Chapter 1 Introduction

General Class License Manual July 2019 – June 2023

General Class Exam Preparation Schedule available at http://www.k4vrc.com/

How will this class works?

- Individual reading of chapter prior to class
- Watch the Class Lecture Videos at home, courtesy of Dave Casler
- Work chapter sample problems prior to class
- Use the Class Notes to supplement your reading
- Class Review of assignment, discussion and help with problems
- Individual practice tests (online) at home between classes

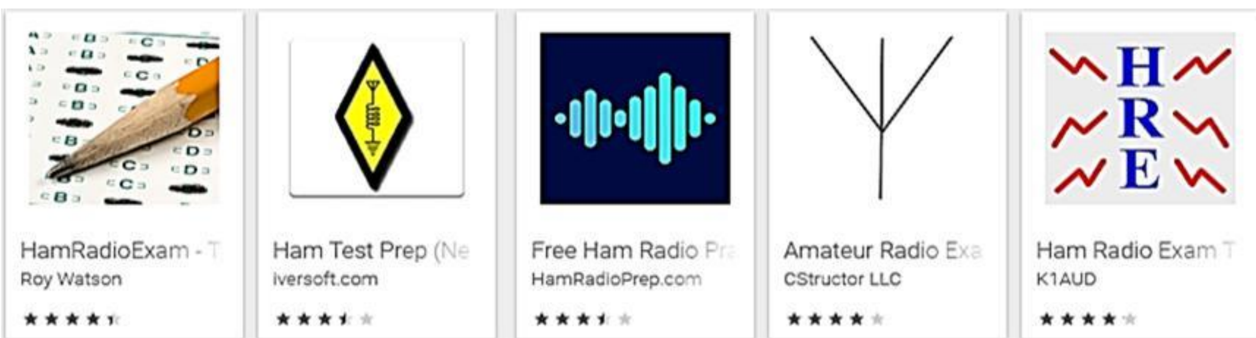
Text Book used in the course

ARRL General Class License Manual 9th Edition
ISBN: 978-1-62595-106-9 (for use July 1, 2019 to June 30, 2023).

School supplies used in the course

- Calculator, just a simple add subtract, multiple, divide (NO Memory Functions)
- Notebook and pen, just a simple spiral bond pad

Practice Tests Apps for all License levels



https://play.google.com/store/apps and https://www.apple.com/ios/app-store/

On-Line Practice Tests

http://arrlexamreview.appspot.com/
https://hamexam.org/
https://hamstudy.org/
https://www.qrz.com/hamtest/

KE0OG Dave Casler / General Class Exam Videos > https://dcasler.com/ham-radio/general/

Guides to Amateur Radio

Ham Radio for Dummies free PDF book
http://www.arrl.org/licensing-education-training
Ethics and Operating Procedures for the Radio Amateur free PDF book

Bands

The **upper end of the voice** portion of a band is not available to General Class licensees
Secondary users are permitted if they do not cause harmful **interference** to primary users
Move to a clear frequency if a primary service interferes with your contact
"CQ DX" is looking for any station **outside their own country**
Break into phone by **saying call sign during a break** between other stations
60M other than a dipole antenna, you must **keep a record of the antenna gain No**
one has priority access to frequencies, common courtesy should be a guide
If you notice **increasing interference** from another station **move to another frequency**
Use NATO Phonetic Alphabet = Alpha, Bravo, Charlie, Delta, Foxtrot, Golf, Hotel, India, etc
Avoid harmful interference >> ask if the **frequency is in use**, followed by your **call sign**
Follow the voluntary band plan for the operating mode you intend to use
Log Contact >> **Date, Time, Freq, Call Sign RST** & may be needed if the FCC requests

information **SOS >** Emergency Communications

Acknowledge a station in **distress** and determine **what assistance** may be needed
RACES = Radio Amateur Civil Emergency Service
The **FCC may restrict amateurs participating in RACES** when **War Emergency Powers** are invoked
When normal communications systems are not available an **amateur station** may **use any means** of radio communications at its disposal for essential communications in connection with immediate safety of **human life** and **protection of property**

SSB > Single Sideband is a form of Amplitude Modulated (AM) Signal

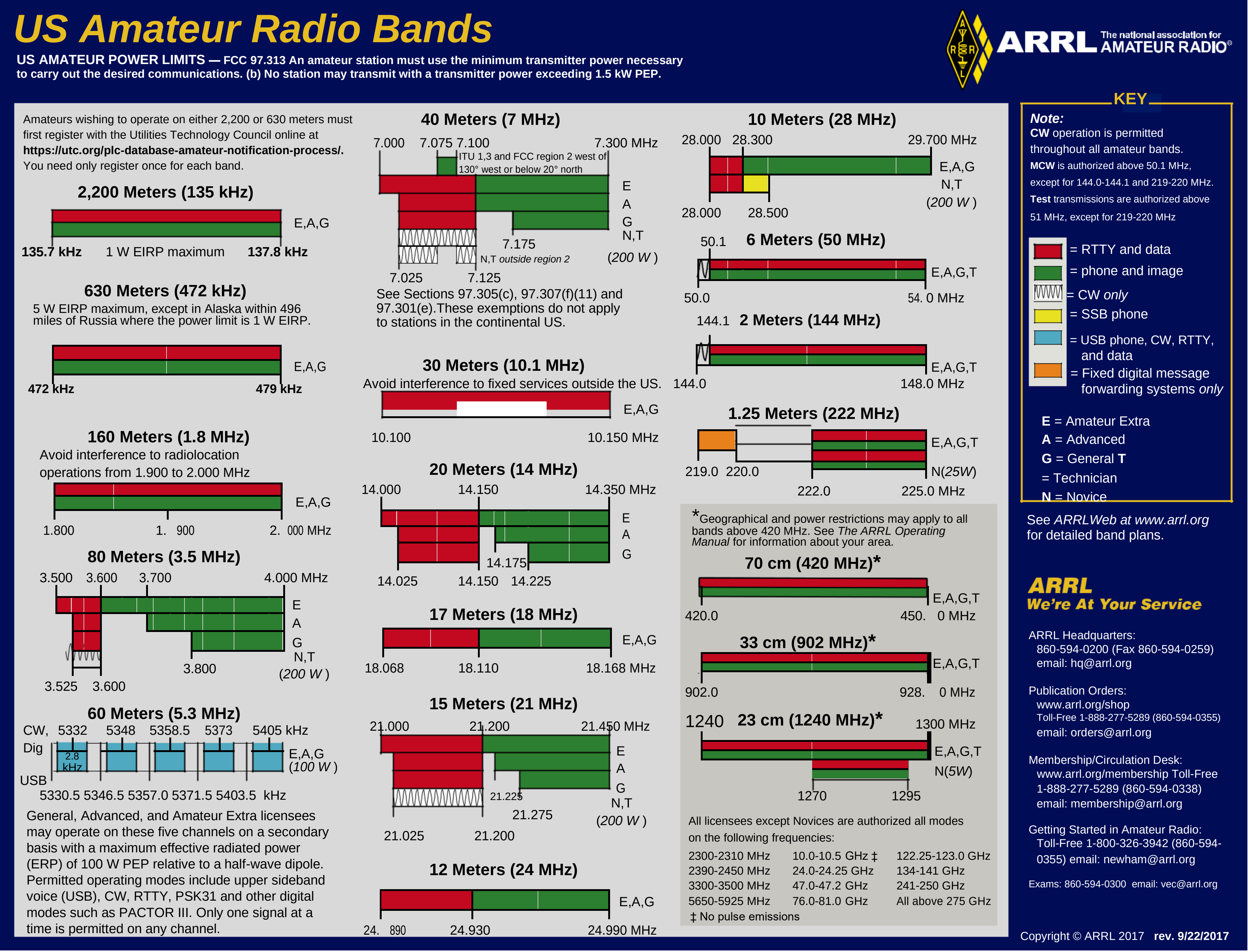
SSB uses **Less bandwidth** used and **higher power efficiency**
Only **one sideband is transmitted;** the other sideband **and carrier are suppressed**
SSB most often used for **HF Voice**
USB is normally used for 30M **(10 MHz up),** VHF and UHF SSB
LSB is normally used for 40M & down **(7 MHz down)**
SSB **VOX** operation allows **"hands free"** operation
SSB most often used for weak signal VHF and UHF
SSB **frequency separation** to minimize interference is **3 KHz vs CW at 150 Hz**
In **Split Mode** the transceiver is set to different transmit and receive frequencies
Dual VFO permits monitoring of two different frequencies

CW > Send Continuous Wave using; a Straight Key, an Electronic Keyer and a Computer Keyboards

Reply to a CQ **at the speed the CQ was sent**
"ZERO BEAT" is matching TX frequency to the received signal
CW **frequency separation** to minimize interference is **150 to 500**
Hz "C" added to an **RST** report means **Chirpy** or unstable signal
CW has the narrowest bandwidth (150 Hz)

Abbreviations and "Q" Signals

Can you hear me between your signals >>> **QSK**
I acknowledge receipt >>> **QSL**
I am ready to receive messages >>> **QRV**
Indicates send faster >>> **QSQ**
Indicates send slower >>> **QRS**
Indicates low power operation >>> **QRP**
Indicates that you are receiving interference from other stations >>> QRM
Indicates that you are changing frequency >>> QSY
Indicates listening only for a specific station >>> **KN**
Indicates Closing station >>> **CL**
Indicates the end of a formal message >>> **AR**



US Amateur Radio Bands
ARRL The national association for AMATEUR RADIO®
US AMATEUR POWER LIMITS — FCC 97.313 An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.
Amateurs wishing to operate on either 2,200 or 630 meters must first register with the Utilities Technology Council online at https://utc.org/plc-database-amateur-notification-process/. You need only register once for each band.
2,200 Meters (135 kHz)
E,A,G
135.7 kHz
1 W EIRP maximum
137.8 kHz
630 Meters (472 kHz)
5 W EIRP maximum, except in Alaska within 496 miles of Russia where the power limit is 1 W EIRP.
E,A,G
472 kHz
479 kHz
160 Meters (1.8 MHz)
Avoid interference to radiolocation operations from 1.900 to 2.000 MHz
E,A,G
1.800
1.900
2.000 MHz
80 Meters (3.5 MHz)
3.500
3.600
3.700
4.000 MHz
E
A
G
N,T
(200 W)
3.800
3.525
3.600
60 Meters (5.3 MHz)
CW, Dig
5332
5348
5358.5
5373
5405 kHz
2.8 kHz
E,A,G
(100 W)
USB
5330.5 5346.5 5357.0 5371.5 5403.5 kHz
General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated power (ERP) of 100 W PEP relative to a half-wave dipole. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III. Only one signal at a time is permitted on any channel.
40 Meters (7 MHz)
7.000
7.075 7.100
7.300 MHz
ITU 1,3 and FCC region 2 west of 130° west or below 20° north
E
A
G
N,T
7.175
N,T outside region 2
(200 W)
7.025
7.125
See Sections 97.305(c), 97.307(f)(11) and 97.301(e). These exemptions do not apply to stations in the continental US.
30 Meters (10.1 MHz)
Avoid interference to fixed services outside the US.
E,A,G
10.100
10.150 MHz
20 Meters (14 MHz)
14.000
14.150
14.350 MHz
E
A
G
14.175
14.025
14.150
14.225
17 Meters (18 MHz)
E,A,G
18.068
18.110
18.168 MHz
15 Meters (21 MHz)
21.000
21.200
21.450 MHz
E
A
G
N,T
21.225
21.275
(200 W)
21.025
21.200
12 Meters (24 MHz)
E,A,G
24.890
24.930
24.990 MHz
10 Meters (28 MHz)
28.000
28.300
29.700 MHz
E,A,G
N,T
(200 W)
28.000
28.500
6 Meters (50 MHz)
50.1
E,A,G,T
50.0
54.0 MHz
2 Meters (144 MHz)
144.1
E,A,G,T
144.0
148.0 MHz
1.25 Meters (222 MHz)
E,A,G,T
N(25W)
219.0
220.0
222.0
225.0 MHz
*Geographical and power restrictions may apply to all bands above 420 MHz. See The ARRL Operating Manual for information about your area.
70 cm (420 MHz)*
E,A,G,T
420.0
450.0 MHz
33 cm (902 MHz)*
E,A,G,T
902.0
928.0 MHz
23 cm (1240 MHz)*
1240
1300 MHz
E,A,G,T
N(5W)
1270
1295
All licensees except Novices are authorized all modes on the following frequencies:
2300-2310 MHz
10.0-10.5 GHz ‡
122.25-123.0 GHz
2390-2450 MHz
24.0-24.25 GHz
134-141 GHz
3300-3500 MHz
47.0-47.2 GHz
241-250 GHz
5650-5925 MHz
76.0-81.0 GHz
All above 275 GHz
‡ No pulse emissions
KEY
Note:
CW operation is permitted throughout all amateur bands.
MCW is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.
Test transmissions are authorized above 51 MHz, except for 219-220 MHz
= RTTY and data
= phone and image
= CW only
= SSB phone
= USB phone, CW, RTTY, and data
= Fixed digital message forwarding systems only
E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice
See ARRLWeb at www.arrl.org for detailed band plans.
ARRL We're At Your Service
ARRL Headquarters: 860-594-0200 (Fax 860-594-0259) email: hq@arrl.org
Publication Orders: www.arrl.org/shop Toll-Free 1-888-277-5289 (860-594-0355) email: orders@arrl.org
Membership/Circulation Desk: www.arrl.org/membership Toll-Free 1-888-277-5289 (860-594-0338) email: membership@arrl.org
Getting Started in Amateur Radio: Toll-Free 1-800-326-3942 (860-594-0355) email: newham@arrl.org
Exams: 860-594-0300 email: vec@arrl.org
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Operating Rules

Broadcast to the public only when safety of life or property and there no other means available One beacon signal in the same band from a single location
A **beacon** station is for observation of **propagation and reception**
Occasional **retransmission** of weather and propagation information is permitted **One-way transmissions** to learn Morse code are permitted
PRB-1 = state and local governments must be reasonably accommodate antenna structures **Space station control** is permitted to use secret codes (encryption)
Publicly documenting the technical characteristics of a **digital protocol** required Use of abbreviations or procedural if they **do not obscure the meaning**
A transmitting frequency should follow; **Part 97 Rules, band plans** & **avoid interfering**
TX about **sale of apparatus normally used and not done on a regular basis** is permitted
Not covered by Part 97 rules then use **good engineering and good amateur practice**
Who determines "good engineering and good amateur practice" **the FCC 200 feet is the maximum** height antenna without FAA
Move to a clear frequency if a primary service interferes with your contact
Beacon stations on 14.100, 18.110, 21.150, 24. 930 and 28.200 MHz
Amateurs share the **13cm Band** with the unlicensed **Wi-Fi** on **2.4 GHz**

Transmitter power and data emission standards

TX the **MINIMUM** power necessary
1500 watts PEP output max
1500 watts PEP output max on the **12M**
1500 watts PEP output max on **28 MHz**
100 watts PEP output is the power limit for **beacon** stations
200 watts PEP output max on **10.140 MHz**
100 watts PEP ERP using a dipole limit on the **60M**
10 watts PEP output max using **Spread Spectrum**
2.8 KHz max BW on USB frequencies in the **60M**
300 baud max for RTTY or data **below 28 MHz**
300 baud max for RTTY or data on **20M**
1200 baud max for RTTY or data on **10M**
19.6 kilobaud max for RTTY or data on **2M**
56 kilobaud max for RTTY or data on **1.25M & 70cm**

Exams, Volunteer Monitoring, Volunteer Examiners and Coordinators

Volunteer Monitoring Program are volunteers who are formally enlisted to monitor for violations **DF skills are used to locate** stations violating FCC Rules
Volunteer Examiners (VE) are accredited by **Volunteer Examiner Coordinator (VEC)**
A **Volunteer Examiner** must be **18 years old**
At **least three VEs** must be present for an exam
A VE holding a **General may administer a Technician** exam (must be higher or Extra for Extra)
A non-U.S. citizen VE must be a General Class or above (no difference than any other VE)
K4VRC / AG >> a new **General with a CSCE may operate** before FCC ULS shows upgrade A Certificate of Successful Completion of Examination (**CSCE) is valid for 365 days Expired** General, Advanced, or Extra may receive partial credit for the elements
Expired General, Advanced, or Extra **must pass element 2 (Tech)** to restore a previously-held license

Control, Repeater, Third Party, ITU

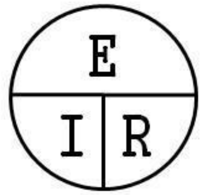
A **Tech may TX on a 2M via a 10M** repeater when the **10M control operator holds a General**
A **third-party** is prohibited by an amateur who ever **had their license revoked**
A **third-party** TX is prohibited unless a **third-party agreement in effect** with that country
A **third-party** is messages must be **personal or emergencies or disaster relief**
Amateurs may communicate with any country except those that object to the ITU
ITU 2 region apply to radio amateurs operating in **North and South America**
You must avoid interference; one mile from **FCC Monitoring Station**, **secondary user** & **spread spectrum**

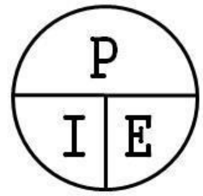
Math Units

MEGA =	1,000,000	Million
KILO =	1,000	Thousand
MILLI =	0.001	1/1,000
MICRO =	0.000,001	1/1,000,000
PICO =	0.000,000,000,001	1/1,000,000,000,000

Ohm's Law, Power, Vpp, RMS, PEP

E = I x R
I=E/R
R=E/I
P = E x I
P = I^2 x R
PEP = [(Vpp/2) x 0.707] ² / R
Vpp = Voltage Peak to Peak = 2 (1.41 x RMS)
RMS = Peak x 0.707
I=P/E





Total current in each branch of a **parallel** circuit equals **sum of the branches**
The **RMS value** of an AC signal is the **power dissipation** as a **DC** voltage of the **same value** The ratio of **peak** envelope power to **average** power for an **unmodulated carrier is 1.00**

Decibel (dB)

+1 dB = 20.5% of X **+3 dB = 2X** +6 dB = 4X +10dB = 10X

Resistors, Inductors & Capacitors

Resistors in series = resistor values added
Equal Resistors in parallel = resistor value / number of resistors
Resistors in parallel = the reciprocal of (the sum of all the reciprocal resistor values)
Equal Inductors in parallel = inductor value / number of inductors
Inductors in parallel = the reciprocal of (the sum of all the reciprocal inductor values)
Inductors in series = inductors values added
Capacitors in parallel = capacitor values added
Equal Capacitors in series = capacitor value / number of capacitors
Capacitors in series = the reciprocal of (the sum of all the reciprocal capacitor values)

Inductors or Resistors in Parallel

$$L = \frac{1}{\frac{1}{L} + \frac{1}{L} + \cdots \frac{1}{L}}$$

Inductors or Resistors in Series

$$L = L + L + \cdots L$$

Capacitors in Series

$$C = \frac{1}{\frac{1}{C} + \frac{1}{C} + \cdots \frac{1}{C}}$$

Capacitors in Parallel

$$C = C + C + \cdots C$$

A **wire-wound resistor's inductance** could make circuit performance unpredictable
Electrolytic capacitors are used in power supply circuits to filter the rectified AC
Reverse polarity of applied to polarized capacitors may cause a short-circuit, overheat and explode Ceramic capacitors are low cost compared to other types
High capacitance for given volume is an advantage of an electrolytic capacitor
Lead inductance in a capacitor **reduces** effectiveness at **VHF** and above **Inter-turn capacitance** in an inductor may cause **self resonant** at some frequencies **Mutual inductance** between inductors causes **unwanted coupling** between circuits
Inductor is operated **above its self-resonant frequency** becomes capacitive
A ferrite core toroidal has; **large inductance, freq optimized properties, magnetic field stay in core** The **"mix,"** determines the performance of a **ferrite core** at different frequencies

Electrical Terms

Impedance is the **opposition** to the flow of current in an **AC** circuit
Impedance is measured in **Ohms**
Reactance is the **opposition** to AC caused by **capacitance or inductance**
Reactance opposes the flow of **AC** in an **inductor**
Reactance opposes the flow of **AC** in a **capacitor**
Reactance is measured in **Ohms**

Electrical Properties

Inductor reactance **increases with frequency**
Capacitor reactance **decreases with frequency**
When the impedance of **load equals the source** the **maximum power** is delivered
To **maximize power transfer,** use an **impedance matching transformer**
Insert an **LC network to match impedance** between circuits
A **transformer, Pi-network or transmission line** can be used for **impedance matching**

Digital Circuits, Integrated Circuits

Linear voltage regulator is an analog integrated circuit
Integrated circuit **operational amplifier** is an **analog** device
MMIC >> **Monolithic Microwave Integrated Circuit**
ROM >> **Read Only Memory**
"NON-VOLATILE" memory information is maintained even if power is
removed A microprocessor is a **computer on a single integrated circuit**
CMOS integrated circuits have **lower power consumption** compared to
TTL **Binary** "ones" and "zeros" are easy to represent with an **"on" or "off"**
state AND gate output is high only when **both** inputs are high **NOR gate**
output is low when **either or both** inputs are high
Eight states in a **3-bit binary** counter
A **shift register** is a clocked array that **passes data in steps** along the

array **Transistors, Diodes, Vacuum Tubes**

Saturation and cut-off regions are stable operating points for a bipolar transistor used in a logic
circuit A **MOSFET gate is separated from the channel** with a thin insulating layer
Control grid of a triode tube regulates the flow of electrons between cathode and plate
A **screen grid** in a vacuum tube **reduces grid-to-plate capacitance**
0.3 volts junction threshold voltage of a **germanium diode**
0.7 volts junction threshold voltage of a **conventional silicon**
diode An LED is **Forward Biased** when emitting light (conducts)
A **liquid crystal display requires** ambient or back **lighting**

Power Supplies

The **peak-inverse-voltage** across the rectifiers in a **full-wave PS = PS output voltage** The
peak-inverse-voltage across the rectifiers in a **half-wave PS = 2 X PS output voltage 360**
degrees of the AC cycle is converted to DC by a **full-wave rectifier 180 degrees** of the AC
cycle is converted to DC by a **half-wave rectifier**
The output waveform of a **full-wave rectifier** = Series of DC **pulses 2X freq** of the AC input
Capacitors and inductors are used in a **power-supply filter network**
Filter choke smoothes DC output from the rectifier in a power supply
A power-supply **bleeder resistor** discharges the filter capacitors
A **switch-mode PS high freq operation** allows the use of smaller

components **Transformers**

Mutual inductance causes a voltage to appear across the **secondary winding** of a transformer
The **primary** of a transformer is normally connected to the **incoming source**
The transformer output **= Input x (Np/Ns)**
The transformer output **= Input x Square Root of (Pimp/Simp)**

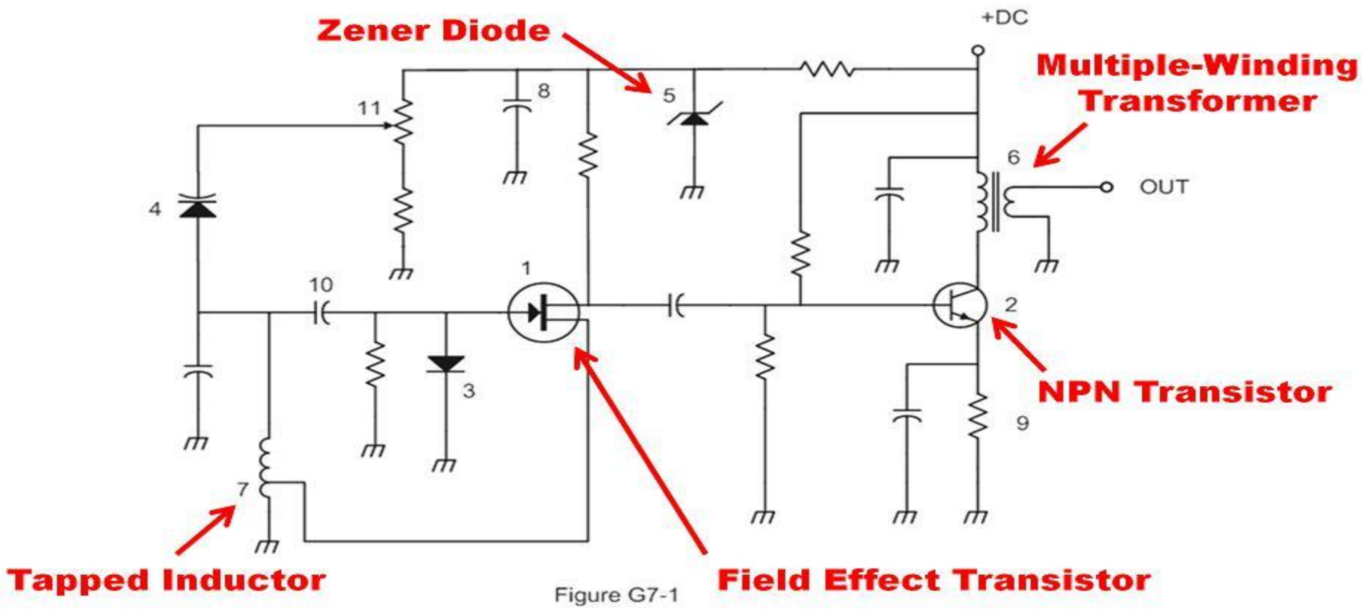


Figure G7-1

Solar, Wind, Batteries

Nickel-Cadmium batteries provide **high discharge current** and low internal resistance
10.5 volts is the **minimum discharge voltage** of a standard **12 volt lead acid** battery
Photovoltaic process turns sunlight is changed directly into electricity
The open-circuit voltage from a fully illuminated silicon **photovoltaic cell is 0.5 VDC**
A **series diode** between a solar panel and a storage battery **prevents self-discharge** of the
Wind turbines require a large energy storage system **(batteries)**

Connectors

Computer and transceiver might be connected using a **USB interface**
DE-9 connectors would be a good choice for a **serial data port**
RCA Phono connectors are commonly used for **audio signals PL-259** connectors are commonly used for RF service at **frequencies up to 150 MHz SMA connector** is a small threaded connector suitable for signals up to several GHz **N connector** is a moisture-resistant RF connector useful to 10 GHz

Test and Measurement Equipment

An **oscilloscope** contains **horizontal and vertical channel** amplifiers
An oscilloscope can **measure complex waveforms**
An oscilloscope can **check the keying waveform of a CW transmitter**
The attenuated TX RF is connected to **the vertical of an oscilloscope to check RF envelope**

A **high input impedance voltmeter** decreases the **loading on circuits** being measured **A digital voltmeter has better precision** than an analog meter

A **field strength meter** can be used for **close-in radio direction-finding**
A **field strength meter** can be used for **relative RF output** on antennas and transmitters
A **field strength meter** can be used to **radiation pattern** of an antenna

An **antenna analyzer** is used for **antenna and feed line SWR measurements**
An **antenna analyzer** is used to **determine the impedance of a coaxial cable**
Strong signals can affect the **accuracy of antenna analyzer** measurements
An **analog** readout may be **preferred** when **adjusting tuned circuits**
Standing wave ratio (SWR) can be determined with a **directional wattmeter**

AMPLIFIERS & OSCILLATORS

Class A amplifier has **low distortion**
A **linear** amplifier **preserves the input** waveform
Class C amplifier is appropriate for amplifying **CW signal**
Class C amplifiers have the **highest efficiency**
Efficiency of an RF amplifier = RF output power / DC input power
Neutralizing the final amplifier stage of a transmitter **eliminates self-oscillations**
The **basic sine wave oscillator** has a filter & amplifier operating in a feedback loop
Direct Digital Synthesizer (DDS) is a high-stability **variable frequency oscillator** (VFO)
The **inductance and capacitance** in the **tank circuit** determines the **frequency** of an LC oscillator

Superhetrodyne > Mixing of Oscillator & RF SHIFTS to Intermediate Frequency (IF) STAGE

A **mixer** combines input **signal** with **oscillator** signal to produce **intermediate frequency (IF)** = **455 KHz Heterodyning** is another term for the **mixing of two RF signals**. (sum and difference)
The unused product of mixing (i.e. **-** 455 KHz) **Image Response causing interference in the receiver.**
A **balanced modulator** removes the carrier and leaves the **upper and lower sidebands**
Multiplier stage in a **VHF FM transmitter** uses a **HF harmonic to reach RF** frequency

Receivers, Transmitters

Best signal-to-noise ratio is when the receiver bandwidth equals the signal bandwidth
Discriminator in FM receivers to convert signals coming from the **IF amplifier to audio**
A **filter processes** signals from the **balanced modulator before the mixer** in a SSB phone TX
Balanced modulator combines carrier **oscillator & audio** and the result to a **filter** in a SSB phone TX
Product detector combines **IF** amplifier & **BFO** and send the result to the AF amplifier in SSB RX The **RF** amplifier & **local oscillator** are **mixed** and the result to the **IF filter** in a superheterodyne RX **HF oscillator, mixer, detector** are basic stages of a superheterodyne RX
The impedance of a **low-pass filter should equal** the Impedance of the **transmission line**
Direct Digital Synthesizer (DDS) provides variable frequency with the stability of a crystal oscillator

Digital Signal Processor (DSP) and **Software Defined Radio** (SDR)

DSP filtering **converts the signal from analog to digital and using digital processing**
SDR performs most major **signal processing functions are performed by software 90-degree phase** difference between the **I and Q signals** for SDR Mod/Demod **SDR or I/Q can create any modulation the** with appropriate processing (Software)

AM > Sends information by **varying the power** of the transmitted **RF Envelope** proportional to the microphone input Modulator > Combines speech and RF
AM has a 6 KHz bandwidth

SSB > Single Sideband is a form of Amplitude Modulated (AM) Signal

Transmitter power can be used more effectively More transmitter power in one sideband SSB has a **narrower (3 KHz)** bandwidth
Overmodulation creates excessive bandwidth
Signal distortion caused by **excessive SSB drive produces "flat-topping"** distortion
Intermodulation is two signals mixed in a non-linear circuit producing unwanted spurious outputs

FM > Frequency Modulation changes the **frequency** of an RF wave to convey information

RF carrier **frequency** changes proportionally to the **instantaneous amplitude of the modulating** signal FM phone transmission with **5 kHz deviation** and a **3 kHz modulating** signal has a **16 kHz bandwidth**
(5 KHz + 3KHz) X 2 = (8 KHz) X 2 = 16 KHz.
FM 146.52 MHz with **5 kHz deviation** using a **Reactance Modulator 12.21 MHz Osc** has a **416.7 Hz Dev**
5 KHz / (146.52 MHz / 12.21 MHz) = 5 KHz / 12 = 416.66 Hz

PM > Phase Modulation changes the **phase angle** of an RF wave to convey information

PM is produced by a **reactance modulator** connected to an RF power amplifier

Transceiver Functions

TX RF picked up in audio can cause **distortion, timeouts and stuck Tx VOX**
Noise blanker reduce receiver gain during a **noise pulse**
Too much Noise blanker may cause **distorted received** signals
Digital Signal Processing (DSP) removes noise from received signals
A **DSP IF filter** has a **range of filter bandwidths and shapes**
A **DSP filter** can perform **automatic notching** of interfering carriers

"NOTCH FILTER" reduces interference from carriers in the receiver passband
Low-pass filter cutoff frequency is the frequency above which a filter's output is **half the input**
Ultimate rejection specifies a filter's reject signals outside its passband
Upper and lower **half-power points** is the **bandwidth of a band-pass filter**
Insertion loss specifies a filter's attenuation inside its passband

Reverse SSB may be possible to reduce or eliminate interference from other signals
IF shift control avoids interference from stations very close to the receive frequency
In **Split Mode** the transceiver is set to different transmit and receive frequencies
Attenuator reduces signal overload due to strong incoming signals
Automatic Level Control (ALC) reduces over drive distortion in an RF power amp

Excessive drive power may damage a solid-state RF power amplifier

Max power out without exceeding max plate current for control of a tube RF amp
Plate current DIP indicates correct adjustment of a tube amp plate tuning control
Transmitter Linearity performance is determined by a **two-tone test**
Two **non-harmonically related audio signals** are used to conduct a **two-tone test**
TIME DELAY keying allows RX / TX changeover to complete properly before RF output is allowed

Speech processors; S meters; sideband operation near band edges

A **speech processor increases the intelligibility** of phone signals
A **speech processor increases average power** of a SSB phone TX
An **incorrectly adjusted** speech processor; **Distorted speech, Splatter, Excessive background 3 kHz LSB** with a carrier frequency 7.178 MHz occupies 7.175 to 7.178 MHz (3 KHz below)
3 kHz USB with a carrier frequency 14.347 MHz occupies 14.347 to 14.350 MHz (3 KHz above)
An **S Meter** measures **received signal strength**
Receivers have S meters (signal strength meters)
S Meter reading of **S9 = S8 times 4** (S Unit = ~6dB = 4X)
S meter **20 dB over S-9** = S-9 signal **X 100**

Transmitter Interference

Distorted speech can be heard on telephone if there is interference from a **SSB TX** (Donald Duck)
On-and-off humming or clicking on telephone if there is interference from a **CW TX Connect all grounds to a single point** to avoid a **ground loop**
HUM could be a symptom of a **ground loop** somewhere in your station
A **ferrite bead** on cables reduces RF interference (**common-mode current on an audio cable**) A **bypass capacitor reduces RF interference** to audio-frequency devices
Connect all equipment grounds together to avoid unwanted effects of stray RF **(HOT SPOTS)**
Grounding Metal Enclosures ensures that **hazardous voltages** cannot appear on the chassis
High RF voltages on station equipment can be caused by a **resonant ground**
A **high impedance ground** on a frequency can cause an **RF burns** when HF TX
Arcing can cause of interference covering a wide range of frequencies

HF Mobile Radio Installations and Emergency Power

Efficiency of the electrically **short antenna limits an HF mobile** operation
Vehicle **control computer** may cause **interfering signals** in the receiver of an HF mobile
Vehicle **fuel system** may cause **interfering signals** in the receiver of an HF mobile
Vehicle **charging system** may cause **interfering signals** in the receiver of an HF mobile
Wire a 100W HF mobile **directly to a fused battery connections** using **heavy gauge wire**
Do NOT wire a 100W HF mobile to an **automobile's auxiliary power socket (too much current)**

DIGITAL COMMUNICATIONS

14.070 - 14.112 MHz of the **20M** is used for **data**
80M is frequency used for **data = 3570 – 3600 kHz**
Higher symbol rates require higher bandwidth
A **waterfall display (frequency = horizontal, signal strength = intensity, time = vertical)**
A station **initiating a digital contact must be under local or remote control** outside the auto control segments
Software Defined Radio (SDR)
Digital Signal Processing (DSP)
DSP IF filter have; **analog to digital converter, digital processor, digital to analog converter**
DSP filtering **converts the signal from analog to digital and using digital processing**
Matching receiver BW to operating mode BW results in the **best signal to noise ratio**
SSB over modulation causes **distortion** and occupies **more bandwidth**
Improper action of ALC distorts the signal and can cause spurious emissions
Transmitting a **data** mode know the **duty cycle** to prevent **damage to your transmitter's** final stage.

RTTY (**Radioteletype)**

RTTY uses a **170 Hz** frequency shift for **Mark and Space**
LSB is used with **RTTY** via **AFSK** with an SSB transmitter
Baudot code is a 5-bit code with additional start and stop bits

PSK / QAM / Coding

PSK31 > Approximate transmitted **symbol rate is 31**
20M is frequency used for **PSK-31 = 14.070 MHz**
Forward Error Correction correct errors in received data by **TX redundant info with the data Varicode** means the number **of bits** varies data bits in a **PSK31 character**
Using Upper case letters with PSK31 slows down transmission due to Varicode
USB is normally used for **PSK31**
QPSK31 bandwidth is approximately the same as BPSK31

FT8 / JT65 / JT9 / FSK

USB is used to generate **JT65, JT9, or FT8**
"MFSK" means Multi (or Multiple) Frequency Shift Keying
Typical **FT8** exchanges are limited to **call signs, grid locators, and signal reports**
FT8 digital mode requires a **computer time accurate** within approximately **1 second**
FT8 is an 8-tone frequency shift keying
FT8 is a **narrow-band** digital mode that can receive with **very low signal-to-noise ratios**

PACTOR / WINLINK / WINMOR

The **Header** of a data packet contains the **routing and handling information**
Request the packet be **retransmitted** if **ARQ data mode packet contains errors**
Request the packet be **retransmitted** is meant by an **NAK response** to a transmitted packet
The approximate bandwidth of a **PACTOR-III signal at maximum data rate is 2300 Hz**
Transmit a connect message to establish contact with a digital messaging system gateway
A **PACTOR modem in monitor allows monitoring** communications without a connection
PACTOR connections are limited to two stations
Signals interfering with PACTOR or WINMOR cause; **retries, timeouts and connection failures**
Winlink uses the internet to transfer messages

Losses, Attenuation, SWR, Matching

Attenuation (loss) of **coaxial** cable increases as the **frequency increases**
SWR = **ratio** of **feed line** impedance to **load** impedance, format is "xx to 1"
High SWR = Reflected power caused by the difference between **feedline** and **antenna** impedances
If a transmission line is lossy, **high SWR will increase the loss**
The higher the **transmission line loss**, the more the **SWR will read artificially low**
Tuners (**matching** network) match **transmitter output impedance** to an impedance **not equal to 50 ohms**
Matching network between the feed and antenna **match the unbalanced coax to the balanced** parallel feedline
The antenna **feed point impedance must be matched** to the feed line to **prevent standing waves**

Antenna Length > Physical Length (**Shorter is Higher Frequency**)
1/4 Wave Antenna = Physical Length of **234 Ft.** / F MHz)
1/2 Wave Antenna = Physical Length of **468 Ft.** / F MHz)
1 Wave Antenna = Physical Length of 936 Ft. / F MHz)

Dipoles

dBi refers to an **isotropic** antenna
dBd refers to a **dipole** antenna
dBi gain figures are 2.15 dB higher than dBd gain figures
Radiation pattern of a **horizontal dipole LESS than 1/2 wavelength** above ground is almost **Omni-directional**
Radiation pattern of a **horizontal dipole MORE than 1/2 wavelength** above ground is almost a **figure-eight**
Impedance of a horizontal dipole 1/4 wavelength above ground **decreases as the antenna is lowered**
Impedance of a dipole **increases** as the **feed point is moved** toward the **ends** (OCF-Off Center Feed)
Impedance of an **end fed dipole feed point is very high**
You may experience **RF burns** when touching metal objects in your station when using a **random-wire antenna**
A **Horizontally** polarized antenna has **less ground reflection losses**
Multiband antennas have **poor harmonic rejection**
Traps installed on an antenna permit **multiband** operation
Inverted V is the common name of a **dipole with a single central support**

YAGI Antenna

A **Yagi** antenna consists of a **driven** element, **reflector** and **director** element(s)
The Yagi **driven** element is **1/2 wavelength**
The Yagi **director** is the **shortest element**
The Yagi **reflector** is the **longest element**
Increasing the **boom length and adding directors** to a Yagi antenna **increases the gain** Using **larger diameter** elements will **increase** the **SWR bandwidth** of a Yagi
The **"main lobe"** is direction of **maximum radiated field strength** from the antenna
The "front-to-back ratio" (FB) means the **"main lobe"** compared to the opposite direction
The forward gain of a **3 Element Yagi** antenna is **9.7 dBi** on paper
The **boom length**, **number** of elements and element **spacing** determine gain, FB ratio, SWR BW
The Yagi antenna is used to **reduce interference** from other stations to the **side or behind** the antenna A "**gamma** match" **driven element is NOT insulated from the YAGI boom**
A "**gamma** match" is used to **match** the **low impedance** Yagi to 50 ohms
A beta or **hairpin match is a stub placed** at the feed point of a Yagi to provide impedance matching **Stacked Yagi antennas** spaced 1/2 wave have **3dB gain** more than a single Yagi
Stacking Horz Yagi antennas **narrows main lobe in elevation**

Monopole Antennas

Place **radial wires** of a vertical antenna on the surface or buried a **few inches below the ground**
Downward sloping radials on a ground-plane antenna bring the feed-point impedance to **50 ohms**
The radiation pattern of a **quarter-wave, vertical antenna is Omnidirectional** in azimuth
The **antenna limits an HF mobile** transceiver operating in the 75M
A **shortened mobile** antenna has **limited BW** compared to a full size
A **"screwdriver"** mobile antenna adjusts its feed-point impedance by **varying the base inductance "CAPACITANCE HAT"** electrically lengthens a physically short antenna **"CORONA BALL"** reduces high voltage discharge from the tip of the antenna

Parallel & Coaxial Feedline Impedance

Impedance of a parallel conductor feedline is determined by the **distance between the conductors** Typical characteristic **impedance** of **coaxial** cables is **50 and 75 ohms**
Characteristic **Impedance of "window line"** parallel transmission line is. **450 ohms**
RF feed line **losses** is expressed in **dB per 100 ft**
RF feed line losses increase with frequency

Cubical Quad, Delta and Loop Antennas

A Quad is two **square loops** of **one wavelength** and separated by 0.2 WL
A Quad has the **same gain** of a 3 element **Yagi** antenna
A Quad **feed** at the **bottom center** wire has **horizontal** polarization A Quad **feed** at a side **vertical center** wire has **vertical** polarization
A **Delta** is two **triangular loops** of **one wavelength** and separated by 0.2 WL A **Delta** has the **same gain** of a **Quad** antenna
The (Quad, Delta, Loop) **driven** element is **one wavelength** or 1/4 Wavelength per side The (Quad, Delta, Loop) **reflector** is the **longest element** or **5% longer**
Radiation pattern of a **HALO** is almost **Omni-directional**
Radiation pattern of a **horizontal loop** is almost **Omni-directional**
An electrically **small loop** (1/3 WL) has **pattern nulls broadside to the loop**

"**NVIS**" Near Vertical Incidence Skywave

The advantage of an **NVIS** is the **high vertical angle radiation for short skip** during the day
An **NVIS** antenna typically installed between **1/10 and 1/4 wavelength above ground**

Log Periodic Antenna

A **log periodic** antenna **spacing of elements** increases **logarithmically** along the boom
A **log periodic** antenna has **wide bandwidth**

Beverage Antenna

A **Beverage** antenna has high **transmit losses** compared to other types of antennas
A **Beverage** antenna is used for **directional receiving** for low HF bands
A **Beverage** antenna is a very **long and low receiving** antenna that is highly directional

Chapter 8 Propagation

Propagation

A **Sudden Ionospheric Disturbance (SID) disrupts on lower frequencies** more than higher frequencies
HF communications are disturbed by the charged particles from **solar coronal holes**
Near Vertical Incidence Skywave **(NVIS) is Short distance MF or HF propagation**
If HF radio-wave **propagation (skip) is good** on now expect it **again 28 days later**
The **sun's rotation** causes **HF propagation** to vary on a **28-day cycle**
DX Frequencies **above 20 MHz** are **least reliable** during periods of **low solar activity**
"LONG-PATH" is opposite direction **180 degrees from its short-path heading**
A world map projection centered on a particular location is an **Azimuthal Projection**
map High atmospheric **noise is typical of the lower HF during the summer**

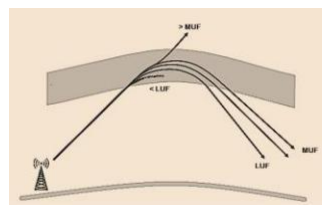
Solar Disturbances

The **radio energy emitted by the sun** is measured by the **solar flux index**
The **solar-flux index** is a measure of solar activity at **10.7 cm** wavelength
The **sunspot number** is based on **counting sunspots** and sunspot groups
It takes **20 to 40 hours** for charged particles from **Coronal Mass Ejections to affect**
Earth The ultraviolet and X-ray **radiation** from solar **flares** take **8 Minutes** to affect Earth
The typical **sunspot cycle is 11 years**
Higher sunspot indicates better propagation at higher frequencies
DX in the **upper HF and lower VHF range is enhanced** by high **sunspot numbers**
20 meters supports worldwide propagation during **daylight at any point in the solar cycle**

Magnetic Disturbances

The **K-index** is the **short term** stability of the Earth's **magnetic field**
The **A-index** is the **long term** stability of the Earth's **magnetic field**
Geomagnetic storm is a temporary disturbance in Earth's **magnetosphere**
A **sudden change** in the **Earth's magnetic field is a geomagnetic disturbance**
North or South Latitudes **above 45 degrees** are **more sensitive to geomagnetic disturbances**
Degraded high-latitude HF is caused by **geomagnetic storm** on radio-wave propagation
Aurora from periods of **high geomagnetic reflect VHF signals** (good DX on VHF)

Maximum Usable Frequency; Lowest Usable Frequency; propagation "hops"



"MUF" the maximum usable freq for communications between two points
The **best propagation is** a frequency just **below the MUF**
Beacons are a way to determine if the **MUF is high enough** to support skip
Distance, location, Time, Season, Solar Flux & SID all affect MUF
"LUF" the Lowest Usable Frequency for communications between two points
Frequencies **below the LUF are completely absorbed** by the ionosphere
LUF < Freq < MUF = **best propagation is** frequency is **bent back to the Earth**
LUF > MUF = No HF radio frequency will support skywave communications
2,500 miles is the maximum distance covered in **one hop using the F2 region**
1,200 miles is the maximum distance covered in **one hop using the E region**
An **ECHO** can be heard when **both short and long path propagation are received**

Ionospheric Layers

The **D layer is closest** to the surface of the Earth **absorbing** most long **skip signals**
The D layer absorbs lower HF frequencies during daylight hours The **F2**
region will reach its **maximum height at noon** (sun is overhead)
F2 region is the **highest ionospheric** region and provides the **longest distance**

propagation Sky waves

"Critical Angle" is the highest takeoff angle that **bends RF back to Earth**
Combining of **several paths** makes HF scatter signals **sound distorted**
HF scatter signals are weak as a small part of the signal get to the skip
zone A **wavering sound** is a characteristic of **HF scatter** signals
Scatter allows a signal to be detected **too far for ground wave but too near for sky** wave
Signals heard above the MUF are scatter propagation

Radio Frequency Radiation Exposure Hazard

RF energy can **heat human body tissue**

RF **MAXIMUM PERMISSIBLE EXPOSURE (MPE)** is determined by **power density, freq & duty cycle** Frequency, RF Power, Distance & Radiation Pattern of the antenna affect the RF exposure

You must **take action to prevent human exposure to the excessive RF fields** A **lower TX duty cycle permits** greater short-term RF exposure levels

The total RF exposure averaged over a certain time is **"TIME AVERAGING"**

Perform a routine RF exposure evaluation specified in part 97.13 Re-evaluating the station whenever equipment is changed to ensure RF safety

A **calibrated field-strength meter** can be used to accurately measure an RF field

Take steps to **prevent directional antenna exceeding MPE** from point at neighbor

Installed ground-mounted antenna **to protected against unauthorized access**

Ensure **MPE limits are not exceeded** in occupied areas **with indoor transmitting antenna**

FCC OET Bul 65, computer model or field strength meter determine complies with RF

Electrical Hazards

ONLY Hot wires in a four-conductor line cord **should be fused** from a 240-VAC single-phase source **Ground** station equipment to ensure **hazardous voltages cannot appear on the chassis**

Ground Fault Circuit Interrupter (GFCI) disconnects when current is flowing directly to ground **#14** AWG Wire >> **15 amperes** of continuous current **#12** AWG Wire >> **20 amperes** of continuous current

Disconnect the incoming utility power feed when powering your house from an emergency generator

An emergency generator should be **located in a well ventilated area**

Danger of carbon monoxide poisoning using a placing a gasoline-fueled generator inside When being **charged a lead acid** storage battery gives off **explosive hydrogen gas**

TX power supply interlock ensures that **dangerous voltages are removed if the cabinet is opened** Lead (lead-tin solder) can **contaminate food if hands are not washed carefully after handling Electrical safety** inside the ham shack is covered by the **National Electrical Code**

Antenna Tower Safety

Confirm that the safety **harness is rated weight** of climber and within **service life**

Make sure all **circuits that supply power to the tower are locked out and tagged** prior to climb **Turn off the transmitter and disconnect the feed line** when working on antenna

A **soldered joint** will likely be **destroyed by the heat of a lightning strike** (do not solder ground rods) Good engineering practice requires **lightning protection grounds be bonded together**