SECTION 6

DETAILED RF TECHNICAL INFORMATION

Theory of Operation

Equipment Description

The APV series radios are portable (handheld) VHF transceivers operating in the 136 to 174 MHz band using frequency modulation. The units are designed for use in the Land Mobile Services, both domestic and foreign. They are multi-channel digitally synthesized radios using a single temperature compensated crystal oscillator. Usable channels are dealer programmable from 136 to 174 MHz in 2.5 kHz increments.

The radios are available in a sixteen-channel configuration (APV5016) with a single bank or group and in larger configurations (APV5240) using multiple banks. Channel frequency information is stored in an EEPROM with up to 15 banks of channels available to yield a capability of up to 240 channels.

The APV5240 is comprised of a main printed circuit board (PCB) assembly and a front panel display printed circuit board assembly, and the APV5016 is only comprised of a main board assembly. The main PCB consists of the micro-controller, EEPROM, transmitter, receiver, and audio circuits. The EEPROM is used to store frequencies, configurations, and other user specific information. The front panel assembly of the keyboard/display model consists of the LCD display, display controller circuit, and keypad.

Main PCB Assembly

Microprocessor Control

The Microprocessor (U12) controls the radio functions such as loading the synthesizer, detecting the keyboard and various switch modes, adjusting the transmitter and receiver circuit tuning drivers, and generating and detecting the various signaling formats.

Regulation

The 6V switching power supply U14 supplies voltage to U11 (5-Volt regulator), U13 (5-Volt regulator), U16 (5-Volt regulator), U27 (5-Volt regulator), U17 and U18 (IF analog switches), and to U15 (Sub-IF IC).

U11 supplies 5 volts to U12 (Microprocessor), U4 (D/A converter), U8 (EEPROM) and to all the controlling and logic switching circuits.

U13 supplies 5 volts to the various RX audio circuits such as U1 (Audio LSI), U7 (DTMF Receiver), and the various op amps associated with these circuits.

U16 supplies 5 volts to Q13 (IF amplifier) and to U19 (pre-selector tuners).

U27 supplies 5 volts to G1 (TCXO), U21 (Synthesizer ASIC), U29 (Phase Detector), U30 (Loop Filter) and, U31 (Pre-scalar).

Synthesizer

U21 is a 44pin QFP Synthesizer ASIC IC. It provides highly stable, low noise, frequency source for 2.5 kHz, 5 kHz, and 6.25 kHz channel spacing resolution. The ASIC includes a Reference Divider, Phase Accumulator, Digital Compensation, Phase Detector, and CPU interface and decoder. The synthesizer is a Fractional-N type based on the 3rd order loop of the ASIC design.

The phase detector including U28 provides a DC voltage that is proportional to the phase error between the divided down frequency from the ASIC and the divided down carrier frequency. This voltage is fed to the loop filter and then to the VCO. This error correction voltage causes the VCO frequency adjustment in a direction to maintain phase lock between the divided down frequency.

The synthesizer employs a two-point modulation scheme. One modulation point leads to the VCO and the other point leads to the phase detector. The phase detector modulation point allows true data to be modulated.

TCXO

The hybrid 12.8 MHz temperature compensated crystal oscillator (G1) is fed into he ASIC as the reference oscillator for all frequency synthesis. The hybrid design with temperature compensations provides less than +/- 2.5ppm of drift between -30°C and +60°C.

The ASIC divides the reference into other external references such as 8 MHz for U12 (Microprocessor), 320 kHZ/349 kHz for U14 (Switching Regulator).

Prescaler

The “dual modulus” prescaler U31 is the frequency divider in the feedback path of the synthesizer.

Loop Filter

The loop filter including U30 removes noise and unwanted frequency components from the output of the phase detector (U29). The synthesizer employs a multiple filter bandwidth design, thus, optimizing the filter response during steady state or scanning modes.

VCO

Q27 and Q28 are the TX/RX VCO’s. They are configured as a Colpitts, low phase noise type oscillators. Each VCO has a Coarse and Fine voltage tune line leading in from the synthesizer to varactors diodes CR41-48. VCO selection is through PUMX transistors Q25 and Q26. The transmitter audio is fed to CR67 and CR40 for VCO modulation.

Receiver Section

The receive signal from the antenna connector is fed through the harmonic filter and split from the TX path to the RF amplifier (Q12) and pre-selectors. “Tuner” voltage amplifiers of U19 tune the pre-selector varactors CR18-CR33 for the desired selectivity. The RF signal is then mixed with the RX LO drive signal from the VCO. The major components of the active mixer consist of T1, T2, and Q14-17. From the mixer, the 16.9 MHz “resulting” IF frequency is filtered through FL1 a 4-pole crystal filter. The IF signal is then amplified by Q13 and fed into the 2nd mixer input of U15 of the sub-IF IC.

U15 includes the 2nd mixer, 2nd IF amp, “Limiter”, and “Quadrature”. The 16.445 MHz 2nd LO crystal Y2 is connected to the oscillator input/output for 2nd LO mixing. Ceramic filters FL3, FL4, FL8, and FL9 provide 2nd IF wide and narrow band filtering through the respective ports of U15. The discriminated audio output from pin 8 is split off into two circuit directions. One path delivers a discriminator voltage used for calibration and the other path leads to audio processing circuits and to U1 the Audio LSI IC.

Audio

The receiver audio from the discriminator is split again and filtered before being processed in the Audio LSI IC. One path (voice) is connected to a 300Hz high pass filters including U5 and U10 before the LSI processing. The other path (sub-audio) is connected to a 250 Hz sub LPF including U5 to pass the sub-audio tones to the DC restoration circuit including U34 and CR2-3. The squared wave from the restoration circuit is fed into a comparator within the LSI and then back out to the microprocessor for decoding.

Within the LSI, a portion of the HP audio is filtered as noise for noise squelch usage and a portion is filtered and amplified as audio. After being filtered the, audio exits the LSI and routed to U6 for final audio amplification. De-emphasis occurs outside the LSI by R44 and C29.

The transmitter audio from the internal microphone is ejected into the audio LSI, switched by an internal mux, and routed back out through the same 300 Hz high pass filter including U5 and U10 that is used for the receiver audio. After the HPF, pre-emphases of the TX audio occurs by C359 and R336 before passing through gain/clipper circuit of U34. At this point, the audio re-enters the Audio LSI, passes through a clipper circuit, a 3KHz low pass filter circuit, and a modulation limiting circuit before it exits the Audio LSI IC to the VCO Mod input circuit.

A portion of the transmit audio from the external microphone takes the same path of that of the internal audio signal and a portion is split away for VOX (voice operated transmit) detection. The VOX detection and voice compression occurs through op-amp circuits of U3 before entering the Audio LSI for processing of the VOX interrupt and VOX PTT signals.

The audio tones and data signals are injected at the same point where the voice audio signal enters the gain/clipper circuit of U34.

Processed receiver audio from the Audio LSI IC is sent to the BTL amplifier, IC U6, for hi level amplification and volume control. The audio amplifier delivers up to 500 mw of audio power (with less than 5% distortion) across the 32-ohm speaker. Volume control occurs as the volume potentiometer changes a 5 volt control voltage that is processed through the microprocessor, U12, and sent to the volume control port of U6.

Transmitter Section

The transmitter drive from the VCO is amplified through pre-driver Q21, driver U24, and PA Module PA1. PA1 delivers up to 5 watts of Rf output to the antenna connector. Approximately 30 mw of power is required at the input of PA1 to produce the rated output. RF output from PA1 is sampled by T3, rectified by CR34, fed to the power control circuit of U23, and then to the gain control input of PA1. This feedback loop stabilizes the power out from the PA module as well as controls the level of power being produced by the PA module.

The power control signal from the digital/analog converter IC, U4, drives the two power control circuits of U23. One circuit controls the TX drive level from the VCO and the other controls the amount of power control feedback that is delivered to the PA module. Harmonic filter, L37- L39 and C311-C318, suppress harmonicas by greater than 70dB.

Font Panel PCB Assembly (APV5240 Only)

Eight bit serial data from the microprocessor is converted to a parallel output via U3. U3 also detects switch closures from the keypad.

Display driver U1 interprets the parallel output data coming from U3. The display driver controls all the respective segments of the display. The LCD has 14 characters (each being an 8 x 5 dot matrix) and 8 icons. The external reference oscillator (555 timer, U1) provides a 260 kHz reference for the display driver.

Q1-Q10 provides the switching and current drive for keypad and LCD back-lighting LED's DS1-DS12.