Frydenlund's Crib Sheet For General Ham Radio License

This is a summary of the information that you need to have under control to answer the various questions that will appear on the General Class Ham exam. These are taken from the sample questions in the 2004 pool.

I used to prepare sheets like this to study for exams in grad school and have taken the same approach here. This crib sheet presupposes that you have some understanding of the material and primarily need to be reminded of key ideas. It is no substitute for a text.

Each question is taken from a group of approximately ten questions. In some cases most of the questions are quite similar and only a small amount of information need be learned to master the group. These questions are suffixed here with an "E" for easy. As the amount, or difficulty, of the information necessary to master the questions in a pool goes up, my subjective ratings increase from "E" to "M" to "H" to "VH". YMMV.

You must get 26 out of 35 questions correct to pass. My approach was to target 30 so that I had some margin for error. Being lazy, I mastered the easiest questions first. Interestingly, the first question, requiring essentially straight memorization, was the first that I threw away...

In my opinion:
There is one VH question (1A).
There are six H questions.
If you master all the E and M questions, you will get 28 correct on the exam, enough to pass (with a few to spare).

Since all the questions in the General Test are prefixed with "G", I have omitted that prefix in the references here.

Good Luck   KG6LRP

1.Commission's Rules

1A Frequency Privileges (VH) – Requires memorizing the spectrum allocation in the question pool.

1B Antenna Structure, good engineering practice, beacons, restricted operation, retransmission (M) -

Maximum antenna height 200 feet
Always operate in accordance with good engineering and amateur practice
Beacon Stations may transmit One Way Comms, one signal per band, <100W
Expediency does NOT allow Ham to be used for news information gathering
Music is ONLY allowed incident to rebroadcast of space craft comms
You CAN NOT send secret codes, EVER (except for space telecontrol)

Widely published codes are not secret nor are common abbreviations
You CAN NOT use obscene or indecent language, EVER

1C Power Standards, Amplifiers, HF Data Standards (E) -
On 80 and 30 Meters, max power is restricted to 200W PEP
The minimum power necessary to carry out the comms is what is allowed
More than 1500W PEP is never legal for routine comms
Band = Wave length (Meters) = 300/Freq(MHz)
60 Meters is special, USB only, 5 channels, narrow (2.8KHz), max power 50W

1D Exam Prep and Administration, temporary station ID (E) -
You may only prepare elements below your highest number
You may administer the same elements
Techs pass element 2
Generals add elements 1 and 3
Extras add element 4
Techs who pass element 1 get limited HF CW privs
To administer tests you must be an accredited Volunteer Examiner (VE)
It takes 3 VEs to administer a test
After you pass but before you receive your upgrade you may operate with your new privs by adding /AG to your call sign
You only need to add /AG when using General Privs

1E Local control, Repeaters, Harmful Interference, 3rd Party comms (E) -
If you operate a station using your privs and the station owner does not rate those privs you give the call as Owner Call/Your Call
A Ham can use any repeater where he has the right to the input frequency and the owner has the right to the output frequency
Repeaters repeat messages simultaneously on a shifted output frequency
Coordinated Repeaters have precedence over uncoordinated ones
Harmful interference is called Harmful Interference
Third Party Traffic must be either technical or personal (never commercial)
Such traffic CAN NOT be passed under automatic control
Secondary Users ALWAYS yield to Primary Users
NEVER cause Harmful Interference to a Primary User if you are Secondary
US licensed Hams MUST give their call signs in ENGLISH

1F Power Amp Certification, HF Data Standards (M) -
AMPS below 144 MHz may require FCC Certification
If you build only 1/yr no certification is required
Certified AMPS CAN NOT reach full power if driven by less than 50W
Max Power gain = 6 db at 10 Meters
AMPS should not operate between 24 and 35 MHz (CB Freqs) nor be User Modifiable to operate there

RTTY baud rates <10 Meter = 300 bauds, above 28 MHz = 1200 bauds,
above 50 MHz = 19.6 kbauds
RTTY and unspecified digital bandwidth at 2 and 6 meters 20 KHz

2 Operating Procedures

2A Phone (E) -
20 meters and up in freq = USB for phone, convention
HF phone usually SSB
SSB Narrow BW, More power to Signal, No Carrier

2B Courtesy (E) -
If you interfere, move, net or not
phone separation 3 – 5 KHz
CW separation 150 – 500 Hz
RTTY 250 – 500 Hz
Band Plans are voluntary guidelines
All emission types: follow rules, follow band plans, listen first
Always listen first
CW send QRL? De Call and listen

2C Emergency Comms (M) -
Can use ANY means available
Only when normal means NOT available
FCC can declare temporary communications emergency
FCC may set special rules by notice, you must follow them
Power limitations are suspended
Any frequencies and mode may be used
Station in distress should be given priority and be answered
RACES drills prep for real emergencies
Distressed stations should give location and nature of distress
Use "best" means available

2D Amateur Auxiliary, antenna orientation, HF, logging (M) -
Amateur Auxiliary consists of volunteers who encourage self regulation and
compliance
Fox Hunts provide practice in RDF
Azimuthal projection map is centered on a given geographic location
Gives Great Circle compass bearings to rest of world
Long Path and Short Path 180 deg apart
Logs are NO LONGER REQUIRED but are useful records
Logs normally have dtg, Band, freq, call sign and RST of contact plus comments
Log can aid in resolving interference complaints
Unidirectional antenna best focus of beam
On 60 meters if not using dipole, you must keep record of antenna gain

2E 3rd Party, VOX, ITU regions (E) -
ITU = International Telecommunications Union
ITU Regions, Americas = 2, Europe/Africa = 1, Australia/Asia = 3
International comms should be technical, personal and “unimportant”
VOX allows hands free ops using voice actuated transmission
VOX controls include anti-VOX, VOX Delay, VOX sensitivity
VOX sensitivity sets loudness level when VOX keys transmitter
Anti-VOX prevents received signal from keying transmitter
“End of Message” is used to signify completion of formal voice message

2F CW procedures, RTTY Procedures, prosigns, digital procedures (H) -
QSK, full break in telegraphy, signals can be heard between dots and dashes
80 meter data in 3580 – 3620 KHz
20 meter RTTY 14.070 – 14.095 MHz
ASCII is 7 bit, Baudot is 5 bit, AMTOR error corrects
RTTY stands for radioteletype
RTTY typically uses freq shift FSK of 170 Hz
RYRYRY is used to aid in tuning in RTTY
NNNN means end of message in RTTY
Prosign AR means end of message in CW
PSK31 is in varicode and data bits per character varies
Data Packet routing and handling info are in “Header”

3 Radio Wave Propagation

3A Ionospheric disturbance (ID), solar effects (M) -
When comms suffer in Ionospheric Disturbance go UP in frequency
Ionospheric Disturbance mostly affects low freqs
UV and Xrays from solar flares travel at speed of light (8 min Sun to Earth)
Solar Flux is Radio Energy emitted by Sun, measured by SF Index
Geomagnetic Disturbance is sudden, dramatic change in magnetic field
Geomagnetic Disturbance effects HF comms above 45 degrees Latitude
K Index is measure of geomagnetic stability
A Index is daily measure of geomagnetic disturbance
High Sunspots = enhanced upper HF and lower VHF comms
Sunspot cycle is approximately 11 years
High Corona Activity (Coronal Hole) = bad HF coms due to emitted charged particles
Charged particles arrive Earth 20 to 40 hours behind light and EM waves
Charged particles generate visible aurora

3B Maximum Usable Frequency (MUF), hops (E) -
Wavelength (Meters) = 300/frequency(MHz)
Skip conditions tend to repeat every 28 days (Solar rate of rotation)

Frequencies below MUF are bent back to earth, above go to space
During low solar activity, high frequencies are least reliable hops
20 Meters is usually good at any point in the sunspot cycle
F2 hops are usually maxed out at 2500 miles
E hops at 1200 miles
If Lowest Usable freq (LUF) exceeds MUF, there is no ionosphere HF comms
MUF a function of locations, season, time, solar radiation, ionospheric factors
Signal reaching you by both long and short path has echo
If hops are getting shorter on current band, MUF probably rising

3C Height of Ionospheric regions, critical angle/freq, HF scatter (E)
E layer = 70 miles
F layer max (summer) = noon
F2 layer gives longest hops because it is highest
HF Scatter typically has wavering sounds due to multiple atmospheric paths
HF scatter signal typically weak because only some propagated into skip zones
HF scatter detectable in area between hops
HF scatter most often on freqs above MUF
Absorption in ionosphere minimized near MUF
40 Meter daylight fading associated with D level absorption

4 Amateur Radio Practices

4A Two Tone Test, TR switch, Amp neutralization (E) -
Two tone test is used to test amplitude linearity of SSB on O-scope
Two tone test uses two non-harmonically related tones, within audio bypass
TR (transmit/receive) switch normally between XMTR and low pass filter
Electronic TR switches much faster than mechanical
Minimum grid current change with output change indicates best neutralization
Neutralization required to cancel oscillation caused by inter electrode capacitance
Called self oscillation
Neutralization uses negative feedback to cancel positive feedback
Diodes only allow current to flow in one direction (according to its bias)

4B Test Equip, O-scope, signal trace, antenna noise bridge, field strength meters (M) -
Oscilloscopes have vertical and horizontal channel amps
Monitoring O-scope good for monitoring signal quality
RF output of Xmitter goes to vertical O-scope input to check signal quality
For AM/SSB trapezoidal check, set sweep to twice modulating frequency
A signal tracer is useful to identify inoperative stage in receiver
Noise bridge finds impedance. Placed between rcvr and antenna and tuned to minimum noise
Field strength meter (FSM) monitors RELATIVE RF output
FSM useful for measuring antenna output field patterns

FSM useful for final RDF in high signal strength situation
S Meter theory, increase 1 S unit = 6 dB = 4 times the power

4C Audio Rectification, RF Ground (E) -
Bypass capacitors can reduce audio-freq interference in home entertainment equip
RFI filters can be added to telephone circuits
SSB interference in PA circuit usually garbled or distorted voice
CW usually on and off humming or clicking
Long (resonant) Ground wires make antennas, try to keep grounds short
If ground resonates, generates RF hot spots in shack
Good ground reduces noise, interference, and probability of electric shock
Good ground rod minimum 8 feet
NEC says only ONE ground SYSTEM per building (all must tie together)
NEC silent on RF exposure
All shack equipment should be grounded
Avoid ground loops by connecting all equipment to same ground point
Coax braid makes good ground buss
Intermittent grounds can cause severe broadband RF noise
Poor contact in wires increases chance of rectification and induced currents

4D Speech processors, PEP calcs, wire size, fuses (M) -
Speech processors improve intelligibility at receiver
SP increases average power without increasing PEP
PEP = (0.707 x PEV) x (0.707 x PEV)/R where PEV = Peak Envelope Volts
For unmodulated carrier, average power = PEP
In AC circuits, only “hot” wires should be fused, never neutral or ground
20 amp circuit requires #12 AWG wire, gets 20 amp fuse/breaker
Speech Clipping circuit prevents transmitter modulator overdrive
P = I x E, E = I x R where P = power, I = current, E = voltage, R = resistance

4E Common connectors, fastening methods, HF mobile installs, generators, batteries, wind, solar (E) -
PL-259, Type N, BNC, all radio connectors... DB-25 not (computer connector)
Power plug should be neat, follow color codes, be properly grounded
HF mobile rigs should use short, heavy-gauge, fused wires, direct to battery
Cigarette lighter sockets have limited current capacity (<8 amps?)
Mobile HF effectiveness typically antenna limited
Emergency generators should be well ventilated, grounded, and have safe fuel storage
Lead/acid batteries give off hydrogen while being charged
Sunlight to electricity is called photovoltaic conversion
Photovoltaic typically = 0.5V per cell
Panel size should be selected based on max volts and current required
Wind power requires large storage for times with no wind
Emergency Generators should not feed output to electric wiring of house unless

there is cutoff switch because:
Restoration of power may damage generator
Hazard to electric company workers who expect dead circuits
Other household devices may draw power overloading generator

5 Electrical Principles

5A Impedance, resistance, reactance, inductance, capacitance, metric measure (E) -
Impedance is resistance to AC current (measured in Ohms)
Reactance is impedance caused by action of inductors and capacitors to AC
Coils have inductance, as freq goes up, reactance goes up
Capacitors have capacitance, as freq goes up, reactance goes down
When source impedance = load impedance, power transfer is maximized
Core saturation in coils leads to harmonics and distortion

5B Decibels, Ohms law, current and voltage dividers, power calcs, series and parallel components, transformers, RMS values (H) -
3dB increase = twice the power
dB = 10 x log10 (P2/P1) where P2 = measured power, P1 = reference power
Sum of all currents entering junction = sum off all currents leaving
Kirchoff's Law
P = I x E, E = I x R where P = power, I = current, E = voltage, R = resistance
Es = Ep x (Ns/Np) where E = volts, s = secondary, p = primary,
N = nr of windings (transformer calculations)
turns ratio = sqrt impedance ratio = sqrt (Ip/Is)
For sine wave, power from DC volts = RMS power AC volts
Be careful when volts are given or asked peak to peak. Which is double
normal description of AC voltage
Mutual inductance makes volts appear on secondary of transformer
C series = (C1 x C2)/(C1 + C2)
R parallel = 1/(1/R1 + 1/R2 + 1/R3 + ...)

6 Circuit Components

6A Resistors, capacitors, inductors, rectifiers, transistors (H) -
Resistors change resistance with temperature change by
temperature coefficient rating
Electrolytic capacitors are typical for filters in AC power supplies
Capacitors that filter voltage spikes are “suppressor capacitors”
Input to a transformer goes to the primary coils
Current in the primaries of a no load transformer is the “magnetizing current”
Peak inverse voltage of a rectifier is the max voltage it will handle in non-conducting direction
Power supply rectifiers should not exceed peak inverse voltage and ave forward current

Output of unfiltered full wave rectifier = pulses at 2X freq of AC
Half wave rectifier conducts through 180 degrees
Full wave rectifier conducts through 360 degrees
Diodes in parallel have equalizing resistors in series to prevent one from taking most of load
Wire wound resisters should not be used in tuned circuit because windings act as inductor and detune circuit
Ferrite toroidal inductors can have large values, be core saturated, contain most magnetic field in core
Transistor (bipolar) used as switch should be stable in saturation and full off
Solenoid inductors should be mounted at right angle to minimize mutual inductance
Mutual inductance should be minimized to reduce stray coupling between RF stages

7 Practical Circuits

7A Power Supplies and filters, SSB XMTR and RCVRS (H) -
Bleeder resistors discharge filter capacitors
Power supply filters include capacitors and inductors
Minimum peak inverse rating of rectifier should be 2 X peak output voltage
Impedance of low pass filter should be ~= transmission line impedance
In typical SSB XMTR signal goes from balanced modulator to filter to mixer
In typical SSB XMTR signal goes from speech amp and carrier oscillator to balanced modulator
In typical SSB superhet RCVR signal goes from RF amp and local oscillator to mixer
In typical SSB superhet RCVR signal goes from IF amp and BFO to detector
Over voltage in power supply often protected by “crowbar” circuit
Rectified DC power often filtered by low equivalent series capacitors
Switched power supply allows small light low cost transformers
First step in switched power supply is to rectify and filter input

8 Signals and Emissions

8A Signal Info, AM, FM, SSB, DSB, bandwidth, modulation, deviation (H) -
Amplitude Modulation changes signal level proportional to intelligence (audio)
Frequency Modulation changes freq proportional to intelligence
Phase Modulation changes phase proportional to intelligence
Reactance modulator modulates phase
In SSB and DSB Carrier should be suppressed at least 40 dB
With carrier suppression, more power can be put into sideband(s)
SSB is the narrowest bandwidth phone emission
Overmodulated SSB and DSB distort and spread in bandwidth (splatter)
Flat topping is distortion caused by over driving SSB

Microphone gain should be adjusted to give slight movement on ALC meter on modulation peak
In FM the freq changes with the instantaneous audio amplitude change
The signal out of the balanced modulator includes both modulating signal and unmodulated carrier

8B Frequency mixing, multiplication, bandwidth, HF data comms (H) -
In RCVR, stage that combines oscillator and input is called “mixer”
In XMTR mixer local oscillator with IF to create (after filtering) an output RF
In FM XMTR stage that selects harmonic for transmit is the multiplier
FM bandwidth too wide (16 Khz) below 29.5 Mhz
For FM Bw = 2 X (D + M) D = deviation, M = Modulating frequency
In FM transmit freq provided by multiplier stage(s) Oscillator is multiplied too
To compute correct freq deviation for oscillator must reverse multiplication
Multiplication factor = XMIT FREQ / HF Oscillator FREQ
Deviation Oscillator FREQ = Deviation/Multiplication Factor
Image Response (interference) results when there is a received signal the same amount as the IF above and below the VFO
In FSK as speed goes up frequency shift must go up
RTTY, CW, and PSK31 are all digital modes
When sending data modes duty cycle is important so you do not overheat
In 20 meter, most PSK found low (below RTTY at 14.070)
On 60 meter, max USB bandwidth 2.8 Khz
Mixing 2 RF signals call heterodyning

9 Antennas and Feed Lines

9A Yagis (M) -
Larger diameter elements have wider freq response (SWR bandwidth)
½ wavelength YAGI (feet) = 468/Freq (Mhz) (Driven element, dipole)
Reflector = 1.05 driven element, director = 0.95 driven element
Increased boom length, increased directors = increased gain
Yagis have good side and back signal rejection
Front to back ratio = power radiated forward vs. power radiated backward
Main lobe = forward radiation
Optimizing boom length and element spacing optimizes Yagi
Polarization does NOT effect forward gain

9B Loop Antennas (M) -
1 Wavelength driven element (feet) = 1005 / Freq (Mhz) (Quad or delta)
Reflector = 1.025 driven element
Quads perform much like 3 element Yagi
Quads more directive, horizontal and vertical, than dipole
Quad horizontal feed = horizontal polarization, vertical = vertical

Front to back ratio = power radiated forward vs. power radiated backward
Main lobe = forward radiation

9C Random Wires, impedance matching, radiation patterns, feed points, dipoles, verticals (M) -
End fed random wires do NOT require feed line
End fed random wires are multi-band
End fed random wires may introduce RF feed back to station
Sloping Radials on ground plane antenna increases impedance, 45 deg ~= 50 ohm
Dipole ½ wavelength above ground exhibits figure 8 emissions pattern perpendicular to antenna
Lowering antenna makes pattern omni directional
Most energy goes out in major lobe
Parasitic elements in dipole work like Yagi...
Radials of ground mounted vertical antenna typically on surface or down couple of inches

9D Feedlines (E) -
Twin lead feed: main factors for impedance = diameter of wire and separation
Flat Ribbon feed typically 300 Ohm
Coax is typically 50 or 75 Ohm
Impedance mismatch between feed and antenna reflects power back into feed
To prevent standing waves (SWR), match impedance
Inductively coupled network matches unbalanced XMTR output to balanced feed lines
In coax, higher freqs have higher losses
Normal measure of loss is dB per 100 feet
50 Ohm to 200 Ohm connection will result in 4:1 SWR (big number always first)

0 RF Safety

0A RF Safety Principles (E) -
RF duty cycle, frequency, power density, polarization all factors in heating body tissue
Frequency (wavelength) most important effect on permitted RF exposure
Most important measure is “Spectral Absorption Rate (W/Kg)
1270 Mhz has most effect on eyes
Athermal effects are biological impacts other than heating
Body absorbs radiation most efficiently in VHF
Total RF exposure limits usually time averaged
RF evaluation must be performed if PEP and Frequency are in certain limits in Part 97
If eval shows you are above limits, you must prevent human exposure
In multi XMTR environment, each device operating at more than 5% of max must be included in overall site eval

0B RF Safety Rules (M) -

RF safety rules control max permissible human exposure to RF
At multi site, any XMTR contributing over 5% must ensure rules are met
Low Duty cycles allow higher instantaneous exposure
20 Meter max PEP before one must do evaluation = 225 W
15 Meter max PEP before one must do evaluation = 100 W
10 Meter max PEP = 50 W
VHF to 10 meters all at 50 W
< 10 Mhz max PEP = 500 W
Maximum Permissible Exposure (MPE) levels are freq dependent
All stations exceeding power parameters are subject to routine environmental eval

0C Routine Station Evaluation Measurements (M) -

Free space far field strength decreases linearly with distance
Free space far power density decreases as a square with distance
Boundary between far and near space function of wavelength and size of antenna
A routine RF exposure eval will ensure compliance with RF safety regs
In free space far field, electric field and magnetic field constant impedance relationship of 377 Ohms where E/H = 377, E in V/Meter, H in Amps/M
RF field measured by field strength meter
If in compliance at a power level, always in compliance at lower power

0D Practical RF Safety apps (E) -

Locate antennas as far away from living space as practical
When adjusting feed lines, disable XMTR
When working on Antenna, disable XMTR, disconnect feeds
Fence around ground mounted vertical will control access to MPE RF
Directional antennas should be mounted high to reduce MPE RF in surrounding structures
At 1270 Mhz be especially careful with radiation to eyes
Car roofs act as good RF shield
Attic mounted antennas may expose people in structure to MPE RF
EME moon bounce antennas typically high gain, high directivity and have high ERP causing MPE risk, interference, and self detuning if aimed at nearby structures

0E RF Safety solutions (E) -

RF burns in shack indicate possible MPE RF in shack
Too much RF in shack? Reduce power, improve grounds, tighten equipment covers
If indoor dipole creates too much MPE, move antenna to safer location
To minimize RF exposure problems, install antenna far away, avoid pointing at populated areas, minimize feed line radiation, minimize power
Dummy antennas convert “all” power to heat
Conductive materials make best equipment enclosures (RF containment)

High Gain, narrow antennas let you point power away from people but may point power at people
High mounted antennas have less RF risk than low ones
Fences can keep people away from MPE RF risk areas

Useful Formulas:

Wavelength (Meters) = 300/frequency(MHz)
PEP = (0.707 x PEV) x (0.707 x PEV)/R where PEV = Peak Envelope volts
P = I x E, E = I x R where P = power, I = current, E = voltage, R = resistance
dB = 10 x log10 (P2/P1) where P2 = measured power, P1 = reference power
Es = Ep x (Ns/Np) where E = volts, s = secondary, p = primary,
N = nr of windings (transformer calculations)
turns ratio = sqrt impedance ratio = sqrt (Ip/Is)
Cseries = (C1 x C2)/(C1 + C2)
Rparallel = 1/(1/R1 + 1/R2 + 1/R3 + ...)
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