Ray240 RF PCB Circuit Description

The RF PCB is the FM transmitter and receiver section for the Ray240 marine VHF radio with Class "D" digital selective calling, and has one transmitter, one 'channel selectable' receiver (for audio purposes) and one fixed frequency receiver which is used solely for the reception of digitally encoded messages on Channel 70. The radio can only be in either a transmit or receive mode, and cannot do both at the same time. As a result of this, there is a central VCO/Synthesiser whose output is used as the transmit carrier when the radio is transmitting and LO for the first down converter for the Channel selectable receiver. Below is brief summary detailing the main performance criteria of the radio.

Power Supply	
Supply voltage +12V	Rx mode: 200 mA Max., Tx mode: 6 A Max
Supply voltage +5V	10 mA Max
Transmitter	
Transmitter Frequency Range	155.00 to 165.00 MHz with 25 kHz channel spacing
Transmitter Output Power	25 Watts, switchable to 1 Watt
Modulation	Frequency modulated at 16F3 (±4.5 kHz at 1kHz)
Receiver	
Receiver Frequency Range	155.00 to 163.275 MHz with 25 kHz channel spacing
Receiver Usable Sensitivity	-3 dbμV (emf) or –116 dBm
Channel selectable 1st IF	21.4 MHz
CH 70 1st IF	16.9 MHz
Channel selectable and CH70 2nd IF	455 kHz

The RF PCB goes through an electronic alignment/set up procedure, and the resulting data from this alignment process is stored in an EEPROM located on the PCB.

VCO/synthesiser

The VCO is phase locked to a 21.85 MHz crystal oscillator by using an LMX2306 synthesiser from National Semiconductor. The frequency of the reference oscillator is fine tuned with a varacter diode. The voltage across the diode is controlled be a D/A converter.

The synthesiser is programmed (via an SPI link) to enable the VCO to change its output frequency in 12.5 kHz steps. When the radio is transmitting, the VCO operates between 155.000 MHz and 165.000 MHz, and when the radio is in receive mode, operates between 133.600 MHz and 141.875

MHz. Digital signals control the band of operation of he VCO, by switching in/out capacitors in the VCO circuitry.

The synthesiser controls the frequency of the VCO by altering a voltage level on a varacter diode. To reduce the phase noise in the adjacent channel, this tuning voltage is kept between 3 and 4 volts. This tuning voltage is coarsely controlled by the switched capacitors mentioned above and another varacter diode, which is controlled by a D/A converter.

The output of the VCO is switched between the transmit chain and the mixer in the Channel Selectable receiver.

Transmitter

The transmit chain is comprised of two amplifiers. Firstly a buffer amplifier is used to increase the power of the signal from 0 dBm to +18 dBm. This amplifier is heavily compressed to ensure the input power to the main PA module remains constant. This signal is then amplified by the main PA module to either 1Watt (+30 dBm) or 25 Watts (+44 dBm), with an RA35H1516M power amplifier module from Mitsubishi. This device has a gain control pin, which in conjunction with an automatic power control loop, controls the output power of the radio

Antenna switch/filter

A PIN diode switch connects the antenna connector of the radio to either the transmitter or the receiver. To ensure the receiver is not damaged when the radio is transmitting at 25 Watts, the switch has a high degree of isolation between the transmitter and the receiver. The antenna terminal of this switch is connected to a low pass filter. This ensures that the harmonics of the output signal from the Mitsubishi amplifier are attenuated to a level less than 0.25 μW (–36 dBm).

Receiver

The receiver port of the antenna switch is connected to a bandpass filter and a low noise amplifier. The bandpass filter is tuned to 160.000 MHz and has a 3 dB bandwidth 10 MHz. This filter prevents the LNA from being saturated by large out of band signals.

The output signal of the LNA is then split between the channel selectable receiver and the CH70 receiver. An attenuator can be switched into the channel selectable path allowing the user to desensitise the radio when in the presence of high power signal levels

Both the receivers are comprised of the same blocks, and these are described below.

Bandpass filters and LNA

The main purpose of the bandpass filter is to attenuate the 1st image frequency of the receiver. This is defined as *Nominal frequency of the receiver – (2x 1st IF frequency).*

As the nominal frequency of the channel selectable receiver can change, the bandpass filter has the ability to be tuned accordingly. This is achieved by four varacter diodes, which are controlled by voltages generated by the processor PCB.

The filters for the CH70 receiver are tuned using the method mentioned above, however these voltages remain at a fixed level. The processor PCB also generates these voltages.

Mixer

The received signal is down converted to the 1st IF by mixing it with an LO frequency.

For the channel selectable receiver, the LO signal is generated by the VCO/Synthesiser. The nominal frequency of the receiver is defined as *LO Frequency + 1st IF Frequency*

For the CH70 receiver, the LO signal is generated by a crystal controlled oscillator at 46.524 MHz, and then tripled to produce the 139.625 MHz signal.

Crystal bandpass filter

The crystal filters have a centre frequency equal to the 1st IF frequency of the receiver. These filters are designed to attenuate two different frequencies. The 2nd image frequency of the receiver is attenuated by this filter, which is defined as *Nominal frequency of the receiver – (2x 2nd IF frequency).*

The filters also attenuates signals >25 kHz away from the nominal frequency of the receiver (ie the adjacent channel).

Detector IC

The outputs of the crystal filters are connected to a BA4116FV detector IC from Rohm. This device down converts the 1st IF frequency to the 2nd IF frequency by using a crystal oscillator. This down converted signal is then demodulated by a quadrature detector to produce the received audio signal

This device has an output pin whose voltage is relative to how noise the received signal is. This voltage is used by the processor PCB to determine whether the squelch should be opened or closed.