people pick who they are looking for. A common general CQ would sound like "CQ CQ CQ this is KE7OSN calling CQ CQ CQ"
- The other thing that comes up is the number 73, this goes back to the old Western Union Telegraph 92 codes, these were numbers that could be used in place of certain phrases, most of them dealing with packages or trains. 73 means "Beast Regards" and is generally used as "goodbye"

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Power

In most amateur bands the maximum legal limit for power output is 1500 Watts, PEP. PEP - Peak Envelope Power is the largest amplitude of a signal. On some bands the limit is lower, for each band there is also a point at which you have to do a safety evaluation of your station to avoid unsafe exposure. You should always use the minimal power required to do what you need to do.

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- **T2C06 Which of the following is common practice during net operations to get the immediate attention of the net control station when reporting an emergency?**
  C. Begin your transmission with Priority or Emergency followed by your call sign
- **T2C07 What should you do to minimize disruptions to an emergency traffic net once you have checked in?**
  C. Do not transmit on the net frequency until asked to do so by the net control station
- **T2C08 What is usually considered to be the most important job of an amateur operator when handling emergency traffic messages?**
  A. Passing messages exactly as written, spoken or as received
- **T2C09 When may an amateur station use any means of radio communications at its disposal for essential communications in connection with immediate safety of human life and protection of property?**
  B. When normal communications systems are not available
- **T2C10 What is the preamble in a formal traffic message?**
  D. The information needed to track the message as it passes through the amateur radio traffic handling system
- **T2C11 What is meant by the term "check" in reference to a formal traffic message?**
  A. The check is a count of the number of words or word equivalents in the text portion of the message

101 of 396 25.5%

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Electromagnetic Waves

Electromagnetic waves are energy waves that move through space, similar to the way waves move in water or sound through air.
In a vacuum these waves move at the speed of light 299,792,458m/s or 186,282.397$miles/second$. This is good as these waves are light.

Speed of light

We can round up to 300,000,000m/s. Some distance measured in terms of light-time

Average distance between the Sun and Earth - 8 minutes

GEO Satellite to Earth's Surface - about a half second

Nearest other star to our Sun 4.25 Years

Voyager Space probe to the Sun at 18,884,401,200 Km from the sun?

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Frequency - not just an ok movie

We often refer to a wave by it's frequency. Frequency is the number of times a wave cycles in a given time. We use Hertz (Hz) which has the unites of $\frac{1}{Seconds}$.
Middle C is 440Hz, or 440 cycles per second.
KLOO-AM is 1.340MHz, or 1,340,000 cycles per second.

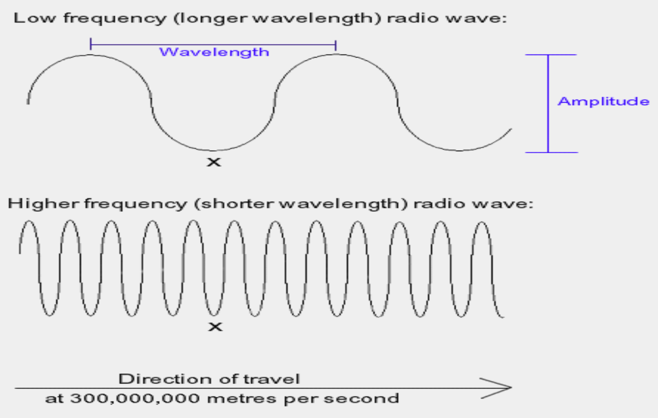
SI Prefixs

Sometimes it is a lot easier to shorten things up a bit.

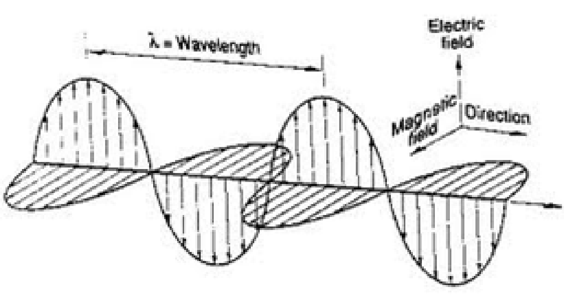
Tera	T	10^{12}	1,000,000,000,000
Giga	G	10^{9}	1,000,000,000
Mega	M	10^{6}	1,000,000
Kilo	K	10^{3}	1,000
Deci	d	10^{-1}	0.1
Ceni	c	10^{-2}	0.01
Milli	m	10^{-3}	0.001
Micro	μ	10^{-6}	0.000001
Nano	n	10^{-9}	0.000000001
Pico	p	10^{-12}	0.000000000001

Wavelength

We also use wavelength to describe waves. The wavelength is the distance between two like points on the wave exactly one cycle apart, e.g. the distance between peaks.



ElectoMagnetic



Electromagnetic waves have two parts, one electric part, and one magnetic part. The magnetic part is rotated and phase shifted by 90°

Wavelength to frequency and back

It is easy to convert between wavelength and frequency just use the equation below.

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We'll practice on the next slide

MATH!!!

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  That fits nicely in the 40meter band

MATH!!!

- Lets try to convert 7.025MHz into a wavelength to figure out which band it belongs to.
  $Wavelength(\lambda) = \frac{300}{7.025}$ that comes out to 42.7meters
  That fits nicely in the 40meter band
- Now lets try 223.50MHz
  $\frac{300}{223.50} = ?$

MATH!!!

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  That fits nicely in the 40meter band
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  $\frac{300}{223.50} =?$ 1.35, for the 1.25meter band.

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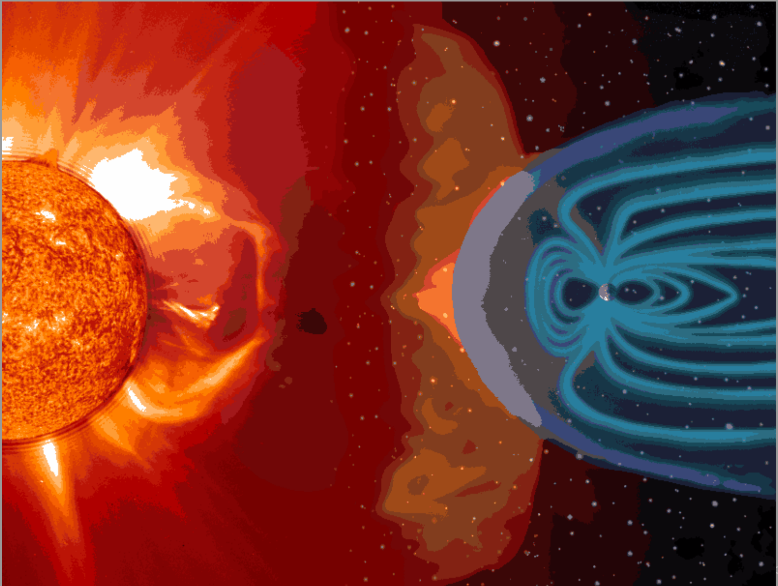
Reflections can be really useful when you don't have a direct line of sight.
Radio waves will also refract.

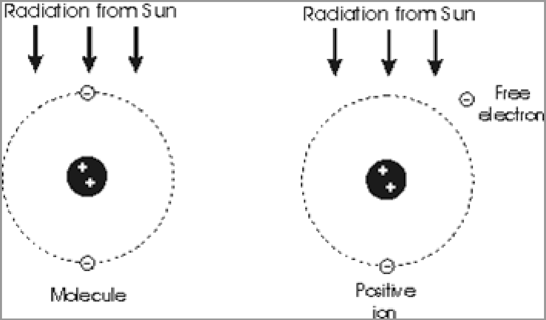
Solar Wind



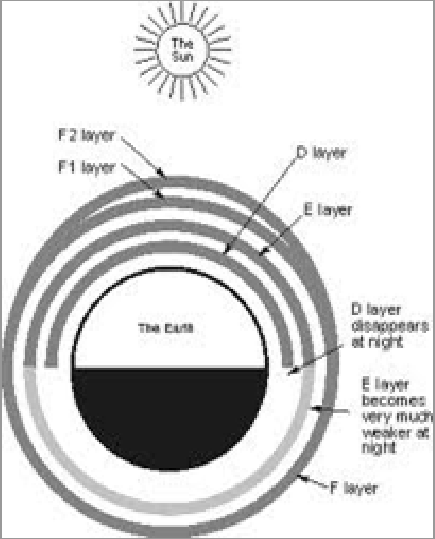
Solar Radiation

Solar radiation charges atoms in the atmosphere, breaking loose electrons, to create ions, which can interact with radio waves.

At night the electrons recombined with their atoms. This means things change from day to night.



Ionosphere



The parts of the atmosphere most affected by ionization are collectively called the Ionosphere!
It has multiple layers, each interact differently with radio waves. The D layers mostly absorbs RF, while the E and F layers reflect.
HF is is ruled by the ionosphere
VHF and up . . . not so much.

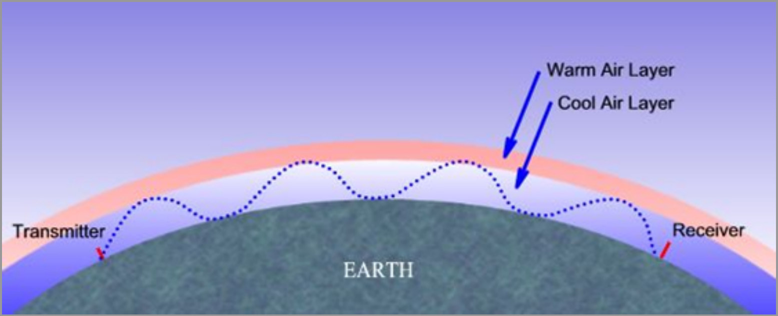
Ionosphere

During the day the D layers absorbs a large chunk of HF, at night it goes away and signals bounce (refract) off the E and F layers.
VHF and above mostly just goes through the ionosphere. . .
But sometimes at night there is just enough E layer to refract VHF signals. We call this "Sporadic E"

Auroras and Meteor Showers

The auroras are a visible sign of ionization, as they move they can cause received signals to sound fluttery.
Meteor showers leave short lived trails of ionized gases, that can refract signals, these effects are impossible to predict and last seconds.
You can even bounce radio signals off the moon!

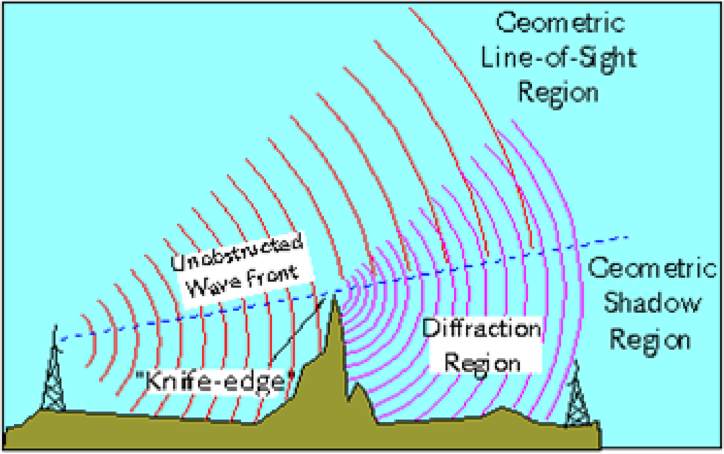
Tropospheric Ducting



Air can refract electromagnetic radiation. A temperature inversion (warm air above cold) can cause VHF signals to refract and travel long distances.

This is called "Tropospheric Ducting" and often happens between here and Hawaii, it mostly affects VHF.

Knife Edge



knife-edge effect

Polarization

Antennas tend to radiate and receive waves polarized along the direction of the antenna. An antenna pointing vertically produces vertically polarized waves, and the equivalent is true for a horizontal antenna.

If the polarization of the receiving antenna does not match the wave it is receiving then the signal strength is reduced by a significant degree. In an ideal world without the magnetic portion of a wave two antennas rotated $\pm 90^{\circ}$ would not be able to "see" each other.

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Technician and General Class Amateur Radio & Satellite Stuff

Anthony Odenthal, KE7OSN Amateur Extra

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  C. 3 to 30 MHz
- **T3B11 What is the approximate velocity of a radio wave as it travels through free space?**
  B. 300,000,000 meters per second

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Title

- **T3C01 Why are "direct" (not via a repeater) UHF signals rarely heard from stations outside your local coverage area?**
  C. UHF signals are usually not reflected by the ionosphere

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- **T3C01 Why are "direct" (not via a repeater) UHF signals rarely heard from stations outside your local coverage area?**
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- **T3C03 What is a characteristic of VHF signals received via auroral reflection?**
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  C. The Earth seems less curved to radio waves than to light

Technician class section 4

This section is going to be really short as much of the details fit in better elsewhere

Table of Contents

Station setup; microphone, speaker, headphones, filters, power source, connecting a computer, RF grounding

Some microphones include push-to-talk and voltage connections. Headphones can be useful in a noisy area instead of a speaker. A regulated power supply reduces voltage fluctuations. Filters between the transmitter and antenna can reduce harmonic emissions. A band-reject filter is a good first step if your 2 meter radio is causing problems with a TV. A terminal node controller is a modem for your radio, your soundcard can be a modem too. Flat straps are good grounding cables. Ferrite chokes can reduce RF current in cables. If your radio whines in your car and it goes along with the engine its probably the alternator. A radio installed in a car should be connected to a good "ground"

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Operating controls; tuning, use of filters, squelch, AGC, repeater offset, memory channels

If your mic is turned up to loud your signal may distort. You can set the frequency of a radio with the keypad or VFO knob. Squelch lets you mute the receiver when no signal is coming in. You can program favorite frequencies in memory. The noise blanker option can reduce noise. The RIT or Receiver Incremental Tuning control can change the pitch of the received audio. A good filter setting for SSB is 2400Hz, and 500Hz for CW. A repeater offset is the difference in its receive and transmit frequencies.

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T4A questions

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  A. At the battery or engine block ground strap

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  A. 500 Hz

T 4B questions

- **T4B01 (B) What may happen if a transmitter is operated with the microphone gain set too high?**
  B. The output signal might become distorted
- **T4B02 (A) Which of the following can be used to enter the operating frequency on a modern transceiver?**
  A. The keypad or VFO knob
- **T4B03 (D) What is the purpose of the squelch control on a transceiver?**
  D. To mute receiver output noise when no signal is being received
- **T4B04 (B) What is a way to enable quick access to a favorite frequency on your transceiver?**
  B. Store the frequency in a memory channel
- **T4B05 (C) Which of the following would reduce ignition interference to a receiver?**
  C. Turn on the noise blanker
- **T4B06 (D) Which of the following controls could be used if the voice pitch of a single-sideband signal seems too high or low?**
  D. The receiver RIT or clarifier
- **T4B07 (B) What does the term "RIT" mean?**
  B. Receiver Incremental Tuning
- **T4B08 (B) What is the advantage of having multiple receive bandwidth choices on a multimode transceiver?**
  B. Permits noise or interference reduction by selecting a bandwidth matching the mode
- **T4B09 (C) Which of the following is an appropriate receive filter to select in order to minimize noise and interference for SSB reception?**
  C. 2400 Hz
- **T4B10 (A) Which of the following is an appropriate receive filter to select in order to minimize noise and interference for CW reception?**
  A. 500 Hz
- **T4B11 (C) Which of the following describes the common meaning of the term repeater offset ?**
  C. The difference between the repeater s transmit and receive frequencies

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Ohm, Ohm on the range

Most metals are good at conducting electricity, this means they allow electrons to move around. We make wires that allow us to move electrons from one specific place to another.

Current

The movement of electrons is called **Current**. We measure current in the Ampere, aka the Amp, aka A (or I).

Current that moves in only one direction is called **Direct Current (DC)**. Current that changes direction regularly is called **Alternating Current (AC)**.

A device that measures current is an ammeter.

Ideas of current

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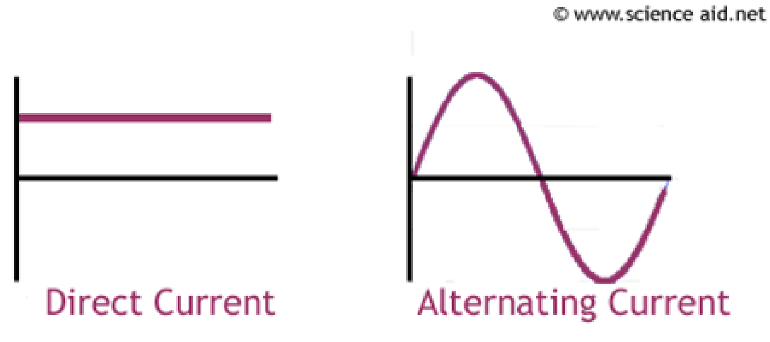

The Electromotive Force

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Voltage

Electrons like to spread out. It's their "natural desire" to not get bunched up that causes voltage. There can be voltage without current, but not current without voltage.
An unconnected battery has a voltage, but until it is hooked up to a complete circuit the electrons can't go anywhere.
Voltage is the difference in electrical potential between two points.
Think of something falling down stairs.

The Resistor

Resistance, impedes the flow of electrons.
The unit of resistance is the Ohm, or Ω.

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Now sing along ...
Alpha A, Beta B, Gamma Γ, Delta Δ, Epsilon E, Zeta Z, Eta H, Theta Θ, Iota I.
Anyone?

The Resistor

Resistance, impedes the flow of electrons.
The unit of resistance is the Ohm, or Ω. If that looks Greek, that's because it is, that Omega, a letter from the Greek alphabet
Resistance is measured with an ohmmeter.
Never use an ohmmeter on a live circuit

Ohms Law

The voltage across a resistor is equal to the resistance times the current. $V = IR$.
If we take a 9volt battery and connect it to a 90Ω resistor, what is the current through it?

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$V = IR \rightarrow I = \frac{V}{R} \rightarrow I = \frac{9}{90} \rightarrow 0.1 = \frac{9}{90}$ 0.1 Amps, or 100 milliamps.

Power

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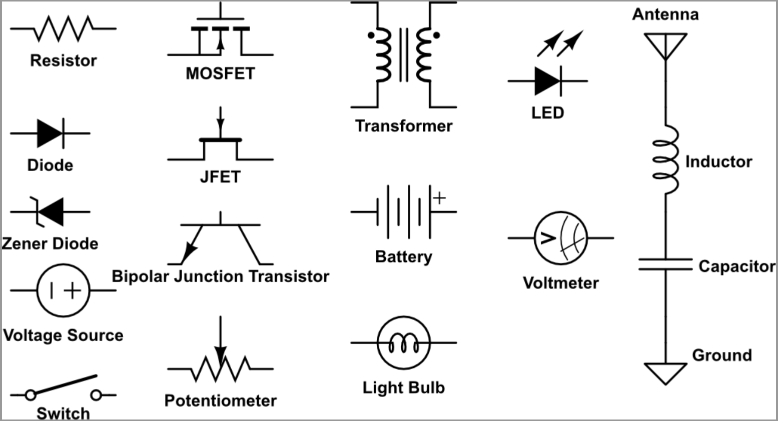
Electrical Components



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The Capacitor

Capacitors store energy in an electrostatic field. They are made of two conducting plates separated by an insulated material. electrons build up on one plate when charged. They pass AC fairly well, but can block DC. They are represented as two parallel lines, one may be curved. There are three types, a normal type that can be reversed, an electrolytic type that is polarized (they have a + or a - to note which way the go), and variable ones with an arrow through them.

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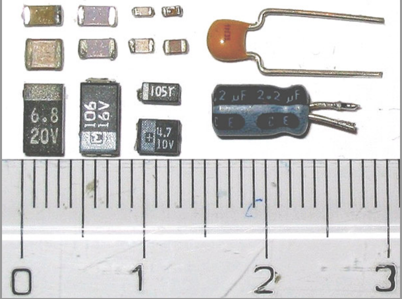


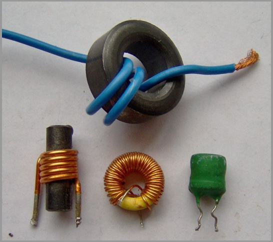
Warning

Capacitors can store a charge for some time. They can shock with ease, at best it will hurt, at worst it can cause burns and even stop your heart.

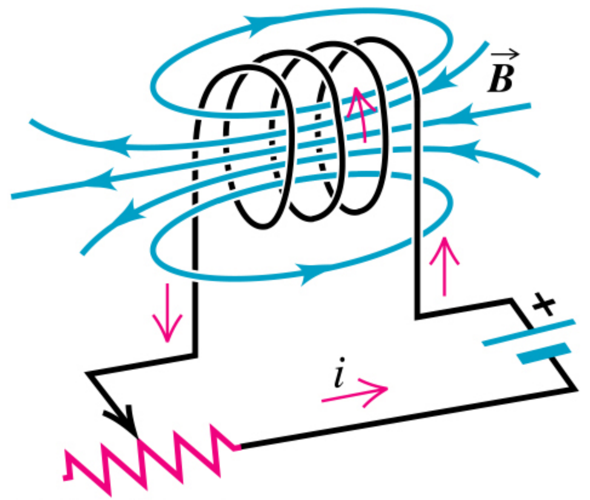
The Inductor

Inductors pass current in DC circuits, and impedes AC. They store energy in a magnetic field, magnetic fields require energy to change. This means that **any** change in current. The unit of inductance is the Henry.

They are made by winding wire in a coil. The more winds the more inductance. Sometimes iron is inserted in the middle to increase the inductance.



More Inductance

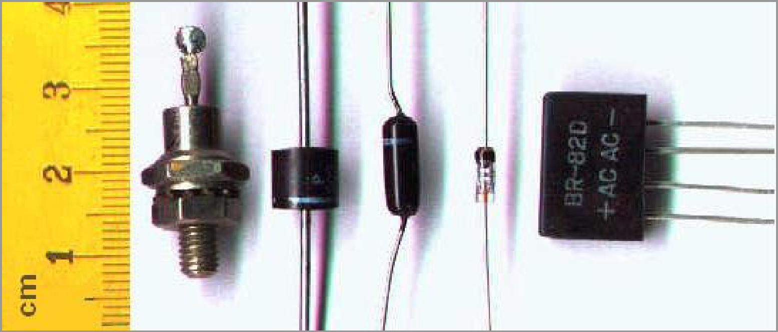


Relays

An inductor next to a magnetic switch creates a relay. They can be used to separate high current, or voltage circuits from low ones.

Diodes

Diodes prevent current from moving in one direction, while doing not much to current in the other. Some of them give off light. Others known as Zener diodes will let current flow against them if the voltage is high enough.



Transistors

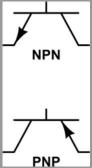
Transistors allow a small current to control a much larger one. This gives transistors "gain". Two types we care about are Bi-polar Junction (BJT), and Field Effect (FET).

BJT's

Technician and General Class Amateur Radio & Satellite Stuff

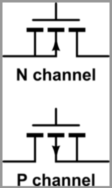
Anthony Odenthal, KE7OSN
Amateur Extra

Bipolar Junction Transistors come in two types, NPN and PNP. Both have three connections, an emitter, a collector, and a base. In diagrams the emitter is the wire with an arrow, the collector is on the same "side" as the emitter, and the base goes out the other way, if you turn it so it would stand on the two legs the base is the top. With an NPN current is allowed to flow from the collector to the emitter when there is enough voltage between the emitter and the base. in NPN's the arrow **N**ever **P**oints i**N**.
PNP's allow current to flow from the emitter to the collector when there is enough voltage between the emitter and the base. For PNP's the arrow **P**oints i**N** **P**ermanently



MOSFET's

Metal Oxide Semiconductor Field Effect Transistors work much like BJT's but they are a little different. In the diagrams if the arrow points out they are P-channel, and if it points i**N** its an N-channel. The three wires are a Gate, a Drain, and a Source. The wire with the arrow is the source, the drain is on the same side as the source, and the other one is the gate. In either case if there is a large enough voltage between the source and the gate current can flow in the direction of the arrow between the source and the drain.



Batteries

Similar to capacitors batteries store electrical energy, however they store that energy via chemical reaction instead of an electric field. There are many different types of batteries. They fall into two categories; Primary, that can produce current as soon as they are made, and Secondary, that have to be charged first. There are also Dry cells and Wet cells. Common batteries are Alkaline, Li-Ion, NiCad, NiMH,ZiC, Lead-Acid. Each type has different properties, advantages and disadvantages.

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- **T5C04 (C) What is the basic unit of inductance?**
  C. The henry
- **T5C05 (A) What is the unit of frequency?**
  A. Hertz
- **T5C06 (C) What is the abbreviation that refers to radio frequency signals of all types?**
  C. RF

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- **T5C01 (D) What is the ability to store energy in an electric field called?**
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  A. 138 watts

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  A. 138 watts
- **T5C10 (B) How much power is being used in a circuit when the applied voltage is 12 volts DC and the current is 2.5 amperes?**
  B. 30 watts

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- **T5C01 (D) What is the ability to store energy in an electric field called?**
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  A. Hertz
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  C. RF
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  A. 138 watts
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  B. 30 watts
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  B. 10 amperes

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- **T5D01 (B) What formula is used to calculate current in a circuit?**
  B. Current (I) equals voltage (E) divided by resistance (R)

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- **T5D01 (B) What formula is used to calculate current in a circuit?**
  B. Current (I) equals voltage (E) divided by resistance (R)
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  A. Voltage (E) equals current (I) multiplied by resistance (R)

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- **T5D01 (B) What formula is used to calculate current in a circuit?**
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  B. Resistance (R) equals voltage (E) divided by current (I)

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  B. Resistance (R) equals voltage (E) divided by current (I)
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  B. 30 ohms

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- **T5D04 (B) What is the resistance of a circuit in which a current of 3 amperes flows through a resistor connected to 90 volts?**
  B. 30 ohms
- **T5D05 (C) What is the resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?**
  C. 8 ohms

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- **T5D01 (B) What formula is used to calculate current in a circuit?**
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  B. 30 ohms
- **T5D05 (C) What is the resistance in a circuit for which the applied voltage is 12 volts and the current flow is 1.5 amperes?**
  C. 8 ohms
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  A. 3 ohms

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- **T5D01 (B) What formula is used to calculate current in a circuit?**
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  B. 30 ohms
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  C. 8 ohms
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  A. 3 ohms
- **T5D07 (D) What is the current flow in a circuit with an applied voltage of 120 volts and a resistance of 80 ohms?**
  D. 1.5 amperes

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  A. 3 ohms
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  D. 1.5 amperes
- **T5D08 (C) What is the current flowing through a 100-ohm resistor connected across 200 volts?**
  C. 2 amperes

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- **T5D01 (B) What formula is used to calculate current in a circuit?**
  B. Current (I) equals voltage (E) divided by resistance (R)
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  A. 3 ohms
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  D. 1.5 amperes
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  A. 1 volt

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- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
  D. Transistors

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- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
  D. Transistors
- **T6B02 (C) What electronic component allows current to flow in only one direction?**
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- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
  D. Transistors
- **T6B02 (C) What electronic component allows current to flow in only one direction?**
  C. Diode
- **T6B03 (C) Which of these components can be used as an electronic switch or amplifier?**
  C. Transistor
- **T6B04 (B) Which of these components is made of three layers of semiconductor material?**
  B. Bipolar junction transistor
- **T6B05 (A) Which of the following electronic components can amplify signals?**
  A. Transistor
- **T6B06 (B) How is a semiconductor diode s cathode lead usually identified?**
  B. With a stripe
- **T6B07 (B) What does the abbreviation "LED" stand for?**
  B. Light Emitting Diode
- **T6B08 (A) What does the abbreviation "FET" stand for?**
  A. Field Effect Transistor

T6B Questions

- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
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- **T6B08 (A) What does the abbreviation "FET" stand for?**
  A. Field Effect Transistor
- **T6B09 (C) What are the names of the two electrodes of a diode?**
  C. Anode and cathode

T6B Questions

- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
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  C. Anode and cathode
- **T6B10 (A) Which semiconductor component has an emitter electrode?**
  A. Bipolar transistor

T6B Questions

- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
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  A. Bipolar transistor
- **T6B11 (B) Which semiconductor component has a gate electrode?**
  B. Field effect transistor

T6B Questions

- **T6B01 (D) What class of electronic components is capable of using a voltage or current signal to control current flow?**
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- **T6B10 (A) Which semiconductor component has an emitter electrode?**
  A. Bipolar transistor
- **T6B11 (B) Which semiconductor component has a gate electrode?**
  B. Field effect transistor
- **T6B12 (A) What is the term that describes a transistor's ability to amplify a signal?**
  A. Gain

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
  A. Resistor

T6A Questions

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  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
  A. Resistor
- **T6C03 (B) What is component 2 in figure T1?**
  B. Transistor

T6A Questions

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- **T6C03 (B) What is component 2 in figure T1?**
  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp

T6A Questions

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  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery

T6A Questions

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  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor

T6A Questions

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  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
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- **T6C03 (B) What is component 2 in figure T1?**
  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode
- **T6C08 (C) What is component 9 in figure T2?**
  C. Variable resistor

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
  A. Resistor
- **T6C03 (B) What is component 2 in figure T1?**
  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode
- **T6C08 (C) What is component 9 in figure T2?**
  C. Variable resistor
- **T6C09 (D) What is component 4 in figure T2?**
  D. Transformer

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
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  B. Transistor
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  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode
- **T6C08 (C) What is component 9 in figure T2?**
  C. Variable resistor
- **T6C09 (D) What is component 4 in figure T2?**
  D. Transformer
- **T6C10 (D) What is component 3 in figure T3?**
  D. Variable inductor

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
  A. Resistor
- **T6C03 (B) What is component 2 in figure T1?**
  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode
- **T6C08 (C) What is component 9 in figure T2?**
  C. Variable resistor
- **T6C09 (D) What is component 4 in figure T2?**
  D. Transformer
- **T6C10 (D) What is component 3 in figure T3?**
  D. Variable inductor
- **T6C11 (A) What is component 4 in figure T3?**
  A. Antenna

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
  A. Resistor
- **T6C03 (B) What is component 2 in figure T1?**
  B. Transistor
- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode
- **T6C08 (C) What is component 9 in figure T2?**
  C. Variable resistor
- **T6C09 (D) What is component 4 in figure T2?**
  D. Transformer
- **T6C10 (D) What is component 3 in figure T3?**
  D. Variable inductor
- **T6C11 (A) What is component 4 in figure T3?**
  A. Antenna
- **T6C12 (A) What do the symbols on an electrical circuit schematic diagram represent?**
  A. Electrical components

T6A Questions

- **T6C01 (C) What is the name for standardized representations of components in an electrical wiring diagram?**
  C. Schematic symbols
- **T6C02 (A) What is component 1 in figure T1?**
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- **T6C04 (C) What is component 3 in figure T1?**
  C. Lamp
- **T6C05 (C) What is component 4 in figure T1?**
  C. Battery
- **T6C06 (B) What is component 6 in figure T2?**
  B. Capacitor
- **T6C07 (D) What is component 8 in figure T2?**
  D. Light emitting diode
- **T6C08 (C) What is component 9 in figure T2?**
  C. Variable resistor
- **T6C09 (D) What is component 4 in figure T2?**
  D. Transformer
- **T6C10 (D) What is component 3 in figure T3?**
  D. Variable inductor
- **T6C11 (A) What is component 4 in figure T3?**
  A. Antenna
- **T6C12 (A) What do the symbols on an electrical circuit schematic diagram represent?**
  A. Electrical components
- **T6C13 (C) Which of the following is accurately represented in electrical circuit schematic diagrams?**
  C. The way components are interconnected

T6A Questions

- **T6D01 (B) Which of the following devices or circuits changes an alternating current into a varying direct current signal?**
  B. Rectifier
- **T6D02 (A) What best describes a relay?**
  A. A switch controlled by an electromagnet
- **T6D03 (A) What type of switch is represented by item 3 in figure T2?**
  A. Single-pole single-throw
- **T6D04 (C) Which of the following can be used to display signal strength on a numeric scale?**
  C. Meter
- **T6D05 (A) What type of circuit controls the amount of voltage from a power supply?**
  A. Regulator
- **T6D06 (B) What component is commonly used to change 120V AC house current to a lower AC voltage for other uses?**
  B. Transformer
- **T6D07 (A) Which of the following is commonly used as a visual indicator?**
  A. LED
- **T6D08 (D) Which of the following is used together with an inductor to make a tuned circuit?**
  D. Capacitor
- **T6D09 (C) What is the name of a device that combines several semiconductors and other components into one package?**
  C. Integrated circuit
- **T6D10 (C) What is the function of component 2 in Figure T1?**
  C. Control the flow of current
- **T6D11 (B) Which of the following is a common use of coaxial cable?**
  B. Carry RF signals between a radio and antenna

Graphics

Graphics for 2010 Technician Question Pool – Exam Element 2 Effective July 1, 2010

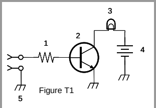

Figure T1

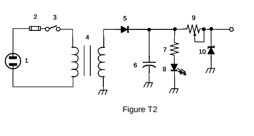

Figure T2

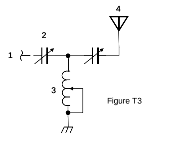

Figure T3

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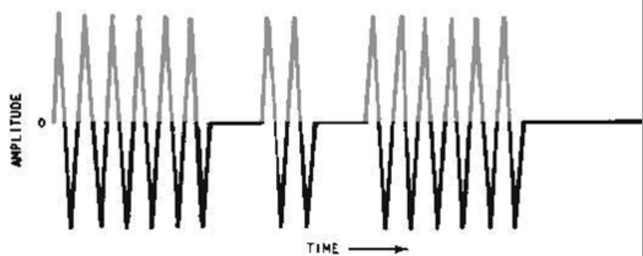
Modulation

In radio we use different methods for "encoding" information on electromagnetic waves. All methods take advantage of some of the really cool parts of waves and trig.
Yes that math is good for something!

CW

Continuous Wave or CW communicates information by turning a signal on and off. If two parties agree on what different pasterns of On's and Off's mean then they can share information. The most common system is International Morse Code.

CW picture

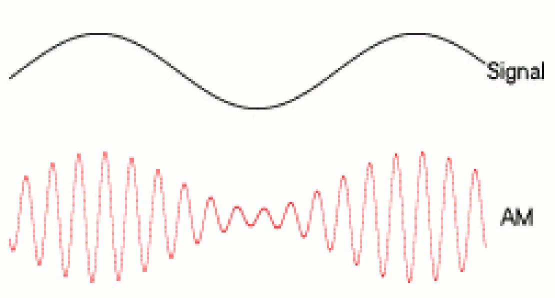


(C) RESULTANT CARRIER WAVE TRANSMITTED ALONG CONNECTING PATH.

AM

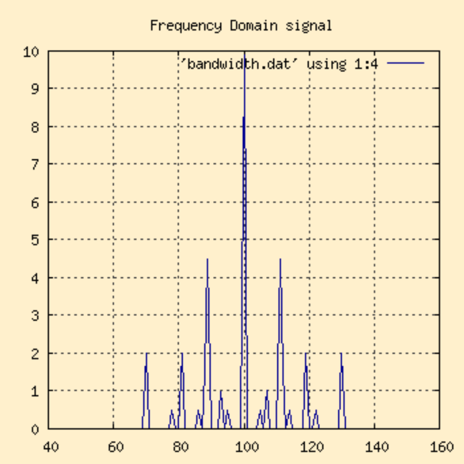
Amplitude Modulation or AM, works by keeping the frequency of a signal steady and varying the amplitude or intensity of the wave. For sounds, we simply add the sound wave to the radio wave. There are commercial AM stations, generally in lower frequencies bands. AM waves can be subject to many different forms of interference. Next to CW, AM makes for the simplest transmitters and receivers.

AM picture



SSB

AM is really easy but isn't very efficient. The image to the right shows the power of an AM wave. The center spike is the Carrier, and holds no useful information. The smaller peaks on either side are mirrored across the carrier. If we remove everything but on of the sides we can more efficiently use power and bandwidth. This is called Single Side band



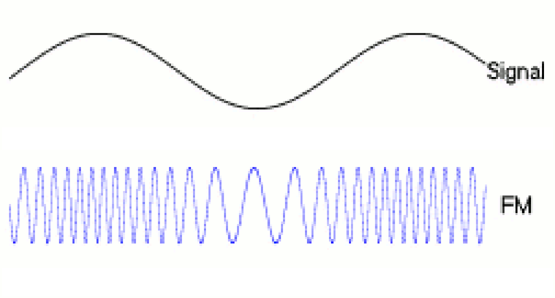
SSB Continued

From the graph we can see there are two different sidebands, one on either side of the carrier. The one that is higher in frequency is the "Upper" Sideband and the lower one is the "Lower" Sideband. For historical reasons we Upper Sideband (USB) on frequencies higher than 10MHz, and Lower Sideband on frequencies lower than 10MHz. There are also times when we use Vestigial Sideband, that is one and a part sidebands, namely for sending images.

FM

FM or frequency modulation works by varying the frequency of the signal to encode information. FM takes the most bandwidth in that you have clear enough room on either side of the center frequency to allow for a fully modulated signal.

FM Picture



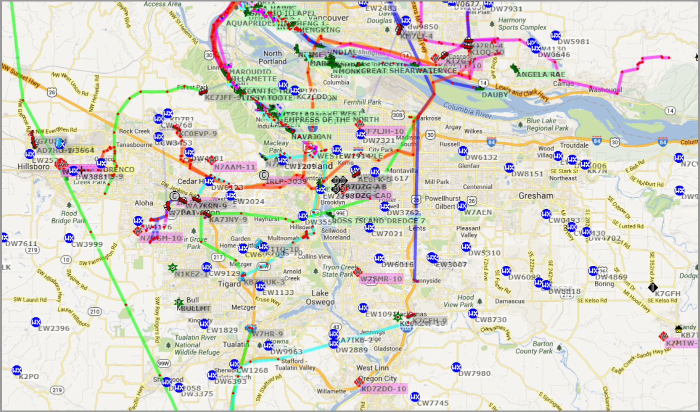
Phase Modulation

Related to FM is Phase Modulation. Instead of changing the frequency, we adjust the phase of a signal. The same cirucits that process FM can handle PM.

AFSK, Packett, etc.

We can add layers on top of these simple modulation systems to encode information. AFSK Audio Frequency Shift Keying, is a digital mode that encodes 0's and 1's as audio tones that can be sent using one of the modulations. Packet radio is a particular protocol for sending information, generally using AFSK. APRS is a way of formatting data send via packet to report the position and other information that can show up on a map.

APRS


Vancouver
North Portland
Columbia River
Hillsboro
Aloha
Gresham
Troutdale
Camas
Washougal
Tigard
Lake Oswego
Tualatin
West Linn
Oregon City

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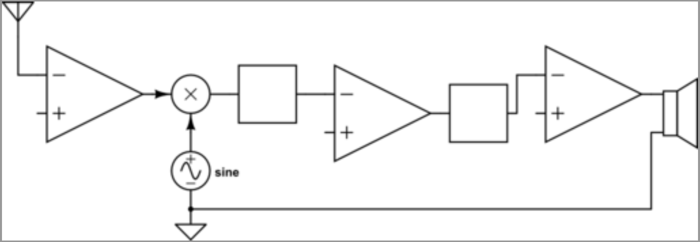
De-Modulation

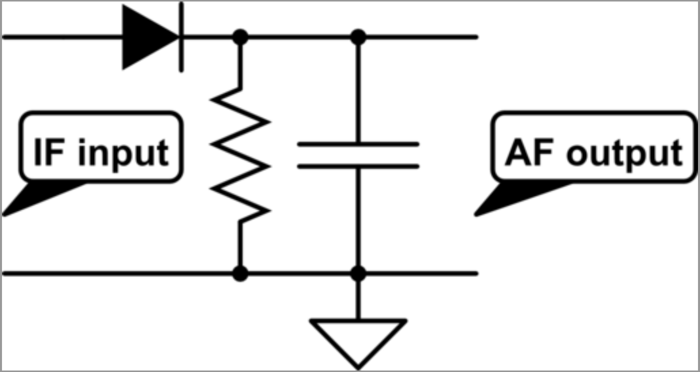
De-Modulation is the process of extracting information from a radio wave. All receivers are built from the same basic components. The antenna feeds an RF amplifier, A mixer and local-oscillator steps the frequency down to something easier to process, an intermediate frequency (IF). An IF amplifier feeds the de-modulation stage which then into an audio amplifier and out to a speaker.
It is important to remember that these devices are made of circuits built from the components from the previous section.

Simple Radio



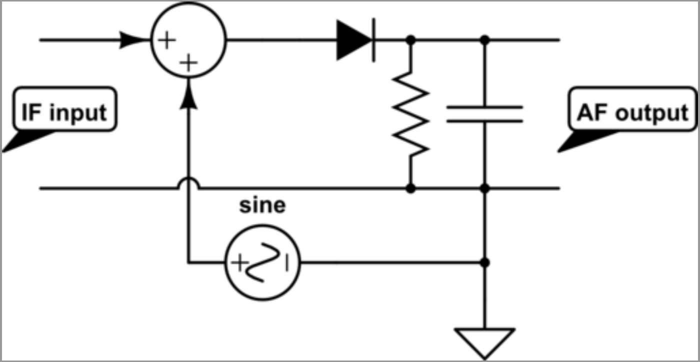
The detector

The AM demodulation device is called a Detector. Essentially it removes the carrier from the signal and leaves only the information, which for the most part is audio.



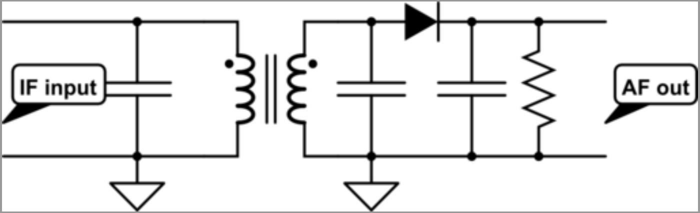
SSB

As a SSB signal is just an AM signal without the carrier, it is simple enough to replace it and use the same Detector. An extra component called a Beat Frequency Oscillator is used to replace the carrier that is removed from when transmitting.



FM

By far the most complex demodulation circuit is the discriminator used with FM signals. For the purpose of the test you only need to know the type of circuit, not how to build one.



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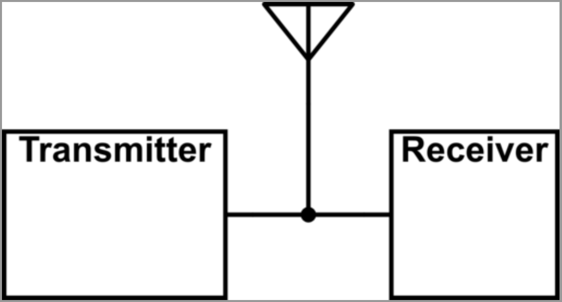
Modulation and De-modulation together

For the sake of space it is worth while to combine a transmitter and receiver.

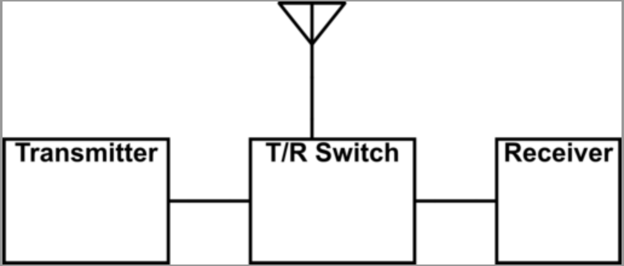
Basic

The simple looking idea is to just hook both a receiver and transmitter to the same antenna, like so.



Real

The problem with the simple setup is that the energy from the transmitter goes right into the receiver. Remember all those amplifiers in the receiver, they will amplify the very strong signal and then the magic smoke that makes everything work will get out. So . . .



TR Switch

The Transmit Receive switch very quickly disconnects either the transmitter or the receiver so that the reliever doesn't blow up.

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Repeaters

A repeater is just a radio that transmits what it hears. They are generally placed on high places where they can see large areas. They use a technique called Duplex, where it simultaneously receives and transmits on different frequencies. Radios automatically switch between the "input" and "output" frequencies so you don't have to. We often refer to repeaters by their output frequency, and sometimes by their callsign.

Offset

The difference between the input, the frequency the repeater listens to, and the output, the frequency the repeater transmits on, is called the offset. The standard offset is part of the band plan. The direction of the offset is also part of the band plan.

2m	600 KHz
1.25m	1.5MHz
70cm	5MHz

Offset Examples

A couple of sample offsets on 2 meters are.
147.16MHz uses a standard positive offset, has an input of 147.76MHz.
146.78MHz again with a standard but negative offset has an input of 146.18MHz.
It can be difficult to remember if one part of a band is positive or negative so we often write frequency as 147.16+ or 146.78-

Tones

Because there is a limited number of locations that are good to place repeaters lots of them end up at the same place. If we don't do anything one can easily cause another to activate. To prevent this we use special signals to make sure we only activate, these are referred to as sub-audible tones.
There are two types, CTCSS Continuous Tone Coded Squelch System, and DCS Digital Coded Squelch.

Repeater Directory

How does one find out information like offset, and tone, and other useful information about a repeater?
The ARRL publishes a book called the Repeater Directory.

Duplexers

Unlike normal radios that don't need to transmit and receive at the same time and can use a switch repeaters inherently have to do both at the same time. The solution is called a duplexer. Duplexers are very selective filters that allow only the transmit frequency between the transmitter and antenna, and only the receive frequency between the antenna and the receiver.

Repeater Picture

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Satellite Duplexing

Remember those large duplexer cans from a repeater that allow transmission and reception on the same band. Well there isn't much extra space on satellites, especially small ones for them. So how do we have satellite repeaters? Simple we separate the transmit and receive frequencies by large margins. The greater the offset the smaller the duplexer can be, when the separation is large enough the device becomes what is known as a diplexer. A diplexer uses simple low-pass and high-pass filters to separate signals from two different bands. More practically they feed different antennas.

Satellite Duplexing

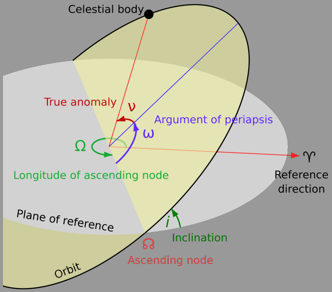
The convention for describing which bands a satellite operates on uses one or two letters. If there is one letter then the satellite only beacons on that band, if there are two letters the satellite receives on the first letter and transmits on the second. Band letters are H for HF, V for VHF, U for UHF, L for L-band, K for K-band. Most satellites use mode V/U, meaning they listen on VHF (2-meters) and transmit on UHF (70-cm).

Doppler Shift

Satellites are moving really, really fast, on a few to tens of miles per second. At this speed as they move overhead we have to contend with the Doppler shift, the apparent change in frequency of a wave of emitted by a moving object. As the satellite aproaches the frequency increases, and as it moves away the frequency decreases. This is just like a passing car. The hard part with satellites is the shift you see, is the same shift it sees from you, meaning while you have to tune "up" to hear it when listening, you have to tune "down" so it can hear you.

Satellite Tracking

In order to keep track of where satellites are we use specially formatted numbers called orbital elements. These describe certain aspects of the where a satellite is at. Given these numbers, your location, and the time you can calculate exactly where a satellite is at.



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Its a digital World

There are many digital modes out there, some encode digital data into digital signals.
Some encode analog signals into digital signals.

Baud

In the digital world there are two important rates.
The first is the Baud rate or number of symbols sent per second. In this case a symbol can be a particular tone, or even a change in phase or amplitude.
The second is the bit rate, to calculate the bit rate you take the number of bits per symbol and multiply it by the baud rate.
Often the bit rate and baud rate are the same, but not always. Some techniques such as Phase Shift Keying can support many bits per symbol.

Digital Voice

There are several digital modes that allow analog voice to be sent using digital signals. These are APCO Project 25 (p25), D-STAR, and AOR ARD9800. These all work similarly to cellphones and VoIP.

RTTY

RTTY - Radio TeleTYpe, is the original digital mode. It is slow 50 to 300 baud, or bits per second, that is a single text message in 4-25 seconds. It uses Frequency Shift Keying (FSK) and transmits two tones one for a "high" or 1, and a different one for a "low" or 0. RTTY machines have long been used by military and diplomatic posts, using encryption methods RTTY allows for slow, but reliable communications.

Packet

Packet radio uses AFSK generally sent using FM on VHF and above, and SSB on HF. In packet the baud rate is the bit rate. On HF speeds of a whopping 300 baud, and on VHF and up speeds range from the common 1200 baud and the extreme 9600 baud. This translates into 1.2-9.6Kbps, or about 0.5-4.3 MegaBytes per hour, or one seventy-fifth the speed required to stream netflix on the lowest quality setting.

Packet modems

To use things like packet you need something to MODulate, and to DEModulate signals. Put them together and we get a modem. Many devices add features for controlling things like.

- Mailbox(es)
- BBS
- DigiPeaters
- Addressing
- Error correction

Together we call this a Terminal Node Controller or TNC.

Packet Networks

Packet networks are configured much like how the internet works, just much smaller. "Users" connect to nodes, these nodes can connect to each other. If there are enough nodes lined up, messages can move over great distances. At times it is possible for messages to move across the country and even the world entirely by bouncing from radio to radio.

The Internet

There are message handling systems that combine the scale and speed of the internet and the robustness of radio. One such system is Winlink 2000 (yes people still use things like 2000 in names). Nodes in the system decide try to move messages through the internet, and if not over radio, special servers track messages to ensure they get delivered to the appropriate user.

APRS

The Automatic Position Reporting System APRS (pronounced A-pers) encodes position data in standard packet formats. Other information such as weather, messages, even icons. The system has "Igates" or internet gateways that pass information to internet servers. findu.com and aprs.fi

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Linked Repeaters

Some repeaters are linked using radios, one such system is the Peak Radio Association system. This network allows users all over the state and parts of Washington and California to speak to each other. It does take a second or two for all the links to activate.

IRLP and EchoLink

The Internet Repeater Linking Project or IRLP connects repeaters using the internet, audio from one repeater are sent to others. Echolink allows users to connect radios, computers, phones, tablets, etcto their network. The result is similar to IRLP though you don't have to have a radio to use echolink.

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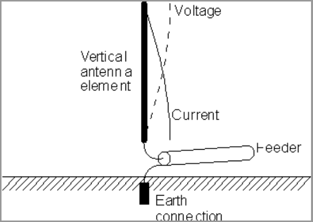
Antennas

Any radio amateur will tell you that while a million watts is cool, at the end of the day its the antenna that does the real work. Antennas take radio signals in the form of electrons moving in wires and converts that signal into electromagnetic waves, and back. Improperly antenna configurations can even damage your radio! A 5 watt radio with a great antenna can get a lot more work done than 1000 watt radio with a poor antenna.

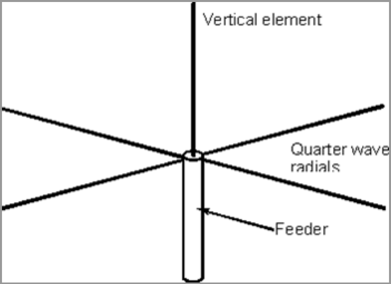
Quarter Wave Vertical

Probably the simplest antenna to look at is the 1/4 vertical. It is made of two parts, a vertical section of wire that is 1/4 the wavelength long, and ground. The wavelength is that of the wave in the wire, which is not the same as in free space. Fortunately the math has already been done for us, over and over and the equation is: $L\,(ft) = \frac{234}{F(MHz)}$



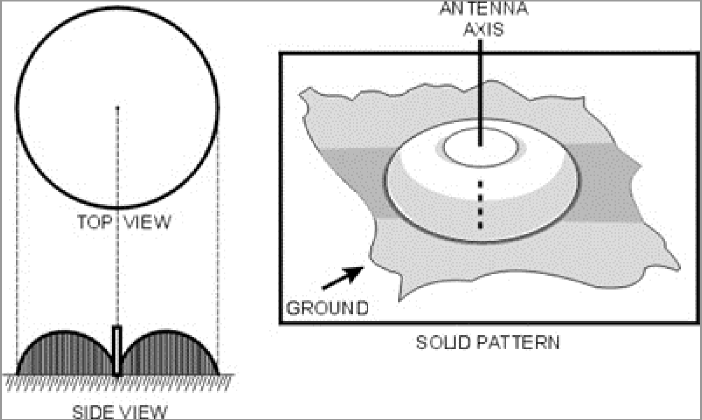
Grounding

The problem with this is that the antenna needs to be close to ground, but we want antennas to be really high up so they can "see" further.
The solution is to create a "fake" ground that can elevated with the vertical section.



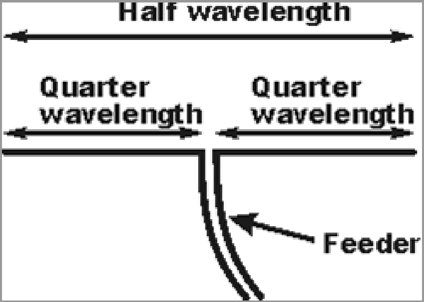
Vertical Radiation Patern

The vertical radiates well in all horizontal directions, but doesn't do very well up or down.



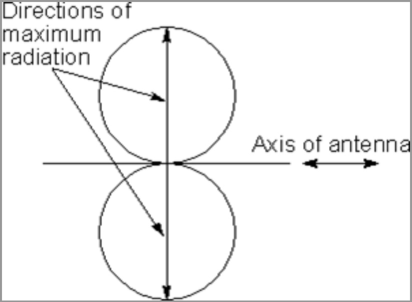
1/2 Wave Dipole

Another common antenna is the 1/2 wave dipole. This is made by placing two 1/4 wave wires in lines and feeding them in the middle. This uses one of the wires as the "ground". The total length is twice that found for the 1/4 vertical.



Dipole Radiation patern

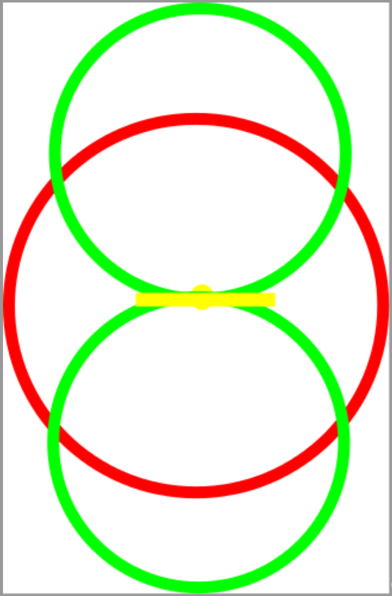
The dipole radiates well perpendicular to the length of the wire. A dipole running north-south will radiate east-west.



Gain

The yellow dot and line are the antennas. The red circle is the radiation pattern of the vertical, and the green circles are the pattern for the dipole. The distance from the center indicates the strength.

Notice how the dipole is better in two directions but worse the other two. The apparent increase in signal strength when the dipole is "pointed" in the right direction is called Gain.

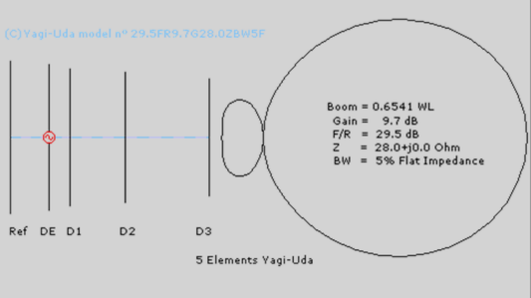


dB's

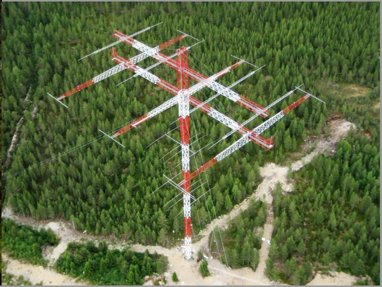
We generally measure Gain in terms of decibels, dB. This is a ratio measurement, meaning it compares two things. We often will compare antennas to an "isotropic" antenna or a perfect 1/2 wave dipole, dBi and dBd. If an antenna claims some gain without saying what it is compared to ASK!. for POWER the equation is $dB = 10 \log \frac{P}{P_0}$ and for voltage its $dB = 20 \log \frac{V}{V_0}$ where P and V are your apparent signal and P_0 and V_0 are the starting points.
A good rule to remember is that a change of 3dB in power is a change of a factor of 2 for power, and a change of 6dB is a factor of 2 for voltage. We almost always talk in terms of power.

The Yagi-Uda

If we add another length of wire behind the dipole to reflect incoming signals into the antenna, and more in front to direct signals we get a Yagi-Uda, or Yagi.



Giant Antennas



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Technician and General Class Amateur Radio & Satellite Stuff

Anthony Odenthal, KE7OSN Amateur Extra

Feed Me!

Antennas need a connection to the radio. We call this connection "feedline". It has one job, carry the signal between the radio and antenna as efficiently as possible.

Wave Guide

One type of feedline is the waveguide, which is really just a hollow tube in which a signal bounces off the walls as it moves from end to end. Fiber optic cables are an example of a waveguide for light. In the waveguide the signal moves as a radio wave. The size of the guide depends on the wavelength of the wave, they are almost never used below UHF as they get really really big.

Coax

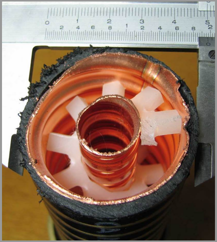
By far the most common feedline in use is Coaxial Cable. They are made of a center wire surrounded by an insulator, which is in turn surrounded by a metal shield and another outer insulator. More layers of shields and insulators can be added as needed. The term Coaxial refers to the fact that all the components share a common axis.

More Coax

Coax has several advantages over other feedlines. It is generally flexible and the metal shield and outer insulator allows it to go almost anywhere, even underground. However it is important to watch out for kinks, damage to the insulation and water.
Once water gets into the cable it is done for, it corrodes the metal components, and changes the properties of the cable.

Hardline

One type of coax is called hardline, it is not flexible. It is very low loss, can be pressurized to keep water out, and is less affected by water in the first place.
However it is hard to work with, it requires special equipment, its is heavy and very expensive.



Losses

Attenuation of coaxial cable at various frequencies
dB/ 100 ft (dB/ 100 m)

Cable Type	144 MHz	220 MHz	450 MHz	915 MHz	1.2 GHz	2.4 GHz	5.8 GHz
RG-58	6.2 (20.3)	7.4 (24.3)	10.6 (34.8)	16.5 (54.1)	21.1 (69.2)	32.2 (105.6)	51.6 (169.2)
RG-8X	4.7 (15.4)	6.0 (19.7)	8.6 (28.2)	12.8 (42.0)	15.9 (52.8)	23.1 (75.8)	40.9 (134.2)
LMR-240	3.0 (9.8)	3.7 (12.1)	5.3 (17.4)	7.6 (24.9)	9.2 (30.2)	12.9 (42.3)	20.4 (66.9)
RG-213/214	2.8 (9.2)	3.5 (11.5)	5.2 (17.1)	8.0 (26.2)	10.1 (33.1)	15.2 (49.9)	28.6 (93.8)
9913	1.6 (5.2)	1.9 (6.2)	2.8 (9.2)	4.2 (13.8)	5.2 (17.1)	7.7 (25.3)	13.8 (45.3)
LMR-400	1.5 (4.9)	1.8 (5.9)	2.7 (8.9)	3.9 (12.8)	4.8 (15.7)	6.8 (22.3)	10.8 (35.4)
CNT-400 (C2FP)	1.5 (5.0)	1.9 (6.0)	2.7 (8.8)	3.9 (12.7)	4.94 (16.2)	6.7 (22)	12.2 (40.2)
3/8" LDF	1.3 (4.3)	1.6 (5.2)	2.3 (7.5)	3.4 (11.2)	4.2 (13.8)	5.9 (19.4)	8.1 (26.6)
LMR-600	0.96 (3.1)	1.2 (3.9)	1.7 (5.6)	2.5 (8.2)	3.1 (10.2)	4.4 (14.4)	7.3 (23.9)
1/2" LDF	0.85 (2.8)	1.1 (3.6)	1.5 (4.9)	2.2 (7.2)	2.7 (8.9)	3.9 (12.8)	6.6 (21.6)
7/8" LDF	0.46 (1.5)	0.56 (2.1)	0.83 (2.7)	1.2 (3.9)	1.5 (4.9)	2.3 (7.5)	3.8 (12.5)
1 1/4" LDF	0.34 (1.1)	0.42 (1.4)	0.62 (2.0)	0.91 (3.0)	1.1 (3.6)	1.7 (5.6)	2.8 (9.2)
1 5/8" LDF	0.28 (0.92)	0.35 (1.1)	0.52 (1.7)	0.77 (2.5)	0.96 (3.1)	1.4 (4.6)	2.5 (8.2)

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Impedance

Impedance is the opposition to the flow of current in an AC circuit (e.g. RF). It is a combined measure of the ohmic resistance, capacitance, and inductance of a circuit. Antennas have an impedance, feedlines are designed to have a known impedance, and radios have input and output impedance.
Common impedance measurements in amateur radio are 50Ω and 300Ω, while TV cables are normally 75Ω

Impedance Matching

If there is a mismatch in impedance then power will reflect from the point of the mismatch. This is bad! signals from the antenna bounce back to the antenna and don't reach the radio. Even more dire strong signals from the radio don't make it to the antenna and bounce back into the radio!
The most efficient systems match impedance as closely as possible.

The SWR meter

A simple tool for checking impedance matches is the SWR meter, they simply show you the ratio of power going out to power coming back. A match of 1:1 is perfect, most things will work with a mismatch of up to 2:1, any higher and there is a real problem.

Check everything first

So a good SWR means all is good right?

Check everything first

So a good SWR means all is good right? Well not exactly...

Check everything first

So a good SWR means all is good right? Well not exactly...
Lets say you have a 50W radio and a broken antenna with really lossy cable say 10.6dB.
When it reaches the antenna and reflects back it is down to 4.3W and radio only sees 0.4W.
$SWR = \frac{F+R}{F-R} = \frac{50.4}{49.6} = 1.01 : 1$
This is a great SWR but all the power is going into the cable. The radio will be happy but you have just made your feedline a 50W heater.

SWR Problems

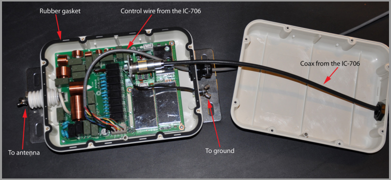
So how do you deal with SWR problems?

1. Adjust the impedance of feedline and antennas to minimize the extent of the mismatch and reduce the SWR.
2. Use an antenna tuner that doesn't fix the mismatch, but will protect the radio from reflected power by making it look like there is a match.

Antenna Tuners

Antenna tuners work by changing the apparent electrical properties of a system by adding inductance or capacitance thus are able to match the impedance between two components at a single point. The two places tuners are commonly found are right at the output of the transmitter (some radios even have built in tuners), and at the base of the antenna. Tuners at the radio protect if from reflected power, tuners at antennas maximize the power that gets radiated.

Tuner Pictures



Dummy Load

Sometimes you want to test your equipment without actually transmitting over the air. In this case you need something that has an impedance match, and will be able to safely dissipate the RF energy. Enter the Dummy load, a device made to do just that. Be sure to always check the ratings for power and duty cycle.

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The SMA or Sub Miniature is to the BNC what the N is to the 259, better performance into SHF, but lower power.

Connectors continued

259's and N's are common for "Base" or "Mobile" stations, namely in cases where you are not likely to disconnect and reconnect cables often. In "Hostile" weather environments it is not common to protect these connections from water.
BNC's and SMA's are common on handheld radios. While the spec's say they are safe up to several thousand watts it isn't advised to run more than 50-ish on either. BNC's are also prone to tarnish and this changes the properties of the connector. They do not handle outdoors well for any length of time, though a threaded version TNC is an option.

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Shock!

Electricity is the number one cause of electrocution in the US!
You may have heard that its the voltage that hurts and the current that kills. While true remember that $V = IR$ and if V goes up I probably is as well.
Less than 100mA can disrupt your heart, and it can take only 30V on your skin to reach 100mA across the heart. Besides heart problems current creates heat that can cause serious burns.

Shock Prevention

Some ways to mitigate shock danger are.

- Turn off and disconnect equipment before working on it.
- Remember to discharge capacitors.
- Don't circumvent safety features such as power interlocks.
- If you can't power down something then:
  - Use one hand, keep the other in your pocket
  - Take of rings, watches, and anything else metal
  - Remember things happen faster than you can react, one wrong move and you could be dead before you know it.

Fuses

Fuses are your friend.

Fuses are designed to open a circuit when overloaded, they burn so you and your equipment don't.

Always be sure to use the proper fuse, they are rated for voltage, current, and slow/fast burn

Fuse Picture

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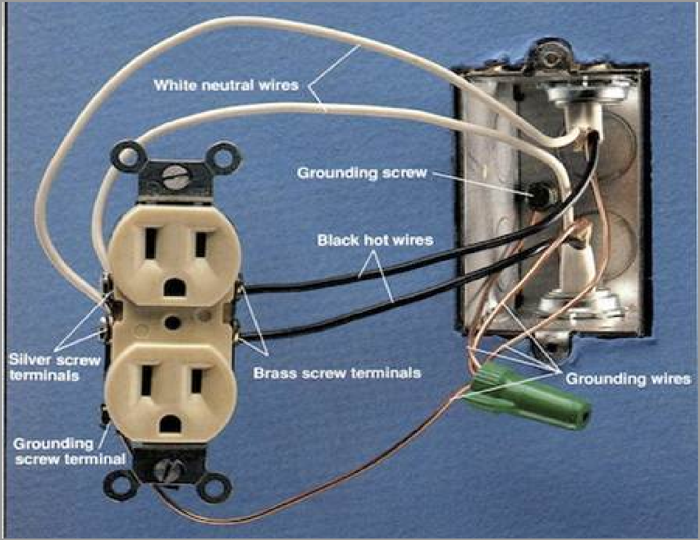
House wiring

The current standard code for electrical wiring in the US calls for 3-prong outlets. The three prongs are Hot, Common, and Ground. The hot supplies the current, the common provides a return route, and the ground acts as a safety. In the breaker box the common and ground are supposed to be bonded together.

House picture



GFCI

In some cases a Ground Fault Circuit Interrupter may be required by code. These devices open the circuit if there is a current imbalance between the hot and common lines. They look like normally outlets with two buttons on them. These provide an extra level of protection especially in locations such as outdoors or bathrooms. Though be aware that some devices may not function properly when connected to GFCI protected circuits, namely devices with their own GFCI installed.

Radio Grounding

Radio equipment should be properly grounded on its own. Large, clean conductors should be used running in straight lines, and as short as reasonably possible. Electrical supply stores will sell grounding bars that allow you to run short runs from devices to a common point and ground that point.

Towers

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Lead Acid

Lead acid batteries come in several different types, common in amateur use are Deep-cycle and sealed cells.
Typical deep-cycle batteries are rated to discharge a much larger percentage of their capacity than say a car battery. They can be charged off your car or a charger, and are relatively cheap and easy to find. However their are filled with acid that can leak if handled improperly, and can emit explosive gasses during charging.
Sealed cells are more expensive and harder to find, but are much more resistant to mishandling. However they can crack and leak if overcharged, overheated, or abused.
Both contain Lead!

Lithium

Lithium batteries are becoming much more common especially in handheld radios. While most have built in circuits to prevent damage care must be taken to prevent physical abuse. Overcharge, overheat, and a physical break in the container can release lithium which reacts violently with just about everything causing fire or even explosions.

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RF Safety

RF energy is non-ionizing radiation, meaning it isn't capable of breaking chemical bonds. However those things that absorb it convert the RF energy into heat. RF burns can be caused without direct contact with an antenna.

Body resonaces

The body is resonant between 30 and 70 MHz, the head around 400MHz. The amount of absorption depends on the exact frequency, and field strength.
Higher power and more directional antennas create higher field strengths.

Regs

The FCC regulates exposure limits on all frequencies, and amateurs are included.
There are exemptions and special rules for stations that emit less that 50W PEP, Mobile and portable, and stations with power less than those listed in the table 1 of FCC OET Bulletin 65.

RF limites

MF

- 160m 500W

HF

- 80m 500W
- 75m 500W
- 40m 500W
- 30m 425W
- 20m 225W
- 17m 125W
- 15m 100W
- 12m 75W
- 10m 50W

VHF All bands 50W

UHF

- 70cm 70W
- 33cm 150W
- 23cm 200W
- 13cm 250W

SHF all bands 250W
EHF all bands 250W
Repeaters 500W

Table 1. Power thresholds for routine evaluation of amateur radio stations, watts from FCC OET 65.

Measurements

There are two areas with limits, the Controlled area in which everyone inside the area knows about the radiator and can control the radiator. Uncontrolled areas are those areas where people are unaware or otherwise unable to mitigate their exposure.

There are three methods approved.

- Use field strenght equipment to measure the exposure.
- Use antenna modeling software to predict field strengths.
- Use the tables in OET Bulletin 65

The last one is the easiest and most often used.

RF mitigation

There are several ways to mitigate exposure to RF radiation: Move the antenna, decrease antenna gain, lower power output, and change the orientation of the antenna.

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Tower Safety

Whenever you do anything with a tower LOOK UP! Every year people are killed by not looking for power lines.
Always use safety gear! Falling from a tower is bad, getting hit by something/someone falling from a tower is also bad.
Always plan ahead, place towers such that if they fall they and everything on them will miss power lines. 10ft is the rule.
Use special equipment to help

That's it

Questions?