DESCRIPTION

The Model T220 is a 2.5-watt self-contained transmitter for the 220 to 225 MHZ frequency range featuring small size, low spurious emissions, easy assembly, true FM modulation and wide RF bandwidth.

It is well suited to applications such as custom-built transceivers, repeater control links, point-to-point linking, repeaters, etc.

Built on a 4" x 4.5" circuit board, the entire assembly consists of the T144 exciter, Model AF-10 Audio Processor and the Model TO-6 Oscillator. This combination provides all of the functions needed to assemble a complete voice FM transmitter, yet the assemblies can be sheared apart to accommodate special applications.

TYPICAL SPECIFICATIONS (12V DC operation)

Range:	220 - 225	MHZ
Power output:	2.0	Watts min
Spurious outputs and harmonics:	-50	db
RF Bandwidth:	8	mhz @ -1db
Deviation (max)	7	khz

AUDIO PROCESSOR

This unit has everything for high quality audio; high microphone gain, pre-emphasis, symmetrical clipping and a 3-pole Chebyshev low-pass splatter filter. Separate gain controls are provided for deviation and mike gain so you can set the deviation properly. In addition, a tone-pad interface is provided for insertion of control tones without upsetting microphone audio, and it has a third independent level control. The tone input may also be used as a repeater audio input, allowing you to operate with a local microphone without interaction with the repeater audio (see applications data). A dynamic microphone is recommended, but sufficient gain is available and the input impedance is high enough accommodate ceramic or other types of microphones.

OSCILLATOR ASSEMBLY

The Model TO-6 utilizes fundamental cut crystals and provides sufficient deviation capability for the T220 exciter. The strip is directly modulated for true FM.

It can be interfaced to the Model OC-1 Oven Controller for high stability.

For purposes of your GLB kit, capacitor identification can best be accomplished by checking and sorting the components against the parts list. The number of a given value found, when checked against the list, should clear up any question that you might have about its identification.

The easiest way to find trouble in a kit is to avoid it. Even if it takes twice as long to build the kit, you are still way ahead because trouble-shooting is a slow process. Check each step as you make it. Use a magnifying glass to inspect the connection, then recheck the value of the component installed.

Keep your work area uncluttered and always have good lighting conditions. Do not work on your kit if you become over-tired. This may lead to mistakes, adding to your eventual completion time.

All ceramic and mylar capacitors should be mounted with the shortest possible leads and the capacitor body against the top of the board as closely as possible.

Capacitors are identified in several ways. Some are marked with the value printed in uf (microfarads), others in uuf (the old micro-microfarad symbol which has been adopted to be picofarad, or pf) and still others are coded as follows:

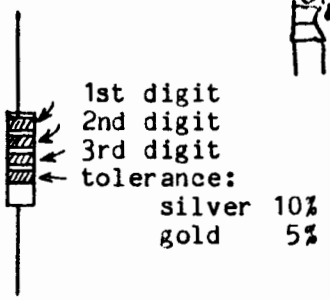
1 0 3 = 10,000 pf or .01uf

1st sig. digit decimal multi.
2nd sig. digit

473 =47,000 pf or .047uf
101 = 100 pf
102 = 1,000 pf or .001uf
.....etc.

RESISTOR COLOR CODE

1 brown
2 red
3 orange
4 yellow
5 green
6 blue
7 violet
8 gray
9 white
0 black

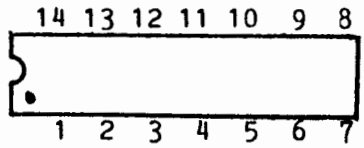


MOLDED TANTALUM CAPACITORS

Color strip, + sign or even a dimple built into them indicates the positive lead

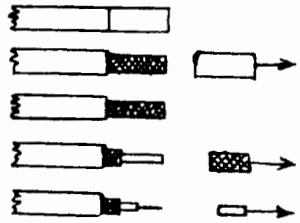
Aluminum and tantalum types are both polarized electrolytic capacitors.

Top view of an IC with pin #'s

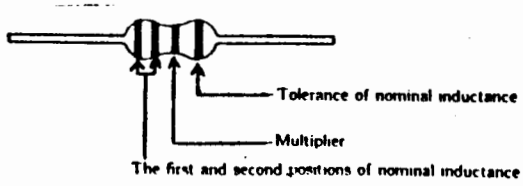


If TEFLON Coax is to be used in your kit construction, follow these simple steps:

1. Score the outer jacket with knife
2. Pull off outer jacket
3. Tin braid and score with knife
4. Bend braid back and forth, it will break
5. Score the inner conductor insulation and strip. DO NOT NICK THE CONDUCTOR.



MOLDED INDUCTORS



Classification	Colour Zone		
	The first and second positions of nominal inductance	Multiplier	Tolerance
Black	0	10^0	±20%
Brown	1	10^1	-
Red	2	10^2	-
Orange	3	10^3	-
Yellow	4	10^4	-
Green	5	-	-
Blue	6	-	-
Purple	7	-	-
Grey	8	-	-
White	9	-	-
Gold	-	10^{-1}	± 5%
Silver	-	10^{-2}	± 10%

PARTS LISTING

MISCELLANEOUS

Instructions		( )
Circuit board		( )

DIODES		QUANTITY	
D1	1N4148	( ) 1	for test loop

TRANSISTORS		QUANTITY
Q1	PN3563	( ) 1
Q2	BFX89	( ) 1
Q3	2N4427	( ) 1
Q4	MRF227	( ) 1
Q5	TIP ~~31~~ 32 OR EQUIV	( ) 1

PARTS LIST Con't

CAPACITORS	DESCRIPTION		QUANTITY	
C1	4.7 pf	ceramic	( ) 2	
C2	15 pf	ceramic	( ) 2	
C3	33 pf	ceramic	( ) 1	
C4	47 pf	ceramic	( ) 2	
C5	.001 uf	ceramic	( ) 12	
C6	22 pf	ceramic	( ) 1	
C7	.001 uf	ceramic		
C8	2.2 pf	ceramic	( ) 1	
C9	6.8 pf	ceramic	( ) 1	
C10	.001 uf	ceramic		
C11	4.7 pf	ceramic		
C12-C13	.001 uf	ceramic		
C14	8-25 pf	ceramic	( ) 3	
C15	.001 uf	ceramic		
C16	47 pf	ceramic		
C17	.001 uf	ceramic		
C18-C19	8-25 pf	ceramic		
C20-C23	.001 uf	ceramic		
C24	10 uf 16 volt	uf ceramic	( ) 1	with ferrite bead
C25	22 pf	ceramic	( ) 1	
C26	.001 uf	ceramic	( ) 1	for tuning loop
C27	15 pf NPO	ceramic	( ) 1	
C28	.001 uf	ceramic		

RESISTORS	DESCRIPTION		QUANTITY	COLOR CODE
R1	4.7K	ohm carbon 1/4W	( ) 2	yellow-violet-red
R2	1K	ohm carbon 1/4W	( ) 3	brown-black-red
R3	330	ohm carbon 1/4W	( ) 2	orange-orange-brown
R4	100	ohm carbon 1/4W	( ) 2	brown-black-brown
R5	4.7K	ohm carbon 1/4W		
R6	1K	ohm carbon 1/4W		
R7	100	ohm carbon 1/4W		
R8	2.2K	ohm carbon 1/4W	( ) 1	red-red-red
R9	1K	ohm carbon 1/4W		
R10-R11	47	ohm carbon 1/4W	( ) 2	yellow-violet-black
R12	470	ohm carbon 1/4W	( ) 1	yellow-violet-brown
R13 470		ohm carbon 1/2W	C) 1	

INDUCTORS		QUANTITY	
L1-L2	slug-tuned form. GREEN	( ) 2	5.5T #26 WIRE
L3-L4	slug-tuned form, YELLOW	( ) 2	4.5T #26 WIRE
L5	3.5T #24 WIRE .165" dia	( ) 1	use L1 of TO6 as form
L6-L7	.33 uh	( ) 2	orange orange silver
L8	see drawings	( ) 2	with ferrite bead
L9-L13	see drawings		
L14	see drawings		with ferrite bead
L15	see drawings		

WIRE & CABLE

2" #26 wire - magnet
10" #24 wire - magnet
1" #18 wire - tin1986
1 " coil stock

End of list

T220 ASSEMBLY INSTRUCTIONS

1. Check the parts off on the parts list in the "( )" spaces next to the quantities shown. Report any shortages to GLB immediately.

2. Insert and solder all resistors and molded chokes, following the component locations printed on top of the board. Solder the leads of each component as you install it and check it.

3. EXCEPT FOR Q4, install all of the transistors. The body of each transistor must be in contact with the board. Solder and trim the leads.

4. Install the ceramic disc capacitors in accordance with the instructions on page 2, page 7 fig. 6, and the board designations shown on page 8. Remember that at 220 MHZ, construction is critical.

5. Observe the color coding and pin connections for prewound coils L1-L4. The correct position for the inductors is with the lead from the top of the winding to the Dot on the PC Board. See Page 8 for "Dot" positions.

6. Wind and form L5, L8, L11, L12 and L14, as shown in the coil drawings figures 1-5 on page 7, following the instructions below:

For L11,(page 7, fig. 3) use the plastic coil form to wind this coil; it shows the correct diameter. FROM T06 KIT

For L8, (page 7, fig. 3) wind as you did for L11, but notice that it includes a ferrite bead.

For L5, (page 7, fig. 2) again wind as you did for L11.

Form L14 around the ferrite bead as shown in the coil drawings page 7, fig. 5. Be sure to pull the loop snug on the ferrite bead.

For L12, start with a 0.7" length of #24 magnet wire. Tin each of the ends about 0.1" from the ends. Form the loop and insert into the board as shown in page 7, fig. 4.

For L9, form the inductor to the PC Board holes. This is shown on page 7, fig. 11.

Solder each of the coils into the board as it is completed. The solderable wire that we supply does not require stripping. When it gets hot enough the insulation melts and the wire takes solder.

7. Cut L10 and L13 from the coil stock provided. Notice that these coils are not close wound, the spacing between the coils should be equal to the diameter of the wire. Form the leads and space the windings as shown in page 7, figures 1 & 2. Solder each of the coils into the board as it is completed.

8. Insert and solder the trimmer capacitors. Trimmer capacitor orientation is critical! The outlines on the layout represent the body pattern of the capacitor. The rotor must be oriented to the ground foil on the board. See page 7 fig. 7.

9. Insert and solder the electrolytic capacitor. Note that the positive lead of this capacitor has a ferrite bead on it.

With all of the top-side components in place, check your work for missing or bad solder joints, wrong values or improperly installed parts.

10. Install Q4 on the TRACE SIDE of the board as shown on page 6. First tin the area of the ground trace where the transistor is to go (lightly). Insert the transistor leads from the trace side. Using a soldering iron having sufficient heat capacity heat the adjacent trace area all around while pressing the transistor against the metal surface. (use an implement or you'll burn your fingers!) When the transistor sinks flat into the molten solder add solder around the periphery to flow a smooth joint, then hold it in place while the solder solidifies.

11. Loop the collector and base leads thru the indicated holes. Push them in until the leads are flattened against the top of the board. Solder them to the trace on the other side.

12. Clip off the emitter lead about 1/8th inch from where it emerges and flatten it out of the way against the board.

13. Inspect your work. Locate the collector of Q5 on the trace side of the board and, with an ohmmeter, make sure there is some resistance (a few hundred ohms) between that point and ground.

14. Before testing, check the following points for electrical shorts. Also check visually for near-shorts. When testing use an ohmmeter on the lowest range. A short is zero ohms; most normal conditions will be hundreds or thousands of ohms.

(a) L11 may be shorted to a metal part of C14. Bend it clear.

(b) L10 may be shorted to metal parts of C18 or C19. Bend it clear.

(c) Check for a short to ground from the of collector of Q5. If there is a short here, it will immediately burn out Q5.

NOTE: When making preliminary tests, it's a good idea to solder a wire bridge from collector to emitter of Q5. This measure protects Q5 against a accidental B+ short. Remove the bridge when you install the transmitter.

15. Construct the tuning loop as shown on page 12, fig. 8.

At this time proceed to the assembly instructions for the AF-10 and the TO-6.

COIL INFORMATION AND ILLUSTRATIONS

REF	FIGURE	DESCRIPTION
L1–L2		5.5 turns #26 wire (green)
L3–L4		4.5 turns #26 wire (yellow)
L5	2	4.5 turns #24 wire, .165 dia.
L6–L7		.33 uh chokes
L8	3	4.0 turns #24 wire, .165 dia. – with a ferrite bead
L9	11	.4" loop #18 wire – lay this loop flat on the pc board
L10	1 , 2	2 turns #18 wire – from preformed stock
L11	2	2 turns #24 wire, .165 dia
L12	4	.7" loop #24 wire lay this loop flat on the pc board
L13	1 , 2	1.5 turns #18 wire – from preformed stock
L14	5	1 turn #26 wire – through a ferrite bead

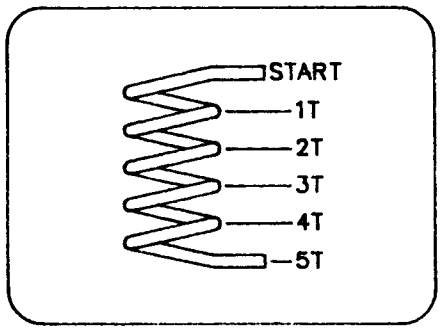


FIGURE 1

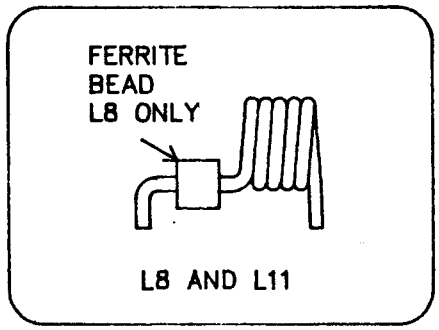


FIGURE 3

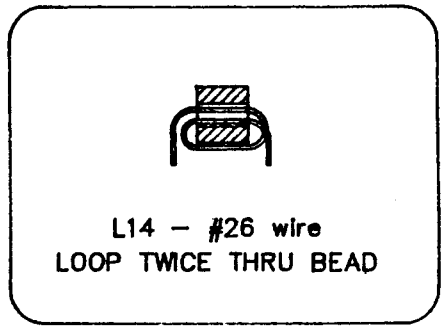


FIGURE 5

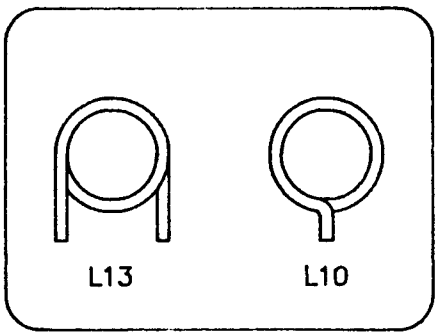


FIGURE 2

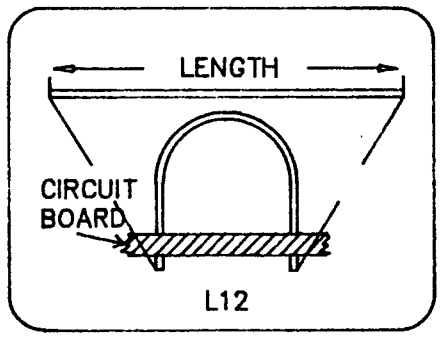


FIGURE 4

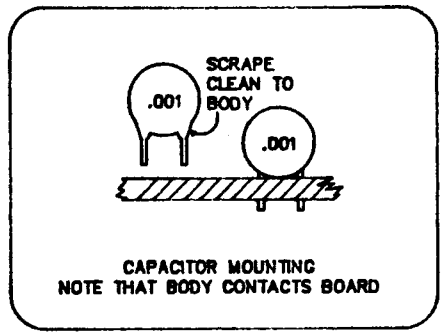


FIGURE 6

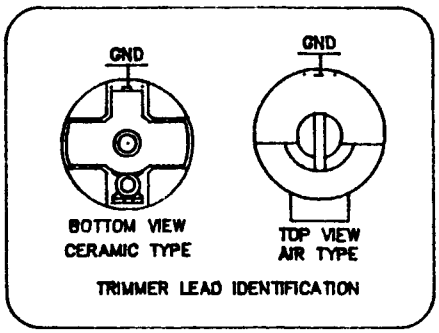


FIGURE 7

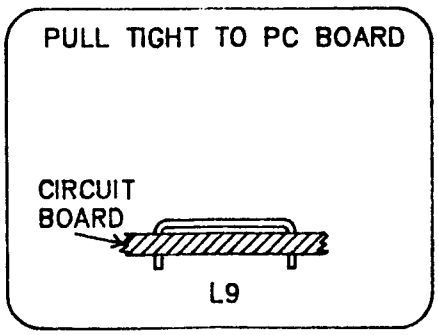
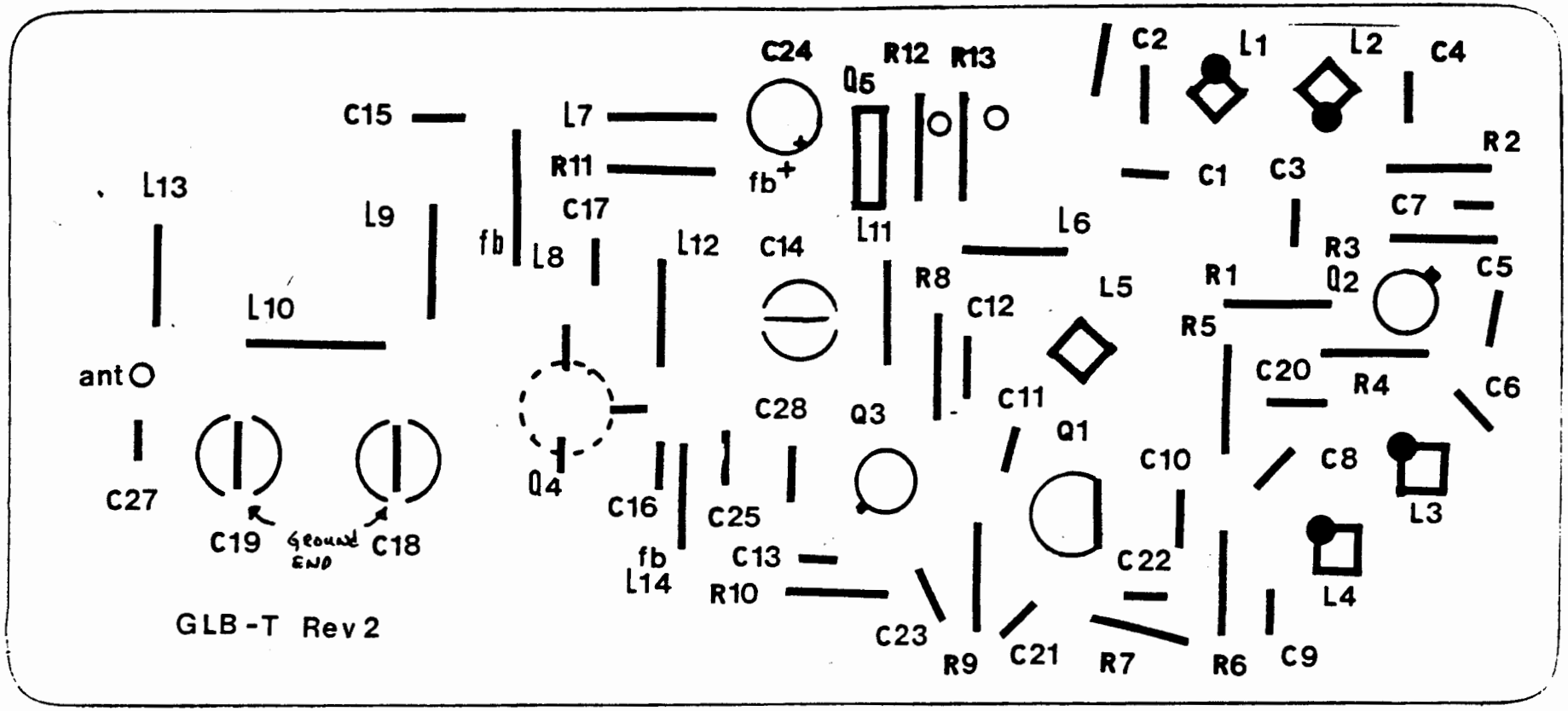


FIGURE 11



GLB ELECTRONICS MODEL T220 ASSEMBLY CHART

Step	Item number	Value	Check
1	R1, R5	4.7K	
2	R2, R6, R9	1K	
3	R3	330	
4	R4, R7	100	
5	R8	2.2K	
6	R10, R11	47	
7	C1, C11	4.7 pf	
8	C25	22 pf	
9	C3	33 pf	
10	C4, C16	47 pf	
11	C5, C7, C10, , C13, C15	.001	
12	C17, C20, C21, C22, C23	.001	
13	C28	.001	
14	C6, C8	2.2 pf	

Step	Item number	Value	Check
15	C9	6.8 pf	
16	C14, C18, C19	5-25 pf	
17	C24 ש/ FB	10/16E	
18	C27, C2	15 pf	
19	Q1	2N5130	
20	Q2	2N5179	
21	Q3	2N4427	
22	Q4	MRF227	
23	L1, L2, L3, L4, L5	slug-tuned	
24	L6, L7	.33 uh	
25	L8, L14	(has bead)	
26	L9, L12	loop	
27	L10, L13	coil stock	

TUNING PROCEDURE

EQUIPMENT REQUIRED

1. A good 50-ohm dummy load.
2. An RF detector (see page 12, fig. 8 "tuning Loop").
3. A DC volt-ohm-milliammeter with 20,000 ohms per volt sensitivity.
4. A DC power supply, 12 to 14 volts regulated DC at 3/4 amp.
   (or 1 1/4 amp when used with a Channelizer).
5. An RF output indicator. (SWR meter or wattmeter)

RF ALIGNMENT

1. Interconnect the equipment as shown in page 12, fig. 9.
(At this point it is assumed that you have built and tuned the TO-6 and the AF-10.)

2. Connect the VOM + lead to the ungrounded side of R3 and the - lead to ground. (The entire outside area of the foil on the board is grounded). Tune L1 for a peak, approximately 1.25 volts. Tune L2 for an increase of 0.2 volts or more. Then carefully repeak L1 and again L2 for maximum indication.

3. Connect the VOM leads to the "Tuning Loop" as shown on page 12 fig. 8. Place the loop near L5. Tune L3 and L4 for the greatest peak. This peak will be when the slugs are near the top of the coil forms.

4. Shut off the power supply. Connect the meter in series with the positive lead of the supply (meter + to + output of the supply, meter - to the +12V input of the transmitter), as shown in page 12, fig. 7, switch the meter to the 1 or 2 ampere scale.

5. Turn on the power and tune C14 for maximum current drain. Spread L5 until maximum current is drain is observed then retune C14.

6. Tune C18 and C19 for maximum power output. Then retune C14, C18 and C19 in that order.

7. If you have an RF wattmeter you should be showing 2.5 watts or more with 13.6V of supply. If the power is low, check the current drain of the transmitter. It should draw at least 0.7 amps to get this power output. If it isn't drawing enough current check the board completely for errors, particularly in capacitor values and coil winding accuracy. Try repeating steps 1 thru 6.

If a RF wattmeter is not available, the detector loop can be used by coupling it close to L13.

NOTE: Final adjustment of L1 and L2 is done in step 2. DO NOT TOUCH the adjustment of these coils in later steps. Similarly, L3 and L4 should not be readjusted after step 3. If you think they need readjustment, go back and repeat the appropriate steps.

REPRESENTATIVE VOLTAGE

POINT	VOLTAGE	POINT	VOLTAGE
Q1 emitter	1.4	collector	12.0
Q2 emitter	1.7	collector	12.0
Q3 emitter	2.9	collector	12.0

OPERATIONAL NOTES

Power (+12 to +14.5 V) is brought in at the trace connected to the Emitter of Q5. This connection puts the supply voltage on the keying circuit continuously, but it won't draw current until the transmitter strip is keyed. Keying is accomplished by providing a ground to R13, point "ptt" (see schematic). This ground turns on switching transistor Q5 which supplies power to the board.

AUDIO

The transmitter modulation input can be driven directly with an audio signal, but the response at the audio input terminal (point z) is not limited or pre-emphasized. The audio level required at the transmitter input varies from crystal to crystal, but typically it takes about 1 volt to achieve 5 KHZ of deviation. Our audio processor is designed for voice operation, and it provides the functions of preamplification, pre-emphasis, deviation limiting and splatter filtering, plus a tone input.

THEORY OF OPERATION

Refer to the schematic diagram. Audio is applied to the TO6 via Rfm, thus using a common interconnecting line for both audio and RF. The AF-10 Audio processor provides the necessary pre-emphsis, deviation limiting, and harmonic filtering in the audio circuits for balanced response.

DRIVING SOURCE

The source of drive for the T220 should be rich in harmonic output. When this is provided for, the T220 can be driven from either an 18 or 24 MHZ fundamental. The input circuitry will filter out either the 2nd or the 3th harmonic respectively producing 73.5 MHZ at the input of Q2.

This frequency is then tripled in Q2 to nominally 220 MHZ. L3 and L4 filter out any undesirable products of Q2, providing a clean 220 MHZ signal to the base of Q1. Q1 and Q3 amplify the signal to approximately 1/4 watt to drive the power amplifier Q4 via L11, L12, C25 and C16. Q4 is operated in class C, hence its collector current depends upon the RF drive level. Output impedance matching and harmonic filtering is provided by L9, L10, L13, C18, C19 and C27. L8, C15, L7, R11 and C24 are chosen to keep the stage stable. The Ferrite bead acts as a parasitic suppressor.

KEYING

The on-board keying circuit consists of Q5, R12, and R13. This stage is operated as a saturated switch. Keying is accomplished by providing a ground potential to R13.

TRANSMITTER APPLICATIONS DATA

The T220 transmitter is designed to be driven directly from the GLB Channelizer. When used with the 220 or 220 A series Channelizers, the transmit mode should be programmed X6 and the output low-pass filter in the transmit line should be removed. This filter consists of two capacitors and a choke mounted on a printed circuit board square under the output jack. The choke is replaced with a jumper and the capacitors are disconnected. In addition, the output IC (Z11 on the VCO) should be replaced with a 75S00 or a 74H00 instead of a 7400.

When the T220 is driven with a GLB Channelizer, the fundamental output frequency of the Channelizer is set to nominally 24.5 MHZ. Since the Channelizers are rich in harmonic output, (with the output low-pass filters removed) it is only necessary to filter out the 2nd harmonic in L1-C1-C2 and L2-C3-C4 to obtain a 55.0 MHZ signal.

With all of the Channelizers audio is applied to one of the coax cables for FM. In the 220 series channelizers you use the transmitter coax (see the instruction book on your unit.)

The same technique is used with our crystal oscillator strips.

If the audio processor board is adjacent to the transmitter strip, the audio coupling resistor (Rfm) can be connected directly across from board-to-board, but if the lead would exceed 1 or 2 inches, stand the resistor on end on the transmitter strip, make a loop in the top lead (cutting it as required) and use it as a solder lug to connect the length lead required to reach the audio board.

Page 12, figure 10 shows a simple automatic push-to-talk system, using outputs available from the Model AF-10 audio processor board. With this circuit a simple series connection of the microphone element and push-to-talk button will provide transmitter keying. Also, depressing any button on the tone pad will key the transmitter and provide interdigit timing. We don't offer kits for this circuit, but it is simple enough to wire on perf board.

ANTENNA SWITCHING

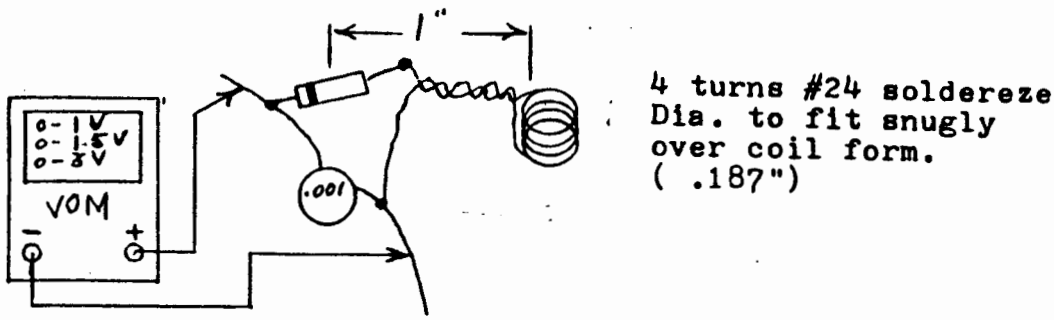
If you use a relay to do the antenna switching, avoid relays with long contact springs or connecting leads. The best way to do it, particularly on the 220 MHZ band is to use a coaxial relay. The next choice is a crystal-can type miniature relay, If you keep the center conductor short and ground the coax shield to the relay can, it can provide results as good as many coaxial relays. Some open-frame relays can be used, but usually they have too much capacitance between the coil and the RF-exposed parts. In some otherwise acceptable relays this condition can be overcome by floating the relay coil with RF chokes on both coil leads.

Diode switching is popular because it doesn't involve moving parts. However, diodes invariably introduce more loss than a well-implemented relay system and they often generate harmonics of the transmitter output, defeating the harmonic filtering in the transmitter. However, good diode T/R switching systems can be built, and they offer higher reliability than relays.

Tuning and Applications Diagrams

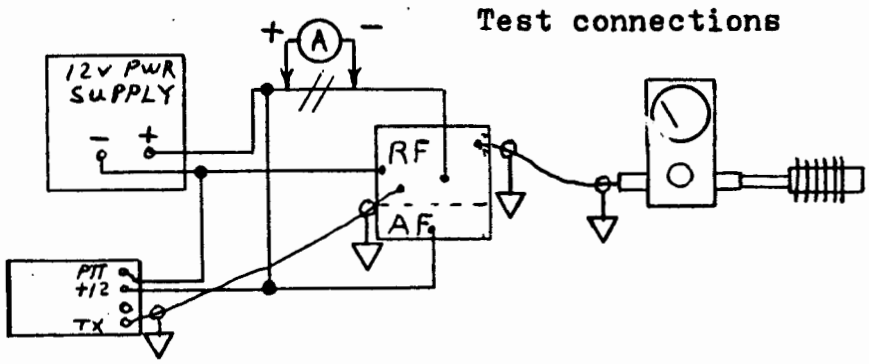
TUNING LOOP CONSTRUCTION AND HOOK-UP

FIGURE 8



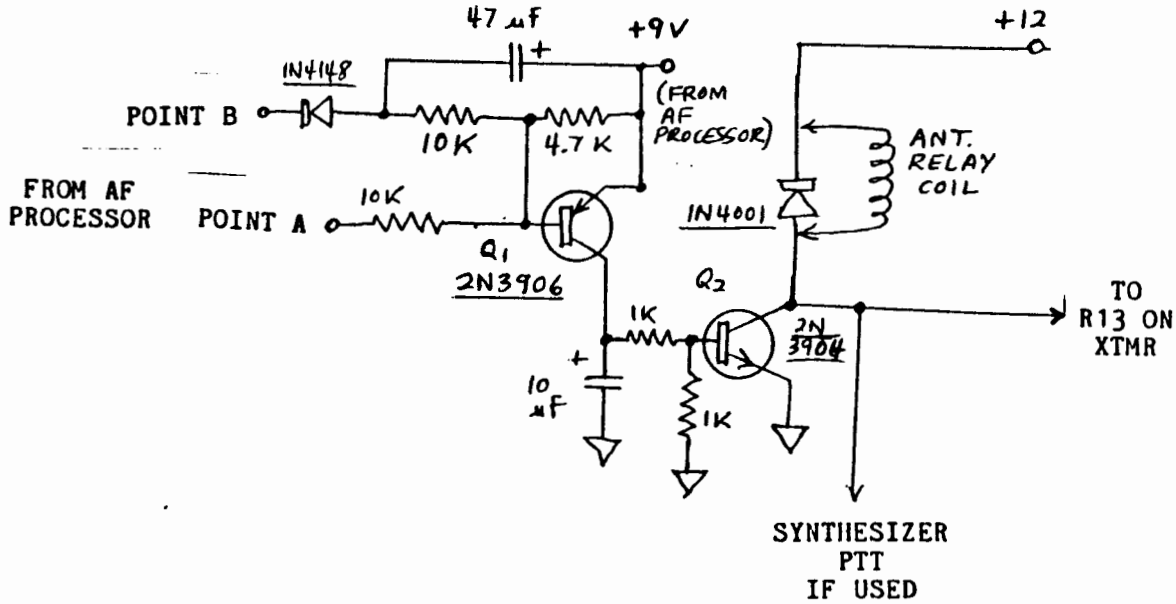
TEST CONNECTIONS

FIGURE 9

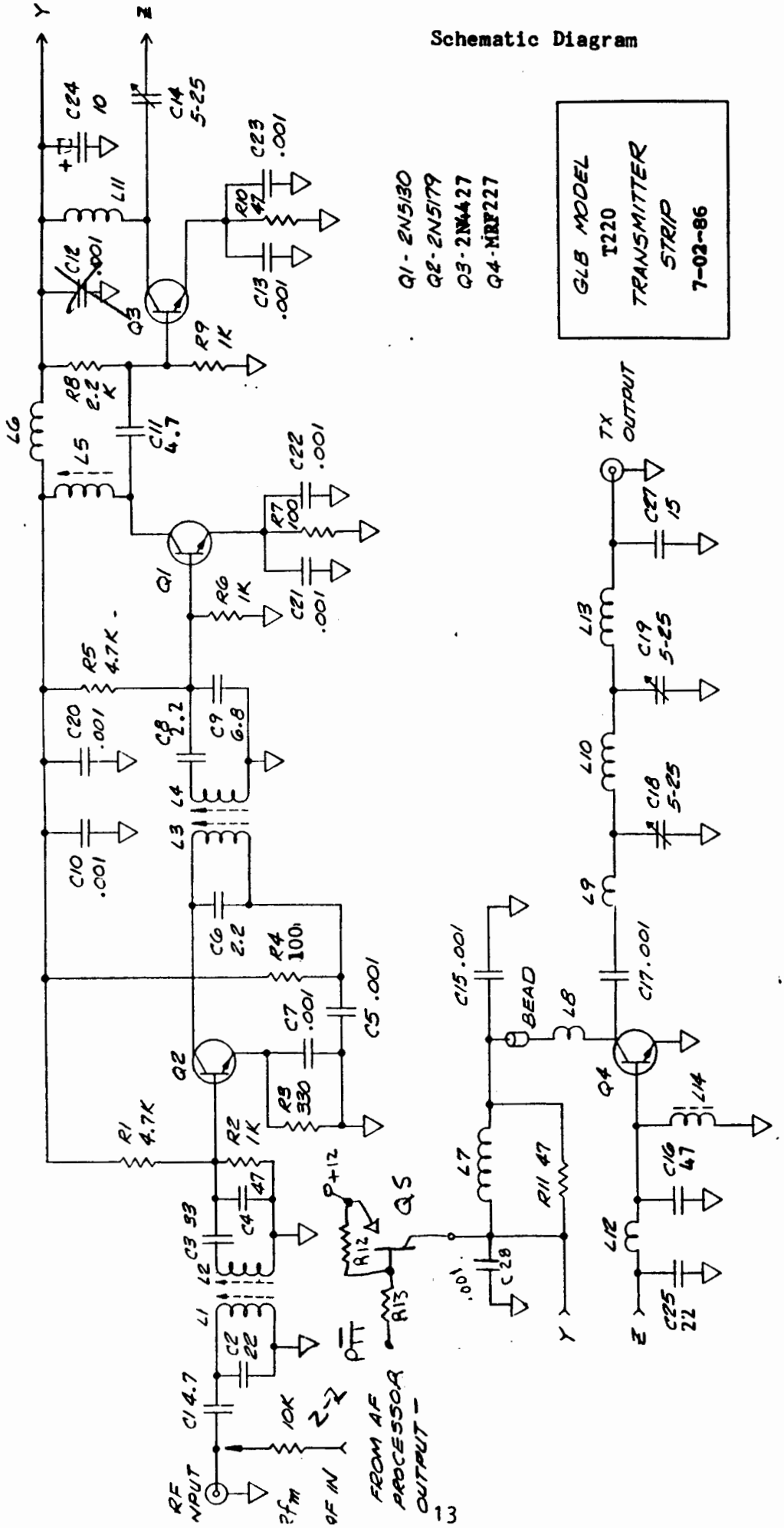


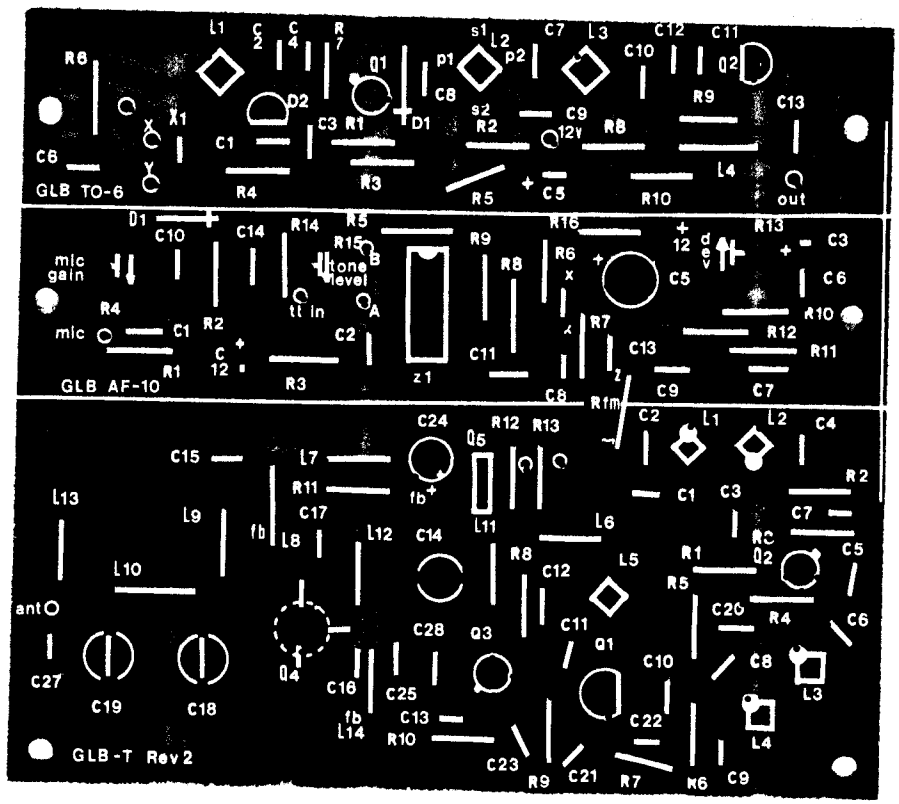
A SIMPLE T/R HOOK UP

FIGURE 10



Schematic Diagram




GLB TO-6
GLB AF-10
GLB-T Rev2
mic gain
mic
tone level
ant
out