Basic Amateur Radio Course

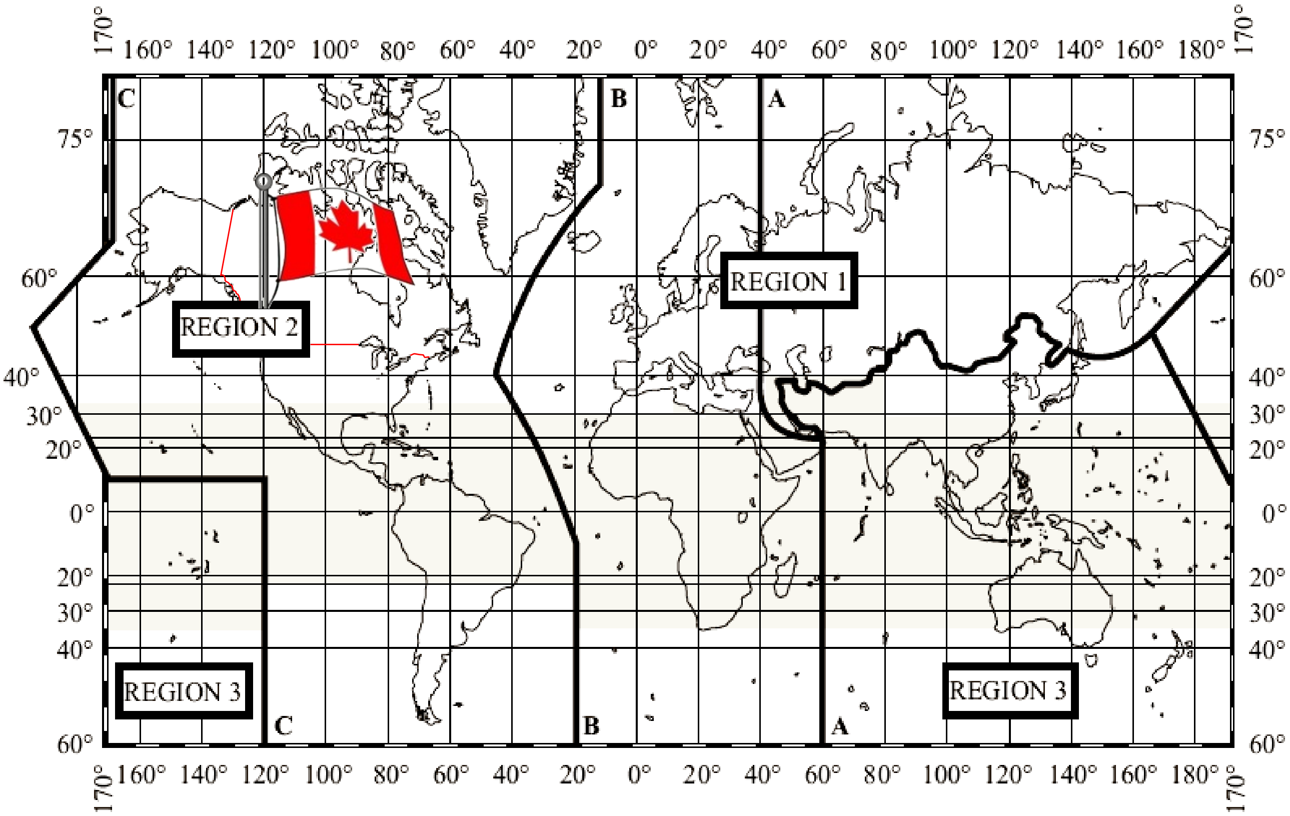
Toronto Emergency Communication (EmComm) Group

http://www.emergencyradio.ca/course/

July 23, 2009

Regulations & Policies

Lesson One



Regulations & Policies

Lesson One

1-1) Radio Licences, Applicability, Eligibility of Licence Holder

•Authority to make "Radiocommunication Regulations" is derived from **the Radiocommunication Act**

•Authority to make "Standards for the Operation of Radio Stations in the Amateur Radio Service" is derived from **the Radiocommunication Act**

•The Department that is responsible for the administration of the Radiocommunication Act **is Industry Canada**

•The "amateur radio service" is defined in **the Radiocommunication Regulations**

RAC

Industry Canada Industrie Canada

Canada

Regulations & Policies

Lesson One

1-2) Licence Fee, Term, Posting Requirements, Change of Address

- The Amateur Radio Operator Certificate should be retained **at the address notified to Industry Canada**
- Whenever a change of address is made **Industry Canada must be advised of any change in postal address**
- An Amateur Radio Operator Certificate is **valid for life**
- The fee for an Amateur Radio Operator Certificate is **free**
- The holder of a radio authorization shall, at the request of a duly appointed radio inspector, show the radio authorization, or a copy thereof, to the inspector, within **48 hours** after the request
- Out of amateur band transmissions are prohibited - **penalties could be assessed to the control operator**

Regulations & Policies

Lesson One

1-2) Licence Fee, Term, Posting Requirements, Change of Address

Industry Canada / Industrie Canada

CERTIFICATE OF PROFICIENCY IN AMATEUR RADIO / CERTIFICAT DE COMPÉTENCE EN RADIO AMATEUR

Certificate Holder – Titulaire du certificat

Patrick Stoddard

Qualifications – Compétences

Basic

Morse Code

Advanced

Call Signs – Indicatifs d'appel

VA7EWK

FOLD / PLIER

Issued by – Émis par

The certificate holder is authorized to operate amateur radio apparatus in accordance with the regulations made pursuant to the ***Radiocommunications Act.***

Le titulaire du certificat est autorisé de faire fonctionner des appareils radio amateur conformément aux règlements établis en vertu du la ***Loi sur la radiocommunication.***

Number – Numéro

[redacted]

Issue Date – Date d'émission

05 November 2003

IC 2755 (1999/12)

Canada

Industry Canada / Industrie Canada

Certificate of Proficiency in Amateur Radio

This is to certify that

Patrick Stoddard

has obtained the following qualifications:

Basic

5 W.P.M. Morse Code

The certificate holder is authorized to operate amateur radio apparatus in accordance with the regulations made pursuant to the ***Radiocommunication Act***, and to use the following call signs:

VA7EWK

Certificate Number: [redacted]

Issue date: 30 April 2002

Issued by

Canada

Regulations & Policies

Lesson One

1-3) Licence Suspension or Revocation, Powers of radio Inspectors, Offences & Punishments

- If an amateur pretends there is an emergency and transmits the word "MAYDAY," this is called **False or deceptive signals**

- A person found guilty of transmitting a false or fraudulent distress signal, or interfering with, or obstructing any radio communication, without lawful cause, may be liable, on summary conviction, to a penalty of: **a fine, not exceeding $25 000, or a prison term of one year, or both**

- The Minister may suspend or revoke a radio authorization WITHOUT NOTICE: **where the holder has failed to comply with a request to pay fees or interest due**

=

Regulations & Policies

Lesson One

1-4) Operators Certificates, Applicability, Eligibility, Equivalents, Reciprocal Recognition

- There are **no age limit** on who can hold an Amateur Radio Operator Certificate with Basic Qualification

- A **basic examination** must be passed before an Amateur Radio Operator Certificate is issued

- The holder of an Amateur Digital Radio Operator's Certificate **has equivalency for the Basic and Advanced qualifications**

- After an Amateur Radio Operator Certificate with Basic qualifications is issued, the holder may be examined for additional qualifications **in any order**

- One Morse code qualification is available for the Amateur Radio Operator Certificate. It is: **5 w.p.m**.

- The holder of an Amateur Radio Operator Certificate with Basic Qualification is authorized to operate the following stations: **a station authorized in the amateur service**

Regulations & Policies

Lesson One

1-5) Operation, Repair & Maintenance of Radio Apparatus On Behalf of Other Persons

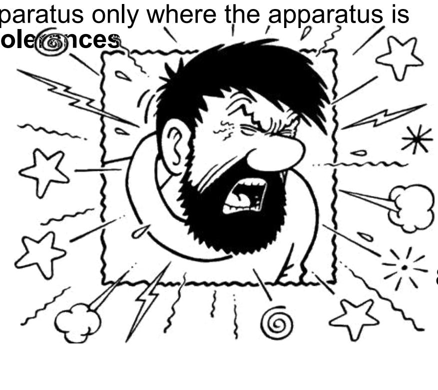
- Radio apparatus may be installed, placed in operation, repaired or maintained by the holder of an Amateur Radio Operator Certificate with Advanced Qualification on behalf of another person: **if the other person is the holder of a radio authorization to operate in the amateur radio service**
- The holder of an Amateur Radio Operator Certificate may build transmitting equipment for use in the amateur radio service provided that person has the: **Advanced qualification**
- Where a friend is not the holder of any type of radio operator certificate, you, as a holder of an Amateur Radio Operator Certificate with Basic Qualification, may, on behalf of your friend: **not install, place in operation, modify, repair, maintain, or permit the operation of the radio apparatus**
- A radio amateur with Basic and 5 w.p.m. Morse qualifications may install an amateur station for another person: **only if the other person is the holder of a valid Amateur Radio Operator Certificate**

Regulations & Policies

Lesson One

1-6) Operation of Radio Apparatus, Terms of Licence, Applicable Standards, Exempt Apparatus

- An amateur station with a maximum input to the final stage of 2 watts: **must be licensed at all locations**
- An amateur station may be used to communicate with: **similarly licensed stations**
- A radio amateur may not transmit **superfluous signals** *(su·per·flu·ous [soo-pur-floo-uhs])**
- A radio amateur may not transmit **profane or obscene language or messages**
- A radio amateur may not operate, or permit to be operated, **a radio apparatus which he knows is not performing to the Radiocommunication Regulations**
- No person shall possess or operate any device, for the purpose of amplifying the output power of **a licence-exempt radio apparatus**
- A person may operate or permit the operation of radio apparatus only where the apparatus is **maintained to the Radiocommunication Regulations tolerances**



* ***•Unnecessary or needless***
•Obsolete. possessing or spending more than enough or necessary; extravagant
•Being more than is sufficient or required; excessive.

Regulations & Policies

Lesson One

1-7) Content Restrictions – Non-Superfluous, Profanity, Secret Code, Music, Non-Commercial

- **Business planning** CANNOT be discussed on an amateur club net.
- A radio amateur is **Never** allowed to broadcast information to the general Public.
- False or deceptive amateur signals or communications may **Never** be transmitted?
- An amateur station in two-way communication may **Never** transmit a message in a secret code in order to obscure the meaning of the communication?

Regulations & Policies

Lesson One

1-8) Installation and Operating Restrictions – Number of stations, Repeaters, Home-Built, Club Stations

- The holder of an Amateur Radio Operator Certificate operate an amateur radio station **anywhere** in Canada.
- A Beacon station **Only** may transmit one-way communications.
- In order to install any radio apparatus, to be used specifically for receiving and automatically retransmitting radiotelephone communications within the same frequency band, a radio amateur must hold an Amateur Radio with a minimum of **Basic and Advanced qualifications**
- In order to install any radio apparatus, to be used specifically for an amateur radio club station, the radio amateur must hold an Amateur Radio Operator Certificate, with a minimum of the following qualifications: **Basic and Advanced**
- In order to install or operate a transmitter or RF amplifier that is not commercially manufactured for use in the amateur service, a radio amateur must hold an Amateur Operator's Certificate, with a minimum of **Basic and Advanced**

Regulations & Policies

Lesson One

1-9) Participation in Communications by Visitors, Use of Station by Others

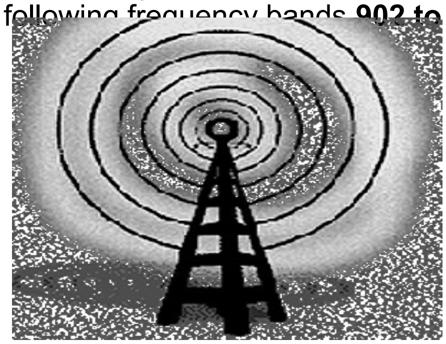
- **Both the control operator and the station licensee** is responsible for the proper operation of an amateur station
- The owner of an amateur station may: **permit any person to operate the station under the supervision and in the presence of the holder of the amateur operator certificate.**

Regulations & Policies

Lesson One

1-10) Interference, Determination, Protection from Interference

- You may **Never** deliberately interfere with another station's communications.
- If the regulations say that the amateur service is a secondary user of a requency band, and another service is a primary user, **Amateurs are allowed to use the frequency band only if they do not cause interference to primary users**
- What rule applies if two amateur stations want to use the same frequency? **Both station operators have an equal right to operate on the frequency**
- Where interference to the reception of radiocommunications is caused by the operation of an amateur station: **the Minister may require that the necessary steps for the prevention of the interference be taken by the radio amateur**
- Radio amateur operations are not protected from interference caused by another service operating in the following frequency bands **902 to 928 MHz**



Regulations & Policies

Lesson One

1-11) Emergency Communications (Real or Simulated), Communications with Non-Amateur Stations

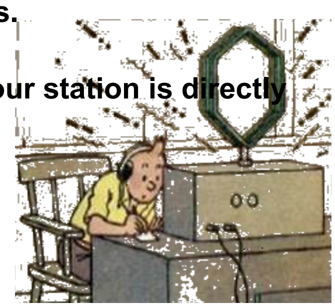
- Amateur radio stations may communicate: **with any station involved in a real or simulated emergency**
- In the amateur radio service, business communications: **are not permitted under any circumstance**
- If you hear an unanswered distress signal on a amateur band where you do not have privileges to communicate: **you should offer assistance**
- In the amateur radio service, it is permissible to broadcast: **radio communications required for the immediate safety of life of individuals or the immediate protection of property**
- An amateur radio station in distress may use: **any means of radiocommunication**

Regulations & Policies

Lesson One

1-11) Emergency Communications (Real or Simulated), Communications with Non-Amateur Stations

- During a disaster, when may an amateur station make transmissions necessary to meet essential communication needs and assist relief operations? **When normal communication systems are overloaded, damaged or disrupted**
- There are **no power limitations** during an emergency.
- During a disaster: **most communications are handled by nets using predetermined frequencies in amateur bands. Operators not directly involved with disaster communications are requested to avoid making unnecessary transmissions on or near frequencies being used for disaster communications.**
- Messages from recognized public service agencies may be handled by amateur radio stations: **during peace time and civil emergencies and exercises.**
- It is permissible to interfere with the working of another station if: **your station is directly involved with a distress situation**

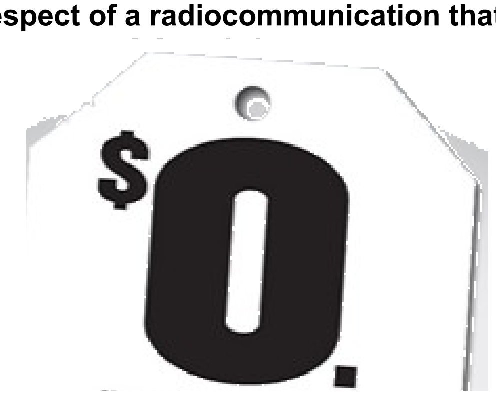


Regulations & Policies

Lesson One

1-12) Non-remuneration, Privacy of Communications

- **No payment of any kind** is allowed for third-party messages sent by an Amateur Station
- Radiocommunications transmitted by stations other than a broadcasting station may be divulged or used: **if it is transmitted by an amateur station**
- The operator of an amateur station: **shall not demand or accept remuneration in any form, in respect of a radiocommunication that the person transmits or receives.**

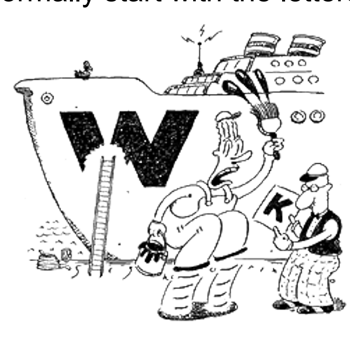


Regulations & Policies

Lesson One

1-13) Station Identification, Callsigns, Prefixes

- An amateur station must identify: **At least every thirty minutes, and at the beginning and at the end of a contact.**
- You must transmit **your call sign** to identify your amateur station.
- When may an amateur transmit unidentified communications? **Never, except to control a model craft.**
- What language may you use when identifying your station? **English or French**
- The call sign of a Canadian amateur radio station would normally start with the letters: **VA, VE, VO or VY**



Regulations & Policies

Lesson One

1-13) Station Identification, Call signs, Prefixes

Call Sign Prefix	Province or Territory
CY0	Sable Island (Nova Scotia)
CY9	St-Paul Island (Nova Scotia)
VA1, VE1	Nova Scotia
VA2, VE2	Quebec
VA3, VE3	Ontario
VA4, VE4	Manitoba
VA5, VE5	Saskatchewan
VA6, VE6	Alberta
VA7, VE7	British Columbia
VE8	North West Territories
VE9	New Brunswick
VO1	Newfoundland
VO2	Labrador
VY0	Nunavut
VY1	Yukon
VY2	Prince Edward Island

CY0 Sable Island
CY9 St. Paul's Island

St. Paul's and Sable Island are protected under the Canada Shipping Act, which means that permission must be obtained from the Canadian Coast Guard to visit the islands, hence why they have special call signs.

Regulations & Policies

Lesson One

1-14) Foreign Amateur Operation in Canada, Banned Countries, Third-Party Messages

- If a non-amateur friend is using your station to talk to someone in Canada, and a foreign station breaks in to talk to your friend, what should you do? **Have your friend wait until you find out if Canada has a third-party agreement with the foreign station's Government.**

- If you let an unqualified third party use your amateur station, what must you do at your station's control point? **You must continuously monitor and supervise the third party's participation.**

- A person operating a Canadian amateur station is forbidden to communicate with amateur stations of another country: **when that country has notified the International Telecommunication Union that it objects to such communications.**

- Third-party traffic is: **a message sent to a non- amateur via an amateur station**

Regulations & Policies

Lesson One

1-15) Frequency Bands & Qualification Requirements

- If you are the control operator at the station of another amateur who has additional qualifications to yours, what operating privileges are you allowed? **Only the privileges allowed by your qualifications.**

- In addition to passing the Basic written examination, what must you do before you are allowed to use amateur frequencies below 30 MHz? **Advanced test or attain a mark of 80% on the Basic exam.**

- The licensee of an amateur station may operate radio controlled models: **on all frequencies above 30 MHz**

Regulations & Policies

Lesson One

1-15) Frequency Bands & Qualification Requirements

In Canada, the 160 meter amateur band corresponds in frequency to: **1.8 to 2.0 MHz**

In Canada, the 75/80 meter amateur band corresponds in frequency to:**3.5 to 4.0 MHz**

In Canada, the 40 meter amateur band corresponds in frequency to: **7.0 to 7.3 MHz**

In Canada, the 20 meter amateur band corresponds in frequency to:**14.000 to 14.350 MHz**

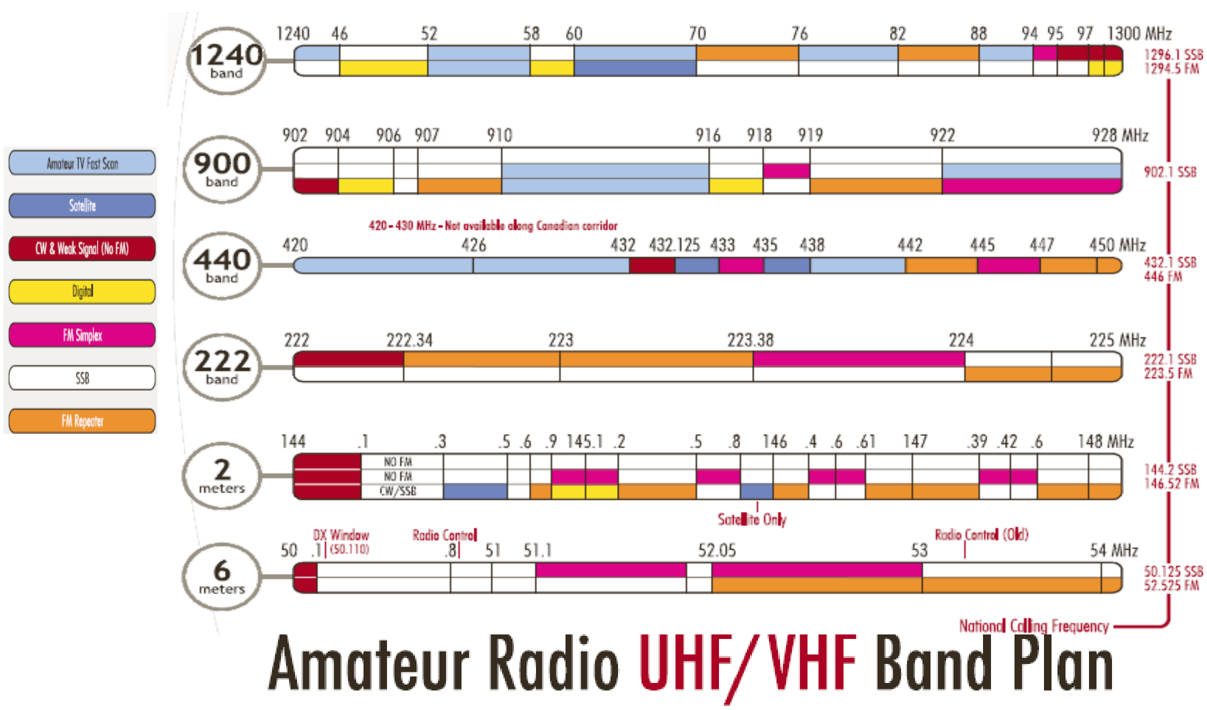
In Canada, the 15 meter amateur band corresponds in frequency to:**21.000 to 21.450 MHz**

In Canada, the 10 meter amateur band corresponds in frequency to:**28.000 to 29.700 MHz**

Regulations & Policies

Lesson One

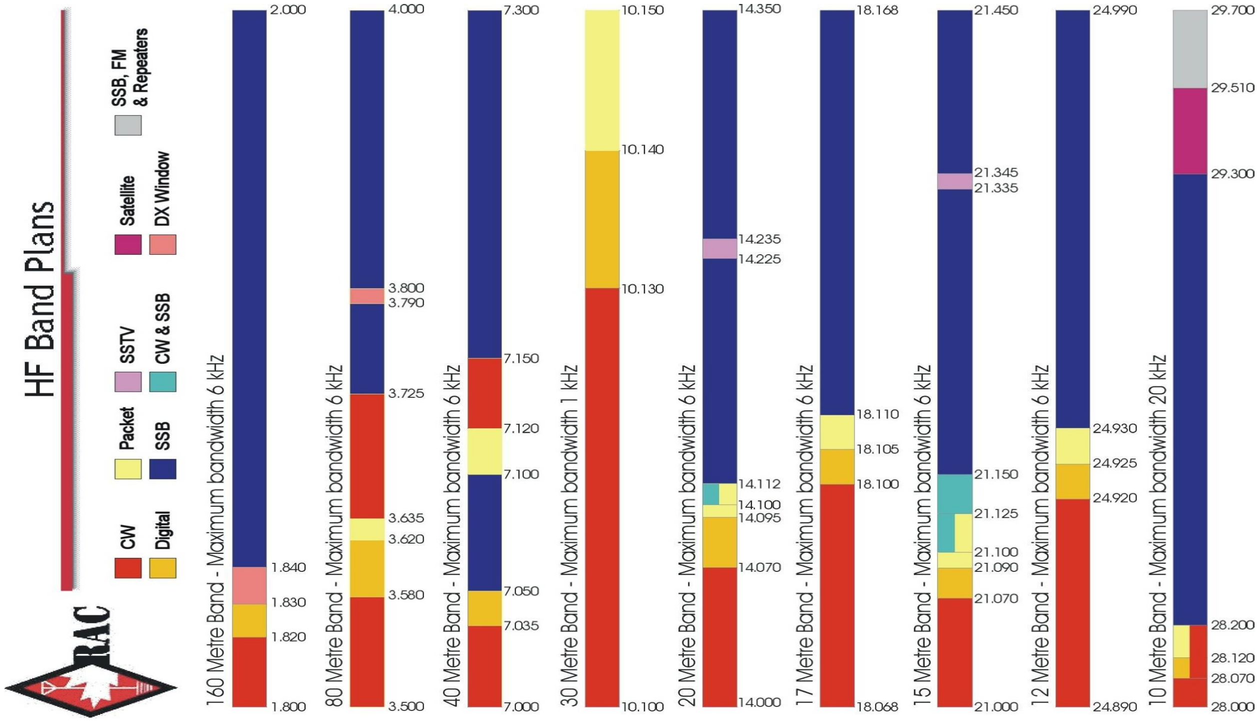
1-15) Frequency Bands & Qualification Requirements



Regulations & Policies

Lesson One

1-15) Frequency Bands & Qualification Requirements



Regulations & Policies

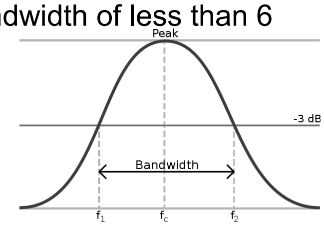
Lesson One

1-16) Maximum Bandwidth by Frequency Bands

The maximum authorized bandwidth within the frequency range of 50 to 148 MHz **shall not exceed 10 times that of a CW emission 30 kHz**

The maximum bandwidth of an amateur station's transmission allowed in the band 28 to 29.7 MHz is: **20 kHz**

Only one band of amateur frequencies has a maximum allowed bandwidth of less than 6 kHz. That band is: **10.1 to 10.15 MHz**



Single sideband is not permitted in the band: **10.1 to 10.15 MHz.**

The bandwidth of an amateur station shall be determined by measuring the frequency band occupied by that signal at a level of **26** dB below the maximum amplitude of that Signal.

1-17) Restrictions on Capacity & Power Output by Qualifications

What amount of transmitter power must radio amateurs use at all times? **The minimum legal power necessary to communicate**

What is the most FM transmitter power a holder of only **Basic Qualification** may use on 147 MHz? **250 W DC input**

At what point in your station is transceiver power measured? **At the antenna terminals of the transmitter or amplifier**

What is the maximum transmitting power an amateur station may use for SSB operation on 7055 kHz, if the operator has Basic+ qualifications: **560 watts PEP output.**

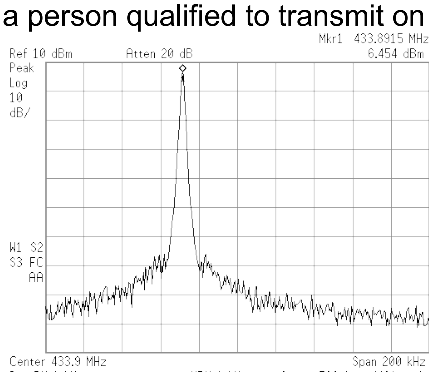
The DC power input to the anode or collector circuit of the final RF stage of a transmitter, used by a holder of an Amateur **Radio Operator Certificate with Advanced Qualification,**shall not exceed: **1000 watts**

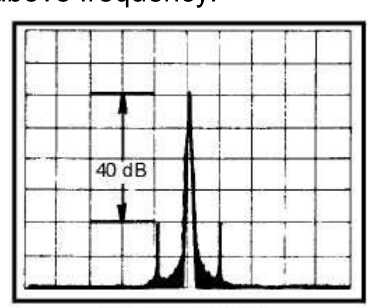
1-18) Unmodulated Carriers, Re-Transmission

What kind of amateur station automatically retransmits the signals of other stations? **Repeater station**

An unmodulated carrier may be transmitted only: **for brief tests on frequencies below 30 MHz**

Radiotelephone signals in a frequency band below **29.5 MHz** MHz cannot be automatically retransmitted, unless these signals are received from a station operated by a person qualified to transmit on frequencies below the above frequency:





2% MODULATION
SIDEBANDS 40 dB DOWN

Regulations & Policies

Lesson One

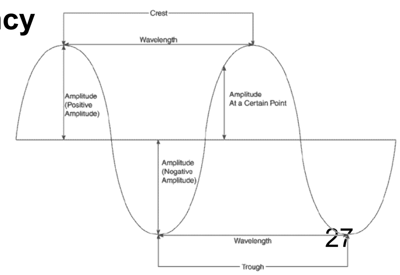
1-19) Amplitude Modulation, Frequency Stability, Measurements

When operating on frequencies below 148 MHz: **the frequency stability must be comparable to crystal control**

An amateur station using radiotelephony must install a device for indicating or preventing: **overmodulation**

The maximum percentage of modulation permitted in the use of radiotelephony by an amateur station is: **100 percent**

All amateur stations, regardless of the mode of transmission used, must be equipped with: **a reliable means of determining the operating radio frequency**



Regulations & Policies

1-20) International Telecommunication Union (ITU) Radio Regulations, Applicability

What type of messages may be transmitted to an amateur station in a foreign country? **Messages of a technical nature or personal remarks of relative unimportance**

The operator of an amateur station shall ensure that: communications are limited to: **messages of a technical or personal nature**

In addition to complying with the Act and Radiocommunication Regulations, Canadian radio amateurs must also comply with the regulations of the: **International Telecommunication Union**

In which International Telecommunication Union Region is Canada? **Region 2**

Regulations & Policies

Lesson One

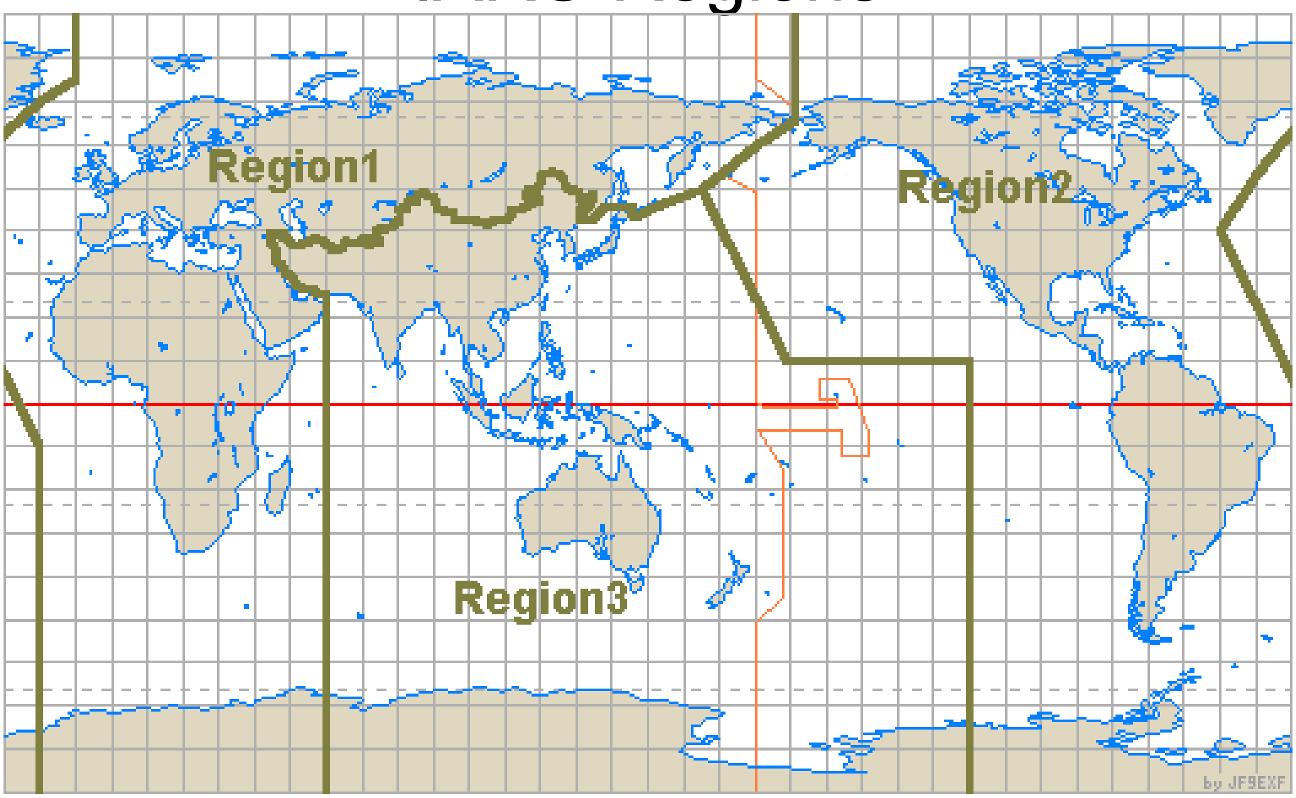
1-21) Operation Outside Canada, ITU Regions, Reciprocal Privileges, International Licences

A Canadian radio amateur, operating his station 7 kilometers (4 miles) offshore from the coast of Florida, is subject to which frequency band limits? **Those applicable to US radio amateurs**

Australia, Japan, and Southeast Asia are in which ITU Region? **Region 3**

Canada is located in ITU Region: **Region 2**

IARU Regions



Regulations & Policies

Lesson One

1-22) Examinations, Department's Fees, Delegated Examinations, Fees, Disabled Accommodation

The fee for taking examinations for amateur radio operator certificates by an accredited volunteer examiner is: **to be negotiated between examiner and candidate**

The fee for taking amateur radio certificate examinations at an Industry Canada office is: **$20 per qualification**

Regulations & Policies

Lesson One

1-23) Antenna Structure Approval, Neighbour and Land-Use Authority Consultation

Before erecting an antenna structure, for which community concerns could be raised, a radio amateur must consult with: **the land-use authority, and possibly the neighbors**

Regulations & Policies

Lesson One

1-24) Radiofrequency Electromagnetic Filed Limits

What organization has published safety guidelines for the maximum limits of RF energy near the human body? **Health Canada**

What is the purpose of the Safety Code 6? **It gives RF exposure limits for the human body**

According to Safety Code 6, what frequencies cause us the greatest risk from RF energy? **30 to 300 MHz**

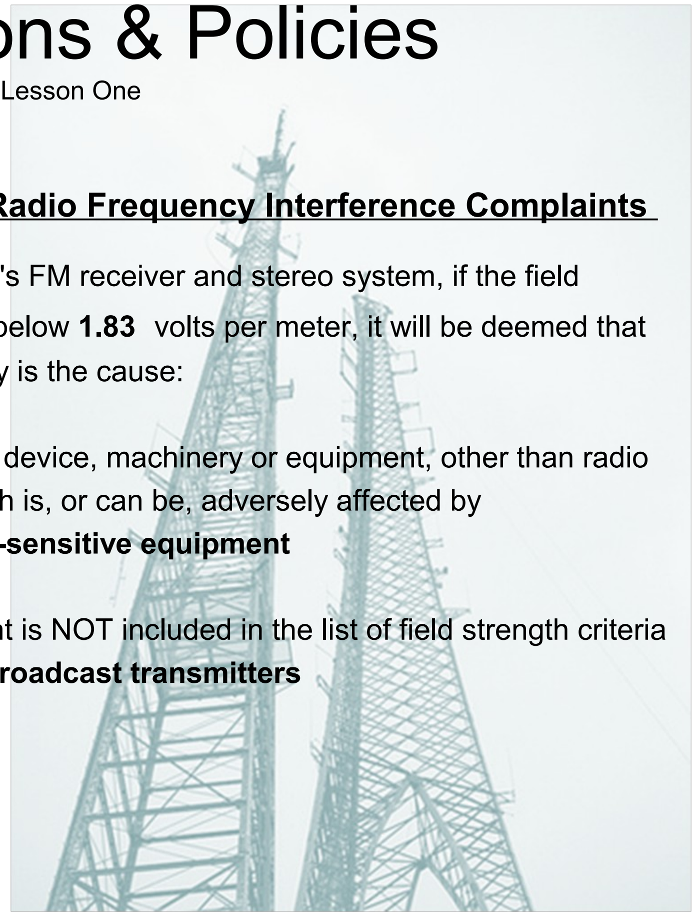
Why is the limit of exposure to RF the lowest in the frequency range of 30 MHz to 300 MHz, according to Safety Code 6? **The human body absorbs RF energy the most in this range**

Regulations & Policies

Lesson One

1-24) Radiofrequency Electromagnetic Filed Limits

The permissible exposure levels of RF fields: **increases, as frequency is increased above 300 MHz**



1-25) Criteria for Resolution of Radio Frequency Interference Complaints

In the event of interference to a neighbor's FM receiver and stereo system, if the field strength of the amateur station signal is below **1.83** volts per meter, it will be deemed that the affected equipment's lack of immunity is the cause:

Which of the following is defined as "any device, machinery or equipment, other than radio apparatus, the use or functioning of which is, or can be, adversely affected by radio communication emissions"? **radio-sensitive equipment**

Which of the following types of equipment is NOT included in the list of field strength criteria for resolution of immunity complaints? **broadcast transmitters**

OPERATING AND PROCEDURES

AGENDA

1. PHONETIC ALPHABET
2. NUMBERS
3. VOICE OPERATING PROCEDURES
4. HF / UHF / VHF / BAND PLANS
5. TUNE UPS, TESTING, DUMMY LOADS
6. CW OPS, PROCEDURAL SIGNS / PROWORDS
7. “Q” SIGNALS
8. R.S.T. CODES - READABILITY, STRENGTH, TONE
9. EMERGENCY OPERATING PROCEDURES
10. RECORDING KEEPING, CONFIRMATION, MAPS, CHARTS, ANTENNA ORIENTATION

PHONETIC ALPHABET

- **Use words to represent letters**
- **First letter corresponds to the letter**
- **Prevents confusion on a radio, “B” can sound much like “D”**

- **“B”** - **“BRAVO”**
- **“D”** - **“DELTA”**

VICTOR
ECHO
3 THREE
ECHO
MIKE
OSCAR

THIS IS A CALL SIGN

PHONETIC ALPHABET

A	Alpha	B	Bravo	C	Charlie
D	Delta	E	Echo	F	Foxtrot
G	Golf	H	Hotel	I	India
J	Juliet	K	Kilo	L	Lima
M	Mike	N	November		
O	Oscar	P	Papa	Q	Quebec
R	Romeo	S	Sierra	T	Tango
U	Uniform	V	Victor	W	Whiskey
X	X-Ray	Y	Yankee	Z	Zulu

NUMBERS

- Spell out numbers greater than 9
- Some numbers are pronounced differently to avoid confusion

0	ZEE-ROE	6	SIX
1	WUN	7	SAY-VEN
2	TOO	8	ATE
3	THU-REE	9	NINER
4	FOWER	10	WUN - ZEE-ROE
5	FIFE	11	WUN- WUN

<u>VOICE OPERATING PROCEDURES</u>

<u>**UHF / VHF CHANELIZED**</u>

Main purpose of repeaters is to **increase the range of mobile and portable stations**

Two frequencies involved: #1 for Receive, #2 for Transmit. Or, you receive on one frequency and transmit out on the second frequency i.e**. "DUPLEX"**

Calling via repeater **say the call sign of the desired station and then yours**
i.e.VE3EOT THIS IS VA3SUG

Pause between transmission to **listen to or allow anyone else who wants to use the repeater**

Transmissions should be short to **allow for emergency use of repeaters** (don't tie them up) switch to a simplex frequency if distance or time allows

To break into a conversation (non-emergency) on a repeater, **wait for a pause and say your call sign. "contact"** although used **is <u>NOT proper procedure</u>**

*"***AUTOPATCH"** a device to allow telephone calls via a station or radio (repeater)

Repeater **"TIME OUT"** timer limits the amount of transmit time via a repeater

An Autopatch is a feature of a repeater to access an outgoing telephone connection. Users with a transceiver capable of producing Dual-tone multi-frequency or touch tones (DTMF) can make a telephone call via public telephone system.

VOICE OPERATING PROCEDURES

"Continuous Tone-Coded Squelch System" **CTCSS or** "Private Line" **PL Tone,** a sub-audible tone added to a carrier which causes a repeater to accept a signal

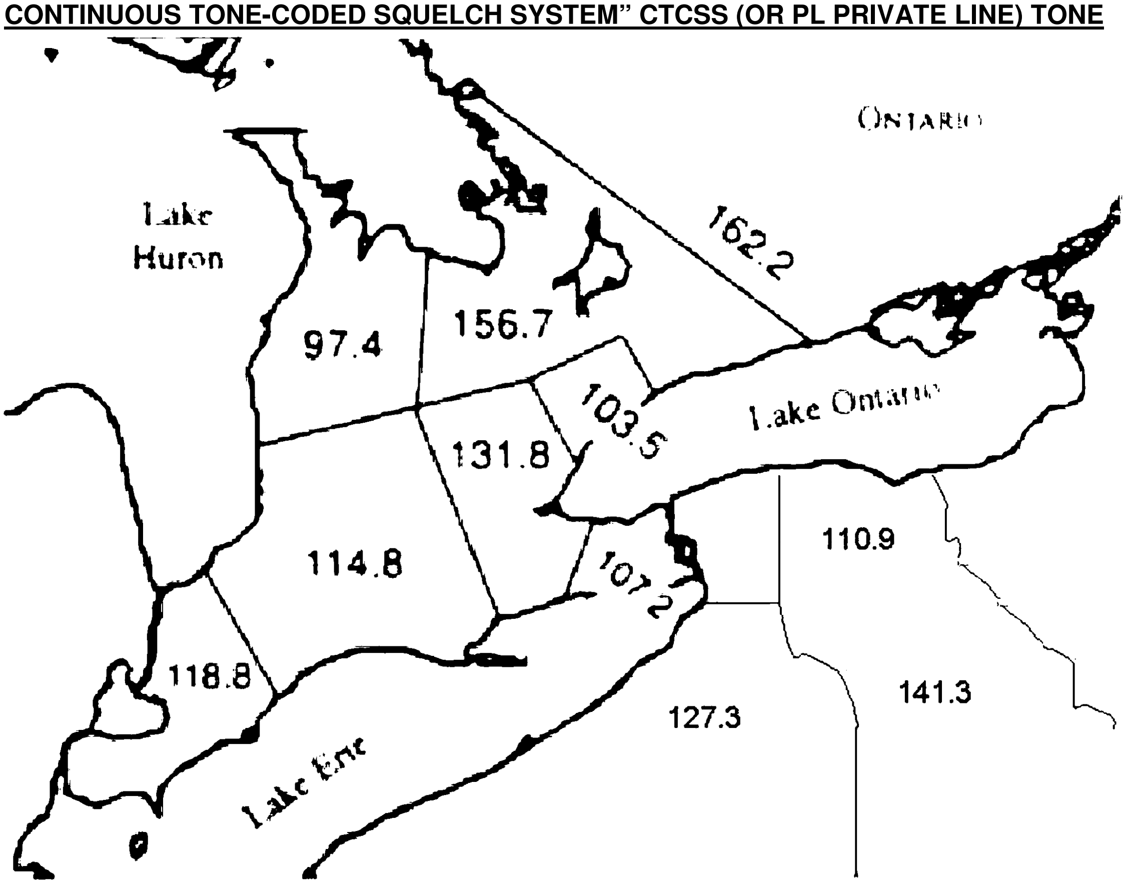
2 Meter FM Repeaters use one frequency for transmit and one for receive (duplex operation), **The difference between the frequencies (or offset) is usually 600 kHz.**

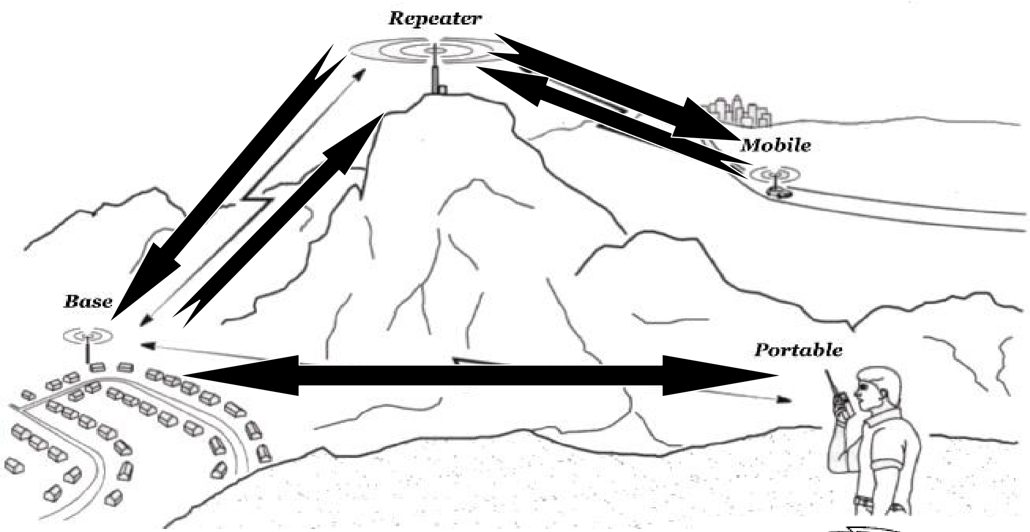
*i.e. if the repeater output was on **146.940 MHz**, then an operator could reliably assume that setting the input frequency **600 KHz** lower to **146.340** MHz would allow him to communicate on this frequency.*

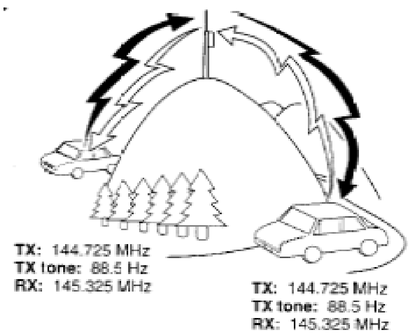
BAND	OFFSET
10 meters -	100 KHz
2 meters -	600 KHz
222 MHz -	1.6 MHz
70 centimeters -	5 MHz
33 centimeters -	12 MHz
23 centtmeters -	12 MHz

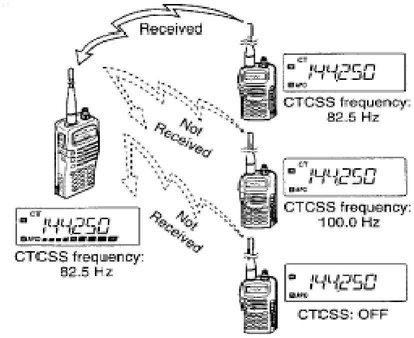
To properly ask some ones location, you simple ask them **"what is your location, where are you"**

CONTINUOUS TONE-CODED SQUELCH SYSTEM" CTCSS (OR PL PRIVATE LINE) TONE









VOICE OPERATING PROCEDURES

HF / UHF / VHF SIMPLEX

"SIMPLEX" operation is transmitting and receiving on the same frequency

Switch to simplex from repeaters when possible or if distance and situation permits

Local communications should use VHF and UHF to **reduce and free up interference on HF Bands**

Do not tie up repeaters unnecessary

If you can hear the station you are talking to **on "reverse" or the "input" frequency of the transmitter, you could and should use simplex**

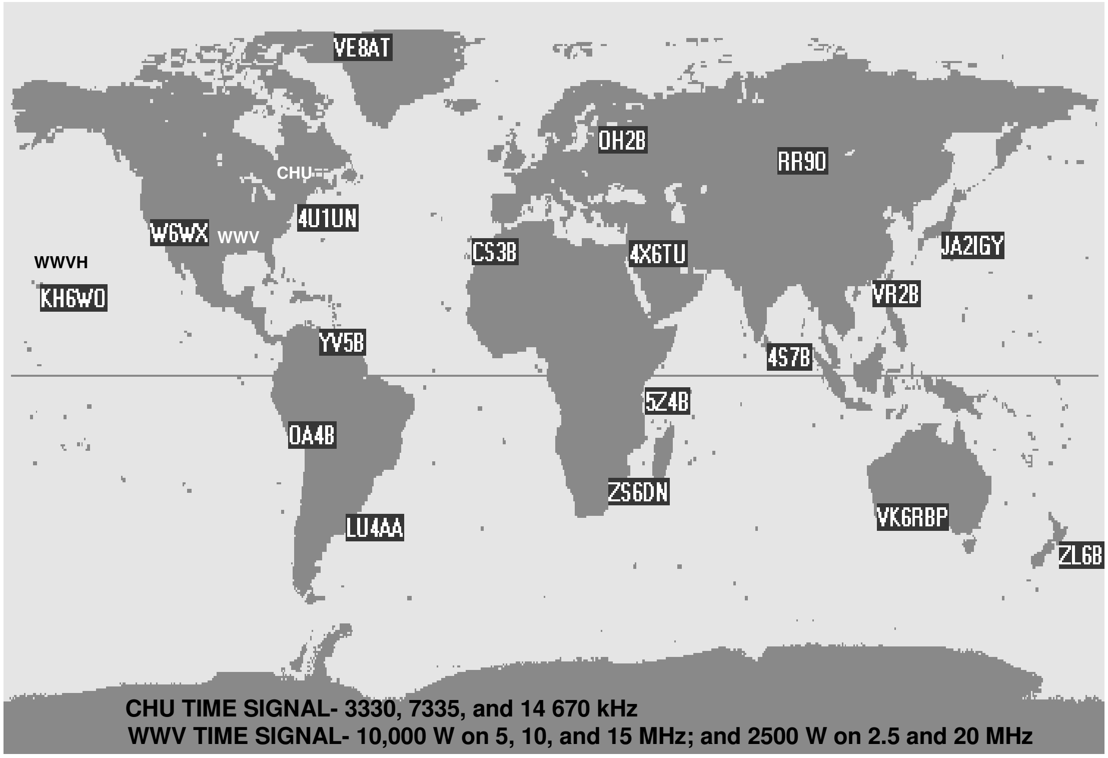
If operating simplex on a repeater frequency don't try to change the repeater frequency because you can't, **change to another frequency**

To find out if band conditions are open in a specific area or distant location, you should **listen for a Beacon signal from that area, a foreign broadcast, or TV station on a nearby frequency**

To call a station, **Say "CQ" Three times and then your call** *i.e. CQCQCQ This is VA3EOT, VA3EOT, VA3EOT*

To answer, say the other stations call sign once followed by your own Phonetically
i.e. VA3EOT this VICTOR ALPHA THREE SERIA UNIFORM GULF (VA3SUG)

BEACONS LOCATIONS WORLDWIDE



CANADIAN BAND PLAN

Lower side band is used for 3755Khz phone — **HF LSB**

CW & DIGITAL MODES ONLY

Upper side band is used for 20 meters phone — **HF USB**

ENOUGH BW TO HAVE FM PHONE

VHF

UHF

Frequency (MHz) Lower edge	Frequency (MHz) Upper edge	Maximum Bandwidth
1.8	2.0	6 kHz
3.5	4.0	6 kHz
7.0	7.3	6 kHz
10.1	10.15	1 kHz
14.0	14.350	6 kHz
18.068	18.168	6 kHz
21.0	21.450	6 kHz
24.890	24.990	6 kHz
28.0	29.7	20 kHz
50.0	54.0	30 kHz
144	148	30 kHz
220	225	100 kHz
430	450	12 MHz
902	928	12 MHz
1,240	1300	Not Specified
2,300	2,450	Not Specified
3,300	3,500	Not Specified
5,650	5,925	Not Specified
10,000	10,500	Not Specified
24,000	24,050	Not Specified
24,050	24,250	Not Specified
47,000	47,200	Not Specified
75,500	76,000	Not Specified
76,000	81,000	Not Specified
142,000	144,000	Not Specified
144,000	149,000	Not Specified
241,000	248,000	Not Specified
248,000	250,000	Not Specified

The HF Band Plan is a voluntary, gentleman's agreement, intended for the guidance of and observation by Canadian Radio Amateurs.

A guideline for using different operational modes within an amateur band.

CANADIAN HF BAND PLAN

160 Metre Band - Maximum bandwidth 6 kHz
1.800 - 1.820 MHz - CW
1.820 - 1.830 MHz - Digital Modes
1 830 - 1.840 MHz - DX Window
1.840 - 2.000 MHz - SSB / band modes

80 Metre Band - Maximum bandwidth 6 kHz
3.500 - 3.580 MHz - CW
3.580 - 3.620 MHz - Digital Modes
3.620 - 3.635 MHz - Packet/Digital Secondary
3.635 - 3.725 MHz - CW
3.725 - 3.790 MHz - SSB / side band modes
3.790 - 3.800 MHz - SSB DX Window
3.800 - 4.000 MHz - SSB / wide band modes

40 Metre Band - Maximum bandwidth 6 kHz
7.000 - 7.035 MHz - CW
7.035 - 7.050 MHz - Digital Modes
7.040 - 7.050 MHz - International packet
7.050 - 7.100 MHz - SSB
7.100 - 7.120 MHz - Packet within Region 2
7.120 - 7.150 MHz - CW
7.150 - 7.300 MHz - SSB / wide band modes

30 Metre Band - Maximum bandwidth 1 kHz
10.100 - 10.130 MHz - CW only
10.130 - 10.140 MHz - Digital Modes
10.140 - 10.150 MHz - Packet

20 Metre Band - Maximum bandwidth 6 kHz
14.000 - 14.070 MHz - CW only
14.070 - 14.095 MHz - Digital Mode
14.095 - 14.099 MHz - Packet
14.100 MHz - Beacons
14.101 - 14.112 MHz - CW, SSB, Packet
14.112 - 14.350 MHz - SSB
14.225 - 14.235 MHz - SSTV

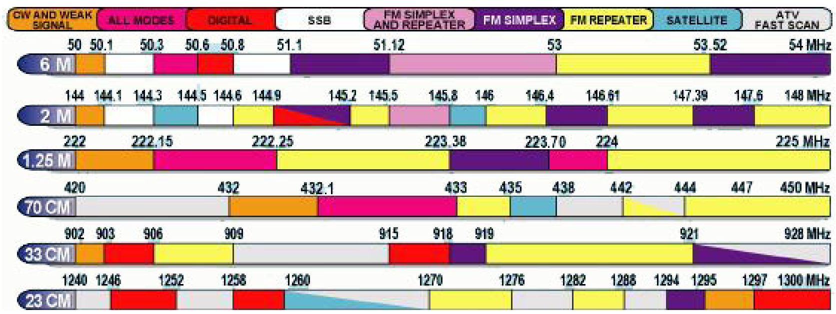
17 Metre Band - Maximum bandwidth 6 kHz
18.068 - 18.100 MHz - CW
18.100 - 18.105 MHz - Digital Modes
18.105 - 18.110 MHz - Packet
18.110 - 18.168 MHz - SSB / wide band modes

15 Metre Band - maximum bandwidth 6 kHz
21.000 - 21.070 MHz - CW
21.070 - 21.090 MHz - Digital Modes
21.090 - 21.125 MHz - Packet
21.100 - 21.150 MHz - CW and SSB
21.150 - 21.335 MHz - SSB / wide band modes
21.335 - 21.345 MHz - SSTV
21.345 - 21.450 MHz - SSB / wide band modes

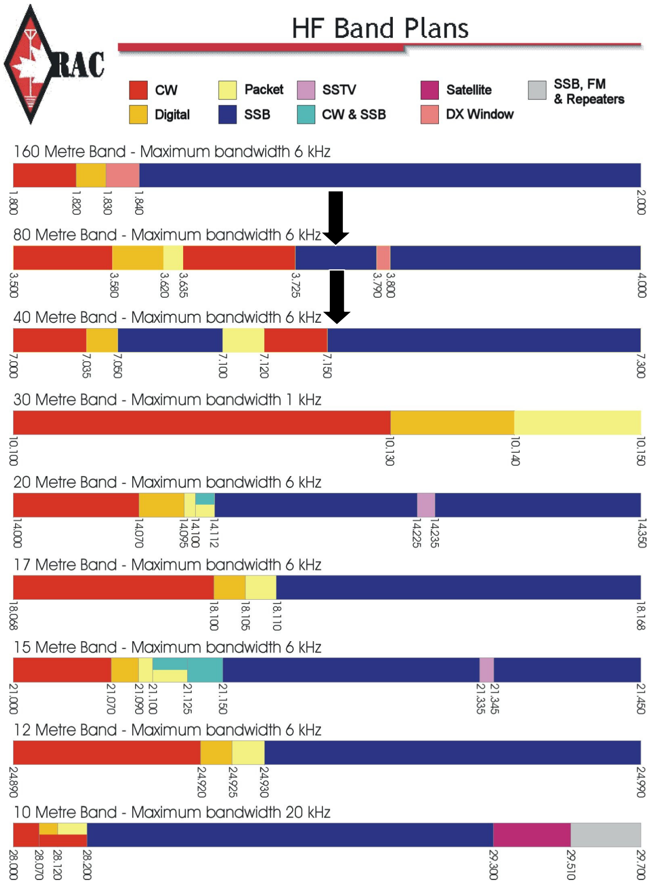
12 Metre Band - Maximum bandwidth 6 kHz
24.890 - 24.930 MHz - CW
24.920 - 24.925 MHz - Digital Modes
24.925 - 24.930 MHz - Packet
24.930 - 24.990 MHz - SSB / wide band modes

10 Metre Band - Maximum band width 20 kHz
28.000 - 28.200 MHz - CW
28.070 - 28.120 MHz - Digital Modes
28.120 - 28.190 MHz - Packet
28.190 - 28.200 MHz - Beacons
28.200 - 29.300 MHz - SSB /wide band modes
29.300 - 29.510 MHz - Satellite
29.510 - 29.700 MHz - SSB, FM and repeaters

CANADIAN VHF/UHF BAND PLAN



During a wide area emergency, ARES Ontario and the NTS will use 3.742 MHz and 7.153 MHz, adjusted for QRM, for province wide voice communications.



TUNE UPS, TESTING, DUMMY LOADS

A dummy load is a device used to simulate an electrical load, usually for testing purposes in place of an antenna

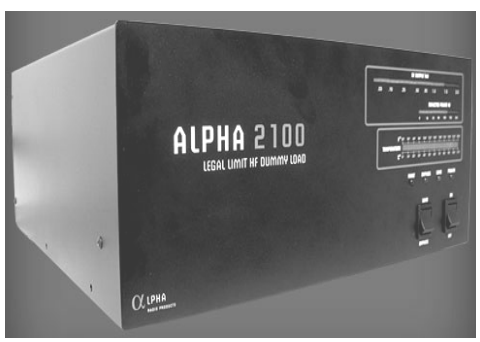
Tuning into a dummy load will shorten transmitter tune up time on air and avoid interference to stations on frequency.

On air interference can be avoided by using a dummy load to test transmissions, or loading up procedures.

Using a **dummy antenna will allow tuning without causing interference**

TUNE UPS, TESTING, DUMMY LOADS

Cantenna dummy load suitable up to 30 MHz and up to 1 kW

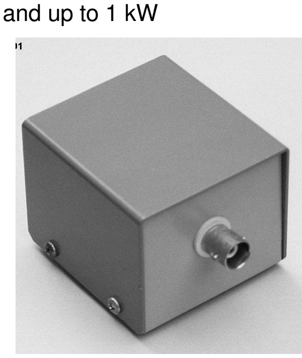


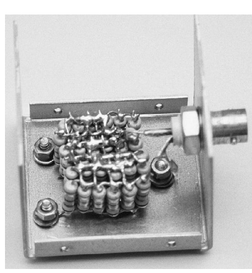
A dummy load capable of dissipating four times the legal limit (6 kW) for 2 to 3 minutes and legal limit (1500 watts)

The "dummy load" is an indispensable accessory for any radio amateur. Using a dummy load, transmitter adjustments can be made "off-the-air" so that no unnecessary interference is generated on the ham bands.

Dummy loads are an easy useful project that just about anyone with moderate soldering skills can build.

A very simple and effective dummy load can be made from several resistors, a connector, and a small metal plate or piece of PC board stock.





25 Watt dummy Load
"HOME BREW"

TUNE UPS, TESTING, DUMMY LOADS

If propagation or band conditions change during a contact and you notice increasing interference **you should move to a different frequency**

Before transmitting you should **always listen to ensure the frequency is not occupied**, you should also ask if the frequency is in use.

During a contact you find you have a extremely strong signal into your contact station, one adjustment you might consider **is to turn down your output power to the minimum necessary**.

TUNE UPS, TESTING, DUMMY LOADS

When selecting a single side band (SSB) phone transmitting frequency, the **minimum separation between you and a contact in progress is 3 kHz** to avoid interference.

If your a net control station on a daily HF net and your normal frequency is occupied you should conduct the **net 3 to 5 KHz** away from the normal net frequency

If a net is about to begin on the frequency your on, as a courtesy to the net, you should **move to another frequency**

<u>CW OPS, PROCEDURAL SIGNS / PROWORDS</u>

LISTEN FIRST to ensure the frequency is **NOT** in use

CW or Morse code is sent at **any speed <u>you can reliably receive.</u>**

CW Transmitting frequency should be be between **<u>150-500 Hrz for minimum interference</u>**

<u>Full Break-in Telegraphy</u> = **incoming signals received between transmitted Morse code "signals"** (or dots) (This enables the other station to "break-in" while you are still sending)

<u>CW OPS, PROCEDURAL SIGNS / PROWORDS</u>

CQ = Calling any station
-"CQ CQ CQ DE VE3EMO VE3EMO VE3EMO"
-CQ Three time your call sign three times

To answer or reply
-"VE3EMO VE3EMO DE VA3SUG VA3SUG K"

DE = from (like the French "from" or "of")

K = any station transmit, or go ahead, or over to you

CW OPS, PROCEDURAL SIGNS / PROWORDS

DX = Long distance

73 = Best wishes / Good Bye **(not 73's)**

AR = End of message

BT = (or TV), Break in the text

SK = End of transmission

RST = **R**eadability, **S**trength, **T**one - Signal report

"Q" SIGNALS

The Q-code are a list of signals abbreviating a detailed question or answer.

The Q code is a standardised collection of three-letter message encodings, all starting with the letter "Q",

Agreed upon by the International Telecommunication Union (ITU), is used worldwide on radiotelegraph.

Abbreviations are given the form of a question when followed by a question mark. i.e. "QTH?" what is your location?

“Q” SIGNALS

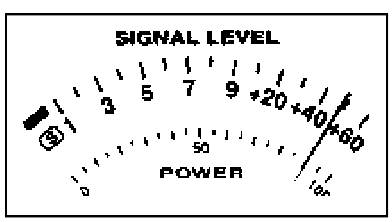
- QR**L** “Is this frequency in use?” *(or are you busy?)*
- QR**M** “I’m being interfered with” *Man Made (e.g. jamming)*
- QR**N** “I’m troubled by static” *Non Man Made interference*
- QR**S** “Send more slowly”
- QR**X** “I will call you again”
- QR**Z** “Who is calling me?”
- QS**O** “A contact is in progress” (i.e. *thanks for the QSO*)
- QS**Y** “Change frequency” *(QSY to 14.210)*
- QT**H** “My location is” *My QTH is Toronto*
- QSL “I acknowledge” *I understand, Roger …*
- QRT “Stop sending” *I’m QRT for the day (finished, done)*

RST SIGNALS

Readability, Strength, Tone

A short way to describe or give a signal or reception report (i.e. radio check) based upon your “S” meter reading and what you actually hear.

An “S” meter is used to measure relative signal strength in a receiver



Poor Good

RST =	READABILITY	1-5
	SINGNAL STRENGTH	1-9
	TONE	1-9

RST SIGNALS - READABILITY

A qualitative assessment of how easy or difficult it is to correctly copy the information being sent

1 Unreadable
2 Barely readable, occasional words distinguishable
3 Readable with considerable difficulty
4 Readable with practically no difficulty
5 Perfectly readable

RST SIGNALS - STRENGTH

An assessment of how powerful the received signal is at the receiving location

1 Faint signal, barely perceptible
2 Very weak
3 Weak
4 Fair
5 Fairly good
6 Good
7 Moderately strong
8 Strong
9 Very strong signals

RST SIGNALS - TONE

Used only in Morse code and digital transmissions

therefore omitted during voice operations

1 Very rough and broad
2 Very rough, very harsh and broad
3 Rough, tone, rectified but not filtered
4 Rough note, some trace of filtering
5 Filtered rectified, but strongly ripple-modulated
6 Filtered tone, definite trace of ripple modulation
7 Near pure tone, trace of ripple modulation
8 Near perfect tone, slight trace of modulation
9 Perfect tone, no trace of ripple or modulation of any kind

RST SIGNALS

AN RST OF 599 BEST READING *i.e. "you're 59"*

- 11 = Unreadable and barely perceptible
- 57 = Perfectly readable, moderately strong
- 33 = Readable, some difficulty, weak in strength
- 59 **plus 20db** = Signal strength is 20 db's over strength 9 *i.e. "your 20 over 9"*
- RST of 459 = Quite readable, fair strength, perfect tone (tone is usually used for CW)
- RST of 579 = Perfectly readable, moderately strong, perfect tone
- An increase of power **4 times** will raise you "S" meter by **ONE "S" unit**
- Thus to raise the meter from **S8 to S9** you power on a transmitter would need to increase power **4 times**

EMERGENCY OPERATING PROCEDURES

MAYDAY or SOS precedence over all calls!!!

REAL EMERGENCIES ONLY, IT IS ILLEGAL TO KNOWENLY TRANSMIT A FALSE DISTRESS SIGNAL!

URGENCY (PAN-PAN) Say three time, safety for a person, vehicle, aircraft, vessel, residence etc is threatened. ***"Pan-Pan, Pan-Pan, Pan-Pan this is VE3EOT with ....."***

SECURITY (Securitay) Weather warnings, aids to navigation, used mostly in or by maritime situations. ***"Sécurité, Sécurité, Sécurité. All ships, all ships, all ships this is VA3XMJ"***

EMERGENCY OPERATING PROCEDURES

If you need immediate emergency assistance, the appropriate voice signal is “MAYDAY” and the appropriate Morse code signal is “SOS”

Used only in a life threatening situation to you or some one else

Derived from the French venez m'aider, meaning "come [to] help me, venez" is dropped, thus MAYDAY.

The Proper way to say is to say “MAYDAY” several times
I.E. “MAYDAY MAYDAY MAYDAY this is VA3NSC”

For CW “SOS” --- … ---

If your using a repeater and you want to interrupt a conversation with a distress call, you say “BREAK” twice and then you call sign ***i.e. break break this is VA3SUG with emergency traffic***

EMERGENCY OPERATING PROCEDURES

During a contact you hear a distress call or break in, you:

A. ACKNOWLEDGE THE STATION IN DISTRESS
B. DETERMINE THEIR LOCATION “QTH”
C. ASK WHAT ASSISTANCE IS NEEDED

If you hear a distress call and can not assist, you maintain watch on the frequency until certain that assistance is forthcoming to the caller

If you are in contact with a station and you hear a emergency call, on your frequency you:

A. STOP YOUR CONTACT
B. TAKE THE CALL

EMERGENCY OPERATING PROCEDURES

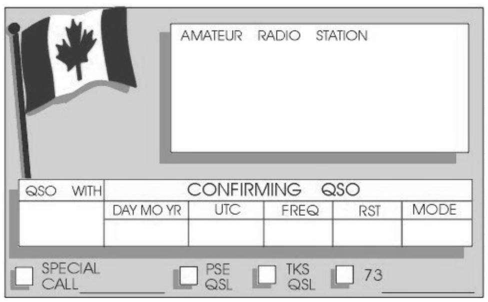
- HAVE BACK UP POWER TO USE YOUR STATIONS IN AN EMERGENCY AND NOT BY COMMERICAL AC LINES
- HAVE SEVERAL SETS OF BATTEIRS FOR HANDHELDS
- DIPOLE ANTENNAS ARE A GOOD CHOICE FOR PORTABLE AND OR EMERGENCY HF STATIONS

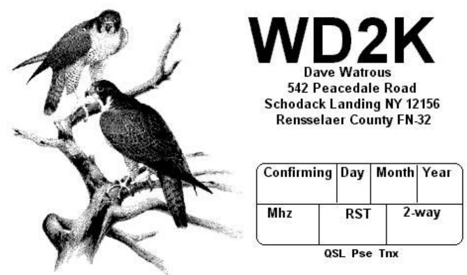
RECORDING KEEPING, CONFIRMATION, MAPS, CHARTS, ANTENNA ORIENTATION

QSL CARDS & STATIONS LOGS

QSL CARD IS WRITTEN PROOF OF COMMUNICATIONS BETWEEN TWO AMATEURS, TODAY THERE IS ALSO E-QSL VIA THE INTERNET.

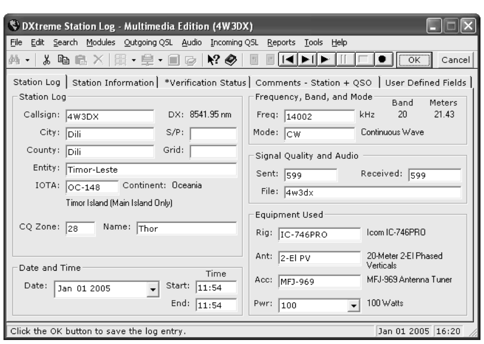
QSL CARDS ARE A SIGNED POST CARD LISTING THE DATE TIME FREQUENCY MODE AND POWER



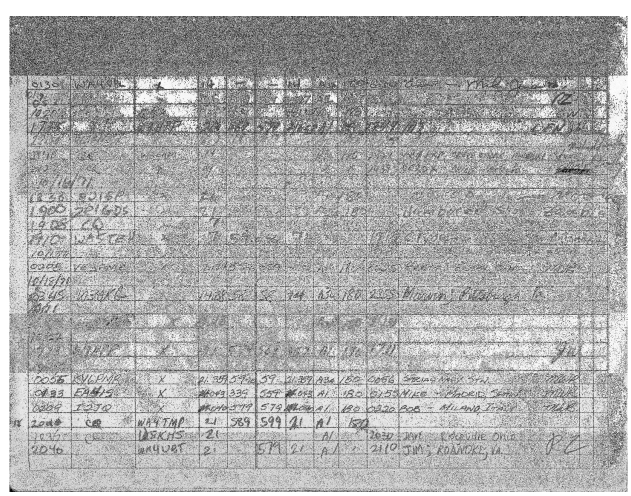


RECORDING KEEPING, CONFIRMATION, MAPS, CHARTS, ANTENNA ORIENTATION

STATION LOGS AND QSL CARDS ARE ALWAYS KEEP IN UTC (UNIVERSAL TIME COORDINATED / FORMERLY GREENWICH MEAN TIME - GMT. GMT IS BASED ON THE LOCATION / MERIDIAN THAT RUINS THROUGH GREENWICH ENGLAND.



RECORDING CONTACTS AND KEEPING STATION LOG BOOKS IS NO LONGER REQUIRED BY INDUSTRY CANADA



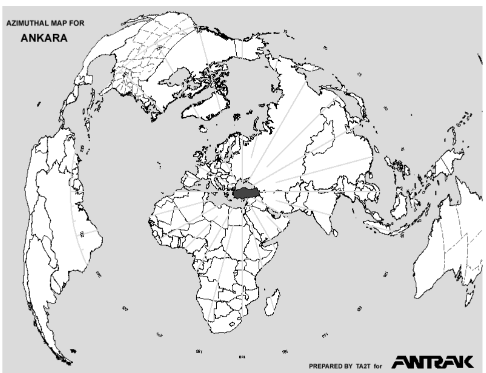
TO SET YOUR CLOCK TO GMT TIME LISTEN TO EITHER CHU CANADA, WWV OR WWVH TIME SIGNALS IN THE UNITED STATES

AZIMUTHAL MAPS

THE MOST USEFUL MAP TO USE WHEN ORIENTING A DIRECTIONAL HF ANTENNA TOWARDS A DISTANT STATION / CONTACT IS A AZIMUTHAL MAP

A AZIMUTHAL MAP IS PROJECTED OR CENTRED ON A SPECIFIC LOCATION AND IS USED TO DETERMINE THE SHORTEST PATH BETWEEN THE CENTRED AND DESIRED LOCATIONS OF CONTACT.

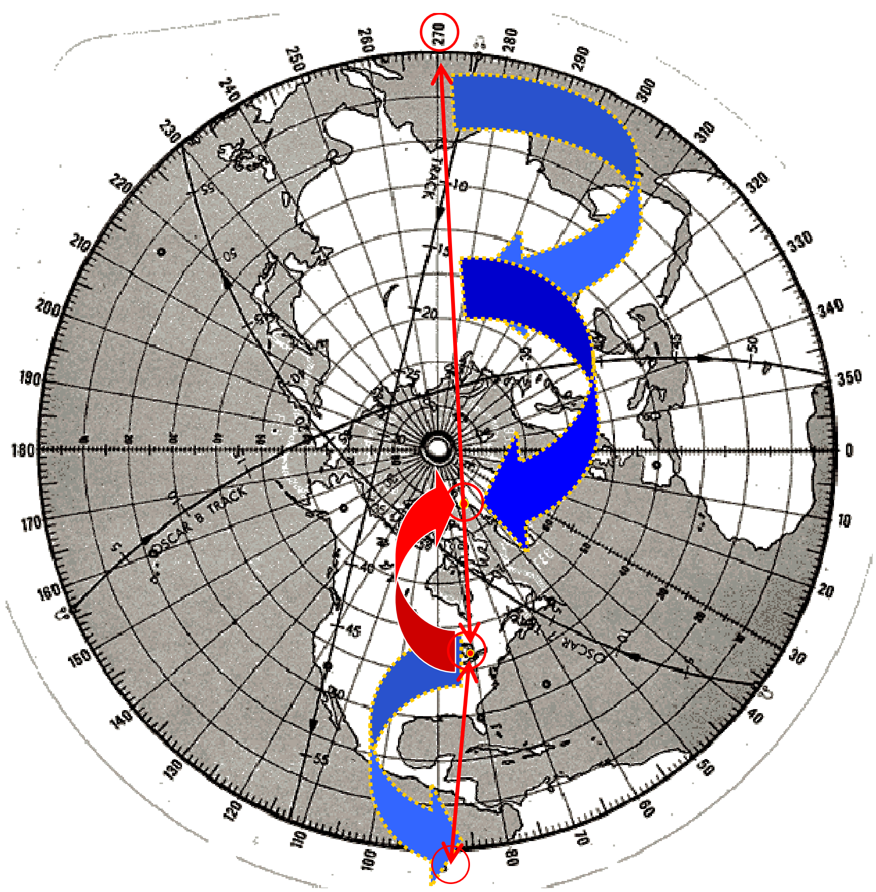
A AZIMUTHAL MAP WILL ALSO SHOW A COMPAS BEARING FROM YOUR LOCATION TO ANY POINT ON THE MAP AND WILL ASSIST IN ANTENNA PLANING AND POINTING.



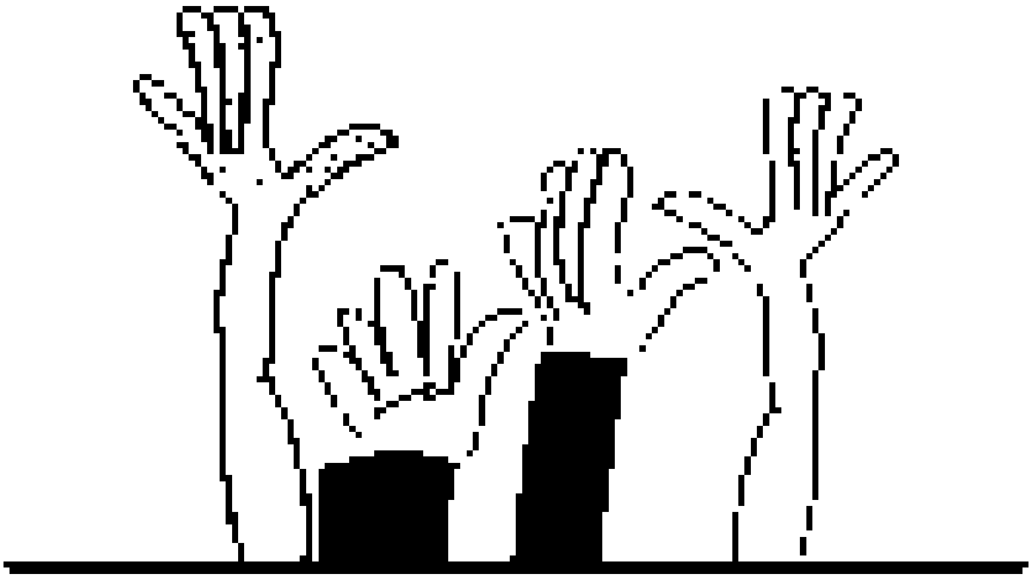
LONG PATH

A DIRECTIONAL ANTENNA POSITION 180 DEGREES (REVERSE BEARING) FROM THE SHORTEST PATH IS REFEREED TO LONG PATH.

IF LISTENING TO LOCAL STATIONS MAKING CONTACT WITH DISTANT STATIONS (I.E. DX NEW ZEALAND) BUT YOU CAN NOT HEAR THE DX STATION, TRY POINTING YOUR ANTENNA IN A LONG PATH DIRECTIONS (BEAMED 180 DEGREES) AND LISTEN FOR INCOMING STATIONS.

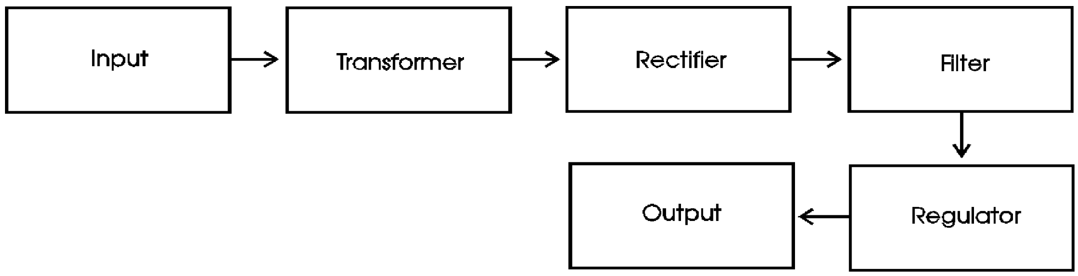


QUESTIONS ????



Block Diagrams Definitions
& Safety

Regulated Power Supply



Power supply

- A power supply (sometimes known as a power supply unit or PSU) is a device or system that supplies electrical or other types of energy to an output load or group of loads. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarely to others.

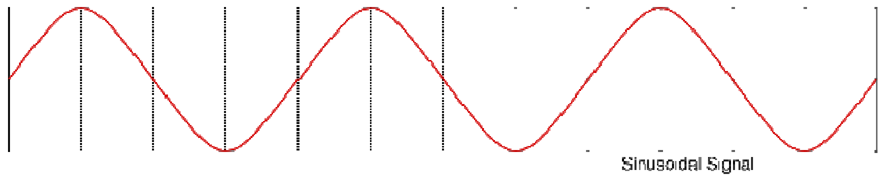
Transformer

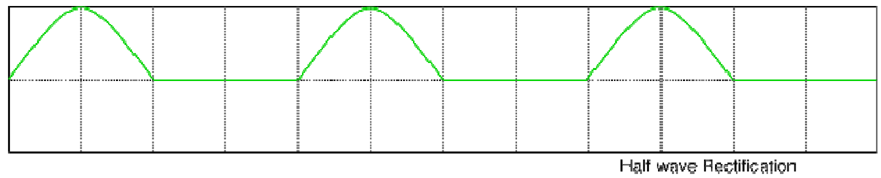
- A transformer is a device that transfers electrical energy from one circuit to another through a shared magnetic field. A changing current in the first circuit (the primary) creates a changing magnetic field; in turn, this magnetic field induces a changing voltage in the second circuit (the secondary). By adding a load to the secondary circuit, one can make current flow in the transformer, thus transferring energy from one circuit to the other.

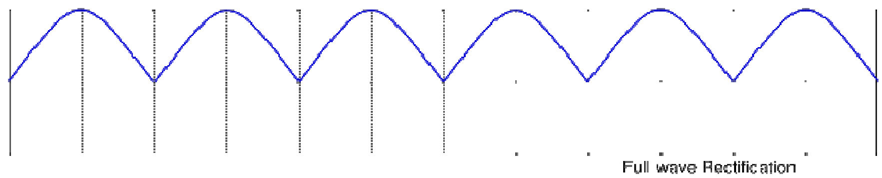
Rectifier

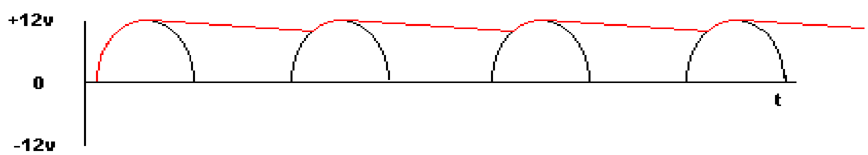
- A rectifier is an electrical device that converts alternating current to direct current, a process known as rectification. Rectifiers are used as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid state diodes, vacuum tube diodes, mercury arc valves, and other components.

- A circuit which performs the opposite function (converting DC to AC) is known as an inverter.





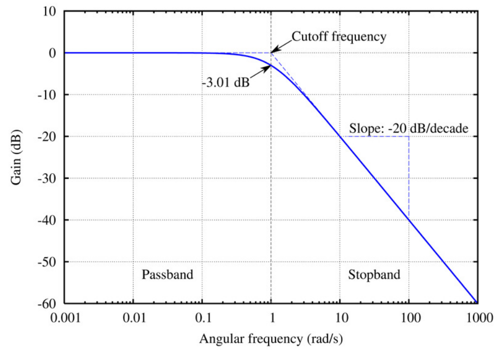




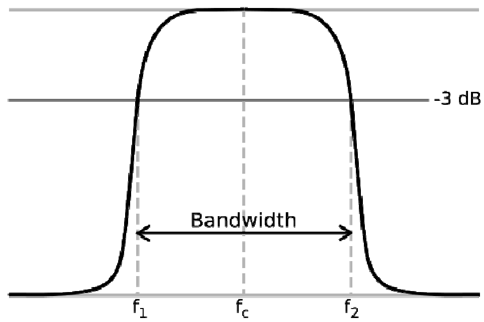
Filter

- Electronic are electronic circuits which perform signal processing functions, specifically intended to remove unwanted signal components and/or enhance wanted ones.
- Low-pass filter - Low frequencies are passed, high frequencies are attenuated.
- High-pass filter - High frequencies are passed, Low frequencies are attenuated.
- Band-pass filter - Only frequencies in a frequency band are passed.
- Band-stop filter - Only frequencies in a frequency band are attenuated
- Attenuated or Attenuation is the reduction in amplitude and intensity of a signal

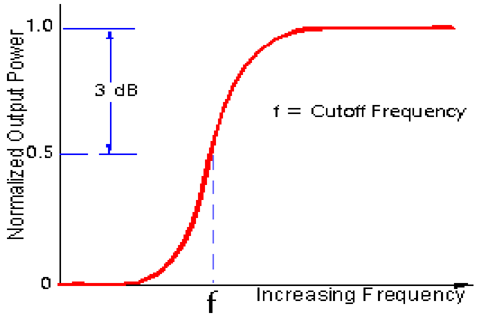
Filters



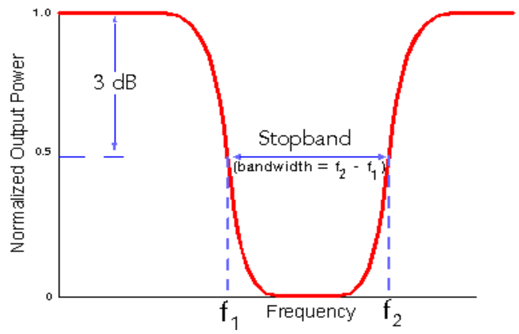
LOW PASS



BAND PASS



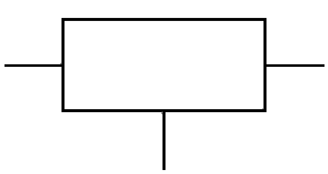
HIGH PASS



BAND STOP

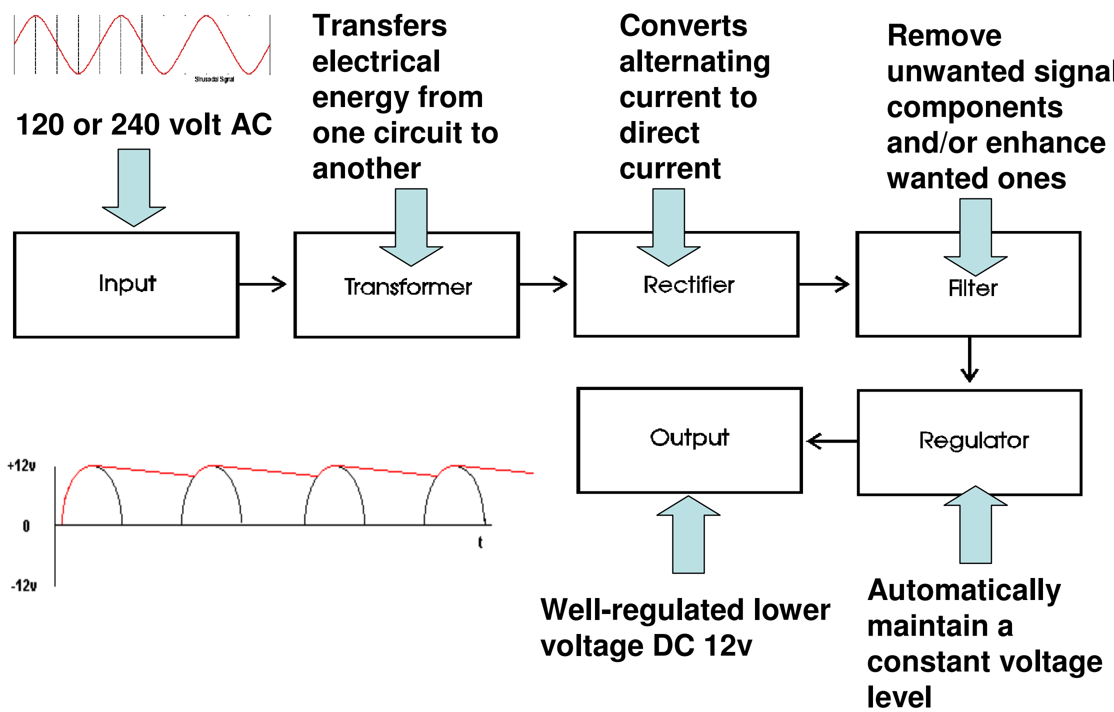
Regulator

- A voltage regulator is an electrical regulator designed to automatically maintain a constant voltage level.

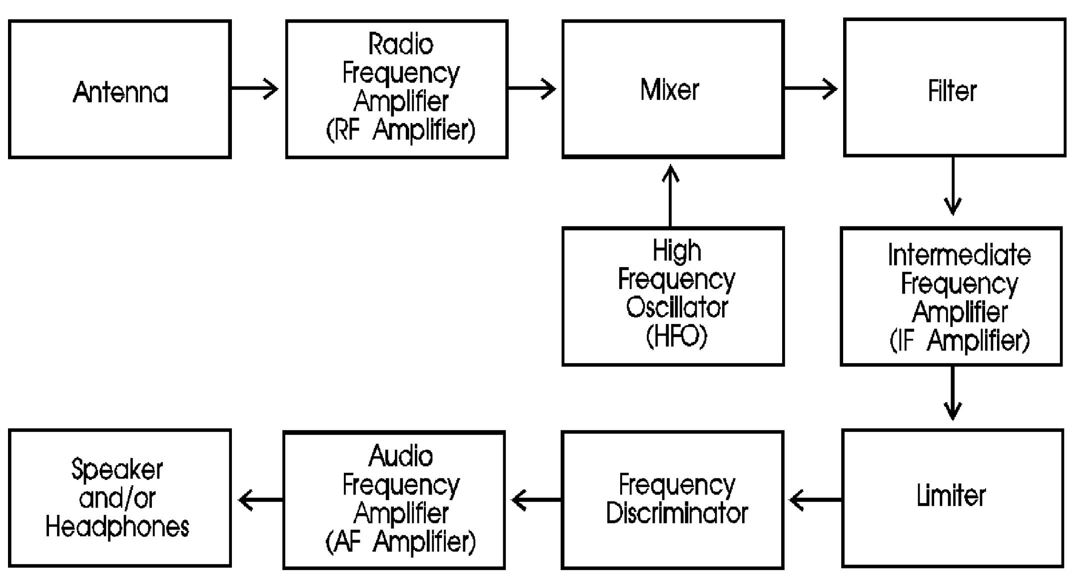


Voltage-Regulator-IEC-Symbol

Regulated Power Supply



Frequency Modulation Receiver



Heterodyning

- Heterodyning is the generation of new frequencies by mixing two or more signals in a nonlinear device such as a vacuum tube, transistor, diode mixer.
- The mixing of each two frequencies results in the creation of two new frequencies, one at the sum of the two frequencies mixed, and the other at their difference.
- A heterodyne receiver is a telecommunication receiver which uses this effect to produce frequency shifts.

Superheterodyne Receiver

- The word *heterodyne* is derived from the Greek roots *hetero-* "different", and *-dyne* "power".
- A Superheterodyne Receiver converts any selected incoming frequency by heterodyne action to a preselected common intermediate frequency, for example, 455 kilohertz or 10.7 megahertz, and provides amplification and selectivity, or filtering.
- The term *heterodyne* is sometimes also applied to one of the new frequencies produced by heterodyne signal mixing.

Superheterodyne Receiver

- incoming radio frequencies from the antenna are made to mix (or multiply) with an internally generated radio frequency from the VFO in a process called mixing.

- The mixing process can produce a range of output signals:

- * at all the original frequencies,
- * at frequencies that are the sum of each two mixed frequencies
- * at frequencies that equal the difference between two of the mixed frequencies
- * at other, usually higher, frequencies.

- If the required incoming radio frequency and the VFO frequency were both rather high (RF) but quite similar, then by far the lowest frequency produced from the mixer will be their difference.

- In very simple radios, it is relatively straightforward to separate this from all the other spurious signals using a filter, to amplify it and then further to process it into an audible signal. In more complex situations, many enhancements and complications get added to this simple process, but this mixing or heterodyning principle remains at the heart of it.

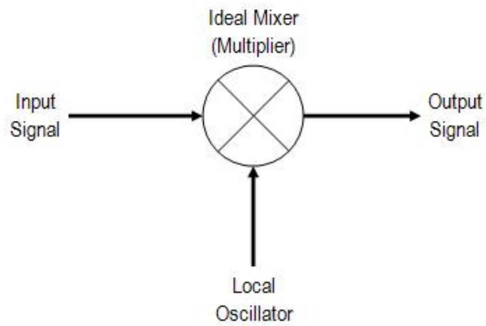
Amplifier

- amplifier is any device that will use a small amount of energy to control a larger amount of energy.

- The relationship of the input to the output of an amplifier is usually expressed as a function of the input frequency and is called the transfer function of the amplifier, and the magnitude of the transfer function is termed the gain.

- gain is a measure of the ability of a circuit to increase the power or amplitude of a signal. It is usually defined as the mean ratio of the signal output of a system to the signal input of the same system. It may also be defined as the decimal logarithm of the same ratio.

Mixer



- mixer is a nonlinear circuit or device that accepts as its input two different frequencies and presents at its output a mixture of signals at several frequencies:
- the sum of the frequencies of the input signals
- the difference between the frequencies of the input signals
- both original input frequencies — these are often considered parasitic and are filtered out.
- The manipulations of frequency performed by a mixer can be used to move signals between bands, or to encode and decode them. One other application of a mixer is as a product detector

Local Oscillator

- A local oscillator is a device used to generate a signal which is beat against the signal of interest to mix it to a different frequency.
- The oscillator produces a signal which is injected into the mixer along with the signal from the antenna in order to effectively change the antenna signal by heterodyning with it to produce the sum and difference (with the utilization of trigonometric angle sum and difference identities) of that signal one of which will be at the intermediate frequency which can be handled by the IF amplifier.
- These are the beat frequencies. Normally the beat frequency is associated with the lower sideband, the difference between the two.

Limiter

- a limiter is a circuit that allows signals below a set value to pass unaffected, as in a Class A amplifier, and clips off the peaks of stronger signals that exceed this set value, as in a Class C amplifier.

- Removes all traces of AM from the received signal, improves S2N ratio, removes static crashes

Demodulator

- A demodulator is an electronic circuit used to recover the information content from the carrier wave of a signal. The term is usually used in connection with radio receivers, but there are many kinds of demodulators used in many other systems.

- Another common one is in a modem, which is a contraction of the terms modulator/demodulator.

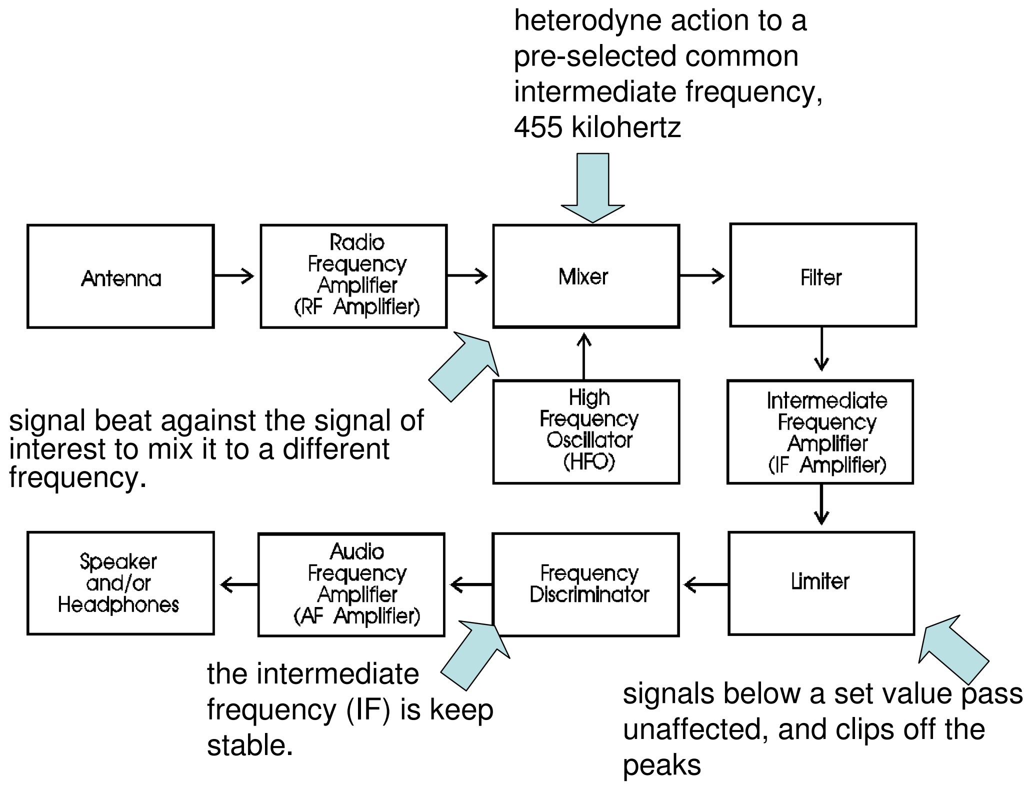
Frequency Discriminator

- The frequency discriminator controls the varicap. A varicap is used to keep the intermediate frequency (IF) stable.
- Gives our a faithful reproduction of the original audio
- Converts frequency variations to voltage variation
- varicap diode, varactor diode or tuning diode is a type of diode which has a variable capacitance
- Capacitance is a measure of the amount of electric charge stored

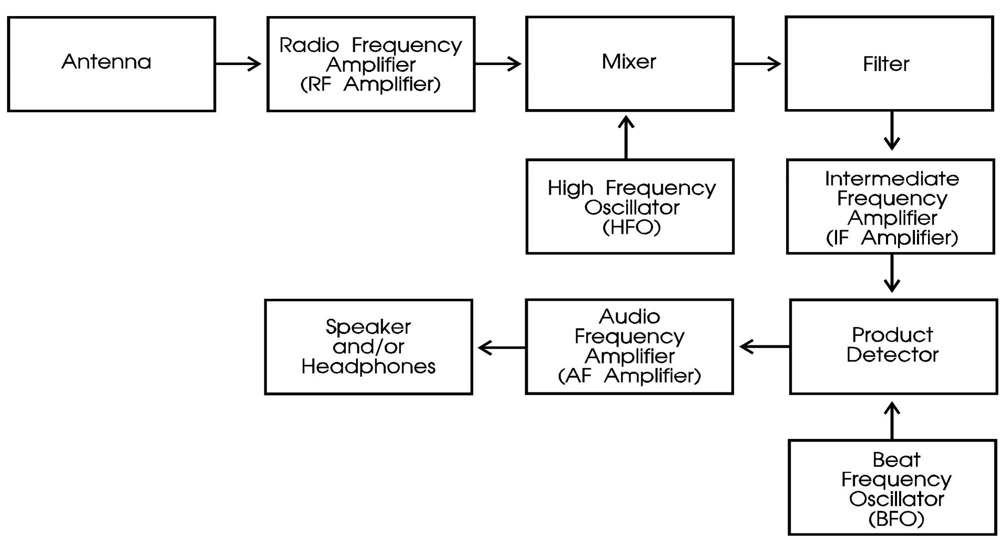
Intermediate Frequency

- **An intermediate frequency (IF) is a frequency to which a carrier frequency is shifted as an intermediate step in transmission or reception.**
- **It is the beat frequency between the signal and the local oscillator in a radio detection system.**
- **IF is also the name of a stage in a superheterodyne receiver. It is where an incoming signal is amplified before final detection is done. There may be several such stages in a superheterodyne radio receiver.**

Frequency Modulation Receiver



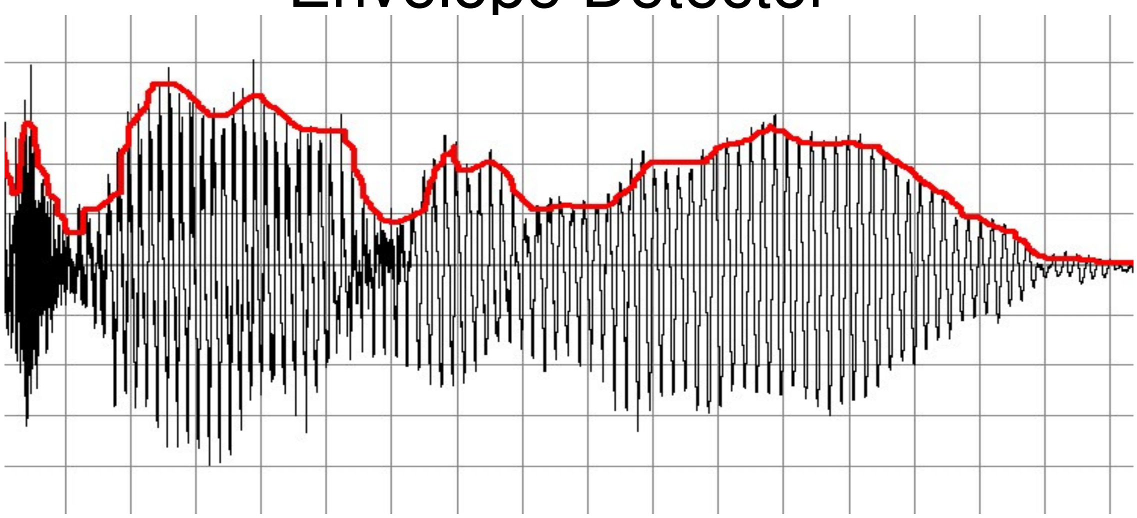
Single-Sideband and CW Receiver



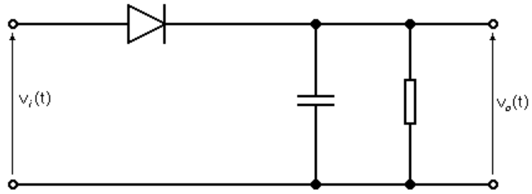
Envelope Detector

- An envelope detector is an electronic circuit that takes a high-frequency signal as input, and provides an output which is the "envelope" of the original signal.
- The capacitor in the circuit stores up charge on the rising edge, and releases it slowly through the resistor when the signal falls. The diode in series ensures current does not flow backward to the input to the circuit.
- Most practical envelope detectors use either half-wave or full-wave rectification of the signal to convert the AC audio input into a pulsed DC signal.
- Filtering is then used to smooth the final result. This filtering is rarely perfect and some "ripple" is likely to remain on the envelope follower output, particularly for low frequency inputs such as notes from a bass guitar. More filtering gives a smoother result, but decreases the responsiveness of the design, so real-world solutions are a compromise.

Envelope Detector



A signal and its envelope marked with red



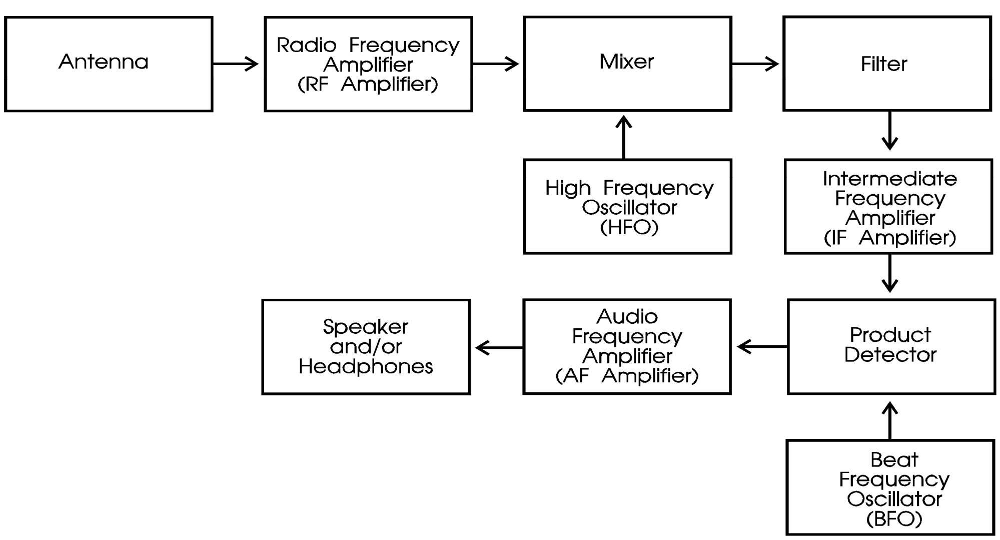
simple envelope demodulator circuit.

Product Detector

- A product detector is a type of demodulator used for AM and SSB signals. Rather than converting the envelope of the signal into the decoded waveform like an envelope detector, the product detector takes the product of the modulated signal and a local oscillator, hence the name. A product detector is a frequency mixer.

- Product detectors can be designed to accept either IF or RF frequency inputs. A product detector which accepts an IF signal would be used as a demodulator block in a superheterodyne receiver, and a detector designed for RF can be combined with an RF amplifier and a low-pass filter into a direct-conversion receiver.

Single-Sideband and CW Receiver



Receiver

- Receiver is an electronic circuit that receives its input from an antenna, uses electronic filters to separate a wanted radio signal from all other signals picked up by this antenna, amplifies it to a level suitable for further processing, and finally converts through demodulation and decoding the signal into a form usable for the consumer, such as sound, pictures, digital data, measurement values, navigational positions, etc.

Beat Frequency Oscillator or BFO

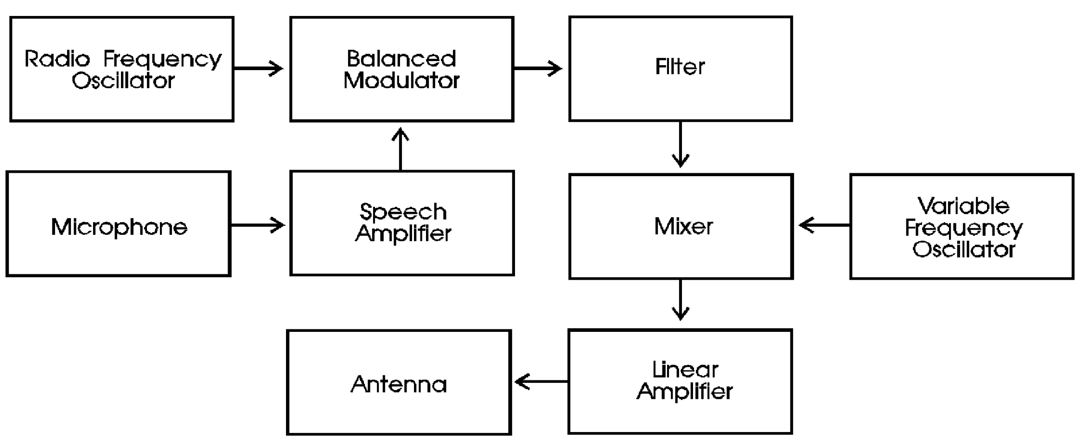
- A beat frequency oscillator or BFO in radio telegraphy, is a dedicated oscillator used to create an audio frequency signal from carrier wave transmissions to make them audible, as they are not broadcast as such.

- The signal from the BFO is then heterodyned with the intermediate frequency signal to create an audio frequency signal.

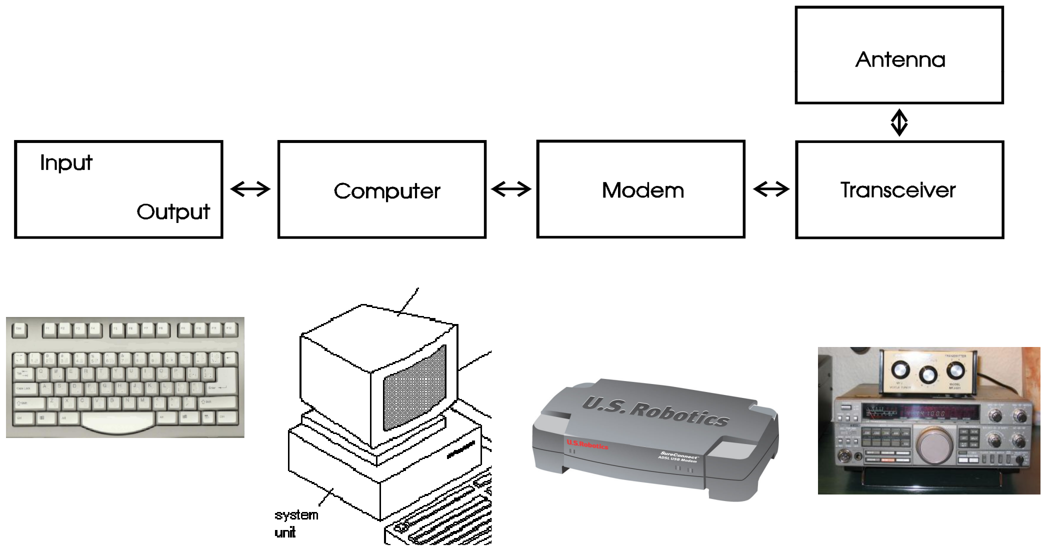
Variable Frequency Oscillator

- A variable frequency oscillator (VFO) is a component in a radio receiver or transmitter that controls the frequency to which the apparatus is tuned.
- It is a necessary component in any radio receiver or transmitter that works by the superheterodyne principle, and which can be tuned across various frequencies.

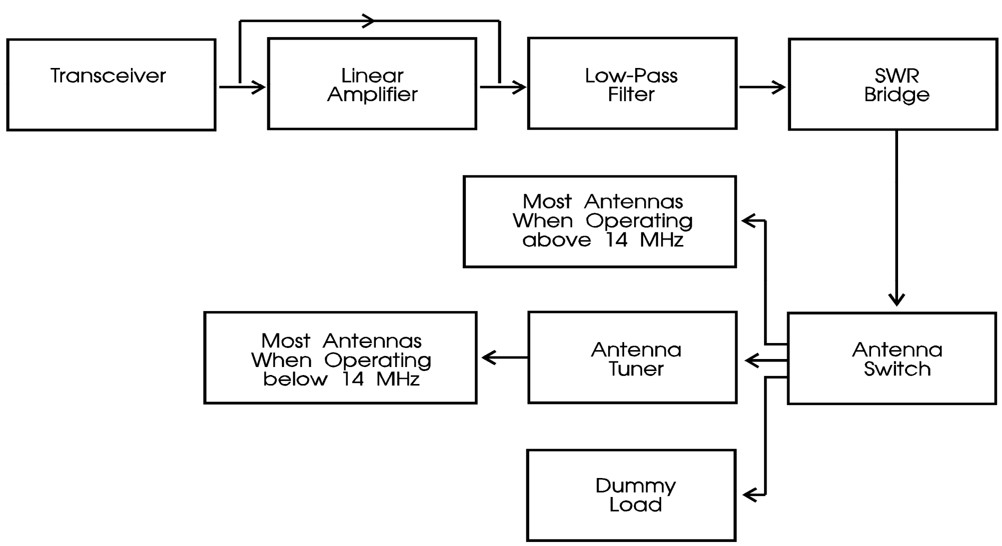
Single-Sideband Transmitter



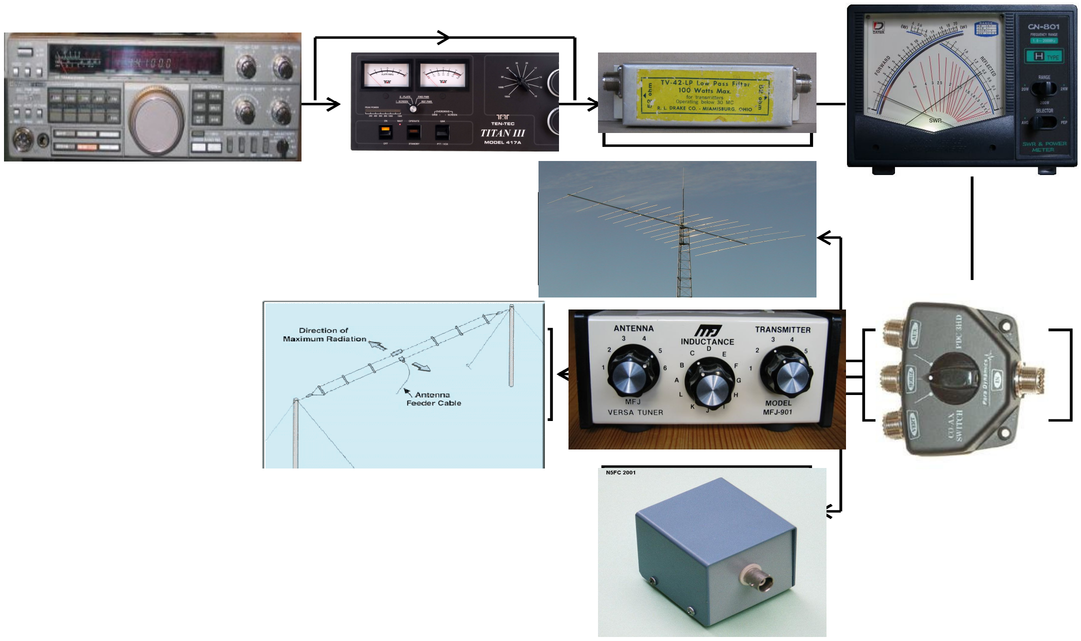
Digital System



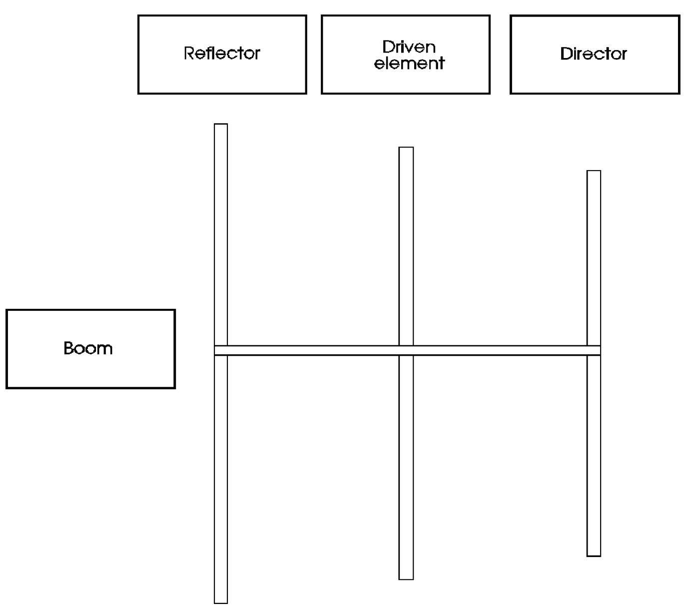
Placement of Component in a HF Station



Placement of Component in a HF Station



Yagi-Uda Three-Element Directional Antenna



SAFETY

Building and operating a “ham” radio station is a perfectly safe pastime.

- However, carelessness can lead to severe injury, burns or even death by electrocution. .
- **Antenna Safety – Look Up and Live!**

SAFETY

- **Assume all overhead power lines are energized and dangerous. They are not covered!** This includes the service drop, which typically runs from the power pole to your home or shack.
- **Look for power lines** which can be hidden by trees and buildings.
- **Plan the work and work the plan.** Before you put up or take down an antenna, assess the job; discuss the project’s activities with your helpers and agree on specific assignments. Ask yourself… “at any time can arms, legs, head, the antenna, wires or tools come in contact with power lines?”
- **Use a safety spotter.** Nobody can do the work alone and assess safety distances. A safety spotter’s *only* job it to keep people and equipment safely away from power lines.
- **Remember the 10-foot rule.** Keep all equipment, tools, your antenna, guy wire and tower at least 10 feet away from power lines.

SAFETY

- **Never use metal ladders or long-handled metal tools** when working near power lines.
- **Make sure the antenna cannot be rotated into power lines.** Or that it cannot fall into a power line if the guy wires fail and the tower falls.
- **Use non-conductive guys.**
- **Have a solid earth ground for your antenna and operating equipment.** This helps reduce the risk of electrical shock and also provides a low-impedance path to ground for stray RF.

SAFETY

- Outdoor antennas should be grounded with an approved lighting arresting device. Local codes may apply.
- The radio should also be grounded to an earth ground to help protect both the radio and its user
- Antenna mast, cable, and guy wires are all excellent conductors of electrical current.
- If the tower assembly starts to drop . . . get away from it and let it fall.
- DO NOT use hot water pipes or gas lines as a ground source.
- DO NOT place antennas where People or Animals are likely to run into or encounter
- DON"T BE AFRAID TO ASK QUESTSION OR ASK FOR ASSISTANCE

"Safety Code 6"

- The rules and guidelines covering the subject of RF Safety, are published by the Federal Government in a document entitled **"Safety Code 6"**
- Limits of Human Exposure to Radiofrequency Electromagnetic Fields in the Frequency Range from 3 KHZ to 300 GHZ - Safety Code 6

"Safety Code 6"

- **RF energy has *thermal effects* (i.e., it can cause body heating) if the power density is high enough.**
- **The thermal effects of RF energy can include blindness and sterility, among other health problems**

Good practices to follow when putting up your antenna's

- At least two people to do the job. Three is better.

- Equipment
- Safety Belt
- Safety Rope / use of it while climbing No Mold inside (twist open to inspect it) Proper Length

- Tool Pouch: Roomy, not packed full

- Clothing
- Close fitting, not sloppy, not tight
- Gloves (for protection and warmth)
- NO Sneakers, Hard Soles, Good fit

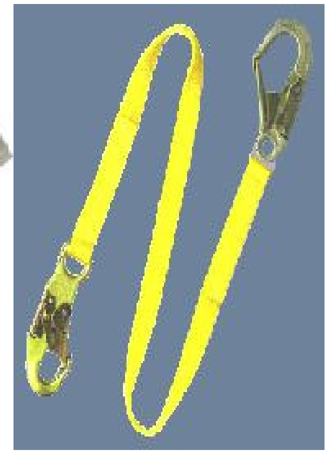
Safety belt

- For your safety it is of the uttermost importance that you borrow or buy a **safety belt**.

- This is in fact a generic term that we must divide in 2 elements : first, the leather belt, at least 5 cm wide or 2", which length is adjustable to the perimeter of the tower like an ordinary belt.

- It is independent of the security hardness (but has to be attached on it). Then you need either of a **strap snap** or a **safety belt with seat harness** that you will attach around your waist. This is a 10 cm wide (4") belt including a leather belt and some fasteners to attach various steel loops or tools.

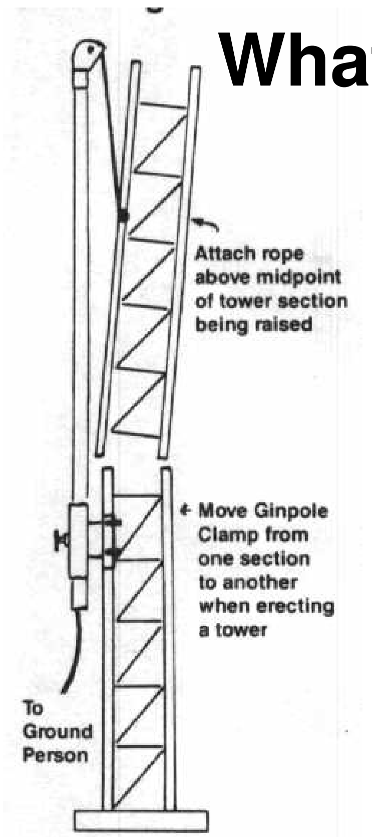
Safety belt

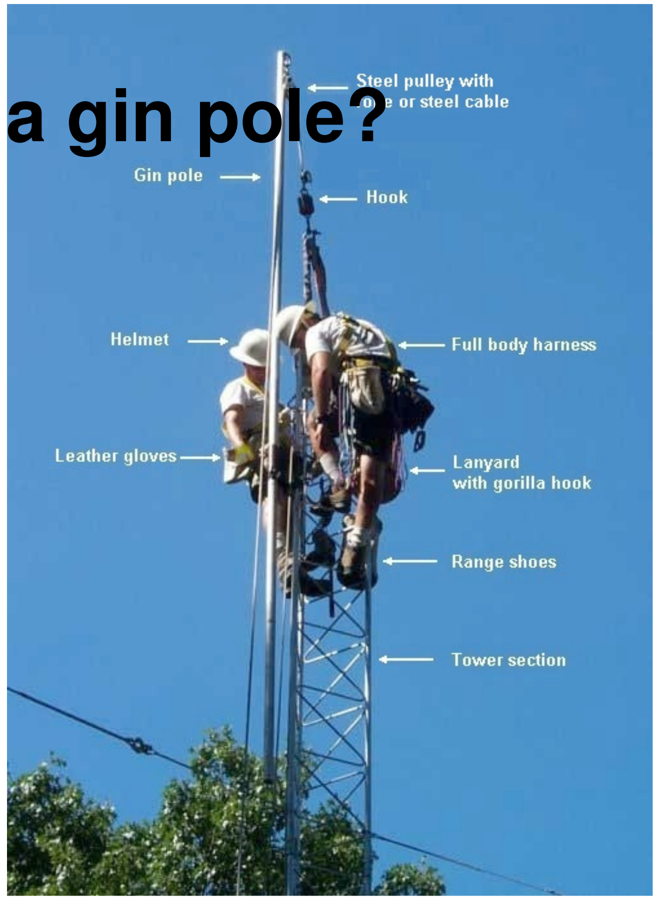
  

What is a gin pole?

- A gin pole, or raising fixture, provides this safety by giving the tower climber the needed heavy lifting ability the ground person provides.
- A gin pole consists of 3 basic parts: (1) a pulley assembly to provide mechanical advantage when lifting, (2) a pole to gain height needed for the lift, and (3) the clamp assembly to attach everything to the tower.
- Typically the ground person does the heavy lifting, while the tower person above has the freedom to guide and fasten the tower and antenna components together.
- Proper use of a gin pole provides a controllable and safe method to erect and maintain a tower and antenna assembly, use it!

What is a gin pole?





Circuit Components

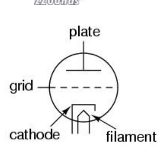
Lesson 4

4.1 Amplifier Fundamentals

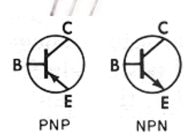
The role of a amplifier is to produce an output which is an enlarged reproduction of the features of the signal fed into the input. The increase in signal by an amplifier is called **gain.** We can amplify voltage, current, or power. **Note: Resistance IS NOT amplified by a amplifier.**

A device with gain has the property of amplification.

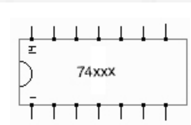
Vacuum Tube



Transistor



Integrated Circuit (IC)



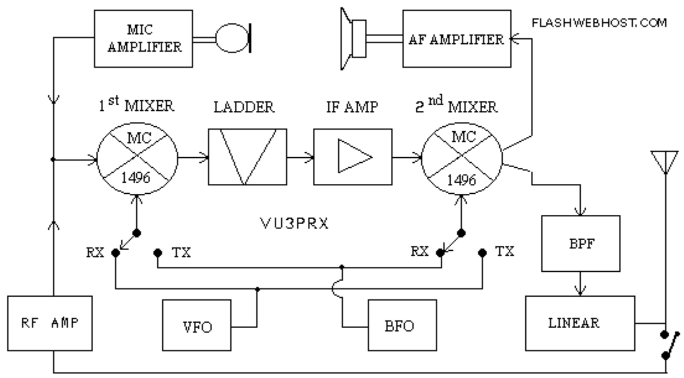
Circuit Components

Lesson 4

4.1 Amplifier Fundamentals

Audio frequency or **AF amplifiers** are used to amplify AC signals in the audio frequency spectrum, from about 20 Hz to 20 kHz.

To increase the level of very weak signals from a microphone you would use a audio (AF) amplifier.



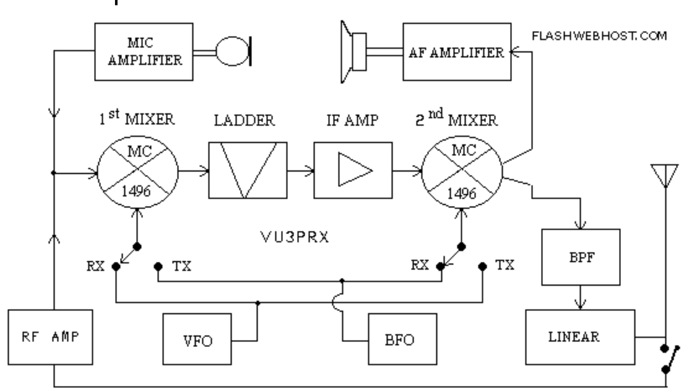
Circuit Components

Lesson 4

4.1 Amplifier Fundamentals

Radio frequency or **RF amplifiers** are used for signals above 20 kHz. You will encounter both types of amplifiers when you deal with receivers and transmitters.

To increase the level of very weak radio signals from an antenna, you would use a RF amplifier



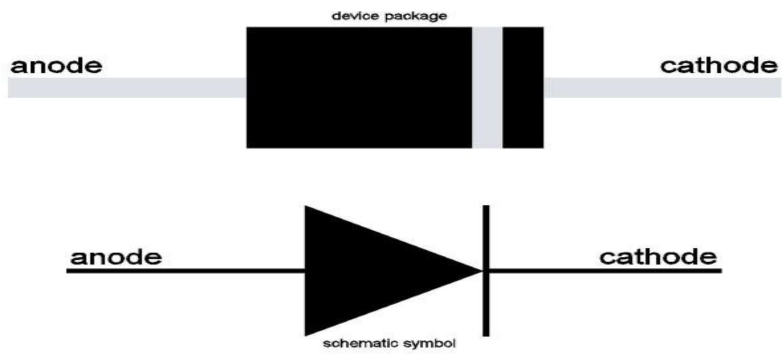
Circuit Components

Lesson 4

4.2 Diode Fundamentals

The electrodes of a semiconductor diode are known as **anode and cathode.**

In a semiconductor diode, electrons flow from **cathode to anode**. In order for a diode to conduct, it bust be **forward-biased**.



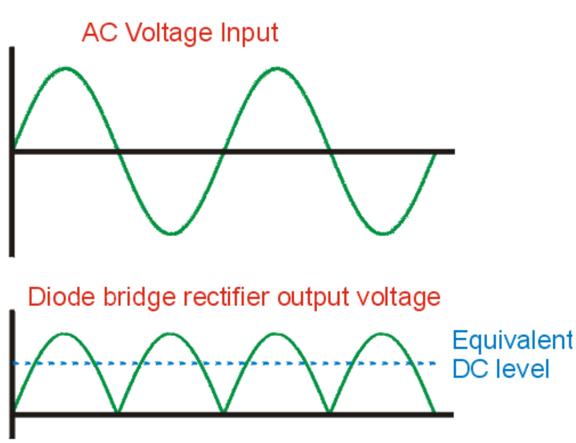
Circuit Components

Lesson 4

4.2 Diode Fundamentals

If alternating current is applied to the anode of a diode, at the cathode of the diode you would expect to see **pulsating direct current**.

The action of changing alternating current (AC) to direct current (DC) is called **rectification**.

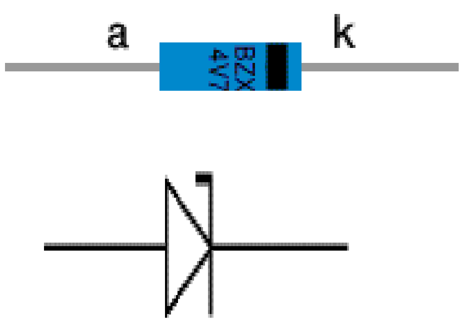


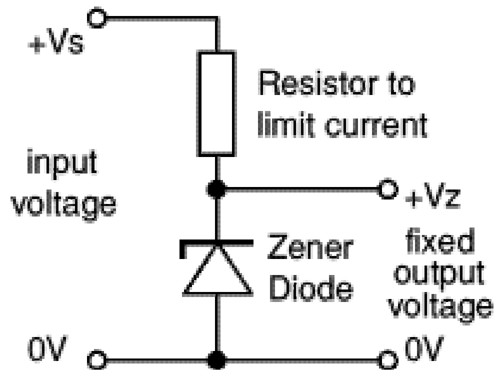
Circuit Components

Lesson 4

4.2 Diode Fundamentals

Zener diodes are used to maintain a fixed voltage. They are designed to 'breakdown' in a reliable and non-destructive way so that they can be used **in reverse** to maintain a fixed voltage across their terminals. The diagram shows how they are connected, with a resistor in series to limit the current.





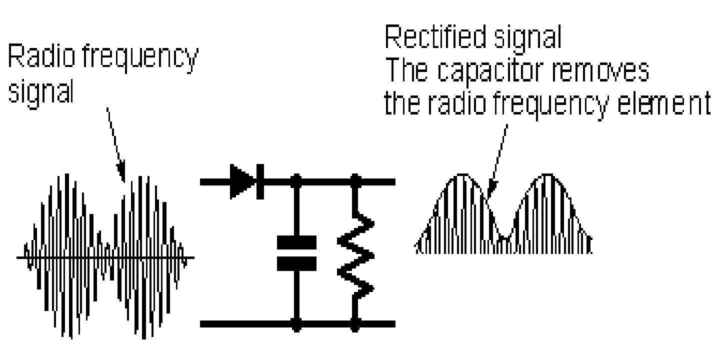
Circuit Components

Lesson 4

4.2 Diode Fundamentals

One important application for diodes is recovering information from transmitted signals. This is referred to as **demodulation.**

The AM detector or demodulator includes a capacitor at the output. Its purpose is to remove any radio frequency components of the signal at the output.

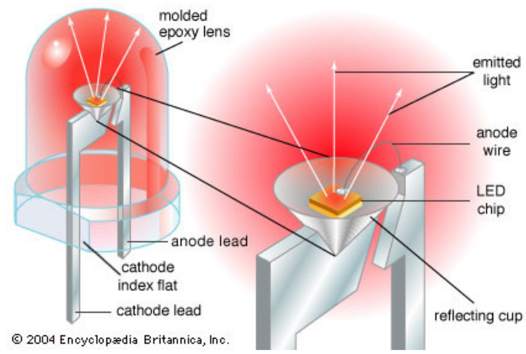


Circuit Components

Lesson 4

4.2 Diode Fundamentals

Light Emitting Diodes (LEDs) are solid-state semiconductor devices that convert electrical energy directly into light. LED "cold" generation of light leads to high efficacy because most of the energy radiates within the visible spectrum. Because LEDs are the solid-state devices, they can be extremely small and durable; they also provide longer lamp life than other sources.



LEDs are made of various semiconducting compounds, depending on the desired colour output. Infrared and red LEDs generally use a gallium, aluminum, and arsenide compound. Orange and yellow LEDs most often use gallium, aluminum, and either indium or phosphorus. Green and blue LEDs typically use either silicon and carbon, or gallium and nitrogen.

Circuit Components

Lesson 4

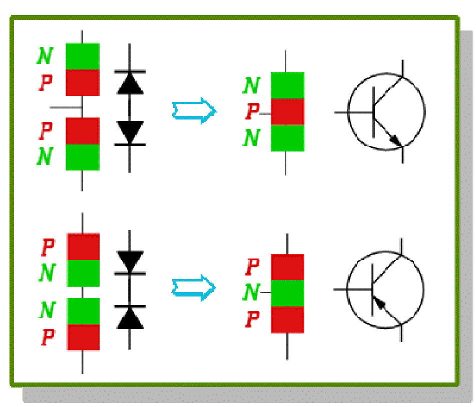
4.3 Bipolar Transistor Fundamentals

The basic semiconductor amplifying device is the **transistor**

A *Bipolar Transistor* essentially consists of a pair of *PN Junction Diodes* that are joined back-to-back.

This forms a sort of a sandwich where one kind of semiconductor is placed in between two others.

There are therefore <u>two</u> kinds of Bipolar sandwich, the ***NPN*** and ***PNP*** varieties. The three layers of the sandwich are conventionally called the ***Collector***, ***Base***, and ***Emitter***.



Circuit Components

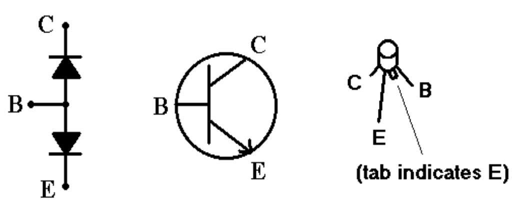
Lesson 4

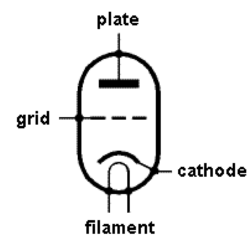
4.3 Bipolar Transistor Fundamentals

In a bipolar transistor the **base** compares closest to the **control grid** of a triode vacuum tube

In a bipolar transistor the **collector** compares closest to the **plate** of a triode vacuum tube

In a bipolar transistor the **emitter** compares closest to the **cathode** of a triode vacuum tube



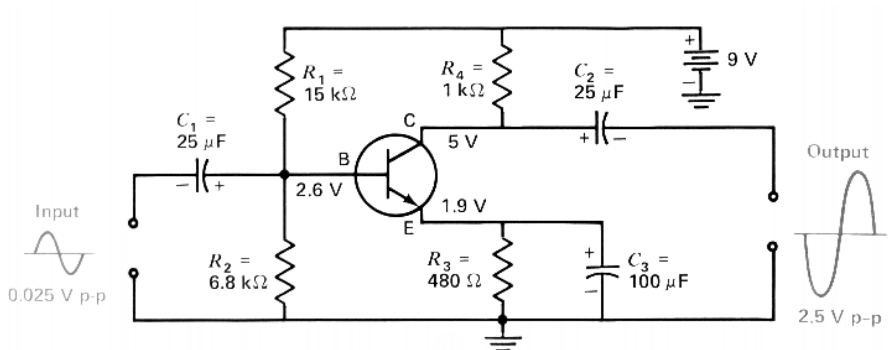


Circuit Components

Lesson 4

4.3 Bipolar Transistor Fundamentals

A **PNP transistor** can amplify a small signal using low voltages. If a low level signal is placed at the input to a transistor, a higher level of signal is produced at the output lead. This effect is known as **amplification**

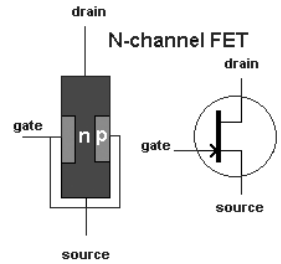


Circuit Components

Lesson 4

4.4 Field Effect Transistor Fundamentals

A field effect transistor has only two layers of semiconductor material, one on top of the other. Electricity flows through one of the layers, called the channel. A voltage connected to the other layer, called the gate, interferes with the current flowing in the channel. Thus, the voltage connected to the gate controls the strength of the current in the channel. There are two basic varieties of field effect transistors-the junction field effect transistor (JFET) and the metal oxide semiconductor field effect transistor (MOSFET).



In a field effect transistor, the **gate** controls the conductance of the channel, the **source** is where the charge carriers enter the channel and the **drain** is where the charge carriers leave the channel.

The control element in a field effect transistor is the **gate**.

Circuit Components

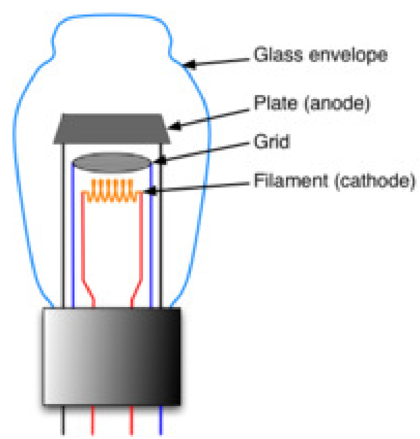
Lesson 4

4.5 Triode Vacuum Tube Fundamentals

A vacuum tube consists of arrangements of electrodes in a **vacuum** within an insulating, temperature-resistant envelope.

The electrodes are attached to leads which pass through the envelope via an air tight seal.

When hot, the filament releases electrons into the vacuum: a process called thermionic emission.



The resulting negatively-charged cloud of electrons is called a space charge. These electrons will be drawn to a metal plate inside the envelope, if the plate (also called the anode) is positively charged relative to the filament (or cathode). The result is a flow of electrons from filament to plate.

Circuit Components

Lesson 4

4.5 Triode Vacuum Tube Fundamentals

Vacuum Tube verses Transistor

- triode vacuum tube can be used instead of a transistor to handle **higher power**
- vacuum tube can amplify small signals but must use high voltages.
- both tubes and transistors can amplify signals

In a vacuum tube;
- the electrode that is operated at the highest positive potential is the **plate**.
- the electrode that us usually a cylinder of wire mesh is the **grid.**
- the electrode that is farthest away from the plate is the **filament**.
- the electrode that emits electrons is the **cathode.**

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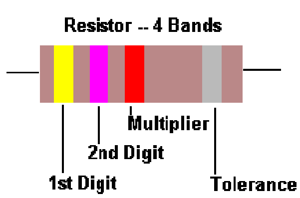
Circuit Components

Lesson 4

4.6 Resistor Colour Codes, Tolerances



Band Color	Digit	Multiplier	Tolerance
Black	0	1	---
Brown	1	10	±1%
Red	2	100	±2%
Orange	3	1,000	±3%
Yellow	4	10,000	±4%
Green	5	100,000	---
Blue	6	1,000,000	---
Violet	7	10,000,000	---
Gray	8	100,000,000	---
White	9	---	---
Gold	---	0.1	±5%
Silver	---	0.01	±10%
None	---	---	±20%

0	1	2	3	4	5	6	7	8	9
Bad	**Booze**	**Rots**	**Our**	**Young**	**Guts**	**But**	**Vodka**	**Goes**	**Well**
Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White

Circuit Components

Lesson 4

4.6 Resistor Colour Codes, Tolerances, Temperature Coefficient

The color code chart is applicable to most of the common four band and five band resistors. Five band resistors are usually precision resistors with tolerances of 1% and 2%. Most of the four band resistors have tolerances of 5%, 10% and 20%.

The color codes of a resistor are read from left to right, with the tolerance band oriented to the right side. Match the color of the first band to its associated number under the digit column in the color chart. This is the first digit of the resistance value. Match the second band to its associated color under the digit column in the color chart to get the second digit of the resistance value.

Match the color band preceding the tolerance band (last band) to its associated number under the multiplier column on the chart. This number is the multiplier for the quantity previously indicated by the first two digits (four band resistor) or the first three digits (five band resistor) and is used to determine the total marked value of the resistor in ohms.

Circuit Components

Lesson 4

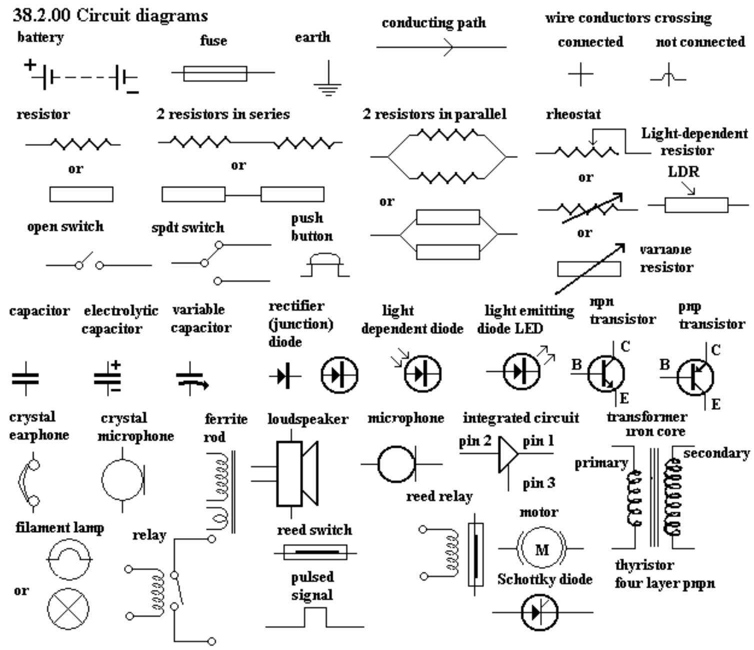
4.6 Resistor Colour Codes, Tolerances, Temperature Coefficient

To determine the resistor's tolerance or possible variation in resistance from that indicated by the color bands, match the color of the last band to its associated number under the tolerance column. Multiply the total resistance value by this percentage.

For example, the first resistor shown at the top of this page has a resistance of (47 X 100) = 4700 ohms. The tolerance is plus or minus (10% X 4700) = plus or minus 470 ohms. The second resistor has a resistance of (470 X 1) = 470 ohms. The tolerance is plus or minus (2% X 470) = plus or minus 9.4 ohms.

Circuit Components

Lesson 4



Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes

Metric prefixes you'll need to know ...

1 Giga (G) = 1 billion = 1,000,000,000
1 Mega (M) = 1 million = 1,000,000
1 kilo (k) = 1 thousand = 1,000
1 centi (c) = 1 one-hundredth = 0.01
1 milli (m) = 1 one-thousandth = 0.001
1 micro (u) = 1 one-millionth = 0.000001
1 pico (p) = 1 one-trillionth = 0.000000000001

... and a few you might want to know ...

1 Tera (T) = 1trillion = 1,000,000,000,000
1 hecto (h) = ten = 10
1 deci (d) = 1 tenth = 0.1
1 nano (n) = 1 one-billionth = 0.000000001

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes

The prefix enables us to reduce the amount of zeros that are used in writing out large numbers.

For example... instead of saying that the frequency of my signal is 1,000,000 Hz (Hertz or cycles per second) I can say that it is 1,000 kilohertz (kHz) or even 1 Megahertz (MHz). The prefix enables us to write the number in a shorter form. This especially becomes useful when we need to measure VERY large or VERY small numbers.

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes Mega- (one million; 1,000,000)

Just to make certain that this stuff makes sense, lets go back and look at large frequencies again.

1,000 Hz = 1 kHz
"One thousand Hertz equals one kilohertz"
1,000,000 Hz = 1 Mhz

"One million Hertz equal one megahertz"
So how many kilohertz are in one megahertz? 1000 kHz = 1 MHz
"One thousand kilohertz equals one megahertz"

So if your radio was tuned to 7125 kHz, how would you express that same frequency in megahertz?

1000 kHz = 1 MHz || 7125 kHz = 7.125 MHz

(It takes 1000 kilohertz to equal 1 megahertz, so 7125 kilohertz would equal 7.125 megahertz.)

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes Mega- (one million; 1,000,000)

Lets do another frequency problem. This time, your dial reads 3525 kHz. What is the same frequency when expressed in Hertz? This should be simple...

1 kHz = 1000 Hz || 3525 kHz = 3,525,000 Hz

(Notice that since we have to add three zeros to go from 1 kHz to 1000 Hz, we must also do the same to go from 3525 kHz to 3,525,000 Hz.)

Now, let's work another frequency problem, except we're going to do it backwards. Your displays shows a frequency of 3.525 MHz. What is that same frequency in kilohertz?

1 MHz = 1000 kHz || 3.525 MHz = 3525 kHz

(See how the 1 became 1000? To go from megahertz to kilohertz, you multiply by 1000. Try multiplying 3.525 MHz by 1000 to get your frequency in kilohertz.)

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes   Giga- (one billion; 1,000,000,000)

Now we're going to deal with an even larger frequency. Remember, kilo equals one thousand, and mega equals one million. What equals one billion? There is a prefix for one billion - Giga. One billion Hertz is one gigahertz (GHz). What if you were transmitting on 1.265 GHz? What would your frequency be in megahertz? How many millions equals one billion? 1 billion is 1000 millions, so 1 gigahertz (GHz) is 1000 megahertz (MHz).

1 GHz = 1000 MHz || 1.265 GHz = 1265 MHz

As you begin to see how these metric prefixes relate to each other, it will become easier to express these large and small numbers commonly used in radio and electronics.

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes Milli- (one one-thousandth; 0.001)

If you were to take an ammeter (a meter that measures current) marked in amperes and measure a 3,000 milliampere current, what would your ammeter read?

First, what does milli- mean? Milli might be familiar to those of you who were already familiar with the ever popular centimeter.

The millimeter is the next smallest measurement. There are 100 centimeters in 1 meter... there are also 1000 millimeters in 1 meter.

So milli must mean 1 one-thousandth.

If your circuit has 3,000 milliamps (mA), how many amps (A) is that?

1,000 mA = 1 A || 3,000 mA = 3 A

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes

Now lets say, on a different circuit, you were using a voltmeter marked in volts (V), and you were measuring a voltage of 3,500 millivolts (mV). How many volts would your meter read?

1,000 mV = 1 V || 3,500 mV = 3.5 V

How about one of those new pocket sized, micro handheld radio you're itching to buy once you get your license? One manufacturer says that their radio puts out 500 milliwatts (mW) , while the other manufacturer's radio will put out 250 milliwatts (mW). How many watts (W) do these radios really put out?

1000 mW = 1 W || 500 mW = 0.5 W

1000 mW = 1 W || 250 mW = 0.25 W

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes Pico- (one one-trillionth; 0.000000000001)

Capacitors are devices that usually have very small values. A one farad capacitor is seldom ever used in commercial electronics (however I understand that they are sometimes used when a lot of stored up energy is needed for an instant).

Usually, your run of the mill capacitor will have a value of 1 thousandth of a farad to 1 trillionth of a farad.

This is the other end of the scale compared with kilo, mega, and giga. Now we'll learn about micro and pico.

If you had a capacitor which had a value of 500,000 microfarads, how many farads would that be?

Since it takes one million microfarads to equal one farad...

1,000,000 uF = 1 F || 500,000 uF = 0.5 F

Basic Electronics & Theory

Lesson 5

5.1 Metric Prefixes   Pico- (one one-trillionth; 0.000000000001)

What if we had a capacitor with a value of 1,000,000 picofarads? Pico is a very, very small number, so to have 1 million pico farads is saying that the value is just very small instead of very, very small. One picofarad is one trillionth of a farad. One picofarad is also one millionth of a microfarad. So it takes one million picofarads (pF) to equal one microfarad (uF)...

1,000,000 pF = 1 uF

By the way, just so you get a grasp of just how small a picofarad really is, remember, it would take one trillion (i.e. one million-million) picofarads (pF) to equal one farad (F), or...

1,000,000,000,000 pF = 1 F

Basic Electronics & Theory

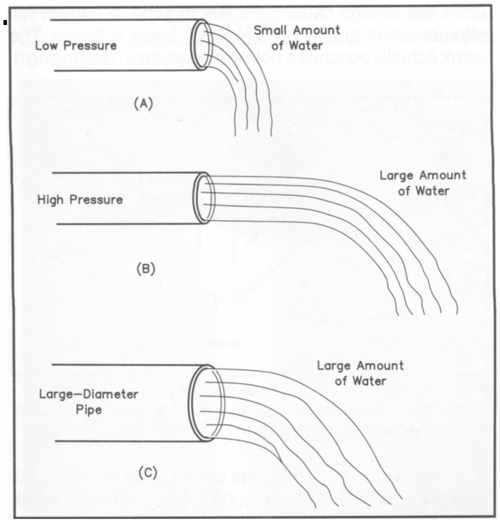
Lesson 5

5.2 Concepts of Current, Voltage, Conductor, Insulator, Resistance Current

Water flowing through a hose is a good way to imagine electricity **Water** is like **Electrons** in a wire (flowing electrons are called **Current**)

Pressure is the force pushing water through a hose – **Voltage** is the force pushing electrons through a wire

Friction against the holes walls slows the flow of water – **Resistance** is an impediment that slows the flow of electrons



Basic Electronics & Theory

Lesson 5

- There are 2 types of current
  - The form is determined by the directions the current flows through a conductor
- **Direct Current** (**DC**)
  - Flows in only one direction from negative toward positive pole of source
- **Alternating Current** (**AC**)
  - Flows back and forth because the poles of the source alternate between positive and negative

Basic Electronics & Theory

Lesson 5

5.2 Concepts of Current, Voltage, Conductor, Insulator, Resistance

Conductors and Insulators

There are some materials that electricity flows through easily. These materials are called conductors. Most conductors are metals.

Four good electrical conductors are gold, silver, aluminum and copper.

Insulators are materials that do not let electricity flow through them.

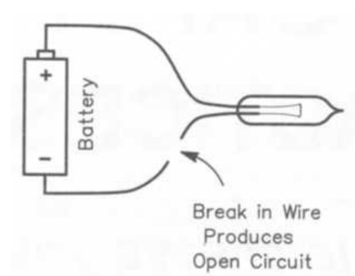
Four good insulators are glass, air, plastic, and porcelain.

Basic Electronics & Theory

Lesson 5

5.3 Concepts of Energy & Power, Open & Short Circuits

The Open Circuit



The open circuit is a very basic circuit that we should all be very familiar with. It is the circuit in which no current flows because there is an open in the circuit that does not allow current to flow. A good example is a light switch. When the light is turned off, the switch creates an opening in the circuit, and current can no longer flow.

You probably figured that since there are "open circuits" that there are probably also "closed circuits". Well, a closed circuit is when the switch is closed and current is allowed to flow through the circuit.

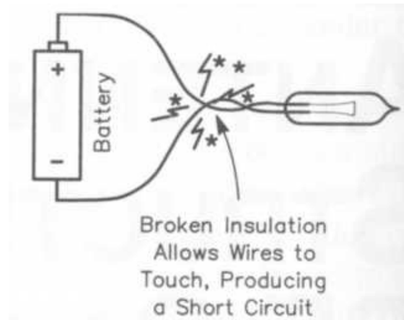
A fuse is a device that is used to create an open circuit when too much current is flowing.

Basic Electronics & Theory

Lesson 5

5.3 Concepts of Energy & Power, Open & Short Circuits

The Short Circuit

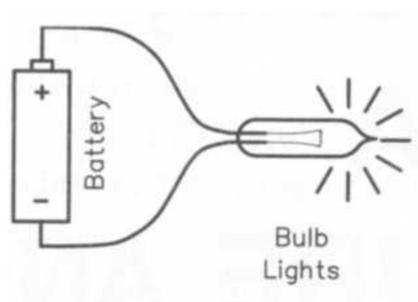


A short circuit can be caused by incoming power wires (wires that are normally insulated and kept separate) coming in contact with each other. Since a circuit usually has resistance, and the power wires that "short out" have very little resistance, the current will tend to flow through the path of least resistance... the short. Less resistance at the same amount of voltage will result in more current to flow.

Therefore a short circuit will have too much current flowing through it. What's the best way to stop a short circuit from doing damage (because it is drawing too much power from the source)? By using a fuse. Fuses are designed to work up to a certain amount of current (e.g. 1 amp, 15 amps, ...). When that maximum current is exceeded, then the wire within the fuse burns up from the heat of the current flow. With the fuse burnt up, there is now an "open circuit" and no more current flows.

5.3 Concepts of Energy & Power, Open & Short Circuits

Power



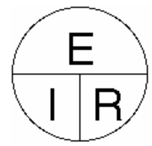
Every circuit uses a certain amount of power. Power describes how fast electrical energy is used. A good example is the light bulbs used in each circuit of your home. When you turn on a light bulb, light (and heat) are produced. This is because of the current flowing through a resistor built into the bulb. The resistance turns the electrical power into primarily heat, and secondarily light (assuming an incandescent bulb).

Each light bulb is rated at a certain power rating. This is how much power the bulb will use in a normal 110 Volt house circuit. Three of the most popular power values for inside light bulbs are 60, 75, and 100 Watts (Power is measured in Watts). Which of these light bulbs uses the most power? The 100 Watt bulb uses the most power.

Basic Electronics & Theory

- **5.4 Ohm's Law**

- E = electromotive force (a.k.a. Voltage)
- I = *intensity* (French term for Current)
- R = resistance



- **Voltage:** E = I x R *(Volts)*
- **Current:** I = E / R *(Amps)*
- **Resistance:** R = E / I *(Ohms)*

Basic Electronics & Theory

Lesson 5

5.4 Ohm's Law **Calculating Voltage and Current and Resistance**

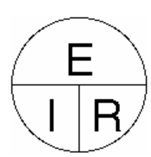
Current?

There is a very easy way to determine how much current will flow through a circuit when the voltage and resistance is known. This relationship is expressed in a simple equation (don't let the word scare you... this is going to be easy as "pie"...

Let's start with the "pie"...

This circle will help you to know how to figure out the answer to these electrical problems. The three letters stand for...

E = electromotive force (a.k.a. Voltage)
I = *intensity* (French term for Current)
R = resistance



Basic Electronics & Theory

Lesson 5

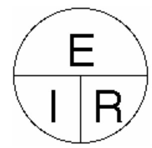
5.4 Ohm’s Law   Calculating Voltage and Current and Resistance

Current?

Lets say you have 200Volts hooked up to a circuit with 100 Ohms of resistance. How much current would flow?

Since our "unknown" value in this problem is the current, then we put our finger over the "I". What you see is "E over R". This means you take the Voltage and divide it by the Resistance. This is 200 Volts divided by 100 Ohms. The result is 2 Amps.

E = electromotive force (a.k.a. Voltage)
I = *intensity* (French term for Current)
R = resistance



Basic Electronics & Theory

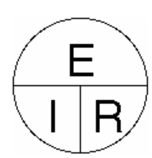
Lesson 5

5.4 Ohm’s Law   Calculating Voltage and Current and Resistance

Voltage?

What if we wanted to find out the voltage in a circuit when we know the current and resistance? Go back to the "pie" and cover up the E. You're now left with I times R. How much voltage would you need in a circuit with 50 ohms and 2 amps? E=IxR... E=2x50... E=100 Volts.

E = electromotive force (a.k.a. Voltage)
I = *intensity* (French term for Current)
R = resistance



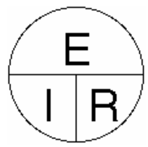
Basic Electronics & Theory

Lesson 5

5.4 Ohm's Law **Calculating Voltage and Current and Resistance**

Resistance?

Finally, if you had a circuit with 90 Volts and 3 amps, and you needed to find the resistance, you could cover up the R... the result is E over I (Volts divided by Current). R=E/I... R=90/3... R=30 Ohms. This circuit would have 30 Ohms of resistance if it was hooked up to 90 Volts and 3 amps flowed through the circuit.



Ohm's Law

This relationship between voltage, current, and resistance is known as Ohm's Law. This is in honour of the man who discovered this direct relationship (his last name was Ohm). The relationship described in Ohm's Law is used when working with almost any electronic circuit.

Basic Electronics & Theory

Memorizing Ohm's law

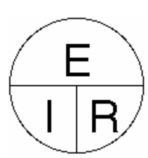
Memorizing Ohm's law may sound like a time consuming and daunting task, but if remember this little story you'll have it committed to memory for life within a few minutes!

An old Indian was walking across the plains one day and he saw an eagle soaring high in the sky over a rabbit.

Now, picture things from the Indian's stand point - he sees the Eagle flying over the Rabbit:

Say to yourself Indian equals Eagle over Rabbit.

Now just use the first letter of each word: I = E over R, which is this formula:



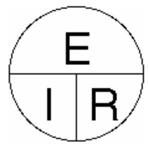
Voltage: E = I x R *(Volts)*
Current: I = E / R *(Amps)*
Resistance: R = E / I *(Ohms)*

Basic Electronics & Theory

Memorizing Ohm's law

However, from the Rabbit's point of view, he sees things a little differently. The Rabbit looks out and sees the Eagle flying over the Indian.

Say to yourself Rabbit equals Eagle over Indian.
Now just use the first letter of each word: R = E over I, which is this formula:



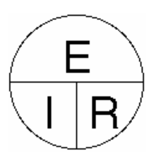
Voltage: E = I x R *(Volts)*
Current: I = E / R *(Amps)*
Resistance: R = E / I *(Ohms)*

Basic Electronics & Theory

Memorizing Ohm's law

Finally, the Eagle up in the sky sees both the Indian and the Rabbit standing on the ground together.

Say to yourself Eagle equals Indian and Rabbit together.
Now just use the first letter of each word: E = IxR, which is this formula:



Voltage: E = I x R *(Volts)*
Current: I = E / R *(Amps)*
Resistance: R = E / I *(Ohms)*

Now if you simply remember the story of the Indian, Eagle and Rabbit, you will have memorized all three formulae!

Basic Electronics & Theory

Memorizing Ohm's law

So now we have 3 different ways that we can algebraically express Ohm's Law.

$$E = I \times R \quad \text{or} \quad I = \frac{E}{R} \quad \text{or} \quad R = \frac{E}{I}$$

Voltage: E = I x R *(Volts)*
Current: I = E / R *(Amps)*
Resistance: R = E / I *(Ohms)*

But of what significance is it? Here is the gist of it. If we know 2 out of the 3 factors of the equation, we can figure out the third. Let's say we know we have a 3 Volt battery. We also know we are going to put a 100 W resistor in circuit with it. How much current can we expect will flow through the circuit?

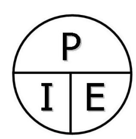
Without Ohm's Law, we would be at a loss. But because we have Ohm's Law, we can calculate the unknown current, based upon the Voltage and Resistance.

$$I = \frac{3 \text{ Volts}}{100\ \Omega} = .03 \text{ Amperes}$$

Basic Electronics & Theory

Lesson 5

Power calculations



- The unit used to describe electrical *power* is the **Watt.**

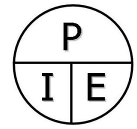
- The formula: Power (P) equals voltage (E) multiplied by current (I).

P = I x E

Basic Electronics & Theory

Lesson 5

- **Power calculations** **(cont)**



  - How much power is represented by a voltage of 13.8 volts DC and a current of 10 amperes.
    - **P = I x E**   P = 10 x 13.8 = ***138 watts***

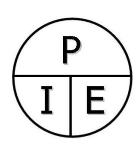
  - How much power is being used in a circuit when the voltage is 120 volts DC and the current is 2.5 amperes.
    - **P = I x E**   P = 2.5 x 120 = ***300 watts***

Basic Electronics & Theory

Lesson 5

- **Power calculations** **(cont)**
  - You can you determine how many watts are being drawn [consumed] by your transceiver when you are transmitting by measuring the DC voltage **at** the transceiver and multiplying by the current drawn when you transmit.

  - How many amperes is flowing in a circuit when the applied voltage is 120 volts DC and the load is 1200 watts.
    - **I = P/E**   I = 1200/120 = ***10 amperes***.



Basic Electronics & Theory

Memorizing Ohm's law

Power Formula P= I x E

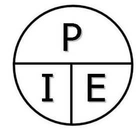
Lets try some examples we are familiar with;

P= 60 watt light bulb
E=120 volts
I= .5 amps

P=100 watt light bulb
E=120 volts
I=.83 amps

Electric Kettle consumes
P=900 watts
E=120 volts
I= 7.5 amps

Electric Toaster
P= 1200 watts
E=120 volts
I=10 amps



Power: P = I x E *(Watts)*
Current: I = P / E *(Amps)*
Voltage: E = P/ I *(Volts)*

E = Electromotive Force aka Volts
I = Intensity aka Current

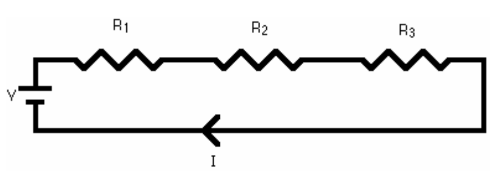
Basic Electronics & Theory

Lesson 5

5.5 Series & Parallel Resistors

Series circuits

A series circuit is a circuit in which resistors are arranged in a chain, so the current has only one path to take. The current is the same through each resistor. The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors: equivalent resistance of resistors in series : **R = R1 + R2 + R3 +** ...

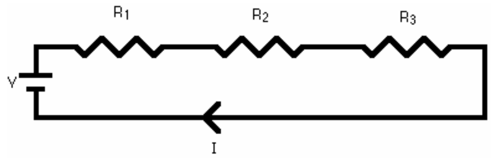


Basic Electronics & Theory

Lesson 5

5.5 Series & Parallel Resistors

Series circuits



A series circuit is shown in the diagram above. The current flows through each resistor in turn. If the values of the three resistors are:

$R_1 = 8\,\Omega$, $R_2 = 8\,\Omega$, and $R_3 = 4\,\Omega$, the total resistance is $8 + 8 + 4 = 20\,\Omega$.

With a 10 V battery, by V = I R the total current in the circuit is:
I = V / R = 10 / 20 = 0.5 A. The current through each resistor would be 0.5 A.

Basic Electronics & Theory

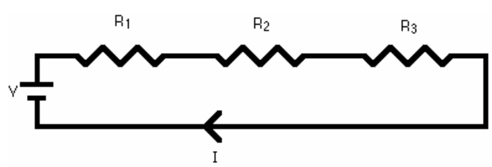
Lesson 5

5.5 Series & Parallel Resistors

Series circuits

R = R1 + R2 + R3 + ...

R1=100 ohms
R2=150 ohms
R3=370 ohms
RT= ? ohms



Basic Electronics & Theory

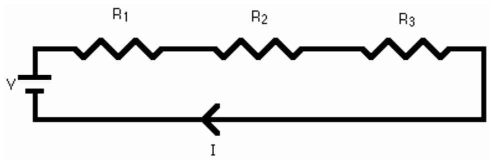
Lesson 5

5.5 Series & Parallel Resistors

Series circuits

R = R1 + R2 + R3 + ...

R1=100 ohms
R2=150 ohms
R3=370 ohms
RT= 620 ohms



Basic Electronics & Theory

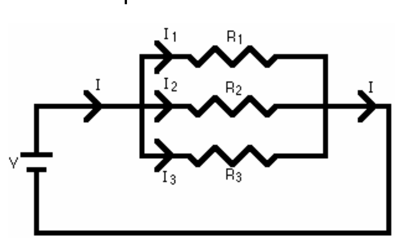
Lesson 5

5.5 Series & Parallel Resistors

Parallel circuits

A parallel circuit is a circuit in which the resistors are arranged with their heads connected together, and their tails connected together. The current in a parallel circuit breaks up, with some flowing along each parallel branch and re-combining when the branches meet again. The voltage across each resistor in parallel is the same.

The total resistance of a set of resistors in parallel is found by adding up the reciprocals of the resistance values, and then taking the reciprocal of the total: equivalent resistance of resistors in parallel: 1 / R = 1 / R1 + 1 / R2 + 1 / R3 +...



Basic Electronics & Theory

Lesson 5

5.5 Series & Parallel Resistors

Parallel circuits

A parallel circuit is shown in the diagram above. In this case the current supplied by the battery splits up, and the amount going through each resistor depends on the resistance. If the values of the three resistors are:

$R_1 = 8\ \Omega$, $R_2 = 8\ \Omega$, and $R_3 = 4\ \Omega$, the total resistance is found by:

$1 / R = 1 / 8 + 1 / 8 + 1 / 4 = 1 / 2$. This gives $R = 2\ \Omega$.

With a 10 V battery, by V = I R the total current in the circuit is: I = V / R = 10 / 2 = 5 A.

The individual currents can also be found using I = V / R. The voltage across each resistor is 10 V, so:
I1 = 10 / 8 = 1.25 A
I2 = 10 / 8 = 1.25 A
I3=10 / 4 = 2.5 A

Note that the currents add together to 5A, the total current.

Basic Electronics & Theory

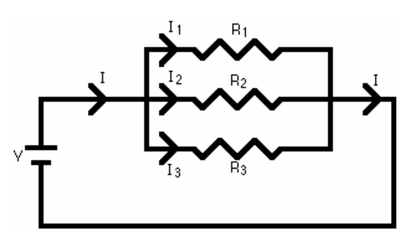
Lesson 5

5.5 Series & Parallel Resistors

Parallel circuits

1 / R = 1 / R1 + 1 / R2 + 1 / R3 +...

R1=100 ohms
R2=100 ohms
R3=100 ohms
RT= ? Ohms



Basic Electronics & Theory

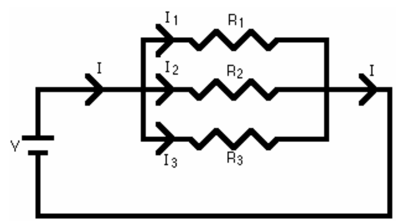
Lesson 5

5.5 Series & Parallel Resistors

Parallel circuits

1 / R = 1 / R1 + 1 / R2 + 1 / R3 +...

R1=100 ohms
R2=100 ohms
R3=100 ohms
RT= ? Ohms



1/100 + 1/100 + 1/100 =

.01 + 01 + .01 = .03

1/.03= 33.33 ohms

Basic Electronics & Theory

Lesson 5

5.5 Series & Parallel Resistors

A parallel resistor short-cut

If the resistors in parallel are identical, it can be very easy to work out the equivalent resistance. In this case the equivalent resistance of N identical resistors is the resistance of one resistor divided by N, the number of resistors. So, two 40-ohm resistors in parallel are equivalent to one 20-ohm resistor; five 50-ohm resistors in parallel are equivalent to one 10-ohm resistor, etc.

When calculating the equivalent resistance of a set of parallel resistors, people often forget to flip the 1/R upside down, putting 1/5 of an ohm instead of 5 ohms, for instance. Here's a way to check your answer. If you have two or more resistors in parallel, look for the one with the smallest resistance. The equivalent resistance will always be between the smallest resistance divided by the number of resistors, and the smallest resistance. Here's an example.

You have three resistors in parallel, with values 6 ohms, 9 ohms, and 18 ohms. The smallest resistance is 6 ohms, so the equivalent resistance must be between 2 ohms and 6 ohms (2 = 6 /3, where 3 is the number of resistors).

Doing the calculation gives 1/6 + 1/12 + 1/18 = 6/18. Flipping this upside down gives 18/6 = 3 ohms, which is certainly between 2 and 6.

Basic Electronics & Theory

Lesson 5

5.5 Series & Parallel Resistors

Circuits with series and parallel components

Many circuits have a combination of series and parallel resistors. Generally, the total resistance in a circuit like this is found by reducing the different series and parallel combinations step-by step to end up with a single equivalent resistance for the circuit. This allows the current to be determined easily. The current flowing through each resistor can then be found by undoing the reduction process.

General rules for doing the reduction process include:
Two (or more) resistors with their heads directly connected together and their tails directly connected together are in parallel, and they can be reduced to one resistor using the equivalent resistance equation for resistors in parallel.

Two resistors connected together so that the tail of one is connected to the head of the next, with no other path for the current to take along the line connecting them, are in series and can be reduced to one equivalent resistor.

Finally, remember that for resistors in series, the current is the same for each resistor, and for resistors in parallel, the voltage is the same for each one

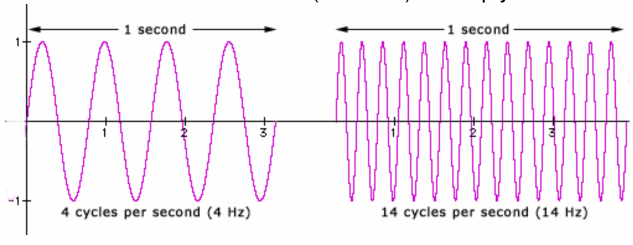
Basic Electronics & Theory

Lesson 5

5.7 AC, Sinewave, Frequency, Frequency Units

What is frequency?

The number of cycles per unit of time is called the **frequency**. For convenience, frequency is most often measured in **cycles per second (cps)** or the interchangeable **Hertz (Hz)** (60 cps = 60 Hz), 1000 Hz is often referred to as 1 kHz (kilohertz) or simply '1k' in studio parlance.

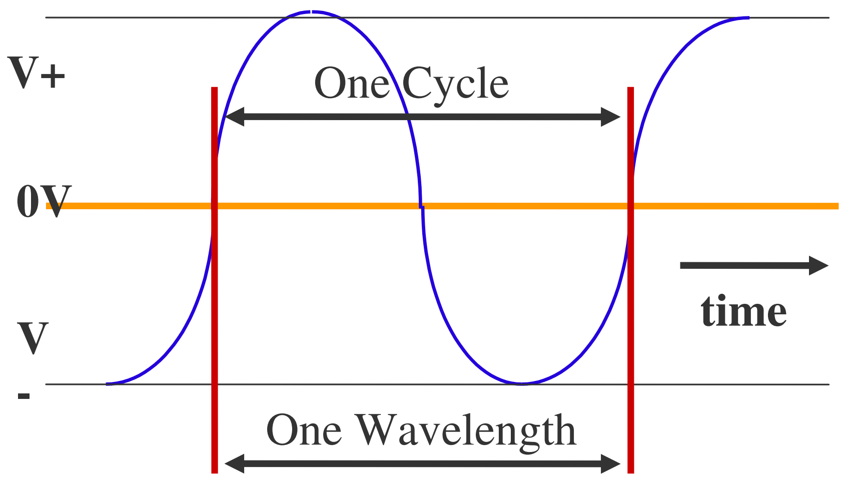


The range of human hearing in the young is approximately 20 Hz to 20 kHz—the higher number tends to decrease with age (as do many other things). It may be quite normal for a 60-year-old to hear a maximum of 16,000 Hz.

We call signals in the range of 20 Hz to 20,000 Hz audio frequencies because the human ear can sense sounds in this range

The Relationship of Frequency and Wavelength

The distance a radio wave travels in one cycle is called wavelength.



Basic Electronics & Theory

Lesson 5

Names of frequency ranges, types of waves

- Voice frequencies are ***Sound waves*** in the range between 300 and 3000 Hertz.

- *Electromagnetic waves* that oscillate more than 20,000 times per second as they travel through space are generally referred to as ***Radio waves***.

Basic Electronics & Theory

Lesson 5

Relationship between frequency and wavelength

- Frequency describes number of times AC flows back and forth per second
- Wavelength is distance a radio wave travels during one complete cycle
- The wavelength gets shorter as the frequency increases.
- Wavelength in meters equals 300 divided by frequency in megahertz.
- A radio wave travels through space at the speed of light.

Basic Electronics & Theory

Lesson 5

Identification of bands

The property of a radio wave often used to *identify* the different *bands* amateur radio operators use is the *physical length* of the wave.

The frequency range of the **2-meter band** in Canada is **144 to 148 MHz**.

The frequency range of the **6-meter band** in Canada is **50 to 54 MHz**.

The frequency range of the **70-centimeter band** in Canada is **420 to 450 MHz**.

Basic Electronics & Theory

Lesson 5

5.8 Decibels

The decibel is used rather than arithmetic ratios or percentages because when certain types of circuits, such as amplifiers and attenuators, are connected in series, expressions of power level in decibels may be arithmetically added and subtracted.

In radio electronics and telecommunications, the decibel is used to describe the ratio between two measurements of electrical power

Decibels are used to account for the gains and losses of a signal from a transmitter to a receiver through some medium (free space, wave guides, coax, fiber optics, etc.)

Basic Electronics & Theory

Lesson 5

5.8 Decibels

-A two-time increase in power results in a change of 3dB higher

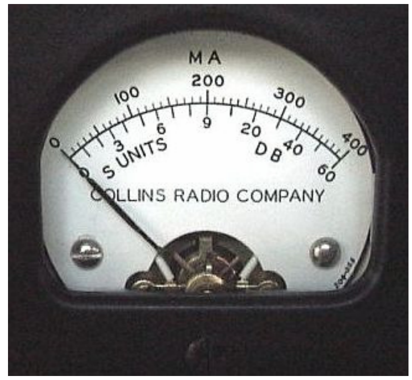
-You can decrease your transmitter's power by 3dB by dividing the original power by 2

-You can increase your transmitter's power by 6dB by multiplying the original power by 4

Basic Electronics & Theory

Lesson 5

5.8 Decibels



If a signal-strength report is “10dB over S9” , if the transmitter power is reduced from 1500 watts to 150 watts, the report should now be S9

If a signal-strength report is “20dB over S9”, if the transmitter power is reduced from 1500 watts to 150 watts the report should now be S9 plus 10dB

The power output from a transmitter increases from 1 watt to 2 watts. This is a dB increase of 3.3

The power output from a transmitter increases form 5 watts to 50 watts by a linear amplifier. The power gain would be 10 dB.

Basic Electronics & Theory

Lesson 5

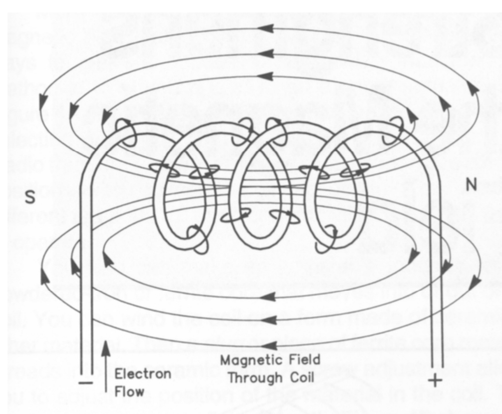
5.9 Inductance

The Inductor

- There are two fundamental principles of electromagnetics:
  1. Moving electrons create a magnetic field.
  2. Moving or changing magnetic fields cause electrons to move.
- An inductor is a coil of wire through which electrons move, and energy is stored in the resulting magnetic field.

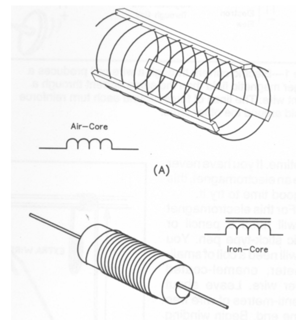
The Inductor

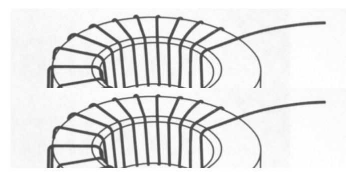
- Like capacitors, inductors temporarily store energy.
- Unlike capacitors:
  - Inductors store energy in a magnetic field, not an electric field.
  - The magnetic field is proportional to the current. When the current drops to zero the magnetic field also goes to zero.



The Inductor

- Inductors are simply coils of wire.
  - Can be air wound (just air in the middle of the coil)
  - Can be wound around a permeable material (material that concentrates magnetic fields)
  - Can be wound around a circular form (toroid)



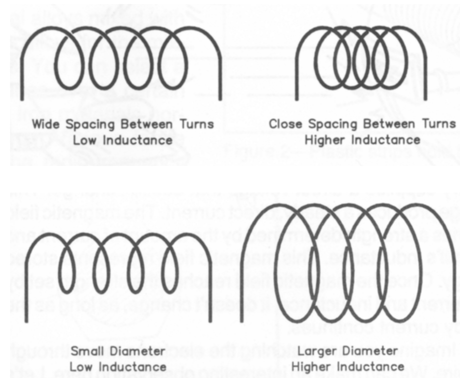


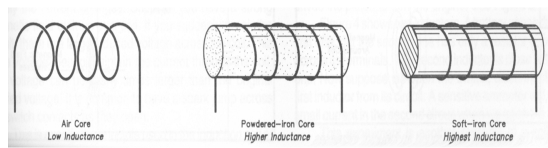
The Inductor

- The rate at which current through an inductor changes is proportional to the voltage across it.
- A coil (or inductor) has a property called its inductance. The larger the inductance, slower the rate at which the current changes.
- The unit that measures the size of the inductance is the Henry.
- Typical inductor values used in electronics are in the range of several Henrys down to microhenrys (1/1.000,000 Henry)

The Inductor

- The amount of inductance is influenced by a number of factors:
  - Number of coil turns.
  - Diameter of coil.
  - Spacing between turns.
  - Size of the wire used.
  - Type of material inside the coil.





Inductor Performance With DC Currents

- When a DC voltage is applied to an inductor the current starts to build. The increasing current produces an increasing magnetic field that causes a (back) EMF that opposes the applied voltage .
- "In a real inductor the wires (and, perhaps the voltage source) have resistance. Ultimately, this resistance prevents the current from rising any higher.
- In an ideal inductor (one where the wires have no resistance) the current would flow round and round forever. In order to cause the current to slow down and stop, a voltage in the opposite direction would have to be applied.
- If the circuit is actually broken (a switch is opened) the current is forced to stop immediately. Since the current does not 'want' to stop suddenly, a large voltage will be generated, often with the production of a spark.

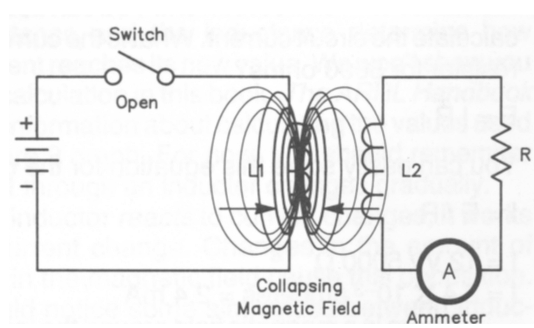
Inductor Performance With AC Currents

- When AC voltage is applied to an inductor the current rises when the voltage is positive; it holds constant when the voltage is zero, and it decreases when the voltage is negative. This gives rise to the rather counter-intuitive situation that, for part of the cycle, a negative current will be associated with a positive voltage – and vice versa.

- Unlike the case of a resistor, the current does not follow lock-step along with the voltage. Although the AC current does tend to do the same thing as the voltage, it doesn't do it at the same time; it does it later in the cycle.

The Inductor

- Because the magnetic field surrounding an inductor can cut across another inductor in close proximity, the changing magnetic field in one can cause current to flow in the other … the basis of transformers

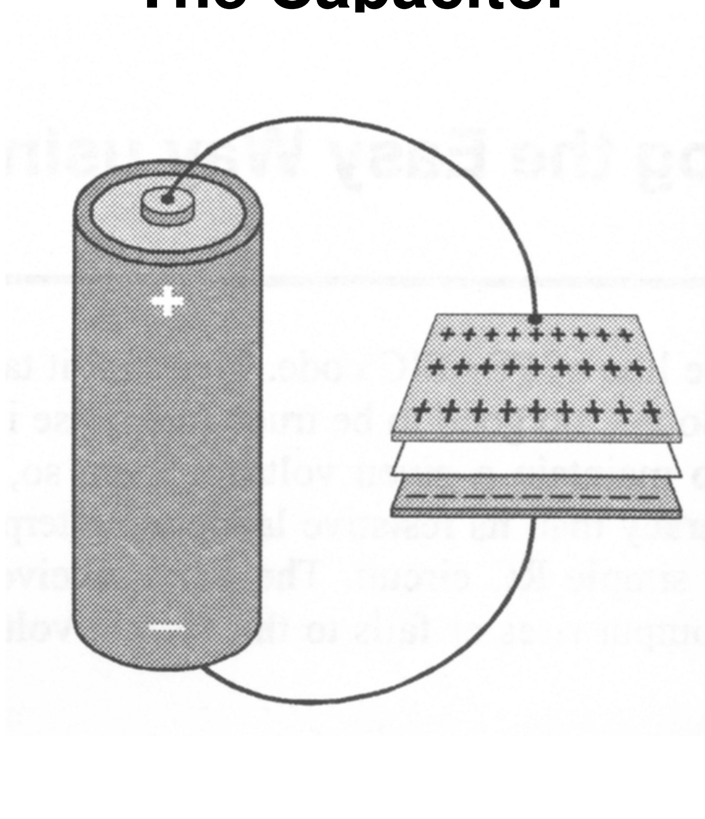


Basic Electronics & Theory

Lesson 5

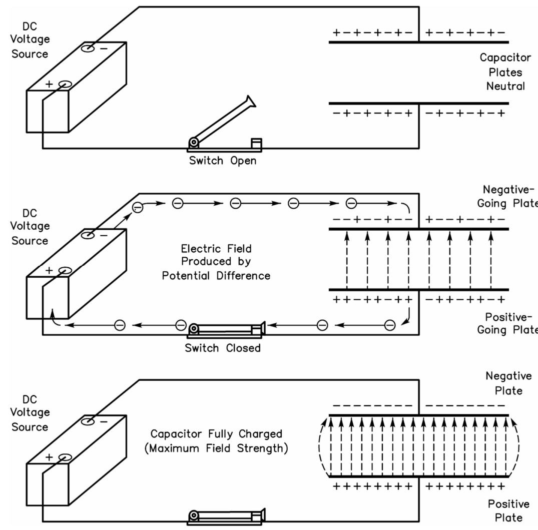
5.9 Capacitance

The Capacitor



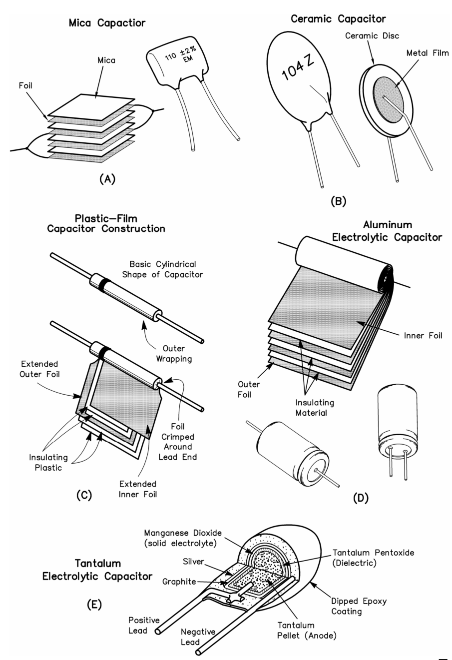
The Capacitor
Defined

- A device that stores energy in electric field.
- Two conductive plates separated by a non conductive material.
- Electrons accumulate on one plate forcing electrons away from the other plate leaving a net positive charge.
- Think of a capacitor as very small, temporary storage battery.



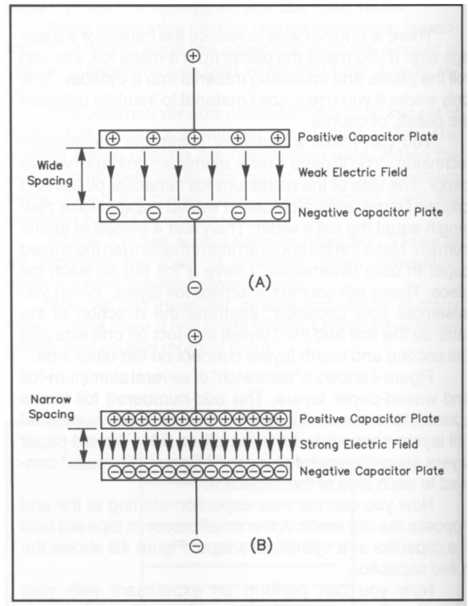
The Capacitor Physical Construction

- Capacitors are rated by:
  - Amount of charge that can be held.
  - The voltage handling capabilities.
  - Insulating material between plates.

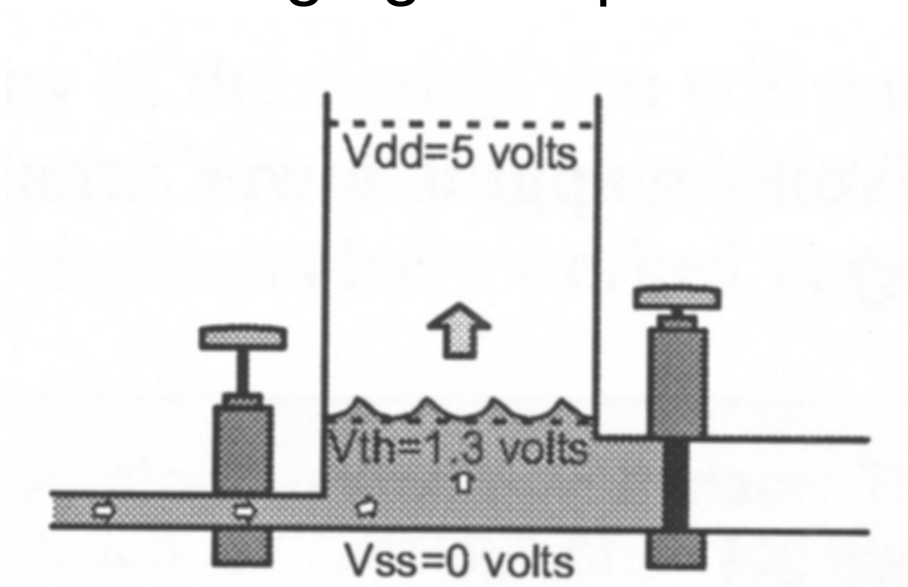


The Capacitor
Ability to Hold a Charge

- Ability to hold a charge depends on:
  - Conductive plate surface area.
  - Space between plates.
  - Material between plates.



Charging a Capacitor



The Capacitor
Behavior in DC

- When connected to a DC source, the capacitor charges and holds the charge as long as the DC voltage is applied.
- The capacitor essentially blocks DC current from passing through.

The Capacitor
Behavior in AC

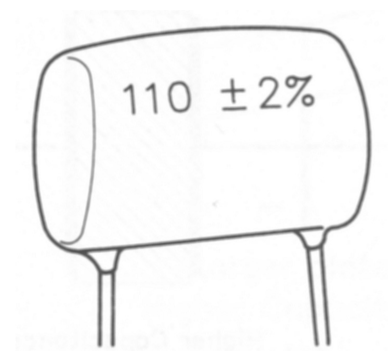
- When AC voltage is applied, during one half of the cycle the capacitor accepts a charge in one direction.
- During the next half of the cycle, the capacitor is discharged then recharged in the reverse direction.
- During the next half cycle the pattern reverses.
- It acts as if AC current passes through a capacitor

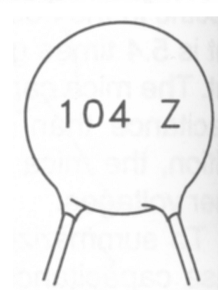
The Capacitor
Capacitance Value

- The unit of capacitance is the farad.
  - A single farad is a huge amount of capacitance.
  - Most electronic devices use capacitors that are a very tiny fraction of a farad.
- Common capacitance ranges are:
  - Micro μ 10^{-6}
  - Nano n 10^{-9}
  - Pico p 10^{-12}

The Capacitor
Capacitance Value

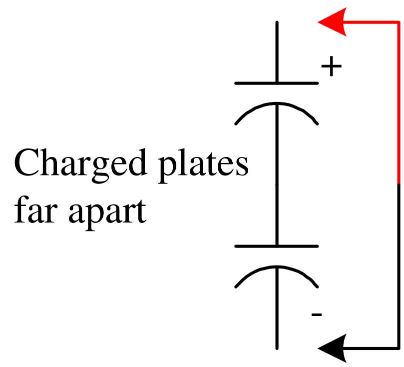
- Capacitor identification depends on the capacitor type.
- Could be color bands, dots, or numbers.
- Wise to keep capacitors organized and identified to prevent a lot of work trying to re-identify the values.





Capacitors in Circuits

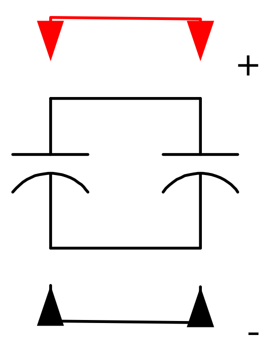
- Three physical factors affect capacitance values.
  - Plate spacing
  - Plate surface area
  - Dielectric material
- In series, plates are far apart making capacitance less



$$C_E = \frac{C_1 C_2}{C_1 + C_2}$$

Capacitors in Circuits

- In parallel, the surface area of the plates add up to be greater.
- This makes the total capacitance higher.



$$C_E = C_1 + C_2$$

Basic Electronics & Theory

Lesson 5

5.11 Magnetics & Transformers

The transformer is essentially just two (or more) inductors, sharing a common magnetic path. Any two inductors placed reasonably close to each other will work as a transformer, and the more closely they are coupled magnetically, the more efficient they become.

When a changing magnetic field is in the vicinity of a coil of wire (an inductor), a voltage is induced into the coil which is in sympathy with the applied magnetic field. A static magnetic field has no effect, and generates no output. Many of the same principles apply to generators, alternators, electric motors and loudspeakers, although this would be a very long article indeed if

I were to cover all the magnetic field devices that exist.
When an electric current is passed through a coil of wire, a magnetic field is created - this works with AC or DC, but with DC, the magnetic field is obviously static. For this reason, transformers cannot be used directly with DC, for although a magnetic field exists, it must be changing to induce a voltage into the other coil.

The ability of a substance to carry a magnetic field is called permeability, and different materials have differing permeabilities. Some are optimised in specific ways for a particular requirement - for example the cores used for a switching transformer are very different from those used for normal 50/60Hz mains transformers.

5.11 Magnetics & Transformers (Continued)

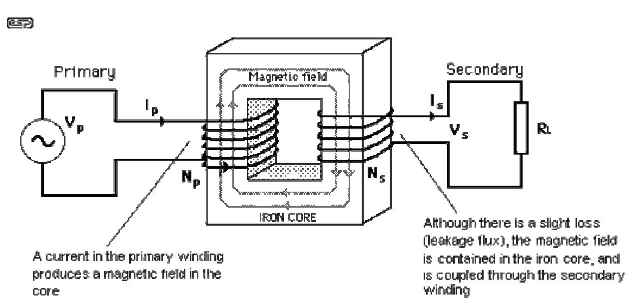


Figure 1.1 - Essential Workings of a Transformer

Figure 1.1 shows the basics of all transformers. A coil (the primary) is connected to an AC voltage source - typically the mains for power transformers. The flux induced into the core is coupled through to the secondary, a voltage is induced into the winding, and a current is produced through the load.

5.11 Magnetics & Transformers (Continued)

How a Transformer Works At no load, an ideal transformer draws virtually no current from the mains, since it is simply a large inductance. The whole principle of operation is based on induced magnetic flux, which not only creates a voltage (and current) in the secondary, but the primary as well! It is this characteristic that allows any inductor to function as expected, and the voltage generated in the primary is called a "back EMF" (electromotive force). The magnitude of this voltage is such that it almost equals (and is effectively in the same phase as) the applied EMF.

When you apply a load to the output (secondary) winding, a current is drawn by the load, and this is reflected through the transformer to the primary. As a result, the primary must now draw more current from the mains. Somewhat intriguingly perhaps, the more current that is drawn from the secondary, the original 90 degree phase shift becomes less and less as the transformer approaches full power. The power factor of an unloaded transformer is very low, meaning that although there are volts and amps, there is relatively little power. The power factor improves as loading increases, and at full load will be close to unity (the ideal).

Transformers are usually designed based on the power required, and this determines the core size for a given core material. From this, the required "turns per volt" figure can be determined, based on the maximum flux density that the core material can support. Again, this varies widely with core materials.

Multimeters will measure Voltage, Current and Resistance.

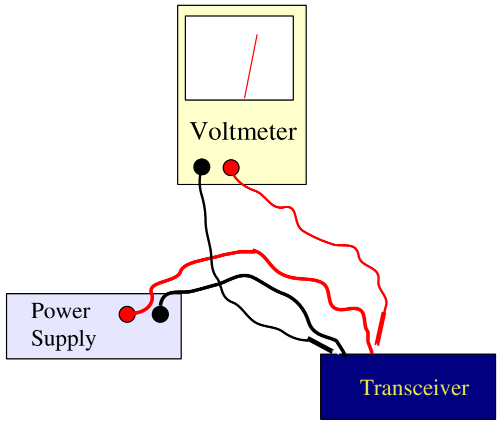
Be sure it is set properly to read what is being measured.

If it is set to the ohms setting and voltage is measured the meter could be damaged!

Basic Electronics & Theory

Lesson 5

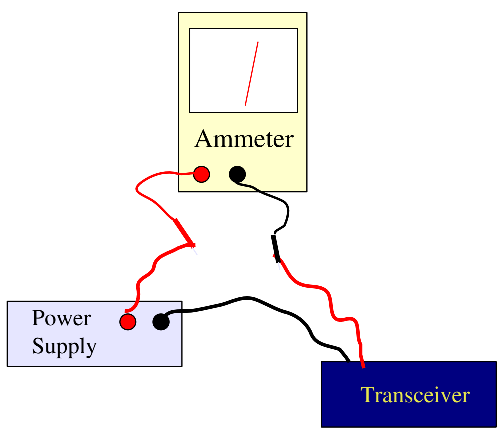
Potential difference (voltage) is measured with a voltmeter, the voltmeter is connected to a circuit under test **in parallel with the circuit.**



Basic Electronics & Theory

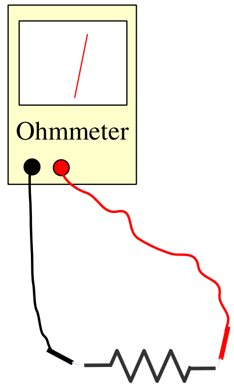
Lesson 5

The instrument to measure the flow of electrical current is the ammeter. An ammeter is connected to a circuit under test **in series with the circuit**



Radio and electronic fundamentals T4A

The instrument to measure resistance is the ohmmeter. An ohmmeter is connected to a circuit under test **in parallel with the circuit.**



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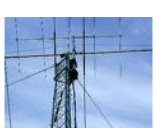
Antennas

A good antenna works

A bad antenna is a waste of time & money

Antenna systems can be very inexpensive and simple

They can also be very, very expensive



Antenna Considerations

–The space available for an antenna

–The proximity to neighbours

–The operating frequencies you will use

–The output power

–Money

Antenna Types

High Frequency

1.6 - 30 Mhz + 50 Mhz

160 - 6 metres

An antenna's size/length depends on the frequency

It's functionality largely depends on the height above ground, as well as the polarity and it's configuration

Some Math

Velocity of propagation 300,000,000 m/sec

For 1 wavelength, above 30 MHz

Frequency (f) = 300 / wavelength
Wavelength (λ) = 300 / frequency

Frequency measured in megahertz
Wavelength measured in meters

Above 30 MHz, λ = 300/f metres or 984/f feet
For a half wave λ = 150/f metres or 492/f feet
Below 30 MHz λ = 286/f metres or 936/f feet (including the velocity factor 0f 0.95)
For a half wave λ = 143/f metres or 468/f feet

The length of a half wave dipole for 3.65 MHz

The length of a half wave dipole for 3.65 MHz

L = 143/f = 143/3.65 = 39.18 metres

The higher the frequency the shorter the antenna
The lower the frequency the longer the antenna

Types of Antennas

Simple wire

- Dipole
- Folded dipole
- Trap dipole
- Offset or Windom antenna
- Phased dipoles
- Vertical or horizontal (both)
- Beverage wave antenna

Types of Antennas

–Metal
–Vertical
–Yagi
–Trap Yagi
–Phased arrays
–Loops
–Vertical or Horizontal
–Horns for super ultra high frequencies
–Mobile antennas

Antenna Polarization

- Vertical or horizontal

- Electrical vs Magnetic radiation
(Diagram)

- Vertical waves travel @ 90° to the earths surface

- Horizontal waves travel parallel to the earth's surface

- Usually wire antennas are horizontal but an inverted 'V' dipole has a vertical component

- Yagi type antennas can be either vertical or horizontal
Circular antennas can be both

- Usually, horizontally polarized antennas hear less noise

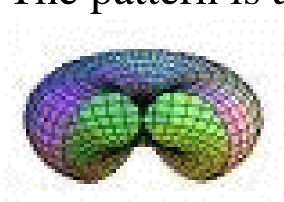
Isotropic Antenna

- The isotropic antenna is a hypothetical point source.

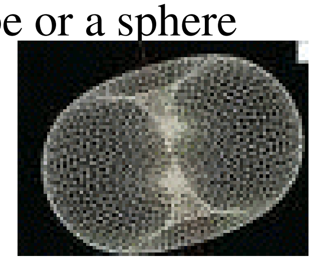
- It does not exist in reality but is considered as an important starting point considering different

- antennas from the theoretical to the practical

- The pattern is a Cardioid - a donut shape or a sphere



Dipole Radiation Pattern



Polarization - Practical

Antennas radiating a vertical polarization are best received by an antenna of like polarization

Cross polarization reduces reception by as much as 30 db

Bouncing DX signals probably have both polarizations

Designing antenna polarization usually depends on the frequency being used - at 70 cm in th eUHF band the elements are very short so either polarization is possible. Usually vertical is used as repeaters are vertically polarized.

Resonance

Antenna length is dependant on frequency

The lower the frequency the longer the antenna elements

Examples

80 metres	3.750 Mhz	124 ft
40	7.055	66
10	28.5	16.4
6	52	9
2	145	3.2

Isotropic Source

An isotropic antenna is a: **hypothetical point source**

What is the antenna radiation pattern for an isotropic radiator? **A sphere**

Polarization of an antenna is determined by: **the electric field**

What does horizontal wave polarization mean? **The electric lines of force of a radio wave are parallel to the earth's surface**

What does vertical wave polarization mean? **The electric lines of force of a radio wave are perpendicular to the earth's surface**

Polarization by Element Orientation Con't

What electromagnetic wave polarization does a Yagi antenna have when its elements are parallel to the earth's surface? **Horizontal**

What electromagnetic wave polarization does a half-wavelength antenna have when it is perpendicular to the earth's surface? **Vertical**

VHF signals from a mobile station using a vertical whip antenna will normally be best received using a: **vertical ground-plane antenna**

A dipole antenna will emit a vertically polarized wave if it is: **Parallel with the ground mounted vertically**

If an electromagnetic wave leaves an antenna vertically polarized, it will arrive at the receiving antenna, by ground wave: **vertically polarized**

Compared with a horizontal antenna, a vertical antenna will receive a vertically polarized radio wave: **at greater strength**

Wavelength vs Physical Length

The speed of a radio wave: **is the same as the speed of light**

The velocity of propagation of radio frequency energy in free space is: **300 000 kilometres per second**

If an antenna is made longer, what happens to its resonant frequency? **It decreases**

If an antenna is made shorter, what happens to its resonant frequency? **It increases**

The resonant frequency of an antenna may be increased by: **shortening the radiating element**

Wavelength vs Physical Length

Con't

To lower the resonant frequency of an antenna, the operator should: **lengthen it**

Adding a series inductance to an antenna would: **decrease the resonant frequency**

Wavelength vs Physical Length

- The wavelength for a frequency of 25 MHz is:
  12 metres (39.4 ft)

- The wavelength corresponding to a frequency of 2 MHz is:
150 m (492 ft)

- At the end of suspended antenna wire, insulators are used.
These act to: **limit the electrical length of the antenna**

- One solution to multi-band operation with a shortened radiator is the "trap dipole" or trap vertical. These "traps" are actually: **a coil and capacitor in parallel**

Gain, Directivity, etc.

- What is meant by antenna gain? **The numerical ratio relating the radiated signal strength of an antenna to that of another antenna**

- The gain of an antenna, especially on VHF and above, is quoted in dBi. The "i" in this expression stands for: **isotropic**

- Approximately how much gain does a half-wave dipole have over an isotropic radiator? **2.1 dB**

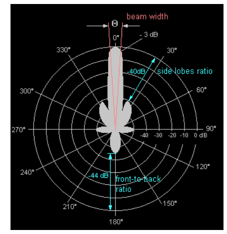
- What is a parasitic beam antenna? **An antenna where some elements obtain their radio energy by induction or radiation from a driven element**

- If a slightly shorter parasitic element is placed 0.1 wavelength away from an HF dipole antenna, what effect will this have on the antenna's radiation pattern? **A major lobe will develop in the horizontal plane, toward the parasitic element**

- If a slightly longer parasitic element is placed 0.1 wavelength away from an HF dipole antenna, what effect will this have on the antenna's radiation pattern? **A major lobe will develop in the horizontal plane, away from the parasitic element, toward the dipole**

Gain, Directivity, etc.

- In free space, what is the radiation characteristic of a half-wave dipole? **Minimum radiation from the ends, maximum broadside**



- The front-to-back ratio of a beam antenna is: **the ratio of the maximum forward power in the major lobe to the maximum backward power radiation**

- The property of an antenna, which defines the range of frequencies to which it will respond, is called its: **bandwidth**

- What is meant by antenna bandwidth? **The frequency range over which the antenna may be expected to perform well**

- How can the bandwidth of a parasitic beam antenna be increased? **Use larger diameter elements**

Vertical Antennae

- To calculate the length in metres (feet) of a quarter wave vertical antenna you would : **Divide 71.5 (234) by the antenna's operating frequency (in MHz)**

- If you made a quarter-wavelength vertical antenna for 21.125 MHz, how long would it be? **3.6 metres (11.8 ft)**

- If you made a half-wavelength vertical antenna for 223 MHz, how long would it be? **64 cm (25.2 in)**

- If a magnetic-base whip antenna is placed on the roof of a car, in what direction does it send out radio energy? **It goes out equally well in all horizontal directions**

- What is an advantage of downward sloping radials on a ground plane antenna? **It brings the feed point impedance closer to 50 ohms**

Vertical Antennae

Con't

What happens to the feed point impedance of a ground-plane antenna when its radials are changed from horizontal to downward-sloping? **It increases**

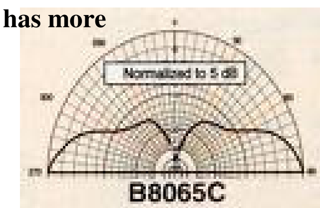
Which of the following transmission lines will give the best match to the base of a quarter-wave ground-plane antenna? **50 ohms coaxial cable**

The main characteristic of a vertical antenna is that it will: **receive signals equally well from all compass points around it**

Why is a loading coil often used with an HF mobile vertical antenna? **To tune out capacitive reactance**

What is the main reason why so many VHF base and mobile antennas are 5/8 of a wavelength? **The angle of radiation is low**

Why is a 5/8-wavelength vertical antenna better than a 1/4-wavelength vertical antenna for VHF or UHF mobile operations? **A 5/8-wavelength antenna has more gain**



Yagi Antennae

How many directly driven elements do most Yagi antennas have? **One**

Approximately how long is the driven element of a Yagi antenna for 14.0 MHz? **10.21 metres (33 feet and 6 inches)**

Approximately how long is the director element of a Yagi antenna for 21.1 MHz? **6.4 metres (21 feet)**

Approximately how long is the reflector element of a Yagi antenna for 28.1 MHz? **5.33 metres (17.5 feet long)**

The spacing between the elements on a three-element Yagi antenna, representing the best overall choice, is : **0.2 of a wavelength.**

What is one effect of increasing the boom length and adding directors to a Yagi antenna? **Gain increases**

What are some advantages of a Yagi with wide element spacing? **High gain, less critical tuning and wider bandwidth**

Yagi Antennae

Con't

What are some advantages of a Yagi with wide element spacing? **High gain, less critical tuning and wider bandwidth**

Why is a Yagi antenna often used for radiocommunications on the 20-metre band? **It helps reduce interference from other stations off to the side or behind**

What does "antenna front-to- back ratio" mean in reference to a Yagi antenna? **The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction**

What is a good way to get maximum performance from a Yagi antenna? **Optimize the lengths and spacing of the elements**

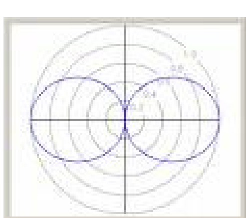
If the forward gain of a six- element Yagi is about 10 dB, what would the gain of two of these antennas be if they were "stacked"? **13 dB**

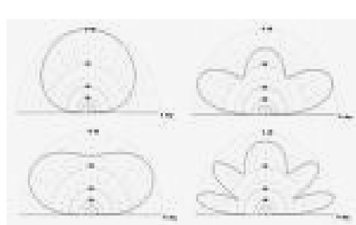
Wire Antennae

If you made a half-wavelength dipole antenna for 28.550 MHz, how long would it be? **5.08 metres (16.62 ft)**

What is the low angle radiation pattern of an ideal half-wavelength dipole HF antenna installed parallel to the earth? **It is a figure-eight, perpendicular to the antenna**

The impedances in ohms at the feed point of the dipole and folded dipole are, respectively: **73 and 300**





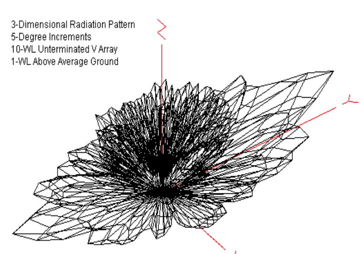


Fig. 4

Wire Antennae

A dipole transmitting antenna, placed so that the ends are pointing North/South, radiates: **mostly to the East and West**

How does the bandwidth of a folded dipole antenna compare with that of a simple dipole antenna? **It is greater**

What is a disadvantage of using an antenna equipped with traps? **It will radiate harmonics**

What is an advantage of using a trap antenna?
It may be used for multi- band operation

What is one disadvantage of a random wire antenna? **You may experience RF feedback in your station**

Quad / Loop antennae

What is a cubical quad antenna? **Two or more parallel four- sided wire loops, each approximately one-electrical wavelength long**

What is a delta loop antenna? **A type of cubical quad antenna, except with triangular elements rather than square**

The cubical "quad" or "quad" antenna consists of two or more square loops of wire. The driven element has an approximate overall length of: **one wavelength**

The delta loop antenna consists of two or more triangular structures mounted on a boom. The overall length of the driven element is approximately: **one wavelength**

Approximately how long is each side of a cubical quad antenna driven element for 21.4 MHz? **3.54 metres (11.7 feet)**

Approximately how long is each side of a cubical quad antenna driven element for 14.3 MHz? **5.36 metres (17.6 feet)**

Approximately how long is each leg of a symmetrical delta loop antenna driven element for 28.7 MHz? **3.5 metres (11.5 feet)**

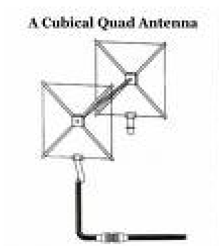
Quad / Loops

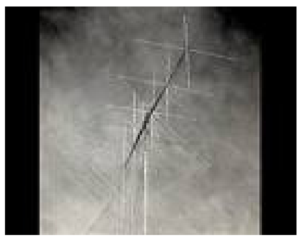
Which statement about two- element delta loops and quad antennas is true? **They compare favorably with a three element Yagi**

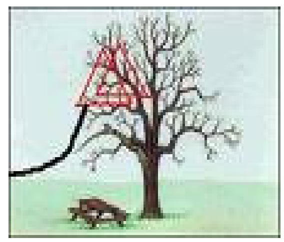
Compared to a dipole antenna, what are the directional radiation characteristics of a cubical quad antenna? **The quad has more directivity in both horizontal and vertical planes**

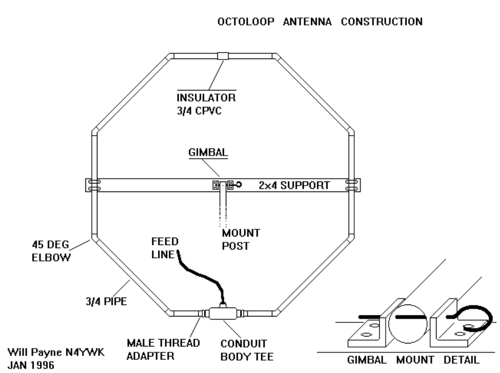
Moving the feed point of a multi-element quad antenna from a side parallel to the ground to a side perpendicular to the ground will have what effect? **It will change the antenna polarization from horizontal to vertical**

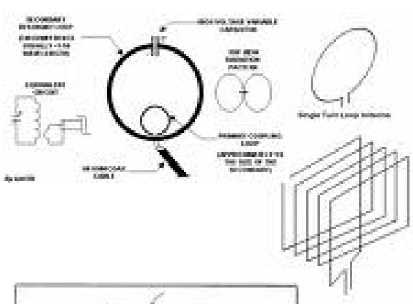
What does the term "antenna front-to back ratio" mean in reference to a delta loop antenna? **The power radiated in the major radiation lobe compared to the power radiated in exactly the opposite direction**

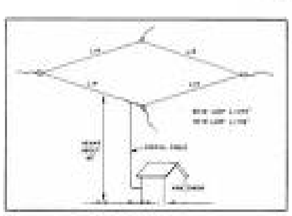


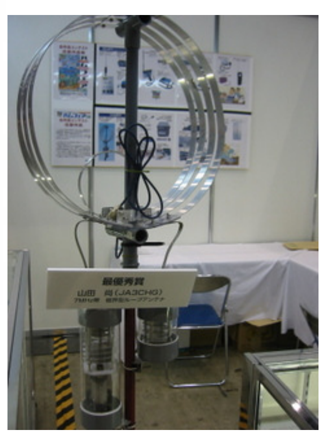












FEEDLINES

Perfect Feedline (ya, really)

A perfect feedline will have:

– No radiation from the feedline itself

– No loss of signal while passing along the line

– Constant electrical characteristics throughout
Such a feedline will pass 100% of the RF energy through it.

NOTE: This situation does not ever exist! (yet)!!

Feedline (transmission line)

2 CONDUCTORS

–Capacitance because of 2 parallel lines (plates) Inductance because of the length of the lines and their proximity to each other.

–Resistance in the metal itself slowing the flow

–Therefore a feedline is a circuit which has reactance to the passage of AC current and which varies inversely as the operating frequency which means the value stays approximately the same over any given length. This value is called the characteristic impedance of the circuit. (Z_o)

–At HF frequencies, the signal passes through the conductor while at frequencies above 10 MHz, the signal passes along the surface, or skin of the wire. This is known as 'skin effect' where the losses increase with the frequency

Balanced feedlines

Open wire feedlines

Characteristic impedance of 200 – 600 Ω depending on the diameter of the wire and the distance between them.

Z_o= 276 log 2(S/D)
S=Distance between and
D=diameter

Unbalanced feedlines

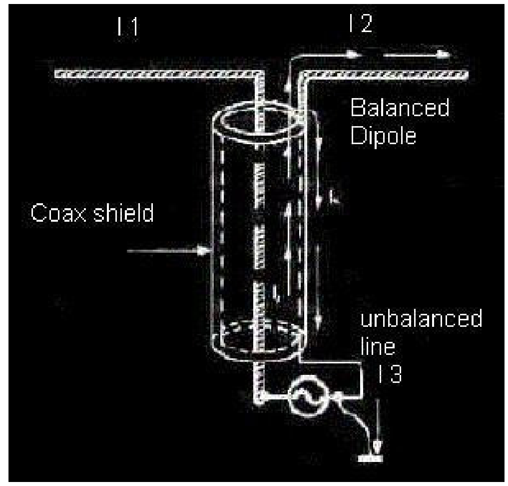
One side to ground

Other side carries

RF to antenna

Coaxial cable is waterproof

Hardline or Heliax is best for VHF/UHF and up (Heliax uses copper not braid for the shield) – hard to bend -



Z_o=138/√e log D/d

e=dielectric constant

D=diameter of the outer conductor

D=diameter of the inner conductor

Feed Lines

Feedlines connect a radio to an antenna

They must be matched to the radio system - they should have like impedence

Radios usually have a 50 ohm output

Antenna feedpoints have a very wide impedence range

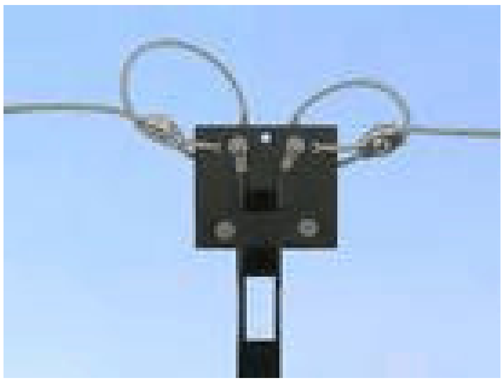
Velocity factor .66 - .95

Feed Lines

Con't

Feedlines can be easily made

The two favourite for amateur radio are the coaxial cable and open wire feedlines



Feed Line Questions

See Page 45

What connects your transceiver to your antenna?
Feed Line

What kind of feed line can be buried in the ground for some distance without adverse effects? **Coaxial Cable**

A transmission line differ from an ordinary circuit or network in communications or signal devices in one important way. That important way is **Propagation Delay**

Feed Line Questions Con't

The characteristics of a transmission line is determined by the **Physical dimensions and relative positions of the conductors**

The characteristics of a transmission line is equal to the **Pure Resistance which, if connected to the end of the line, will absorb all the power arriving along it**

Think of the paper towel absorbsion advertisment

The characteristic impedence of a coaxial antenna feed line is determined by the **Ratio of the diameter of the inner conducter to the diameter of the braid**

Feed Line Questions Con't

The characteristic impedance of a parallel wire transmission line does <u>not</u> depend on the **velocity of energy on the line**

What factors determine the characteristic impedance of a parallel-conductor antenna feed line? **The distance between the centres of the conductors and the radius of the conductors**

Any length of transmission line may be made to appear as an infinitely long line by: **Terminating the line in its characteristic impedance**

The characteristic impedance of a 20 metre piece of transmission line is **52 ohms**

Feed Line Questions

Con't

The impedance of a coaxial line:

can be the same for different diameter line

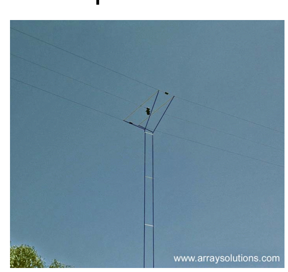
Balanced & Unbalanced Feed Lines

A balanced transmission line: **is made of two parallel wires**

What is parallel-conductor feed line? Two wires side-by-side held apart by insulating rods

What kind of antenna feed line is made of two conductors held apart by insulated rods? **Open-conductor ladder line**

What kind of antenna feed line can be constructed using two conductors which are maintained a uniform distance apart using insulated spreaders? **600 ohm open-wire**



Balanced & Unbalanced Feed Lines - 2

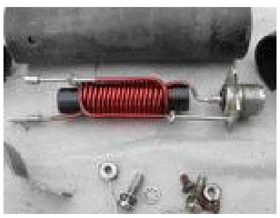
What is an unbalanced line? **Feed line with one conductor connected to ground**

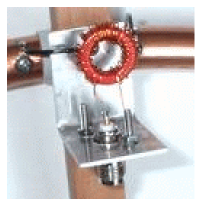
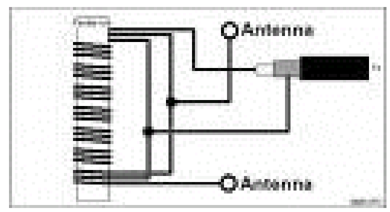
What is a coaxial cable? **A center wire inside an insulating material which is covered by a metal sleeve or shield**

A flexible coaxial line contains: **Braid and insulation around a central conductor**

What device can be installed to feed a balanced antenna with an unbalanced feed line? **A balun**

What does the term "balun" mean? **Balanced to unbalanced**

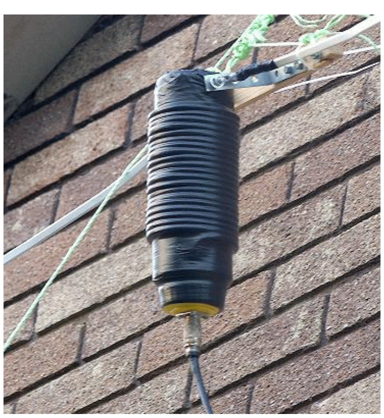
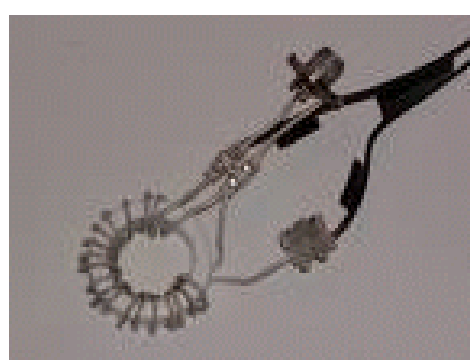


Balanced & Unbalanced Feed Lines - 3

Where would you install a balun to feed a dipole antenna with 50-ohm coaxial cable? **Between the coaxial cable and the antenna**

A 75 ohm transmission line could be matched to the 300 ohm feedpoint of an antenna: **by using a 4 to 1 balun**

Popular Antenna Feed Lines

Why does coaxial cable make a good antenna feed line? **It is weatherproof, and its impedance is higher than that of most amateur antennas**

What is the best antenna feed line to use, if it must be put near grounded metal objects? **Coaxial cable**

What commonly available antenna feed line can be buried directly in the ground for some distance without adverse effects? **Coaxial cable**

If you install a 6 metre Yagi antenna on a tower 50 metres from your transmitter, which of the following feed lines is best? **RG-213**

What are some reasons not to use parallel-conductor feed line? **It does not work well when tied down to metal objects, and you must use an impedance-matching device with your transceiver**

TV twin-lead feed line can be used for a feed line in an amateur station. The impedance of this line is approximately: **300 ohms**

Connectors

What common connector usually joins RG-213 coaxial cable to an HF transceiver? A **PL-259** connector

What common connector usually joins a hand-held transceiver to its antenna? A **BNC** connector

Which of these common connectors has the lowest loss at UHF? A **type-N** connector

Why should you regularly clean, tighten and re-solder all antenna connectors? **To help keep their resistance at a minimum**

Line Losses

Why should you use only good quality coaxial cable and connectors for a UHF antenna system? **To keep RF loss low**

In what values are RF feed line losses expressed?
dB per unit length

Losses occurring on a transmission line between transmitter and antenna results in: **less RF power being radiated**

If the length of coaxial feed line is increased from 20 metres (65.6 ft) to 40 metres (131.2 ft), how would this affect the line loss? **It would be increased by 100%**

What are some reasons to use parallel conductor feed line? **It will operate with a high SWR, and has less loss than coaxial cable**

Line Losses

Con't

If your transmitter and antenna are 15 metres apart, but are connected by 65 metres of RG-58 coaxial cable, what should be done to reduce feed line loss? **Shorten the excess cable**

The lowest loss feed line on HF is: **300 ohm twin- lead**

As the length of a feed line is changed, what happens to signal loss? **Signal loss increases as length increases**

As the frequency of a signal is changed, what happens to signal loss in a feed line? **Signal loss increases with increasing frequency**

Standing Waves

If the characteristic impedance of the feedline does not match the antenna input impedance then: **standing waves are produced in the feedline**

The result of the presence of standing waves on a transmission line is: **reduced transfer of RF energy to the antenna**

What does the standing wave ration means? **ratio of maximum to minimum voltages on a feed line**

What does an SWR reading of 1:1 mean?
The best impedance match has been attained

What does an SWR reading of less than 1.5:1 mean? **A fairly good impedance match**

A resonant antenna having a feed point impedance of 200 ohms is connected to a feed line and transmitter which have an impedance of 50 ohms. What will the standing wave ratio of this system be? 4:1

What kind of SWR reading may mean poor electrical contact between parts of an antenna system? **A jumpy reading**

Standing Waves

What does a very high SWR mean? **The antenna is the wrong length, or there may be an open or shorted connection somewhere in the feed line**

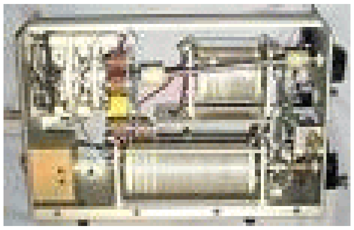
If your antenna feed line gets hot when you are transmitting, what might this mean? **The SWR may be too high, or the feed line loss may be high**

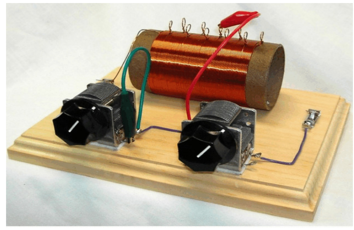
The type of feed line best suited to operating at a high standing wave ratio is: **600 ohm open-wire**

SWR meter measures the degree of match between transmission line and antenna by: **comparing forward and reflected voltage**

Impedence Matching

What device might allow use of an antenna on a band it was not designed for? **An antenna tuner**





What does an antenna matching unit do? **It matches a transceiver to a mismatched antenna system**

What would you use to connect a coaxial cable of 50 ohms impedance to an antenna of 35 ohms impedance? **An impedance-matching device**

When will a power source deliver maximum output to the load? **When the impedance of the load is equal to the impedance of the source**

Impedence Matching

Page 48

What happens when the impedance of an electrical load is equal to the internal impedance of the power source? **The source delivers maximum power to the load**

Why is impedance matching important? **So the source can deliver maximum power to the load**

To obtain efficient power transmission from a transmitter to an antenna requires: **matching of impedances**

If an antenna is correctly matched to a transmitter, the length of transmission line: **will have no effect on the matching**

If the centre impedance of a folded dipole is approximately 300 ohms, and you are using RG8U (50 ohms) coaxial lines, what is the ratio required to have the line and the antenna matched? **6:1**

Impedance

A reading (for interest only)

DEFINITIONS

Impedance, denoted Z, is an expression of the opposition that an electronic component, circuit, or system offers to alternating and/or direct electric current.Impedance is a vector (two-dimensional)quantity consisting of two independent scalar (one-dimensional) phenomena: resistance and reactance.

Resistance, denoted R, is a measure of the extent to which a substance opposes the movement of electrons among its atoms.The more easily the atoms give up and/or accept electrons, the lower the resistance, which is expressed in positive real number ohms.Resistance is observed with alternating current (AC) and also with direct current (DC). Examples of materials with low resistance, known as electrical conductors, include copper, silver, and gold.High-resistance substances are called insulators or dielectrics, and include materials such as polyethylene, mica, and glass.A material with an intermediate levels of resistance is classified as a semiconductor. Examples are silicon, germanium, and gallium arsenide.

Reactance, denoted X, is an expression of the extent to which an electronic component, circuit, or system stores and releases energy as the current and voltage fluctuate with each AC cycle.Reactance is expressed in imaginary number ohms.It is observed for AC, but not for DC.When AC passes through a component that contains reactance, energy might be stored and released in the form of a magnetic field, in which case the reactance is inductive (denoted +jXL); or energy might be stored and released in the form of an electric field, in which case the reactance is capacitive (denoted -jXC). Reactance is conventionally multiplied by the positive square root of -1, which is the unit imaginary number called the j operator, to express Z as a complex number of the form R + jXL (when the net reactance is inductive) or R - jXC (when the net reactance is capacitive).

The illustration shows a coordinate plane modified to denote complex-number impedances.Resistance appears on the horizontal axis, moving toward the right.(The left-hand half of this coordinate plane is not normally used because negative resistances are not encountered in common practice.)Inductive reactance appears on the positive imaginary axis, moving upward.Capacitive reactance is depicted on the negative imaginary axis, moving downward.As an example, a complex impedance consisting of 4 ohms of resistance and +j5 ohms of inductive reactance is denoted as a vector from the origin to the point on the plane corresponding to 4 + j5.

Impedance

In series circuits, resistances and reactances add together independently. Suppose a resistance of 100.00 ohms is connected in a series circuit with an inductance of 10.000 ?H.At 4.0000 MHz, the complex impedance is:

ZRL = R + jXL = 100.00 + j251.33

If a capacitor of 0.0010000 ?F is put in place of the inductor, the resulting complex impedance at 4.0000 MHz is:

ZRC = R - jXC = 100.00 - j39.789

If all three components are connected in series, then the reactances add, yielding a complex impedance of:

ZRLC = 100 + j251.33 - j39.789 = 100 + j211.5

This is the equivalent of a 100-ohm resistor in series with an inductor having +j211.5 ohms of reactance.At 4.0000 MHz, this reactance is presented by an inductance of 8.415 ?H, as determined by plugging the numbers into the formula for inductive reactance and working backwards.(See the definition of for this formula, and for the corresponding formula for capacitive reactance.)

Parallel RLC circuits are more complicated to analyze than are series circuits.To calculate the effects of capacitive and inductive reactance in parallel, the quantities are converted to inductive susceptance and capacitive susceptance.Susceptance is the reciprocal of reactance.Susceptance combines with conductance, which is the reciprocal of resistance, to form complex admittance, which is the reciprocal of complex impedance.

Appendix

Impedance matching

Levers do it.
Pulleys do it.
Ramps, transformers, gears, megaphones, and wheelbarrows do it.
Even screws do it.

Match impedance, that is.

Impedance is the opposition to the flow of energy.

If you try to lift your refrigerator, you will experience an opposition to the flow of energy. The refrigerator will just sit there, and you will get tired. The ability of your muscles to lift the weight is not matched to the weight.

There are a number of ways you can lift a 500 pound refrigerator by matching the impedance of your muscles to the impedance of the load. You could push the load up a ramp. You could use a lever, or a block and tackle, or a hydraulic jack, or a screw jack. Each of these devices allows you to trade lifting the 500 pound load for lifting a smaller load, say 50 pounds. You generally trade off time, pushing 50 pounds for ten seconds instead of 500 pounds in one second. The same amount of energy is expended, but at a much lower power level.

Appendix

When impedances are mismatched, energy put into the system is reflected back. If you jump on a see-saw with a refigerator on the other end, you will bounce back off as if you were on a diving board. But if you move the fulcrum closer to the refrigerator, you can jump onto the see-saw, and your end will move down, lifting the heavy load at the other end.

You can line up a row of billiard balls, and hit the row with the cue ball, and the last ball in the row will shoot off down the table. But if one of the balls is made of steel, the cue ball will simply bounce off of it, and most of the energy will be reflected.

We can match the impedances to get the steel ball to move. We put a row of balls in front of it, each one made of a slightly lighter weight material than the last, until the ball nearest us is almost the same mass as the cue ball. Now the speeding cue ball will stop dead when it hits the row of balls, and the steel ball will slowly move off down the table, having absorbed all of the energy.

When you shout to a friend who is underwater in a swimming pool, the sound from your voice bounces off the water, and very little sound energy gets to your friend's ears. But take a traffic cone and put the narrow end of it into the water and shout into the large end. Now your friend can hear you, because the low pressure sound waves over a large area are converted into high pressure waves over a small area, and the water moves from the high power sound. Here we are not trading time. Instead, we are trading a large area for a smaller one.

An electrical transformer also matches impedance. It takes high voltage, low current energy, and matches it to a load the needs low voltage, high current. It also works the other way around. Without the transformer, most of the energy is reflected back to the source, and little work gets done.

A water nozzle is an impedance matcher. So is cupping your hand behind your ear. A telescope is an impedance matcher. So is a magnifying glass, or a winding mountain road, or the gears on your bicycle. Now that you are aware of impedance matchers, you will start to see them everywhere.

RADIO WAVE PROPAGATION

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OBJECTIVES:

- PROPAGATION – INTRO
- RADIO WAVES
- POLARIZATION
- LINE OF SIGHT, GROUND WAVE, SKY WAVE
- IONOSPHERE REGIONS
- PROPAGATION, HOPS, SKIPS ZONES
- THE IONOSPHERIC LAYERS
- ABSORPTION AND FADING
- SOLAR ACTIVITY AND SUN SPOTS
- MF, HF CRITICAL FREQUENCIES
- BEACONS
- UHF, VHF, SPORADIC E, AURORAS, DUCTING
- SCATTER, HF, VHF,UHF
- SAMPLE QUESTIONS

Major General Urquhart:

"My communications are completely broken down.
Do you really believe any of that can be helped by a cup of tea?"

Corporal Hancock:

"Couldn't hurt, sir"

-Arnhem 1944

PROPAGATION - INTRO

Propagation: how radio waves get from point A to point B. The events occurring in the transmission path between two stations that affect the communications between the stations.

When the electrons in a conductor, (antenna wire) are made to oscillate back and forth, Electromagnetic Waves (EM waves) are produced.

These waves radiate outwards from the source at the speed of light, 300 million meters per second.

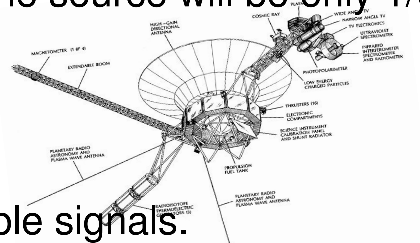
Light waves and radio waves are both EM waves, differing only in frequency and wavelength.

PROPAGATION – INTRO CONT'D

EM waves travel in straight lines, unless acted upon by some outside force. They travel faster through a vacuum than through any other medium.

As EM waves spread out from a point they decrease in strength in what is described as an "inverse square relationship".

A signal 2 km from the source will be only 1/4 as strong as that 1 km from the source. A signal 3 km from the source will be only 1/9 that at the 1 km point.

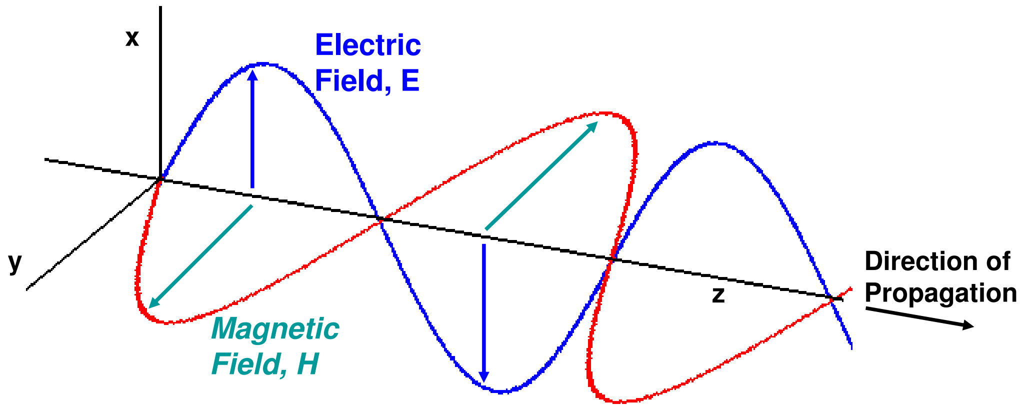


HOWEVER…..

Modern receivers are very sensitive and extremely small powers provide usable signals.

Waves can be received many thousands of kilometers from the transmitting station. Voyager 2 transmitted signals over many billions of kilometers from outer space with only 25 W of power.

RADIO WAVES



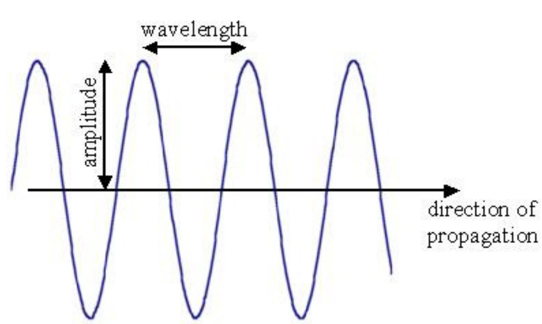
- Electromagnetic radiation comprises both an Electric and a Magnetic Field.
- The two fields are at right-angles to each other and the direction of propagation is at right-angles to both fields.
- The Plane of the Electric Field defines the Polarisation of the wave.

RADIO WAVES CONT'D

Two types of waves:
Transverse waves and Longitudinal

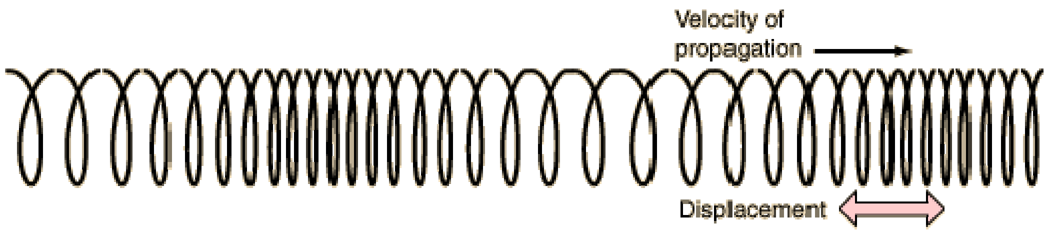
Transverse waves:
vibration is from side to side; that is, at
right angles to the direction in which they travel

Guitar string vibrates with transverse motion.
EM waves are always transverse.



RADIO WAVES CONT'D

- **Longitudinal waves:**
- Vibration is parallel to the direction of propagation. Sound waves, Pressure waves are longitudinal.Oscillate back and forth, vibrations along or parallel to their direction of travel



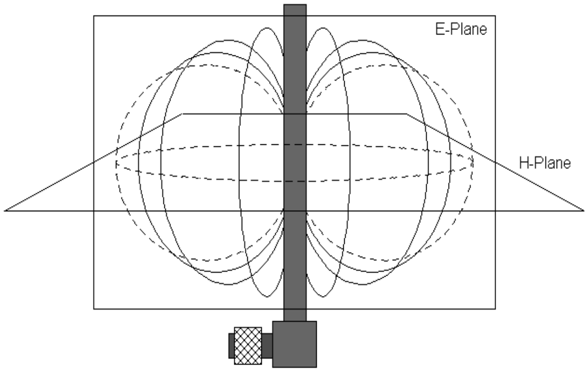
A wave in a "slinky" is a good visualization.

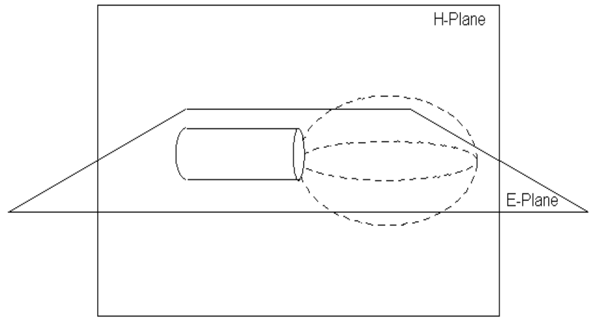
POLARIZATION

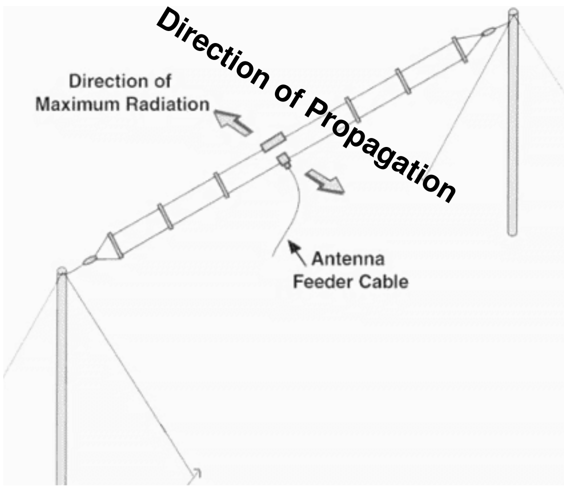
- The polarization of an antenna is the orientation of the electric field with respect to the Earth's surface and is determined by the physical structure of the antenna and by its orientation

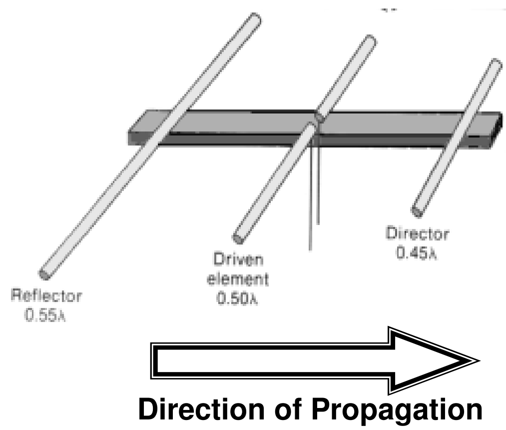
- Radio waves from a vertical antenna will usually be vertically polarized.

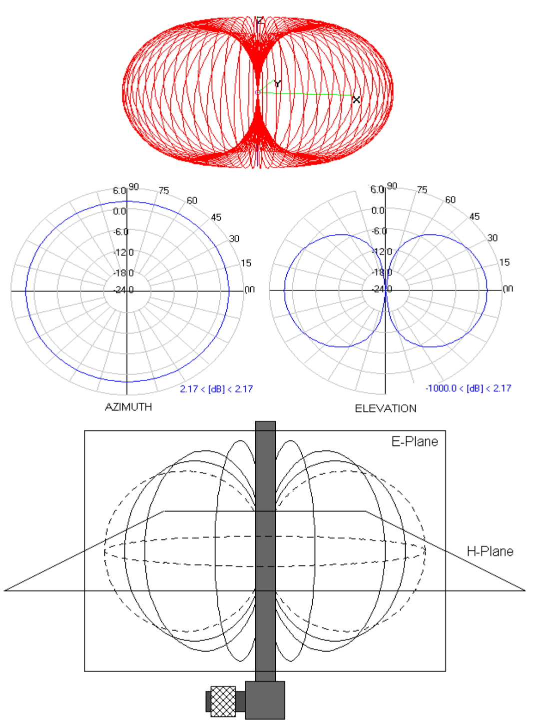
- Radio waves from a horizontal antenna are usually horizontally polarized.



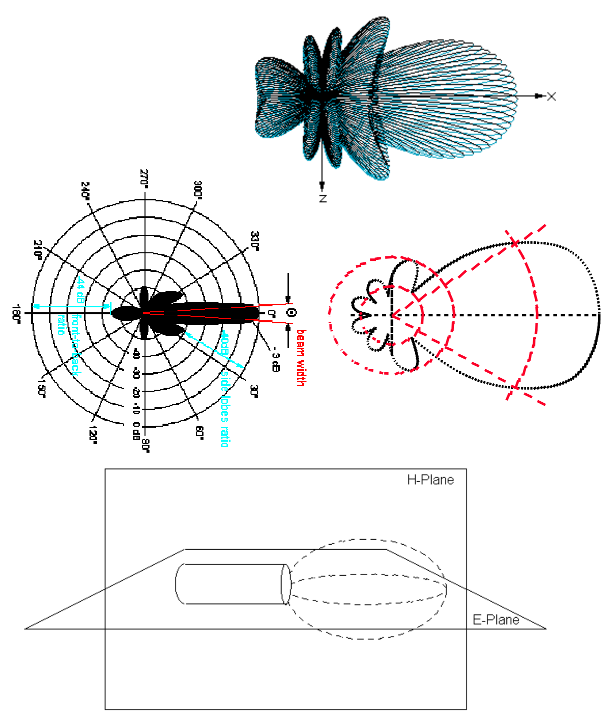






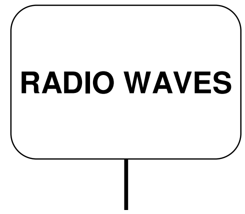


Vertically polarized omnidirectional dipole antenna



Horizontally polarized directional yagi antenna

RADIO WAVES CONT'D



LINE OF SIGHT, GROUND WAVE, SKY WAVE

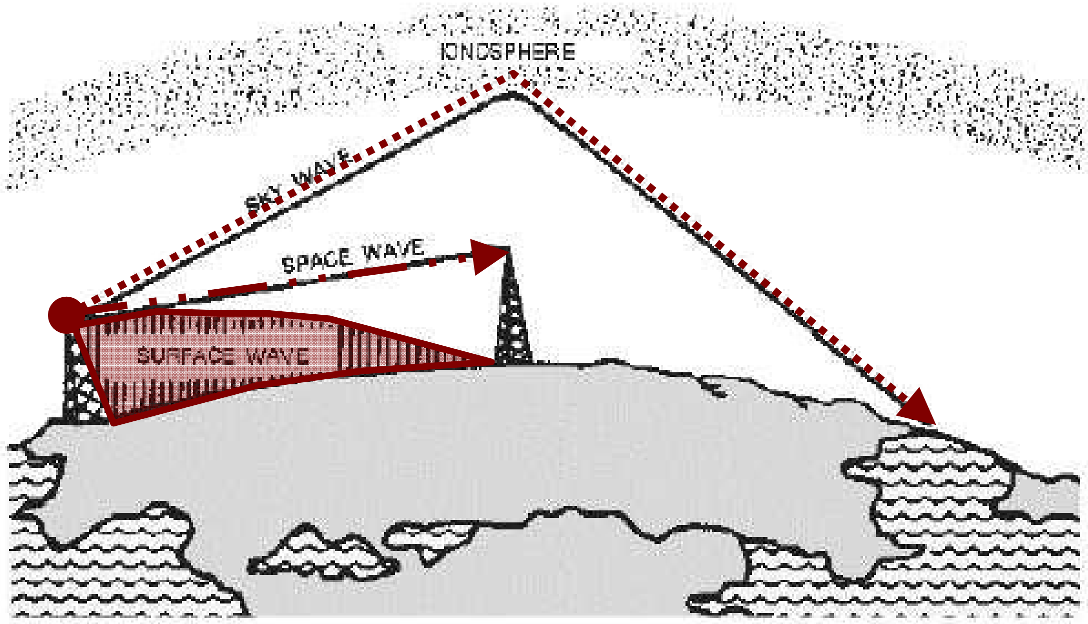
- **Ground Wave** is a surface wave that propagates close to the surface of the Earth.

- **Line of Sight** (Ground wave or Direct Wave) is propagation of waves travelling in a straight line. The rays or waves are deviated or reflected by obstructions and cannot travel over the horizon or behind obstacles. Most common of the radio propagation modes at VHF and higher frequencies. At higher frequencies and in lower levels of the atmosphere, any obstruction between the transmitting antenna and the receiving antenna will block the signal, just like the light that the eye senses

- **Space Waves**: travel directly from an antenna to another without reflection on the ground. Occurs when both antennas are within line of sight of each another, distance is longer that line of sight because most space waves bend near the ground and follow practically a curved path. Antennas must display a very low angle of emission in order that all the power is radiated in direction of the horizon instead of escaping in the sky. A high gain and horizontally polarized antenna is thus highly recommended.

- **Sky Wave** (Skip/ Hop/ Ionospheric Wave) is the propagation of radio waves bent (refracted) back to the Earth's surface by the ionosphere. HF radio communication (between 3 and 30 MHz) is a result of skywave propagation.

LINE OF SIGHT, GROUND WAVE, SKY WAVE



LINE OF SIGHT, GROUND WAVE, SKY WAVE CONT'D

The range of sky-wave propagation **is much longer** than ground-wave propagation. RAC: 6.2

When a signal is returned to earth by the ionosphere, this is called **sky-wave propagation.** RAC: 6.2

VHF signals are propagated within the range of the visible horizon **by direct wave.** RAC: 6.2

Line-of-sight propagation usually occurs from one hand-held VHF transceiver to another nearby. RAC: 6.2

That portion of the radiation which is directly affected by the surface of the earth is called **ground wave.** RAC: 6.2

A line of sight transmission between two stations uses mainly the **ground wave.** RAC: 6.2

The distance travelled by ground wave is **less at higher frequencies.** RAC: 6.3

The radio wave which follows a path from the transmitter to the ionosphere and back to earth is known correctly as the **ionospheric wave.** RAC: 6.3

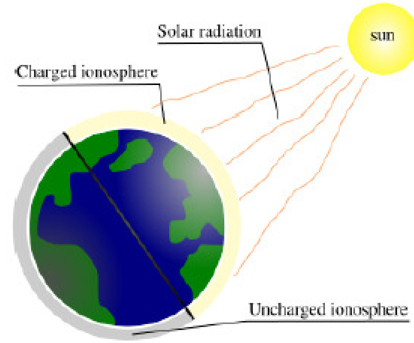
Reception of high frequency (HF) radio waves beyond 4000 km is generally possible by **ionospheric wave.** RAC: 6.3

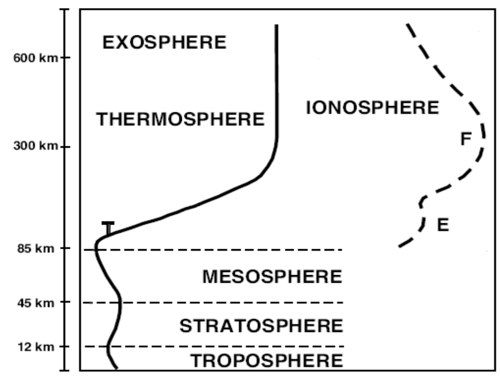
Skywave is another name for **ionospheric wave.** RAC: 6.2

IONOSPHERE REGIONS

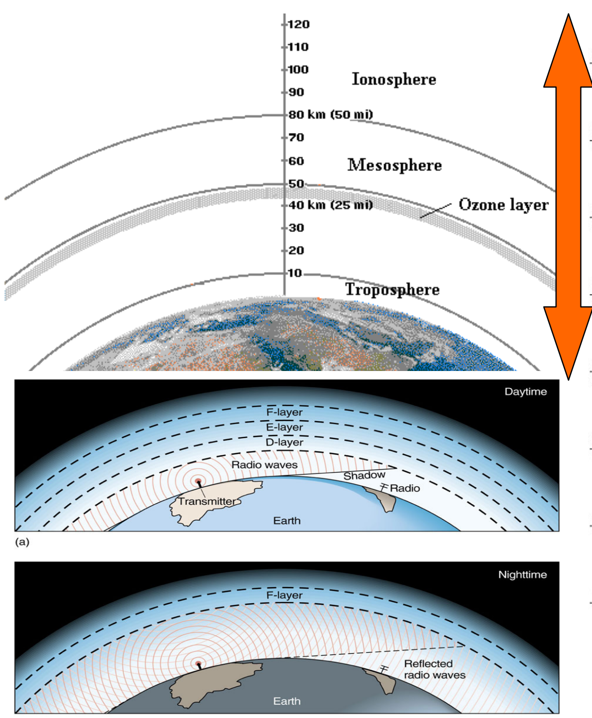
- The ionosphere is the uppermost part of the atmosphere, it is ionized by solar radiation.
- Ionization is converting an atom or molecule into an ion by light (heating up or charging) from the sun on the upper atmosphere.
- Creates an horizontally stratified medium where each layer has a peak density and a definable width, or profile.

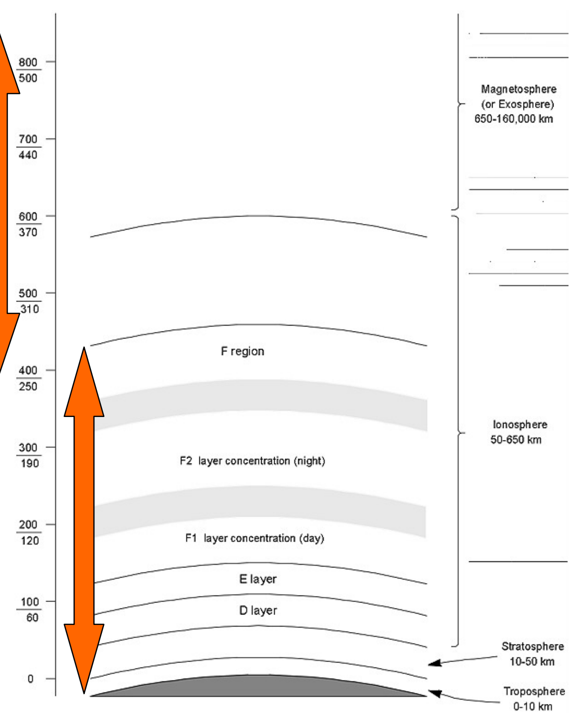
Thus, it influences radio propagation





IONOSPHERE REGIONS





IONOSPHERE REGIONS CONT'D

Solar radiation ionizing the outer atmosphere causes the ionosphere to form. RAC: 6.3
Ultraviolet solar radiation is most responsible for ionization in the outer atmosphere. RAC: 6.3
The ionosphere is most ionized at **midday**. RAC: 6.3
The ionosphere is least ionized **shortly before dawn**.

The **D** ionospheric region is closest to the earth. RAC: 6.3
The **D** region of the ionosphere is the least useful for long-distance radio-wave propagation. RAC: 6.3
The main reason the 160, 80 and 40 metre amateur bands tend to be useful only for short-distance communications during daylight hours is because of **D-region absorption**. RAC: 6.9
The position of the E layer in the ionosphere is **below the F layer**. RAC: 6.3

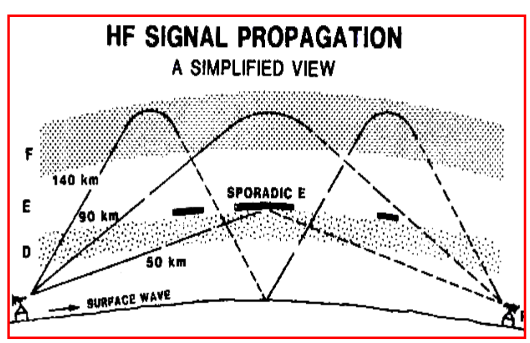
During the day, one of the ionospheric layers splits into two parts called **F1 & F2**. RAC: 6.3
The **F1 and F2** sub-regions of the ionosphere exist only in the daytime. RAC: 6.3
The F2 region is mainly responsible for the longest-distance radio-wave propagation **because it is the highest ionospheric region**. RAC: 6.3

PROPAGATION, HOPS, SKIPS ZONES

- **Multihop:** via the F2-layer can reach DX stations in doing several hops communicating on the other side of the Earth.

- It's subject to fading and attenuation each time the radio wave is reflected or partially refracted at either the ground or ionosphere results in loss of energy signals, can also be stable with few attenuation if the ionospheric absorption is very weak.

•20 and 15m are the best for this type of traffic. In these bands you can work stations located over 10000 km away, and, from Europe.



PROPAGATION, HOPS, SKIPS ZONES

- **Attenuation**: when the distance doubles, the signal becomes half less strong. obstacles placed between emitter, receiver, and travelling around the earth; radio waves lose their energy as they forced to bend to follow the earth curvature.

- **Reflection**: similar to its optical counterpart as wave enters in contact with a surface. Long wavelengths, from 80 meters long and above don't practically "see" small obstacles like cars, trees or buildings. These objects are proportionally too small can't reflect its energy. The long waves pass thus across these materials without be reflected. Due to its large surface, long waves are however reflected by the ground and can penetrate it up to some meters depth. V/UHF waves (2m and 70 cm long) are on the contrary very sensitive to small obstacles. Depending of their thickness metal objects can be used as reflectors.

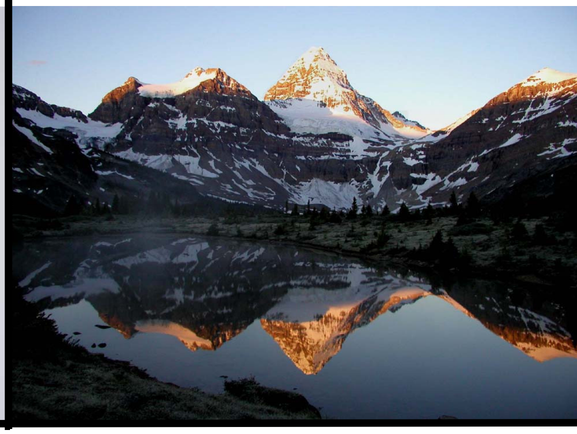
- **Refraction**: the bending of waves that occurs when they pass through a medium (air or ionosphere) produce variation in the velocity of waves that tend to go further or dropping sooner that expected. For example, the wave refracts and bend gradually given the appearance that the path is curved.

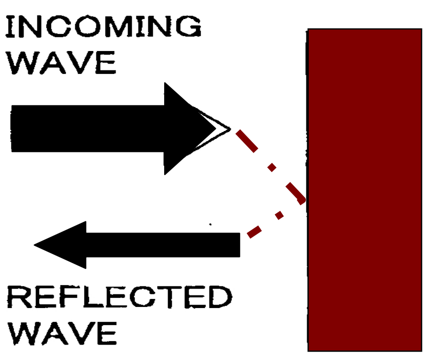
PROPAGATION, HOPS, SKIPS ZONES

- **Diffraction**: due to its high frequency bends around the edge of the object and tends to make the borders of it lighter. That means that some light reaches well some places that we considered as plunged into darkness. The same effect applies to radio waves. A spot located out of sight from a transmitter, say behind a hill, can receive weakly its emissions because its signals are bending gradually by diffraction and can reach the remote receiver. This effect has practically no influence in HF because waves arrive usually to the receiver by many other means such as refraction or reflection in the upper atmosphere, including sometimes ground waves if the transmitter is not too far (say 150-200 km away).

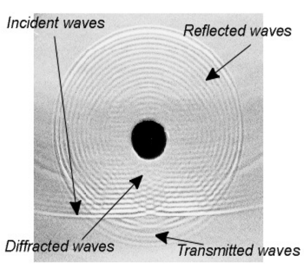
- **Skip Zone:** the region between the furthest transmission points and the nearest point refracted waves can be received. Within this region, no signal can be received as there are no radio waves to receive.

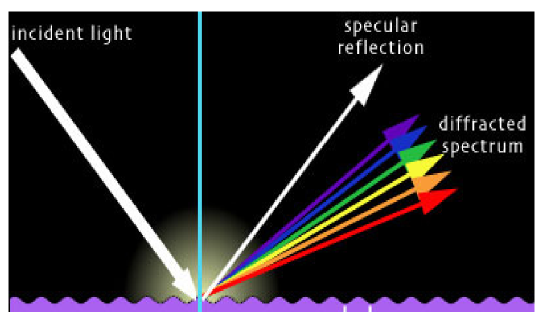
- **Skip Distance:** the least distance between point of transmission and the point of reception



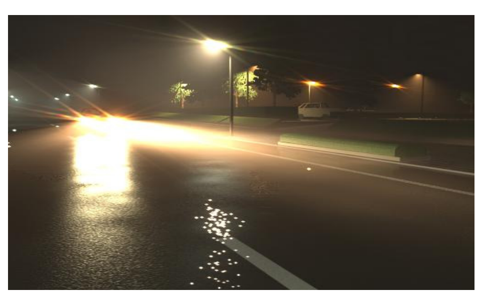


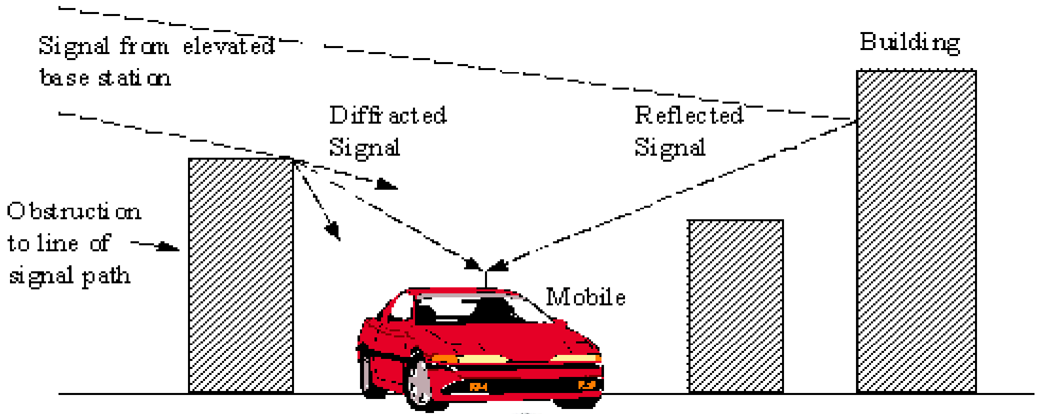
Attenuation is the reduction in amplitude and intensity of a signal. Can also be understood to be the opposite of amplification. Attenuation is important in determining signal strength as a function of distance

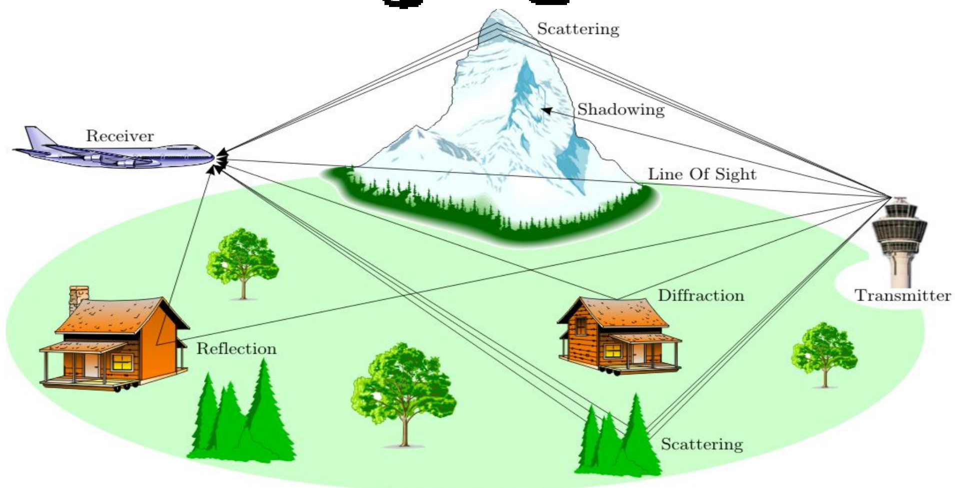




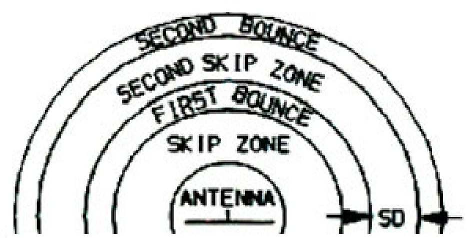
Diffraction refers to various phenomena associated with wave propagation, such as the bending, spreading and interference of waves passing by an object or aperture that disrupts the wave

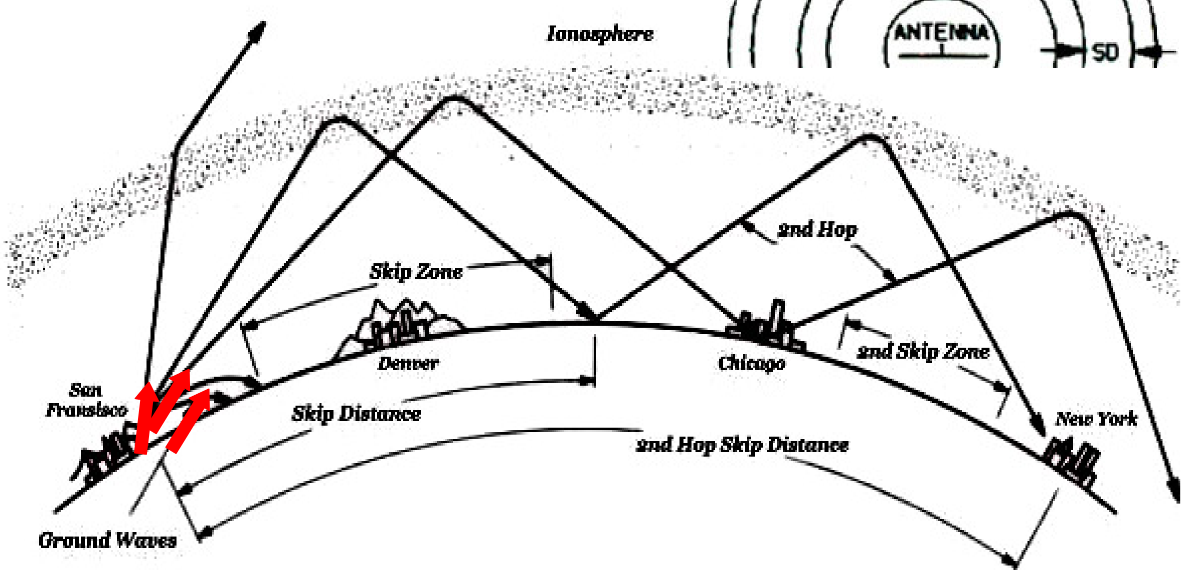




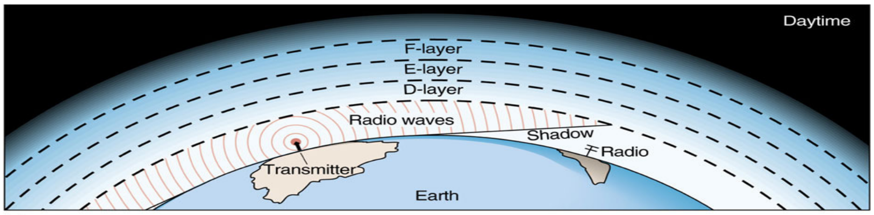


PROPAGATION, HOPS SKIPS ZONES

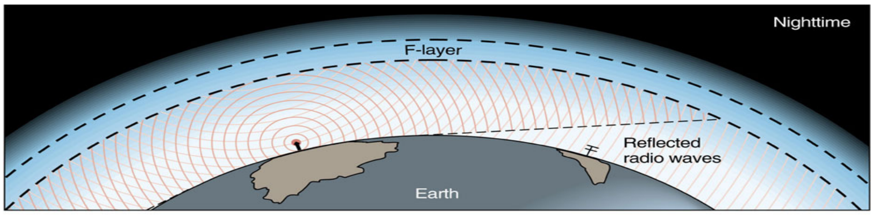




PROPAGATION, HOPS SKIPS ZONES CONT'D



(a)



(b)

The maximum distance along the earth's surface that is normally covered in one hop using the F2 region is 4000 Km (2500 miles).

The maximum distance along the earth's surface that is normally covered in one hop using the E region is 2000 Km (1200 miles)

The distance to Europe from your location is approximately 5000 Km. Multihop propagation is most likely to be involved.

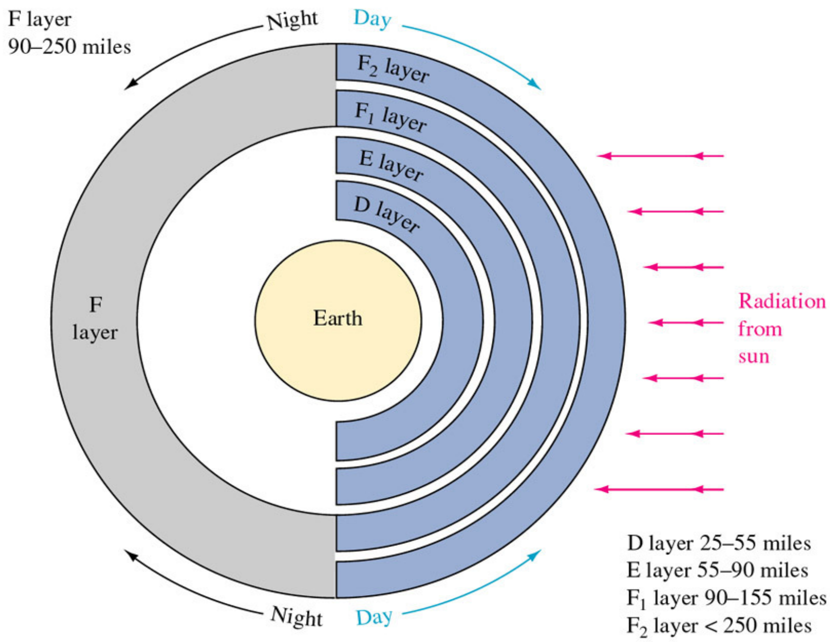
THE IONOSPHERIC LAYERS

The D layer: is the innermost layer, 50 km to 90 km above the surface of the Earth. when the sun is active with 50 or more sunspots, During the night cosmic rays produce a residual amount of ionization as a result high-frequency (HF) radio waves aren't reflected by the D layer. **The D layer is mainly responsible for absorption of HF radio waves**, particularly at 10 MHz and below, with progressively smaller absorption as the frequency gets higher. The **absorption is small at night** and **greatest about midday**. The layer reduces greatly after sunset. A common example of the D layer in action is the disappearance of distant AM broadcast band stations in the daytime.

The E layer: is the middle layer, 90 km to 120 km above the surface of the Earth. This layer can only reflect radio waves having frequencies less than about 10 MHz. It has a negative effect on frequencies above 10 MHz due to its partial absorption of these waves. At night the E layer begins to disappear because the primary source of ionization is no longer present. The increase in the height of the E layer maximum increases the range to which radio waves can travel by reflection from the layer.

The F layer: or region, is 120 km to 400 km above the surface of the Earth. It is the top most layer of the ionosphere. Here extreme ultraviolet (UV) (10-100 nm) solar radiation ionizes atomic oxygen (O). The F region is the most important part of the ionosphere in terms of HF communications. The F layer combines into one layer at night, and in the presence of sunlight (during daytime), it divides into two layers, the **F1 and F2**. The F layers are responsible for most skywave propagation of radio waves, and are thickest and most reflective of radio on the side of the Earth facing the sun.

PROPAGATION, HOPS SKIPS ZONES CONT’D



THE IONOSPHERIC LAYERS CONT’D

Ionospheric Storms: Solar activity such as flares and coronal mass ejections produce large electromagnetic radiation incident upon the earth. It leads to disturbances of the ionosphere and changes the density distribution, electron content, and the ionospheric current system. Can disrupt satellite communications and cause a loss of radio frequencies previously reflecting off the ionosphere. Ionospheric storms can last typically for a day or so.

When the ionosphere is strongly charged (daytime, summer, much solar activity) longer waves will be absorbed and never return to earth. You don't hear distant AM broadcast stations during the day. Shorter waves will be reflected and travel further. **Absorption occurs in the D layer** which is the lowest layer in the ionosphere. The intensity of this layer is increased as the sun climbs above the horizon and is greatest at noon. Radio waves below 3 or 4 MHz are absorbed by the D layer when it is present.

When the ionosphere is weakly charged (night time, winter, low solar activity) longer waves will travel a considerable distance but shorter waves may pass through the ionosphere and escape into space. VHF waves pull this trick all the time, hence their short range and usefulness for communicating with satellites.

Faraday Rotation: EM waves passing through the ionosphere may have their polarizations changed to random directions. Waves decomposed into two circularly polarized rays which propagate at different speeds. The rays can re-combine upon emergence from the ionosphere, however owing to the difference in propagation speed they do so with a net phase offset, resulting in a rotation of the angle of linear polarization.

THE IONOSPHERIC LAYERS CONT'D

- Solar radiation, acting on the different compositions of the atmosphere generates layers of ionization
- Studies of the ionosphere have determined that there are at least four distinct layers of D, E, FI, and F2 layers.
- The F layer is a single layer during the night and other periods of low ionization, during the day and periods of higher ionization it splits into two distinct layers, the F1 and F2.
- There are no clearly defined boundaries between layers. These layers vary in density depending on the time of day, time of year, and the amount of solar (sun) activity.
- The top-most layer (F and F1/F2) is always the most densely ionized because it is least protected from the Sun.

ABSORPTION AND FADING

- Fading of signals is the effect at a receiver do to a disturbed propagation path. A local station will come in clearly, a distant station may rise and fall in strength or appear garbled. Fading may be caused by a variety of factors:
- **A reduction of the ionospheric** ionization level near sunset.
- **Multi-path propagation:** some of the signal is being reflected by one layer of the ionosphere and some by another layer. The signal gets to the receiver by two different routes The received signal may be enhanced or reduced by the wave interactions. In essence, radio signals' reaching the receiving antenna by two or more paths. Causes include atmospheric ducting, ionospheric reflection and refraction, and reflection from terrestrial objects, such as mountains and buildings.
- **Increased absorption as the D** layer builds up during the morning hours.
- Difference in path lengths caused by **changing levels of ionization** in the reflecting layer.
- **E layer starts to disappear** radio waves will pass through and be reflected by the F layer, thus causing the skip zone to fall beyond the receiving station.
- **Selective fading:** creates a hollow tone common on international shortwave AM reception. The signal arrives at the receiver by two different paths, and at least one of the paths is changing (lengthening or shortening). This typically happens in the early evening or early morning as the various layers in the ionosphere move, separate, and combine. The two paths can both be skywave or one be groundwave.

ABSORPTION AND FADING

The **ionization of the D region** causes the ionosphere to absorb radio waves. RAC: 6.3

The D region of the ionosphere **absorbs** lower-frequency HF signals in the daytime. RAC: 6.3

Two or more parts of the radio wave follow different paths during propagation and this may result in phase differences at the receiver. This "change" at the receiver is called **fading.** RAC: 6.4

A change or variation in signal strength at the antenna, caused by differences in path lengths, is called **fading**. RAC: 6.4

When a transmitted radio signal reaches a station by a one-hop and two-hop skip path, small changes in the ionosphere can cause **variations in signal strength**. RAC: 6.4

The usual effect of ionospheric storms is to **cause a fade-out of sky-wave signals.** RAC: 6.6

On the VHF and UHF bands, polarization of the receiving antenna is very important in relation to the transmitting antenna, yet on HF bands it is relatively unimportant. This is because **the ionosphere can change the polarization** of the signal from moment to moment.

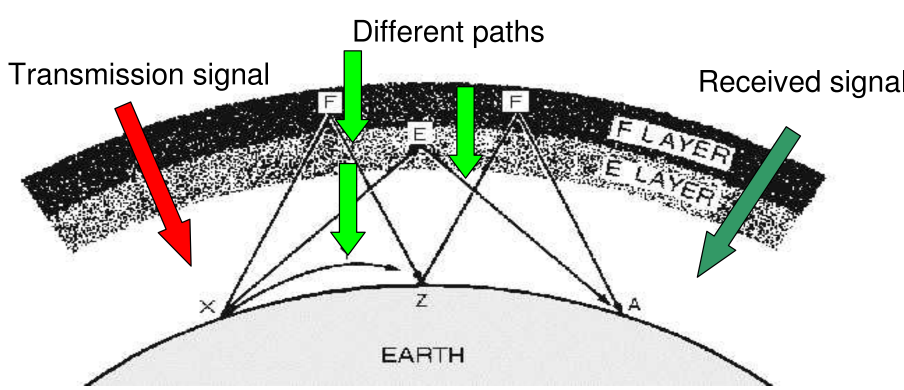
Polarization change often takes place on radio waves that are propagated over long distances. **Reflections, passage through magnetic fields (Faraday rotation) and refractions all cause polarization change.**

ABSORPTION AND FADING

Phase differences between radio wave components of the same transmission, as experienced at the receiving station cause selective fading.

Selective fading is **more pronounced at wide bandwidths.**

Reflection of a SSB transmission from the ionosphere causes **little or no phase-shift distortion.**

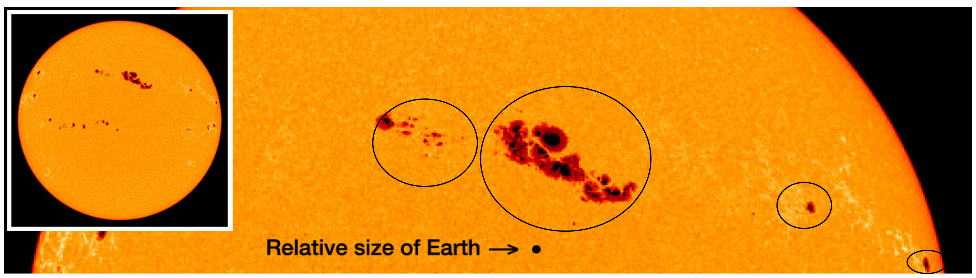


SOLAR ACTIVITY AND SUN SPOTS

- The most critical factor affecting radio propagation is solar activity and the sunspot cycle. Sunspots are cooler regions where the temperature may drop to a frigid 4000K. Magnetic studies of the sun show that these are also regions of very high magnetic fields, up to 1000 times stronger than the regular magnetic field.

- Our Sun has sunspot cycle of about 22 years which reach both a minima and maxima (**we refer to a 11 year low and high point or cycle**). When the sunspots are at their maximum propagation is at its best.

- Ultraviolet radiation from the sun is the chief (though not the only) source of ionization in the upper atmosphere. During periods of low ultraviolet emission the ionization level of the ionosphere is low and radio signals with short wavelengths will pass through and be lost to space. During periods of high ultraviolet emission higher levels of ionization reflect higher frequencies and shorter wavelengths will propagate much longer distances.



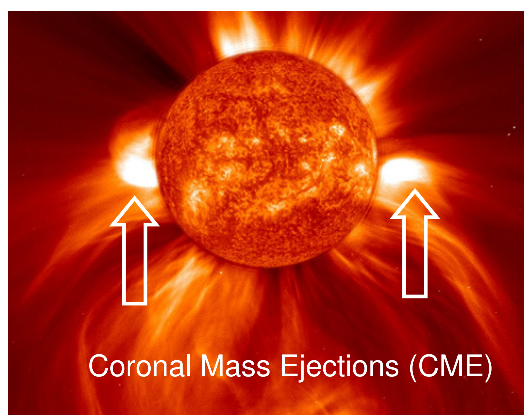
SOLAR ACTIVITY AND SUN SPOTS CONT'D

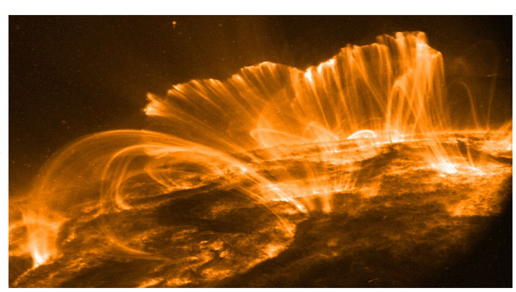
Emission of larger amounts of ultraviolet radiation corresponds to increased surface activity on the sun.

Length of a solar cycle can vary by one or two years in either direction from the 22 and 11 year average but it has remained near this value throughout geologic time.

Solar maxima can also lead to highly variable propagation conditions due to periods of disturbance during solar magnetic disturbances *(solar storms)* which occur at this period.

Solar Flux (Index): is a measure of the radio energy emitted from the sun. The solar flux value is considered to be one of the best ways of relating solar activity to propagation. When sun spot cycles hit their peaks the solar flux may have a value over 200. When the sun spot cycle is at its lowest point the solar flux values can be as low as 50 or 60. The higher the solar flux value the better propagation will be.





SOLAR ACTIVITY AND SUN SPOTS CONT'D

- Electromagnetic emissions and particle emissions hit the Earths ionosphere at various speeds with different energy levels. Effects of their impact varies accordingly but mainly with sky waves. The particles emitted are accompanied by a tiny pulse of electromagnetic radiation. Electromagnetic and particle radiations can potentially modify the ionosphere and affect its properties.

- Electromagnetic emissions hit first the F-layer of the ionosphere increasing its ionization; atoms and molecules warm up and free one or more electrons. The higher the solar activity, the stronger the ionization of the F-layer. A strong ionization of the F-layer increases its reflecting power. Stronger the ionization, the higher the **maximum usable frequency (MUF)**, exceeding regularly 40 or 50 MHz in such occasions.

- Particle emissions are constituted of high-energy protons electrons forming solar cosmic rays when the sun releases huge amount of energy in Coronal Mass Ejections (CME). These particles of protons and heavy nuclei propagate into space, creating a shockwave. The pressure created by the particles clouds is huge and has a large effect on the ionosphere communications are interrupted.

SOLAR ACTIVITY AND SUN SPOTS

All communication frequencies throughout the spectrum are affected in varying degrees by the **sun.** RAC: 6.6

Solar activity influences all radio communication beyond ground-wave or line-of-sight ranges. RAC: 6.6

Solar flux is the **radio energy emitted by the sun.**

The solar-flux index is a **measure of solar activity** that is taken at a specific frequency. RAC: 6.6

Two types of radiation from the sun that influence propagation are **electromagnetic and particle emissions.** RAC: 6.6

The ability of the ionosphere to reflect high frequency radio signals depends on the **amount of solar radiation.** RAC: 6.6

The greater the ionization of the atmosphere the **more sunspots** there are.

An average sunspot (propagation) cycle is **11 years** long. RAC: 6.6

When sunspot numbers are high, **frequencies up to 40 MHz or higher are normally usable for long-distance communication.** RAC: 6.6

MF, HF CRITICAL FREQUENCIES

- **Critical Frequency:** the penetrating frequency and the highest frequency at which a radio wave, if **directed vertically upward**, will be refracted back to earth by an ionized layer. Radio waves at a frequency above the Critical Frequency will not be refracted/reflected. This will create a zone around the transmitter that will not receive signals known as the Skip Zone. The size of this zone will vary with the layer in use and the frequency in use.

- **Maximum Usable Frequency (MUF):** the highest frequency that will be reflected back to earth by the ionized layers. Above this frequency there is no reflection and thus no skip. MUF depends on the layer that is responsible for refraction/reflection and so contact between two stations relying on skip will depend on the amount of sunspot activity, the time of day, and the time of year, latitude of the two stations and **antenna transmission angle**. The MUF is not significantly affected by transmitter power and receiver sensitivity

- **Frequency of optimum transmission:** is the highest effective (i.e. working) frequency that is predicted to be usable for a specified path and time for 90% of the days of the month. It is often abbreviated as FOT and normally just below the value of the maximum usable frequency (MUF). The FOT is usually the most effective frequency for ionospheric reflection of radio waves between two specified points on Earth

- **The lowest usable high frequency (LUF):** the frequency in the HF band at which the received field intensity is sufficient to provide the required signal-to-noise ratio. The amount of energy absorbed by the lower regions of the ionosphere (D region, primarily) directly impacts the LUF

  Angle of incidence: is a measure of deviation of something from "straight on", for example in the approach of a ray to a surface.

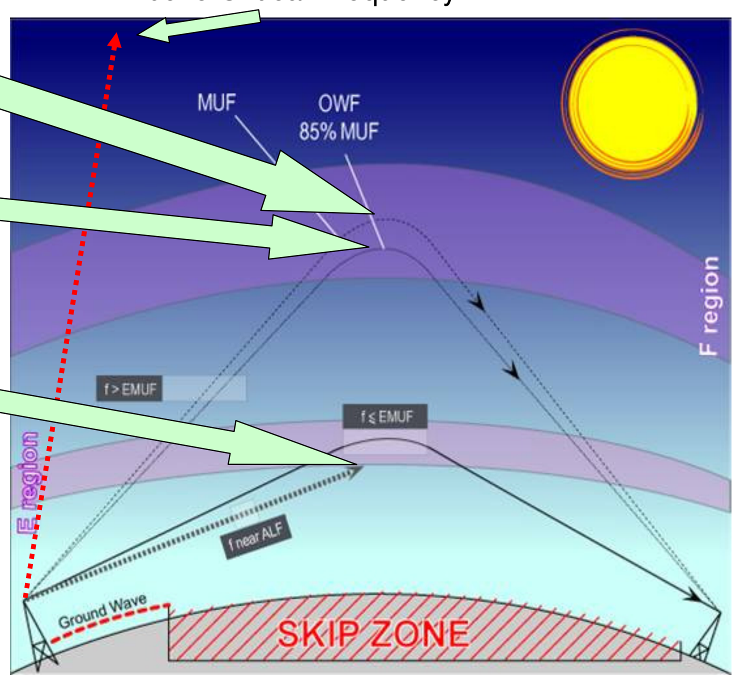
MF, HF CRITICAL FREQUENCIES

Above Critical Frequency

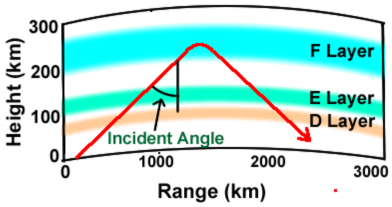
Maximum Useful Frequency (MUF)

Frequency of optimum transmission (FOT) /Optimal Working Frequency (OWF)

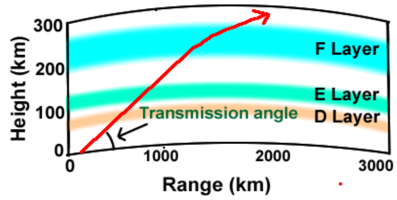
Lower Absorption Frequency (ALF) / The lowest Usable frequency (LUF):



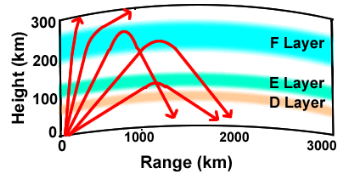
MF, HF CRITICAL FREQUENCIES



incident angle and refraction



transmission angle is higher frequency than the MUF.



waves of the same frequency at several different transmission (and incident) angles

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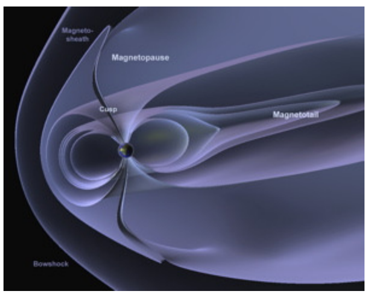
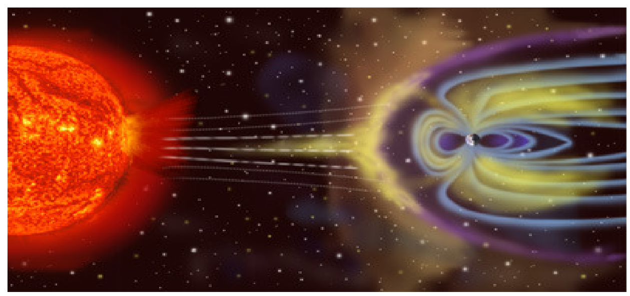
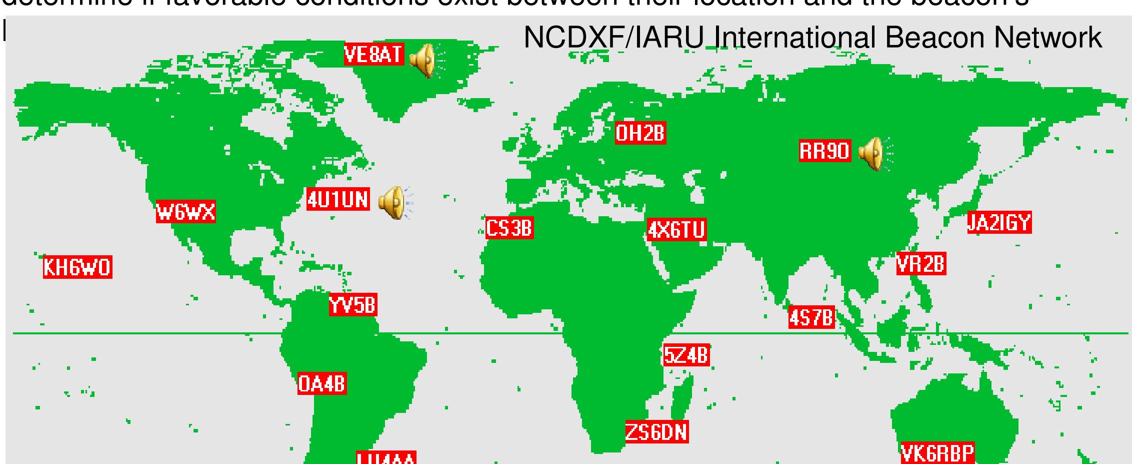
- **Earth's Geomagnetic Fields:** Activity in this field caused by interaction with charged particles from the sun can affect propagation.





BEACONS - 10 METERS

Operated by Amateur operators to determine propagation conditions. Ten meter beacons can be found between 28.175 and 28.300 MHZ. Beacons usually identify their location and power output by CW. Amateur operators can use this information to determine if favorable conditions exist between their location and the beacon's l



28.200	4U1UN	UNITED NATIONS
28.200	VE8AT	CANADA
28.200	W6WX	SAN JOSE, CA
28.200	KH6WO	HONOLULU, HI
28.200	ZL6B	NEW ZEALAND
28.200	VK6RBP	AUSTRALIA
28.200	JA2IGY	MT ASAMA, JAPAN
28.200	RR9O	NOVOSIBIRSK RUSSIA
28.200	VR2R	HONG KONG CHINA

28.200	4S7B	SRI LANKA
28.200	ZS6DN	WINGATE PK S. AFRICA
28.200	5Z4B	KENYA, AFRICA
28.200	4X6TU	TEL AVIV
28.200	OH2B	KIRKKILA, FINLAND
28.200	CS3B	MADERIA IS
28.200	LU4AA	ARGENTINA
28.200	OA4B	PERU
28.200	YV5B	CARACAS, VEN

BEACONS (HF)1.8170 - 24.9860 MHZ (THERE ARE MANY MORE!!!!)

CALLSIGN	FREQUENCY	GRID	LOCATION	POWER	ANTENNA
ZS1J/B	1.8170	KF16PF	Plettenberg Bay	N/A	N/A
OK0EV	1.8450	N/A	N/A	N/A	N/A
DK0WCY	3.5790	JO44VQ	Scheggerott	30	dipole
ZS1J/B	3.5865	KF16PF	Plettenberg Bay	N/A	N/A
OK0EN	3.6000	JO70AC	Kam.Zehrovice	150m	dipole
ZS1AGI	7.0250	KF16EA	George Airport	1	dipole
ZS1J/B	10.1235	KF16PF	Plettenberg Bay	N/A	N/A
OK0EF	10.1340	JO70BC	Kladno	500m	dipole
HP1RCP/B	10.1390	FJ09HD	testing,intermittant	2	vertical
PY3PSI	10.1400	GF49KX	Porto Alegre, 85m asl	2	dipole N-S
HB9TC	10.1400	N/A	off (ausser Betrieb)	N/A	N/A
DK0WCY	10.1440	JO44VQ	Scheggerott	30	Horiz.loop
LU0ARC	14.0460	N/A	South Atlantic	N/A	N/A
HP1AVS/B	18.0990	FJ09HD	Cerro Jefe	1	1/2 vertical
KH6AP	21.1420	N/A	off (Kihei/Maui, HI)	50	vertic.AV640
VE9BEA/B	21.1455	FN66	Crabbe Mtn, NB	220m	N/A
PY3PSI	21.3935v	GF49KX	Porto Alegre, 85m asl	4	slope dipole
IK6BAK	24.9150	JN63KR	N/A	12	2 dipoles
IY4M	24.9200	JN54OK	Bologna(Marconi Memorial)	2	GP
DK0HHH	24.9310	JO53AM	Hamburg-Rothenburgsort	10	dipole N-S
JE7YNQ	24.9860	QM07	Fukushima	N/A	N/A

MF, HF CRITICAL FREQUENCIES

The maximum usable frequency is **the highest frequency signal that will reach its intended destination.** RAC: 6.8

The **amount of radiation received from the sun, mainly ultraviolet**, causes the maximum usable frequency to vary. RAC: 6.8

One way to determine if the Maximum Usable Frequency (MUF) is high enough to support 28-MHz propagation between your station and western Europe is to **listen for signals on the 10-metre beacon frequency**. RAC: 6.6

If we transmit a signal, the frequency of which is so high we no longer receive a reflection from the ionosphere, the signal frequency is above the **maximum usable frequency (MUF)**. RAC: 6.8

Radio waves with frequencies below the Maximum Usable Frequency (MUF) when they are sent into the ionosphere are **bent back to the earth.** RAC: 6.8

The Optimum Working Frequency provides the best long-range HF communication. Compared with the Maximum Useable Frequency (MUF), it is usually **slightly lower**. RAC: 6.8

Signals higher in frequency than the critical frequency **pass through the ionosphere.**

MF, HF CRITICAL FREQUENCIES CONT'D

During a sudden ionospheric disturbance an amateur station may be able to continue HF communications if it tries a **higher frequency**. RAC: 6.6

During summer daytime the **160 and 80 metre** bands are the most difficult for communications beyond ground wave. RAC: 6.9

Communication on the 80 metre band is generally most difficult during **daytime in summer**. RAC: 6.9

At any point in the solar cycle, the 20-metre band usually supports worldwide propagation during daylight hours. RAC: 6.9

UHF, VHF, SPORADIC E, AURORAS, DUCTING

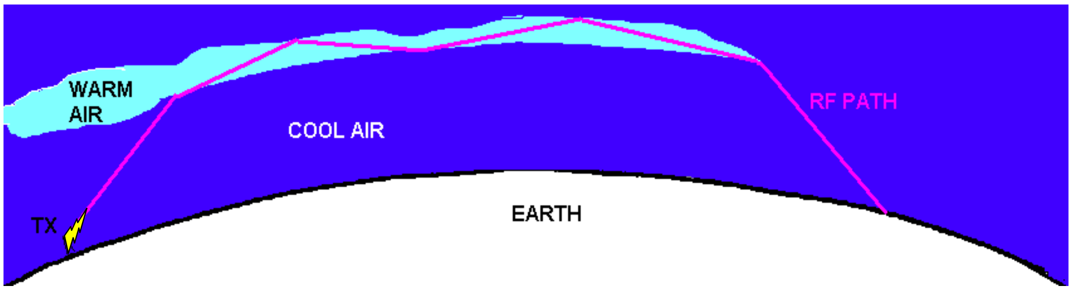
Propagation above 30 MHz is normally not affected by conditions of the ionosphere. These radio waves pass through the ionosphere without refraction and escape to space. These frequencies are useful for **Direct Wave communication** and for working **Amateur satellites (ARISS / OSCAR) and moon-bounce (EME)**. The **6 metre band** is an exception as under conditions of high sunspot activity it acquires some of the characteristics of the 10 metre band.

The VHF band and above use direct waves and line of sight communications. The range of propagation can be slightly greater at times by a factor of 4/3 due to refraction effects in the Troposphere. This means under the right conditions, you can make contact with stations beyond the horizon. The effects diminish as the frequency increases. In certain favorable locations, enhanced tropospheric propagation may enable reception signals up to 800 miles or more. Other conditions which affect the propagation of VHF signals (and above) are:

Sporadic-E: strongly ionized clouds can occur in the "E" layer of the ionosphere and VHF signals will be refracted back to earth extending the range to a few thousand kilometers. Conditions occur primarily in the spring and late fall. Until recently 50 MHz (6 metre band) was considered to be the highest frequency useable for Sporadic-E operation. Increased 2 metre activity in the last decades show several DX records have been set using suspected Sporadic-E propagation and the highest frequency at which this propagation mode can be used must be considered to be as yet unknown.

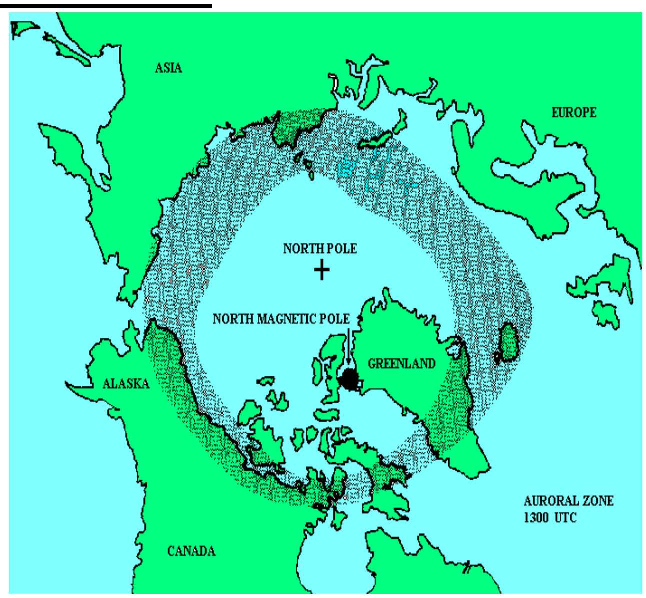
UHF, VHF, SPORADIC E, AURORAS, DUCTING

Temperature Inversion / Troposphere Ducting: Certain weather conditions produce a layer of air in the Troposphere that will be at a higher temperature than the layers of air above and below it. Such a layer will provide a "duct" creating a path through the warmer layer of air which has less signal loss than cooler layers above and below. These ducts occur over relatively long distances and at varying heights from almost ground level to several hundred meters above the earth's surface. This propagation takes place when hot days are followed by rapid cooling at night and affects propagation in the 50 MHz - 450 MHz range (6 meter, 2 meter, 1 1/4 meter and 70 centimeter bands). Signals can propagate hundreds of kilometers up to about 2,000 kilometers (1,300 mi).



UHF, VHF, SPORADIC E, AURORAS, DUCTING

Auroral Effects: Borealis or Northern Lights is evidence of strong ionization in the upper atmosphere and can be utilized to reflect signals. Requires a relatively high power transmitter and both stations point their antennas north toward the aurora. The preferred mode when working VHF aurora is CW although SSB can be used at 50 MHz. The received tone quality when using CW is very different than what you may be used to. Characteristic buzz, echo, very raspy and garbled tones can be expected.



The reason auroral signals sound different is they are being reflected by changing and rapidly-moving reflector (the ionised gases in the aurora). This results in multi-path reflections and the introduction of doppler shift into the signals.

UHF, VHF, SPORADIC E, AURORAS, DUCTING

Hilly Terrain: mountainous area signals tend to be much shorter than those in open country. Signals are reflected off mountains and are also absorbed by them. If a signal passes over the top of a hill it may bend or refract back down the other side.

The Concrete Jungle: Propagation in the city is similar to the effects found in mountainous terrain. A city will often be plagued by "mobile flutter", caused by multiple reflections of the signal off buildings. A move of 20 cm or so can make all the difference in the world. Working through a repeater can be complicated by the fact that you are using two different frequencies (some times called fence picketing).

Equatorial E-skip: a regular daytime occurrence over the equatorial regions and is common in the temperate latitudes in late spring, early summer and, to a lesser degree, in early winter. For receiving stations located within +/– 10 degrees of the geomagnetic equator, equatorial E-skip can be expected on most days throughout the year, peaking around midday local time.

Earth – Moon – Earth (EME) propagation (Moon bounce): Radio amateurs have been experimenting with lunar communications by reflecting VHF and UHF signals off the moon between any two points that can observe the moon at a common time. Distance from earth means path losses are very high. The resulting signal level is often just above the noise.

UHF, VHF, SPORADIC E, AURORAS, DUCTING

The **E** ionospheric region most affects sky-wave propagation on the 6 metre band.

That portion of the radiation kept close to the earth's surface due to bending in the atmosphere is called the **tropospheric wave**.

Tropospheric ducting of radio waves is caused by a **temperature inversion**. RAC: 6.10

Tropospheric ducting is responsible for propagating a VHF signal over 800 kM (500 miles). RAC: 6.10

Tropospheric bending affects 2-metre radio waves by **letting you contact stations farther away**. RAC: 6.10

Excluding enhanced propagation modes, the approximate range of normal VHF tropospheric propagation is **800 kM (500 miles)**.

A **sporadic-E condition** occurs when there are patches of dense ionization at E-region height. RAC: 6.10

The extended-distance propagation effect of sporadic-E is most often observed on the **6 metre band.** RAC: 6.10

In the northern hemisphere, a directional antenna should be pointed **North** to take maximum advantage of auroral propagation. RAC: 6.10

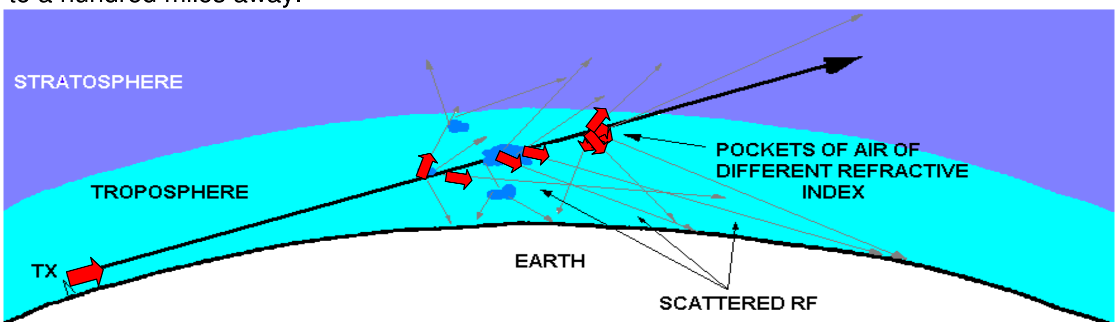
In the ionosphere, auroral activity occurs at **E-region height**. RAC: 6.10

CW and SSB emission modes are best for auroral propagation. RAC: 6.10

SCATTER, HF, VHF,UHF

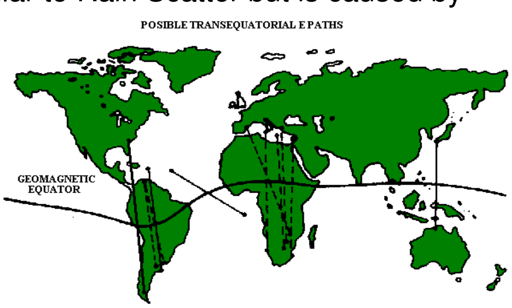
Scatter : A propagation type which occurs on a frequency very close to the maximum usable frequency. It produces a weak, and distorted signal when heard with in a skip zone since only parts of the signal is being recovered. Ionospheric scatter takes place as a result of anomalies in the propagating layer of the ionosphere that is being used for a particular path. Patches of intense ionisation, or local variations in height, can cause abnormal refraction to take place. Differences in the angles of incidence and refraction occur allowing over-the-horizon communication between stations as far as 500 miles (800 km) apart.

Tropospheric scatter (or troposcatter) : Signals via the troposphere travel farther than the line of sight. This is because of the height at which scattering takes place. The magnitude of the received signal depends on the number of turbulences causing scatter in the desired direction and the gain of the receiving antenna. The signal take-off angle (transmitting antenna's angle of radiation) determines the height of the scatter volume and the size of the scatter angle. The tropospheric region that contributes most strongly to tropospheric scatter propagation lies near the midpoint between the transmitting and receiving antennas and just above the radio horizon of the antennas. This effect sometimes allows reception of stations up to a hundred miles away.

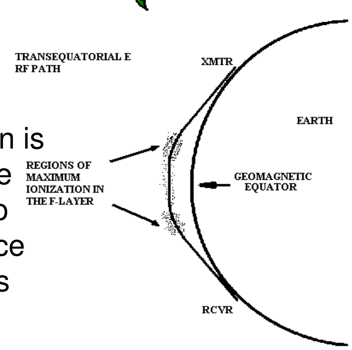


SCATTER, HF, VHF,UHF

Rain Scatter: A band of very heavy rain (or rain and hail) can scatter or even reflect signals. Distances are typically around 160 km. though up to 650 km (400 mi) is theoretically possible. (Note that heavy snow is not an useful reflector). **Ice Pellet Scatter** (called Sleet Scatter in the US). is similar to Rain Scatter but is caused by bands of Ice Pellets in the wintertime.



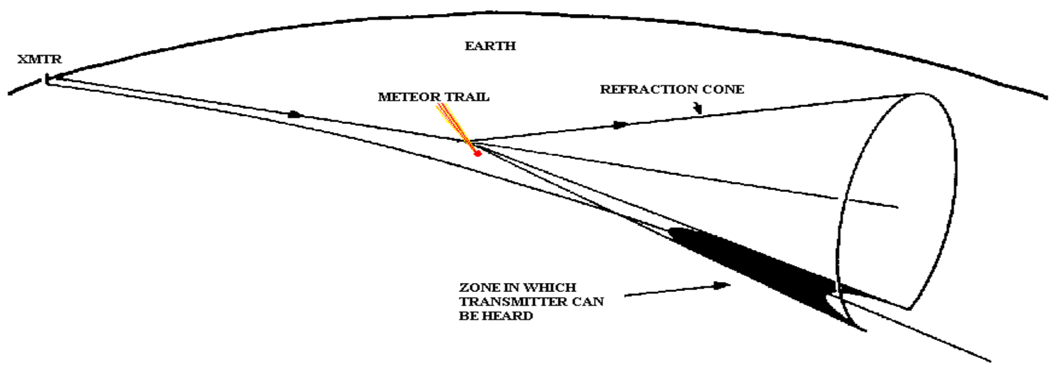
Trans-Equatorial Scatter: it possible for DX reception of television and radio stations between 3000–5000 miles or 4827–8045Km across the equator on frequencies as high as 432MHz., DX reception of lower frequencies in the 30–70MHz range is far more common. For this mode to work both transmitting and receiving stations should be almost the same distance from the equator.



Aircraft Scatter (Tropospheric Reflection): reflection off aircraft, (reflections off of flocks of birds are also possible). A rare form of reflection is "Chaf Scatter"(strips of metal foil sent out by the military during training exercises). Chaf helps to confuse enemy radars. but also helps to produce DX. Maximum distances for all reflection modes are again up to 800 km (500 mi).

SCATTER, HF, VHF,UHF

Meteor Scatter: as Meteors burn up entering the atmosphere it creates a quantity of ionized particles which reflect VHF radio waves. CW or SSB can make several rapid contacts during the brief openings that do occur. These openings may last from a few seconds to a minute or so.



Lightning Scatter: there is little documentation on it but the theory is that lightning strikes produce ionized trails a mode that is very hard to distinguish and rarely reported.

SCATTER, HF, VHF,UHF

Scatter propagation would best be used by two stations within each other's skip zone on a certain frequency.

If you receive a weak, distorted signal from a distance, and close to maximum usable frequency, **scatter propagation** is probably occurring.

A **wavering sound** is characteristic of HF scatter signals

Energy scattered into the skip zone through several radio-wave paths makes HF scatter Signals often sound distorted.

HF scatter signals are usually weak because **only a small part of the signal energy is scattered into the skip zone.**

Scatter propagation allows a signal to be detected at a distance to far for ground-wave propagation but to near for normal sky-wave propagation.

Scatter propagation on the HF bands most often occurs **when communicating on frequencies above the maximum usable frequency (MUF)**

Side, Back, and Forward, Meteor, Ionospheric, and Tropospheric are all scatter modes.

Inverted and Absorption are **NOT scatter modes.**

In the **30 – 100 MHz** frequency range, meteor scatter is the most effective for extended-range communications.

Meteor scatter is the most effective on the **6 metre band**.

Sample Questions From The IC Question Bank

A. The medium which reflects HF radio waves back to the earth's surface is called:
1) biosphere
2) stratosphere
3) ionosphere
4) troposphere

B. All communications frequency throughout the spectrum are affected in varying degrees by:
1) atmospheric conditions
2) ionosphere
3) aurora borealis
4) sun

C. Solar cycles have an average length of:
1) 1 year
2) 3 years
3) 6 years
4) 11 years

D. Wave energy produced on frequencies below 4 MHz during daylight hours is almost always absorbed by the - layer:
1) C
2) D
3) E
4) F

E. If the distance to Europe from your location is approximately 5000 km what sort of propagation is the most likely to be involved?
1) sporadic-E
2) tropospheric scatter
3) back scatter
4) Multihop

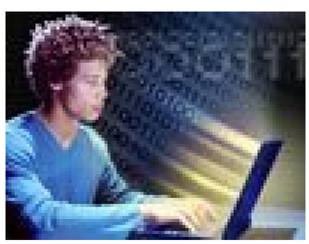
-END-

INTERFERENCE

Interference & Suppression

Front-End Overload, Cross-Modulation

•What is meant by receiver overload? **Interference caused by strong signals from a nearby transmitter**



•What is one way to tell if radio frequency interference to a receiver is caused by front-end overload? **If the interference is about the same no matter what frequency is used for the transmitter**

•If a neighbour reports television interference whenever you transmit, no matter what band you use, what is probably the cause of the interference? **Receiver overload**

•What type of filter should be connected to a TV receiver as the first step in trying to prevent RF overload from an amateur HF station transmission? **High-pass**

•When the signal from a transmitter overloads the audio stages of a broadcast receiver, the transmitted signal: **can appear wherever the receiver is tuned.**

Front-End Overload, Cross-Modulation

•Cross-modulation of a broadcast receiver by a nearby transmitter would be noticed in the receiver as: **the undesired signal in the background of the desired signal**

•What is cross-modulation interference? **Modulation from an unwanted signal is heard in addition to the desired signal**

•What is the term used to refer to the condition where the signals from a very strong station are superimposed on other signals being received? **Cross-modulation interference**

•What is the result of cross-modulation? **The modulation of an unwanted signal is heard on the desired signal**

•If a television receiver suffers from cross-modulation when a nearby amateur transmitter is operating at 14 MHz, which of the following cures might be effective? **A high pass filter attached to the antenna input of the television**

•How can cross-modulation be reduced? **By installing a suitable filter at the receiver**

Audio Rectification etc.

What sound is heard from a public address system if audio rectification of a nearby single-sideband phone transmission occurs? **Distorted speech from the transmitter's signals**

What sound is heard from a public address system if audio rectification of a nearby CW transmission occurs? **On-and-off humming or clicking**

How can you minimize the possibility of audio rectification of your transmitter's signals? **By ensuring that all station equipment is properly grounded**

An amateur transmitter is being heard across the entire dial of a broadcast receiver. The receiver is most probably suffering from: **cross-modulation or audio rectification in the receiver**

Cross-modulation is usually caused by: **rectification of strong signals**

Audio Rectification etc.

Con't

What devices would you install to reduce or eliminate audio-frequency interference to home entertainment systems?
Bypass capacitors

Stereo speaker leads often act as antennas to pick up RF signals. What is one method you can use to minimize this effect? **Shorten the leads**

Stereo amplifiers often have long leads which pick up transmitted signals because they act as:
receiving antennas

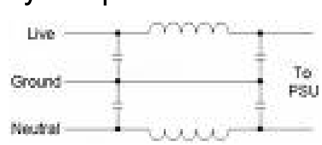
Audio Rectification etc.

Con't

What device can be used to minimize the effect of RF pickup by audio wires connected to stereo speakers, intercom amplifiers, telephones, etc.?
Ferrite core

One method of preventing RF from entering a stereo set through the speaker leads is to wrap each of the speaker leads around a: **ferrite core**

What should be done if a properly operating amateur station is the cause of interference to a nearby telephone? Ask the telephone company to install
RFI filters



Intermodulation & Key Clicks

If someone tells you that signals from your hand-held transceiver are interfering with other signals on a frequency near yours, what may be the cause? **Your hand-held may be transmitting spurious emissions**

If your transmitter sends signals outside the band where it is transmitting, what is this called? **Spurious emissions**

What problem may occur if your transmitter is operated without the cover and other shielding in place? **It may transmit spurious emissions**

A parasitic oscillation: **is an unwanted signal developed in a transmitter**

Intermodulation & Key Clicks

Con't

Parasitic oscillations in the RF power amplifier stage of a transmitter may be found: **at high or low frequencies**

Transmitter RF amplifiers can generate parasitic oscillations: **on either side of the transmitter frequency**

In Morse code transmission, local RF interference (key-clicks) is produced by: **the making and breaking of the circuit at the Morse key**

Key-clicks, heard from a Morse code transmitter at a distant receiver, are the result of: **too sharp rise and decay times of the carrier**

How can you prevent key-clicks? **By using a key-click filter**

In a Morse code transmission, local RF interference (key-clicks) is produced by: **Sparking at the key contacts**

Key-clicks can be suppressed by: **inserting a choke and a capacitor at the key**

If a neighbour reports television interference on one or two channels only when you transmit on 15 metres, what is probably the cause of the interference? **Harmonic radiation from your transmitter**

What is meant by harmonic radiation? **Unwanted signals at frequencies which are multiples of the fundamental (chosen) frequency**

Why is harmonic radiation from an amateur station not wanted? **It may cause interference to other stations and may result in out-of-band signals**

What type of interference may come from a multi-band antenna connected to a poorly tuned transmitter? **Harmonic radiation**

If you are told your station was heard on 21,375 kHz, but at the time you were operating on 7,125 kHz, what is one reason this could happen? **Your transmitter was radiating harmonic signals**

Your amateur radio transmitter appears to be creating interference to the television on channel 3 (60-66 MHz) when you are transmitting on the 15 metre band. Other channels are not affected. The most likely cause is: **harmonic radiation from the transmitter**

Harmonics, Splatter etc.

Con't

One possible cause of TV interference by harmonics from an SSB transmitter is from "flat topping" - driving the final amplifier into non-linear operation. The most appropriate remedy for this is: **reduce microphone gain**

In a transmitter, excessive harmonics are produced by: **overdriven stages**

An interfering signal from a transmitter is found to have a frequency of 57 MHz (TV Channel 2 is 54 - 60 MHz). This signal could be the: **transmission of the second harmonic of a 10 metre transmission**

Harmonics may be produced in the RF power amplifier of a transmitter if: **excessive drive signal is applied to it**

What causes splatter interference? **Over-modulation of a transmitter**

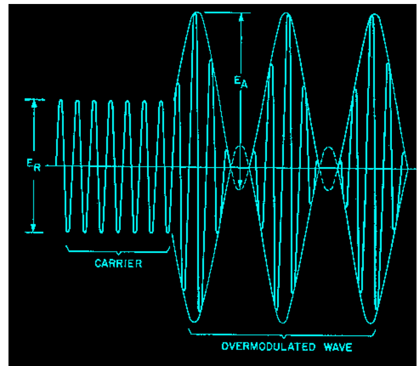
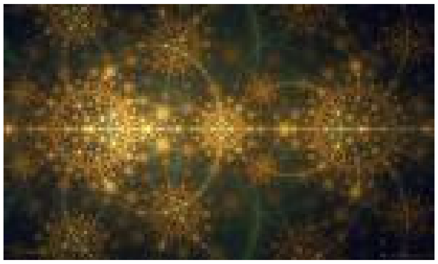
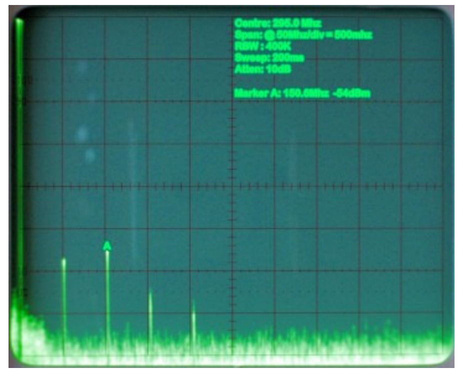


Figure 6. Overmodulation of carrier.





Use of Filters, etc.

What type of filter might be connected to an amateur HF transmitter to cut down on harmonic radiation? **A low pass filter**

In order to reduce the harmonic output of a high frequency (HF) transmitter, which of the following filters should be installed at the transmitter? **Low pass**

To reduce harmonic output from a transmitter, you would put a _____ in the transmission line as close to the transmitter as possible: **A low pass filter**

Why do modern HF transmitters have a built-in low pass filter in their RF output circuits? **To reduce harmonic radiation**

What should be the impedance of a low pass filter as compared to the impedance of the transmission line into which it is inserted? **About the same**

A low pass filter suitable for a high frequency transmitter would:
attenuate frequencies above 30 MHz

A high pass filter would normally be fitted: **at the antenna terminals of the TV receiver**

Use of Filters, etc.

- When considering filters remember

  High pass filters go on the receiver end

  Low pass filters go on the transmitter

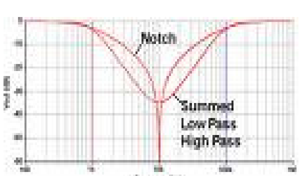
Use of Filters, etc.

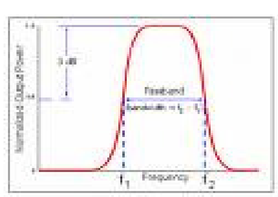
Con't

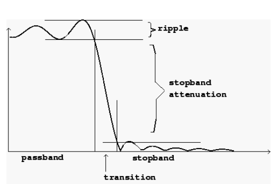
What circuit blocks RF energy above and below a certain limit? **A band pass filter**

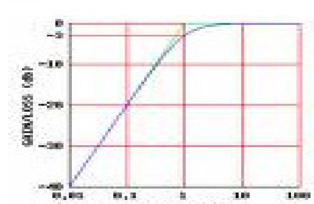
A band pass filter will: **allow only certain frequencies through**

A band reject filter will: **pass frequencies each side of a band**









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