Amplifier "Do It Yourself" Testing and Repairs

First, let's talk about some basics of solid state amplifiers.

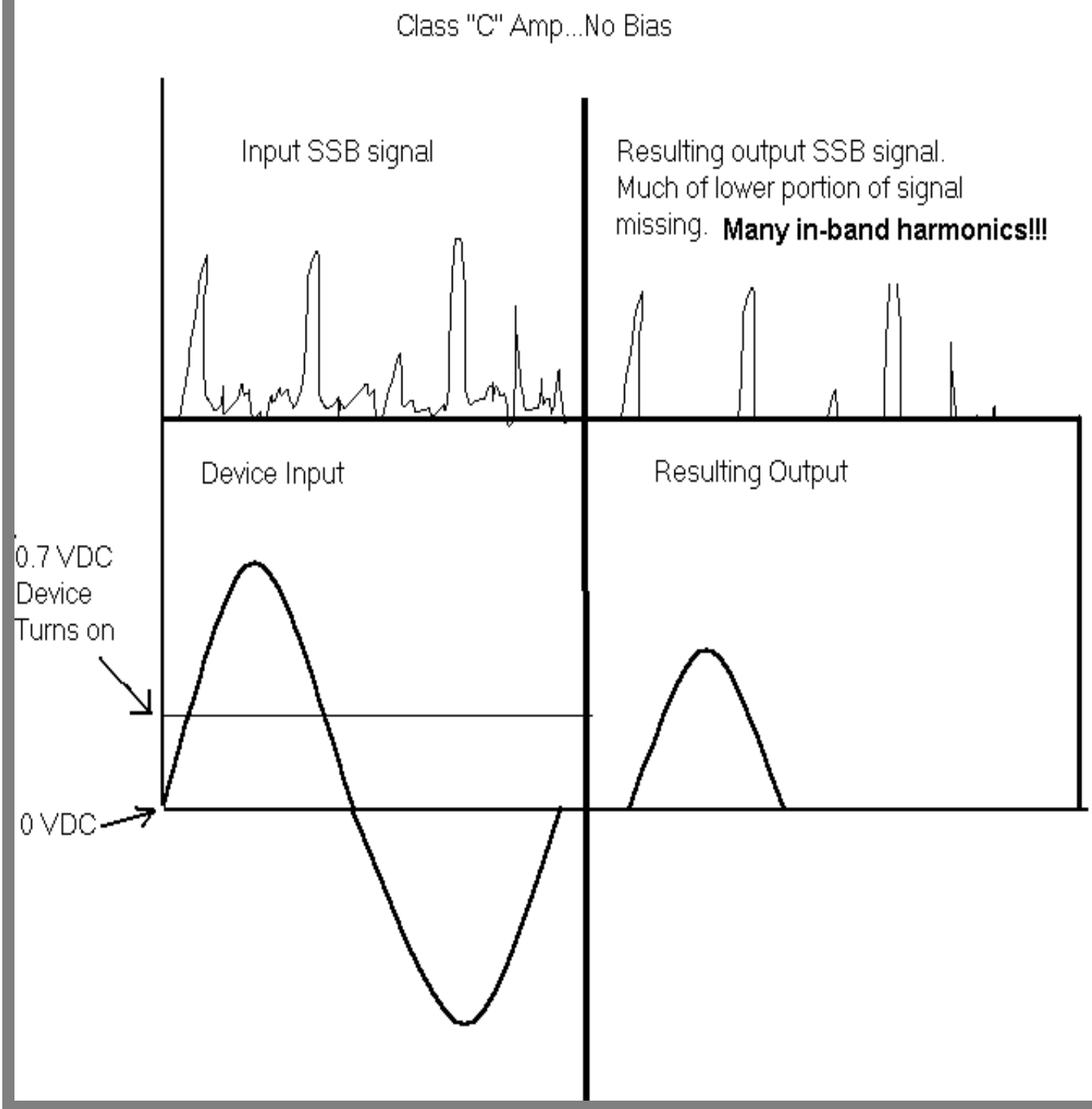
BIAS:

Bias is used to "turn on" the transistor or transistors in an amplifier. A transistor, like a diode, doesn't do anything until it's input voltage rises above 0.7 VDC. Bias simply raises the voltage on the input of a transistor to the point just above it's "turn on" point. That way, it will be able to amplify even the weakest signals with minimal distortion. With no bias, the amplifier would be running in the class "C" mode where it is either on at or near full power, or off completely. This mode is very efficient, but NOT linear by any definition. Class "C" is mainly used for FM. Class "AB" is used for many amplifiers and is good for SSB and other modes where fair linearity is desired. Class "AB" is used in most of the commercially available amateur VHF/UHF and HF amplifiers. The only "true" linear amplifier is a class "A" amplifier. This is where the bias is increased to where the transistor is completely on at full current 100% of the time. This allows exact waveform reproduction but at the expense of very poor efficiency. A class "A" amp will only be aprox. 25% efficient and require massive heat dissipation and power supplies. Class "A" is generally only used in amplifiers where multiple signals are present at one time or in broadcast television. I only know of one amateur tranciever that uses class "A" and it cuts the output in half when switched to the class "A" mode.

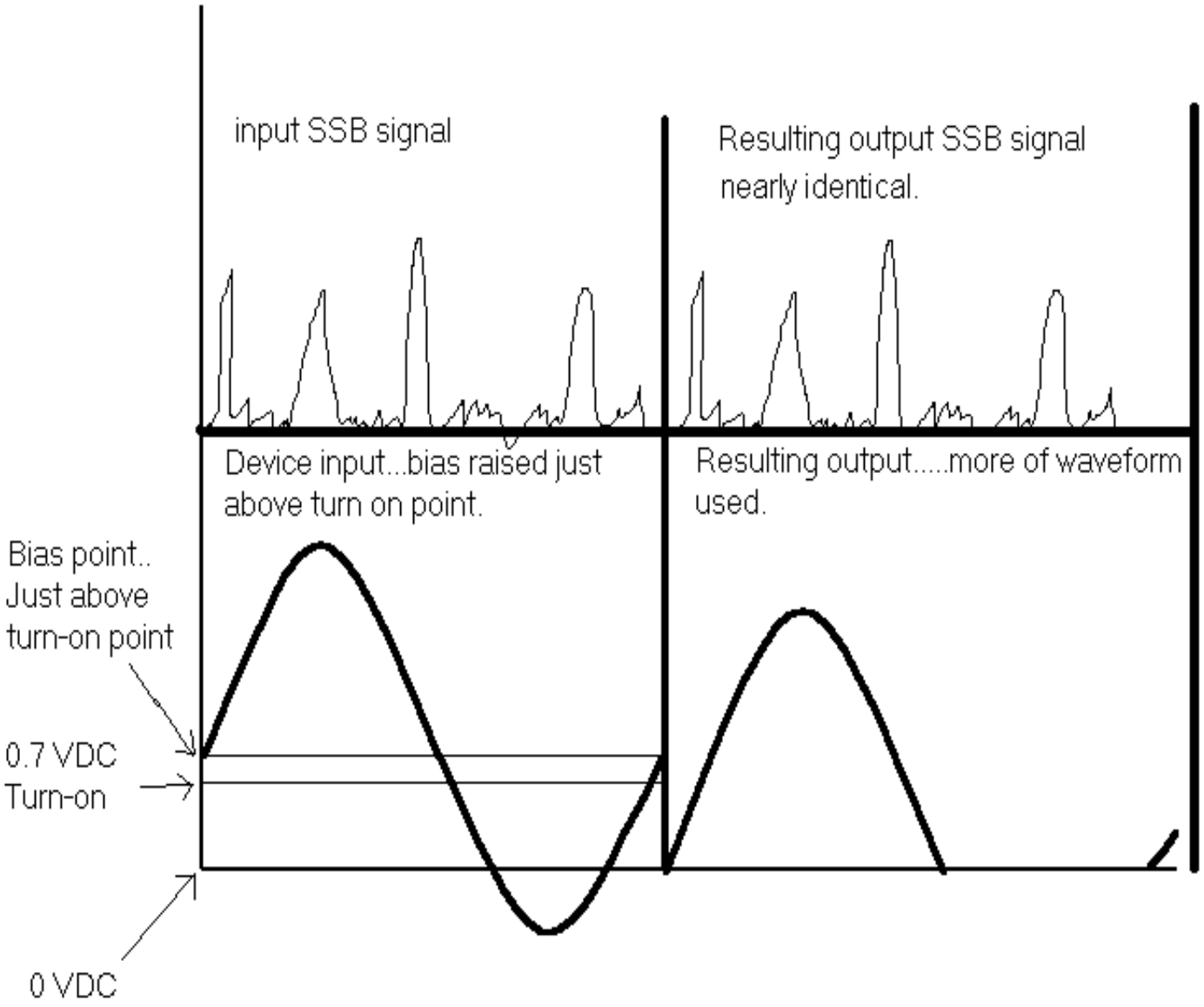
TESTING BIAS:

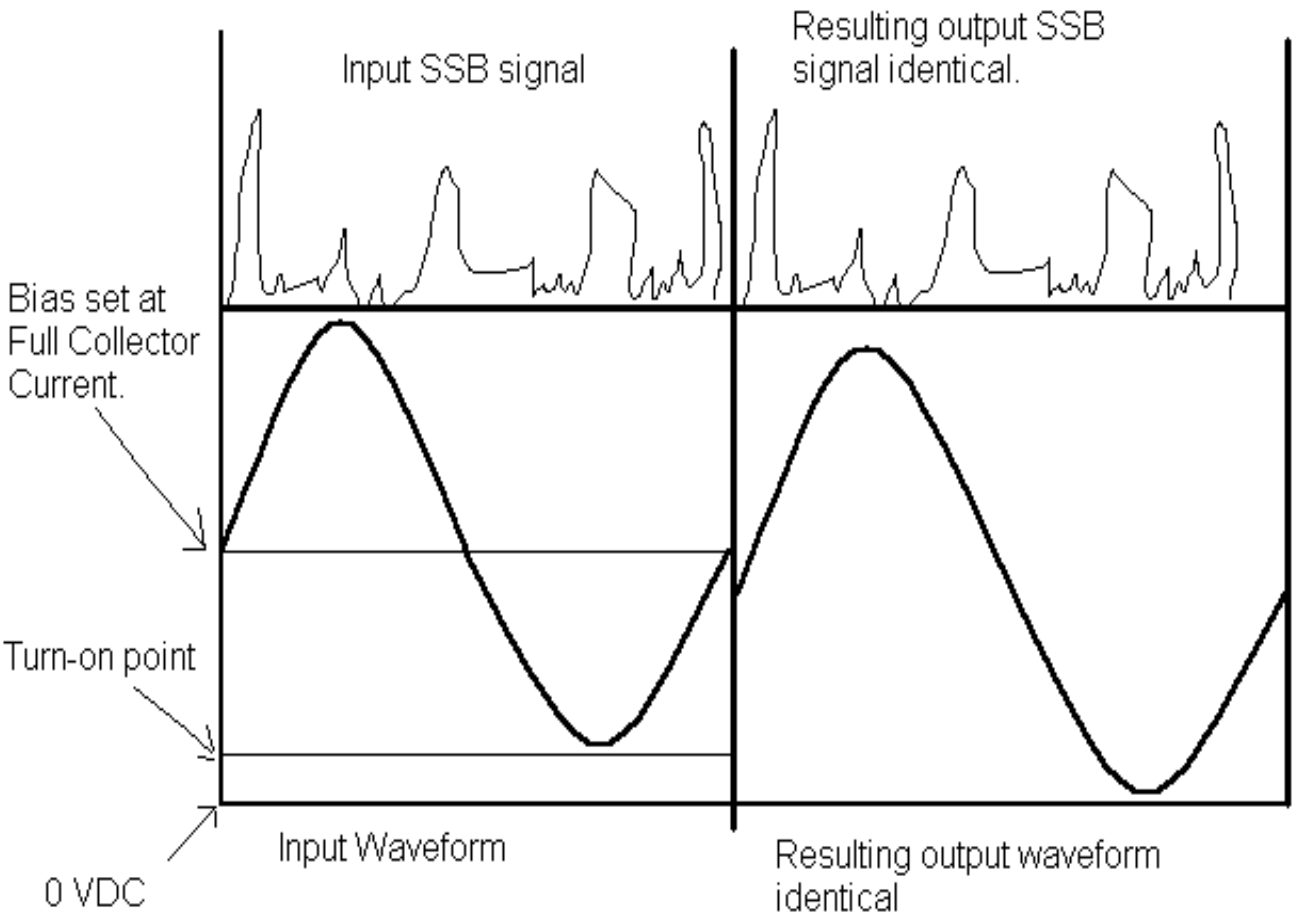
A simple on-air test of bias is to key the suspect amp, and with the tranciever in SSB, transmit with the microphone away from your mouth ane have someone listen to see if they can hear the background noise in your shack. If they can hear background noise with the amp off and not hear it with the amp on, there is probably some sort of bias problem in the amp. The background noise should be the same with or without an amp in line.

To test bias current in a class "AB" amp, you must put a current meter between the +VDC and the collector of the device under test. Then key the amp manually with NO RF!! and read the current. Generally, the bias current should be less than 2% of the total current draw of the amp at full power, but less than 1% is OK and won't make much difference. In other words, if you have a 150W amp that draws 25A at 12VDC, your bias should be around the 100-200ma range.


Class "C" Amp...No Bias
Input SSB signal
Resulting output SSB signal.
Much of lower portion of signal
missing. Many in-band harmonics!!!
Device Input
Resulting Output
0.7 VDC
Device
Turns on
0 VDC

Class "AB' Amplifier





Testing Transistors:

This part is easy.....the hard part is usually removing the device from the circuit!

First....the operational test. Apply power to the amp in question for a few seconds, then un-key it and immediately feel each transistor with your finger for temperature. Don't do this while transmitting as the heat you feel may be RF burning your finger, not the temperature of the device. The devices themselves will cool down within a couple of seconds as they dissipate heat to the heatsink. If one device is obviously cold, proceed on to the following tests. If the amp has equalizing resistors between the different transistors (usually about a 10 ohm high power resistor across the two output strips and usually across the inputs also) these will get very hot due to the unbalance between the two devices. This is a sign of one bad device or a mismatched pair of transistors.

Another thing to look for is the resistors on the feedback circuits (usually a resistor, coil and cap in series from the base to collector) being burned. This is a sign that the amp is oscillating. Many amps and especially TE's will go into a high current oscillation if one of the devices is bad. I have seen them draw as much as 40A with the switches off and even the radio off!

Second.....Passive DC test. Completely isolate any DC connections from the device to be tested.....this means removing the DC supply and bias supply lines from the device...also any resistors to ground and equalizing resistors that may be connected to the other transistors in the amp. Then, using a diode tester, with the positive lead on the base of the device, you should show a diode (.5 - .7 volt drop) from the base to collector and a diode from the base to ground (emitter). There should be no connection in the opposite direction from either the collector or emitter. NOTE: On very rare occasions, I have seen a diode from emitter to Collector on a working device??!!! I really couldn't explain it!

Third.....Operational DC test. If it passes the tests above, try this. Follow the instructions above for setting BIAS and see if the device actually

works from a DC standpoint. If it does, chances are there is a bad PASSIVE device in the circuit. Believe me....it happens!

Another problem that has shown up in older amps, usually over 10 years old, is weak or partially damaged transistors. The symptoms are usually nothing more than low output power. After seeing a few of these come across my bench, I finally was overcome by my curiosity and opened a suspect transistor up and examined it under a microscope. What I saw was about half of the internal "wires" in the device were burned in two or non existant. This basically creates a working device at half the capacity. It can fool you in to believing that it is something in the tuning has gone bad as sometimes tuning the circuit will bring back a small amount of the lost power. Don't bother, just replace the devices. It is much quicker and easier. Nothing can be more time consuming than trying to find a bad or intermittent passive device when it is not the problem.

CLEANING RELAYS

Sounds simple....right? Not so fast.....Relays are very touchy. You should only clean relays with special relay contact cleaning devices....they are available at most electronic shops. Most sandpapers remove precious metals from the contacts, reducing their life. If you must, try a thin piece of construction paper dipped in alcohol. This works well.

Replacing and tuning transistors

If you have determined that one or more transistors in your amp are bad, it is always best to replace both of them with a matched pair. Many times a mismatched set will work OK if the date codes are close, but you may have problems if one device has more gain than the other. The stronger of the two will saturate sooner and will be subject to being overdriven. When tuning, start with the input at a ***low power*** *level and tune for best*

SWR looking into the amplifier with it in TX. When a good SWR has been achieved, tune the output for max power. When it is close, increase drive until you reach compression (the point where output doesn't increase as much when increasing the input) and tune again for MAX output. Re-tune the input one more time for best SWR, NOT maximum output, and you are in business!

Some Solid State Amp Characteristics

RATED POWER

Here is a good subject. Most manufacturers rate their amplifiers outputs at full saturation under ideal conditions. As an example, a TE 350W 2M amp's transistors are rated at only 300W by Motorola. I'm sure many people have claimed higher outputs by increasing voltage and this is actually the only valid way to increase it! It is very safe to run 14.8 VDC to these amps, but I have still to find a TE that will surpass 350W on my bench! Even so, at that point, the transistors are so heavily saturated that they would sound terrible on SSB! Some good advice.....keep it around 300W and keep the band clean! True, some devices are much better on power and compression curves. Take for example the Teletec UHF amps. The transistors in these amps were excellent! Why Motorola quit making them, I'll never understand! They were only rated at 65W each but didn't begin to compress until 80-100W!! Many blamed this performance on Teletec's bias, but the bias was a small contribtion to the performance.

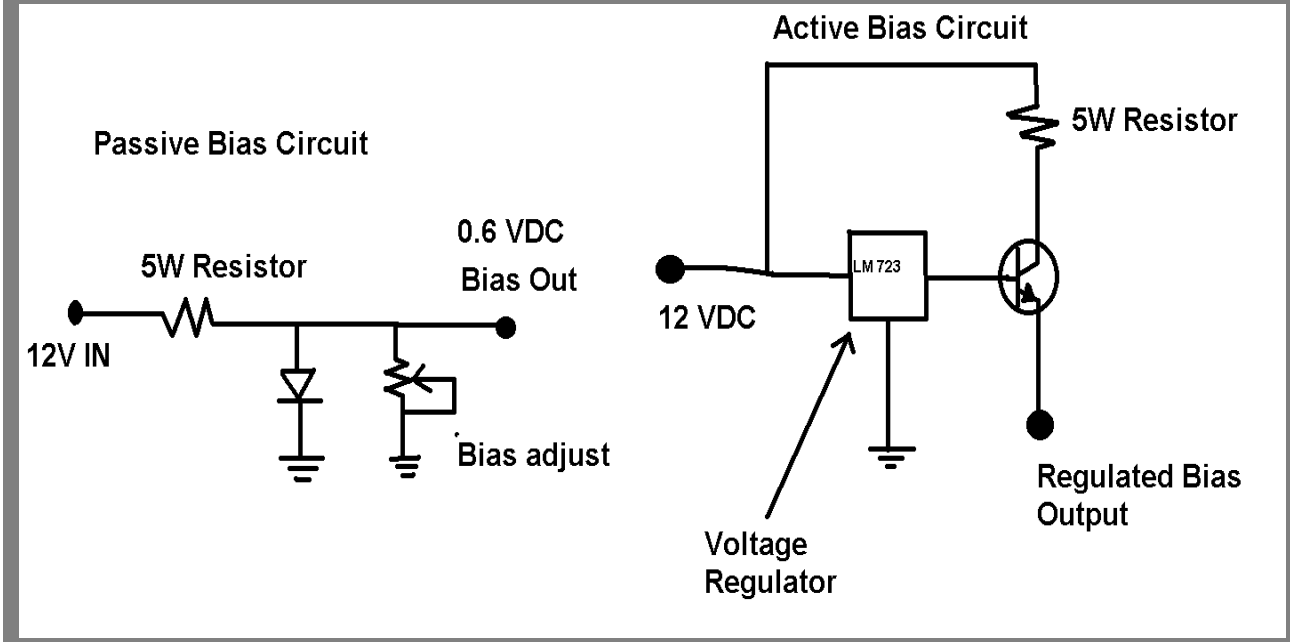
Using A Solid State Amp To Drive A Tube

This one is easy.....Solid state amps are not as clean as a tube when operated at full rated power. Therefore, if you need 100W to drive a big tube amp, use a 160W amp and cut back your drive! Because transistors are more linear at about 50-60% of their rated output, this will keep the tube amp's output clean. Using something like an 80W amp in this situation at maximum output to drive a tube will cause the tube amp to amplify and increase the distortions generated in the solid state amp. Did you know that the PA's in most solid state radios are only rated at about 60-70% of their actual output abilities? This is to keep them clean! Example.....An Icom 275H is rated at 100W output. The PA in this radio is capable of 160-180W and the service manual instructs you to tune the amp in this radio at those power levels! The same goes for HF radios. A Kenwood TS-430 is capable of over 160W, yet it is rated and set to operate at 100W. Again, this is all to keep them clean!

"Active Bias" vs the "Rest of the World"

Here's what I have heard a lot about lately. The difference between an active bias and a passive bias is pretty simple. In order to create bias current in a transistor, you have to raise the voltage on the base of the transistor above the 0.6VDC level. The most widely used is the passive method which simply uses a current limiting resistor with a diode to ground using the voltage drop across the diode to keep the voltage at around 0.6 VDC. Diodes are good also as this voltage drop changes with temperature, and so does the transistor being biased. This is why many bias circuits have this diode thermally connected to the device being biased. This is called "Thermal Tracking". The problem with this type of bias is that it is used simply to activate the device during low power levels only. This results in the device operating almost in the class "C" mode when at full power.In ***most*** *cases, this is not a problem as the harmonics generated are usually second harmonics and higher and can be easily*

*filtered out. It also does reduce the gain slightly at higher power levels resulting in a **MINOR** loss of linearity. Again, this is acceptable in most cases. ALL HF, VHF and UHF radios I have ever been inside of use this type of bias. They just drastically underrate their power levels to keep them clean. The Active Bias systems I have seen used are simply a voltage regulator circuit driving a transistor to feed the bias voltage to the device being biased. This type of bias forces the amp to take bias current even at full power. This improves linearity slightly but creates more heat and draws more current. All Teletec amps use this type of bias, but that is only part of the reason they are so much better than the other guys. Teletec had far superior circuit board design and used the best transistors they could get from Motorola. The bottom line is, if you are a purist, and like to see an extra 20-30W out of your 300W amp and have enough power supply to handle the extra 3-5 amps....go for it.*



I am in the process of building this page so check back.....there will be MUCH more!!!