Circuit Description

The **HX470S** consists of RF UNIT, CNTL UNIT, VCO UNIT and AF UNIT. The RF UNIT contains the receiver front end, PLL IC, power and switching circuits, and the VCO UNIT for transmit and receive local signal oscillation. The CNTL UNIT contains the CPU, and audio ICs, and the power circuitry for the LCD. The AF UNIT contains the IF, and audio ICs.

Receiver Signal Flow

The **HX470S** includes three receiver front ends, each optimized for a particular frequency range and mode combination.

Triplexer

Signals between 0.5 and 1.8 MHz received at the antenna terminal pass through a first low-pass filter composed of L1041, L1001, C1203 and C1007.

Received VHF bands signals, after passing through a low-pass filter to the VHF T/R switch circuit composed of diode switch **D1033** (**RLS135**), **D1034** (**1SV307**).

Received UHF bands signals, after passing through a low-pass filter to the UHF T/R switch circuit composed of diode switch **D1030** (**RLS135**) and **D1031** (**1SV307**).

VHF Bands Reception

Received VHF bands signals pass through the Triplexer circuit, low-pass filter/high-pass filter circuit, VHF T/R switch circuit and protector diode **D1002** (**1SS362**) before additional filtering by a band-pass filter prior to application to RF amplifier **Q1002** (**2SC5555**). The amplified RF signal is pass through the band-pass filter to first mixer **Q1006** (**2SC5555**). Meanwhile, VHF output from the VCO UNIT is amplified by **Q1011** (**2SC5374**) and applied through diode T/R switch **D1022** (**DAN222**) to mixer **Q1006** as the first local signal.

The 47.25 MHz (WFM: 45.8 MHz) intermediate frequency product of the mixer is delivered to the AF UNIT.

The TUNE-voltage from the CPU on the CNTL UNIT is amplified by DC amplifier **Q3014** (**NJU7007F2**) and applied to varactors **D1008** and **D1010** (both **HVC369B**), **D1007**, **D1009**, **D1011**, **D1012**, **D1013**, and **D1019** (all **1SV325**) in the variable frequency band-pass filters. By changing the electrostatic capacitance of the varactors, optimum filter characteristics are provided for each specific operating frequency.

UHF Band Reception

Received UHF bands signals pass through the Triplexer circuit, low-pass filter/high-pass filter circuit, UHF T/R switch circuit and protector diode **D1001** (**1SS362**) before additional filtering by a band-pass filter prior to application to RF amplifier **Q1001** (**2SC5555**). The amplified RF signal is pass through the band-pass filter, RF amplifier **Q1003** (**2SC5555**) and band-pass filter to first mixer **Q1005** (**2SC5555**). Meanwhile, UHF output from the VCO UNIT is amplified by **Q1010** (**2SC5374**) and applied through diode T/R switch **D1021** (**DN222**) to mixer **Q1005** as the first local signal.

The 47.25 MHz intermediate frequency product of the mixer is delivered to the AF UNIT.

0.5 - 1.8 MHz Reception

Received MW signals pass through the Triplexer circuit, low-pass filter circuit, protector diode **D1005** (**1SS362**) before additional filtering by a band-pass filter prior to application to RF amplifier **Q1004** (**2SC4915**). The amplified RF signal is pass through the band-pass filter to first mixer **Q1007** (**2SC4915**). Meanwhile, MW output from the VCO UNIT is amplified by **Q1012** to mixer **Q1007** as the first local signal.

The 47.25 MHz intermediate frequency product of the mixer is delivered to the AF UNIT.

The TUNE voltage from the CPU on the CNTL UNIT is amplified by DC amplifier **Q3014** and applied to varactors **D1013** (**HVR100**) in the variable frequency band-pass filters. By changing the electrostatic capacitance of the varactors, optimum filter characteristics are provided for each specific operating frequency.

First Intermediate Frequency (Narrow FM / AM)

The 47.25 MHz first intermediate frequency from first mixers is delivered from the RF UNIT to the AF UNIT through jacks J1003 and J2002. On the AF UNIT, the IF for AM and FM-narrow signals is passed through NAR/WIDE switch **D2001** (**DAP222**) and 47.25 MHz monolithic crystal filter (MCF) **XF2001** to narrow IF amplifier **Q2002** (**2SC4915**) for input to pin 16 of Narrow IF IC **Q2013** (**TA31136FN**) after amplitude limiting by **D2002** (**DA221**).

Meanwhile, a portion of the output of 11.7 MHz crystal **X1001** on RF UNIT is multiplied fourfold by **Q2005** (**2SC4915**) and **Q2010** (**2SC4154E**) to provide the 46.8 MHz second local signal, applied to the Narrow IF IC. Within the IC, this signal is mixed with the 47.25 MHz first intermediate frequency signal to produce the 450 KHz second intermediate frequency.

This second IF is filtered by ceramic filter **CF2002** (**ALFYM450F=K**) and amplified by the limiting amplifier within the Narrow IF IC before quadrate detection by ceramic discriminator **CD2001** (**CDBM450C7**).

Circuit Description

Demodulated audio is output from pin 9 of the Narrow IF IC through narrow mute analog switch **Q2020** (**2SJ364**) and squelch gate **Q2026** (**2SJ364**) before de-emphasis at **Q2019** (**DTC144EE**).

The resulting audio is amplified by AF amplifier **Q2028** (**TDA7233D**) and output through MIC/EAR jack J2001 to internal speaker SP1001 or an external earphone.

First Intermediate Frequency (Wide FM)

The 45.8 MHz first intermediate frequency from first mixers is delivered from the RF UNIT to the AF UNIT through jacks J1003 and J2002. On the AF UNIT, the IF for Wide FM signals is passed through NAR/WIDE switch **D2001** (**DAP222**) and IF amplifier **Q2004** (**2SC4915**) and second mixer **Q2009** (**2SC4915**).

The 10.7 MHz intermediate frequency product of the mixer is delivered to the 10.7 MHz ceramic filter **CF2001** passed through NAR/WIDE switch **D2002** (**DAN222**) for input to pin 16 of IF IC **Q2013** after amplitude.

Meanwhile, a portion of the output of 11.7 MHz crystal **X1001** on RF UNIT is multiplied fourfold by **Q2007** (**2SC4915**) to provide the 35.1 MHz second local signal, applied to the second mixer **Q2009**. Within the second mixer, this signal is mixed with the 45.8 MHz first intermediate frequency signal to produce the 10.7 MHz second intermediate frequency.

Also, a portion of the output of 11.7 MHz crystal **X1001** on RF UNIT is amplitude by **Q2005** and **Q2010** to provide the 11.7 MHz third local signal, applied to the IF IC **Q2013**. Within the IC, this signal is mixed with the 10.7 MHz second intermediate frequency signal to produce the 450 KHz second intermediate frequency.

Demodulated audio is output from pin 9 of the Narrow IF IC through narrow mute analog switch **Q2020** and squelch gate **Q2026** before de-emphasis at **Q2019**.

The resulting audio is amplified by AF amplifier **Q2028** and output through MIC/EAR jack J2001 to internal speaker SP1001 or an external earphone.

Squelch Control

Signal components in the neighborhood of 15 KHz contained in the discriminator output pass through an active band-pass filter composed of R2059, R2060, R2062, C2076, C2078 and the operational amplifier between pins 7 and 8 within IF IC **Q2013**. They are then rectified by D2006 and **D2007** (**MC2850**) to obtain a DC voltage corresponding to the level of noise. This voltage is input to pin 51 of CPU **Q3023** (**HD64F2238RTF13**), which compares the input voltage with a previously set threshold. When the input voltage drops below the threshold, normally due to the presence of a carrier, turning on squelch gate **Q2026** and allowing any demodulated audio to pass. At the same time, **Q3001** and/or **Q3003** and/or **Q3004** goes on, causing the BUSY/TX lamp **D3010** (**FRGB1312CE-10-TF**) to light.

Transmitter Signal Flow

VHF Band Transmit/Receive Switching

Closing PTT switch S2002 on the AF UNIT pulls the base of **Q3008** (**DTA144EE**) low, causing the collector to go high. This signal is input to pin 41 (PTT) of CPU **Q3023**, allowing the CPU to recognize that the PTT switch has been pushed. When the CPU detects closure of the PTT switch, pin 17 (TX/RX) goes high. This control signal is delivered to the RF UNIT, where it switches **Q1029** (**UMW1**) and **Q1028** (**CPH6102**) to produce the TX control signal that activates **Q1035** (**2SA1774**). At the same time, PLL division data is input to PLL IC **Q1013** (**MB15A01PFV1**) from the CPU, to disable the receiver power saver. Also, switching **Q1033** (**KRC654U**) to disable the receiver circuits. Then causing the red side of BUSY/TX lamp **D3033** to light.

Modulation

Voice signal input from either built-in microphone MC1001 (EM-140) on CNTL UNIT or external jack J2001 on the AF UNIT is pre-emphasized by C3011 and R3025, and processed by microphone amplifier **Q3006** (**NJM3403AV**), IDC (instantaneous deviation control) circuit to prevent overmodulation, and active low-pass filter.

During CTCSS operation, the voice signal is mixed with the TONE ENC subaudible tone signal from pin 43 of the CPU and delivered to the RF UNIT through jacks J3003 and J1003.

VHF Band Transmission

Modulating audio from the CNTL UNIT passes through deviation setting D/A converter **Q3010** to VHF MOD of the VCO UNIT mounted on the RF UNIT. This signal is applied to varactor **D4005** (**HSC277**) in the tank circuit of VHF VCO **Q4004** (**EC3H07B**), which oscillates at the desired VHF transmitting frequency. The modulated VCO signal is buffered by amplifier **Q4006** (**EC3H07B**) and **Q1011** and delivered through VHF T/R diode switch **D1022** to the RF UNIT. The modulated low-level VHF transmit signal from the VCO is passed through diode switch **D1024** (**DAN222**) to amplifier **Q1008** (**2SC5226-5**). The modulated VHF transmit signal from the VCO is amplified by **Q1016** (**2SK3475**) and RF power amplifier **Q1019** (**2SK3476**) up to 5 W (Marine). The RF output passes through TX diode switch **D1033**. RF output is passed by T/R switch and low-pass filter to suppress harmonics and spurious products before output to the antenna at the antenna terminal.

Circuit Description

UHF Band Transmission

Modulating audio from the CNTL UNIT passes through deviation setting D/A converter **Q3010** to UHF MOD of the VCO UNIT mounted on the RF UNIT. This signal is applied to varactor **D4002** (**HSC277**) in the tank circuit of UHF VCO **Q4002** (**EC3H07B**), which oscillates at the desired UHF transmitting frequency. The modulated VCO signal is buffered by amplifier **Q4006** and **Q1010** and delivered through UHF T/R diode switch **D1021** to the RF-UNIT. The modulated low-level UHF transmit signal from the VCO is passed through diode switch D1024 to amplifier **Q1008**. The modulated UHF transmit signal from the VCO is amplified by **Q1016** and RF power amplifier **Q101**9 up to 0.5 W (FRS). The RF output passes through TX diode switch **D1030**. RF output is passed by T/R switch and low-pass filter to suppress harmonics and spurious products before output to the antenna at the antenna terminal.

PLL Frequency Synthesizer

PLL IC **Q1013** on the RF UNIT consists of a data shift register, reference frequency divider, phase comparator, charge pump, intermittent operation circuit, and band selector switch. Serial PLL data from the CPU is converted into parallel data by the shift register in the PLL IC and is latched into the comparative frequency divider and reference frequency divider to set a frequency dividing ratio for each. An 11.7 MHz reference signal produced by **X1001** is input to REF pin 1 of the PLL IC. The internal reference frequency divider divides the 11.7 MHz reference by 2,050 (or 1,640) to obtain a reference frequency of 5 kHz (or 6.25 kHz), which is applied to the phase comparator. Meanwhile, a sample of the output of VHF VCO **Q4004** or UHF VCO **Q4002** on the VCO UNIT, buffered by **Q4006**, is input to the PLL IC, where it is frequency-divided by the internal comparative frequency divider to produce a comparative frequency also applied to the phase comparator. The phase comparator compares the phase between the reference frequency and comparative frequency to output a pulse corresponding to the phase difference between them. This pulse is input to the charge pump, and the output from the charge pump passes through a loop filter composed of L1018, R1054, C1096, and either R1055, C1110, R1065 and C1113 for VHF, or R1051, C1107, R1064 and C1112 for UHF, or R1056, C1111, R1066 and C1114 for MW band, which convert the pulse into a corresponding smoothed varactor control voltage (VCV). The VCV is applied to varactor **D4004** and **D4013** (**1SV325**) in the VHF VCO tank circuit, or to varactor **D4001** (**HVC355B**) in the UHF VCO tank circuit, or to varactor **D4007** (**1SV325**) in the MW band VCO to eliminate phase difference between the reference frequency and comparative frequency, and so locking the VCO oscillation frequency to the reference crystal. The VCO frequency is determined by the frequency-dividing ratio sent from the CPU to the PLL IC. During receiver power save operation, the PLL circuit operates intermittently to reduce current consumption, for which the intermittent operation control circuit reduces the lock-up time.