

SHIELDING EFFECTIVENESS TEST REPORT

ACCORDING TO:

KEC method (100 kHz – 2 GHz range)

Test method based on MIL-DTL-83528C (1 – 18 GHz range)

FOR:

Carmel B.K. Engineering Ltd.

Conductive Coating Pro

C/N: CCP-1014

**Sample 1 of 15x15 cm & 3 mm
thickness**

**Sample 2 of 45x35 cm & 3 mm
thickness**

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Table of contents

1	Applicant information.....	3
2	Equipment under test attributes	3
3	Manufacturer information	3
4	Test details.....	3
5	Tests summary.....	4
6	EUT description.....	5
6.1	General information.....	5
7	Shielding effectiveness.....	6
7.1	Test methods and procedures.....	6
8	APPENDIX A Test equipment and ancillaries used for tests.....	15
9	APPENDIX B Test laboratory description.....	16
10	APPENDIX C Measurement uncertainties	17
11	APPENDIX D Abbreviations and acronyms	17
12	APPENDIX E Specification references.....	17

1 Applicant information

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Contact name: Mr. Gil Koren

2 Equipment under test attributes

Product name: Conductive Coating Pro
C/N: CCP-1014
Samples: Sample 1 of 15x15 cm & 3 mm thickness
Sample 2 of 45x35 cm & 3 mm thickness
Receipt date: 16-Jul-2018

3 Manufacturer information

Manufacturer name: Carmel B.K. Engineering Ltd.
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4 Test details

Project ID: 31125
Location: Hermon Laboratories Ltd. P.O. Box 23, Binyamina 3055001, Israel
Test started: 16-Jul-2018
Test completed: 22-Jul-2018
Test specifications: KEC method (100 kHz – 2 GHz range)
Test method based on MIL-DTL-83528C (1 – 18 GHz range)

5 Tests summary

Test




KEC method

Electromagnetic interference (EMI) suppression (shielding effectiveness) in 100 kHz – 2 GHz range

Test method based on MIL-DTL-83528C

Electromagnetic interference (EMI) suppression (shielding effectiveness) in 1 – 18 GHz range

The test results relate only to the items tested.

	Name and Title	Date	Signature
Prepared by:	Mr. S. Samokha, test engineer	July 22, 2018	
Reviewed by:	Ms. N. Averin, certification engineer	October 16, 2018	
Approved by:	Mr. M. Nikishin, EMC and radio group leader	December 17, 2018	



6 EUT description

6.1 General information

The EUTs are two samples of 15x15 cm and of 45x35 cm made of non-conductive and non-magnetic material of 3 mm thickness.

7 Shielding effectiveness

7.1 Test methods and procedures

7.1.1 General

The test was performed to measure attenuation of electromagnetic shielding material over 100 kHz – 2 GHz using KEC method and over 1 – 18 GHz using test method based on MIL-DTL-83528C. The test parameters are provided in Table 7.1.1.

Table 7.1.1 Shielding attenuation test parameters

Shielding effectiveness type	Assigned frequency range, MHz
Electric field	0.1 – 2000
Magnetic field	0.1 – 2000
Electromagnetic field	1000 – 18000

7.1.2 Shielding attenuation to electric field measurement procedure in 100 kHz – 2000 MHz range

7.1.2.1 The test setup was set up as shown in Figure 7.1.1.

7.1.2.2 The EUT sample was placed into the jig and shielding attenuation was measured with spectrum analyzer and reference result was saved.

7.1.2.3 The EUT sample was removed from the jig and measurement was repeated. The delta between reference measurement and measurements without sample was measured and provided in associated plot. The measured result was recorded in Table 7.1.2.

7.1.3 Shielding attenuation to magnetic field measurement procedure in 100 kHz – 2000 MHz range

7.1.3.1 The test setup was set up as shown in Figure 7.1.1.

7.1.3.2 The EUT sample was placed into the jig and shielding attenuation was measured with spectrum analyzer and reference result was saved.

7.1.3.3 The EUT sample was removed from the jig and measurement was repeated. The delta between reference measurement and measurements without sample was measured and provided in associated plot. The measured result was recorded in Table 7.1.2.

7.1.4 Shielding attenuation to electromagnetic and plane wave calibration procedure in 1000 – 18000 MHz range

7.1.4.1 The test equipment was set according to Figure 7.1.2.

7.1.4.2 The transmitting antenna in vertical polarization was placed outside the shielded enclosure at a distance of 1.0 m in vertical polarization pointed to the test point of the window of 295 by 395 mm clear opening without sample.

7.1.4.3 The receiving antenna in vertical polarization was placed inside the shielded enclosure coplanar to transmit antenna at a distance of 0.5 m from the internal wall pointed to the transmit antenna.

7.1.4.4 The RF signal sweep for calibration in frequency range from 1 to 18 GHz to transmit antenna was applied.

7.1.4.5 The measured result was saved as reference.

7.1.4.6 The above procedure was repeated with the transmitting antenna installed in horizontal polarization.

7.1.5 Shielding attenuation to electromagnetic and plane wave measurement procedure in 1000 – 18000 MHz range

7.1.5.1 The test equipment was set according to Figure 7.1.3.

7.1.5.2 The transmitting antenna in vertical polarization was placed outside the shielded enclosure at a distance of 1.0 m in vertical polarization pointed to the test point of the window of 295 by 395 mm clear opening with sample.

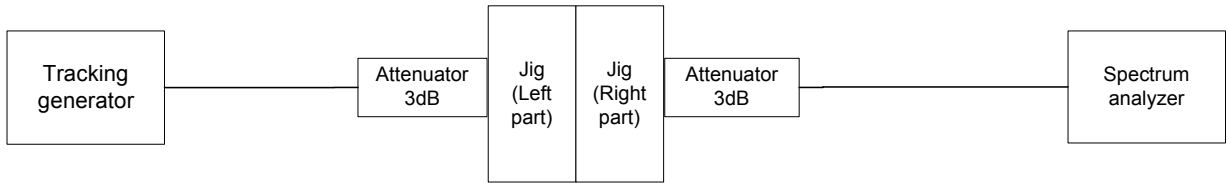
7.1.5.3 The receiving antenna in vertical polarization was placed inside the shielded enclosure coplanar to transmit antenna at a distance of 0.5 m from the internal wall pointed to the transmit antenna.

7.1.5.4 The same RF signal sweep as used for calibration at the selected frequency range from 1 to 18 GHz to transmit antenna was applied.

7.1.5.5 The measured result was recorded in Table 7.1.3.

7.1.5.6 The above procedure was repeated with the transmitting antenna installed in horizontal polarization.

Figure 7.1.1 Shielding attenuation test setup in 100 kHz – 2 GHz range



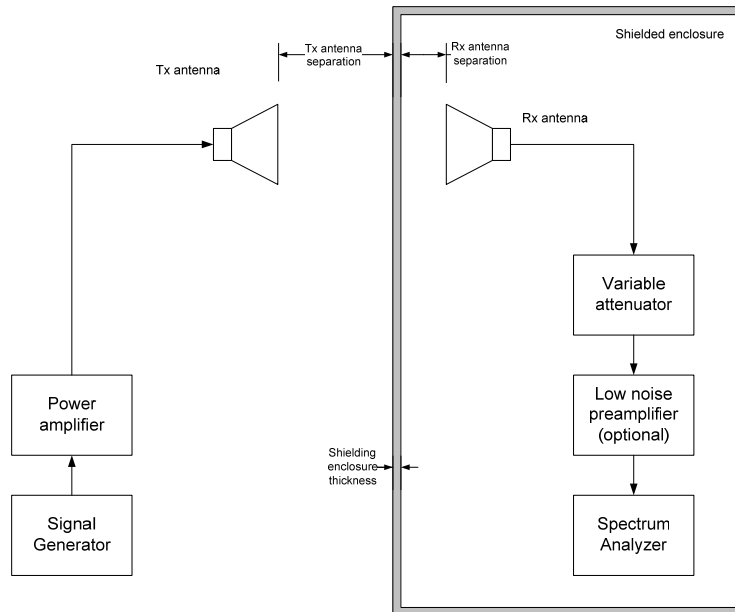
Photograph 7.1.1 Shielding attenuation test setup in 100 kHz – 2 GHz range, magnetic field



Photograph 7.1.2 Shielding attenuation test setup in 100 kHz – 2 GHz range, electric field



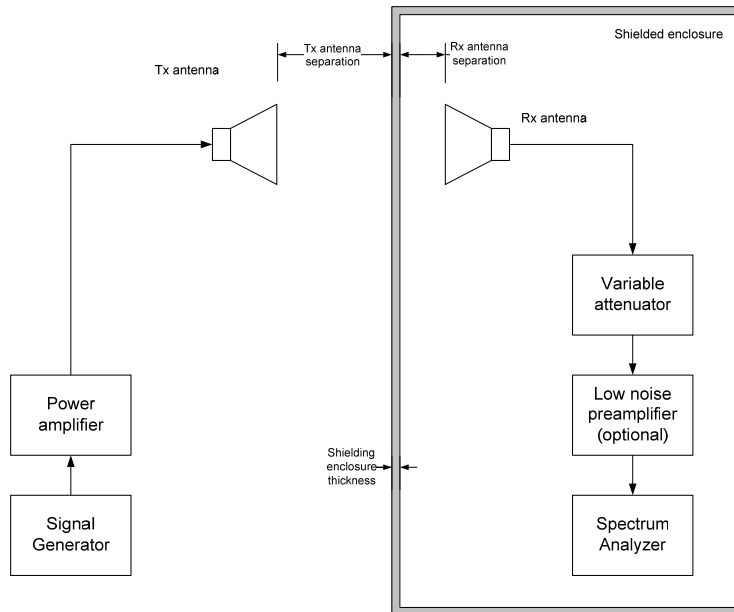
Figure 7.1.2 Shielding attenuation to electromagnetic and plane waves calibration setup in 1 – 18 GHz range



Photograph 7.1.3 Shielding attenuation for electromagnetic and plane waves calibration setup in 1 – 18 GHz range



Figure 7.1.3 Shielding attenuation to electromagnetic and plane waves test setup in 1 – 18 GHz range



Photograph 7.1.4 Shielding attenuation for electromagnetic and plane waves test setup in 1 – 18 GHz range



Table 7.1.2 Shielding attenuation test results in 100 kHz – 2 GHz range

DETECTOR USED: Peak
SWEEP MODE: Single
SWEEP TIME: Auto
RESOLUTION BANDWIDTH: 10 kHz
VIDEO BANDWIDTH: 30 kHz

Shielding effectiveness type	EUT sample	Assigned frequency range, MHz	Shielding effectiveness, dB	Reference plot
Electric field	Sample 1	0.1 – 1.8	> 43	Plot 7.1.1
		1.8 - 10	> 60	Plot 7.1.1
		10 - 500	> 65	Plot 7.1.2
		500 - 2000	> 57	Plot 7.1.3
Magnetic field	Sample 1	0.1 – 6	< 10	Plot 7.1.4
		6 - 10	> 10	Plot 7.1.4
		10 - 50	> 10	Plot 7.1.5
		50 - 500	> 40	Plot 7.1.5
		500 - 2000	> 50	Plot 7.1.6

Table 7.1.3 Shielding attenuation test results in 1 – 18 GHz range

WINDOW SIZE: 295 x 395 mm
DETECTOR USED: Peak
SWEEP MODE: Single
SWEEP TIME: Auto
RESOLUTION BANDWIDTH: 100 kHz
VIDEO BANDWIDTH: 300 kHz
ANTENNA POLARIZATION: Vertical

Shielding effectiveness type	EUT sample	Assigned frequency range, MHz	Shielding effectiveness, dB	Reference plot
Electromagnetic field	Sample 2	1000 – 2600	> 48.07	Plot 7.1.7
		2600 - 9120	> 28.49	Plot 7.1.7
		9120 – 10100	> 36.21	Plot 7.1.7
		10100 – 12000	> 41.25	Plot 7.1.7
		12000 – 14200	> 45.75	Plot 7.1.7
		14200 – 18000	> 50.17	Plot 7.1.7

ANTENNA POLARIZATION: Horizontal

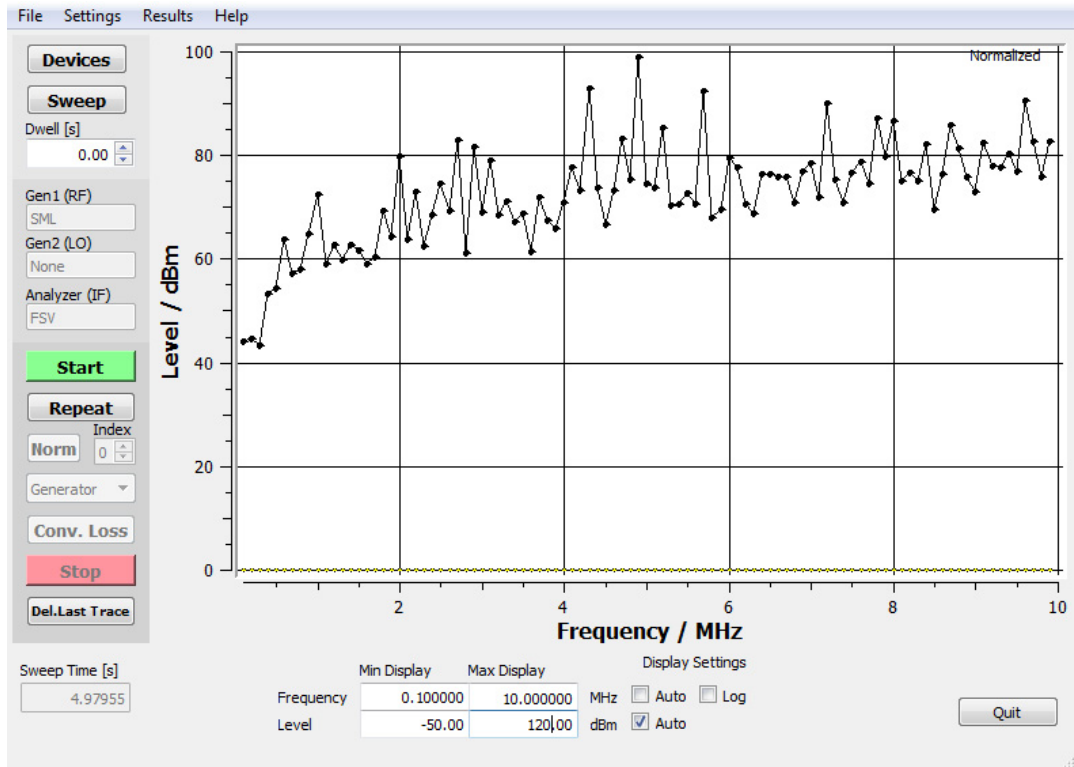
Shielding effectiveness type	EUT sample	Assigned frequency range, MHz	Shielding effectiveness, dB	Reference plot
Electromagnetic field	Sample 2	1000 – 2730	> 42.30	Plot 7.1.8
		2700 – 4720	> 38.06	Plot 7.1.8
		4720 – 8420	> 32.35	Plot 7.1.8
		8420 – 11200	> 41.03	Plot 7.1.8
		11200 – 12800	> 49.28	Plot 7.1.8
		12800 – 18000	> 53.87	Plot 7.1.8

Reference numbers of test equipment used

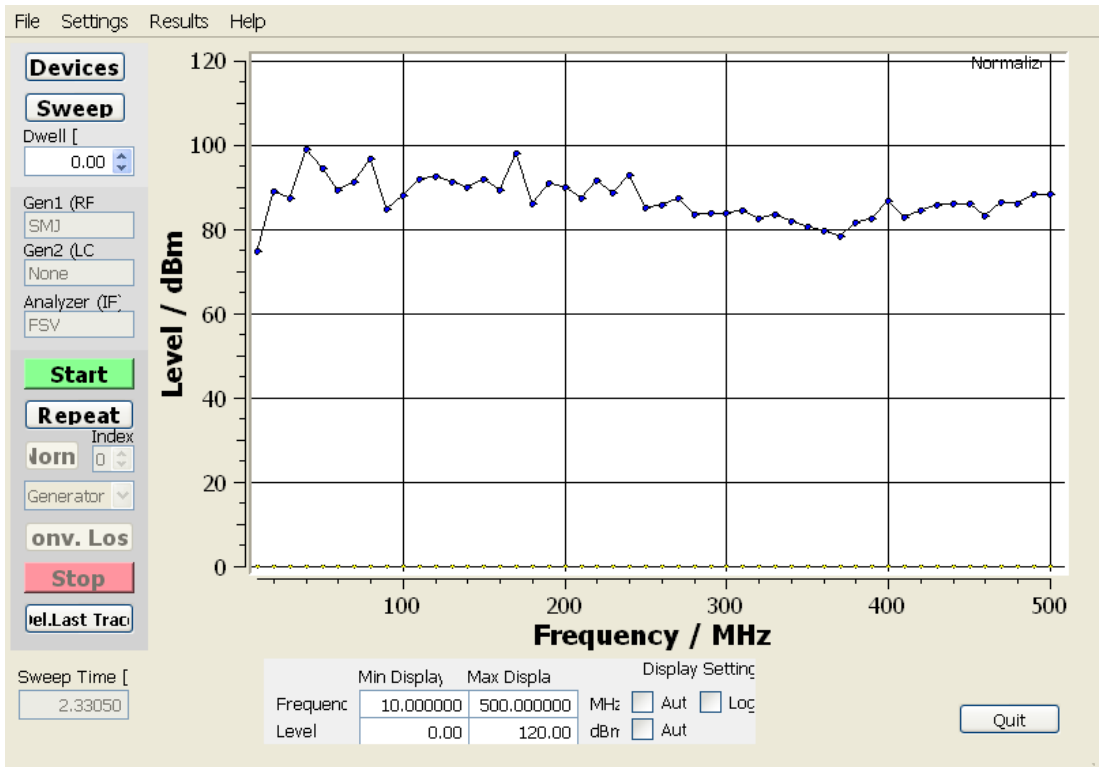
HL 2770	HL 2771	HL 3388	HL 3434	HL 3766	HL 4114	HL 4275	HL 4343	HL 4354
HL 4355	HL 4360	HL 4474	HL 4932	HL 5108	HL 5111			

Full description is given in Appendix A.

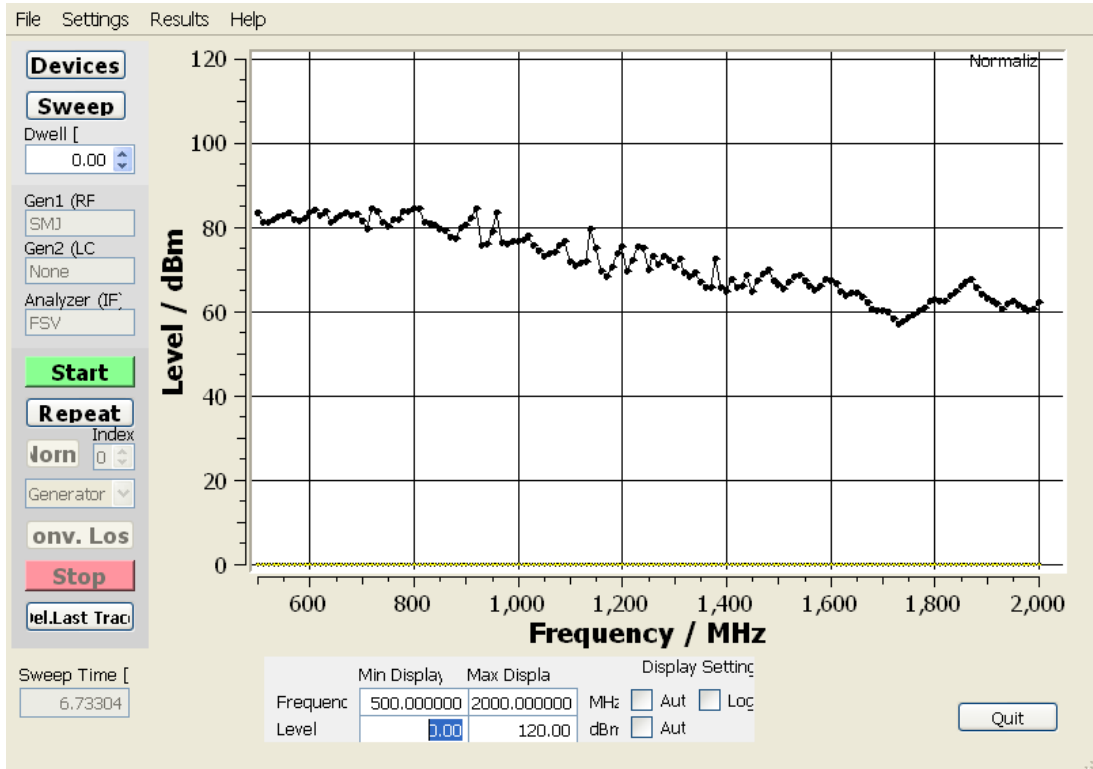
Plot 7.1.1 Shielding attenuation test results in 100 kHz – 10 MHz range, electric field



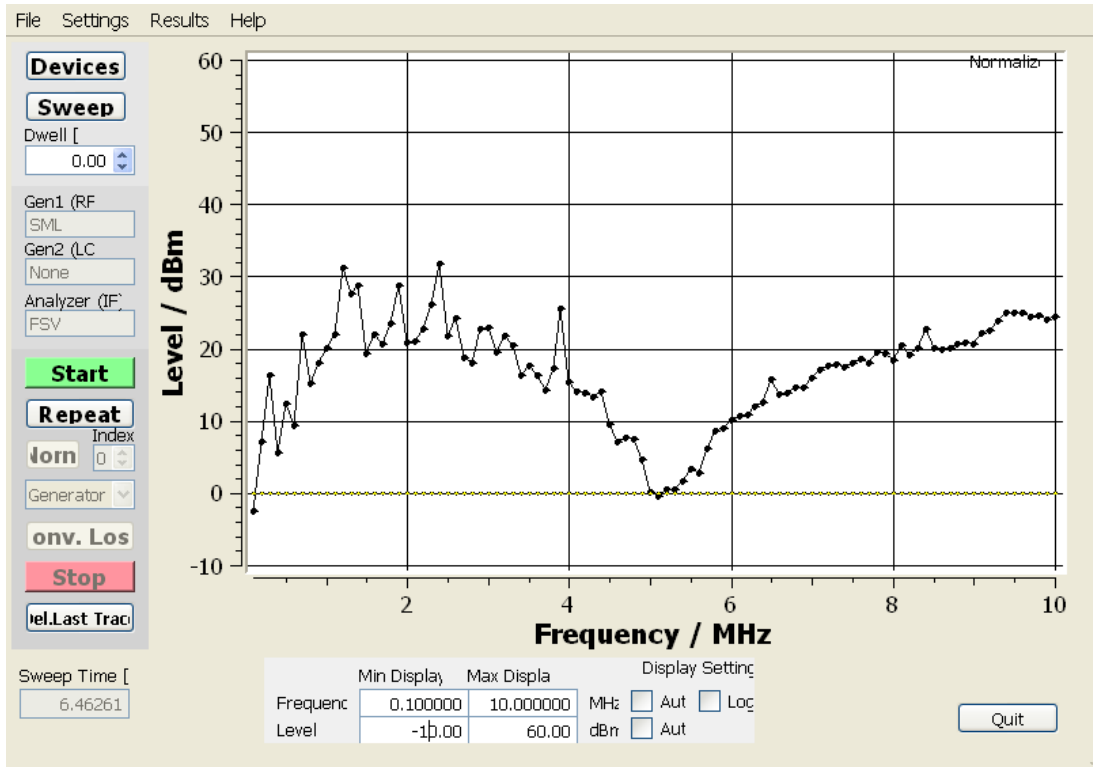
Plot 7.1.2 Shielding attenuation test results in 10 – 500 MHz range, electric field



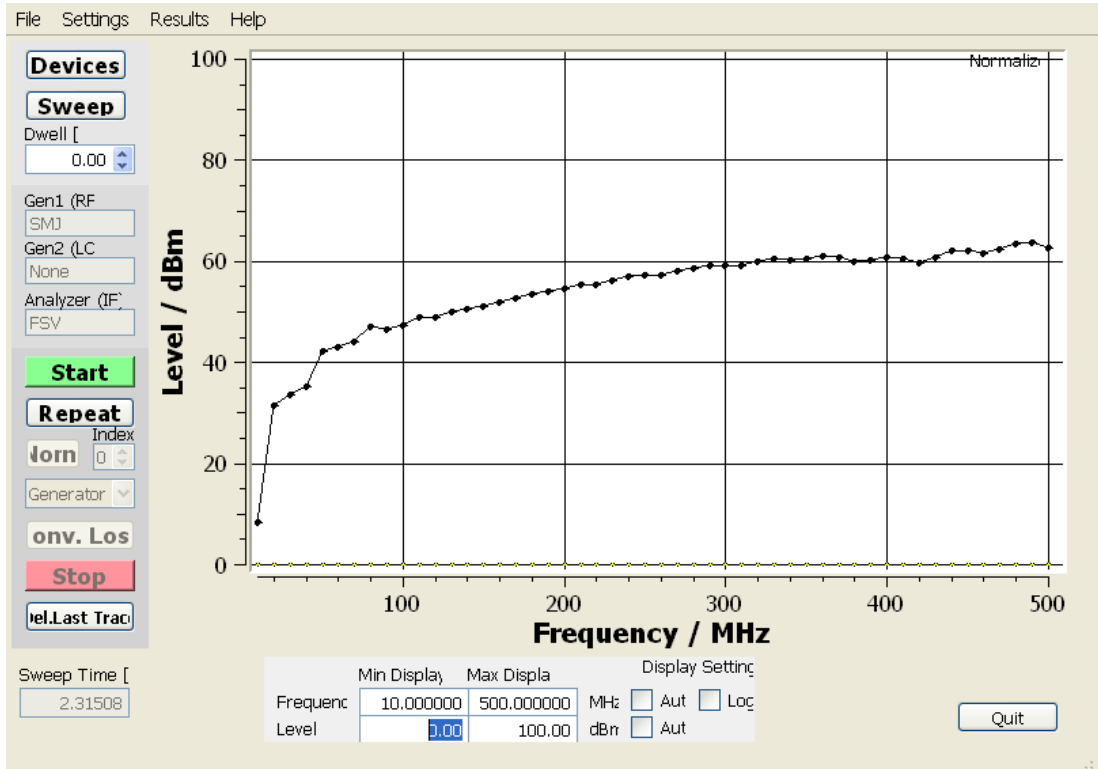
Plot 7.1.3 Shielding attenuation test results in 500 – 2000 MHz range, electric field



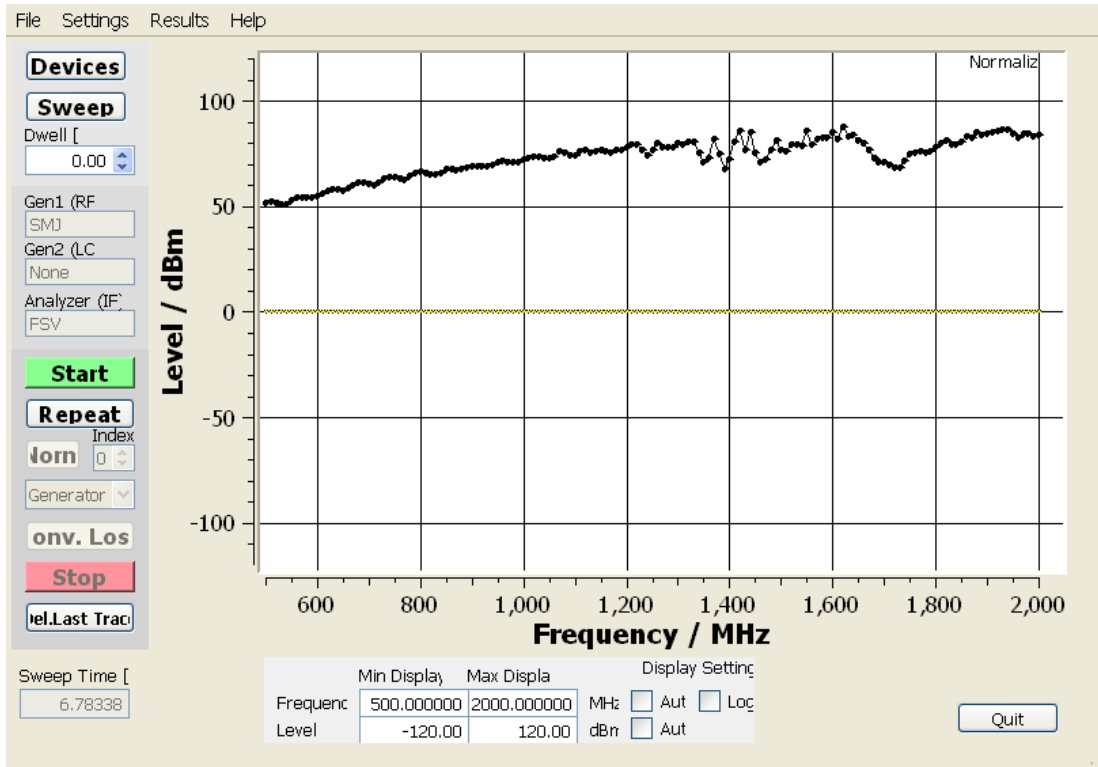
Plot 7.1.4 Shielding attenuation test results in 100 kHz – 10 MHz range, magnetic field



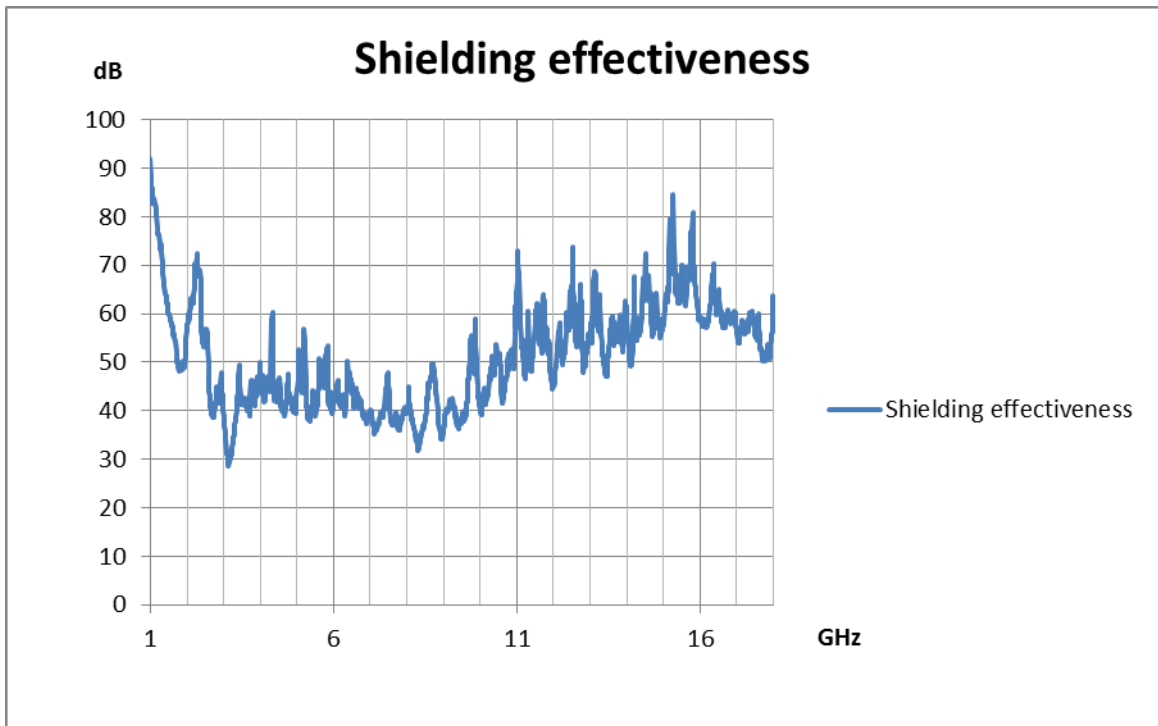
Plot 7.1.5 Shielding attenuation test results in 10 – 500 MHz range, magnetic field



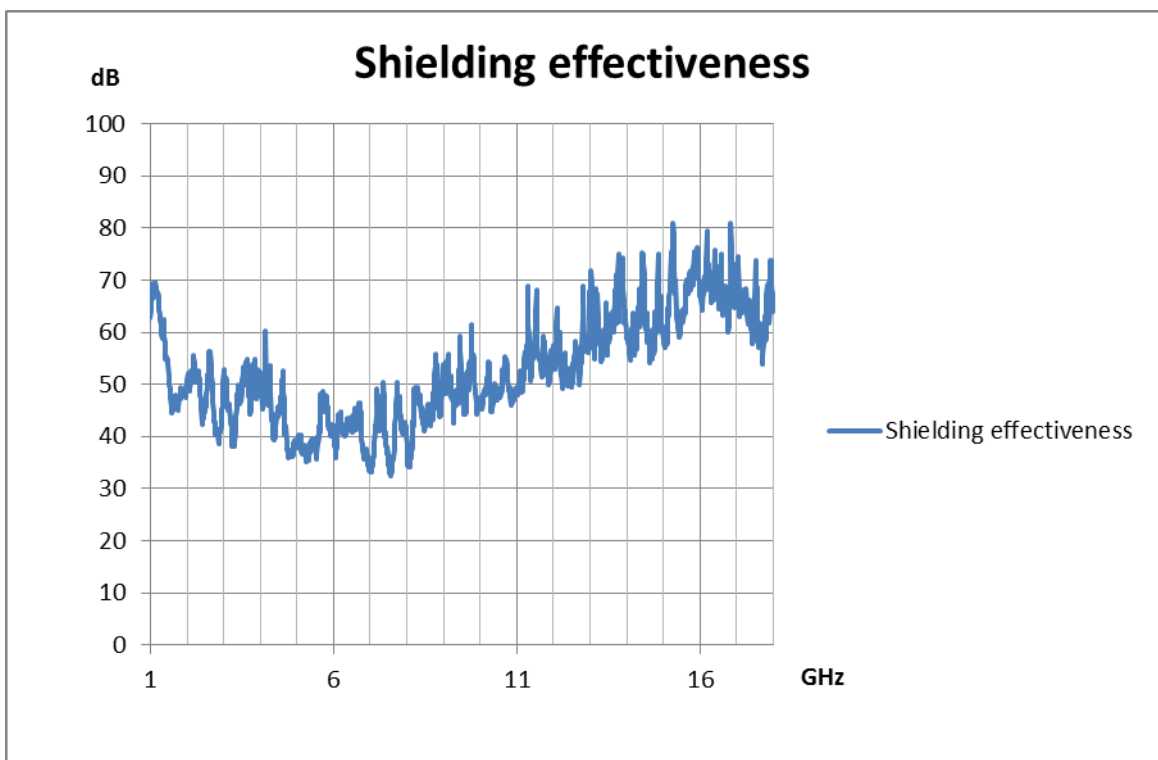
Plot 7.1.6 Shielding attenuation test results in 500 – 2000 MHz range, magnetic field



Plot 7.1.7 Shielding attenuation test results in 1000 – 18000 MHz range, vertical antenna polarization, electromagnetic field



Plot 7.1.8 Shielding attenuation test results in 1000 –18000 MHz range, horizontal antenna polarization, electromagnetic field



**8 APPENDIX A Test equipment and ancillaries used for tests**

HL No	Description	Manufacturer	Model	Ser. No.	Last Cal./Check	Due Cal./Check
2770	Electric field jig for measurement of the shielding effectiveness for sheet materials.	Hermon Laboratories	EFG-1	2770	05-Jul-18	05-Jul-20
2771	Magnetic field jig for measurement of the shielding effectiveness for sheet materials.	Hermon Laboratories	MFG-1	2771	05-Jul-18	05-Jul-20
3388	Microwave Cable Assembly, 26.5 GHz, 1.0 m, N type/N type	Suhner Sucoflex	104EA	3388	02-Nov-17	02-Nov-18
3434	Test Cable , DC-18 GHz, 1.5 m, SMA - SMA	Mini-Circuits	CBL-5FT-SMSM+	25683	28-Mar-18	28-Mar-19
3766	Attenuator, N-type, 20 dB, DC to 18 GHz, 5 W	Mini-Circuits	BW-N20W5+	NA	09-Aug-18	09-Aug-19
4114	Antenna, Double-Ridged Waveguide Horn, 1 to 18 GHz	ETS Lindgren	3117	00123515	04-Jan-18	04-Jan-19
4275	Test Cable , DC-18 GHz, 1.8 m, SMA/M - N/M	Mini-Circuits	CBL-6FT-SMNM+	70050	28-Mar-18	28-Mar-19
4343	Signal Generator, 100 kHz to 40 GHz	Rohde & Schwarz	SMB 100A	175291	31-Mar-17	31-Mar-19
4354	Vector Signal Generator, 100 kHz to 6.0 GHz	Rohde & Schwarz	SMJ 100A	1403.4507K02-101777-rc	01-May-18	01-May-19
4355	Signal and Spectrum Analyzer, 9 kHz to 7 GHz	Rohde & Schwarz	FSV 7	101630	28-Jun-18	28-Sep-19
4360	EMI Test Receiver, 20 Hz to 40 GHz.	Rohde & Schwarz	ESU40	100322	26-Dec-17	26-Dec-18
4474	Double Ridged Waveguide Antenna, 0.8 to 18 GHz	FT-RT Antenna, Inc.	HA-08M18G-NF	2012060901	29-Aug-18	29-Aug-19
4932	Microwave preamplifier, 500 MHz to 18 GHz, 40 dB Gain	COM-POWER CORPORATION	PAM-118A	551029	26-Apr-18	26-Apr-19
5108	RF cable, 18 GHz, 4.5 m, N-type	Huber-Suhner	SF106A/11N/11N/4500MM	500846/6A	01-Aug-18	01-Aug-19
5111	RF cable, 40 GHz, 5.5 m, K-type	Huber-Suhner	SF102EA/11SK/11SK/5500MM	502493/2EA	09-Apr-18	09-Apr-19

9 APPENDIX B Test laboratory description

Tests were performed at Hermon Laboratories Ltd., which is a fully independent, private, EMC, Radio, Safety, Environmental and Telecommunication testing facility.

Hermon Laboratories is recognized and accredited by the Federal Communications Commission (USA) for 1, 2, 15, 18 parts of Code of Federal Regulations 47 (CFR 47), Test Firm Registration Number is 927748, Designation Number is IL1001; registered by Industry Canada for electromagnetic emissions, file number IC 2186A-1 for OATS, certified by VCCI, Japan (the registration numbers are R-808 for OATS, R-1082 for anechoic chamber, G-869 for RE measurements above 1 GHz, C-845 for conducted emissions site and T-1606 for conducted emissions at telecommunication ports).

The laboratory is accredited by American Association for Laboratory Accreditation (USA) according to ISO/IEC 17025 for electromagnetic compatibility, product safety, telecommunications testing, environmental simulation and calibration (for exact scope please refer to Certificate No. 839.01, 839.03 and 839.04).

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Person for contact: Mr. Michael Nikishin, EMC&Radio group manager

10 APPENDIX C Measurement uncertainties

Expanded uncertainty at 95% confidence in Hermon Labs EMC measurements

Test description	Expanded uncertainty
Shielding attenuation measurements	
0.1- 30 MHz	± 2.3 dB
30-200 MHz	± 2.6 dB
200-1000 MHz	± 2.6 dB
1- 2.9 GHz	± 2.9 dB
2.9- 6.46 GHz	± 3.5 dB
6.46- 13.2 GHz	± 4.3 dB
13.2- 18 GHz	± 4.9 dB

Hermon Laboratories is accredited by A2LA for calibration according to present requirements of ISO/IEC 17025 and NCSL Z540-1. The accreditation is granted to perform calibration of parameters that are listed in the Scope of Hermon Laboratories Accreditation.

Hermon Laboratories calibrates its reference and transfer standards by calibration laboratories accredited to ISO/IEC 17025 by a mutually recognized Accreditation Body or by a recognized national metrology institute. All reference and transfer standards used in the calibration system are traceable to national or international standards.

In-house calibration of all test and measurement equipment is performed on a regular basis according to Hermon Laboratories calibration procedures, manufacturer calibration/verification procedures or procedures defined in the relevant standards. The Hermon Laboratories test and measurement equipment is calibrated within the tolerances specified by the manufacturers and/or by the relevant standards.

11 APPENDIX D Abbreviations and acronyms

cm	centimeter
dB	decibel
dBm	decibel referred to one milliwatt
dB _μ V	decibel referred to one microvolt
DRG	double ridged guide
EUT	equipment under test
GND	ground
H	horizontal
HL	Hermon laboratories
Hz	hertz
k	kilo
kHz	kilohertz
L	length
m	meter
MHz	megahertz
MIL	military
mm	millimeter
ms	millisecond
NA	not applicable
PS	power supply
Rx	receive
STD	standard
Tx	transmit
V	vertical

12 APPENDIX E Specification references

KEC method	Test method for shielding effectiveness measurements
MIL-DTL-83528C	Detail specification. Gasketing material, conductive, shielding gasket, electronic, elastomer, emi/rfi. General specification for

END OF DOCUMENT