ENGINEERING STATEMENT

For Type Certification of

TriSquare Communications

Model No: FR60A
FCC ID: XXXFR60

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 FR60 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: September 7, 2000

A. INTRODUCTION

The following data are submitted in connection with this request for type certification of the FR60 transceiver in

accordance with Part 2, Subpart J of the FCC Rules.

The FR60 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.

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: XXXFR60

   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. Maximum power permitted is 0.5 watts, and the FR60 fully complied with that power limitation.
   e. The dc voltage and dc currents at final amplifier:

      Collector voltage: 4.4 Vdc
      Collector current: 0.40 A

   f. Function of each active semiconductor device: See Appendix 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.

   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 3.
   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)

The FR60 has a permanently attached built-in antenna without provisions for a coaxial connector.

Therefore RF power output was calculated, see Table 1. The transmitter was tuned by the factory.

TABLE 1

Operating Freq., MHz	Power watts into a dipole antenna
462.5625	0.48

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. Occupied Bandwidth
(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 2690 Hz, the frequency of maximum response. Measured modulation under these conditions was 2.4 kHz.

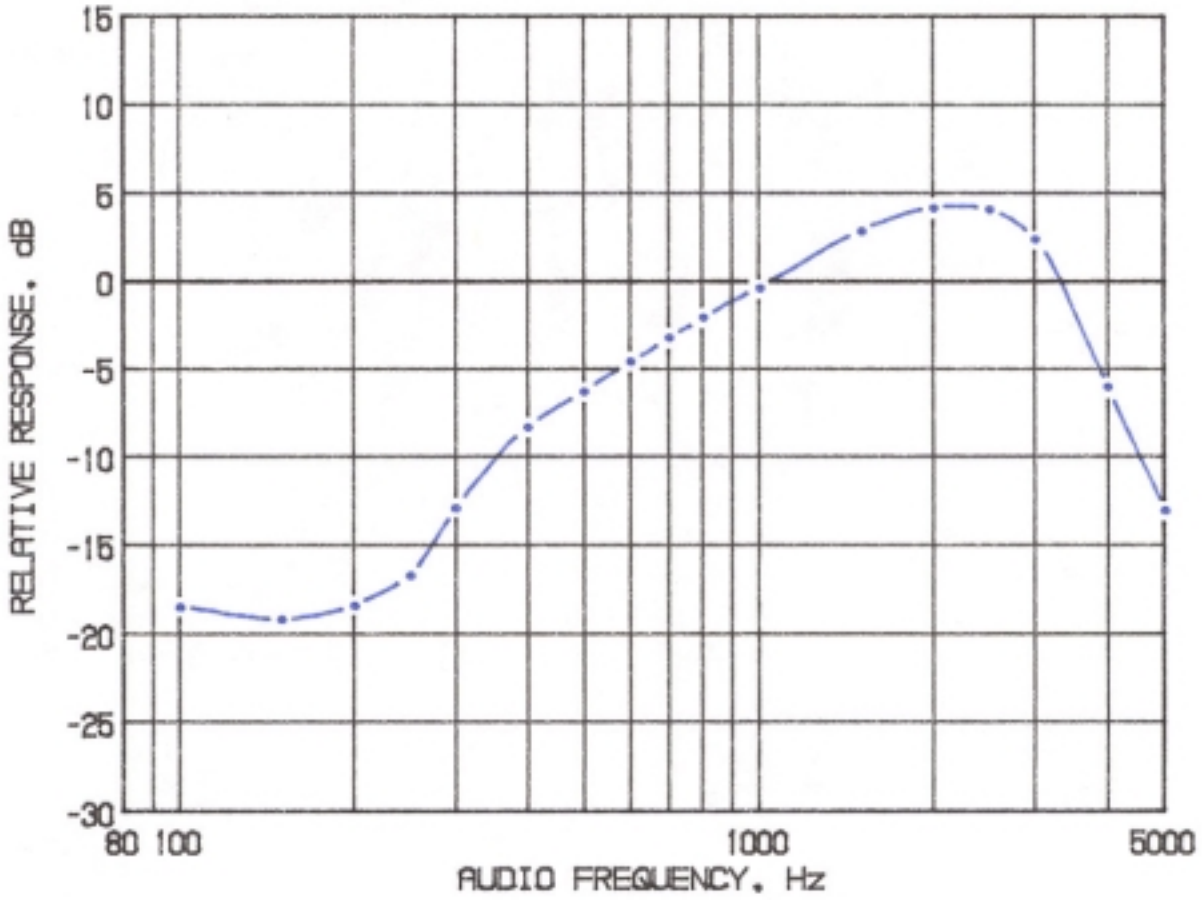
Emission designator:

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

*Deviation @ 1500 Hz was 2.5 kHz.

FIGURE 1

MODULATION FREQUENCY RESPONSE

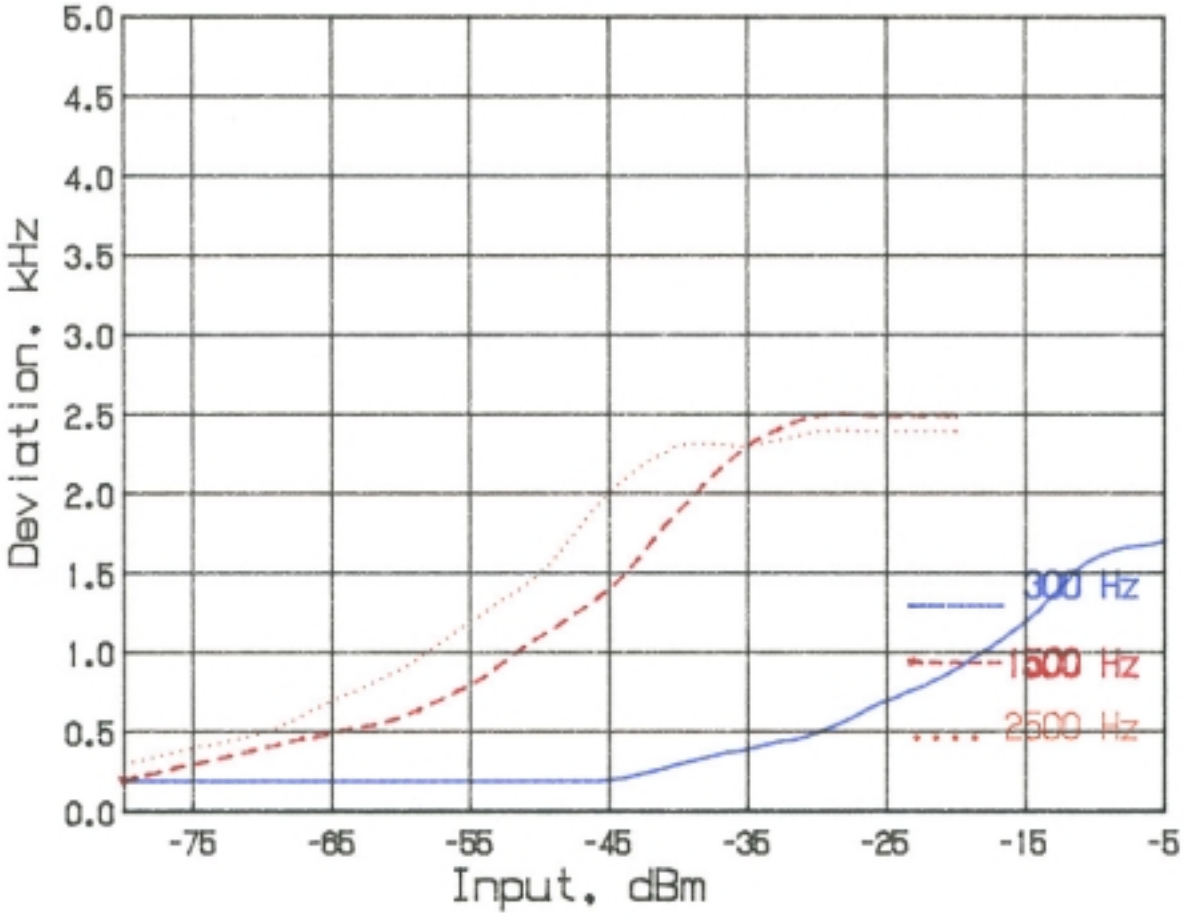


MODULATION FREQUENCY RESPONSE
FCC ID: XXXFR60

FIGURE 1

FIGURE 2

AUDIO LIMITER CHARACTERISTICS

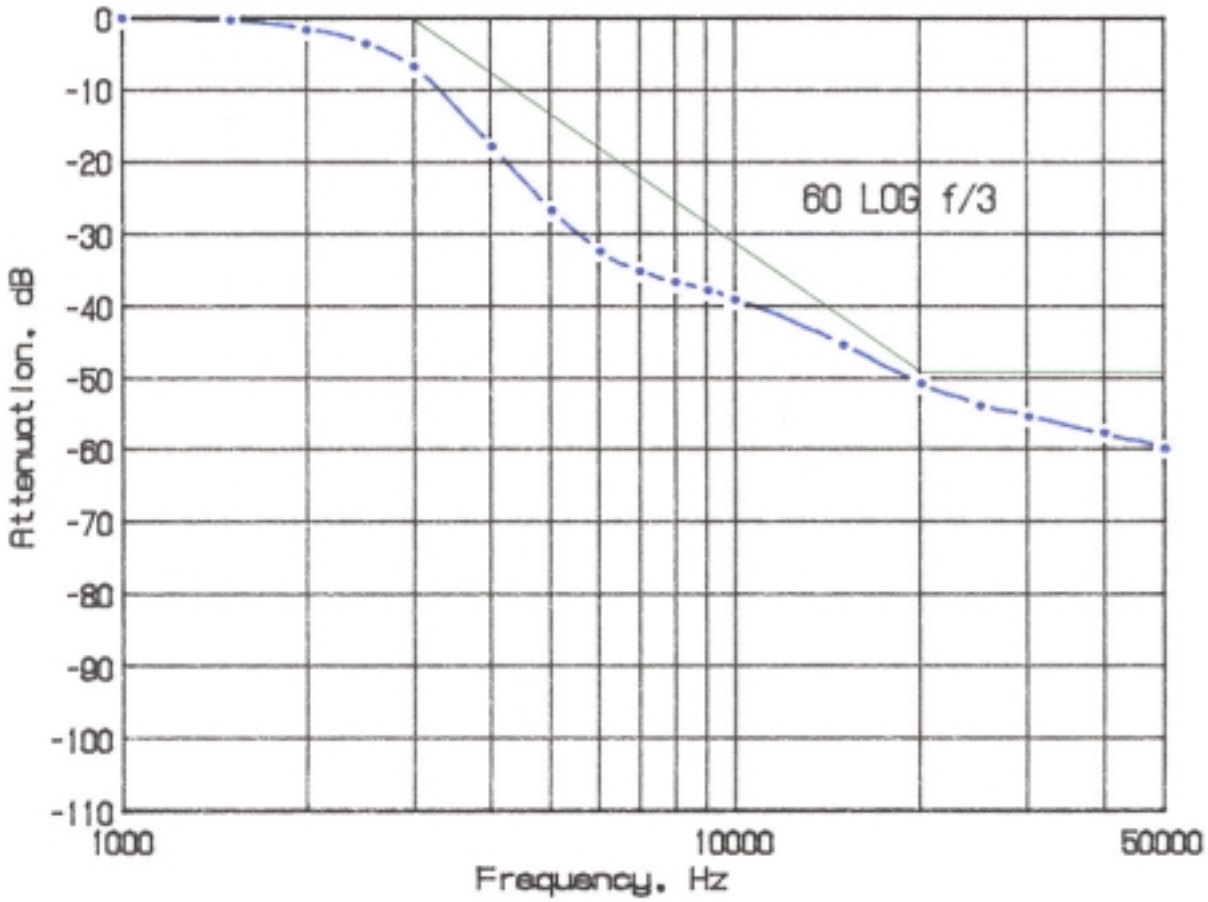


AUDIO LIMITER CHARACTERISTICS
FCC ID: XXXFR60

FIGURE 2

FIGURE 3

AUDIO LOW PASS FILTER RESPONSE



AUDIO LOW PASS FILTER
RESPONSE
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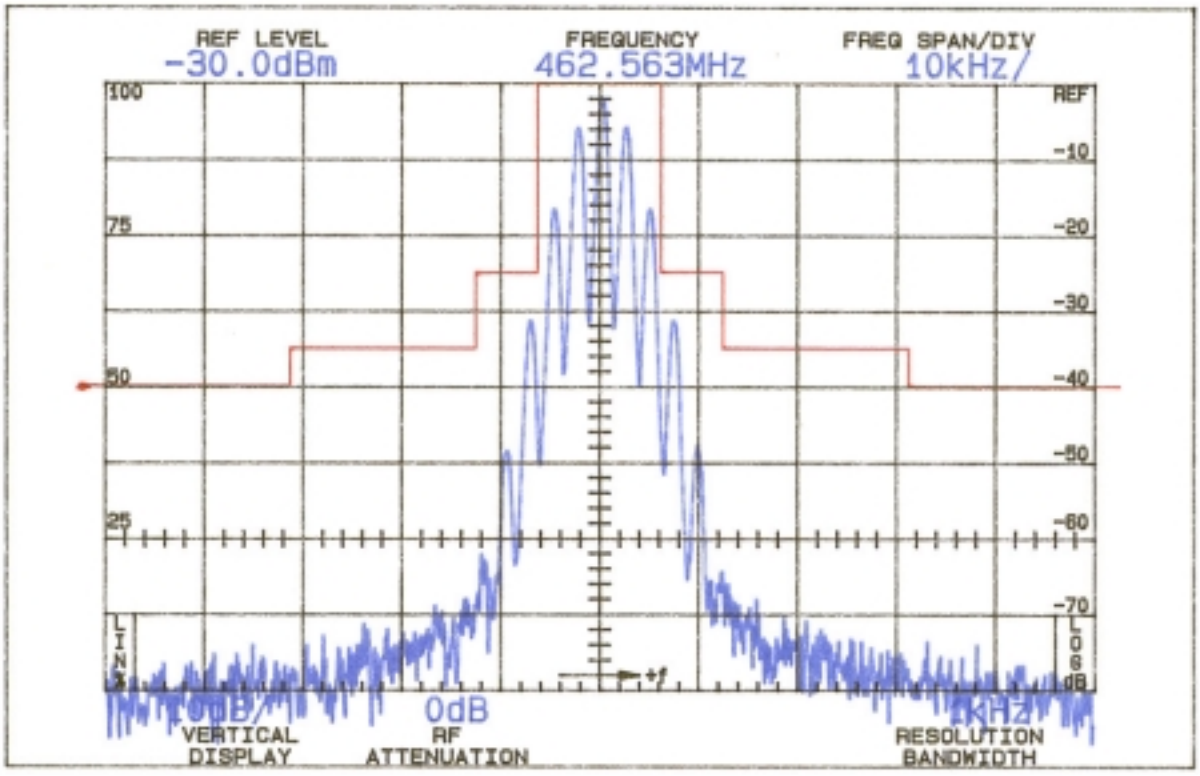
FIGURE 3

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 = 0.48)

OCCUPIED BANDWIDTH
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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 FR60 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. FIELD STRENGTH MEASUREMENTS OF SPURIOUS RADIATION

Field intensity measurements of radiated spurious emissions from the FR60 were made 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.

The measurement system was capable of detecting signals 100 dB or more below the reference level. Measurements were made from the lowest frequency generated within the unit (12.8 MHz), 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, 0.48 watts

Spurious	Radiated	dB Below

Frequency MHz	Field uV/m @ 3M	Carrier Reference[1]
462.563	1621810	0V
925.125	2130	58V
1387.688	738	67V*
1850.250	65	88V*
2312.813	87	85V*
2775.375	83	86V*
3237.938	93	85H*
3700.500	104	84V*
4163.063	85	86V*
4625.625	68	88V*

Required: 43+10 Log(P) = 40

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

*Reference data only, more than 20 dB below FCC limit.

All other spurious from 10.475 MHz to the tenth harmonic were 20 dB or more below FCC limit.

Power:

$P = (F.I.x3)^2/49.2$

$= (1.621810)^2/49.2$

$= 0.48$ W

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, 0.48 W

Temperature, °C	Output Frequency, MHz	p.p.m.
-19.0	462.562230	-0.6
- 9.7	462.562761	0.6
0.5	462.562759	0.6
10.2	462.562821	0.7
20.2	462.562458	-0.1
30.6	462.562455	-0.1
40.0	462.562535	0.1
50.1	462.562719	0.5
Maximum frequency error:	462.562821	
	462.562500	
	+ .000321 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; 0.48W

Supply_Voltage		Output_Frequency,_MHz	p.p.m.
5.2	115%	462.562818	0.7
5.0	110%	462.562648	0.3
4.7	105%	462.562535	0.1
4.5	100%	462.562458	-0.1
4.3	95%	462.562418	-0.2
4.1	90%	462.562393	-0.2
3.8	85%	462.562368	-0.3
3.6 *	80%	462.562350	-0.3

Maximum frequency error: 462.562818
462.562500

+ .000318 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
FR60

Designator	Description	Function
U1	Dual PLL Synthesizer	Frequency synthesizing
U2A	Operational Amplifier	3V Regulator Circuit
U2B	Operational Amplifier	TCXO compensation comparator
U2C	Operational Amplifier	Remote PTT detection
U2D	Operational Amplifier	Receive high pass (300Hz) audio filter

U3A/B	Operational Amplifier	CTCSS low pass (250Hz) filter
U3C/D	Operational Amplifier	Receive high pass (300Hz) audio filter
U4A	Operational Amplifier	Transmit high pass (300Hz) audio filter
U4B	Operational Amplifier	Transmit limiter
U4C	Operational Amplifier	Transmit low pass (3.5Khz) audio filter
U4D	Operational Amplifier	Transmit low pass (3.5Khz) audio filter & mic amp
U5A/B	Compander	Compresses and Expands audio signal
U6	Audio Amplifier	Final stage audio amplifier for 200mW output & low pass (3Khz) audio filter
U9	Narrowband FM IF	2^{nd} IF amplifier, 2^{nd} LO mixing, audio detector
U401	8 Bit Microcontroller	Transmit/Receive control, key decode, power control

D1	PIN Diode	Transmit/Receive antenna switch
D2	PIN Diode	Transmit/Receive band switch
D3	Varactor Diode	TCXO compensation circuit
D4	General Purpose Diodes	Squelch noise detector
D5	General Purpose Diodes	TCXO compensation circuit
D6	General Purpose Diodes	3V regulator circuit
D7	General Purpose Diodes	3V regulator circuit
D8	Varactor Diode	VCO tuning
D9	PIN Diode	Transmit/Receive antenna switch

Q1	Bias Transistor	Transmit/Receive antenna switch
Q2	RF Transistor	LNA stage amplifier
Q3	RF Transistor	1^{st} IF mixer stage amplifier
Q4	IF Transistor	1^{st} IF buffer stage amplifier
Q5	Bias Transistor	3V regulator switch
Q6/Q7	RF Transistor	VCO – fundamental transmit and LO
Q8	Bias Transistor	Receive/Transmit band switch for VCO
Q9	Bias Transistor	Receive power switch (4.5V)
Q11	Bias Transistor	VCO power switch
Q13	Bias Transistor	Main microphone mute
Q14	RF Power Transistor	PA final stage amplifier – class B
Q15	RF Transistor	PA 2^{nd} stage amplifier – class A
Q16	RF Transistor	PA 1^{st} stage amplifier – class A
Q17	Bias Transistor	Transmit power switch
Q400/Q401	Bias Transistor	CTCSS control level translator
Q402	Bias Transistor	Temperature level translator

APPENDIX 2

CIRCUITS AND DEVICES TO STABILIZE FREQUENCY

SYNTHESIZER

A phase locked loop (PLL) circuit establishes and stabilizes operating frequency.

The data for producing necessary frequencies is established by the microcontroller on the digital board.

The frequency stability of the TX/RX is maintained by the TCXO, which generates a stable frequency of 10.475 MHz.

CIRCUITS AND DEVICES TO
STABILIZE FREQUENCY
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APPENDIX 2

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 Q7, Q2, and Q3. 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 (U401D), a hard clipper circuit (U401A) to limit maximum deviation to ± 2.5 kHz and a three-pole low pass or splatter filter at 2.8 kHz (U5B & U401C). The low pass filter insures that the occupied bandwidth of the FM modulated signal meets FCC requirements under all input conditions.

CIRCUITS TO SUPPRESS SPURIOUS
RADIATION AND LIMIT MODULATION
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APPENDIX 3