1W VHF AMPLIFIER ASSEMBLY

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1.0 Amplifier Chassis Assembly 40D2180G1 & 2 Figure 94-1.

The Amplifier Chassis consists of a standard 19" rack mounted 3.5", 2RU enclosure containing a line filter, a power supply, an amplifier module assembly, a directional coupler, metering board, bandpass filter and a metering panel. Its basic part number is 40D2180. There are two groups in this assembly. Group 1 covers channels 7-13, while group 2 covers channels 2-6. The only difference between the two assemblies is the output bandpass filter.

117VAC to the amplifier chassis comes in via a fused line filter, 2LF1. Pressing the ON/OFF switch to the ON position (UP) applies AC to the primary of the power supply transformer, thus, applying DC power to the amplifier stage and metering circuitry.

Metering is achieved using a directional coupler which samples the RF signal. It is fed to a peak detection metering board which then displays the corresponding power level in percent on the front panel analog meter.

The chassis is wired according to the wiring diagram, 20B2449, shown on Figure 94-2.

Chassis parts lists are provided on the last pages of this manual. The circled numbers seen on the assembly drawing correspond to the "symbol" item numbers on the parts list.

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2.0 Power Amplifier Module 10A1453G8 : Figures 94-3

The Pre-amplifier module is a conservatively designed broadband amplifier which can operate on frequencies between 54MHz to 216MHz with a excellent gain of about 18dB. It also has a very good return loss and DC current stability with temperature.
The RF output of the Channel Processor or Exciter which is about +12dBm is fed to this amplifier which then raises the level to 1Watt sync peak. This module requires no tuning nor bias adjustments. The amplifier DC supply voltage is 24V, and it draws about 400mA (class A).

The amplifier module is broadband thus covering the entire VHF television spectrum ranging from 54MHz to 216MHz (channels 2-13).

3.0 VHF Directional Coupler Assembly 10A1250G4: Figure 94-4

The main function of the directional coupler is to supply RF sample to the metering board such that the forward power can be monitored for the purpose of metering. The RF sample level is about 14 dB below 1W which amounts to about 40mW. This signal is fed to the metering board forward input, 5J1.

4.0 Bandpass Filters

4.1. GENERIC Helical Resonator Bandpass Filter:

Many selective filter designs for VHF applications are based on helical resonator tuned circuits to achieve the required selectivity. As an introduction to the subject of filters, we will examine helical resonators first.

The helical resonator was developed during the late 1950's and first described in "Proceedings of the IRE" magazine by W. W. McAlpine and R. O. Schildknecht, *"Coaxial Resonators with Helical Inner Conductor," Proceedings of the IRE, vol. 47, no. 12, pp. 2099-2105; December, 1959.* The same authors later published another magazine article *"Helical Resonator Design Chart," Electronics, p. 140; 12 August 1960.*

IRE stood for the "Institute of Radio Engineers" which was responsible for some of the television transmission standards that remain in use today. IRE later merged with the "American Institute of Electrical Engineers" to become the "Institute of Electrical and Electronic Engineers" which is known to us as the "I-triple-E" and which continues publication of important electrical and electronic engineering research papers in the "Proceedings of the IEEE" and in the "IEEE Transactions" dealing with electrical and electronics interests.

We generally avoid such papers in our manuals except for the rare instance where critical information is involved, as the content of most of these publications are considered to be excessively arcane and esoteric for the beleaguered technician whose sole interest is to get the transmitter back on the air. Should you wish further information, we refer you to the above cited publications; to *"Reference Data for Radio Engineers, sixth edition"* published by Howard W. Sams & Co.; to *"The Radio Handbook"* which is specific to amateur radio applications and published by Editors and Engineers; and to the *"ARRL Radio Amateur's Handbook"* published annually by the American Radio Relay League. The latter also publishes *"QST"* magazine every month, and back issues of this publication may also be available in your public library system.

LARCAN bandpass filter implementations for the VHF channels, generally consist of a cascaded series of coupled resonators. Some use helical resonators, essentially a self supporting high Q coil (the helix) mounted inside a metallic shield enclosure. One end of the coil is solidly connected to the shield enclosure, and the other end is open circuited except for a small trimmer capacitance to ground. The dimensions of the coil are critical to the frequency of operation; the assembly behaves as though it were a quarter wave coaxial transmission line resonator.

The desired response shape is presented as Figure 1 below, and the filter electrical equivalents are presented on the next page as Figure 2. When we examine the assembly, and take capacitances into account, the equivalent circuit of a helical resonator becomes simply a parallel resonant LC tank circuit having low (trimmer) capacitance and relatively high inductance. Adjustment of the trimmer produces a change of capacitance, and the trimmer's moveable slug is shaped to appear as a shorted turn, which is coupled to the helix and therefore alters its inductance at the same time.

Matching from and to 50 ohm transmission lines is accomplished with taps on the input and output helixes.

Coupling between sections is electrically a bridged T network of capacitors, and is made up of the small capacitance between the free ends of the coils, controllable by the amount of capacitance to ground that is introduced by the coupling adjustment screws; the coupling is maximum when the screws are backed out fully from the enclosure. Shielding partitions placed inside the enclosure between helixes, produce fixed area apertures which affect the coupling capacitance between helixes. Helix #3 in the Figure 3 drawing has taller partitions on both sides of it, giving lower capacitance and less coupling than the others.

For system use, the tuning and coupling is adjusted for a flat topped response with steep sides, and the desired shape typically is such that f_V - 4.5 MHz and f_V + 9.0 MHz are both 30 dB down, but the carriers must be f_V less than 0.6 dB and f_A less than 0.7 dB departure from flatness. Input and output return loss must be 20 dB or better over the full 6 MHz bandwidth. These idyllic sweep curves are shown below.

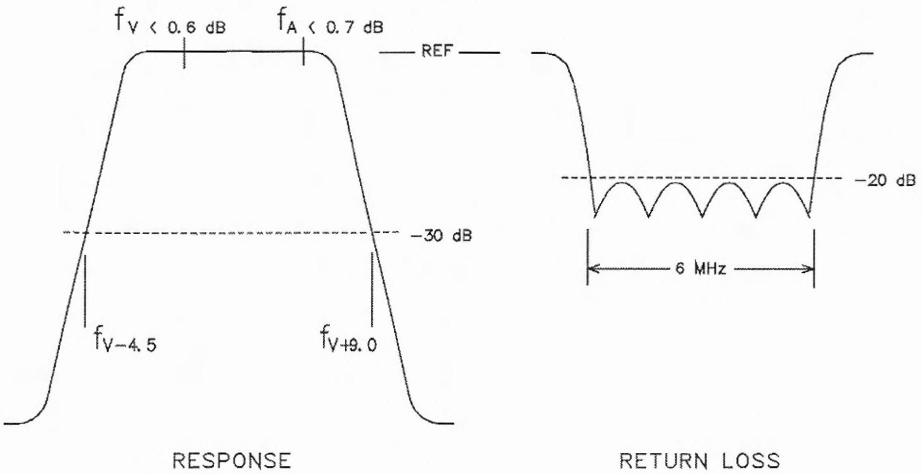

Figure 1: Typical 5-Pole Bandpass Filter Curves.

There are nine screw adjustments and two I/O matching (with soldering iron) adjustments that need to be made simultaneously, and unfortunately all of them interact with each other.

To make these adjustments properly, a network analyzer is mandatory, and because this is an expensive piece of test equipment not likely to be available in the field, for this reason we say the unit is not user-adjustable. Our recommendation: don't mess with the filter adjustments at all. This statement applies to any filter, not just the generic one we are talking about here.

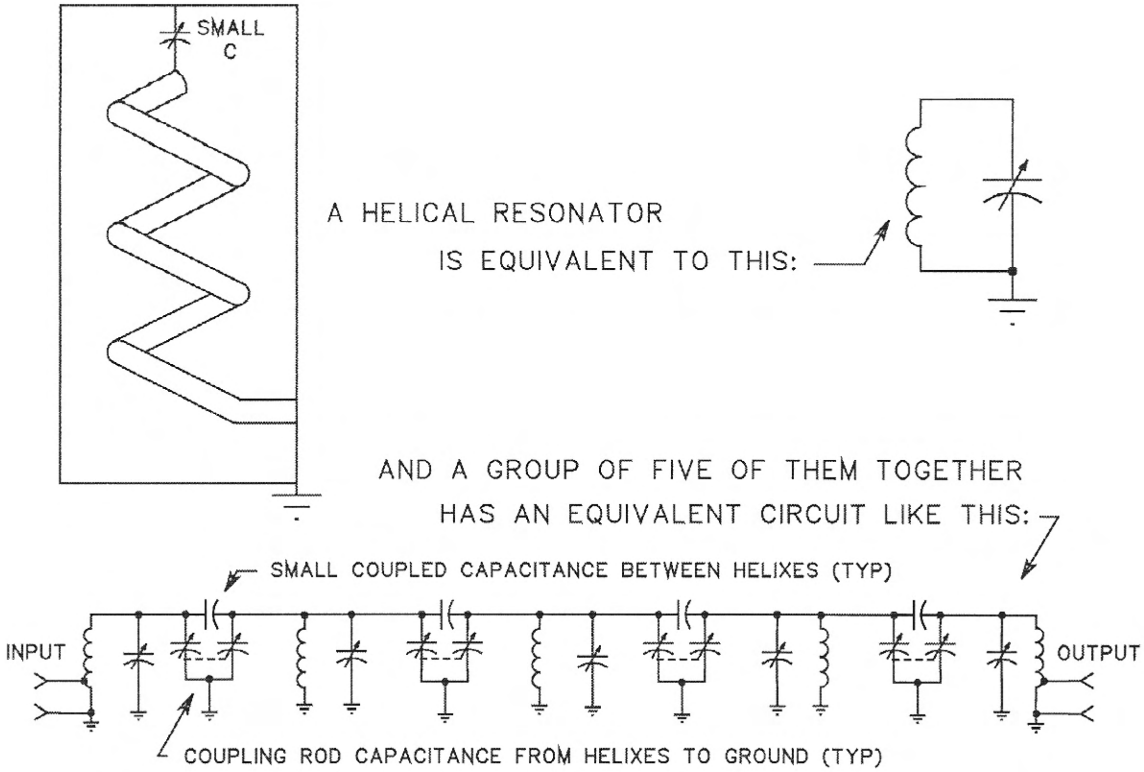

Figure 2: Typical 5-Pole Bandpass Filter.

This is the electrical equivalent of a series of five coupled helical resonators. Similar lower power filters are built using conventional air wound coils and ceramic trimmer capacitors, and these will be described next:

In the MX1V series, the Bandpass filter is the only part in the amplifier that is channel dependent. Also, this is the only part that differentiate a low from a high band amplifier assembly. Below is the description of the high band filter (ch. 7-13) followed by the low band version (ch.2-6).

4.2 Bandpass Filter Assembly for High Band 20B704G1: Figure 94-5

The configuration of this filter is similar to a helical resonator type in that it uses five LC resonant circuits, but it differs in that two of these resonant circuits (L1-C1, L5-C5) behave as high Q traps for frequencies outside the band edge (for example –4.5 and +9 MHz), so the overall response has a reasonably flat top and steep sides. Factory adjustment is made to achieve the same in-band response (carriers must be f_V less than 0.6dB and f_A less than 0.7 dB departure from flatness) as described for the helical resonator filter. Typically, the in-band insertion loss is about 0.5 dB, and reject notches offer approximately 55 to 60 dB reduction of specific out-of-band signal.

Like the helical resonator filter, coupling is through the stray capacitance between resonant circuits. There are nine screw adjustments and two I/O matching (with soldering iron) adjustments that need to be made simultaneously, and all of them are interactive. Accurate adjustment is virtually impossible without the aid of a network analyzer, and because of the expense of this test gear it is not as likely to be available in the field; for this reason alone we say the filter is not user-adjustable.

It is possible to use a sweep generator and detector for setting the response of any filter, but *an accurate 50 ohm return-loss bridge must be used* with the sweep generator for setting input and output matching.

4.3 **Bandpass Filter Assembly for Low Band 20B712G2**: Figure 94-6

The schematic indicates this filter is a little different from the helical resonator types discussed above. In those, the resonant elements are between signal nodes and ground, and coupled each to the next with small capacitances; the low band filter resonant elements are in series with the signal and coupling is done through currents flowing in common through the shunt capacitors to ground.

For the past fifty years at least, filters have been designed using so-called "image parameter theory", and each section of this one can be thought of as "m-derived series bandpass type I" arranged three in a pi-configuration, with the ends terminated by shunt capacitors. "Image parameters design" works well for applications in which close approximations are acceptable, especially as in the present application where all filter elements can be adjusted to precise values.

Oversimplifying the explanation, basically the three tuned circuits L1-C3, L2-C6, and L3-C9 are resonant to one frequency in the center of the passband. The coupling between them is provided by C4-C5 and C7-C8. This coupling is tighter than so-called "critical" coupling, and the end result is a bandpass curve that looks similar to that for the High Band helical resonator filter discussed earlier in this section.

L4-C13 coupled through small capacitor C12 to the output of the filter, provides in effect an adjustable high-Q trap at any desired specific frequency which is usually at the band edge or in an adjacent channel, and this network acts to sharpen one edge of the passband, providing enhanced attenuation for a close-in unwanted high amplitude signal. (This is exactly the same thing as in L1-C1 and L5-C5 of the High Band filter; they too act as traps for unwanted signals.)

There are ten adjustments provided; all of them interact, and furthermore all are greatly dependent on the input matching network in the front end module, therefore proper adjustment procedures are mandatory. We must therefore repeat, if you don't have a good network analyzer or at least a decent sweep generator, detector, and accurate return-loss bridge, don't touch the filter!

5.0 **RF Metering Board Assembly 20B1235G5:** Figures 94-7, 94-8

The function of this board is to monitor the amplifier forward power. A 100% reading on the front panel meter indicates that the amplifier output is at 1W sync peak. Keep in mind, however, that this reading is not accurate once the transmitters operating channel is changed from its original channel. It must be re-calibrated.

a) **RF Detector:**

The forward RF power sample is applied to J1 and is terminated by R2 . A small amount of forward bias is applied to CR1 via R1 and R5 to overcome the threshold voltage of the diode and enhance its detection linearity at low signal levels. The opposing connection of CR1 diode junction and Q1 emitter-base junction provides temperature compensation.

Q1 buffer amplifier provides a low impedance source to drive the trap C3, C4, and L1, through R9. This trap is broadly resonant to 4.3 MHz, and significantly attenuates 3.58 MHz NTSC colour subcarrier as well as any 4.5 MHz intercarrier that may be generated in CR1 or CR2 due to the presence of visual and aural RF signals together in the system. Removal of these subcarrier components before the signal is peak detected, enables the circuit to be responsive to sync peak power only (for visual) or just CW (aural) power, and relatively immune to undesired carriers.

CR3 is a peak detector with a time constant set by C7 and R11. The signal from this peak detector is fed to op-amp U1pin 5 and the gain of this stage is 0.5x, and its output on pin 7 feeds the meter which is located on the front panel of the amplifier.

U1 output pin 7 zero-offset voltage is controlled by R18. This pot should be set with no RF input, so that while you watch the voltage on TP1 as you are setting the pot, you will observe the decrease of the voltage towards zero. When it ceases decreasing, stop adjusting. Expect about 50 mV offset voltage when the op-amp output is almost touching ground. If the pot is turned beyond this point, the output stage of the op-amp will be driven into saturation thus unable to respond to low power levels.

The output of U1-7 drives the RF power meter through R32 which set the meter deflection with a known RF signal. U1-7 drives. Forward calibration is done with full rated power and a forward RF sample from the directional coupler applied to J1. R32 is adjusted for a 100% reading on the forward power meter position.

5.1 RF Metering Board Test and Calibration:

a) Forward Power Meter Calibration - Zero Adjust

With no RF input connected, measure the DC voltage at U1-7 (or TP1) and adjust R18 until the output voltage at U1-7 (TP1) drops to a minimum, approximately 10 to 50 mVDC. A DC coupled scope will make the adjustment easier to see; the objective is to place the U1 output as near the op-amp ground rail as possible without the op-amp going into saturation. Turning the pot farther will decrease the sensitivity of the system for small signals. Once this minimum voltage has been reached, do not re-adjust R18.

b) Forward Power calibration

Set the exciter/processor RF output for the transmitter to run at its operating power, i.e., *1W sync peak. Adjust R32 for a forward power meter reading of 100%.

Measuring power using the `average' power meter method:
*1W sync peak: A **mod-ramp** 80 video signal plus the **aural carrier switched `ON'** set at 10dB below visual would normally read about **0.59W** on an `AVERAGE power meter'.
or
*1W sync peak: **Black** video signal (no setup) with **no aural** carrier present would also read 0.59W on the average power meter according to the formula: Pav=Psp/1.685.

Measuring power using the spectrum analyzer method:
Connect the output of the amplifier to the spectrum analyzer using a short low loss cable. To protect the spectrum analyzer from overdrive, a 10, 20 or 30dB attenuator must be used in line with the cable.
*1W sync peak is equal to **+30dBm.**
or
Use a directional coupler with a known coupling level. Connect the output of the amplifier to a load thru this coupler. If the coupling is –20db then the reading on the analyzer should be +10dbm.