Amateur Radio: Standard Exam Preparation Cheat Sheet No. 1

(The author of this document does not actually endorse cheating!)

Introduction and Regulations

1. Amateur Radio is intended to facilitate the hobby of Radiocommunications.

2. Types of Licenses:

   AMATEUR, CITIZEN BAND, LAND MOBILE, POINT TO POINT, BROADCASTING

3. The Amateur Service ONLY operates within the allocated frequency bands. Amateurs share some frequency bands with users of other services. Other Radiocommunications Services use bands appropriate to their purpose.

4. The LCD (1997) was borne out of the Radiocommunications Act, 1992 and subsequent Regulations, 1993

5. An Amateur License authorises activities, relating to Radiocommunications; SELF-TRAINING, INTERCOMMUNICATIONS and TECHNICAL INVESTIGATION

6. Except in distress or emergency situations, intercommunication must only be Amateur to Amateur

7. Conditions apply to the transmission of third-party messages as well as to Amateurs in another country; (eg. Business related, DX to China)

8. Emergency and Distress communications:

Situation	Definition	Telephony	C.W.
EMERGENCY	Life in immediate peril	MAYDAY	. . . - - - . . . (SOS)
DISTRESS	Urgent response needed	PAN-PAN	- . . - - . . - - . . -

9. Use your callsign at the beginning and end of every QSO as well as every 10 minutes within it. This includes Test Transmissions.

10. Australian callsigns start with **VK** and use our State-Based numerical code. Islands of Pacific and Indian; **VK9.** Stations in Antarctica; **VK0.** Special Event Callsigns; **VI**, **AX** or **VK100**

11. Individual callsign suffixes are not now limited but still exclude three letter callsigns beginning with **Q.**

12. The transmission of secret coded messages is generally not permitted. Any form of entertainment is not permitted.

13. Amateur Frequency Bands:

Band	Frequency Range	Licenses
2200m	135.7 - 137.8kHz	Advanced
160m	1.800 - 1.875MHz	Advanced
80m	3.500 - 3.800MHz	ALL
40m	7.000 - 7.300MHz	ALL
30m	10.10 - 10.15MHz	Advanced
20m	14.00 - 14.35MHz	Std + Adv
17m	18.068 - 18.168M	Advanced
15m	21.00 - 21.45MHz	ALL
12m	24.89 - 24.99MHz	Advanced
10m	28.00 - 29.70MHz	ALL
6m	50.00 - 54.00MHz	Std + Adv
2m	144.0 - 148.0MHz	ALL
70cm	420.0 - 450.0MHz	ALL
23cm	1240 - 1300MHz	Std + Adv
Other bands: 13cm, 9cm, 6cm, 3cm…		

Modes: (PM = Phase Modulation)

Mode	AM	SSB
Morse (**A**)	2K1**A**1A	2K1**J**2A
Voice (**E**)	8K0**A**3E	5K0**J**3E
Data (**D**)	8K0**A**2D	5K0**J**2D
RTTY (**D**)	2K5**A**2D	2K5**J**2D
FAX (**C**)	2K5**A**2C	2K5**J**2C
FSTV (**F**)	5M0**A**3F	5M0**J**3F
SSTV (**F**)	8K0**A**2F	8K0**J**2F
Mode	**FM**	**PM**
Morse (**A**)	2K1**F**1B	2K1**G**1B
Voice (**E**)	8K0**F**3E	8K0**G**3E
Data (**D**)	8K0**F**1D	8K0**G**1D
RTTY (**D**)	2K1**F**2D	2K1**G**2D
FAX (**C**)	2K5**F**2C	2K5**G**2F
FSTV (**F**)	5M0**F**3F	5M0**G**3F
SSTV (**F**)	8K0**F**2F	8K0**G**2F

*Mode format: [Bandwidth - **Modulation** - Signal type - Information type]*

14. Max TX Power: Foundation- 10W, Standard- 100W, Advanced- 400W (PEP)

15. You are required to notify ACMA of a change of address.

16. You must not cause harmful interference to other stations. ACMA can give directions or restrict your operation in order to avoid interference.

17. You must produce your license for an ACMA Inspector upon request.

18. Recall these and other conditions from the LCD.

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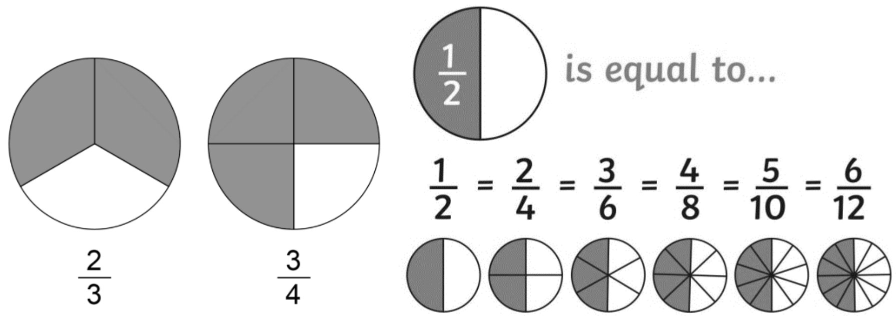
Mathematics

1. Use Addition, Subtraction Multiplication and Division; and the proper Order of Operations.

Order	Symbols	Other terms	Example
Brackets:	( )	"First do…"	2 x (6 + 5) = 22
Indices:	X^3	"to the power of"	3^4 = 3 x 3 x 3 x 3 = 81
Multiplication:	×	"times" or "lots of"	2 x 2 = 4 4 x 7 = 28
Division:	÷	"divided by" or "over"	10 ÷ 2 = 5 9 ÷ 2 = 4.5
Addition:	+	"the sum of" or "plus"	7 + 4 + 6 = 17
Subtraction:	-	"take away" or "minus"	23 - 5 = 18 3 - 2 = 1

2. Fractions



3. Improper Fractions and Decimals is where the number on top (numerator) is larger than the number below the line (denominator).

4. Decimal numbers:

Ten Thousands	Thousands	Hundreds	Tens	Ones	Decimal Point	Tenths	Hundreths	Thousandths	Ten Thousandths
10000	1000	100	10	1	.	0.1	0.01	0.001	0.0001
10000	1000	100	10	1	.	$\frac{1}{10}$	$\frac{1}{100}$	$\frac{1}{1000}$	$\frac{1}{10000}$
$\times10^4$	**$\times10^3$**	**$\times10^2$**	**$\times10^1$**	**$\times10^0$**		**$\times10^{-1}$**	**$\times10^{-2}$**	**$\times10^{-3}$**	**$\times10^{-4}$**

5. Engineering Notations and Measurement Unit Multiples and Sub-Multiples

Prefixes	Value	Standard form	Symbol
Tera	1 000 000 000 000	10^{12}	T
Giga	1 000 000 000	10^9	G
Mega	1 000 000	10^6	M
Kilo	1 000	10^3	k
deci	0.1	10^{-1}	d
centi	0.01	10^{-2}	c
milli	0.001	10^{-3}	m
micro	0.000 001	10^{-6}	µ
nano	0.000 000 001	10^{-9}	n
pico	0.000 000 000 001	10^{-12}	p

6. **Calculating Using Formulae**
   - Simplify the information in words, in the question by reducing it to symbols and values using the 'scratch paper' available.
   - Use the formula sheet to decide which formula can be used based on the information given and what you are being asked to find.
   - Transpose the formula to a form that shows the unknown quantity is on the left of the equal sign and the rest of the expression is on the right.
   - When transposing, ensure that whatever you do to the Left-Hand Side, you also do to the Right-Hand Side to maintain equality.
   - When it is in the right form, rewrite the formula, substituting the symbols for all the known quantities with those values.
   - When you use a calculator, enter the values in the order they are in within the expression; using brackets to clarify the structure.
   - Remember that some questions may require you to do two separate stages of calculation.

   Remember to use the Ohm's Law and Power triangles to save you time in the exam.

Amateur Radio: Standard Exam Preparation Cheat Sheet No. 3

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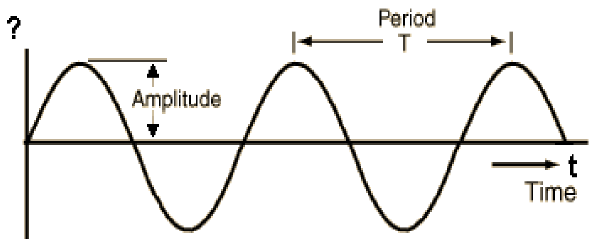
Technical Basics - Part 1 - Electrical Concepts

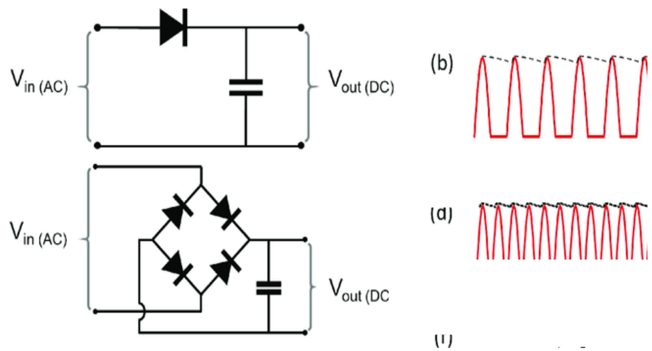
1. The **mains** voltage in Australia is **230** Volts (RMS). The frequency is **50** Hertz.
2. The **Active** conductor carries the voltage. The potential of the **Neutral** and **Earth** conductors is **zero Volts**.
3. In electrical cords, the **Active** is **BROWN**. The **Neutral** is **BLUE**. The **Earth** is **GREEN** with a **YELLOW** stripe.
4. The Earth connection is used so that the fuse will blow when there is a short to the chassis of the equipment. It is designed to protect people from electrocution.
5. A fuse is designed to protect equipment from damage due to over-current. Over-current can permanently damage devices in the equipment. Over-current will also cause heat that can lead to fire.

   Switches isolate equipment from the supply. Never open the case of equipment while it switched on.

6. DC current means that the flow of electrons is only ever in one direction.
7. AC current means that the direction of **flow of electrons** alternates as the voltages change. The voltage follows a **sinewave** curve. If the Frequency of supply is 50Hz, the period of that sinewave is 20ms.



8. A **DC Power Supply** uses diodes **to rectify** the AC. Diodes only pass current in the direction of the arrow in the symbol. The DC voltage can be smoothed using filter capacitors.

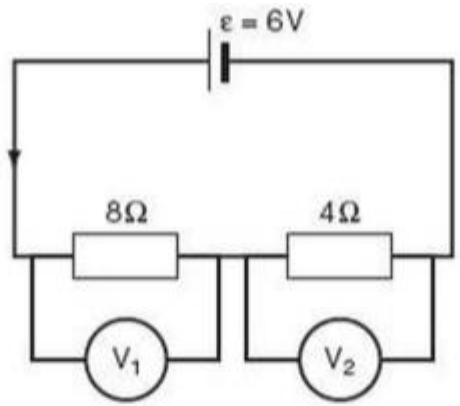


9. Electrical quantities and units:

QUANTITIY	SYMBOL	DESCRIPTION	UNITS
Voltage	V or E	Pressure, potential difference or EMF	Volts (V)
Resistance	R	Opposition to current flow	Ohms (Ω)
Current	I	The rate of flow of electrons	Amperes (A)
Power	P	The rate at which work is done (Heat)	Watts (W)

10. EMF is "Electromotive Force" it describes the Potential of a Voltage supply. Potential difference is another term for Voltage, but this refers to the difference in voltage between any two points in a circuit.

    Here, the EMF is 6 V but the potential difference across the 8 Ω resistor (V_1) will be 4 Volts and the potential difference across the 4 Ω resistor will be 2 Volts. This is because the total of the voltage drops will be equal to the supply voltage. You can also see that the voltage drops are proportional to the resistances. 4 Volts across 8 Ohms and 2 Volts across 4 Ohms.



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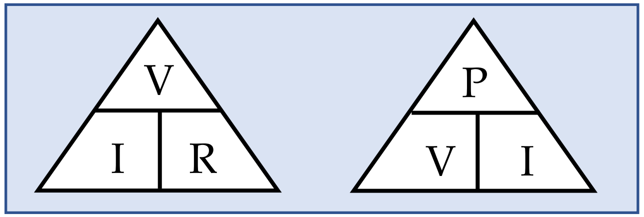
11. Ohms Law and Power calculations: **Practice using these to save exam time in the exam.**

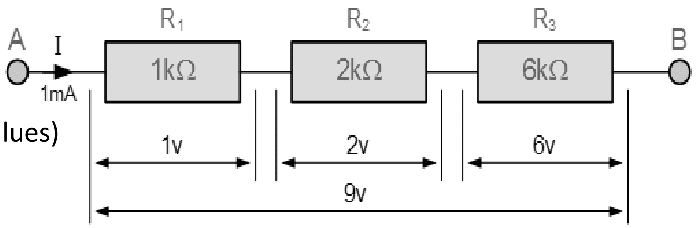


Technical Basics - Part 2 - Resistors

1. Remember that resistors restrict the flow of current.

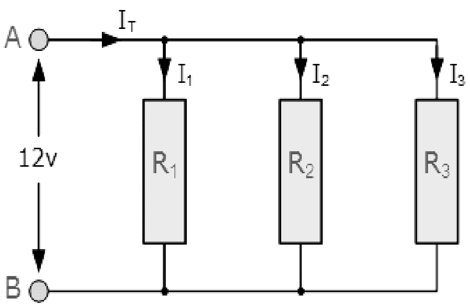
2. Resistors in series:

   $R_T = R_1 + R_2 + R_3$
   (Add the resistor values)
   $V_T = V_1 + V_2 + V_3$
   $I_T = I_1 = I_2 = I_3$



(There is only one current path)

3. Resistors in Parallel:



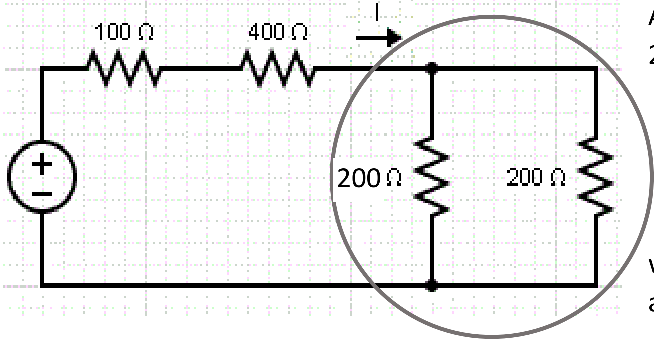
Each time you add another parallel path, you increase the total circuit current (I_T).

That means that the circuit's equivalent resistance decreases.

NOTE: In an exam question, the parallel resistors will be of the same value. **Just divide the resistor value by the number of resistors!**

If each resistor is 330 Ω, then the circuit's resistance will be 110 Ω.

4. <u>Simplifying Series-Parallel networks</u>: You cannot calculate Series and Parallel together so break it down into sections and reduce each section to a single equivalent resistance.



A... - Parallel
200Ω // 200Ω = 100Ω

B... - Series
100Ω + 400Ω + (100Ω) = 600Ω

NOTE: Each question will need a different approach.

5. The Resistor Colour Code provides resistance value and tolerance information in the form of coloured bands:

BLACK	BROWN	RED	ORANGE	YELLOW	GREEN	BLUE	VIOLET	GREY	WHITE
0	1	2	3	4	5	6	7	8	9

A resistor with four colour bands - is 4k7 $^+$/- 1% — YELLOW | VIOLET | RED | BROWN — **4** **7** **(00)** **$^+$/- 1%**

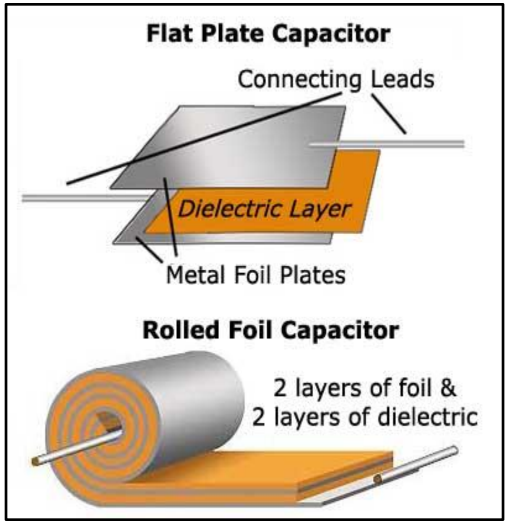
A resistor with four colour bands - is 560k $^+$/- 5% — GREEN | BLUE | YELLOW | GOLD — **5** **6** **(0000)** **$^+$/- 5%**

Capacitors

1. Capacitors consist of two conductive plates separated by a **dielectric** (insulating material).

   Electrolytic capacitors, such as is pictured below, are **polarised** and cannot be connected in the reverse polarity.

   The unit for Capacitance is large. It is the **Farad**. Most capacitors are measured in picofarads (pF), nanofarads (nF), or microfarads (µF).



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Because of their construction, many capacitors, especially Electrolytics, have a **Maximum Working Voltage** which is quite low. (See the Electrolytic Capacitor to the left)

2. Variable capacitors are used in tuning circuits in radios. By rotating the shaft of the capacitor to the right, the overlapping area changes.
   It's dielectric material is air!

3. REMEMBER THAT, **EVEN WHEN THE POWER IS DISCONNECTED**, CAPACITORS WILL RETAIN A CHARGE.

4. Capacitors in parallel:

   $C_T = C_1 + C_2 + C_3$

   Capacitors in series:

   $C_T = 1 \div (1/C_1 + 1/C_2 + 1/C_3)$

Technical Basics - Part 3 - Inductors and Resonance

1. Reactance is the property of a capacitor or a coil that reacts to a changing (AC) voltage. The unit of reactance is Ohms. Just like resistance, reactance in an AC circuit will restrict current flow.
   A Note on Reactance:
   The reactance of a capacitor decreases as the frequency of the AC increases.
   The reactance of an inductor (coil) increases with frequency.

$$Xc = \frac{1}{2\pi fC}$$

Where Xc = Capacitive Reactance
f = frequency in cps
C = capacity in farads
$2\pi = 6.28$

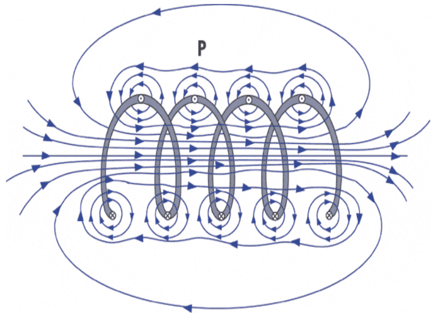
$$X_L = 2\pi fL$$

Where:

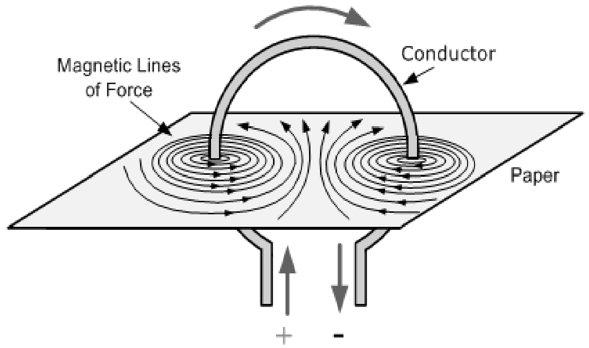
X_L = the inductive reactance in ohms
f = the frequency in hertz
L = the inductance in henries
π = 3.1416

2. As current flows through a wire, a magnetic field is created around it. This conversion of electrical energy into magnetic energy is reversable. Electromagnetic induction is when movement between an inductor and a magnetic field induces a current in the windings. This happens in a generator.

3. The property that determines the magnetic effect is called inductance. Inductance increases with the **coil diameter**, with **the number of turns** in the coil and a reduction in the **spacing between the turns**. It also increases when a **ferromagnetic material** is used in the core of an **inductor**. Inductance is measured in Henrys.



   If an A.C. signal is applied to a coil, the <u>continually</u> changing magnetic field creates a voltage. This "Back e.m.f." presents opposition to the changing current that is causing it. This gives rise to the reactance of an inductor.

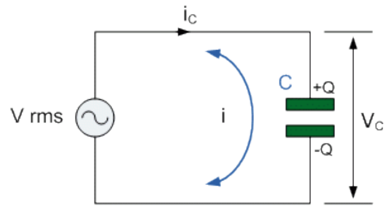


   The higher the frequency, the steeper the rate of change and so, the Inductive Reactance increases with frequency.

4. The Root Mean Squared (**RMS**) value of voltage in a sinewave signal or an AC supply is 0.707 × V_{PEAK}. **AC Voltages are usually specified by their RMS value.**
5. V_{PEAK} = 1.414 × V_{RMS}.

6. The period of a wave is the time it takes for **one cycle**. The period of a 50Hz Supply is 20ms.

7. **Capacitive reactance** changes with frequency. It decreases as the frequency increases. Generally, reactance represents the opposition to the flow of AC current based on its rate of change.



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8. The reactance of a capacitor causes the current to lead the changing voltage by 90°.
   Remember that AC current in a capacitive circuit charges the capacitor and then discharges in and charges it in the opposite direction. **No electrons** move through the dielectric! **Coupling capacitors** can be used to allow an AC signal to pass, while blocking DC current.

9. The **Impedance (Z)** of a circuit is a combination of Reactance and Resistance.

$$Z_{RLC\text{-}series} = \sqrt{R^2 + (X_L - X_C)^2}$$

10. Impedance is also measured in Ohms. The total Impedance of an AC circuit will determine the current in that circuit.
11. LC Tuned Circuits, use an Inductor and a Capacitor, in series or in parallel. A circuit is said to be in resonance when $\mathbf{X_C = X_L}$. Note in the Series RLC formula above, that if $\mathbf{X_L = X_C}$, The only thing limiting the current is the resistance.

12. The resonant frequency of a tuned circuit is calculated using the following formula:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

13. In a parallel resonant circuit, the Impedance is a maximum and AC **current is a minimum**.

14. In a series resonant circuit, the Impedance is a minimum and **current is a maximum**.

15. **Q-Factor** is an indicator of the amount of **loss (L/R) in a tuned circuit**.

Transformers

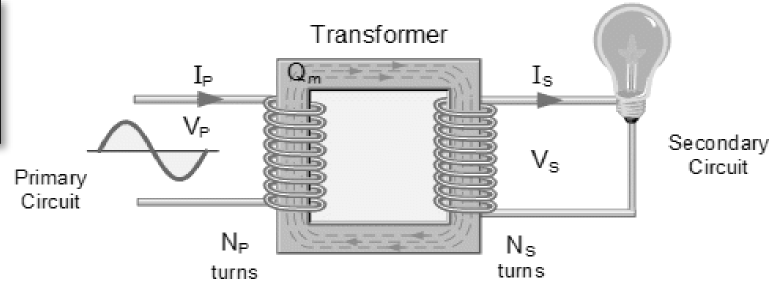
1. Transformers use Mutual Induction to transfer energy from one coil to another coil. We say that the coils are magnetically coupled.

Electrical Power → Magnetic Flux → Electrical Power

Remember that, except for the losses that occur, $\mathbf{Power_{In} = Power_{Out}}$

The Turns Ratio and Voltage Ratio are the same.

$$\mathbf{N_P : N_S = V_P : V_S = I_S : I_P}$$

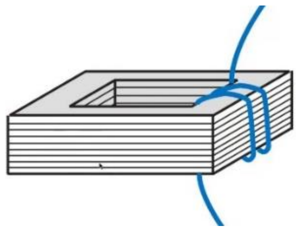


2. Step down Voltage Transformers are used in Linear Power Supplies to drop voltage from 230 Volts to an Extra Low Voltage. After rectification, filtering and voltage regulation, the output is a DC Voltage. For example, 13.8 Volts.

3. Rectification is achieved using Diodes. Voltage Regulation uses Voltage Regulators. (Examples of Integrated Circuits)

4. In Radiocommunications, transformers are used for scaling voltages as well as for matching impedances. A **BALUN** is a form of transformer. **To the right is a ferrite core, 4:1 current balun: Reducing a 200 Ω impedance to 50 Ω**

5. The changing magnetic field in an Iron core induces **Eddy Currents, circular currents that heat up the Iron**. To minimise Eddy Currents induced in a steel core, it is laminated. The core is made from thin sheets of steel. Those are lacquered to isolate them electrically before they are assembled to become a large. Heat due to Eddy Currents are referred to as Iron Losses.



As well as **Iron Losses**, transformers also suffer Copper Losses. The current in the windings of a coil or transformer causes heat. **Copper Loss is also Heat Loss**.

Amateur Radio: Standard Exam Preparation Cheat Sheet No. 7

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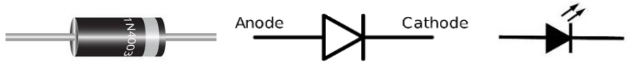
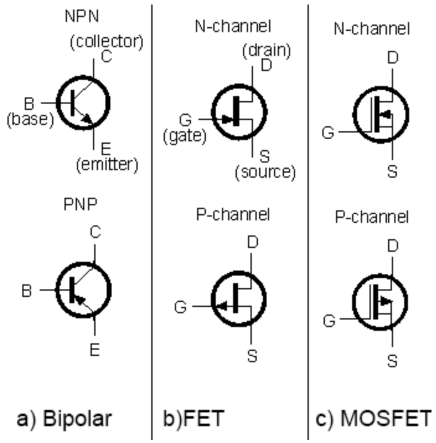
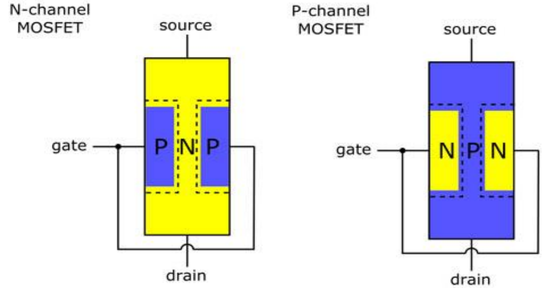
Technical Basics - Part 4 - Electronic Devices

6. A **Diode** consists of a **junction** between N-Type and P-Type semiconductor material.



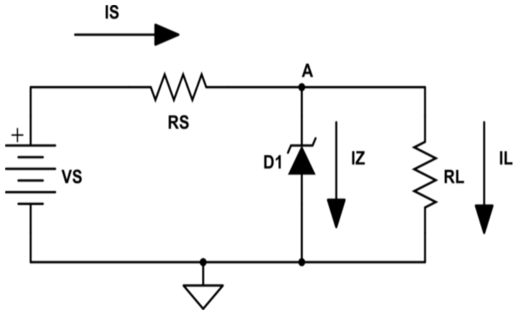
When the **anode** (P-Type material) is connected to a voltage more positive than that of the **cathode** (N-Type), it is said to be forward biased. A Silicon diode requires about **0.6 Volts** to break down the depletion layer. Once that is achieved, the diode will conduct. This condition is called **Forward Bias**. Diodes do not conduct at all in **Reverse Bias**. Silicon Diodes are used to steer current from an AC circuit so that all of the current is going one way. We call this Rectification.

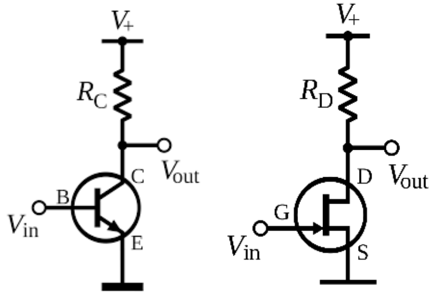




In the MOSFET there is an insulating layer of metal oxide between the N and P type materials. It is repulsion due to the electrical field that chokes off the channel current.

7. A **Zener diode** is used in reverse bias. At a very specific voltage, the device begins to conduct (to break down). This is the **breakover voltage**, or **avalanche voltage** of the Zener**.** It is a fixed voltage, and makes the Zener diode a good **voltage reference**.



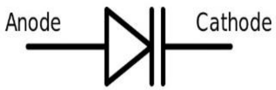


The circuits to the left are simple amplifier circuits. The first is a **BJT** amplifier known as a **Common Emitter**. (The Emitter is connected to Ground).

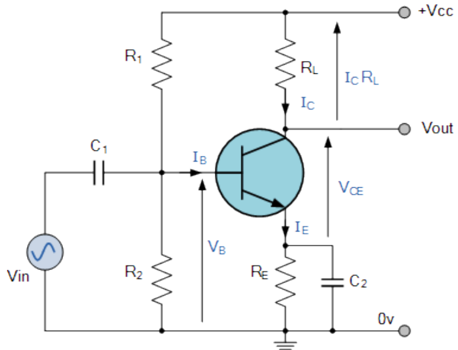
The second is a FET amplifier known as a **Common Source Amplifier.**

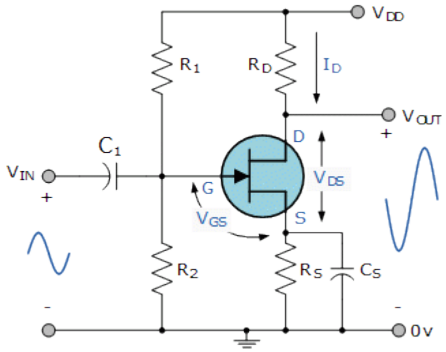
The output signal is typically bigger than the input signal. **V_{out} / V_{in} is Voltage Gain.**

8. Remember that a **Varicap** or **Varactor** is a **reverse biased** diode. The **depletion layer** is used as the **dielectric**. As the reverse bias voltage changes, the thickness of the depletion layer will change.
https://www.youtube.com/watch?v=6zH0QMeQaXg



For the Standard Assessment, the Common Emitter and the Common Source are the only Amplifier Configurations you need to be able to identify. Here are some other circuit diagrams:





9. The **Bipolar Junction Transistor** (BJT) is a three-layer semiconductor device. It can be used as a **current-controlled switch** or as an **amplifier**.
Collector Current/Base Current (I_C/I_B) is what we call **Current Gain**.

Field Effect Transistors (FETs) have a conductive channel of N-type or P-type material. As a reverse bias voltage is applied to the Gate, the depletion layer expands and **chokes off** the channel current. Because the Gate-Source junction is reverse biased, the input impedance of a FET is Very High!

Amateur Radio: Standard Exam Preparation Cheat Sheet No. 8

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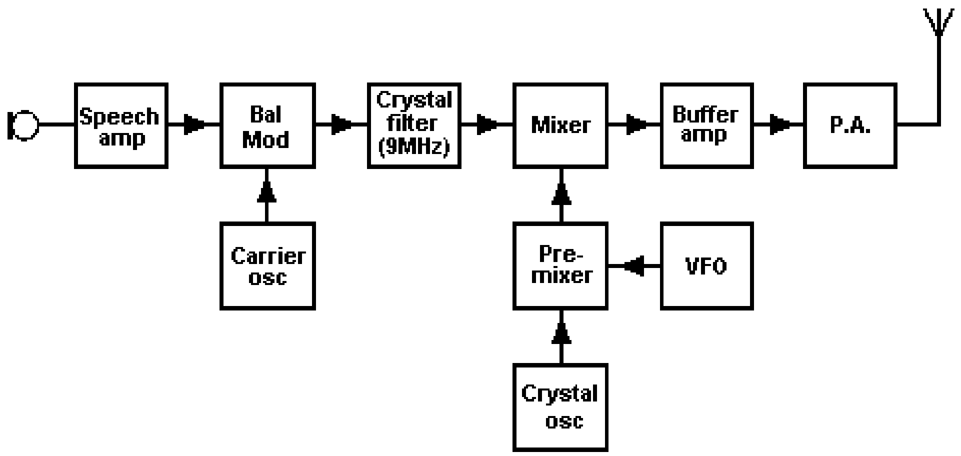
Transmitters, Mixers, Amplifiers and Modulation

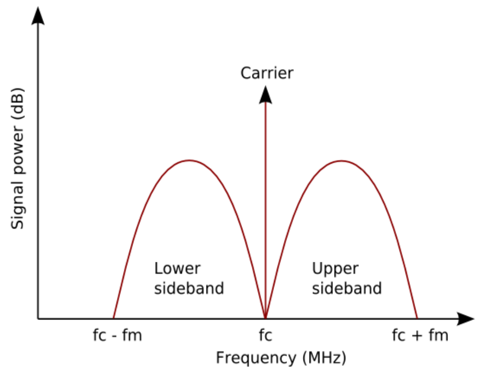
Below is a block diagram representing an AM, SSB transmitter:



1. The **Speech Amp,** or Audio Amplifier, magnifies the millivolt signal from the microphone so that it can be used to modulate the carrier signal.

2. The **Carrier Oscillator** generates a fixed frequency, 9MHz, RF sinewave.

3. A **Balanced Modulator** is a type of **Mixer.** When two frequencies are mixed, the result is a combination of each of the input frequencies and **$F_1 + F_2$** as well as, **$F_1 - F_2$** . These added and subtracted frequencies are called **Sidebands.** Because of the design of the **Balanced Modulator** it also suppresses the carrier frequency and only passes the two sidebands.



4. The **Crystal Filter** will filter out one or the other of the Sidebands to make the signal **Single Sideband,** but it is still not at the correct transmission frequency. In the example, it is around 9MHz.

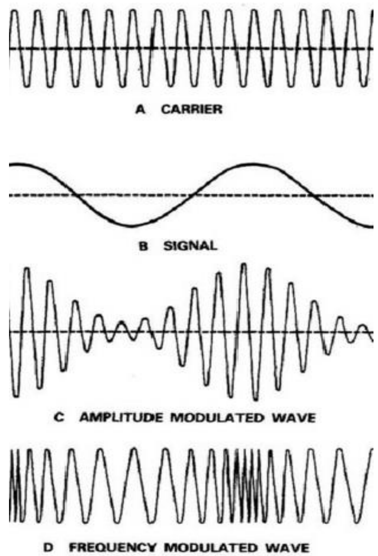
5. In the block diagram, another **Crystal Oscillator** signal is **Mixed** with a sinewave from a **Variable Frequency Oscillator**. The **VFO** is what provides the **tuning capability** of the transmitter.

6. If the second **Crystal Oscillator** operates at 5MHz and the **VFO** from 0 to 350kHz, the sum of all these **input frequencies** would give you a resultant **frequency range** of 5.0 to 5.35 MHz. When this is further mixed with the 9 MHz, you get frequencies from **14.000MHz** to **14.350MHz**. This lines up perfectly with the included frequency range of the **20m Band**.

7. **Mixers** are used to translate a signal from one frequency to another. Usually, the unwanted **products** of the **mixing** processes would be **filtered out**.

8. The **Buffer Amplifier** has a **High Input Impedance** so that it does not cause losses in the preceding **Mixer.** It is used to drive the main **Power Amplifier**. This **P.A.** is a linear, RF amplifier. A linear amplifier does not distort the modulated waveshape.The output of the **P.A.** is connected to an **impedance matched** antenna; typically, **50 Ω**.

9. **Single Sideband is a form of Amplitude Modulation. Amplitude Modulation** occurs when the **Amplitude** of the Carrier is modified based on the **Audio Frequency** signal from the Microphone. **Overmodulation** occurs when the modulating signal (eg. Voice) is too strong. It causes distortion and, as a result, **spurious emissions**. Don't turn your **Mic Gain** up too high!



10. **Frequency Modulation** is when the carrier frequency is changed, or **deviated**, slightly in sympathy with the **information signal** (Audio Frequencies). The **Peak Deviation** of an **FM** signal determines the transmitted signal's **Bandwidth. FM** transmissions use a **constant Power**. **AM** and **SSB** transmission power will peak when the **Audio Frequency** component is the **loudest**.

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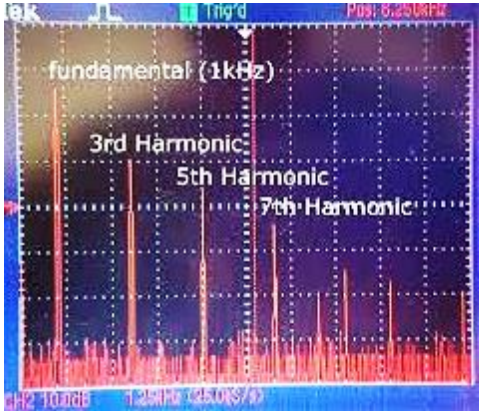
Transmission and Reception Quality

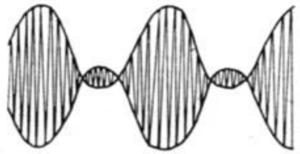
1. **Frequency drift** results from instability in an oscillator. Valve radios used to have such problems and fine readjustments of the transmit frequency were often necessary.

2. There are two types of **spurious emissions**. The first is harmonics. These occurs when a distorted sinewave is transmitted. Even or odd harmonics occur at multiples of the **fundamental** frequency.



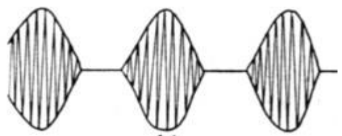
   The other type is referred to as **parasitic oscillations**. These can occur as a result of small values of capacitance and inductance associated with components and tracks on the printed circuit board, or adjacent conductors in connecting cables.

3. One of the reasons for harmonic emissions due to distortion of the sinewave is **over-modulation.** To the right, the diagram shows cases of overmodulation.



(A)

4. **Low Pass** or **Band Pass Filters** can be used at various points in a transmitter to eliminate the problem of spurious emissions.

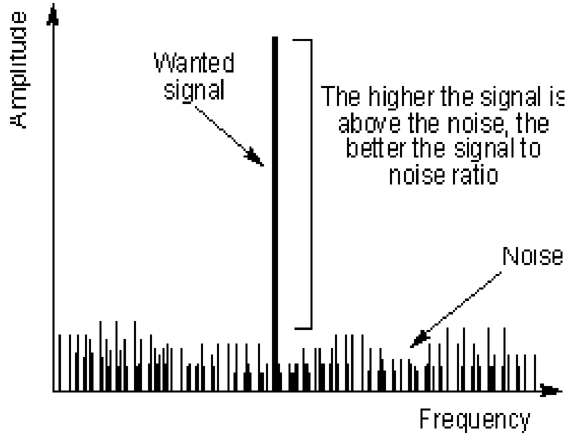


(C)

5. **Receiver Sensitivity** is the capability of a receiver to pick up very weak signals. It has a lot to do with the noise generated within the radio. Usually sensitivity is measured in dBm (Decibel milliwatts) **eg. -92 dBm**. The larger the negative number, the more sensitive the receiver.

6. **Receiver Selectivity** is the capability of a receiver to receive a signal when there are adjacent signals or interference sources on the band.

   Receiver selectivity is about the **effective bandwidth** of the tuner circuits and its ability to reject signals at adjacent frequencies.



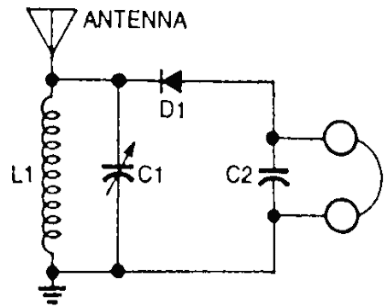
7. **Signal to Noise Ratio** is another receiver specification. **SNR** is the average signal power divided by the average noise power.

8. An **AM and SSB Superheterodyne Receiver** is made up of several circuits.

9. An **FM Superheterodyne Receiver** is very similar but some of the incorporated circuits are named differently, for example, its Demodulator is usually referred to as a Detector.

10. **Superheterodyne** refers to a receiver that converts the received RF signal to an **Intermediate Frequency (IF)** and then that, to the **Audio Frequency** that will be amplified and sent to the speaker. Converting the frequencies in **two stages** helps the receiver to maintain a good sensitivity and selectivity across the range of frequencies for which it was designed. The reception properties of a receiver that converts RF directly to AF are very poor.

Simple AM receiver (Crystal Set)



- L1 and C1 form a tuned circuit. It is resonant at a frequency within the AM broadcast band.
- D1 (Germanium) is the demodulator.

- C2 acts as a low pass filter that smooths out the rectified RF, revealing the AF component.

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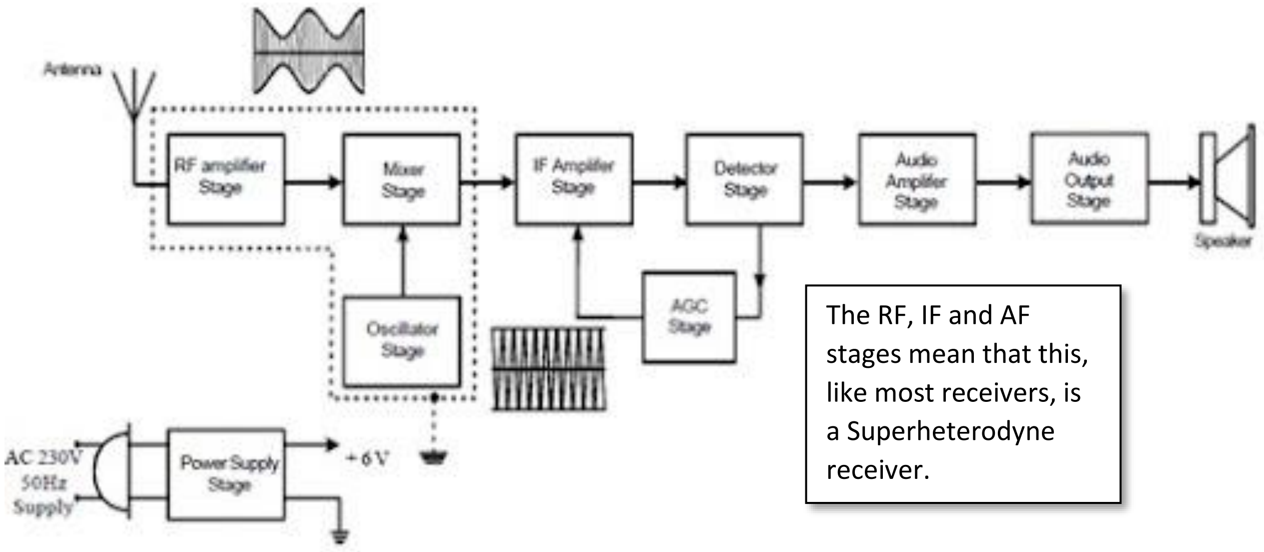
Receiver Block Diagram and Features



The RF, IF and AF stages mean that this, like most receivers, is a Superheterodyne receiver.

1. The **Power Supply** provides a regulated DC voltage; typically between 6 Volts and 13.8 Volts with no low frequency Ripple that would cause **Audio Frequency (AF)** interference.

2. The **Antenna** is simply a length of wire that is erected to gather **Radio Frequency (RF)** signals. Usually, its length is tuned to be resonant, and have an impedance of 50Ω at a specific frequency within the desired **Band**.

3. The **Radio Frequency Amplifier** amplifies the very low-level RF signal seen at the Antenna terminal.

4. The **Variable Frequency Oscillator (VFO)** is adjusted to operate at a frequency that, when added to the RF in the **Mixer**, produces a fixed frequency IF signal which is amplified by the **IF Amplifier.**

   Note: The subtractive product of the mixer: **Radio Freq - Osc. Freq**, is filtered out because the IF amplifier has the advantage of having a very narrow band.

5. The **Detector** extracts the AF from the IF signal. This is then amplified in an **Audio Preamplifier** and then, again, in an **Audio Power Amplifier** in order to drive the **Speaker**.

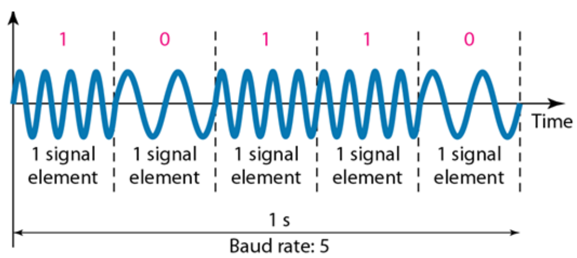
6. **AGC** stands for **Automatic Gain Control**. The AGC circuit includes Peak detector. It detects the strength (amplitude) of the AF signal and delivers the voltage to the IF stage. This, in turn, adjusts the gain of the IF stage **Voltage Controlled Amplifier (VCO)**. The purpose of the AGC is to ensure that despite large differences in the strength of a received signal, the Volume level at the speaker will be consistent.

7. Most **Transceivers** are economically designed; to share parts of their circuits between the Transmitter function and the Receiver function. This would include Oscillators, IF Amplifiers and Filters.

8. A **"Frequency Converter"**, indicated in the receiver diagram by the dotted line, combines a mixer and oscillator to <u>convert one frequency to another</u>. This feature is found in many different receiver and transmitter designs.

9. If there are small differences between your chosen transmit frequency and the carrier frequency on which another Amateur is transmitting, you can use a receiver feature called **Receiver Incremental Tune (RIT).** Your radio will adjust the frequency of the receiver tuning but will revert to the nominal frequency when transmitting. This is useful when having a **QSO** with an Amateur whose transmitter is suffering **frequency drift**. If you don't have an RIT control, the demodulation of their signal will leave their voice sounding too high or a too low.

10. The **Bandwidth** of signals, especially for Data Transmissions, will depend on the **data transfer rate** (sometimes referred to as **Baud Rate**) and the **type of modulation** employed.



Eg. FSK transmission at 5 bits per second

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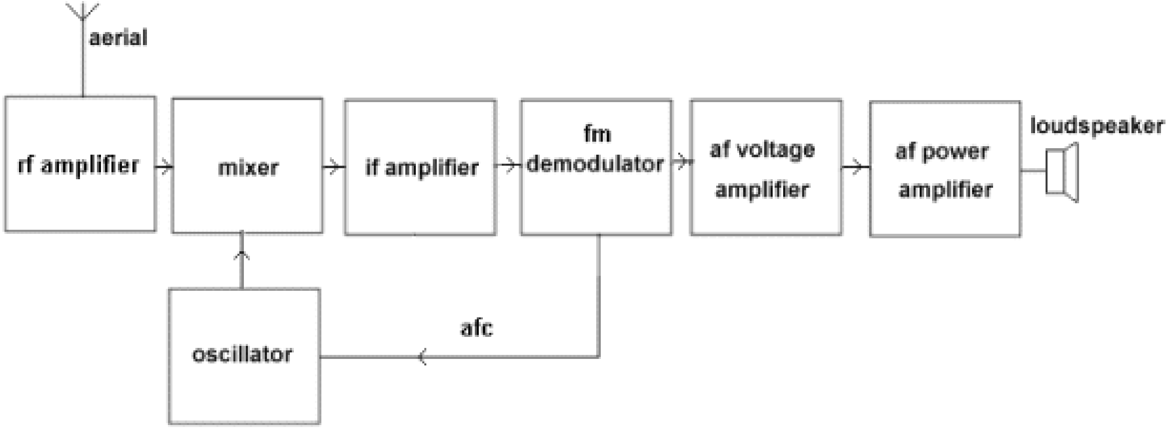

11. **Above is a Block Diagram of an FM Receiver.** Some of the blocks are similar to the SSB Block Diagram but they are sometimes named specifically for FM. An FM demodulator, for instance, is often called a Discriminator whereas with AM modes, the term Detector is most common.

12. The **AFC** is the Automatic Frequency Control. It is a feedback loop that stablises the Oscillator, reducing drift and ensuring successful demodulation.

13. The Oscillator, together with the Mixer, form a **Frequency Converter**. Remember that a mixer outputs both the sum and the difference between the two frequencies. In this instance, the desired output is the IF frequency. The other products of the mixer need to be filtered out. This is why the IF Amplifier can always be a high gain, <u>very narrow band</u> amplifier. We only want it to amplify the small region around the fixed IF frequency. Crystals are often used in the IF Oscillator. Crystal filters can be added to further improve the IF stage performance.

14. The **Automatic Gain Control** (AGC) in a radio is there to ensure that weak signals and strong signals both can be heard in the speaker, at a similar level.

15. Looking back at the Transmitter and Receiver Block Diagrams, you will notice several blocks that have similar functions. To make a transceiver build less costly, those <u>blocks are shared</u>! The design will usually utilise some blocks for receiving as well as transmitting. The connections are just switched.

16. Below are sections of the front panel of an IC-751 Transceiver. Locate and discuss the functions of the following Controls:

AGC Fast/Slow	**NB Level**	**Squelch**	**Mic Gain**	
RIT	**AF Gain**	**RF Gain**	**Filter**	**Notch**

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Interference and Electromagnetic Compatibility

8.1: Understand that amateur transmissions may enter television and radio receivers through the radio frequency or intermediate frequency stages.

Recall that amateur transmissions can enter audio stages via long speaker leads or other interconnections. Understand that television receivers and most broadcast radio receivers employ superheterodyne circuits.

Amateur Radio Transmissions vs Other Radiocommunications Services

FREQUENCY	FUNCTION	FREQUENCY	FUNCTION
0.3 to 3MHz	LF Amateur Bands	50 to 225MHz	VHF Television (Obsolete)
3 to 30MHz	HF Amateur Bands	470 to 854MHz	UHF Television (Now Digital)
30 to 300MHz	VHF Amateur Bands	33 to 40MHz	Intermediate Frequency
0.3 to 3GHz	UHF Amateur Bands	0 to 5MHz	Video Baseband
3 to 30GHz	SHF Amateur Bands	0.5 to 1.6MHz	AM Broadcast Radio Band
30 to 300GHz	EHF Amateur Bands	88 to 108MHz	FM Broadcast Radio Band
455kHz	IF for HF Bands	455kHz	IF for AM Receivers
10.7MHz	IF for VHF and UHF Bands	10.7MHz	IF for FM Receivers

8.2: Understand that mast-head amplifiers and distribution amplifiers used for television reception are generally wide band devices and are easily overloaded by strong signals.

VHF & UHF TV Masthead Amplifier

These broadband amplifiers can be swamped with RF from Amateur Transmissions that will overpower the TV reception signal. This is often due to proximity to, or alignment of the antenna.

Resolutions

- Transmit using lower power
- Relocate/realign the Amateur Radio antenna

8.3: Understand the non-linearity of an overloaded audio amplifier can demodulate RF signals.

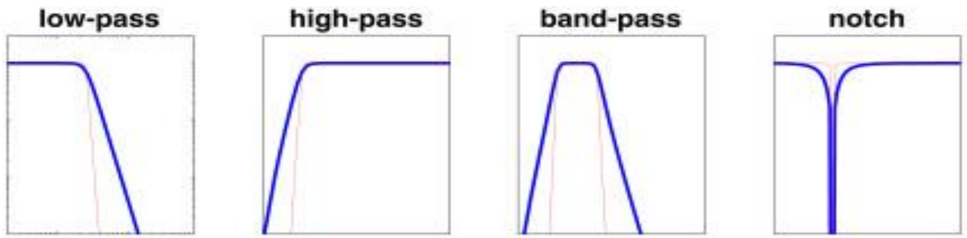
RF Carrier or Harmonics, picked up through the power supply or electronic circuits can be demodulated, amplified, and sent to the speakers.

Wires in your home entertainment system and other audio systems in the home can act as antennas and feed RF from your shack into the amplifier circuits forcing demodulation to occur.

Resolutions

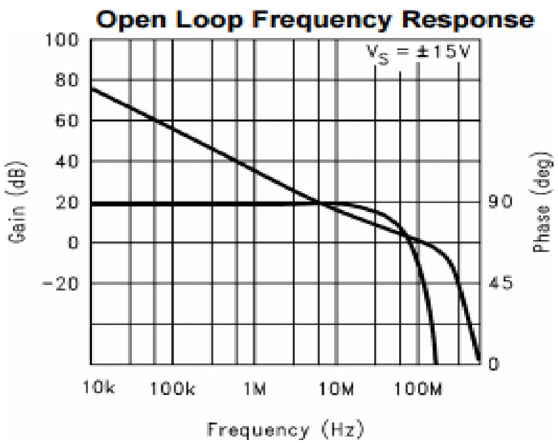
- Install an RF choke on the stereo system's power supply cable
- Ensure your RF Earth and the House wiring earthing system are isolated

8.4: Identify the response curves of low pass, high pass, band pass and band stop (notch) filters.



Response Curves

- The horizontal axis is frequency and has a logarithmic scale
- The vertical axis is gain (or loss) in decibels (dB). The Decibel is a logarithmic unit.



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8.5: Understand the use if high pass, low pass, bandpass and bandstop (notch) filters in providing interference immunity to affected electronic devices.

Scenario A:

Your neighbour’s TV picture is jumbled whenever you transmit. He does not have a masthead amplifier and your transmission antenna is not close to his TV antenna.

Solution A:

Install an RF Choke (Low pass filter) by wrapping the TV’s power lead through it a few times.

Scenario B:

The Club Shack cannot participate in a Radio Contest because if the 80m or 40m antennas are used for transmission, the other cannot receive due to harmonic interference.

Solution B:

Install a narrow bandpass filter in your antenna feedlines close to each to the transmitters.

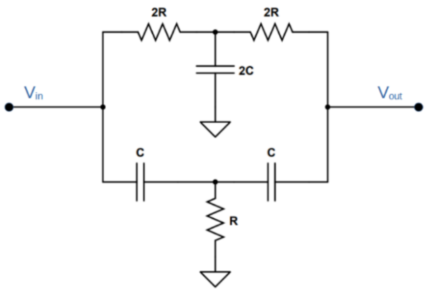
8.6: Recall typical uses for low pass, high pass, band pass and band stop filters. Understand the use of ferrite beads or toroids in filtering.

Scenario A:

The Off-Peak Hot Water, automatic switch signal overlaid on the 50Hz mains is causing a 1050Hz tone to be head whenever the switch is being activated.

Solution A:

Install a 1kHz Notch Filter on the power lead of the affected equipment.
R = 1kΩ
C = 80nF



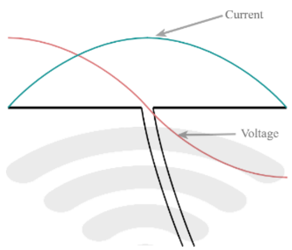
8.7: Recall that reducing field strength to the minimum required for effective communication is good radio practice.

WHY?

- Less chance of causing interference to other services
- Less chance of distortion due to being driven too hard
- Improves frequency availability for other users some distance away
- Increases the over all capacity of the band
- Lower energy consumption
- Lower near field radiation
- Increase battery life (if applicable)

8.8: Recall that balanced antenna systems tend to cause fewer electro magnetic compatibility (EMC) problems than unbalanced antennas.

Recall that the transmission line (balanced or unbalanced) should leave the antenna at right-angles to minimise EMC problems.



Balanced antennas such as dipoles present a signal as a differential voltage on the two elements. Much of the noise that they receive is voltage that we might call “common mode”. The voltage on each element is the same; not out of phase. Because the RF amplifier in your receiver is effectively a differential amplifier, that common mode noise id rejected (cancelled out).

Transmitted signals that carry interference can have less impact on other services for the same reason. The noise from each element will, to some degree, undergo phase cancelling.

Capacitance is one of the things that will impact antenna performance, whether that capacitance is to ground or to your transmission line. Your antenna elements should not irradiate your transmission line by running them side by side. Vertical dipoles always use a stand-off to maintain some distance.

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8.9: Understand that EMC problems in motor vehicles can interfere with the operation of computerised engine management and other electronic systems. Recall suitable precautions to minimise EMC problems in vehicles.

EMC stands for **E**lectro**M**agnetic **C**ompatability.

https://www.youtube.com/watch?v=AHbrVad86xw&t=1s

https://www.youtube.com/watch?v=7nTRIxloDcI&t=1s

https://www.youtube.com/watch?v=CND9dLR3Bb4

- Capacitive filters to ground
- Electromagnetic Shielding
- Inductive filters in series

8.10: Recall that EMC problems have the potential for causing neighbourhood disputes. Understand the need for diplomacy, the sources of advice available and the role of the ACMA.

I'm not saying to be an Angel. I'm just trying to remind everyone to work with your neighbours. They are not your enemy.

Just use common sense, and common decency.

Ultimately, if issues are unresolved, the ACMA have the right to stop you from transmitting or to suspend your licence.

Help your neighbour and your community to find technical solutions to things like interference to TV reception or RF in Audio Systems.

Interference in Speaker Cables: https://www.youtube.com/watch?v=gL4O_Do2PuQ

Remember that the degree of Electromagnetic Interference from a Transceiver will increase if the signal is over-modulated. Also, in general terms the interference caused by a transmission will depend on Transmit Power, Proximity to the affected equipment and transmission Frequency.

Transmission Lines and Antennas

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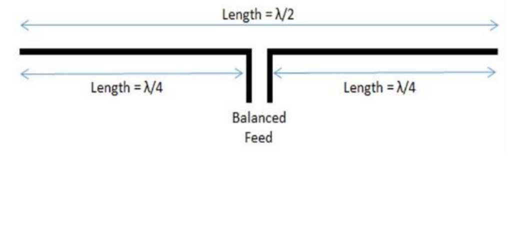
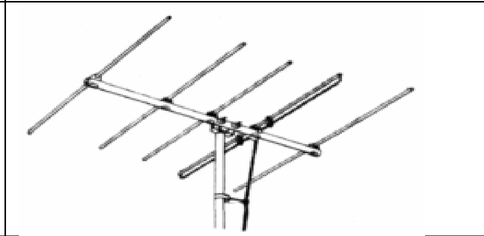
Balanced Antennas

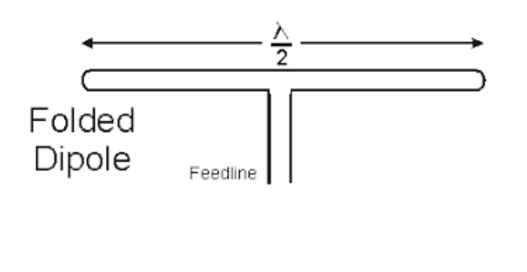
Dipole: 73 Ω - ½ Wavelength x 0.95
Gain = 2.15 dB



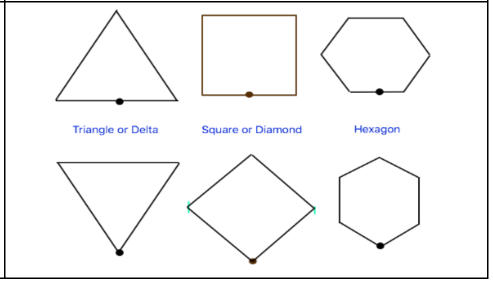
Yagi 20 Ω - Wider than ½ Wavelength
High Gain, High Directionality



Folded Dipole: 300 Ω - ½ Wavelength
Gain = 2.1 dB

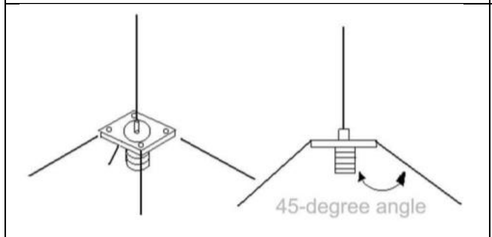


Loop Antenna: Triangle: 2.79dB 121 Ω
Square: Gain = 3.3dB Z = 129 Ω

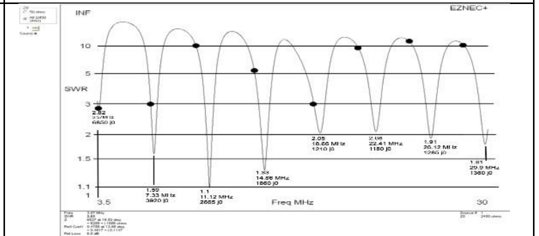


Unbalanced Antennas

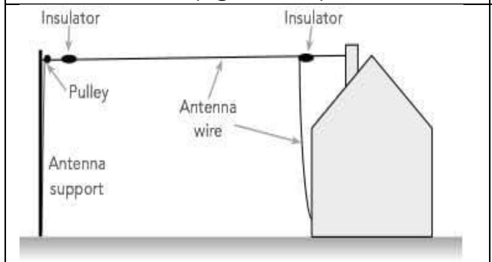
¼ Wave Vertical: Z = 50 Ω Gain = 3 dB



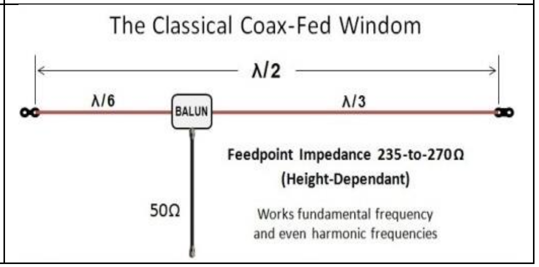
½ Wave End-Fed: 2500 Ω



Random Long Wire: Z = 450 Ω
Non-resonant (eg. 22.5m)

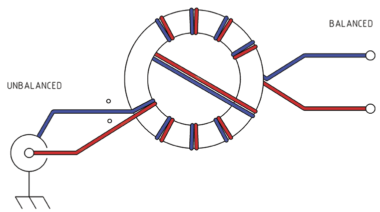


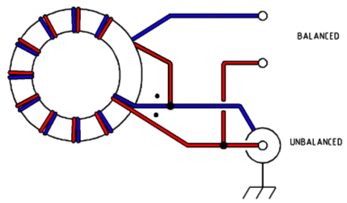
Off-Centre-Fed Dipole: 200 to 300 Ω
Gain = 5 to 7 dB

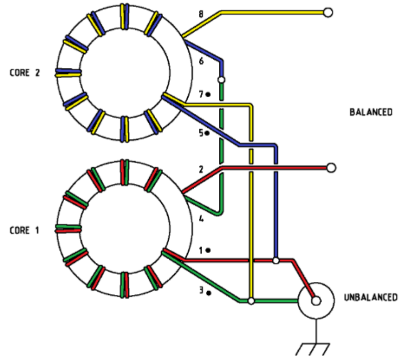


https://www.iz2uuf.net/wp/index.php/2016/04/26/great-spaces-longwire-or-dipole/

Baluns







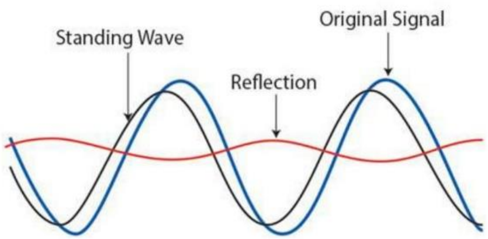
Standing Waves

VSWR (Voltage Standing Wave Ratio)

- For an improperly terminated(mismatch) transmission line consisting of two waves

1. A forward travelling wave
2. A reflected wave

- These two waves superimpose each other and resultant wave is known standing wave.



https://www.everythingrf.com/community/what-is-vswr

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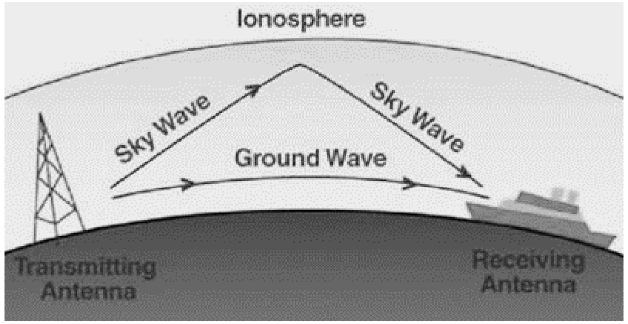
Propagation

Radio waves can propagate from transmitter to receiver in four ways

Ground Waves, **Sky Waves**, **Free Space Waves** and **Open Field Waves**.

Ground waves exist only for vertical polarization, produced by vertical antennas when the transmitting and receiving antennas are close to the surface of the earth. The transmitted radiation induces currents in the earth, and the waves travel over the earth's surface, being attenuated according to the energy absorbed by the conducting earth. The reason that horizontal antennas are not effective for Ground Wave propagation is that the horizontal electric field that they create is short-circuited by the earth.

Ground Wave propagation is dominant only at relatively low frequencies, up to a few MHz. Skywave propagation is dependent on reflection from the ionosphere, a region of rarified air high above the earth's surface that is ionized by sunlight (primarily ultraviolet radiation).



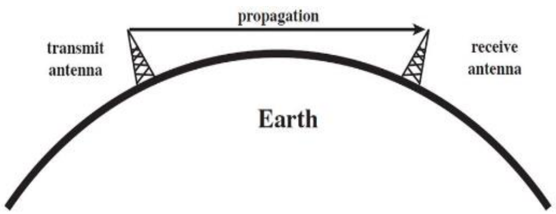
The **ionosphere** is responsible for long-distance communication in the high-frequency bands between 3 and 30 MHz. It is very dependent on the time of day, season, longitude on the earth, and the multiyear cyclic production of sunspots on the sun. It makes possible long-range communication using very low power transmitters.

Free space propagation

Here the radio waves travel in free space, or away from other objects which influence the way in which they travel. It is only the distance from the source which affects the way in which the signal strength reduces. This type of radio propagation is encountered with radio communications systems including satellites where the signals travel up to the satellite from the ground and back down again. There is little influence from elements such as the atmosphere.

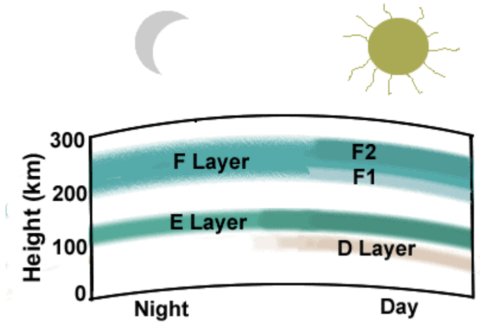
Ground Wave propagation

When signals travel via ground wave, they are modified by the ground or terrain over which they travel. They also tend to follow the Earth's curvature. Signals heard on the medium wave band during the day use this form of RF propagation.



Line-of-sight (LOS) propagation (above 30 MHz)

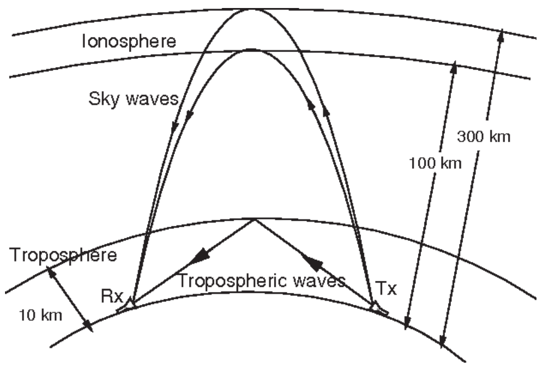
Ionospheric propagation



Here the radio signals are modified and influenced by a region high in the earth's atmosphere known as the ionosphere. This form of radio propagation is used by radio communications systems that transmit on the HF or shortwave bands. Using this form of propagation, stations may be heard from the other side of the globe dependent upon many factors including the radio frequencies used, the time of day, and a variety of other factors.

Tropospheric propagation

Here the signals are influenced by the variations of refractive index in the troposphere just above the earth's surface. Tropospheric radio propagation is often the means by which signals at VHF and above are heard over extended distances.



In addition to these main categories, radio signals may also be affected in slightly different ways. Sometimes these may be considered as sub-categories, or they may be quite interesting on their own.

Amateur Radio: Standard Exam Preparation Cheat Sheet No. 17

(The author of this document does not actually endorse cheating!)

Amateur Radio: Standard Exam Preparation Cheat Sheet No. 18

(The author of this document does not actually endorse cheating!)

GLOSSARY OF TERMS AND ABBREVIATIONS

AM	Amplitude Modulation
Band	A frequency range allocated to Amateurs
CB	Citizen Band
FM	Frequency Modulation
FSK	Frequency Shift Keying
Noise	Electromagnetic interference
Packet Radio	A form of digital transmission
PSK	Phase Shift Keying
RTTY	Radio Teletype
SNR	Signal to Noise Ratio
Spurious	Unwanted, In addition to the desired…
SSB	Single Sideband
TLA	Three Letter Acronym
________	______________________________ Add your Own …