TECHNICAL DESCRIPTION
PR4000 WX
FCC ID: BBOPR4000WX

December 6, 2002

A). GENERAL DESCRIPTION

The PR4000 WX radio is a self-contained transceiver unit intended for use as a general communication tool. The PR4000 WX model is a combination FRS/GMRS unit and has 22 channels of which channels 1-7 share the FRS channels 1-7. The PR4000 WX has the capability of switching transmit power .5W, 2W and 3W with FRS channels 8-14 limited to .5W only. Other features include a CTCSS system with 38 pre-defined, user selectable sub-audible tones for channel quieting. The useable range, while dependent upon terrain, power setting and other radio propagation principles, is typically seven miles based on the transmit power specified at 3 watts ERP and 2 miles based on the transmit power of 1/2 watt ERP. Product features are as follows:

MODEL	PR4000WX
FEATURES	
Number of Channels	22
CTCSS SubCodes	38
Range (Low Power)	2 Miles
Range (Medium Power)	5 Miles
Range (High Power)	7 Miles
Alkaline Battery Source	4 AA
Weather Channels	10
Transmitter Output Power	0.5/2/3 W
Channel Indicator	LCD
Backlit LCD	Yes
Detachable Antenna	No
Call/Ring Alert	10 Tones
Auto Squelch	Yes
Internal VOX	Yes
Automatic Battery Save	Yes
Auto Channel/User State Saver	Yes
Channel Scan Function	Yes
Channel Monitor	Yes
Key Lock	Yes
Supports NiMH Battery Source	Yes
Low Battery Alert and/or Gauge	Both
Water Resistant	Yes
Headset Jack	Yes
On/Off/Volume	Rotary
Belt Clip Included	Yes
Chg Contacts on radio bottom	Yes

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B). FREQUENCY DETERMINING CIRCUITS

The fundamental frequency for both the transmitter and the receiver local oscillators are controlled by a phase lock loop (PLL) circuit U300 (Toshiba TB31202). The frequency of operation of the voltage controlled oscillator (VCO), composed of Q50 and Q51 operating in cascode, is phase locked to a voltage controlled crystal reference (VCXO) operating at 10.475 MHz (X300). Compensation for temperature variations on the crystal reference is accomplished using a thermister (TH300) to change the reactance of the reference crystal circuitry. Compensation for voltage variations on the crystal reference is accomplished through a supply voltage regulator

The VCO is locked to the fundamental of the transmit signal in the transmit mode and is locked to the receive 1st LO (Fundamental channel frequency minus 21.4 MHz) in the receive mode. The crystal reference frequency is fed through a doubler circuit to generate the 2nd LO of 20.950 MHz.

C). TRANSMITTER CIRCUITS

The transmitter amplifies the 0 dBm signal from the VCO to approximately 34.8dBm that is fed to the antenna. The transmitter is a three stage amplifier composed of Q200, Q201 and Q202. The first stage is operated class A, and the driver and final is operated class AB. The fundamental transmit signal is fed through a low pass filter in order to suppress the harmonics to below –60 dBc. Transmit power level setting is controlled by the micro-controller (U400). When pin 88 of U400 is driven to a logic low level Q200 is biased for 0.5W-conducted and 2W-conducted operation. When pin 88 of U400 is not driven by U400 to a logic level low Q200 is biased for 3W-conducted output mode. When pin 88 of U400 is driven low for 0.5W-conducted or 2W-conducted operation pin 11 of U400 is driven to a logic level high to drive Q203 to turn on D201 to change the matching network load condition to cause the transmitter to output 0.5W-conducted power. The desired frequency modulation of the carrier is accomplished by modulating the current in the VCO directly with the microphone audio signal. The microphone audio is conditioned with a three-pole high pass filter at 300 Hz (U230-C), a hard clipper circuit (U230-B) to limit maximum deviation to +/-2.5 kHz and a three-pole low pass or splatter filter at 2.7 kHz (U230-A). The low pass filter insures that the occupied bandwidth of the FM modulated signal meets FCC requirements under all input conditions.

D). RECEIVER CIRCUITS

The received signal from the antenna is band limited to 600 Mhz by the transmitter harmonic filter. The desired signal is fed to a low noise amplifier (LNA – Q101) centered from 460 to 470 MHz that provides approximately 15 dB of gain. The output of the LNA is filtered with a SAW filter (SF100) with passband of 460 to 470 MHz and stopband attenuation of 50 dB. The filtered receive signal is one input to the 1st mixer, the other mixer input (1st LO) is the output of the VCO at the desired channel frequency minus 21.4 MHz. The output of the mixer is tuned to the 1st IF of 21.4 MHz. The 1st IF fed to a crystal filter centered at 21.4 MHz with a bandwidth of 15 kHz. The filtered 1st IF is then amplified by Q103 and fed to the 2nd mixer input of the multi-function receiver IC (U130). The 2nd LO (20.95 MHz) is generated by the 10.475 MHz VCXO that is the reference frequency for the PLL. The 2nd mixer output of 450 kHz is filtered through a 6 section ceramic filter that in combination with the 21.4 MHz crystal filter provides approximately 55 dB of adjacent channel attenuation. The 450 kHz 2nd IF is then amplified, limited and fed to a quadrature detector for FM demodulation. The resulting audio output signal is bandpass filtered from 300 to 3 kHz (U150-A, U150-B) and amplified to provide 350 mW of audio power (U160), which differentially drives the 16 ohm speaker. A squelch circuit is provided (U130 pins 10 through 14) to mute

the receiver noise under low signal conditions. The squelch circuit amplifies and detects noise in a narrow bandwidth at approximately 7 kHz. When the detected noise exceeds a threshold set to trigger at approximately 12 dB SINAD receive signal strength, the audio output is muted.

E). WEATHER RADIO SECTION

The weather radio mode is controlled by data sent to U300 from micro-controller (U400). When the weather radio mode is selected the micro-controller (U400) switches Q301 on applying +3.8V to bias PIN diode D350. This causes the receive path to be switched to the weather radio LNA. The receive signal is applied from the antenna and is band limited to 166 MHz by the transmitter harmonic filter. The desired signal is fed to the low noise amplifier (Q350) centered from 161 to 164 MHz that provides approximately 8dB of gain. The output of the LNA is filtered with an impedance matching network (C353 and L351) with band pass of 161 to 164 MHz. The filtered receive signal is the input to the base of mixer (Q102). The LO is coupled to the emitter of the mixer (Q102) through C117. The LO is the VCO output at the desired channel frequency minus 21.4 MHz. The output of the mixer is tuned to the 1st IF of 21.4 MHz.

F). TRANSMIT/RECEIVE SWITCH

When the radio is in the transmit mode, pin diode switches D100 is turned on (representing less than 0.7 ohms). The transmit signal to pass to the antenna and D100 shorts one leg of a Pi matching network (C2,L100, and C104) to ground in the receive path. This results in a parallel tuned circuit high impedance being presented to the transmit signal so that the receive path does not load the transmit signal. In the receive mode D100 is off, resulting in the antenna signal being coupled into the receive LNA through the 50 ohm Pi matching network and the unwanted load of the transmit final amplifier is reduced to less than 1 pF by Q200 being turned off.

G). RADIO CONTROL CIRCUIT

A microprocessor (U400) is used to control the transceiver. User stimulus is provided through a tack switch for PTT (push to talk), along with the keypad for channel selection, channel monitor, call, mode, compass power level and lock. Pressing the PTT switch instructs U400 to switch to the transmit mode. This is accomplished by loading the proper channel counter information through a 3-wire serial link to the PLL IC (U300), turning on power to the PLL and VCO, microphone and transmit audio circuits and the transmit RF amplifiers. Pressing the channel Up/Down buttons instructs U400 to increment or decrement respectively the channel frequency by one channel from the channel previously selected.

In receive mode the microcontroller periodically switches on the VCO and receiver power and checks for a valid received signal by monitoring the squelch circuit output. If a valid signal is present, the audio output is turned on and receive power is maintained for the duration of the valid signal. If the valid signal is removed or no valid signal is present, the microcontroller removes power from the VCO and receiver, waits for approximately 100 ms and then checks again. This periodic cycling of the power to the receiver circuits results in a much longer battery life vs. leaving power on continuously. The total period of the cycling is selected such that the worst-case delay in ‘seeing’ a valid receive signal is not disruptive to normal two-way voice communications.