UHF COMMUNICATION SYSTEM

GENERAL

Two complete and independent systems are installed providing the air crew with UHF radio communications with other aircraft or ground facilities.

These systems, because of their operating frequencies, will be subject to line-of-sight characteristics and the maximum range will depend on the altitude of the aircraft.

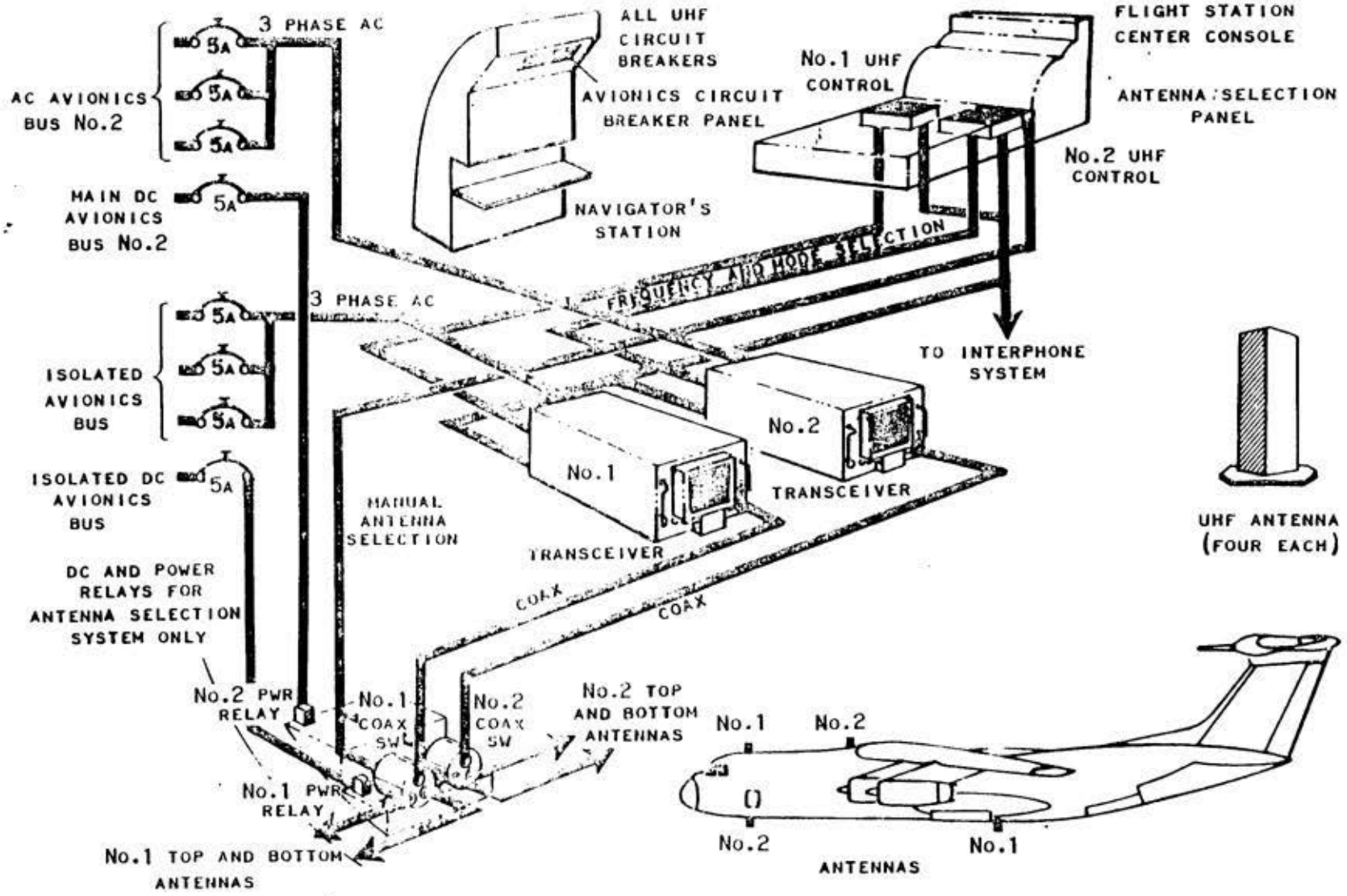
AIRCRAFT INSTALLATION

The aircraft installation diagram will show locations and general cabling of the systems components. Those components are as follows:

- Transceiver — RT-641/ARC-90
- Control Panel — C-3894A/ARC-90
- Antenna Coaxial Switch — SA-521/A
- Antenna — AT-256A/ARC
- Antenna Selection Panel

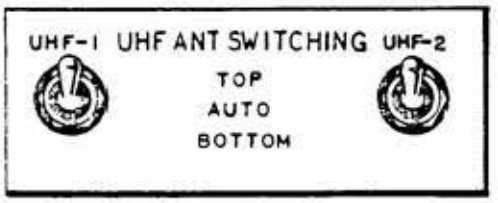
SYSTEM OPERATION

Since each system is independent of the other, operation of only one system will be discussed.

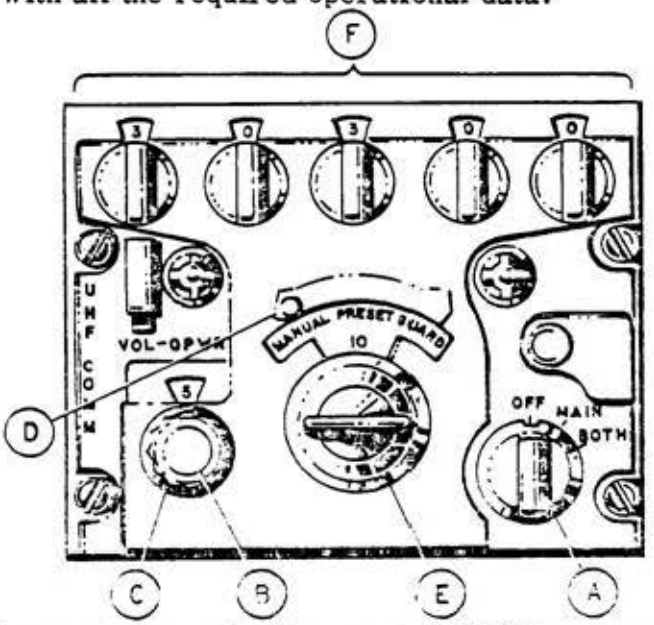


AIRCRAFT INSTALLATION

The three position toggle switches on the antenna selector panel will determine the antenna used for transmission and reception. (Automatic antenna selection has been disabled.)



The control panel provides the transceiver with all the required operational data.



The (A) knob on the control panel, when set to "MAIN", activates the main receiver. Knob (B) adjusts the volume of the receiver audio to the interphone system. To receive and transmit the interphone rotary switch must be set to the UHF system being operated.

The main receiver and transmitter sections of the transceiver are always tuned to the selected frequency. Three modes of frequency selection are possible with knob (D).

With knob (D) in "MANUAL" position the (F) knobs are activated permitting manual frequency selection. Do not select below 225.00 with the five manual knobs.

The operating frequency appears in the (F) windows. With the (D) knob in "PRESET" position the (F) knobs are inoperative and the (E) knob is in control.

The (E) knob has channel numbers, not operating frequency, appearing in the PRESET window. Twenty channels are available. (The operating frequency of

each channel may be changed from the bottom side of the control panel.) With the (D) knob set to "GUARD" position the main receiver and transmitter are tuned to the "guard" or "emergency" frequency. No channel or frequency display occurs in this mode.

The "BOTH" position of knob (A) activates an additional guard receiver which is permanently tuned to the emergency frequency. Knob (B) also affects the guard receiver volume. The operation of this receiver does not affect or is not affected by any other operation of the control panel. However both receivers are disabled during transmission. Both receivers and the transmitter are disabled during tuning. When the operator changes frequency or channels by any mode the transceiver tuning is started. Transceiver tuning is indicated to the operator by a 400 Hz audio tone in the headsets. When the tuning cycle is completed the tone ceases. Transmission is provided by pressing the interphone mic button and speaking into the microphone. Releasing the button provides reception.

NOTE: Knob (C) must be set to position 10 for full transmission power. This knob's function will be discussed in detail in Specifications and Block Diagram Operation sections of this chapter.

With the tone button cover removed, tone transmission is accomplished by pressing the button.

ARC-90 UHF RADIO COMMUNICATIONS SYSTEM

CHARACTERISTIC	SPECIFICATION
Number of Channels	3500
Number of preset channels	20 on preset drum 1 on guard channel
Frequency accuracy and stability:	
Main receiving system	±5.6KHz
Transmitting system	±3.6KHz
(With external modem)	±600Hz
Guard receiver	±5.0KHz
Channel tuning time	6 seconds (maximum)
Frequency range	225.00 to 399.95 MHz
Channel separation	50 KHz
Carrier output power	30 watts (minimum) internal modem 75 watts (minimum) external modem
Power output control	0 - to 86-db attenuation in 10 steps
Receiving system bandwidth	
(Internal modem)	44 KHz (minimum) at ±6 db
(External modem)	10 MHz at ±3 db
Transmitting system bandwidth	
(Internal modem)	8 KHz (minimum) at ±3 db
(External modem)	10 MHz at ±3 db
Main receiver RF gain	25 db (minimum)

SPECIFICATIONS (continued)

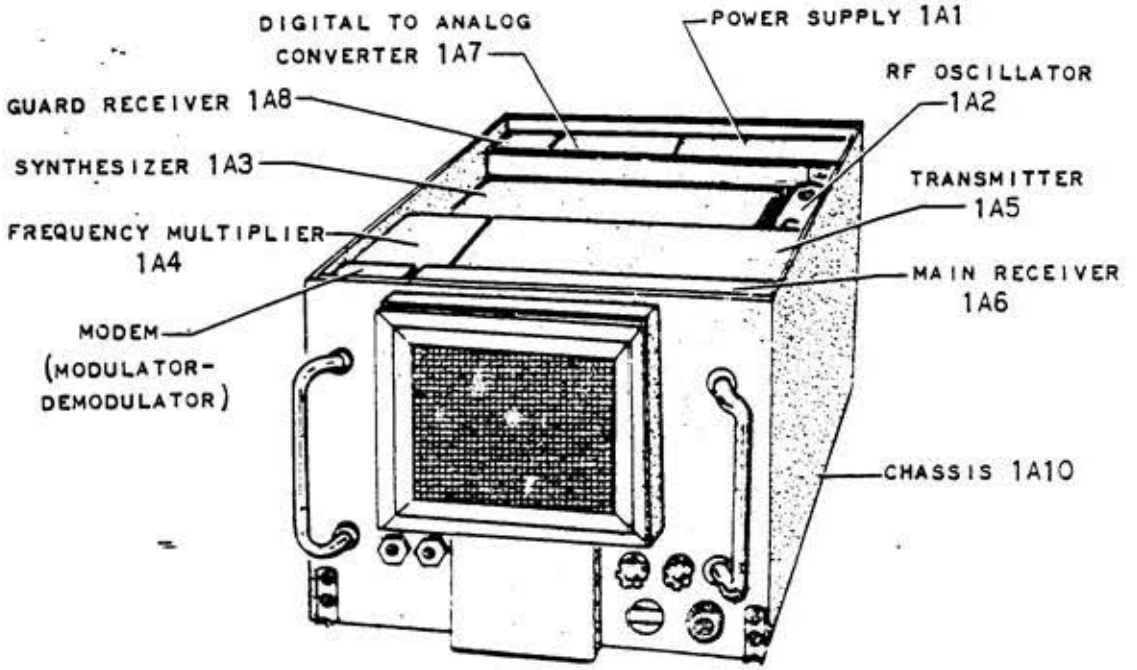
ARC-90 UHF RADIO COMMUNICATIONS SYSTEM

CHARACTERISTIC	SPECIFICATION
Noise figure	6 db
Main receiver sensitivity (for 10-db S+N/N ratio)	3 UV
Guard receiver sensitivity (for 10-db S+N/N ratio)	3 UV
Receiver Audio Output Power	100 MW to a 150 ohm load
Ambient temperature range	-55 degrees C to +71 degrees C
Maximum altitude	70,000 feet
Equipment classification	MIL-E-5400, Class II
Power requirements	3-phase, 115 volts, AC, 400-Hz, 3A per phase
Warm-up time	2 minutes (operational); 15 minutes (full performance)

BLOCK DIAGRAM THEORY OF OPERATION

Modules

The transceiver has ten modules. Below are shown the module numbers and locations in the transceiver.



TRANSCEIVER

MODULE PURPOSES

The chassis is considered a module. The remaining nine modules plug into the chassis for electrical interconnection and mechanical support. The nine plug-in modules are mechanically independent of each other.

The chassis serves also as an air channel allowing forced air cooling of the modules.

The power supply module provides the regulated and unregulated A-C and D-C voltages required by the transceiver and operates on a 3-phase, 400 Hz, 115-volt, 3-amperes-per-phase input supply.

POWER SUPPLY OUTPUT POWER TABLE

VOLTAGE (nominal)	CURRENT (maximum)
450 volts, DC	600 milliamperes (MA)
250 volts, DC	150 MA
130 volts, DC	150 MA
28 volts, DC (regulated)	500 MA
28 volts, DC (unregulated)	3 A (steady) 14 A (surge)
-95 volts, DC	60 MA
26 volts, AC, 400 Hz	0.9 amperes
6.3 volts, AC, 400 Hz (two outputs)	3 amperes (each output)
6.3 volts, AC, 400 Hz	3.75 amperes

The digital-to-analog converter module changes digital data to tuning information for the transmitter, main receiver, and frequency multiplier modules. The digital data is provided by the control panel and is a function of the selected frequency.

The RF oscillator module produces two highly accurate output frequencies of 1.999999 Mhz and 4.136363 MHz. This is accomplished by two temperature compensated crystal oscillators. These two signals are used as standard or reference frequencies for the synthesizer module.

The synthesizer module uses the two RF oscillator reference frequencies and digital frequency selection data from the control panel to provide 3500 usable output frequencies. Each frequency is dependent on control panel frequency selection. These output frequencies are used as input to the frequency multiplier module.

The frequency multiplier module multiplies the output of the synthesizer by a factor of nine and increases the power level for injection to the transmitter or main receiver. The frequency multiplier contains a servomechanism that automatically tunes the module. The servo receives tuning voltage from the digital to analog converter. The tuned frequency of this module is a function

of the frequency selected at the control panel. The frequency multiplier output is approximately one watt and is 60 MHz higher than the selected frequency.

The modem module modulates the transmitter with the interphone mic signal during transmission. This is provided by the modulator section. The demodulator section serves as the main receiver, 60 MHz IF amplifier, and detector. During reception the main receiver signal is amplified, detected and supplied to the interphone system. The transmit output signal, from the modem, is actually a 60 MHz, amplitude modulated subcarrier. The level of this signal is 30 milliwatts modulated 95 percent.

The transmitter module translates or converts the 60 MHz, AM signal from the modem to the selected operating frequency and provides necessary amplification to raise the power to a carrier level of 30 watts minimum. A servomechanism automatically positions the tuned circuits within a maximum time of four seconds. The servomechanism requires tuning information from the digital to analog converter.

The 60 MHz, AM signal from the modem is amplified and mixed with the UHF injection signal from the frequency multiplier. The difference frequency is the operating frequency selected at the control panel.

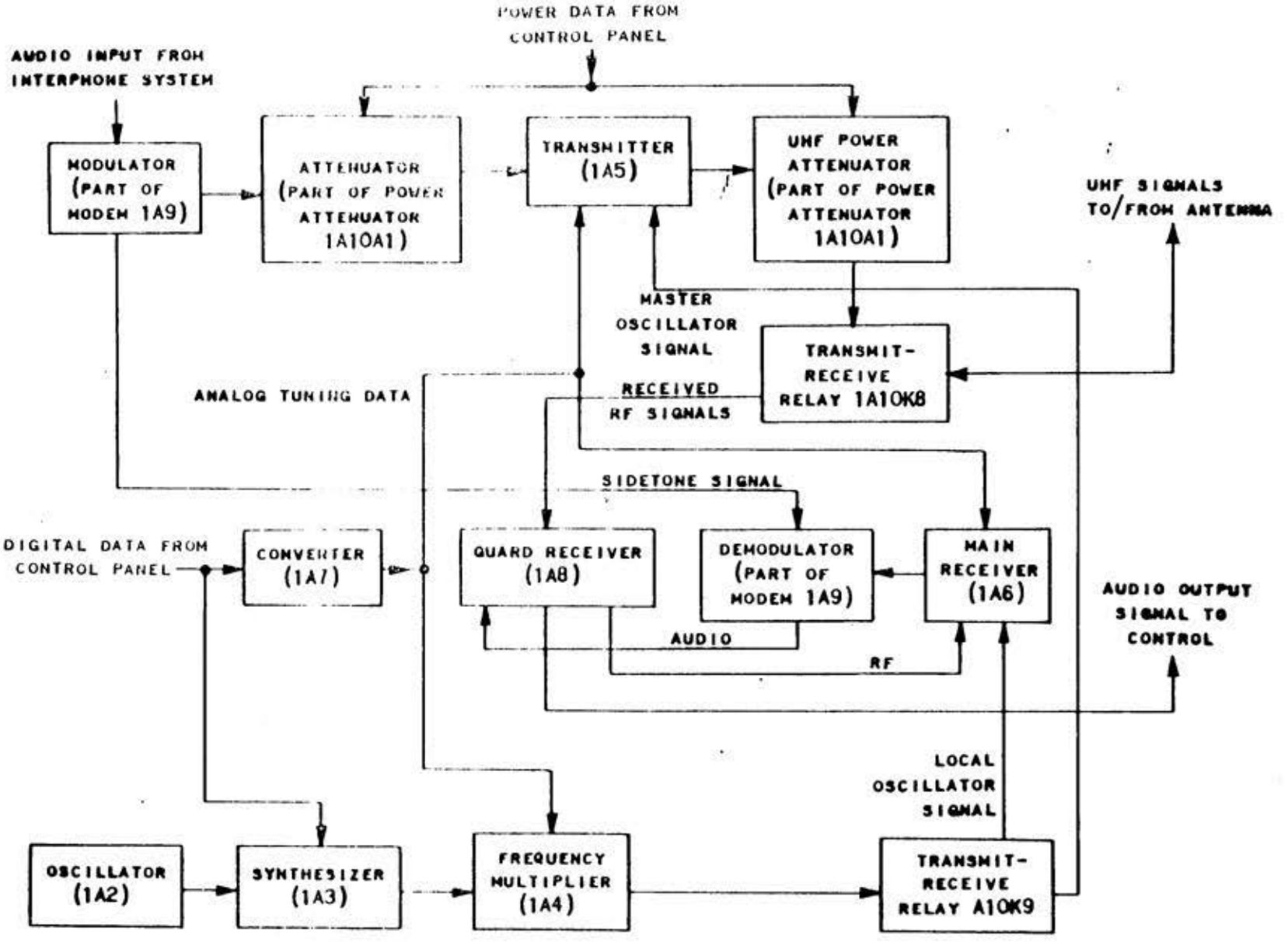
The main receiver module amplifies the received operating frequency and converts it to the 60 MHz IF required by the modem. The IF output to the demodulator portion of the modem is the difference of the received frequency and the output of the frequency multiplier.

A servomechanism automatically tunes the main receiver module to the selected frequency by using tuning information from the digital to analog converter.

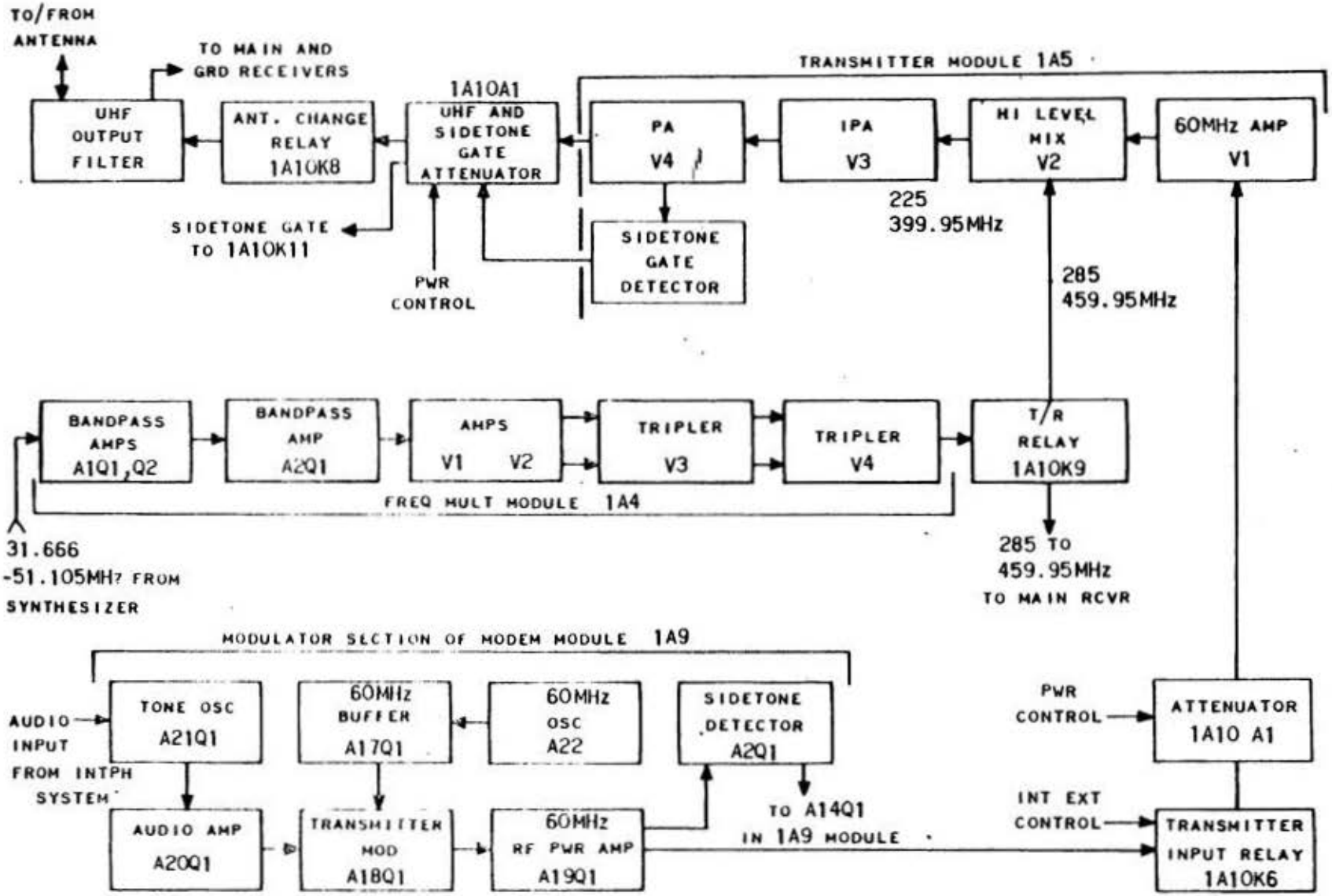
The guard receiver module is a complete single-channel receiver for independent reception of emergency communications on one frequency within the 238.00- to 248.00- MHz range. 243 MHz has been chosen as the emergency frequency.

TPANSMIT BLOCK DIAGRAM

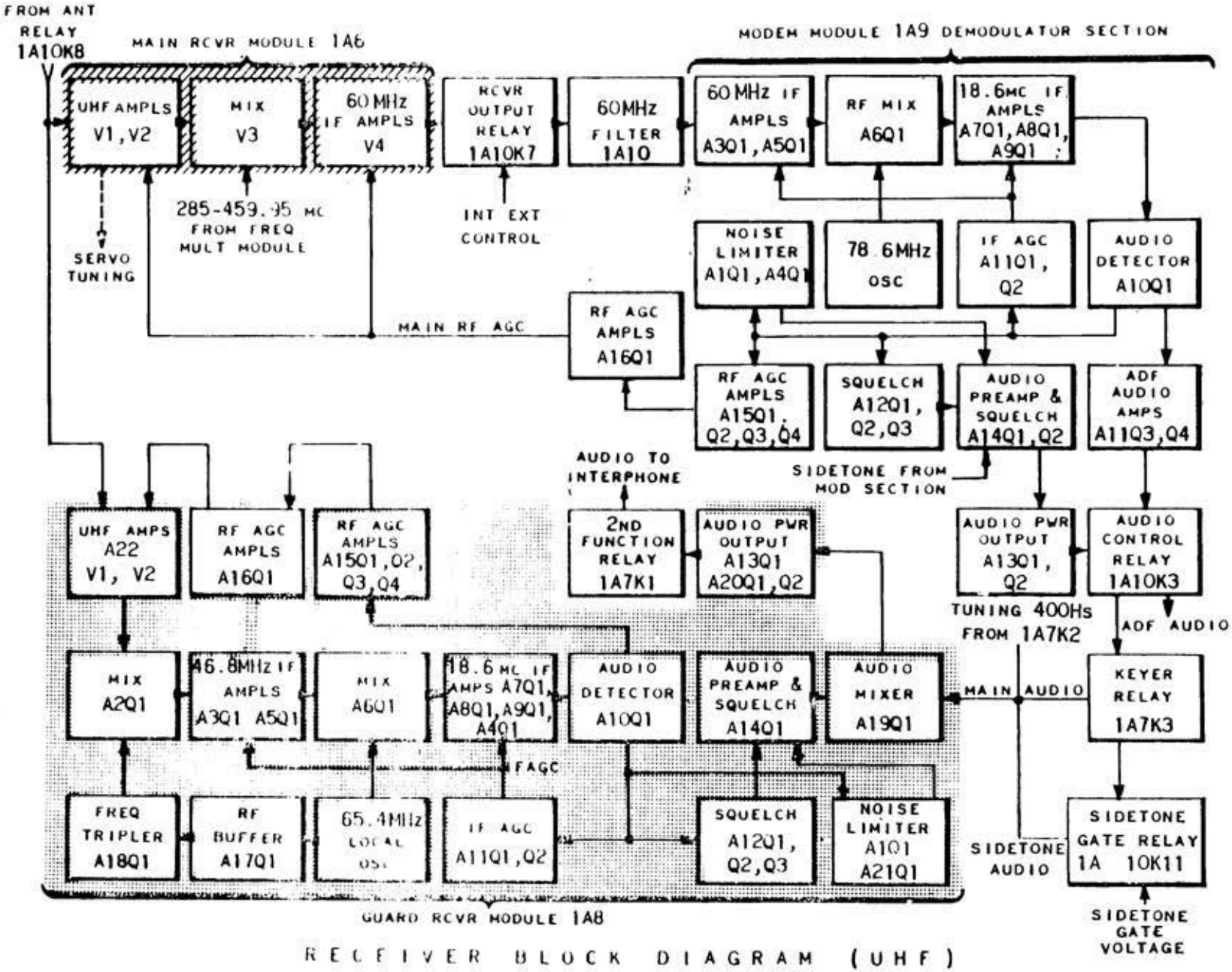
The interphone mic signal passes through the tone oscillator circuit to the audio amplifier A20Q1. The amplifier audio then modulates a 60 MHz signal from an oscillator providing a 60 MHz, AM signal. This signal is amplified by A19Q1. The modulated signal is detected by A2Q1 providing sidetone audio to receiver audio circuits, which will be heard by the operator. The modulating signal from A19Q1 passes through the deenergized contacts of K6 in the chassis to the transmitter module. However the level of this signal is varied by the control panel "PWR" knob. This knob (switch) has ten power positions which affects the attenuator 1A10A1. However, only positions 8, 9, and 10 affect the attenuator



OVERALL BLOCK DIAGRAM



TRANSMIT BLOCK DIAGRAM



RECEIVER BLOCK DIAGRAM (UHF)

at this point. This provides three power levels to the transmitter. The signal is applied to V1 in the transmitter module and is mixed by V2 with the output of the frequency multiplier module 1A4. The frequency multiplier module will be further discussed in the Frequency Generation Block Diagrams section. The output frequency of the 1A4 is always 60 MHz above the selected frequency, thus XXX.XX MHz + 60.0 MHz = 1A4 output. Example: 225.00 + 60.0 = 285.00 MHz.

The output frequency of V2 is the selected frequency and is amplified by the Intermediate Power Amplifier (IPA). The V4 (PA) output is detected by the sidetone gate detector. The output voltage of the detector passes through the attenuator to be adjusted by the "PWR" setting from the control panel. Since the PA signal level is changed to three levels by the "PWR" control the sidetone gate voltage will also have three levels. This is undesirable for the sidetone gate relay 1A10 K11 which must have a relatively constant voltage regardless of "PWR" setting. This is corrected by the attenuator adjustment. The sidetone gate relay (K11) in the chassis (1A10) provides coupling of the sidetone audio signal to the interphone system only if the transmitter power output is sufficient for a given "PWR" setting.

The UHF output of the PA passes through the attenuator for the seven remaining steps of the "PWR" setting, thus there are ten power output levels. The UHF signal then passes through the energized (transmit) contacts of 1A10 K8 antenna relay to the output (low pass) filter. This is the final output to the antenna.

GUARD RECEIVER

The 243 MHz signal passes from the antenna through the deenergized (receive) 1A10K8 to the guard receiver module. With the function knob on "BOTH" (guard receiver on) the signal is amplified by A22 V1 and V2 and mixed with 196.2 MHz from the tripler A15Q1. The output of A2Q1 (1st IF) is 46.5 MHz from the local oscillator. The output of A6Q1 (2nd IF) is 15.6 MHz and is amplified by four stages. The audio detector A10Q1 demodulates the IF signal. The detected audio from A10Q1 has four signal paths. The audio output level controls the RF AGC circuits which in turn regulate the gain of the RF amplifiers A22 V1 and V2. The audio output level also controls the IF AGC circuits which in turn regulate the gain of the 1st and 2nd IF amplifier circuits. The audio output signal passes through the noise limiting circuits A1Q1 and A2Q1 to the audio preamplifier A14Q1. This preamplifier is only turned on when the audio output lefel from A10Q1 is sufficient to operate the squelch circuits A12Q1, Q2, and Q3. With sufficient level the squelch circuits turn on A14Q1 permitting the audio signal to pass. The audio level required to operate the squelch circuits is determined by the GUARD squelch adjustment on the front panel of the transceiver. The guard audio signal passes from A14Q1 to A19Q1. The main audio also passes through A19Q1. A19Q1 is operative also in the "MAIN" position of the control panel function knob. The guard audio signal

is amplified by the audio power output stages, muted during tuning by 1A7K1, and is coupled to the control panel. The volume control varies the audio level to the interphone system.

MAIN RECEIVER BLOCK DIAGRAM

The operating frequency selected at the control panel passes from the antenna through deenergized (receive) 1A10K8 to the main receiver module. The signal is amplified by V1 and V2 and mixed with the Frequency Multiplier signal. The V3 output (1st IF) is 60 MHz and is amplified by V4. The 1st IF signal is coupled to relay 1A10K7 in the chassis. The 1st IF signal passes through the deenergized contacts of the relay to a 60 MHz filter in the chassis. The output of the filter is connected to the modem module. The 60 MHz IF is amplified by 1A9A3Q1 and mixed with 78.6 MHz. The output of A4Q1 (2nd IF) is 18.6 MHz and is amplified by three stages.

The audio detector A10Q1 demodulates the IF signal. The detected audio from A10Q1 has four signal paths. The audio output level controls the RF/AGC circuits which in turn regulate the gain of the RF amplifiers 1AG V1 and V2. The audio output level also controls the IF AGC circuits which in turn regulate the gain of the 1st and 2nd IF amplifier circuits. The audio output signal passes through the noise limiting circuits A1Q1 and A4Q1. This preamplifier is only turned on when the audio output level from A10Q1 is sufficient to operate the squelch circuits A12Q1, Q2, and Q3. With sufficient level the squelch circuits turn on A14Q1 permitting the audio signal to pass. The audio level required to operate the squelch circuits is determined by the MAIN squelch adjustment on the front panel of the transceiver. The main audio signal passes from A14Q1 to A14Q2. The main audio signal is amplified by the audio power output stages A13Q1 and Q2. The main audio signal leaves the modem and is coupled to 1A10K3. The deenergized contacts of K3 couples the main audio through the deenergized (receive) 1A7K3 to the guard receiver audio mixer A19Q1. This line also receives a 400 Hz tone from 1A7K2 during tuning. The tune tone or main audio signal now passes through the same circuits as discussed in the Guard Receiver Block Diagram.

SIDETONE REVIEW

During transmit the detected sidetone signal passes through the modem audio circuits. The modem output to 1A7K3 is routed to the sidetone gate relay 1A10K11. If the transmitter power output is sufficient for any given "PWR" setting K11 will energize coupling the sidetone audio to the guard receiver audio mixer 1A5A19Q1.

FREQUENCY GENERATING BLOCK DIAGRAMS

The entire discussion of the main receiver and transmitter was based on

assuming the correct output frequency of the frequency multiplier module. The following discussion will show the frequency multiplier output.

Three modules are required for frequency generation; the RF oscillator module, synthesizer module, and frequency multiplier module.

To simplify this discussion "MANUAL" frequency selection at the control panel will be used.

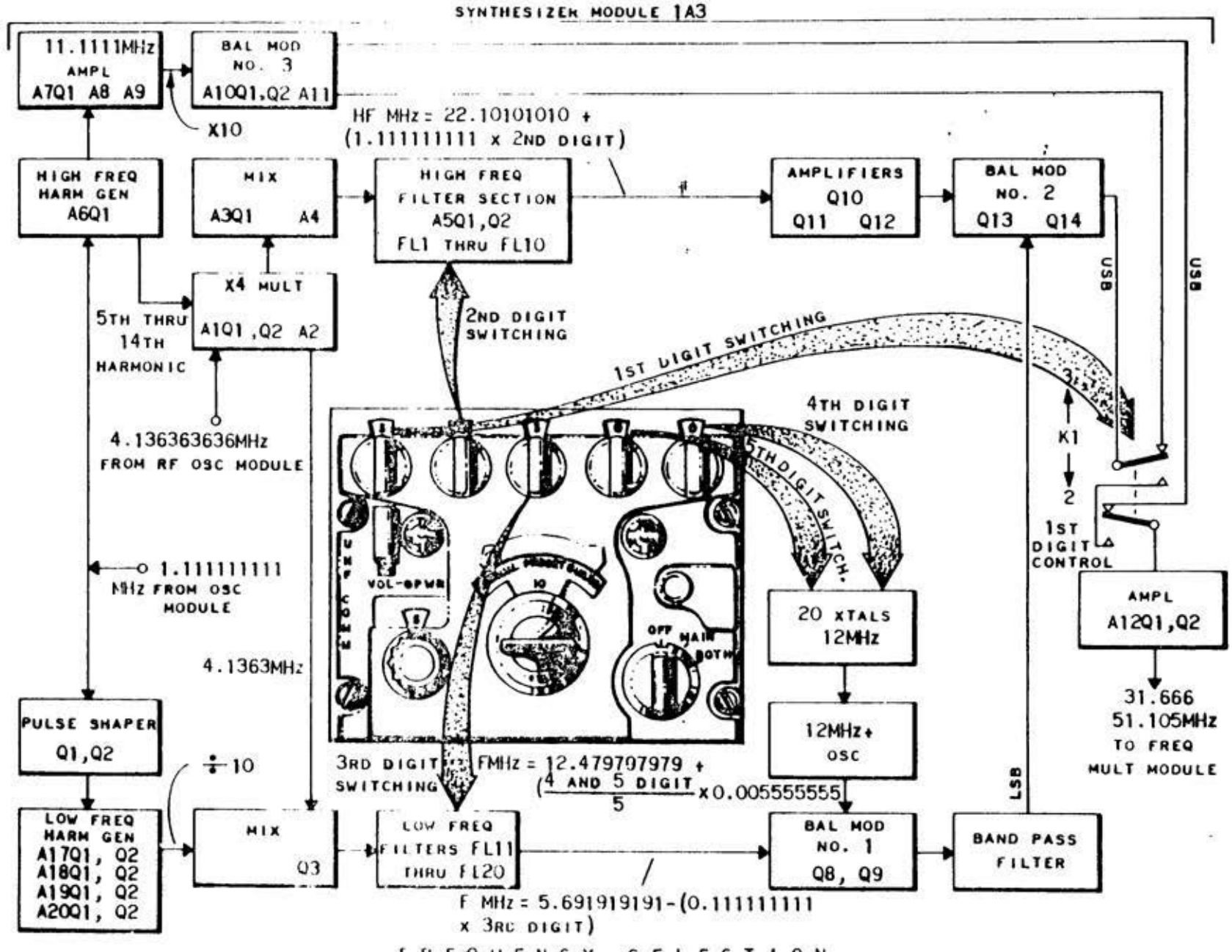
The Frequency Selection Block Diagram shows each knob (digit) controlling switching functions in the high frequency filter section, low frequency filter section, 12 MHz oscillator, and relay 1A3K1.

The 1.111111111 MHz signal from the RF oscillator module provides a 1.111111111 MHz spectrum in the outputs of A4Q1. The 4.136363636 MHz signal from the RF oscillator Module is multiplied by 4 (16.545454544 MHz) and mixed by A3Q1 with the spectrum. This shifts the spectrum up to a usable range. The usable spectrum range is ten simultaneous frequencies in 1.111111111 MHz steps from 22.101010101 MHz to 32.101010101 MHz. The high frequency filter selected by the 2nd digit will pass only one frequency. HF MHz = 22.101010101 + (1.111111111 x 2nd digit). The 1.111111111 MHz signal is also divided by the low frequency harmonic generator.

This generator is a series of multivibrators producing 0.111111111 MHz square wave to mixer Q3. Since this signal is a square wave its harmonic content will be rich thus a 0.111111111 MHz spectrum. This spectrum mixes with 4.136363636 MHz shifting the spectrum to a usable range. The usable spectrum range from Q3 will be ten simultaneous frequencies in 0.111111111 MHz steps from 4.691919191 MHz to 5.691919191 MHz. The low frequency filter selected by the 3rd digit will pass only one frequency. LF MHz = 5.691919191 - 6.111111111 x 3rd digit. The selected low frequency modulates the 12 MHz oscillator signal in balanced modulator No. 1. The difference (LSB) frequency is passed by the band pass filter. The 4th and 5th digits together chooses the crystal frequency for the oscillator. FM Hz = 12.479797979 + $\left(\frac{\text{4th and 5th digit}}{5} \times 0.005555555\right)$.

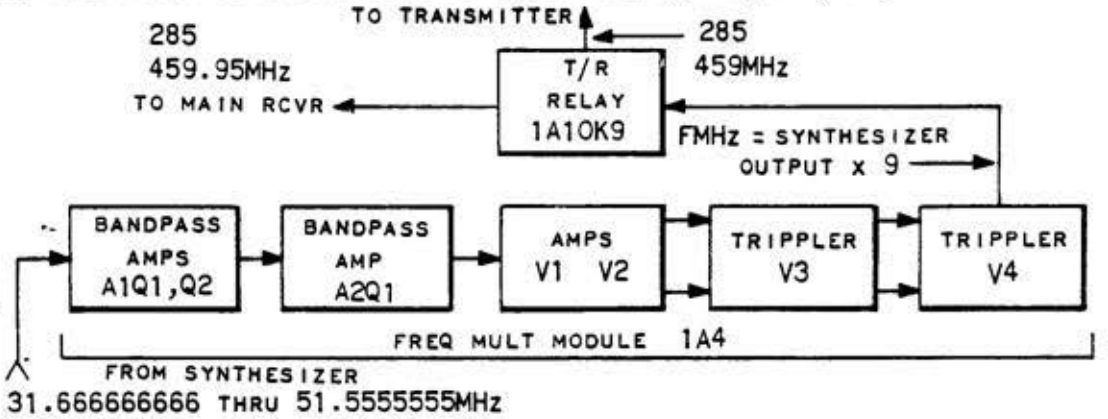
The low frequency signal modulates the amplified high frequency signal in balanced modulator No. 2 and sum frequency (USB) is used. This signal will be amplified by A1ZQ1 and Q2 when the control 1st digit is 2. This signal is coupled to the frequency multiplier module. When the 1st digit is 3 the balanced modulator No. 2 output is coupled to balanced modulator No. 3 where 11.111111111 MHz is added. This signal is then amplified and sent to the frequency multiplier module.

"PRESET" or "GUARD" frequency selection provides the same type digital data for the synthesizer module. The frequency multiplier module amplifies and multiplies the synthesizer output signal by 9 providing the transmitter module



FREQUENCY SELECTION

and main receiver module with the injection frequency they require.

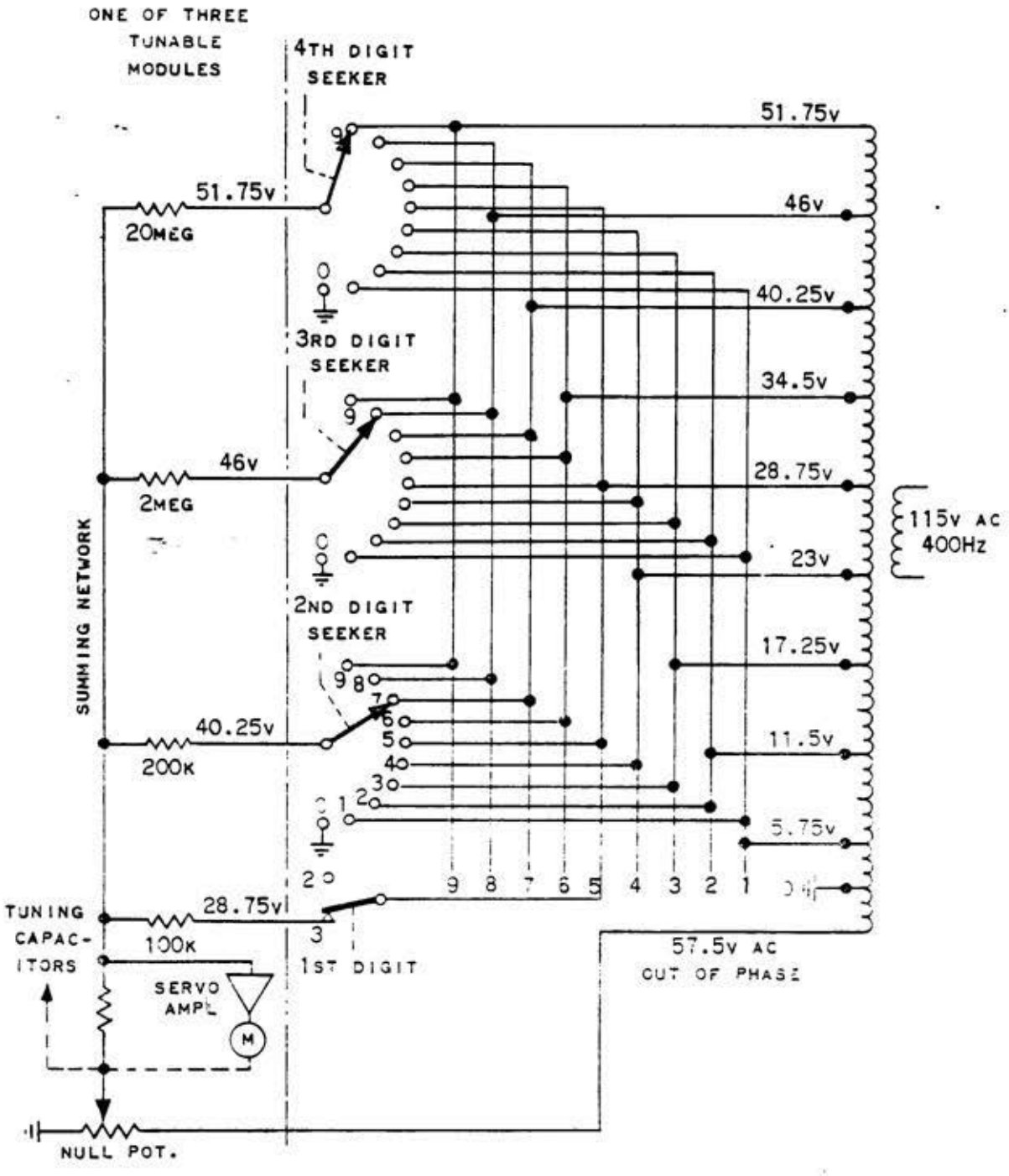


TUNING SYSTEM

The transmitter, frequency multiplier and main receiver modules must be tuned to the proper frequencies according to the control panel frequency selection. These modules tune in 100 KHz steps. (50 KHz tuning is not necessary.) The digital-to-analog converter module changes the control panel digital date to 400 Hz output voltages. Four output circuits of the converter couple these voltages to the three tunable modules.

The control panel 1st digit (3) operates the converter 1st digit relay providing 28.75 volts, AC to the first digit inputs of the three tunable modules. When the 1st digit is 2, no voltage is provided. The control box 2nd digit (0 - 9) operates a mechanical digit seeker in the converter. The seeker positions a voltage selector switch (10 positions) providing ten possible voltages (OV thru 51.75 VAC) to the 2nd digit inputs of the three tunable modules. The 3rd and 4th digit seekers and selectors provide the same ten voltages to the 3rd and 4th digit inputs to the tunable modules.

The four voltage inputs (for a given control box selection) are summed in summing resistor networks in each tunable module. The summed voltage to the servo amplifier has 2000 possible voltages. However, the mechanical tuning limits of the tuned modules permit only 1750 tuning points corresponding to 225 to 399.9 MHz. The servo will drive in the proper direction until the null "pot" is positioned to the proper point providing an out-of-phase voltage amplitude cancelling the summing network voltage. The servo motor also positions the tuning components in the module.



TUNING SYSTEM