NVLAP Lab Code 200087-0

ROGERS LABS, INC.
4405 West 259th Terrace
Louisburg, KS 66053
Phone / Fax (913) 837-3214

Test Report - Maximum Permissible Exposure, Radio Frequency (RF) Exposure Report

47CFR, PART 1.1310 / MPE and RSS-102 Issue 5

Model: AB4560

9300-9500 MHz
Shipborne Radar

FCC ID: IPH-B4560
IC: 1792A-B4560

Garmin International, Inc.

1200 East 151st Street
Olathe, KS 66062

FCC Designation: US5305
ISED Registration: 3041A

Test Report Number: 221203

Test Date: December 3, 2022

Authorized Signatory: Scot D Rogers
Scot D. Rogers

Revisions

Revision 1 Issued March 14, 2023

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Customer Information

Applicant: Garmin International, Inc.
Address: 1200 East 151st Street
Olathe, KS 66062

M/N: AB4560 HVIN: AB4560
FCC ID: IPH-B4560 IC: 1792A-B4560
Operating Frequency Range: 9300-9500 MHz

Equipment Tested

Model: AB4560

Garmin International, Inc.
1200 East 151st Street
Olathe, KS 66062

Equipment	Model / PN	Serial Number
EUT (test sample, Power Load or antenna)	AB4560	3433643756
Power cable (0.8-meter)	Custom Cable (No P/N)	N/A
Power cable (2-meter)	Custom Cable (No P/N)	N/A
Power cable (15-meter)	320-00246-40	N/A
I/O cable (2-meter)	320-01038-00	N/A
I/O cable (15-meter)	011-05671-00	N/A
Chart Plotter (GPSMap 8208)	010-01016-01	3855826969
DC Power Supply	BK 1745	209C13
Marine Battery (12Volt)	Duracell	N/A

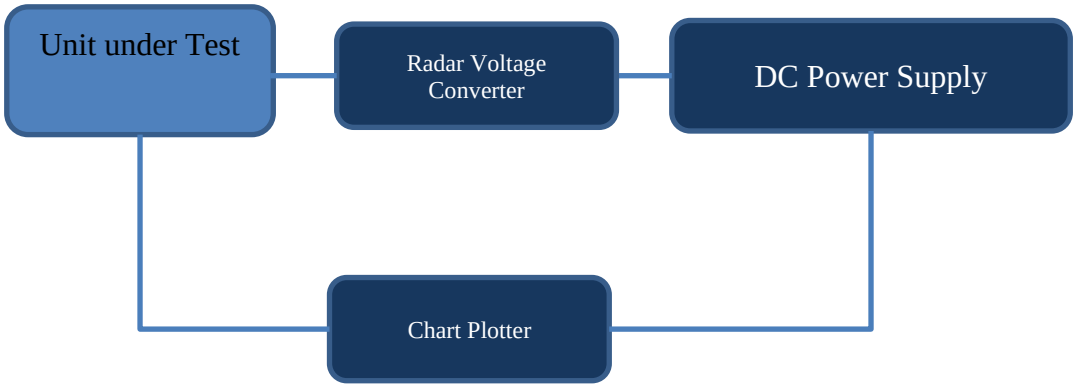
Test results in this report relate only to the items tested. Worst-case configuration data recorded in this report.

Software: 0.21, Antennas: 4-foot open array (pk-27, ave-3.99 dBi), 6-foot open array (pk-29, ave-3.85 dBi)

Equipment Function

The EUT is ship borne marine radar designed to provide bearing and distance information of ship and land targets located within the field of view (near the ship). The radar unit must be integrated into a full Marine system installation for operation, including chart plotter for display and control purposes. As the radar sweeps through 360°, reflected signals are interpreted and displayed on the chart plotter as indication of potential above surface hazards. Test results in this report relate only to the products described in this report.

Equipment Configuration



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Test Site Locations

Conducted EMI	AC line conducted emissions testing performed in a shielded screen room located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Antenna port	Antenna port conducted emissions testing was performed in a shielded screen room located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Radiated EMI	The radiated emissions tests were performed at the 3 meters, Open Area Test Site (OATS) located at Rogers Labs, Inc., 4405 West 259th Terrace, Louisburg, KS
Registered Site information:	FCC Site: US5305, ISED: 3041A, CAB Identifier: US0096
NVLAP Accreditation	Lab code 200087-0

Environmental Conditions

Ambient Temperature	22.1° C
Relative Humidity	29 %
Atmospheric Pressure	1029.2 mb

Applicable Standards and Regulatory Limits

In accordance with Title 47 Code of Federal Regulations (47CFR), dated December 3, 2022, Parts 1 and 2 (2.1091 and 2.1093), and Innovation, Science and Economic Development, the following information is submitted. Test procedures used follow the guidance of FCC KDB 447498 D01 General RF Exposure Guidance v06 as per 47CFR 1.1310, and 2.1093, and Innovation, Science and Economic Development (ISED) RSS-102 Issue 5.

FCC Limits for Maximum Permissible Exposure

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm2)	Averaging time (minutes)
(i) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*(100)	≤6
3.0-30	1842/f	4.89/f	*(900/f^2)	<6
30-300	61.4	0.163	1.0	<6
300-1,500			f/300	<6
1,500-100,000			5	<6
(ii) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*(100)	<30
1.34-30	824/f	2.19/f	*(180/f^2)	<30
30-300	27.5	0.073	0.2	<30
300-1,500			f/1500	<30
1,500-100,000			1.0	<30

f = frequency in MHz. * = Plane-wave equivalent power density.

ISED RSS-102 RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m2)	Reference Period (minutes)
0.003-10$_{21}$	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142f^{0.3417}$	$0.008335f^{0.3417}$	$0.02619f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

ISED RSS-102 RF Field Strength Limits for Controlled Use Devices (Controlled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m2)	Reference Period (minutes)
0.003-10$_{23}$	170	180	-	Instantaneous*
1-10	-	$1.6/f$	-	6**
1.29-10	$193/f^{0.5}$	-	-	6**
10-20	61.4	0.163	10	6
20-48	$129.8/f^{0.25}$	$0.3444/f^{0.25}$	$44.72/f^{0.5}$	6
48-100	49.33	0.1309	6.455	6
100-6000	$15.60f^{0.25}$	$0.04138f^{0.25}$	$0.6455f^{0.5}$	6
6000-15000	137	0.364	50	6
15000-150000	137	0.364	50	$616000/f^{1.2}$
150000-300000	$0.354f^{0.5}$	$9.40 \times 10^{-4} f^{0.5}$	$3.33 \times 10^{-4} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

Applicable information and equations

f = Transmit Frequency (MHz)

PT = Power Input to Antenna (mW)

Duty cycle (percentage of operation)

PA = Adjusted Power due to Duty cycle or Cable Loss (mW)

GN = Numeric Gain of the Antenna

S20 = Power Density of device at 20cm (mW/m2) S20=(PAGN)/(4πR20)2

RC = Minimum distance to the Radiating Element for Compliance (cm) FCC RC=√(PAGN/4πSL)

SC = Power Density of the device at the Compliance Distance RC (W/m2) FCC SC=(PAGN)/(4πRC)2

Power Density

E(V/m) = SQRT (30*P*G)/D

$Pd(W/m^2) = E^2 / 377$

$S = EIRP / (4*PI* D^2)$

Where:

D = Separation Distance in cm
EIRP = Equivalent Isotropic Radiated Power, in mW
S = Power density in mW/cm^2

Power density converted from units of mW/cm^2 to units of W/m^2 by multiplying by 10

mW/cm^2 by 10 => W/cm^2

Distance

D = SQRT [EIRP / (4*PI*S)]

Where:

D = Separation Distance in cm
EIRP = Equivalent Isotropic Radiated Power, in mW
S = Power density in mW/cm^2

Source-based time-average EIRP = (DC /100) *EIRP

Where:

DC = Duty Cycle in percent as applicable
EIRP = Equivalent Isotropic Radiated Power, in mW

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RF Exposure Results

	HVIN:	AB4560 (4-foot array)	Test Number:	221203				
MPE Calculator	RF Exposure uses EIRP for calculation. EIRP is based on TX power added to the antenna gain in dBi.							
	dBi = dB gain compared to an isotropic radiator.							
	S = power density in mW/cm^2							
		Transmitter Output power (mW)	4,000,000.0					
		Transmitter Output power (W)	4,000.0					
Output Power for % duty Cycle operation (mWatts)	0.099		3,961.600		Antenna Gain (dBi)	3.99		
	Output Power for Duty Cycle operation (Watts)		3.962		Antenna Gain (Numeric)	2.51		
Tx Frequency (MHz)	9400	Calculation power (Watts)	3.962	dBd + 2.17 = dBi	dBi to dBd	2.17		
					Antenna Gain (dBd)	1.82		
Cable Loss (dB)	0.0	Adjusted Power (dBm)	35.98		Antenna minus cable (dBi)	3.99		
					Antenna Gain (Numeric)	2.51		
	Calculated ERP (mw)	6,023.801			EIRP = Po(dBm) + Gain (dB)			
	Calculated EIRP (mw)	9,928.202			Radiated (EIRP) dBm	39.969		
					ERP = EIRP - 2.17 dB			
					Radiated (ERP) dBm	37.799		

Power density (S) mW/cm² = EIRP / (4 p r^2)

r (cm) EIRP (mW)

	Occupational Limit	FCC radio frequency radiation exposure limits per 1.1310		
5	mW/cm²	Frequency (MHz)	Occupational Limit (mW/cm²)	Public Limit (mW/cm²)
50.0	W/m²	30-300	1	0.2
	General Public Limit	300-1,500	f/300	f/1500
1	mW/cm²	1,500-10,000	5	1
10.0	W/m²			

	Occupational Limit			
50	W/m²	IC radio frequency radiation exposure limits per RSS-102		
50.0	W/m²	Frequency (MHz)	Occupational Limit (W/m²)	Public Limit (W/m²)
	General Public Limit	100-6,000	$0.6455 f^{0.5}$	
10	W/m²	6,000-15,000	50	
10	W/m²	48-300		1.291
		300-6,000		$0.02619 f^{0.6834}$
		6,000-15,000	50	10

			General Public	Occupational	
f = Transmit Frequency (MHz)	f (MHz) =	9400	9400	MHz	
P_T = Power Input to Antenna (mW)	P_T (mW) =	3,961,600.0000	3,961,600.0000	mW	
Duty cycle (percentage of operation)	% =	0.09904	0.09904	%	
P_A = Adjusted Power due to Duty cycle or Cable Loss (mW)	P_A (mW) =	3,961.60	3,961.60	mW	
G_N = Numeric Gain of the Antenna	GN (numeric) =	2.51	2.51	numeric	
S_{20} = Power Density of device at 20cm (mW/m²) $S_{20}=(P_A G_N)/(4\pi R_{20})^2$	S_{20} (mW/m²) =	1.98	1.98	mW/m²	
S_{20} = Power Density of device at 20cm (W/m²) $S_{20}=(P_A G_N)/(4\pi R_{20})^2$	S_{20} (W/m²) =	19.75	19.75	W/m²	
S_L = Power Density Limit (W/m²) FCC	S_L (W/m²) =	10.000	50.000	W/m²	
S_L = Power Density Limit (W/m²) Canada	S_L (W/m²) =	10.000	50.000	W/m²	
R_C = Minimum distance to the Radiating Element for Compliance (cm) FCC $R_C=\sqrt{(P_A G_N/4\pi S_L)}$	R_C (cm) =	28.1	12.6	cm	
R_C = Minimum distance to the Radiating Element for Compliance (cm) Canada $R_C=\sqrt{(P_A G_N/4\pi S_L)}$	R_C (cm) =	28.1	12.6	cm	
S_C = Power Density of the device at the Compliance Distance R_C (W/m²) FCC $S_C=(P_A G_N)/(4\pi R_C)^2$	S_C (W/m²) =	10.00	50.00	W/m²	
S_C = Power Density of the device at the Compliance Distance R_C (W/m²) Canada $S_C=(P_A G_N)/(4\pi R_C)^2$	S_C (W/m²) =	10.00	50.00	W/m²	
R_{20} = 20cm	R20=	20	20	cm	

For Compliance with Canada General Population Limits, User Manual must indicate a minimum separation distance of 28.1 cm

Or in Meters for Compliance with Canada General Population Limits, a minimum separation distance of 0.28 Meters

Summary: Standalone MPE Calculations and Summary					Public Limit		Public	
	Tx Duty Cycle (%)	Tx Frequency (MHz)	Power Total (mW)	Antenna Gain (numeric)	S_L (W/m²)	S_{20} (W/m²)	R_C (cm)	S_C (W/m²)
FCC	0.09904	9400	3,962	2.51	10.000	19.75	28.1	10.00
Canada	0.09904	9400	3,962	2.51	10.000	19.75	28.1	10.00

		Limit		Overall Minimum (cm)	Overall Minimum (inches)
		Public	Occupational		
	FCC (cm)	28.1	12.6		
	FCC (inches)	12.0	5.0		
	Canada (cm)	28.1	12.6		
	Canada (inches)	12.0	5.0		

Overall Minimum Limit Public	Overall Minumu Limit Occuppational
29 cm	13 cm
12 inches	6 inches

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	HVIN:	AB4560 (6-foot array)	Test Number:	221203				
MPE Calculator	RF Exposure uses EIRP for calculation. EIRP is based on TX power added to the antenna gain in dBi.							
	dBi = dB gain compared to an isotropic radiator.							
	S = power density in mW/cm^2							
		Transmitter Output power (mW)	4,000,000.0					
		Transmitter Output power (W)	4,000.0					
Output Power for % duty Cycle operation (mWatts)	0.099		3,961.600		Antenna Gain (dBi)	3.85		
	Output Power for Duty Cycle operation (Watts)		3.962		Antenna Gain (Numeric)	2.43		
Tx Frequency (MHz)	9400	Calculation power (Watts)	3.962	dBd + 2.17 = dBi	dBi to dBd	2.17		
					Antenna Gain (dBd)	1.68		
Cable Loss (dB)	0.0	Adjusted Power (dBm)	35.98		Antenna minus cable (dBi)	3.85		
					Antenna Gain (Numeric)	2.43		
	Calculated ERP (mw)	5832.713			EIRP = Po(dBm) + Gain (dB)			
	Calculated EIRP (mw)	9613.259			Radiated (EIRP) dBm	39.829		
					ERP = EIRP - 2.17 dB			
					Radiated (ERP) dBm	37.659		
					Duty Cycle Correction	0.039446351		

Power density (S) mW/cm² = EIRP / (4 p r^2)

r (cm) EIRP (mW)

	Occupational Limit	FCC radio frequency radiation exposure limits per 1.1310		
5	mW/cm^2	Frequency (MHz)	Occupational Limit (mW/cm^2)	Public Limit (mW/cm^2)
50.0	W/m^2	30-300	1	0.2
	General Public Limit	300-1,500	f/300	f/1500
1	mW/cm^2	1,500-10,000	5	1
10.0	W/m^2			

	Occupational Limit			
50	W/m^2	IC radio frequency radiation exposure limits per RSS-102		
50.0	W/m^2	Frequency (MHz)	Occupational Limit (W/m^2)	Public Limit (W/m^2)
	General Public Limit	100-6,000	$0.6455f^{0.5}$	
10	W/m^2	6,000-15,000	50	
10	W/m^2	48-300		1.291
		300-6,000		$0.02619f^{0.6834}$
		6,000-15,000	50	10

		General Public	Occupational	
f = Transmit Frequency (MHz)	f (MHz) =	9400	9400	MHz
P_T = Power Input to Antenna (mW)	P_T (mW) =	3,961,600.0000	3,961,600.0000	mW
Duty cycle (percentage of operation)	% =	0.09904	0.09904	%
P_A = Adjusted Power due to Duty cycle or Cable Loss (mW)	P_A (mW) =	3,961.60	3,961.60	mW
G_N = Numeric Gain of the Antenna	GN (numeric) =	2.43	2.43	numeric
S_{20} = Power Density of device at 20cm (mW/m^2)	$S_{20}=(P_AG_N)/(4\pi R_{20})^2$ S_{20} (mW/m^2) =	1.91	1.91	mW/m^2
S_{20} = Power Density of device at 20cm (W/m^2)	$S_{20}=(P_AG_N)/(4\pi R_{20})^2$ S_{20} (W/m^2) =	19.12	19.12	W/m^2
S_L = Power Density Limit (W/m^2) FCC	S_L (W/m^2)=	10.000	50.000	W/m^2
S_L = Power Density Limit (W/m^2) Canada	S_L (W/m^2)=	10.000	50.000	W/m^2
R_C = Minimum distance to the Radiating Element for Compliance (cm) FCC	$R_C=\sqrt{(P_AG_N/4\pi S_L)}$ R_C (cm) =	27.7	12.4	cm
R_C = Minimum distance to the Radiating Element for Compliance (cm) Canada	$R_C=\sqrt{(P_AG_N/4\pi S_L)}$ R_C (cm) =	27.7	12.4	cm
S_C = Power Density of the device at the Compliance Distance R_C (W/m^2) FCC	$S_C=(P_AG_N)/(4\pi R_C)^2$ S_C (W/m^2) =	10.00	50.00	W/m^2
S_C = Power Density of the device at the Compliance Distance R_C (W/m^2) Canada	$S_C=(P_AG_N)/(4\pi R_C)^2$ S_C (W/m^2) =	10.00	50.00	W/m^2
R_{20} = 20cm	R20=	20	20	cm

For Compliance with Canada General Population Limits, User Manual must indicate a minimum separation distance of 27.7 cm

Or in Meters for Compliance with Canada General Population Limits, a minimum separation distance of 0.28 Meters

Summary: Standalone MPE Calculations and Summary					Public Limit		Public	
	Tx Duty Cycle (%)	Tx Frequency (MHz)	Power Total (mW)	Antenna Gain (numeric)	S_L (W/m^2)	S_{20} (W/m^2)	R_C (cm)	S_C (W/m^2)
FCC	0.09904	9400	3,962	2.43	10.000	19.12	27.7	10.00
Canada	0.09904	9400	3,962	2.43	10.000	19.12	27.7	10.00

		Limit		Overall Minimum (cm)	Overall Minimum (inches)
		Public	Occupational		
	FCC (cm)	27.7	12.4		
	FCC (inches)	11.0	5.0		
	Canada (cm)	27.7	12.4		
	Canada (inches)	11.0	5.0		

Overall Minimum Limit Public	Overall Minumu Limit Occuppational
28 cm	13 cm
12 inches	6 inches

Annex

Laboratory Certificate of Accreditation

United States Department of Commerce
National Institute of Standards and Technology

Certificate of Accreditation to ISO/IEC 17025:2017

NVLAP LAB CODE: 200087-0

Rogers Labs, Inc.
Louisburg, KS

is accredited by the National Voluntary Laboratory Accreditation Program for specific services, listed on the Scope of Accreditation, for:

Electromagnetic Compatibility & Telecommunications

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communique dated January 2009).

2022-03-22 through 2023-03-31
Effective Dates

For the National Voluntary Laboratory Accreditation Program