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Test report

309146-1TRFWL

Date of issue: December 2, 2016

Applicant:

Garmin International, Inc.

Product:

Marine Radar Equipment

Model:

A03121

Model variant:

Fantom 18, Fantom 24

FCC ID:

IPH-03121

IC Registration number:

1792A-03121

Specifications:

- FCC 47 CFR Part 80 Subpart E

  Stations in the maritime services

- RSS-238, Issue 1, July 2013

  Shipborne Radar in the 2900–3100 MHz and 9225–9500 MHz bands

Test location

Company name	Nemko Canada Inc.
Address	303 River Road
City	Ottawa
Province	Ontario
Postal code	K1V 1H2
Country	Canada
Telephone	+1 613 737 9680
Facsimile	+1 613 737 9691
Toll free	+1 800 563 6336
Website	www.nemko.com
Site number	FCC: 176392; IC: 2040A-4 (3 m semi anechoic chamber)

Tested by	Andrey Adelberg, Senior Wireless/EMC Specialist
Reviewed by	Kevin Rose, Wireless/EMC Specialist
Date	December 2, 2016
Signature of the reviewer	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Garmin International, Inc.
Address	1200 East 151st Street
City	Olathe
Province/State	KS
Postal/Zip code	66062
Country	USA

1.2 Test specifications

FCC 47 CFR Part 80 Subpart E	Stations in the maritime services
FCC 47 CFR Part 2 Subpart J	Equipment Authorization Procedures
RSS-238, Issue 1, July 2013	Shipborne Radar in the 2900–3100 MHz and 9225–9500 MHz bands

1.3 Test methods

ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 80 test results

Part 2	Part 80	Test description	Verdict
§2.1046	§80.215 (n)(3)	RF power output	Pass
§2.1049	§80.205	Occupied bandwidth	Pass
§2.1053	§80.211	Field strength of spurious radiation	Pass
§2.1055	§80.209	Frequency stability	Pass

Notes: None

2.2 RSS-238, Issue 1 test results

Part	Test description	Verdict
4.1	Frequency stability	Pass
4.2	Transmitter Output Power and Antenna Gain	Pass
4.3	Transmitter Unwanted Emissions	Pass
3.2	40 dB Bandwidth	Pass

Notes: None

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
6.6	Occupied bandwidth	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	September 8, 2016
Nemko sample ID number	133-002782 (24" antenna), 133-002781 (18" antenna), 133-002780 (Plotter)

3.2 EUT information

Product name	Marine Radar Equipment
Model	A03121
Model variant	Fantom 18, Fantom 24
Serial number	FFP #22 (24" antenna), FFP #8 (18" antenna)
Part number	011-04199-00 (Fantom 18) and 011-04199-01 (Fantom 24)

3.3 Technical information

Frequency band	9300–9500 MHz
Frequency Min (MHz)	9335
Frequency Max (MHz)	9455
Rated output power (W)	40 peak power and 4.5 average power
RF power Max (W)	29.44 peak power and 3.29 mean power
Field strength, Units @ distance	N/A
Measured BW (kHz) (99 %)	60890
Emission classification (F1D, G1D, D1D)	P0N
Transmitter spurious, Units @ distance	81.91 dBµV/m at 18.75 GHz @ 3 m
Power requirements	10–32 V_{DC}, or typical 12 V_{DC} from vessel battery
Antenna information	18" antenna with 21.3 dBi gain 24" antenna with 22.6 dBi gain The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.

3.4 Product description and theory of operation

The EUT is a ship borne marine radar designed to provide bearing and distance of ships in land targets in the vicinity from the ship. The radar unit is integrated into a full Marine system installation, including the chart plotter for display purposes. As the radar sweeps through 360°, reflected signal s are displayed on the chart plotter as indications of hazards.

3.5 EUT exercise details

EUT was powered up, transmission of Radar was enabled via plotter display at selected channel (1 – low, 2 – mid, 4 – high) and distance sensitivity was selected between 48 nmi to 1/16 nmi

3.6 EUT setup diagram

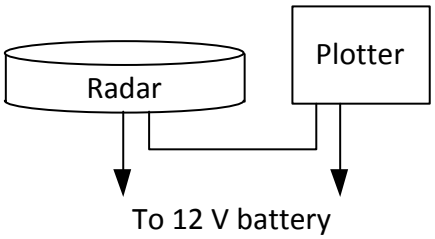

Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
24” antenna	Garmin	A03121	FFP #22
18” antenna	Garmin	A03121	FFP #8
Plotter/display GPSmap 8012	Garmin	M2APGN02	1928 3855827065

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	Dec. 01/16
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
DC Power source	Ametek	SGA80X125C-0AAA	FA002737	—	VOU
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	Jan. 07/17
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	Apr. 15/17
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	Apr. 28/17
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	Apr. 26/17
Pre-amplifier (1–18 GHz)	JCA	JCA118-503	FA002091	1 year	April 26/17
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU
Pre-amplifier (26–40 GHz)	Narda	DBL-2640N610	FA001556	—	VOU
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	Apr.15/17

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 FCC 2.1046, 80.215 and RSS-238 4.3 RF output power

8.1.1 Definitions and limits

FCC:
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.

FCC 80.215(n)(3):
For radiodetermination stations operating above 2400 MHz the output power must be as follows:
For all other transponder stations the output power must not exceed 20 watts (43 dBm) peak e.i.r.p. Licensees of non-selectable transponder coast stations operating in the 2920–3100 MHz and 9320–9500 MHz bands must notify in writing the USCG District Commander of any incremental increase of their station's output power above 5 watts (37 dBm) peak e.i.r.p.

ISED:
The transmitter output power shall not exceed 60 kW (77.8 dBm) and the antenna gain shall not exceed 35 dBi.

8.1.2 Test summary

Test date	September 21, 2016	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1007 mbar
Verdict	Pass	Relative humidity	31 %

8.1.3 Observations, settings and special notes

The test was performed with the spectrum analyzer:

Resolution bandwidth	≥ OBW
Video bandwidth	≥ 3 × RBW
Detector	Peak
Trace mode	Max hold

8.1.4 Test data

Table 8.1-1: *Output power measurement result for 18" antenna*

Transmitter range setting, NM	Channel	Peak field strength, dBµV/m @ 3 m	Peak EIRP, dBm	EIRP Limit, dBm	Margin, dB	Antenna gain, dBi	Peak power, dBm	Peak power, W	Duty cycle	Average power, W
1/16	Low	145.41	50.18	77.80	27.62	21.3	28.88	0.77	0.00065	0.00050
48	Low	161.22	65.99	77.80	11.81	21.3	44.69	29.44	0.11200	3.29775
1/16	Mid	154.61	59.38	77.80	18.42	21.3	38.08	6.43	0.00065	0.00418
48	Mid	161.12	65.89	77.80	11.91	21.3	44.59	28.77	0.11200	3.22269
1/16	High	143.12	47.89	77.80	29.91	21.3	26.59	0.46	0.00065	0.00030
48	High	159.05	63.82	77.80	13.98	21.3	42.52	17.86	0.11200	2.00087

Table 8.1-2: *Output power measurement result for 24" antenna*

Transmitter range setting, NM	Channel	Peak field strength, dBµV/m @ 3 m	Peak EIRP, dBm	EIRP Limit, dBm	Margin, dB	Antenna gain, dBi	Peak power, dBm	Peak power, W	Duty cycle	Average power, W
1/16	Low	147.39	52.16	77.8	27.62	22.6	29.56	0.90	0.000654	0.00059
48	Low	161.55	66.32	77.8	11.81	22.6	43.72	23.55	0.112040	2.63860
1/16	Mid	147.58	52.35	77.8	18.42	22.6	29.75	0.94	0.000654	0.00062
48	Mid	161.91	66.68	77.8	11.91	22.6	44.08	25.59	0.112040	2.86664
1/16	High	144.19	48.96	77.8	29.91	22.6	26.36	0.43	0.000654	0.00028
48	High	159.04	63.81	77.8	13.98	22.6	41.21	13.21	0.112040	1.48038

The average power output was calculated using the pulse width and pulse repetition frequency, which define the duty cycle:
Average power = Peak power (W) × duty cycle factor
Duty cycle factor = Pulse width (s) × Pulse repetition frequency (Hz)

Table 8.1-3: *Modulation Details*

Transmitter range setting, nmi	First gate		Second gate		Third gate		Transmit time per frame, µs	Total frame length, µs	Overall duty cycle, %
	Pulse width, µs	Number of pulses	Pulse width, µs	Number of pulses	Pulse width, µs	Number of pulses			
1/16	0.11	4	0.21	4	–	–	1.28	1955.84	0.07
1/8	0.11	4	0.21	4	–	–	1.28	1955.84	0.07
1/4	0.11	4	0.43	4	1.71	4	8.96	2933.76	0.31
1/2	0.11	4	0.43	4	1.71	4	8.96	2933.76	0.31
3/4	0.21	4	0.85	4	3.41	4	17.92	2933.76	0.61
1	0.21	4	0.85	4	3.41	4	17.92	2933.76	0.61
1 1/2	0.43	4	1.71	4	6.83	4	35.84	2933.76	1.22
2	0.43	4	1.71	4	6.83	4	35.84	2933.76	1.22
3	0.85	4	3.41	4	13.65	4	71.68	2933.76	2.44
4	0.85	4	3.41	4	13.65	4	71.68	2933.76	2.44
6	1.71	4	6.83	4	27.31	4	143.36	2933.76	4.89
8	1.71	4	6.83	4	27.31	3	116.05	2689.28	4.32
12	3.41	4	27.31	4	–	–	122.88	2135.47	5.75
16	3.41	3	27.31	4	–	–	119.47	2096.21	5.70
24	6.83	3	54.61	3	–	–	184.32	2304.64	8.00
36	6.83	3	54.61	3	–	–	184.32	2778.24	6.63
48	13.65	3	109.23	3	–	–	368.64	3290.24	11.20

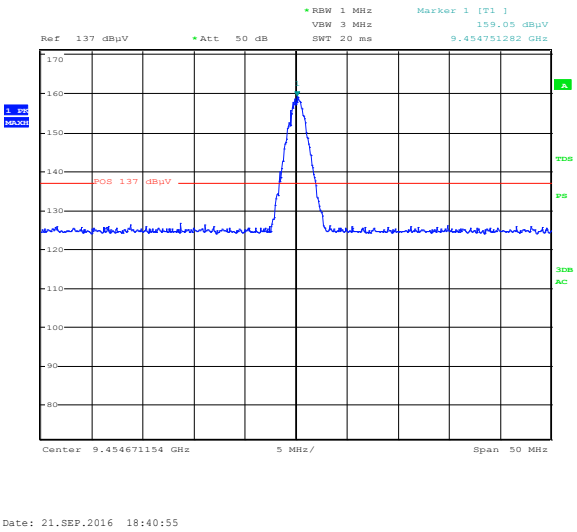

Figure 8.1-1: *Field strength of fundamental emission for 18" antenna, sample plot*

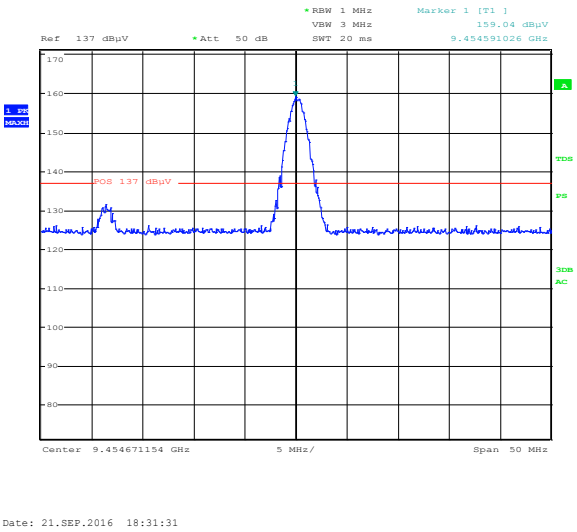

Figure 8.1-2: *Field strength of fundamental emission for 24" antenna, sample plot*

Maximum allowed antenna gain as per RSS-238 is 35 dBi.
EUT comes in two variants: 18" antenna (Fantom 1) with 21.3 dBi gain and 24" antenna (Fantom 2) with 22.6 dBi gain.

8.2 FCC 2.1049 and RSS-238 3.2 Occupied bandwidth

8.2.1 Definitions and limits

FCC:
The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission
ISED:
In addition to the required information and measurements specified in RSS-Gen, the test report submitted with the application shall contain the following information: the 40 dB bandwidth.

8.2.2 Test summary

Test date	September 20, 2016	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1020 mbar
Verdict	Pass	Relative humidity	31 %

8.2.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	1% to 5% of the anticipated OBW
Video bandwidth	≥ 3 × RBW
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: *Occupied bandwidth measurement results*

Transmitter range setting, NM	99% occupied bandwidth, MHz	40 dB bandwidth, MHz	23 dB bandwidth, MHz
1/16	60.89	200.96	42.95
48	2.88	5.92	2.12

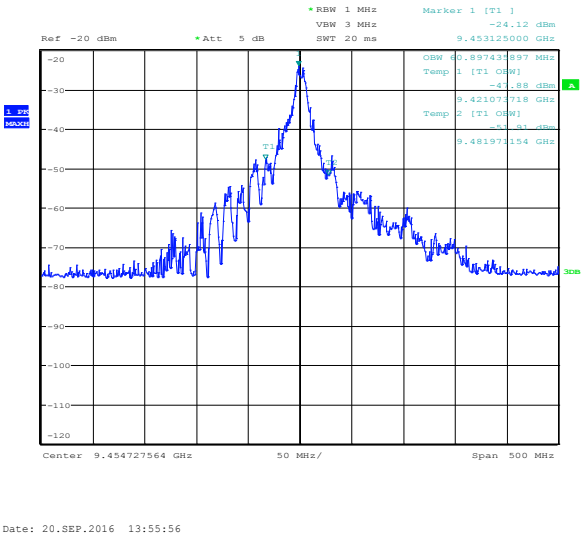

Figure 8.2-1: *99 % Occupied bandwidth, sample plot*

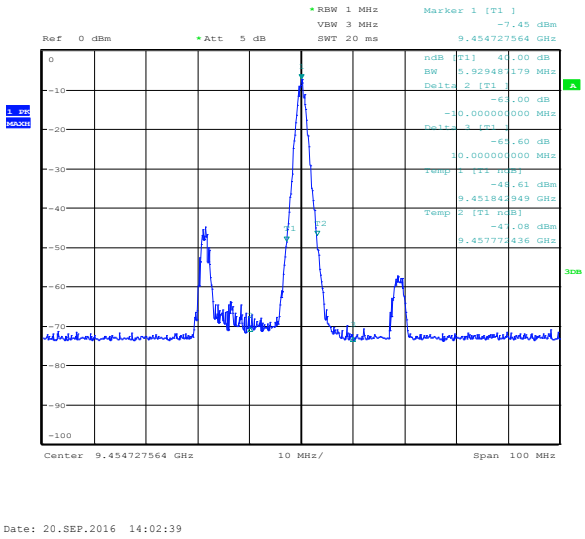

Figure 8.2-2: *40 dB bandwidth, sample plot*

8.3 FCC 2.1053, 80.211(f) and RSS-238 4.3 Field strength of spurious radiation

8.3.1 Definitions and limits

FCC:

(a) 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. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required; with the measuring instrument antenna located in the far field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections, which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from half wave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:

(1) Those in which the spurious emissions are required to be 60 dB or more below the mean power of the transmitter.
(2) All equipment operating on frequencies higher than 25 MHz.
(3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.
(4) Other types of equipment as required, when deemed necessary by the Commission.

80.211(f)

(f) The mean power when using emissions other than those in paragraphs (a), (b), (c) and (d) of this section:

(1) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: At least 25 dB;
(2) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: At least 35 dB; and
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus $10\log_{10}$ (mean power in watts) dB (−13 dBm).

ISED:

The unwanted emission and the transmitter power shall be measured using a peak detector.
The unwanted emission power in any 1 MHz bandwidth shall be attenuated below the transmitter peak power by at least 20 dB per decade from the edge of the 40 dB bandwidth and beyond.
The unwanted emissions power shall not need to be attenuated more than 60 dB below the transmitter peak power.

Table 8.3-1: *Spurious emissions limit as per FCC requirements*

Frequency range, MHz	Attenuation below carrier, dBc	Spurious emissions, dBm	Field strength of spurious radiation* at 3 m, dBµV/m
30–40 000	43 + 10 Log_{10} (P)	−13	82.23

Note: theoretical conversion is for the preliminary results only.

8.3.2 Test summary

Test date	September 21, 2016	Temperature	22 °C
Test engineer	Andrey Adelberg	Air pressure	1007 mbar
Verdict	Pass	Relative humidity	31 %

8.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to 40 GHz. The measurements above 18 GHz were performed at 1 m.
RSS-238 requires out of band emissions be at least 60 dB below fundamental emission. Maximum field strength of fundamental was measured at 159.05 dBµV/m, therefore as per RSS-238, spurious (out of band) emissions limit is 99.05 dBµV/m
Spectrum analyser settings for measurements below 1 GHz:

Resolution bandwidth	120 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for measurements above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak
Trace mode	Max Hold

8.3.4 Test data

Table 8.3-2: *Spurious emissions measurement results, general*

Frequency, MHz	Spurious emission (Peak), dBµV/m	Quasi peak limit, dBµV/m	Margin, dB
45.741	37.46	40.00	2.54
54.165	35.62	40.00	4.38
150.042	38.04	43.50	5.46
237.252	36.70	46.00	9.30
399.960	36.49	46.00	9.51
634.740	38.79	46.00	7.21
761.65	40.28	46.00	5.72

Note: Peak field strength measurement results were below Quasi-peak limit; therefore no additional Quasi-peak measurements were performed.

Table 8.3-3: *Spurious emissions measurement results, harmonics*

Antenna size	Channel	Frequency, GHz	Spurious emission at 1 m, dBµV/m	Spurious emission at 3 m*, dBµV/m	Limit, dBµV/m	Margin, dB
18”	Low	18.67	90.69	81.15	82.23	1.08
24”	Low	18.67	91.09	81.55	82.23	0.68
18”	Mid	18.75	90.59	81.05	82.23	1.18
24”	Mid	18.75	91.45	81.91	82.23	0.32
18”	High	18.90	88.52	78.98	82.23	3.25
24”	High	18.90	88.58	79.04	82.23	3.19

Note: FCC limit is more stringent than the RSS-238 one; therefore compliance with FCC limit guarantied compliance with RSS-238 limit.
* - Distance correction factor (9.54 dB) was used to offset the 1 m measurement in order to compare with 3 m limit.
No other harmonics were detected.

8.4 FCC 2.1055, RSS-238 4.1 Frequency stability

8.4.1 Definitions and limits

FCC:
(a) The frequency stability shall be measured with variation of ambient temperature as follows:
(1) From −30°C to +50°C for all equipment except that specified in paragraphs (a)(2) and (3) of this section
(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° C through the range.
(d) 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.

ISED:
The carrier frequency shall not depart from the reference frequency in excess of 800 ppm for equipment which operates in the band 2900–3100 MHz nor in excess of 1250 ppm for equipment which operates in the band 9225–9500 MHz.

8.4.2 Test summary

Test date:	September 20, 2016	Temperature:	22 °C
Test engineer:	Andrey Adelberg	Air pressure:	1006 mbar
Verdict:	Pass	Relative humidity:	31 %

8.4.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	≥ 1 % of emission bandwidth
Video bandwidth	≥ 3 × RBW
Frequency span	Wider than emission bandwidth
Detector mode	Peak

8.4.4 Test data

Table 8.4-1: *Frequency drift measurement results*

Test conditions	Frequency, Hz	Drift, ppm	Limit, ppm	Margin, ppm
+50 °C, Nominal	9454747596	-0.339	1250	1249.661
+40 °C, Nominal	9454746795	-0.424	1250	1249.576
+30 °C, Nominal	9454748398	-0.254	1250	1249.746
+20 °C, +15 %	9454749599	-0.127	1250	1249.873
+20 °C, Nominal	9454750801	Reference	Reference	Reference
+20 °C, -15 %	9454747596	-0.339	1250	1249.661
+10 °C, Nominal	9454744391	-0.678	1250	1249.322
0 °C, Nominal	9454745994	-0.508	1250	1249.492
−10 °C, Nominal	9454750801	0.000	1250	1250.000
−20 °C, Nominal	9454753205	0.254	1250	1249.746
−30 °C, Nominal	9454748398	-0.254	1250	1249.746

Note: Offset was calculated as per the following formula:

$$\frac{F_{Measured} - F_{reference}}{F_{reference}} \times 1 \cdot 10^{6}$$

Section 9. Block diagrams of test set-ups

9.1 Radiated emissions set-up