SECTION 4 CIRCUIT DESCRIPTION

4.1 GENERAL

4.1.1 INTRODUCTION

The main subassemblies of this transceiver are the RF board, VCO board, TCXO. A block diagram of the transceiver is located in Figure 4-1.

The VCO board is enclosed by a metal shield and soldered directly to the RF board. The VCO is not serviceable.

The 3474 is available with a reference oscillator stability of ±1.5 PPM. The TCXO (Temperature Compensated Crystal Oscillator) is soldered directly to the RF board.

4.1.2 SYNTHESIZER

The VCO (voltage-controlled oscillator) output signal is the receiver first injection frequency in the Receive mode and the transmit frequency in the Transmit mode. The first injection frequency is 52.95 MHz above the receive frequency. The frequency of this oscillator is controlled by a DC voltage produced by the phase detector in synthesizer chip U801.

Channels are selected by programming counters in U801 to divide by a certain number. This programming is performed over a serial bus formed by the Synth Clock, Synth Enable, and Synth Data pins of J201. This programming is performed by user supplied hardware and software (see Section 3).

The frequency stability of the synthesizer in both the receive and transmit modes is established by the stability of the reference oscillator described in the preceding section. These oscillators are stable over a temperature range of -30° to +60° C (-22° to +140° F).

4.1.3 RECEIVER

The receiver is a double-conversion type with intermediate frequencies of 52.95 MHz / 450 kHz. Two helical bandpass filters reject the image, half IF, injection, and other unwanted frequencies. A four-pole crystal filter enhances receiver selectivity

4.1.4 TRANSMITTER

The transmitter produces a nominal RF power output of 2W adjustable to 500 mW (-XX0) or 500 mW adjustable to 75 mW (with Low Power Kit). Frequency modulation of the transmit signal occurs in the synthesizer. Transmit audio processing circuitry is contained in the customer-supplied equipment.

4.2 SYNTHESIZER

4.2.1 INTRODUCTION

A block diagram of the synthesizer is shown in Figure 4-1 and a block diagram of Synthesizer IC U801 is shown in Figure 4-2. As stated previously, the synthesizer output signal is produced by a VCO (voltage controlled oscillator). The VCO frequency is controlled by a DC voltage produced by the phase detector in U801. The phase detector senses the phase and frequency of the two input signals and causes the VCO control voltage to increase or decrease if they are not the same. The VCO is then "locked" on frequency.

Programming of the synthesizer provides the data necessary for the internal prescaler and counters. One input signal is the reference frequency. This frequency is produced by the 17.5 MHz reference oscillator (TCXO). The other input signal is the VCO frequency.

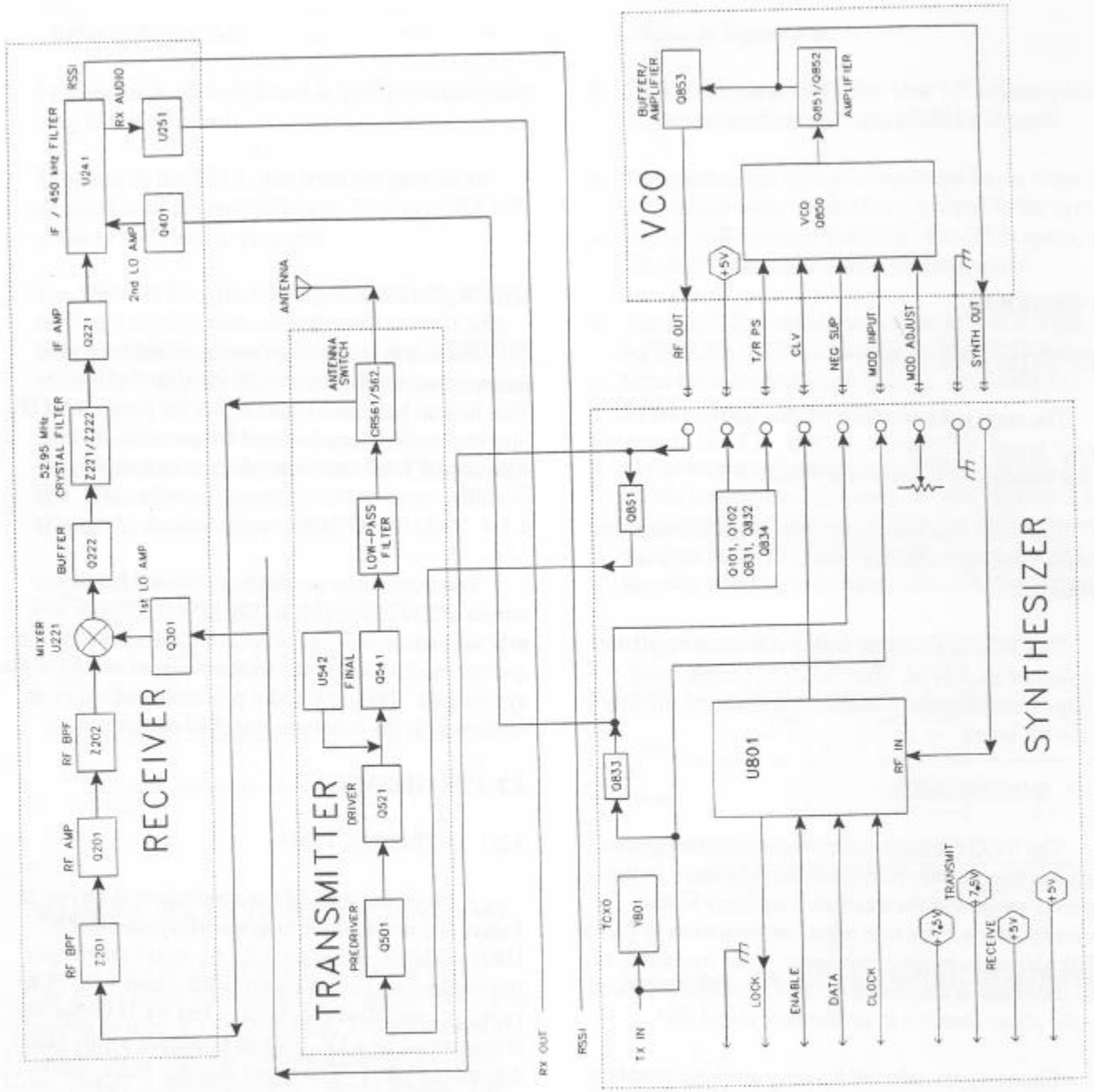

Figure 4-1 DATA TRANSCEIVER BLOCK DIAGRAM

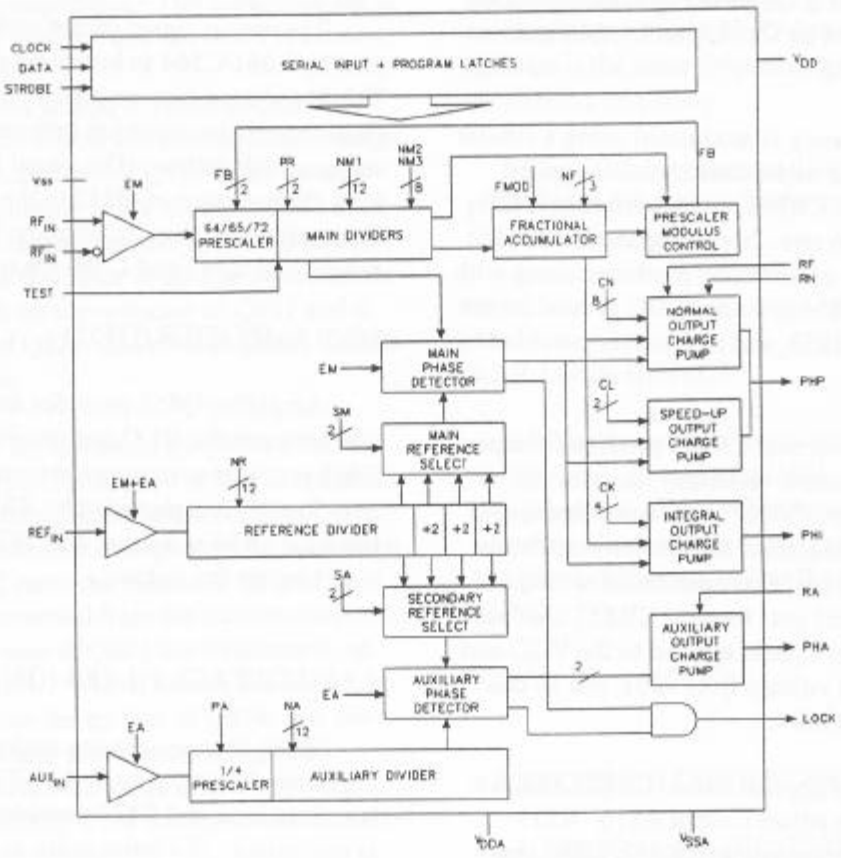

Figure 4-2 U801 SYNTHESIZER BLOCK DIAGRAM

4.2.2 VOLTAGE-CONTROLLED OSCILLATOR

Oscillator (Q850)

The VCO is formed by Q850, several capacitors and varactor diodes, and a ceramic resonator. It oscillates at the transmit frequency in transmit mode and first injection frequency in the receive mode (approximately 450 MHz in transmit and 500 MHz in receive).

Biasing of Q850 is provided by R862, R867 and R868. An AC voltage divider formed by C859, C861 and C862 initiates and maintains oscillation and also matches Q850 to the tank circuit. The ceramic resonator is grounded at one end to provide shunt inductance to the tank circuit.

Frequency Control and Modulation

The VCO frequency is controlled in part by DC voltage across varactor diodes CR854, CR855, CR856 and CR851. As voltage across a reverse-biased varactor diode increases, its capacitance decreases. Therefore, VCO frequency increases as the control voltage increases. CR854/CR855 and CR856/CR851 are paralleled varactors to divide the capacitance and improve liniarity. The varactors are biased at -2V to adjust to the voltage output of U801. The control line is isolated from tank circuit RF by choke L851 and L854 and decoupling capacitor C854. The amount of frequency change produced by CR854/CR855/CR856/CR851 is controlled by series capacitor C853.

The -2V applied to the VCO is derived from the TCXO frequency that is amplified by Q833, rectified by CR831 and filtered by C844, C845, C846 and C847 on the RF board.

The VCO frequency is modulated using a similar method. The transmit audio/data signal is applied across varactor diode CR852 which varies the VCO frequency at an audio rate. Series capacitors C856/C870 set the amount of deviation produced along with CR853 and C858. R854 provides a DC ground on the anodes of CR852/CR853, and isolation is provided by R852 and C855.

The DC voltage across CR853 provides compensation to keep modulation relatively flat over the entire bandwidth of the VCO. This compensation is required because modulation tends to increase as the VCO frequency gets higher (capacitance of CR854/CR855/CR856/CR851 gets lower). CR853 also balances the modulation signals applied to the VCO and TCXO. An external voltage from J201, pin 14 can also adjust the modulation.

The DC voltage applied across CR853 comes from the modulation adjust control R810. R811 applies a DC biasing voltage to CR852; C814 provides DC blocking; and C818 attenuates AC signals applied through R811. RF isolation is provided by C858, R853, C817 and R812.

4.2.3 VCO AND REFERENCE OSCILLATOR MODULATION

Both the VCO and reference oscillator (TCXO) are modulated in order to achieve the required frequency response. If only the VCO was modulated, the phase detector in U801 would sense the frequency change and increase or decrease the VCO control voltage to counteract the change (especially at the lower audio frequencies). If only the reference oscillator frequency is modulated, the VCO frequency would not change fast enough (especially at the higher audio frequencies). Modulating both VCO and reference oscillators produces a flat audio response. Potentiometer R810 sets the VCO modulation sensitivity so that it is equal to the reference oscillator modulation sensitivity.

4.2.4 CASCODE AMPLIFIERS (Q851/Q852)

The output signal on the collector of Q850 is coupled by L861/C864 to buffer amplifier Q851/Q852. This is a shared-bias amplifier which provides amplification and also isolation between the VCO and the stages which follow. The signal is direct coupled from the collector of Q852 to the emitter of Q851. The resistors in this circuit provide biasing and stabilization, and C865 and C866 are bypass capacitors.

4.2.5 AMPLIFIER (Q853)

Amplifier Q853 provides amplification and isolation between the VCO and receiver and transmitter. C868 provides matching between the amplifiers. Bias for Q853 is provided by R871, R872 and R874. Inductor L856 and capacitor C873 provide impedance matching on the output.

4.2.6 VOLTAGE FILTER (Q832)

Q832 is a capacitance multiplier to provide filtering of the 4.6V supply to the VCO. R836 provides transistor bias and C834 provides the capacitance that is multiplied. If a noise pulse or other voltage change appears on the collector, the base voltage does not change significantly because of C834. Therefore, base current does not change and transistor current remains constant. CR832 decreases the charge time of C834 when power is turned on. This shortens the startup time of the VCO. C841, C840 and C855 are RF decoupling capacitors.

4.2.7 VCO FREQUENCY SHIFT (Q831)

The VCO must be capable of producing frequencies from approximately 403-564.95 MHz to produce the required receive injection and transmit frequencies. If this large of a shift was achieved by varying the VCO control voltage, the VCO gain would be undesirably high. Therefore, capacitance is switched in and out of the tank circuit to provide a coarse shift in frequency.

This switching is controlled by the T/R pin shift on J201, pin 4, Q831/Q834 and pin diode CR850. When a pin diode is forward biased, it presents a vary

low impedance to RF; and when it is reverse biased, it presents a very high impedance. The capacitive leg is switched in when in transmit and out when in receive.

When J201, pin 4 is high in receive, Q834 is turned off, Q101 is turned on and the collector voltage goes low. A low on the base of Q102 turns the transistor on and the regulated +5.5V on the emitter is on the collector for the receive circuitry. With a low on the base of Q831 the transistor is off and the collector is high. With a high on the collector of Q831 and a low on the emitter of Q834, this reverse biases CR850 for a high impedance.

The capacitive leg is formed by C851, CR850, C852 and C876. When J201, pin 4 is low in transmit, Q834 is turned on and a high is on the emitter, Q101 is turned off and the collector voltage goes high. A high on the base of Q102 turns the transistor off and the regulated +5.5V is removed from the receive circuitry. With a high on the base of Q831 the transistor is on and the collector is low. With a low on the collector of Q831 and a high on the emitter of Q834, this forward biases CR850 and provides an RF ground through C851 and C852/C876 are effectively connected to the tank circuit. This decreases the resonant frequency of the tank circuit.

4.2.8 SYNTHESIZER INTEGRATED CIRCUIT (U801)

Introduction

Synthesizer chip U801 is shown in Figure 4-2. This device contains the following circuits: R (reference), Fractional-N, NM1 and NM2; phase and lock detectors, prescaler and counter programming circuitry. The basic operation was described in Section 4.2.1.

Channel Programming

Frequencies are selected by programming the R, Fractional-N, NM1 and NM2 in U801 to divide by a certain number. These counters are programmed by a user supplied programming circuit. More information on programming is located in Section 3.

As previously stated, the counter divide numbers are chosen so that when the VCO is oscillating on the correct frequency, the VCO-derived input to the phase detector is the same frequency as the reference oscillator-derived frequency.

The VCO frequency is divided by the internal prescaler and the main divider to produce the input to the phase detector.

4.2.9 LOCK DETECT

When the synthesizer is locked on frequency, the SYNTH LOCK output of U801, pin 18 (J201, pin 7) is a high voltage. Then when the synthesizer is unlocked, the output is a low voltage. Lock is defined as a phase difference of less than 1 cycle of the TCXO.

4.3 RECEIVER CIRCUIT DESCRIPTION

4.3.1 HELICAL FILTER (Z201), RF AMPLIFIER (Q201)

Capacitor C201 couples the receive signal from the antenna switch to helical filter Z201. (The antenna switch is described in Section 4.4.5.) Z201 is a bandpass filter tuned to pass only a narrow band of frequencies to the receiver. This attenuates the image and other unwanted frequencies. The helicals are factory set and should not be tuned.

Impedance matching between the helical filter and RF amplifier Q201 is provided by C203, C204 and L201. Q201 amplifies the receive signal to recover filter losses and also to increase receiver sensitivity. Biasing for Q201 is provided by R201, R202 and R203; and C208/C209 provide RF bypass. CR201 protects the base-emitter junction of Q201 from excessive negative voltages that may occur during high signal conditions. Additional filtering of the receive signal is provided by Z202. L202, and C205 provide impedance matching between Q201 and Z202. Resistor R204 is used to lower the Q of L202 to make it less frequency selective.