ENGINEERING STATEMENT

For Type Certification of

Trisquare Communications

Model No: T5210
FCC ID: O9GT5210

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 type certification measurements on the model T5210 transceiver. These tests made by me or under my supervision in our Springfield laboratory.

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

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Rowland S. Johnson

Dated: April 17, 2001

A. INTRODUCTION

The following data are submitted in connection with this request for type certification of the model T5210 transceiver in accordance with Part 2, Subpart J of the FCC Rules.

The model T5210 is a portable, battery operated, UHF, frequency modulated transceiver intended for 12.5 kHz channel family radio service applications in the 462.5625-467.7125 MHz band. It operates from a nominal 4.5 Vdc battery supply. MFR rated output power is 0.5 watts ERP(d)

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

1. Name of applicant: Trisquare Communications

2. Identification of equipment: FCC ID: O9GT5210

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

3. Quantity production is planned.

4. Technical description:

   a. 11k0F3E emission
   b. Frequency range: 462.5625 - 467.7125 MHz.
   c. Operating power of transmitter is fixed at the factory at less than 0.5 W ERP(d)
   d. Maximum power permitted is 0.5 watts, and the model T5210 fully complied with that power limitation.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 4.3 Vdc
      Collector current: 0.67 A

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

B. GENERAL INFORMATION (continued)

   j. A description of circuits for stabilizing frequency is included in Exhibit 2.
   k. A description of circuits and devices employed for suppression of spurious radiation and for limiting modulation is included in Exhibit 3.
   l. Not applicable.

5. Data for 2.985 through 2.997 follow this section.

C. <u>RF Power Output</u> (Paragraph 2.985(a) of the Rules)

The model T5210 has a permanently attached built-in antenna without provisions for a coaxial connector.

Therefore RF power was determined by substitution.

TABLE 1

Operating Freq., MHz	Power watts into a dipole antenna
462.5625	0.49

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 integrated test system.

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

3. Figure 3 is a graph of the post-limiter low pass filter which provides 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 integrated test system on the Boonton 8220 modulation meter audio output.

4. <u>Occupied Bandwidth</u>
(Paragraphs 2.989(c) of the Rules)

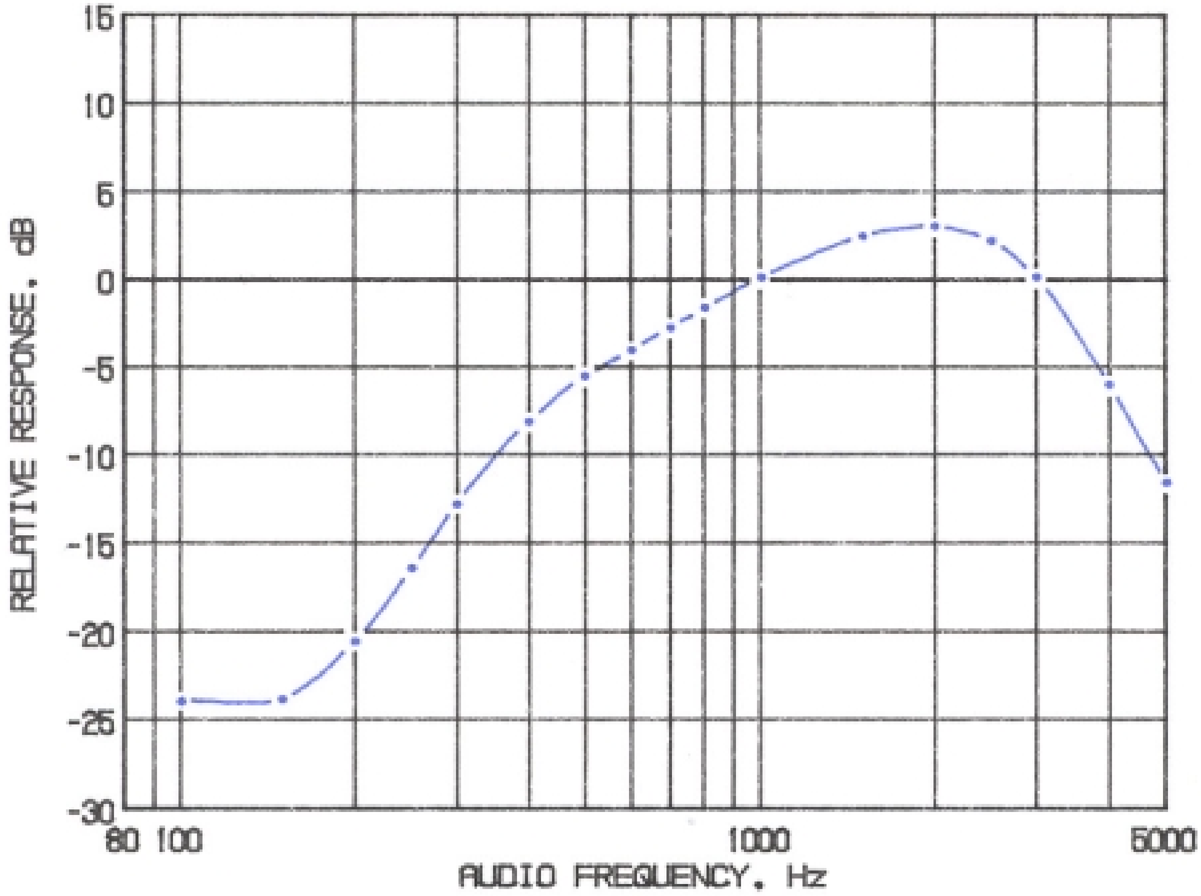
Figure 4 is a plot of the sideband envelope of the transmitter output taken with a Tektronix 494P spectrum analyzer. Modulation corresponded to conditions of 2.989(c)(1) and consisted of 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50% modulation at 2340 Hz, the frequency of maximum response.

Emission designator:

(2M + 2D) (2 x 3 kHz) + (2 x 2.5 kHz) = 11k0F3E

FIGURE 1

MODULATION FREQUENCY RESPONSE

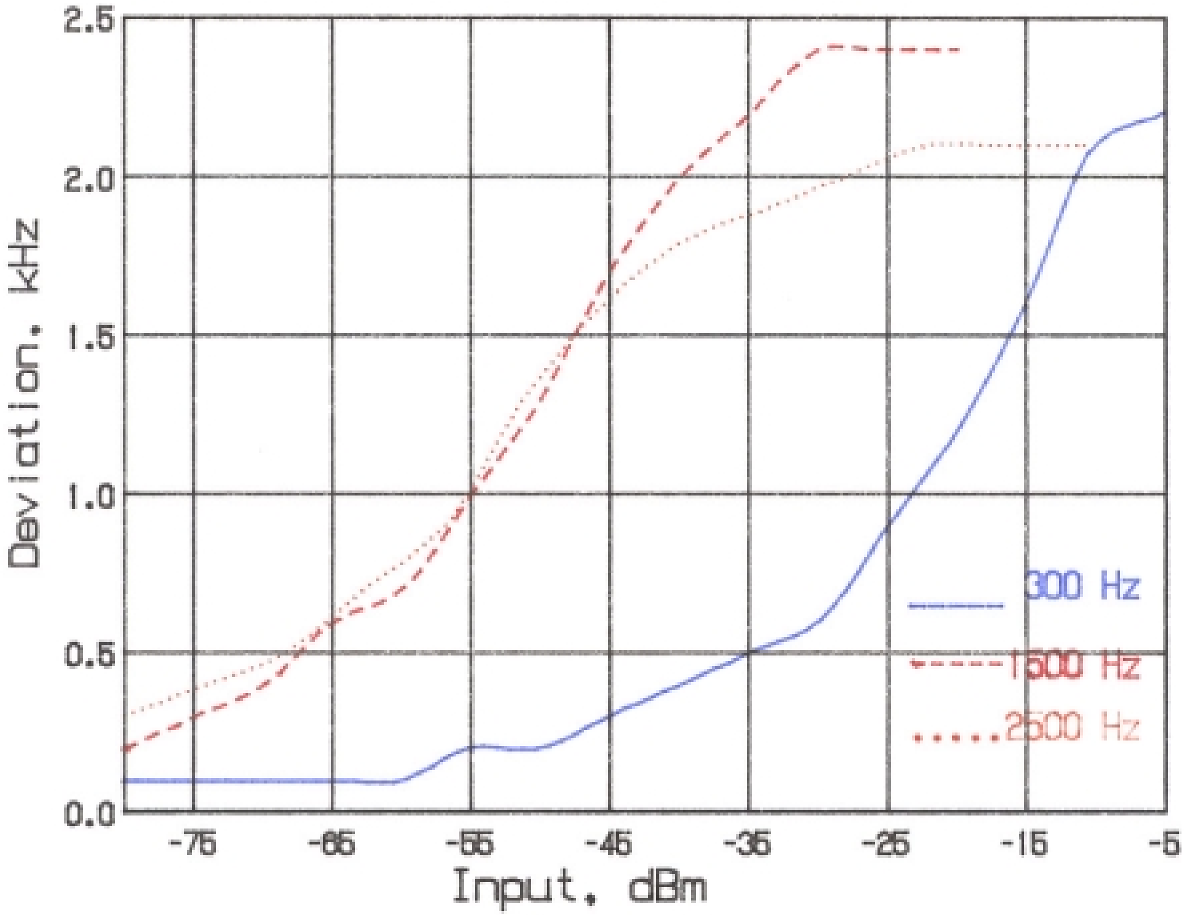


MODULATION FREQUENCY RESPONSE
FCC ID: O9GT5210

FIGURE 1

FIGURE 2

AUDIO LIMITER CHARACTERISTICS

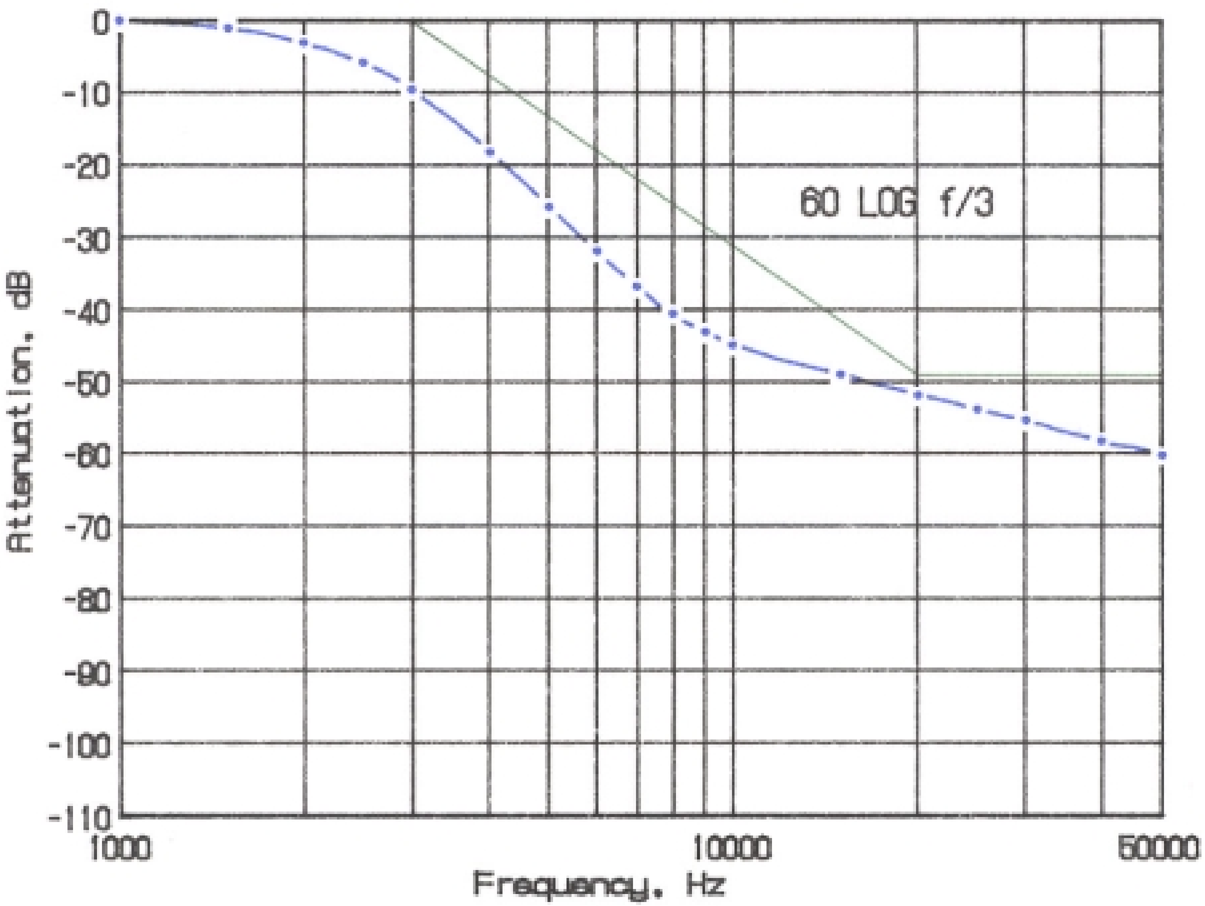


AUDIO LIMITER CHARACTERISTICS
FCC ID: O9GT5210

FIGURE 2

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE

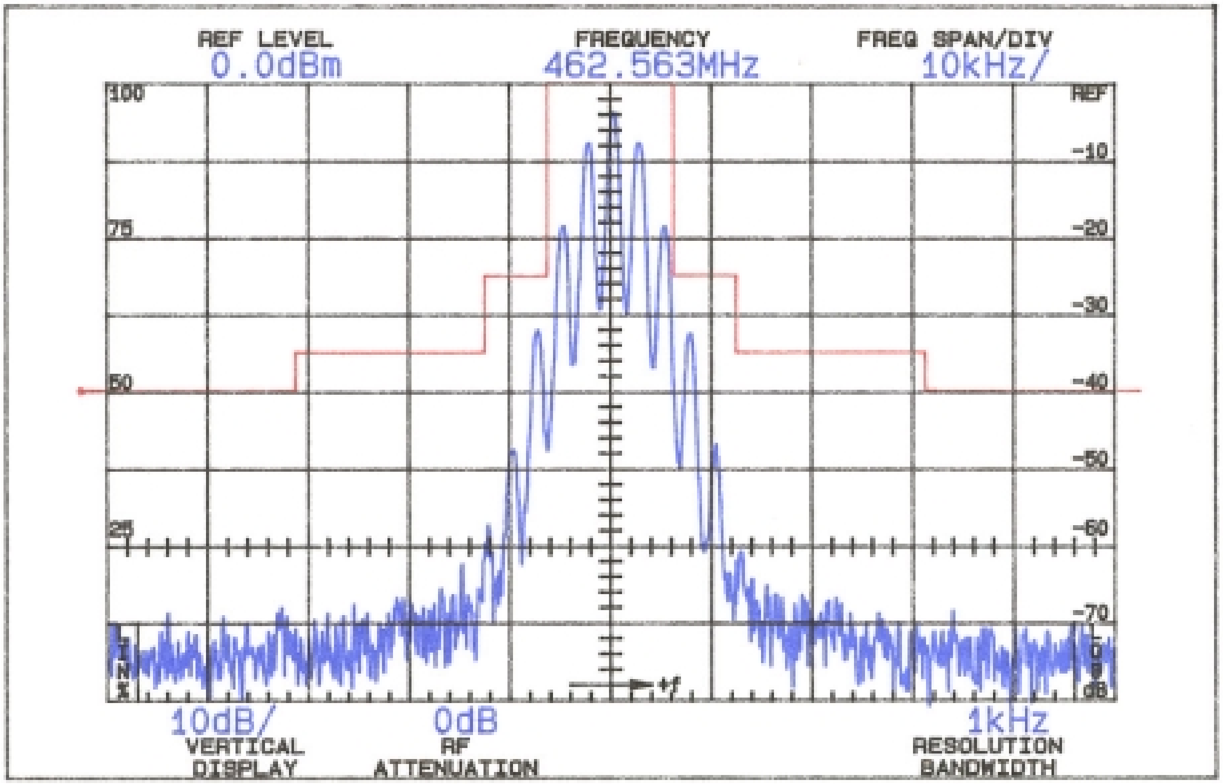


AUDIO LOW PASS FILTER
RESPONSE
FCC ID: O9GT5210

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, 12.5 kHz (6.25-12.5 kHz)	25
On any frequency more than 100%, up to and including 250% of the authorized bandwidth (12.5-31.25 kHz)	35
On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth (over 31.25 kHz)	43+10LogP = 40 (P = 0.49)

OCCUPIED BANDWIDTH
FCC ID: O9GT5210

FIGURE 4

D. MODULATION CHARACTERISTICS (Continued)

The plots are within FCC limits. The horizontal scale frequency) is 10 kHz per division and the vertical scale amplitude) is a logarithmic presentation equal to 10 dB per division.

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

The model T5210 has a permanently attached antenna. There is no connector for an external antenna. Therefore, no antenna terminal conducted measurements were made.

F. DESCRIPTION OF RADIATED SPURIOUS MEASUREMENT FACILITIES

A description of the Hyak Laboratories' radiation test facility is a matter of record with the FCC. The facility was accepted for radiation measurements from 25 to 1000 MHz on October 1, 1976 and is currently listed as an accepted site.

G. MEASUREMENTS OF SPURIOUS RADIATION

Spurious emissions from the model T5210 were made by substitution with a Tektronix 494P spectrum analyzer using Singer DM-105 for the measurements to 1 GHz, and EMCO 3115 horn to 4.8 GHz.

The transmitter was located in an open field 3 meters from the test antenna. Supply voltage was a power supply with a terminal voltage under load of 4.5 Vdc.

The transmitter and test antennae were arranged to maximize pickup. Both vertical and horizontal test antenna polarization were employed.

Measurements were made from the lowest frequency generated within the unit to 10 times operating frequency. Data after application of antenna factors and line loss corrections are shown in Table 2.

TABLE 2

TRANSMITTER CABINET RADIATED SPURIOUS

462.5625 MHz, 4.5 Vdc, 0.49 watts

Spurious	dB Below

Frequency MHz	Carrier Reference[1]
462.563	0
925.125	56V
1387.688	57V
2312.813	60V
Required: 43+10 Log(P) =	40

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

All other spurious from 10.75 MHz to the tenth harmonic were 20 dB or more below FCC limit.

H. FREQUENCY STABILITY
(Paragraph 2.995(a)(2))

Measurement of frequency stability versus temperature was made at temperatures from –20°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 3, starting with –20°C.

A Thermotron S1.2 temperature chamber was used. Temperature was monitored with a Keithley 871 digital thermometer. The transmitter output stage was terminated in a dummy load. Primary supply was 4.5 volts. Frequency was measured with a HP 5385A frequency counter connected to the transmitter through a power attenuator. Measurements were made at 462.5625 MHz. No transient keying effects were observed.

TABLE 3

FREQUENCY STABILITY AS A FUNCTION OF TEMPERATURE
462.5625 MHz, 4.5 Vdc, 0.49 W

Temperature, °C	Output_Frequency,_MHz	p.p.m.
-19.7	462.563610	2.4
-10.2	462.563479	2.1
0.2	462.563211	1.5
10.6	462.562743	0.5
20.1	462.562679	0.4
30.6	462.562137	-0.8
39.5	462.562084	-0.9
49.9	462.562344	-0.3

Maximum frequency error: 462.563610
462.562500

\+ .001110 MHz

FCC Rule 95.627(b) specifies .00025% (2.5 p.p.m.) or a maximum of ±0.001156 MHz, which corresponds to:

High Limit	462.563656 MHz
Low Limit	462.561344 MHz

I. 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 frequency counter as supply voltage provided by an HP 6264B variable dc power supply was varied from ±15% above the nominal 4.5 volt rating to below the battery end point. A Fluke 197 digital voltmeter was used to measure supply voltage at transmitter primary input terminals. Measurements were made at 20°C ambient.

TABLE 4

FREQUENCY STABILITY AS A FUNCTION OF SUPPLY VOLTAGE

462.5625 MHz, 4.5 Vdc Nominal; 0.49W

Supply_Voltage		Output_Frequency,_MHz	p.p.m.
5.17	115%	462.562680	0.4
4.95	110%	462.562674	0.4
4.73	105%	462.562677	0.4
4.50	100%	462.562679	0.4
4.28	95%	462.562687	0.4
4.05	90%	462.562707	0.4
3.83	85%	462.562683	0.4
3.60	80%	462.562437	0.4

Maximum frequency error: 462.562707
462.562500

+ .000207 MHz

FCC Rule 95.627(b) specifies .00025% (2.5 p.p.m. or a maximum of ±0.001156 MHz, corresponding to:

High Limit	462.563656 MHz
Low Limit	462.561344 MHz

*Battery end point.

APPENDIX 1

FUNCTION OF DEVICES
Model T5210

Designator	Description	Function
U300	Dual PLL Synthesizer	Frequency synthesizing
U270 A/B	Compander	Compresses and Expands audio signal
U30	3V Regulator	3V Regulator Circuit
U150 A/C/D	Operational Amplifier	CTCSS low pass (250Hz) filter
U150-B	Operational Amplifier	Receive high pass (300Hz) audio filter

U200-D	Operational Amplifier	Transmit high pass (300Hz) audio filter / mic amp
U200-C	Operational Amplifier	Transmit limiter amp
U200-A	Operational Amplifier	Transmit low pass (3.5Khz) audio filter
U200-B	Operational Amplifier	Receive high pass (300Hz) 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
D231	GP Diode	NI-MH charge protection
D230	General Purpose Diodes	REM PTT/PTT switch
D100	PIN Diode	Transmit/Receive antenna switch
D51	PIN Diode	Transmit/Receive band switch
D300	Varactor Diode	TCXO compensation circuit
D130	General Purpose Diodes	Squelch noise detector
D400	General Purpose Diodes	TCXO compensation circuit
D50	Varactor Diode	VCO tuning
D200	PIN Diode	Transmit/Receive antenna switch
D232	PIN Diode	Transmit audio limiter
D233	PIN Diode	Transmit audio limiter
Q100	Bias Transistor	Transmit/Receive antenna switch
Q101	RF Transistor	LNA stage amplifier
Q102	RF Transistor	1st IF mixer stage amplifier
Q103	IF Transistor	1st IF buffer stage amplifier
Q50/Q51	RF Transistor	VCO – fundamental transmit and LO
Q52	Bias Transistor	Receive/Transmit band switch for VCO
Q300	Bias Transistor	Receive power switch (3.0V)
Q301	Bias Transistor	VCO power switch
Q232	Bias Transistor	Main microphone mute
Q200	RF Power Transistor	PA final stage amplifier – class B
Q201	RF Transistor	PA 2nd stage amplifier – class A
Q202	RF Transistor	PA 1st stage amplifier – class A
Q402	Bias Transistor	Transmit power switch
Q150	Bias Transistor	CTCSS squarer
Q160	Bias Transistor	Receive mute
Q230	Bias Transistor	Transmit mute
Q231	Bias Transistor	Remote PTT detect

APPENDIX 2

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

The fundamental frequency for both the transmitter and the receiver local oscillators are controlled by a phase lock loop (PLL) circuit U300. 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 by measuring the ambient temperature through an analog to digital converter (ADC) circuit. Compensation for voltage variations on the crystal reference is accomplished through a supply voltage regulator. The micro-controller (U400) then converts these measurements to a correction voltage output through a PWM to maintain the frequency of the VCXO within the +/12.5 ppm requirement.

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.

APPENDIX 3

CIRCUITS TO SUPPRESS SPURIOUS RADIATION AND LIMIT MODULATION

The transmitter amplifies the 0 dBm signal from the VCO to approximately 27 dBm that is fed to the antenna. The transmitter is a three stage amplifier composed of Q202, Q201 and Q200. The first two stages are operated class A and the final is operated class B in full saturation to help prevent unwanted amplitude modulation. The fundamental transmit signal is fed through an elliptical low pass filter (5-pole, 2 zero) 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 (U200-D), a hard clipper circuit (U200-C) to limit maximum deviation to +/-2.5 kHz and a three-pole low pass or splatter filter at 2.8 kHz (U200-A). The low pass filter insures that the occupied bandwidth of the FM modulated signal meets FCC requirements under all input conditions.