PRELIMINARY
TECHNICAL MANUAL
for
TRANSISTORIZED SSB TRANSMITTER/RECEIVER
MODEL TTR-10

WORLD WIDE SUPPLIERS • OF ELECTRONIC COMMUNICATIONS EQUIPMENT •

THE TECHNICAL MATERIEL CORPORATION
MAMARONECK, N.Y. OTTAWA, ONTARIO

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NOTICE

Warranty

The Technical Materiel Corporation, hereinafter referred to as TMC, warrants the equipment (except electron tubes,* fuses, lamps, batteries and articles made of glass or other fragile or other expendable materials) purchased hereunder to be free from defect in materials and workmanship under normal use and service, when used for the purposes for which the same is designed, for a period of one year from the date of delivery F.O.B. factory. TMC further warrants that the equipment will perform in a manner equal to or better than published technical specifications as amended by any additions or corrections thereto accompanying the formal equipment offer.

TMC will replace or repair any such defective items, F.O.B. factory, which may fail within the stated warranty period, PROVIDED:

1. That any claim of defect under this warranty is made within sixty (60) days after discovery thereof and that inspection by TMC, if required, indicates the validity of such claim to TMC's satisfaction.

2. That the defect is not the result of damage incurred in shipment from or to the factory.

3. That the equipment has not been altered in any way either as to design or use whether by replacement parts not supplied or approved by TMC, or otherwise.

4. That any equipment or accessories furnished but not manufactured by TMC, or not of TMC design shall be subject only to such adjustments as TMC may obtain from the supplier thereof.

Electron tubes* furnished by TMC, but manufactured by others, bear only the warranty given by such other manufacturers. Electron tube warranty claims should be made directly to the manufacturer of such tubes.

TMC's obligation under this warranty is limited to the repair or replacement of defective parts with the exceptions noted above.

At TMC's option any defective part or equipment which fails within the warranty period shall be returned to TMC's factory for inspection, properly packed with shipping charges prepaid. No parts or equipment shall be returned to TMC, unless a return authorization is issued by TMC.

No warranties, express or implied, other than those specifically set forth herein shall be applicable to any equipment manufactured or furnished by TMC and the foregoing warranty shall constitute the Buyers sole right and remedy. In no event does TMC assume any liability for consequential damages, or for loss, damage or expense directly or indirectly arising from the use of TMC Products, or any inability to use them either separately or in combination with other equipment or materials or from any other cause.

***Electron tubes also include semi-conductor devices.**

PROCEDURE FOR RETURN OF MATERIAL OR EQUIPMENT

Should it be necessary to return equipment or material for repair or replacement, whether within warranty or otherwise, a return authorization must be obtained from TMC prior to shipment. The request for return authorization should include the following information:

1. Model Number of Equipment.
2. Serial Number of Equipment.
3. TMC Part Number.
4. Nature of defect or cause of failure.
5. The contract or purchase order under which equipment was delivered.

PROCEDURE FOR ORDERING REPLACEMENT PARTS

When ordering replacement parts, the following information must be included in the order as applicable:

1. Quantity Required.
2. TMC Part Number.
3. Equipment in which used by TMC or Military Model Number.
4. Brief Description of the Item.
5. The *Crystal Frequency* if the order includes crystals.

PROCEDURE IN THE EVENT OF DAMAGE INCURRED IN SHIPMENT

TMC's Warranty specifically excludes damage incurred in shipment to or from the factory. In the event equipment is received in damaged condition, the carrier should be notified immediately. Claims for such damage should be filed with the carrier involved and not with TMC.

All correspondence pertaining to Warranty Claims, return, repair, or replacement and all material or equipment returned for repair or replacement, within Warranty or otherwise, should be addressed as follows:

THE TECHNICAL MATERIEL CORPORATION
Engineering Services Department
700 Fenimore Road
Mamaroneck, New York

RECORD OF CORRECTIONS MADE

Change No.	Date of Change	Date Entered	Entered By

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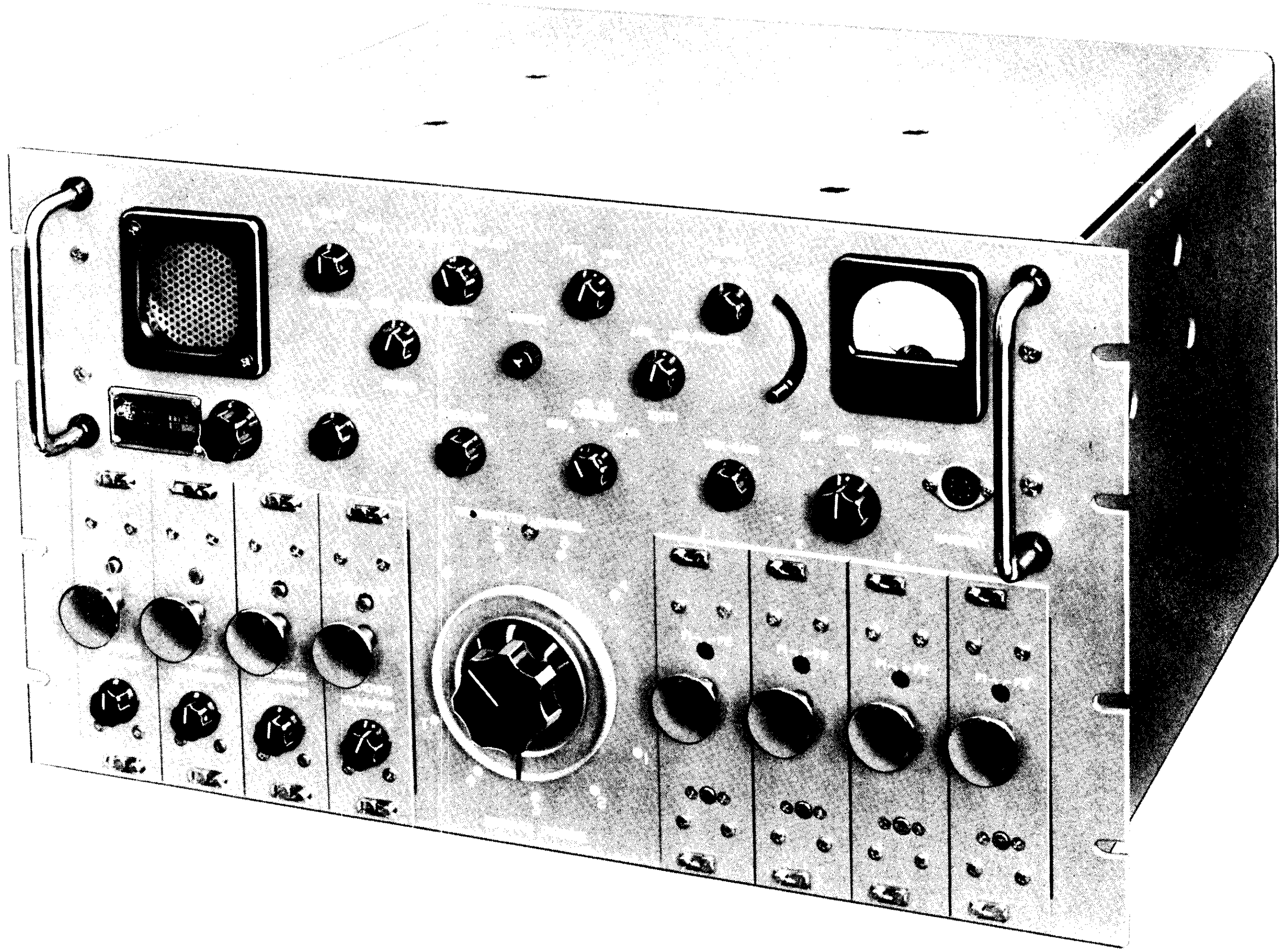


Model TTR-10 Transistorized SSB Transmitter/Receiver

SECTION 1

GENERAL INFORMATION

INTRODUCTION TO TTR-10

The Model TTR-10 is a 4-channel transistorized transmitter-receiver with a frequency range of 2 to 32 mc. Operating in either upper or lower sideband, cw, a-m equivalent, mcw or sideband with carrier 20 db below peak power, the unit's flexibility allows it to be used in simplex and duplex telephone and telegraph systems with compatible operation with conventional double sideband a-m systems. Four pre-tuned receiver transmitter plug-in modules afford selection of two closely related frequencies.

The transmitter section consists of an all transistor double conversion exciter having a PEP two-tone output power of .25 watt which is amplified to a level of 100 watts by a two stage vacuum tube final. The transmitter features both push-to-talk and VOX (voice operated relay) operation.

The receiver section consists of a double conversion all-transistor superhetrodyne unit with a sensitivity of one microvolt or better for a 15 db signal-plus-noise to noise ratio. Features found in the receiver include agc, squelch, and two separate audio outputs: 3.2 and 600 ohms.

The unit is capable of operating from 115 vac, 208 vac, or 230 vac, 50 to 400 cps; an optional power supply permits 12, 24 and 32 vdc operation.

AMPLITUDE MODULATION VRS SINGLE SIDEBAND

In order to explain single sideband (SSB) and its advantages ov r amplitude modulation, let's take a long look at the amplitude modulated signal. Figure la shows an ordinary carrier modulated by an audio tone sinusoidal signal, while in figure lb, its relative spectrum is illustrated. It will be seen that for a full 100% modulation, 50% of the power is developed in producing the envelope, so that if, for arguments sake, we use a 100-watt transmitter to produce this envelope, such a transmitter will actually be producing 150 watts of r-f power with 50 watts being used in the sidebands and 100 watts being required to produce the carrier.

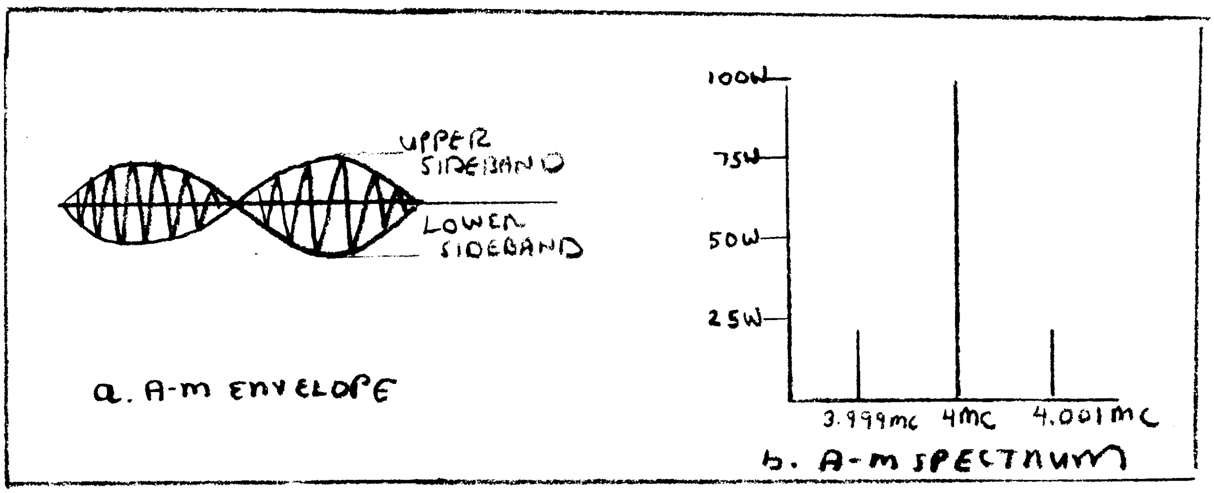


FIGURE 1. A-M SIGNAL

Looking at diagram 1b, note that it depicts a vector showing th rat d carrier power of 100 watts and on either side of it, spaced in the frequency spectrum according to the frequency of the modulation used, we have the two sidebands, the lower and upper, each having 25 watts of power. Now, looking back at the modulation envelope, you will s e that the intelligence on the upper sideband, is identical with the intelligence on the low r sideband, displaced by 180 degrees, and is, in fact, the mirror image of it. Important to remember, is that either one of these sidebands, upper or lower, carries the same intelligence and either one of them is sufficient to produce, in a radio receiver under the right conditions, all the intelligence that is necessary for communications.

If this is the case, then you can see from the diagram that, in order to produce 25 watts of intelligence power, we really have to use a system capable of handling 150 watts.

Now supposing we were to remove the carrier completely. With the same input power available, you would now find that the distribution contained in the sidebands would be 50 watts in each sideband. S e Figure 2a. So that by the mere removal of the carrier itself, even using both sidebands, we have increased the talk or intelligence power of our transmitting system by a factor of two, i.e. 3db. This is exactly what happens, assuming that both power sources are the same in either case. Now, as we have shown that both sidebands contain the same identical intelligence, it is really quite unnecessary to use them both if one will do, so let us remove one of the sidebands and you now have immediately doubled the power in the remaining sideband. See Figure 2b. In other words we have 100 watts full rated power contained in the intelligence of the sideband we are using and we have increased our talk or intelligence power over the amplitude modulated condition, four times, or 6db, a very important advantage you will no doubt agree.

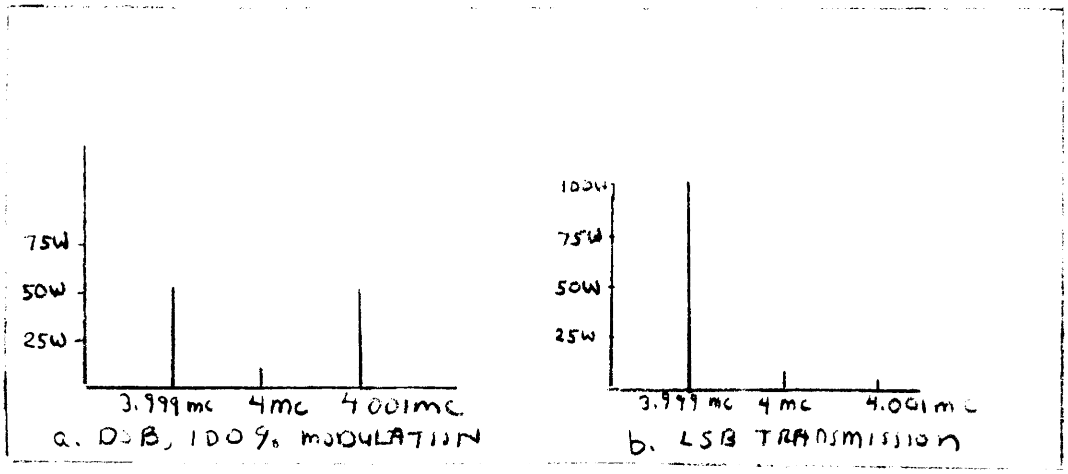


FIGURE 2. SIDEBAND SPECTRUM

COMPARISON OF SIGNAL-TO-NOISE RATIO WITH SSB AND A-M

One of the most straightforward manners in which to evaluate the r lative advantages of AM systems and SSB systems, is to determine the transmitting power necessary to produce a given signal-to-noise ratio at the receiver for the two systems. This is considered a fair comparison as it is the S/N ratio which determines the intelligibility of the received signal. Figure 3 shows such a comparison, where 100% signal tone modulation is assumed. Fig A in this diagram shows the power spectrum for an AM transmitter rated at one unit of carrier power with 100% sine wave modulation. Such a transmitter actually produces on and one-half units of R.F., power; 1/4 unit of power in each of th two sidebands and one unit in the carrier. This transmitter is compar d with a Single Sideband transmitter rated at 1/2 unit of P ak Envelope Power (Peak Envelope Power being defined as the rms power dev lop d attthe crest of the modulation envelope). These graphs show that an SSB transmitter rated at 1/2 unit of Peak Envelope Power (PEP), will produce the same S/N ratio in the output of the receiver as the AM transmitter rated at one unit of carrier power. Fig B in this diagram indicates the voltage vectors related to the power spectrum. Th AM voltag v ctors show th upp r and lower sid band voltages of 1/2 unit, rotating in opposit dir ctions around th carrier voltage of one unit. For AM modulation, th r sultant of the two sid band vectors must either be directly in phas or dir ctly out of phas with the carrier and the resultant shown when the upper and lower sid band voltages are instantaneously in phase, produces a peak envelope voltag equal to twice the carrier voltage with 100% modulation. The 1/2 unit shown in Fig. A, power being proportional to the square of the voltage. In the SSB case, the signal vector of .7 unit of voltage at the upper sideband frequency, produces the 1/2 unit of power shown in Fig. A. In Fig. C, of this diagram, is shown the RF envelopes developed by the voltage vectors. That of the AM signal is shown to have a Peak Envelop Voltage (PEV) of two units, the sum of the two sideband voltages plus the carrier voltage. This results in a Peak Envelope Power of four units of power. In the case of SSB, the Peak Envelope Voltage is 0.7 units of voltage for a resultant Peak Envelope Power of 1/2 unit of power. Fig. D, in this diagram shows the respective demodulated signals in both cases. In the case of AM, an audio voltage develops which is equivalent to the sum of the upper and the lower sideband voltages in this instance, one unit of voltage. In the case of the SSB receiver, an audio voltage of 0.7 units develops, which is equivalent to th transmitter upper sideband signal.

If an arbitrary broadband noise level of 0.1 unit of voltage is chosen for the 6 kc bandwidth of the AM receiver, then the same noise l vel is equal to 0.07 of voltage for the 3 kc bandwidth of the SSB signal, and this is shown in Fig. E, of the diagram. These values repr sent the same noise power level per Kc of bandwidth:-

i.e. $\frac{.1^2}{6} = \frac{.07^2}{3}$

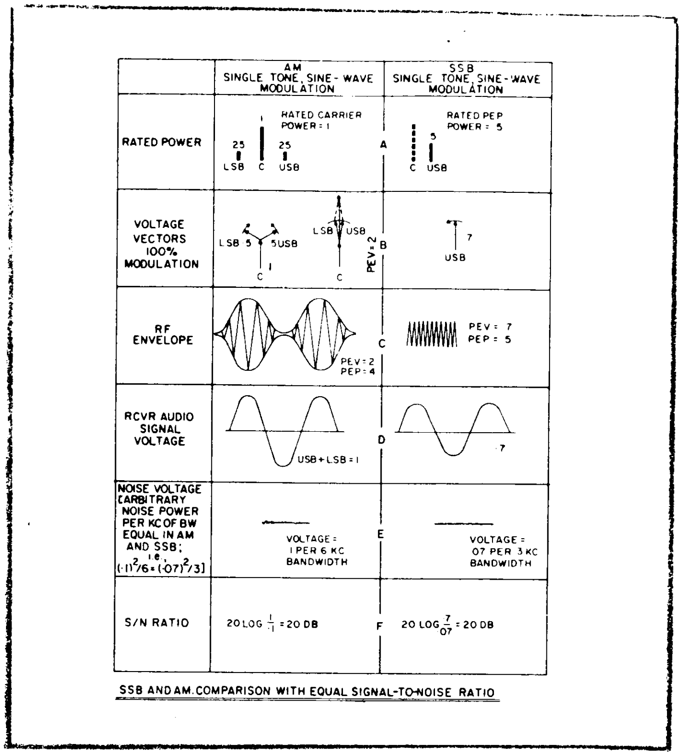


FIGURE 3. SSB AND AM COMPARISON

With this chosen noise level, the S/N ratio in the AM system is 20 log S/N in terms of voltage, or 20db and the S/N ratio of the SSB system is also 20db, the same as for the amplitude modulated system. Therefore the 1/2 power unit of rated Peak Envelope Power for the SSB transmitter produces the same signal intelligibility as the one power unit rated carrier power for the AM signal. This conclusion can be r - stated as follows:-

Under ideal propagation conditions but in the presence of broadband noise, the SSB and AM systems perform equally if the total sideband power of the two transmitters is equal.

This means that the SSB transmitter will perform as well as an AM transmitter, with TWICE the carrier power rating, under ideal propagation conditions.

It is a basic fact that the more selective the receiver, the b tter the S/N ratio, and due to the 3 Kc bandwidth required for SSB as opposed to 6Kc for AM., it can b said that an additional 3db gain in the reception of SSB is achiev d, thus making the total gain of power incr as over AM, of 9db. There is a considerable difference of opinion as to whether or not this last 3db gain exists, especially in the presence of impulse-type noise, so that this is subject to debate. How much of the total 9db gain is actually realized in operation depends entirely on the frequency spectrum band conditions. Under ideal conditions, there is little difference in AM or SSB signals, but as the propagation conditions deteriorate, SSB has an increasing advantage over AM signals. This is adequately displayed in the graph depicted in Figure 4. In this presentation you will see the "Intelligibility" in decibels plotted on the "Y" axis against varying propagation conditions on the "X" axis. Taking zero db as a reference point, it will be seen that either the AM or SSB transmitter with equal sideband power, will perform equally well for ideal conditions. Under somewhat less than ideal conditions, termed "Good" in the graph, you will see that the SSB transmitter has a gain of 3db over the AM transmitter, a gain of 6db for poor conditions and approximately 9db under severe fading and interference.

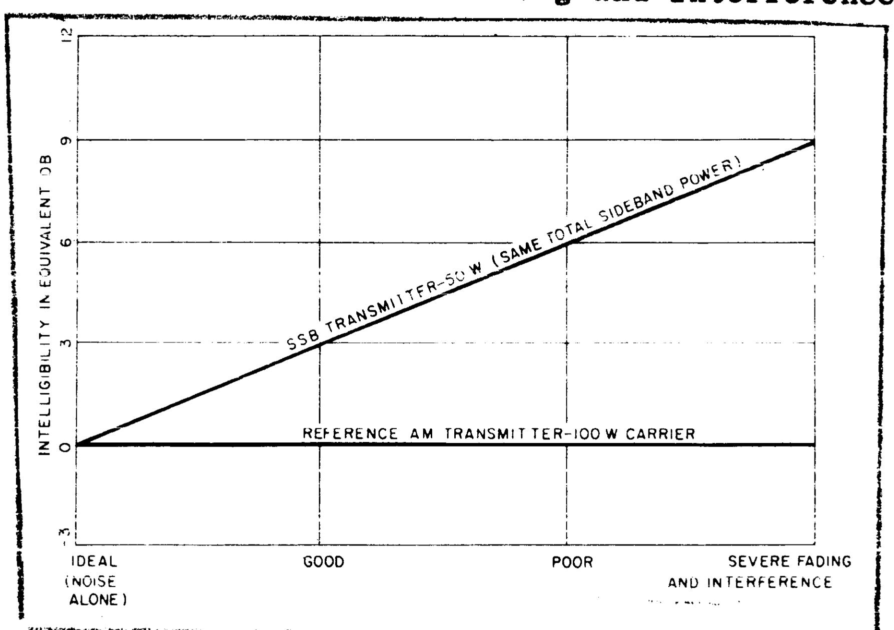


FIGURE 4. SSB VRS AM WITH LIMITING PROPAGATING CONDITIONS

extreme distortion upon demodulation, in fact over-modulation. This condition is depicted in Figs D, E and F, of the diagram under the Carrier Fading, heading.

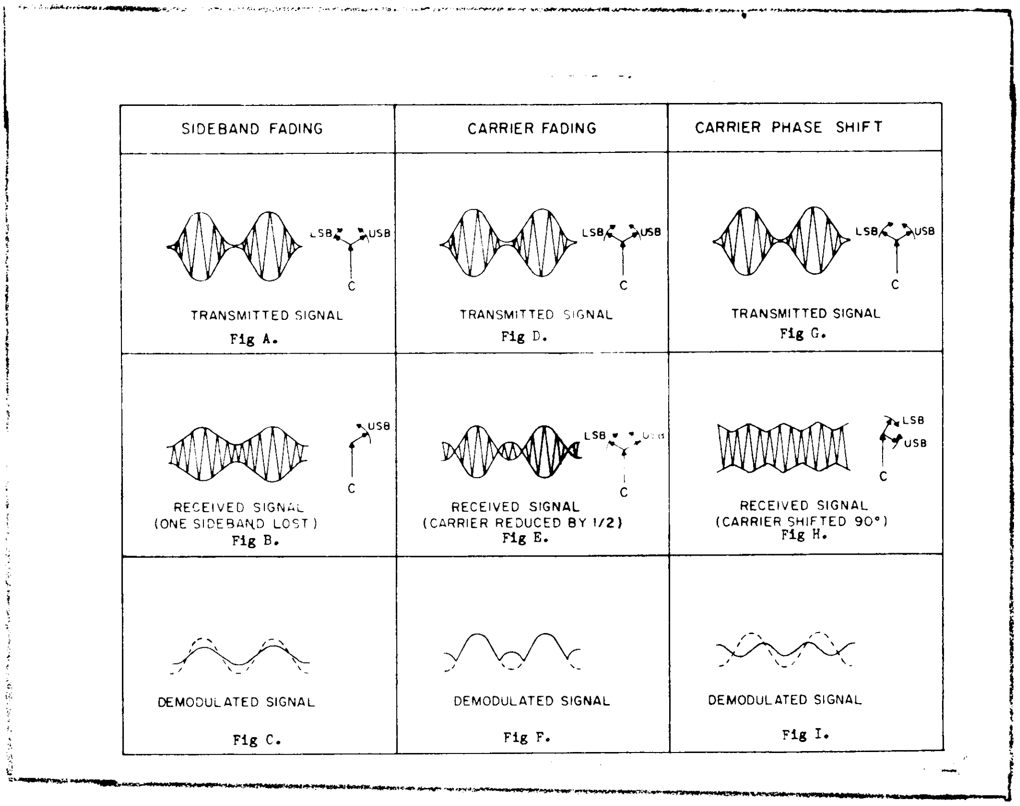


FIGURE 5. DETERIORATION OF AM SIGNAL WITH SELECTIVE FADING

In the category of "Selective Fading" there is also a shifting between the relative phase position of the carrier and the sidebands and, as shown in the diagram Figs G and H, the AM signal is vectorially represented by two counter-rotating sideband vectors which rotate with respect to the carrier vector. The resultant of the sideband vectors is always directly in-phase or directly out-of-phase with the carrier vector. In extreme cases the carrier may be shifted 90° from its original position (Fig. H) and of course, when this occurs, the resultant of the sideband vectors is $\pm 90^{\circ}$ out of phase with the carrier vector. This has the eff ct of converting th original AM signal to a phase-

SSB ADVANTAGES DURING SELECTIVE FADING CONDITIONS

Single Sid band transmission and reception has another distinct advantage over AM, under selective fading conditions. With long distance H/F transmissions (Sky wave), AM transmission is subject to selective fading, producing severe distortion in many instances and often a weak signal due to fading that is quite unintelligible. The AM transmission is subject to deterioration under these poor propagation conditions because all three components of the transmitted signal, th upp r sideband, the lower sideband and the carrier, must be rec ived exactly as transmitted to realize fidelity and the theoretical power from the signal. Figure 5 depicts this deterioration of the AM signal under different types of selective fading. In the case of sideband fading, the loss of one of the two transmitted sidebands, r sults only in a loss of signal voltage from the demodulator, with som slight distortion. This distortion is not basically detrimental to th signal as the ONE SIDEBAND CONTAINS THE SAME INTELLIGENCE AS THE OTHER. Howver, as the receiver is operated on a broad bandwidth, the noise level r mains constant even though only one sideband is received and this is equivalent to a 6db deterioration in the S/N ratio out of the receiv r. Looking at Figure 5, we see in Fig A, the original transmitted signal for AM conditions, in Fig B, the form of the received signal when on sid band is lost and in Fig C, the resultant demodulated signal.

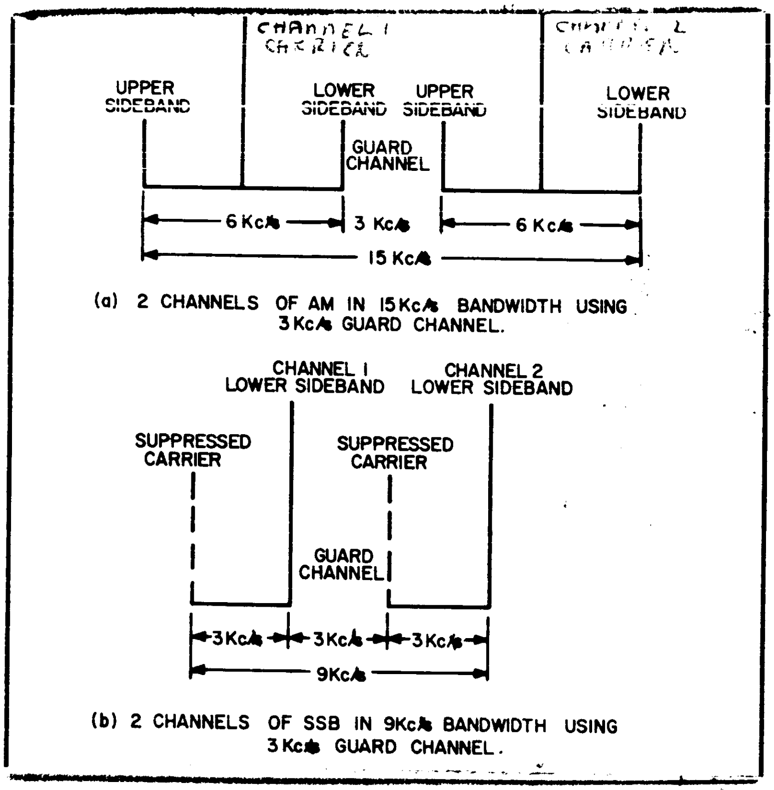
The most serious result of selective fading to an AM signal, and incidentally, the most common occurs when the carrier level is attenuat d more than the sidebands. Under these conditions, the carrier voltage at the receiver is less than the sum of the two sideband voltag s and th RF envelope does not retain its original shape, with resultant modulated signal and th envelope b ars no resemblance to the original. Consequencly the conventional detector will not produce an intelligibl signal.

In single sideband, the signal is not subject to deterioration due to selective fading. Since only one sideband istransmitted, th r ceived signal level does not depend upon the resultant amplitude of the two sideband signals as it does in AM. Since this is so, no distortion can result, or loss of carrier power, or phase shift. Selective fading within the one sideband of the SSB only changes the amplitude and the frequency response of the signal. It rarely produces enough distortion to cause the received signal or voice to be unintelligible.

FREQUENCY SPACE CONSERVATION

Another very important advantage of SSB is the conservation and greater utilization of the frequency spectrum. It has been established that int lligent voice frequencies can be contained in the audio frequ ncy ranges from 300 to 3000 cycles. Taking this premise, you can see that in the AM condition a total bandwidth of 6Kc is required, 3kc for th upper sideband and 3kc for the lower sideband.

Now if a guard channel of 3kc is used, the next AM station taking up a further 6kc means that the two AM channels require a total frequency sp ctrum space of 15 kc. (See Figure 6). In the case of SSB, two voice channels can be contained in a frequency spectrum space in Figure 7. Further by judicious choice of locations and non-interfering antenna, two SSB stations could be operated on the same frequency, one using lower sideband and the other using upper sideband, thereby more than doubling the channel capacity of the already overcrouded high frequency spectrum. This close spacing of frequency allocations for SSB is within practical limitations due to the fact that only one sid band is b ing us d and mor important, we have removed the carrier from th sp ctrum. The carrier in its lf is a source of troubl creating interference due to the heterodyning principle where two carriers adjacent to on another often create audible interference in the demodulating stages of the receiver. Once this carrier is removed, as in SSB, this annoyance is no longer present.



(a) 2 CHANNELS OF AM IN 15Kc/s BANDWIDTH USING 3Kc/s GUARD CHANNEL.

(b) 2 CHANNELS OF SSB IN 9Kc/s BANDWIDTH USING 3Kc/s GUARD CHANNEL.

FIGURE 6. FREQUENCY SPACE CONVERSION

COMPARISON OF SSB WITH FM

We must note that most of the experimental work carried out to valuate the performance of SSB systems, has been in its comparison to AM signals. For the record, it must be stated that some work has be n done to evaluate its performance with FM systems slso, and Diagram 7 shows the predicted results in one such study of an FM system as measured against a comparable SSB system. In this diagram the S/N ratio in decibels is shown against the attenuation between the transmitter and receiver also in decib ls. This graph shows that betwe n 150 and 160 db of attenuation between the transmitter and the receiver, i.e. a strong signal, the narrowband FM system provides a b tter S/N ratio than the SSB system. However, on a weaker signal, attenuation from 168db onwards, the S/N ratio of the SSB system is better. The conclusions are, that for strong signals the FM system will be better; but this is not an important advantage because when the S/N level is high, a still better S/N ratio will not improve intelligibility. For weaker signals however, SSB will provide an intelligible signal where the FM will not. However, the most important advantage for SSB over FM is that it conserves spectrum space by a factor of 3, as compared to the narrow-band FM:- 4kc versus 12kc in the instance shown on the diagram. An even further saving in spectrum space would be achieved if a 3kc SSB system was used.

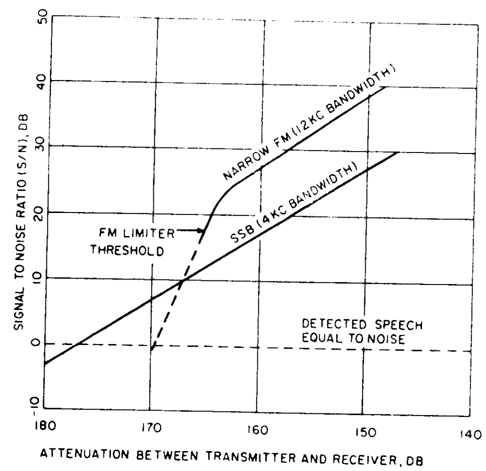


FIGURE 7. SSB PERFORMANCE COMPARED WITH FM

SECTION 2

TECHNICAL SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

TRANSMITTER

FREQUENCY RANGE: - - - - - - - - - -	2-32 mcs. Four fixed tuned channels in any combination of the following bands: 2-4, 4-8, 8-16, 16-32 mcs.
FREQUENCY CONTROL:- - - - - - - - -	1. The transmitter and receiver modules are crystal controlled, with front panel selection of one of two crystals, as standard equipment. 2. Optional/crystal ovens control stability to 1 part in 10^6 or better.
TUNING: - - - - - - - - - - - - - -	Front panel switches provide selection of any one of four transmit and receive channels separately or ganged.
MODES OF OPERATION: - - - - - - -	Front panel selectable SSB (upper or lower), compatible a-m, -20 db, mcw, and c-w. Simplex operation by use of coaxial antenna transfer relay, or duplex operation can be accomplished with separate antennas.
FREQUENCY RESPONSE: - - - - - - -	$\pm$2 db 300 to 3300 cps (mechanical filter).
NOISE LEVEL: - - - - - - - - - -	Better than 40 db below full PEP.
METERING: - - - - - - - - - - -	Front panel meter monitors PA plate current, PA drive and RF output voltage.
MECHANICAL: - - - - - - - - - - -	Standard 19" relay rack mount. Optional cabinets are also available.

ELECTRICAL CHARACTERISTICS (Cont)

TRANSMITTER/RECEIVER SPECIFICATIONS

POWER SUPPLIES: (plug-in) - - - - - - - - - -
1. AC power supply for operation on 115, 208 or 230v ±10%, 50 to 400 cps or 12, 24 and 32 vdc.
2. Other supplies available on request.

SAFETY FEATURES: - - - - - - - - - -
1. PA magnetic operated overload circuit breaker on front panel.
2. All DC operating voltages fused.
3. Transformer primary fused.
4. Oven supply lines fused.
5. Interlock on output modules prevents accidental operation when no module is in place.

DIMENSIONS: - - - - - - - - - - - - 10-1/2" h x 19" w x 16-1/2" d.

WEIGHT: - - - - - - - - - - - - - - Approximately 65 lbs less cabinet and slides.

RECEIVER SPECIFICATIONS

INPUT IMPEDANCE: - - - - - - - - - - Nominal 50 ohms unbalanced.

SENSITIVITY: - - - - - - - - - - - - 1 uv for 15 db, signal + noise to noise ratio.

SELECTIVITY: - - - - - - - - - - - - Nominal 3.0 kc USB or LSB.

IMAGE REJECTION: - - - - - - - - - - Minimum 50 db from 2-28 mcs; minimum of 40 db 28-32 mcs.

INTERMODULATION: - - - - - - - - - - Intermodulation distortion products are down a minimum of 35 db from PEP with 100 microvolts two tone at the antenna.

SQUELCH: - - - - - - - - - - - - - - Threshold adjustable squelch. AGC activated relay has contacts brought to rear panel for remote indication of receiver signal activity.

ELECTRICAL CHARACTERISTICS (Cont)

RECEIVER SPECIFICATIONS

AF OUTPUT - - - - - - - - - - - - -	1 milliwatt into 600 ohm line available for headset, extended service or telephone handset. 500 milliwatts into 3.2ohm speaker.
AGC: - - -- - - - - - - - - - - - -	Delayed AGC. Output rise less then 6 db for 100 db antenna rise from 1 uv.
SPEECH CLARIFIER: - - - - - - - -	Manually controlled frequency adjustment.

TRANSMITTER SPECIFICATIONS

OUTPUT IMPEDANCE: - - - - - - - - -	Nominal 50 ohms unbalanced with VSWR of 2:1 maximum.
POWER OUTPUT: - - - - - - - - - - -	A minimum of 100 watts PEP.
CARRIER SUPPRESSION: - - - - - - -	+6, -20, -50 db from full PEP output.
SPURIOUS & HARMONIC OUTPUT:- - - -	50 db minimum below full PEP output.
UNWANTED SIDEBAND REJECTION: - - -	At least 50 db below full PEP output.
DISTORTION PRODUCTS: - - - - - - - -	35 db minimum below full PEP output.
AUDIO INPUT: - - - - - - - - - - - -	600 ohm, -20 dbm, balanced and center tapped telephone handset carbon mike, hi and lo Z mike.
AF RESPONSE: - - - - - - - - - - - -	Nominal 3 kc at 3 db points. ± 2 db 300 to 3300 cps.
OVERLOAD LIMIT: - - - - - - - - - -	Special built-in circuitry minimizes overloading of transmitter.
VOICE OPERATED RELAY: - - - - - -	Voice operated relay with adjustable VOX and anti-VOX controls available on front panel.

TRANSISTOR AND TUBE COMPLEMENT

Table 1 lists the transistors and tubes along with their reference symbols and functions as found in the TTR-10. The 100, 200, 300, and 400 series modules refer to the 2-4, 4-8, 8-16, 16-32 mc modules respectively in the receiver section while the 500, 600, 700, and 800 series refer to the same frequency coverage modules found in the transmitter.

TABLE 1. TRANSISTOR AND TUBE COMPLEMENT

REFERENCE SYMBOL	TYPE	FUNCTION
	RECEIVER	
Q101,Q201	2N2084	1st RF Amplifier
Q301,Q401	2N2495	1st RF Amplifier
Q102,Q302	2N2084	2nd RF Amplifier
Q402	2N2495	2nd RF Amplifier
Q203,Q303	2N2084	3rd RF Amplifier
Q403	2N2495	3rd RF Amplifier
Q103,Q204) Q304,Q404)	2N2084	1st Mixer
Q104,Q205,Q305	2N2084	Buffer
Q405	2N2495	Buffer
Q105,Q206,Q306	2N2084	Oscillator
Q406	2N2495	Oscillator
Q1601	2N2084	IF Amplifier
Q1602	2N2084	2nd Mixer
Q1603,Q1604	2N1370	1st Audio Amplifier
Q1605	2N2084	BFO Buffer
Q1606	2N2084	BFO
Q1607,Q1608	2N2084	Sideband Selection OSC
Q1609	2N2084	Sideband Selection Buffer
Q1610	2N207	AVC Amplifier
Q1611	2N214	AVC Amplifier
Q1612	2N213A	AVC Amplifier
Q1613,1614,1615	2N1370	Audio Amplifier, Driver
Q1616,Q1617	2N1033	Audio Output AMP
Q1618	2N1370	0 DBM Amplifier
Q1619,1620	2N1370	Monostable Multivibrator (Squelch)
Q1621	2N2001	Squelch Relay Driver

TABLE 1. TRANSISTOR AND TUBE COMPLEMENT (Cont)

REFERENCE SYMBOL	TYPE	FUNCTION
TRANSMITTER		
Q501	2N2084	HF Oscillator
Q601,70,801	2N2495	
Q502	2N2484	HF Oscillator
602,702,802	2N2495	Buffer
Q503,504	2N2084	2nd Balanced
603,604,703,704, 803,804	LN2495	Mixer
Q505	2N2084	1st RF Amplifier
605,705,805	2N2495	
Q506	2N2084	2nd RF Amplifier
606,706,806	2N2495	
Q507,607,707,807	TX100(2N2219)	3rd RF Amplifier (1/4W)
Q1701	2N214	VOX Antitrip AMPμ
Q1702,Q1703	2N1370	Audio Amplifiers
Q1704,1705	2N1370	VOX Amplifier
Q1706	2N213	DC Amplifier Vox
Q1707	2N1370	" "
Q1708	2N2001	VOX Relay Driver
Q1709,1710	2N2084	1st Balanced Mixer (Sideband Selection)
Q1711	2N2084	IF Amplifier
Q1712	2N2084	Carrier Oscillator (250k)
Q1713,1714	2N2084	" " Buffers
Q1715	2N2084	Sideband Sel. Buffer
Q1716,1717	2N2084	Sideband Sel. OSCμ
Q1501	2N1213A	CW Oscillator
V1500	6GK6	IPA
V1501	8117	Power Amplifier
POWER SUPPLY		
Q901,Q902, Q903	2N350A	Series Regulators

DIODE COMPLEMENT

Table 2 lists the diodes found in the TTR-10 along with their reference symbols and functions.

TABLE 2. DIODE COMPLEMENT

REFERENCE SYMBOL	TYPE	FUNCTION
	TRANSMITTER	
CR1701, CR1702	IN23A	Antivox Det
CR1703, CR1704	IN23A	Vox Det
CR1704	IN34A	Clipper
CR1706-CR1709	IN34A	Balanced Modulator
CR1500, CR1501	IN67	Meter detector
	RECEIVER	
CR1601-CR1604	IN34A	Demodulator
CR1605-CR1607	IN68	AGC Detector
	POWER SUPPLY	
CR901-CR904	IN547	Bias Network Rectifier
CR905	IN300 GRB	Bias Regulator
CR906, CR907, CR908	IN300 6RB	Screen Grid Regulator
CR909	DD-109	HV Rectifier
CR910, CR911 CR913, CR914, CR916, CR917	IN547	LV Rectifier
CR912, CR915	IN3022B	Voltage Reference
CR918	IN3033B	Voltage Reference

FUSE COMPLEMENT

Table 3 lists the fuses found in the TTR-10.

TABLE 3. FUSE COMPLEMENT

REFERENCE SYMBOL	TYPE
F900	5A/115 vac 3A/208 vac 3A/230 vac
F901	depends upon number of ovens
F902	.1 Amp Slo-Blo
F903	1/4 Amp Slo-Blo
F904,F905	3/4 Amp Slo-Blo
F906	.187 Amp Slo-Blo

SECTION 3

INSTALLATION

INITIAL INSPECTION

The TTR-10 Unit has been carefully tested and calibrated at the factory prior to shipment. Upon arrival at the operating site, inspect the packing case and contents for possible damage. Inspect all packing material for parts which may have been shipped as "loose items".

The Technical Materiel Corporation will assist in describing methods of repair and the furnishing of replacement parts for damage for which the carrier is liable.

Check the front panel of the TTR-10 to make sure that all knobs are tight. Note that all modules are securely locked in place by the small catch-locks located on each module. Then remove the top and bottom dust covers by removing the screws which secure the covers to the main chassis. Once the covers are removed, inspect the circuitry inside to make sure that everything is firmly in place. Also check power amplifier tubes, wiring, and connections. The power supply sub-chassis, located at the rear of the main chassis, should be removed and inspected then replaced. Finally inspect fuses.

LOCATION AND MOUNTING

The TTR-10 is designed for rack or cabinet mounting. When the TTR-10 is housed in a well-ventilated case for fixed operation, place the unit on any sturdy mounting area of 19 inches wide by 16 inches deep. When the unit is housed in a cabinet and used for mobile operation, securely bolt the shock mounts to a table or shelf that is rigidly fastened to the vehicle. Allow space for ventilation, for access to the connections at the rear panel and for withdrawal of the various modules and power supply sub-chassis from the case on servicing. The unit is bolted in place at the front panel and at the rear of cabinet. Figure 2-1 shows the outline dimensions of the unit.

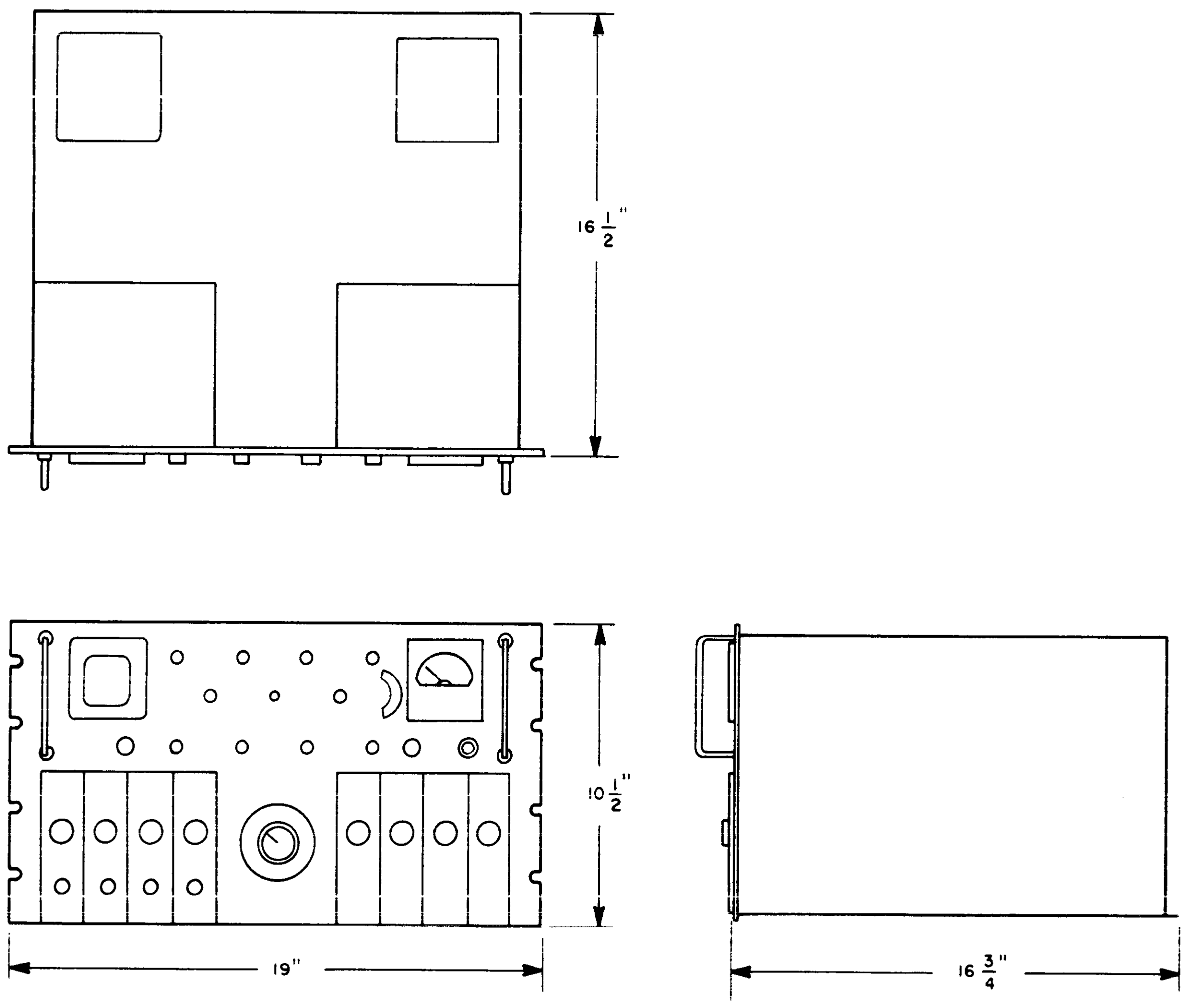


Figure 8. Outline Drawing

POWER SOURCE

Because of the versitility of the power sources which can be used for the TTR-10, make sure that proper connections are made to the two power transformers. The unit will operate on 115 vac, 208 vac, or 230 vac $\pm$ 10%, 50 to 400 cps. Source voltages of 12, 24 or 32 vdc can also be used with the proper power supply. To change the transformer connections the power supply sub-chassis must be removed from the main chassis. Do this by unscrewing the four screws at the rear of the unit and two side screws and then pulling the sub-chassis out.

Figure 9 shows input connections to the transformers for various source voltages. Wire accordingly. A note of caution: should it be desirable to use an external oven voltage instead of the internal one, use the voltage stamped on the ovens in the modules only. Transformer connections are normally made at factory for specified operating voltage. The right amperage fuse must be used at F900; it should be 5 amps for 115 vac and 3 amps for 208 or 230 vac.

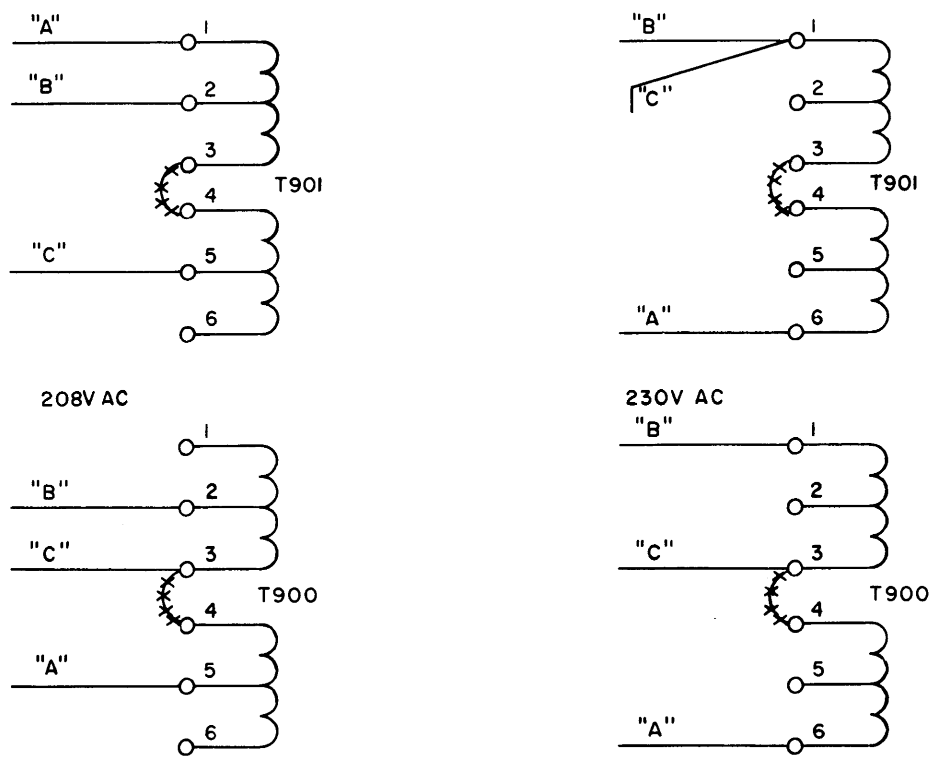


Figure 9. Transformer Connections

ELECTRICAL CONNECTIONS

Figure 10 shows the rear panel of the unit. The source voltage is connected to AC INPUT jack J900. Should it be desirable to use an external 115 vac for the oven, place the OVEN VOLTAGE switch in EXT' position, otherwise leave it in the INT position.

A handset may be connected to the HANDSET jack (J1515) located on the front panel. A 600-ohm line input may be connected to terminals 1, 2, 3 in terminal board TB1500. A high impedance microphone (in the order of 20 K) is connected to terminal 5 on terminal board TB1500 while a low impedance microphone (in the order of 1 K) may be connected to terminal 6. Other connections at this terminal board include a carbon microphone input (terminal 4) and a push-to-talk connection (terminal 5).

An external speaker is connected at terminal 8 of TB1501. IF it is desired to have both an external speaker and the internal speaker operate, leave the wire connected between terminals 8 and 9 there. If it is desirable to operate just the external speaker, disconnect wire from terminal 9 and disconnect speaker to terminal 8. An earpiece or headphone can be connected across terminal 12 of TB1500. A 600-ohm audio output is connected across pins 1, 2, and 3 of terminal board TB1501. An external squelch alarm can be connected at pins 4, 5, and 6 of TB1501.

For telegraph operation, a key can be connected to terminal 12 and 11 of TB1500. A remote sideband selector switch used to determine which sideband is demodulated can be connected to pins 9 and 10 of TB1501. Selection of a sideband for transmission can be done from a remote source by connecting a sideband selector switch to terminals 9 and 10 on TB1500.

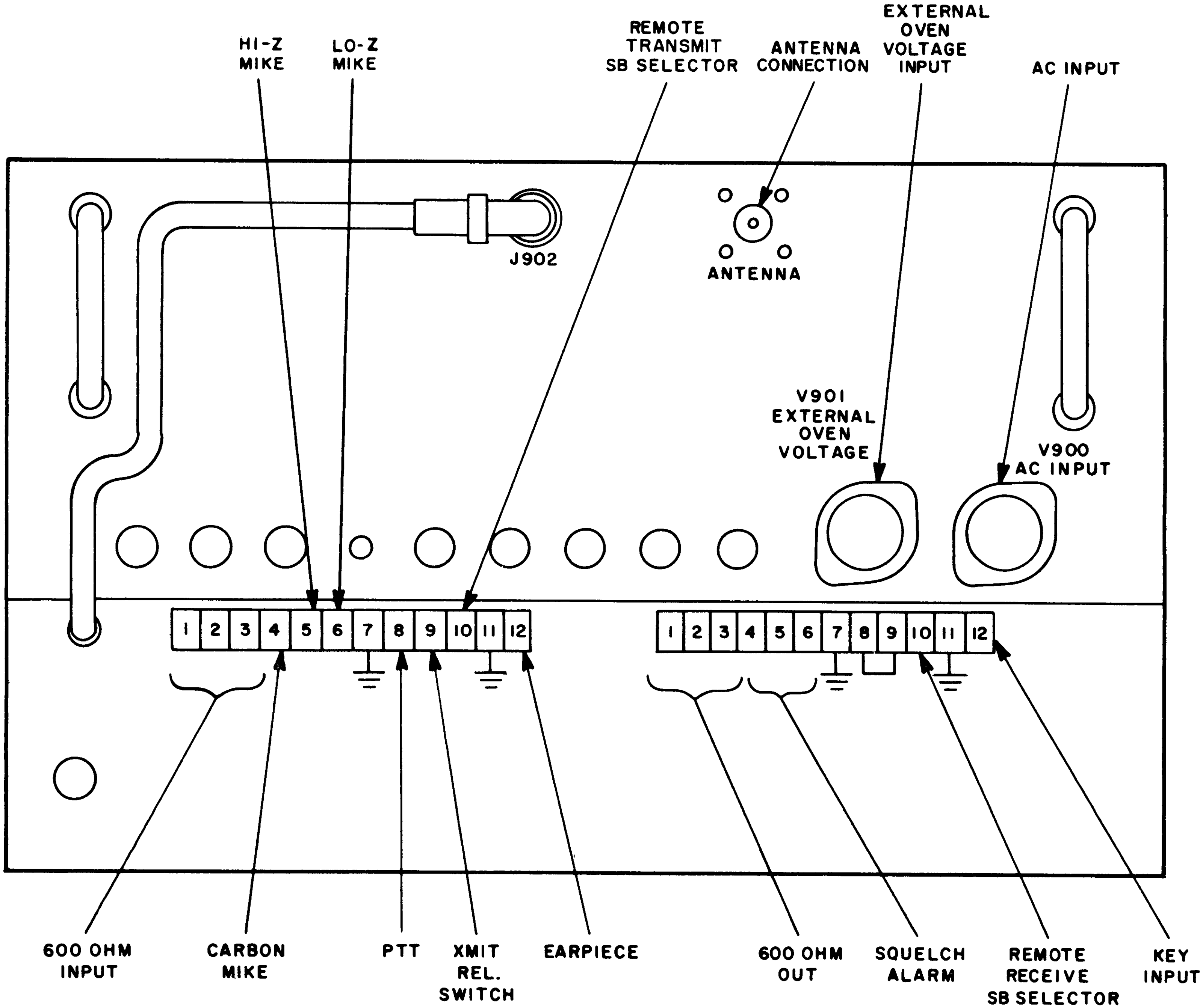


Figure 10. Electrical Connections at Rear of Unit

TUNING AND INITIAL ADJUSTMENTS

Th receiv r and transmitter modules are tuned at the factory for the frequencies specified in the sales order. With proper antenna systems no readjustment of the modules should be necessary. However, if unsatisfactory operation is obtained due to mishandling in shipment or a change of operating frequency is desired, adjust the modules as described in Section of this manual. To tune the output to the antenna in use, proceed as follows:

(1) Set the front panel controls as follows:

VOLUME Control	Extreme ccw
ANTI-VOX Control	Extreme ccw
PA METER Switch	Ib
SQUELCH Control	Extreme cw
PTT/VOX Switch	PTT
SIMPLEX/DUPLEX Switch	SIMPLEX
TRANSMITTER Male Switch	CW
XMTR AF GAIN CONTROL	Extreme cw
TRANSMITTER CHANNEL SWITCH ...	I
RECEIVER CHANNEL Switch	T
PA OVLD Switch	UP

(2) Connect a handset to HANDSET jack then connect operating voltage to unit.

(3) Insert key plug into key jack on rear apron.

(4) Remove top cover.

WARNING

HIGH VOLTAGE IS PRESENT IN THE PA ENCLOSURE WHENEVER POWER SWITCH 51500 IS IN XMIT/REC POSITION

(5) Install card xt nder AX b tw en modul for chann 1 to be adjusted and quipment to facilitate adjustment.

(6) Push PA OVLD switch down.

(7) Rotate power switch to XMIT/REC.

(8) Depress key and rotate VOX-GAIN Control until vox relay closes. (There should be an audible snap.)

(9) Adjust screw "D" on RF Module until meter reads ________ release key.

(10) Rotate PA METER Control to Ib position

(11) Depress key and adjust "PA Tune" screw on output module until current dips as indicated by the meter. Reading should be no than 150 ma. Adjust for minimum reading. Release key.

(12) Rotate PA METER switch to EORF and key transmitter. Reading should be ______. If not, readjust "PA Load" Controls and dip. final as described in Step 13.

(13) When Steps 11 and 12 are satisfactory, recheck grid voltage by repeating Steps 8 and 9.

(14) Repeat the above procedure for remaining module pairs installing card extender for each channel in turn.

(15) When all modules have been adjusted and card extender removed, recheck Dip (Steps 11 and 12). Any readjustment of grid drive will require removing module, turning screw D a little at a tim and reinserting module since lead length of extender will change the adjustments.

ANTENNA SYSTEMS

GENERAL. Th use of single sideband transmission does not introduc any peculiar requirements on an antenna system. Single sideband, like any high-frequency communication system, can adapt itself to a wide variety of good high-frequency antenna systems. The next f w paragraphs are devoted to basic descriptions of the various typ of antennas available for use with the TTR-10 (though the 35-foot whip antenna is the most desirable for point-to-point communication).

VERTICAL QUARTER WAVE

Easily one of the most versatile and efficient antennas available for low-angle radiation, the vertical quarter-wavelength ant nna readily adapts itself for use with the TTR-10. TMC's Model A-1486 35-Foot Whip Antenna, described more fully in Section of this manual, is an ideal antenna for the unit. This receiver-antenna combination is even more desirable because of the availability of an antenna coupler (TMC's) which will match the impedance of the antenna with the 50-ohm transmission line betwe n 2 and 32 megacycles.

To find the desired length of a vertical quarter-wavelength radiator calculate the following:

$$\text{Length in feet} = \frac{234}{\text{freq (mc)}} \qquad (1)$$

Figure 11 indicates the relationships between antenna length and and frequency. Remember, in determining the length of an antenna, cut the antenna to a half wavelength at the highest channel fr quency.

HALF-WAVE ANTENNA

The most fundamental form of horizontal antenna is a single wire whose length is approximately equal to half the transmitting wavelength. Also referred to as a Hertz, Zepp and other names such as doublet or delta-matched, this particular type antenna is recommended for use with the TTR-10.

If high angle radiation is desired, place the antenna at a mean height of about a quarter of a wavelength or less above the ground. Mean height takes in the factor of wire sag. Also, the antenna should be broadside to the desired places of communication. For example, if two places, one 100 miles north and the other 350 miles south, form a net along with your rig, place the antenna in an east-west direction to take advantage of the desired directivity.

The half-wave dipole consists of a wire (No.14 or No.12 AWG copper) cut to length from the formula below and supported at each end by glass or ceramic insulators.

$$\text{Length in feet} = \frac{468}{\text{freq (mc)}} \qquad (2)$$

Should an antenna be constructed of rod or tubing, and designed to work above 30 mc, use the following equation:

$$\text{Length in feet} = \frac{492 \times K}{\text{freq (mc)}} \qquad (3)$$

where K = ratio of half wavelength to conductor diameter.

The relationship between frequency and antenna length is shown in figure 11. As with quarter-wave antennas, cut or adjust the antenna to a half wavelength at the highest channel frequency.

PARASITIC ARRAYS

When it is desired to produce a concentration of r-f energy in a specific direction, a directive antenna such as a parasitic array must be used. Basically, this type antenna can be more easily understood by considering the parasitic el m nt as a reflecting mirror

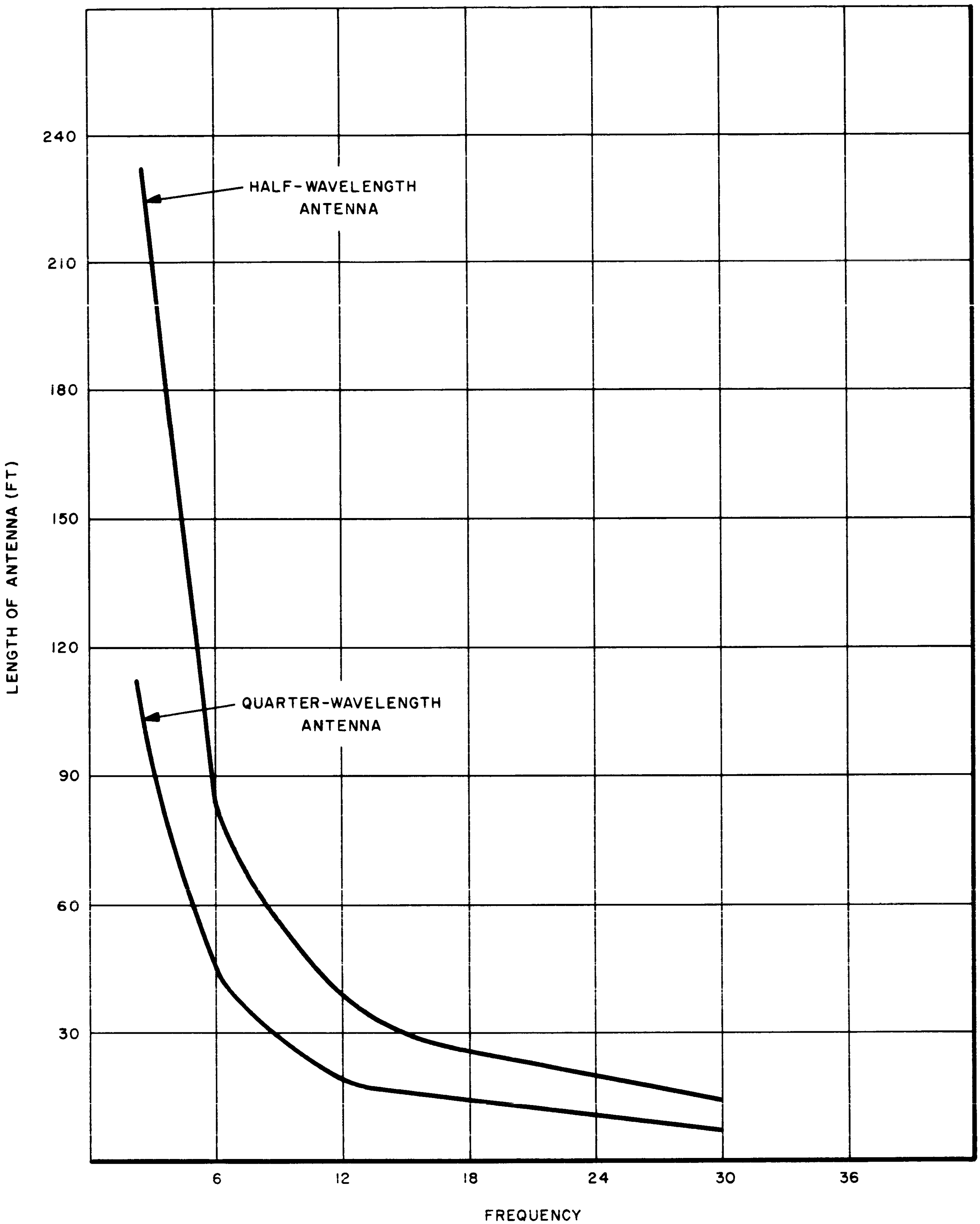


Figure 11. Frequency vrs. Antenna Length

for the wav s traveling in its dir ction from the half wav length driv r lem nt. This is tru providing that th two conductors are suffici ntly separated (greater than 0.14 wavelength). Conversely, if the elements are separated by less than 0.14 wavelength, the radiat d wave will be reinforced in the direction toward the parasitic lem nt. The spacing is the chief factor in determining the gain of an antenna reflector while the lengths of the parasitic elements det rmine the sharpness of resonance of the multi-element array.

~~The physical arrangment of a two-element parasitic array is shown in Figure~~ . Calculate the physical length of the radiator by th formula:

$$\text{Length of } 1/2 \text{ in feet} = \frac{468}{\text{freq (mc)}} \qquad (4)$$

Th maximum gain of the three element array is considerable gr ater than that of the two element array. A four element array, r pr senting the practical limit, has greater directivity than the oth rs described above. Table below indicates the input impedance and gain of various parasitic arrays.

TABLE 4 . INPUT IMPEDANCE AND GAIN OF VARIOUS PARASITIC ARRAYS

TYPE OF ANTENNA	INPUT (OHMS) IMPEDANCE	GAIN OVER DIPOLE (DB)
Dipole	72	0
Fold d Dipole	300	0
Dipole and Reflector	60	3 to 4
Fold d Dipole and Reflector	250	3 to 4

TABLE 4 . INPUT IMPEDANCE AND GAIN OF VARIOUS PARASITIC ARRAYS (Cont)

TYPE OF ANTENNA	INPUT (OHMS) IMPEDANCE	GAIN OVER DIPOLE (DB)
Dipole, Reflector, Director	20 to 30	4 to 6
Folded Dipole, Reflector, Director	80 to 120	4 to 6
Stacked Dipoles	35 to 40	3 to 4
Stacked Folded Dipoles	150	3 to 4
Stacked Dipoles and Reflectors	25 to 30	6 to 7
Stacked Folded Dipoles and Reflectors	100 to 120	6 to 7
Dipole Turnstile	35 to 40	-1.5
Folded Dipole Turnstile	150	-1.5

ANTENNA CONSTRUCTION

If you plan to construct your own antenna, note that th wires in the antenna and feeder system must have good conductivity to keep electrical losses low and the insulators must have low diel ctric loss and surface leakage. Usually either the No. 14 gauge hard-drawn enameled copper wire or No. 12 enameled copper-clad steel wir should be used. It is best to make feeders and matching stubs of ordinary soft-drawn No. 14 or No. 12 wire.

Pyrex glass or ceramic insulators with long leakage paths are r commended. These insulators should be connected at the end of ach side of the antenna. For center-feed, the antenna wire is cut at mid-point and another insulator is added. Each conductor of a balanced or unbalanced transmission line is connected to either side of the center insulator. With a coaxial shielded transmission line being used with the antenna, the shield and conductor wires are connected as shown in figure 12. Recommended guy clamps and strain insulators are also shown.

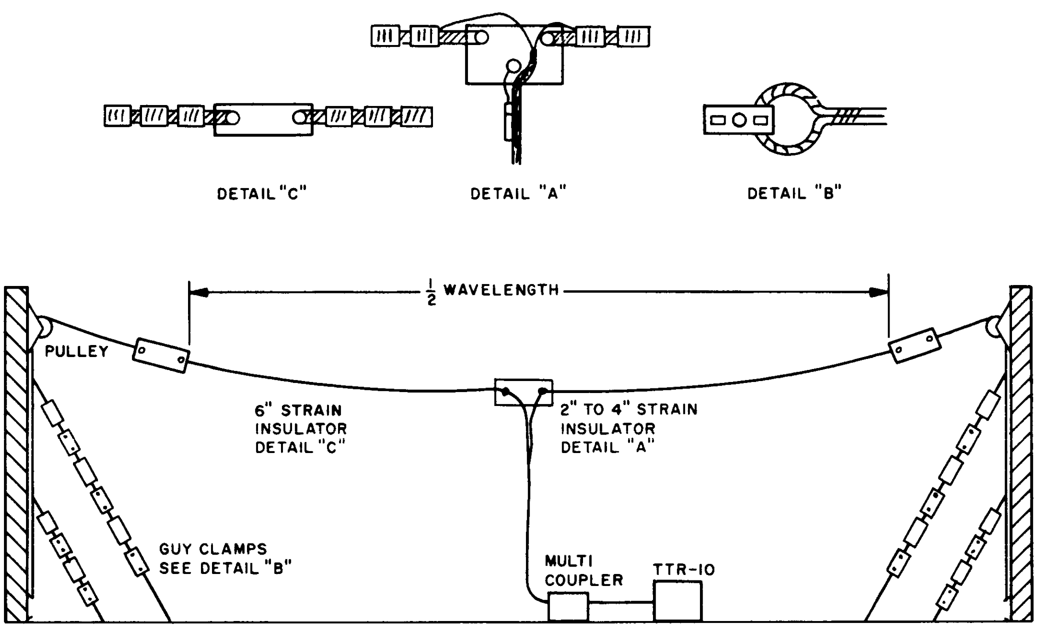


Figure 12. Installation of Center-Fed Antenna

SECTION 4

OPERATION

GENERAL

All operating controls and indicators are located on the front panel of the equipment. Three charts are supplied with the equipment. Explaining how to operate theequipment, they are written in English, French and Spanish.

OPERATING CONTROLS AND INDICATORS

Table 5 below lists the panel and component designations and functions of the various controls and indicators found on the unit. Refer to figure 13 when learning the use of these controls.

TABLE 5. FRONT PANEL CONTROLS AND INDICATORS

REFERENCE DESIGNATION	PANEL AND COMPONENT DESIGNATION	FUNCTION
1	OFF-REC-XMIT/REC switch S1500	In OFF position, disconnects all operating voltages from transceivers, except external oven voltage. In REC position, connects power only to entire receiver and xmtr audio portion, while in XMIT/REC position, operating voltages are applied to both receiver and transmitter portions
2	Power Lamp DS1500	Lights when switch S1500 is in REC or XMIT/REC

TABLE 5. FRONT PANEL CONTROLS AND INDICATORS (Cont)

REFERENCE DESIGNATION	PANEL AND COMPONENT DESIGNATION	FUNCTION
3	F1-F2 switches S10, S20, S30, S40	Allows choice of either crystal frequency at each receiver converter module. F2 position is provided to allow the operator to put the CW signal on his assigned carrier frequency or for certain teletype operations requiring the center frequency to be the assigned carrier frequency.
4	RECEIVER CLARIFIER Control	Compensate for slight frequency differences between other SSB transmitters. Adjusted for normal voice reproduction.
5	RECEIVER CHANNEL Switch S1507	Independently controlled receiver r-f module selectors. In position T, both transmit and receive r-f modules are selected by the TRANSMITTER SELECTOR switch.
6	TRANSMITTER CHANNEL Switch S1508	Transmitter r-f module selector switch which selects one of four plug-in modules.
7	RCVR LSB - USB/REMOTE Switch S1503	In LSB position, tunes to the lower sideband of any selected channel. In USB/REMOTE position, tunes to upper sideband signal of any channel or allows remote selection of either the upper or lower sideband.

TABLE 5. FRONT PANEL CONTROLS AND INDICATORS (Cont)

REFERENCE DESIGNATION	PANEL AND COMPONENT DESIGNATION	FUNCTION
8	VOLUME Control R1515	Controls audio level of received signal.
9	SQUELCH Control R1518	Quiets receiver during operation.
10	ANTI-VOX Control R1517	Adjusts an out of phase voltage to the vox circuit from the receiver to prevent accidental operation of vox from receiver.
11	SIMPLEX-DUPLEX Switch S1506	Normal power distribution in SIMPLEX position. In DUPLEX position, power is supplied to both receiver and transmitter portions of unit.
12	XMTR LSB - USB/ REMOTE Switch S1502	In LSB position, lower sideband of selected channel is transmitted. In USB/REMOTE position, the upper sideband is selected for transmission and allows remote selection of either the upper or lower sideband.
13	PTT-VOX Switch S1501	In PTT position, selects push-to-talk operation; while in VOX position the operator's voice will automatically turn on transmitter.
14	Transmitter Mode Selector Switch S1500	Selects transmitter mode of operation.

TABLE 5. FRONT PANEL CONTROLS AND INDICATORS (Cont)

REFERENCE DESIGNATION	PANEL AND COMPONENT DESIGNATION	FUNCTION
15	F1-F2 Switches S50, S60, S70, S80	Allows choice of either crystal frequency at each transmitter converter module. F2 position is provided to allow the operator to put the CW signal on his assigned carrier frequency or for certain teletype operations requiring the center frequency to be the assigned carrier frequency.
16	XMTR AF GAIN Control R1514	Controls the sideband level.
17	PA METER Switch S1511	Ib position - meter M1500 indicates PA plate current. EgRF position - meter M1500 indicates grid during voltage of final stage. EoRF position - meter M1500 - indicates output r-f voltage.
18	PA OVLD circuit breaker CB1500	A magnetically controlled circuit breaker which can be manually reset.
19	Meter M1500	A meter which indicates plate current and grid driving voltage of final stage and output r-f voltage. Particular indication determined by PA METER switch S1511.
20	VOX-GAIN Control R1513	Adjusts the threshold voltage for which the VOX relay automatically switches on transmitter.

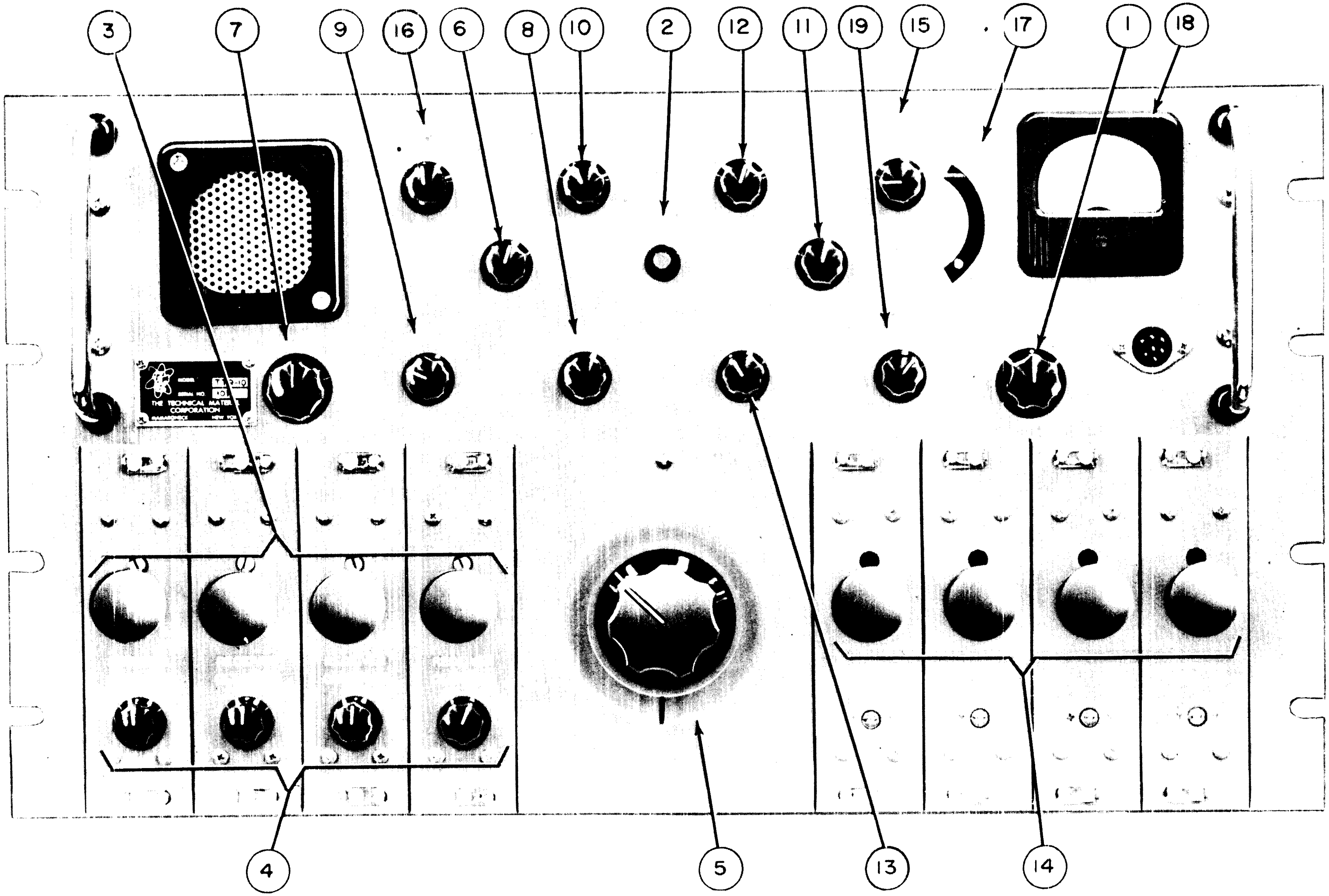


Figure 13. Front Panel of Unit

SIMPLEX OPERATION

Simplex operation is defined basically as transmission and reception between two stations on a single channel. Either a key or microphone input can be used with the unit. However, with this type of transmission, phone or key "conversation" is limited since both parties have to take turns transmitting. The party transmitting cannot hear the other party, or be interrupted, unitl he changes the unit's mode of operation. Figure 14 shows a typical simplex system.

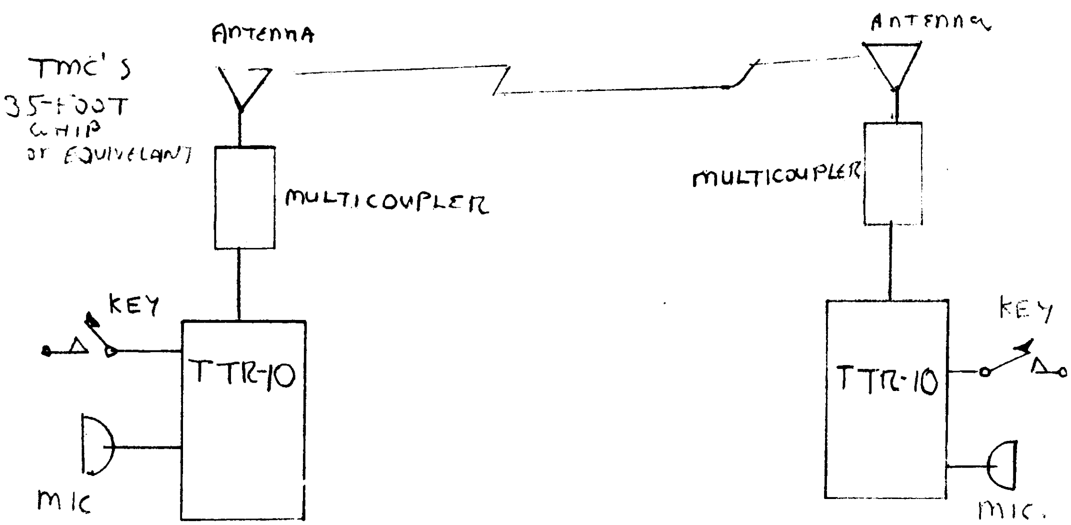


FIGURE 14. SIMPLEX SYSTEM

The accessory items shown in Figure 14 are available from TMC. See section 8 of this manual. To operate the unit in a simplex mode, perform the following basic steps:

(1) Set the RECEIVER CHANNEL switch to "T" position and then rotate TRANSMITTER CHANNEL selector to desired module. At the selected converter modules, the F1/F2 switch is kept in the F1 position since it is the primary module frequency. The F2 frequency is used for side-stepping and C-W operation.

(2) Place power switch in XMIT/REC position if both transmission and reception is desired. With the switch in the REC position, the unit is powered for receiving only.

(3) Place SIMPLEX/DUPLEX switch in SIMPLEX position.

(4) Place RECVR switch in either LSB or USB/REMOTE position, depending on desired sideband. By placing this switch in USB/REMOTE position, the selection of either the upper or lower sideband can be selected from an external source.

(5) Turn VOLUME control until desired audio level is reached. Then adjust RECEIVER CLARIFIER control at the operating module for the most natural voice reproduction of received signals.

(6) Turn SQUELCH control until desired noise quieting is achieved. This ends the receiver adjustments.

The following adjustments are for the transmitter section:

(7) Select mode of operation and place XMTR switch in LSB or USB/REMOTE position as desired. Like the receiver sideband selector, the transmitter sideband can be selected by a remote source providing the switch is placed in USB/REMOTE position.

(8) Place the PA METER switch in the Ib position; meter should indicate ________. Then place switch in EgRF position; meter should indicate ________. Finally place the switch in EoRF position; meter should indicate ________. Factors such as antenna resistance and input signal level incluence this reading. The XMTR AF GAIN control can be varied to give the proper transmitter gain. The PA METER switch is left in the EoRF position during normal operation.

(9) A circuit breaker, called PA OVLD, can be reset if it trips because of excessive output current.

(10) Slight frequency adjustments can be made regarding operating frequency at each module. These adjustments are screwdriver controls.

(11) Select the transmitter mode of operation with the front panel selection switch.

DUPLEX TELEPHONE OPERATION

A duplex telephone system permits simultaneous two-way transmission and reception, because two different frequencies are used. To avoid interference, the selected frequencies should be at least 50 kc. With duplex operation, check transmitter antenna to insure a VSWR of less than 2:1. Figure 15 shows a full duplex system.

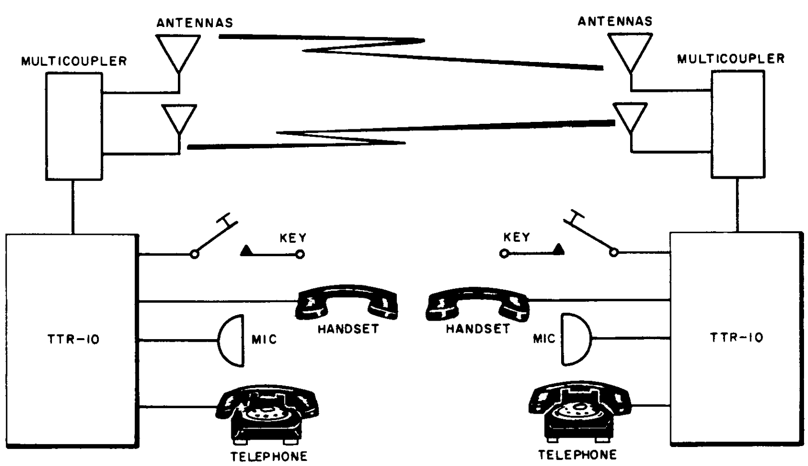


Figure 15. Duplex Telephone Operation

The unit is operated primarily the same as with simplex operation except on the following:

(1) With duplex operation, the transmit and receive channels operate independently. Place RECEIVER CHANNEL and TRANSMITTER CHANNEL switches in the desired channels.

(2) Place SIMPLEX/DUPLEX switch in DUPLEX position and power switch in XMIT/REC.

(3) With VOX operation, adjust the VOX GAIN control until a normal or desired voice signal trips the transmitter. In conjunction with this, adjust the ANIT-VOX control so that received signals do not automatically trip the equipment.

SECTION 5

THEORY of OPERATION

SIMPLIFIED BLOCK DIAGRAM ANALYSIS OF UNIT

The Model TTR-10 SSB Transceiver/Receiver is a 16 channel transistorized transceiver with a frequency range between 2 and 32 mc. See figure 16. Four pre-tuned receiver and four pre-tuned transmitter plug-in modules afford 16 channel operation because of dual frequency selection and sideband selection at each module.

The receiver is a double conversion superheterodyne featuring a built-in clipping and agc networks, and standard and 600 ohm audio output lines.

The transmitter consists of an all transistor double conversion exciter and two-stage vacuum tube final amplifier capable of generating 100 watts. The transmitter features both push-to-talk and VOX (voice operated relay) operation.

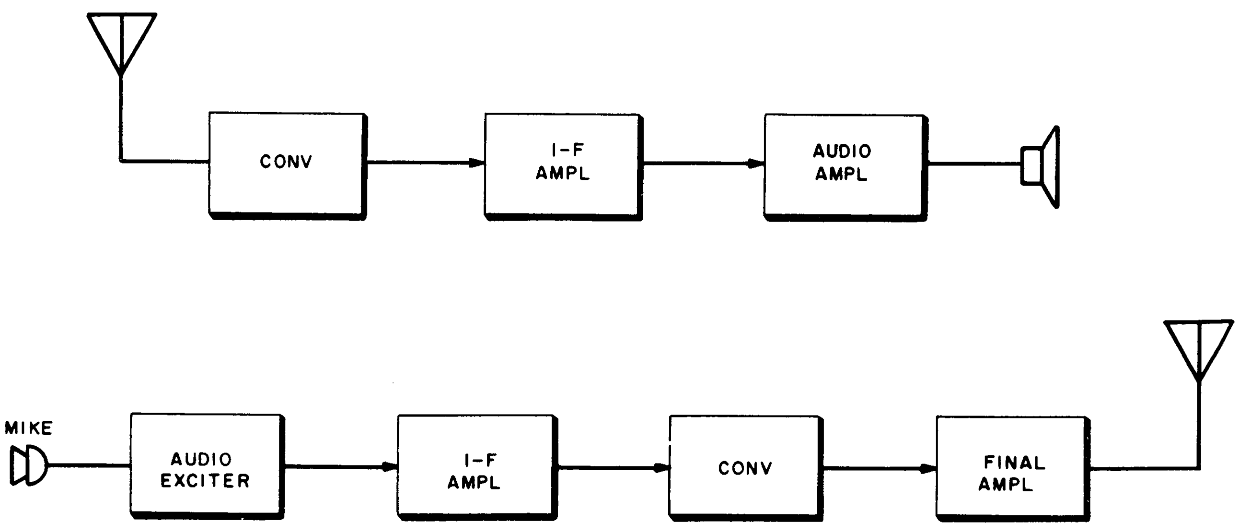


Figure 16. Simplified Block Diagram of Unit

BLOCK DIAGRAM ANALYSIS OF RECEIVER (Se figure 17)

Signals between 2 and 32 m gacycles are coupled from the antenna through the appropriate converter module. These modules, as selected by the RECEIVER CHANNEL switch, convert the input to and intermediate frequency of 1.75 megacycles. The four plug-in units comprising the r-f section are identified by the band number designations: 1, 2, 3, 4. They tune the ranges of 2 to 4 mc, 4 to 8 mc, 8 to 16 mc, 16 to 32 mc, respectively. A typical r-f converter module (the 2-4 mc module for example) contains r-f amplifier stages and a converter stage.

The input signal is amplified through r-f amplifiers Q101, Q102, and Q103. Crystal oscillator Q106 oscillates 1.75 mc above the incoming signal. Buffer Q105 provides the low impedance high levl injection voltage for converter Q104. Each receiver converter module is pretuned to two frequencies. Selection of the desired frequency is made by rotating the screwdriver control into either the F1 or F2 position. From here the 1.75 mc signal is coupled to the receiver i-f module.

The i-f module contains the converter, detector, and agc stages. Amplified through Q1601, the 1.75-mc signal is coupled to mixer Q1602 along with either a 1.5-mc or 2.0-mc heterodyning signal. Selection of either the 1.5-mc or 2 mc heterodying signal is determined by the position of RECVR switch S1503. With S1503 in the USB/REMOTE position, the operating power is applied to 1.5-mc oscillator Q1607 while in the LSB position, operating power is applied to 2-mc oscillator Q1608.

The 250-kc second i-f signal is coupl d through 3 kc upper sideband filter F1601 to both a detector network and agc amplifier Q1610. Amplified through Q1610, the signals are peak detected by diodes CR1605 and CR1606. When the signal exceeds the delay voltage in the detector, current flows through agc amplifier Q1611 and emitter follower Q1612.

A ring detector, composed of diodes CR1601 through CR1604, is switched at 250 kc by buffer Q1605 fed from 250 kc oscillator Q1606. The balanced audio output from the ring detector is converted to a single-ended signal before applying it to the VOLUME control by transistors Q1603 and Q1604. The agc and signal output voltages are applied to the receiver audio module.

The receiver audio module consists of a line output amplifier, speaker and headphones amplifier, and electronically-controlled relay squelch circuitry.

The audio output from the i-f module is applied to amplifier Q1613 through VOLUME control R1515 which controls the signal level at Q1613 thus determining the output level at the headset and loudspeaker. The amplified output from Q1613 is applied to push-pull amplifiers Q1614 and Q1615 which in turn feed power amplifiers Q1616 and Q1617. The amplified output is applied through squelch control relay K1601 to loudspeaker LS1500.

The squelch circuit consists of a comparator circuit (Q1619 and Q1620) which compares the agc line voltage with a voltage obtained from the SQUELCH control potentiometer. When the agc voltage becomes more positive than the SQUELCH voltage, the circuit switches states thus driving relay driver Q1621 which in turn activates relay K1601. When K1601 activates, the audio output is switched across a resistive load rath r than the loudspeak r.

Line amplifi r Q1618 obtains the same input as amplifi r Q1613 but unlike th speaker amplifiers produces a 600-ohm balanced output.

BLOCK DIAGRAM ANALYSIS OF TRANSMITTER (See figure 17)

Capable of generating a 100-watt PEP output, this transmitter is composed of all transistorized exciter and amplifier stag s with a two stage vacuum tube final power amplifier. It is capable of operating cw, mcw, am, supressed carrier (-20 db) and ssb.

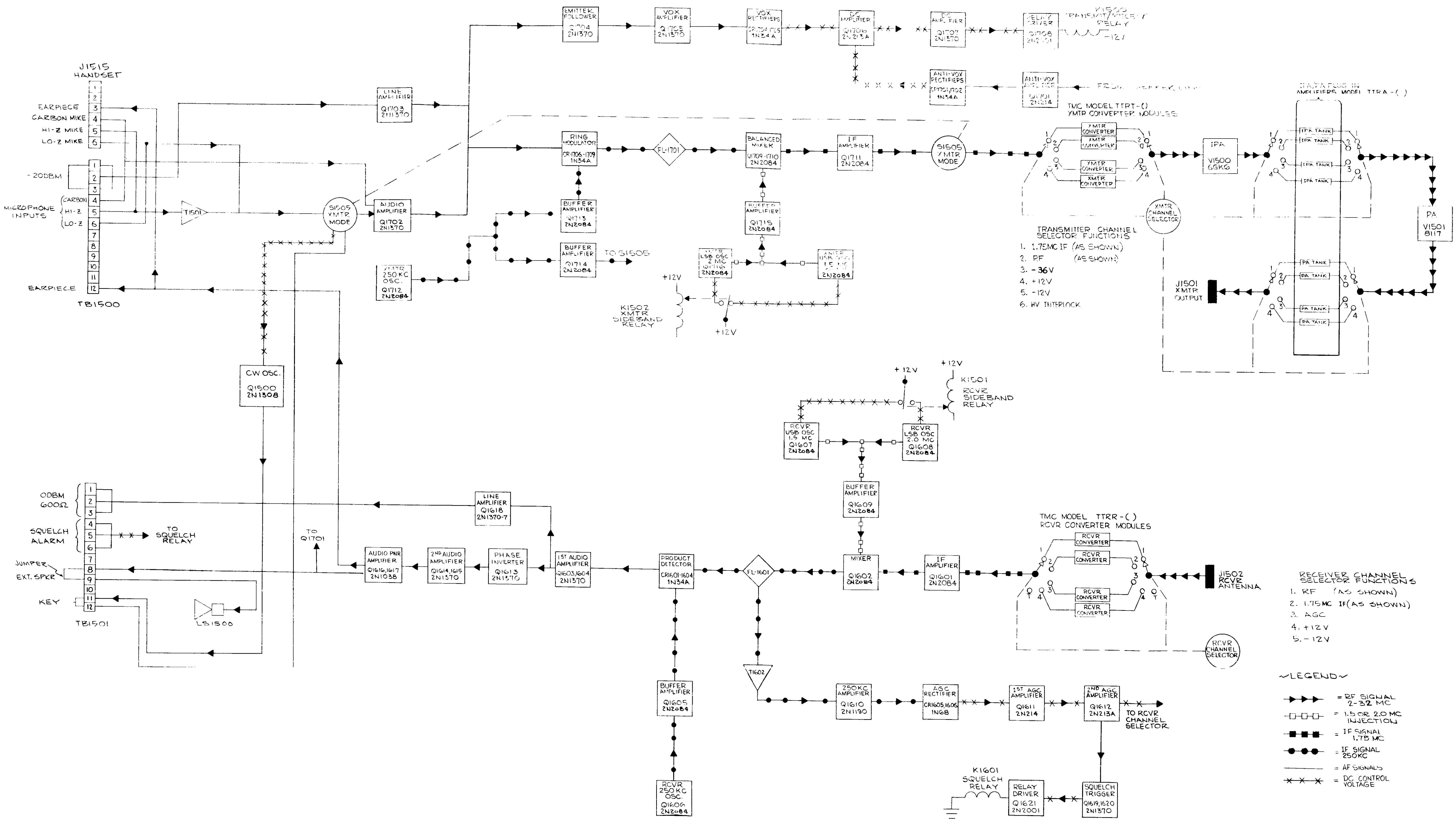
For phone operation both high and low impedance microphones are accepted, as is a 600 -ohm line input. Amplifiers Q1702 and Q1703 handle all the audio and key inputs. The amplified audio output from these amplifiers are transformer coupled through T1701 to the transmitter i-f module. The transmitter audio module also contains vox and anti-vox networks. The vox network functions as a threshold level adjust which is adjusted to automatically turn on the transmitter upon speaking into the microphone with a normal tone of voice. The anti-vox network serves as a threshold level adjust which prevents received signals from tripping the vox network.

These two networks are adjusted to the desired threshold setting. The anti-vox input coupled through ANTI-VOX control R1517 is tapp d from the loudspeaker output. Amplified through Q1701, the audio signal is rectified through diode detectors CR1701 and CR1702; the resulting negative pulse train is coupled to emitter follow r Q1706.

The vox input is coupled through VOX GAIN control R1513 from audio amplifi r Q1702. It is appli d to emitter follower Q1704 and vox amplifi r Z1705. Th signal is th n det ct d across th diod s CR1704 and CR1705; th positiv puls train is coupl d to emitter follow r Q1706. From here the signals are coupled to multivibrator Q1707 and Q1708, the output of which is coupled to transmit/receive relay K1500 which closes during periods of transmission.

The balanced audio signal from the exciter audio module is routed to a balanced ring modulator consisting of diodes CR1706 through CR1709. The 250 kc carrier insertion signal, generated by oscillator Q1712, is coupled through buffers Q1713 and Q1714 to the balanced modulator. The 250 kc oscillator output, also called the "carrier out" signal is also coupled to the AM and MCW positions of the transmitter mode selector switch. The 250 kc signal is again converted; this time to 1.75 mc in balanced mixer Q1709 and Q1710. Selection of either the upper or lower sideband is determined by the front panel XMTR switch. When placed in the LSB position, power is applied to 2 mc oscillator Q1716; conversely, in USB/REMOTE position, power is applied to 1.5 mc oscillator Q1717. Both the 1.5 and 2 mc signals are fed to the balanced mixer through buffer Q1715.

With the transmitter mode selector switch in either the CW or MCW positions, a 250-kc carrier is reinserted into the signal. With c-w, the carrier is at least 60 db above sideband noise, while with mcw the carrier is 6 db above the peak envelope sideband signal. In the AM position, the carrier is also re-inserted for purposes of compatability. The carrier in this case lies 6 db above the peak envelope sideband signal and at least 60 db above unwanted sideband noise. With the switch in th -20 DB position, a suppressed carri r is r insert d in the signal spectrum at a l vel 20 db below th d sired sideband.


J1515 HANDSET
EARPIECE
CARBON MIKE
HI-Z MIKE
LO-Z MIKE
-20DBM
MICROPHONE INPUTS
CARBON
HI-Z
LO-Z
EARPIECE
TB1500
T1501
S1505 XMTR MODE
AUDIO AMPLIFIER Q1702 2N1370
LINE AMPLIFIER Q1703 2N1370
EMITTER FOLLOWER Q1704 2N1370
VOX AMPLIFIER
VOX RECTIFIERS 1N34A
DC AMPLIFIER
RING MODULATOR CR1706-1709 1N34A
FL-1701
BALANCED MIXER Q1709-1710 2N2084
IF AMPLIFIER Q1711 2N2084
S1505 XMTR MODE
BUFFER AMPLIFIER Q1713 2N2084
BUFFER AMPLIFIER Q1714 2N2084
TO S1505
XMTR 250 KC OSC. Q1712 2N2084
BUFFER AMPLIFIER Q1715 2N2084
+12V
K1502 XMTR SIDEBAND RELAY
TMC MODEL TTRT-() XMTR CONVERTER MODULES
XMTR CONVERTER
IPA V1500 6GK6
PA V1501 8117
PA TANK
J1501 XMTR OUTPUT
XMTR CHANNEL SELECTOR
TRANSMITTER CHANNEL SELECTOR FUNCTIONS
1. 1.75MC IF (AS SHOWN)
2. RF (AS SHOWN)
3. -36V
4. +12V
5. -12V
6. HV INTERLOCK
CW OSC. Q1500 2N1308
K1501 RCVR SIDEBAND RELAY
RCVR USB OSC 1.5 MC Q1607 2N2084
RCVR LSB OSC 2.0 MC Q1608 2N2084
BUFFER AMPLIFIER Q1609 2N2084
ODBM 600Ω
SQUELCH ALARM
TO SQUELCH RELAY
JUMPER
EXT. SPKR
KEY
TB1501
LS1500
LINE AMPLIFIER Q1618 2N1370-7
TO Q1701
AUDIO PWR AMPLIFIER Q1616,1617 2N1038
2ND AUDIO AMPLIFIER Q1614,1615 2N1370
PHASE INVERTER Q1613 2N1370
1ST AUDIO AMPLIFIER Q1603,1604 2N1370
PRODUCT DETECTOR CR1601-1604 1N34A
FL-1601
MIXER Q1602 2N2084
IF AMPLIFIER Q1601 2N2084
TMC MODEL TTRR-() RCVR CONVERTER MODULES
RCVR CONVERTER
J1502 RCVR ANTENNA
RCVR CHANNEL SELECTOR
RECEIVER CHANNEL SELECTOR FUNCTIONS
1. RF (AS SHOWN)
2. 1.75MC IF (AS SHOWN)
3. AGC
4. +12V
5. -12V
BUFFER AMPLIFIER Q1605 2N2084
RCVR 250 KC OSC Q1606 2N2084
T1602
250KC AMPLIFIER Q1610 2N1190
AGC RECTIFIER CR1605,1606 1N68
1ST AGC AMPLIFIER Q1611 2N214
2ND AGC AMPLIFIER Q1612 2N213A
TO RCVR CHANNEL SELECTOR
K1601 SQUELCH RELAY
RELAY DRIVER Q1621 2N2001
SQUELCH TRIGGER Q1619,1620 2N1370
~LEGEND~
= RF SIGNAL 2-32 MC
= 1.5 OR 2.0 MC INJECTION
= IF SIGNAL 1.75 MC
= IF SIGNAL 250KC
= AF SIGNALS
= DC CONTROL VOLTAGE

The suppressed sideband signal is used mainly for tune up and reference purpos s.

The 1.75-mc second i-f signal is coupled through TRANSMITTER CHANNEL switch 51505 to the selected transmitter converter module. This module converts the 1.75-mc signal into the desired transmitting frequency. Oscillator Q1501 can be operated at either of two crystal-controlled frequencies as determined by the position of the F1/F2 switch..The selected oscillator frequency feeds balanced modulator Q503 and Q504 through buffer Q502.

The r-f output from the exciter position of the transmitter converter module is then coupled to intermediate power amplifying (IPA) V1500. Final power amplifier stage V1501 amplifies the signal to a level of 100 watts pep. The signals are coupl d through a pi network to the antenna.

BLOCK DIAGRAM OF POWER SUPPLY (See figure 18)

The power supply circuit consists basically of a power supply module and associated control networks. The input voltage is coupled through POWER switch S1500 to power transformer T901 which has three step-down secondary windings. Rectifiers CR916 and CR917, which are connected across the first secondary winding, and a regulator network consisting of transistor Q902 and diode CR918, supply a stable 40-vdc output which is us d in the transmitter converter modules.

A-12vdc transistor bias voltage is developed across the second secondary winding of T901. Rectifiers CR913 and CR914 and regulator network Q901 and CR915 produce a stable -12 vdc output. Th +12-vdc transistor bias output is dev lop d by r ctifi rs CR910 and CR911 and r gulators Q900 and CR912 which ar conn ct d cross th third winding of T901.

The +12-vdc output is also coupled to high voltag con- trol relay K900 which activates and consequ ntly coupl s the source voltage across transformer T900. This also results in a control voltage being coupled through transmit receive relay K1500 (providing its in transmit position) to antenna relay K901. Normally K901 makes contact with the receiver antenna. However, with the applying of a control,voltage, the relay activates thus connecting the transmitter section output to the antenna.

Transformer T900 is used to provide operating voltages for the vacuum tube final stages. The first secondary winding of T900 steps the voltage down to 6.3 vac. High voltage rectifier CR909 connected across a step-up winding for power amplifier V1501. This high voltage output is also coupled to a voltage output network consisting of resistor R905 and diodes CR906 through CR908 in one branch and resistor R908 in the other. The diode branch produces a 315-vdc screen voltage for power amplifier V1501 while the other branch produces 300 volts for IPA V1500's plate and screen voltage.

Diodes CR901 through CR904 along with bias regulator CR905 generate both blocking and operating bias voltages for power amplifier V1501. Potentiometer R1500 is used to adjust the bias on the tube. The selection of either a blocking or operating bias depends on the position of transmit/receive relay K1500. In th transmit mode, the operating bias is coupled to the tube while during reception, a block bias is used to cut-off the stag .

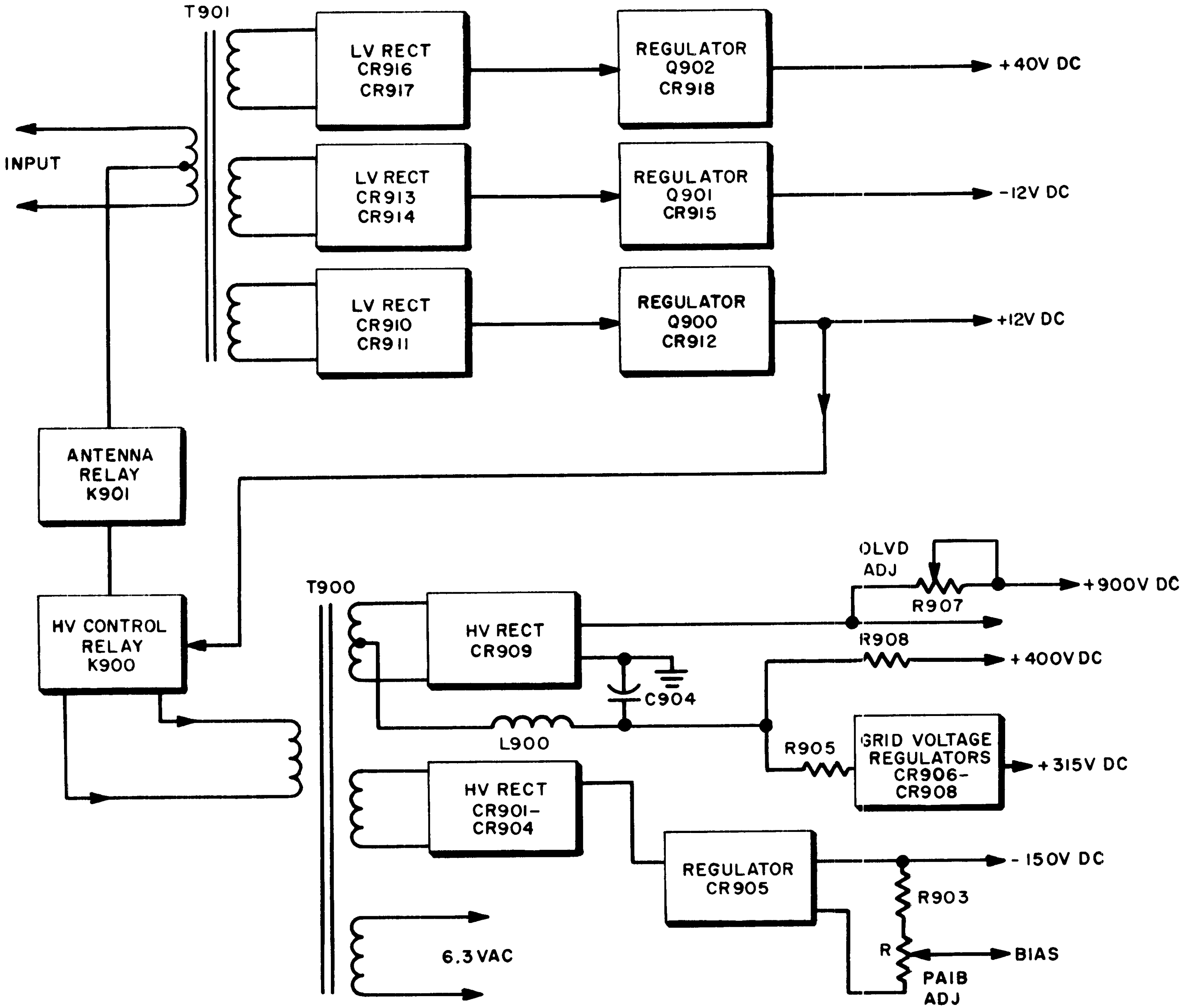


Figure 18. Block Diagram of Power Supply

DETAILED CIRCUIT ANALYSIS OF RECEIVER

INPUT AND RECEIVER CONVERTER MODULE (See figure 11)

The antenna is connected through antenna relay K901, which acts as a T-R switch, and RECEIVER CHANNEL switch S1507, to the select d receiver converter module. Normally K901 is in the transmit mod , thus connecting the antenna to the selected receiver converter module. Relay K901 is activated in the transmitting mode of operation by either a voice-operated relay (VOX) or by placing PTT/VOX switch S1501 in PTT position and depressing the corresponding microphone press-to-talk button.

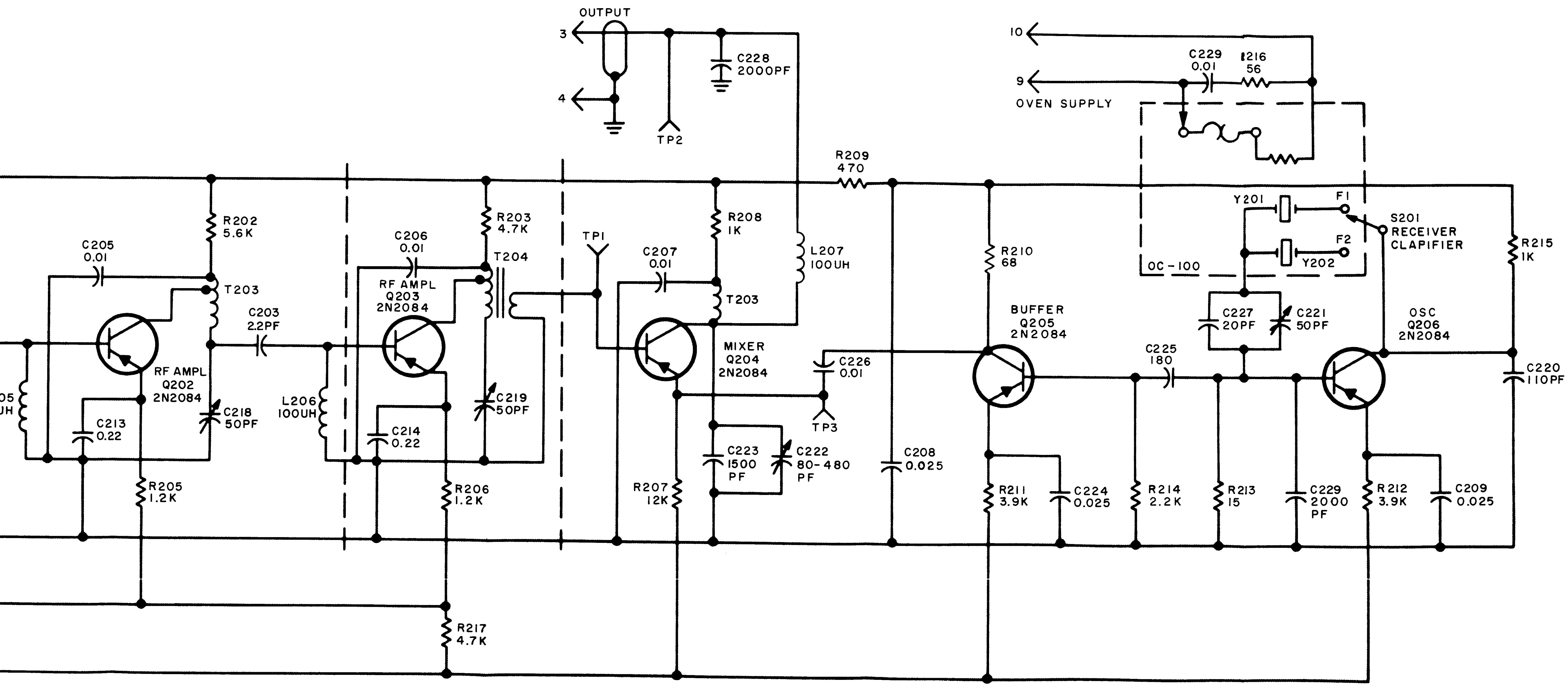
There are four receiver converter modules (100,200,300 and 400 series) which are selectable by the RECEIVER CHANNEL switch. Each of these r-f modules are designed to operate at either of two frequencies. For purposes of discussion the 200 series module will be analyzed since this represents a typical cross-section of this module. The module covering band 1 (2 - 4 mc) is slightly different than the other modules in that it has only two stages of r - f amplification instead of the normal three stages.

The r-f input is coupled through jack J201 to single-tuned matching transformer T201 which presents a load of 50 to 70 ohms. From here the signals are amplified through collector-tuned,common emitt r r-f amplifiers Q201, Q202 and Q203. With a "forward" agc applied to these amplifiers they realize an r-f gain of approximately 100 db. The high impedance LC coupling method employed throughout the amplifiers maintain a relatively constant coupling ratio over the entire frequency range by taking advantage of the changing imp danc s of th transistors and tank circuits.

The agc is briefly xplained as follows: As th signal l vel increases, the voltage on the agc line increases causing more current to flow through the emitter base junctions of Q201, Q202 and Q203. This results in an increase of collector current resulting in a greater voltage drop across the collector d coupling resistors. As the collector current increases, the collector voltage is gradually pulled down through the saturation region. At the AGC voltage maximum of +8 volts, the collector voltage of the r-f amplifiers will be zero or slightly positiv . The decreasing impedance at the base of the transistors contribut s to the gain control function while also increasing the linearity of the base-emitter junction. The primary parameter of control, however, is the collector voltage.

The first local oscillator (Q206) operates 1.75 mc abov the received carrier frequency. From 2 to 16 mc untuned, crystal-controlled Clapp oscillators followed by a buffer are used. Th 16 to 32 mc band (band 4) oscillator is a Butler oscillator controlled by crystals operating on third mechanical overtones. Each oscillator module has two operating frequencies which are selected by the front panel F1-F2 controls. The F2 position is provided to allow an operator to put the cw signal on his assigned carrier frequency or for certain teletype operations requiring the center fr quency to be the assigned carrier frequency.

The crystals in the oscillators are sufficiently overdriven to allow the oscillator frequency to be "pulled" approximately $\pm$ 0.005% by varying the front panel RECEIVER CLARIFIER controls. Th se controls adjust the crystal circuit capacitance by 20 to 80 pf.



SPECIFIED.
ES IN OHMS.
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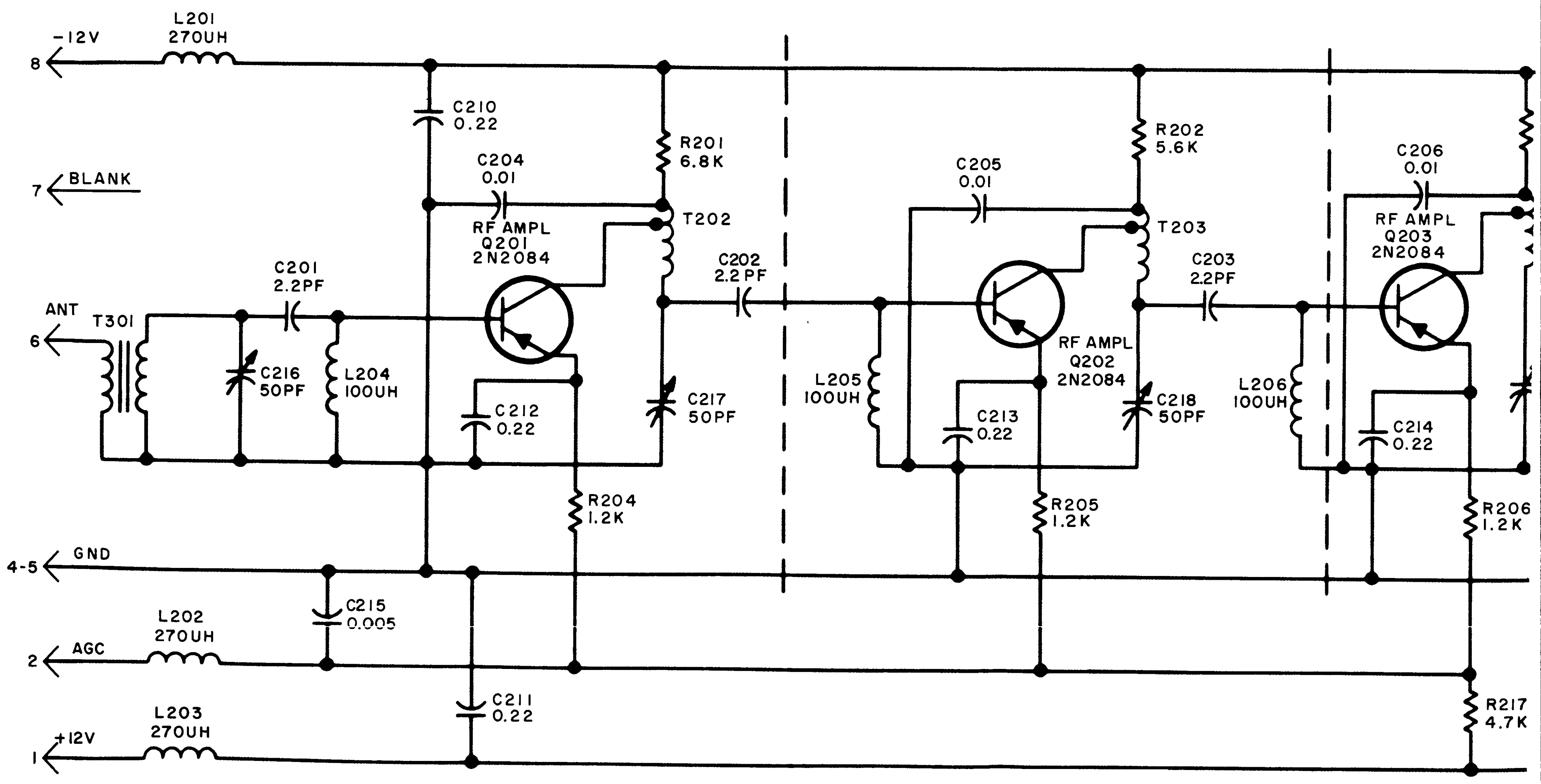


NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFD'S.

Table 6 b low lists th pull-in rang abov and below the mentioned oscillator fr quencies.

TABLE 6 . PULL-IN FREQUENCIES

BAND	OSCILLATOR FREQUENCY	PULL-IN +CPS	PULL-IN -CPS
4	33.75	1217	1180
4	24.5	746	1141
4	17.75	1005	238
3	17.75	1805	1474
3	13.75	1783	500
3	9.75	600	590
2	9.75	1246	1006
2	7.75	1005	600
2	5.75	916	423
1	5.75	879	563
1	4.75	661	421
1	3.75	451	211

An untuned buffer amplifier provides the low impedance high level injection voltage for the converter without excessively loading the oscillator. The buffer also isolates the oscillator from any possible pulling effect of the received carrier.

If it is desired, some or all of the converter module crystals can be oven controlled. Operating off the power supply, the oven maintains the crystals at a temperature of 75 degrees C$\pm$2 degrees. This results in an oscillator stability of at least 1 part in 10^6.

RECEIVER I-F MODULE

The receiver i-f module functions as a converter, demodulator, and agc network. The 1.75-mc receiver converter module output is coupled to the base circuit of i-f amplifier Q1601 which functions as an isolation network. Image frequencies of 1.25 and 2.25 mc are rejected before the second converter with the symmetrical 7-kc output being transform r coupled through T1601 to mixer Q1602. Se figur 20 .

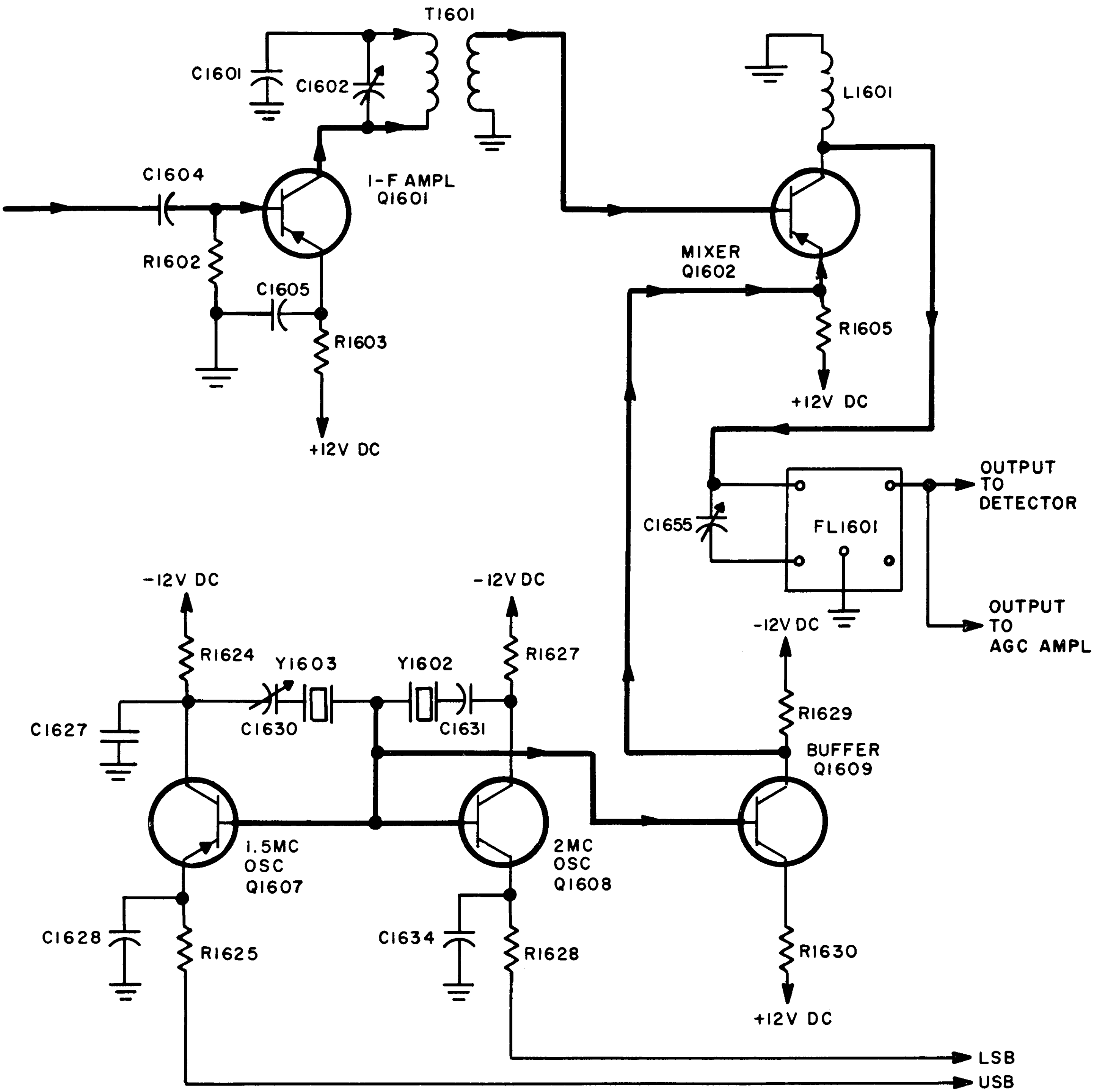


Figure 20. Converter Stage of Receiver I-F Module

If upper sideband rec ption of a 1-kc ton modulation is desired from a chann l frequency of 4 megacycl s, for exampl , the front panel RECVR switch must be placed in the USB/REMOTE position. By doing this a +12-vdc bias voltage is applied to oscillator Q1607--a crystal clapp oscillator generating a heterodyning signal of 1.5 mc. This 1.5 mc output is coupled to th emitter circuit of Q1602 through buffer Q1609 which isolates the oscillator from the mixer to minimize loading effects on the oscillator's frequency and amplitude stability.

In single-ended mixer Q1602, the 1.75-mc i-f and 1.5-mc oscillator frequencies are heterodyned to produce a 250-kc upp r sideband signal.

With the RECVR switch in the LSB position, the +12-vdc operating voltage is applied to 2-mc oscillator Q1608; thus a 2-mc output is coupled to mixer Q1602 through buffer Q1609 from the sideband oscillator. The heterodyned output from mixer Q1602 is a 250-kc upper sideband signal.

Reception of either an upper or lower sideband signal will result in an upper sideband signal at 250 kc; thus only one bandpass filter need be used. Filter FL1601, a Collins parallel-tuned mechanical filter provides extremely sharp selectivity, e.g., for a center frequency of 250 kc and a -3db bandwidth of 3.2 kc, the skirt selectivity is 40 to 60 db attenuation 600 cycles away from the -3db frequency.

Since either sideband and the carrier are eliminated, the original information contained in the modulating signal can be recov red at th r c iver by th use of 250-kc oscillator Q1605 and Q1606. This typ of signal transmission is known as single-sideband suppr ssed carrier modulation. A fr quency rror in the 250-kc ref rence carrier of 10 to 20 cps is acceptable for sp ech transmission; however, an error of 50 cps seriously degrades intelligibility. This occurs when the oscillator has an approximate stability of 2 parts in 10^5.

As described above, the signal for carrier insertion is generated by 250-kc oscillator Q1606 and its associated buffer, Q1605. The stable 250-kc output is coupled to the detector circuit across resistor R1663. The ring detector, consisting of diodes CR1601 through CR1604 and balanced filter components C1612 and C1613 and resistors R1608 and R1609 produce a balanced audio output. Any r-f remaining in the audio is bypassed by capacitors C1612 and C1613 while the audio signals are dropped across resistors R1608 and R1609.

Emitter-coupled amplifiers Q1603 and Q1604 convert the balanced detector output into a single-ended signal which is routed through VOLUME control R1515 to the receiver audio module. This same audio output is also coupled through 0 dbm adj. control R1516 to 600-ohm line amplifier Q1618.

A filtered output from FL1601 serves as the take-off point for the agc network. The signal from the agc pick-off point is appli d to the base of untuned agc amplifier Q1610. Amplified through Q1610, the signals are peak detected by diodes CR1605 and CR1606. When the signal level exceeds the delay voltage in the d tector, current flows through agc amplifier Q1611. The delay voltag is high enough that temperature variations only slightly ffect the agc level. The base circuit of Q1611 is clamped at a positive 3 volts, th voltag at which th r-f amplifiers are at

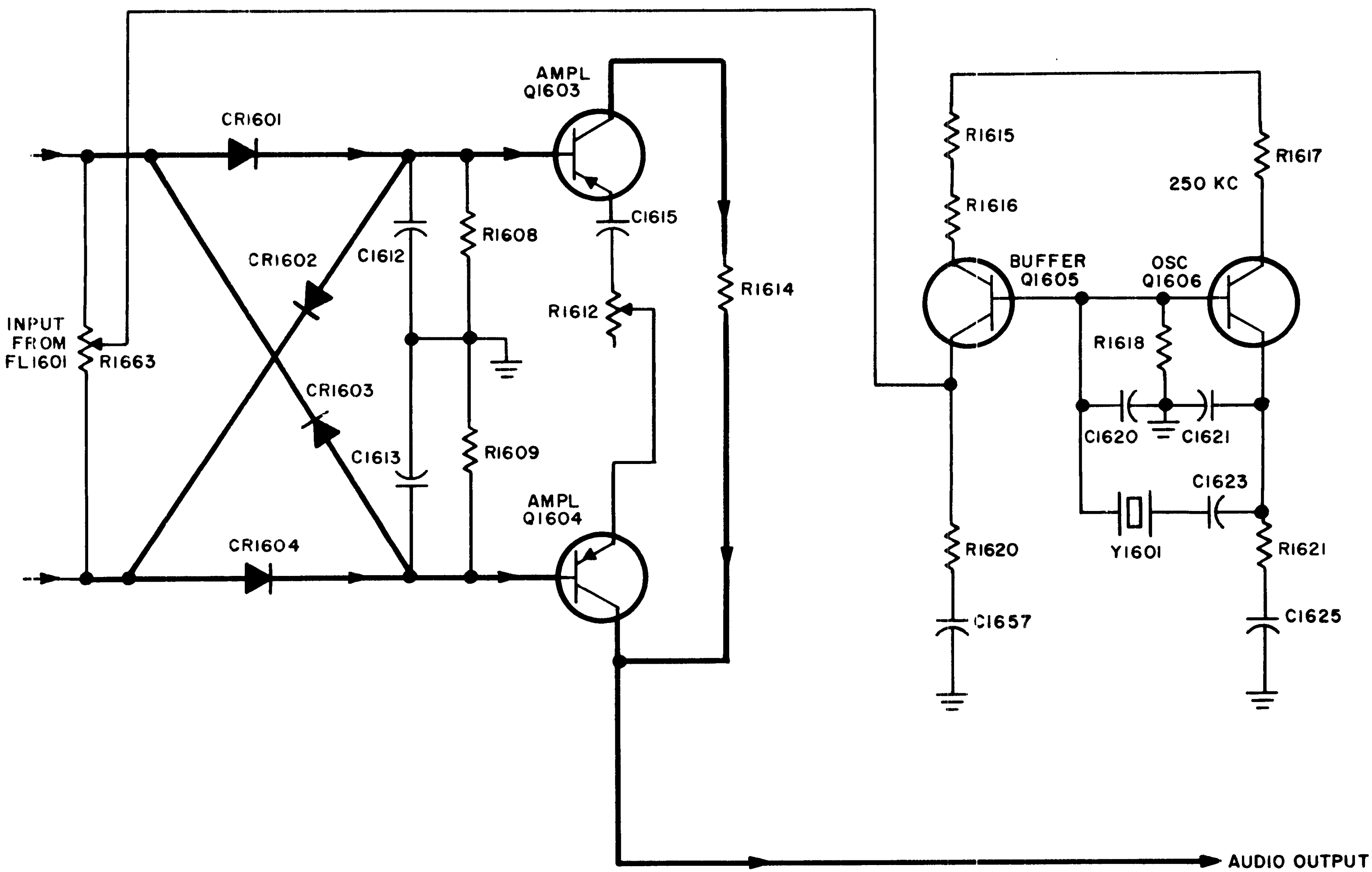


Figure 21. Demodulator Stage of Receiver I-F Module

maximum gain. Diod CR1607 is used as th clamp. Th agc output is then coupled through emitter follower Q1612 to the r c iver converter and audio modules.

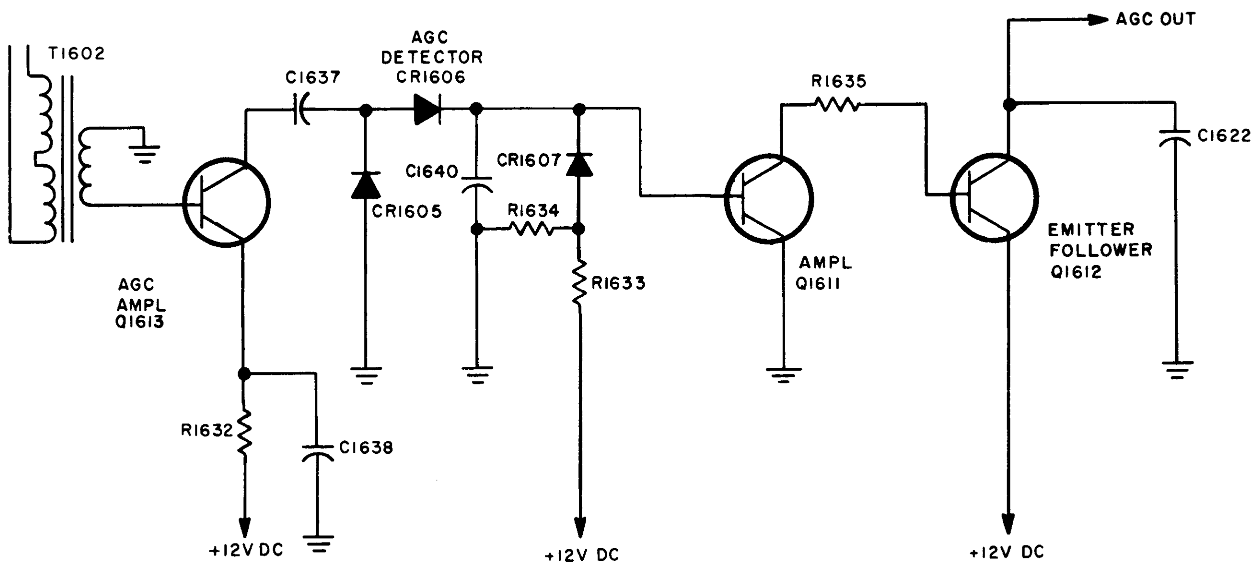


Figure 22. AGC Stage of Receiver I-F Module

RECEIVER AUDIO MODULE

The rec iver audio module consists of a lin amplifi r, speaker and headphone amplifier, and electronically controlled relay switch circuitry.

The audio output from the receiver i-f module is coupled through VOLUME control R1515 to amplifier Q1613 and through 0 dbm adj. resistor R1516 to 600-ohm amplifier Q1618 which provides a one miilliwatt output across a balanced 600-ohm line.

The audio input to n-p-n transistor Q1613 is amplified and then distributed to push-pull drivers Q1614 and Q1615. Th output from the emitter-coupled drivers is transformer coupl d to power amplifiers Q1616 and Q1617. Operating class AB, the power amplifiers provide a 1-watt output between 250 cps and 10 kc. Transformer T1604, in the common collector circuit,couples the audio output through the normally closed contacts of squelch relay K1601 to loudspeaker LS1500 across terminals 8 and 9 on TB . Normally these terminals are bridged to allow continuity. By disconnecting the speaker wire from the terminal board an external speaker can be used to replace it. Without disconnecting this wire, an external speaker can be placed in parallel with the equipment speaker.

A squelch circuit consisting of a comparator, relay driver, and relay, disconnects the speaker during periods of high noise. The comparator consisting of a regenerative bistable circuit whose state depends on the amplitude of the input voltage, compares sqelch and agc voltage levels. The squelch input is generated by eith r the LSB or USB oscillators in the receiver i-f module. Th select d sinusoidal signal is coupled through relay K1501 and SQUELCH control R1518 to the bas circuit of Q1620. Th agc input is coupl d from the agc n twork in the receiver i-f module to the base circuit of Q1619. When the agc voltage becomes more positive than the squelch voltage, the circuit changes state. With a low agc voltage level, Q1619 is non-conducting, and the base of Q1620 is fixed at a voltage d termined by the setting of the SQUELCH control. If the input is l ss than the required trigger level, Q1619 remains off. As the input agc reaches the trigger level, Q1619 begins to conduct and regeneratively turns off Q1620. This particular circuit operates over an agc voltage range between +2 to +8 volts. Relay driver Q1621, a current amplifier, activates relay R1601 after an established current level has been reached in its emitter circuit. Upon activating, the audio output is switched across resistor R1660. Provision is also made to connect an ext rnal squelch alarm across termanals 4, 5, and 6 on TB_____.

DETAILED CIRCUIT ANALYSIS OF TRANSMITTER

INPUT CIRCUITS (See figure 23)

Provisions are available for using a handset, or a microphone (high or low impedance) and headset, or telegraph key with the unit. The handset is connected to HANDSET jack J1515. The various inputs are connected to terminal board TB at the rear of the unit. For example, a 600-ohm line input is connected across terminals 1, 2, and 3 of TB , while high and low imp dance microphones are connected across terminals 5 and 6 r spectively. Low impedance microphones (about 1,000 ohms) are conn cted dir ctly into the audio xcit r module whil high impedanc microphones (in th ord r of 200K) ar imp danc -matched

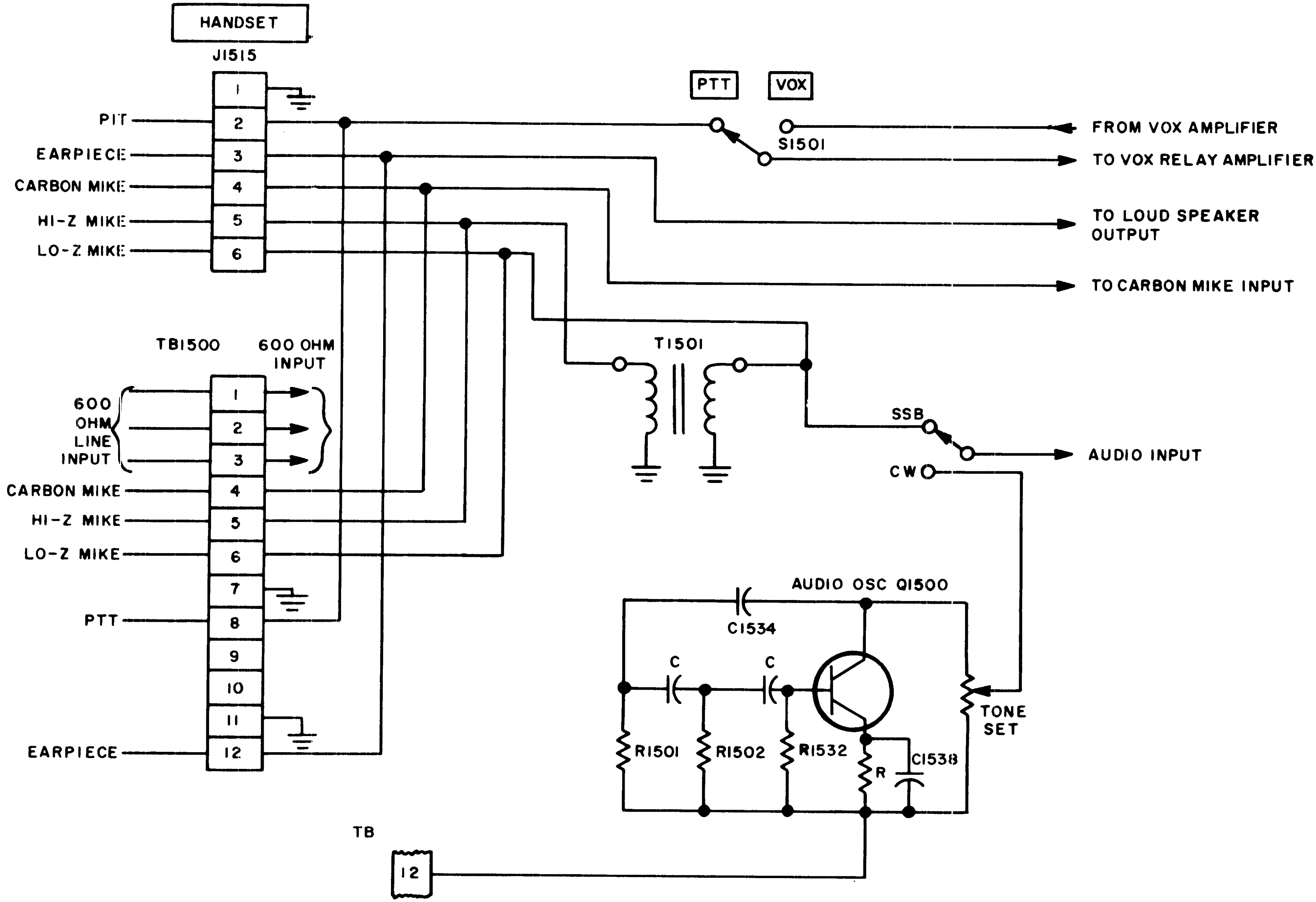


Figure 23. Input Transmitter Circuitry

to the 1,000 ohm audio input through transformer T1501. Both the high and low impedanc inputs ar coupled through the SSB position of S1512 to the exciter audio module.

Provision is made to connect a telegraph key to terminal 12 of TB . The key is connected to a phase shift oscillator (Q1501) which generates a sideband tone output. The tone level set control (R15--) adjusts the tone of the keyed audio; the audio itself is coupled through the CW position of switch S1512 to the base circuit of amplifier Q1702 in the exciter module. The carbon mike input is fed to the amplifier through module pin 5; the 600-ohm line input is fed to the amplifier through module pins 9, 10, 11; and the high and low impedance crystal mike and/or key inputs are fed to the amplifier through pin 6.

AUDIO AMPLIFIERS AND CLIPPER NETWORK (See figure 24)

The microphone and key inputs are coupled to voltage amplifi r Q1702 while the 600-ohm line input is coupled to amplifier Q1703 are fed to common-connected transformer T1701 in their coll ctor circuits. The balanced audio output is coupled to the exciter i-f module.

Features found in the audio stages are the XMTR GAIN control (R1514), which sets the gain of the audio modulating signal, and a clipper network. The clipping action, controlled by the setting of clipping adj control R1719, which varies the emitter currents in both amplifiers, provides up to 20 db attenuation. Switch S1504 has to be in the handset position before clipping occurs. With S1504 in the O dbm position, a straight +12-vdc biasing voltage is coupled to the module. Proper adjustment of the clipping pot ntiomet r is an important factor in th op ration of th low level clipp r sinc th control must b set so that th transmitter

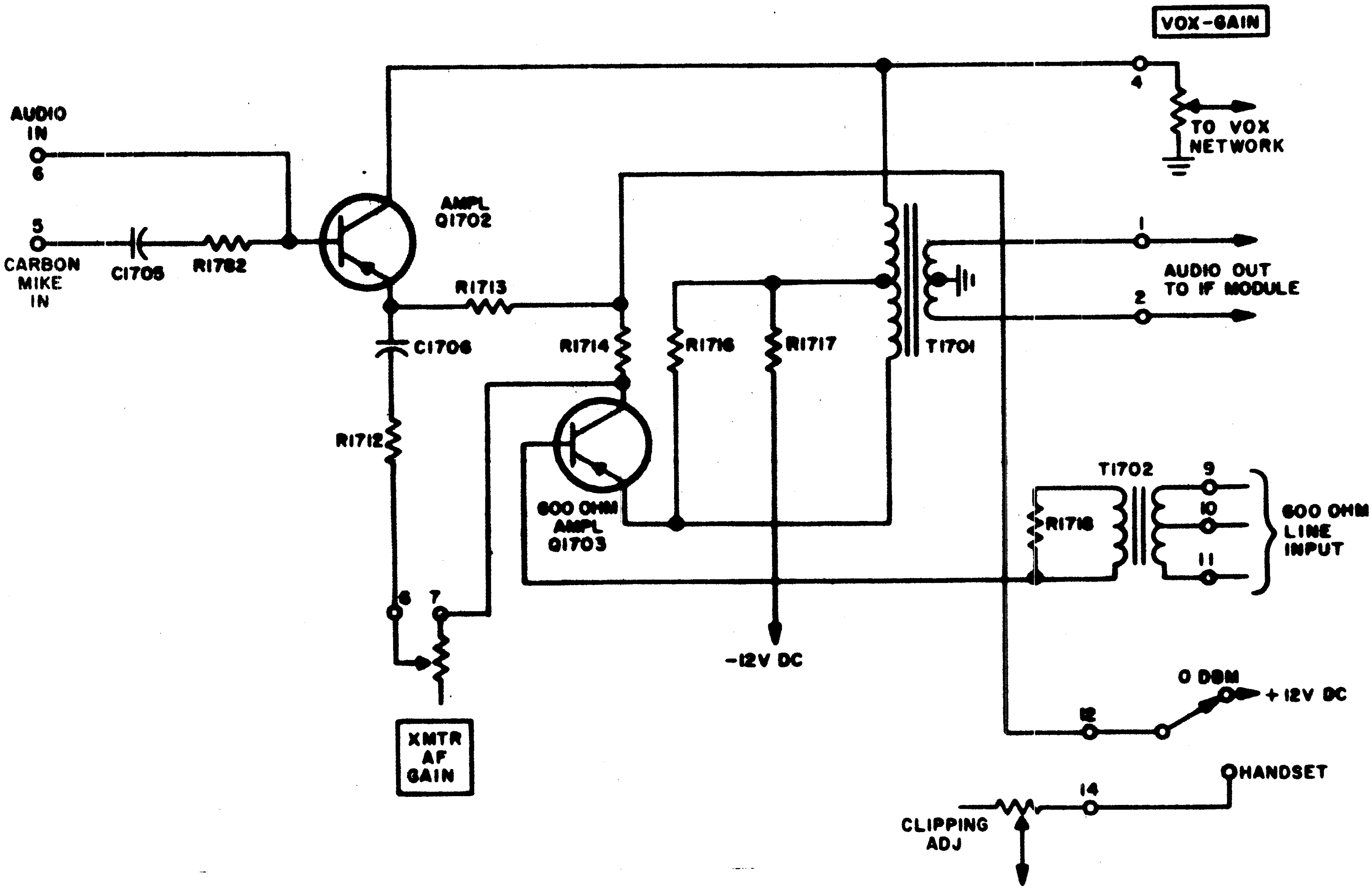


Figure 24. Audio Amplifier and Clipper Networks in Transmitter Audio Module

cannot be overmodulated when speaking in a normal voice. This method of clipping obtains a high level of modulation without overmodulating during volume peaks; thus occasional high-amplitude volume peaks are clipped resulting in a signal whose maimum amplitude is only equal to a slightly higher than that of the average voice peaks.

VOX AND ANTI-VOX NETWORKS

Although at first glance they seem oppositional, these two controls work in unison to set the voice-operated relay (VOX) signal threshold. Basically, they function as follows: The ANTI-VOX front panel control (R1517) is adjusted so that the amplitude of the received signals (voice or otherwise) do not trip the voice-operated relay resulting in the automatic switching on of the transmitter. On the other hand, front panel VOX-GAIN control R1513 is adjusted to vary the threshold level which controls the switching-in point of the transmitter. Usually it is adjusted so that a normally loud voice will switch the transmitter into operation.

One audio output from Q1702 is coupled through pin 4 of the module, routed through VOX-GAIN control R1513, and returned through pin 3 of the module and fed to an emitter follower-vox amplifier composed of cascaded transistors Q1704 and Q1705. Diodes CR1704 and CR1705, in the collector circuit of Q1705, rectify the resulting amplified audio signals; the pulsating d-c output is coupled to the base of emitter follower along with the negative pulsating d-c output from the anti-vox network.

The anti-vox signals, originally tapped from the loudspeaker output, are coupled through ANTI-VOX control R1517 to th base of anti-vox amplifi r Q1701. Not unlike the vox network, this stage with its collector connected diodes produc a pulsating d-c signal

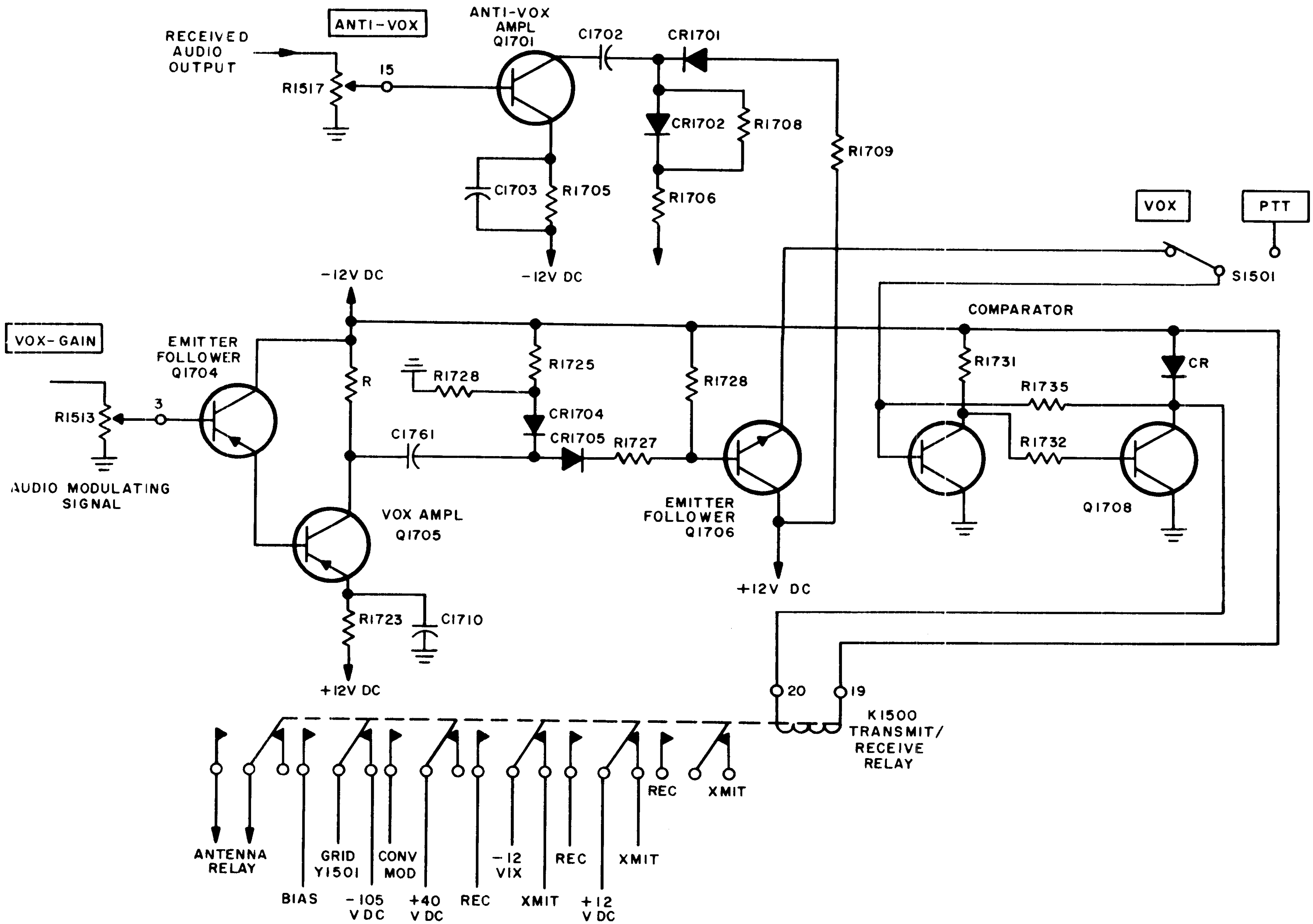


Figure 25. VOX and Anti-Vox Networks in Transmitter Audio Modules

(only its negative this time) which is coupl d, as mentioned before , to Q1705.

The total voltage polarity at the bas of Q1706 will determine its effective "turn on state." For example, on the application of a voice, the rectified voice signals will abruptly trigg r the quiescent amplifier thus resulting in a d-c output. The emitter output from Q1706 is coupled to the VOX position of PTT/VOX switch S1501. With S1512 in the VOX position, the d-c output is coupled to a comparator circuit which contains transistors Q1707 and Q1708. With just an anti-vox signal at the base, the transistor is sufficiently back-biased so as not to operat . With a vox signal, however, the back-bias is overcome and the resulting output is coupled to current control transistor Q1708.

The current-amplified output from Q1708 is then coupled to transmit/receive relay K1500 which is normally connected in the receive position.

This relay (K1500), which operates in both the PTT and VOX modes, controls the various circuits in both the transmitter and rec iver sections. During reception, a -105 vdc blocking bias voltage is coupled through contact 10 to the control grid of power amplifier V1501. While transmitting, an operating bias is coupled through contact 9 to the same grid. Also, a bias voltage of 40 vdc is coupled to the transmitter converter module. Both plus and minus 12-vdc bias voltages are coupled to the various modules during both transmission and reception.

SIMPLEX/DUPLEX switch S1506 is used to distribute the ±12 vdc transistor voltag s in th SIMPLEX position, th re ar no connections sinc ith r transmission or r ception is occurring, and normal power distribution is n eded. In th DUPLEX position, how ver, ±12 vdc bias voltages are coupled to both transmitting and receiving circuits since simultaneous reception and transmission occurring.

TRANSMITTER I-F AMPLIFIER MODULE

This module functions as a converter which produces a 1.75-mc output. Composed of two balanced modulator networks, it also generates upper and lower sideband signals.

BALANCED MODULATOR

The balanced modular stage is composed of balanced diodes CR1706 through CR1709, 250-kc oscillator Q1712, and buffers Q1713 and Q1714. The purpose of a balanced modulator is to obtain the side-frequency components of modulation without passing the carrier. The 250 kc carrier is generated by crystal controlled oscillator Q1712 which is connected in a modified clapp configuration. The 250 kc oscillator buffers are Q1713 and Q1714. The output from Q1713 is injected into the balanced modulator while Q1714's output is used as the reinserted carrier for various modes of operation.

Figure 3 shows a simplified schematic of the balanced modulator along with equivalent signal circuits. These equivalent circuits are shown for any half-cycle of the carrier voltage with switches shown in place of the rectifiers.

The output of the balanced modulator consists of a series of pulses whose polarity and repetition frequency are determined by the switching or carrier voltage, and whose amplitude is controlled by the input audio signal. Resistors R1736 through R1739 each in a diode leg, are used to reduce the drift so that .55 db of carrier balance can be achieved at the output of filt r F1701 without too much difficulty. The carrier is balanced out by a phase balanc

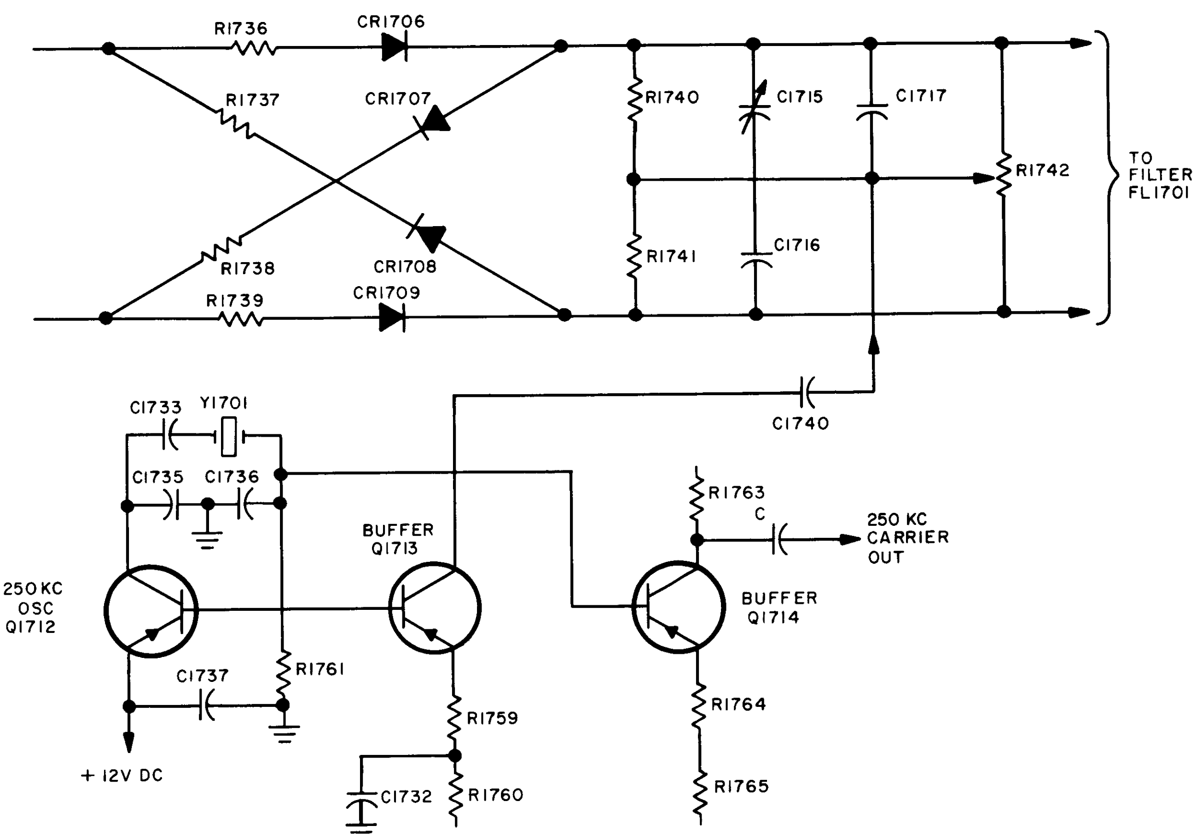


Figure 26. Balanced Modulator Circuit in Transmitter I-F Module

trimmer (C1715) and amplitude balance control (resistor R1742). If, for example, a 1-kc tone is fed into the balanced modulator, the output would consist of two signals: one at 249 kc and one at 251 kc (the sum of 250 kc and 1 kc).

Since the objective is to transmit only a single sid band signal and since both 251 kc and 249 kc signals exist at the balanced modulator output, a means of frequency discrimination must be provided. In this particular circuit this is done by filter FL1701, a 3 kc upper sideband filter. Figure 27 shows the frequency response of this electromechanical filter. Note that all frequencies inside the passband are limited to a bandwidth of approximately 3.25 kc at the 6-db points. Thus only the upper sideband is passed.

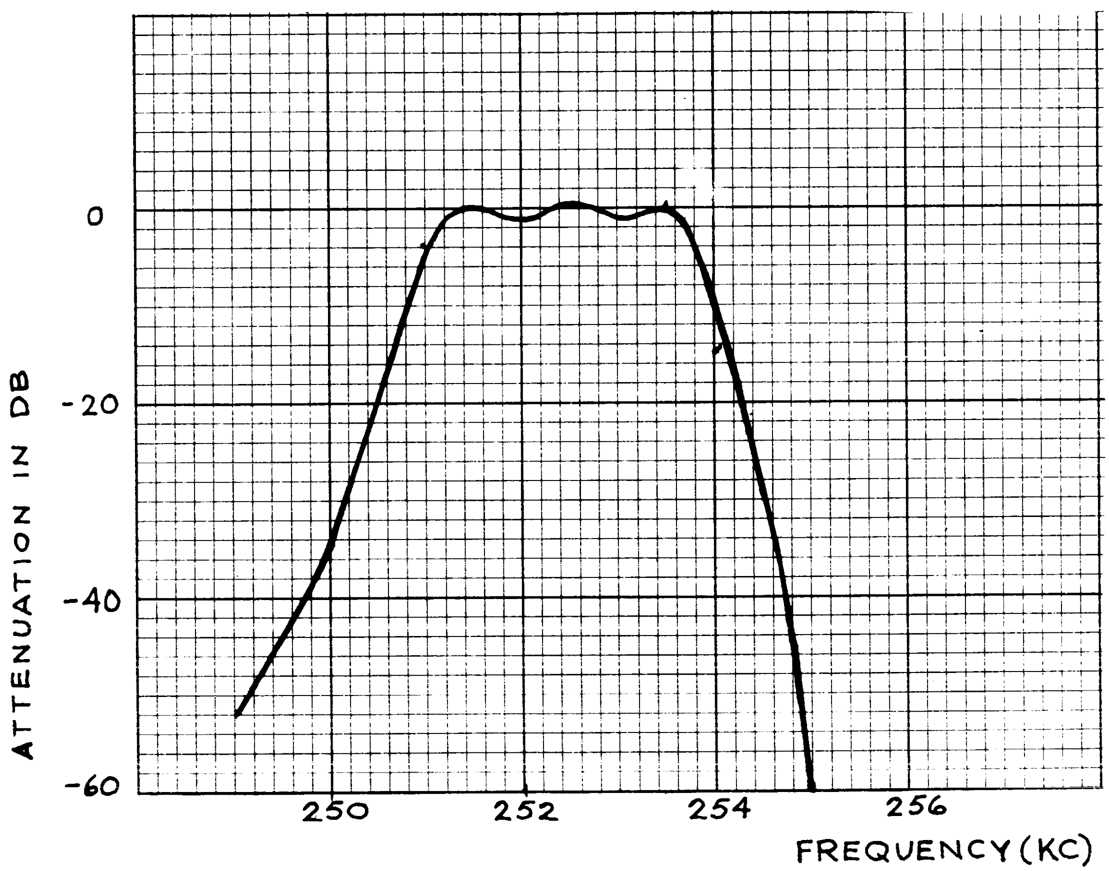


Figure 27. Frequency Response of FL1701

Sinc the output of th balanced modulator is balanced, and a low impedance, it was connect d in seri s with the resonating capacitors and the input coil in the filter. Normally, the filter is parallel resonated, and loaded with an impedance of 100 k, to give an input circuit Q of 15. In the series connection, where the balanced modulator looks like 400 ohms, the Q is still 15 and, since the filter is bilateral, the output is similarily coupled to the balanced mixer.

BALANCED MIXER

This stage heterodynes the 250-kc signal with a 1.75-mc i-f upper or lower sideband signal. Selection of either upper or lower sideband operation is dependent on the position of XMTR switch S1502. With S1502 in the LSB position, sideband relay K1502 is grounded thus activating it and consequently coupling a +12 vac bias voltage to the emitter circuit of 2-mc oscillator Q1716. Thus a 2-mc carrier injection frequency is introduced into the balanced mixer. With S1502 in the USB/REMOTE position, relay K1502 switches its contacts to allow the +12-vdc bias voltage to be coupled to 1.5-mc oscillator Q1717.

Also, since the relay is left open, a remote connection mad through terminal on TB located at the rear of the unit can be used to control the selection of an upper or lower sideband. Thus it is possible to control the selection of a sideband from remote position.

Both the 1.5-mc and 2.0-mc oscillators feed into balance control potentiometer R1748 through buffer Q1715 which provides a low source impedance for driving the mixer. The oscillator signal lev 1 at th mix r is about 100 milliwatts. Whil the conversion gain of th balanced mix r is constant ov r an oscillator inj ction l v l of from 80 millivolts to 200 millivolts.

Emitter conn cted transistors Q1709 and Q1710 are used as the balanced mixer which produces a 1.75-mc output through fr - quency translation. With S1502 in the LSB position, the 2-mc oscillator injects the carrier which heterodynes with the 250 kc signal to make a 1.75-mc lower sideband signal. Conversely with S1502 in the USB/REMOTE position, injects 1.5-mc carrier which produces an upper side-band signal.

TRANSMITTER MODE SELECTOR SWITCH

Switch S1512, located on the front panel, selects the various modes of transmission. In the CW position, the telegraph key input is coupled through the switch to the transmitter audio module. Refer to the discussion on input circuits found on page for more information. No carrier reinsertion occurs with the switch in this position. And any carrier found in the output will be at least 60 db down from the peak of the sideband tone envelope. Figure 28 shows the outputs at the various positions of the transmitter mode selector switch.

In the AM and MCW positions of the switch, the 250-kc carrier signal generated by oscillator Q1712 is reinserted through a voltag divider network and coupled to the second converter stage (balanced mixer Q1709, Q1710). The resulting output waveforms in both compatable a-m and c-w operation have a reinserted carrier 6 db greater than the peak envelope sideband with at least 60 db attenuation of the unwanted sideband.

In the -20 DB position of the switch, practically the same thing happens only this time the carrier is attenuated by 20 db; the resulting output has a carrier down 20 db from the peak envelope of the sideband signal. Finally, in the SSB position, no carrier reinsertion occurs and only the sideband is transmitted. The carrier is suppressed at least 60 db from the peak envelope sideband signal. Refer to the discussion on input circuits found on page .

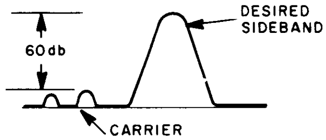
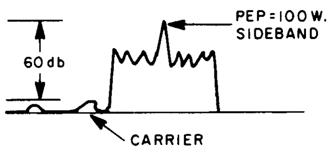
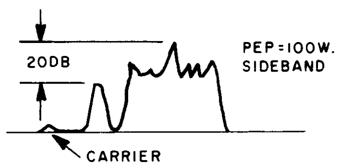
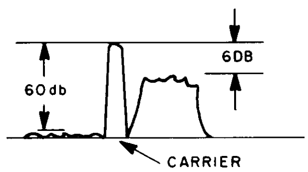
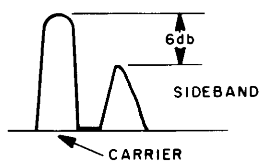
SWITCH POSITION	OUTPUT WAVEFORM	NOTES
CW		RECEIVING UNIT MUST HAVE BFO
SSB		RECEIVING UNIT MUST HAVE VERY STABLE BFO
-20DB		FOR TUNE-UP OR REFERENCE PURPOSES
AM		COMPATIBLE A-M NO BFO NEEDED IN RECEIVING UNIT
MCW		NO BFO NEEDED IN RECEIVING UNIT

Figure 28. Transmitter Mode Switch and Output Waveforms

TRANSMITTER CONVERTER MODULE (S e figur 29)

Th re ar four transmitt r conv rt r modul s in th unit, ach one design d to cov r S l ct d Fr qu nci s within a band. The module designed to cover frequencies between 2 and 4 mc has a 500 series designations, the 4 to 8-mc module has a 600 series designations, the 8 to 16-mc module has a 700 series designation, while the 16 to 32-mc module has a 800 series designation. For purposes of discussion, it's assumed that the TRANSMITTER CHANNEL selector is in the 1 position (this indicates that the 500 series module is switched into place).

This module functions as a frequency translator in that it heterodynes the input to produce two switched selected output frequencies between 2 and 4 megacycles. The 1.75-mc input is coupled through pin of J and transformer coupled to a balanced modulator network consisting of Q503 and Q504. Potentiometer R501 is a resistive balance control,designed to null out the straight-through oscillator signals.

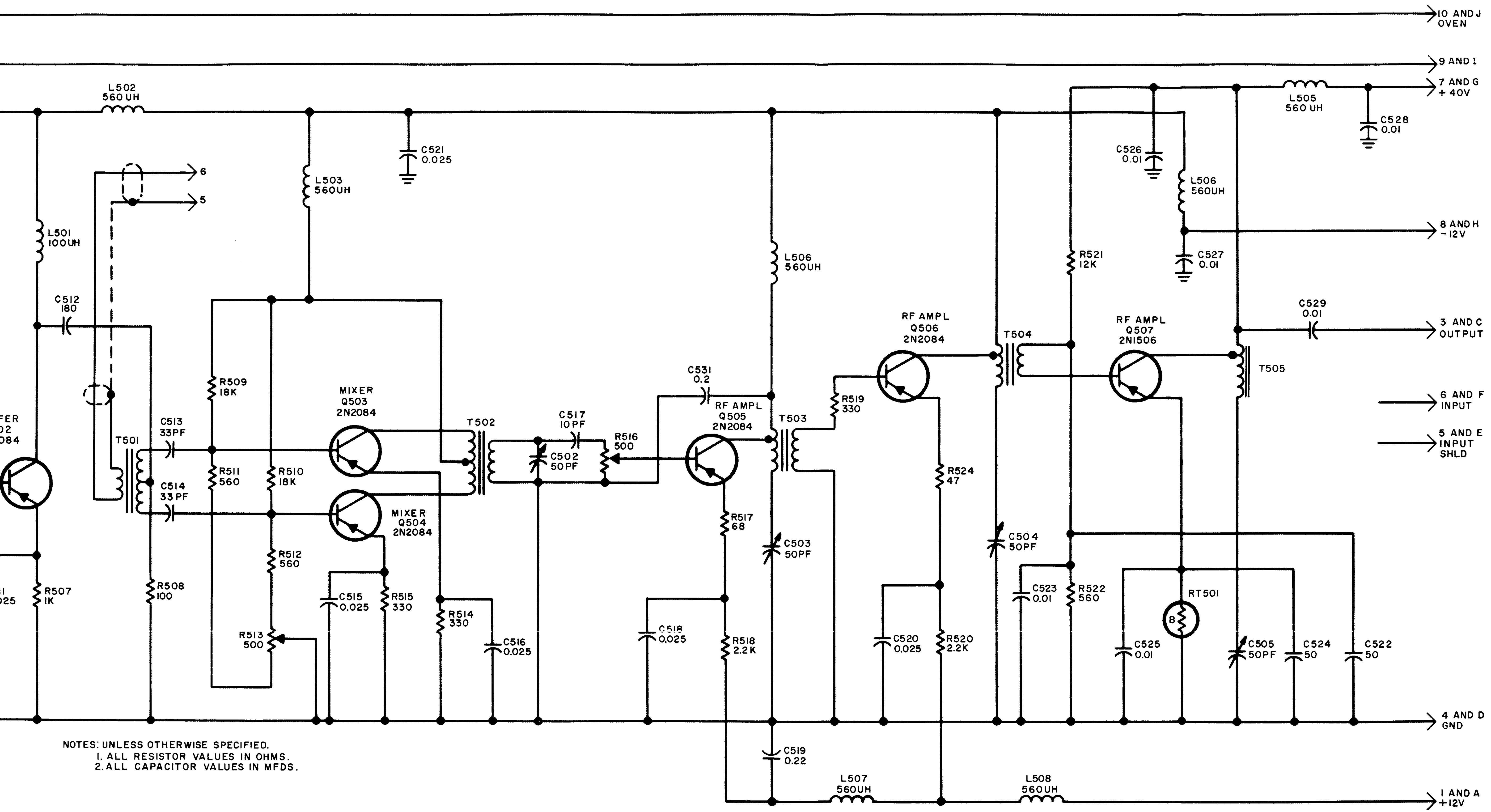
Oscillator Q501 is a crystal clapp type on the lower three bands, and since fundamental mode crystals are not available above 20 megacycles, an overtone modified Butler oscillator is used on the 16 to 32-mc band. Selection of two different fr quencies is possible by switching in either the F1 or F2 crystals. Each oscillator module has a fine frequency control which is a front panel accessible trimmer caoacitor. Called the SPEECH CLARIFIER control, it allows the oscillator frequency to be adjusted slightly to compensate for possible fluctuating crystal parameters. Tabl 7 below lists the pull-in frequency limits about the cent r fr qu ncy of th oscillator, which is 1.75 mc abov the output fr qu ncy.

TABLE 7. PULL-IN FREQUENCIES (TRANSMITTER)

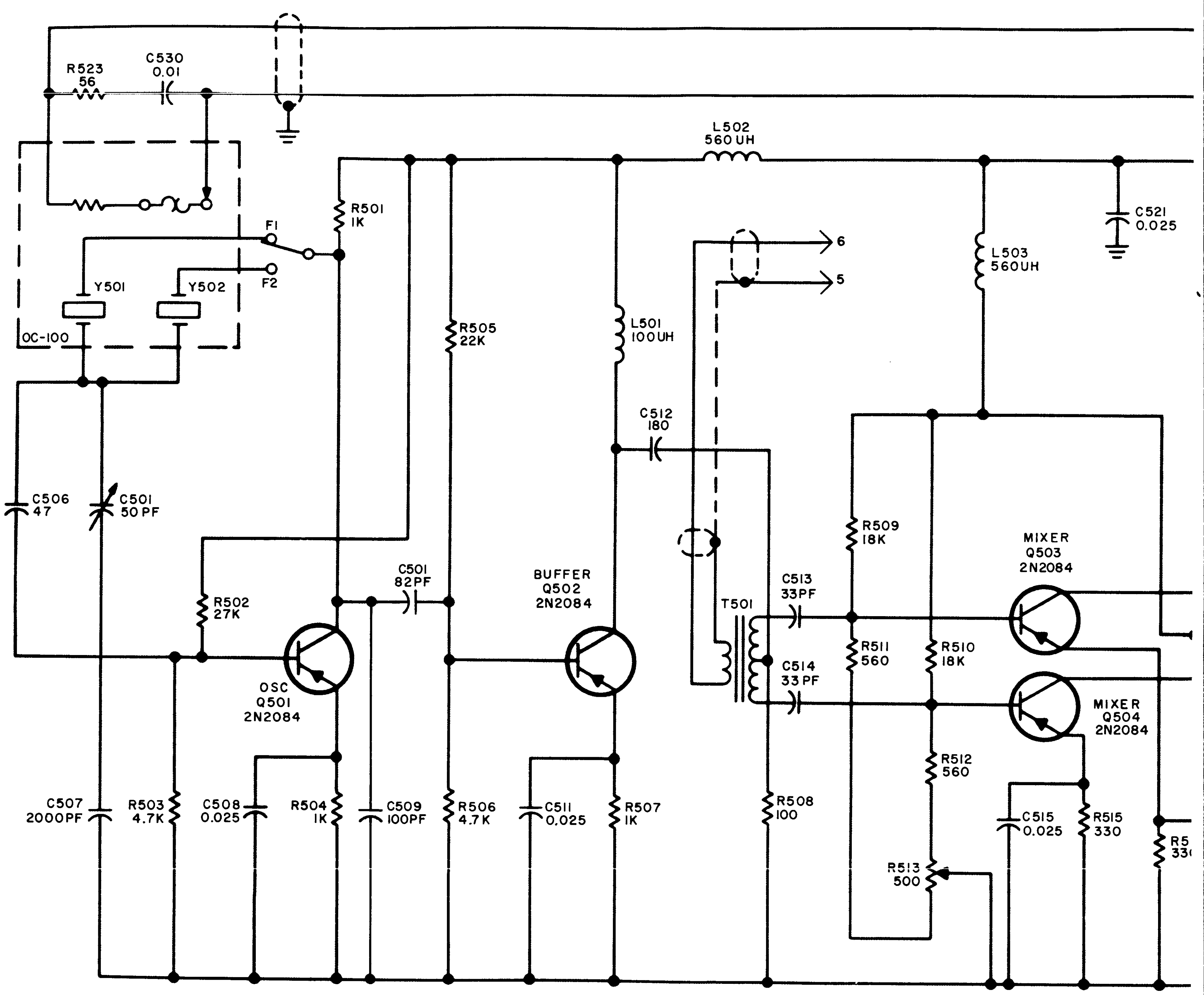
BAND	OSC FREQ (MC)	PULL-IN +CPS	PULL-IN -CPS
1	3.75	553	218
1	4.75	798	386
1	5.75	1170	484
2	5.75	1238	493
2	7.75	1422	679
3	13.75	2480	840
3	17.75	2849	2101
4	24.5	700	1118

The oscillator is connected to the balanced modulator network through a buffer stage (Q502) which is a video-type amplifier on the lower three bands and a video amplifier which is part of the two transistor oscillators on the upper band. The buffer amplifiers are driven from a low impedance point in the oscillator to maintain frequency stability. The buffer serves to isolate the load from the oscillator to minimize loading effects on the oscillator's frequency and amplitude stability. An external oscillator jack is provided in the chassis for tune-up and to allow operation using a signal generator on synthesizer as the conversion oscillator.

The output of the balanced modulator is coupled through transformer T502 and capacitor T501 to the base of amplifier Q505 which is in a common emitter configuration with a variable level input provided by a gain control potentiometer on the chassis. Since the transistor's output impedance is very much a function of frequency, the gain control must be adjusted when the pretuned channel frequency is changed in order to keep from over-driving the final amplifier stages. Th primary purpose of Q505 is to



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFDS.



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFDS.

provid s lectivity since it has a nominal gain of unity.

The second amplifier stag consists of two transistors (Q506 and Q507) in a parallel common-emitter configuration and has less selectivity than the first amplifier. These transistors are connected in parallel to provide a usable power level. The output is a 50-ohm resistive link, coupled from the tank, and is bought out through the TRANSMITTER SELECTOR switch to the vacuum tube final amplifier stages.

POWER AMPLIFIER STAGES (See figure)

The r -f output from the selected transmitter converter module is transformer coupled through T1500 to the grid of pentode IPA (intermediate power amplifier) V1500. This is the exciter output and is about five milliwatts. Essentially a driver, this tube provides a 25-watt PEP output. One tube can be used for the entire frequency range because of individual channelized single-tuned interstage tuning. Figure 31 shows a typical interstage tuning chassis interconnect.

The r - f output from V1500 is coupled through parasitic suppressor PS1500 and capacitor C1503 to a parallel-tuned tank circuit. In the example shown, the interconnect used tunes between 2 and 4 mc. Exact frequency tuning can be accomplished by adjusting C1101, a 210 to 1000 pf capacitor. The 300-vdc plate voltage for V1500 is tapped from pin 3 of J1501 and coupled through a chain of r - f chokes to pin 7 of the tube. This same voltage is also coupled to the screen grid of the tube. The tube operates Class C.

Coupled through the tuned plate circuit, the 25-watt r - f output is coupled to the grid of power amplifier V1501, a dual triod capable of producing outputs up to 100-watts PEP. The plate

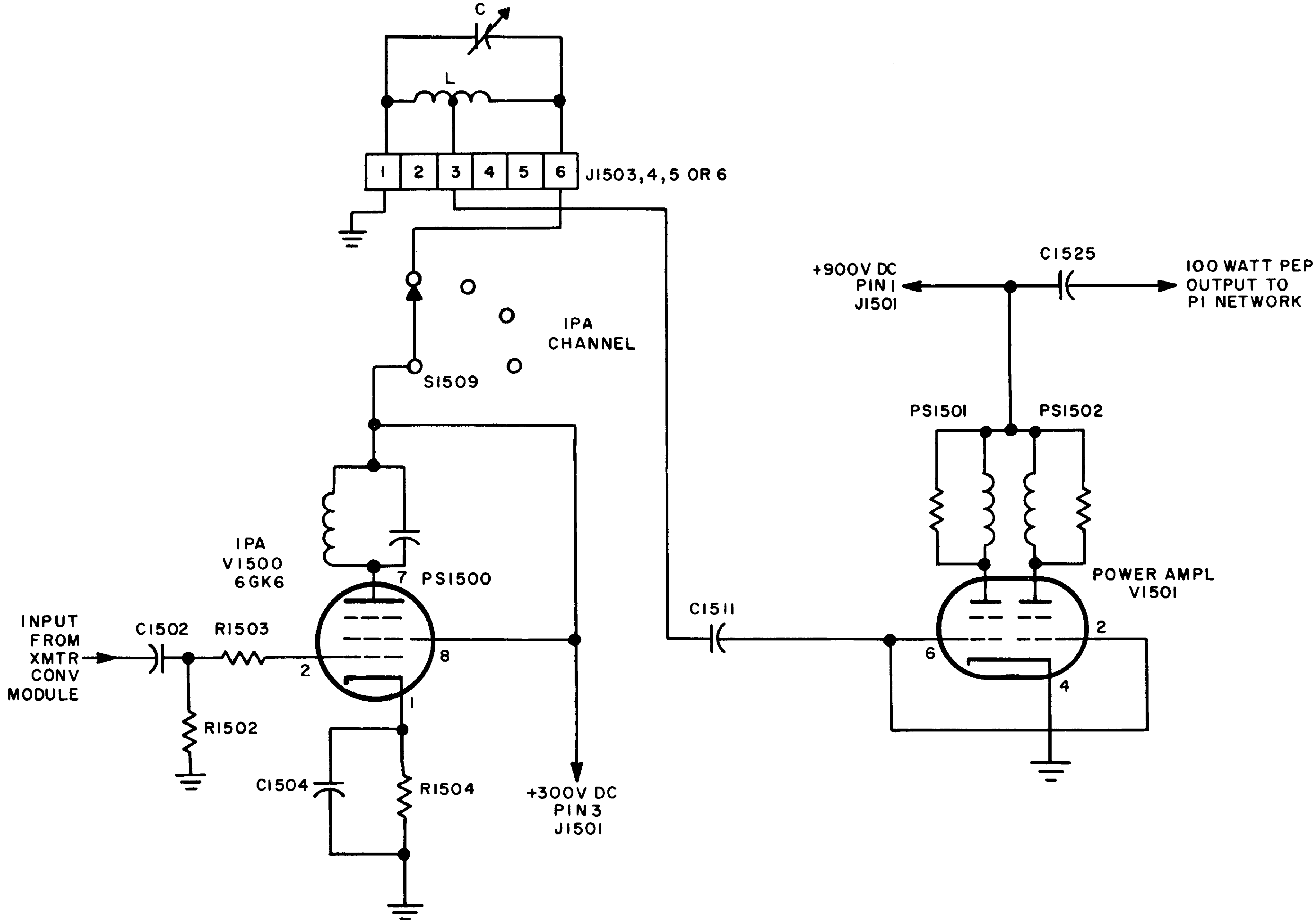


Figure 30. Vacuum Tube Final Amplifier Stages

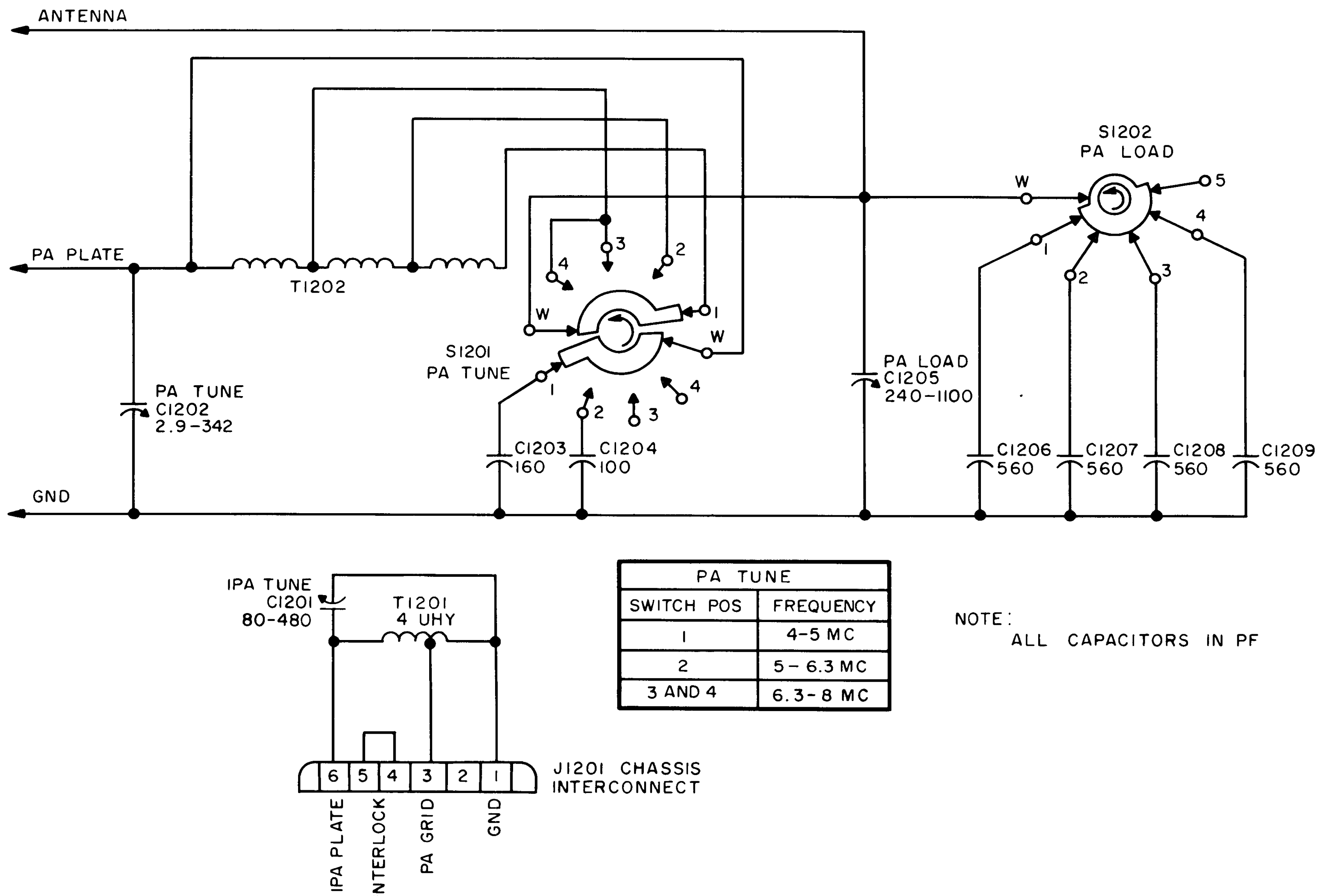
circuit of the power amplifier consists of a pi network locat d in th selected front pan 1 plug-in unit. Th pi network matches the 50-ohm antenna impedance to V1501's plate impedance.

A 900-vdc plate voltage for V1501 is tapped from pin 1 of J1501 is coupled to the plates through a circuit breaker and chain of r - f chokes. A 300-vdc screen grid voltage for this tetrode is coupled from pin 4 of J1501 to pin 3 through a s ries of r - f chokes. During transmission, the grid bias is coupled from across potentiometer R1500 which can be used to adjust the voltage output of the bias circuit in the power supply modul . On the other hand, during reception a -105 vdc control voltage is coupled to the grid of the tube thus completly cutting it off. Selection of either the operating or blocking bias is determined by the position of the contacts in transmit/receive relay K1500.

PI OUTPUT FILTER (Figure 31)

The plate tank circuit for V1501 is made up of a selected pi network which is tuned and loaded by adjusting continuously variable capacitors and a tapped inductor. To illustrate this, let's take a look at the 2 to 4 mc module. The PA tune switch (S1101) and load switch (S1102) have four positions. In position 1, it tunes to frequency between 2 and 2.2 mc; in position 2, it tunes between 2.2 and 2.5 mc; in position 3, it tunes betwe n 2.5 and 3.1 mc; amd in position 4, it tunes between 3.1 and 4 mc.

The matched r - f output from the pi filter output is coupled to transmitter output jack J1501. From here the signals can be directly doubled to an antenna or, when duplex operation is used, it is coupled to an antenna through antenna relay K901.



PA TUNE	
SWITCH POS	FREQUENCY
1	4-5 MC
2	5 - 6.3 MC
3 AND 4	6.3 - 8 MC

NOTE:
ALL CAPACITORS IN PF

Figure 31. Typical Pi Output Filter

ANTENNA CONNECTIONS

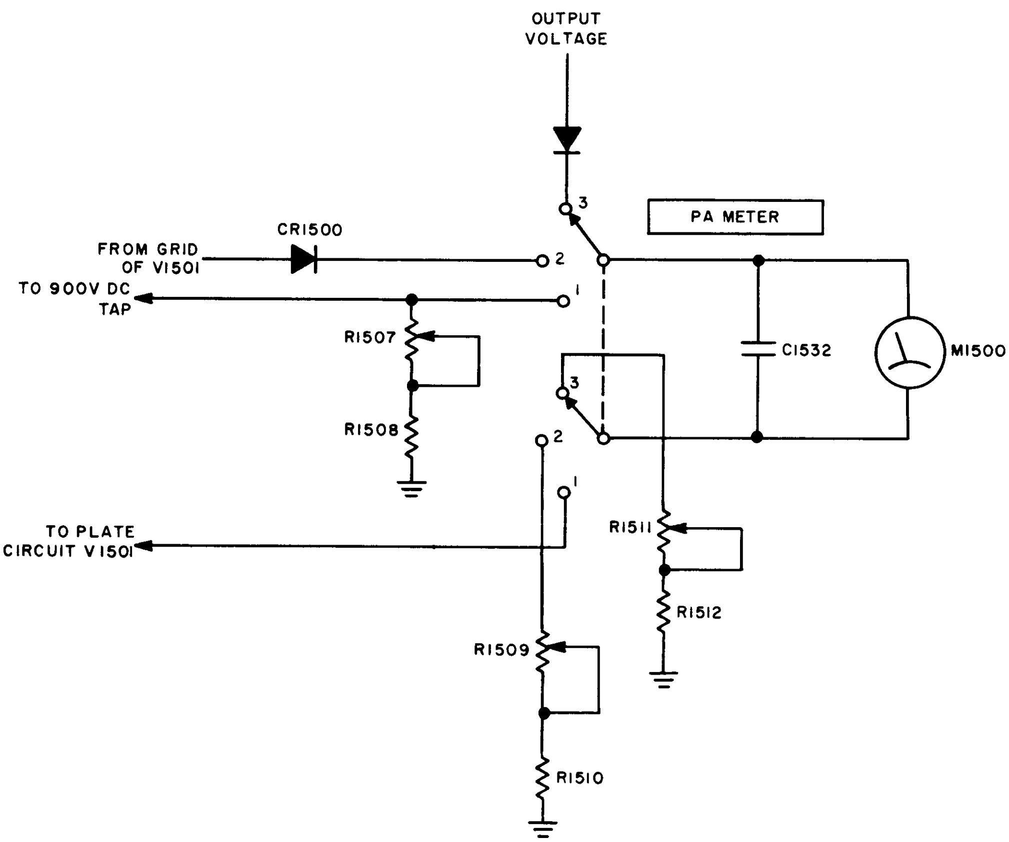
The primary condition stipulating as to what antenna or how many antennas is determined by the desirability to operat the equipment either simplex or duplex. In simplex applications, where transmission and reception on one frequency is used, only one antenna is needed. The antenna is connected to jack J which routes the signal to or from either the receiver or transmitter functional sections.

With duplex operation, simultaneous reception and transmission on two different frequencies occur. The transmitter antenna is coupled to jack J1501.

METER CIRCUITRY (See figure)

The meter circuitry allows the operator to keep a close check on the performance of the equipment. Consisting essentially of a front panel meter and PA METER switch, it's capable of measuring the plate current and grid voltage of the final amlifier stage and output voltage. The meter and PA METER switch are color matched for easy identification; the black scale is for the plate voltage, the green scale for the grid voltage, and red scale for output voltage. The Ib scale is calibrated between zero and 250 ma in 50-ma increments. The green grid voltage scale is calibrated between zero and 50 volts r-f in 10-volt increments. The output voltage is measured on the red zero to 10 scale which is calibrated to read the output voltage level up to 1000 volts.

With the PA METER switch (S1511) in the Ib position, th plate current feeding power amplifier V1501 is tapped and coupled through meter M1500. Resistor R1507 in series with the meter is used to set th met r to the inscribed I_b ADJ line. In th EgRF position, a portion of th grid voltag is r ctifi d through diod CR1500 and coupl d through meter M1500 and calibrat resistor R1509. With the switch in the EoRF position, a tapped portion of the output is rectified through a diode and necessary filters to meter M1500. Calibrate potentiometer R1511 zeros the meter in this particular mde of measurement.



METER SWITCH	
1	Ib
2	Eg RF
3	EoRF

Figure 32. Meter Circuitry

DETAILED CIRCUIT ANALYSIS OF POWER SUPPLY

LOW VOLTAGE CIRCUITRY

The power supply circuit consists basically of a power supply module and associated control networks. Capable of operating with input voltages of 115 vac, 208 vac, or 230 vac, 50 to 60 cps, the power supply generates ±12 vdc transistor bias voltages and operating voltages for the power amplifier output stages.

The input voltage (115 vac for purposes of discussion) is coupled from a-c input J900, through terminals 20 and 21 of J903, to POWER switch S1500. With S1500 in either the REC or XMIT/REC positions, power is applied to power transformer T901 in the power supply module.

The first secondary winding produces 100 vac across half wave rectifiers CR916 and CR917. Resistor R918 and capacitor C914 filter the pulsating d-c signal which, in turn, is coupled to a regulator circuit consisting of series regulator Q902 and Zener diode CR910. The Zener diode in series with the series regulator transistor will tend to maintain an essentially constant load voltage of 40-vdc providing the operating limits of the tube are not exceeded. Since the voltage across the Zener is essentially constant, even in the presence of a varying load current, voltage variations are felt across series regulator Q902 which varies its impedance directly in proportion to the flux in voltage conditions. Hence, if the output voltage tends to increase above 40 vdc, a correspondingly larger voltage drop appears across Q902 thus effectively reducing the output to its normal 40 vdc.

The opposite reaction occurs should the operating voltage drop below 40 vdc. Since there is some nois g n rated in the Zen r diod , a low pass filt r consisting of L904, R920, R921, and capacitors C915 through C917 is us d at its output. The 40-vdc output is coupled across C918 to pin 9 of J903. Capacitor C918, in shunt with power supply, minimizes power supply impedance variations.

The second secondary winding generates 38 vac across half wav diode CR913 and CR914. Filtered across capacitor C911 and resistors R91d and R915, the d-c output is routed to a regulator network consisting of regulator Q901 and Zener diode CR915. This regulator network works exactly as the one in the 40-vdc network above. The -12 vdc output is coupled to pin 15 of J903.

The +12-vdc transistor voltage is developed in the next network. A secondary voltage of 38 vac is applied to half wave diodes CR910 and CR911. A regulator network consisting of Q900 and Zener CR912 produce a stabile -12 vdc output which is coupled to pin 14 of J903 and to high voltage control relay K900.

The purpose of this relay is to disconnect the high voltage should the final stages overload. Thus it acts as a safety device. The ±12 vdc output normally activates the relay resulting in the application of operating voltages to power transformer T900. It also functions as an activator for antenna relay K901 which acts as a transmit-receive (TR) switch. Operating voltages is coupled across pin 18 of T903 to contacts of transmit/receive relay K1500. When in transmit mode, the operating voltage is coupled back to relay K901 which activates and couples the transmitter output to the antenna. During receiver operation, the receiver input is connected to the same antenna. Thus a single antenna can be used for both reception and transmission.

HIGH VOLTAGE CIRCUITRY

Transformer T900 in the high voltage circuitry provides the operating voltages for the final vacuum tube amplifier stages. Filament voltage of 6.3 vac is coupled to the vacuum tubes from the first secondary winding (pins 7 and 8) of T900. The second secondary winding (pins 9, 10, 11) produce 925 volts across high voltage rectifier CR909 which consists of four bridge-coupled rectifiers. The pulsating output is filtered across a single section choke input filter consisting of L901 and R906. A 900 vdc top-off between capacitor C905 and the PA overload adjust R907 is coupled through PA OVLD circuit breaker CB1500 to the plate circuit of power amplifier V1501. Should an overload occur in this circuit, CB1500 opens thus cutting off all high voltage networks.

A +400 vdc output is also coupled from the same network. Dropped to 300 volts across resistor R908, it is coupled to the plate circuit of the 6GK6 IPA stage. This 400 vdc is dropped down to 315 vdc across R905 and stabilized across tandem connected Zener diodes CR906, CR907, and CR908. The 315 vdc output is coupled to the screen grid of the 8117 vacuum tube.

The third secondary winding produces 180 vac across bridge rectifiers CR901 through CR904 which in turn generate a pulsating d-c output. An R-C filter composed of R900, R901, R902 and C902 and C903 is used to filter the pulsating d-c. Zener diode CR905 across the bias producing network stabilizes the output. The purpose of this network is to produce both an operating bias and -105 vdc blocking bias for power amplifier V1501.

The -105 vdc blocking bias is taken from the function of CR905 and R903 and is routed to the grid of V1501 through transmit/receive relay K1500 during reception. The operating bias voltage for V1501 is coupled across potentiometer R1500 which can adjust the amount of bias on the tube. It is connected to V1501 through the same contacts of relay K1500; however, it is coupled to the power amplifier stage during periods of transmission only.

SECTION 6

MAINTENANCE

GENERAL

This section contains troubleshooting techniques and alignment procedures. Usually, the only necessary routine maintenance is a periodic cleaning and inspection of the chassis and connections. If it becomes necessary to track down a trouble or align a certain part, follow procedures outlined in this section.

BASIC TROUBLESHOOTING

On the first indication of trouble, check fuses and tubes. Once satisfied that no fuses are blown, quickly check tubes by substituting a good type for the suspected defective one. Many troubles can be quickly checked this way. Then make a careful visual inspection of all components under the chassis. Look for signs of burning or overheating as well as loose wiring.

If it is summized that the power supply is functioning properly, systematic isolation of the trouble must be done. By checking the voltages and resistances at terminal boards, jacks, and tubes, an indication of circuit performance can be had.

EQUIPMENT REQUIRED

Table 6-1 lists the types and preferred models of equipment necessary for the troubleshooting and alignment of the unit. Use equivalent equipment if these particular types cannot be had.

TABLE 6-1. EQUIPMENT REQUIRED

Type	Model
VOM	Simpson 260
Power Supply	TMC Model AX-413

TABLE 6-1. EQUIPMENT REQUIRED (Cont)

Type	Model
Line Cord	TMC Model CA-555-4
Metered Variac	Model W10MT3W
Resistors (all 5%)	22K, 600 ohms, 47 ohms
Spectrum Analyzer	TMC Model PTE-3
AC VTVM	Ballantine Model 314
Audio Oscillator	
Frequency Counter	Hewlett Packard Model 524C
Signal Generator	Hewlett Packard Model 606A
AC VTVM	Hewlett Packard Model 410
Power Amplifier Module	TMC Model TTRA-4
Dummy Load	50 ohms + 5%, 100 watts, minimum dissipation, non-inductive
1.75 mc test jig	
Sonic Analyzer	Panoramic Model LP-1A
Coaxial Cables	RG-174/U and RG-58/U are recommended with RG-58/U used for transmitter output

RESISTANCE CHECK OF MAIN CHASSIS

In the event of failure, or in a periodic checkup, use the following procedures to check resistances at various points of the main chassis.

(1) Remove the four screws located below the terminal boards on the rear of the main chassis. This will allow the printed circuit boards assemblies to swing out on their hinges. Check for easy swing of each assembly. Figure 6-1 shows a typical printed circuit board locked on its hinges.

(2) Turn RECEIVER CHANNEL switch in channel 1 position. Place the probes of the ohmmeter between the center conductor of RCVR ANT jack J1502 and pin 6 of jack J1514, the receiver module jack for channel 1. The meter should read zero ohms.

(3) Set RECEIVER CHANNEL switch to position T and the TRANSMITTER CHANNEL switch to channel 1. The meter should indicate zero.

(4) Repeat steps 2 and 3 above for channels 2, 3, and 4.

(5) Place the TRANSMITTER CHANNEL switch in channel 1 position. Place the probes of the ohmmeter between the green lead of transformer T1500 and pin 3 of jack J150, the transmitter exciter module jack for channel 1. The meter should read zero ohms. Repeat this procedure for channels 2, 3, and 4.

(6) Place ohmmeter probes between pins 23 and 24 on jack J1500. The meter should indicate infinity. The meter should also indicate infinity between pin 23 and ground and pin 24 and ground.

(7) Table 6-1 below lists critical points of measurement; use this table as a guide. Before taking these measurements, however, place front panel mode switch to CW position and the power switch in XMIT/REC position.

TABLE 6-1. RESISTANCE MEASUREMENTS

FROM	TO	VALUE	CHECK
Plate caps, V1501	Ground	∞	
Pin 1 & 7, V1501	Ground	0	
Pins 2 & 6, V1501	Ground	∞	
Pin 3, V1501	Ground	∞	
Pin 4, V1501	Ground	0	
Pin 1, V1500	Ground	180 ohms	
Pin 2, V1500	Ground	10K	

TABLE [illegible]. RESISTANCE MEASUREMENTS (Cont)

FROM	TO	VALUE	CHECK
Pins 3,4,9, V1500	Ground	0	
Pin 7, V1500	Ground	∞	
Pin 8, V1500	Ground	∞	
Term 3, A-3278*	Ground	∞	
Plate caps, V1501	Term 4, A-3278	0	
Term 16, A-3221*	Ground	50Ω	
Term 21, A-3221*	Ground	250Ω	
Pin 9, J1500	Ground	∞	

* A-3278 is CW oscillator printed circuit board. A-3221 is the transmitter audio printed circuit board. With A-3221, place receiver and transmitter sideband switches in USB/REMOTE position.

MAIN CHASSIS VOLTAGE CHECKS

Voltages on the main chassis can be checked as follows:

(1) Replace a mounting screw in each printed circuit assembly to hold them in place. Then make sure power supply is connected correctly. Cable W900 at the rear of the power supply should be connected to RCVR ANT jack J1502. The other end of ~~the~~ W900 should be connected through a right-angle adapter to jack J902 on the power supply. Connect cable W901 from the antenna relay on the power supply to XMTR OUTPUT jack J1501 on the main chassis. Also check that jumper is connected between terminals 8 and 9 on terminal board TB1501.

(2) At the rear of the TTR, throw LINE-MIKE switch in LINE position and turn PA IB ADJ potentiometer clockwise. Then turn OFF the OVEN VOLTAGE switch.

(3) Remove the mounting screws so that the printed circuit assemblies will hinge out as before.

(4) Set front panel controls of TTR as follows:

(a) VOLUME control - - - Max clockwise

(b) PA METER switch - - IB

(c) RCVR switch - - - - USB/REMOTE

(d) SIMPLEX/DUPLEX switch - SIMPLEX

(e) SQUELCH control - - maximum clockwise

(f) PTT/VOX switch - - - PTT

(g) XMTR switch - - - - USB/REMOTE

(h) XMTR AF GAIN - - - - maximum clockwise

(i) Power switch - - - - OFF

(j) PA OVLD breaker . . . up

(5) Connect a variac between equipment and a-c line. Then set range switch on variac to low and adjust for 115 volts. Then turn power switch on TTR to REC. The red POWER lamp should light. The variac voltmeter should read approximately 10 watts.

(6) Connect the positive lead of a voltmeter (set to 50-volt scale) to terminals 7 and 3 on the receiver i-f printed circuit board. The meter should read 12 volts ± 5%.

(7) Set RCVR switch to LSB position and repeat above step for terminal 4. Then place RCVR switch to USB/REMOTE.

(8) At the receiver i-f board, ground terminal 10 on terminal board TB1501 and repeat step 6 at terminal 4. Grounding terminal 10 should produce a clicking sound due to energization of relay K1501. Remove ground and meter upon completion of this test.

(9) Set the voltmeter to read -DC and repeat step 6 at terminal 8 of TB1501.

(10) Place probe of voltmeter to terminal 14 of receiver if printed circuit board. Meter should indicate 12 volts ± 5%. Next, set meter to read +DC volts and place probe on terminal 11. Meter should again read 12 volts ± 5%. Then place meter probe on terminal 8 of the cw oscillator printed circuit board. The meter should again read 12 volts ± 5%. Leave meter connected.

(11) Rotate mode switch on the TTR to its various positions: the voltmeter should indicate no voltage in the SSB, -20 DB CARRIER, or AM positions. In MCW position, voltage should be present. After completing this step remove meter and set mode switch to SSB.

(12) Connect voltmeter to terminal 21 at the transmitter a-f printed circuit board. The meter should read 12 ± 5% .

(13) Place meter on terminal 7 of the transmitter i-f printed circuit board. Meter should read 0 volts. Leave meter connected and ground terminal 8 on terminal board TB1500. Meter should read 12 ± 5% volts. Remove meter and ground.

(14) Set meter to read + volts DC and place probe on terminal 5 of transmitter i-f board. Meter should rear zero volts. Then ground terminal 8 of terminal board TB1500. Meter should read 12 ± 5% volts. Remove ground and meter. Then place meter on terminal 4. Meter should read 12 ± 5% volts.

(15) Set XMTR switch to LSB and place meter at terminal 6 of TB1500. Meter should read 12 volts ± 5%. Remove meter and reset switch to USB/REMOTE.

(16) Ground terminal 10 on terminal board TB1500. A clicking sound due to energization of relay K1502 should be heard. Then remove ground.

(17) Set power switch on front panel to XMIT/REC and TRANSMITTER CHANNEL switch to channel 1. Place the meter probe on pin 7 of jack J1510 (J1510 is the transmitter module jack for channel 1).

(18) Ground terminal 8 of terminal board TB1500. The meter should read 40 ± 10% volts. Then throw front panel power switch to REC. The meter should still read 40 ± 10% volts. Then remove meter and unground terminal 8 on terminal board TB1500.

(19) Install the TMC Model TTRA-4 Power Amplifier Module for channel 1. Then with the Simpson 260 meter set to 500 ma,

place the probes between terminals 3 and 4 on the CW oscillator printed circuit board. Use clip leads to firmly attach the probes with the ground probe on terminal 4 and the positive probe on terminal 3.

WARNING

The no-load voltage at these terminals may exceed 800 volts when transmitter is on. Use caution.

(20) Set power switch on front panel to XMIT/REC. Then push PA OVLD circuit breaker down. A click should be heard due to the energization of the relay. The filaments of both the IPA and power amplifier tubes should light and the wattmeter on the variac should read approximately 90 watts.

WARNING

All transmitter voltages are now on. Contact with these voltages can be fatal. Use extreme caution when performing steps (21) through (26) below.

(21) Set the VTVM to read +DC volts on the 1000-volt scale. With extreme caution measure the voltage present at each plate cap of the power amplifier. VTVM should indicate 820 volts.

(22) Measure the voltage at pin 3 of power amplifier V1501. It should be 320 ± 5% volts. Then set meter to measure -DC volts in the 300 volt range and measure the voltage at pin 6 of the power amplifier (V1501). It should be 105 ± 5% volts.

(23) Set meter to read +DC volts on the 1000-volt range. Then measure the voltages at pins 7 and 8 of IPA V1500. The voltage should be 300 ± 10% volts.

(24) Ground terminal 8 on terminal board TB1500. A loud click should be heard due to the antenna relay energizing. Leave terminal 8 grounded.

(25) With a screwdriver rotate the PA IB ADJ potentiometer to obtain 50 ma on the Simpson meter. Then lock the potentiometer at this setting. Let it run for five minutes and check for fluctuations.

(26) Push the PA OVLD breaker lever up. The antenna relay and high voltage relay will de-energize and current should drop to zero. Then remove meter.

(27) Solder a piece of No. 22 buss bar between terminals 3 and 4 on the CW oscillator printed circuit board. Then reset PA OVLD breaker lever in down position and allow unit five minutes to warm-up.

(28) Then adjust calibrating potentiometer R1507 (CAUTION: use an insulated screwdriver) for a reading of 50 ma on the black scale of the front panel meter. (50 ma is indicated by the heavy black line labeled Ib ADJ.)

(29) Set the TRANSMITTER CHANNEL selector to channel 2. The antenna and high voltage relays should de-energize and the Ib indicated by the front panel meter should drop to zero. Then set the PA OVLD breaker to the upward position and remove the ground from terminal 8 of terminal board TB1500.

(30) Turn SQUELCH control clockwise and connect VTVM between terminal 1 of the receiver audio printed circuit board and ground. The meter should read $+1.7 \pm 0.3$ volts. By turning the SQUELCH completely counterclockwise the meter reading should rise to 6.5 ± 5 volts.

ALIGNMENT OF MAIN CHASSIS ASSEMBLY

The following procedures describe the tuning and adjustment of main chassis assembly AX-418.

Transmitter Audio Alignment

(1) Set the transmitter mode switch on the front panel to SSB position. Check to see that S1504 on the rear of the unit is in the LINE position.

(2) Connect the output of the TTG Two Tone generator within the PTE between terminal 6 on TB1500 and ground. Set the TTG terminal board to TONE 1.

(3) Connect the AC VTVM between terminal 6 of terminal board TB1500 and ground and set the Audio Output control on the TTG for a deflection of 14.0 millivolts.

(4) Move the AC VTVM to terminal 1 and ground on the transmitter audio printed circuit board. The deflection should be 46mv with the XMTR AF GAIN control maximum clockwise. Rotating this control counterclockwise should reduce this signal to 3.5 mv. Then rotate control clockwise.

(5) Connect the output of the TTG between terminals 1 and 3 on terminal board TB1500. Using the AC VTVM, set the output of the TTG at 77.5mv.

(6) Connect the AC VTVM between terminal 1 and ground on the transmitter audio printed circuit board. Adjust potentiometer R1718 for a defection of 46mv. Remove meter. Reduce the TTG output to zero.

(7) Connect the AC VTVM between terminal 6 on the transmitter a-f printed circuit board and rotate the VOX GAIN and ANTI-VOX controls on the front panel maximum clockwise. Set the PTT-VOX switch to VOX.

(8) Connect the TTG output between terminal 6 of terminal board TB1500 and ground. Increase the TTG output until transmit-receive relay K1500 trips. The value of audio voltage required to trip the relay should be between 40 and 50 mw as indicated on the AC VTVM.

(9) Rotate the VOX GAIN control maximum counterclockwise. The transmit-receive relay should de-energize. Remove meter and TTG input connections. Set the PTT-VOX switch to PTT.

(10) Connect a jumper between terminal 8 on terminal board TB1500 and ground. The transmit-receive relay should energize. Proceed with I-F alignment.

<u>Transmitter IF Alignment</u>

(1) Connect the frequency counter to the arm of potentiometer R1742 on the transmitter i-f printed circuit board. The arm of potentiometer R1742 is accessible through the rear of the printed circuit assembly. The counter should register a frequency of 250KC ± 50 cps. Then set XMTR switch to USB/REMOTE

(2) Connect counter to the emitter lead of transistor Q1715 and adjust tra~~nsist~~or capacitor C1749 for a frequency of 1.5mc ± 2 cps as registered on the counter.

(3) Set the XMTR switch to LSB. Leave counter connected to the emitter lead of transistor Q1715 and adjust capacitor C1746 for a frequency of 2.0mc ± 2 cps as registered on the counter.

(4) Set the AC VTVM to the 1 volt scale and measure the voltages between the resistor R1742 side of capacitor C1718 and ground and also between the resistor R1742 side of capacitor C1719 and ground. If the two voltages are not equal, adjust resistor R1742 to obtain the closest reading to equality.

(5) Tack a 47 ohm, 1/2 watt, 5% resistor across terminals 9 and 10 of the transmitter i-f printed circuit board.

(6) Connect the AC VTVM between the collector of transistor Q1711 and ground (terminal 10 on printed circuit board). Adjust resistor R1748 for a null reading on the 100mv scale.

(7) Connect the AC VTVM across the 47-ohm resistor with the ground lead at terminal 10. Use 1-volt scale.

(8) Set the MODE switch on the front panel to AM position. Then adjust capacitors C1725 and C1730 for a peak indication on the meter.

(9) Set the MODE switch on the front panel to SSB position. Connect the TTG between terminal 6 on terminal board TB1500 and ground. Connect the AC VTVM between terminal 6 on terminal board TB1500 and ground and adjust the TTG output for a 14mw reading on the meter

(10) Connect the AC VTVM across the 47 ohm resistor with the ground lead at terminal 10.

(11) Adjust capacitor C1762 and C1763 for a peak indication on the meter. The maximum voltage reading on the meter should be approximately 45mv. Remove meter.

(12) Connect the SIGNAL INPUT jack on the PTE-3 analyzer across the 47-ohm resistor on the printed circuit board.

(13) Set the PTE-3 to accept an input signal of 1.75 mc. A single tone should appear on the screen with possible distortion indicated -40db below tone level.

(14) Adjust capacitor C1715 for minimum distortion level. Minimum distortion level should fall between -45 and -50db below tone level.

(15) Locate the carrier by increasing the analyzer gain 20db. The carrier signal should appear to the right of the audio tone in the LSB position of the XMTR sideband switch and to the left of the audio tone in the USB/REMOTE position. Reducing the audio

input from the TTG to zero will leave only the carrier signal on the screen.

(16) With the audio input at zero readjust resistor R1742 for a minimum carrier amplitude on the analyzer screen.

(17) Reapply signal at 14mv. The carrier level should be at least 50db below the audio tone level.

(18) Set the transmitter mode switch to the -20DB CARRIER position. The carrier signal should reappear on the screen 25db ± 2db below the audio tone level.

(19) Set the transmitter mode switch to the AM position. The carrier signal should be 8db ± 2db above the audio tone.

(20) Set the transmitter mode switch to the CW position. The audio tone and carrier signal should disappear from the analyzer screen Reduce TTG output to zero.

(21) Connect a short jumper between terminals 11 and 12 on terminal board TB1501 a single tone should appear on the screen. Distortion products will appear also.

(22) Connect the AC VTVM between terminal 10 on the CW oscillator printed circuit board and ground.

(23) Adjust resistor R1533 on the CW oscillator board for a reading of 14mv on the meter. Remove meter.

(24) A second harmonic distortion signal should appear in addition to the audio tone from the CW oscillator. This distortion level should be more than 30db below the audio oscillator tone.

(25) Set the transmitter mode switch on the front panel to the MCW position. A carrier signal should appear on the analyzer screen in addition to the audio tone from the CW OSCILLATOR. The carrier signal should be 8db ± 2db above the audio tone. The second harmonic of the audio tone should be 42db ± 2db below the

carrier signal level. Lock R1533 in the set position.

(26) Set the transmitter mode switch to the SSB position. The audio tone and carrier signals, including distortion, should disappear from the analyzer screen.

(27) Increase the TTG output to obtain 14mv at terminal 6 of TB1500 as measured on the AC VTVM. Audio tone should appear on analyzer screen.

(28) Check the TTG on TONE 2. The meter should still read 14mv at terminal 6 of TB1500. Remove meter.

(29) Set the TTG AUDIO TONE SELECTOR to the TWO TONE position. Two tones should appear on the analyzer screen. Third order distortion should be more than 45db below the level of each tone. Then disconnect analyzer and TTG.

TRANSMITTER AUDIO AND I-F BANDWIDTH CHECK

The audio and i-f bandwidths can be checked as follows:

(1) Connect an audio oscillator set to 1 kc to terminal 6 on terminal board TB1500. A frequency counter should be connected across the audio oscillator. The audio oscillator should be adjusted to give a 1 kc output. The VTVM should be connected across a 47-ohm resistor connected across terminals 9 and 10 of the i-f printed circuit board. Then set the audio generator level to 315 millivolts across the 47-ohm load.

(2) Figure 33 shows a typical audio and i-f response curve. (The 315 mv indicated on meter is the 0 db reference). Compare the output with this typical response curve. The overall response should be better then $\pm$ 3 db from 300 to 3300 cps above and below 1.75 mc.

OPERATIONAL CHECK OF IPA V1500 AND PA V1501

The IPA and PA stages can be checked as follows:

(1) Disconnect all test equipment from the transmitter i-f and a-f printed circuit board assemblies and fasten assemblies using the mounting screws. Then remove ground from terminal 8 on terminal board TB1500 and unsolder 47-ohm resistor across terminals 9 and 10 on transmitter i-f circuit board.

(2) Tune a signal generator to 32 mc at 3-volts output. Set the red output voltage knob maximum counterclockwise to obtain minimum generator output. Set generator to CW modulation and its crystal calibrator off. Then connect generator to green lead of transformer T1500 and ground. T1500 is located with the lower IPA/PA section in front of tube V1500. The dummy load is connected to ANTENNA jack on power supply.

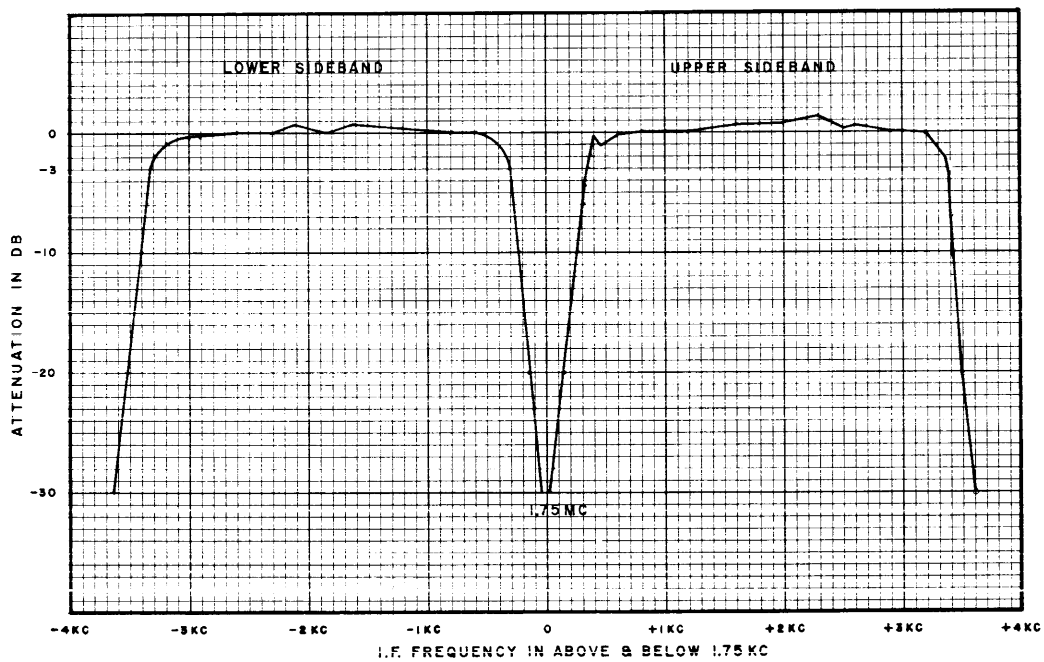


FIGURE 33. TYPICAL RESPONSE CURVES

NOTE

It is absolutely necessary to have the AX-418 in the normal operating position while tuning the IPA and PA circuits. This may be accomplished by mounting the unit in a rack. If the unit has been provided with slide tracks, it should be extended outward to facilitate adjustments. If the unit does not have tracks, a rack with sufficient working space under the equipment should be used. At no time should the unit be placed on the bench so that air convection around the PA is impeded. With the unit mounted as noted above, proceed to step 3, below.

(3) Set the TRANSMITTER CHANNEL selector to channel 1 and the PA OVLD circuit breaker to the downward position. A click should be heard due to the energization of the high voltage relay within the power supply. Allow the unit to warm up for at least three minutes.

WARNING

HIGH VOLTAGES PRESENT. USE CAUTION

(4) Connect a jumper between terminal 8 on terminal board TB1500 and ground. A loud click should be heard due to the energization of the ANTENNA RELAY in the power supply. A PA plate current of 50 ma should be read on the front panel meter with the PA METER switch in the Ib (black dot) position. The variac should read approximately 150 watts.

(5) Connect the VTVM across the dummy load. ~~Set VTVM~~ to 100-volt AC scale. On the TTR, set the following controls: PA LOAD and PA TUNE maximum clockwise (these switches are accessable through the right sideplate), and IPA TUNING and PA LOADING

(10) Remove VTVM from across load and connect it between pins 2 and 6 on the PA tube socket and ground. Set VTVM to 30-volt scale.

(11) Set PA OVLD breaker to down position and allow unit to warm up for about three minutes. Then connect a jumper between terminal 8 on terminal board TB1500 and ground. Increase signal generator output for a reading of 20 volts on the VTVM.

(12) Set the PA METER switch to EgRF position (green); some voltage should appear on the panel meter. Adjust potentiometer R1509 on the CW oscillator board for a reading of 20 volts on the green scale. Then lock potentiometer R1509.

(13) Set PA METER switch to the Ib position. Turn PA OVLD ADJ potentiometer on the rear of the power supply completely counterclockwise and increase the output of the signal generator until 180 ma is indicated. Then slowly rotate the PA OVLD ADJ. potentiometer until the PA OVLD circuit breaker trips.

(14) Remove ground from terminal 8 of terminal board TB1500 and reduce signal generator output to zero. Then reset PA OVLD circuit breaker and allow unit to warm up. Next ground terminal 8 of terminal board TB1500.

(15) Increase signal generator output slowly until plate current on PA METER reads slightly over 180 ma. After a slight delay the PA OVLD breaker should trip. Then repeat step (14) above.

(16) Set signal generator output to 175 ma on the PA METER then let the unit run for 30 seconds or so to determine if the PA OVLD breaker will trip. If the PA OVLD trips, another setting of the PA OVLD ADJ. potentiometer slightly more counterclockwise than the initial setting will have to be tried. The object is to obtain

continuous operation at 175 ~~ma~~ with the PA OVLD breaker tripping at a current over 180 ma but as close to 180 ma as possible. Then lock the PA OVLD ADJ. potentiometer.

(17) Remove ground from terminal 8 on terminal board TB1500, set PA OVLD circuit breaker to up position, and disconnect all test equipment except for variac.

RECEIVER AUDIO CHECK

The receiver audio sections can be checked as follows:

(1) On front panel of TTR-10 rotate VOLUME control maximum clockwise, the power switch to the REC position, and SQUELCH control maximum clockwise.

(2) Connect a 600 ohm 1/2 watt resistor between terminals 1 and 3 on terminal TB1501. Then swing out the receiver i-f and a-f circuit board assembly.

(3) Set the audio signal generator at 1 kc and connect to the receiver i-f board. Place 22-k resistor in series with a lead and connect ~~the audio generator~~ across terminal 11 and ground. Connect an AC VTVM across generator output. Then increase the audio generator output until a 1-kc tone is heard through the loud-speaker.

(4) Rotate the SQUELCH control counterclockwise. The tone should disappear.

(5) Set the audio generator output for a 10 mv reading and connect VTVM across terminals 1 and 3 on terminal board TB1501. The meter should read 780 mv.

(6) Connect the VTVM across terminals 1 and 2 on terminal board TB1501. The meter should read exactly half of the reading in step (5) above.

(7) Connect the VTVM across resistor R1660 on the receiver

a-f printed circuit board. It should indicate about 1.4 volts.

(8) Rotate VOLUME control counterclockwise. The voltage across resistor R1660 should drop proportionally with rotations of VOLUME control. Then turn VOLUME control maximum clockwise.

RECEIVER IF ALIGNMENT

The receiver i-f section can be aligned as follows:

(1) Connect a frequency counter to arm of potentiometer R1663 on the receiver i-f printed circuit board. The arm of R1663 is accessible through the rear of the printed circuit board assembly. The counter should indicate 250 kc ± 50 cps.

(2) Turn RCVR switch to USB/REMOTE position. Then connect frequency counter to emitter lead of transistor Q1602 and adjust capacitor C1629 until frequency counter indicates 1.5 mc ± 2 cps.

(3) Turn RCVR switch to LSB position and adjust capacitor C1631 for a frequency of 2 mc ± 2 cps.

(4) Connect the VTVM between the collector of transistor Q1610 and ground. Then adjust potentiometer R1663 for a null at the VTVM.

(5) Connect the VTVM between terminal 9 on the receiver i-f printed circuit board and ground. The meter should read 2.8 vdc.

(6) Set the RCVR sideband switch to USB/REMOTE and remove crystal Y1603.

(7) Connect the VTVM between the base of transistor Q1602 and ground. Then connect the r-f generator between terminals 1 and 2 on the receiver i-f board with the generator's output set at zero.

(8) Set potentiometer R1612 on the receiver i-f board maximum clockwise. Then set the generator output to 1.75 mc at 1 mv. The VTVM connected to the base of transistor Q1602 should indicate some voltage. Adjust capacitor C1602 for a peak indication (approximately 2.5 mv) on the meter. Then replace crystal Y1603.

(9) Connect the VTVM across terminals 10 and 11 on the receiver i-f board. Set the r-f generator to 1.75 mc ± 1 kc as indicated on the frequency counter. Make sure SQUELCH control is maximum counterclockwise. Then increase the signal generator output until meter indicates same voltage (use 10 mv scale on meter).

(10) Adjust capacitors C1655 and C1656 for a peak indication on the meter.

(11) Set the signal generator output to 260 microvolts and adjust potentiometer R1612 for a reading of 10 mv on the VTVM.

(12) Connect the VTVM across terminals 1 and 2 on terminal board TB1501. The meter should read 390 mv with the VOLUME control maximum clockwise. Readjust resistor R1612 to obtain the reading if necessary.

RECEIVER AUDIO AND I-F BANDWIDTH AND INTERMODULATION CHECK

To check the audio and i-f bandwidth and intermodulation connect test equipment as shown in figure below.

(1) Set various front panel controls as follows: Set the knob on the front of the 1.75 mc test jig to USB. Set the INPUT ATTENUATOR on the spectrum analyzer of the PTE-3 at 15 db attenuation and the GAIN control at 8.5. Set up the VOX-5 in the PTE-3 for a 1.75mc input to the spectrum analyzer. (Approx. 2250 kc). Rotate the AUDIO OUTPUT control on the TTG clockwise and obtain

a two tone test signal indication on the PTE-3 spectrum analyzer. A combination of tones should be heard on the speaker and some voltage indicated on the AC VTVM.

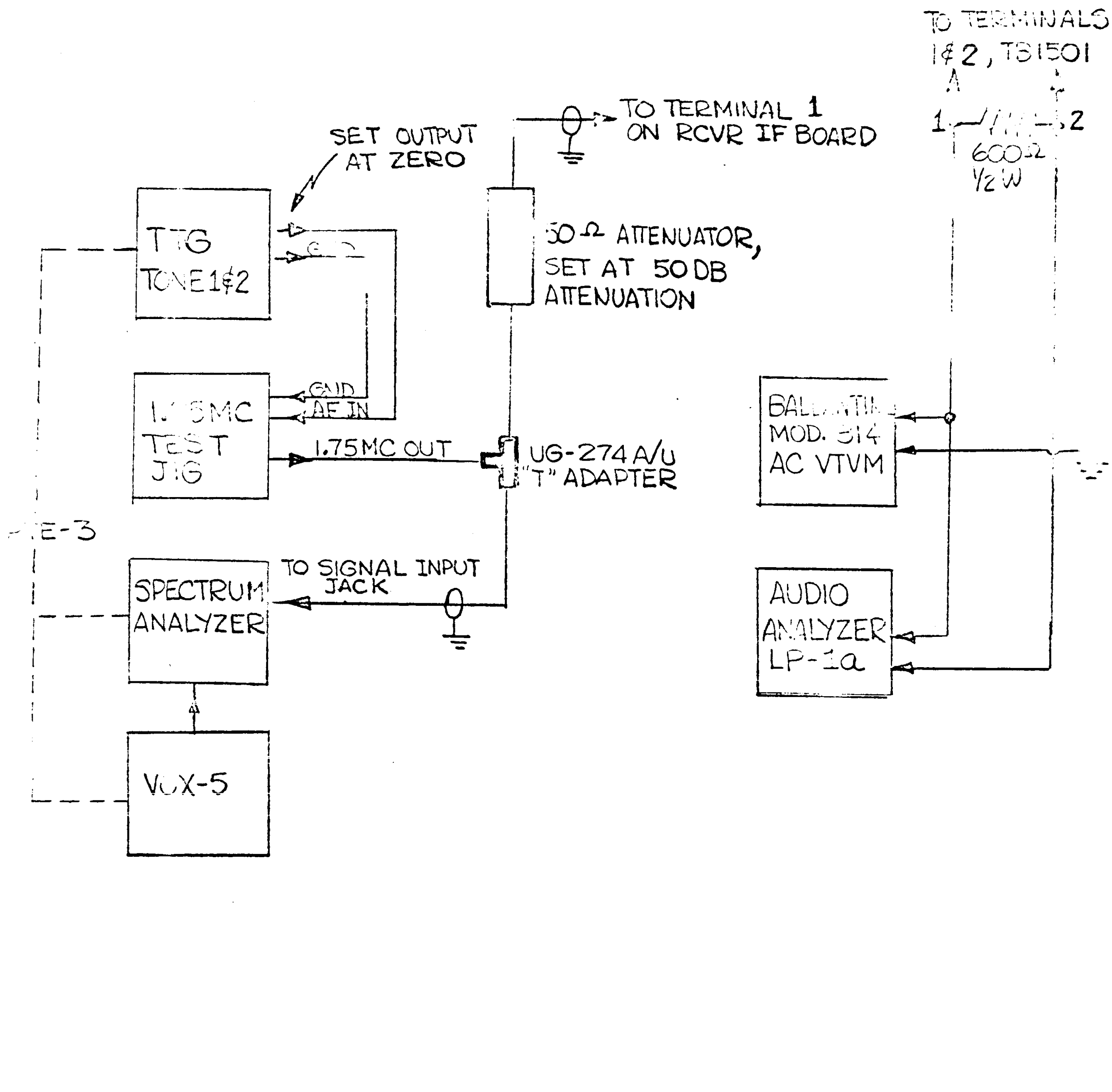


FIGURE 34. TEST SET-UP

(2) Rotate the VOLUME control on the TTR-10 to reduce the tone output. Then increase the TTG output for a reading of 780 mv on the VTVM.

(3) The output of the 1.75 mc test jig should be two tones of equal amplititude with distortion products not less than 50db below the peak of either tone. Tone amplitudes may be adjusted within the TTG unit.

(4) Set up the audio analyzer to obtain a two tone test signal. Some recommended settings on the audio analyzer are:

CONTROL	SETTING
Vert. Calib. Selector - - - - - - - - -	DB
Scale Selector - - - - - - - - - - - - - -	2.5
Center Frequency - - - - - - - - - - - -	1KC
Sweep Range Selector - - - - - - - - - -	20KC LOG
Input Multiplier - - - - - - - - - - --	X1
Input Pot. - - - - - - - - - - - - - - -	Approximately .5

The intermodulation distortion present should not be less than 29db below the amplitude of TONE 1 (Approx. 900 cps)

(5) Set the VTVM to read (+) DC VOLTS on the 10 volt range and connect between terminal 9 on the receiver IF printed circuit board. The meter should read between 5 and 6 volts. Remove meter.

(6) Slowly rotate the VOLUME control on the TTR-10 until a tone of easily audible amplitude is heard.

(7) Slowly rotate the SQUELCH control counterclockwise to the point where the audio tone abruptly disappears.

(8) Remove 1db of attenuation from the attenuator box between the 1.75 mc test jig and the receiver IF board. The audio tone should abruptly disappear.

(9) Reinsert the 1db of attenuation. After a slight time delay (approx. 2 to 3 seconds), the tone should abruptly disappear.

(10) Reset the VOLUME control maximum counterclockwise.

(11) Remove the audio analyzer but leave the VTVM connected across terminals 1 and 3, terminal board TB1501.

(12) Remove the audio connections between the TTG and the 1.75mc test jig.

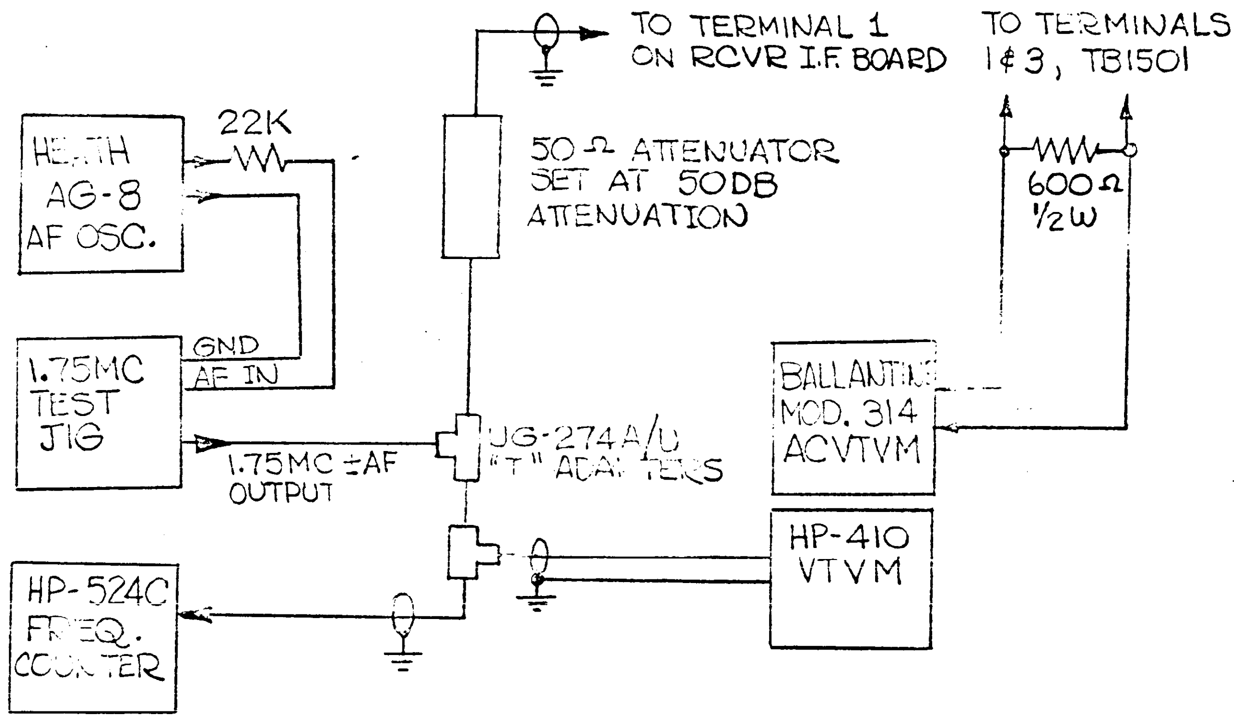


FIGURE 35. TEST SET-UP

(13) With the RCVR sideband selector set to USB/REMOTE, adjust the audio oscillator output and frequency controls to obtain a 780mv reading on the AC VTVM at an input i-f frequency of 1.75mc + 1kc as read on the frequency counter. Note the reading on the VTVM.

(14) Using the graph in figure as a guide and the 780mv indicated on the VTVM as the 0db reference, vary the audio oscillator frequency. The i-f input voltage as measured on the VTVM should be maintained constant by adjusting the audio oscillator output voltage control. Compare the output change as read on the VTVM with the graph. The overall response must be better than ± 3db from 300 to 3300 cps above and below 1.75mc. Be sure the sideband selector on the TTR-10(RCVR) and on the 1.75mc test jig are both set to LSB when checking frequencies below 1.75mc.

MAIN CHASSIS VOLTAGE CHART

Table below lists the voltages found in the main chassis circuits.

V MAIN CHASSIS CIRCUITS, DC VOLTAGE CHART

NOTE: VOLTAGES MEASURED TO CHASSIS GROUND USING 20K ohms-per-volt meter

TRANSISTOR VOLTAGE CHART

SYMBOL	EMITTER	BASE	COLLECTOR	REMARKS
Q1701	-5.5	-5.6	-4.2	
Q1702	+.20	-.06	-9.0	
Q1703	+.16	0	-9.5	
Q1704	-1.6 to +1.6	-.15 to +.15	-12.5	
Q1705		-1.6 to +1.6		
Q1706	+.70 to -1.8	-2.0	+12.5	
Q1707	0	0	-12.5	Term. 8, TB1500 grounded
	0	-.22	0	Term. 8, TB1500 ungrounded
Q1708	0	-.30	0	Term. 8, TB1500 grounded and K1500 energized
	0	+.5	+12.5	K1500 de-energized
Q1709	+.15	0	-12.0	
Q1710	+.15	0	-12.0	
Q1711	+.30	0	-10.5	

SYMBOL	EMITTER	BASE	COLLECTOR	REMARKS
Q1611	+3.0	+3.1	+12.5	NO SIGNAL
Q1611	+5.6	+5.9	+12.5	1MV SIGNAL AT BASE OF Q1601
Q1612	+2.6	+2.6	+12.5	NO SIGNAL
	+5.5	+5.6	+12.5	1MV SIGNAL AT BASE OF Q1601
Q1613	+.25	+.12	-7.1	
Q1614	+.20	+.06	-12.3	
Q1615	+.14	0	-12.3	
Q1616,1617	+12.5	+12.5	-12.4	
Q1618	+.17	+.02	-10.0	
Q1619	+1.8	+1.65	-6.3	SQUELCH max. clockwise
	+5.1	+7.1	-12.6	SQUELCH max. counterclockwise
Q1620	+1.8	+2.8	-8.0	SQUELCH max. clockwise, no signal
Q1620	+5.1	+2.8	+ 3.2	SQUELCH max clockwise, no signal
Q1620	+1.8	+5.0	-8.6	SQUELCH max clockwise, 1mV signal at base Q [illegible]01
Q1621	-7.8	-8.0	-8 2	SQUELCH max. clockwise nosignal K1601 energized

SYMBOL	EMITTER	BASE	COLLECTOR	REMARKS
Q1712	+.28	+.15	-6.0	
Q1713, 1714	+.38	+.15	-8.0	
Q1715	+.18	0	-11.0	
Q1716	0	0	-6	K1502 energized
	0	0	-12.5	K1502 de-energized
Q1717	0	0	-6	K1502 de-energized
	0	0	-12.5	K1502 energized
Q1500	+1.1	+1.2	+9.4	S1505 set at CW or MCW
Q1601	+.27	+.02	-11.5	
Q1602	-.32	0	-11.0	
Q1603	+.14	0	-11.7	
Q1604	+.17	0	-5.9	
Q1605	+.12	+.12	-7.7	
Q1606	+.29	+.12	-5.7	
Q1607	+.01	0	-5.4	K1501 de-energized
	0	0	-12.5	K1501 energized
Q1608	+.01	0	-5.4	K1501 energized
	0	0	-12.5	K1501 de-energized
Q1609	+ 05	0	-11.5	
Q1610	+ 12	0	-11.3	

SYMBOL	EMITTER	BASE	COLLECTOR	REMARKS
Q1621	0	+3.2	-12.6	SQUELCH max. counterclockwise, no signal, K1601 de-energized
Q1621	-8.4	-8.6	-8.5	SQUELCH max. clockwise, 1MV signal at base Q1601, K1601 energized

ELECTRON TUBE VOLTAGE CHART

SYMBOL	PLATE(S)	SCREEN	CONTROL GRID	CATHODE	FILAMENT
V1500	+300 pin 7	+300 pin 8	0 pin 2	+9 pin 1	6.3AC pin 5
V1501	+800 both caps	+320 pin 3	-50 to -30 pins 2 & 6 when keyed -105 when not keyed	0	6.3AC pin 5

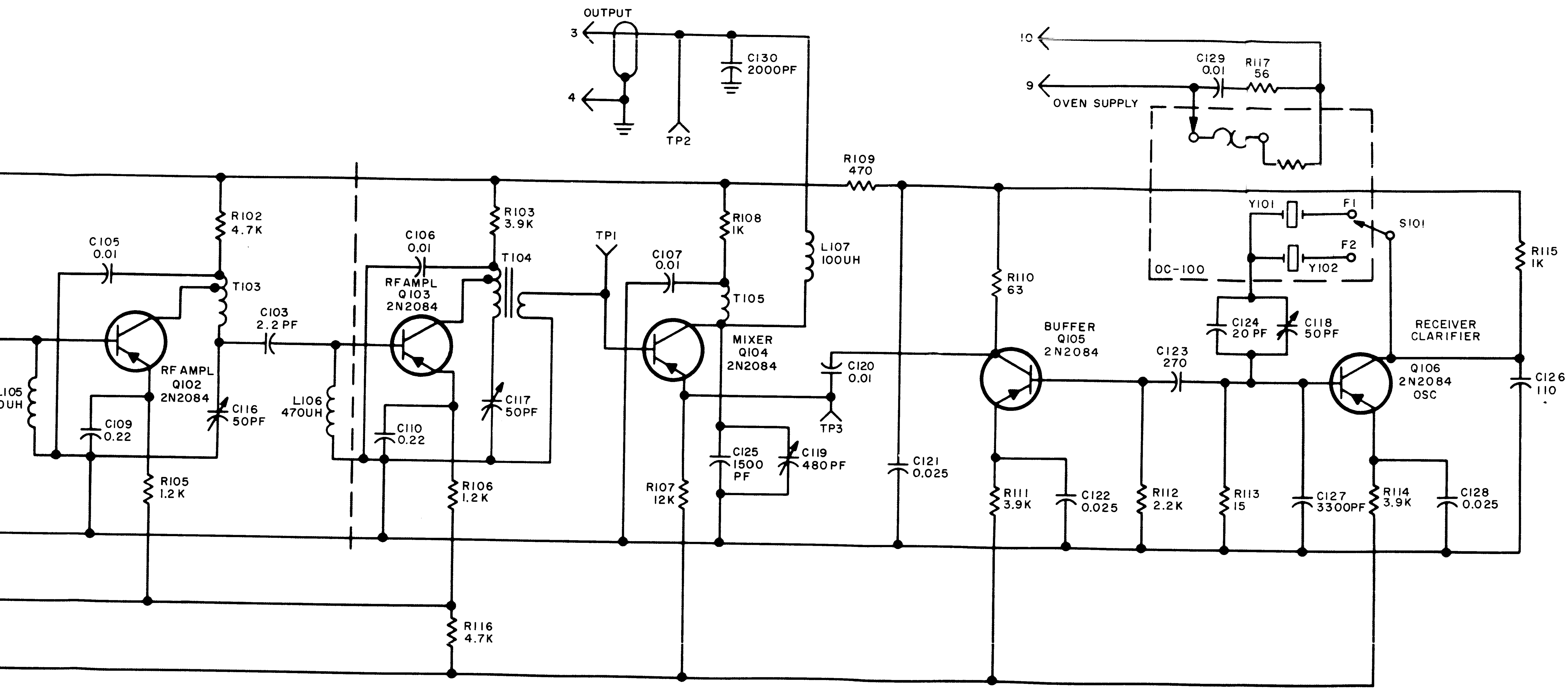
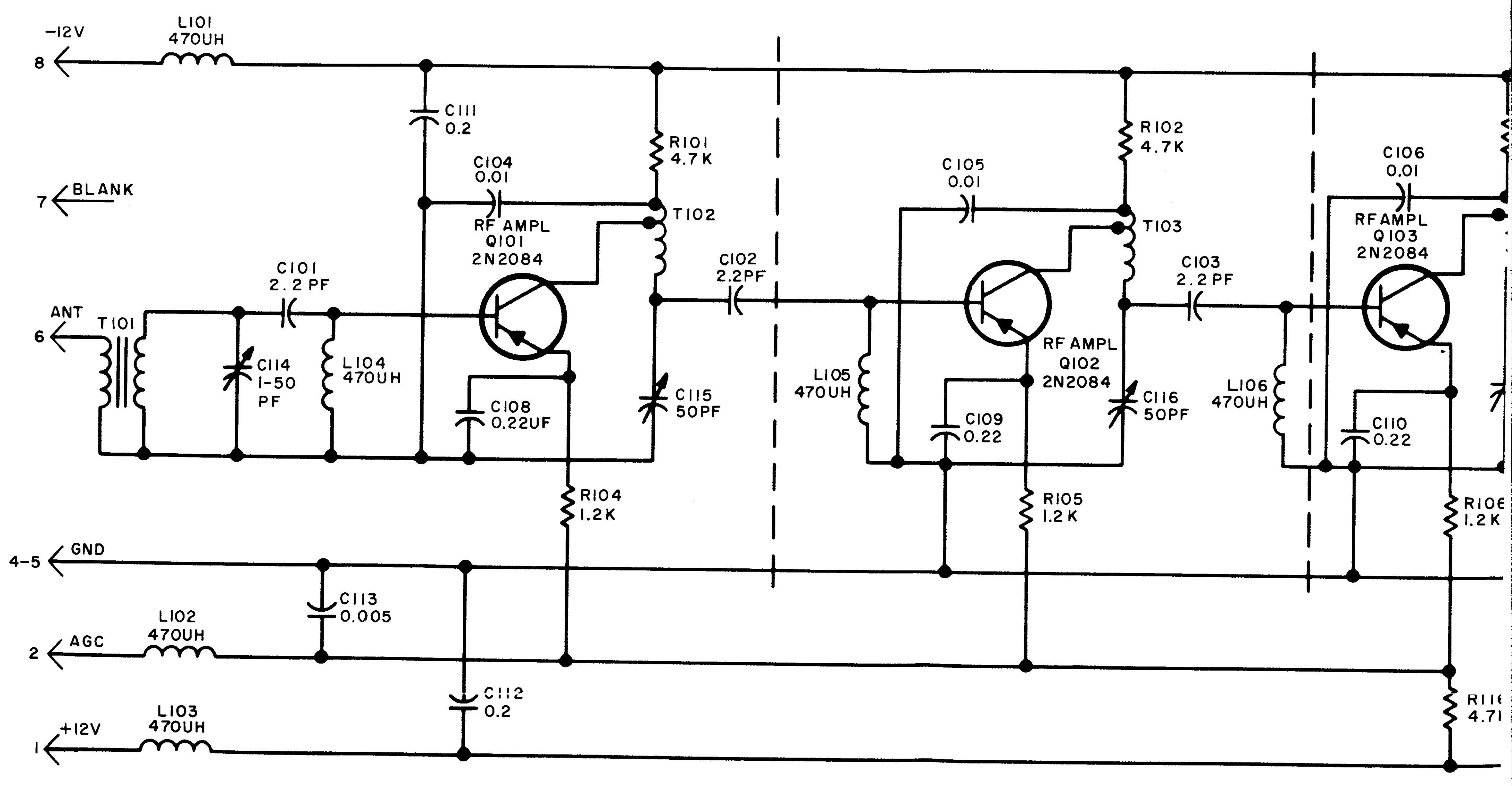


Figure 36. TTRR-1 Receiver Converter (2-4 mc) Module, Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFDS.

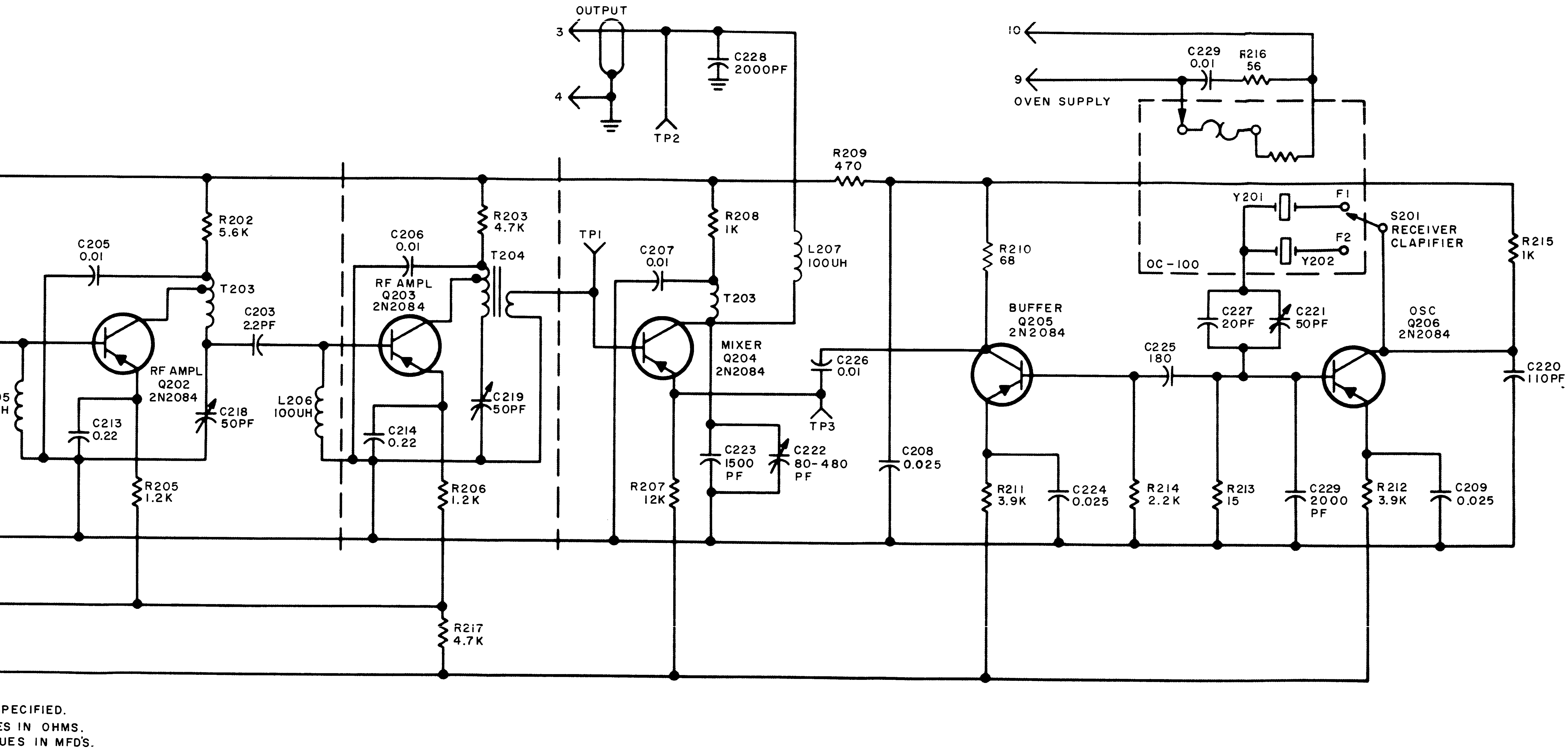
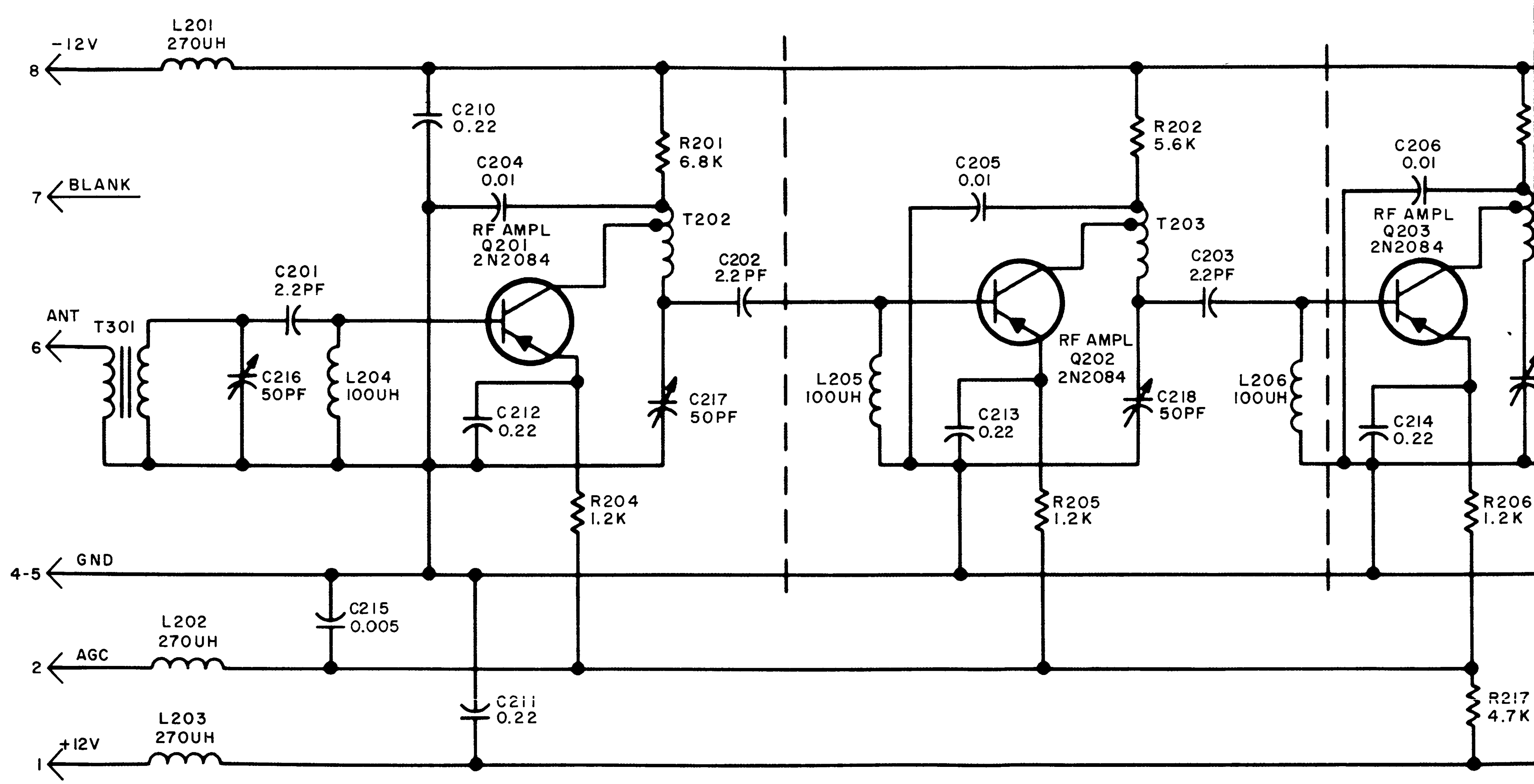


Figure 37. TTRR-2 Receiver Converter (4-8 mc) Module, Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFD'S.

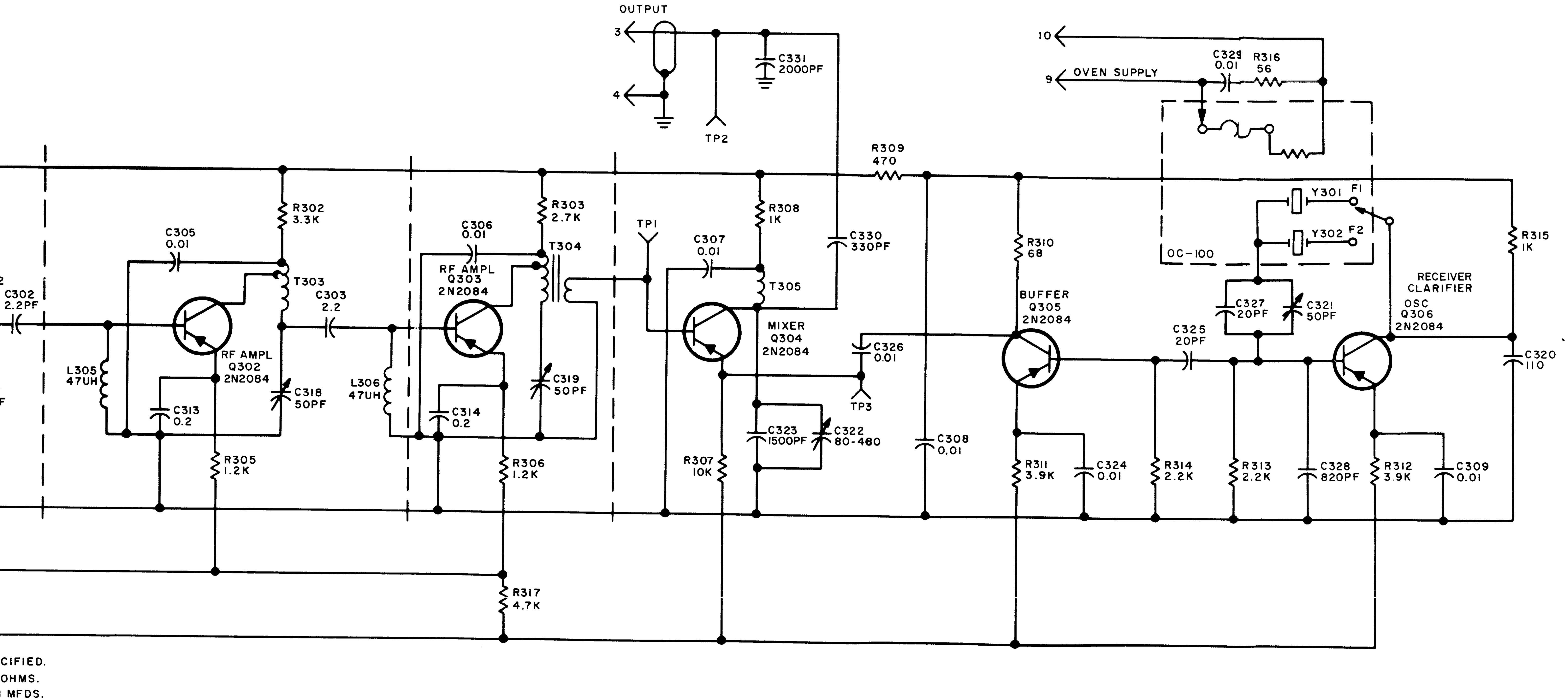
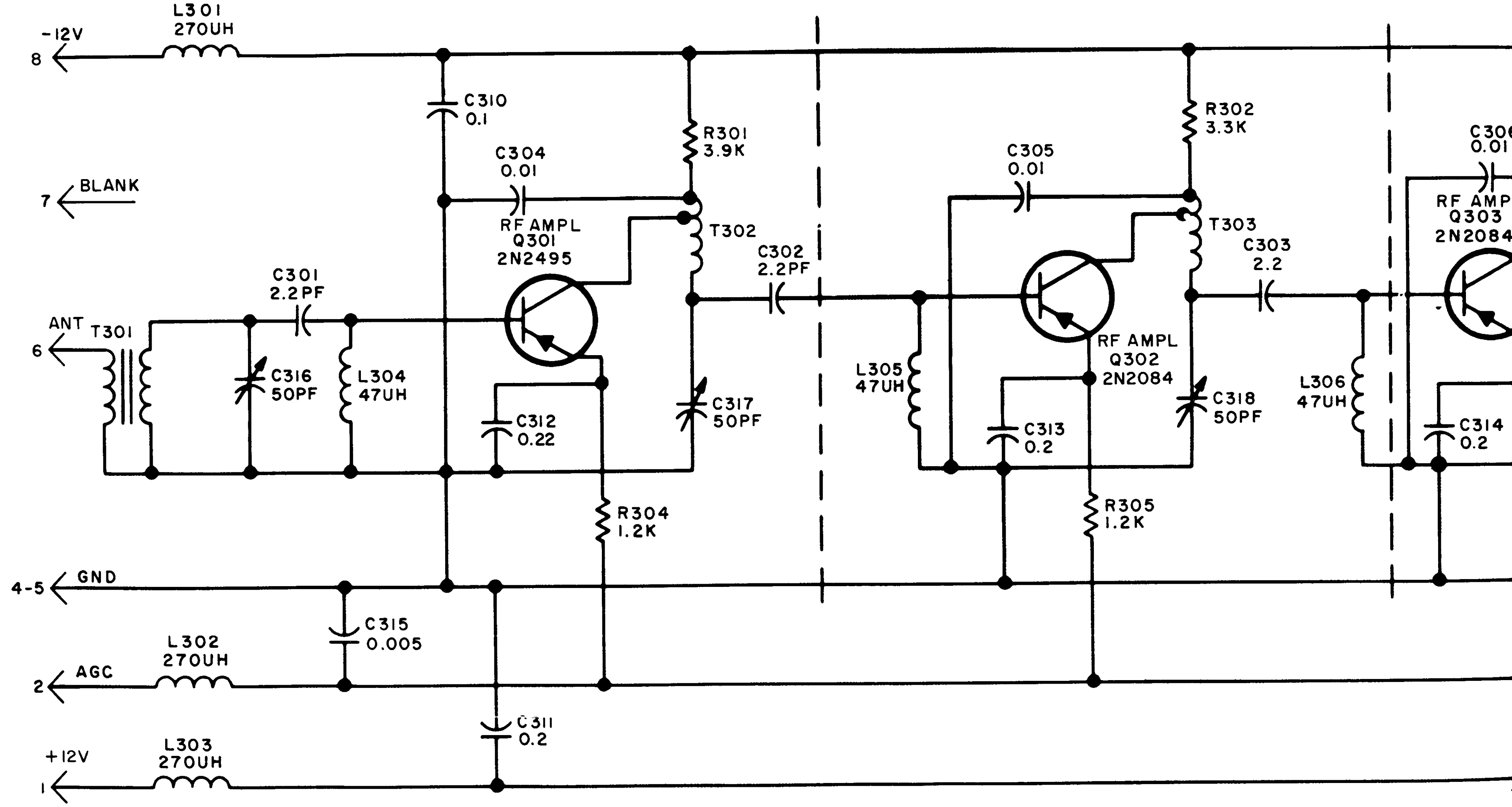


Figure 38. TTRR-3 Receiver Converter (8-16 mc) Module, Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED.
1.ALL RESISTOR VALUES IN OHMS.
2.ALL CAPACITOR VALUES IN MFDS.

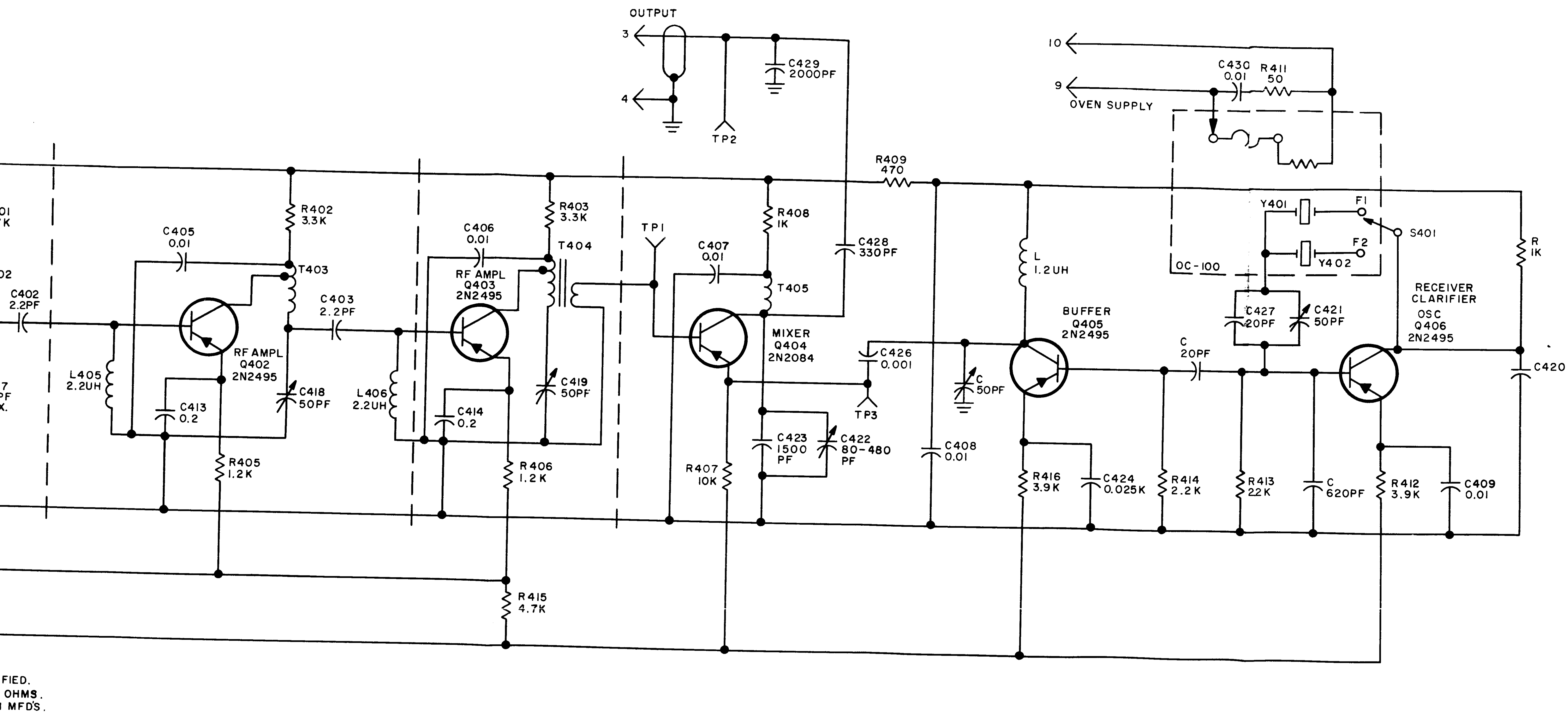
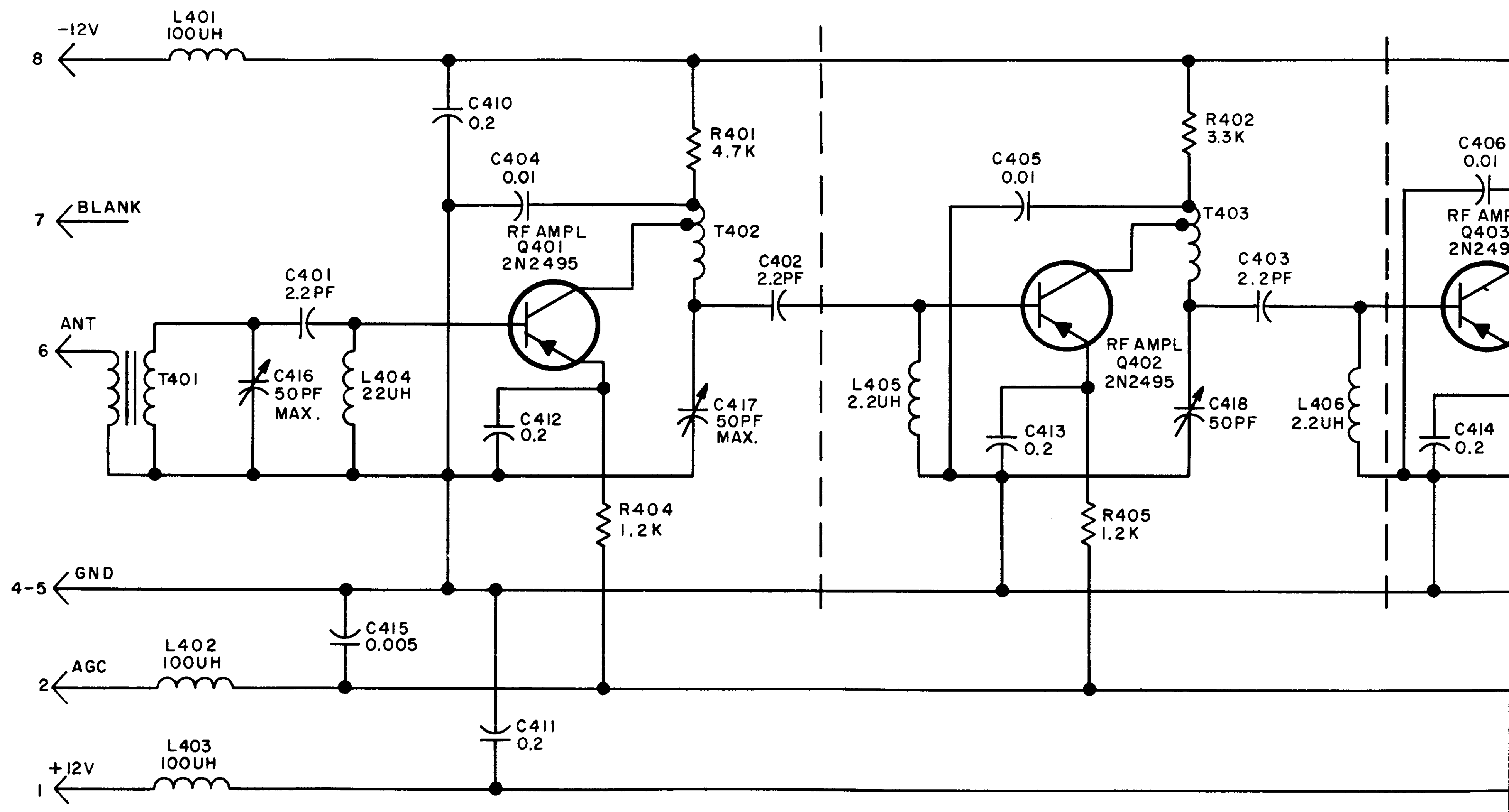


Figure 39. TTRR-4 Receiver Converter (16-32 mc) Module. Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFD'S.

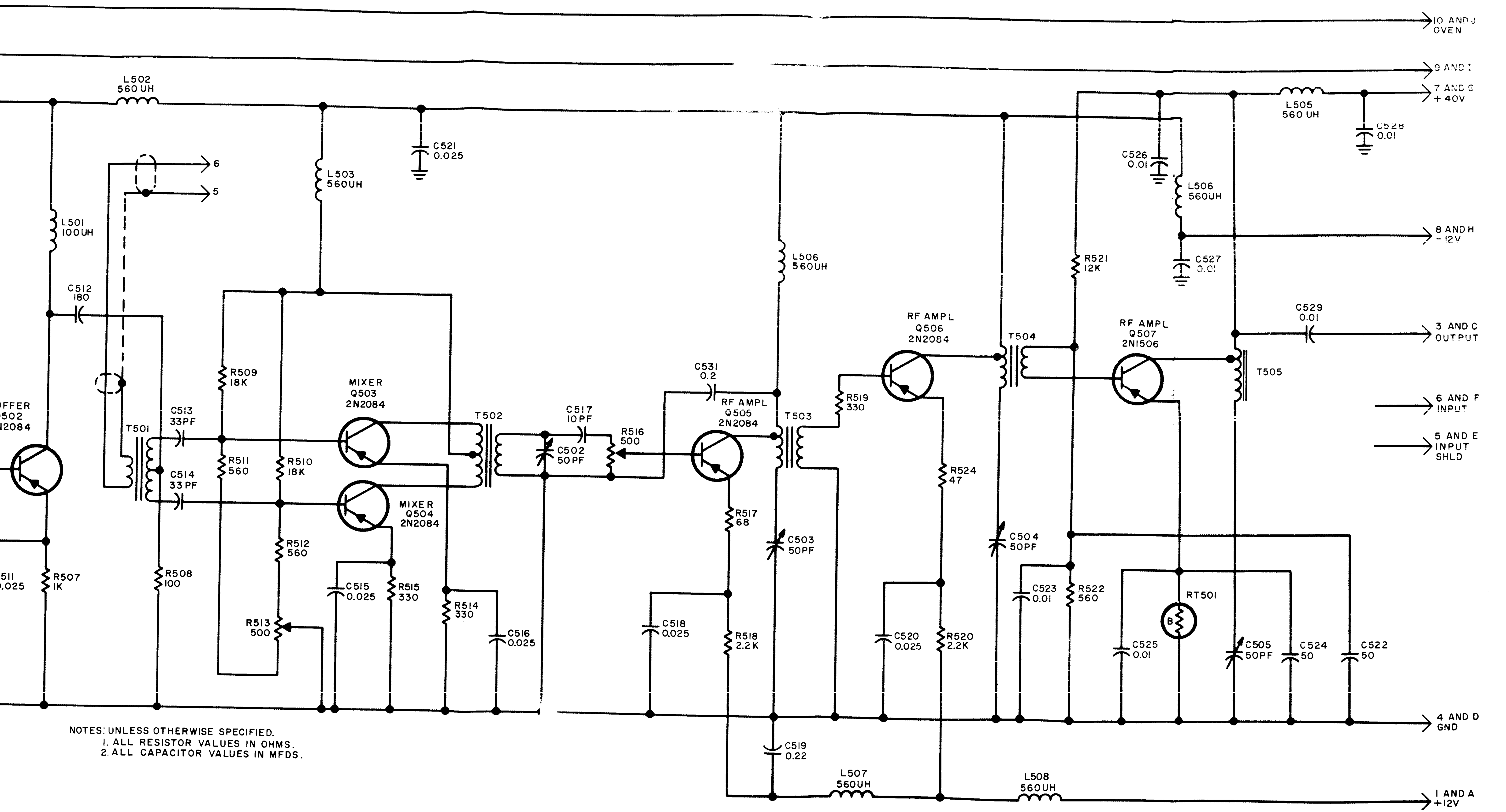
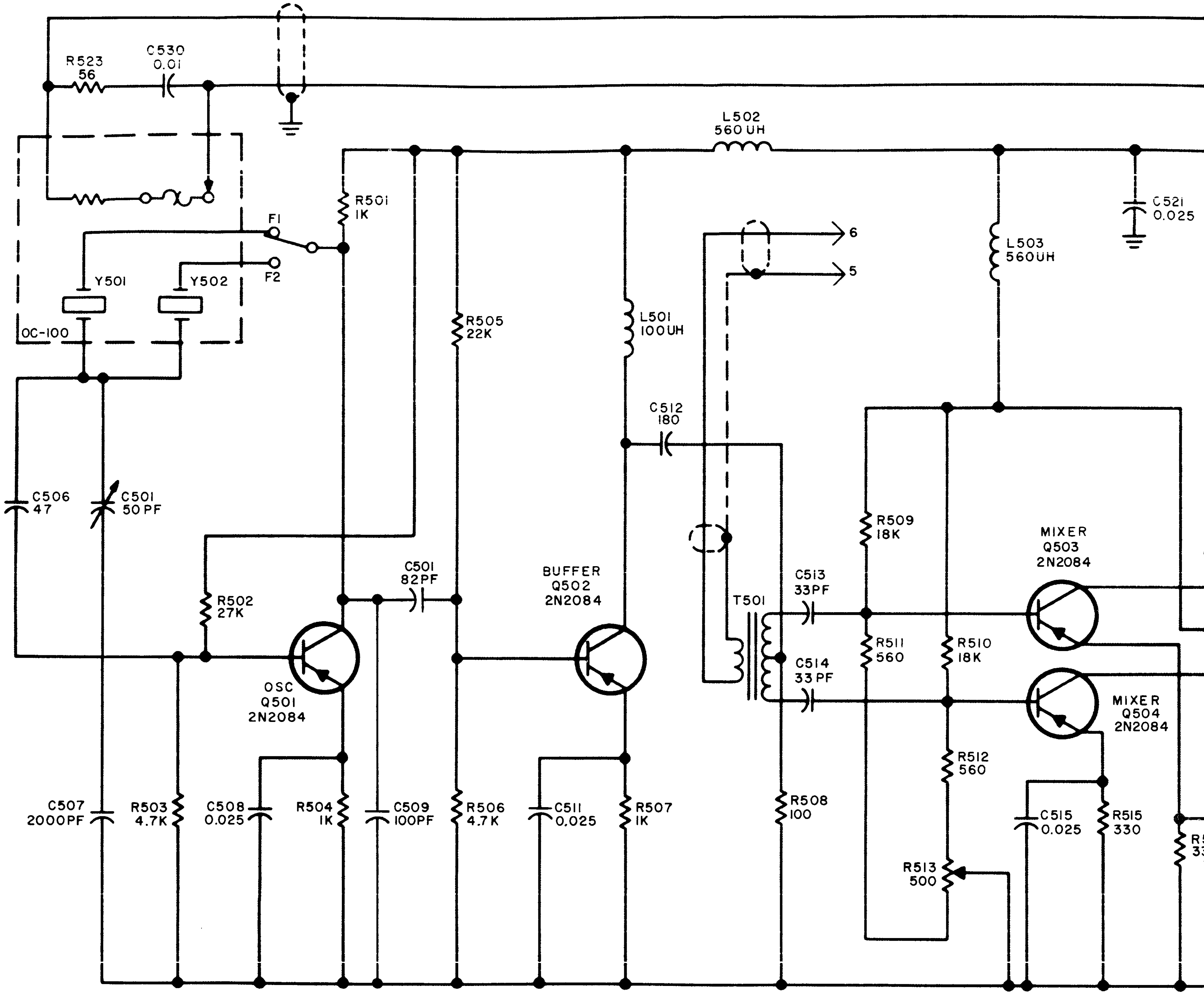
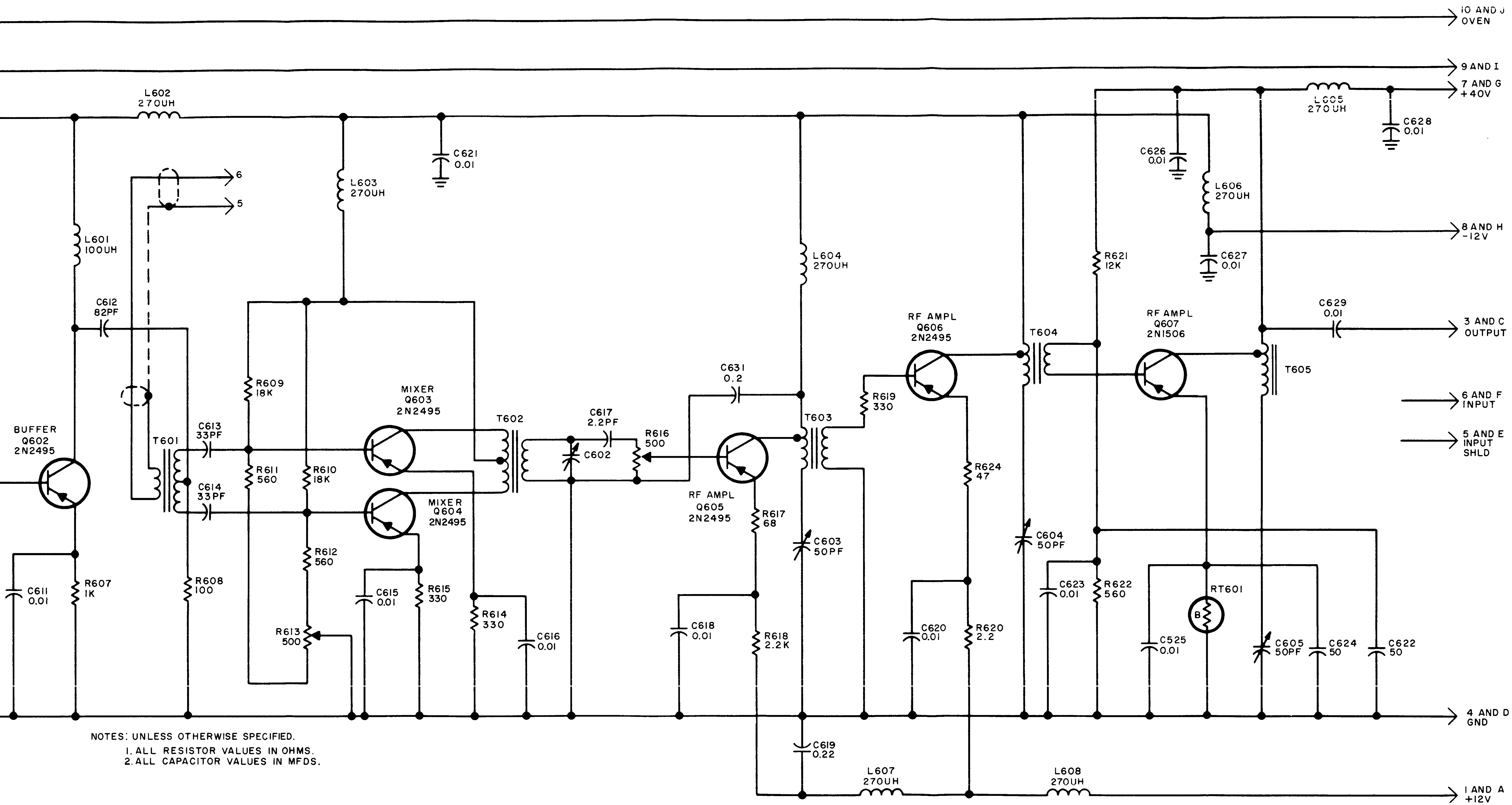


Figure 40. TTRT-1 Transmitter Converter (2-4 mc) Module, Schematic Diagram

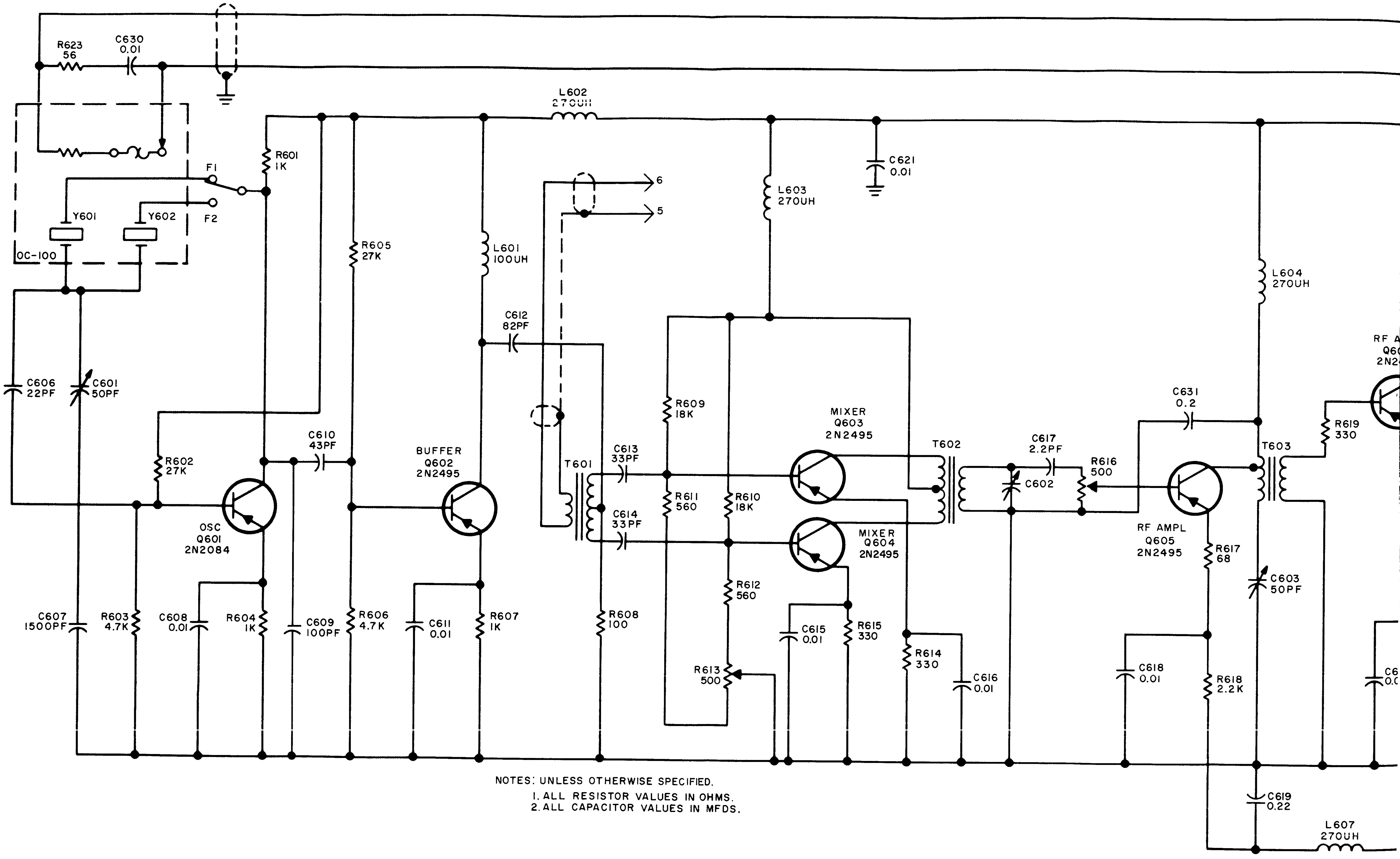


NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFDS.



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFDS.

Figure 41. TTRT-2 Transmitter Converter (4-8 mc) Module, Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITOR VALUES IN MFDS.

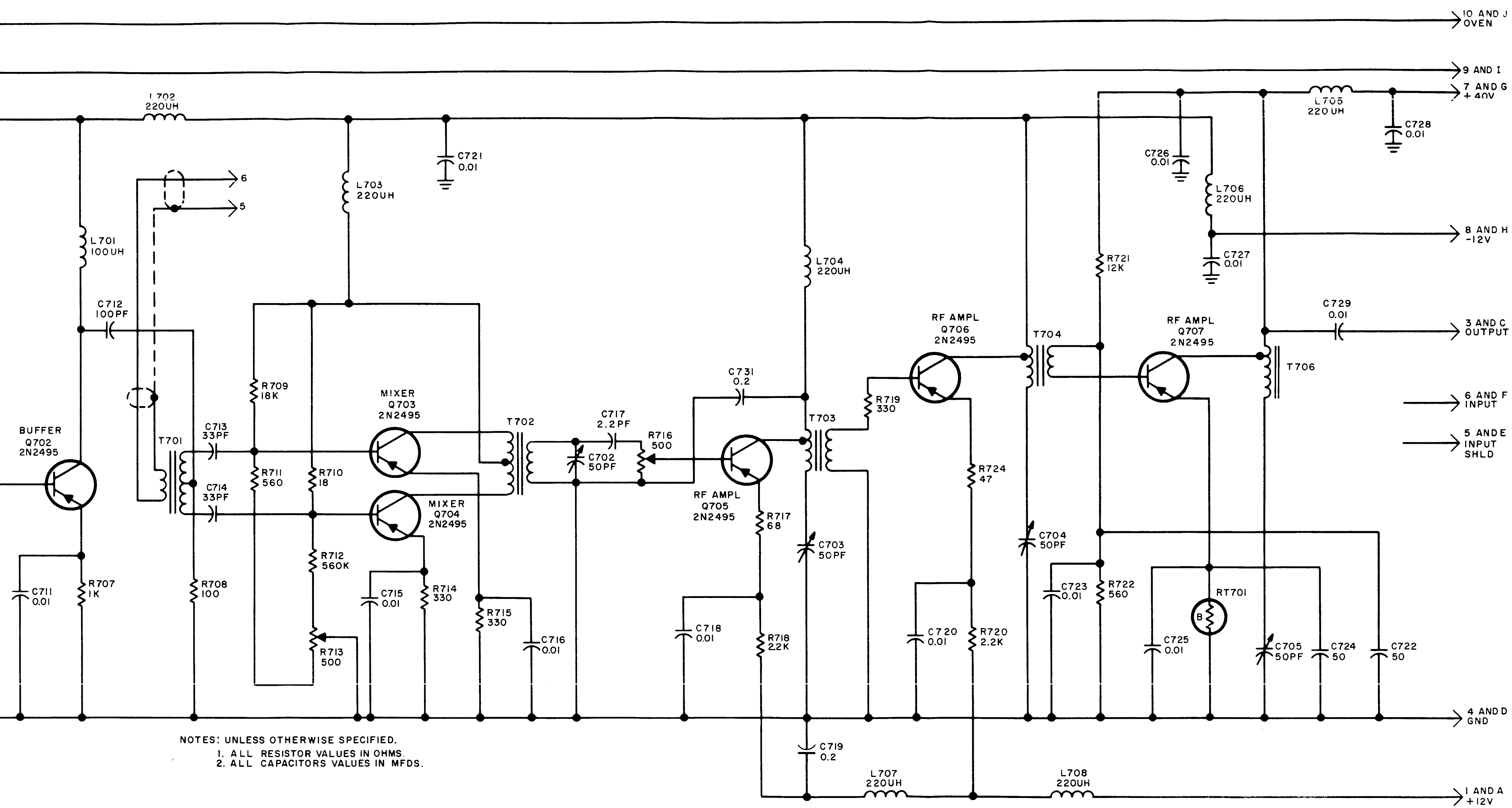
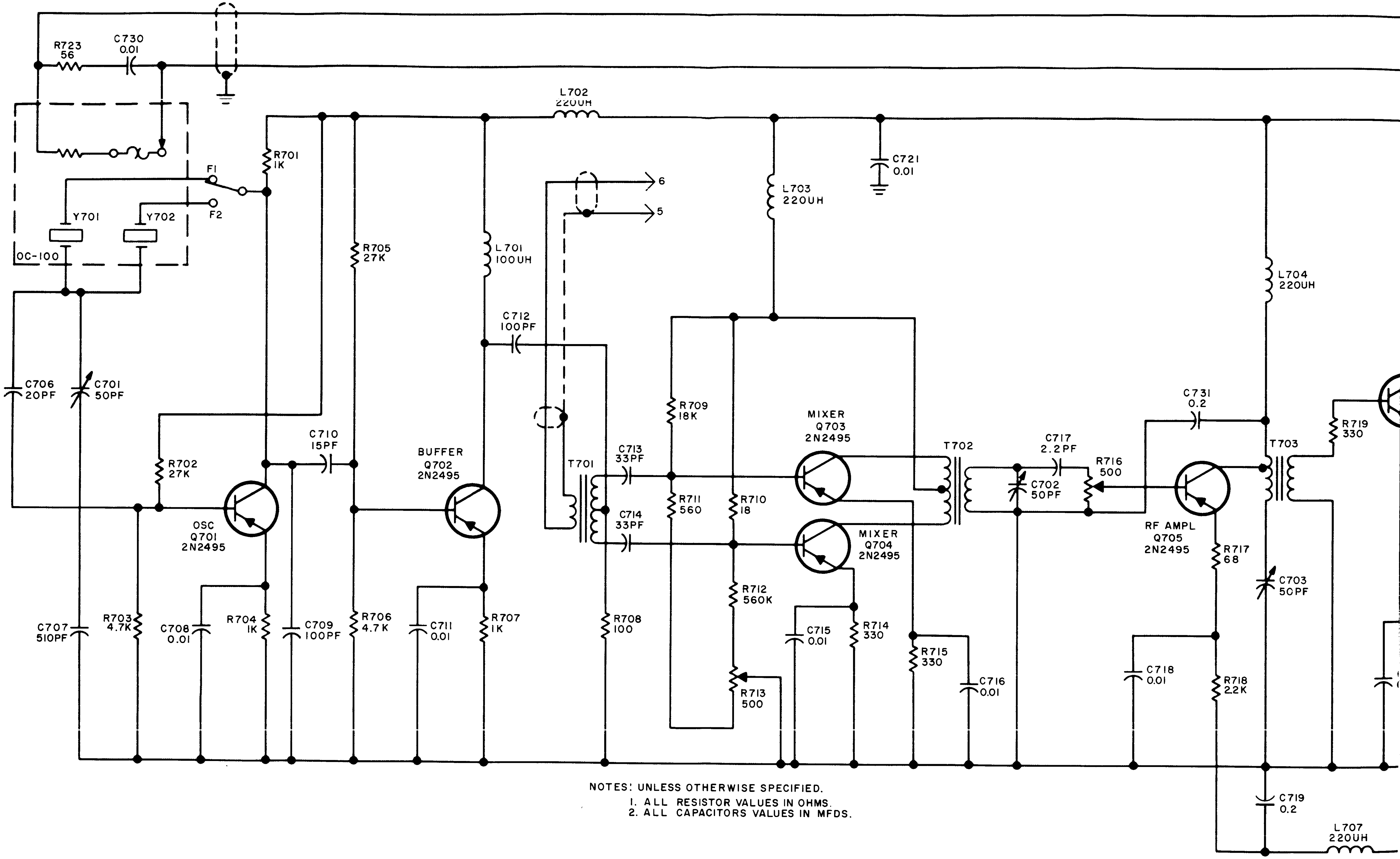


Figure 42. TTRT-3 Transmitter Converter (8-16 mc) Module, Schematic Diagram



NOTES: UNLESS OTHERWISE SPECIFIED.
1. ALL RESISTOR VALUES IN OHMS.
2. ALL CAPACITORS VALUES IN MFDS.

Fig

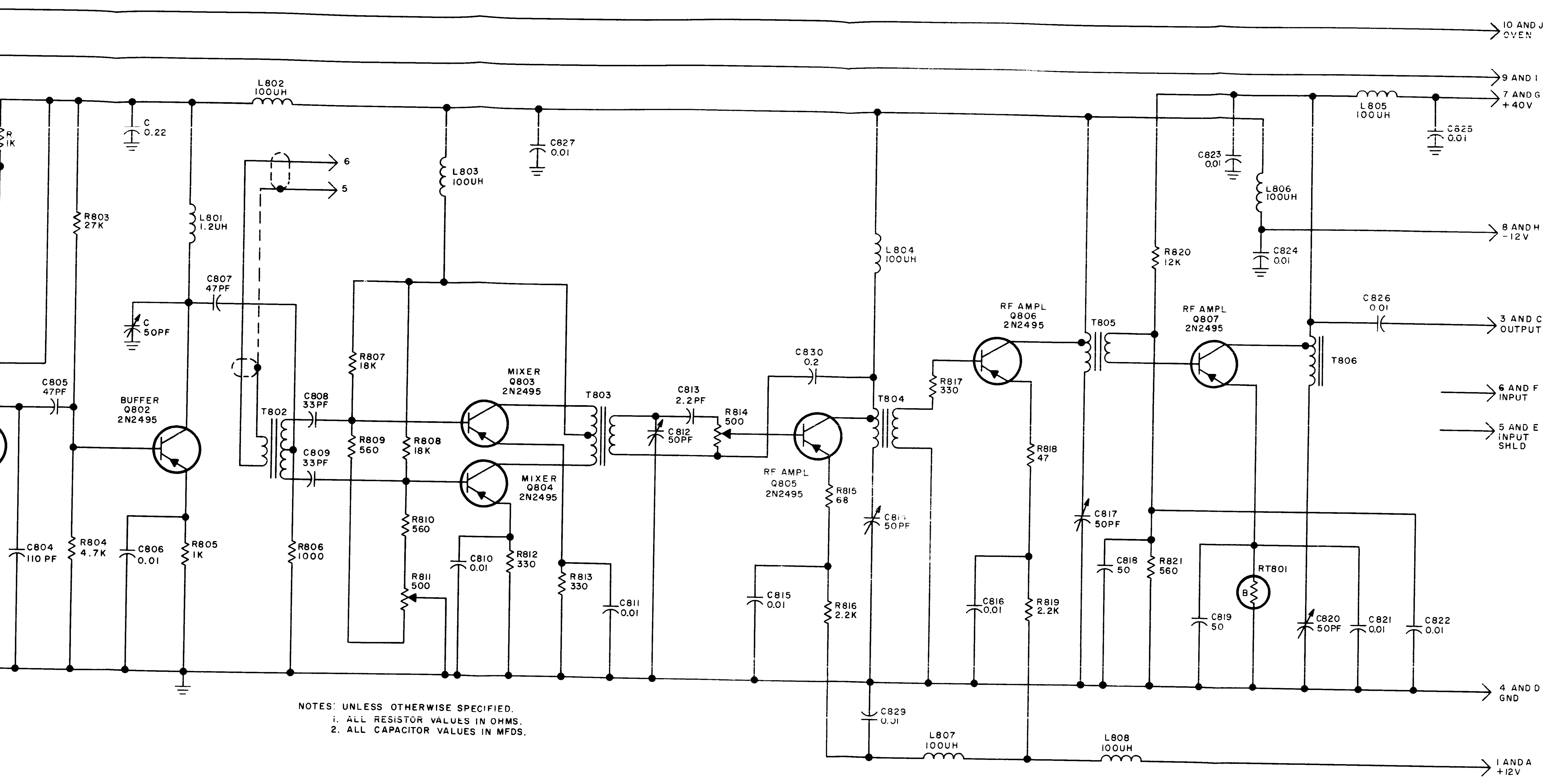
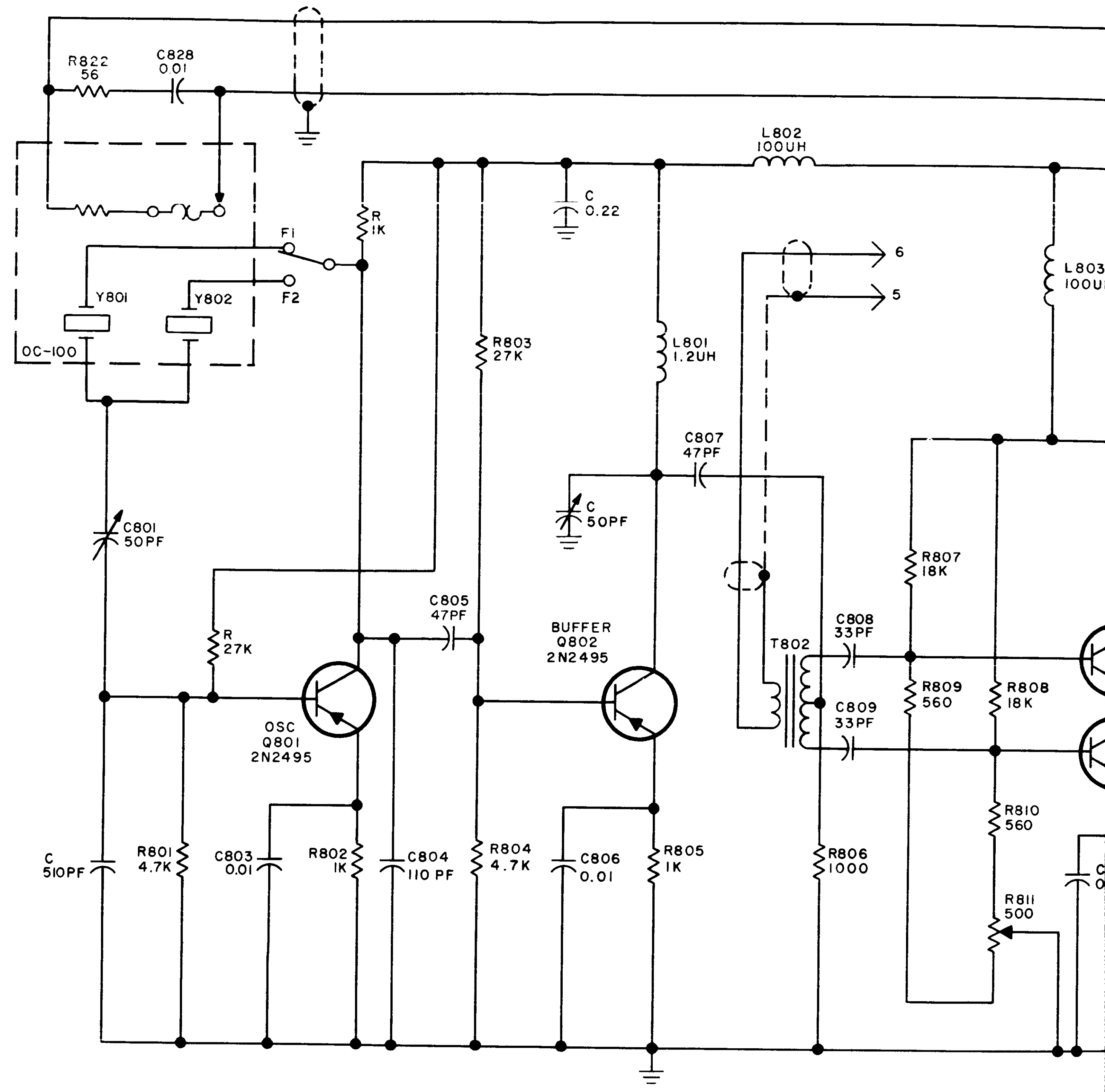
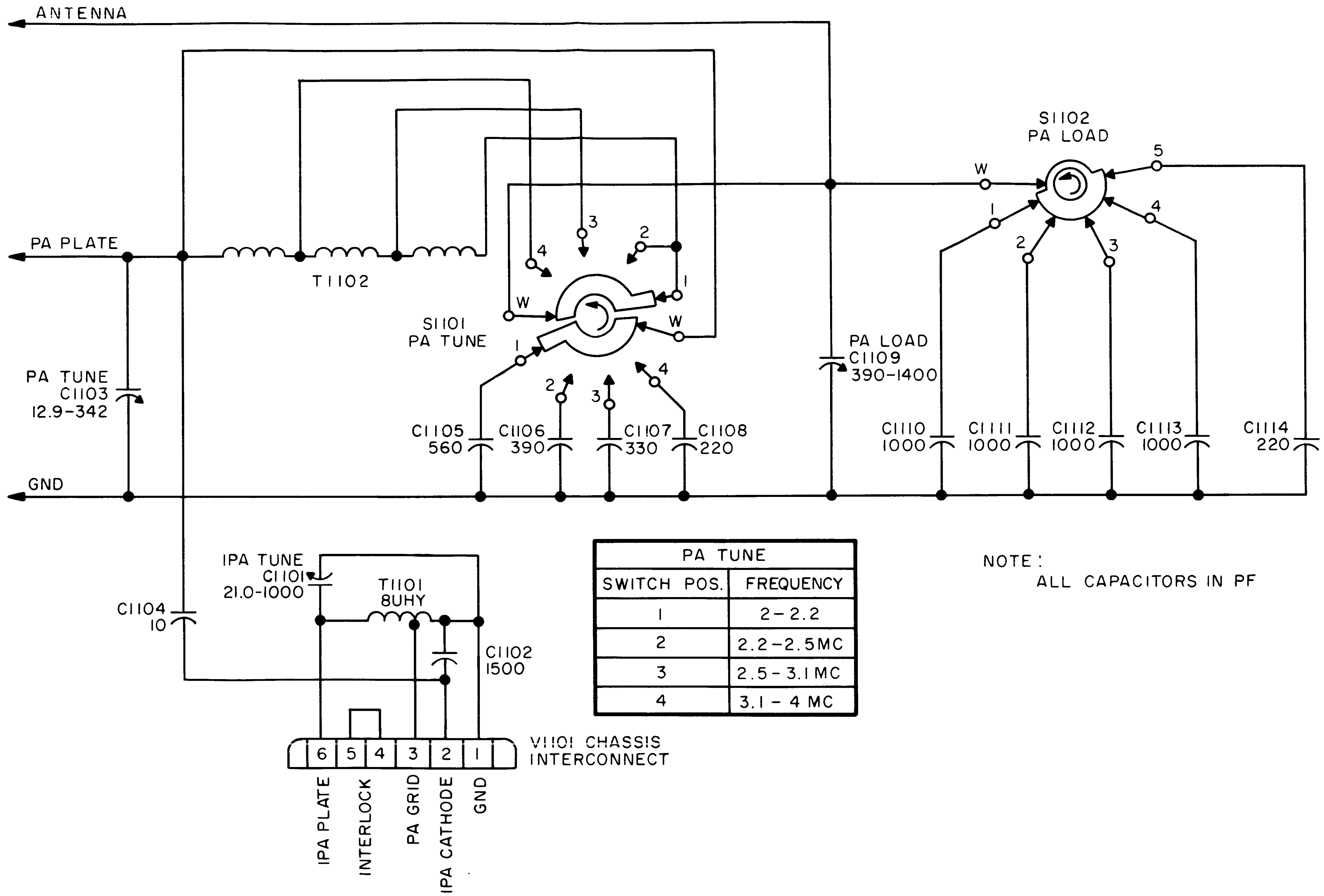


Figure 43. TTRT-4 Transmitter Converter (16-32 mc) Module. Schematic Diagram



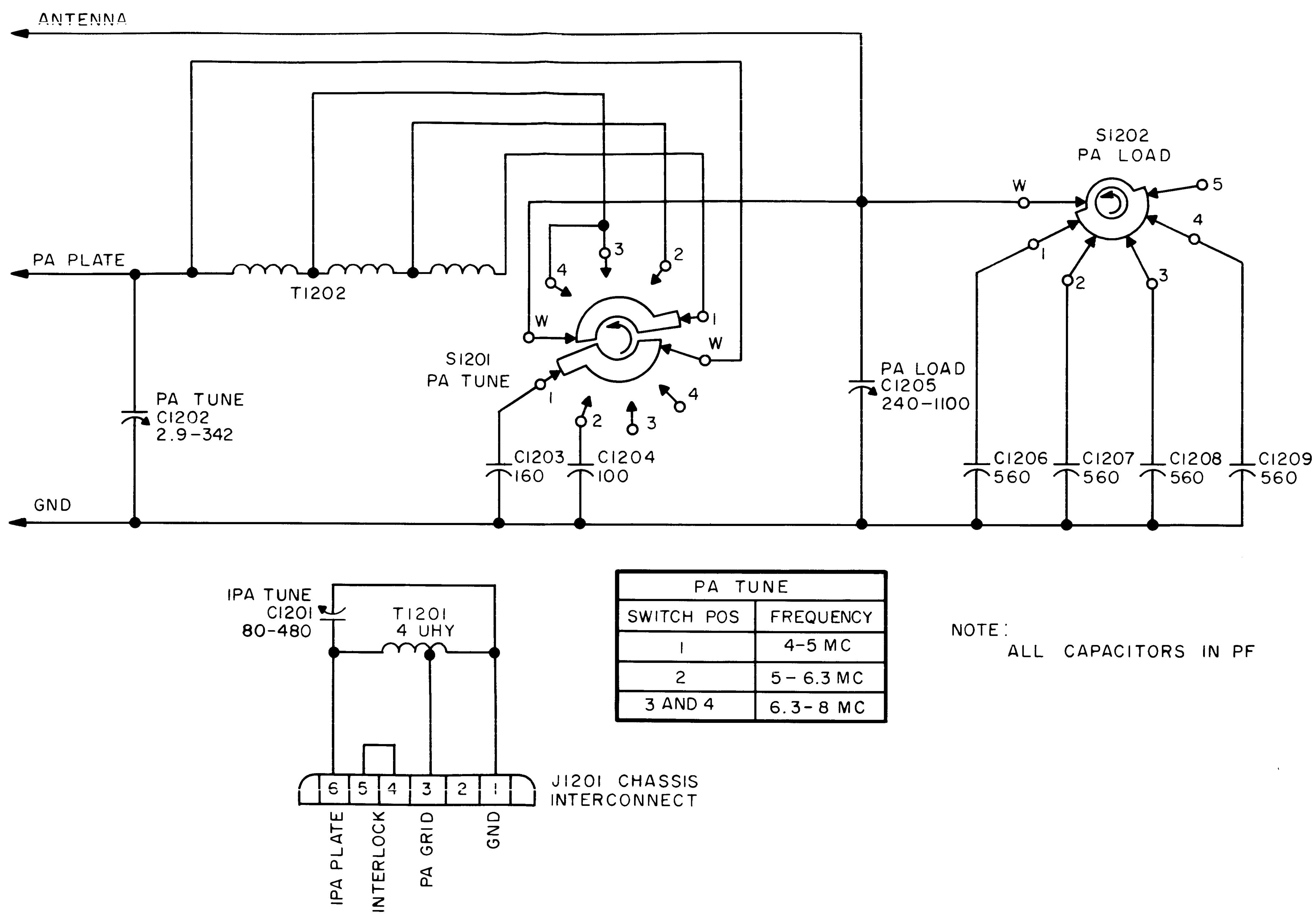
NOTES: UNLESS OTHERWISE SPE
1. ALL RESISTOR VALUES
2. ALL CAPACITOR VALUES



PA TUNE	
SWITCH POS.	FREQUENCY
1	2 – 2.2
2	2.2 – 2.5 MC
3	2.5 – 3.1 MC
4	3.1 – 4 MC

NOTE:
ALL CAPACITORS IN PF

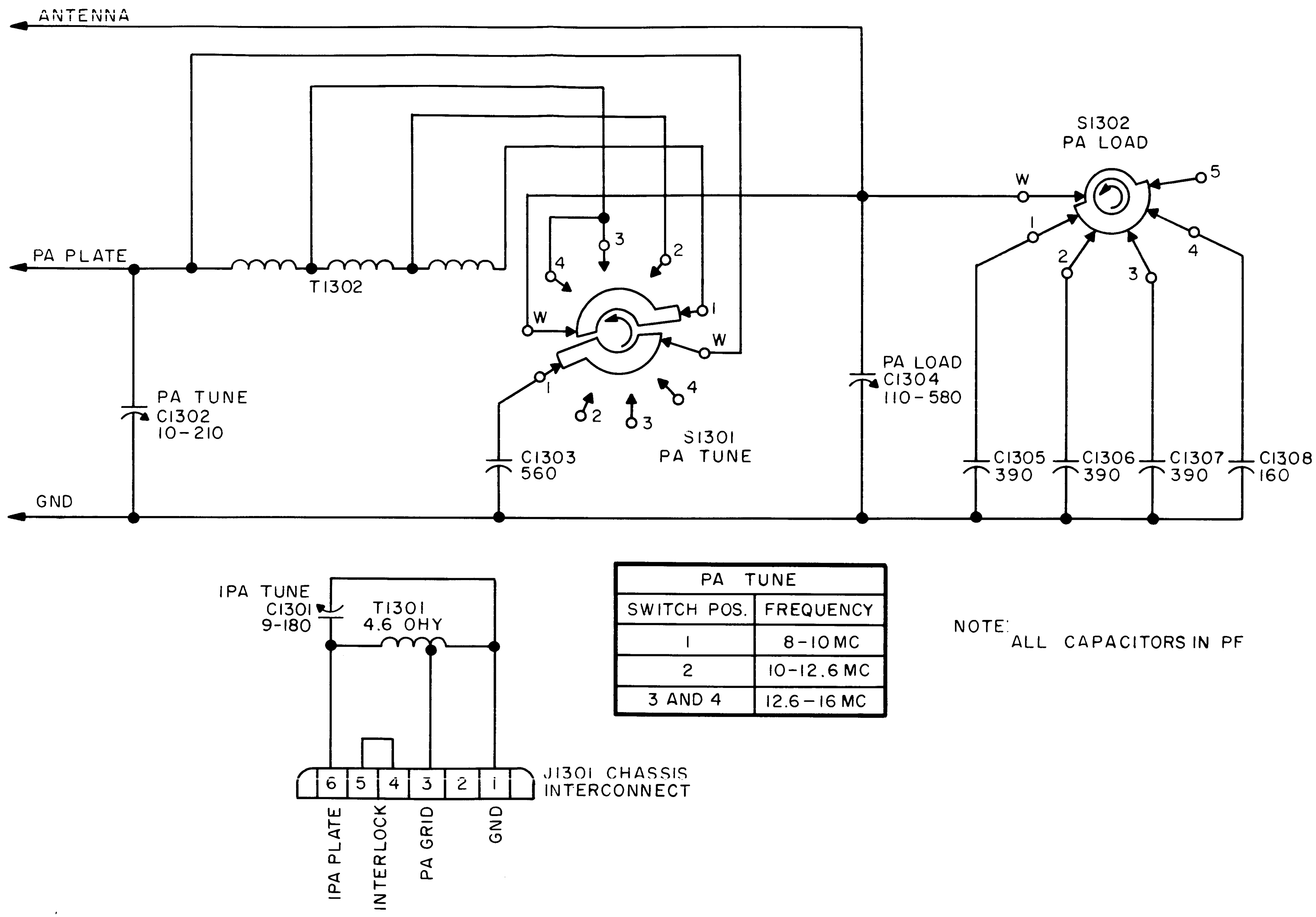
Figure 44. AX-409 PI Filter, Schematic Diagram



PA TUNE	
SWITCH POS	FREQUENCY
1	4-5 MC
2	5 - 6.3 MC
3 AND 4	6.3 - 8 MC

NOTE:
ALL CAPACITORS IN PF

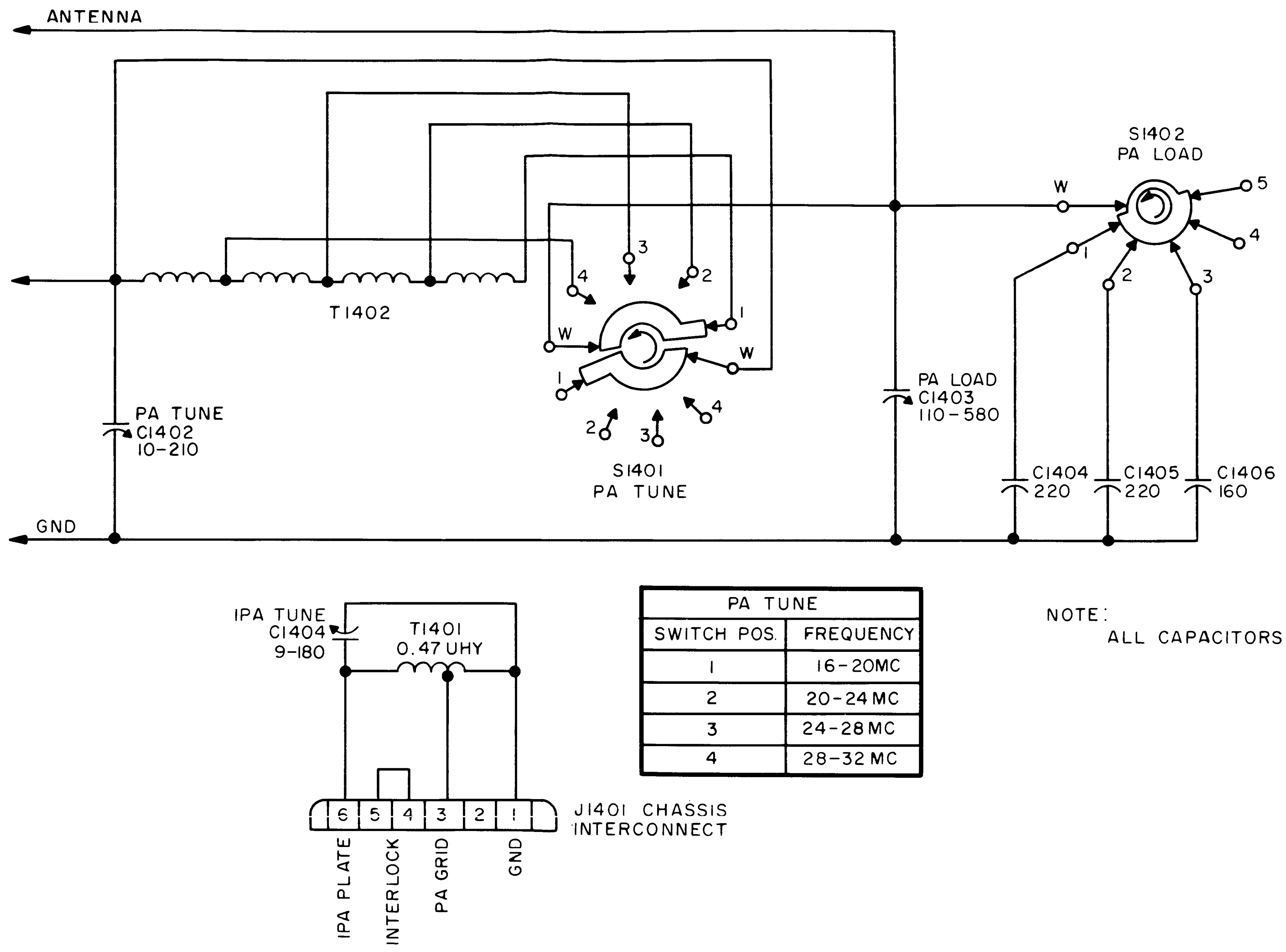
Figure 45. AX-410 PI Filter, Schematic Diagram



PA TUNE	
SWITCH POS.	FREQUENCY
1	8-10 MC
2	10-12.6 MC
3 AND 4	12.6-16 MC

NOTE:
ALL CAPACITORS IN PF

Figure 46. AX-411 PI Filter, Schematic Diagram



PA TUNE	
SWITCH POS.	FREQUENCY
1	16-20MC
2	20-24 MC
3	24-28 MC
4	28-32 MC

NOTE:
ALL CAPACITORS IN PF

Figure 47. AX-412 PI Filter, Schematic Diagram