1. General

The *SYNTOR X* frequency synthesizer generates injection frequencies for both first and second receive mixers as well as generating the transmitter carrier. It is composed of the receive injection doubler, the transmit injection doubler, the transmit mixer and buffer, and a phase-locked loop (PLL) consisting of a 14.4-MHz reference oscillator, a phase modulator, a low-noise voltage-controlled oscillator (VCO), a programable divider, a sample-and-hold phase detector, and an adaptive loop filter. In the receive mode, the PLL locks on a frequency 75.7 MHz (first IF) above the receive frequency for injection into the first mixer. The receive injection doubler doubles the third harmonic of the 14.4-MHz reference oscillator, and the result is the second mixer injection frequency.

In the transmit mode, the the transmit injection doubler redoubles the signal from the receive injection coubler and amplifies it, and the result is high-side injection to the transmit mixer. The PLL generates the frequency which, when mixed with the transmit injection, yields the transmitter carrier. The VCO and phase modulator modulate the transmitter carrier.

The synthesizer circuits are on the RF board, in the internal casting, and on a small board above the personality board.

2. Theory of Operation

2.1 INTRODUCTION

2.1.1 The PLL synthesizer is a single negative-feedback loop that uses the phase of the input signals to the phase detector as the controlling variable. The output of a high-accuracy, temperature-compensated crystal reference oscillator (U608) is divided down in frequency by the reference divider (part of U602). The reference divider puts out a high-stability 5.00-kHz (6.25-kHz for some customer frequencies) squarewave signal that is routed from the reference divider through the phase modulator to the phase detector (U603-2) to serve as the reference frequency input.

2.1.2 The loop frequency input of the phase detector (U603-23) receives the negative feedback for the PLL. This comes from the VCO, the output frequency of which is proportional to the voltage on the VCO's steering line (P650-2).

2.1.3 The VCO is a FET RF oscillator (Q1401) that covers the frequency range from 105.2 MHz to 143.1 MHz. A programable N divider divides the VCO frequency down to the loop frequency as follows:

$$f_{loop} = f_{vco}/N$$

where: f_{loop} = N divider loop frequency output
f_{vco} = VCO output frequency
N = integer

2.1.4 The loop frequency and the reference frequency are applied to the phase detector (U603-23 and U603-2, respectively), whose function is to generate a dc output voltage proportional to the phase difference between these two frequencies. Phase is the controlling variable, since there may be small phase errors in the locked loop, but frequency errors cannot occur. The dc output voltage of the phase detector (PHASE DET OUT at U603-15) is applied via the loop adaptive filter to the VCO steering line, thus completing the feedback loop. The loop filter controls the PLL closed loop response and removes noise from the phase detector output.

2.1.5 If the VCO output frequency goes high, the N divider loop frequency output also goes high, thus causing a leading phase displacement at the phase detector loop input. Since the reference signal phase does not change, the internal circuits of the phase detector detect this condition and lower the dc voltage at the output U603-15. This signal goes to the VCO steering line via the loop adaptive filter, causing a reduction in frequency. This compensates for the original frequency difference.

2.2 LOOP PROGRAMING AND CONTROL

2.2.1 For frequency generation and control, the microcomputer reads the programing information from the personality board memory module, combines it with the synthesizer control information, and multiplexes this information to the programable divider (U602). The programing information, contained in six four-bit words, goes to the multiplex programed divider via four data lines (D0, D1, D2, and D3) and via three data word address lines (A0, A1, and A2). Address lines A0, A1, and A2 in the multiplexing sequence tell the divider which of the six four-bit words the microcomputer is sending on the data lines.

2.2.2 Of the bits sent to the divider, two determine the frequency range of the VCO. These bits are transferred from the divider (U602-19 and U602-20) to the synthesizer switching hybrids (HY604-5 and HY605-5, respectively), which supply 9.6 V to the VCO pin switch circuitry via P650-5 and P650-6. These switching hybrids also load the modulation circuitry of the VCO via P650-4 to maintain level modulation across the frequency range. Sixteen bits program the A and B counters, which are inside the programable divider. Two bits program a reference divider. One latched bit goes from the divider (U602-15) to the extender circuitry (Q241) to enable or disable the extender. The sample-and-hold phase detector (U603-3 and U603-5) uses two other latched outputs from the divider to control the adaptive loop filter. When set high, U603-5 indicates a change in frequency. In this case, the seventh word clears the frequency change indication by setting U602-18 (same as U603-5) low, thus generating a control pulse. U602-17 switches between the transmit and receive loop filters (high for transmit filter). One bit is not used.

2.2.3 The six four-bit words on the data lines remain the same once the condition of synthesizer operation and the frequency have been selected. Any change in radio mode makes the microcomputer address different memory locations in the memory module. Consequently, the six four-bit words may send different information to the divider via the data lines. The microcomputer notifies the divider, via the STROBE line, when the binary information on the data and address lines can be read into the divider and latched in without any chance of error.

2.3 DIVIDER

2.3.1 The programable N divider works by "dual-modulus prescaling," using a divide-by-63-or-64 prescaler. The divide-by-63-or-64 prescaler, with programable counters A and B, is inside divider U602. The input frequency of each prescaler is first divided by one divisor to obtain a fixed number of counts, then divided by a second divisor to obtain a different number of counts. The total division performed by this system may be set to an integral value N by the programing of counters A and B.

2.3.2 Each PLL output frequency requires that a different value of N be programed into the programable counters. On the positive-going loop pulse edge, the divide-by-63-or-64 starts dividing by 64 for the number of times programed by the A counter. When the A counter counts to zero, the loop pulse goes low and the prescaler changes to the divide-by-63 mode. It stays in this mode until the B counter reaches zero. At this time the loop pulse goes high and the cycle repeats.

2.3.3 Another programable divider acts on the 14.4-MHz reference oscillator input frequency at U602-2 to produce one of two reference frequencies: 5 kHz or 6.25 kHz. One word of the frequency select data contains two bits (D0 and D1) that select one reference frequency, as shown in Table 1.

Table 1. Reference Frequency Selection

D0	D1	Reference Frequency
0	0	unused
1	0	6.25 kHz
1	1	5.00 kHz

2.3.4 The frequency select data also contains bits VCO1 and VCO2 which, through synthesizer switching hybrids HY604 and HY605, select the operating range of the VCO. When the VCO bits are latched into the divider, VCO1 and VCO2 go from U602-19 and U602-20 to HY604-5 and HY605-5. Each hybrid inverts its bit and then sends it out through Pin 9 to the VCO via P650-5 and P650-6, respectively. Also, when either VCO bit goes high, an NPN transistor on its hybrid turns on, adding in a shunt resistance on the VCO modulation line, which has the effect of reducing the level of the audio signal to the VCO. This maintains a constant level of deviation across the entire frequency band.

2.4 PHASE DETECTOR

2.4.1 Phase detector U603 compares the reference and loop frequency outputs of the divider circuit and uses this information to generate a dc output signal that controls the VCO frequency. The phase detector also monitors the FREQUENCY CHANGE line (U608-18) and the LOW BANDWIDTH SELECT line (U602-17) and uses this information to generate control signals for the adaptive filter.

2.4.2 The phase detector output signal level is controlled by the length of time between the positive transition of the reference signal and the positive transition of the loop signal. When the reference signal goes high (at U603-2), ramp generator Q600 turns on, maintaining a constant current through C630. This constant current generates a linear rise (ramp) in the voltage at U603-24. The rise of the ramp voltage halts when the LOOP signal (at U603-23) switches to a high level, causing Q600 to turn off.

2.4.3 The positive transition of the loop signal, in addition to halting the ramp generator, resets an internal sample timing circuit. The ramp voltage is held constant for a time determined by sample timing capacitor C631. During this time, the hold capacitor (C632) is charged to a level determined by the ramp voltage. At the end of the sample time, the ramp capacitor is discharged in preparation for the next cycle.

2.4.4 The accumulated charge on the hold capacitors controls the conduction of a push-pull output driver. The output driver consists of an internal NPN transistor and an external PNP transistor controlled by the signal at U603-17. The PHASE DETECTOR OUTPUT signal at U603-15 is coupled, via the adaptive filter, to the VCO, where it controls the generation of injection frequencies.

2.4.5 The phase detector also generates control signals for the adaptive filter. It decodes the FREQUENCY CHANGE signal at U603-5 and the LOW BANDWIDTH SELECT signal at U603-3 to generate four control signals that are coupled to the adaptive filter. These four control signals are: ADAPT, $\overline{\text{ADAPT}}$, RX, and TX (appearing at U603-10, -7, -12, and -6, respectively).

2.4.6 When operating channels are being changed in the receive mode or the mode is being changed from transmit to receive, the FREQUENCY CHANGE pulse at U603-5 causes the ADAPT line to go high and the $\overline{\text{ADAPT}}$ line to go low. Since the LOW BANDWIDTH SELECT line is low, the RX line is driven high, the TX is driven low, and the adaptive filter is forced into the receive-adapt mode. The $\overline{\text{ADAPT}}$ line returns to a high level and the ADAPT line returns to a low level after approximately 2.4 milliseconds under phase detector control, forcing the adaptive filter to enter into the normal receive mode.

2.4.7 When the PTT button is pushed, the FREQUENCY CHANGE pulse causes the ADAPT line to go high and the $\overline{\text{ADAPT}}$ line to go low. Since the LOW BANDWIDTH SELECT line is high, the TX line is driven high, the RX is driven low, and the adaptive filter is forced into the transmit-adapt mode. The ADAPT and $\overline{\text{ADAPT}}$ lines switch states after approximately 12 milliseconds under control of the phase detector, and the adaptive filter is forced to enter into the normal transmit mode.

2.4.8 Whiie the ADAPT line is high during the transmit-adapt mode, the power amplifier is disabled. (This line is connected to the personality board via J602-11.) Moreover, the ADAPT line is forced to switch to a high state when the synthesizer cannot achieve lock, thus preventing the radio from transmitting unstable or off-frequency signals.

2.4.9 For maximum switching speed, the microcomputer sends new data to the synthesizer at the appropriate time of the divide cycle. The phase detector forwards a SYNTHESIZER SYNC signal, from U603-4 via J601-9, notifying the microcomputer of the appropriate time to send new frequency programing information.

2.5 ADAPTIVE FILTER

2.5.1 General

2.5.1.1 The adaptive filter is a low-pass filter in the steering line between the phase detector and the VCO. It removes noise and variations in the steering line level to prevent unwanted modulation of the VCO.

2.5.1.2 The phase detector controls the adaptive filter through PHASE DETECTOR OUTPUT line U603-15 to operate in one of the four selectable modes, depending upon the state of the synthesizer at a given time. The modes are transmit adapt, receive adapt, transmit, and receive. The transmit adapt mode and the receive adapt mode differ only in the amount of time spent in the adapt condition, whereas the transmit mode and receive mode each require different filter characteristics. These characteristics are selected by transmission gates that switch the filter components into and out of the steering line signal path, as required.

2.5.2 Filter Mode Selection

Each of the four selectable modes, transmit, receive, transmit-adapt, and receive-adapt, is selected by a unique combination of states of the RX, TX, and ADAPT lines. These lines are coupled from the phase detector (U603-12, -6, and -1, respectively) to transmission gates U605A-D and U606A-D. Transmission gates U605A-D have ON impedances of less than 200 ohms, and gates U606A-D have ON impedances of less than 500 ohms.

2.5.3 Transmit Mode

2.5.3.1 When the synthesizer is in the normal transmit mode, the phase detector drives the TX line high and the RX and ADAPT lines low. The high on the TX line turns on transmission gates U605A, U606A, and U606D. The natural loop frequency in this mode is approximately 15 Hz. The adaptive filter stays in this mode as long as the radio is transmitting.

2.5.3.2 In this mode, the steering line is filtered by R652 and a shunt path to ground consisting of R653 in parallel with C649 and C641, and C637 and C654. This signal passes throgh the VCO via a test jumper (JU600) and J650-2.

2.5.4 Receive Mode

2.5.4.1 When the synthesizer is in the receive mode, the phase detector drives the RX line high and the TX and ADAPT lines low. With the RX line high, transmission gates U605C and U606C are turned on. The natural loop frequency in this mode is 75 Hz. The adaptive filter remains in this mode while the radio is in the receive mode.

2.5.4.2 In this mode, the steering line is filtered by R635, a shunt path consisting of R636 in parallel with C640, and R637, C654, and C637. (The ON impedance of the transmission gates is neglected.) The signal passes through the test jumper (J600) to the VCO via J650-2.

2.5.5 Transmit-Adapt Mode

2.5.5.1 When the synthesizer is in the transmit-adapt mode, the TX and ADAPT lines are driven high by the phase detector, and their respective complements, RX and $\overline{\text{ADAPT}}$, are driven low. Transmission gates U605B, U605D, and U606B are directly turned on by the ADAPT line. The synthesizer has a high natural loop frequency in this mode, allowing it to change frequencies rapidly. The adaptive filter is switched into this mode for approximately 15 milliseconds while the radio changes from the receive mode to the transmit mode. The transmitter is inhibited in this mode by the SYNTHESIZER ADAPT line.

2.5.5.2 In this mode, transmission gate U606B bypasses the greater part of the adaptive filter. A grounded capacitor, C641, is connected to the steering line. While the filter is in this mode, C641 and C654 are being charged. The charge on C654 prevents the VCO from changing frequency during the transition from the transmit-adapt mode to the transmit mode. C654 always remains connected to the steering line. The steering line passes to the VCO through the test jumper via J650-2.

2.5.6 Receive-Adapt Mode

2.5.6.1 When the synthesizer is in the receive-adapt mode, the RX and ADAPT lines are driven high by the phase detector, and their respective complements, TX and $\overline{\text{ADAPT}}$, are driven low. Transmission gates U605B, U605D, and U606B are directly turned on by the ADAPT line. The synthesizer has a high natural loop frequency in this mode, allowing it to change injection frequencies rapidly. The adaptive filter switches into this mode for approximately three milliseconds while the radio changes from the transmit mode to the receive mode or from one receive frequency to another (as when changing the operating channel).

2.5.6.2 In this mode, the greater part of the adaptive filter is shorted by transmission gate U606B, and the steering line is connected to C641. When the filter is in the receive-adapt mode, C641 and C654 are being charged. The accumulated charge on C654 prevents the VCO from changing frequencies during the transition from the receive-adapt mode to the receive mode. C654 always remains connected to the steering line. The steering line passes to the VCO through the test jumper and J650-2.

2.5.6.3 When the frequency is changed (or if, for any reason, the loop falls out of lock), the phase detector makes the adaptive filter switch to the ADAPT mode. Consequently, the $\overline{\text{ADAPT}}$ line switches to a low state, which turns on the LED indicating out-of-lock. Therefore, in normal operation of the frequency synthesizer, the out-of-lock LED flashes briefly whenever the frequency is being changed. During *Channel Scan* operation, the radio can be changing frequencies continuously and fast, making the out-of-lock LED glow dimly. A brightly lighted LED points to the presence of an out-of-lock fault in the frequency synthesizer, making this LED useful for troubleshooting.

2.5.6.4 Various radio functions are deactivated each time the frequency synthesizer goes into the ADAPT mode. First the high ADAPT output disables the radio audio stages via the squelch circuits on the common circuits board. In addition, the transmitter and IDC circuits are disabled via the personality board. This fail-safe feature prevents transmitter key-up (if a loss-of-lock malfunction occurs), thus preventing the generation and transmission of uncontrolled RF signals.

2.5.7 Super Filter

2.5.7.1 Because the VCO requires a very pure dc supply voltage, an ultra-low-pass filter (U600) supplies the VCO with a very-low-noise +8.6 V output voltage. The filter removes any ripple or noise present on the +9.6 V supply line, thus preventing unwanted modulation of the VCO. It also lowers the voltage from +9.6 to +8.6 V.

2.5.7.2 The super filter consists of a low-pass filter, an error amplifier, and an external series-pass transistor (Q603). The +9.6 V supply is connected to U600-1 as well as to the emitter of Q603. Internally, the input from U600-1 passes through a low-pass filter to the non-inverting input of the error amplifier. C603, connected to U600-2, forms part of the low-pass filter. The output line (also connected to the collector of Q601) is fed back to the inverting input of the error amplifier through U600-4. The error amplifier output, connected to the base of Q603 via U600-3, controls the conduction of the transistor. These connections enable the super filter to compare the output line voltage with the filtered input line voltage and to increase or decrease the conduction of Q603 to remove any ripple or noise from the VCO supply line. The VCO supply is further filtered by C604, which is connected to ground. This filtered supply is then forwarded to the VCO via P650-1 and P650-3. It is also applied to synthesizer switching hybrids HY604-4 and HY605-4.

2.5.8 Divider Buffer

A feedback signal from the VCO is routed back into the PLL (to J600 on the RF board) through a coaxial cable from the TX mixer compartment of the internal casting to the divider buffer hybrid (HY600-4). Here the VCO signal is attenuated to a level acceptable to the programable divider. Signal is then routed out of HY600-8 through a coaxial cable to the divider's prescaler input (U602-25).

2.6 VOLTAGE-CONTROLLED OSCILLATOR (VCO)

2.6.1 General

Voltage from the phase detector controls the output of the HLB4086A VCO. Its pin switch circuitry allows it to generate frequencies from 105.4 to 143.1 MHz, which covers the receive first injection as well as a frequency modulated transmit injection. The oscillator, buffer, pin switch, and associated circuitry are constructed on an 0.1-inch alumina substrate in the internal casting.

2.6.2 Oscillator Circuit

2.6.2.1 The VCO is a Colpitts oscillator that uses a low-noise JFET (Q1401) as the amplifying element. Pin diode switching circuitry gives the VCO a relatively large tuning bandwidth by adding additional lengths of transmission line to the tank's main transmission line resonator. The amount of transmission line added depends on four pin states, which are dictated by the switching hybrids (HY604 and HY605).

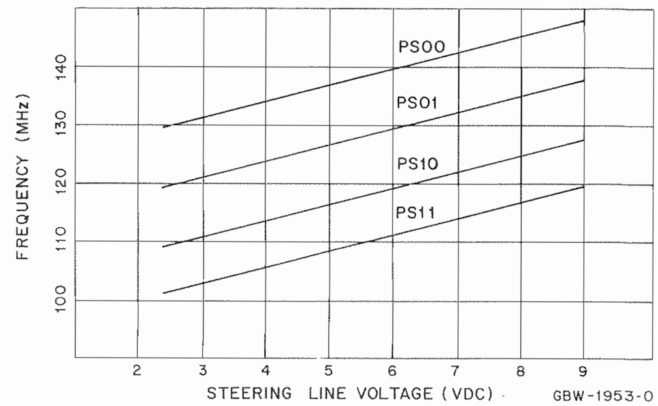


Figure 1. VCO Response to Steering Line Voltage

2.6.2.2 With PS1 (J650-5) and PS2 (J650-6) both high, only the main resonator is present in the oscillator tank. In this mode, the oscillator's output frequency ranges from 105.4 to 113.8 MHz over a steering line range from three to eight volts. With PS1 high and PS2 low, pin diode CR1415 is turned on, adding the pinshift 2 transmission line in parallel with a portion of the main resonator. In this mode, the oscillator can be tuned from 113.8 to 122.8 MHz over the range of steering line voltages. With PS1 low and PS2 high, CR143 is turned on, adding the pinshift 1 T-line in parallel with a portion of the main resonator. In this mode, the oscillator tunes from 122.8 to 132.6 MHz. In the fourth state, both PS1 and PS2 are low. In this state, all PIN diodes are on, so the pinshift 1 T-line is added in as well as a portion of the pinshift 2 T-line. In this mode, the VCO tunes from 132.6 to 143.2 MHz. If actually given an independent steering line supply, the VCO would tune over a wider frequency range, but PROM programing dictates that steering line voltages stay between three and eight volts.

2.6.3 VCO Buffer

The VCO buffer uses a saturated NPN transistor (Q1402) to maintain a constant level of VCO output power across the frequency range. The output of the buffer amplifier goes through a low-pass filter to attenuate higher-order harmonics before going out of the VCO compartrment of the internal casting to the TX mixer compartment through a short coaxial cable.

2.6.4 Steering Line Circuit

2.6.4.1 The steering line, in conjunction with the pinshift lines, determines the operating frequency of the VCO. The steering line is driven by the phase detector (U603) and is coupled to the VCO via the adaptive filter. The phase detector supplies a dc output voltage to maintain the VCO output at the desired frequency. When the frequency is changed, the phase detector dc output voltage shifts to change the oscillator frequency and then maintain this new frequency. Figure 1 shows the transmit and receive oscillator frequencies as functions of the steering line dc voltage.

2.6.4.2 The steering line is coupled from the RF board via J650-2 and the VCO interconnect plate. The plate contains the RF filters that shield the VCO. The steering line dc voltage level determines the capacitance of diodes CR1401 through CR1410. An increase in the steering line voltage causes the capacitance of these diodes to decrease and the corresponding oscillator frequency to increase. On the other hand, a decrease in the steering line voltage causes an increase in the capacitance of the diodes and a reduction in the oscillator frequency.

2.6.5 Modulation Line

During transmit, the transmit audio signals modulate the VCO directly, using varactor diode CR1411. The transmit audio signal is coupled, via Pin 4 of the VCO interconnect plate, to CR1411, which modulates the oscillator frequency.

2.7 TRANSMIT AUDIO CIRCUITS

Note

While reading the following, refer to the IDC portion of the Common Circuits Board Schematic attached to the Common Circuits Board section of this manual.

2.7.1 The transmit audio circuits consist of four stages that condition the microphone audio signal for direct frequency modulation of the transmit injection signal. The greater part of the audio path is controlled by the IDC ENABLE signal that is coupled to the IDC (instantaneous deviation control) circuitry via J401-6. This signal controls transmission gate U501A, which enables the transmit audio circuits only when the radio is in the transmit mode. (Transmit +9.5 V is applied to the IDC ENABLE line.)

2.7.2 The MIC HI signal is coupled into pre-emphasis amplifier U502D via J401-5. This amplifier has a frequency response that enhances the audio frequencies toward the high end of the transmit audio frequency range (approximately 300–3000 Hz). The amplifier output (at U502-12) is coupled to U501-1. When PTT is activated, the transmission gate control line (at U501-13) switches to a high level and the signal passes through the gate to limiter/amplifier U502A.

2.7.3 The limiter/amplifier clips the audio signals at seven volts peak-to-peak, thus preventing excessive audio modulation of the transmitted signal. (With lower audio input levels, this amplifier acts as a linear gain stage.) The limited transmit audio signal is coupled from U502-3 to splatter filter stage U502C.

2.7.4 The splatter filter is a 3-kHz low-pass filter that removes higher-order harmonics from the audio signal. With unity gain, this filter attenuates high-frequency harmonics on the clipped audio signal from the limiter stage. The splatter filter output passes from U502-10 to combiner U502B, the gain of which is set by the deviation adjust potentiometer (R517).

2.7.5 External modulation, such as PL or DPL, passes through gates U501B and U501C. These gates are connected in series with the external modulation inputs, and can therefore disable these modulation inputs to circuits that may require such a function. Normally, these enable lines are pulled high by the HY501 resistors. The output of each gate passes to U502B via the resistors that form part of HY502.

2.7.6 The output of combiner U502B is routed to the phase modulator (HY601) via P401-17, and also to the compensation adjust potentiometer (R516). The wiper arm of the compensation adjust potentiometer is routed to the VCO via P401-14. PL and DPL signals at HY601 phase-modulate the reference input to the phase detector, thus preventing the phase detector output from defeating the direct low-frequency modulation of the VCO generated by the PL/DPL signal. (The phase modulator and phase detector form part of the synthesizer schematic.) The compensation adjustment potentiometer, R516, is adjusted at the factory and should be readjusted only if the common circuits board, phase modulator, or VCO is changed. R516 can be readjusted by the procedure presented in the Radio Alignment and Adjustments part of the Maintenance and Troubleshooting Section of this manual.

2.7.7 VCO modulation inhibit switch Q502 is allowed to conduct while the radio is in the receive mode, effectively shorting the VCO modulation signal line to ground. This prevents any noise induced on the line in receive mode from affecting the receive injection frequency. During initial turn-on, C600 is charged through Q602. This action allows a stable receive frequency to be attained almost immediately. Q602 is turned off by TX +9.4 V during transmit, enabling the VCO modulation signal line.

2.8 RECEIVE INJECTION DOUBLER

The receive injection doubler, HY602, supplies 9.6 VDC to the reference oscillator, U608. It also has diplexing circuitry which, along with that on the RF board, presents to the reference oscillator terminating impedances that accent its fundamental (14.4 MHz) and third harmonic (43.2 MHz) outputs. The 43.2-MHz signal from the reference oscillator goes back to the receive injection doubler at HY602-2, where a two-pole monolithic crystal filter (Y1300) filters it to reduce adjacent channel noise levels and 14.4-MHz harmonics. Class C NPN transistor Q1300 now doubles and amplifies the signal, and a three-pole tunable bandpass filter reduces the level of any remaining and undesired harmonics. This filter is factory tuned and does not require readjustment. The 86.4-MHz signal now goes to pin-switch circuitry via C1318. In the receive mode, 9.4 V is present at HY602-19, forward biasing CR1300. This opens up an RF signal path to the receiver's second mixer via C1319, HY602-21, and a short coaxial cable. In the transmit mode, 9.4 V is present at HY602-26, forward biasing CR1301. Resistive padding is present in this path to get the proper drive level to the transmit injection doubler, HY603. Transmit 86.4-MHz output is routed from HY602-24 through JU604 to HY603-3.

2.9 TRANSMIT INJECTION DOUBLER

The transmit injection doubler, HY603, works like the receive doubler, but it runs entirely off of keyed 9.4 V and therefore only operates in the transmit mode. It takes the 86.4-MHz signal from the receive doubler and doubles and amplifies it in Class C NPN transistor Q1351. A two-pole filter now reduces uwanted harmonic levels and passes only 172.8 MHz. The resulting signal now goes through a saturated amplifier, Q1352, to hold a constant power output level. Additional filtering at the output and on the RF board reduces the levels of undesired signals. You can measure power conveniently at J703, where it should measure 21.5 ± 1 dBm.

2.10 TRANSMIT MIXER AND RECEIVE BUFFER

The transmit mixer and the receiver's first injectoin buffer amplifier are in the internal casting adjacent to the VCO compartment. Signal from the VCO goes to the transmit mixer compartment via a short coaxial cable. Here part of the signal is tapped off to become synthesizer feedback, going via a coaxial cable to the RF board (P600). The rest of the signal goes through a lowpass filter to reduce the levels of VCO harmonics.

The transmit mode forward-biases CR1451, opening an RF path to diode quad CR1452 via a resistive pad and transformer T1450. Transmit mixer injection to CR1425 is done by the transmit injection doubler, HY703, through a coaxial cable to the RF board (P603). The resulting frequency spectrum is coupled out through transformer T1451 to the transmitter buffer board through a coaxial cable (P1501). Among the various signals that can be seen at this point is the transmitter frequency (172.8 MHz $-$ f_{VCO}).

In the receive mode, CR1451 is off and CR1450 is on, opening an RF path for the VCO signal to amplifier Q1451. This saturated amplifier sends a minimum 20-dBm injection to the receiver's first mixer via J125.

2.11 TRANSMIT BUFFER

The transmit buffer board is above the audio transformer on the personality board. The transmit mixer output is injected at J1501 and filtered by a seven-pole lowpass filter to reduce the levels of 12.8 MHz, VCO signal, and other mixing products present at the TX mixer output. The transmit frequency then goes through a two-stage amplifier consisting of Q1501 and Q1502 to become a minimum +17-dBm output to the radio's PA. The signal goes to the PA compartment via a short coaxial cable (P801).

3. Synthesizer Troubleshooting Procedure

3.1 GENERAL

3.1.1 The troubleshooting chart at the end of this section gives a comprehensive procedure for troubleshooting the frequency synthesizer.

3.1.2 Major problems that may occur in the frequency synthesizer are:

- Synthesizer does not lock.
- Synthesizer locks on wrong frequency.
- Excessive reference frequency feeds through (spurs).
- Frequency lock is noisy.
- Switching reponse is slow.

3.1.3 Table 2 summarizes these problems and their possible causes. Other tables show pin connections and voltages for the phase detector, divider, and super filter.

3.1.4 The frequency synthesizer troubleshooting chart mentions an open-loop test and the checking of the divider programing. The following paragraphs describe these procedures without using a flowchart.

3.2 OPEN-LOOP TEST

3.2.1 Introduction

3.2.1.1 This test requires a variable power supply, a frequency counter, a dual-trace oscilloscope, a dc voltmeter, and an RF voltmeter. The Maintenance and Troubleshooting Section of this manual recommends specific models of some of these.

Table 2. Problems in Synthesizer and Their Possible Causes

Problems	Possible Source of Trouble
Synthesizer does not lock.	(See synthesizer troubleshooting chart.)
Synthesizer locks on wrong frequency.	reference oscillator (U608) frequency off (should be 14.4 MHz ±72 Hz)
	erroneous divider programing from microcomputer (possible defective memory module, or code plug, or microcomputer)
	defective divider U602
Excessive reference frequency feeds through (spurs).	defective hold capacitor C632 (open or leaky)
	defective ramp capacitor C630
	defective phase detector U603
	adaptive filter in ADAPTIVE mode or shorted input to output; guard band shorted to VCO steering line or other adaptive filter mode
Frequency lock is noisy.	marginal input level to loop divider (U602-25) or reference divider (U602-2)
	loose connection, cold solder joint, or faulty component
	noisy Q600
	defective phase detector U603
	defective divider U602 (jittery)
	noisy 5 V or 9.6 V supplies
	defective adaptive filter (open capacitors)
Switching response is slow.	improper synchronization from microcomputer (Check divider programing.)
	malfunctioning adaptive filter (Check U604, U605, and U606.)
	phase detector U603 gain too low (overdamped response) or too high (underdamped response) (Check R625, R626, RT600, C630, and Q600.)
	leaky adaptive filter capacitors or transmission gates (U605, U606, and C641)
	leaky VCO varactor diodes

3.2.1.2 The open-loop test consists of four procedures:

- VCO frequency test
- loop and reference waveforms check
- phase detector check
- adaptive filter check

3.2.2 VCO Frequency Test

(1) Remove jumper JU600 to open the STEERING LINE loop. Connect a one-kilohm resistor to the plus terminal of a 0–10 V adjustable power supply and connect the free end of the resistor to the VCO side from which JU600 was removed (the side not connected to C637). Connect the negative terminal to B–. This power supply serves as a steering line in this test.

(2) Connect a frequency counter to the VCO feedback from the internal casting (P600). Check the pinshift lines to determine the expected VCO operating range. Verify that the lines are either high (≥9 V) or low (≤0.5 V). Slowly vary the steering line voltage from 3 V to 8 V. Verify that the VCO covers its intended frequency range (see 2.6.2.2 and Figure 1). Also check the power level and verify that it is greater than −2 dBm. Check for proper operation in all pin states. If the pinshift lines are all right and the output level to the divider port is adequate but the VCO cannot be tuned over the desired frequency range with the steering line voltage, then the VCO is faulty and should be replaced.

3.2.3 Loop and Reference Waveforms Check

(1) Connect one channel of a dual-trace oscilloscope to U602-5 (REF OUT) and the other to U602-9 (LOOP OUT). Adjust the oscilloscope so that it triggers on the REFERENCE waveform. The oscilloscope trace should be in the chopped mode.

(2) Observe the LOOP waveform and verify that it is moving smoothly across the screen without any jitter when the steering line is varied from 1.0 V to 9.6 V.

(3) Observe the REFERENCE signal and verify that its period is correct, that it has no jitter, and that one steering line voltage from 2.5 to 9.0 V yields exactly this period on the loop divider output. (The period depends on the customer's programing requirements. In most cases, it is 160 microseconds for a 5-kHz reference.)

(4) If the conditions specified in Steps 2 and 3 are met, then check the divider buffer (HY600), the divider (U602), the reference oscillator (U608), and the divider programing.

3.2.4 Phase Detector Check

Check the phase detector (U603) by adjusting the steering line voltage for a loop period slightly longer than the reference period and then for a slightly shorter period. With a longer loop period, the phase detector output (U603-15) should switch to a high state (greater than 9 V); with a shorter loop period, the phase detector output should switch to a low state (1.2 V). If this does not happen, then check the phase detector and associated circuitry.

3.2.5 Adaptive Filter Check

Check the adaptive filter for short or open circuits by removing jumper JU600 and then checking for a high voltage on the adaptive filter side when the phase detector output is high. The absence of a high voltage is an indication of a faulty condition.

3.2.6 VCO Steering Line Leakage

Note

Be sure to use a shielded cable with the voltmeter when making these measurements.

Check the VCO steering line leakage by removing jumper JU600 and connecting a one-megohm resistor to the VCO side. Connect the free end of the resistor to an adjustable power supply set to 9.5 V. Use a high-impedance voltmeter (impedance greater than 10 megohms) to verify that the voltage drop across the resistor is less than 18 mV. A higher voltage drop (greater than 18 mV) is an indication of either a leaky VCO interconnection plate or defective VCO steering line varacors (CR1400–1410). To determine which is defective, remove the VCO from the RF internal casting and perform the test again. If the voltage drop is greater than two millivolts, replace the interconnection plate.

3.3 DIVIDER PROGRAMING TEST

The synthesizer troubleshooting chart refers to the divider programing test. For this test, use a dual-trace oscilloscope and a test memory module (Motorola Part No. HLN1127A). The Maintenance and Troubleshooting Section of this manual recommends specific models. Table 4 gives the pin numbers and functions of the divider (U602). The timing diagram on the synthesizer troubleshooting chart shows the waveforms generated under Mode 4 of the test memory module.

(1) Connect Channel 1 of a dual-trace oscilloscope to the STROBE line (U602-27) of the divider. Trigger the oscilloscope on the rising edge of the strobe signal.

(2) Connect Channel 2 of the oscilloscope to the A0 line (U602-23) of the divider.

(3) Compare the waveforms on the oscilloscope with those in the timing diagram, and verify that the relationship between the STROBE and A0 signals is the same.

(4) Connect Channel 2 of the oscilloscope to the A1 line (U602-24) and compare the pattern on the oscilloscope with the one in the timing diagram.

(5) Repeat the procedure for A2 (U602-26), D0 (U602-11), D1 (U602-12), D2 (U602-13), and D3 (U602-14).

Note

To check the programing in another way, use a single-trace oscilloscope with an external trigger input. Connect the external trigger to the strobe line and display the strobe signal on the oscilloscope to verify proper triggering. (See the timing diagram on the troubleshooting chart.) Each of the address and data lines can then be checked as in Steps 1 through 5, above.

3.4 INJECTION STRING TESTS

Problems likely to occur becuse of improper injection string operation are:

- Failure of synthesizer to lock
- Low or no transmitter power output
- Poor receiver sensitivity

The best way to find injection string problems is to operate the radio in the transmit mode and working back from the transmit buffer toward the reference oscillator. See also the synthesizer troubleshooting chart at the end of this section, which gives a comprehensive procedure for troubleshooting the injection string.

Table 3. Phase Detector (U603) Pin Connections and Voltages

Pin No.	Function	To/From	Nominal Voltage
1	high current ground	—	0 V dc
2	REFERENCE IN	from HY601-8	0 V to 4.3 V square wave (200 µs period for 5 kHz reference frequency)
3	LOW BANDWIDTH	from U602-17	0 V dc receive; 5 V dc transmit
4	SYNTHESIZER SYNC	to microcomputer	60 µs positive pulse 0–5 V at loop pulse rate; equal to Pin 2 if Pin 11 is low
5	FREQUENCY CHANGE	from U602-18	0.5 V, 11.1 µs when frequency changes
6	TX	to adaptive filter	0 V dc receive, 9.6 V dc transmit
7	$\overline{\text{ADAPT}}$	to adaptive filter	9.6 to 0.6 V single pulse, 3.0 ms (RX) dekey; 15 ms (TX) key
8	no connection	—	—
9	no connection	—	—
10	ADAPT	to adaptive filter	0–9.0 V single pulse, 3.0 ms (RX) dekey; 15 ms (TX) key
11	no connection	—	—
12	RX	to adaptive filter	9.6 V dc receive, 0 V dc transmit
13	HOLD 2	C632	1.4 to 8 V dc (use high-input-impedance voltmeter)
14	Guard Band	—	—
15	PHASE DET OUTPUT	to adaptive filter	1.2 to 9.5 V dc (depending on loop output frequency)
16	low current ground	—	0 V dc
17	EXT PNP BASE	to PNP Q604 base	8.9 V dc
18	VCC	from regulator	9.6 V dc
19	RAMP BASE	to PNP Q603 base (ramp generator)	9.1 V dc
20	FILTERED 9.1 V	to R624, R625, RT600, C629	9.1 V dc
21	RAMP RES	to R626, PNP Q603 emitter	8.0 to 8.7 V dc rectangular wave @ reference rate
22	SAMPLE TIMING CAP	to C631	0 to 2 V sawtooth wave at loop pulse rate
23	LOOP IN PULSE	from U602-9 via C628	1.4 V pulse riding on 1.6 V dc (200 µs, typical period)
24	RAMP CAP	from C630 and ramp PNP Q603 collector	flat-top ramp waveform at reference rate, top voltage 1.4 to 7 V (depending on loop output frequency)

Table 4. Divider (U602) Pin Connections and Voltages

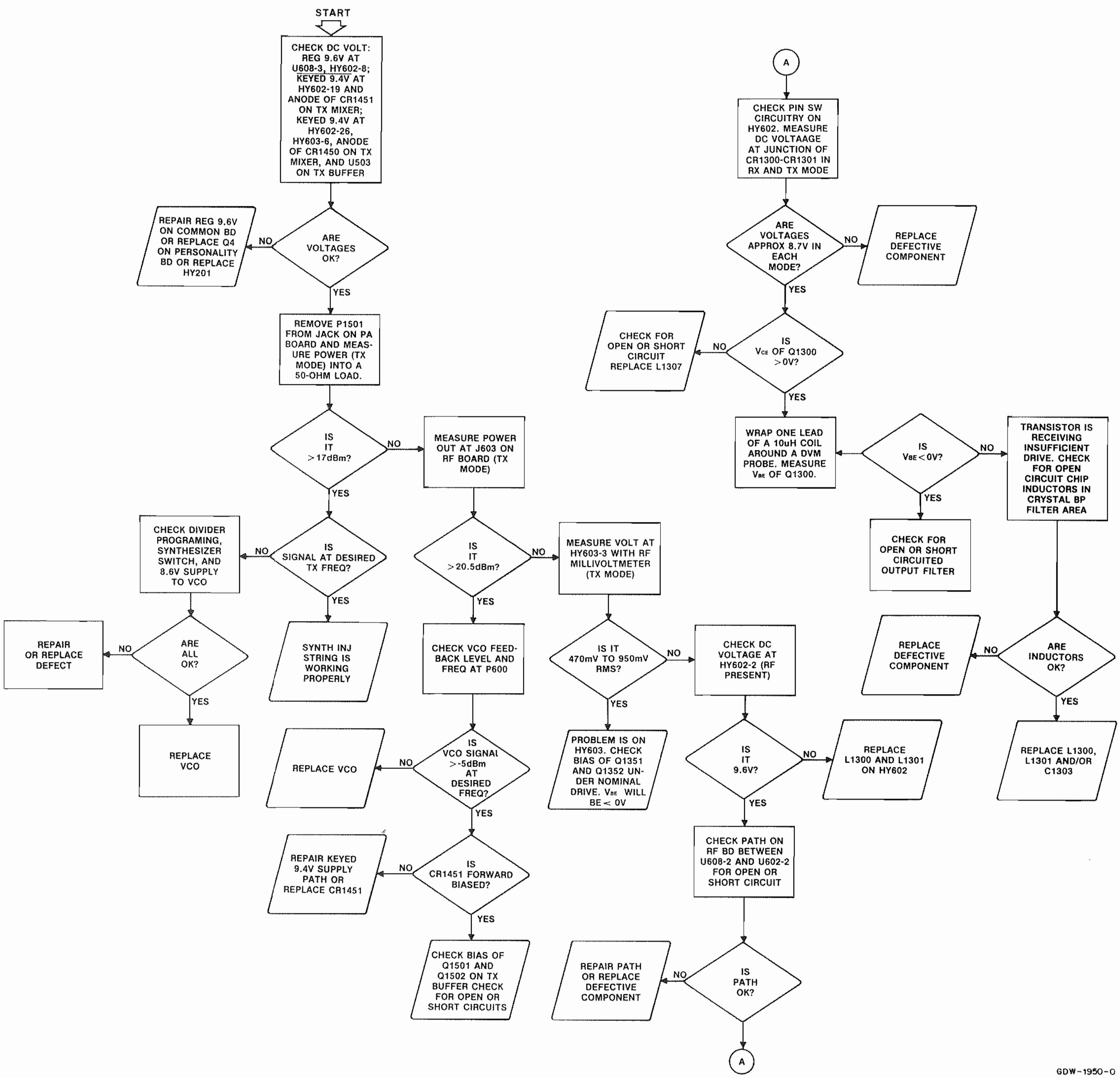
Pin No.	Function	To/From	Nominal Voltages
1*	GND	—	0 V dc
2	REF IN	from U608 (reference oscillator)	1.5 V dc +0.6 V pp ac (14.4 MHz)
3	3.6 MHz OUT	NC	—
4	GND	—	0 V dc
5*	REFERENCE OUT	to HY601 (phase modulator)	0 to 4.3 V square wave (5.0 or 6.25 kHz)
6	NC	—	—
7	NC	—	—
8	NC	—	—
9*	LOOP OUT	to phase detector	2.9 V to 4.3 V narrow pulse (1.4 V pp) (200 μs nominal period)
10*	VCC	from regulator	5 V dc
11	D0	from microcomputer	0 to 5 V pulse train
12	D1	from microcomputer	0 to 5 V pulse train
13	D2	from microcomputer	0 to 5 V pulse train
14	D3	from microcomputer	0 to 5 V pulse train
15	C0	to Q241 (extender)	0 to 5 V dc
16	NC	—	—
17	LOW BANDWIDTH	to phase detector	0 to 5 V dc
18	FREQ CHANGE	to phase detector	0 to 5 V dc
19	VC01	to HY604-5	0 to 0.7 V dc
20	VC02	to HY605-5	0 to 0.7 V dc
21	NC	—	—
22	VBB	to divider	1.5 V dc
23	A0	from microcomputer	0 to 5 V pulse train
24	A1	from microcomputer	0 to 5 V pulse train
25	PRESCALE IN	from HY601-8 via coaxial cable	1.5 V dc +0.7 V pp ac (approx. 50–80 MHz)
26	A2	from microcomputer	0 to 5 V pulse train
27*	STROBE	from microcomputer	0 to 5 V pulse train (7 pulses/train)

*SHOULD BE CHECKED FIRST

Table 5. Superfilter Pin Connections and Voltages

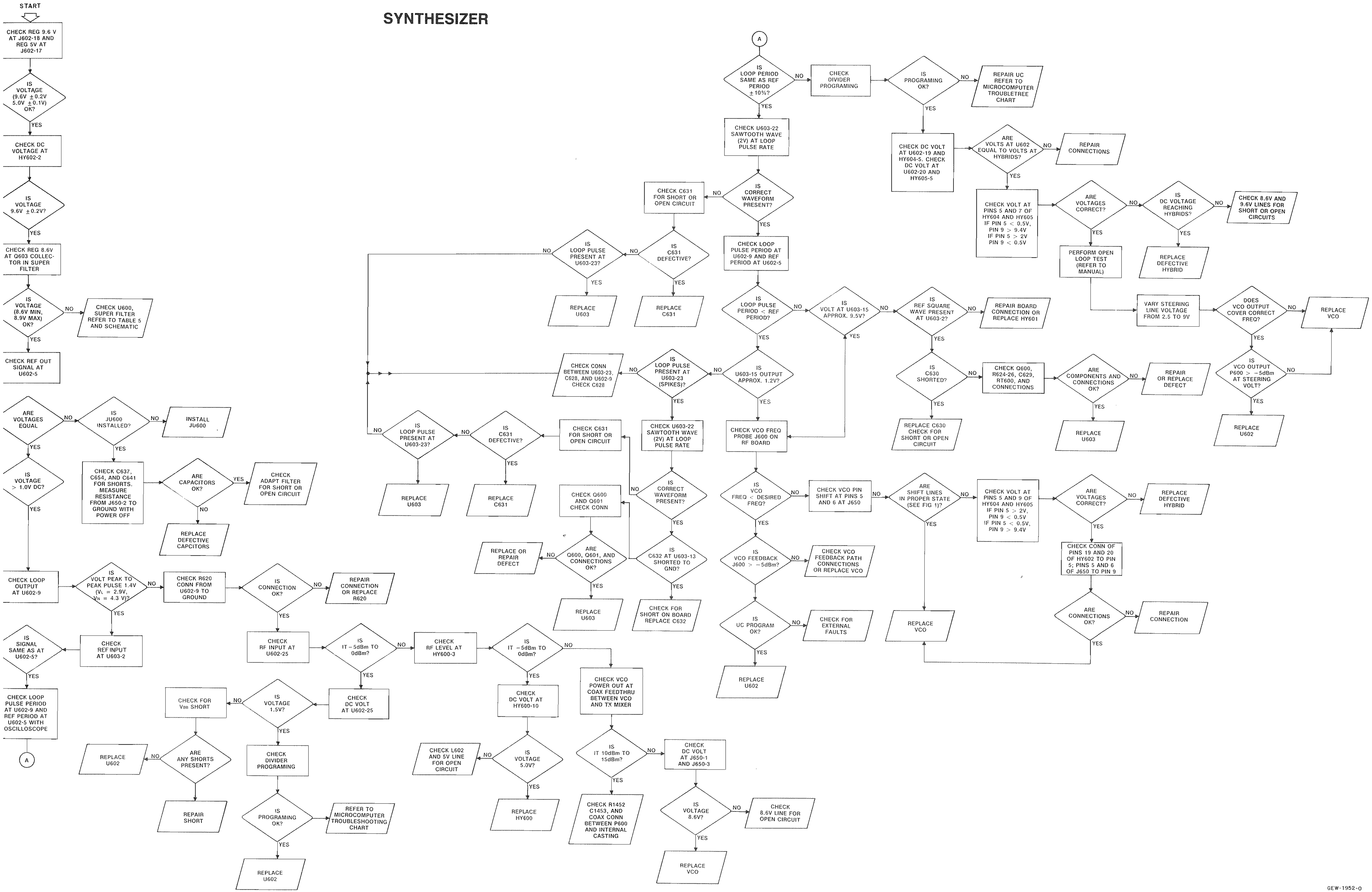
Pin No.	Function	To/From	Nominal Voltage
1	VCC	from 9.6 V regulator	9.6 V dc
2	FILTER CAP	C603	7.1 V dc
3	EXT DRIVER CONTROL	Q601 base	8.9 V dc
4	8.6 V OUT	to VCO switching	8.6 V dc
5	Ground (internal NPN emitter)	from regulator	0 V dc
6	no connection	—	—
7	no connection	—	—
8	no connection	—	—

INJECTION

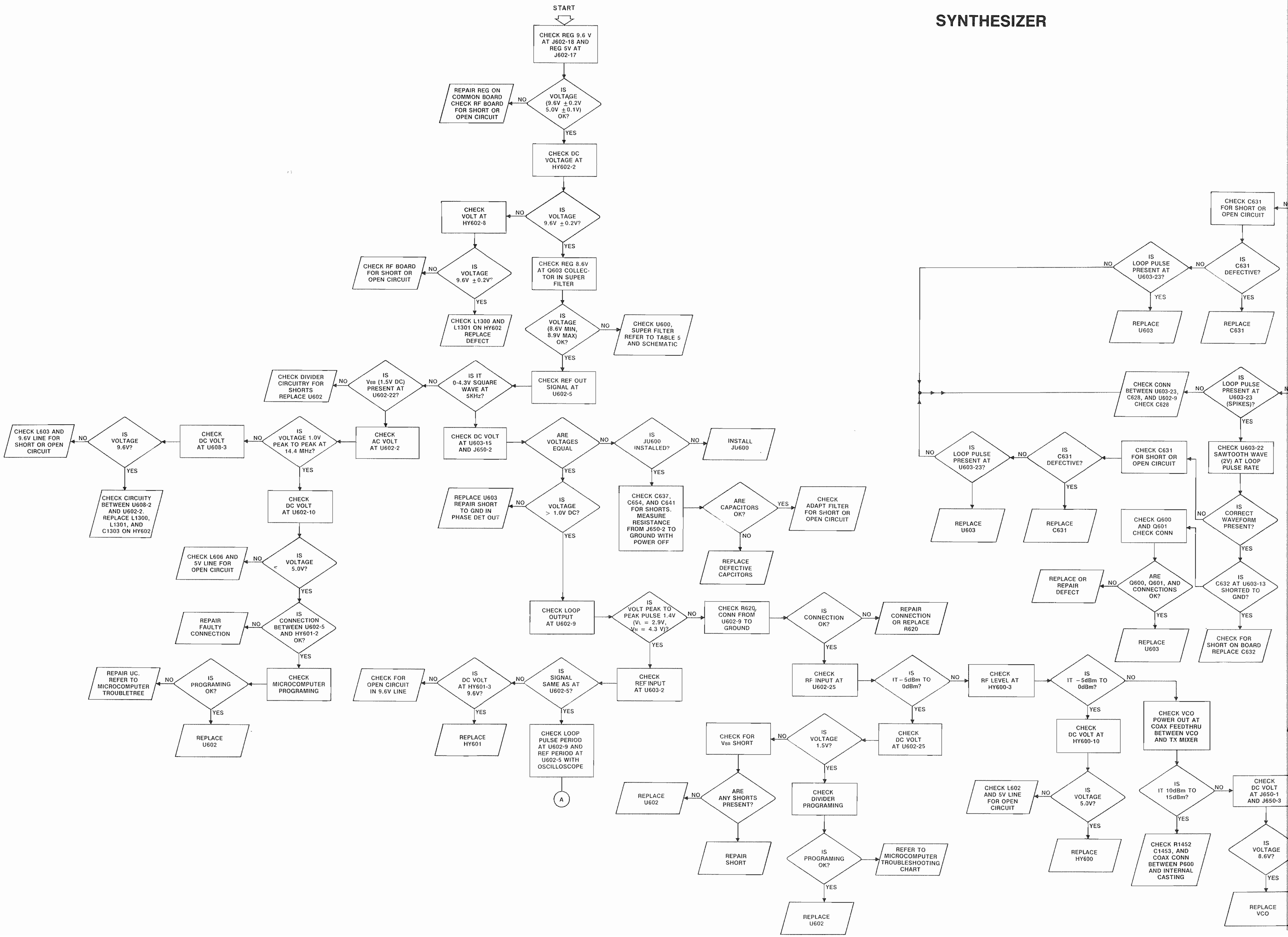


START
CHECK DC VOLT: REG 9.6V AT U608-3, HY602-8; KEYED 9.4V AT HY602-19 AND ANODE OF CR1451 ON TX MIXER; KEYED 9.4V AT HY602-26, HY603-6, ANODE OF CR1450 ON TX MIXER, AND U503 ON TX BUFFER
ARE VOLTAGES OK?
NO
REPAIR REG 9.6V ON COMMON BD OR REPLACE Q4 ON PERSONALITY BD OR REPLACE HY201
YES
REMOVE P1501 FROM JACK ON PA BOARD AND MEASURE POWER (TX MODE) INTO A 50-OHM LOAD.
IS IT >17dBm?
NO
MEASURE POWER OUT AT J603 ON RF BOARD (TX MODE)
YES
IS SIGNAL AT DESIRED TX FREQ?
NO
CHECK DIVIDER PROGRAMING, SYNTHESIZER SWITCH, AND 8.6V SUPPLY TO VCO
YES
SYNTH INJ STRING IS WORKING PROPERLY
ARE ALL OK?
NO
REPAIR OR REPLACE DEFECT
YES
REPLACE VCO
IS IT >20.5dBm?
NO
MEASURE VOLT AT HY603-3 WITH RF MILLIVOLTMETER (TX MODE)
YES
CHECK VCO FEEDBACK LEVEL AND FREQ AT P600
IS VCO SIGNAL >-5dBm AT DESIRED FREQ?
NO
REPLACE VCO
YES
IS CR1451 FORWARD BIASED?
NO
REPAIR KEYED 9.4V SUPPLY PATH OR REPLACE CR1451
YES
CHECK BIAS OF Q1501 AND Q1502 ON TX BUFFER CHECK FOR OPEN OR SHORT CIRCUITS
IS IT 470mV TO 950mV RMS?
YES
PROBLEM IS ON HY603. CHECK BIAS OF Q1351 AND Q1352 UNDER NOMINAL DRIVE. VBE WILL BE < 0V
NO
CHECK DC VOLTAGE AT HY602-2 (RF PRESENT)
IS IT 9.6V?
NO
REPLACE L1300 AND L1301 ON HY602
YES
CHECK PATH ON RF BD BETWEEN U608-2 AND U602-2 FOR OPEN OR SHORT CIRCUIT
IS PATH OK?
NO
REPAIR PATH OR REPLACE DEFECTIVE COMPONENT
A
A
CHECK PIN SW CIRCUITRY ON HY602. MEASURE DC VOLTAAGE AT JUNCTION OF CR1300-CR1301 IN RX AND TX MODE
ARE VOLTAGES APPROX 8.7V IN EACH MODE?
NO
REPLACE DEFECTIVE COMPONENT
YES
IS VCE OF Q1300 >0V?
NO
CHECK FOR OPEN OR SHORT CIRCUIT REPLACE L1307
YES
WRAP ONE LEAD OF A 10uH COIL AROUND A DVM PROBE. MEASURE VBE OF Q1300.
IS VBE < 0V?
YES
CHECK FOR OPEN OR SHORT CIRCUITED OUTPUT FILTER
NO
TRANSISTOR IS RECEIVING INSUFFICIENT DRIVE. CHECK FOR OPEN CIRCUIT CHIP INDUCTORS IN CRYSTAL BP FILTER AREA
ARE INDUCTORS OK?
NO
REPLACE DEFECTIVE COMPONENT
YES
REPLACE L1300, L1301 AND/OR C1303
GDW-1950-O

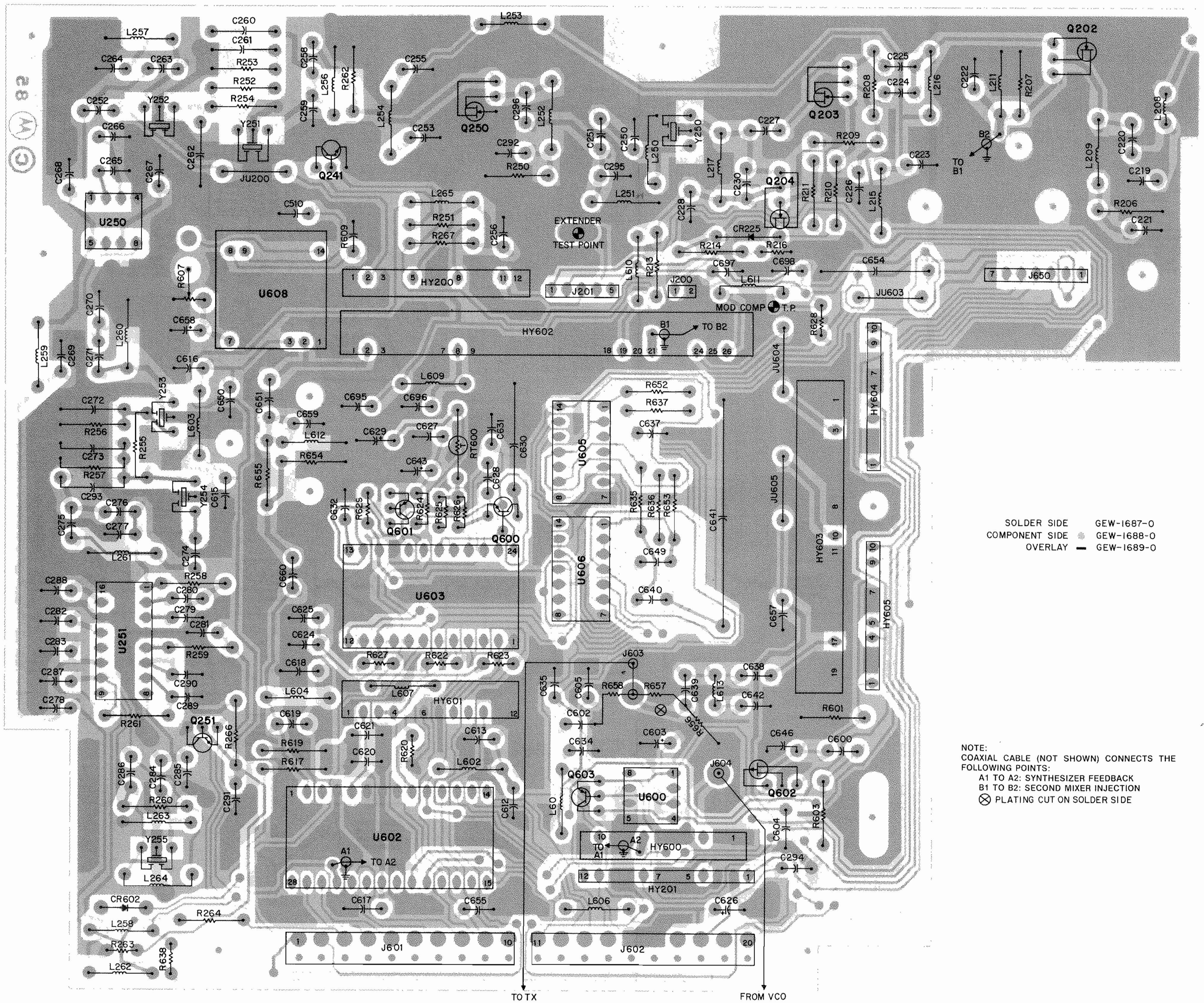
SYNTHESIZER



SYNTHESIZER



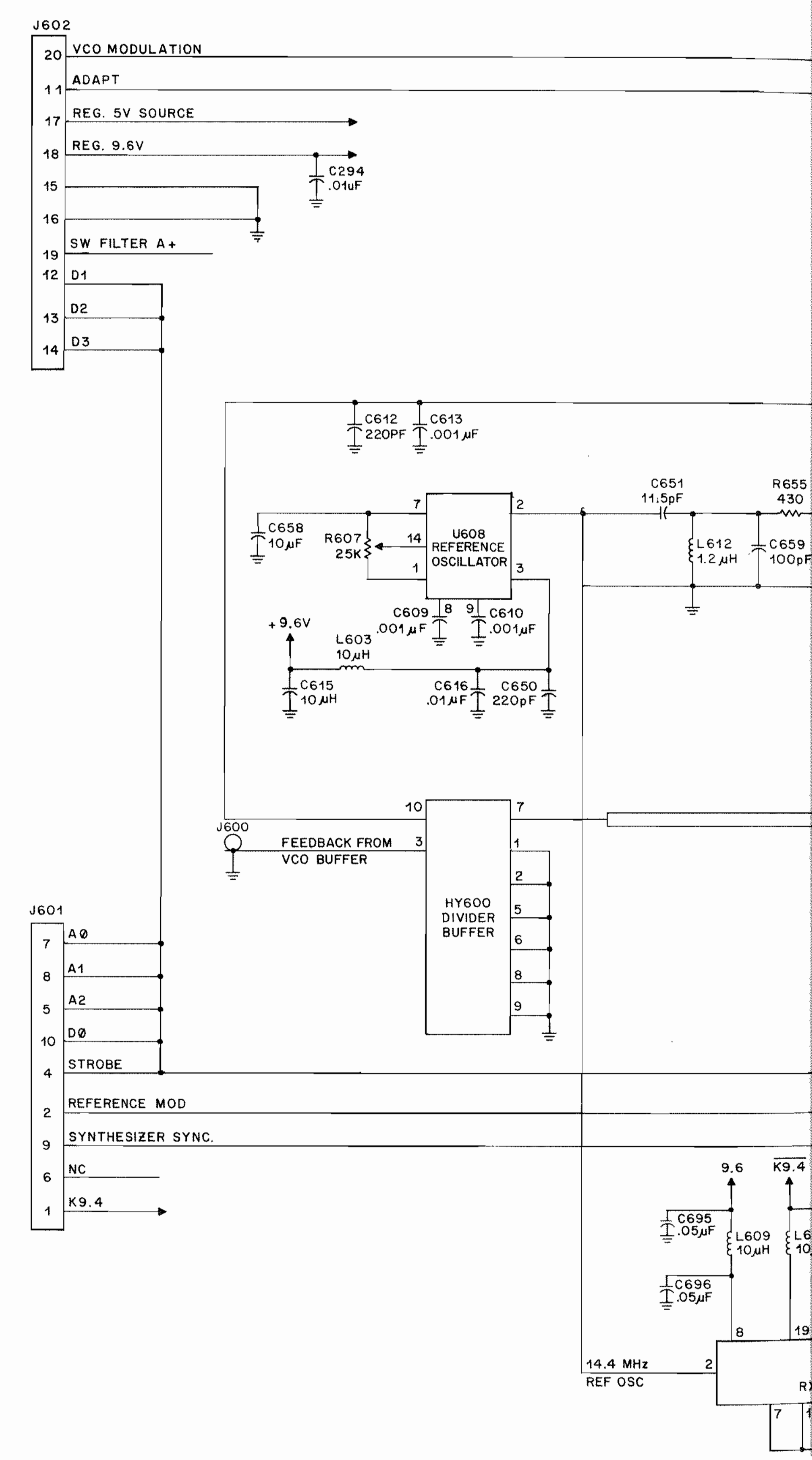
RF BOARD



SHOWN FROM COMPONENT SIDE

SOLDER SIDE — GEW-1687-O
COMPONENT SIDE — GEW-1688-O
OVERLAY — GEW-1689-O

NOTE:
COAXIAL CABLE (NOT SHOWN) CONNECTS THE FOLLOWING POINTS:
A1 TO A2: SYNTHESIZER FEEDBACK
B1 TO B2: SECOND MIXER INJECTION
⊗ PLATING CUT ON SOLDER SIDE



Schematics, Circuit Board Diagrams, and Parts Lists for Frequency Synthesizer
PDW-1684-O
(Sheet 1 of 5)
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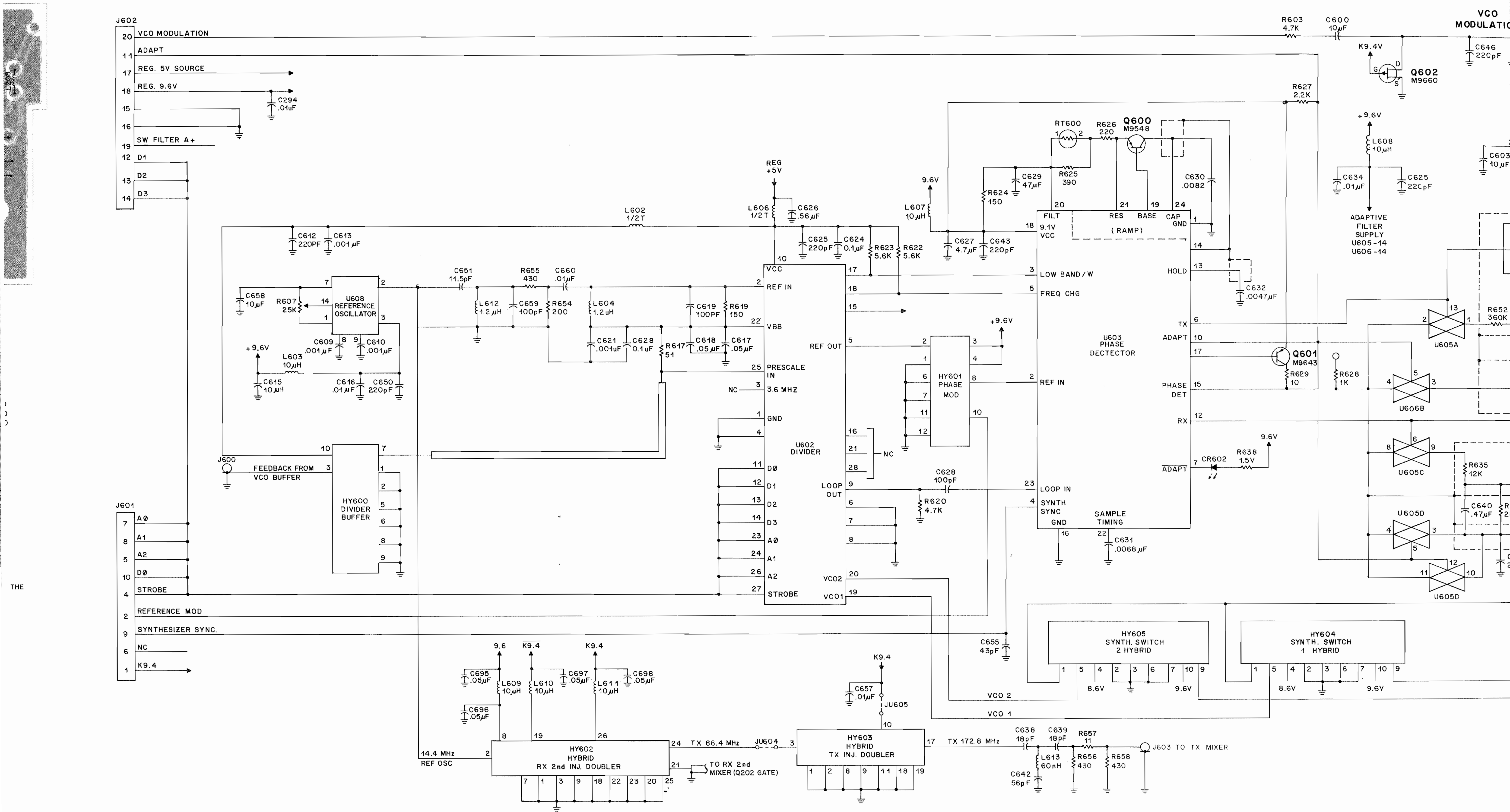
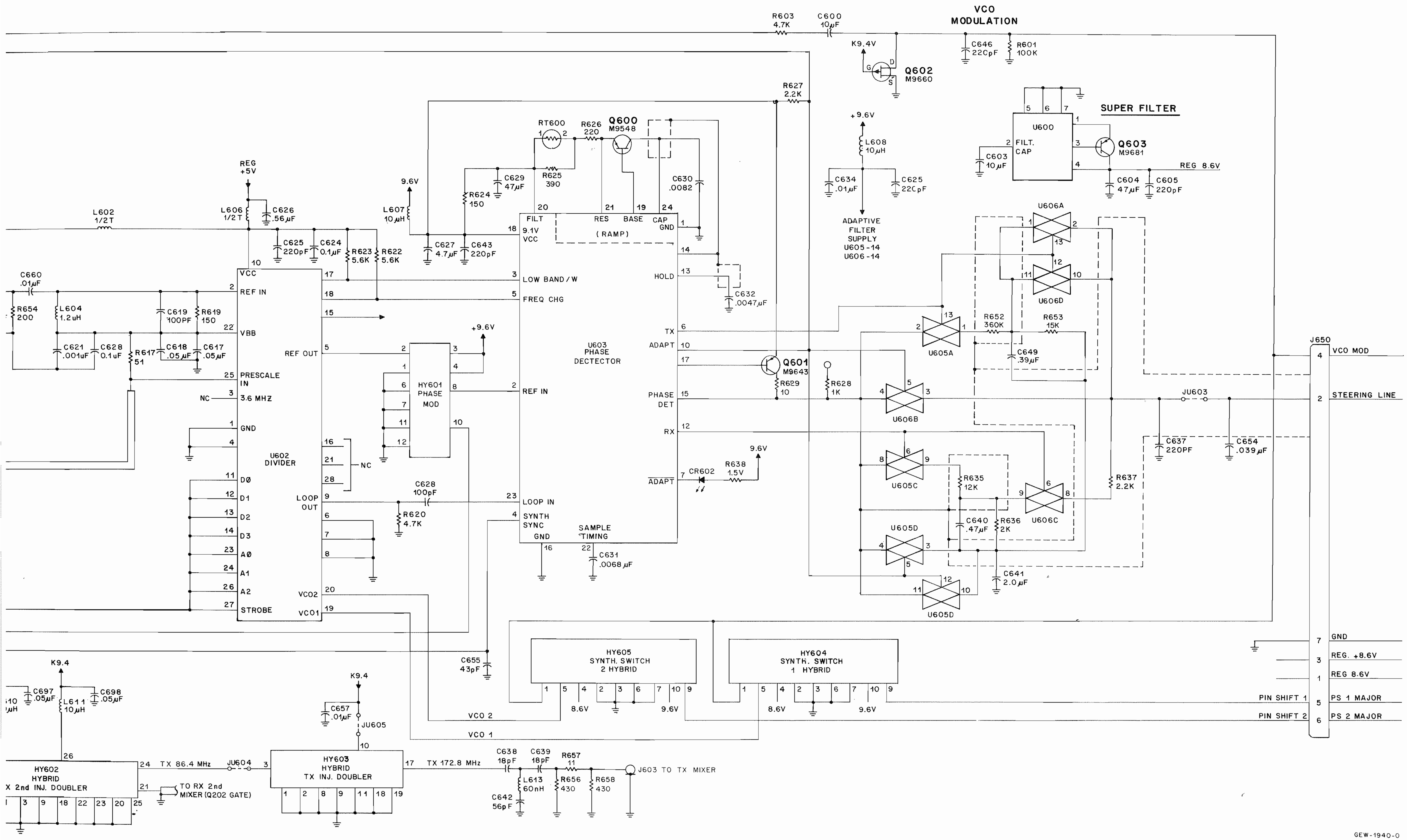
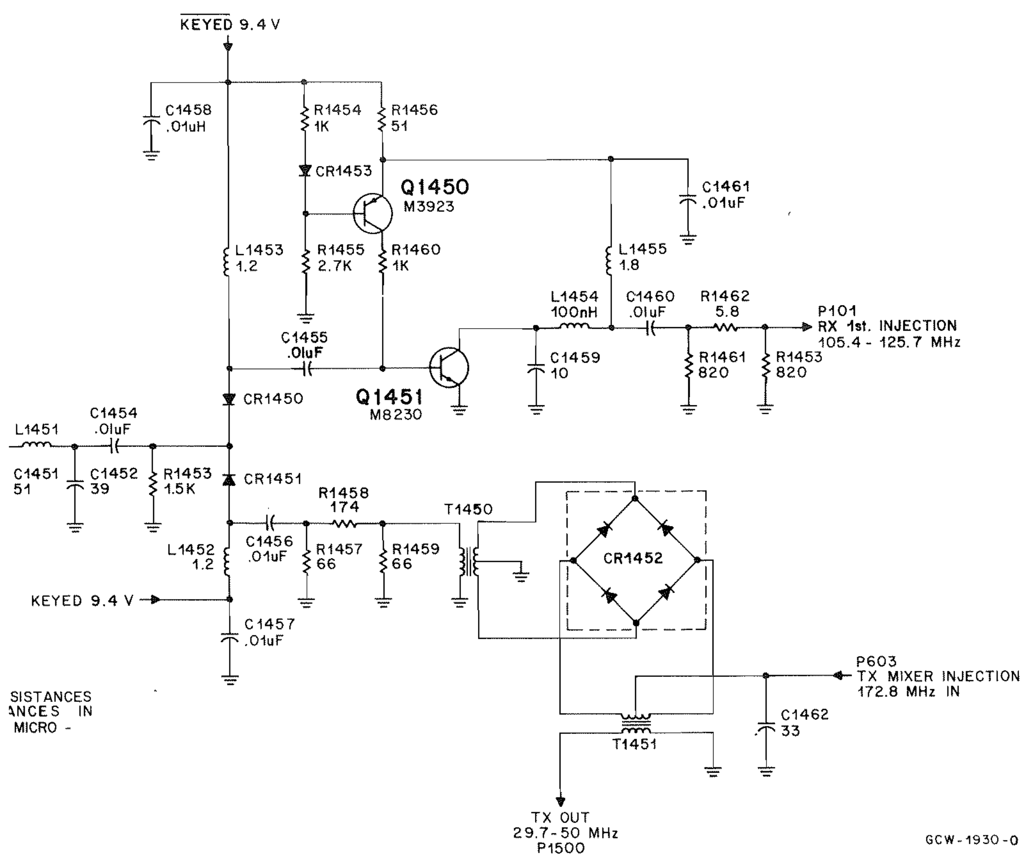
RF BOARD



J602
VCO MODULATION
ADAPT
REG. 5V SOURCE
REG. 9.6V
C294 .01uF
SW FILTER A+
D1
D2
D3
R603 4.7K
C600 10µF
VCO MODULATION
K9.4V
C646 22CpF
Q602 M9660
R627 2.2K
+9.6V
L608 10µH
C634 .01µF
C625 22CpF
ADAPTIVE FILTER SUPPLY U605-14 U606-14
C603 10µF
RT600
R626 220
Q600 M9548
C629 47µF
R625 390
R624 150
C630 .0082
9.6V
L607 10µH
C627 4.7µF
C643 220pF
REG +5V
L606 1/2T
C626 .56µF
L602 1/2T
C612 220PF
C613 .001µF
C625 220pF
C624 0.1µF
R623 5.6K
R622 5.6K
FILT
RES
BASE
CAP
GND
(RAMP)
9.1V VCC
LOW BAND/W
FREQ CHG
HOLD
C632 .0047µF
TX
ADAPT
U603 PHASE DECTECTOR
Q601 M9643
R629 10
R628 1K
REF IN
PHASE DET
RX
ADAPT
CR602
R638 1.5V
LOOP IN
SYNC SYNC
SAMPLE TIMING
GND
C631 .0068µF
R652 360K
U605A
U606B
U605C
R635 12K
C640 .47µF
U605D
C658 10µF
R607 25K
U608 REFERENCE OSCILLATOR
C651 11.5pF
R655 430
C660 .01µF
L612 1.2µH
C659 100pF
R654 200
L604 1.2µH
C619 100PF
R619 150
C621 .001uF
C628 0.1uF
R617 51
C618 .05µF
C617 .05µF
C609 .001µF
C610 .001µF
+9.6V
L603 10µH
C615 10µH
C616 .01µF
C650 220pF
VCC
REF IN
VBB
PRESCALE IN
3.6 MHZ
NC
GND
U602 DIVIDER
REF OUT
+9.6V
HY601 PHASE MOD
NC
C628 100pF
LOOP OUT
R620 4.7K
D0
D1
D2
D3
A0
A1
A2
STROBE
VCO2
VCO1
J600
FEEDBACK FROM VCO BUFFER
HY600 DIVIDER BUFFER
J601
A0
A1
A2
D0
STROBE
REFERENCE MOD
SYNTHESIZER SYNC.
NC
K9.4
C655 43pF
HY605 SYNTH. SWITCH 2 HYBRID
HY604 SYNTH. SWITCH 1 HYBRID
8.6V
9.6V
VCO 2
VCO 1
9.6
K9.4
K9.4
C695 .05µF
L609 10µH
L610 10µH
C697 .05µF
L611 10µH
C698 .05µF
C696 .05µF
K9.4
C657 .01µF
JU605
14.4 MHz REF OSC
HY602 HYBRID RX 2nd INJ. DOUBLER
TX 86.4 MHz
JU604
TO RX 2nd MIXER (Q202 GATE)
HY603 HYBRID TX INJ. DOUBLER
TX 172.8 MHz
C638 18pF
C639 18pF
R657 11
L613 60nH
R656 430
R658 430
C642 56pF
J603 TO TX MIXER
THE



VCO MODULATION
R603 4.7K
C600 10µF
K9.4V
Q602 M9660
C646 22CpF
R601 100K
R627 2.2K
SUPER FILTER
U600
FILT. CAP
Q603 M9681
REG 8.6V
C603 10µF
C604 47µF
C605 220pF
+9.6V
L608 10µH
C634 .01µF
C625 22CpF
ADAPTIVE FILTER SUPPLY U605-14 U606-14
RT600
R626 220
Q600 M9548
R625 390
C629 47µF
R624 150
C630 .0082
9.6V
L607 10µH
C627 4.7µF
C643 220pF
FILT
9.1V VCC
RES
BASE
CAP GND
(RAMP)
HOLD
C632 .0047µF
LOW BAND/W
FREQ CHG
U603 PHASE DECTECTOR
TX
ADAPT
Q601 M9643
R629 10
R628 1K
PHASE DET
RX
CR602
R638 1.5V
ADAPT
LOOP IN
SYNTH SYNC
GND
SAMPLE TIMING
C631 .0068µF
REF IN
REG +5V
L606 1/2T
C626 .56µF
L602 1/2T
C625 220pF
C624 0.1µF
R623 5.6K
R622 5.6K
C660 .01µF
R654 200
L604 1.2uH
C619 100PF
R619 150
C621 .001uF
C628 0.1uF
R617 51
C618 .05µF
C617 .05µF
VCC
REF IN
VBB
REF OUT
PRESCALE IN
NC
3.6 MHZ
GND
U602 DIVIDER
D0
D1
D2
D3
A0
A1
A2
STROBE
LOOP OUT
VCO2
VCO1
+9.6V
HY601 PHASE MOD
C628 100pF
R620 4.7K
C655 43pF
U606A
U606D
U605A
R652 360K
R653 15K
C649 .39µF
U606B
JU603
C637 220PF
C654 .039µF
U605C
R635 12K
U606C
R637 2.2K
C640 .47µF
R636 2K
U605D
C641 2.0µF
J650
VCO MOD
STEERING LINE
GND
REG. +8.6V
REG 8.6V
PIN SHIFT 1
PS 1 MAJOR
PIN SHIFT 2
PS 2 MAJOR
HY605 SYNTH. SWITCH 2 HYBRID
HY604 SYNTH. SWITCH 1 HYBRID
8.6V
9.6V
VCO 2
VCO 1
K9.4
C697 .05µF
L611 10µH
C698 .05µF
K9.4
C657 .01µF
JU605
HY602 HYBRID
X 2nd INJ. DOUBLER
TX 86.4 MHz
JU604
TO RX 2nd MIXER (Q202 GATE)
HY603 HYBRID TX INJ. DOUBLER
TX 172.8 MHz
C638 18pF
C639 18pF
R657 11
L613 60nH
R656 430
R658 430
C642 56pF
J603 TO TX MIXER
GEW-1940-0



parts list

HLB4087A RF Board (Synthesizer Section) MXW-1696-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed, pF ±5%, 100V unless otherwise stated
C600	23-11013C54	10 μF ±20%, 15V, tantalum
C602	21-11015A07	.01 μF +80, −20%
C603	23-11013C54	10 μF ±20%, 15V, tantalum
C604	23-84538G06	47 μF ±20%, 20V, tantalum
C605	21-11015B05	220 ±10%
C609, 610	21-11015B13	.001 μF ±10%
C612	21-11015B05	220 ±10%
C613	21-11015B13	.001 μF ±10%
C615	23-11013C54	10 μF ±20%, 15V, tantalum
C616	21-11015A07	.01 μF +80, −20
C617, 618	21-82372C10	.05 ±20%, 25V
C619	21-11014H49	100
C620	08-11051A13	.1 μF, 63V
C621	21-11015B13	.001 μF ±10%
C624	08-11051A13	.1, 63V
C625	21-11015B05	220 ±10%
C626	23-11013F10	.56 μF ±10%, 35V, tantalum
C627	23-11013D55	4.7 ±20%, 20V, tantalum
C628	21-11015B01	100 ±10%
C629	23-84538G06	47 μF ±20%, 20V, tantalum
C630	08-80027B03	.0082 μF
C631	08-11051A06	.0068 μF, 63V
C632	08-11051A05	.0047 μF, 63V
C634	21-11015A07	.01 μF +80, −20%
C635, 637	21-11015B05	220 ±10%
C638, 639	21-11014H31	18
C640	08-11051A17	.47 μF, 63V
C641	08-80206H01	2 μF ±10%
C642	21-11014H43	56
C643, 646	21-11015B05	220 ±10%
C649	23-11013F08	.39 μF ±10%, 35V, tantalum
C650	21-11015B05	220 ±10%
C651	21-80067A30	11.5 ±2.5, 500V
C654	08-80027B04	.039 μF
C655	21-11014H40	43
C657	21-11015A07	.01 μF +80, −20%
C658	23-11013C54	10 μF ±20%, 15V, tantalum
C659	21-11014H49	100
C660	21-11015A07	.01 μF +80, −20%
C680–682	21-84547A01	.001 μF ±20%, 50V
C691	21-84873H59	100, 50V
C692	23-84677D13	10 μF ±10%, 35V, tantalum
C693	21-84873H34	.0015 μF ±2%, 50V
C694	23-84677D14	22 μF ±10%, 20V, tantalum
C695–698	21-82372C10	.05 μF ±20%, 25V
C1300	21-84547A11	.01 μF ±20%, 50V
C1301	21-11032B13	.1 μF +80, −20%, 50V
C1302	21-05157A14	470 ±10%, 25V
C1303	21-05157A47	56, 50V
C1304	21-11031A08	3.9 ±.25, 50V
C1305	21-84736E24	1.8 ±.25, 50V
C1306	21-84736E25	2.2 ±.25, 50V
C1307	21-84873H75	7 ±.25, 50V
C1308	21-84873H63	39, 50V
C1309, 1311	21-84547A11	.01 μF ±20%, 50V
C1312	21-05157A93	160, 50V
C1313	21-05157A86	43 ±2%, 50V
C1314	21-11031A07	3.3 ±.25, 50V
C1315	21-84873H57	27, 50V
C1316	21-11031A06	2.7 ±.25, 50V
C1317	21-84873H78	30 ±10%, 50V
C1318	21-84547A11	.01 μF ±20%, 50V
C1319	21-84873H56	8.2 ±.5
C1320–1322	21-84547A11	.01 μF ±20%, 50V
C1351	21-84873H50	33, 50V
C1352	21-05157A83	22 ±2%, 50V
C1353	21-05157A71	6 ±.25, 25V
C1354	21-84873H75	7 ±.25, 50V
C1355	21-05157A86	43 ±2%, 50V
C1356	21-82450B47	1 ±5%, 500V
C1357	21-11031A16	11, 50V
C1358	21-05157A87	47 ±2%, 50V
C1359	21-11031A16	11, 50V
C1360, 1361	21-05157A14	470 ±10%, 25V
C1362	21-84873H77	12, 50V
C1363	21-05157A80	30, 50V
C1364	21-05157A96	20, 50V
C1365	21-84547A11	.01 μF ±20%, 50V
C1368	21-05157A14	470 ±10%, 25V
C1369	21-84547A11	.01 μF ±20%, 50V
C1370	21-84547A24	.1 μF ±20%, 25V
C1371	21-84547A13	.1 μF ±10%, 50V
		diode (see note)
CR602	48-84404E01	light emitting, red
CR1300, 1301	48-80010E02	PIN
		hybrid (see note)
HY600	01-80739T79	buffer divider
HY601	01-80736T10	modulator phase modulator
HY602	01-80736T07	receiver injector doubler
HY603	01-80736T08	transmitter injector doubler
HY604	01-80737T91	synthesizer switch 1
HY605	01-80737T92	synthesizer switch 2

MXW-1696-O (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		connector receptacle
J601, 602	09-83445L09	10-contact, female
J603, 604	09-80001F01	phono jack
J610–618	29-80146B01	terminal
J650	09-83730M01	7-contact, female
		jumper
JU603–605	06-11009B23	resistor jumper
		coil
L602	24-80293D02	ferrite core bead
L603	24-80138G05	10 μH
L604	24-83397L12	1.2 μH white
L606	24-80293D02	ferrite core bead
L607–611	24-80138G05	10 μH
L612	24-83397L12	1.2 μH white
L613	24-11030D05	blue
L1300	24-80140E13	820 nH
L1301, 1302	24-80140E08	1.5 μH
L1303	24-80140E01	1.2 μH
L1304	24-80140E15	275 nH
L1305	24-80091G36	airwound
L1307	24-83397L07	10 μH blue/blue
L1308–1310	24-80091G36	airwound
L1311, 1312	24-80140E16	10 μH
L1351	24-80140E11	360 nH
L1352	24-80140E06	130 nH
L1353	24-80140E01	1.2 μH
L1354, 1355	24-80091G07	airwound
L1356	24-80140E15	275 nH
L1357–1360	24-80091G36	airwound
L1361	24-80140E01	1.2 μH
		connector plug
P1300	29-80215H01	terminal
		transistor (see note)
Q600	48-00869548	PNP, type M9548
Q601	48-80182D09	PNP, type M8209
Q602	48-00869660	FET, type M9660
Q603	48-80182D14	PNP, type M8214
Q660	48-84939C24	NPN, type M3924
Q661, 662	48-84939C25	NPN, type M3925
Q670	48-84939C24	NPN, type M3924
Q671, 672	48-84939C25	NPN, type M3925
Q680	48-84939C25	NPN, type M3925
Q691, 692	48-84939C24	NPN, type M3924
Q693, 694	48-84939C26	PNP, type M3926
Q1300, 1351	48-84939C31	NPN, type M3931
Q1352	48-80182D30	NPN, type M8230
Q1353, 1354	48-84939C26	PNP, type M3926
		thermistor
RT600	06-00858402	rod type
		resistor, fixed, Ω ±5%, ¼ W unless otherwise stated
R601	06-11009A97	100k
R603	06-11009A65	4.7k
R607	18-80087E01	25k, variable
R617	06-11009A18	51
R619	06-11009A29	150
R620	06-11009E65	4.7k
R622, 623	06-11009E67	5.6k
R624	06-11009E29	150
R625	06-11009E39	390
R626	06-11009E33	220
R627	06-11009E57	2.2k
R628	06-11009E49	1k
R629	06-11009E01	10
R635	06-11009A75	12k
R636	06-11009A56	2k
R637	06-11009A57	2.2k
R638	06-11009E53	1.5k
R652	06-11009B11	360k
R653	06-11009A77	15k
R654	06-11009A32	200
R655	06-11009A40	430
R660	06-11024A80	20k, ⅛ W
R670	06-11024A87	39k, ⅛ W
R1301	06-11024A79	18k, ⅛ W
R1351	06-11009C34	240
R1352	06-11024A83	27k, ⅛ W
		integrated circuit (see note)
U600	51-84768F65	IC
U602	51-84768F63	IC
U603	51-83977M36	custom IC
U605	51-80073C02	quad bilateral switch
U606	51-80073C03	quad bilateral switch
U608	51-80291B05	reference oscillator
		mechanical parts
	42-82160N01	shield clip
	55-84300B02	handle, 2 used
	42-82160N01	shield clip

MXW-1696-O (3)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	42-80087K01	retaining crystal clip
	26-80137K01	synthesizer shield, solder side
	26-80127K01	synthesizer shield
	26-80292H01	adapter filter shield
	26-80293H01	hybrid shield, receiver injector doubler
	26-80296H01	hybrid mixer doubler shield
	26-80288H01	fence shield
	26-80237K01	synthesizer driver fence shield
	26-83596M01	top circuit board shield

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

HLB4084A Transmit Mixer MXW-1954-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed, pF ±5%, 50V unless otherwise stated
C1450	21-84547A11	.01 μF ±20%
C1451	21-84873H58	51
C1452	21-84873H63	39
C1453–1458	21-84547A11	.01 μF ±20%
C1459	21-84873H76	10
C1460, 1461	21-84547A11	.01 μF ±20%
C1462	21-84873H50	33
		diode (see note)
CR1450, 1451	48-84622E02	silicon
CR1452	48-80236E09	silicon, quad
CR1453	48-84939C29	MMBD 6050
		coil
L1450	24-80091G23	airwound
L1451	24-80091G32	airwound
L1452, 1453	24-82723H27	1.2 μH, green, inductor
L1454	24-80140E10	100 nH, inductor
L1455	24-80140E02	1.8 μH, inductor
		connector plug
P101	28-84227B04	phono
		transistor (see note)
Q1450	48-84939C23	PNP, type M3923
Q1451	48-80182D30	NPN, type M8230
		transformer
T1450, 1451	25-80125J01	trifilar
		mechanical parts
	29-84407M01	connector lug
	64-80190H01	buffer carrier plate

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

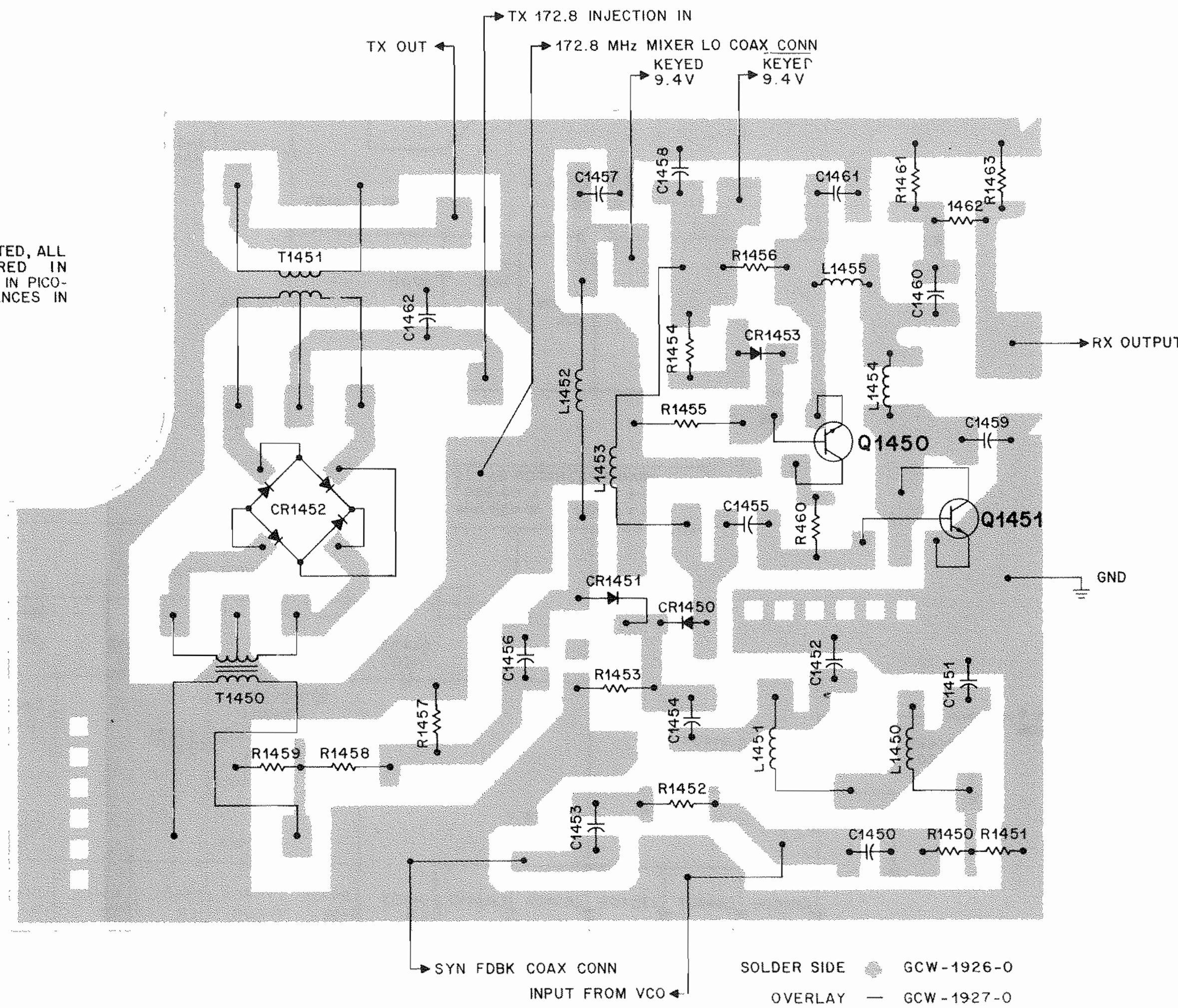
HLN4909A Transmitter Mixer Cables MXW-1957-O

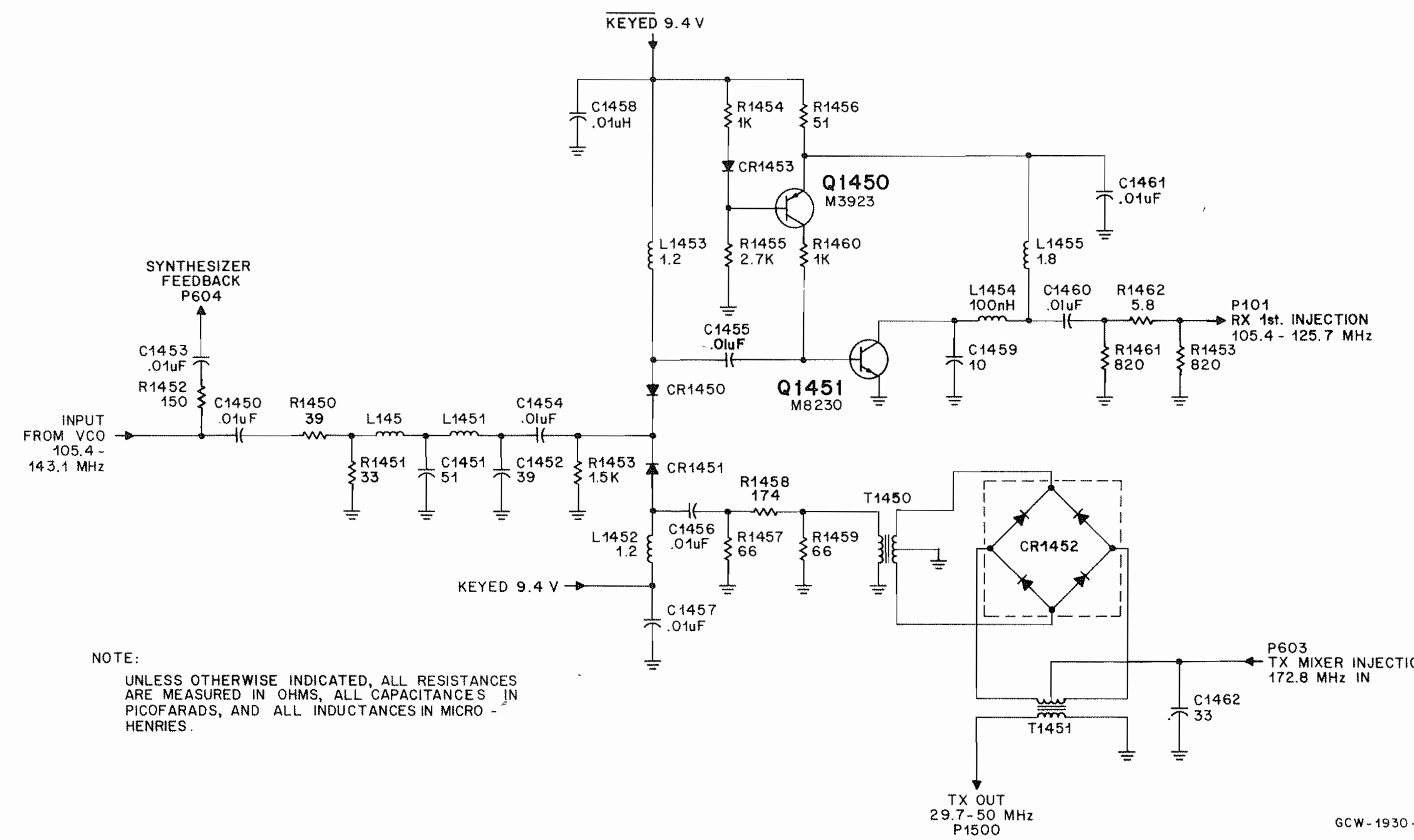
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	01-80736T38	coax cable
	01-80736T39	coax cable
	01-80736T40	coax cable

Schematics, Circuit Board Diagrams, and Parts Lists for Frequency Synthesizer
PDW-1684-O
(Sheet 2 of 5)
8/28/85

TX MIXER

NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPALITANCES IN PICO-FARADS, AND ALL INDUSTANCES IN MICROHENRIES.





NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN PICOFARADS, AND ALL INDUCTANCES IN MICRO-HENRIES.

parts list

HLB4086A VCO MXW-1690-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed, µF ±5%, 50V unless otherwise stated
C1401	21-84736E37	24 pF
C1402	21-84873H75	7 pF ±.25 pF
C1403	21-84873H13	.001
C1404	21-84736E38	68 pF
C1405	21-84736E21	100 pF
C1406	21-84547A11	.01 ±20%
C1407	21-84873H13	.001
C1408	21-84736E28	4.7 pF ±.25 pF
C1409–1418	21-84547A01	.001 ±20%
C1419	21-84873H60	2.7 pF ±.25 pF
C1420	21-11031A07	3.3 pF ±.25 pF
C1421	21-84547A11	.01 ±20%
C1422	21-84873H76	10 pF
C1423	21-84547A11	.01 ±20%
C1424	21-84736E28	4.7 pF ±.25 pF
C1425, 1426	21-84736E23	1.5 pF ±.25 pF
C1427	21-84736E26	2.7 pF ±.25 pF
C1428	21-84547A21	.001 ±20%
C1429	21-05157A96	20 pF
		diode (see note)
CR1401–1411	48-82190H51	silicon varactor
CR1412	48-80236E05	hot carrier
CR1413	48-84622E03	silicon PIN
CR1414, 1415	48-84622E02	silicon PIN
		connector receptacle
J1400	09-83729M01	7-contact
		coil
L1401–1403	24-80140E02	1.8 µH, inductor
L1404	24-82723H27	1.2 µH, green, axial
L1405, 1406	24-80140E02	1.8 µH, inductor
L1407, 1408	24-82723H27	1.2 µH, green, axial
L1409, 1410	24-80140E02	1.8 µH, inductor
L1411	24-80140E06	130 nH, inductor
L1412	24-80140E04	65 nH, inductor
L1413	24-80140E02	1.8 uH, inductor
		connector plug
P1400	07-80162D01	7-contact
		transistor (see note)
Q1401	48-84939C30	field effect, type 39C30
Q1402	48-84939C31	NPN, type 39C31, RF amplifier
Q1403, 1404	48-84939C26	PNP, type 39C26, switching

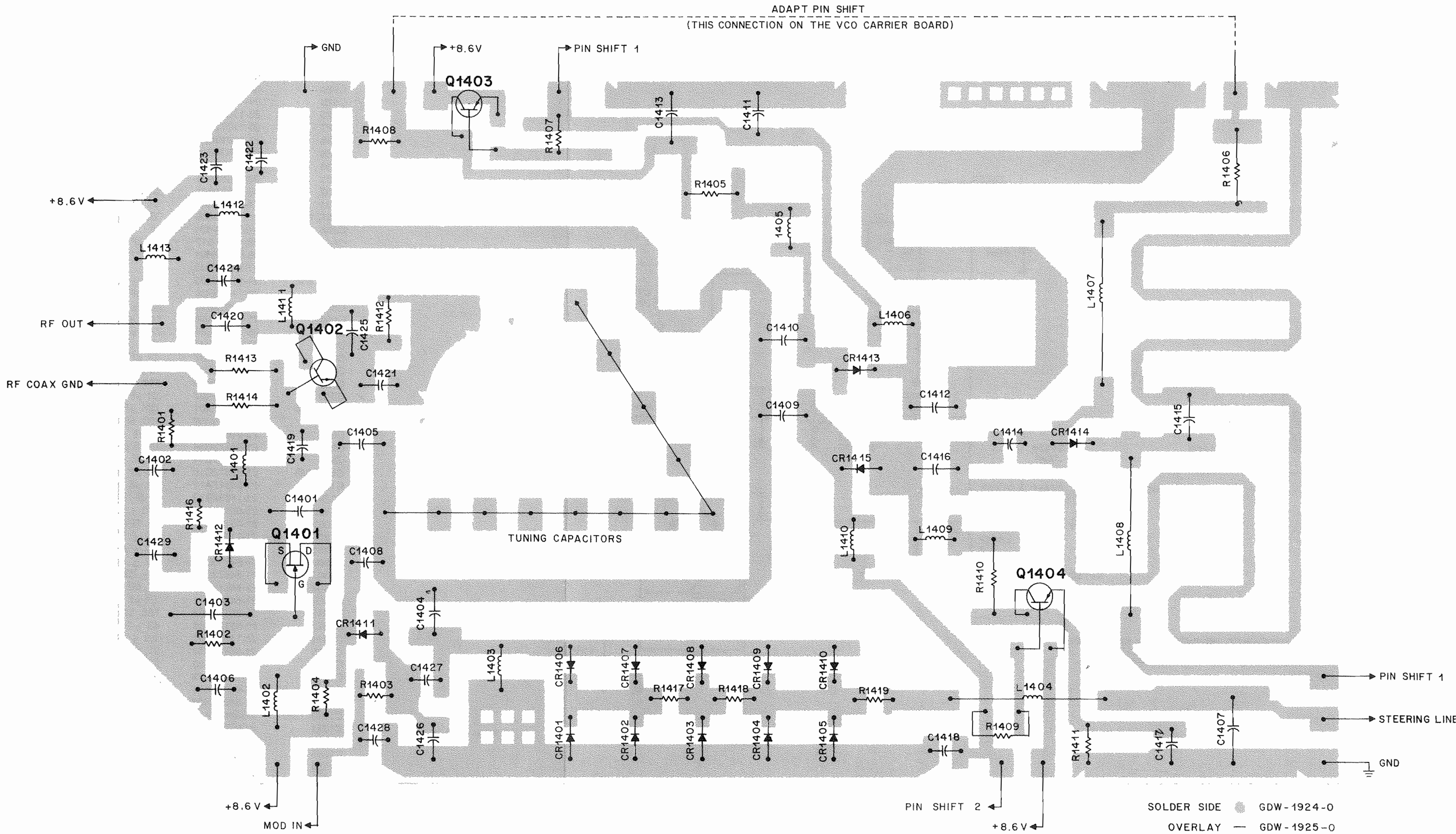
note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

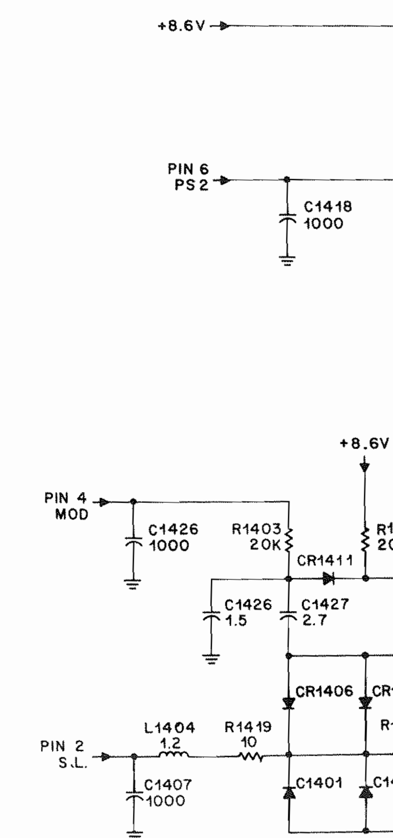
HLN4813A Internal Casting Hardware MXW-1697-O

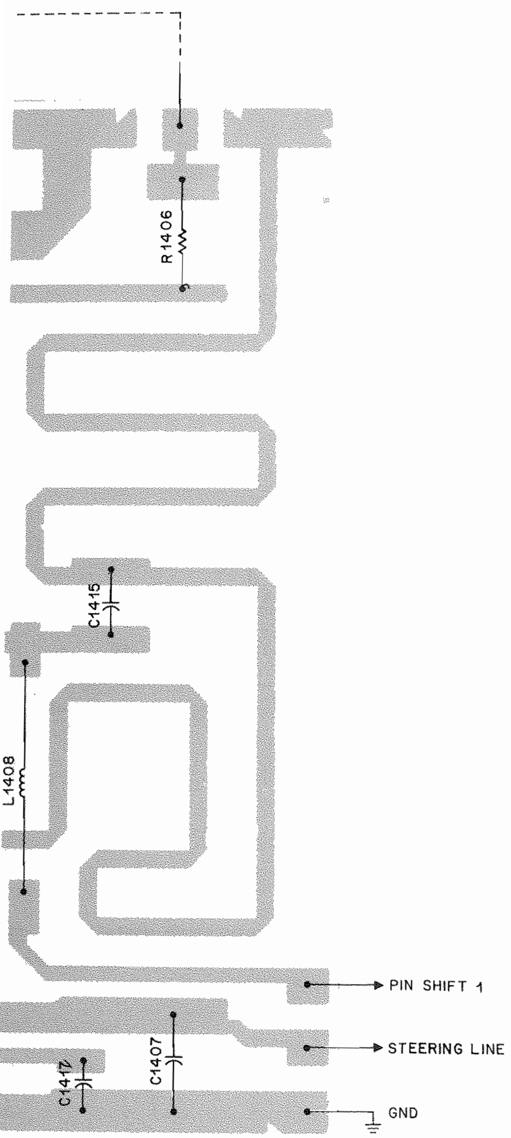
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed, pF unless otherwise stated
C1900, 1902	21-84874K01	470 ±20%, 250V, feedthrough
C1903–1905	21-82812H04	1000 +100, −0%, 500V, feedthrough
C1906	21-84874K01	470 ±20%, 250V, feedthrough
		coil
L200, 201	76-83960B01	ferrite core
L1400, 1401	76-83960B01	ferrite core
		connector plug
P204–208	39-82717M01	receptacle contact
P1900, 1901	09-84135B02	phono jack
		mechanical parts
	42-35424B01	4" cable tie, 2 used
	03-10943M10	tapping screw (3 × .5 × 8)
	03-10943M14	tapping screw (3.5 × .6 × 6), 17 used
	03-10943M16	tapping screw (3.5 × .6 × 10), 2 used
	03-80132J02	tapping screw (3.5 × .6 × 23), 4 used
	04-83755H01	grounding clip
	14-80191C01	feedthrough insulator
	15-80203H01	injection filter cover
	15-80204H01	extender front end cover
	15-83214M01	plug cover
	15-84817M01	VCO cover
	15-84851M01	transmit mixer cover
	15-80126K01	receive mixer cover
	15-84853M01	extender back end cover
	32-80132K01	receive mixer gasket
	32-80043D01	extender back end gasket
	32-82796H01	wire mesh gasket
	32-80207H01	injection filter gasket
	32-80208H01	extender front end gasket
	15-84776M11	internal housing
	43-80294H01	mounting spacer, 2 used
	15-80125K01	high IF board cover
	32-80131K01	high IF board gasket
	43-80190A03	threaded standoff, 4 used
	15-84301K03	five-position connector housing

RF (

	DESCRIPTION
	capacitor, fixed, pF unless otherwise stated
1	470 ±20%, 250V, feedthrough
4	1000 +100, −0%, 500V, feedthrough
1	470 ±20%, 250V, feedthrough
	coil
1	ferrite core
1	ferrite core
	connector plug
)1	receptacle contact
2	phono jack
	mechanical parts
1	4" cable tie, 2 used
10	tapping screw (3 × .5 × 8)
14	tapping screw (3.5 × .6 × 6), 17 used
16	tapping screw (3.5 × .6 × 10), 2 used
2	tapping screw (3.5 × .6 × 23), 4 used
)1	grounding clip
)1	feedthrough insulator
)1	injection filter cover
)1	extender front end cover
)1	plug cover
)1	VCO cover
01	transmit mixer cover
)1	receive mixer cover
01	extender back end cover
)1	receive mixer gasket
)1	extender back end gasket
)1	wire mesh gasket
01	injection filter gasket
01	extender front end gasket
11	internal housing
01	mounting spacer, 2 used
01	high IF board cover
01	high IF board gasket
03	threaded standoff, 4 used
03	five-position connector housing

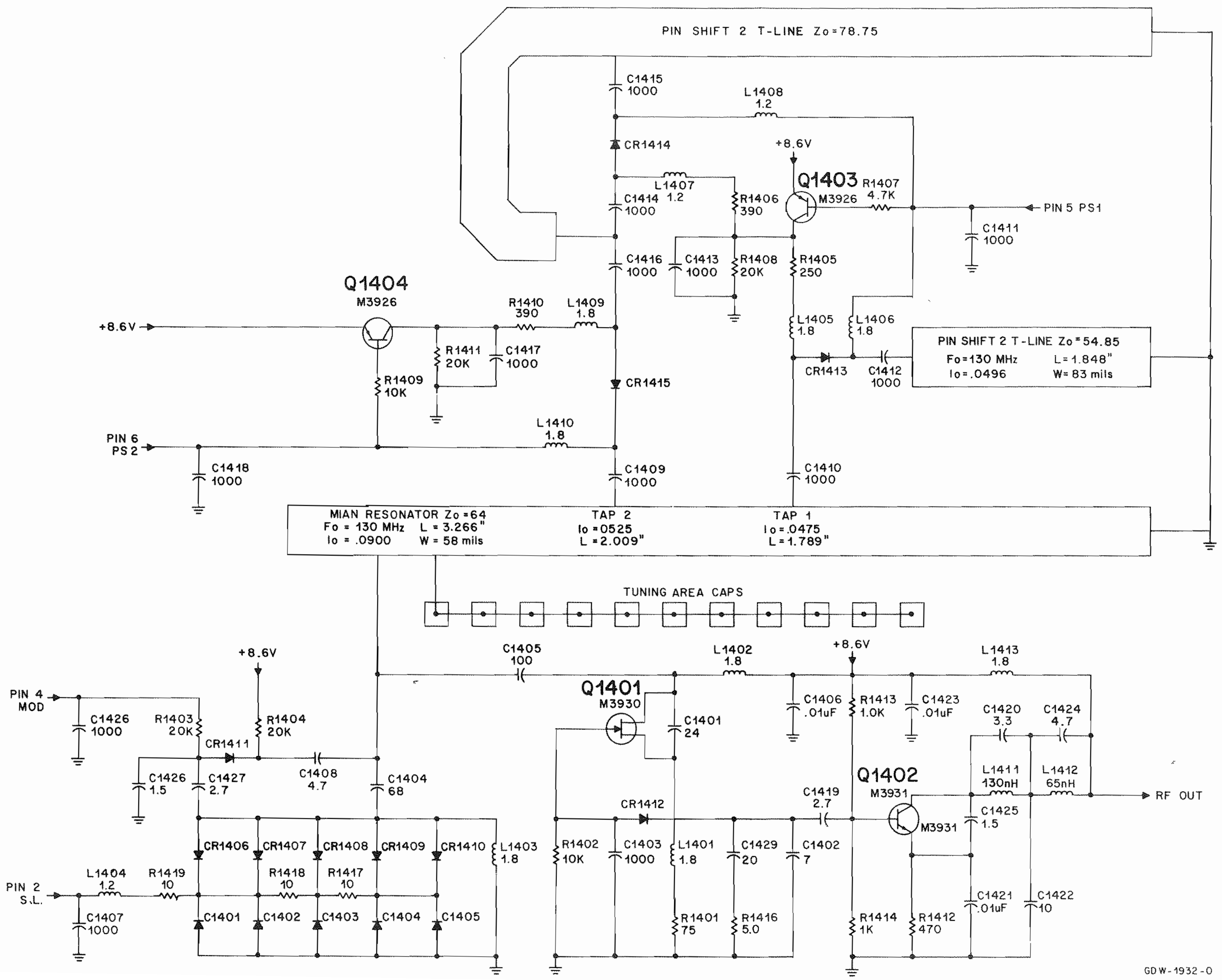






SOLDER SIDE GDW-1924-0

OVERLAY — GDW-1925-0



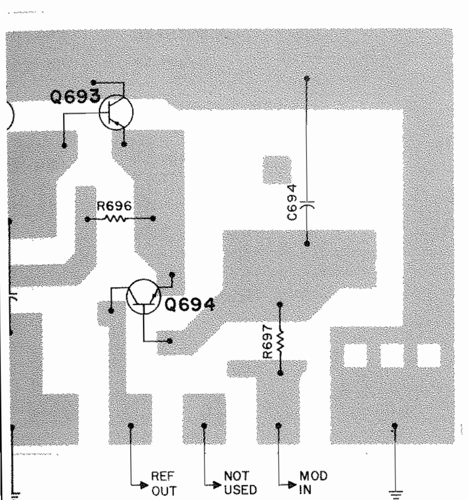
GDW-1932-0

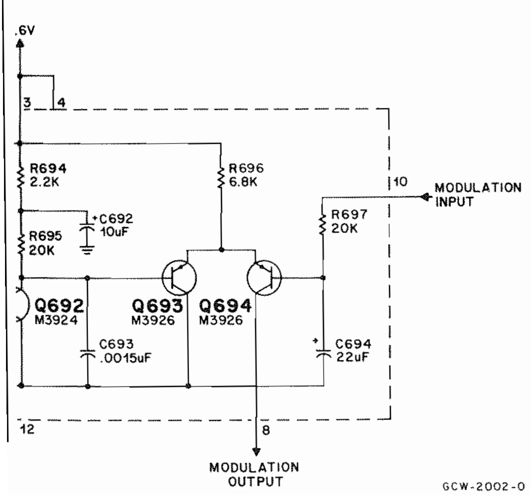
NOTES:

1. UNLESS OTHERWISE NOTED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN PICO FARADS, AND ALL INDUCTANCES IN MICROHENRIES.

2. ALL RESISTORS ARE SCREENED DIRECTLY UPON THE SUBSTRATE.

ODULATOR



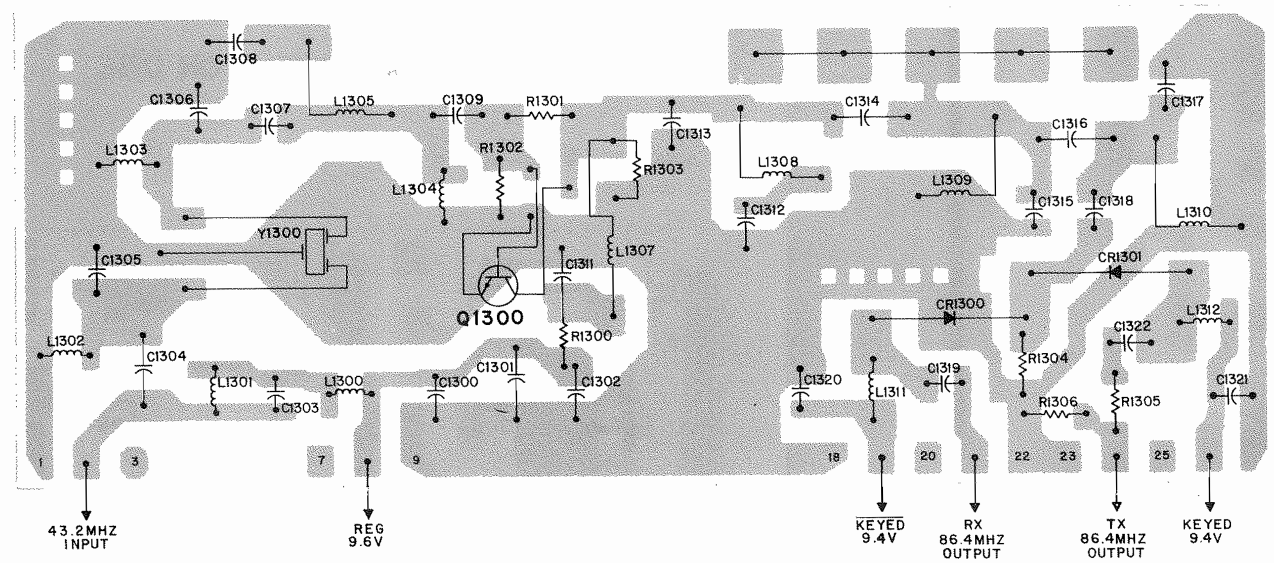


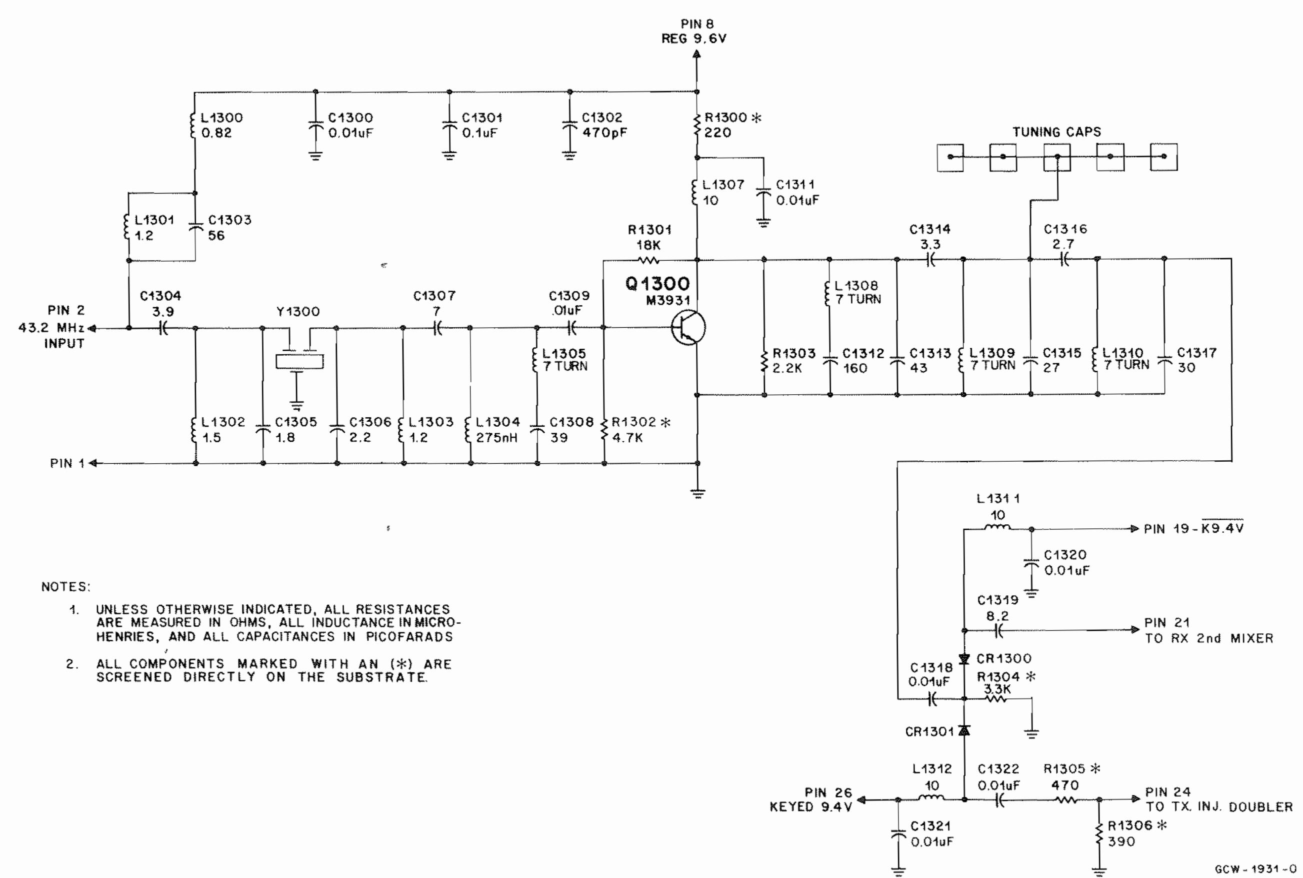
GCW-2002-0

RX INJECTION DOUBLER

SUBSTRATE ▒ GCW-1922-0

OVERLAY — GCW-1923-0





NOTES:

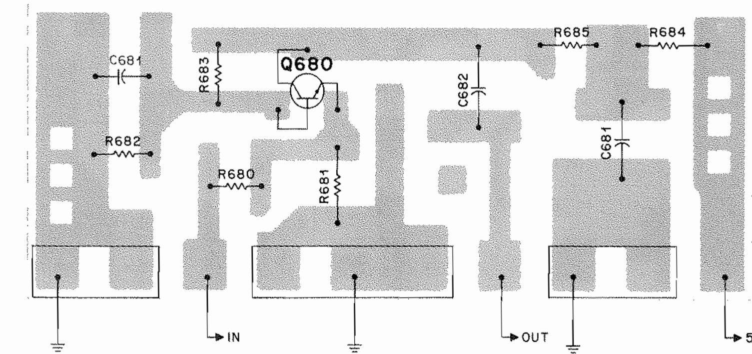
1. UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL INDUCTANCE IN MICRO-HENRIES, AND ALL CAPACITANCES IN PICOFARADS
2. ALL COMPONENTS MARKED WITH AN (*) ARE SCREENED DIRECTLY ON THE SUBSTRATE.

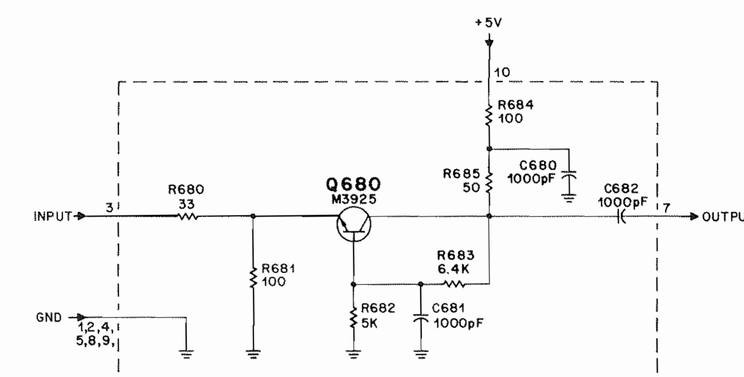
GCW-1931-0

DIVIDER/BUFFER

SUBSTRATE ▒ GCW-1997-0

OVERLAY — GCW-1998-0





GCW-1999-0

Schematics, Circuit Board Diagrams, and Parts Lists for Frequency Synthesizer
PDW-1684-O
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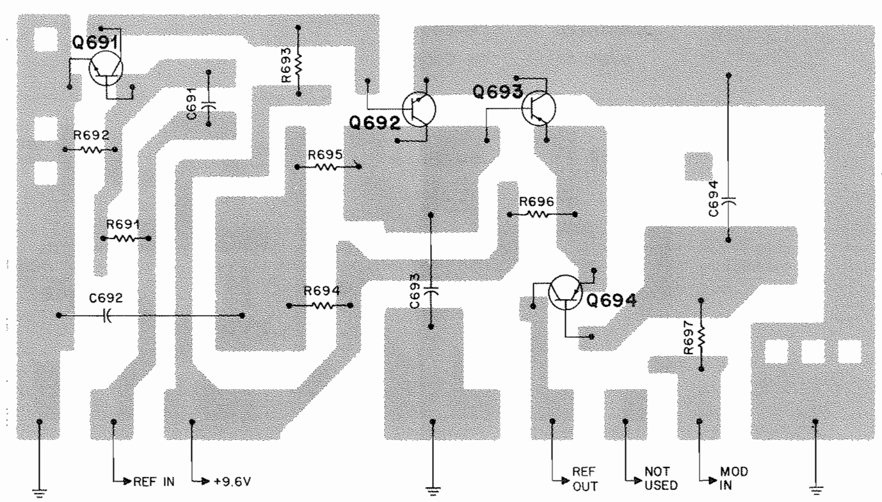
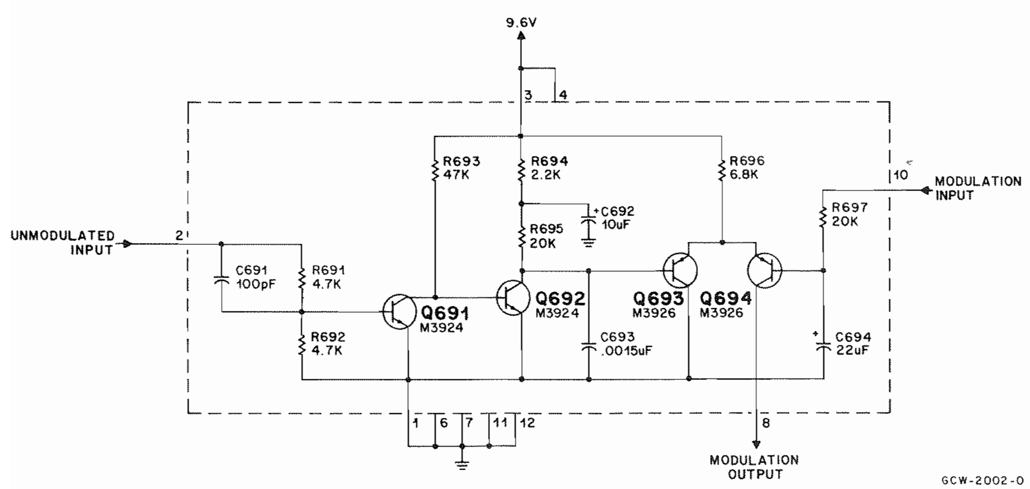
8/28/85

PHASE MODULATOR

SUBSTRATE ● GCW-2000-0
OVERLAY — GCW-2001-0

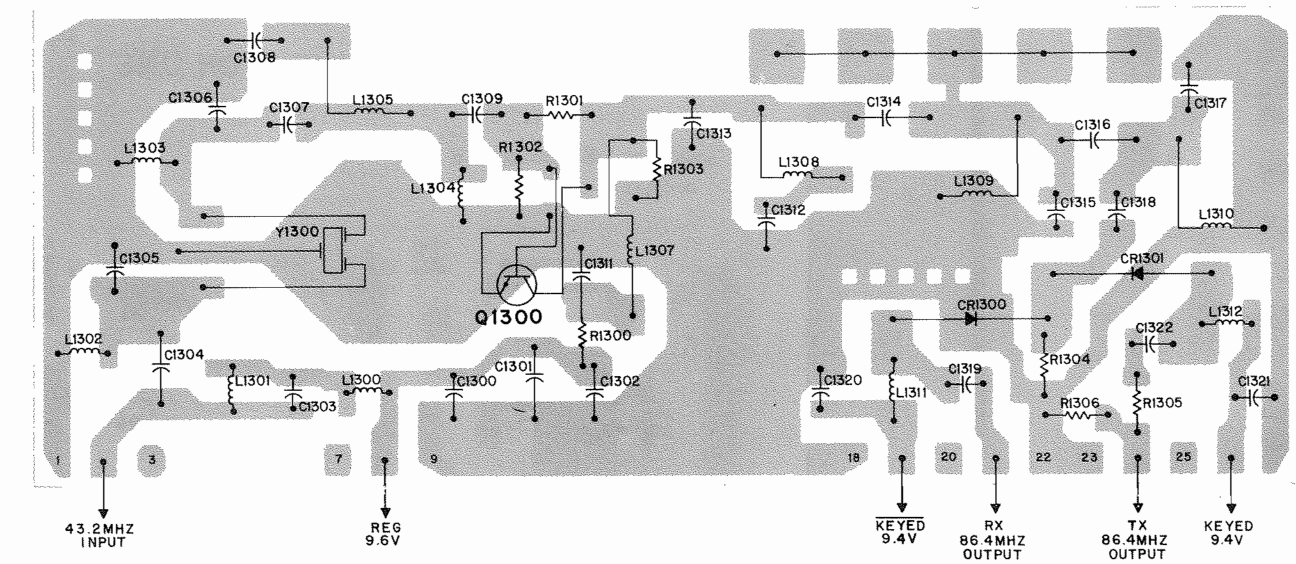


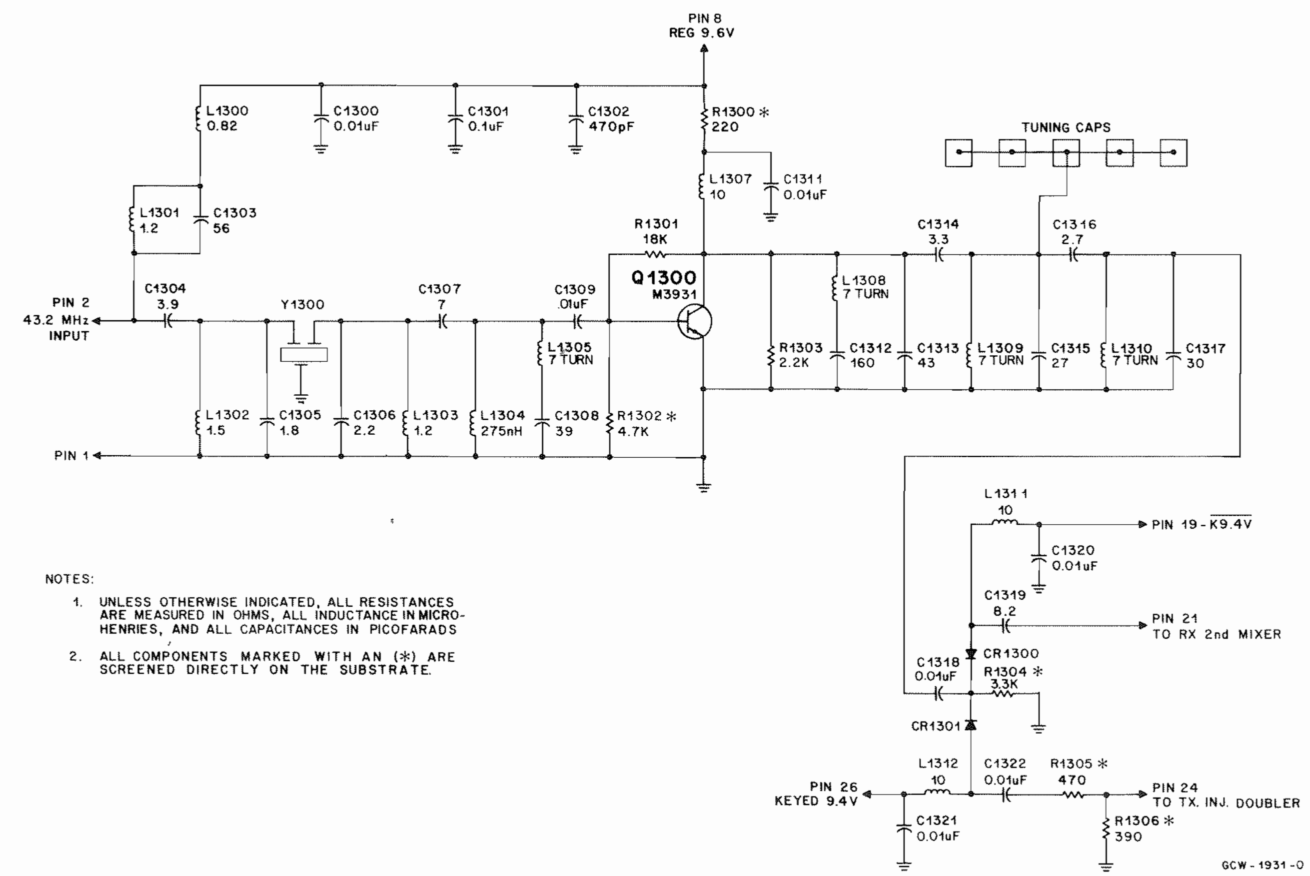


GCW-2002-0

RX INJECTION DOUBLER

SUBSTRATE ● GCW-1922-0
OVERLAY — GCW-1923-0



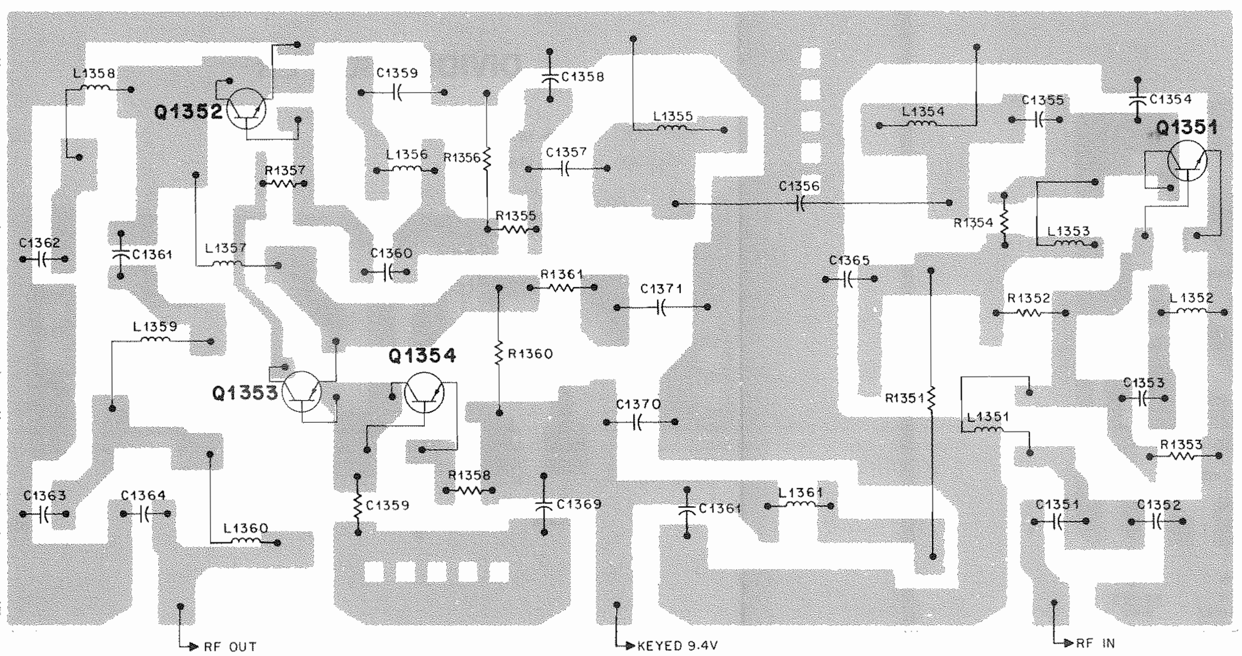


GCW-1931-0

NOTES:

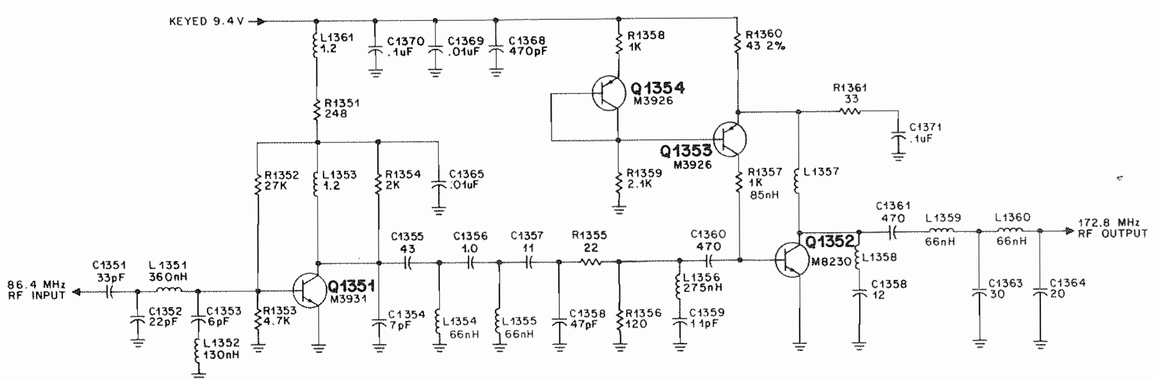
1. UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL INDUCTANCE IN MICRO-HENRIES, AND ALL CAPACITANCES IN PICOFARADS.
2. ALL COMPONENTS MARKED WITH AN (*) ARE SCREENED DIRECTLY ON THE SUBSTRATE.

TX INJECTION DOUBLER



SUBSTRATE ● GCW-1920-0

OVERLAY — GCW-1921-0



NOTE
UNLESS OTHERWISE SPECIFIED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL INDUCTANCES IN MICROHENRIES, AND ALL CAPACITANCES IN PICOFARADS

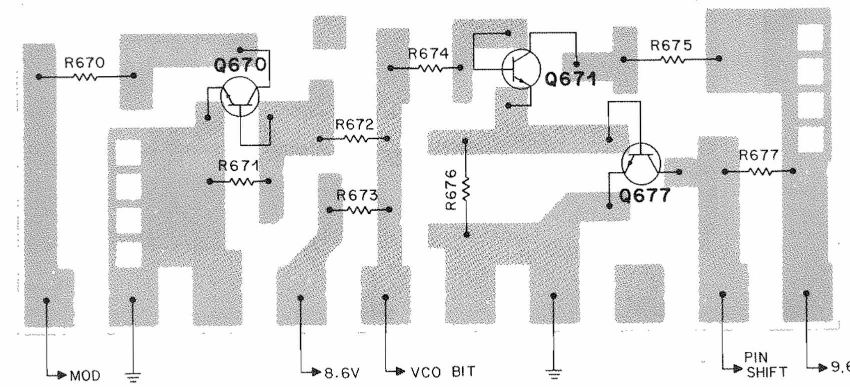
GCW-1935-0

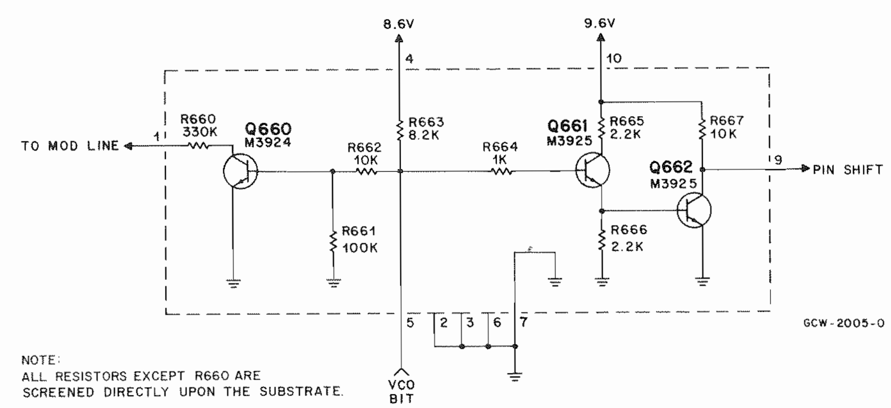
Schematics, Circuit Board Diagrams, and
Parts Lists for Frequency Synthesizer
PDW-1684-O
(Sheet 5 of 5)
8/28/85

SYNTHESIZER SWITCH ONE

SUBSTRATE ● GCW-2006-0

OVERLAY — GCW-2007-0





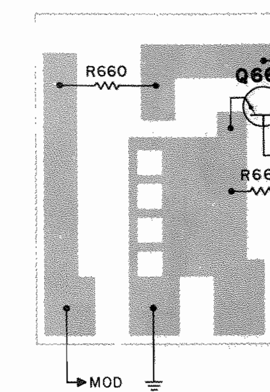
GCW-2005-0

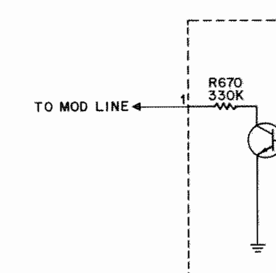
NOTE:
ALL RESISTORS EXCEPT R660 ARE SCREENED DIRECTLY UPON THE SUBSTRATE.

SYN

SUBSTRATE ● GCW-200

OVERLAY — GCW-200

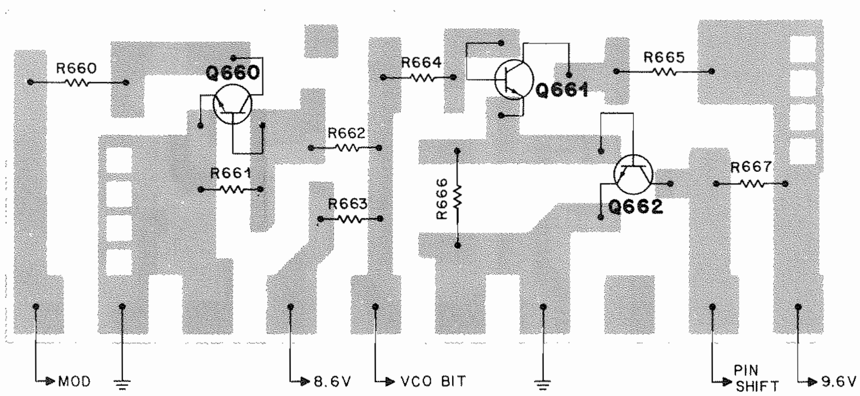


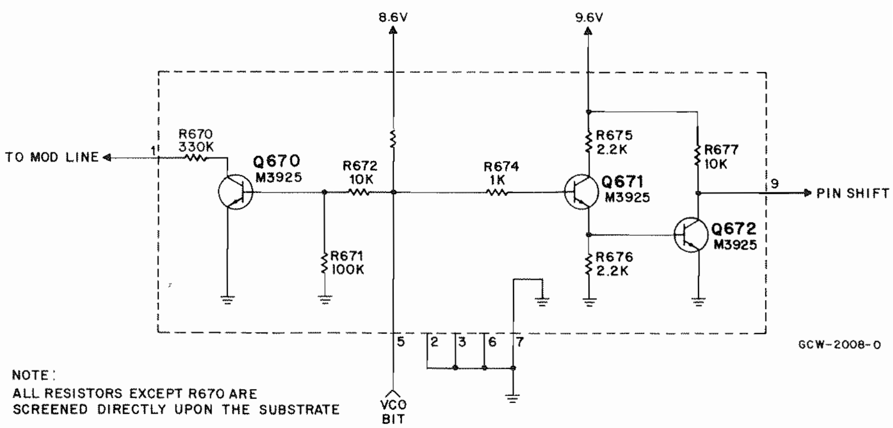


NOTE:
ALL RESISTORS EXCEPT R670 ARE
SCREENED DIRECTLY UPON THE S

SYNTHESIZER SWITCH TWO

SUBSTRATE ● GCW-2003-0
OVERLAY — GCW-2004-0





NOTE:
ALL RESISTORS EXCEPT R670 ARE
SCREENED DIRECTLY UPON THE SUBSTRATE