APPLICATION FOR FCC CERTIFICATION

BZ5MX10V
MODULATOR INPUT
10 WATT VHF TRANSLATOR

EXHIBIT NO.		TITLE	NO. OF PAGES
1		Supporting Statement, Application for FCC Certification of BZ5MX10V	5
2		Instruction Manuals	
	2a	10W VHF Amplifier Manual	
	2b	CAMS-60b Modulator Manual	
3		Test Measurement Set-up	2
	3a	Video Set-up #1	
	3b	Video Set-up #2	
4		Frequency Drift vs.Temperature	2
	4a	Modulator Tabulated Data	
	4b	Temperature Test Set-up	
5		Aural Test Set-up	1
6		Active Devices and Function List	1
7		FCC Identification Label for BZ5MX10V	1
8		Power Measurement Statement	1
9		Overall Attenuation Characteristic	2
	9a	Tabulated Data	
	9b	Graphed Data	
10		Attenuation/Swept Sidebands Tabulated Data	1
11		Video Waveforms	3
	11a	Input Modulated Stair Step	
	11b	Output Unmodulated Stair Step	
	11c	Differential Gain	
	11d	Differential Phase	
12		Group Delay	2
	12a	Overall Group Delay Tabulated Data	
	12b	Overall Group Delay Graph	
13		Audio Frequency Response, 25% Modulation	1
14		Audio Frequency Response, 50% Modulation	1
15		Audio Frequency Response, 100% Modulation	1
16		Photo, Front View	
17		Photo, Interior View	
18		Photo, Rear View with FCC Label	
19		Engineer's Statement	

APPLICATION FOR FCC CERTIFICATION
BZ5MX10V
MODULATOR INPUT
10W VHF TRANSLATOR

EXHIBIT 1

This application requests authorization for video/audio input to our 10 Watt VHF Translator, BZ5MX10V (Certification applied for). The amplifier will be driven directly by a color television modulator.

The intended use of the BZ5MX10V is to rebroadcast a television translator relay station or other legal source of video and audio.

A paragraph by paragraph reference is given herein, presenting the required additional data to that called for on FCC Form 731 for FCC Certification of BZ5MX10V 10 Watt VHF Translator. Exhibits are attached to authenticate this application. If further data is required, it will be furnished on request.

The unit tested specifically for this application was operated on Channel 8. This channel was chosen to provide protection to and from existing radio services, and to facillitate the measurement of possible spurious products conducted or radiated from the 10 Watt VHF Translator.

The results stated here are "worse case" unless otherwise noted. The input signals used in the tests were generated by a color bar generator driving a Blonder Tongue TV Modulator which is typically the modulator used. However, due to varying customer requirements, other modulators are available on customer request. The published specification on any modulator used in this equipment will meet or exceed FCC specifications. The output of the 10 Watt VHF Translator was properly terminated with a resistive type RF load.

2.1033(b)(1): Applicant is the manufacturer of the equipment. See FCC Form 731
2.1033(b)(2): See FCC Form 731
2.1033(b)(3): Exhibit 2 (10W VHF Instruction Manual, CAMS-60b Instruction Manual)
2.1033(b)(4): Exhibit 6 (Active Devices and Function List)
2.1033(b)(5,6,7):See also, the paragraph by paragraph summary of compliance with Part 74, Sub-part G of the FCC Commission Rules that follow.

PART 74.750(c)(1):
The frequency stability of this equipment as measured per Part 2.1055 of the rules is much better than required over the specified range of input voltage and temperature.

PART 74.761(a):
The frequency stability of the visual carrier is totally dependent upon the modulator. Exhibits 4a and 4b document the measurements made, including method and equipment. Modulator output frequency can be, and is normally set to zero deviation at the output channel. As shown in Exhibit 4a, the typical characteristic variation due to temperature is less than $\pm$.02%. This is true for all modulator channels.

EXHIBIT 1

PART 74.750(c)(2):
Observations were made on a properly operating translator video to Channel 8 using a Hewlett-Packard 8558B Spectrum Analyzer with a cut to frequency dipole antenna at 10 meters from the translator and rotated to detect maximum radiation. The following signals were present:

FREQUENCY(MHz)	SOURCE	SPECIFICATION LIMIT uV	MEASURED uV
362.50	2nd Harmonic	293	50
227.00	LO	238133	10

Radiation from the modulator was nil. No spurious products could be detected at 10 meters that were less than 90dB down.

Antenna terminal measurements with the 8591E Spectrum Analyzer showed no change due to the modulator since the power amplifier stages are not affected by this modification.

The above tests were performed using the same equipment hook up and methods described in Exhibit 3a. The translator test data compiled for this application was video to Channel 8. Translator operating with a standard video test signal input (modulated stair step and color burst) and a modulated audio carrier at -10dB of peak visual. Results are typical of performance on all channels.

PART 74.750(c)(3)(i):
Variation of input voltage $\pm$ 15% (reference +48 VDC or 120VAC) during the temperature tests resulted in no discernible frequency variation traceable to the power supply. This is reasonable due to the modulator's internal regulation.

PART 74.750(c)(4):
The stability of the modulator's self-generated RF carrier must be considered to determine the overall 10 Watt VHF Translator's frequency stability. Exhibits 4a and 4b document the performance measurements made including methods and equipment.

PART 74.750(c)(5):
This equipment meets all the requirements for unattended operation. A description of the automatic control circuitry can be found in Exhibit 2a.

PART 74.750(c)(6):
Measurements can be taken while the equipment is in operation. Normal operating constants of the power output stage average +48 volts at 2.25 amps.

PART 74.750(c)(7) AND PART 74.783(a)(2):
Station identification requirements will be supplied by the originating station.

PART 74.750(c)(8):
Wiring, shielding and construction are in accordance with accepted principles of good engineering practice. Apparatus is constructed on an aluminum chassis suitably protected to

resist corrosion. Circuits are properly by-passed and RF shielded as appropriate. Power circuits are fused and overload protected by automatic shutdown.

PART 74.750(d)(1):
This equipment meets the requirements of Part 73.687(a)(1) and Part 73.687(b)(3) at the final RF output terminal.

It is anticipated that the translator will be driven directly by the demodulator output of an FM microwave repeater. No provision is made for tampering with or adjusting the composite video or audio signal, except depth of video modulation. Therefore, all aspects of the input video signal (Transmission Standards 73.682 and 73.687) are determined solely by the originating television station. This performance data has been obtained with an NTSC signal generator that produces standard video test signals. See Exhibits 11a, 11b, 11c, and 11d.

The overall attenuation characteristics, as required by Part 73.687(a)(1) and Part 73.687(a)(2), are tabulated in Exhibit 9a and graphed in Exhibit 9b.

The attenuation characteristics as required by Part 73.687(a)(3) and Part 73.687(a)(4) of the translator are tabulated in Exhibit 10. The field strength of the upper and lower sidebands are well within the prescribed limits. Measurements were made in accordance with Part 73.687(a)(4). This will be measured with each unit shipped.

Exhibit 11 shows photographs of various video test waveforms as seen on the translator, demonstrating that the transmitted waveform is substantially identical to the input. The typical envelope delay response of the modulator as required in Part 73.687(a)(5) will be made on each unit manufactured to ensure that readings meet the FCC specifications. The additional group delay in the translator is negligible. The test equipment and set-up used is described in Exhibit 3. Tabulated data is shown in Exhibit 12a and graphed in Exhibit 12b.

The graphs of Exhibit 11 show linearity of the translator between reference black and white levels.

The audio input to the modulator was measured in accordance with Part 73.687(b). All measurements were made with the equipment adjusted for normal program operation and included all circuits between the modulator input terminal and the antenna output. Test equipment and set-up are shown in Exhibit 5.

Tabulated below, are the frequency response measurements for various percentages of modulation in accordance with Part 73.1570(b)(3). This data is shown in graph form in Exhibits 13, 14, and 15. Note that the measured curves have been drawn offset -1.5dB to show that the measured response is within the prescribed limits.

AUDIO FREQUENCY RESPONSE
REFERENCE 50Hz AT 0dB INTO 600 OHMS

	MODULATION		
FREQUENCY(Hz)	25%	50%	100%
50	0	0	0
100	+0.3	+0.2	+0.2
400	+0.5	+0.5	+0.5
1000	+1.5	+1.5	+1.0
5000	+8.0	+8.5	+8.5
10000	+13.5	+13.5	+14.5
15000	+16.5	+17.5	+18.0

Tabulated below are the audio harmonic distortion measurements.

AUDIO HARMONIC DISTORTION LEVEL (%)

	MODULATION		
FREQUENCY(Hz)	25%	50%	100%
50	0.4	0.4	0.500
100	0.4	0.4	0.300
400	0.4	0.4	0.200
1000	0.4	0.3	0.200
5000	0.7	0.5	0.300
10000	*	*	0.500
15000	*	*	0.800

* Distortion measurements above 7.5kHz at 25% and 50% modulation levels are impractical.

The output noise level (FM measured as prescribed in the band of 50 to 15000Hz) was 66dB below the level representing ± 25kHz frequency swing.

The system noise output (AM) in the same band was 56dB below the level representing 100% amplitude modulation.

The output noise measurement had to be performed with the visual carrier operative because of the translator's common visual/aural amplifiers.

PART 74.750(d)(2):
The modulator of this translator will accept audio from the microwave television translator relay station in one of two possible ways. First, when the microwave signal carries the audio at a separation of 4.5MHz, it will be passed through the translator's modulator multiplexed on the video. Frequency spacing, deviation, and other characteristics including distortion are therefore determined solely by the originating television station.

The sound carrier deviation was monitored while the frequency vs. temperature measurements were taken, see Exhibit 4a. The equipment meets the $\pm$1kHz requirement.

LOW POWER VHF AMPLIFIER CONTROL & METERING PANEL

Contents:

List of Figures:

1. Control Panel:

Amplifier control and monitoring is performed by the Control and Metering Panel. This 19" wide, 3 unit (5¼") panel serves primarily as a mechanical mounting for the amplifier's control switches, status indicator lights, and a multifunction meter. The panel is the mounting for the control circuit board described below, and elsewhere on the chassis is an output metering circuit board which is described later in this manual.

The Amplifier control panel features as seen from the front, are these:

1. 50 µA panel meter fitted with a power scale calibrated 0-125 percent;
2. The meter input selector switch for forward and reflected power;
3. Pushbuttons for ON & OFF;
4. Three LEDs providing indications (from left to right) when lighted: EXT 1 interlock is closed,the output amplifier TEMP thermostat is cool, EXT 2 interlock is closed.

The amplifier is provided with a VSWR cutback function that reduces its power output to save it from harm in the event of very high reflected power such as an open circuit condition.

The VSWR cutback feature is described in the Metering board section of this manual.

2. Amplifier Control Circuit board Assembly 30C1829G2: Figures 1 and 2.

There are seven connectors on the Control circuit board. These connectors perform the following functions:

J2 connects elsewhere in the amplifier, such as the thermal switch, relay, and to the 50 µA meter.
J3 connects to the external interlocks.
J4 interconnects with J3 of the Metering board.

The transmitter interlock chain begins with the +12V at K1-7. When K1 is set ON by energizing its coil K1-1, contacts 7 and 12 close and contacts 7 and 10 open, turning off the LED inside the OFF button S4. The +12V from closed contact 7-12 lights the LED inside the ON button S3 and lights the optodiode in U3D, which provides a logical active low out of its pin 10 for a remote control status interface. This status signal simply tells the remote control through J5-6 that the transmitter was instructed to be ON, nothing more.

The +12V from contact 7-12 also comes out of the board on J3-5, which is one side of the EXT 1 interlock. EXT 1 in larger transmitters is often used with a fire alarm system to stop all blowers, and in lower power transmitters it is still worthwhile that a normally closed fire alarm contact be connected to EXT 1 because the fan(s) in the transmitter could cause enough air currents in the transmitter room to fan the flames.

When the EXT 1 interlock is closed and the +12V appears on J3-4, the +12V is now at DS5 (marked EXT 1) and the optodiode of U3C which both light up to say EXT 1 is closed. The active low from U3C pin 11 informs the remote control via J5-14 that EXT 1 interlock is closed.

The +12V now is applied to J2-8 which connects to a normally closed contact in a thermostat that responds to the temperature of the RF power amplifier. If a cooling fan should stop and the amplifier should overheat, this contact will open and prevent the +12V from appearing at J2-3. This of course breaks the chain and removes the 12V from the solenoid of the power supply contactor.

Assuming the thermostat is cool, DS4 and the optodiode in U3B are lighted, confirming TEMP is okay. The logical active low out of U3B pin 14 informs the remote control of this fact through J5-7.

Assuming the thermostat is closed, the +12V next appears at J3-3, which is EXT 2 interlock. This is the place where RF patch panel link contacts or coaxial switch auxiliary contacts, and/or dummy load thermostat contacts would be connected so that the transmitter can only be ON when valid RF paths are present, consequently the EXT 2 path from J3-3 to J3-7 will be intact.

2. Amplifier Control Circuit board Assembly 30C1829G2: Figs 1 and 2. (continued).

Finally, when the interlock chain is complete, the +12V is applied to the solenoid of the power supply primary contactor through J2-10, and the cooling fans and power supply are all turned on. The DS3 LED marked EXT 2 is lighted, as is the optodiode in U3A. The output active low from U3A at pin 15 informs the remote control via J5-15 that the EXT 2 interlock is intact.

The interlocked +12V is also available at J3-6 so it can be used for special on-site control functions.

The amplifier AGC system (overdrive protection) is based on an RF attenuator located at the input stage of the amplifier, and this is controlled by DC voltage supplied from RF detectors which sample the RF output from the amplifier. If the output rises, the DC voltage increases, and this increases the amount of attenuation, thus the output is maintained at a constant level. The majority of the AGC processing is done by analog op-amp circuits in the Metering Board, but the initial threshold setting is done in the pin attenuator board, potentiometer R5. These simply provide an adjustable reference bias voltage to the AGC circuit, which adjusts the power output inversely according to this bias voltage.

In the event of a VSWR that exceeds a preset amount, the AGC voltage becomes modified a little to reduce the amplifier output by an amount proportional to the reflected signal. This "VSWR Cutback" permits the amplifier to remain on the air at reduced power if the antenna should gradually accumulate a layer of ice.

The AGC voltage and modifications to it from VSWR, are summed in U2A which is basically a buffer amplifier that also provides a telemetry output to the remote control system through J5-3.

Forward and Reflected meter calibration is done with potentiometers on the Metering Board.

A 50 µA meter mechanism that is fitted with a scale 0-125%, is connected to J2-9 and J2-7. The + terminal of the meter connects to J2-9.

Although F1 is drawn in Figure 2 as a fuse, in reality it looks like any ordinary disc ceramic capacitor, but it is a current limiting device similar to a thermistor having an extreme positive temperature coefficient. In normal operation it maintains a low resistance, until it gets hot from too much current and then suddenly switches to a high resistance state so that the current it is able to pass is only a very small amount. This small amount of current is sufficient to keep it warm enough that it remains in its high resistance state. When the power is removed and the device cools down, it resets itself to its low resistance state.

VHF OUTPUT RF METERING BOARD

Contents:

List of Figures:

1. RF Metering Board 20B1235G7: Figures 1 and 2.

The function of this board is to monitor the forward & reflected power. Except for their functions and input names, metering boards have identical RF detectors. For this reason, Detector #1 for "Forward" will be described, and #2 for "Reflected" will be referenced by its component numbers inside parentheses ( ).

a) RF Detectors:

The #1 Forward (#2 Reflected) RF power sample is applied to J1 (J2) and is terminated by R2 (R4). A small amount of forward bias is applied to CR1 (CR2) via R1 and R5 (R3, R6) to overcome the threshold voltage of the diode and enhance its detection linearity at low signal levels. The opposing connection of CR1 (CR2) diode junction and Q1 (Q2) emitter-base junction provides temperature compensation.

Q1 (Q2) buffer amplifier provides a low impedance source to drive the trap C3, C4, and L1 (C5, C6, L2), through R9 (R10). This trap is broadly resonant to 4.3 MHz, and significantly attenuates 3.58 MHz NTSC color 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 (CR4) is a peak detector with a time constant set by C7 and R11 (C8, R12). The signal from this peak detector is fed to op-amp U1 (U2) pin 5 and . The gain of this stage is 0.5x (0.5x), and its output on pin 7 feeds the meter which is located on the front panel of the amplifier.

U1 (U2) output pin 7 zero-offset voltage is controlled by R18 (R20). This pot should be set with no RF input, so that while you watch the voltage on TP1 (TP2) 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.

1. RF Metering Board 20B1235G7: Figures 1 and 2. (continued).

The output of U1-7 (U2-7) drives the RF power meter through R32 (R30) which set the meter deflection with a known RF signal. U1-7 (U2-7) 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.

For Reflected calibration, the same forward RF sample is then applied to J2, R30 is set for a 100% reading on the Reflected Power meter.

2. RF Metering Board Test and Calibration:

(Refer also to the Pin Attenuator section of this manual)

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) Reflected Power Meter Calibration - Zero Adjust

With no RF input connected, measure the DC voltage at U2-7 (or TP2) and adjust R20 for a minimum, which should be approximately 50 mVDC. Once this minimum voltage has been reached, do not re-adjust R20. This adjustment is done in precisely the same way as in step a) above.

c) Forward Power calibration

Set the exciter RF output for the transmitter to run at its operating power. Adjust R32 for a forward power meter reading of 100%.

NOTE: Before proceeding to the next step, ensure that the Pin Attenuator Board has been setup according to the procedure on the Pin Attenuator Board section of this manual (see page 34a-1).

d) Reflected Power calibration

1. Temporarily defeat the VSWR cutback protection (if it's been initially setup) by adjusting R36 fully clocwise (CW). With the transmitter still at "full power", disconnect the RF input cable from J1 and connect it instead to the reflected power input J2. Switch to position `RFL' and adjust R30 so that the reflected power reads 100. This now corresponds to a reflected power of 100%.

2. Enable the VSWR cutback by turning R36 counter clockwise until the meter indicates 10% output. This means that in severe VSWR conditions such as in an open circuit, the amplifier will automatically cuts back to 10% thus protecting itself.

3. Replace the cables in their proper connections. RFL meter reading should be nill and the FWD meter reading should be back to 100%. If the FWD reading is much less than 100%, R36 was probably overadjusted.

VHF POWER AMPLIFIER & HEATSINK ASSEMBLY

Contents:

List of Figures:

1. RF Power Amplifier & Heatsink Assembly 30C1899G1 - G2 - G3: Figure 1.

The 30C1899 RF Power Amplifier basically consists of a fan-cooled heatsink and three circuit boards. These boards are the Preamplifier board, the Amplifier Input board, and the Amplifier Output board. This subassembly is mounted in the Transmitter Chassis (as an example, see drawing 40D2008 - Figure 1 of the 10W/50W Chassis section). Figure 1 shows the basic construction of the RF PA assembly.

A directional coupler (example shown as item 15 on the 10W/50W Chassis Assembly diagram Figure 07-1, and described in the RF Output section of this manual) is also mounted in the chassis and provides an AGC and metering DC signal corresponding to the amplifier output RF.

Figure 32-1 illustrates the arrangement of boards on the amplifier heatsink.

Cooling for the PA heatsink is provided by a 4" axial flow Rotron™ fan which is mounted on a bracket situated at the end of the heatsink, so that the fan can extract air through the finned portion of the heatsink. Air exhaust is normally to the rear of the chassis. If this is not suitable for the application, then the fan can be mechanically reversed so that it blows air into the heatsink instead, and this air would then exhaust through the perforations in the front panel.

The heatsink fan can move approximately 100 cfm of cooling air, and has a DC motor that is powered by the same +50 volts that operates the amplifier.

1. **RF Power Amplifier & Heatsink Assembly 30C1899G1 - G2 - G3:** (continued).

Most LARCAN exciters produce their best linearity at or near their maximum rated output levels, and often the overall system gain is sufficient to result in overdrive of later stages of the transmitter. The transmitter or translator lineup may therefore include an in-line attenuator between the exciter and the preamplifier, to prevent overdrive from certain models of exciter-modulator.

This is especially true for the 10 watt system, because in our basic transmitter family a 10 watt amplifier is simply a lightly driven 50 watt amplifier, and a 50 watt amplifier is likewise a lightly driven 250 watt output stage running without its driver/IPA. (Our 250 watt transmitter lineup needs an additional IPA to get enough drive to the identical final stage that is used in the 50 watt and 10 watt lineups).

2. **RF Preamplifier 10A1453G5 (Low Band) and 10A1453G4 (High Band):** Figures 2 and 6.

This preamplifier design originally appeared in the aural/sound section of a dual RF chain transmitter which operates two single RF chains in quadrature and therefore requires phase and gain control of the input to each chain. The same unpopulated circuit board is used for the present application, therefore has the pads and holes for the components which performed the adjustment of RF gain and phase in the parallel systems. In a single chain transmitter such as the present one under discussion, there is no requirement for control of RF phase nor consequently its components; they are therefore removed and wire jumpers substituted.

In the Low Band preamp, the 50 Ω input cable is matched by C5, which uses the inductance of the traces on the PC board to form a low pass matching network, and fed to amplifier U2 whose output connects through a cable to the PA. U2 is a linear amplifier designed originally for use as a wideband cable system trunk amplifier. Cable amplifiers are nominally 75 ohms in and out, but the MHW6185 is capable of a good match with 50 ohm source and load. C12 and the lead inductance of a CA2885 when used as U2, perform output matching to 50 Ω. C12 is not present in a board using an MHW6185 for U2. The gain of U2 is spec'd as 18 dB, and allowing a few dB of losses, the gain of the Low Band preamp is 14 to 16 dB.

RF power FETs operated in High Band amplifiers exhibit about 6 dB less gain than they do in Low Band, so an additional amplifier is necessary to make up the difference. The High Band preamplifier therefore consists of two stages.

In the High Band preamp, the input is matched by C5 and the PC trace inductance which together forms a low pass matching network, and the signal is fed to an additional preamplifier stage U4, whose output appears as the input of U2, which in turn feeds the board output cable. The specified gain of type MWA330 in the U4 position is 6 dB, and a type MHW6185 or CA2885 (U2) is 18 dB. A few dB of losses exist on the board, so the effective gain of the High Band preamp board 10A1453G4 is about 20 to 22 dB.

High Band preamps 10A1453G1 used in higher powered externally diplexed transmitter aural service, have a type MWA130 instead of an MWA330 for U4. Specified gain of an MWA130 is about 12 dB, but we don't recommend substitution of U4 in any internally diplexed system due to overall linearity and intermod requirements which are much more stringent in the internally diplexed case. This is because the 30 dB (or thereabouts) of aural to colour subcarrier isolation normally provided by the diplexer is not there, and it simply means that internally diplexed system intermod numbers have to be much better.

At the output of U2, a match to 50 Ω is provided by C12 and the device lead inductance, which together create a low pass matching network in boards where a type CA2885 cable amplifier is used; conversely a type MHW6185 device characteristics give it a wideband match to 50 Ω therefore no special output matching is necessary, and C12 is not present.

U3 is a voltage regulator providing +24 V to the preamplifier stage(s).

3. SRF 3943-2 RF Power Amplifier: Figures 3, 4, 5, 7, 8, and 9.

The Power Amplifier (PA) is configured in push-pull, using dual N-channel enhancement mode Field Effect RF power transistors which are packaged into a single case and operated in class AB.

The Low Band and High Band versions of the PA differ slightly due to the frequency ranges to be covered.

3.1 Low Band PA Circuit Description (30C1054 input board, 30C1055 output board)

The PA consists of two, source grounded N-channel, insulated gate Field Effect Transistors (FETs) packaged in a single case, operating class AB in a push-pull configuration. The original schematic indicates a type MRF-151-G as the dual FET used; we now use a "selected MRF-151-G to tightly controlled specifications" which is proprietary to LARCAN and designated type SRF 3943-2. This selection simply tightens the gain specification for operation in High Band, and in case of emergency, there is no reason an MRF-151-G could not be substituted for Low Band operation.

Because these FETs are "enhancement mode N-channel" devices, they require positive gate-to-source bias voltage on each gate to cause source-drain conduction. The quiescent Class AB idling bias current is set at 0.6 ampere for each half. The gate voltage required to produce this idling current may vary between 2 V and 5 V according to the device specification sheet, and typically is 3 to 4 V. FET gate threshold voltages also are temperature sensitive, so thermal compensation is provided by RT1 and RT2.

Gate bias is supplied out of adjustable voltage dividers from +20 V regulated bias sources CR1 and CR2. Current limiting to these zener diodes is provided through R1 and R8. Resistors R9, R2, R3, R4, and RT1 provide gate bias for the "A" half of the amplifier; R10, R7, R6, R5, and RT2 provide bias for the "B" half.

The RF input signal arriving in J1 is applied to balun T1 to provide two signals 180° out-of-phase. These antiphase signals are stepped down to match the low input impedance of the FET through a π-network consisting of C1, C2, C3, L1, L2, C4, and the device input capacitance, and then applied to the gates. The capacitance value of C4 is changed for operation on channels 5 & 6. The gate input impedance at the operating frequency is low compared with the values of R3 and R6, which have little or no effect at RF.

R3 and R6 provide a DC path for bias, and provide loading at lower frequencies where gate impedance is high, in order to assist in maintaining amplifier stability. The choice of C6, C7, C20, and C21 values, their series inductances, and that of board traces, also ensures effective bypassing at critical frequencies.

The output matching π-network, consisting of inductors L3 thru L8, and capacitances C13 thru C16, transforms the very low output impedance of the FET, upwards to a standard 50 Ω. The two antiphase output signals are finally combined in balun T2, L9. Jumpers placed across parts of L7 and L8, plus the changed values of C13, C14, C15 and C16, configures the system for channels 5 & 6 operation.

DC is applied to the FET drains through L3, L4 for the Q1A half, and L5, L6 for the Q1B half. L3 and L6 are short sections of microstrip line which transform the apparent RF impedances of L4 and L5 to higher values as seen by the FET. RF and lower frequencies are bypassed with paralleled C9, C10, and C17 for the "A" half of the amplifier, and C11, C12, and C18 for the "B" half. These groups of capacitors are selected in value and for their internal equivalent series inductances so that they will be an effective bypass at critical frequencies of interest, including video, to assist in maintaining stability. The connections for C20 and C21 also assist in stability due to their return paths through the ground plane of the output board. This connection provides a small amount of negative feedback as a primitive means of neutralizing the amplifier.

The RF output leaves the board from J2.

3.2 Low Band PA Setup Procedures

1. Set up a 48 V power supply, current limited to a little more than 1.2 amps.

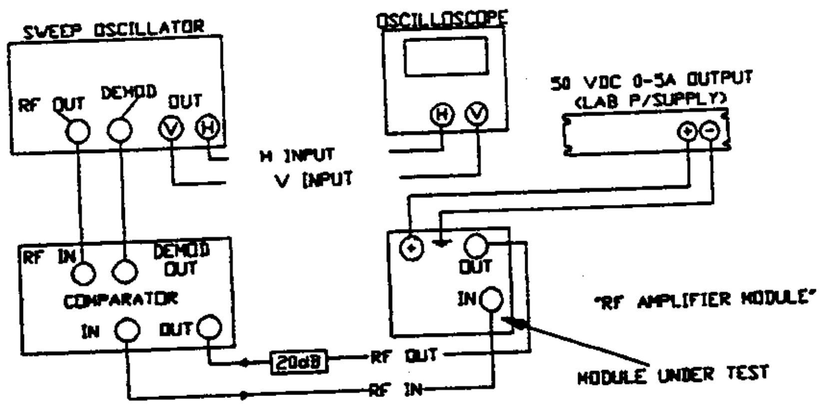
2. Remove both fuses on the power amplifier. Turn both bias potentiometers to their maximum resistance position (minimum gate voltage).

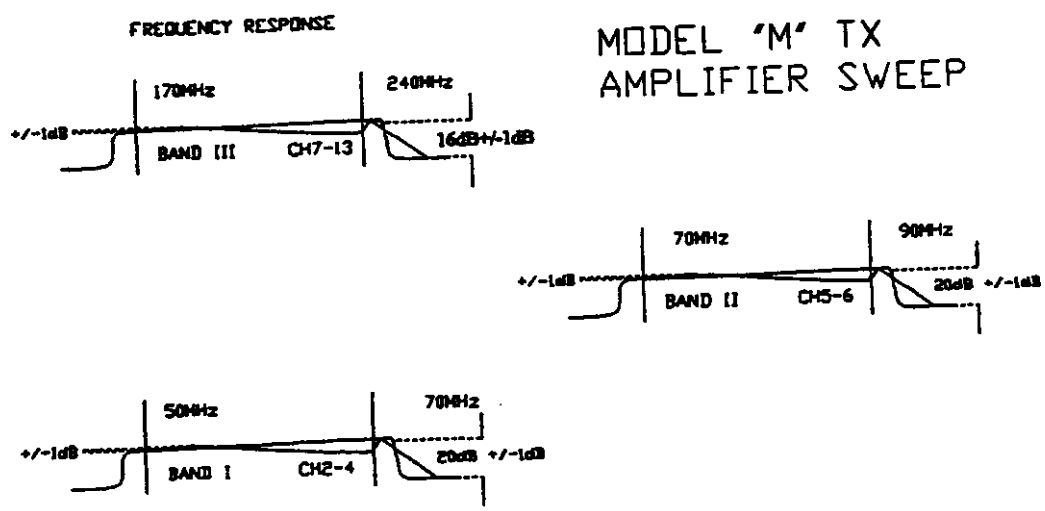
3. Apply the 48V supply to the B+ terminal. Verify that the bias (gate) voltage is at or near minimum by measuring the dc voltage at the gates of the device. This voltage should be less than 1V. Install one of the fuses and slowly adjust the corresponding bias potentiometer for 500 mA drain current. Transfer the fuse to the other side and adjust the corresponding pot for 500 mA of drain current.

4. Connect a 20 dB, 1 W attenuator to the output of the amplifier as shown in the diagram below.

5. Install bothl fuses and apply B+ to both supply connections of the amplifier module.

6. Apply a low level sweep to the amplifier and measure the DC input current (not more than 1.2 amps) and gain. Gain of the amplifier alone should be about 20 to 23 dB, and with the preamp in circuit the combined gain should be between 40 and 43 dB. Flatness over the band should be better than 1 dB, as shown in the following diagram. Curves for chs 2-4 and 5,6 are correct for the PA alone:





Sweep setup and response for PA alone, without preamplifier.

3.3 High Band PA Circuit Description (20B1222G2 input board, 20B1226G1 output board)

The PA consists of two, source grounded N-channel, insulated gate Field Effect Transistors (FETs) packaged in a single case, and operating in a push-pull configuration in class AB. A single specially characterized device designated SRF 3943-2 is used for this High Band amplifier. These N-channel FETs are "enhancement mode" devices, so require a positive gate-to-source bias voltage on each gate to cause source-drain conduction. Quiescent Class AB idling bias current is set at 0.6 ampere for each half.

The gate voltage required to produce this idling current may vary between 2 and 5 V due to variances among FETs, and typically is 3 to 4 V. Gate voltages also are temperature sensitive, so temperature compensation is provided by RT1 and RT2.

Gate bias is supplied out of adjustable voltage dividers from +20 V regulated bias sources CR1 and CR2. Current limiting to these zener diodes is provided through R2 and R8. Resistors R9, R1, R3, R4, and RT1 provide gate bias for the "A" half of the amplifier; R10, R7, R5, R6, and RT2 provide bias for the "B" half.

The input RF arriving in J1 is applied to balun T1, L1 to provide two signal outputs 180° out of phase. These signals are stepped down to match the low input impedance of the device through a dual section, twin π network consisting of C1, C2, L2, L3, C3, and the device input capacitance, and then applied to the gates. The gate impedance at the operating frequency is much lower than R3 and R5, so these resistors have little or no effect at RF.

R3 and R5 provide a DC path for bias, and provide loading at lower frequencies in order to assist in maintaining amplifier stability. The choice of C2 and C6 values, and their internal equivalent series inductances, also ensures effective bypassing at critical frequencies.

The output matching π network, consisting of inductors L5 thru L10, and capacitances C12 thru C16, tunes out the FET drain capacitance and transforms the very low output impedance of the FET, upwards to a standard 50 ohms. The two 180° antiphase output signals are finally combined in balun T2, L11.

DC is applied to the drains through L4, L5 for the "A" half, and L6, L7 for the "B" half. L5 and L6 are also short sections of microstrip transmission line which transform the apparent RF impedances of L4 and L7 to higher values seen by the FET. RF and lower frequencies are bypassed with C1, C10, C11, and C8, C9, C7.

These groups of capacitors are selected in value and for their internal equivalent series inductances so that they will be an effective bypass at all frequencies of interest including video, to assist in maintaining stability. Towards this objective of stability, in addition to resonating with the device drain-to-drain capacitance at RF, inductor L9 places a heavy load on the FET output at low frequencies, where it behaves as a dead short.

3.4 High Band PA Set Up Procedures

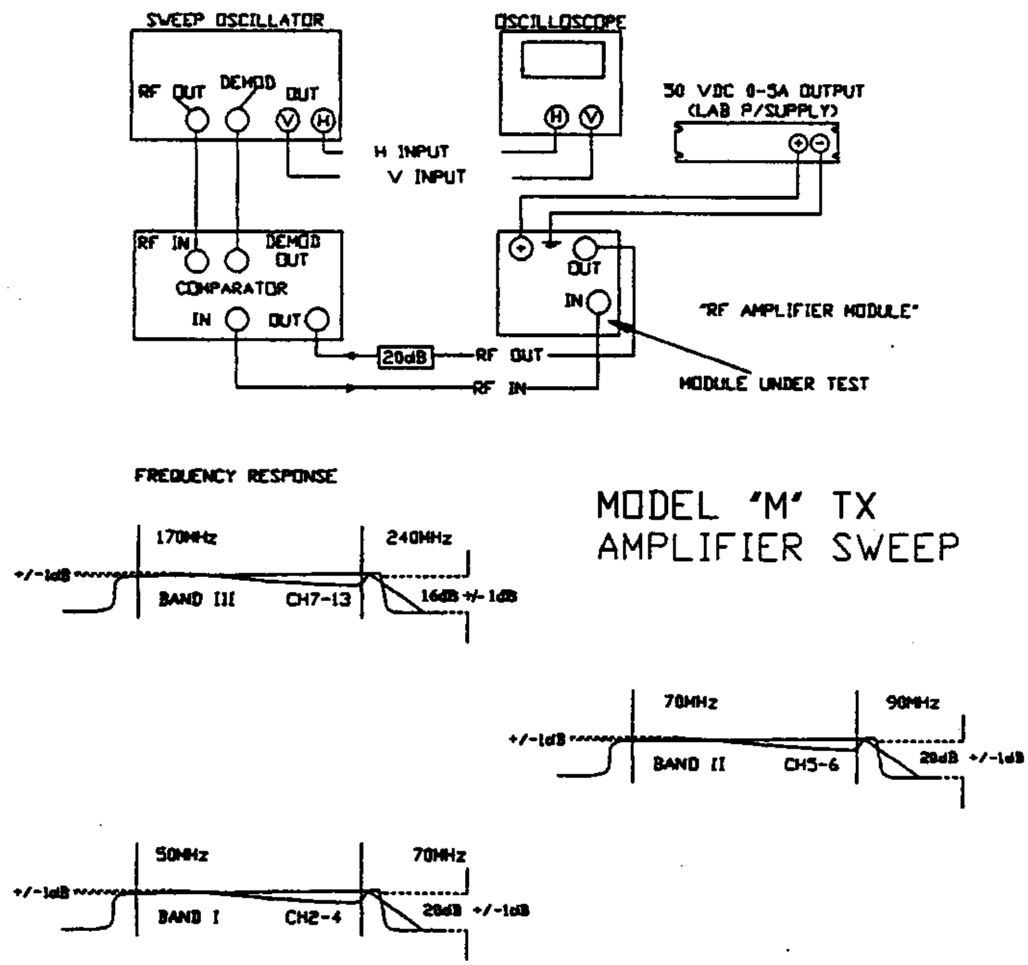
1. Set up a 48V power supply, current limited to a little more than 1.2 A.
2. Remove both fuses on the amplifier. Turn both bias potentiometers to their maximum resistance (minimum gate voltage).
3. Apply the 48V supply to the B+ terminal. Verify that the bias (gate) voltage is at or near minimum by measuring the voltage at the gates of the device. This voltage should be less than 1V. Install one of the fuses adjust one of the potentiometer for 500 mA drain current. Then adjust the other potentiometer for a total current of 1A.

3.4 High Band PA Set Up Procedures (continued).

4. Connect a 20 dB 1W attenuator to the output of the amplifier as shown below.

5. Apply B+ to both supply connections of the amplifier.

6. Apply a low level sweep to the module and measure the DC input current (about 1.2 amps) and gain. Amplifier gain by itself should be 15 to 17 dB, and with preamp included, overall gain should be between 38 and 41 dB. Sweep response should be flat within 1 dB over the band as shown in the sweep diagram from page 4, repeated below. Note that these sweep curves are applicable to the push-pull FET amplifier only and the preamp is not included.



Sweep setup and response for PA alone, without preamplifier.

BASIC TRANSMITTER MAINTENANCE

Contents:

1. GENERAL

When the transmitter was installed and commissioned it was in proper operating condition. During final tests, all circuits were checked for optimum adjustment to ensure both peak performance and conservative operation of components, and test results were recorded for future reference.

Given reasonable care and attention the transmitter will provide efficient and reliable service for many years.

Experience indicates that equipment which is regularly and carefully maintained is far less likely to be subject to sudden failure than that which is operated continuously without regard to basic maintenance requirements. It is therefore desirable that a detailed preventive maintenance program be established to ensure that the original efficiency and picture quality is maintained throughout the life of the equipment.

Preventive maintenance techniques do not necessarily involve extensive dismantling of the various assemblies; on the contrary, this practice is to be discouraged unless a valid reason exists for doing so. Preventive maintenance is more concerned with detailed physical inspection and the general observation of the equipment during and after operation, to detect the presence of any abnormality which if not corrected might later develop more serious proportions, resulting in operational failure.

In preparing any maintenance program, the frequency and scope of the inspections must be determined, and to a great degree will be influenced by site location and the station's market parameters consequently its hours of operation, equipment configuration, and technical personnel deployment. For example, is the station on the air for 24 hours a day, are there main/standby transmitters, and are they attended or unattended? In general, the following routines should form the basis of any maintenance program.

2. DAILY

At an attended site, the operator is afforded the opportunity to make daily or more frequent checks on the equipment and thereby increase his/her familiarity with its operation. The "transmitter log" entries made during these checks would include all meter readings, also any irregularity in performance, or in picture quality, for later analysis. An unattended site where equipment is operated by remote control, and monitored by telemetry and a high quality off-air receiver or demodulator located within the primary coverage area at the studio site, can also be continuously checked for performance by studio technical personnel, using VITS or VBI test signals encoded into the video signal vertical blanking interval.

3. WEEKLY

If the site is unattended, and VITS or VBI test equipment is not available, many broadcasters schedule their operational tests and transmitter inspections to be performed once a week during weekend hours, such as from midnight Sunday to six AM Monday, depending on their market conditions.

If there is an emergency alternator, it should be checked out completely, and run for at least an hour under full load. The checking of this unit should include the condition of its battery, its ease of starting (and its Winter starting enhancers such as block heater, battery warmer, fuel antifreeze), its engine oil level and condition (see "Monthly" below), its radiator coolant condition and level; and its fuel tank should be topped up. This simple check will serve as a reminder to order more fuel if necessary.

4. MONTHLY

In addition to the normal operational tests, thorough physical inspection of every piece of equipment should be made, with all power turned off. All surfaces should be dusted off or wiped down, terminal boards checked for loose connections, and all components examined for any evidence of overheating. Air filter media should be inspected and replaced if necessary. High pressure air, not over 20 psi, may be used with discretion to dislodge dust from inaccessible places.

Change the engine oil and oil filter in the emergency alternator, if it has been operated longer than its manufacturer's recommended time since this was last done. In the absence of recommendations, don't let it run more than about 100 hours between oil changes. When put into perspective, 100 hours is the time logged by a vehicle running 6000 miles at 60 mph. Oil is cheap, when compared with engine parts.

5. SEMI-ANNUALLY and ANNUALLY

Check all external RF connections for tightness. Test the antenna and transmission line with a transmission test set or network analyzer if one is available, to identify any potential problems with the antenna or line. Inspect and clean contacts on all switches and contactors; carefully redress contact surfaces if pitted.

Change the engine oil in the emergency alternator to summer or winter grade, depending on the season. Also inspect and if necessary replace, its fuel filter and air filters.

Inspection and maintenance (tighten all bolts, replace obstruction light bulbs) of the tower, antenna, and grounding system, should be conducted annually.

6. TRANSMITTER COOLING SYSTEM

Air filter material supplied with some transmitter cabinets has been impregnated with a polyester coating, which is designed to attract and hold very fine particles that may be in the air flow. This air filter material should be inspected every month or oftener, and replaced when dirty. Frequency of inspection and replacement, of course, will depend on your particular local environmental conditions.

All cooling fans in the transmitter are Rotron™ or equivalent, and all are fitted with sealed bearings requiring no lubrication during the lifetime of the motor.

7. STATIC 1, EQUIPMENT 0: Static vs Sensitive devices...

Care must be taken at all times because this equipment contains static-sensitive CMOS and FET devices. Here is a brief tutorial on static, particularly pertinent to CMOS and other MOS device handling:

1. It is important to avoid surroundings or situations in which static can be generated. The building floor should have grounded conductive floor coverings, or a grounded conductive mat placed on the floor in front of the bench. Then, the bench itself should also have a grounded conductive mat on which the equipment is placed. Anybody working on the equipment should wear either a grounded wrist strap (preferably) or conductive overshoes. Vacuum cleaner tools should all be conductive and grounded to avoid static from air motion. (Vacuum cleaners made for computer servicing would be suitable). Soldering iron tips must be grounded. Use properly maintained soldering equipment that has a three wire, grounding plug, verifying low path resistance between ground and the tip with an ohmmeter every time this equipment is used.

2. The average person wearing rubber-soled shoes and walking across a woolen or synthetic carpet or untreated vinyl tiled floor is able to generate voltages in excess of 15 to 20 kV. Most MOS devices will suffer puncture of the oxide insulating their gates, at 20 to 40 V. Many CMOS devices are fabricated with built-in zeners which will clamp foreign voltages, but the amount of energy that must be dissipated may easily exceed the rating of this protection. It is therefore prudent to assume that little or no static protection exists in a CMOS device and therefore you must provide your own.

3. A typical unprotected gate of a CMOS logic IC has an input capacitance of about 5 pF and can self-immolate at 20 V, so the energy to destroy the IC is given by the expression $W = CV^2/2$ where W is in watt-seconds, C is in farads, and V is in volts. One watt-second is also known as a Joule. Substituting numeric quantities results in $W = 5 \times 10^{-12} \times 20 \times 20 \div 2 = 1 \times 10^{-9}$ Joule per gate. Stored energy in the approximately 100 pF capacitance of the human body charged to 15 kV, becomes $W = 100 \times 10^{-12} \times 15000 \times 15000 \div 2 = 11.25 \times 10^{-3}$ Joule. *Eleven and a quarter **million** times more energy than is needed to destroy one gate input!* Some of us may therefore be led to conclude that a body can annihilate more than eleven million CMOS gate oxides all at once.

4. This is serious stuff. To avoid destroying CMOS devices, the human body must be grounded first. That is the reason for all the "grounded surroundings" we suggest in paragraph 1. Don't forget, though, that a circuit board has conductive metallic paths connecting into the CMOS parts, which makes them all susceptible to mass devastation as easily as would be the destruction of any one CMOS chip all by itself. Always ground yourself first, then the board.

5. Avoidance of static exposure of boards and CMOS devices is easier. Ensure that boards are always kept in conductive bags or boxes when not in place in the equipment, and that spare CMOS ICs are in conductive chip carriers or plugged into conductive foam. Be careful about this point; many plastic foams can be coloured black, but may still be an insulator. Use your ohmmeter to be sure.

   Don't accept any devices whose pins are punched through aluminum foil into foam plastic. People who don't know better have used this method for shipment and storage of devices, but it cannot be depended upon, because many times the holes made in the foil by the device pins become enlarged simply from the motion of pressing the pins into the foam, and won't make contact any longer. When the device is withdrawn from the foam, the friction of the plastic against the pin can generate enough charge to cause puncture and consequent failure of the CMOS gate insulation.

6. Identical statements to those made in the above paragraphs apply to RF power MOSFETs, and although the gates of these devices might appear to be considerably more robust than those of the average CMOS logic device, this is due only to the much greater gate area and consequently greater input capacitance. The same order of magnitude of gate oxide breakdown voltage exists for RF power FETs as for small CMOS devices, therefore use the same order of care in handling.

7. **STATIC 1, EQUIPMENT 0: Static vs Sensitive devices...** (continued).

7. Believe it or not, ordinary analog meters can also be affected by static. Years ago, meters were made with glass faceplates and had movements that were relatively insensitive, so were affected little by stray static charges accumulating on the glass. Today, almost all meters are made with clear plastic faceplates and many of these, such as the sensitive 50 µA ones we use, have extremely compliant moving parts, thus can be easily caused to read incorrectly from a static charge on their front surfaces. This charge can be readily generated by simply cleaning the meter face.

It is important that meter accuracy be maintained within reasonable tolerances, because you as a broadcaster are responsible for ensuring that the transmitter complies with all regulations pertinent to its operation, and the easiest way of tracking its performance is from its meter readings.

It is recommended for better accuracy that meter faces be given an anti-static treatment, either by cleaning with an antistatic cleaning agent, or sprayed with an antistatic coating, or both.

Suitable antistatic chemicals should be available through your nearest electronics parts distributor, and typically carry such names as *"Zero Charge"* from Tech Spray™, *"Destaticizing Lens Cleaner"* from G-C™, and *"420 Antistatic Screen Cleaner"* from M.G. Chemicals™. Check them out. Similar brands should also be available in most reputable computer shops or office supply stores.

CAUTION: Antistatic cleaners or treatment chemicals must not contain organic solvents such as acetone, MEK, methyl isobutyl ketone, benzene, toluene, xylene, ethyl cellosolve acetate, or many of the chlorinated hydrocarbons including ethylene dichloride and 1,1,1 trichloroethane, as these solvents will etch or even dissolve most of the plastics used for meter faceplates.

Our meter supplier recommends and uses a harmless coating treatment which it keeps in stock under its catalog number FS 681. This coating is otherwise known to the trade as *ANSTAC 2-M.*

ANSTAC 2-M is made by *Chemical Development Corp.*
22 Portsmouth Rd.
Amesbury MA 01913 U.S.A.
Phone (508) 388-2221.

8. **FIELD REPLACEMENT OF FETs and SURFACE MOUNT COMPONENTS:**

TOXIC MATERIALS WARNING... Thermal management in certain RF devices in this equipment is accomplished through the use of Beryllium Oxide ceramic material. Beryllium Oxide is a hard white ceramic used as insulation for heatsinking of RF power semiconductors. *Beryllium Oxide is a POISON if taken into the body. In case of accidental breakage, DO NOT INHALE THE RESULTING BERYLLIUM DUST and AVOID GETTING BERYLLIUM DUST IN YOUR MOUTH. DO NOT LET BERYLLIUM DUST INTO YOUR BLOOD STREAM THROUGH CUTS OR OPEN WOUNDS !! Seek and get IMMEDIATE medical attention if the dust enters your body in any manner.* Avoid cuts by wearing gloves while picking up the broken pieces. Be careful - do not inhale dust while replacing or emptying vacuum cleaner filter bags, and wash your hands thoroughly afterward. Wash your hands thoroughly after replacing RF power devices. Dispose of defective RF power devices only through approved toxic waste facilities.

If for any reason it should become necessary to change a FET in the field, we strongly recommend following the handling precautions outlined on the next few pages:

Any FET can be damaged by static discharge. It is therefore mandatory that static-free handling techniques as discussed in the foregoing "static 1, equipment 0" tutorial should be routine, and that soldering equipment must be suitable for insulated gate MOSFET work, and must be properly maintained.

a) Keep FETs in their anti-static containers until ready to install. The module and the technician should both be earthed/grounded. Observe the handling procedures discussed in Part 7 above, including the use of antistatic bench coverings, conductive overshoes, grounded wrist straps, etc.

b) The soldering iron tip MUST be at earth/ground potential at all times, that is, absolutely no AC voltage must be available on the tip. Test with an ohmmeter each time the iron is used; the test must indicate continuity from tip to ground. Special battery operated soldering irons are also available to avoid any chance of AC voltage being present on the tip, but these are not satisfactory for RF FET work as they do not heat to sufficiently high temperatures. Use an accurately controlled temperature regulated low voltage soldering iron, and set it for about 700° to 750°F.

8.1 FET Replacement Hints and Advice:

a) Back off the FET pressure plate grub screw until the pressure plate under the clamping bridge is able to move freely. Certain IPA boards use different FETs that have a different mounting flange, thus do not require pressure plate nor clamping bridge.

b) Remove the two screws holding the clamping bridge and FET to the heatsink, then salvage the clamping bridge, pressure plate, screws, and spring lockwashers.

c) If you are repairing a High Band module with pushpull amplifier(s), make careful note of the location of hairpin inductor L9 in relation to the FET, measuring the spacing of its two legs and its distance from the FET case. (Low Band modules do not use L9). To minimize board damage, use a sharp "screwdriver" tip on the soldering iron, and carefully help it along with a solder pick tool, working it under one tab first, then once that tab is free and FET mounting screws have been removed, the FET can be rocked gently, allowing other tabs to be easily unsoldered in turn. The defective FET can now be lifted out. Remove excess solder with "no clean" fluxed copper braid wick.

d) Clean the FET heatsink area thoroughly with alcohol ***(CAUTION:- ALCOHOL VAPOUR IS TOXIC)***, and inspect to ensure that there are no defects nor debris present and that all old thermal compound has been completely removed. The board solder areas should be lightly and uniformly pre-tinned.

e) Apply only enough heatsink thermal compound (supplied with the transmitter) to the new FET base and to the heatsink, that will result in a thin uniform coating on the FET base and heatsink. The metal should be faintly visible through the coating on both surfaces. Apply it sparingly; too much compound is every bit as bad for thermal transfer as an insufficient amount would be. To refresh your memory: thermal compound fills the tiny little tool marks left by the milling machine on the heatsink surface, but only enough that no microscopic air spaces remain between FET and heatsink. Heat transfer depends partly on the distance through which the heat must travel from the FET to the heatsink; too much compound effectively adds more distance, which could result in overheating.

f) Lightly pre-tin and gently bend the FET tabs upward slightly, so that the tabs and the circuit board do not prevent the FET from making proper thermal contact with the heatsink.

g) Install the pressure plate and the clamping bridge over the new FET. ***Install the pressure plate so that the raised marks left by its grub screw are facing AWAY from the FET ceramic case, otherwise the case could crack.*** Be sure that screw holes in the clamping bridge, the FET, and the heatsink are all in line and clear; you will know, because the screws should turn easily while being installed.

8.1 FET Replacement Hints and Advice: (continued).

g) When all holes are lined up properly, carefully finger-tighten the two screws and spring lockwashers.

h) Torque the clamping bridge screws evenly to 4.5 inch-pounds. This amount is recommended by the FET manufacturer to allow for thermal expansion of the device. 4.5 inch-pounds also will avoid the possibility of stripping the threads in the heatsink, or breaking the screws. *Use only the special screwdriver-handle torque wrench and its two keys that came with the transmitter for this work; if that wrench becomes lost or strayed, then obtain one that is intended only for use on delicate electronic or aircraft assemblies. Do not get an automotive torque wrench because it is not capable of being adjusted to small torque values. Do not under any circumstances use a regular Allen key or screwdriver, nor depend on the feeling in your fingertips to judge the applied torque. Your hands may be much stronger than you think.*

i) Ensure that the pressure plate is centered evenly, between the clamping bridge and the FET, and tighten the grub screw. Torque it also to 4.5 inch-pounds.

j) Solder each tab to the board in turn, using a solder-pick tool to hold each tab in contact with the board while soldering; apply enough heat to ensure that the pre-tin solder on the boards flows, and apply just enough new solder to give a "butt" free joint. Set the bias resistances at their highest values to get minimum startup current (see step "l" below), and then set the stage bias currents as described in the applicable PA module, Visual Driver, or IPA section of this manual. For a High Band module, position and solder L9 as accurately as possible in its original location.

k) Use eutectic tin-lead 63/37 solder (preferred, but if 63/37 is not available, 60/40 is acceptable). Current manufacturing process at LARCAN uses AIM™ (American Iron & Metal Company Inc.) 63/37 solder containing a "no clean" flux which becomes inert during soldering, therefore does not require subsequent board cleaning. Other good brands are Kester™ and Ersin Multicore™; equivalent 63/37 or 60/40 "no clean" tin-lead solders also should be available from other vendors. If "no-clean" is unavailable, "RMA" (Resin Mildly Activated) core solder can be used; carefully clean the flux residue from the board with an environmentally friendly board cleaning solvent, applied sparingly.

Most commercially available alcohols are reasonable flux solvents that are harmless to circuit boards, and are CFC free and environment-friendly. Proprietary circuit board cleaning solvents are available that also meet these objectives; check with your local electronics parts dealer.

Inexpensive cotton swabs (available in drug stores or supermarkets) can be used for wiping the solvent over the area to be cleaned, then a stiff bristle brush (an old toothbrush) can be used to scrub if necessary. Use the swabs for mopping up the residue. Clean the board thoroughly, then inspect and clean it again; don't merely rearrange the residue. *Be careful - do not allow solvent to run under power transistors where it can dilute the heatsink compound.*

CAUTION: VAPOURS FROM ALCOHOLS AND OTHER SOLVENTS ARE TOXIC AND FLAMMABLE... DO NOT INHALE! IF YOU ARE A SMOKER, DO NOT SMOKE WHILE USING FLAMMABLE SOLVENTS! USE ALL SOLVENTS ONLY IN A PROPERLY VENTILATED LOCATION!

l) Finally, if you have not already done so, set the bias potentiometers for the stage to maximum resistance so that when power is applied, the FET will start at its lowest current. Then set the bias as described in the RF Power Amplifier, Visual/Vision Driver, and IPA RF amplifier sections of this manual. We mentioned this procedure during step "j" above as well, because some circumstances may make it simpler to set the bias in a High Band PA before replacing L9. When L9 is in place, each half of the stage will need to be adjusted concurrently with a bias short on the opposite side (to turn off the side not being set), otherwise the DC path through L9 makes the procedure impossible. This is explained in the applicable PA, Visual Driver, or IPA section of the manual.

8.2 Surface-mount Components Hints and Advice:

Failures of small surface mounted resistors on boards where they were companion to other components having leads, were traced to mechanical overstress of their end caps as a result of the soldering procedure to the component. Our manufacturing procedure has since been altered to fix this problem, and despite our embarrassment, we think it is important that you should know about it. For your information:

1. It is critical that surface mount components are soldered onto a clean flat surface. Use a suction device followed by fluxed braid wick material to ensure that all old solder is removed from pads of the board.

2. If this is not possible due to the presence of other components, try to clean at least one of the pads so it is flat (don't solder this end yet), then solder the other (solder-laden) pad FIRST, pressing the component down into the puddle of solder. (Plain wooden toothpicks will serve well as tools to apply pressure to components while soldering them). The remaining flat pad then can be soldered.

   To ensure minimum stress on any SM component, always be certain that the component is laying flat in contact with the board before soldering except as above when it is necessary to melt the solder on a pad first, and *never force it unless both ends of the component are free to move.*

3. If all the pads are loaded with solder, it will be necessary to heat all terminals of the component simultaneously. Check with your local electronic parts dealer for special soldering iron tips and/or other attachments (in addition to toothpicks) that will aid in surface-mount work.

4. Always keep the tip of your iron clean and freshly tinned (wetted), for maximum heat transfer.

9. REPLACEMENT PARTS

All component parts in the transmitter are available from:

LARCAN Inc., 228 Ambassador Drive, Mississauga, Ontario, Canada L5T 2J2;
Phone (905)-564-9222, or FAX (905)-564-9244, during and after normal working hours.

To expedite delivery of your order, especially if you call after hours and get our answering service, please leave a number where we can return your call, and please identify the parts requested as specifically and completely as possible.

Our Renewal Parts Department may be able to more quickly identify your requirement if the assembly name and number where the part is used, and any applicable revision number for that assembly, are stated in addition to the part's symbol number, description, and its drawing and part number as listed.

Although LARCAN can supply any part when required, in many instances it may be more conveniently obtained from a local source. Part numbers of replaceable components used in LARCAN equipment are almost always the catalog numbers of the various parts manufacturers, with the rare exception of proprietary items such as tightly specified RF power FETs, crystals, or analog 50 µA meters. If your local dealer or distributor should encounter problems and you require further information, please feel free to call upon anyone in our customer service department at the telephone number given above. We have assumed that reliable dealers of electronic components are located in or near your station market area, and that they maintain adequate stocks of "commodity" items such as resistors and capacitors. We have further assumed that you prefer to obtain most non-proprietary replacement parts from your local dealer, therefore we have listed very few such commodity items here, but we believe the following information might be useful to you during your spares requirements planning:

9. REPLACEMENT PARTS (continued).

Capacitors: Generally, most ceramic or film capacitors are reliable, and "5% spares" (1 spare for each 20 identical parts, and 1 each if less than 20) will be found to be a satisfactory inventory level. This includes ceramic, polystyrene, polyester, polycarbonate, polypropylene, and (usually) solid electrolyte tantalums.

Reliability notwithstanding, it is worth the trouble to know exactly what is inside your replacement capacitors. Use a bridge if available, to measure their capacitance (especially for electrolytics), stray inductance, and ESR (equivalent series resistance). Measure leakage current at rated voltage.

Aluminum electrolytics require further consideration. When you consider aluminum electrolytics, usually you will need to consider their operating temperature as well:

The transmitter cooling system was designed to provide worst-case internal temperatures no higher than 60°C, in all modules of the transmitter. This cooling is based on 45°C maximum ambient air temperature and normal air flow through the intakes of the transmitter cabinet.

Most capacitor vendors state that 60°C or lower operating temperatures can be expected to give service lifetimes for their aluminum electrolytic capacitors of ten years or longer, but as their operating temperature increases to the specified maximum of 85°C, the specified service lifetime decreases to a mere 1000 hours.

You may therefore wish to increase your spares level for aluminum electrolytic capacitors if site ambient temperatures are consistently higher than 40°C, because if cooling air flow becomes restricted due to filter saturation, it is entirely possible for on-board temperatures to reach or exceed 85°C. This is why your maintenance program MUST include the regular inspection and replacement of filter media.

Resistors: Experience has shown that a spares stock to the 5% spares level (1 spare for each 20 of the same thing, and 1 of each when less than 20) for each value and size of resistor, is usually sufficient.

Incidentally, when a molded carbon composition resistor (as specified on LARCAN drawings 3R152, 3R77, 3R78, or 3R79) such as those made by Ohmite™ or Allen-Bradley™, is used in an RF circuit, it is not necessarily good practice to make substitution without knowing exactly what the replacement resistor is; in the past, certain makes of FILM resistors have been touted as replacements for molded composition, but unless the resistors are specifically made to be non-inductive, they may be unsuitable because some film resistors are laser-trimmed on a lathe to final value. The resulting helix has significant inductance which can make the resistor unsatisfactory for use in VHF circuits.

It is worth the trouble to know exactly what is inside your replacement components. Use an RF bridge if available, to measure any stray inductance and/or capacitance associated with your replacement resistors.

Spare Parts: The list on the following pages began as computer output listings "STS10B, STS50B, etc." from our database used to compile the parts list data for each Section of the manual, and the computer has classified recommended spare parts and suggested their quantities, by part number. Because the manual is written to apply to the entire low powered basic series of transmitters, we have made a composite suggested spares list by simply combining the computer's Low Band and High Band recommendations.

Because we believe that you are smarter than our computer, we suggest that the parts lists in each Section booklet comprising the manual should be thoroughly and rigorously scrutinized, with the intention of taking your specific local conditions, and your usual dealers or suppliers inventories and order turnaround times into account, before commitment to a sizable inventory of replacement parts.

10. SPARE PARTS RECOMMENDATIONS:

Although it is our sincere hope that they will never be found necessary, it is recommended that a minimum spares stock of the following items be kept on hand.

The STS50B recommendation which follows is for a minimum parts inventory, mostly semiconductors, for a 50 W transmitter built to operate from 105-120 VAC, 1 ϕ, 50/60 Hz, in the frequency ranges encompassing Band I (Low Band channels 2 thru 6) and Band III (High Band channels 7 thru 13). The 10 watt unit uses the same parts as the 50 watt, so the list also applies to the TTS10B and TRS10B models, except for the AC fuse. In the list, the AC fuse for the 50W is marked with a † and the AC fuse for the 10W with a ‡.

The STS50BG1 High Band suggested spares list has one part specific to High Band that naturally does not appear in the STS50BG2 (chans 2-4) or in the STS50BG3 (chans 5&6) Low Band lists, so we have marked that specific part in our composite list with "*" for identification. If your transmitter is High Band (channels 7-13), you may wish to stock all the parts listed; if you have a Low Band unit, simply leave out the "*" part. You may also wish to add more items to the list. Page 10 is available for you to do this.

Recommended quantities for fuses are based on actual usage, but you may find it more economical to purchase them in standard boxes of quantity 5 per value, and replenish when the quantity on hand is equal to the quantity on the list.

LARCAN INC.
Parts List

Level	Parent No.	Description	Quantity
0	40D2168	10 VHF AMPLIFIER COMPOSITE LIST - SUGGESTED SPARES	1 EA

Symbol	Part No.	Description	Quantity
	1N4001	DIODE 1A 50V	2 EA
	1N4148	DIODE SWITCHING	2 EA
	1N5357B	DIODE ZENER 20V 5W	1 EA
	312 007	FUSE 7A 250V <FAST> for RF amplifier	2 EA
	DS2E-SL2-DC12V	RELAY 2 FORM C LATCHING 12VDC	1 EA
	DS2E-S-DC12V	RELAY 2 FORM C MOMENTARY 12VDC	1 EA
	HP5082-2800	DIODE SCHOTTKY see ECG503 or 1N5711	2 EA
	ILQ1	IC OPTO ISOLATOR	1 EA
	LM358N	IC OP AMP DUAL	2 EA
	MC1455P	IC TIMER see 555	1 EA
	MC48B3	FAN, 48 VDC ROTRON	1 EA
	MC7812CT	IC +12 VOLT REG	1 EA
	MC7824CT	IC +24 VOLT REG	1 EA
	MDL-3	FUSE 3A 250V GLASS <SLOW>	1 EA
	MDL 1/4	FUSE 1/4A 250V GLASS <SLOW> for control ps	1 EA
	MHW6185	IC RF AMP	1 EA
	MPS8598	TRANSISTOR PNP GEN PURP	2 EA
	MSC154K	THERMISTOR	2 EA
	MWA330	IC RF AMP in HB preamplifier only	1 EA
	RXE090	PROTECTOR RAYCHEM (control board fuse)	1 EA
	SRF3943-2	TRANSISTOR N-ch DUAL RF POWER FET	1 EA

VHF RF PIN ATTENUATOR BOARD

Contents:

List of Figures:

1. RF Pin Attenuator Board 10A1255G1: Figures 1 and 2.

(Refer also to the RF Metering Board section of this manual)

The function of this board is to limit the output power of the amplifier to about 110% for up to 3dB increase of input power. The Pin Attenuator Board acts as a variable attenuator controlling the input level to the pre-amplifier for AGC and cutback purposes. Operational amplifier U2B controls the amount of attenuation in the circuit. Three inputs are summed at pin 6 from the VSWR and AGC circuits and additionally from U2A which is a "mute" type signal. R5 controls the threshold of these signals. The circuit configuration comprising CR1, CR2 and CR3 form a matched attenuator, biased by the output of U2B, R2, R3, R7 and R8. As the output of U2B lowers due to a voltage increase of one (or more) of the three inputs, the attenuation of the circuit increases, thus decreasing the RF output at J2.

2. AGC/Overpower protection setup

1. Adjust R5 on the Pin Attenuator Board fully clockwise (minimum attenuation).

2. Adjust the input power from the exciter or translator for an output power of about 110% (11Wsp).

3. On the RF Metering Board check that the dc voltage at U1 pin 1 (AGC) is about 1V. If much less, the value of R46 (add-on resistor on the solder side, connected across pins 2 & 8) may need to be changed, i.e. from 560 to 430 ohms.

4. Adjust R5 on the Pin Attenuator board CCW (counter-clockwise) for the output power to drop from 110% to 100%. This 10% reduction corresponds to a dc voltage of about 6V at U2 pin 7 of the Pin Attenuator Board. Check that this is so.

5. Verify AGC/Overpower protection operation by increasing the input to the amplifer (from exciter or channel processor) by about 3dB. The output of the amplifier should not increase by more than 10%.

6. Reduce the level of the exciter or channel processor so that the amplifier output is back to 100%.

AMPLIFIER RF OUTPUT BANDPASS FILTER and DIRECTIONAL COUPLER

Contents:

List of Figures:

1. 30C1064G1 Helical Resonator Bandpass Filter (used with 50 watt High Band):

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., and to the *"ARRL Radio Amateur's Handbook"* published annually by the American Radio Relay League.

AMPLIFIER RF OUTPUT BANDPASS FILTER and DIRECTIONAL COUPLER

1. Bandpass Filter: (continued).

LARCAN bandpass filter implementations 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. Several sizes of coils and enclosures are necessary to cover the desired frequency ranges.

Fold-out Figure 4 indicates the generic assembly of a coupled helical resonator bandpass filter.
The referenced drawing in Figure 4 happens to be a low band filter, but the high band unit is laid out identically and appears almost the same as Figure 4 except the high band helixes have fewer turns of coarser winding pitch, and their shield enclosure dimensions are somewhat smaller.

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 alters the inductance of the helix.

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 4 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 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 < 0.6 dB and f_A < 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 as Figure 1.

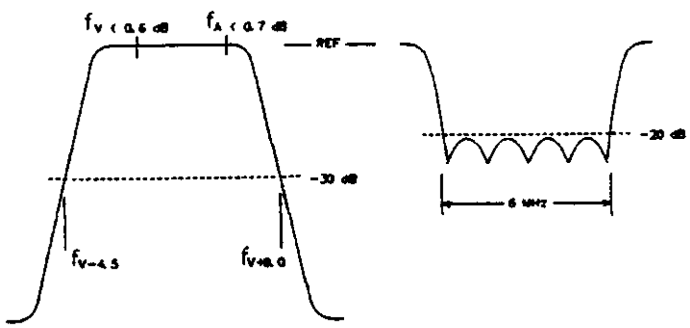


Figure 1: 5-Pole Bandpass Filter Curves.

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.

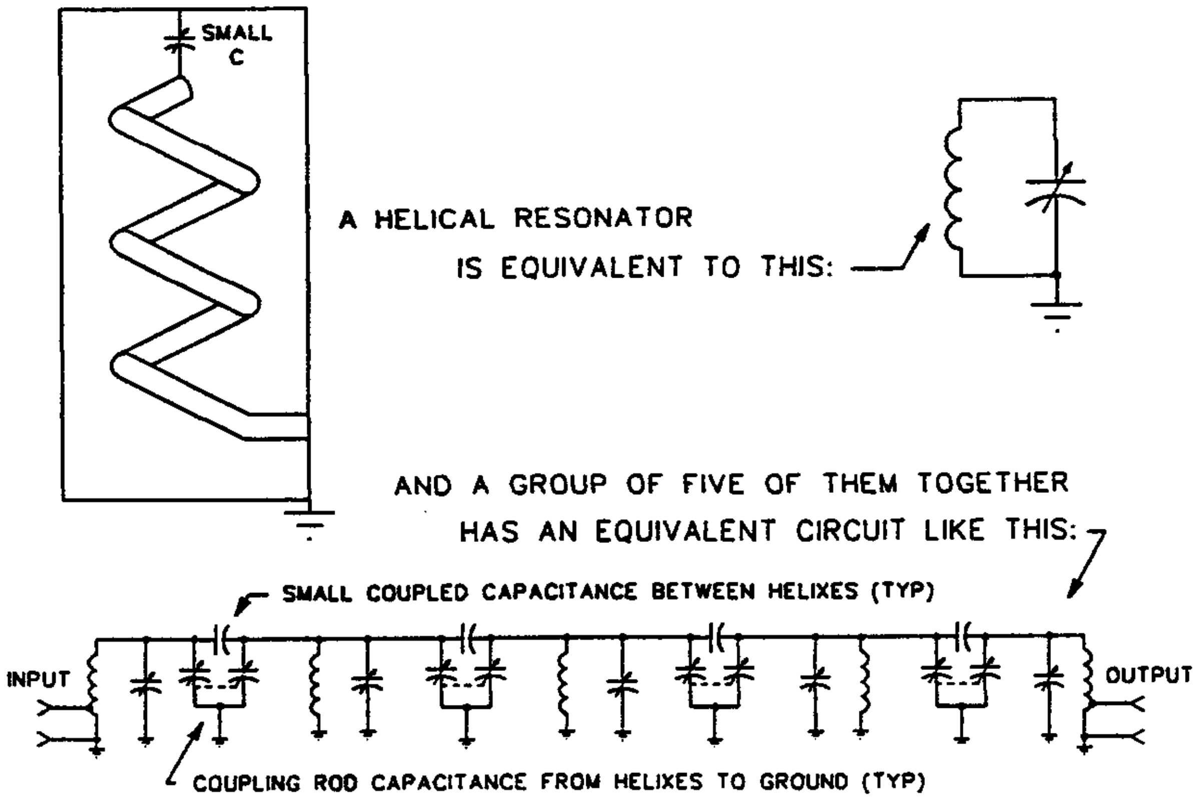


Figure 2: Typical 5-Pole Bandpass Filter.

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.

2. 20B704G1 Low Power Bandpass Filter for High Band:

Please refer to Figure 5. The configuration of this filter is similar to the previously described helical resonator type in that it uses five LC resonant circuits, but it differs in that two of these resonant circuits behave as high Q traps for frequencies outside the band edge (-4.5 and +9 MHz), so that 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 $f_V < 0.6$ dB and $f_A < 0.7$ dB departure from flatness) as described for the helical resonator filter. (We would have preferred to use this 20B704G1 filter for the 50 watt high band system as well, except that the ceramic trimmers overheated due to the higher RF currents at the 50 watt level, so the decision was made to go with the higher power helical resonator filter for 50 watt high band transmitters).

Like the helical resonator filter, 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 impossible without the aid of a network analyzer, and because of the expense of this gear it is not as likely to be available in the field; for this reason we say the filter is not user-adjustable.

Sure, it is possible to use a sweep generator and detector for setting the response of either filter, but unless an accurate 50 ohm return loss bridge is used with the sweep generator, there is no way to properly set up the input and output matching. Our recommendation: don't mess with the filter adjustments at all.

AMPLIFIER RF OUTPUT BANDPASS FILTER and DIRECTIONAL COUPLER

3. 20B1118G1 Low Pass and Notch Filter for Low Band:

Please refer to Figures 6 and 7. Ten adjustable inductors, four fixed inductors (which also can be adjusted slightly by spreading their turns with a suitable tool), and twenty-one fixed capacitors, make up the complete filter. Functionally, it consists of two sections of shunt m-derived low pass network, followed by four bridged-tee notch networks. Its signal direction is intended to be one way only, as indicated in Figure 7.

The low pass section (L1, L2, C1 thru C5) of the filter is designed to cut off at a frequency lower than the second harmonic, so that only the fundamental is able to pass through, but harmonics are blocked.

The four notch sections are tuned to reject f_V-9, f_V-4.5, f_V+9, and f_V+13.5 MHz (down typically 18, 30, 24, and 26 dB respectively - sometimes one of the tuned circuits at f_V-9, either L3 or L5, is readjusted to f_V-4.5 in order to make that notch deep enough that the f_V-3.58 MHz component is sufficiently attenuated).

L4, L7, L10, and L13 are adjusted to set the width and depth of the notch. A typical network analyzer transfer function plot of the filter indicates the four notches at the values stated above, and the band pass of the f_V and f_A frequencies and the channel between, having less than 0.1 dB of ripple.

If your particular filter appears to be missing some of its capacitors, don't be concerned. Probably the "missing" ones are chip capacitors soldered to the pads on the underside of the board. The circuit board is a mature design which was made before surface mount components were in widespread use; occasionally we run out of low value capacitors having leads. Most RF parts used these days are surface mount.

Due to the large number of interacting adjustments in this filter, we recommend DON'T MESS WITH IT.

AMPLIFIER RF OUTPUT BANDPASS FILTER and DIRECTIONAL COUPLER

4. RF Directional Coupler:

A directional coupler is based on the principles of inductive (magnetic) coupling and capacitive coupling.

In the LARCAN quad directional coupler implementation as shown in Figure 3 (schematic equivalent) and Figure 8 (assembly), the RF to be sampled passes through a microstrip transmission line that is connected between the transmitter output filter at J3 and the antenna system at J4. The magnetic field surrounding the hot conductor of this transmission line induces a small RF current flow in other conductors situated parallel to it. One end of each sampling conductor is terminated by a resistor to ground. Sometimes small capacitors are connected across these resistors to provide a termination that remains resistive over the band. The other end of each sampling conductor connects to an external load, usually a 50 Ω input of something such as an RF detector for AGC, the station demodulator, or an RF detector for VSWR sensing.

If the sampling system as described in the forgoing paragraph were dependent only on magnetic coupling and absolutely no capacitance were present, the external loads would be driven with RF samples regardless of the direction they came from. Omnidirectionality is not wanted; our objective is that the system should be directional, that is, a signal coming from the transmitter should be seen by the "forward" ports, and a signal reflected back from the antenna should be seen by the "reflected" ports, but at the same time as little as possible of the forward signal from the transmitter should be seen on these reflected ports.

The desired directivity is achieved by the capacitance between the main line and each sampling line. The presence of this capacitance changes the relative phase of the RF signal seen in the sampling line such that *the capacitively coupled signal adds to the inductively coupled signal at the end of the line nearest the signal source, and subtracts from it at the other end, thus the sample becomes directive.*

This capacitance is trimmed by small "gimmick" capacitors designated (believe it or not) L1 thru L4. This designation arose from a mistaken belief that "inductances are made of wire; ergo, these are inductances." They are in reality short pieces of Teflon sleeved magnet wire which, although they may possess a fraction of a nanohenry of inductance, are mainly small capacitors which are factory adjusted by bending the wire to control the amount of coupling capacitance between the transmission line and the sampling loop concerned. The position of the capacitor along the loop does not seem to matter.

Terminations are provided at the subtractive ends of each of the four sampling lines.

In the enclosure shown in Figure 4, J3 and J4 are the filter and antenna ports respectively, and J1, J5 are "forward" samples which are maximum amplitude for signals incident on J3; while J2, J6 are "reflected" samples which are maximum amplitude for signals incident on J4.

Different coupling values are obtained from the spacing of conductors; the nearer the spacing, the greater the coupling. Coupling is also greater according to frequency, and rises at a rate of about 6 dB per octave. In the boards shown in Figure 4, the J1 and J2 signals will be about 10 dB greater amplitude (about 36 dB below the generator level at 70 MHz on low band or 200 MHz on high band) than the signals sampled from J5 and J6 (about -46 dB). Generally for system purposes the reflected signal sample to the VSWR supervisory system should be taken from the J2 connector because it has greater coupling and we need to measure a much smaller signal in a detector having finite small-signal sensitivity. System forward signals can be taken from J1 for the AGC detector, and J5 for the system monitoring demodulator.

A network analyzer and extremely accurate terminations are required for setting up the directional coupler. The adjustments are made to the trimming capacitances "L1" thru "L4", and the capacitors in parallel with resistors R1 through R4. Our target is directivity of 30 dB or better on each sampling port, and coupling (forward direction) for J1 and J2 about 36 dB down, J5 and J6 about 46 dB down.

No user adjustments are possible nor recommended. Very little can go wrong with the directional coupler other than from the antenna being hit by lightning, and inspection is all that is recommended, nothing more.

SCHEMATIC FOR QUAD DIRECTIONAL COUPLER

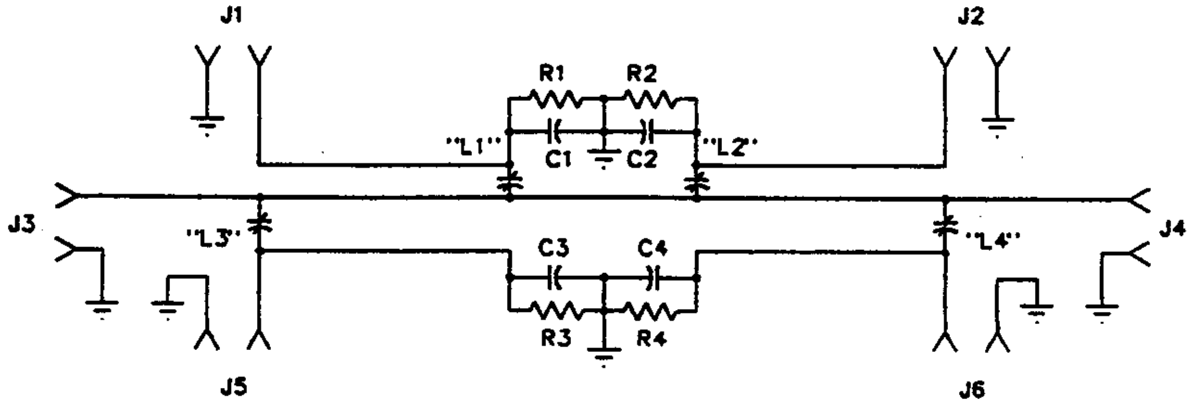


Figure 3: Quad Directional Coupler equivalent Schematic.