

Low duty factor analysis report for SAR test exclusion

The “SAY necklace” device uses the BT classic mode for an Animation Download purposes only. During the download “SAY necklace” receives 60000 bytes per second and transmits two bytes per each batch of 2000 received bytes (60 bytes per second) as acknowledge message, where number N of acknowledge transmissions is :

$$N = 2 \times 60000/2000 = 60 \text{ bytes/s}$$

Transmission time for 1 byte is $1 \text{ s}/60000 \text{ bytes} = 16.7 \text{ } \mu\text{sec}$.

Within a 6 min period the total transmission time will be

$$0.0000167 \text{ s} \times 60 \text{ (bytes/s)} \times 360 \text{ sec} = 0.361 \text{ sec}$$

A duty cycle equals to

$$0.361 \text{ s} / 360 \text{ sec} = 0.001 = 0.1 \%$$

The “SAY necklace” gadget transmitter is used as a portable device operating in 2402 – 2480 MHz band. It is equipped with an integral antenna.

Maximum measured transmitter power derived from section 7.7, Table 7.7.2 of the HERRAD FCC.28858 measurement test report:

P _{out} conducted		Maximum antenna gain, dBi	P _{out} EIRP	
dBm	mW		dBm	mW
13.76	23.8	1.72	15.48	35

The SAR test exclusion threshold for 2.48 GHz at test separation distances 5.0 mm is as follows:

$$[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \times [\sqrt{f(\text{GHz})}] \leq 3.0$$

The max transmitter duty cycle is 0.1%.

The equivalent averaged conducted power is 0.024 mW, the equivalent averaged EIRP is 0.035 mW

$$35 \text{ mW} \times \text{duty cycle} = 35 \text{ mW} \times 0.001 = 0.035 \text{ mW}$$

$$[0.035 \text{ mW}/5.0 \text{ mm}] \times \sqrt{2.48} = 0.007 \times 1.575 = 0.011 \leq 3.0,$$

where 5 mm is the smallest distance from antenna to outer surface of the device.

According to KDB 447498 D01 v06 the device is excluded from SAR evaluation.

SAY necklace
Functional Description

SAY necklace is a wearable consumer device like a medallion. It allows display animations, previously downloaded wirelessly via a BLUETOOTH 4.0 Smart Ready interface from any suitable smartphone. The downloaded animations are shown cyclically on a 128*128 pixels color OLED display. **SAY necklace** is powered from a built-in rechargeable Li-Po battery. It can be charged from any standard 5V DC USB charger via a standard USB-A to micro-USB-B cable. Before operating **SAY necklace** the first time, a proper application should be downloaded and installed on the user's smartphone.

1. Functional Description

The Block Diagram of **SAY necklace** on page 3 includes the following:

- a. Li-Po BATTERY (3.7V 700 mAh);
- b. CHARGING & POWER SUPPLY CIRCUIT;
- c. Micro USB-B CHARGING CONNECTOR;
- d. ESD PROTECTION circuit;
- e. OLED display (128*128 pixels, 262k possible colors);
- f. Serial FLASH MEMORY;
- g. 3-axis ACCELEROMETER;
- h. BLUETOOTH SMART READY TRANSCEIVER;
- i. BLUETOOTH CHIP ANTENNA;
- j. ANTENNA MATCHING CIRCUIT;
- k. RESET BUTTON;
- l. 32.768 KHz crystal;
- m. 26.000 MHz crystal;

2. SAY necklace Operating Description

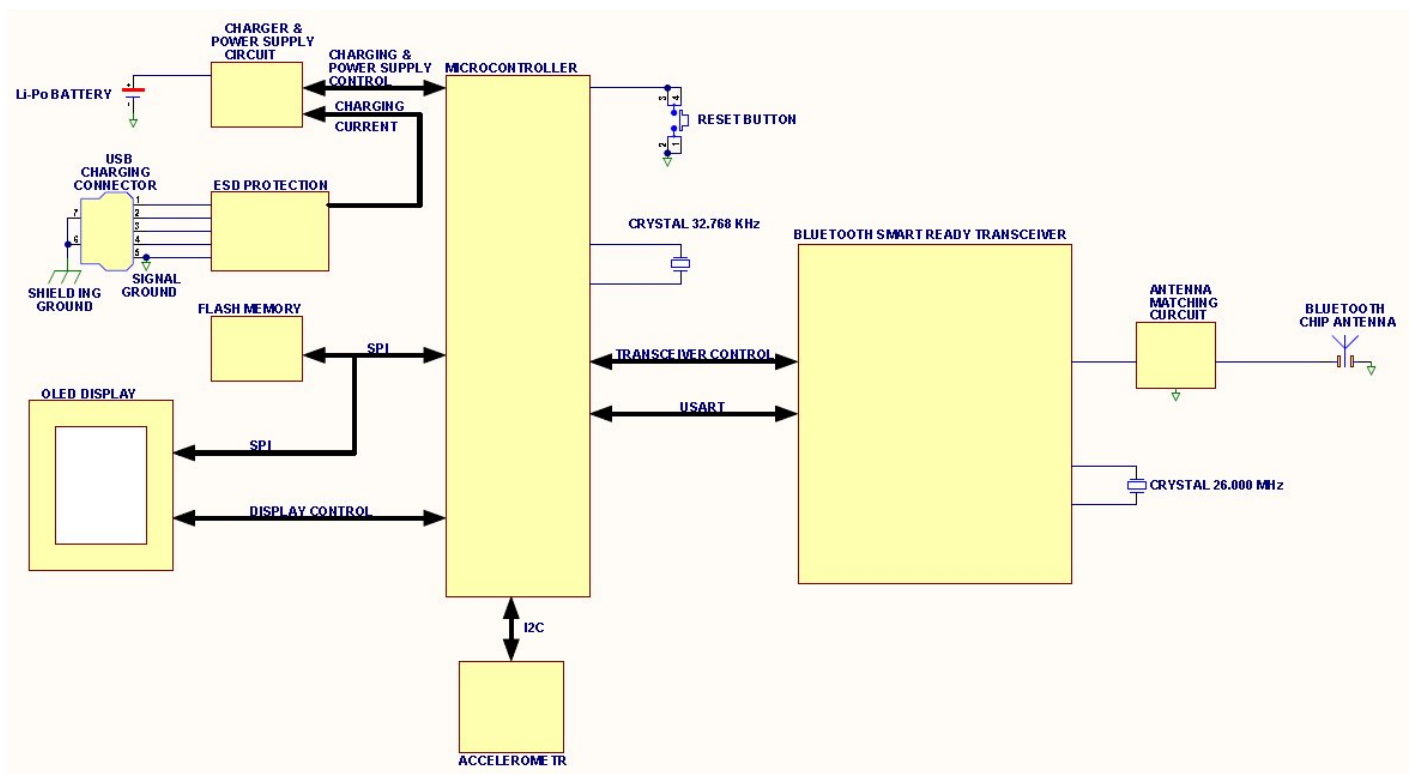
SAY necklace is delivered with battery turned off (disconnected). To turn the battery on **SAY necklace** should be connected to any standard USB host computer, hub or charger using the delivered **USB-A to Micro-USB-B** cable. Being connected to a proper power source, the Constant Voltage/Constant Current CHARGING CIRCUIT turns on the internal power source. After initialization **SAY necklace** will display the "Battery Charging" icon and then it will start some default animation. The battery comprises a built-in an Overcurrent/Overvoltage/Undervoltage circuit. That circuit disconnects the battery in case of any abnormal condition.

In normal condition microcontroller manages a continuous animation reading it frame by frame from the FLASH MEMORY and sending it to the OLED DISPLAY.

The ACCELEROMETER continuously monitors mobility of **SAY necklace**; if it is motionless for some time period, than microcontroller puts it into a Sleep mode. Then any motion resumes the active mode.

The BLUETOOTH TRANSCEIVER periodically applies to the coupled smartphone. If user initiates a New Animation Download process, the new animation file is transmitted via the BLUETOOTH TRANSCEIVER to the MICROCONTROLLER and stored in the FLASH MEMORY. After completing download the new animation replaces the previous one on the OLED DISPLAY.

In case the download process was interrupted for some reason and it cannot be resumed any more, the RESET BUTTON being pressed restarts the “hung” device.



SAY necklace V3.3 Block Diagram

BLUETOOTH SMART READY RF PERFORMANCE

1. Bluetooth BR/EDR RF Performance

All parameters in this section that are fast-clock dependent are verified using a 26-MHz XTAL under a temperature range from -20°C to 70°C and an RF load of $50\ \Omega$ at the BT_RF port.

a. Bluetooth Receiver—In-Band Signals

CHARACTERISTICS	CONDITION		MIN	TYP	MAX	BLUETOOTH SPECIFICATION	UNIT
Operation frequency range			2402		2480		MHz
Channel spacing				1			MHz
Input impedance				50			Ω
Sensitivity, dirty TX on ⁽¹⁾	GFSK, BER = 0.1 %		-91.5	-95		-70	dBm
	Pi/4-DQPSK, BER = 0.01%		-90.5	-94.5		-70	
	8DPSK, BER = 0.01 %		-81	-87.5		-70	
BER error floor at sensitivity + 10dB, dirty TX off	Pi/4-DQPSK		1E-6	1E-7		1E-5	
	8DPSK		1E-6			1E-5	
Maximum usable input power	GFSK, BER = 0.1 %		-5			-20	dBm
	Pi/4-DQPSK, BER = 0.1 %		-10				
	8DPSK, BER = 0.1%		-10				
Intermodulation characteristics	Level of interferers (for n = 3, 4, and 5)		-36	-30		-39	dBm
C/I performance ⁽²⁾ Image = -1 MHz	GFSK, co-channel			8	10	11	dB
	EDR, co-channel	Pi/4-DQPSK		9.5	11	13	
		8DPSK		16.5	20	21	
	GFSK, adjacent ±1 MHz			-10	-5	0	
	EDR, adjacent ±1 MHz, (image)	Pi/4-DQPSK		-10	-5	0	
		8DPSK		-5	-1	5	
	GFSK, adjacent +2 MHz			-38	-35	-30	
	EDR, adjacent, +2 MHz	Pi/4-DQPSK		-38	-35	-30	
		8DPSK		-38	-30	-25	
	GFSK, adjacent -2 MHz			-28	-20	-20	
	EDR, adjacent -2 MHz	Pi/4-DQPSK		-28	-20	-20	
		8DPSK		-22	-13	-13	
	GFSK, adjacent ≥ ±3 MHz			-45	-43	-40	
	EDR, adjacent ≥ ±3 MHz	Pi/4-DQPSK		-45	-43	-40	
		8DPSK		-44	-36	-33	
RF return loss				-10			dB
RX mode LO leakage	Frf = (received RF - 0.6 MHz)			-63	-58		dBm

(1) Sensitivity degradation up to 3 dB may occur for minimum and typical values where the *Bluetooth* frequency is a harmonic of the fast clock.

(2) Numbers show ratio of desired signal to interfering signal. Smaller numbers indicate better C/I performance.

b. Bluetooth Receiver—General Blocking

CHARACTERISTICS	CONDITION	MIN	TYP	UNIT
Blocking performance over full range, according to <i>Bluetooth</i> specification ⁽¹⁾	30 to 2000 MHz		-6	dBm
	2000 to 2399 MHz		-6	
	2484 to 3000 MHz		-6	
	3 to 12.75 GHz		-6	

(1) Exceptions are taken out of the total 24 allowed in the *Bluetooth* specification.

c. Bluetooth Transmitter—GFSK

CHARACTERISTICS	MIN	TYP	MAX	BLUETOOTH SPECIFICATION	UNIT
Maximum RF output power ⁽¹⁾	10	12			dBm
Power variation over <i>Bluetooth</i> band	-1		1		dB
Gain control range		30			dB
Power control step	2	5	8	2 to 8	
Adjacent channel power M-N = 2		-45	-39	≤ -20	dBm
Adjacent channel power M-N > 2		-50	-42	≤ -40	

(1) To modify maximum output power, use an HCI VS command.

d. Bluetooth Transmitter—EDR

CHARACTERISTICS		MIN	TYP	MAX	BLUETOOTH SPECIFICATION	UNIT
Maximum RF output power ⁽¹⁾	PI/4-DQPSK	6	8			dBm
	8DPSK	6	8			
Relative power		-2		1	-4 to +1	dB
Power variation over <i>Bluetooth</i> band		-1		1		dB
Gain control range			30			dB
Power control step		2	5	8	2 to 8	dB
Adjacent channel power M-N = 1			-36	-30	≤ -26	dBc
Adjacent channel power M-N = 2 ⁽²⁾			-30	-23	≤ -20	dBm
Adjacent channel power M-N > 2 ⁽²⁾			-42	-40	≤ -40	dBm

(1) To modify maximum output power, use an HCI VS command.

(2) Assumes 3-dB insertion loss from *Bluetooth* RF ball to antenna

e. Bluetooth Modulation—GFSK

CHARACTERISTICS	CONDITION		SYM	MIN	TYP	MAX	BLUETOOTH SPECIFICATION	UNIT
-20 dB bandwidth	GFSK				925	995	≤ 1000	kHz
Modulation characteristics	Δf1 avg	Mod data = 4 1 s, 4 0 s: 111100001111...	F1 avg	150	165	170	140 to 175	kHz
	Δf2max ≥ limit for at least 99.9% of all Δf2max	Mod data = 1010101...	F2 max	115	130		> 115	kHz
	Δf2avg, Δf1avg			85%	88%		> 80%	
Absolute carrier frequency drift	DH1			-25		25	< ±25	kHz
	DH3 and DH5			-35		35	< ±40	
Drift rate						15	< 20	kHz/ 50 μs
Initial carrier frequency tolerance	f0 - fTX			-75		+75	< ±75	kHz

f. Bluetooth Modulation—EDR

CHARACTERISTICS	CONDITION	MIN	TYP	MAX	BLUETOOTH SPECIFICATION	UNIT
Carrier frequency stability				±5	≤ 10	kHz
Initial carrier frequency tolerance				±75	±75	kHz
RMS DEVM ⁽¹⁾	PI/4-DQPSK		6%	15%	20%	
	8DPSK		6%	13%	13%	
99% DEVM ⁽¹⁾	PI/4-DQPSK			30%	30%	
	8DPSK			20%	20%	
Peak DEVM ⁽¹⁾	PI/4-DQPSK		14%	30%	35%	
	8DPSK		16%	25%	25%	

(1) Max performance refers to maximum TX power.

g. Bluetooth Transmitter—Out-of-Band and Spurious Emissions

CHARACTERISTICS	CONDITION	TYP	MAX	UNIT
Second harmonic ⁽¹⁾	Measured at maximum output power	–14	–2	dBm
Third harmonic ⁽¹⁾		–10	–6	dBm
Fourth harmonics ⁽¹⁾		–19	–11	dBm

(1) Meets FCC and ETSI requirements with external filter shown in [Figure 7-1](#)

2. Bluetooth LE RF Performance

All parameters in this section that are fast-clock dependent are verified using a 26-MHz XTAL under a temperature range from –20°C to 70°C and an RF load of 50 Ω at the BT_RF port.

a. BLE Receiver—In-Band Signals

CHARACTERISTIC	CONDITION	MIN	TYP	MAX	BLE SPECIFICATION	UNIT
Operation frequency range		2402		2480		MHz
Channel spacing			2			MHz
Input impedance			50			Ω
Sensitivity, dirty TX on ⁽¹⁾	PER = 30.8%; dirty TX on	-93	-96		≤ -70	dBm
Maximum usable input power	GMSK, PER = 30.8%	-5			≥ -10	dBm
Intermodulation characteristics	Level of interferers (for n = 3, 4, 5)	-36	-30		≥ -50	dBm
C/I performance ⁽²⁾ Image = -1 MHz	GMSK, co-channel		8	12	≤ 21	dB
	GMSK, adjacent ± 1 MHz		-5	0	≤ 15	
	GMSK, adjacent +2 MHz		-45	-38	≤ -17	
	GMSK, adjacent -2 MHz		-22	-15	≤ -15	
	GMSK, adjacent $\geq \pm 3 $ MHz		-47	-40	≤ -27	
RX mode LO leakage	Frf = (received RF - 0.6 MHz)		-63	-58		dBm

(1) Sensitivity degradation up to 3 dB may occur where the BLE frequency is a harmonic of the fast clock.

(2) Numbers show wanted signal-to-interfering signal ratio. Smaller numbers indicate better C/I performance.

b. BLE Receiver—General Blocking

CHARACTERISTICS	CONDITION	MIN	TYP	BLE SPECIFICATION	UNIT
Blocking performance over full range, according to BLE specification ⁽¹⁾	30 to 2000 MHz		-15	≥ -30	dBm
	2000 to 2399 MHz		-15	≥ -35	
	2484 to 3000 MHz		-15	≥ -35	
	3 to 12.75 GHz		-15	≥ -30	

(1) Exceptions are taken out of the total 10 allowed in the BLE specification.

c. BLE Transmitter

CHARACTERISTICS	MIN	TYP	MAX	BLE SPECIFICATION	UNIT
Maximum RF output power ⁽¹⁾	10	12 ⁽²⁾		≤ 10	dBm
Power variation over BLE band	-1		1		dB
Adjacent channel power M-N = 2		-45	-39	≤ -20	dBm
Adjacent channel power M-N > 2		-50	-42	≤ -30	

(1) To modify maximum output power, use an HCI VS command.

(2) To achieve the BLE specification of 10-dBm maximum, an insertion loss of > 2 dB is assumed between the RF ball and the antenna. Otherwise, use an HCI VS command to modify the output power.

d. BLE Modulation

CHARACTERISTICS	CONDITION		SYM	MIN	TYP	MAX	BLE SPEC.	UNIT
Modulation characteristics	Δf_{1avg}	Mod data = 4 1s, 4 0 s: 1111000011110000...	Δf_{1avg}	240	250	260	225 to 275	kHz
	$\Delta f_{2max} \geq$ limit for at least 99.9% of all Δf_{2max}	Mod data = 1010101...	Δf_{2max}	185	210		≥ 185	kHz
	$\Delta f_{2avg}, \Delta f_{1avg}$			0.85	0.9		≥ 0.8	
Absolute carrier frequency drift				-25		25	$\leq \pm 50$	kHz
Drift rate						15	≤ 20	kHz/50 ms
Initial carrier frequency tolerance				-75		75	$\leq \pm 100$	kHz

TEST REPORT

ACCORDING TO: FCC 47CFR part 15 subpart C § 15.247 (FHSS) and subpart B

FOR:

Hermes Innovation Ltd.
**Smartphone controlled wearable
gadget with OLED display**
Model: SAY necklace
FCC ID:2AKDU100

This report is in conformity with ISO/IEC 17025. The "A2LA Accredited" symbol endorsement applies only to the tests and calibrations that are listed in the scope of Hermon Laboratories accreditation. The test results relate only to the items tested.
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1 Applicant information

Client name: Hermes Innovation Ltd.
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Telephone: +972-72-274-8730
Fax: +972-3-958-5525
E-mail: leveitan@gmail.com
Contact name: Mr. Eitan Lev

2 Equipment under test attributes

Product name: Smartphone controlled wearable gadget with OLED display
Product type: Transceiver
Model(s): SAY necklace
Serial number: Prototype
Hardware version: 3.3
Software release: 1.0
Receipt date 29-Sep-16

3 Manufacturer information

Manufacturer name: Hermes Innovation Ltd.
Address: 12 Ayelet Hashahar St., Even Yehuda 4053085, Israel
Telephone: +972-72-274-8730
Fax: +972-3-958-5525
E-Mail: leveitan@gmail.com
Contact name: Mr. Eitan Lev

4 Test details




Project ID: 28858
Location: Hermon Laboratories Ltd. Harakevet Industrial Zone, Binyamina 30500, Israel
Test started: 29-Sep-16
Test completed: 25-Oct-16
Test specification(s): FCC 47CFR part 15 subpart C § 15.247 (FHSS) and subpart B, class B

5 Tests summary

Test	Status
Transmitter characteristics	
Section 15.247(a)1, 20 dB bandwidth	Pass
Section 15.247(a)1, Frequency separation	Pass
Section 15.247(a)1, Number of hopping frequencies	Pass
Section 15.247(a)1, Average time of occupancy	Pass
Section 15.247(b), Peak output power	Pass
Section 15.247(d), Radiated spurious emissions	Pass
Section 15.247(d), Emissions at band edges	Pass
Section 15.247(i)5, RF exposure	Pass, the exhibit to the application of certification is provided
Section 15.203, Antenna requirements	Pass
Section 15.207(a), Conducted emission	Pass
Unintentional emissions	
Section 15.107, Conducted emission at AC power port	Pass
Section 15.109, Radiated emission	Pass

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

The test results relate only to the items tested. Pass/ fail decision was based on nominal values.

	Name and Title	Date	Signature
Tested by:	Mrs. E. Pitt, test engineer	October 25, 2016	
Reviewed by:	Mrs. M. Cherniavsky, certification engineer	November 16, 2016	
Approved by:	Mr. M. Nikishin, EMC and radio group leader	December 18, 2016	

6 EUT description

6.1 General information

The EUT is a wearable device, comprising OLED display, rechargeable Li-Po battery (600 mAh) and a Smart Ready Class 2 Bluetooth interface. The EUT comprises a non approved BLE/BT module operating in 2402-2480 MHz frequency range. The EUT is powered from external AC/DC adapter connected via the MICRO-USB-B connector and is defined for indoor use only. The AC/DC adapter manufactured by GPT, model PCU-240 was used throughout the testing. The EUT was tested in "Operation during Charging" mode.

6.2 Ports and lines

Port type	Port description	Connected from	Connected to	Qty.	Cable type	Cable length	Indoor / outdoor
Power	MICRO-USB-B	EUT	AC/DC adapter	1	Shielded	0.9 m	Indoor
Power	AC power	AC/DC adapter	AC mains	1	NA	NA	Indoor

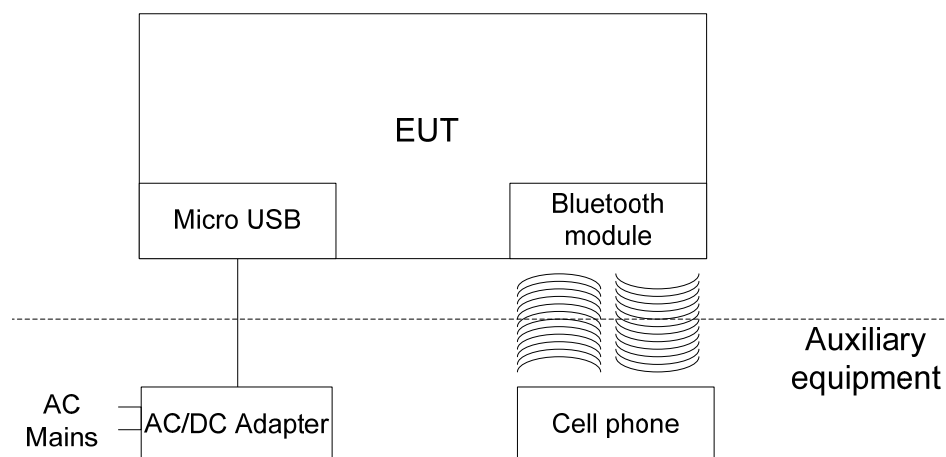
6.3 Auxiliary equipment

Description	Manufacturer	Model number	Serial number
Cellular phone	LG	LG-D821	353490-06-004345-8

6.4 Changes made in EUT

No changes were implemented in the EUT during the testing.

6.5 Test configuration



6.6 EUT test positions

Photograph 6.6.1 EUT in X-axis orthogonal position



Photograph 6.6.2 EUT in Y-axis orthogonal position



Photograph 6.6.3 EUT in Z-axis orthogonal position



6.7 Transmitter characteristics

Type of equipment					
	Stand-alone (Equipment with or without its own control provisions)				
X	Combined equipment (Equipment where the radio part is fully integrated within another type of equipment)				
	Plug-in card (Equipment intended for a variety of host systems)				
Intended use		Condition of use			
	fixed	Always at a distance more than 2 m from all people			
	mobile	Always at a distance more than 20 cm from all people			
X	portable	May operate at a distance closer than 20 cm to human body			
Assigned frequency range		2400-2483.5 MHz			
Operating frequency range		2402 – 2480 MHz			
Maximum rated output power		At transmitter 50 Ω RF output connector		NA	
		Peak output power		12.76 dBm @ BLE modulation	
				13.76 dBm @ GFSK modulation	
				13.23 dBm @ 8DPSK modulation	
				13.71 dBm @ DQPSK modulation	
Is transmitter output power variable?		X	No		
			Yes	continuous variable	
		stepped variable with stepsize			
		dB			
		minimum RF power			
				dBm	
				maximum RF power	
				dBm	
Antenna connection					
unique coupling		standard connector		X	integral
				X	with temporary RF connector
					without temporary RF connector
Antenna/s technical characteristics					
Type	Manufacturer		Model number		Gain
Embedded 2.4 GHz antenna	Ethertronics		P/N 1001312		1.72 dBi
Transmitter aggregate data rate/s					
Type of modulation					
BLE(GFSK)		GFSK		8DPSK	DQPSK
0.25 Mbps		0.925 Mbps		3 Mbps	3 Mbps
Modulating test signal (baseband)		PRBS			
Transmitter power source					
X	Battery	Nominal rated voltage	3.7 V	Battery type	Lithium-Polymer
	DC	Nominal rated voltage	VDC		
X	AC mains	Nominal rated voltage	120 VAC	Frequency	60 Hz
Spread spectrum parameters for transmitters tested per FCC 15.247 only					
FHSS	Total number of hops		79		
	Bandwidth per hop		1378 kHz		
	Max. separation of hops		1015 kHz		

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

7.5 Peak output power at 8DPSK modulation

7.5.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.5.1.

Table 7.5.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain dBi	
	W	dBm			
902.0 – 928.0	0.25 (<50 hopping channels)	24.0(<50 hopping channels)	125.2 (<50 hopping channels)	6.0*	
	1.0 (≥50 hopping channels)	30.0 (≥50 hopping channels)	131.2 (≥50 hopping channels)		
2400.0 – 2483.5	0.125 (<75 hopping channels)	21.0(<75 hopping channels)	122.2 (<75 hopping channels)		
	1.0 (≥75 hopping channels)	30.0 (≥75 hopping channels)	131.2 (≥75 hopping channels)		
5725.0 – 5850.0	1.0	30.0	131.2		

*- Equivalent field strength limit was calculated from the peak output power as follows: $E = \sqrt{30 \times P \times G} / r$, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

** - The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

- by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
- without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
- by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

7.5.2 Test procedure

7.5.2.1 The EUT was set up as shown in Figure 7.5.1, energized and its proper operation was checked.

7.5.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

7.5.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 360° and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.5.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.5.2 and associated plots.

7.5.2.5 The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.

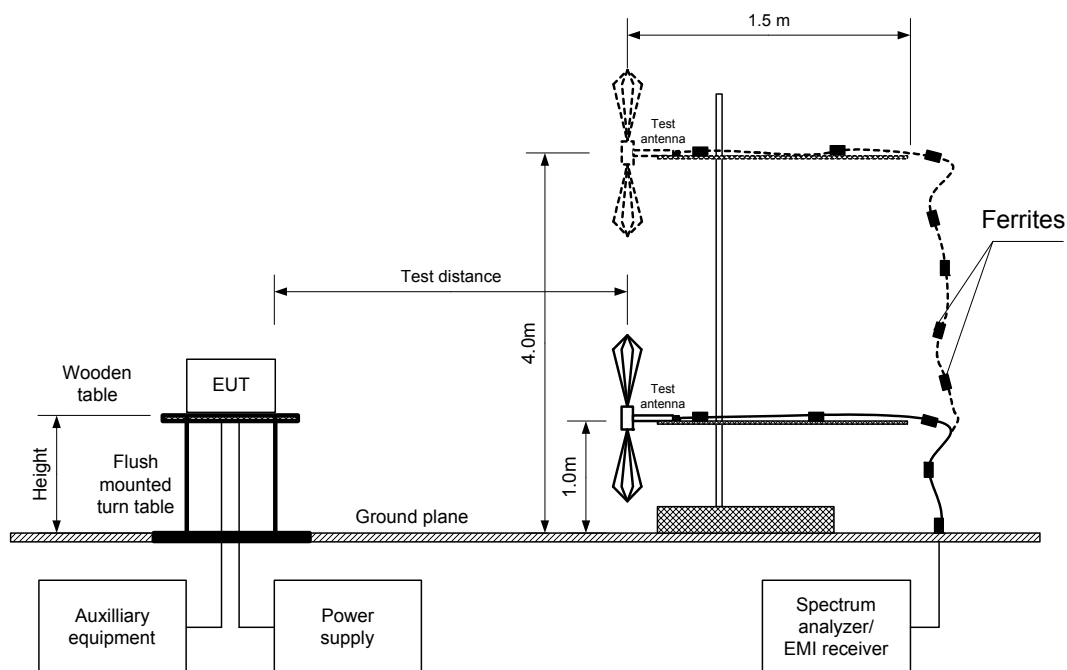
The above equation was converted in logarithmic units for 3 m test distance:

$$\text{Peak output power in dBm} = \text{Field strength in dB(μV/m)} - \text{Transmitter antenna gain in dBi} - 95.2 \text{ dB}$$

7.5.2.6 The worst test results (the lowest margins) were recorded in Table 7.5.2.

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

Figure 7.5.1 Setup for carrier field strength measurements





Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

Table 7.5.2 Peak output power test results

ASSIGNED FREQUENCY: 2400-2483.5 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 1.5 m
 DETECTOR USED: Peak
 TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)
 MODULATION: 8DPSK
 MODULATING SIGNAL: PRBS
 BIT RATE: 3 Mbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 EUT 20 dB BANDWIDTH: 1.371 MHz
 RESOLUTION BANDWIDTH: 3 MHz
 VIDEO BANDWIDTH: 3 MHz
 FREQUENCY HOPPING: Disabled
 NUMBER OF FREQUENCY HOPPING CHANNELS:

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2402	110.15	Horizontal	1.7	10	1.72	13.23	30	-16.77	Pass
2441	107.68	Horizontal	1.7	10	1.72	10.76	30	-19.24	Pass
2480	106.76	Horizontal	1.8	20	1.72	9.84	30	-20.16	Pass

*- EUT front panel refer to 0 degrees position of turntable.

** - Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$, where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi - 95.2 dB*

*** - Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 0521	HL 1984	HL 4353	HL 5101				
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Full description is given in Appendix A.

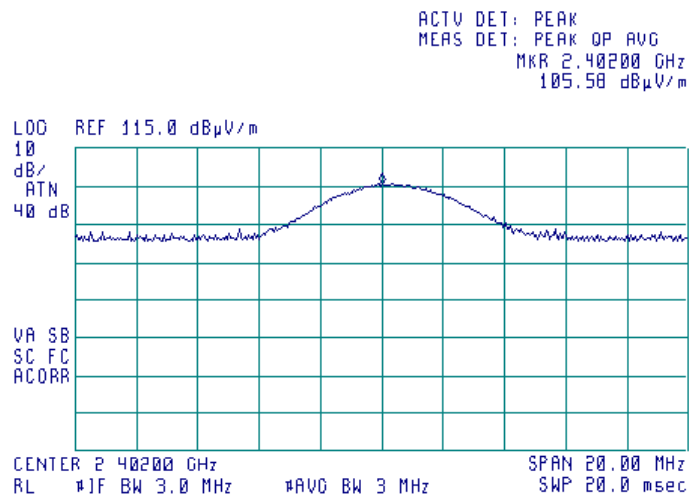


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

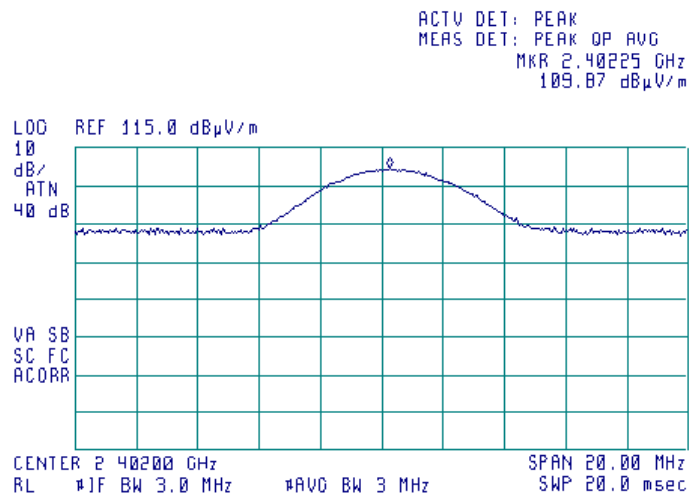
Plot 7.5.1 Field strength of carrier at low frequency, vertical antenna polarization

EUT POSITION: X-axis



Plot 7.5.2 Field strength of carrier at low frequency, vertical antenna polarization

EUT POSITION: Y-axis



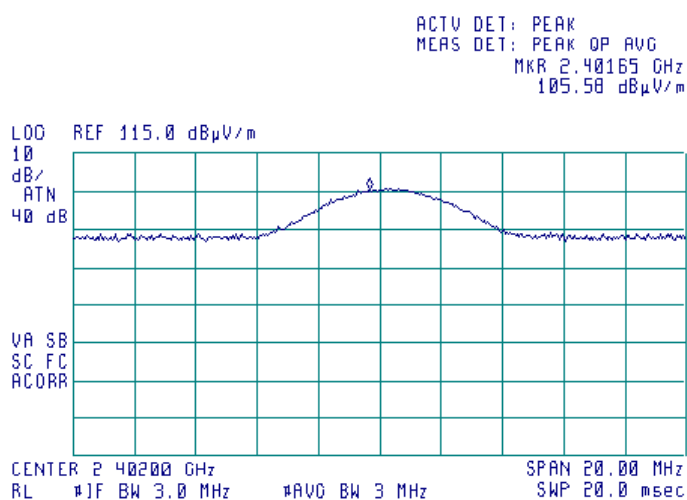


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

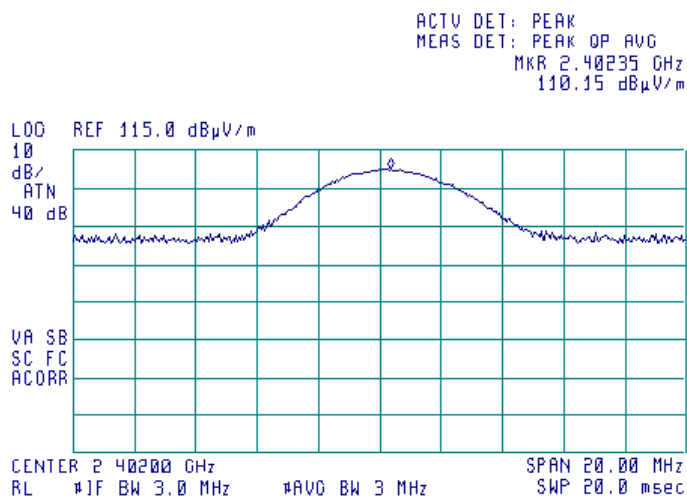
Plot 7.5.3 Field strength of carrier at low frequency, vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.5.4 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: X-axis



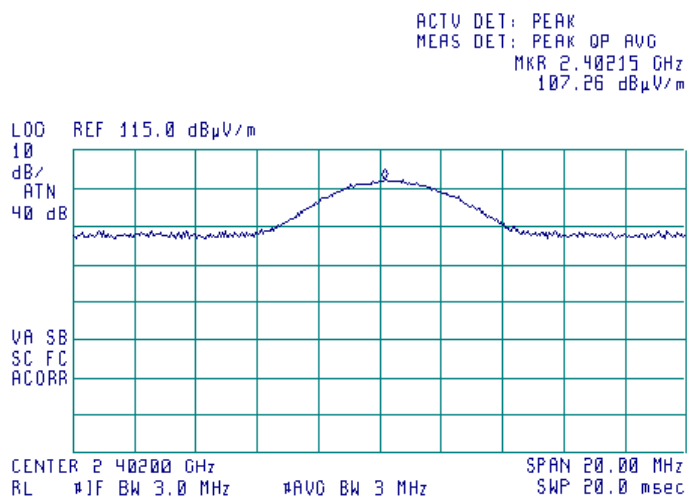


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

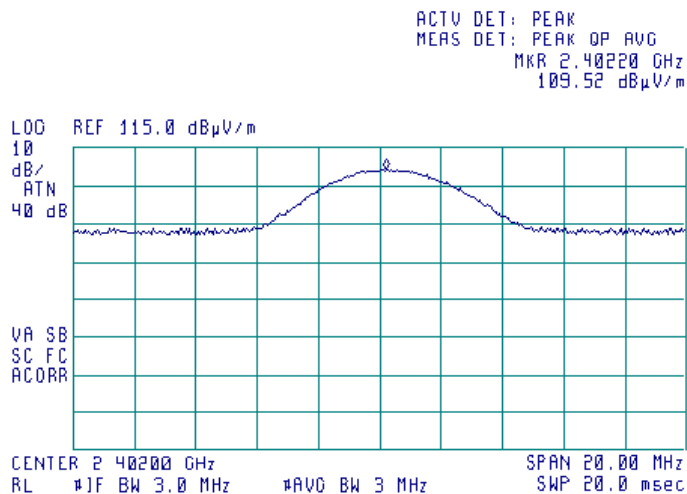
Plot 7.5.5 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.5.6 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Z-axis



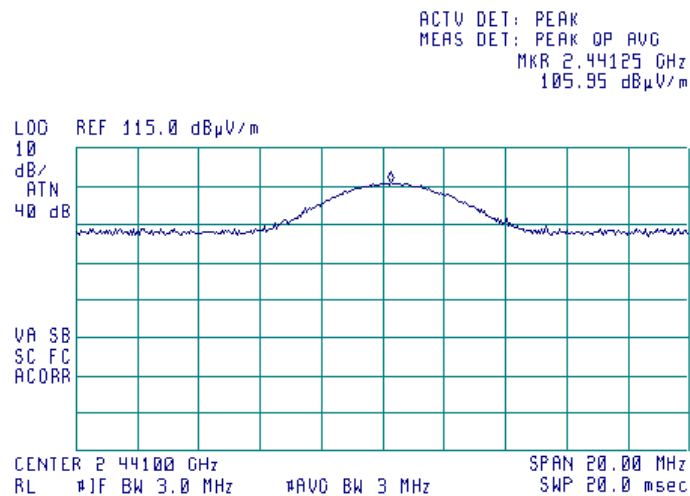


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

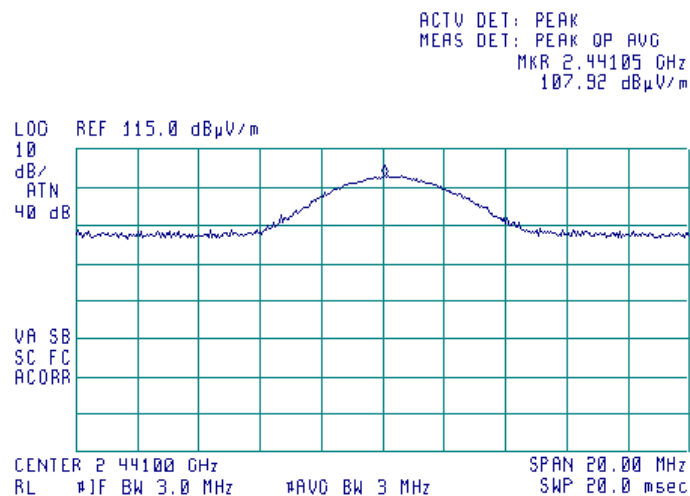
Plot 7.5.7 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.5.8 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Y-axis



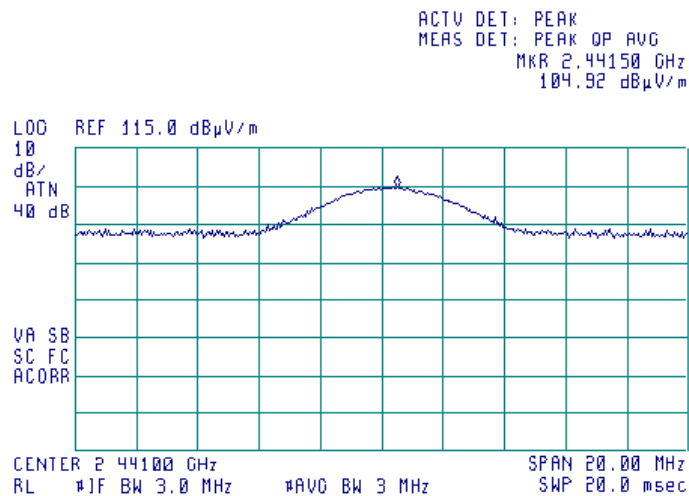


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

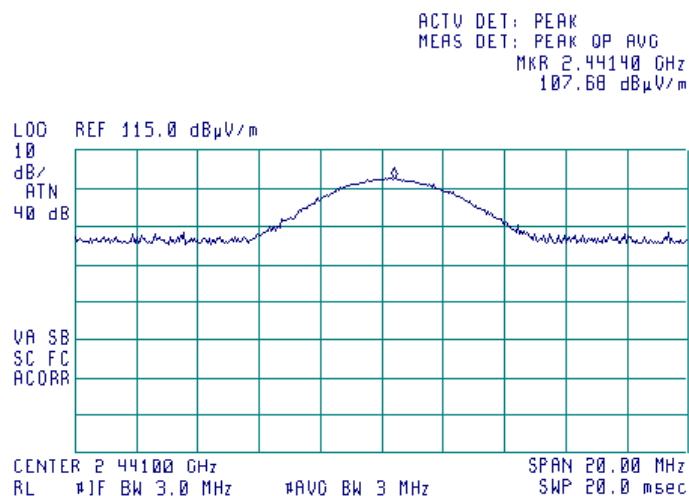
Plot 7.5.9 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.5.10 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: X-axis



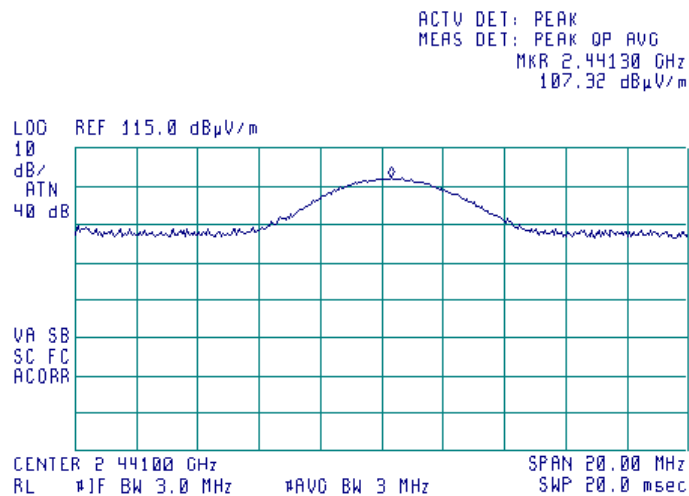


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

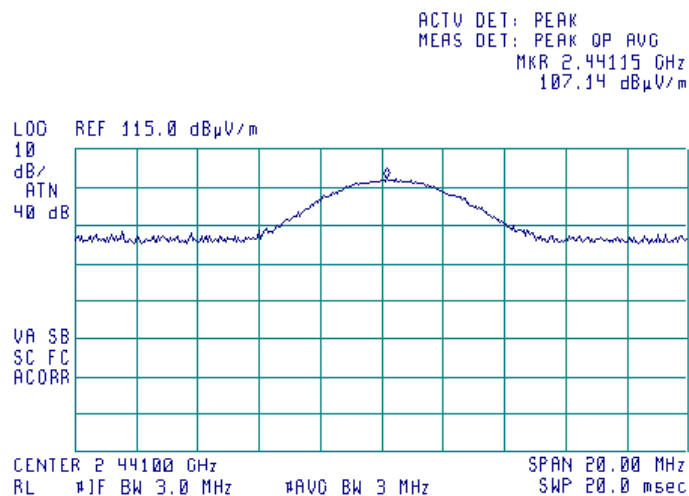
Plot 7.5.11 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.5.12 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Z-axis



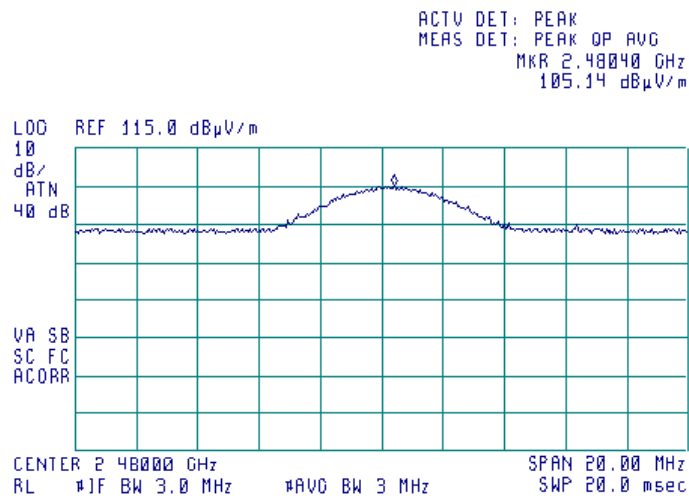


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

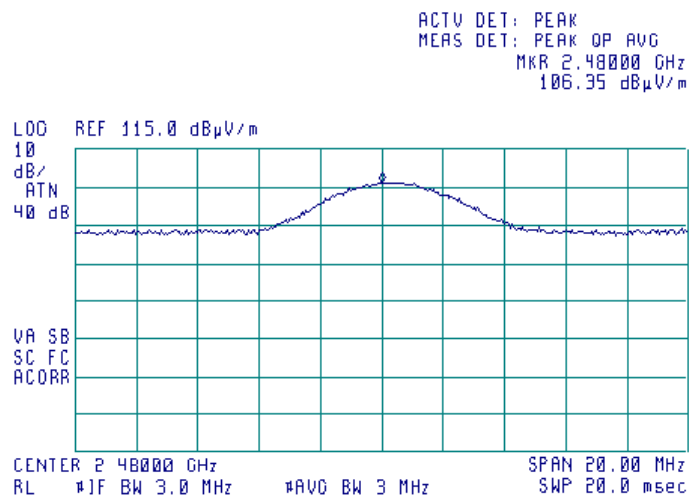
Plot 7.5.13 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.5.14 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Y-axis



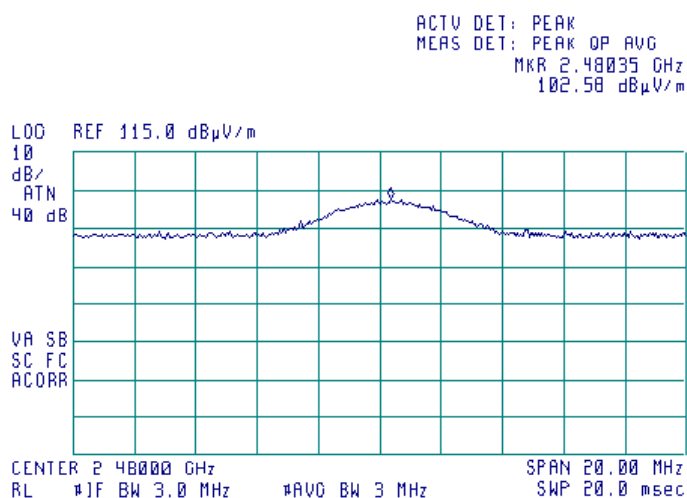


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

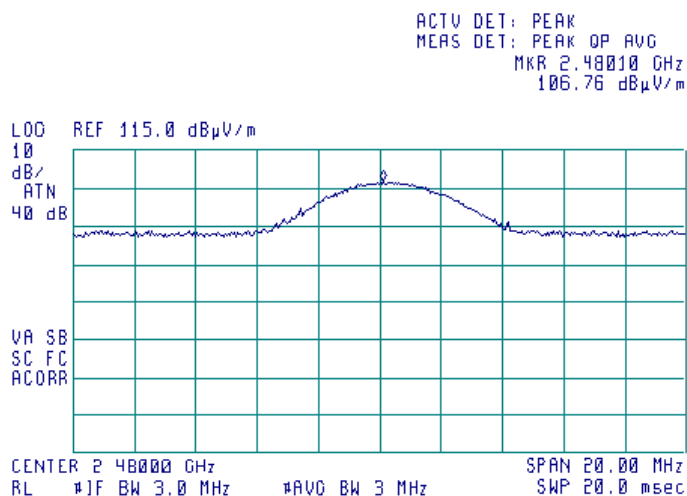
Plot 7.5.15 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.5.16 Field strength of carrier at high frequency horizontal antenna polarization

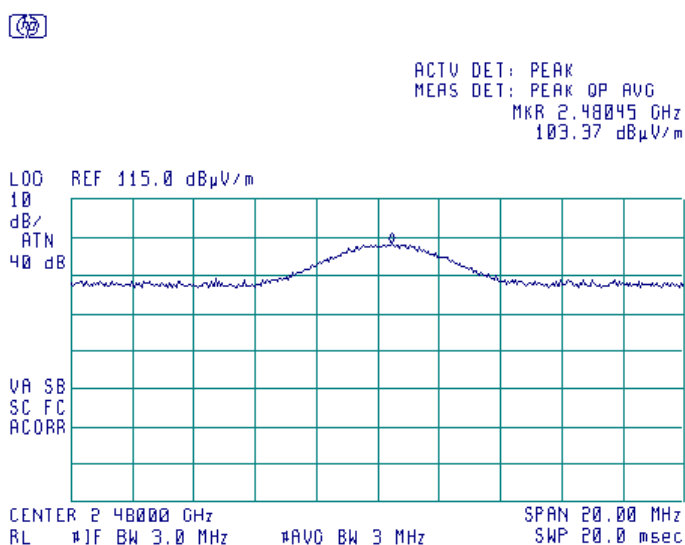
EUT POSITION: X-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: 8DPSK modulation			

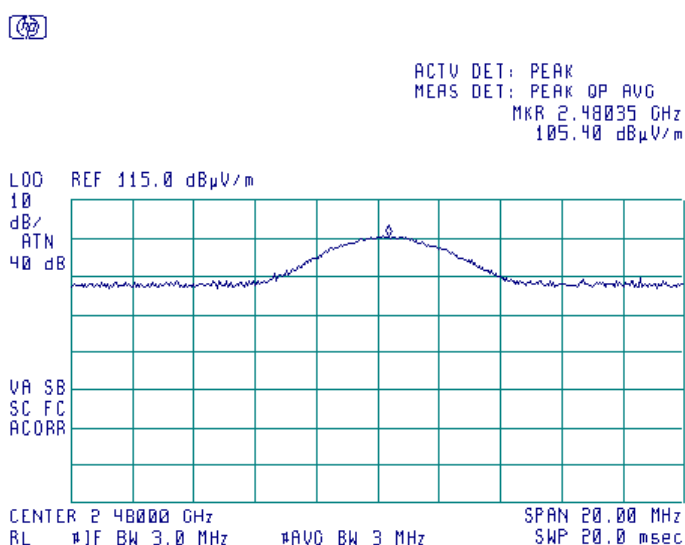
Plot 7.5.17 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.5.18 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Z-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

7.6 Peak output power at DQPSK modulation

7.6.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.6.1.

Table 7.6.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain dBi	
	W	dBm			
902.0 – 928.0	0.25 (<50 hopping channels)	24.0(<50 hopping channels)	125.2 (<50 hopping channels)	6.0*	
	1.0 (≥50 hopping channels)	30.0 (≥50 hopping channels)	131.2 (≥50 hopping channels)		
2400.0 – 2483.5	0.125 (<75 hopping channels)	21.0(<75 hopping channels)	122.2 (<75 hopping channels)		
	1.0 (≥75 hopping channels)	30.0 (≥75 hopping channels)	131.2 (≥75 hopping channels)		
5725.0 – 5850.0	1.0	30.0	131.2		

*- Equivalent field strength limit was calculated from the peak output power as follows: $E = \sqrt{30 \times P \times G} / r$, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

** - The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

- by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
- without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
- by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

7.6.2 Test procedure

7.6.2.1 The EUT was set up as shown in Figure 7.6.1, energized and its proper operation was checked.

7.6.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

7.6.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 360° and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.6.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.6.2 and associated plots.

7.6.2.5 The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.

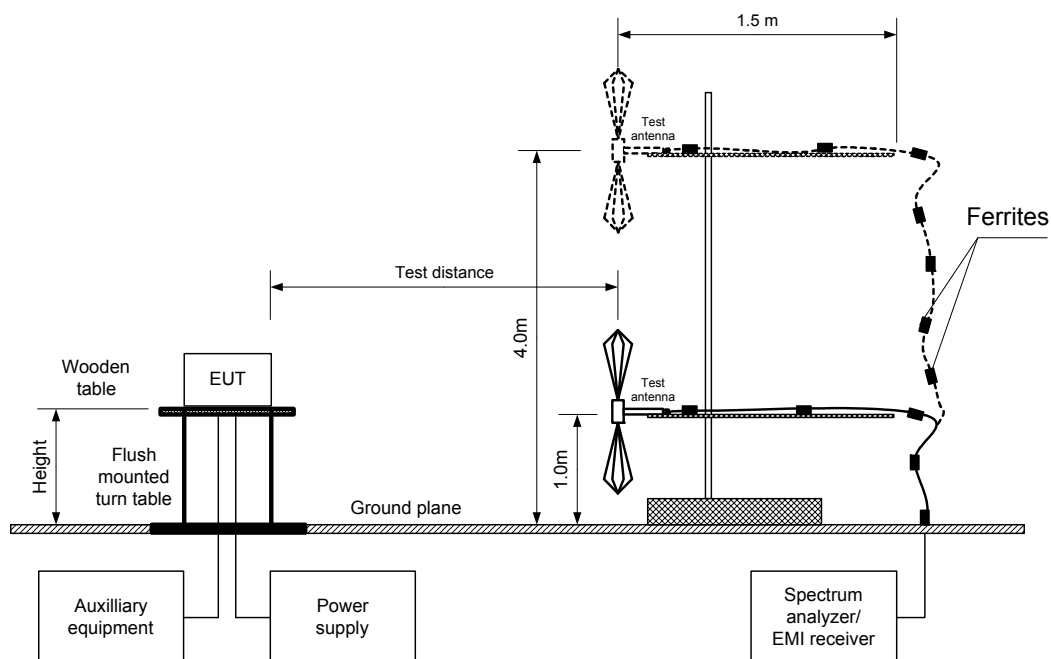
The above equation was converted in logarithmic units for 3 m test distance:

$$\text{Peak output power in dBm} = \text{Field strength in dB(μV/m)} - \text{Transmitter antenna gain in dBi} - 95.2 \text{ dB}$$

7.6.2.6 The worst test results (the lowest margins) were recorded in Table 7.6.2.

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

Figure 7.6.1 Setup for carrier field strength measurements





Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

Table 7.6.2 Peak output power test results

ASSIGNED FREQUENCY: 2400-2483.5 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 1.5 m
 DETECTOR USED: Peak
 TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)
 MODULATION: DQPSK-
 MODULATING SIGNAL: PRBS
 BIT RATE: 3 Mbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 EUT 20 dB BANDWIDTH: 1.379 MHz
 RESOLUTION BANDWIDTH: 3 MHz
 VIDEO BANDWIDTH: 3 MHz
 FREQUENCY HOPPING: Disabled
 NUMBER OF FREQUENCY HOPPING CHANNELS:

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2402	110.63	Horizontal	1.7	10	1.72	13.71	30	-16.29	Pass
2441	106.50	Horizontal	1.7	10	1.72	9.58	30	-20.42	Pass
2480	105.27	Horizontal	1.8	20	1.72	8.35	30	-21.65	Pass

*- EUT front panel refer to 0 degrees position of turntable.

** - Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$, where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi - 95.2 dB*

*** - Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 0521	HL 1984	HL 4353	HL 5101				
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Full description is given in Appendix A.

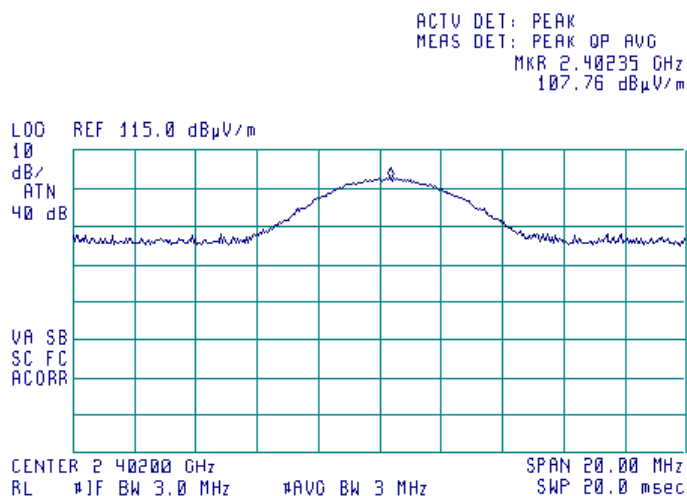


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

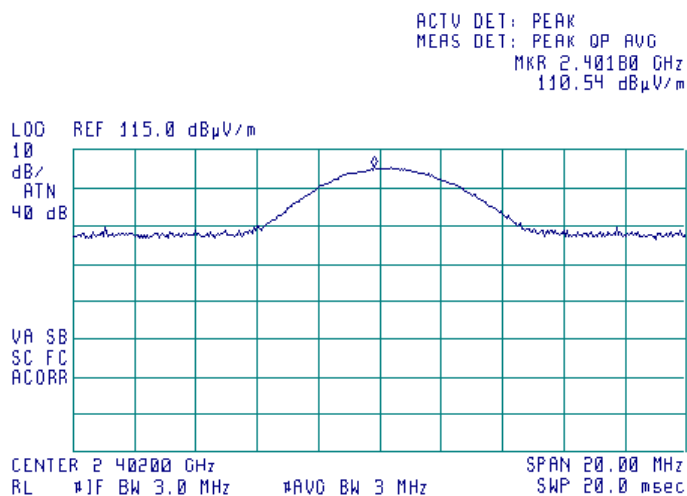
Plot 7.6.1 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.6.2 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: Y-axis



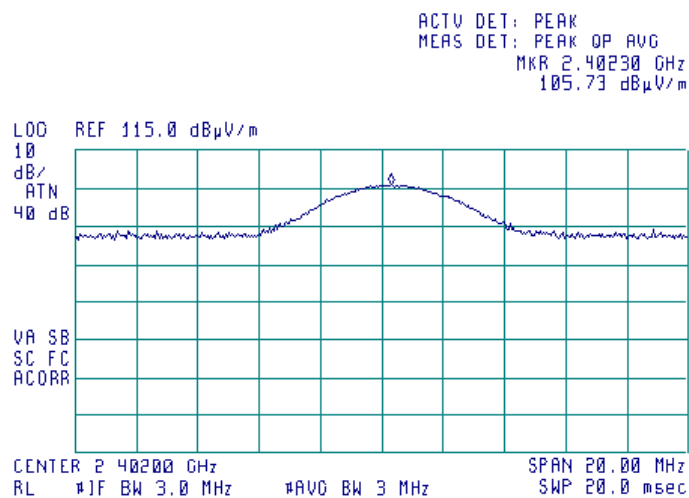


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

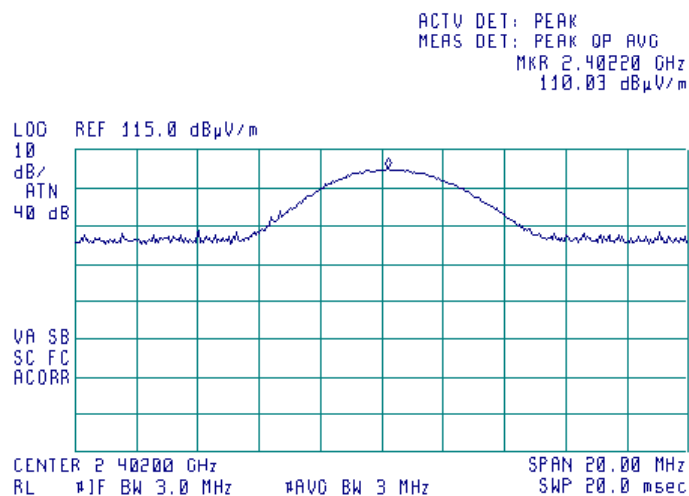
Plot 7.6.3 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.6.4 Field strength of carrier at low frequency horizontal antenna polarization

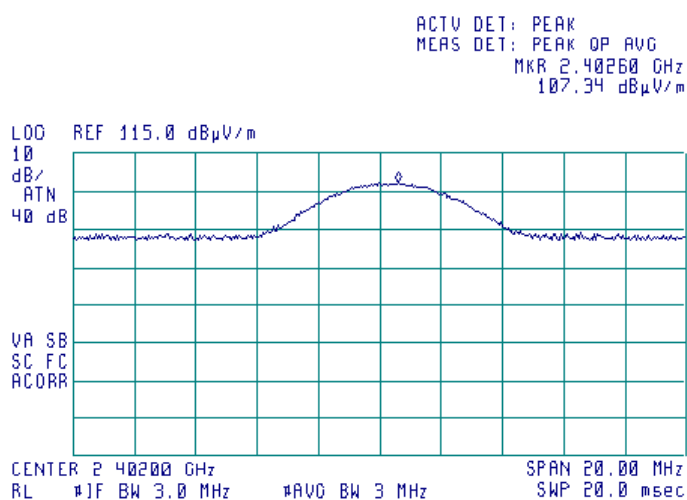
EUT POSITION: X-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

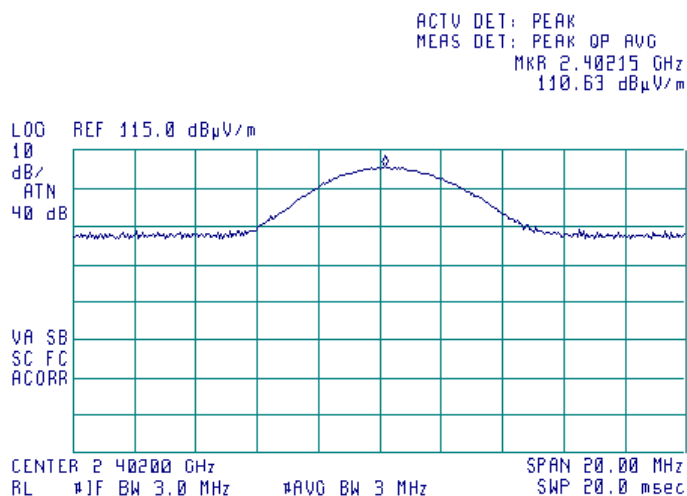
Plot 7.6.5 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.6.6 Field strength of carrier at low frequency horizontal antenna polarization

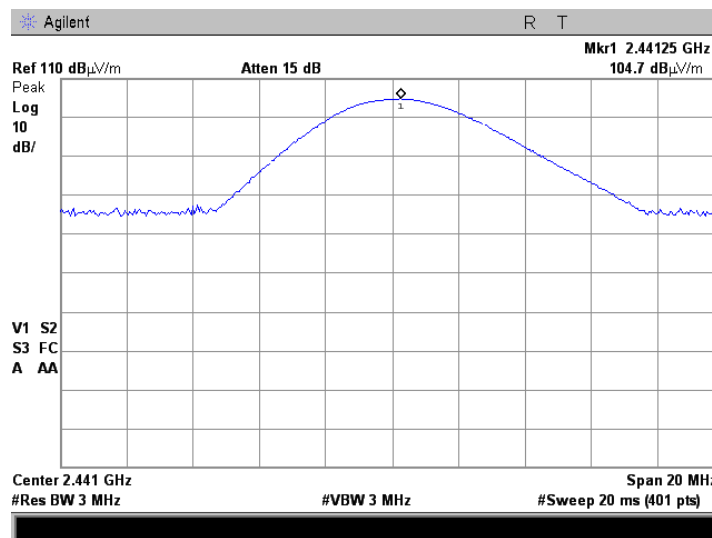
EUT POSITION: Z-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

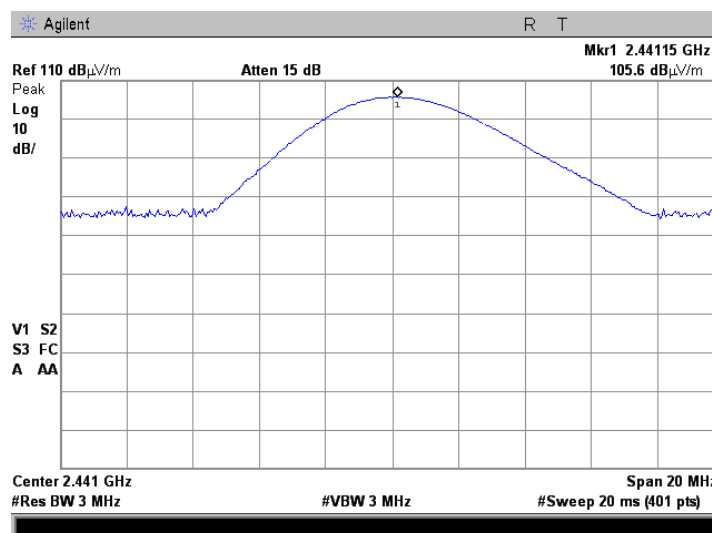
Plot 7.6.7 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.6.8 Field strength of carrier at mid frequency vertical antenna polarization

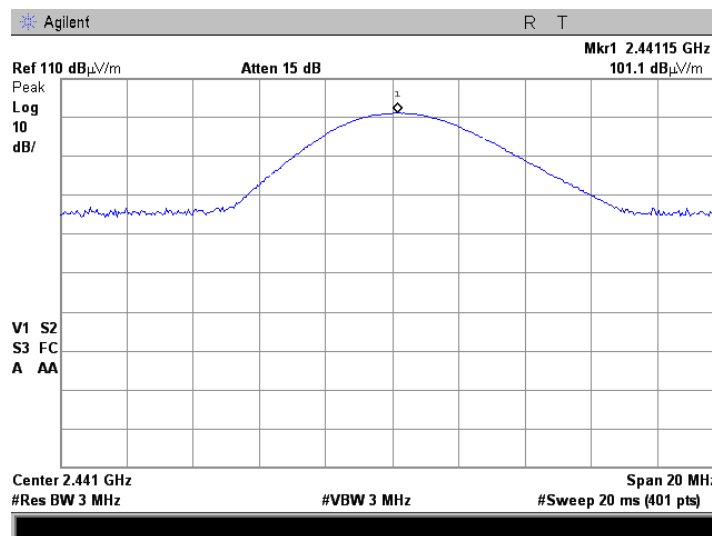
EUT POSITION: Y-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

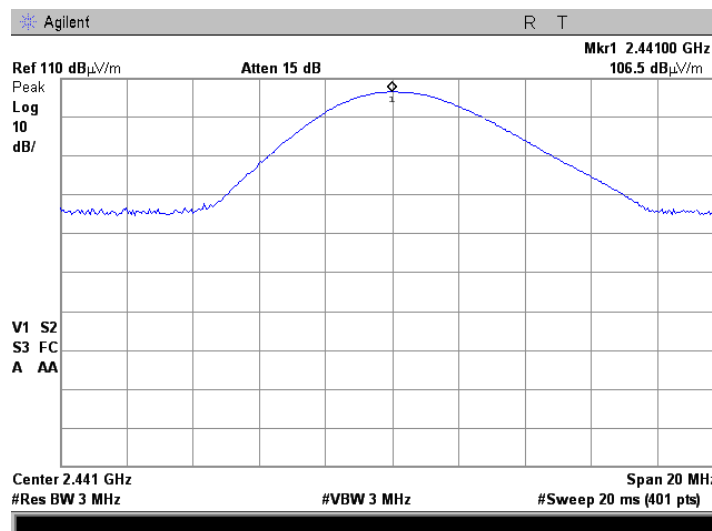
Plot 7.6.9 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.6.10 Field strength of carrier at mid frequency horizontal antenna polarization

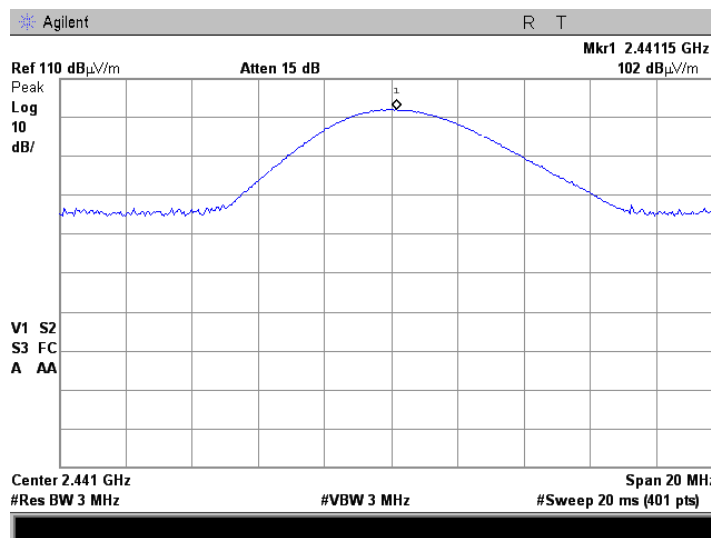
EUT POSITION: X-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

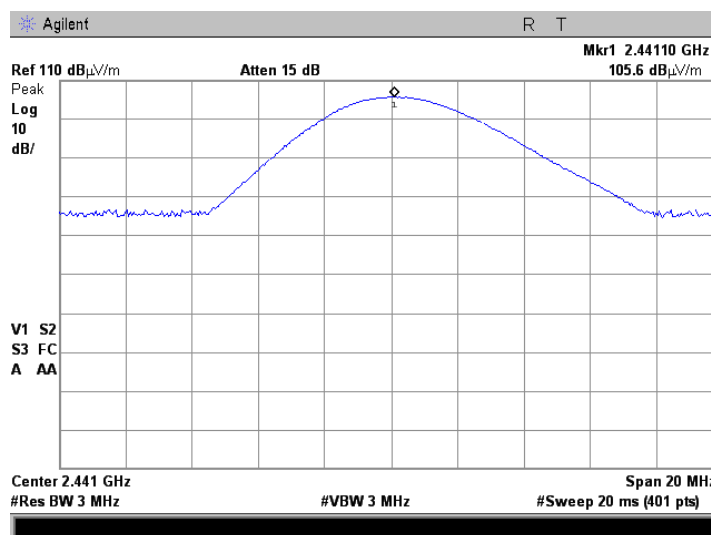
Plot 7.6.11 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.6.12 Field strength of carrier at mid frequency horizontal antenna polarization

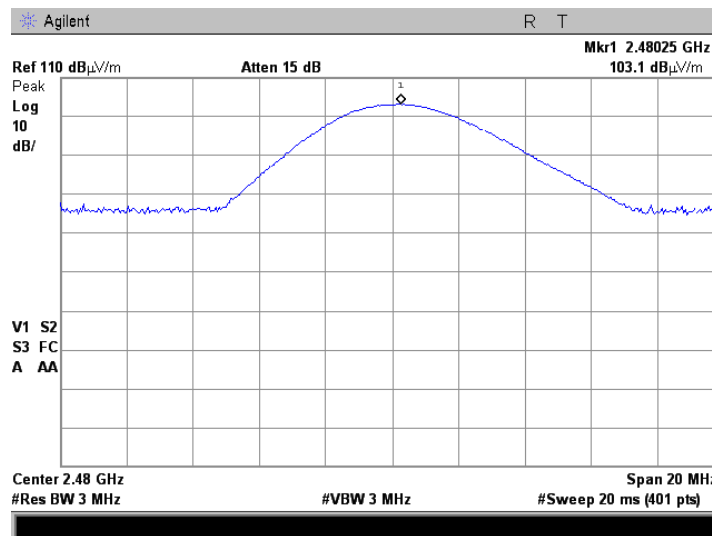
EUT POSITION: Z-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

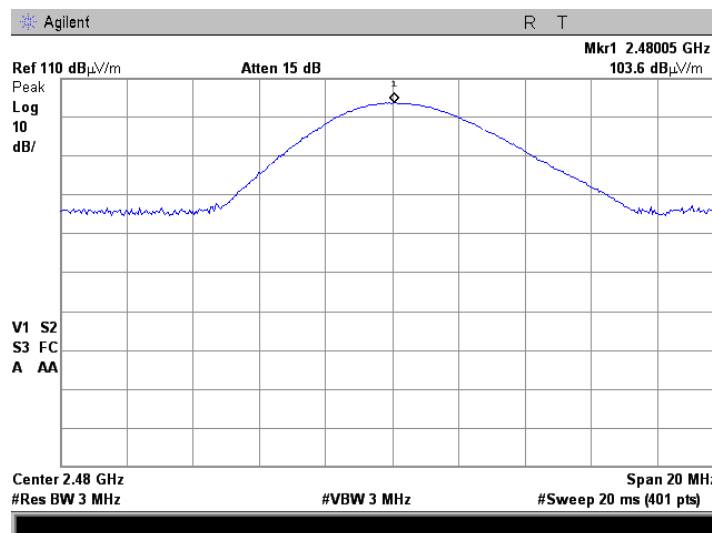
Plot 7.6.13 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.6.14 Field strength of carrier at high frequency vertical antenna polarization

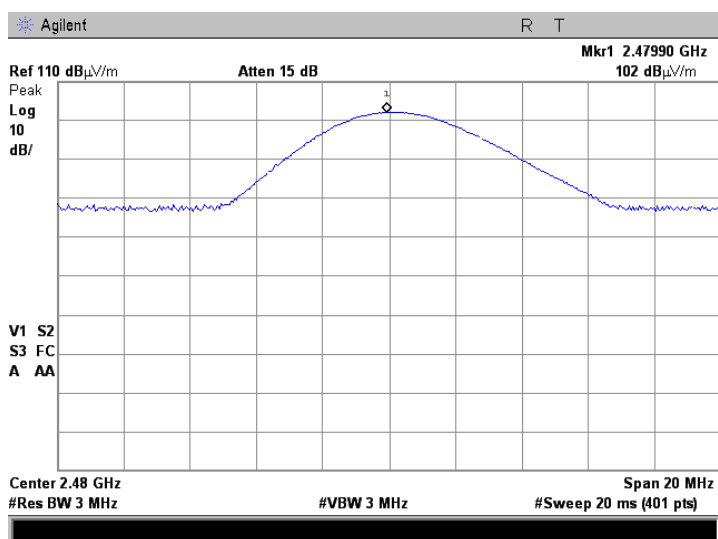
EUT POSITION: Y-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

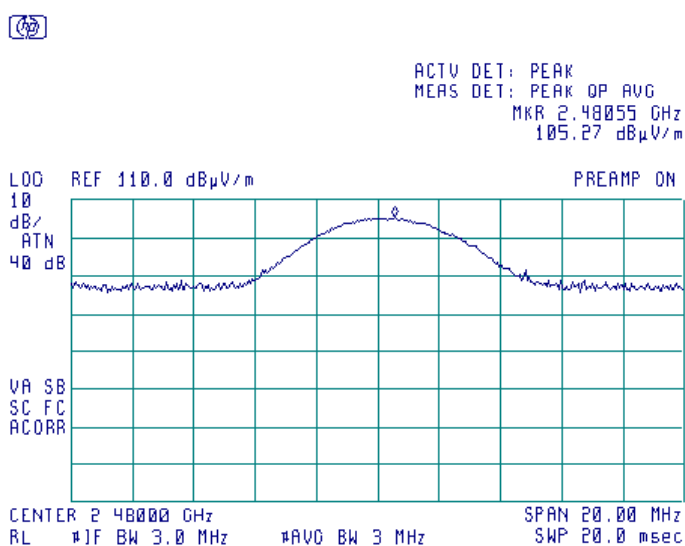
Plot 7.6.15 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.6.16 Field strength of carrier at high frequency horizontal antenna polarization

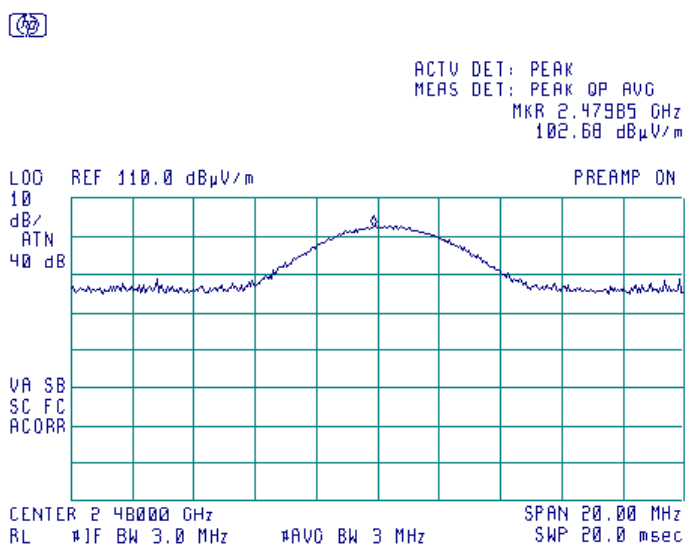
EUT POSITION: X-axis



Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16 - 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: DQPSK modulation			

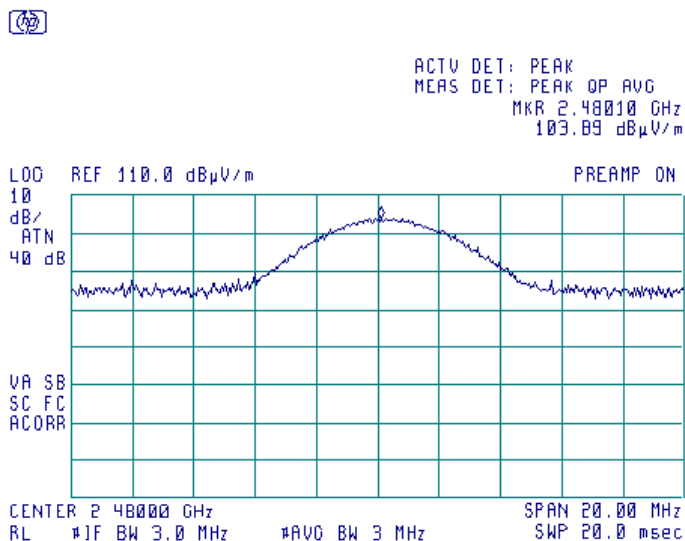
Plot 7.6.17 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.6.18 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Z-axis





Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

7.7 Peak output power at GFSK modulation

7.7.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.7.1.

Table 7.7.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain dBi	
	W	dBm			
902.0 – 928.0	0.25 (<50 hopping channels)	24.0(<50 hopping channels)	125.2 (<50 hopping channels)	6.0*	
	1.0 (≥50 hopping channels)	30.0 (≥50 hopping channels)	131.2 (≥50 hopping channels)		
2400.0 – 2483.5	0.125 (<75 hopping channels)	21.0(<75 hopping channels)	122.2 (<75 hopping channels)		
	1.0 (≥75 hopping channels)	30.0 (≥75 hopping channels)	131.2 (≥75 hopping channels)		
5725.0 – 5850.0	1.0	30.0	131.2		

*- Equivalent field strength limit was calculated from the peak output power as follows: $E = \sqrt{30 \times P \times G} / r$, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

** - The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

- by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
- without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
- by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

7.7.2 Test procedure

7.7.2.1 The EUT was set up as shown in Figure 7.7.1, energized and its proper operation was checked.

7.7.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

7.7.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 360° and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.7.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.7.2 and associated plots.

7.7.2.5 The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.

The above equation was converted in logarithmic units for 3 m test distance:

$$\text{Peak output power in dBm} = \text{Field strength in dB(μV/m)} - \text{Transmitter antenna gain in dBi} - 95.2 \text{ dB}$$

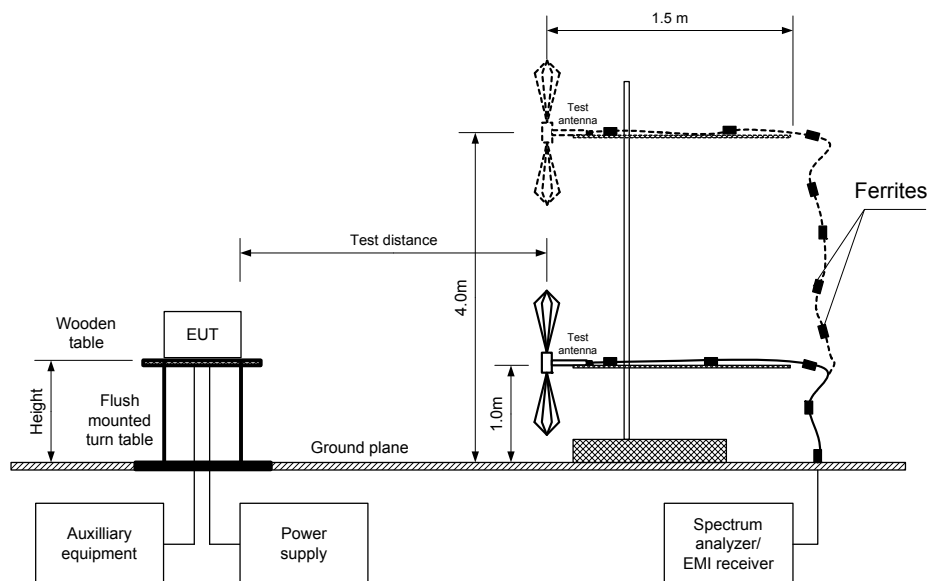
7.7.2.6 The worst test results (the lowest margins) were recorded in Table 7.7.2.



HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

Figure 7.7.1 Setup for carrier field strength measurements





HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

Table 7.7.2 Peak output power test results

ASSIGNED FREQUENCY: 2400-2483.5 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 1.5 m
 DETECTOR USED: Peak
 TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)
 MODULATION: GFSK
 MODULATING SIGNAL: PRBS
 BIT RATE: 0.925 Mbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 EUT 20 dB BANDWIDTH: 0.952 MHz
 RESOLUTION BANDWIDTH: 1 MHz
 VIDEO BANDWIDTH: 3 MHz
 FREQUENCY HOPPING: Disabled
 NUMBER OF FREQUENCY HOPPING CHANNELS:

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2402	110.68	Horizontal	1.7	10	1.72	13.76	30	-16.24	Pass
2441	107.63	Horizontal	1.7	10	1.72	10.71	30	-19.29	Pass
2480	106.94	Horizontal	1.8	20	1.72	10.02	30	-19.98	Pass

*- EUT front panel refer to 0 degrees position of turntable.

** - Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$, where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi - 95.2 dB*

*** - Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 0521	HL 1984	HL 4353	HL 5101				
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Full description is given in Appendix A.

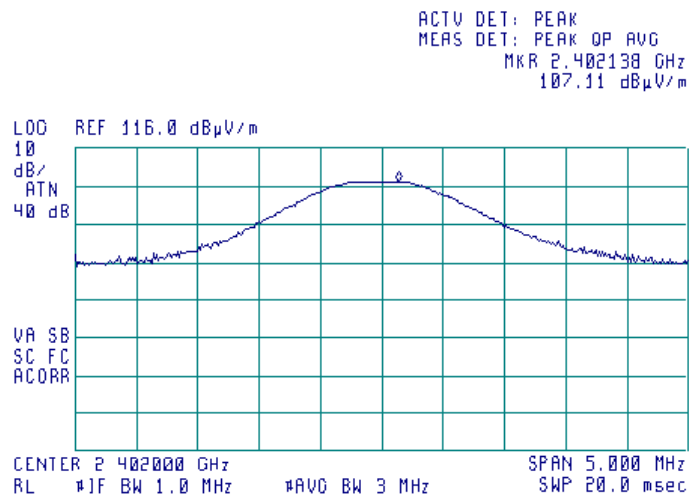


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

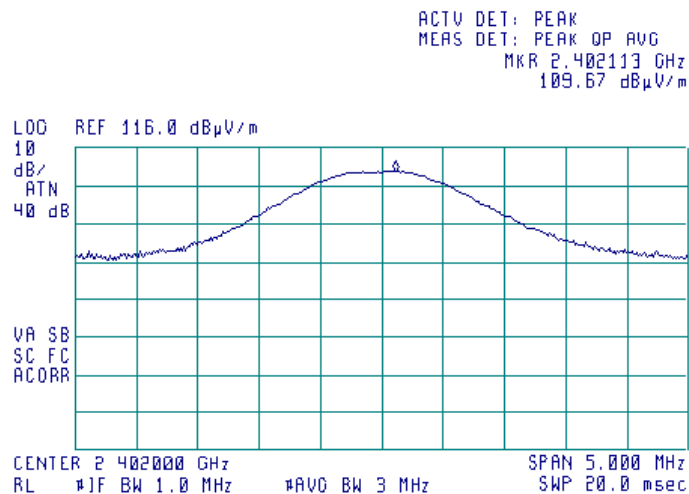
Plot 7.7.1 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.7.2 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: Y-axis



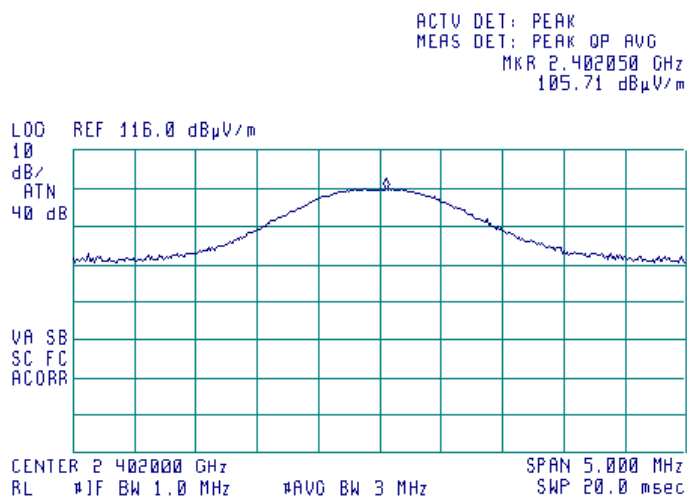


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

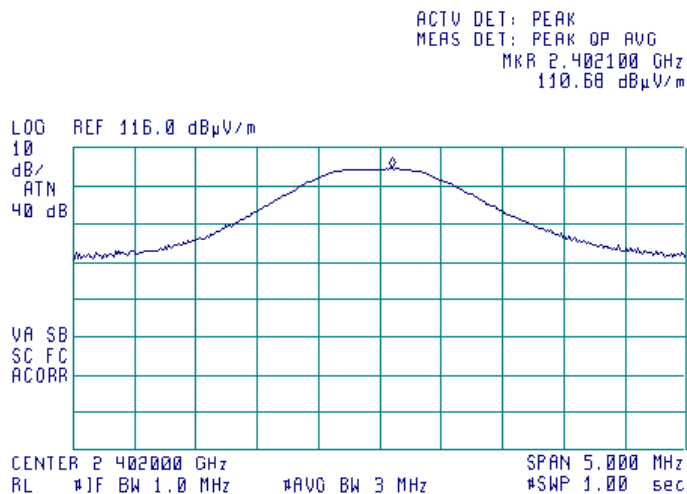
Plot 7.7.3 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.7.4 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: X-axis





HERMON LABORATORIES

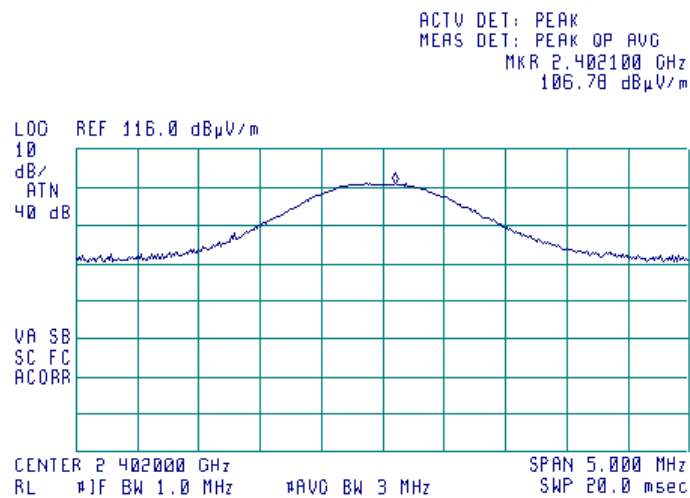
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Date of Issue: 18-Dec-16

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

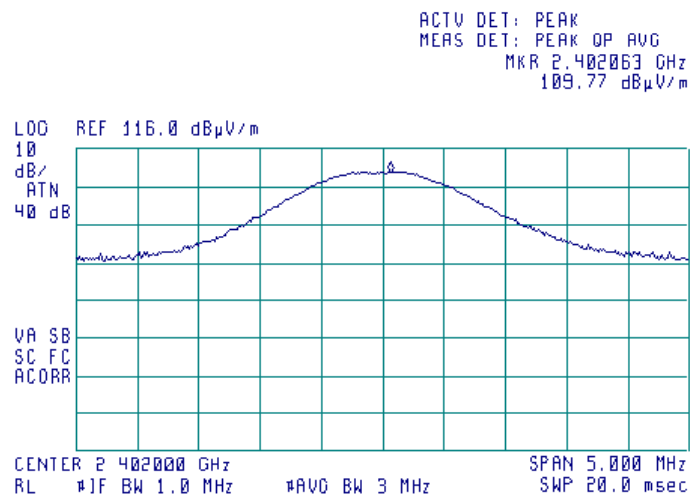
Plot 7.7.5 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.7.6 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Z-axis



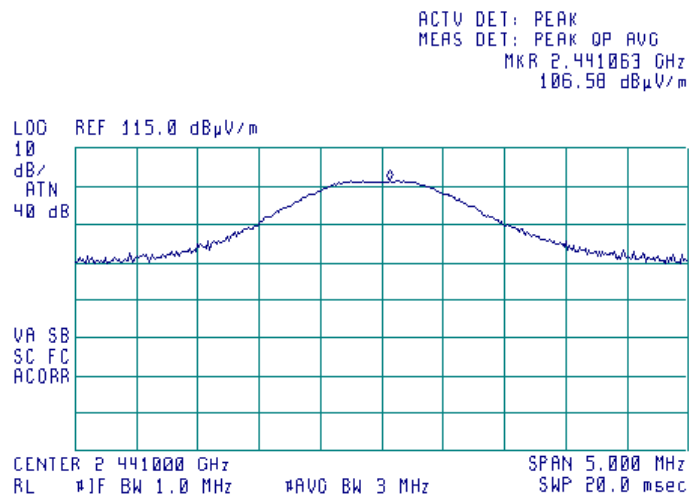


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

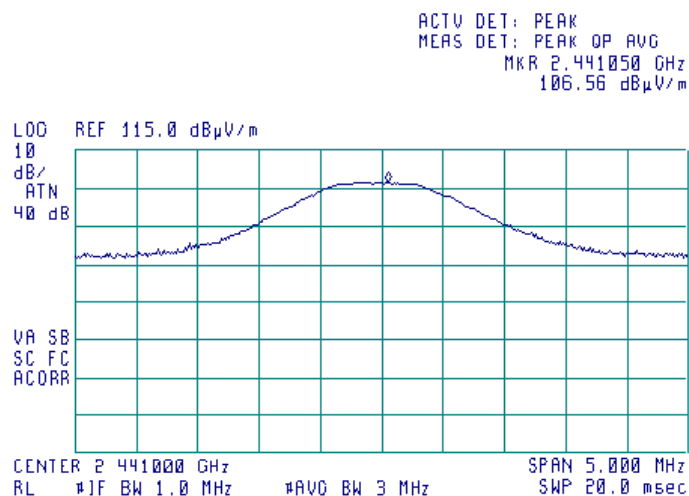
Plot 7.7.7 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.7.8 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Y-axis



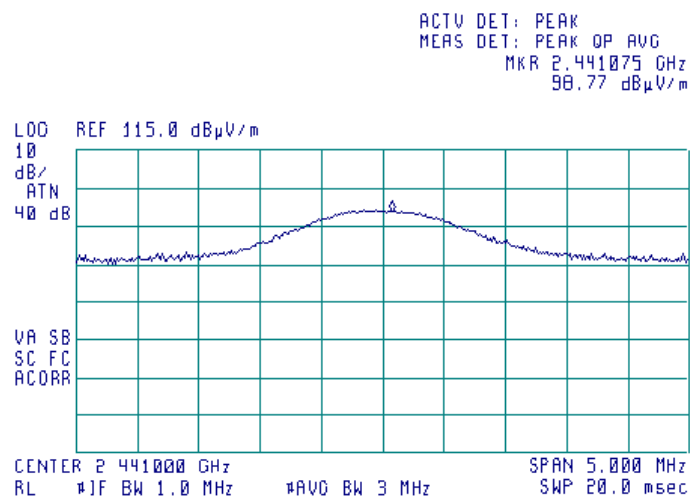


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

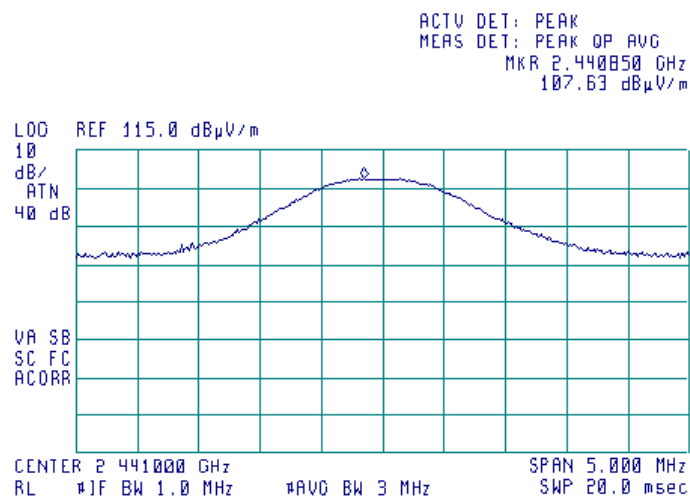
Plot 7.7.9 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.7.10 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: X-axis



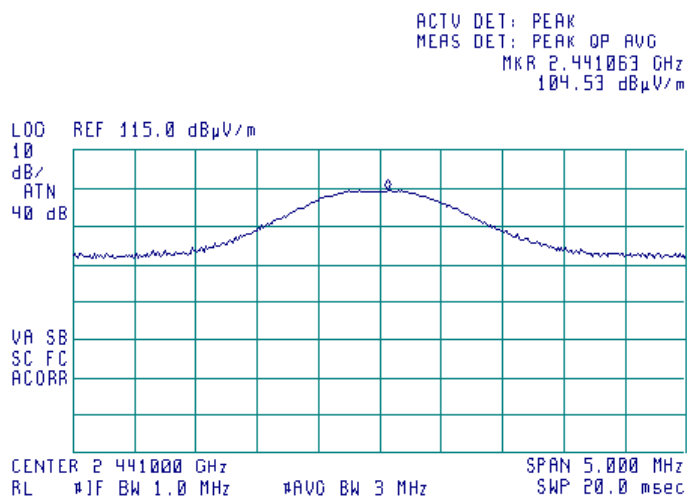


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

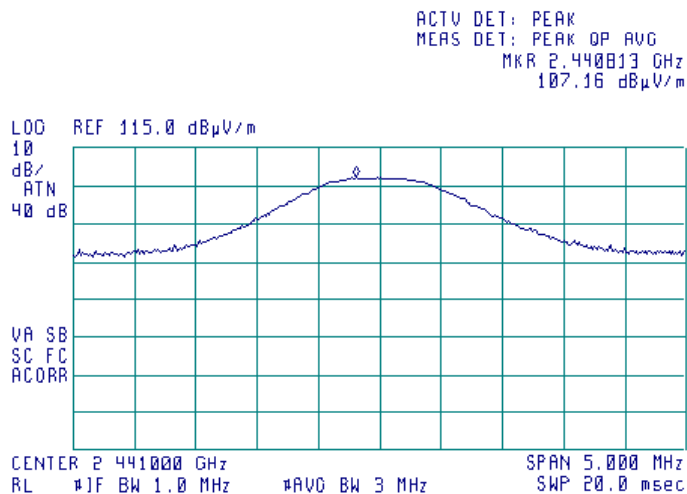
Plot 7.7.11 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.7.12 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Z-axis



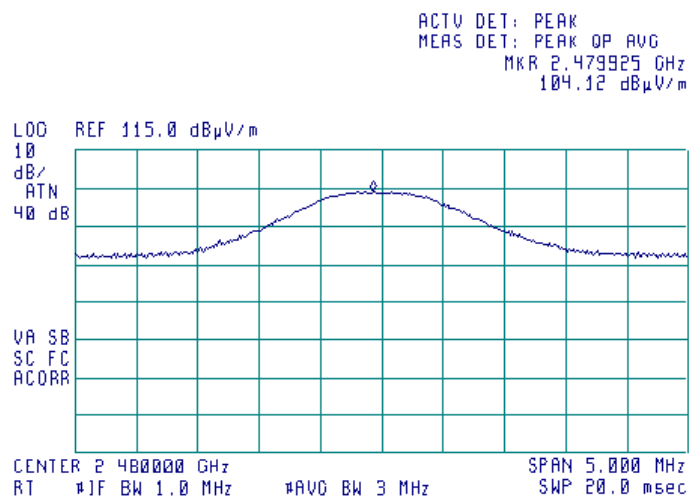


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

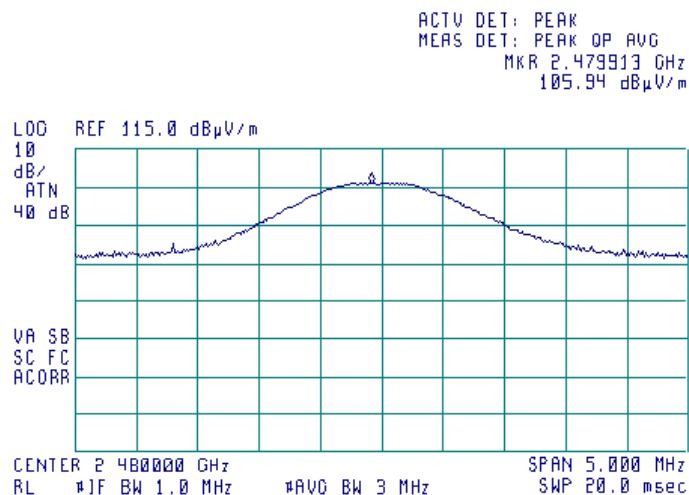
Plot 7.7.13 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.7.14 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Y-axis





HERMON LABORATORIES

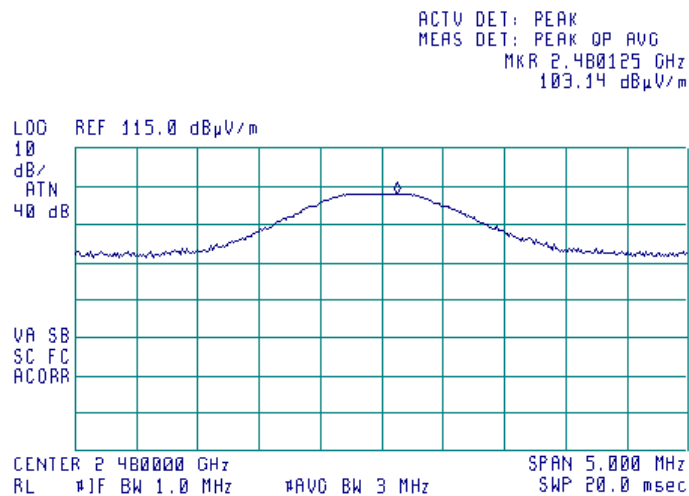
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Date of Issue: 18-Dec-16

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

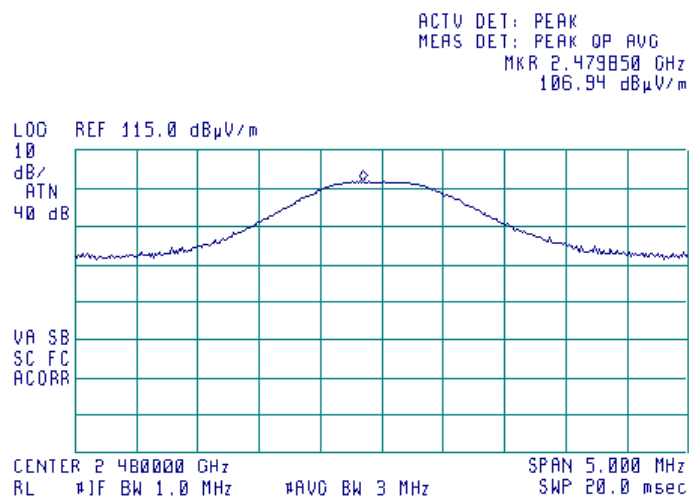
Plot 7.7.15 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.7.16 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: X-axis



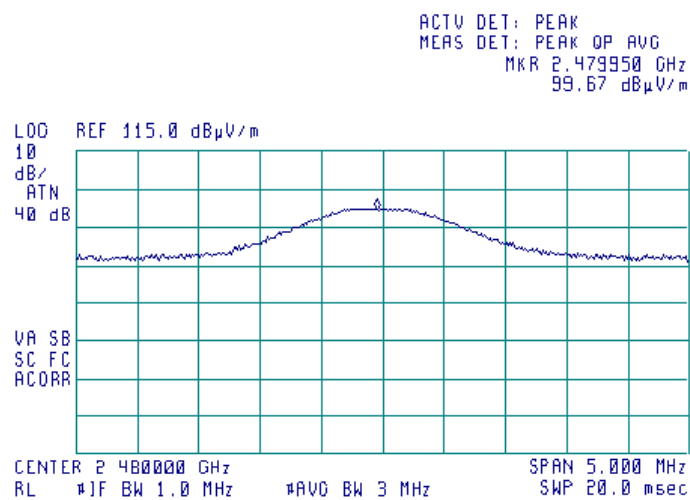


HERMON LABORATORIES

Test specification:		Section 15.247(b), Peak output power	
Test procedure:		ANSI C63.10, section 7.8.5	
Test mode:		Verdict: PASS	
Date(s):			
29-Sep-16			
Temperature: 24 °C	Relative Humidity: 44 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: GFSK modulation			

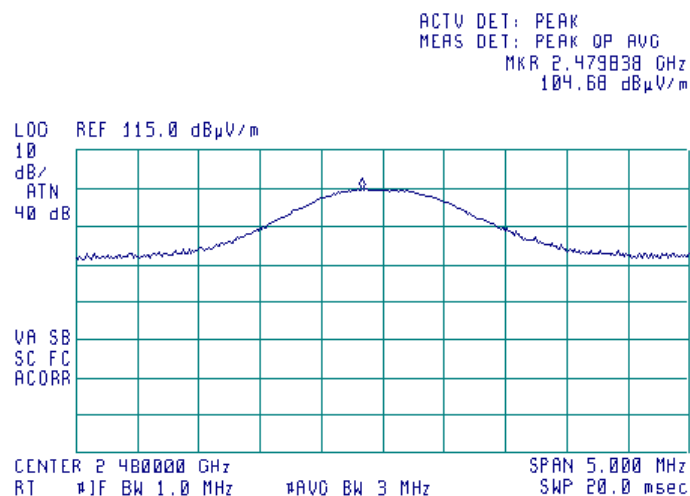
Plot 7.7.17 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.7.18 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Z-axis





Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

7.8 Peak output power at BLE (GFSK) modulation

7.8.1 General

This test was performed to measure the maximum peak output power radiated by transmitter. Specification test limits are given in Table 7.8.1.

Table 7.8.1 Peak output power limits

Assigned frequency range, MHz	Peak output power*		Equivalent field strength limit @ 3m, dB(μV/m)*	Maximum antenna gain, dBi	
	W	dBm			
902.0 – 928.0	0.25 (<50 hopping channels)	24.0(<50 hopping channels)	125.2 (<50 hopping channels)	6.0*	
	1.0 (≥50 hopping channels)	30.0 (≥50 hopping channels)	131.2 (≥50 hopping channels)		
2400.0 – 2483.5	0.125 (<75 hopping channels)	21.0(<75 hopping channels)	122.2 (<75 hopping channels)		
	1.0 (≥75 hopping channels)	30.0 (≥75 hopping channels)	131.2 (≥75 hopping channels)		
5725.0 – 5850.0	1.0	30.0	131.2		

*- Equivalent field strength limit was calculated from the peak output power as follows: $E = \sqrt{30 \times P \times G} / r$, where P is peak output power in Watts, r is antenna to EUT distance in meters and G is transmitter antenna gain in dBi.

** - The limit is provided in terms of conducted RF power at the antenna connector. If transmitting antennas of directional gain greater than 6 dBi are used, the peak output power limit shall be reduced below the stated value as follows:

- by 1 dB for every 3 dB that the directional gain of antenna exceeds 6 dBi for fixed point-to-point transmitters operate in 2400-2483.5 MHz band;
- without any corresponding reduction for fixed point-to-point transmitters operate in 5725-5850 MHz band;
- by the amount in dB that the directional gain of antenna exceeds 6 dBi for the rest of transmitters.

7.8.2 Test procedure

7.8.2.1 The EUT was set up as shown in Figure 7.8.1, energized and its proper operation was checked.

7.8.2.2 The EUT was adjusted to produce maximum available to end user RF output power.

7.8.2.3 The frequency span of spectrum analyzer was set approximately 5 times wider than 20 dB bandwidth of the EUT and the resolution bandwidth was set wider than 20 dB bandwidth of the EUT. To find maximum radiation the turntable was rotated 360° and the measuring antenna height was swept in both vertical and horizontal polarizations.

7.8.2.4 The maximum field strength of the EUT carrier frequency was measured as provided in Table 7.8.2 and associated plots.

7.8.2.5 The maximum peak output power was calculated from the field strength of carrier as follows:

$$P = (E \times d)^2 / (30 \times G),$$

where P is the peak output power in W, E is the field strength in V/m, d is the test distance and G is the transmitter numeric antenna gain over an isotropic radiator.

The above equation was converted in logarithmic units for 3 m test distance:

$$\text{Peak output power in dBm} = \text{Field strength in dB}(\mu\text{V/m}) - \text{Transmitter antenna gain in dBi} - 95.2 \text{ dB}$$

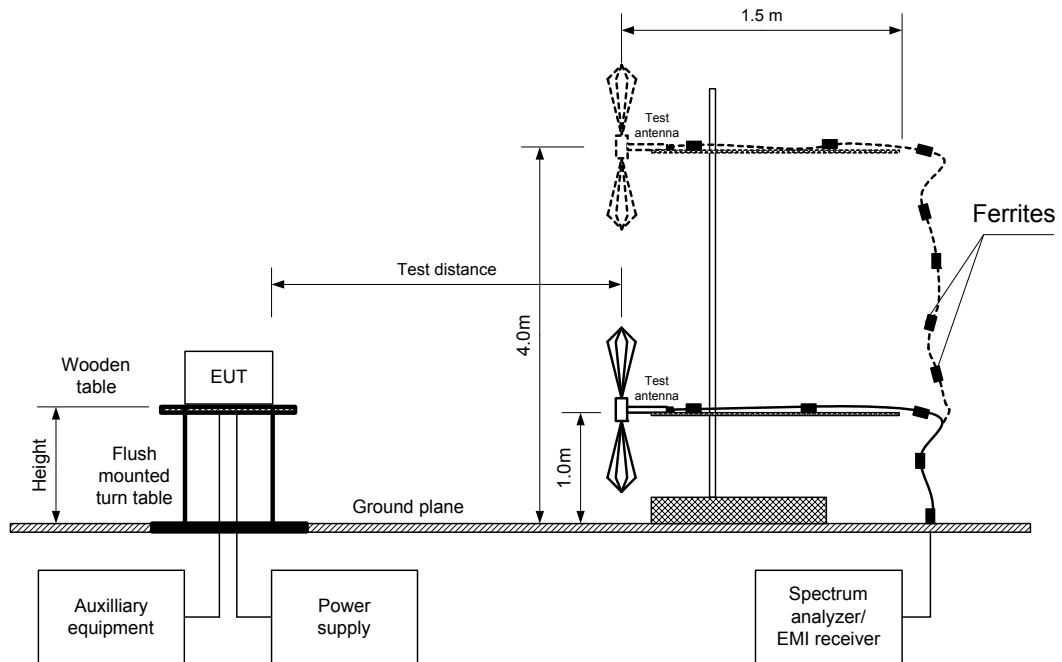
7.8.2.6 The worst test results (the lowest margins) were recorded in Table 7.8.2.



HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

Figure 7.8.1 Setup for carrier field strength measurements





HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode:	Compliance	Verdict: PASS	
Date(s):	05-Oct-16		
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

Table 7.8.2 Peak output power test results

ASSIGNED FREQUENCY: 2400-2483.5 MHz
 TEST DISTANCE: 3 m
 TEST SITE: Semi anechoic chamber
 EUT HEIGHT: 1.5 m
 DETECTOR USED: Peak
 TEST ANTENNA TYPE: Biconilog (30 MHz – 1000 MHz)
 Double ridged guide (above 1000 MHz)
 MODULATION: BLE(GFSK)
 MODULATING SIGNAL: PRBS
 BIT RATE: 0.25 Mbps
 TRANSMITTER OUTPUT POWER SETTINGS: Maximum
 DETECTOR USED: Peak
 EUT 20 dB BANDWIDTH: 1020 kHz
 RESOLUTION BANDWIDTH: 3 MHz
 VIDEO BANDWIDTH: 3 MHz
 FREQUENCY HOPPING: Disabled
 NUMBER OF FREQUENCY HOPPING CHANNELS:

Frequency, MHz	Field strength, dB(μV/m)	Antenna polarization	Antenna height, m	Azimuth, degrees*	EUT antenna gain, dBi	Peak output power, dBm**	Limit, dBm	Margin, dB***	Verdict
2402	109.68	Horizontal	1.7	10	1.72	12.76	30	-17.24	Pass
2441	107.37	Horizontal	1.7	10	1.72	10.45	30	-19.55	Pass
2480	105.49	Horizontal	1.8	20	1.72	8.57	30	-21.43	Pass

*- EUT front panel refer to 0 degrees position of turntable.

** - Peak output power was calculated from the field strength of carrier as follows: $P = (E \times d)^2 / (30 \times G)$, where P is the peak output power in W, E is the field strength in V/m, d is the test distance in meters and G is the transmitter numeric antenna gain over an isotropic radiator. The above equation was converted in logarithmic units for 3 m test distance: *Peak output power in dBm = Field strength in dB(μV/m) - Transmitter antenna gain in dBi – 95.2 dB*

*** - Margin = Peak output power – specification limit.

Reference numbers of test equipment used

HL 0521	HL 1984	HL 4353	HL 5101				
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Full description is given in Appendix A.

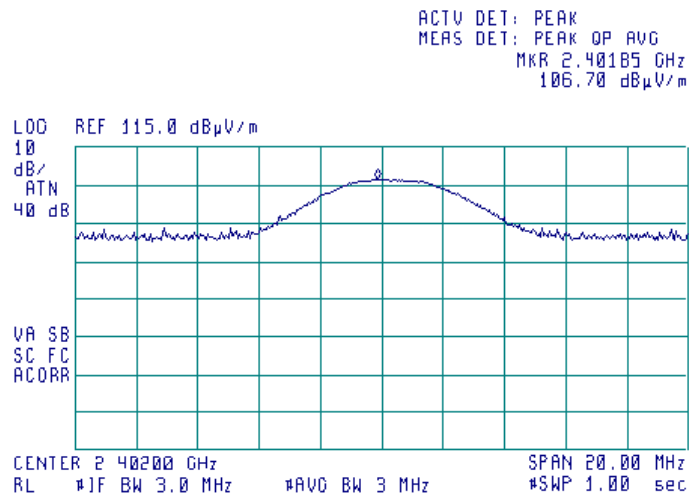


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

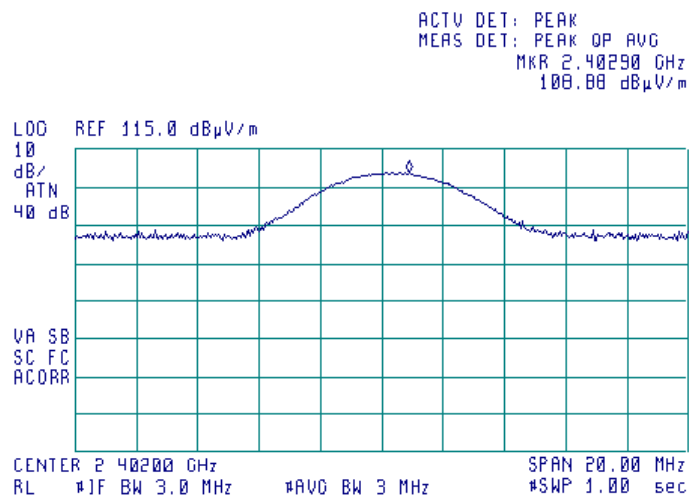
Plot 7.8.1 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.8.2 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: Y-axis



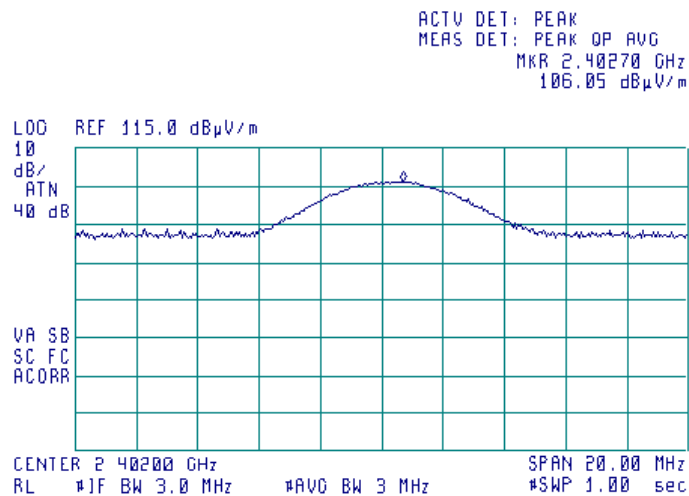


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

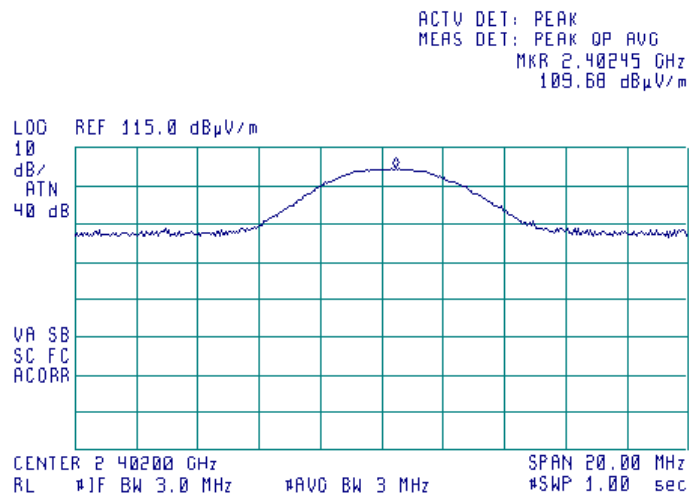
Plot 7.8.3 Field strength of carrier at low frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.8.4 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: X-axis



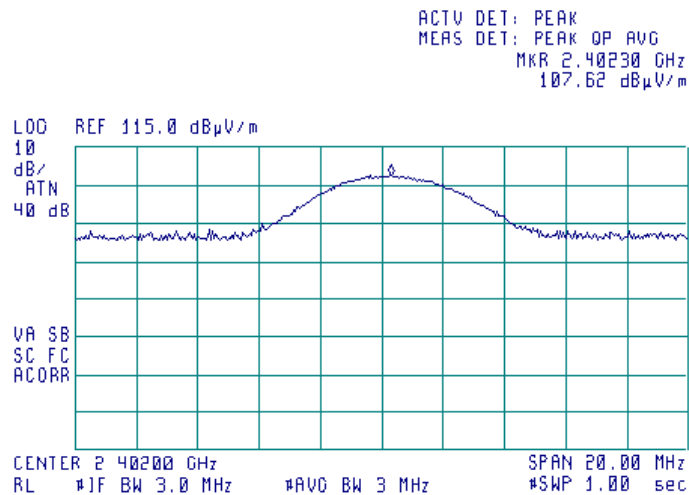


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

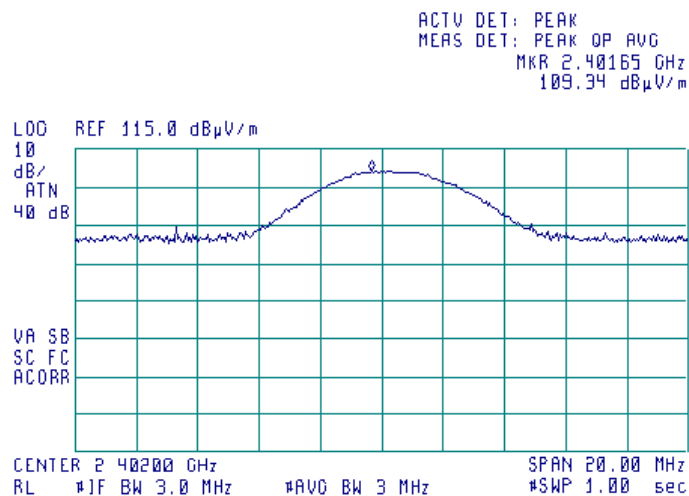
Plot 7.8.5 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.8.6 Field strength of carrier at low frequency horizontal antenna polarization

EUT POSITION: Z-axis



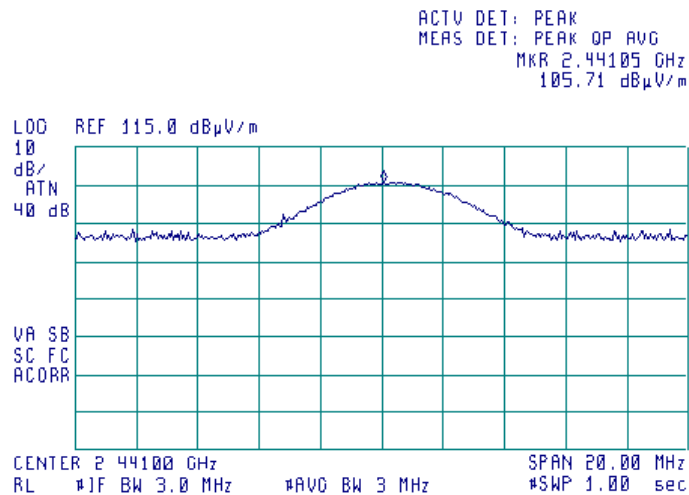


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

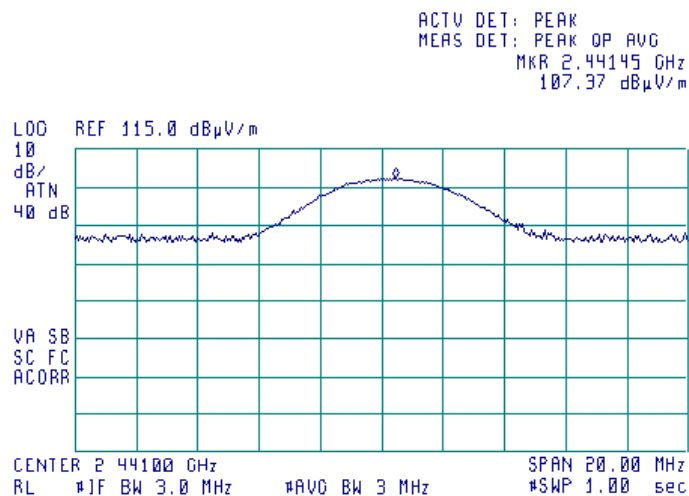
Plot 7.8.7 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.8.8 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Y-axis



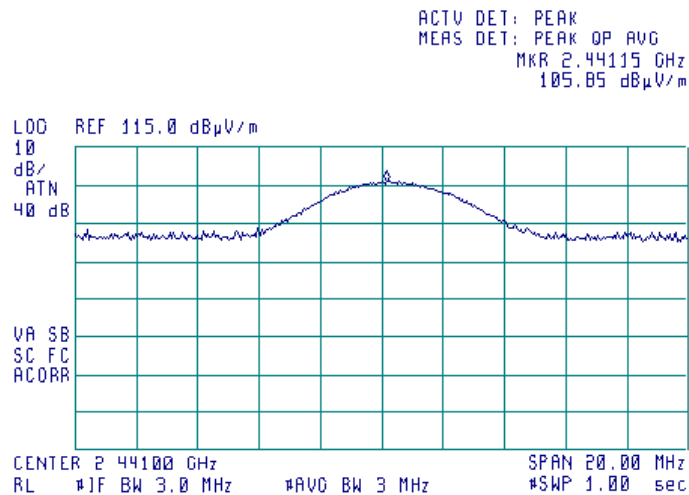


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

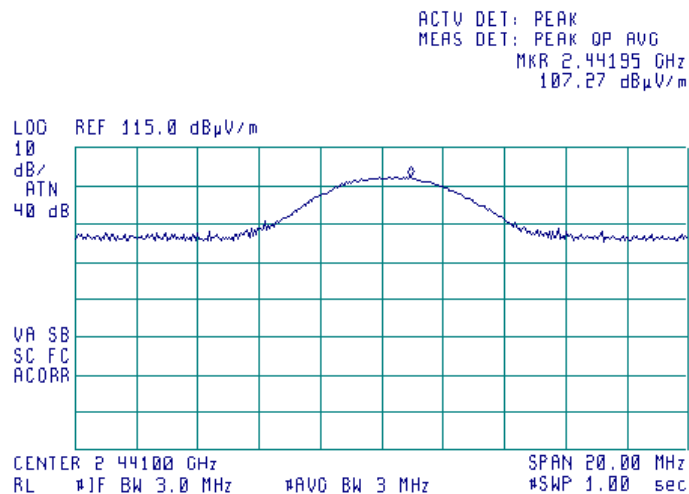
Plot 7.8.9 Field strength of carrier at mid frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.8.10 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: X-axis



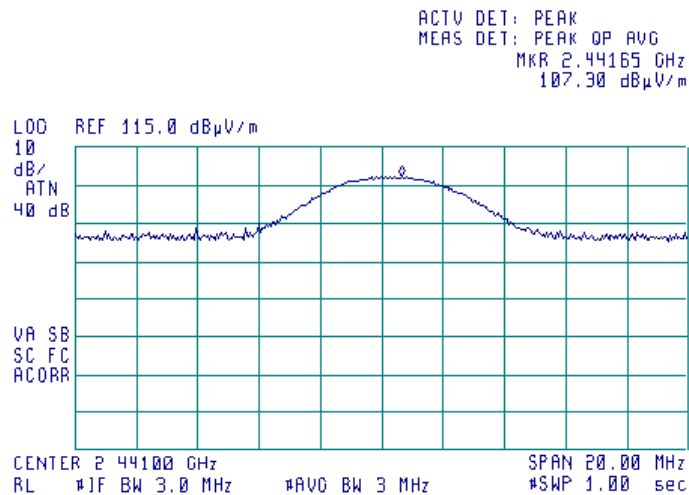


HERMON LABORATORIES

Test specification:		Section 15.247(b), Peak output power	
Test procedure:		ANSI C63.10, section 7.8.5	
Test mode:	Compliance	Verdict: PASS	
Date(s):	05-Oct-16		
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

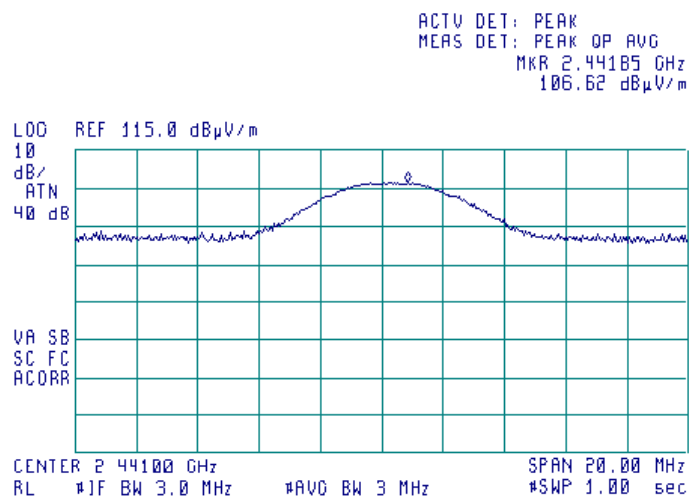
Plot 7.8.11 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.8.12 Field strength of carrier at mid frequency horizontal antenna polarization

EUT POSITION: Z-axis



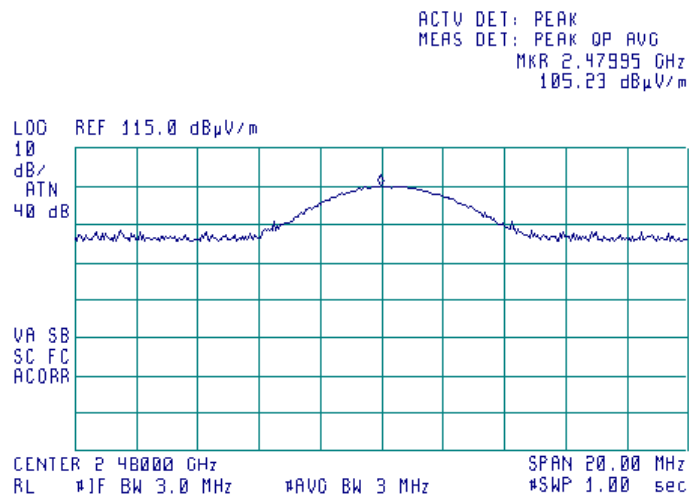


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

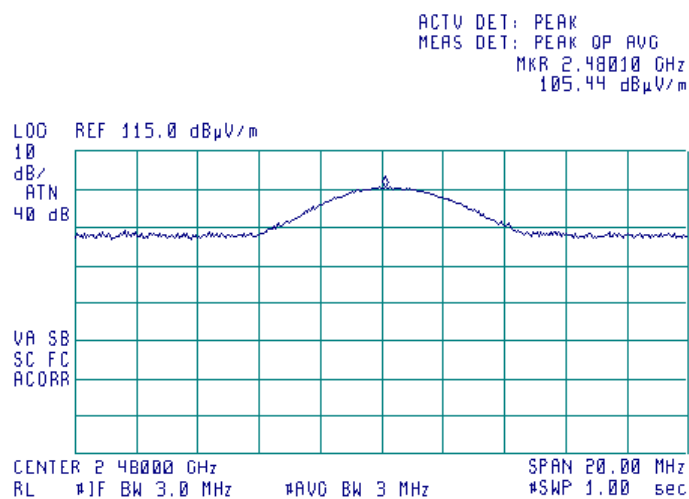
Plot 7.8.13 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: X-axis



Plot 7.8.14 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Y-axis



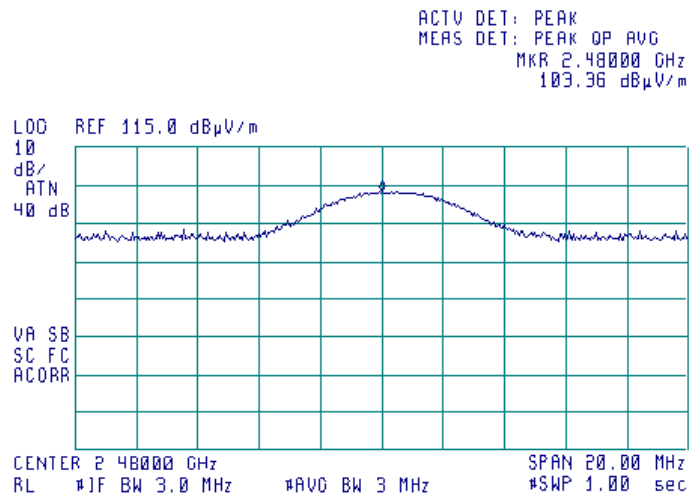


HERMON LABORATORIES

Test specification: Section 15.247(b), Peak output power			
Test procedure: ANSI C63.10, section 7.8.5			
Test mode: Compliance		Verdict: PASS	
Date(s): 05-Oct-16			
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

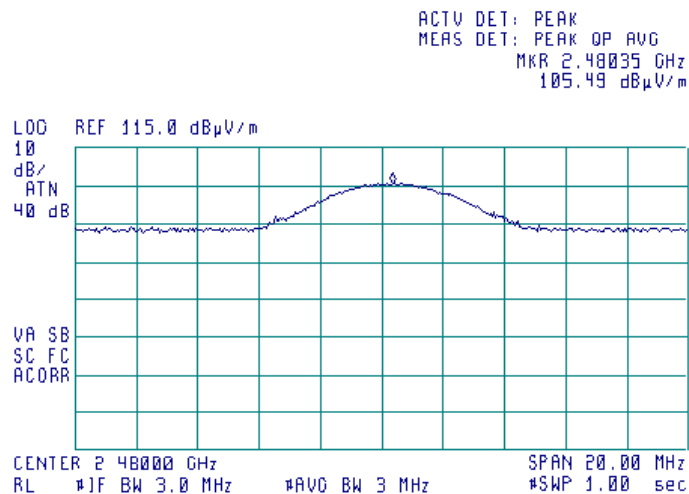
Plot 7.8.15 Field strength of carrier at high frequency vertical antenna polarization

EUT POSITION: Z-axis



Plot 7.8.16 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: X-axis



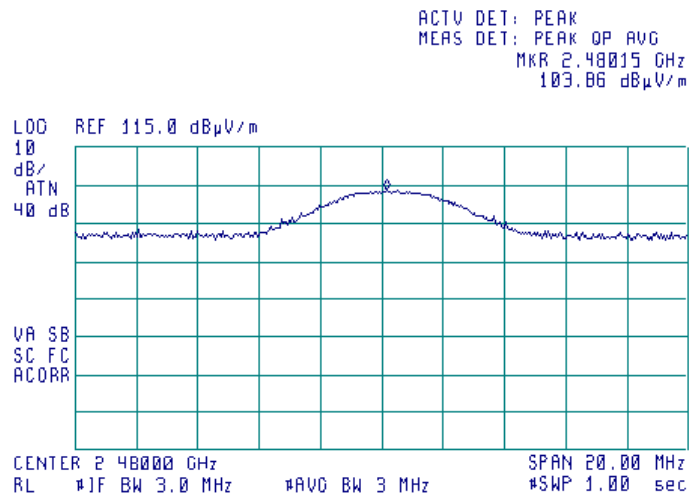


HERMON LABORATORIES

Test specification:		Section 15.247(b), Peak output power	
Test procedure:		ANSI C63.10, section 7.8.5	
Test mode:	Compliance	Verdict: PASS	
Date(s):	05-Oct-16		
Temperature: 24 °C	Relative Humidity: 40 %	Air Pressure: 1005 hPa	Power: 120 VAC
Remarks: BLE(GFSK) modulation			

Plot 7.8.17 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Y-axis



Plot 7.8.18 Field strength of carrier at high frequency horizontal antenna polarization

EUT POSITION: Z-axis

