

TEST REPORT
For
APPLICATION of CERTIFICATION

For

GARMIN INTERNATIONAL, INC.
1200 East 151st Street
Olathe, KS 66062
Phone: (913) 397-8200

MODEL: GTX 327

FREQUENCY: 1090 MHz

FCC ID: IPH-0037600

Test Date: October 26, 1999

Certifying Engineer: *Scot D Rogers*

Scot D. Rogers
ROGERS LABS, INC.
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FORWARD:

In accordance with the Federal Communications Code of Federal Regulations, dated October 1, 1998, Part 2 Subpart J, Paragraphs 2.907, 2.911, 2.913, 2.925, 2.926, 2.1031 through 2.1057; Part 87, Subchapter D, Paragraphs 87.131 through 87.147; and Report and Order FCC 98-58 the following is submitted:

List of Test Equipment

A Hewlett Packard 8591EM and or 8562A Spectrum Analyzer was used as the measuring device for the emissions testing. The analyzer settings used are described in the following table. Refer to Appendix for a complete list of Test Equipment.

HP 8591EM SPECTRUM ANALYZER SETTINGS		
CONDUCTED EMISSIONS:		
RBW	AVG. BW	DETECTOR FUNCTION
9 kHz	30 kHz	Peak/Quasi Peak
RADIATED EMISSIONS (30 - 1000 MHz):		
RBW	AVG. BW	DETECTOR FUNCTION
120 kHz	300 kHz	Peak/Quasi Peak
HP 8562A SPECTRUM ANALYZER SETTINGS		
RADIATED EMISSIONS (1 - 40 GHz):		
RBW	AVG. BW	DETECTOR FUNCTION
1 MHz	1 MHz	Peak/Average
ANTENNA CONDUCTED EMISSIONS:		
RBW	AVG. BW	DETECTOR FUNCTION
100 kHz	300 kHz	Peak

Equipment Tested

<u>EQUIPMENT</u>	<u>MODEL/PART#</u>
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EUT	GTX327
-----	--------

IFR	ATC-1400A
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Power Supply	Trygon
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Test results in this report relate only to the items tested.

Equipment and Cable Configuration

Test Setup

The EUT was arranged in a typical engineering test setup configuration. The EUT was connected to a dc power supply for power and a coaxial cable was connected to the antenna output terminal. The coaxial cable was split by a directional coupler and connected to a spectrum analyzer and the IFR test box. This provided a 50-ohm load and response signals to exercise the EUT. On the attenuated output port of the directional coupler a notch filter, attenuation and spectrum analyzer was connected. The notch filter was used at the spectrum analyzer input to attenuate the fundamental frequency centered at 1090 MHz. Refer to Figure 1 for a diagram of the test setup.

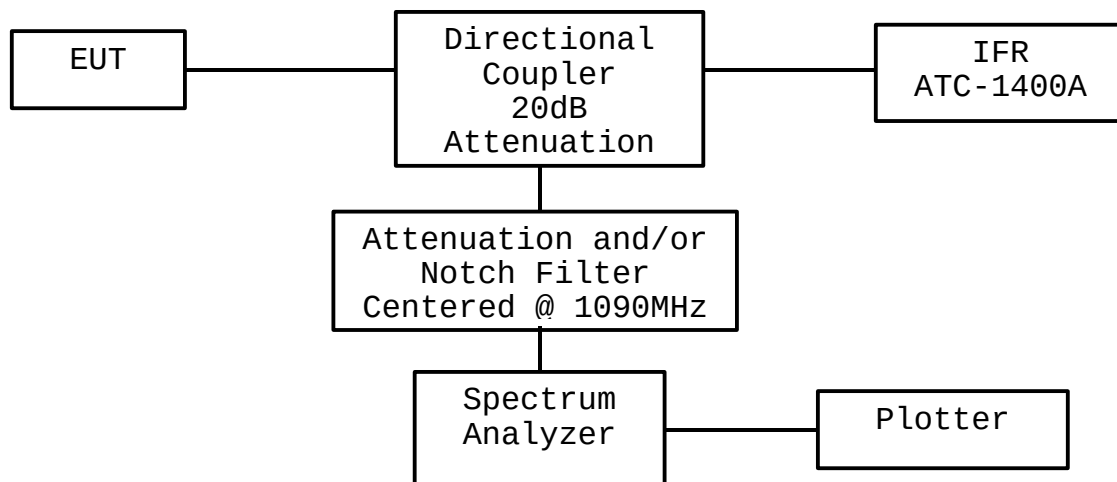


Figure 1. Test Setup

2.1033(c) Application for Certification

1. Manufacturer: GARMIN INTERNATIONAL, INC.
1200 East 151ST Street
Olathe, KS 66062
Phone (913) 397-8200
2. Identification: Model: GTX 327
FCC I.D.: IPH-0037600
3. Refer to Exhibit for Installation and Operating Instructions Manual.
4. Emission Type: 11M0M1D
5. Frequency Range: 1090 MHz.
6. Operating Power Level:
RPS = Replies Per Second
PR = Pulse Reply Rate
PW = Pulse Width
Duty Factor = $1200 \text{ RPS} \times 15 \text{ PR} \times (0.45 \times 10^{-6}) \text{ PW}$
Duty Factor = 0.0081
Nominal Average Power = $P_o(\text{PEP}) \times \text{Duty Factor}$
 $205 \text{ W PEP} \times 0.0081 = 1.7 \text{ W Ave}$
7. Max P_o : 210 W PEP.
8. Power into final amplifier: 561 Watts PEP (54V @ 10.4A).
9. Tune Up Procedure for Output Power:
Refer to tune-up procedures for GTX 327 in the equipment manuals.
10. Description of Circuitry and Devices Provided for Determining and Stabilizing Frequency, for Suppression of Spurious Radiation, Modulation and Power:
A very high Q ceramic resonator controls the transmitter frequency. All components including the PCB material, trimmer capacitors, etc. are very stable. A three pole low pass filter with quarter-wave stubs for the second and third harmonics are incorporated into the output of the power amplifier. Please refer to schematic diagrams for the GTX 327 Transponder.

The transponder uses the standard pulse format as required by ICAO, Annex 10 for both A and C modes of operation. A pulse train from the airborne unit is emitted after being interrogated by the ground unit. Each pulse has a width of 0.45 microseconds spaced 1.45 microseconds apart. Pulse train width between F1 and F2 is 20.3 microseconds. Rise time and fall time of the pulses is typically 75 nanoseconds.

11. FCC ID Label:

Refer to Exhibit for FCC Label Identification.

12. Photographs of Equipment.

Refer to Appendix of this Report.

13. Description of Digital Modulation:

The modulator receives interrogation trigger pulses from the XILINX IC. The modulator circuitry applies control pulses to both the collector and emitter of the RF driver transistor, and simultaneously to the collector of the power amplifier. The exact timing of the modulator pulses along with the wave shaping provided by the modulator circuitry provide excellent control of all aspects of the transmitter characteristics. The unit conforms to ATCRBS and TS0 Standards.

a) ATCRBS

1. Pulse Duration - 0.45 ± 0.10 microseconds.
2. Rise time - 0.05 to 0.1 μ second.
3. Decay time - 0.05 to 0.2 μ second.
4. Pulse amplitude variation ± 1 dB max.
5. Reply Rate - factory adjusted to 1200 replies/second maximum in accordance with TS0 C74C.
6. Reply group pulse content - 2 to 15 pulses.

7. Pulse spacing – $1.45 \pm 0.1 \mu\text{Sec}$ except for the special position identification (SPI) which shall follow the last reply pulse by $4.35 \pm 0.1 \mu\text{Sec}$.

2.1046 RF Power Output

Measurements Required:

Measurements shall be made to establish the radio frequency power delivered by the transmitter into the standard output termination. The power output shall be monitored and recorded and no adjustment shall be made to the transmitter after the test has begun, except as noted below:

If the power output is adjustable, measurements shall be made for the highest and lowest power levels.

Test Arrangement:

The radio frequency power output was measured at the antenna terminal by replacing the antenna with a splitter, appropriate attenuation, a spectrum analyzer, cable, and test equipment (57 dB attenuation).

The spectrum analyzer had impedance of 50Ω to match the impedance of the standard antenna. A HP 8591EM Spectrum Analyzer was used to measure the r.f. power at the antenna port. The data was taken in dBm and converted to watts as shown in the following Table. Refer to Figure 2 showing the output power of the transmitter. Data taken per Paragraph 2.1046 and applicable parts of Part 87.

P_{dBm} = power in dB above 1 milliwatt.

Milliwatts = $10^{(P_{\text{dBm}}/10)}$

Watts = (Milliwatts)(0.001)(W/mW)

53.1 dBm = $10^{(53.1/10)}$
= 205,5000 mW

$$\begin{aligned}
 &= 205 \text{ Watts (PEP)} \\
 &\quad \text{Watts (PEP)} \times \text{Duty Factor} \\
 &= 205 \times 0.0081 \\
 &= 1.66 \text{ Watts (AVE.)}
 \end{aligned}$$

Results:

FREQUENCY	P _{dBm}	OUTPUT POWER WATTS (PEP)	OUTPUT POWER IN WATTS (AVE)
1090	53.1	205	1.66

The specifications of Paragraph 2.1046 and applicable Parts of 87.131 are met. There are no deviations to the specifications.

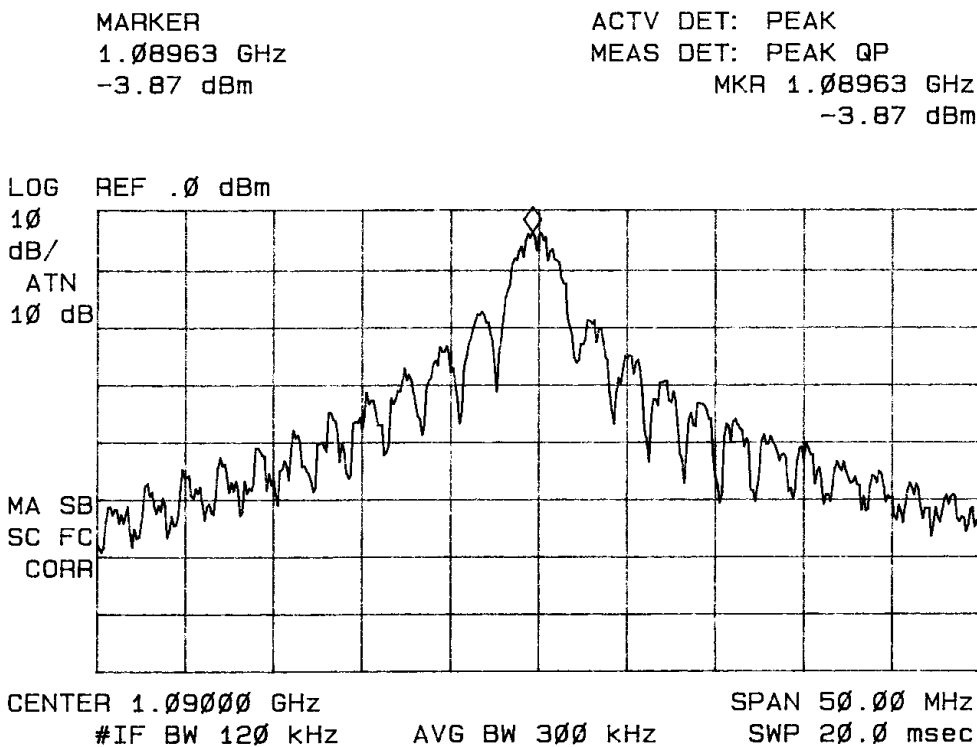


Figure 2: Power Output

2.1047 Modulation Characteristics

Measurements Required:

A curve or equivalent data, which shows that the equipment will meet the modulation requirements of the

rules, under which the equipment is to be licensed, shall be submitted.

Test Arrangement:

The radio frequency output was coupled to a HP Spectrum Analyzer, test equipment and an oscilloscope. The spectrum analyzer was used to observe the radio frequency spectrum with the transmitter operating in a normal mode. The oscilloscope was used to measure the pulse data.

Results:

ATCRBS	SPECIFICATIONS IN μ SEC.
Rise Time	0.05 to 0.10
Pulse Duration	0.45 ± 0.10
Decay Time	0.05 to 0.20
Pulse Amplitude Variation	1 dB Maximum
Reply Rate	1200 PPS
Pulse Content	2-15 pulses
Pulse Spacing	1.45 ± 0.10

The specifications of Paragraph 2.1047 and applicable Parts of 87.141 are met. There are no deviations to the specifications.

2.1049 Occupied Bandwidth

Measurements Required:

The occupied bandwidth, that is the frequency bandwidth such that below its lower and above its upper frequency limits, the mean powers radiated are equal to 0.5 percent of the total mean power radiated by a given emission.

Test Arrangement:

The occupied bandwidth was measured at the antenna terminal by replacing the antenna with a splitter, appropriate attenuation, a spectrum analyzer, cable, and test equipment. The spectrum analyzer had impedance of 50Ω to match the impedance of the standard antenna. A HP 8591EM Spectrum Analyzer was used to measure the occupied bandwidth of the transmitter at the antenna port. The data was taken for the minimum and maximum response pulses.

Results:

RESPONSE	f_c (MHz)	O.B. (MHz)
0000	1090.0	10.88
7777	1090.0	10.75

Refer to figures 3 and 4 for Plots of Occupied Bandwidth.

A spectrum analyzer was used to observe the radio frequency spectrum with the transmitter operating in a normal mode. The power ratio in dB representing 99% of the total mean power was recorded from the spectrum analyzer.

MARKER Δ
 10.88 MHz
 .34 dB

ACTV DET: PEAK
 MEAS DET: PEAK QP
 MKR 10.88 MHz
 .34 dB

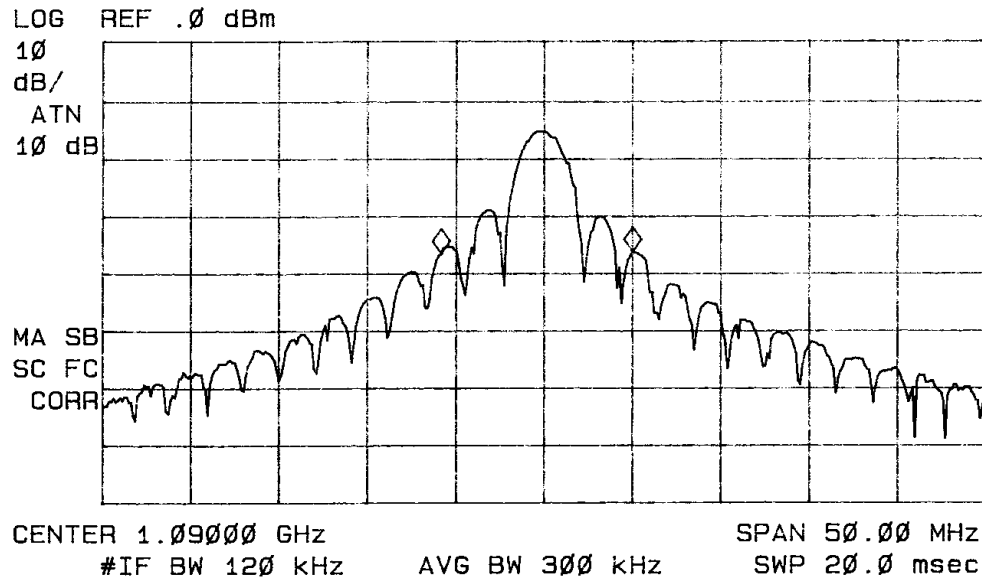


Figure 3: Occupied BandWidth (0000 response).

MARKER Δ
 10.75 MHz
 .25 dB

ACTV DET: PEAK
 MEAS DET: PEAK QP
 MKR 10.75 MHz
 .25 dB

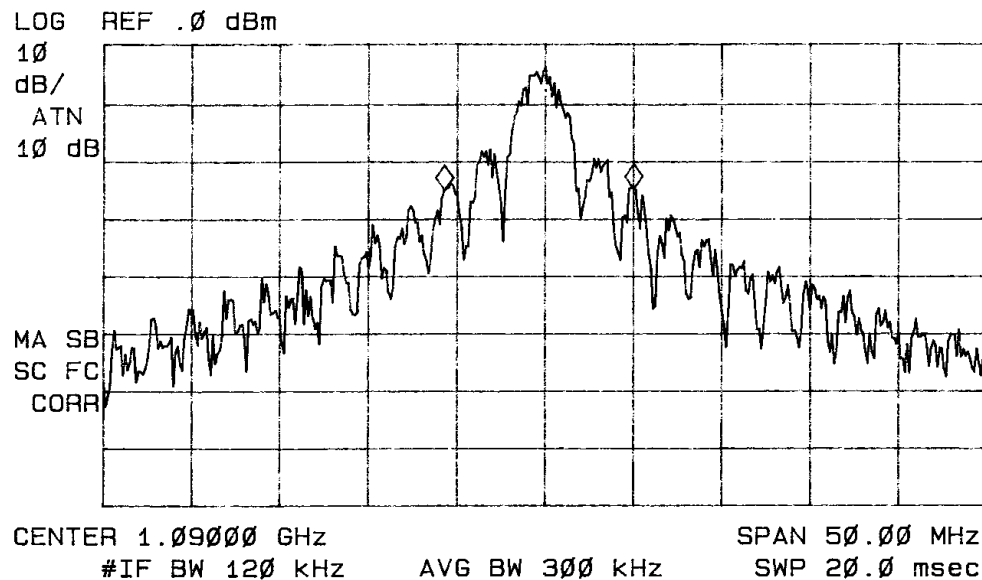


Figure 4: Occupied BandWidth (7777 response).

Requirements of 2.1049(c)(1) and 87.135 are met. There are no deviations to the specifications.

2.1051 Spurious Emissions at Antenna Terminals

Measurements Required:

The radio frequency voltage or power generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna.

Test Arrangement:

The radio frequency output was coupled to a HP 8562A Spectrum Analyzer. The spectrum analyzer was used to observe the radio frequency spectrum with the transmitter operated in a normal mode. The frequency spectrum from 0 MHz to 15 GHz was observed and plots produced of the frequency spectrum. Figures 5 and 6 represent data for the GTX 327. Data taken per 2.1049, 2.1051, 2.1057, and 87.139.

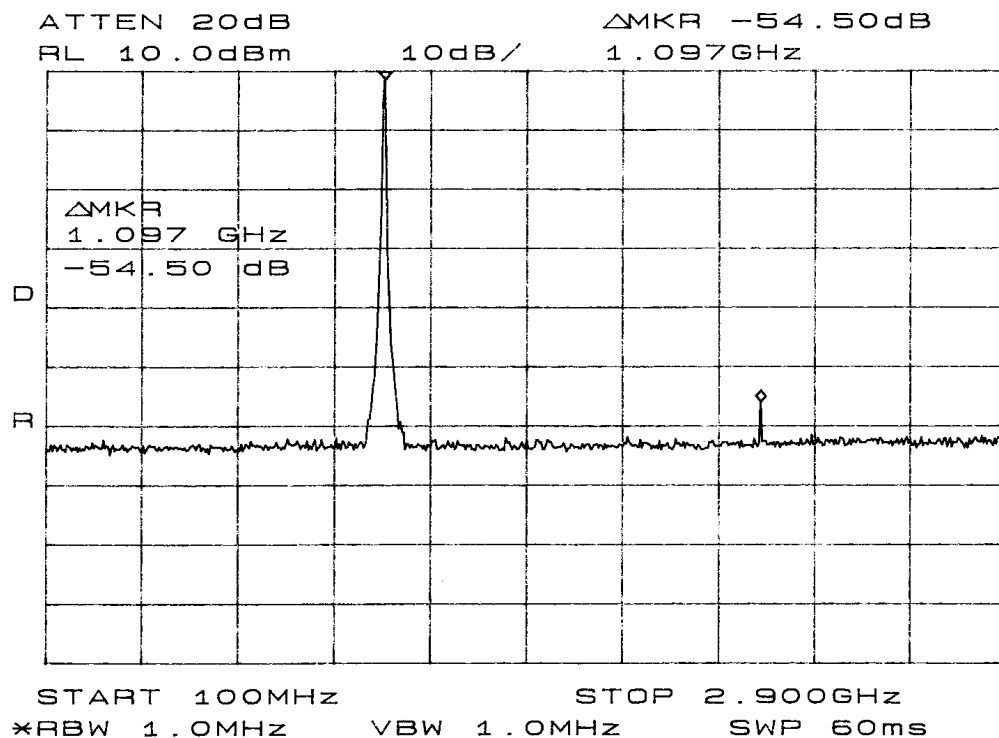


Figure 5: Emissions at Antenna Terminal.

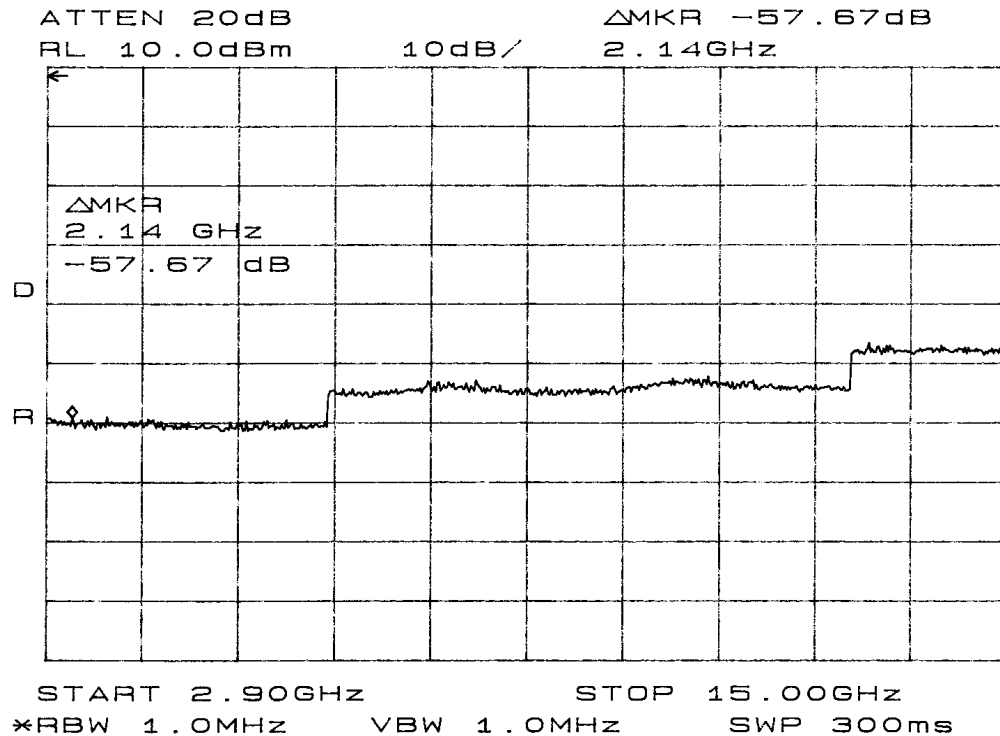


Figure 6: Emissions at Antenna Terminal.

Results:

Data taken per 2.1051 and applicable paragraphs of Part 87. Specifications of Paragraphs 2.1051, 2.1057 and 87.139 are met. There are no deviations to the specifications.

FCC Limit:

$$\begin{aligned}
 &= 43 + 10 \text{ LOG}(P_o \text{ (AVE.)}) \\
 &= 43 + 10 \text{ LOG}(1.7) \\
 &= 43 + 2.2 \\
 &= 45.2 \text{ dB}
 \end{aligned}$$

FREQUENCY MHz	SPURIOUS FREQ. (MHz)	LEVEL BELOW CARRIER (dB)
1090.0	2180.0	54.5
	3270.0	57.6

2.1053 Field Strength of Spurious Radiation

Measurements Required:

Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation.

Test Arrangement:



The transmitter was placed on a wooden turntable 0.8 meters above the ground plane and at a distance of 3 meters from the FSM antenna. The transmitter was activated and the frequency spectrum was observed. The turntable was rotated through 360 degrees to locate the position registering the highest amplitude emission. The frequency spectrum was then searched for spurious emissions generated from the transmitter. The amplitude of each spurious emission was maximized by raising and lowering the FSM antenna and rotating the turntable before data was recorded. A Biconilog antenna for frequencies of 30 MHz to 1 GHz or a log periodic antenna was used for frequencies of 200 MHz to 5 GHz, and pyramidal horn antennas for frequencies of 5 GHz to 40 GHz. Emission levels were measured and recorded from the spectrum analyzer in dBμV. This level was then added to the antenna factor to calculate the field strength at 3 meters. Data was taken at the ROGERS LABS, INC. 3 meters open area test site (OATS). A description of the test facility is on file with the FCC, Reference: 31040/SIT, 1300F2, dated February 6, 1998. The testing procedures used conform to the procedures stated in the ANSI 63.4-1992 document.

Calculations made are as follows:

CFS = Calculated Field Strength
 FSM = Field Strength Measurement
 CFS = FSM + Antenna Factor - Amp. Gain
 CFS = 47.2 + 10.5 - 35
 CFS = 22.7

The limit for emissions are defined by the following equations:

Limit = Amplitude of spurious emission must be attenuated by this amount below the level of the fundamental.

Calculating the field strength at 3 meters for the 205-watt (PEP)(1.7 Watt AVE.) transmitter was done as follows:

$$E = \frac{5.5 \sqrt{PG}}{3} \text{ where } E \text{ is V/m, } P \text{ is Watts, } G = 1.64 \text{ and } d \text{ is meters.}$$

$$E = \frac{5.5 \sqrt{1.7(1.64)}}{3} = 3.1 \text{ V/m} = 3.1 \times 10^6 \text{ } \mu\text{V/m @ 3 Meters}$$

This was converted to dB μ V/m using (20*log μ V/m) for convenience.

$$20 * \log (3.1E6 \text{ } \mu\text{V/m}) = 129.8 \text{ dB}\mu\text{V/m @ 3 meters.}$$

On any frequency removed from the assigned frequency by more than 250% of the authorized bandwidth the emissions shall be at least 43 + 10 Log P_o (AVE.) below the fundamental.

$$\begin{aligned} \text{Attenuation} &= 43 + 10 \text{ Log } (P_o \text{ AVE.}) \\ &= 43 + 10 \text{ Log } (1.7) \\ &= 45.2 \end{aligned}$$

The limit then is expressed as:

$$\begin{aligned} \text{Limit} &= 129.8 - 45.2 \\ &= 84.6 \text{ dB} \end{aligned}$$

Results:

General Emissions

Frequency (MHz)	FSM Horz. (dBµV)	FSM Vert. (dBµV)	Ant. Factor (dB)	Amp. Gain (dB)	CFS Horz. @ 3m (dBµV/m)	CFS Vert. @ 3m (dBµV/m)	Limit
44.2	47.2	38.6	10.5	35	22.7	14.1	40.0
61.6	49.9	58.2	6.7	35	21.6	29.9	40.0
63.5	50.1	51.3	6.7	35	21.8	23.0	40.0
64.3	46.8	50.0	6.7	35	18.5	21.7	40.0
65.5	48.7	52.6	6.7	35	20.5	16.8	40.0
497.3	50.2	46.3	17.4	35	32.6	28.7	46.0

Channel Frequency 1090 MHz

Frequency (MHz)	FSM Horz. (dBµV)	FSM Vert. (dBµV)	Ant. Factor (dB)	Amp. Gain (dB)	CFS Horz. @ 3m (dBµV/m)	CFS Vert. @ 3m (dBµV/m)	Limit
2180.0	22.3	23.3	30.1	25	27.4	28.4	54.0
3270.0	22.1	23.5	34.7	25	31.8	33.2	54.0

Specifications of Paragraph 2.1053, 2.1057 and 87.139 are met. There are no deviations to the specifications.

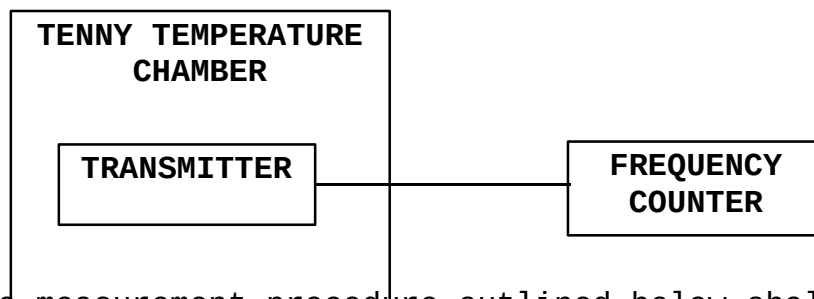
2.1055 Frequency Stability**Measurements Required:**

The frequency stability shall be measured with variations of ambient temperature from -20° to +50° centigrade. Measurements shall be made at the extremes of the temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. In addition

to temperature stability the frequency stability shall be measured with variation of primary supply voltage as follows:

- (1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.
- (2) For hand carried, batteries powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.
- (3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided.

Test Arrangement:



The measurement procedure outlined below shall be followed:

Step 1: The transmitter shall be installed in an environmental test chamber whose temperature is controllable. Provision shall be made to measure the frequency of the transmitter.

Step 2: With the transmitter inoperative (power switched "OFF"), the temperature of the test chamber shall be adjusted to +25°C. After a temperature stabilization period of one hour at +25°C, the

transmitter shall be switched "ON" with standard test voltage applied.

Step 3: The carrier shall be keyed "ON", and the transmitter shall be operated unmodulated at full r.f. power output at the duty cycle for which it is rated, for a duration of at least 5 minutes. The r.f. carrier frequency shall be monitored and measurements shall be recorded.

Step 4: The test procedures outlined in Steps 2 and 3, shall be repeated after stabilizing the transmitter at the environmental temperatures specified, -20°C to 50°C in 10 degree increments.

The frequency stability was measured with variations in the power supply voltage from 85 to 115 percent of the nominal value and at the battery end point. A Sorenson DC Power Supply was used to vary the dc voltage for the power input from 11.0 Vdc to 32.2 Vdc. The frequency was measured and the variation in parts per million was calculated. Data was taken per Paragraphs 2.1055(a)(2) and 80.209.

Results:

FREQ. (MHz)	FREQUENCY STABILITY VS TEMPERATURE IN PARTS PER MILLION (PPM)								
	Temperature in °C								
	-30	-20	-10	0	+10	+20	+30	+40	+50
1090.0	0.002	0.002	0.001	0.001	0.001	0	0.004	0.004	0.004

FREQUENCY IN MHZ	STABILITY VS VOLTAGE VARIATION (15%) IN PPM INPUT VOLTAGE		
	11.0 V _{dc}	27.5 V _{dc}	32.2 V _{dc}
1090.00	0	0	0

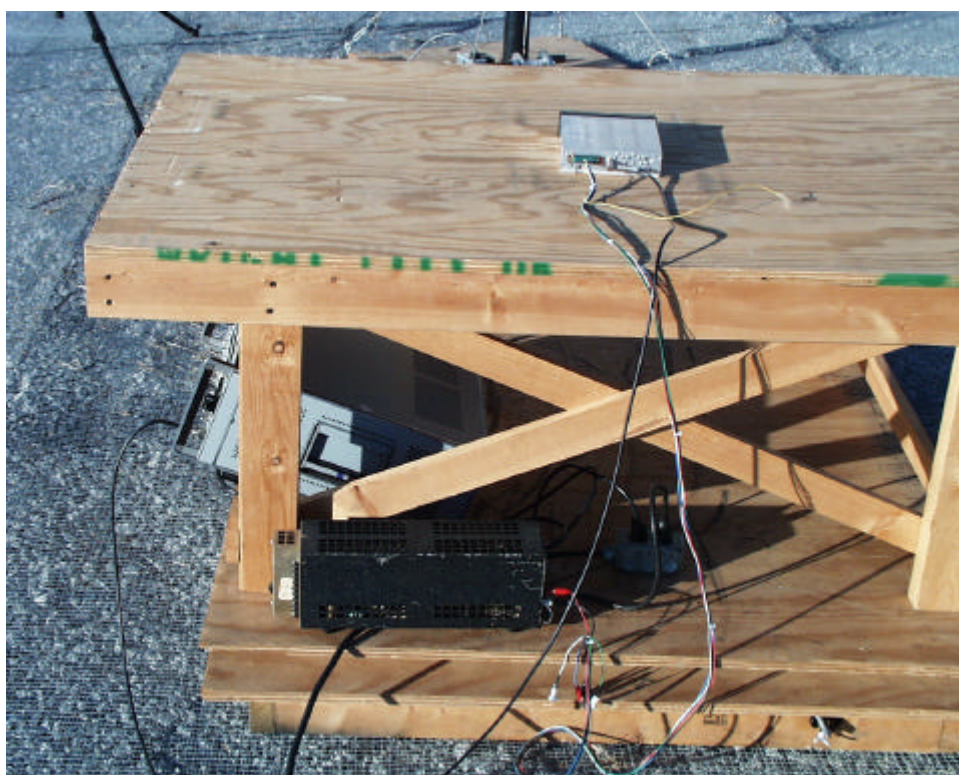
Specifications of Paragraphs 2.1055 and 87.133 applicable parts of 87 are met. There are no deviations to the specifications.

APPENDIX

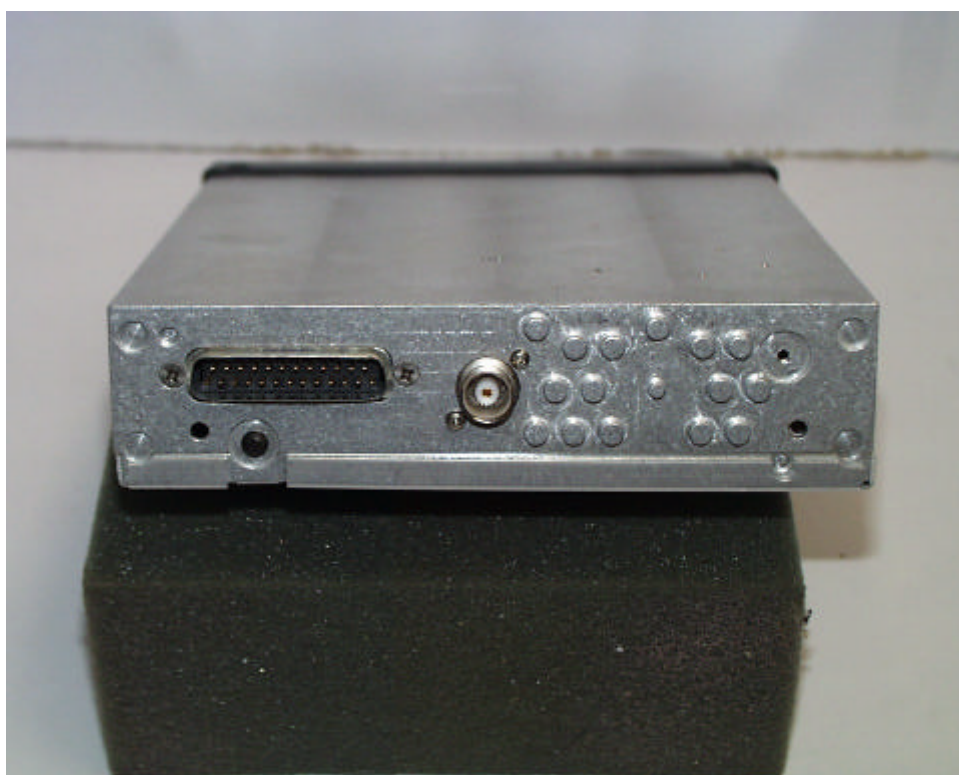
Model: GTX 327

1. Photos of Radiated Emissions Test Set Up.
2. Photos Case Front and Back.
3. Photos RF Printed Circuit Board.
4. Photos RF Printed Circuit Board.
5. Photo Printed Circuit Board.
6. Photo FCC ID Label Location.
7. Test Equipment List.
8. Rogers Qualifications.
9. FCC Site Approval Letter.

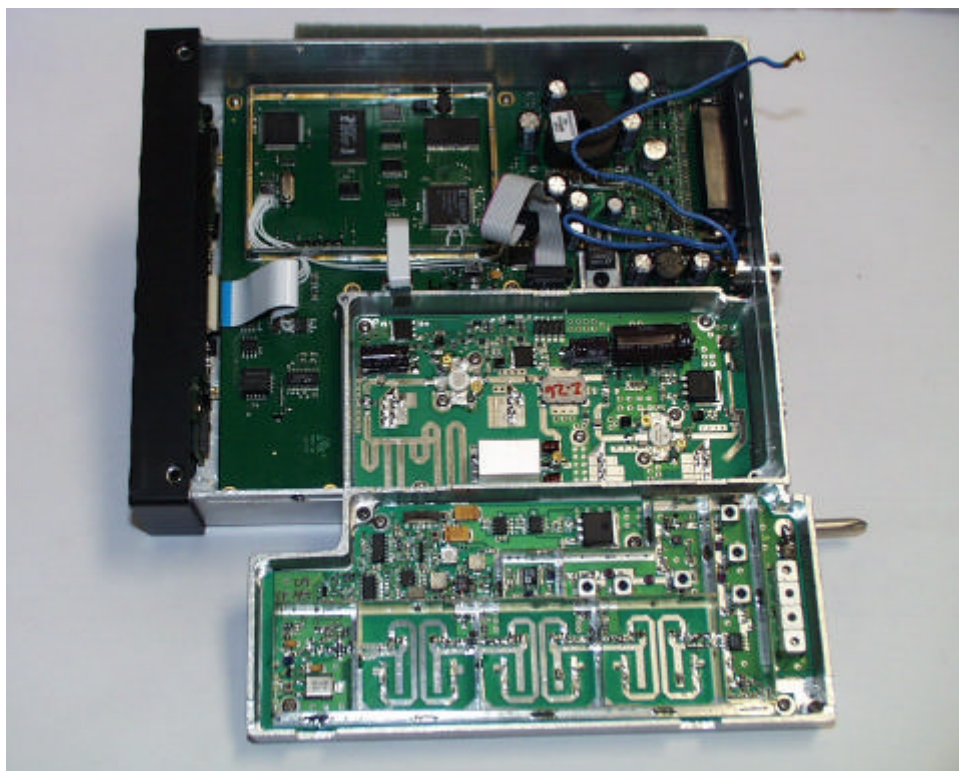
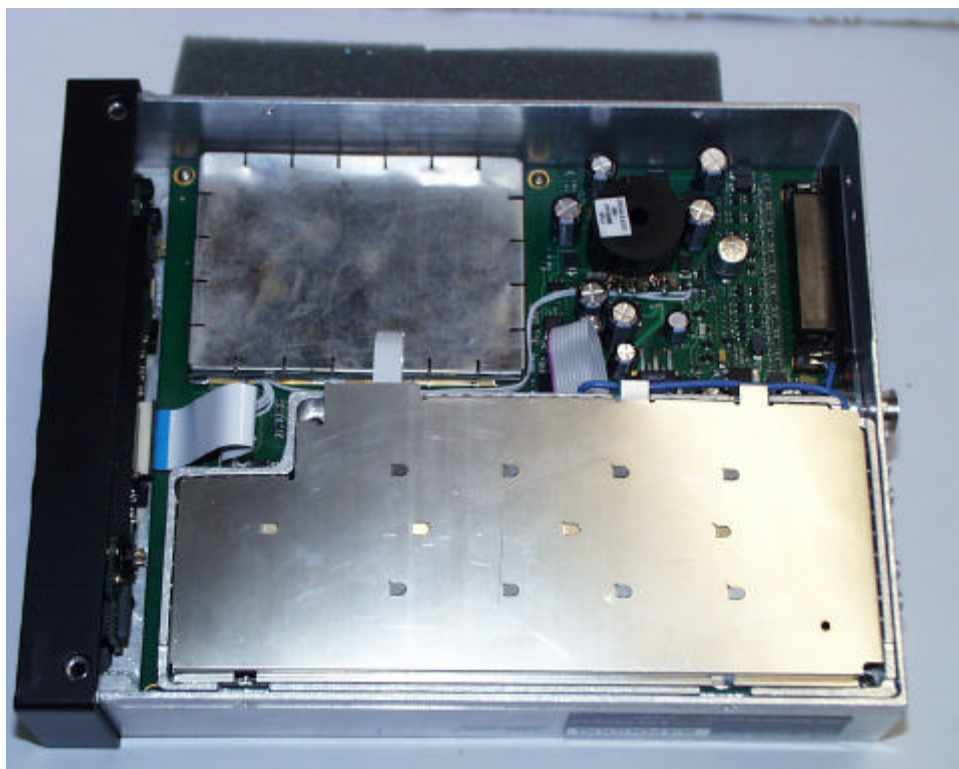
GARMIN INTERNATIONAL, INC.
Model: GTX 327
Photos Radiated Emissions Test Setup



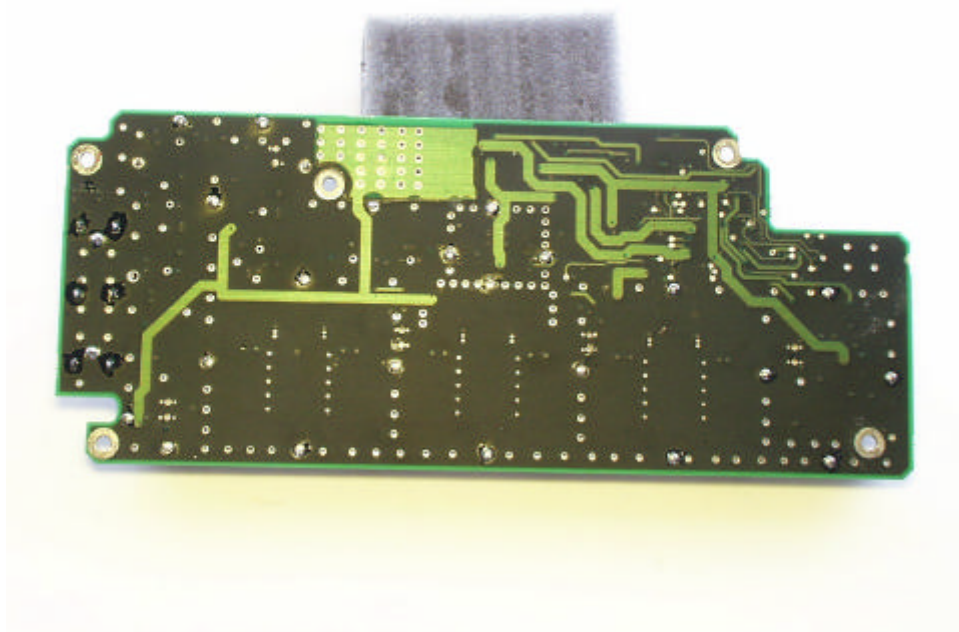
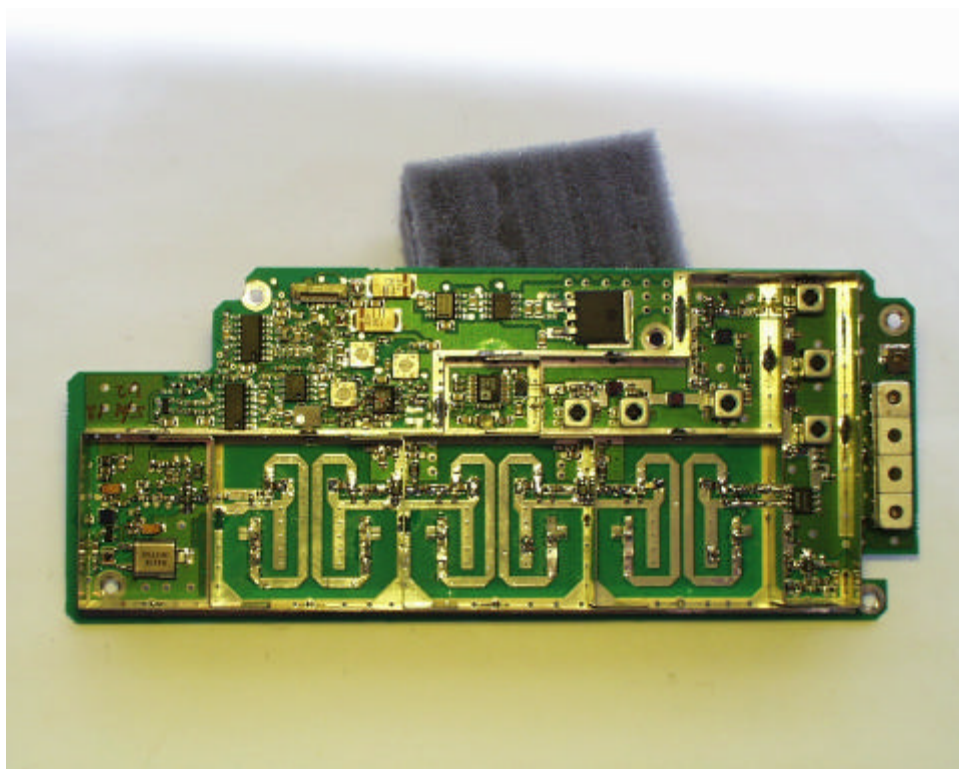
GARMIN INTERNATIONAL, INC.
Model: GTX 327
Photos Case Front and Back



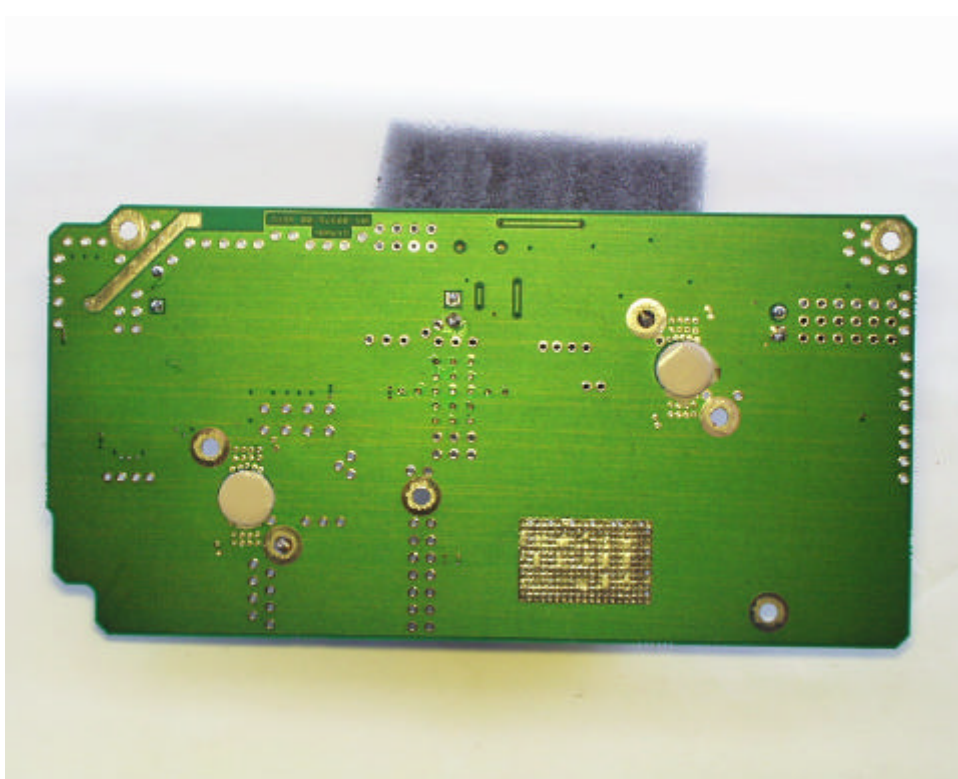
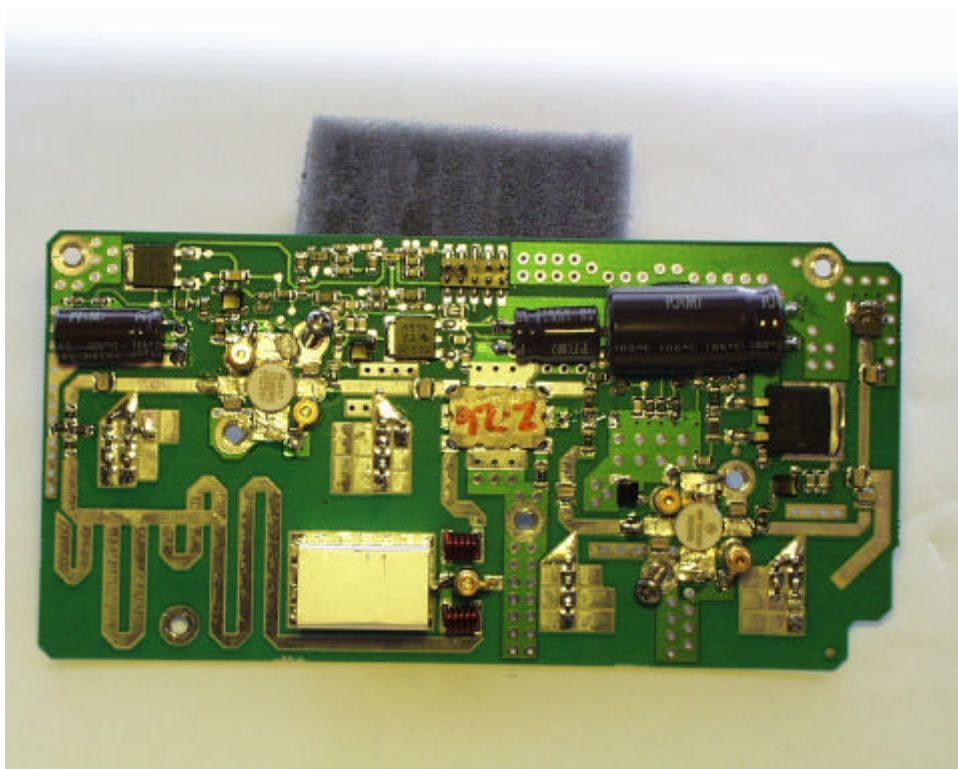
GARMIN INTERNATIONAL, INC.
Model: GTX 327
Photos Inside Case



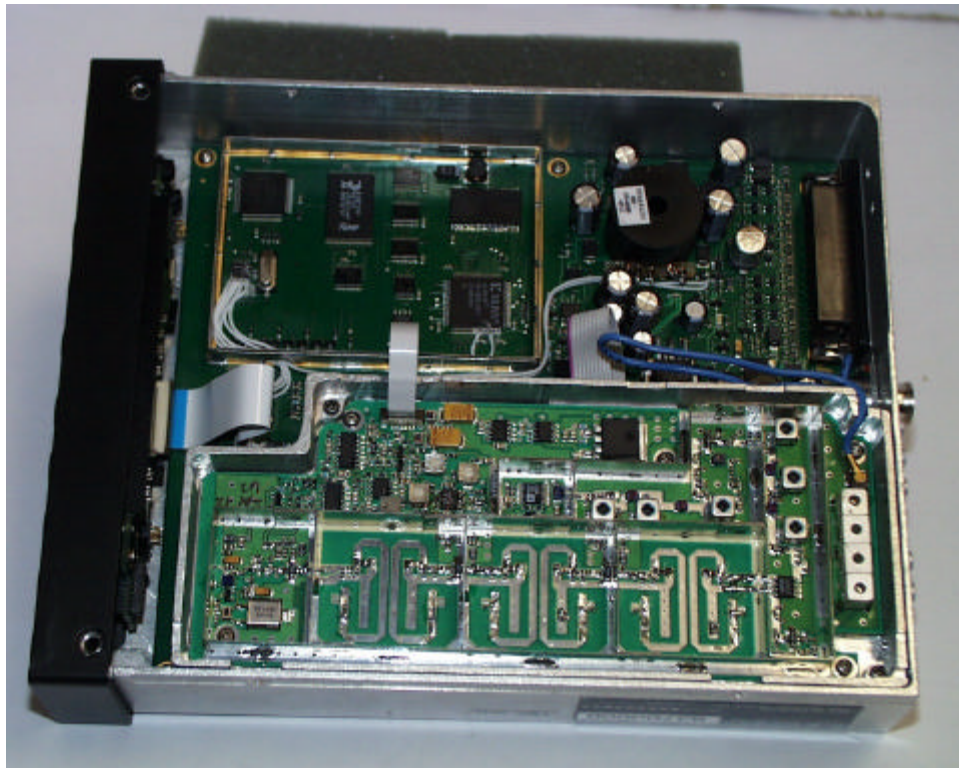
GARMIN INTERNATIONAL, INC.
Model: GTX 327
Photos Receiver/Decoder PC Board



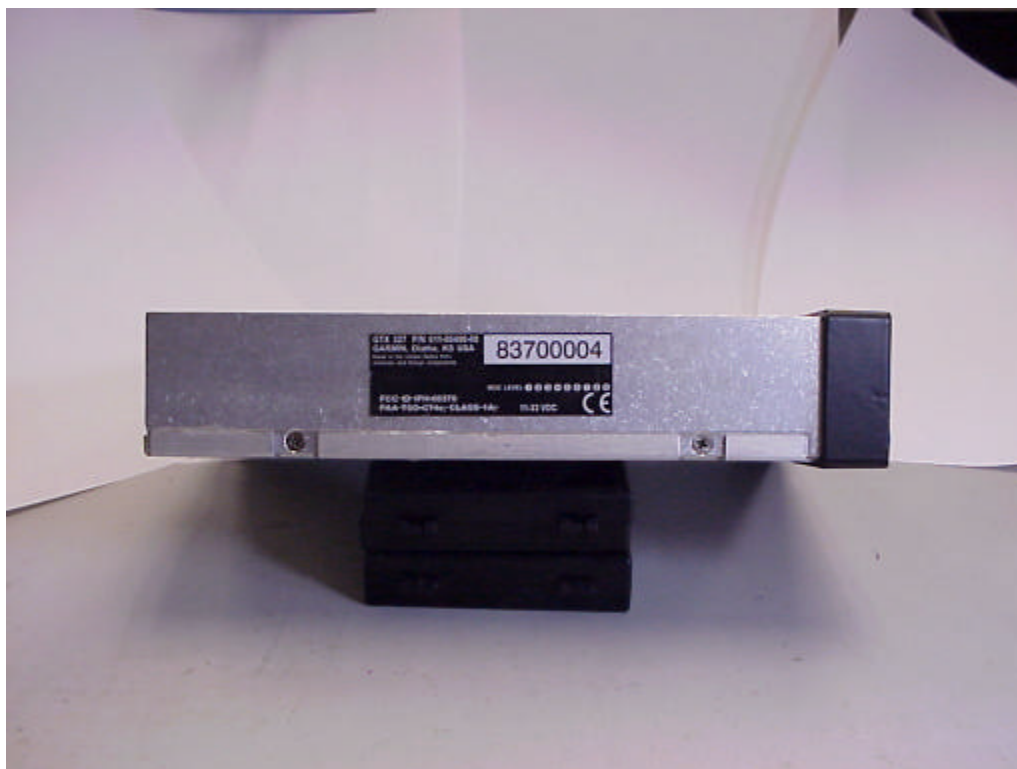
GARMIN INTERNATIONAL, INC.
Model: GTX 327
Photos Modulator/Transmitter PC Board



GARMIN INTERNATIONAL, INC.
 Model: GTX 327
 Photo Internal View of the unit



GARMIN INTERNATIONAL, INC.
Model: GTX 327
Photo FCC ID Label Location



TEST EQUIPMENT LIST FOR ROGERS LABS, INC.

The equipment is used daily and kept in good calibration and operating condition. Calibration of critical items are checked for accuracy each time used.

List of Test Equipment:Calibration Date:

Scope: Tektronix 2230	2/99
Wattmeter: Bird 43 with Load Bird 8085	2/99
Power Supplies: Sorensen SRL 20-25, DCR 150, DCR 140	2/99
H/V Power Supply: Fluke Model: 408B (SN: 573)	2/99
R.F. Generator: Boonton 102F	2/99
R.F. Generator: HP 606A	2/99
R.F. Generator: HP 8614A	2/99
R.F. Generator: HP 8640B	2/99
Spectrum Analyzer: HP 8562A,	2/99
Mixers: 11517A, 11980A & 11980K	
HP Adapters: 11518, 11519, 11520	
Spectrum Analyzer: HP 8591 EM	7/99
Frequency Counter: Weston 1255	2/99
Frequency Counter: Leader LDC 825	2/99
Antenna: EMC0 Log Periodic	10/99
Antenna: BCD 235/BNC Antenna Research	10/99
Antenna: EMC0 Dipole Set 3121C	2/99
Antenna: C.D. B-100	2/99
Antenna: Solar 9229-1 & 9230-1	2/99
Antenna: EMC0 6509	2/99
Microline Freq. Meter: Model 27B	2/99
Dana Modulation Meter: Model 9008	2/99
Audio Oscillator: H.P. 200CD	2/99
R.F. Power Amp 65W Model: 470-A-1000	9/97
R.F. Power Amp 50W M185- 10-500	9/97
R.F. PreAmp CPPA-102	9/97
Shielded Room 5 M x 3 M x 3.0 M (100 dB Integrity)	
LISN 50 μ Hy/50 ohm/0.1 μ f	10/99
LISN Compliance Eng. 240/20	2/99
SCS Power Amp Model: 2350A	2/99
Power Amp A.R. Model: 10W 1000M7	2/99
Power Amp EIN Model: A300	1/99
Linear Amp Mini Circuits: ZHL-1A (2 Units)	2/99
Combiner Unit Mini Circuits: ZSC-2-1 (2 Units)	2/99
ELGAR Model: 1751	2/99
ELGAR Model: TG 704A-3D	2/99
ELGAR Model: 400SD (PB)	2/99
ESD Test Set 2000i	10/95
Fast Transient Burst Generator Model: EFT/B-100	10/95
Current Probe: Singer CP-105	8/97
Current Probe: Solar 9108-1N	8/97
Field Intensity Meter: EFM-018	10/95
KETEK Ecat Surge Generator	10/99

11/01/99

QUALIFICATIONS

Of

SCOT D. ROGERS, ENGINEER**ROGERS LABS, INC.**

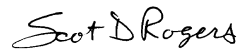
Mr. Rogers has approximately 12 years experience in the field of electronics. Six years working in the automated controls industry and 6 years working with the design, development and testing of radio communications and electronic equipment.

POSITIONS HELD:

Systems Engineer:	A/C Controls Mfg. Co., Inc. 6 Years
Electrical Engineer:	Rogers Consulting Labs, Inc. 5 Years
Electrical Engineer:	Rogers Labs, Inc. Current

EDUCATIONAL BACKGROUND:

- 1) Bachelor of Science Degree in Electrical Engineering from Kansas State University.
- 2) Bachelor of Science Degree in Business Administration Kansas State University.
- 3) Several Specialized Training courses and seminars pertaining to Microprocessors and Software programming.


Scot D. Rogers

6/15/99
Date

1/11/99

FEDERAL COMMUNICATIONS COMMISSION

7435 Oakland Mills Road
Columbia, MD 21046
Telephone: 301-725-1585 (ext-218)
Facsimile: 301-344-2050

February 6, 1998

IN REPLY REFER TO
31040/SIT
1300F2

Rogers Labs, Inc.
4405 West 259th Terrace
Louisburg, KS 66053

Attention: Scot D. Rogers

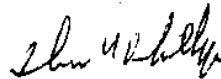
Re: Measurement facility located at above address
(3 and 10 meter site)

Gentlemen:

Your submission of the description of the subject measurement facility has been reviewed and found to be in compliance with the requirements of Section 2.948 of the FCC Rules. The description has, therefore, been placed on file and the name of your organization added to the Commission's list of facilities whose measurement data will be accepted in conjunction with applications for certification or notification under Parts 15 or 18 of the Commission's Rules. Our list will also indicate that the facility complies with the radiated and AC line conducted test site criteria in ANSI C63.4-1992. Please note that this filing must be updated for any changes made to the facility, and at least every three years the data on file must be certified as current.

Per your request, the above mentioned facility has been also added to our list of those who perform these measurement services for the public on a fee basis. This list is updated monthly and is available on the Laboratory's Public Access Link (PAL) at 301-725-1072, and also on the Internet at the FCC Website www.fcc.gov/oet/info/database/testsite/.

Sincerely,



Thomas W. Phillips
Electronics Engineer
Customer Service Branch