

# SECTION 4

## CIRCUIT DESCRIPTION

### 4.1 OPERATING VOLTAGE CONTROL

There is a programmable, Power-Off Feature which turns off the radio after a preset time of non-activity to prevent discharging of the vehicle battery. This feature is mentioned in the discussion of each circuit under its control.

Battery voltage enters the radio on the RED/BLUE battery cable. Fuses are located in this cable. D22 protects the radio from reverse voltage by causing the fuses to blow. LF1 filters noises existing on the automobile supply.

The power switch on the control unit lowers the bias on Q16 which turns on Q23 and Q15 supplying power to the radio. The switched battery voltage is regulated to 5 Volts by IC10 and supplied to all circuits which are not under control of the power-off timer.

Regulator IC13 removes impulse noise from the 12 V line and is used to switch off the power to many circuits upon input from the TIMER IN signal from the logic board at CN6-2.

Q24 filters the 12 V supply to the audio power amplifier.

Q13 and Q14 control operating voltage to an external relay at CN10-5, DECODE HORN for signaling that a call has been received. Q14 is turned on by an active high DECODE HORN input from the logic board on CN6-19. Q14-C pulls Q13-B low turning it on and supplying a voltage to the relay.

IC12 supplies a regulated 7 Volts to the circuits under control of the power-off timer. During transmit, the top half of Q12 turns off B+ to the receiver upon receiving an active high transmit command on the TX1 IN input at CN6-11. The lower half of Q12 provides an inverted active low PTT signal to the VCO at CN2-3.

IC14 provides protection from wide variations in the power supply voltage. If the voltage drops below 8 V or rises above 18 V, a STOP OUT signal is output to the logic board on CN6-3 to stop the CPU and shut down the radio.

### 4.2 RECEIVER

#### 4.2.1 RF SECTION

The received signal enters the antenna connector and passes through Low-Pass Filter made up of L20, 21, 22, 23 and C134 through C 140. The Antenna Switch, D27 and D29, directs the signal to the receiver input at L1. L1 and L2, along with Varactors D1 and D2 tune the RF section to the selected frequency using a tuning voltage from IC4 derived from the PLL circuit. Q1 amplifies the RF and feeds the signal through a bandpass filter to TP1 and on to the mixer made up of T1, T2, D5& D6. The bandpass filter eliminates signals outside the desired band. A signal from the VCO local oscillator is also input to the mixer at CN1-4 to produce the 1st IF signal, 48.5 MHz. (refer to VCO UNIT).

#### 4.2.2 VCO UNIT, RX

Q301 is the receive oscillator. It is tuned by varactors D301 and D311 using the control voltage from the PLL circuit at CN4-6. L301 is adjusted to center the oscillator range in the desired band of frequencies. The oscillator output is amplified by IC301 and Q306 and sent to the receiver mixer on *CN5-4 RX LOCAL*.

Operating voltage for the oscillators is filtered by Q308. Q304 switches voltage to the oscillator and gates Q306 amplifier on and off depending on the state of the Q305-C and the PTT line. Q303 supplies regulated voltage to IC301 in both the receive and transmit modes.

### **4.2.3 HIGH IF (48.5 MHz)**

The IF passes through Crystal Filter XF1, IF Amplifier Q3, IF Transformer T3, Crystal Filter XF2, Amplifier Q4 and on to the input of IC1 -20. IC1 uses crystal X1 to generate 45.045 MHz to convert the 1st IF of 48.5 MHz to the 2nd IF of 455 kHz.

### **4.2.4 LOW IF (455 kHz)**

The 455 kHz IF is filtered by Ceramic Filters CF1 & CF2. IC1 also limits, detects the audio and provides a squelch (BUSY) signal, an RSSI signal (Receive Signal Strength Indication) for use in other circuits of the radio. Discriminator audio leaves IC1-11 to the Audio Processor IC8-40 (see Audio Processing).

### **4.2.5 SQUELCH**

The high frequency noise from the audio is passed through FVR1 and C34 to IC1-13. FVR1 provides an internal adjustment of the squelch range. The high frequency noise present in the audio is reduced when a signal is received. IC1 amplifies and detects the noise and compares it to the squelch threshold set by the operator to produce a squelch logic (BUSY) signal at pin 17. This is buffered by IC2 and used to control the Squelch Gate IC9 which breaks the audio path when no signal is present.

Squelch control data originates in microprocessor, IC203 on the logic unit. Under control of impulses from the channel/squelch switch on the control unit, squelch data is generated by IC203 and appears on pins 41, 42, 43. These are combined to provide eight steps of squelch threshold voltage (SQ-0 thru SQ-7) which enters the main unit on CN6-13, is buffered by IC4 and goes on to the squelch circuit R26, R24, D7 to IC1-15. This voltage is compared to the detected noise level to generate the squelch logic (BUSY) signal mentioned in the last paragraph.

In the transmit mode, the voltage is removed from the receiver which causes a loss of voltage on the anode of D7. This immediately mutes the receiver.

### **4.2.6 RECEIVER MUTE**

Operating voltage for the receiver circuits described above comes from IC12, 5 Volt Regulator. Q12 switches the voltage off during PTT to mute the receiver. Also, all voltage is removed upon activation of the power-off timer.

### **4.2.7 AUDIO PROCESSING**

Discriminator audio from IC1-11 goes to the Audio Processor IC8-40. IC8, contains the audio bandpass filter, 300 to 3000 Hz, de-emphasis @ 6 dB/octave, voice inversion scrambler and CTCSS. The audio leaves on pin 12 and passes to Volume Control chip IC9-6. The volume control on the control unit changes the gain of IC9 by changing the bias on pins 3 and 5. Audio leaves IC9-7 and goes through the Squelch Gate Q10 which is controlled by the BUSY signal from the squelch circuit, the CTCSS decode from the audio processor and the DECODE signal from the logic unit. From the Squelch Gate, the audio goes to the Audio PA IC11-1. Operating voltage for the Audio PA is filtered by Q24 to minimize noise from the automobile 12 volt system. Speaker audio leaves IC11, pin 4 and is fed to CN7-3 and to the rear connector CN10-3. An external speaker may be connected between pins 3 and 1 (ground). To use the internal speaker, a jumper plug connects pins 3 and 4 allowing the audio to pass to CN4-2 & 3 and on to the Control Unit speaker through R414 and CN401 to the speaker. R414 limits the power applied to the internal speaker. Audio is also supplied to the microphone connector through R415 and CN402-12. This permits the use of a handset or another audio accessory. R415 reduces the audio level applied to the external accessory to match the volume of the speaker.

## 4.3 TRANSMITTER

### 4.3.1 TRANSMITTER AUDIO

Microphone audio enters the control unit at the microphone connector, pin 1, passes through preamplifier IC403 and out to the main board on CN4-5.

Transmit audio from an external device may be input to the interface connector on the back of the radio, CN10-6. Resistor R103 provides microphone bias if required. External audio is combined with the mic audio and enters the Audio Processor IC8-2 TX IN. Q8 mutes the microphone audio upon input from the logic board on CN6-14, MIC OFF IN. This occurs when signaling tones are being sent.

The Audio Processor contains an input amplifier, pre-emphasis, 6dB/octave, bandpass filter, amplitude limiter, splatter filter, voice inversion scrambler, output amplifier and CTCSS tone generator. The processed audio leaves on IC8-8 MOD and goes to the VCO modulation input on CN2-5. FVR2 controls the level of modulation. The gain of the internal modulation amplifier is controlled by R65 and R62. R62 is bypassed by Q26 to decrease the gain for narrow band operation. Q26 is controlled by a W/N (Wide/Narrow) input at CN5-19.

CTCSS tone from IC8-33 TX TONE is adjusted by FVR5 and combined with the voice audio. Q9 is also controlled by the W/N input and controls the tone level for Wide and Narrow band operation.

Within the VCO, the combined audio is applied to varactor diodes to modulate the transmit signal.

### 4.3.2 VCO UNIT, TX

Q302 is the transmit oscillator, It is tuned by varactors D302 (also D310 and D312, some bands) using the control voltage from the PLL circuit at CN4-6. L305 is adjusted to center the oscillator range in the desired band of frequencies. The oscillator output is amplified by IC301, Q307 and sent to the transmitter on CN5-1 TX OUT.

Audio enters the VCO at *CN4-5 MOD* and is applied to varactors D303 and D304 to FM modulate the oscillator. For widely spaced transmit channels, FVR301 is used to balance the modulation at low and high channels

Operating voltage for the TX oscillator is filtered by Q308. Q305 switches the voltage to the oscillator and gates Q307 amplifier on and off depending on the state of the PTT line. Q303 supplies regulated voltage to IC301 in both the receive and transmit modes.

A sample of the RF frequency is supplied to the PLL on CN4-4 RF.

### 4.3.3 TRANSMITTER RF

The modulated transmitter signal originates at carrier frequency in the VCO (refer to VCO UNIT) and appears on CN1-1. It is amplified by Q17, Q18 and Power Output Module PM-I, passes through the antenna switch D29 and the low pass filter to the antenna connector.

A directional coupler in the output path senses both output power (D26) and reflected power (D28). The forward power sense voltage from D26 is amplified by IC15 and is used to control series pass regulator Q19 which supplies B+ to amplifiers Q17 and Q18 and the driver section of PM-I. If the power output tends to drop due to low supply voltage or other reason, Q19 will increase the drive and maintain power. The opposite is true for an increase in power. FVR8 adjusts the high power level by adjusting the static bias on IC15. In the low power mode, Q22 is turned on by a signal (P. CONTROL) from the logic board. This connects Low Power adjustment FVR7 to IC15 to reduce the power output.

If the antenna becomes damaged or disconnected, a reverse power sense voltage appears at D28. This is applied to IC15 through Power Protect adjustment FVR9. High reflected power will reduce the output to protect the power amplifier without completely shutting the transmitter.

Operating voltage for IC15 is controlled as follows. During transmit, an active high signal from the logic board, TX2 IN, CN6-6, turns on the top half of Q11 which turns on Q21 applying voltage to IC15. An UNLOCK active high signal from the PLL circuit Q7-C controls the lower half of Q11. When the PLLNCO is out of lock, the top half is prevented from turning on. This disables the transmitter.

The power output section of PM-1 operates directly from un-switched battery voltage. Voltage is present here even if the radio is switched OFF. DISCONNECT THE BATTERY CABLE WHEN SERVICING THIS SECTION. All earlier amplifier stages operate from switched, controlled voltage which is under control of the power-off timer switch IC13.

## 4.4 PLL CIRCUIT

The PLL function is performed by IC3. Reference Oscillator OSC1 sends a 12.0 MHz signal to IC3-1 where it is divided to a reference frequency of 5.0, 10, or 12.5 kHz by counters under control of data from the logic board on pins 9, 10, and 11. A sample of the RF signal from the VCO from CN2-4 RF is applied to IC3-8. This is divided by 64 in a pre-scaler and further divided to the same 5, 10 or 12.5 kHz reference, also under control of data from the logic board. This data changes depending on the selected channel and PTT line. The two references are compared by a phase detector to produce a phase difference voltage on pin 5. Q5 and Q6 are charge pumps which are used in developing the phase difference voltage. This passes through a loop filter composed of D9, D10 and associated components and becomes the control voltage applied to the VCO at CN2-6 where it is used to vary the capacity of varactors used in tuning the oscillator frequency. This control voltage is also buffered by IC4 and is used as a tuning voltage for the receiver RF section. Switch IC5 speeds up the loop filter to allow rapid frequency shifts in the scan mode.

If the VCO is out of lock, a logic low appears at pin 7. This is inverted by Q7 and is applied to Q11 to disable the transmitter.

## 4.5 LOGIC UNIT

The radio operating firmware is programmed into the CPU, IC203, at time of manufacture. The Logic Unit provides most of the control for the radio as indicated in the various sections discussed above, using firmware stored in IC203 and data stored in memory IC201. Regulator IC205 provides 5 V to power the board. IC204 resets the Microprocessor on "power up." A manual reset may be done by shorting the two points marked RESET. These are located near IC201.

IC202 is the DTMF encoder/decoder. FVR201 adjusts the tone output level to the audio processor IC8. Tone input at CN6-16 TONE IN goes to the decoder IC202-2. This signal comes from the Audio Processor IC8-48. A successful decode is sent to the CPU and to the main unit on CN6-4 to open the Squelch Gate.

IC201 is a memory chip which stores data programmed into the radio. This includes frequencies, channel names, CTCSS/DCS, ANI, encode/decode numbers and all timer data entered during initial programming.

## 4.6 CONTROL UNIT

Please refer to the Radio Operation section for complete information on use of the various controls. The Control Unit connects at CN4. This unit contains the channel/squelch switch, volume control, keypad speaker, display, control switches for scan, monitor and shift and the microphone connector. The channel/squelch switch sends pulses to the Logic Unit to select channels or adjust the squelch. This switch is also used to select call numbers stored in memory.

Q401 supplies reduced voltage to the LCD backlight LED's. Q404 changes the brightness of the backlight under control of LED control signal from the logic board on CN4-11 LED.

IC402 supplies regulated 5 V to mic preamplifier IC403. If the radio is in the transmit mode, Q403 and Q402 hold the radio power on until the PTT is released in the event the power switch is turned off.

The keypad permits entry of DTMF or 5-Tone encode messages and various control functions. Other controls include the SHIFT which is used to change the function of various buttons, SCAN which activates the scan function and MUTE (MONITOR) which controls the decoder.

IC401 controls the LCD display using serial data from the logic board at CN3-11, 12, 13, 14.