ENGINEERING STATEMENT

For Certification of

TRISQUARE COMMUNICATIONS

Model No. GMRS380
FCC ID: O9GGMRS380

I am an Electronics Engineer, a principal in the firm of Hyak Laboratories, Inc., Springfield, Virginia. My education and experience are a matter of record with the Federal Communications Commission.

Hyak Laboratories, Inc. has been authorized by Trisquare Communications to make certification measurements on the GMRS380 transceiver. These tests were made by me or under my supervision in our Springfield laboratory.

Test data and documentation required by the FCC for certification are included in this report. The data verifies that the above mentioned transceiver meets FCC requirements and certification is requested.

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Rowland S. Johnson

Dated: January 15, 2002

A. INTRODUCTION

The following data are submitted in connection with this request for type acceptance of the GMRS380 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The GMRS380 is a hand-held, battery operated, UHF, frequency modulated, nominal 2 W transceiver intended for voice communications applications in the 462.5500 - 462.7250 MHz band under Part 95 in the GMRS service.

B. GENERAL INFORMATION REQUIRED FOR TYPE ACCEPTANCE (Paragraph 2.983 of the Rules)

1. Name of applicant: Trisquare Communications

2. Identification of equipment: FCC ID: O9GGMRS380

   a. The equipment identification label is submitted as a separate exhibit.
   b. Photographs of the equipment are submitted as separate exhibits.

3. Quantity production is planned.

4. Technical description:

   a. 16k0F3E emission
   b. Frequency range: 462.5500-462.7250 MHz.
   c. Operating power of transmitter is fixed at the factory at 2 watts conducted.
   d. Maximum power permitted under FCC Part 95 (interstitial) is 5 watts ERP. The GMRS380 fully complied with that power limitation.
   d. The dc voltage and dc currents at final amplifier:

      Collector voltage: 5.9 Vdc
      Collector current: 0.93 A

   f. Function of each active semiconductor device: See Appendix 1.
   g. Complete circuit diagram is submitted as a separate exhibit.
   h. A draft instruction book is submitted as a separate exhibit.
   i. The transmitter tune-up procedure is submitted as a separate exhibit.

B. GENERAL INFORMATION (continuted)

   j. A description of circuits for stabilizing frequency is included in Appendix 2.
   k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Appendix 2.
   l. Not applicable.

5. Data for 2.985 through 2.997 follow this section.

C. RF POWER OUTPUT (Paragraph 2.985(a) of the Rules)

1. Conducted: (No antenna connector, antenna is integral.)

2. ERP(d) by substitution, 1.7 W.

D. MODULATION CHARACTERISTICS

1. A curve showing frequency response of the transmitter is shown in Figure 1. Reference level was audio signal output from a Boonton 8220 modulation meter with one kHz deviation. Audio output was measured with an Audio Precision System One TRMS voltmeter and tracking generator.

2. Modulation limiting curves are shown in Figure 2, using a Boonton 8220 modulation meter. Signal level was established with an Audio Precision System One. The curves show compliance with paragraphs 2.987(b) and 95.633(b).

3. Figure 3 is a graph of the post-limiter low pass filter which meets the requirements of paragraph 95.633(b) in providing a roll-off of 60Logf/3 dB where f is audio frequency in kHz. Measurements were made following EIA RS-152B with an Audio Precision System One on the Boonton 8220 modulation meter audio output.

4. Occupied Bandwidth (Paragraphs 2.989(c), 90.209(b)(4), and 95.629(a) of the Rules)

Figure 4 is a plot of the sideband envelope of the transmitter output taken with a Tektronix 494P spectrum analyzer. Modulation corresponded to conditions of 2.989(c)(1) and consisted of 2500 Hz.

D. MODULATION CHARACTERISTICS (continued)

tone at an input level 16 dB greater than that necessary to produce 50% modulation at 2369 Hz, the frequency of maximum response. Measured modulation under these conditions was 3.2 kHz.

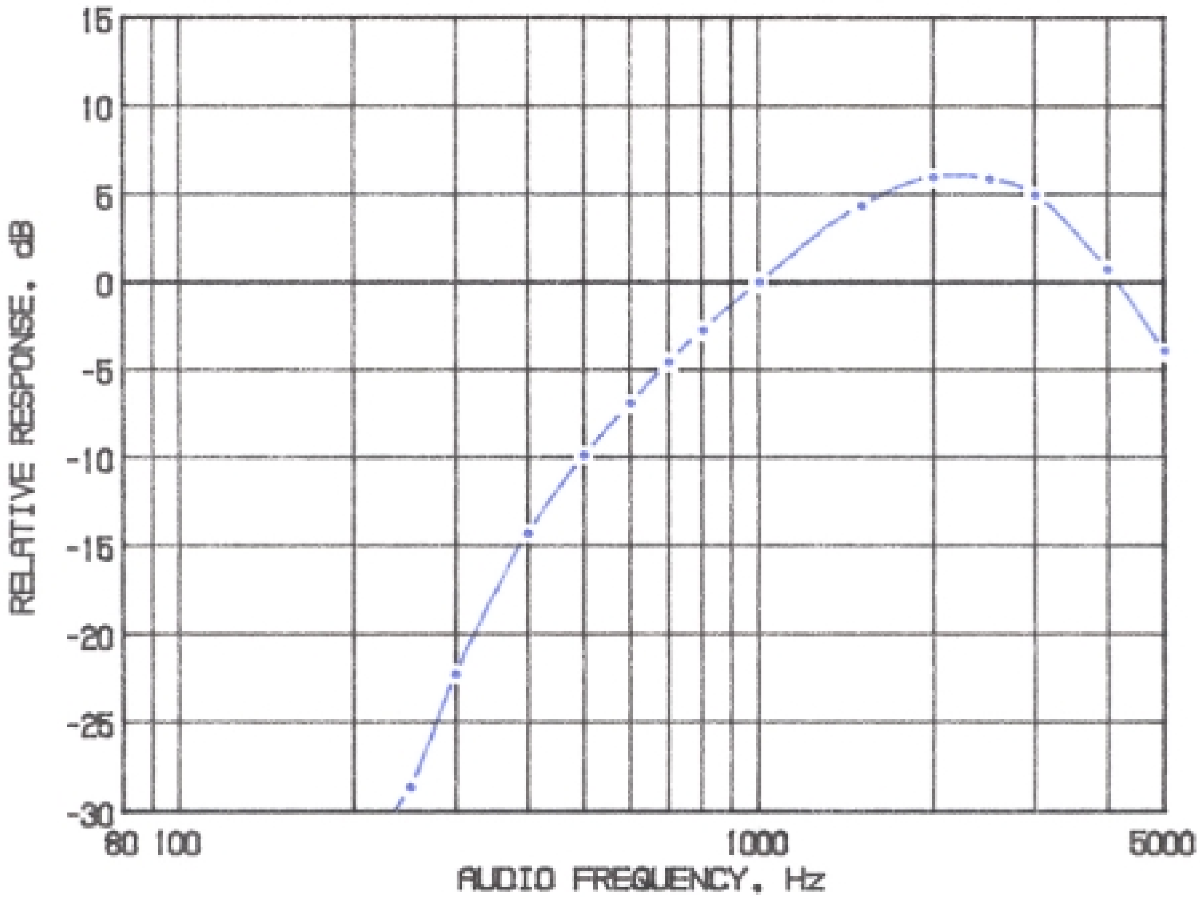
The plot is within the limits imposed by Paragraph 90.211(h) for frequency modulation. The horizontal scale (frequency) is 10 kHz per division and the vertical scale (amplitude) is a logarithmic presentation equal to 10 dB per division.

5. Emission Designator Calculation:

(2D + 2F) 2x5.0 + 2x3.0 = 16k0F3E

FIGURE 1

MODULATION FREQUENCY RESPONSE



MODULATION FREQUENCY RESPONSE
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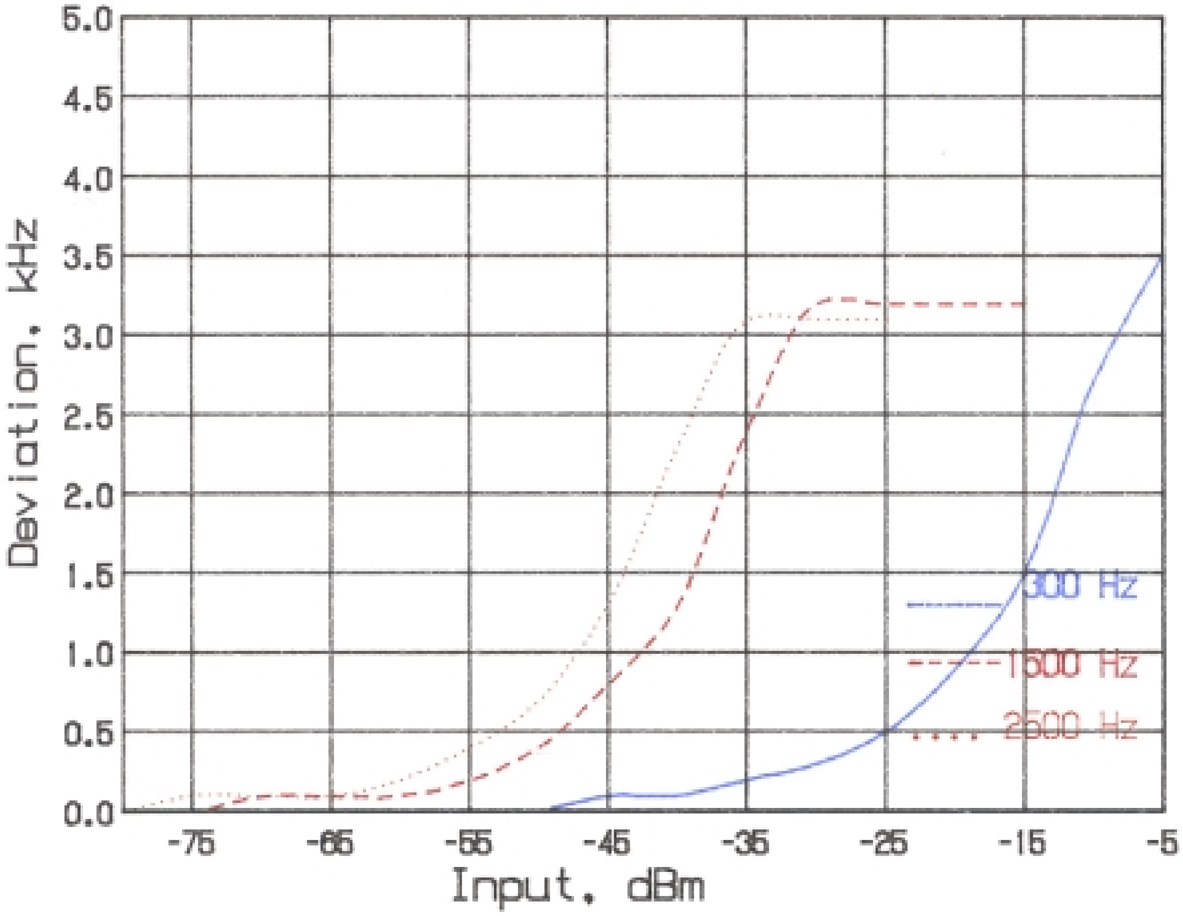
FIGURE 1

FIGURE 2

AUDIO LIMITER CHARACTERISTICS

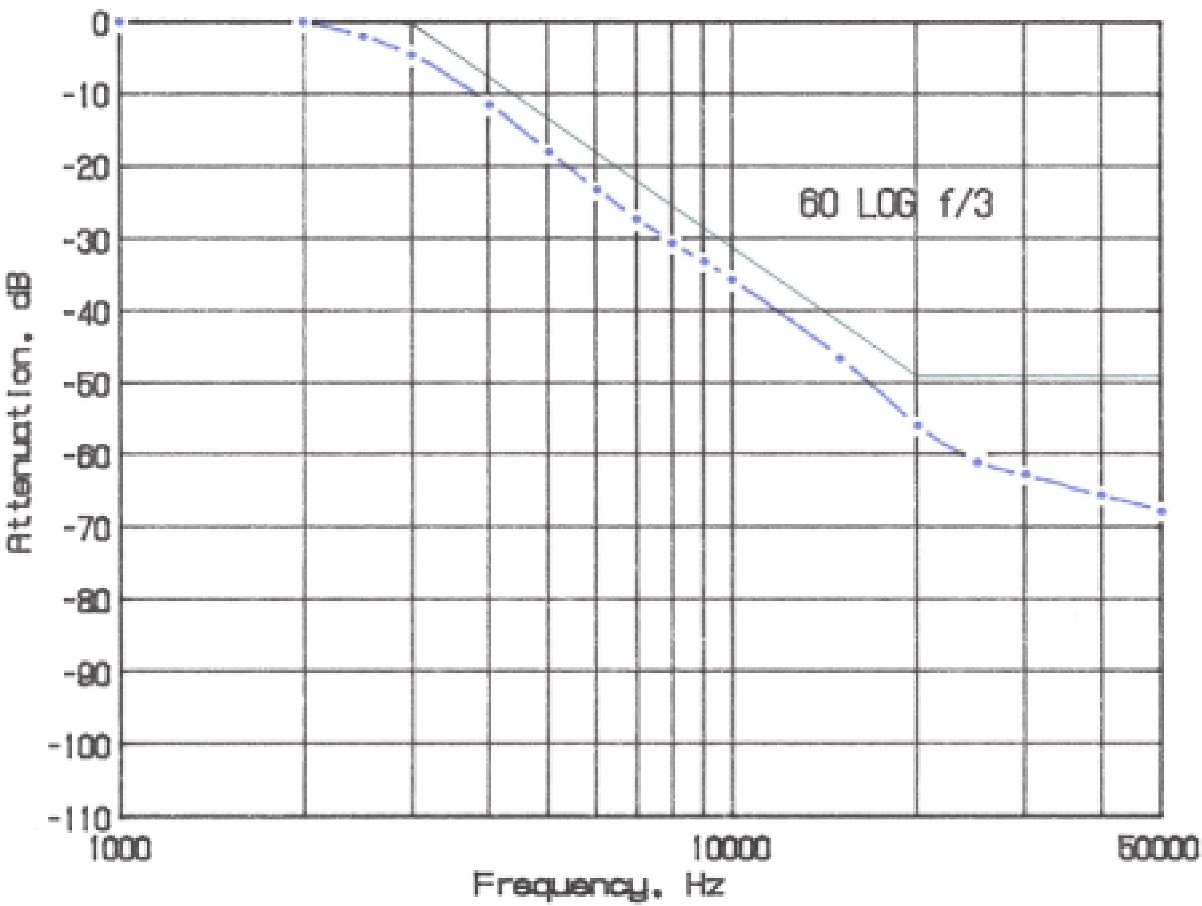


AUDIO LIMITER CHARACTERISTICS
FCC ID: O9GGMRS380

FIGURE 2

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE

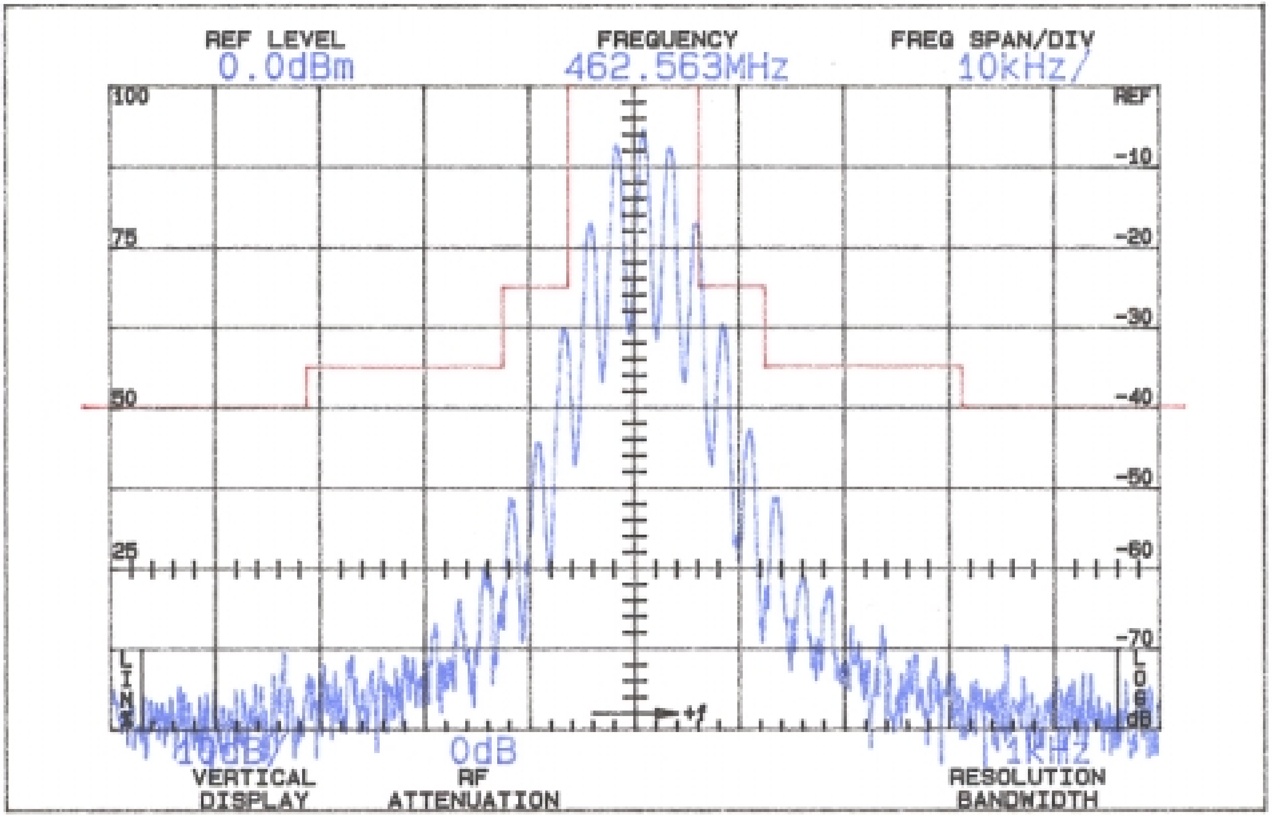


AUDIO LOW PASS FILTER RESPONSE
FCC ID: O9GGMRS380

FIGURE 3

FIGURE 4

OCCUPIED BANDWIDTH



	ATTENUATION IN dB BELOW MEAN OUTPUT POWER Required
On any frequency more than 50% up to and including 100% of the authorized bandwidth, 20 kHz (10-20 kHz)	25
On any frequency more than 100%, up to and including 250% of the authorized bandwidth (20-50 kHz)	35
On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 50 kHz)	43+10LogP = 45 (P = 1.7W)

OCCUPIED BANDWIDTH
FCC ID: O9GGMRS380

FIGURE 4

E. SPURIOUS EMISSIONS AT THE ANTENNA TERMINALS
(Paragraph 2.991 of the Rules)

Not applicable, no antenna connector.

F. MEASUREMENTS OF SPURIOUS RADIATION

Measurement of radiated spurious emissions from the GMRS380 were made by substitution with a Tektronix 494P spectrum analyzer using Singer DM-105A calibrated test antennae for the measurements to l GHz, Polarad CA-L, CA-S, CA-M and/or EMCO 3115. The transmitter and dummy load were located in an open field 3 meters from the test antenna. Supply voltage was a power supply with a terminal voltage under load of 6 Vdc. The transmitter and test antennae were arranged to maximize pickup. Both vertical and horizontal test antenna polarization were employed.

TABLE 1

TRANSMITTER CABINET RADIATED SPURIOUS
462.5625 MHz, 6.0 Vdc, 1.7 watts ERP (dipole)

Frequency MHz	dB Below Carrier Reference[1]
462.563	0
925.120	58V
2312.800	56V
2775.360	63H
4163.040	64V

Required: 43+10Log(1.7) = 45

[1]Worst-case polarization, H-Horizontal, V-Vertical.

All other spurious from 12.8 MHz to 4.7 GHz were 20 dB or more below FCC limit.

G. FREQUENCY STABILITY
(Paragraph 2.995(a)(2) and 95.621(b) of the Rules)

Measurement of frequency stability versus temperature was made at temperatures from -30°C to +50°C. At each temperature, the unit was exposed to test chamber ambient a minimum of 60 minutes after indicated chamber temperature ambient had stabilized to within ±2° of the desired test temperature. Following the 1 hour soak at each temperature, the unit was turned on, keyed and frequency measured within 2 minutes. Test temperature was sequenced in the order shown in Table 2, starting with -30°C.

A Thermotron S1.2 temperature chamber was used. Temperature was monitored with a Keithley 871 digital temperature probe. The transmitter output stage was terminated in a dummy load. Primary supply was 6.0 volts. Frequency was measured with a HP 5385A digital frequency counter connected to the transmitter through a power attenuator. Measurements were made at 462.5625 MHz. No transient keying effects were observed.

TABLE 2

462.5625 MHz, 6.0 V Nominal, 1.7 watts

Temperature, °C	Output_Frequency,_MHz	p.p.m.
-29.7	462.563483	2.1
-19.8	462.564158	3.6
- 9.6	462.564577	4.5
0.7	462.564207	3.7
10.7	462.563565	2.3
20.1	462.562483	0.0
29.9	462.562301	-0.4
40.5	462.562213	-0.6
50.2	462.562849	0.8

Maximum frequency error: 462.564577
462.562500

\+ .002077 MHz

FCC Rule 95.621(b) specifies .0005% or a maximum of ± .002313 MHz, which corresponds to:

High Limit	462.564813 MHz
Low Limit	462.560187 MHz

H. FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE
(Paragraph 2.995(d)(2) of the Rules)

Oscillator frequency as a function of power supply voltage was measured with a HP 5385A digital frequency counter as supply voltage provided by an HP 6264B variable dc power supply was varied from ±15% above the nominal 6.0 volt rating to below the battery end point. A Keithley 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20 ^{o}C ambient.

TABLE 3

462.5625 MHz, 20°C, 6.0 V Nominal, 1.7 watts

%	Supply_Voltage	Output_Frequency,_MHz	p.p.m.
115	6.9	462.562780	0.6
110	6.6	462.562768	0.6
105	6.3	462.562585	0.2
100	6.0	462.562483	0.0
95	5.7	462.562447	-0.1
90	5.4	462.562464	-0.1
85	5.1	462.562501	0.0
*	4.8	462.562622	0.3

Maximum frequency error: 462.562780
462.562500

SEMICONDUCTOR DESIGNATIONS AND FUNCTIONS

GMRS380

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002313

Designator	Description	Function
U300	Dual PLL Synthesizer	Frequency synthesizing
U30	3V Regulator	3V Regulator Circuit
U150 C/D, U230 C	Operational Amplifier	CTCSS low pass (250Hz) filter
U150-B	Operational Amplifier	Receive high pass (300Hz) audio filter
U150-A	Operational Amplifier	Receive high pass (300Hz) audio filter
U230-D	Operational Amplifier	Transmit high pass (300Hz) audio filter / mic amp
U230-B	Operational Amplifier	Transmit limiter amp
U230-A	Operational Amplifier	Transmit low pass (3.5Khz) audio filter
U160	Audio Amplifier	Final stage audio amplifier for 200mW output & low pass (3Khz) audio filter
U130	Narrowband FM IF	2nd IF amplifier, 2nd LO mixing, audio detector
U400	8 Bit Microcontroller	Transmit/Receive control, key decode, power control
D100	PIN Diode	Transmit/Receive antenna switch
D51	PIN Diode	Transmit/Receive band switch
D50	Varactor Diode	VCO tuning
D130	General Purpose Diode	Squelch noise detector
Q100	Bias Transistor	Transmit/Receive antenna switch
Q50/Q51	RF Transistor	VCO – fundamental transmit and LO
Q52	Bias Transistor	Receive/Transmit band switch for VCO
Q200	RF Power Transistor	PA final stage amplifier – class A
Q201	RF Power Transistor	PA 2nd stage amplifier – class C
Q202	RF Transistor	PA 1st stage amplifier – class A

APPENDIX 2

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY,
SUPPRESS SPURIOUS EMISSIONS AND LIMIT MODULATION

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 (X400). Compensation for temperature variations on the crystal reference is accomplished using a thermister (TH400) 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) in the receive mode. The crystal reference frequency is fed through a doubler circuit to generate the 2nd LO of 20.950 MHz.

TRANSMITTER CIRCUITS

The transmitter amplifies the 0 dBm signal from the VCO to approximately 33 dBm 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, the driver stage as class AB and the 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. 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-D), a hard clipper circuit (U230-B) to limit maximum deviation to +/- 5.0 kHz and a three pole low pass or splatter filter at 2.8 kHz (U230-A). The low pass filter insures that the occupied bandwidth of the FM modulated signal meets FCC requirements under all input conditions.

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 – 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 (20.950 MHz) is generated by frequency doubling the output of the 10.475 MHz VCXO that is the reference frequency for the PLL. The 2nd mixer output of 450 kHz is filtered through a 4 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 200 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 5 kHz. When the detected noise exceeds a threshold set to trigger at approximately 12 dB SINAD receive signal strength, the audio output is muted.

TRANSMIT/RECEIVE SWITCH

When the radio is in the transmit mode, +TX bias voltage is applied through R100 to bias D100 which shorts one leg of a Pi matching network (C2, L100 and C101) to ground in the receive path. This results in a parallel tuned circuit high impedance being presented to the transmit signal to 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 T matching network and the unwanted load of the transmit final amplifier is reduced to less than 1 pF when the PA (Q200) is off.

RADIO CONTROL CIRCUIT

A microprocessor (U400) is used to control the transceiver. User stimuli is provided through a tack switch for PTT (push to talk), along with the keypad for channel selection, channel monitor, and page. 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 was 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.

CIRCUITS AND DEVICES TO
STABILIZE FREQUENCY, etc.
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APPENDIX 2