Emissions
Test Report

EUT Name: SolarMagic ™ PowerString Optimizer

EUT Model: SM5400

CFR 47 Part 15.249: 2010, RSS 210, Issue 7, June 2007

Prepared for:

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Report/Issue Date: 12 August 2010
Report Number: 31051011.001

Statement of Compliance

Manufacturer:	National Semiconductor 2900 Semiconductor Drive Santa Clara, CA 95051 (408) 721-2857
Requester / Applicant:	Steven Kim
Name of Equipment:	SolarMagic ™ PowerString Optimizer
Model No.	SM5400
Type of Equipment:	Industrial, Scientific, or Medical (ISM)
Application of Regulations:	CFR 47 Part 15.249: 2010, RSS 210, Issue 7, June 2007
Test Dates:	17 May 2010 to 28 May 2010

Guidance Documents:

Emissions: FCC 47 CFR Part 15

Test Methods:

Emissions: ANSI C63.10:2009, RSS 210 Issue 7 :2007

The electromagnetic compatibility test and documented data described in this report has been performed and recorded by TUV Rheinland of North America, in accordance with the standards and procedures listed herein. As the responsible authorized agent of the EMC laboratory, I hereby declare that a sample of one, of the equipment described above, has been shown to be compliant with the EMC requirements of the stated regulations and standards based on these results. If any special accessories and/or modifications were required for compliance, they are listed in the Executive Summary of this report.

This report must not be used to claim product endorsement by NVLAP or any agency of the U.S. Government. This report contains data that are not covered by NVLAP accreditation. This report shall not be reproduced except in full, without the written authorization of the laboratory.

Jeremy Luong	12 August 2010	Conan Boyle	12 August 2010
Test Engineer	Date	NVLAP Signatory	Date

NVLAP LAB CODE 500011-0

US5254

Industry Canada

2932M-1

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1 Executive Summary

1.1 Scope

This report is intended to document the status of conformance with the requirements of the CFR 47 Part 15.249: 2010, RSS 210, Issue 7, June 2007 based on the results of testing performed on *17 May* 2010 through *28 May* 2010 on the *SolarMagic ™ PowerString Optimizer* Model No. *SM5400* manufactured by National Semiconductor. This report only applies to the specific samples tested under the stated test conditions. It is the responsibility of the manufacturer to assure that additional production units of this model are manufactured with identical or EMI equivalent electrical and mechanical components. This report is further intended to document changes and modifications to the EUT throughout its life cycle. All documentation will be included as a supplement.

1.2 Purpose

Testing was performed to evaluate the EMC performance of the EUT in accordance with the applicable requirements, procedures, and criteria defined in the application of regulations and application of standards listed in this report.

1.3 Summary of Test Results

Table 1 - Summary of Test Results

Emission	Test Method(s)	Test Parameters	Result
Fundamental and Harmonic Emissions – CFR47 Part 15.249 (a)	ANSI C63.10:2009, and RSS 210:2007	Fundamental – 93.98 dBuV @ 3 meter Harmonics – 54 dBuV @ 3 meter	**Complied**
Frequency Stability – CFR47 Part 15.31 (e), 15.215 (c).	ANSI C63.10:2010, RSS-Gen.:2007	-20° C to 55° C 10.2 Vdc to 13.8 Vdc	**Complied**
Band Edge Compliance – CFR47 Part 15.215 (c)	ANSI C63.10:2010, RSS-210:2007	-20 dBr from the fundamental emission	**Complied**
Occupied Bandwidth – CFR47 Part 15.215 ©	ANSI C63.10:2010, RSS-Gen.:2007	20 dB Bandwidth 99% Bandwidth	**Complied**
Transmitter Emissions – CFR47 Part 15.205, 15.209, 15.249 (d)	ANSI C63.10:2009, and RSS 210:2007	30 MHz to 10000 MHz	**Complied**
Receiver Emissions – CRF47 Part 15.109	ANSI C63.10:2009, and RSS 210	30 MHz to 6000 MHz	**Complied**
Conducted Emissions – CFR47 Part 15.207	ANSI C63.10:2009, RSS-210:2007	150 kHz to 30 MHz	**Na**
RF Exposure – CFR47 2.1091	CFR47 2.1091	General Population	**Complied**

1.4 Special Accessories

No special accessories were necessary in order to achieve compliance.

1.5 Equipment Modifications

- Transmitter harmonic emission: removed J17 connector.
- Fundamental Emission: reduced PowerString firmware level setting to -5 dBm for 902-928 MHz.

2 Laboratory Information

2.1 Accreditations & Endorsements

2.1.1 US Federal Communications Commission

TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 is accredited by the commission for performing testing services for the general public on a fee basis. These laboratory test facilities have been fully described in reports submitted to and accepted by the FCC (US5254). The laboratory scope of accreditation includes: Title 47 CFR Parts 15, 18, and 90. The accreditation is updated every 3 years.

2.1.2 NIST / NVLAP

TUV Rheinland of North America is accredited by the National Voluntary Laboratory Accreditation Program, which is administered under the auspices of the National Institute of Standards and Technology. The laboratory has been assessed and accredited in accordance with ISO Guide 17025:2005 and ISO 9002 (Lab Code 500011-0). The scope of laboratory accreditation includes emission and immunity testing. The accreditation is updated annually.

2.1.3 Canada – Industry Canada

TUV Rheinland of North America at the 1279 Quarry Ln, Pleasanton, CA 94566 address is accredited by Industry Canada for performing testing services for the general public on a fee basis. This laboratory test facilities have been fully described in reports submitted to and accepted by Industry Canada (File Number 2932M-1). This reference number is the indication to the Industry Canada Certification Officers that the site meets the requirements of RSS 212, Issue 1 (Provisional). The accreditation is updated every 3 years.

2.1.4 Japan – VCCI

The Voluntary Control Council for Interference by Information Technology Equipment (VCCI) is a group that consists of Information Technology Equipment (ITE) manufacturers and EMC test laboratories. The purpose of the Council is to take voluntary control measures against electromagnetic interference from Information Technology Equipment, and thereby contribute to the development of a socially beneficial and responsible state of affairs in the realm of Information Technology Equipment in Japan. TUV Rheinland of North America at 1279 Quarry Ln, Pleasanton, CA 94566 has been assessed and approved in accordance with the Regulations for Voluntary Control Measures. (Registration Nos. R-3269, C-3637, C-3638, T-1752, T-1753).

2.1.5 Acceptance by Mutual Recognition Arrangement

The United States has an established agreement with specific countries under the Asia Pacific Laboratory Accreditation Corporation (APLAC) Mutual Recognition Arrangement. Under this agreement, all TUV Rheinland at 1279 Quarry Ln, Pleasanton, CA 94566 test results and test reports within the scope of the laboratory NIST / NVLAP accreditation will be accepted by each member country.

2.2 Test Facilities

All of the test facilities are located at 1279 Quarry Lane, Pleasanton, California 94566, USA. The 2305 Mission College, Santa Clara, 95054, USA location is considered a Pleasanton annex.

2.2.1 Emission Test Facility

The Semi-Anechoic chamber and AC Line Conducted measurement facility used to collect the radiated and conducted data has been constructed in accordance with ANSI C63.7:1992. The site has been measured in accordance with and verified to comply with the theoretical normalized site attenuation requirements of ANSI C63.4:2003, at a test distance of 3 and 5 meters. This site has been described in reports dated November 1st, 2006, submitted to the FCC, and accepted by letter dated November 28, 2006. The site is listed with the FCC and accredited by NVLAP (Lab Code 500011-0).

2.2.2 Immunity Test Facility

ESD, EFT, Surge, PQF: These tests are performed in an environmentally controlled room with a 3.7 m x 4.8 m x 3.175 mm thick aluminum floor connected to PE ground.

For ESD testing, tabletop equipment is placed on an insulated mat with a surface resistivity of 10^9 Ohms/square on a 1.6 m x 0.8 m x 0.8 m high non-conductive table with a 3.175 mm aluminum top (Horizontal Coupling Plane). The HCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors. The Vertical Coupling Plane consists of an aluminum plate 50 cm x 50 cm x 3.175 mm thick. The VCP is connected to the main ground plane via a low impedance ground strap through two 470-kΩ resistors.

For EFT, Surge, PQF, the HCP and VCP are removed.

RF Field Immunity testing is performed in a 7.3m x 4.3m x 4.1m anechoic chamber.

RF Conducted and Magnetic Field Immunity testing is performed on a 4.8m x 3.7m x 3.175mm thick aluminum ground plane.

All test areas allow a minimum distance of 1 meter from the EUT to walls or conducting objects.

2.3 Measurement Uncertainty

Two types of measurement uncertainty are expressed in this report, per *ISO Guide To The Expression Of Uncertainty In Measurement*, 1st Edition, 1995.

The Combined Standard Uncertainty is the standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities; it is equal to the positive square root of the sum of the variances or co-variances of these other quantities, weighted according to how the measurement result varies with changes in these quantities. The term *standard uncertainty* is the result of a measurement expressed as a standard deviation.

2.3.1 Sample Calculation – radiated & conducted emissions

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

Field Strength (dBμV/m) = RAW - AMP + CBL + ACF

Where: RAW = Measured level before correction (dBμV)

AMP = Amplifier Gain (dB)

CBL = Cable Loss (dB)

ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

Sample radiated emissions calculation @ 30 MHz

Measurement +Antenna Factor–Amplifier Gain+Cable loss=Radiated Emissions (dBuV/m)

25 dBuV/m + 17.5 dB – 20 dB + 1.0 dB = 23.5 dBuV/m

Table 2: Summary of Uncertainties

Test	System	Combined Standard Uncertainty
Conducted Emissions	LISN, spectrum analyzer, coaxial cables, and pads	± 1.2 dB
Radiated Emissions	antenna, spectrum analyzer, pre-amplifier, coaxial cables, and pads	± 1.6 dB
Radiated Immunity	antenna, amplifier, cables, signal generator field probe, and spectrum analyzer	± 2.7 dB
Conducted Immunity	coupling/decoupling device, amplifier, cables, signal generator, and spectrum analyzer	± 1.5 dB
Voltage Dips, Drops, and Interruptions	AC power source and interruptions generator	± 4.3 dB
Electrical Fast Transient Immunity	AC power output source and fast transient generator	± 5.8 dB
Lightning Surge Immunity	AC power output source and lightning surge generator	± 8.0 dB
Electrostatic Discharge Immunity	air and contact discharge generators	± 4.1 dB
Power Frequency Magnetic Field Immunity	AC voltage source	± 0.58 dB
Damped Oscillatory Wave Immunity	AC power output source and oscillatory wave generator	± 8.7 dB
Harmonic Current and Voltage Flicker	AC power source and detection devices	± 11.6 dB

The expanded uncertainty at a level of 95% confidence is obtained by multiplying the combined standard uncertainty by a coverage factor of 2. Compliance criteria are not based on measurement uncertainty.

2.4 Calibration Traceability

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Measurement method complies with ANSI/NCSL Z540-1-1994 and ISO Guide 17025:2005.

3 Product Information

3.1 Product Description

The SolarMagic PowerString Optimizer is designed to address real-world problems facing PV arrays. These include shading and module-to-module mismatching which could adversely affect the performance and efficiency of the array. PowerString optimizers provide power optimization and monitoring/management for a string level solution.

PV arrays are defined as strings of series-connected PV modules, which are then paralleled together -usually via a combiner box and converted to AC power through an inverter. The key challenge with PV arrays is to prevent a small amount of real-world mismatch within the system from significantly reducing the power output of the entire array. Examples of mismatch causes include module-to-module mismatch, shading (e.g. trees, chimneys, overhead power lines, bird droppings, handrails, etc.), differing module orientation and tilts, and differing string lengths.

To mitigate the effects of mismatch, system integrators are often forced to compromise their installation by reducing the size of the array to avoid shade, thus accepting a lower energy output per square meter, or adding extra modules in a different part of the array.

To maximize the energy output of each string in the array, the SolarMagic PowerString enables each string with the array to produce the maximum available energy regardless of system mismatch. The SolarMagic PowerString optimizer monitors and maximizes the energy harvest of each string within the array through advanced algorithms combined with leading-edge mixed-signal technology to recoup energy lost to mismatches.

The SM5400 uses the integral antenna in the band of 902 MHz to 928 MHz.

3.2 Unique Antenna Connector

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221.

3.2.1 Results

The antenna is permanently attached.

4 Emissions

4.1 *Fundamental and Harmonics Emissions per CFR47 Part 15.249 (a)*

Testing was performed in accordance with ANSI C63.10:2009, and RSS 210:2007. These test methods are listed under the laboratory's NVLAP Scope of Accreditation. This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

4.1.1 Test Methodology

4.1.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

4.1.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

4.1.1.3 Deviations

There were no deviations from this test methodology.

4.1.2 Test Results

Section 4.1.2.1 lists the final measurement data under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and 1.5.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.1.2.1 Final Data

The data recorded in this section contains the final results under the worst-case conditions and with any modifications or special accessories implemented as the manufacturer intends.

Table 3 – Field Strength of Fundamental Emissions

Test Conditions: Radiated Measurement at Normal Conditions					
Antenna Type: Capacitive			**Power Setting:** -5 dBm		
Max. Antenna Gain: 0.23 dBi			**Signal State:** Modulated (GFSK)		
Duty Cycle: 100 %			**Data Rate:** 125 kBps		
Ambient Temp.: 23° C			**Relative Humidity:** 32 %		
Test Results					
Operating Freq. (MHz)	**Axis**	**Polarity**	**Field Strength (dBuV/m)**	**Limit (dBuV/m)**	**Margin**
902.33	X	Horz	88.56	93.98	-5.42
902.33	X	Vert	91.21	93.98	-2.77
902.33	Y	Horz	90.88	93.98	-3.10
902.33	Y	Vert	87.19	93.98	-6.79
902.33	Z	Horz	91.35	93.98	-2.63
902.33	Z	Vert	88.52	93.98	-5.46
914.934	X	Horz	89.57	93.98	-4.41
914.934	X	Vert	90.62	93.98	-3.36
914.934	Y	Horz	93.80	93.98	-0.18
914.934	Y	Vert	85.76	93.98	-8.22
914.934	Z	Horz	91.59	93.98	-2.39

914.934	Z	Vert	90.34	93.98	-3.64
927.93	X	Horz	88.61	93.98	-5.37
927.93	X	Vert	90.44	93.98	-3.54
927.93	Y	Horz	89.08	93.98	-4.90
927.93	Y	Vert	87.71	93.98	-6.27
927.93	Z	Horz	92.04	93.98	-1.94
927.93	Z	Vert	86.72	93.98	-7.26
Note: The plots of highest field strength for each channel are below.					

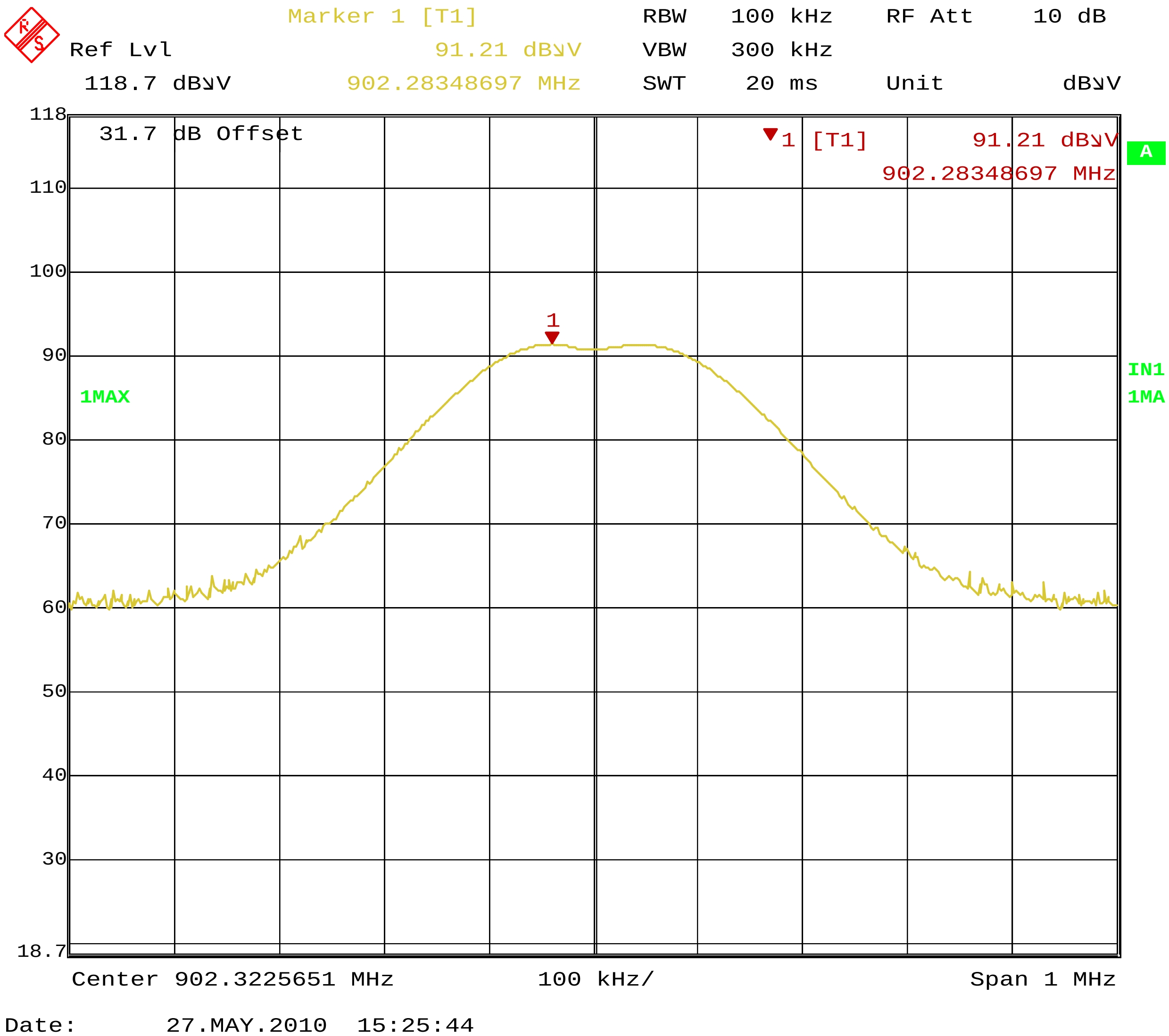

Figure 1 – Fundamental Field Strength at 3 meter Distance – 902.33 MHz on X-Axis (Vertical)

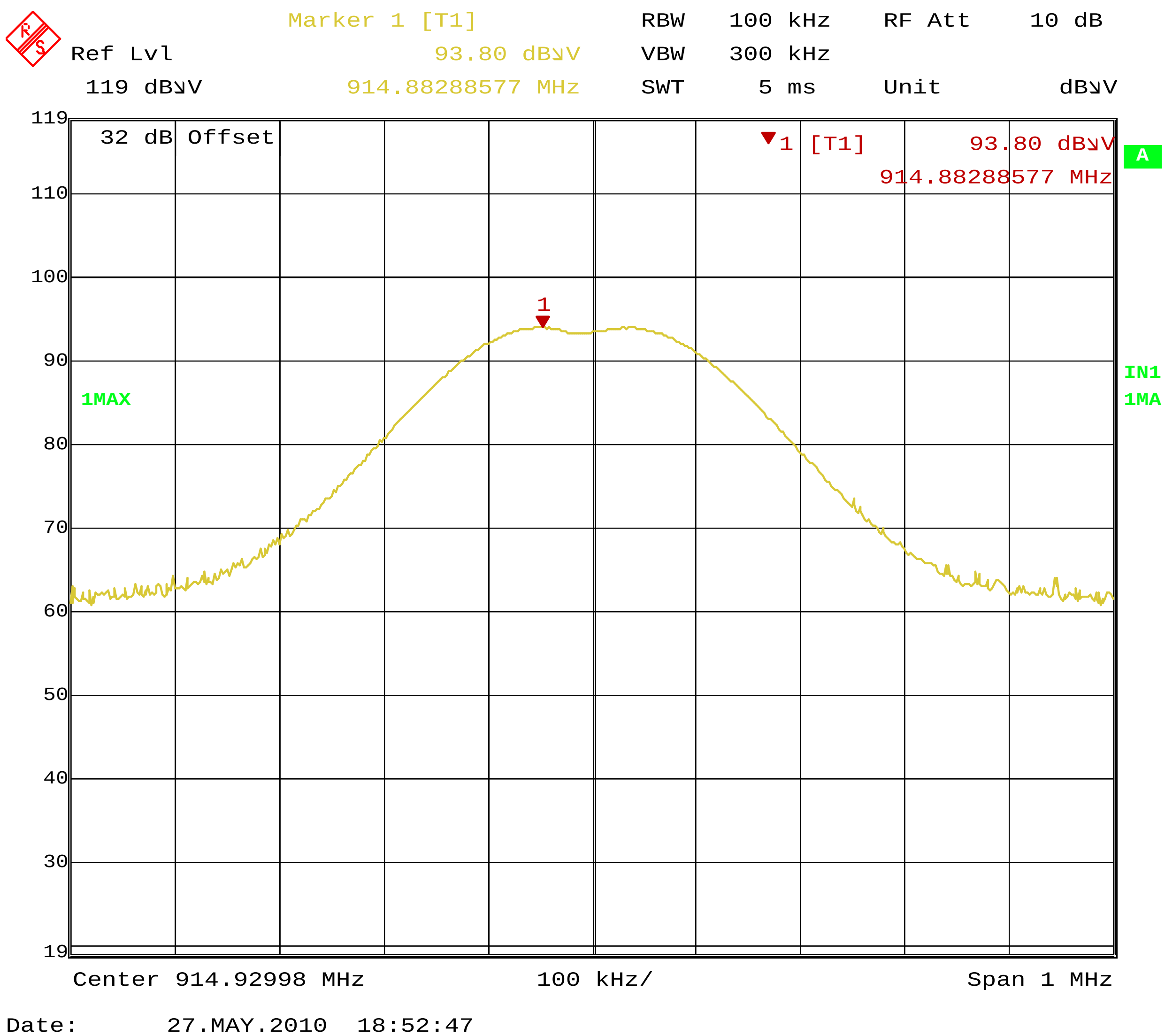

Figure 2 – Fundamental Field Strength at 3 meter Distance – 902.934 MHz on Y-Axis (Horizontal)

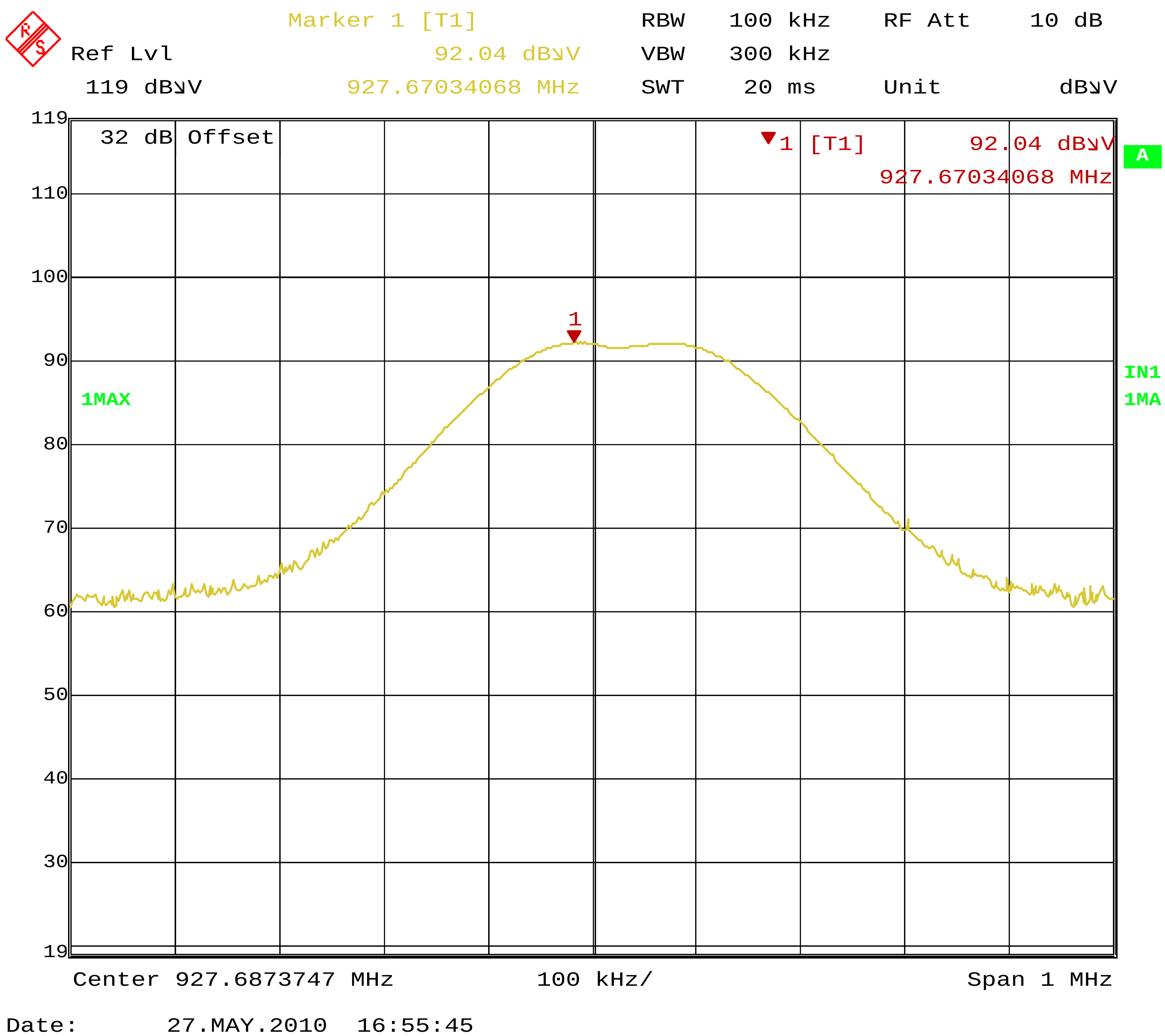

Figure 3 – Fundamental Field Strength at 3 meter Distance – 927.93 MHz on Z-Axis (Horizontal)

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EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 32% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Integrated Antenna, Tabletop	**Line AC / Freq**	12 VDC
Standard	CFR47 Part 15.249	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m / EMCO 3115	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	Table Pos (deg)	ANT Pos (cm)	FIM (Pk) Pk (dBuV/m)	FIM Ave (dBuV/m)	Total CF dBuV	E-Field Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
Transmitted Data at Ch 3, 902.33 MHz										
2707.11	H	104	4	40.97	35.9	0.66	36.56	53.98	-17.42	Harmonic
5414.16	V	103	21	43.85	38.97	6.63	45.6	53.98	-8.38	Harmonic
Transmitted Data at Ch 7, 914.934 MHz										
5489.76	H	122	48	46.15	42.85	6.81	49.66	53.98	-4.32	Harmonic
6404.66	H	121	0	40.75	33.63	8.57	42.20	53.98	-11.78	Harmonic
Transmitted Data at Ch 12, 927.93 MHz										
5567.69	V	101	35	43.23	38.84	6.99	45.83	53.98	-8.15	Harmonic
6495.63	V	144	144	38.50	29.04	8.72	37.76	53.98	-16.22	Harmonic
6495.70	H	163	163	38.15	30.18	8.72	38.90	53.98	-15.08	Harmonic

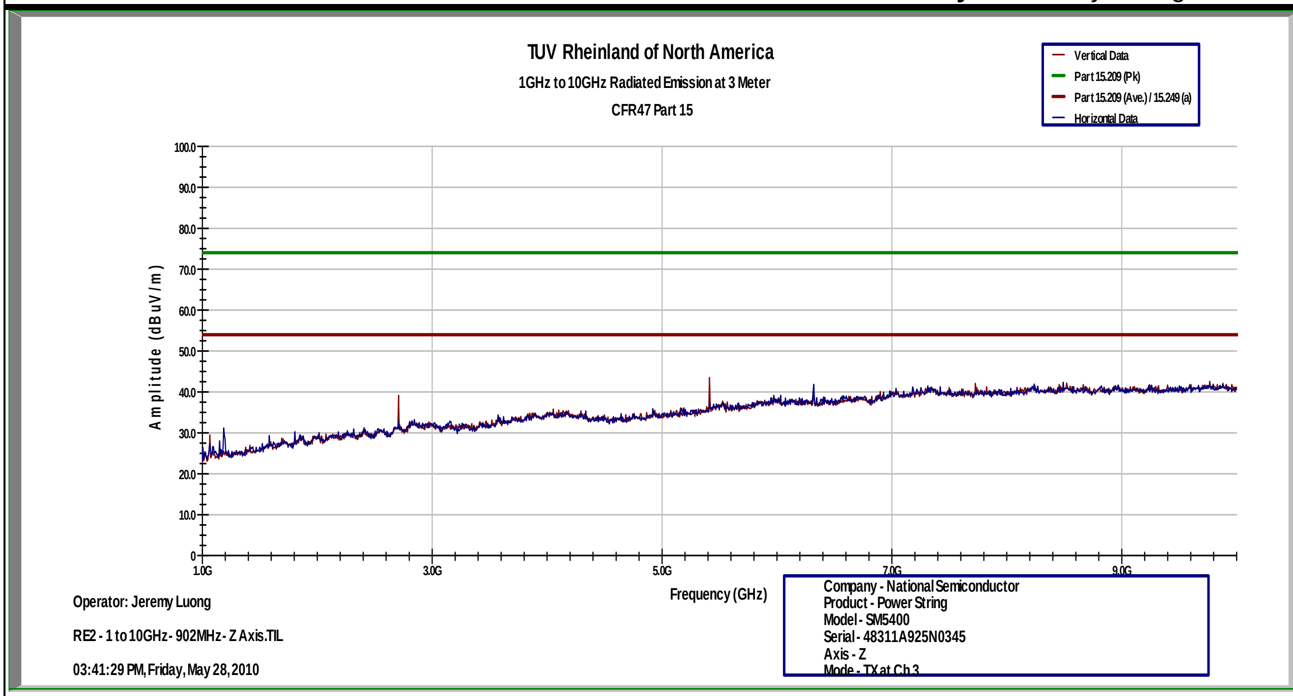
Spec Margin = E-Field Ave - Limit, E-Field Ave = FIM Ave+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 1.6dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Tested at worst case at 1MBit/s on Z-Axis.

SOP 1 Radiated Emissions — Tracking # 31051011.001 Page 2 of 4

EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 32% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Integrated Antenna, Tabletop	**Line AC**	12 VDC
Standard	CFR47 Part 15.249	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m / EMCO 3115	**Performed by**	Jeremy Luong



Notes: Transmitted Data at Ch 3, 902.33 MHz

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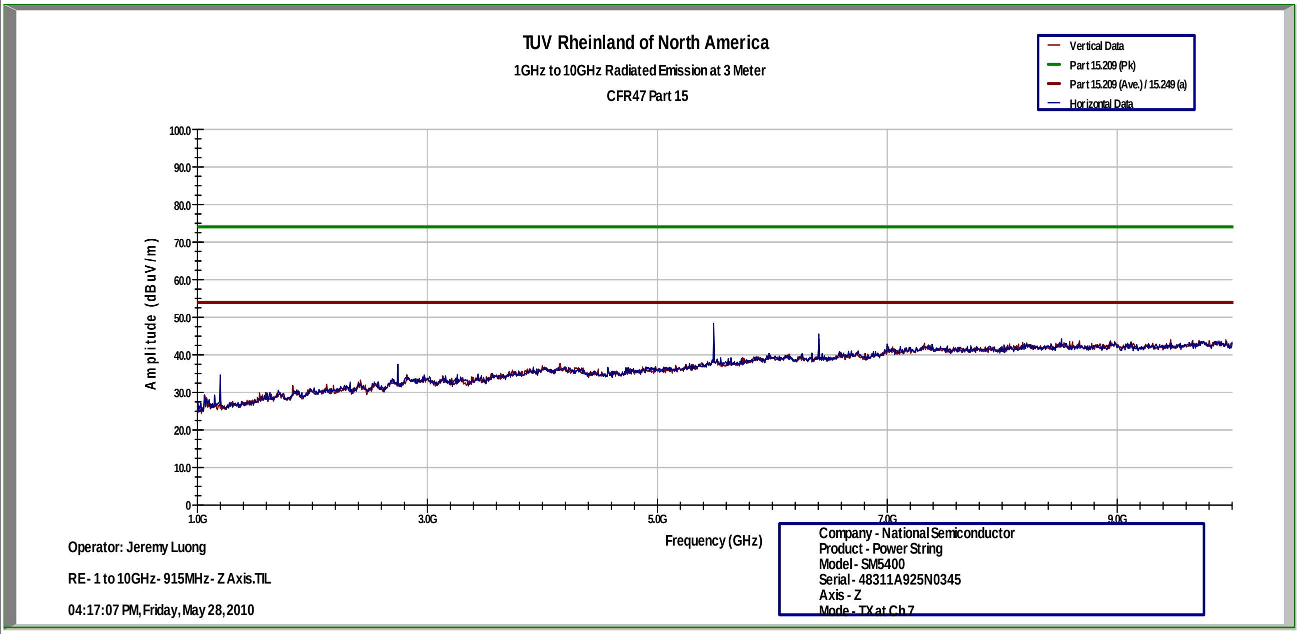
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 32% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Integrated Antenna, Tabletop	**Line AC**	12 VDC
Standard	CFR47 Part 15.249	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m / EMCO 3115	**Performed by**	Jeremy Luong



Notes: Transmitted Data at Ch 7, 914.934 MHz

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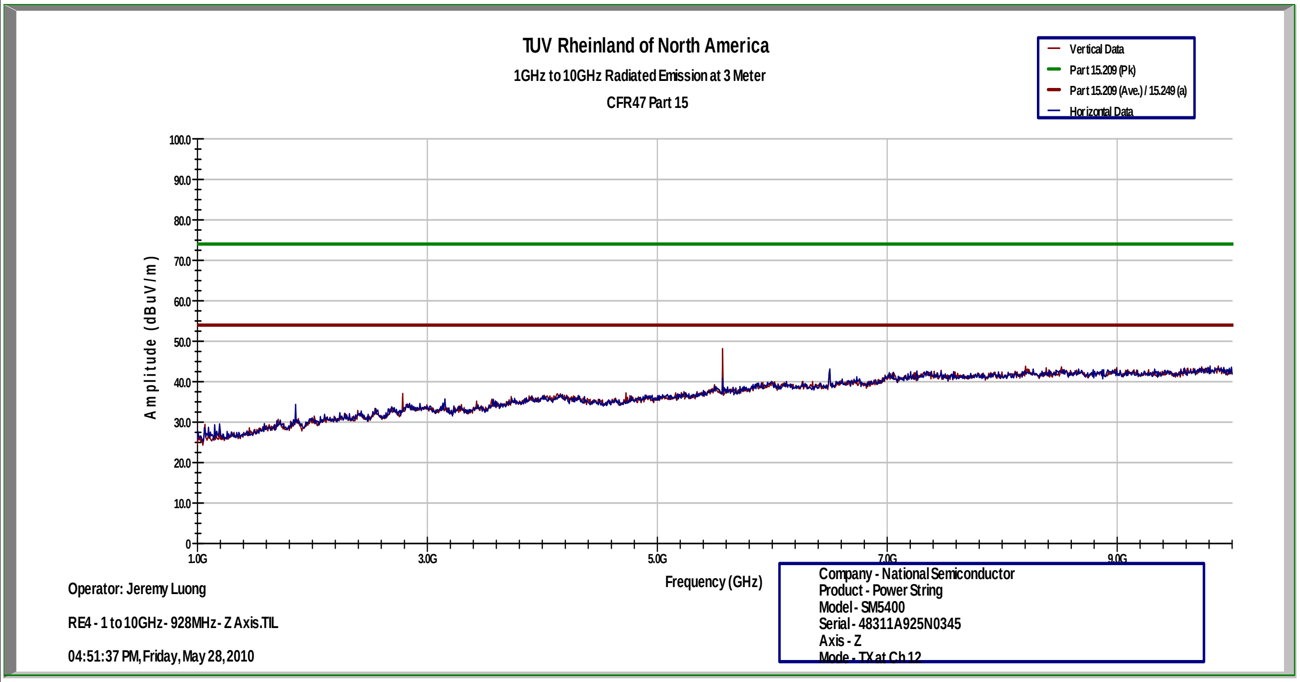
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 32% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Integrated Antenna, Tabletop	**Line AC**	12 VDC
Standard	CFR47 Part 15.249	**RBW / VBW**	1 MHz / 3 MHz
Dist/Ant Used	3m / EMCO 3115	**Performed by**	Jeremy Luong



Notes: Transmitted Data at Ch 12, 927.93 MHz

4.1.3 Sample Calculation

The field strength is calculated by subtracting the Amplifier Gain and adding the Cable Loss and Antenna Correction Factor to the measured reading. The basic equation is as follows:

$$\text{Field Strength } (dB\mu V/m) = FIM - AMP + CBL + ACF$$

Where: FIM = Field Intensity Meter (dBμV)
AMP = Amplifier Gain (dB)
CBL = Cable Loss (dB)
ACF = Antenna Correction Factor (dB/m)

$$\mu V/m = 10^{\frac{dB\mu V/m}{20}}$$

4.2 Frequency Stability per CFR47 Part 15.31(e), 15.215 (c)

According to the CFR47 Part 15.31(e) and 15.215 (c), it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out of band operation. Since the SM5400 utilizes the full range of 902 MHz to 928 MHz, the frequency stability of SM5400 should be less than ±100 ppm over the range -20° C to 55° C at ±15% of rate supply voltage.

The SM5400 was situated inside the environmental temperature chamber. The thermo couple was taped to SM5400's PCB to monitor its actual temperature.

The SM5400 RF output was connected spectrum analyzer to measure the operating channel.

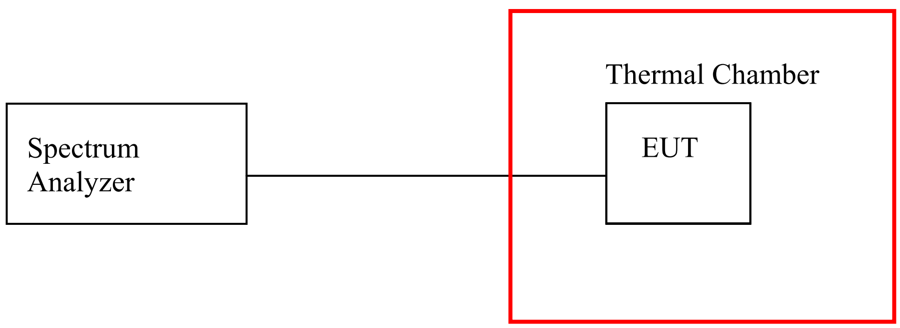
The environmental chamber temperature was programmed to run and soak per ANSI C63.10:2009

The nominal rated voltage to power the RF circuitry is 12 Vdc.

Note: Low Voltage 0.85 x 12 Vdc (nominal DC voltage) = 10.2 Vdc

High Voltage 1.15 x 12 Vdc (nominal DC voltage) = 13.8 Vac

Test Setup:



4.2.1 Test Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s). The highest ppm observed was 19.97 at Channel 3.

Table 4: Frequency Stability Requirements – Test Results

Test Conditions: Conducted Measurement, Extreme Temperature and Voltage

Sample: 48311A925N0345 **Antenna Type:** Capacitive

Signal State: Modulated **Power Level**: -5 dBm

Ambient Temp.: 23° C **Relative Humidity:**41 %

Operating Channel 3 (902.33 MHz)

Temp. (° C)	Voltage (Vac)	Channel	Time	Lower – Edge (MHz)	Center (MHz)	Higher Edge (MHz)
-20	10.2	3	Start	902.16424850	902.33759519	902.51094188
-20	10.2	3	2min	902.16625251	902.33859720	902.51094188
-20	10.2	3	5min	902.16625251	902.33859720	902.51094188
-20	10.2	3	10min	902.16625251	902.33859720	902.51094188
-20	13.8	3	Start	902.16625251	902.33859720	902.51094188
-20	13.8	3	2min	902.16625251	902.33859720	902.51094188
-20	13.8	3	5min	902.16625251	902.33859720	902.51094188
-20	13.8	3	10min	902.16625251	902.33859720	902.51094188
-10	10.2	3	Start	902.17066132	902.34200401	902.51334669
-10	10.2	3	2min	902.17066132	902.34200401	902.51334669
-10	10.2	3	5min	902.17066132	902.34200401	902.51334669
-10	10.2	3	10min	902.17066132	902.34200401	902.51334669
-10	13.8	3	Start	902.16865731	902.34100200	902.51334669
-10	13.8	3	2min	902.17066132	902.34200401	902.51334669
-10	13.8	3	5min	902.17066132	902.34200401	902.51334669
-10	13.8	3	10min	902.17066132	902.34200401	902.51334669
0	10.2	3	Start	902.17466934	902.34801604	902.52136273
0	10.2	3	2min	902.17466934	902.34801604	902.52136273
0	10.2	3	5min	902.17466934	902.34701403	902.51935872
0	10.2	3	10min	902.17466934	902.34701403	902.51935872
0	13.8	3	Start	902.17466934	902.34701403	902.51935872
0	13.8	3	2min	902.17466934	902.34701403	902.51935872
0	13.8	3	5min	902.17466934	902.34701403	902.51935872
0	13.8	3	10min	902.17466934	902.34701403	902.51935872
10	10.2	3	Start	902.17134269	902.34368738	902.51603206
10	10.2	3	2min	902.17134269	902.34368738	902.51603206
10	10.2	3	5min	902.17134269	902.34368738	902.51603206
10	10.2	3	10min	902.17134269	902.34368738	902.51603206
10	13.8	3	Start	902.17134269	902.34368738	902.51603206
10	13.8	3	2min	902.17134269	902.34368738	902.51603206
10	13.8	3	5min	902.17134269	902.34268538	902.51402806
10	13.8	3	10min	902.17134269	902.34268538	902.51402806
20	10.2	3	Start	902.16933868	902.34168337	902.51402806

20	10.2	3	2min	902.16933868	902.34168337	902.51402806
20	10.2	3	5min	902.16933868	902.34068137	902.51202405
20	10.2	3	10min	902.16933868	902.34068137	902.51202405
20	13.8	3	Start	902.16933868	902.34068137	902.51202405
20	13.8	3	2min	902.16933868	902.34068137	902.51202405
20	13.8	3	5min	902.16933868	902.34068137	902.51202405
20	13.8	3	10min	902.16933868	902.34068137	902.51202405
30	10.2	3	Start	902.16665331	902.33799600	902.50933868
30	10.2	3	2min	902.16665331	902.33799600	902.50933868
30	10.2	3	5min	902.16665331	902.33799600	902.50933868
30	10.2	3	10min	902.16464930	902.33699399	902.50933868
30	13.8	3	Start	902.16665331	902.33799600	902.50933868
30	13.8	3	2min	902.16464930	902.33699399	902.50933868
30	13.8	3	5min	902.16464930	902.33699399	902.50933868
30	13.8	3	10min	902.16665331	902.33799600	902.50933868
40	10.2	3	Start	902.16665331	902.34000000	902.51334669
40	10.2	3	2min	902.16464930	902.33899800	902.51334669
40	10.2	3	5min	902.16665331	902.34000000	902.51334669
40	10.2	3	10min	902.16665331	902.34000000	902.51334669
40	13.8	3	Start	902.16665331	902.33899800	902.51134269
40	13.8	3	2min	902.16665331	902.33899800	902.51134269
40	13.8	3	5min	902.16665331	902.33899800	902.51134269
40	13.8	3	10min	902.16665331	902.33899800	902.51134269
50	10.2	3	Start	902.16464930	902.33699399	902.50933868
50	10.2	3	2min	902.16464930	902.33699399	902.50933868
50	10.2	3	5min	902.16464930	902.33599199	902.50733467
50	10.2	3	10min	902.16464930	902.33599199	902.50733467
50	13.8	3	Start	902.16464930	902.33599199	902.50733467
50	13.8	3	2min	902.16464930	902.33599199	902.50733467
50	13.8	3	5min	902.16464930	902.33599199	902.50733467
50	13.8	3	10min	902.16464930	902.33599199	902.50733467
55	10.2	3	Start	902.16464930	902.33699399	902.50933868
55	10.2	3	2min	902.16464930	902.33599199	902.50733467
55	10.2	3	5min	902.16464930	902.33599199	902.50733467
55	10.2	3	10min	902.16464930	902.33599199	902.50733467
55	13.8	3	Start	902.16464930	902.33599199	902.50733467
55	13.8	3	2min	902.16464930	902.33599199	902.50733467
55	13.8	3	5min	902.16464930	902.33599199	902.50733467
55	13.8	3	10min	902.16464930	902.33699399	902.50933868
Max. Drift Frequency (MHz)					902.34801604	
Min. Drift Frequency (MHz)					902.33599199	
PPM Drift from Channel 3 (902.33 MHz)					19.96612658	

Test Conditions: Conducted Measurement, Extreme Temperature and Voltage

Sample: 48311A925N0345 **Antenna Type:** Capacitive

Signal State: Modulated **Power Level**: -5 dBm

Ambient Temp.: 23 °C **Relative Humidity:41** %

Operating Channel 7 (914.93 MHz)

Temp. (° C)	Voltage (Vac)	Channel	Time	Lower – Edge (MHz)	Center (MHz)	Higher Edge (MHz)
-20	10.2	3	Start	914.76072144	914.93406814	915.10741483
-20	10.2	3	2min	914.76072144	914.93406814	915.10741483
-20	10.2	3	5min	914.76272545	914.93507014	915.10741483
-20	10.2	3	10min	914.76272545	914.93507014	915.10741483
-20	13.8	3	Start	914.76180361	914.93561123	915.10941884
-20	13.8	3	2min	914.76272545	914.93507014	915.10741483
-20	13.8	3	5min	914.76272545	914.93507014	915.10741483
-20	13.8	3	10min	914.76274525	914.93508004	915.10741483
-10	10.2	3	Start	914.76464930	914.93799600	915.11134269
-10	10.2	3	2min	914.76665331	914.93799600	915.10933868
-10	10.2	3	5min	914.76665331	914.93899800	915.11134269
-10	10.2	3	10min	914.76665331	914.93799600	915.10933868
-10	13.8	3	Start	914.76665331	914.93799600	915.10933868
-10	13.8	3	2min	914.76665331	914.93799600	915.10933868
-10	13.8	3	5min	914.76665331	914.93799600	915.10933868
-10	13.8	3	10min	914.76665331	914.93799600	915.10933868
0	10.2	3	Start	914.76857715	914.94192360	915.11527005
0	10.2	3	2min	914.76857715	914.94192385	915.11527054
0	10.2	3	5min	914.76857715	914.94192385	915.11527054
0	10.2	3	10min	914.76857715	914.94190210	915.11522705
0	13.8	3	Start	914.76857715	914.94092184	915.11326653
0	13.8	3	2min	914.76857715	914.94192385	915.11527054
0	13.8	3	5min	914.76857715	914.94192385	915.11527054
0	13.8	3	10min	914.76857715	914.94192385	915.11527054
10	10.2	3	Start	914.76667335	914.93901804	915.11136273
10	10.2	3	2min	914.76867735	914.94002004	915.11136273
10	10.2	3	5min	914.76667335	914.93801604	915.10935872
10	10.2	3	10min	914.76667335	914.93801604	915.10935872
10	13.8	3	Start	914.76667335	914.93901804	915.11136273
10	13.8	3	2min	914.76867735	914.93901804	915.10935872
10	13.8	3	5min	914.76667335	914.93801604	915.10935872
10	13.8	3	10min	914.76867735	914.93901804	915.10935872
20	10.2	3	Start	914.76464930	914.93699399	915.10933868
20	10.2	3	2min	914.76464930	914.93699399	915.10933868

20	10.2	3	5min	914.76464930	914.93599199	915.10733467
20	10.2	3	10min	914.76464930	914.93599199	915.10733467
20	13.8	3	Start	914.76649300	914.93791584	915.10933868
20	13.8	3	2min	914.76464930	914.93699404	915.10933878
20	13.8	3	5min	914.76464930	914.93599199	915.10733467
20	13.8	3	10min	914.76464930	914.93599199	915.10733467
30	10.2	3	Start	914.76266533	914.93400802	915.10535070
30	10.2	3	2min	914.76066132	914.93300601	915.10535070
30	10.2	3	5min	914.76266533	914.93400802	915.10535070
30	10.2	3	10min	914.76266533	914.93400802	915.10535070
30	13.8	3	Start	914.76266533	914.93400802	915.10535070
30	13.8	3	2min	914.76266533	914.93400802	915.10535070
30	13.8	3	5min	914.76266533	914.93400802	915.10535070
30	13.8	3	10min	914.76266533	914.93400802	915.10535070
40	10.2	3	Start	914.76266533	914.93501002	915.10735471
40	10.2	3	2min	914.76266533	914.93501002	915.10735471
40	10.2	3	5min	914.76266533	914.93501002	915.10735471
40	10.2	3	10min	914.76266533	914.93501002	915.10735471
40	13.8	3	Start	914.76266533	914.93501002	915.10735471
40	13.8	3	2min	914.76266533	914.93501002	915.10735471
40	13.8	3	5min	914.76266533	914.93501002	915.10735471
40	13.8	3	10min	914.76266533	914.93501002	915.10735471
50	10.2	3	Start	914.76066132	914.93300601	915.10535070
50	10.2	3	2min	914.76066132	914.93300601	915.10535070
50	10.2	3	5min	914.76066132	914.93300601	915.10535070
50	10.2	3	10min	914.76066132	914.93300601	915.10535070
50	13.8	3	Start	914.76066132	914.93300601	915.10535070
50	13.8	3	2min	914.76066132	914.93300601	915.10535070
50	13.8	3	5min	914.76066132	914.93300601	915.10535070
50	13.8	3	10min	914.76066132	914.93300601	915.10535070
55	10.2	3	Start	914.76066132	914.93200401	915.10334669
55	10.2	3	2min	914.76066132	914.93300601	915.10535070
55	10.2	3	5min	914.76066132	914.93300601	915.10535070
55	10.2	3	10min	914.76066132	914.93300601	915.10535070
55	13.8	3	Start	914.76066132	914.93200401	915.10334669
55	13.8	3	2min	914.76066132	914.93200401	915.10334669
55	13.8	3	5min	914.76066132	914.93200401	915.10334669
55	13.8	3	10min	914.76066132	914.93200401	915.10334669
Max. Drift Frequency (MHz)					914.94192385	
Min. Drift Frequency (MHz)					914.93200401	
PPM Drift from Channel 7 (914.93 MHz)					2.190336966	

Test Conditions: Conducted Measurement, Extreme Temperature and Voltage

Sample: 0345 **Antenna Type:** Capacitive

Signal State: Modulated				**Power Level**: -5 dBm		
Ambient Temp.: 23 °C				**Relative Humidity:41** %		
Operating Channel 12 (927.93 MHz)						
Temp. (° C)	**Voltage (Vac)**	**Channel**	**Time**	**Lower – Edge (MHz)**	**Center (MHz)**	**Higher Edge (MHz)**
-20	10.2	3	Start	927.75851703	927.93086172	928.10320641
-20	10.2	3	2min	927.75851703	927.93086172	928.10320641
-20	10.2	3	5min	927.75851703	927.93086172	928.10320641
-20	10.2	3	10min	927.75851703	927.93086172	928.10320641
-20	13.8	3	Start	927.75851703	927.92985972	928.10120240
-20	13.8	3	2min	927.75851703	927.92985972	928.10120240
-20	13.8	3	5min	927.75851703	927.92985972	928.10120240
-20	13.8	3	10min	927.75851703	927.93086172	928.10320641
-10	10.2	3	Start	927.76252505	927.93486974	928.10721443
-10	10.2	3	2min	927.76252505	927.93386774	928.10521042
-10	10.2	3	5min	927.76252505	927.93386774	928.10521042
-10	10.2	3	10min	927.76252505	927.93486974	928.10721443
-10	13.8	3	Start	927.76252505	927.93487029	928.10721553
-10	13.8	3	2min	927.76252505	927.93386774	928.10521042
-10	13.8	3	5min	927.76252505	927.93386774	928.10521042
-10	13.8	3	10min	927.76252505	927.93386774	928.10521042
0	10.2	3	Start	927.76452906	927.93687375	928.10921844
0	10.2	3	2min	927.76452906	927.93687375	928.10921844
0	10.2	3	5min	927.76452906	927.93687375	928.10921844
0	10.2	3	10min	927.76533070	927.93627257	928.10721443
0	13.8	3	Start	927.76452906	927.93687375	928.10921844
0	13.8	3	2min	927.76542906	927.93732375	928.10921844
0	13.8	3	5min	927.76452906	927.93687375	928.10921844
0	13.8	3	10min	927.76452906	927.93687375	928.10921844
10	10.2	3	Start	927.76452906	927.93587175	928.10721443
10	10.2	3	2min	927.76252505	927.93486974	928.10721443
10	10.2	3	5min	927.76452906	927.93587175	928.10721443
10	10.2	3	10min	927.76452906	927.93486974	928.10521042
10	13.8	3	Start	927.76452906	927.93587175	928.10721443
10	13.8	3	2min	927.76452906	927.93587175	928.10721443
10	13.8	3	5min	927.76452906	927.93587175	928.10721443
10	13.8	3	10min	927.76252505	927.93486974	928.10721443
20	10.2	3	Start	927.76066132	927.93300601	928.10535070
20	10.2	3	2min	927.76066132	927.93300601	928.10535070
20	10.2	3	5min	927.76066132	927.93200401	928.10334669
20	10.2	3	10min	927.76066132	927.93200401	928.10334669
20	13.8	3	Start	927.76066132	927.93200401	928.10334669
20	13.8	3	2min	927.76066132	927.93200401	928.10334669

20	13.8	3	5min	927.76066132	927.93200401	928.10334669
20	13.8	3	10min	927.76066132	927.93200401	928.10334669
30	10.2	3	Start	927.76066132	927.93100201	928.10134269
30	10.2	3	2min	927.76066132	927.93100201	928.10134269
30	10.2	3	5min	927.75865731	927.93000000	928.10134269
30	10.2	3	10min	927.75865731	927.93000000	928.10134269
30	13.8	3	Start	927.76066132	927.93100201	928.10134269
30	13.8	3	2min	927.75865731	927.93000000	928.10134269
30	13.8	3	5min	927.75865731	927.93000000	928.10134269
30	13.8	3	10min	927.75865731	927.93000000	928.10134269
40	10.2	3	Start	927.75665331	927.93000000	928.10334669
40	10.2	3	2min	927.75665331	927.93000000	928.10334669
40	10.2	3	5min	927.75665331	927.92899800	928.10134269
40	10.2	3	10min	927.75865731	927.93100200	928.10334669
40	13.8	3	Start	927.75665331	927.93000000	928.10334669
40	13.8	3	2min	927.75665331	927.93000000	928.10334669
40	13.8	3	5min	927.75665331	927.92899800	928.10134269
40	13.8	3	10min	927.75865731	927.93000000	928.10134269
50	10.2	3	Start	927.75865731	927.93000000	928.10134269
50	10.2	3	2min	927.75865731	927.93000000	928.10134269
50	10.2	3	5min	927.75665331	927.92899800	928.10134269
50	10.2	3	10min	927.75665331	927.92899800	928.10134269
50	13.8	3	Start	927.75665331	927.92899800	928.10134269
50	13.8	3	2min	927.75665331	927.92899800	928.10134269
50	13.8	3	5min	927.75865731	927.93000000	928.10134269
50	13.8	3	10min	927.75865731	927.93000000	928.10134269
55	10.2	3	Start	927.75466934	927.92801604	928.10136273
55	10.2	3	2min	927.75466934	927.92701403	928.09935872
55	10.2	3	5min	927.75466934	927.92701403	928.09935872
55	10.2	3	10min	927.75466934	927.92801604	928.10136273
55	13.8	3	Start	927.75466934	927.92801604	928.10136273
55	13.8	3	2min	927.75466934	927.92801604	928.10136273
55	13.8	3	5min	927.75466934	927.92801604	928.10136273
55	13.8	3	10min	927.75667335	927.92901804	928.10136273
Max. Drift Frequency (MHz)					927.93732375	
Min. Drift Frequency (MHz)					927.92701403	
PPM Drift from Channel 12 (927.93 MHz)					3.217882814	

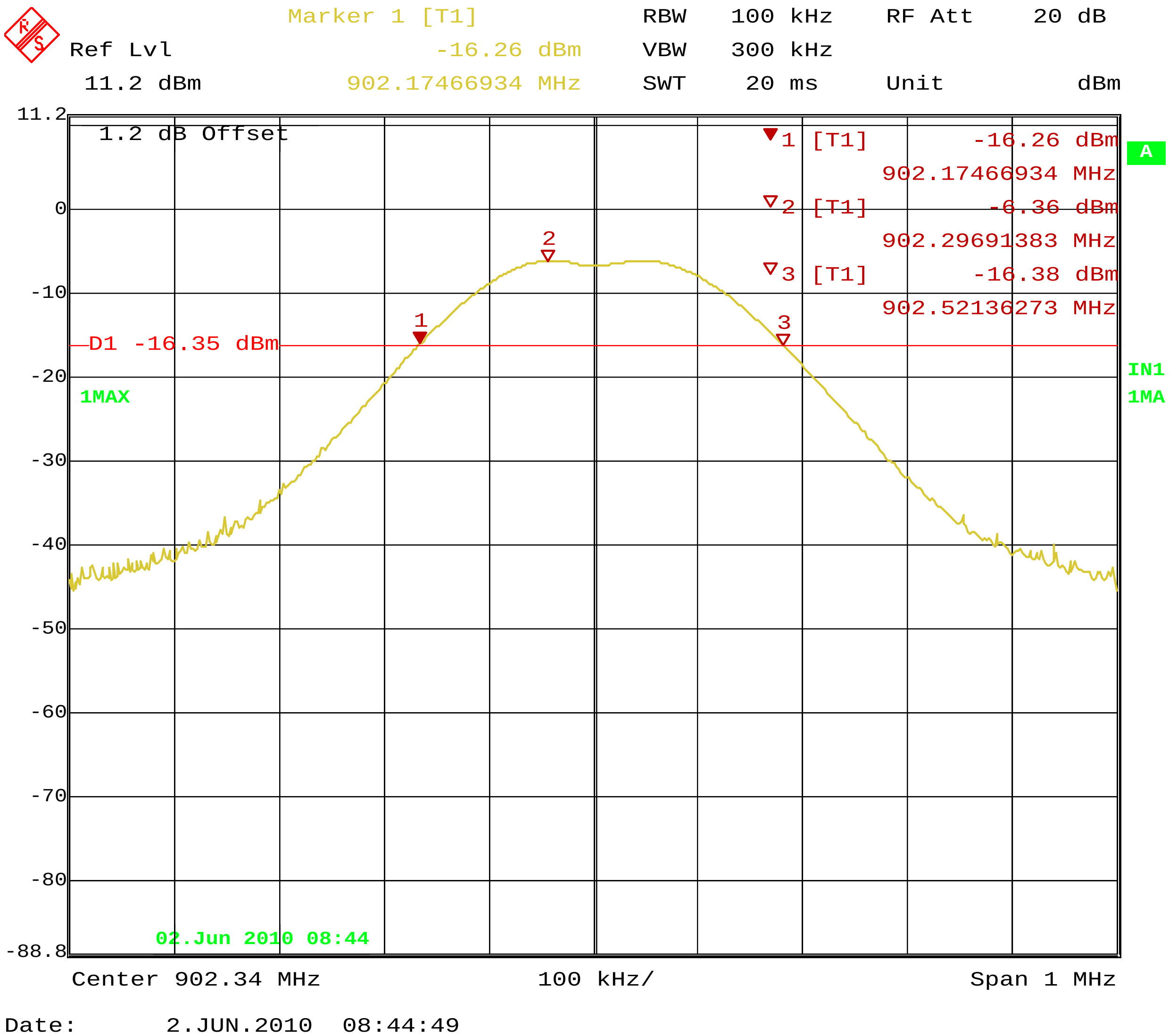


Figure 4 – Frequency Stability at Channel 3 – Worst Case (10.2 Vdc, 0° C, Start)

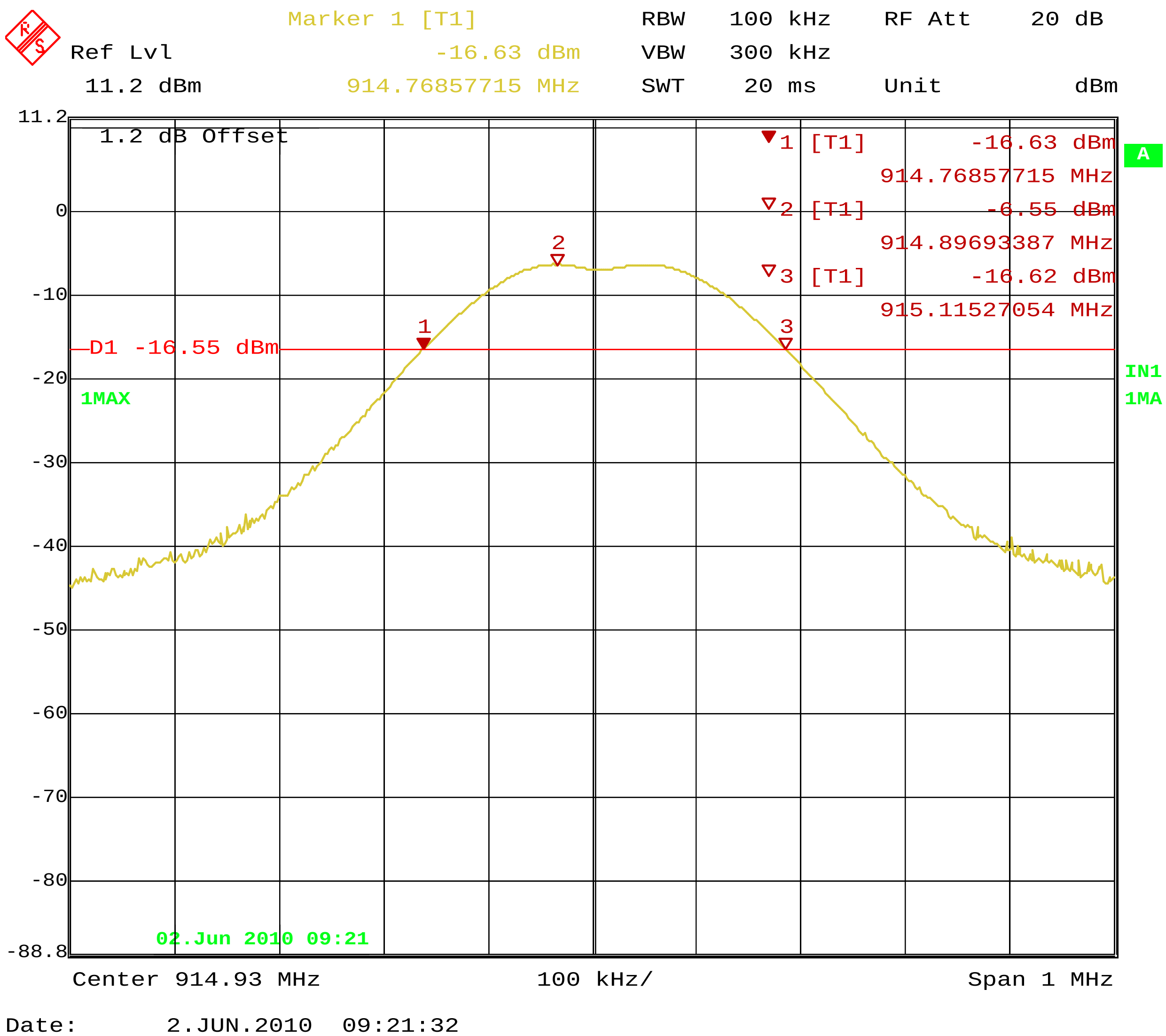


Figure 5 – Frequency Stability at Channel 7 – Worst Case (10.2 Vdc, 0° C, 2 min.)

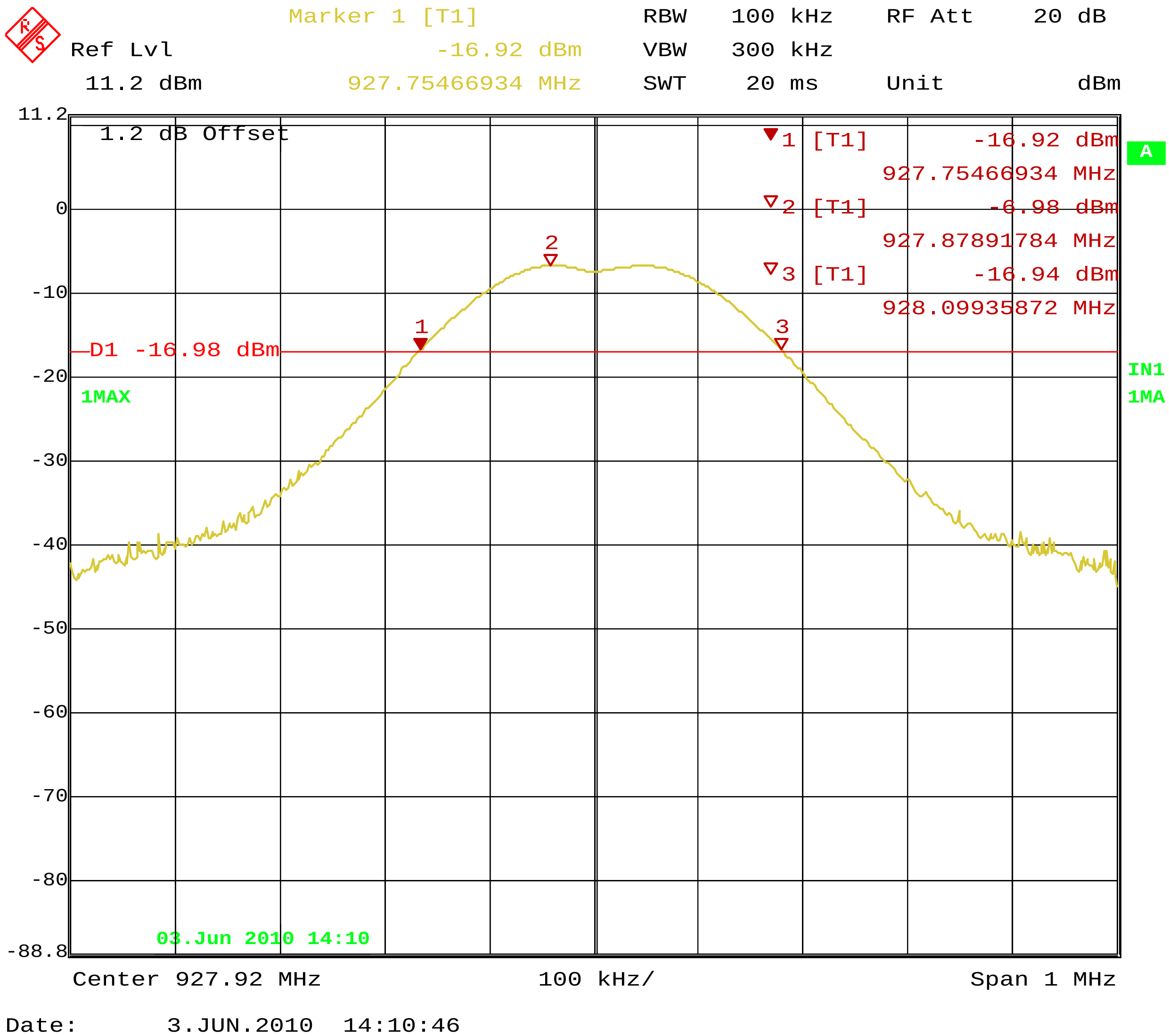


Figure 6 – Frequency Stability at Channel 12 – Worst Case (10.2 Vdc, 55° C, 2 min.)

4.3 Band Edge Compliance per CFR47 Part 15.215 (c)

The setup was identical to radiated emissions. Intentional radiators operating under the alternative provisions to the general emission limits, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If the frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Any frequency outside the band of 902 MHz to 928 MHz, the power output level must be below 20 dB from the in-band transmitting signal; CFR 47 Part 15.215 (c).

4.3.1 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 5: Band-Edge Requirements – Test Results

Test Conditions: Radiated Measurement, Normal Temperature and Voltage only					
Antenna Type: Capacitive			**Power Setting:** -5 dBm		
Signal State: Modulated (GFSK)			**Data Rate:** 125 kBps		
Ambient Temp.: 23° C			**Relative Humidity:**33%		
Band-Edge Results					
Operating Channel	**Mode**	**Polarity**	**Band-edge Level (dBuV/m)**	**20 dB Level (dBuV/m)**	**Margin (dB)**
902.33 MHz	125 kBps	Horz.	64.44	71.40	-6.96
902.33 MHz	125 kBps	Vert.	61.71	66.60	-4.89
927.93 MHz	125 kBps	Horz.	67.75	72.04	-4.29
927.93 MHz	125 kBps	Vert.	62.40	66.68	-4.28

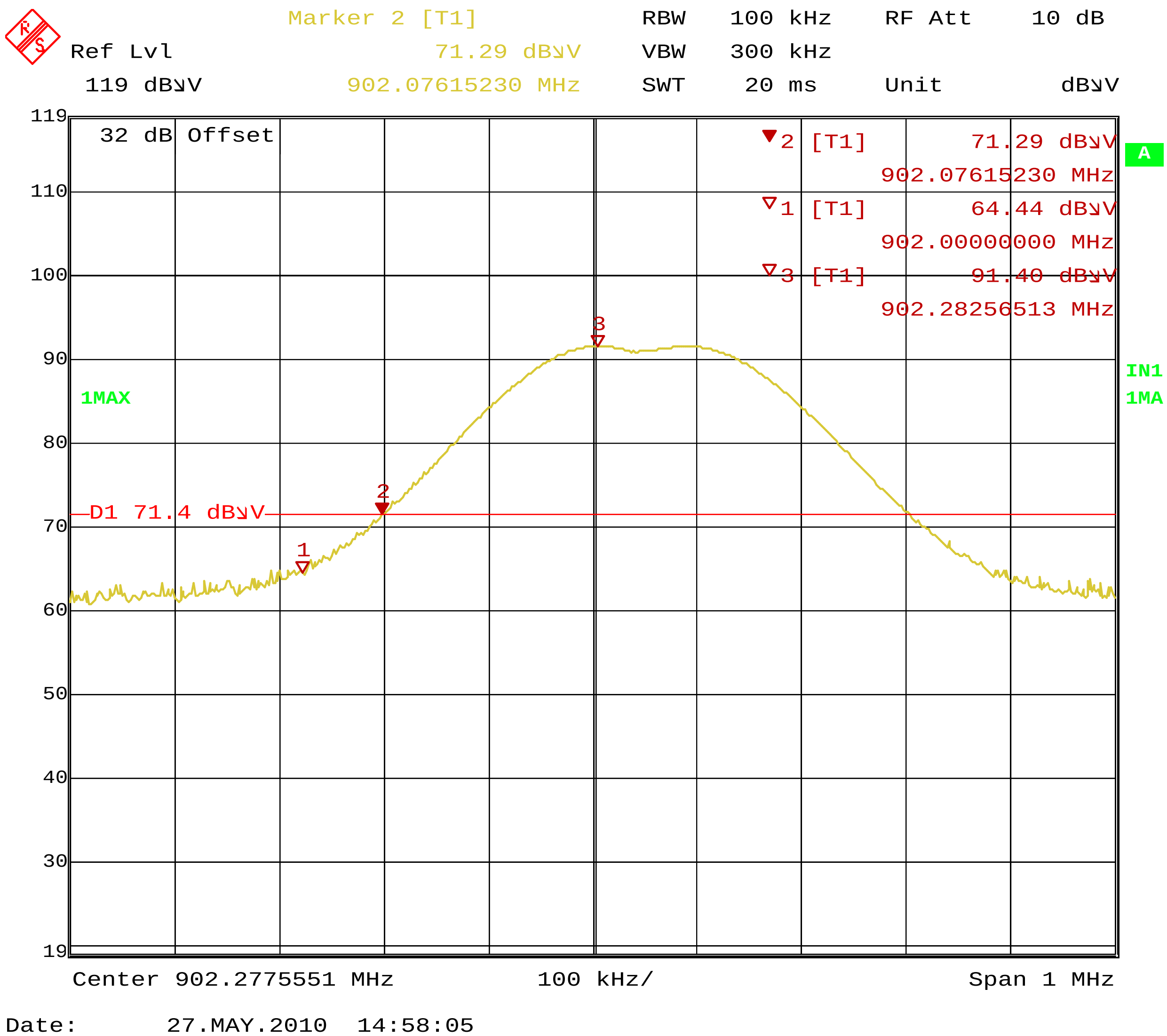


Figure 7 – Band edge Results at 902.33 MHz (Horizontal)

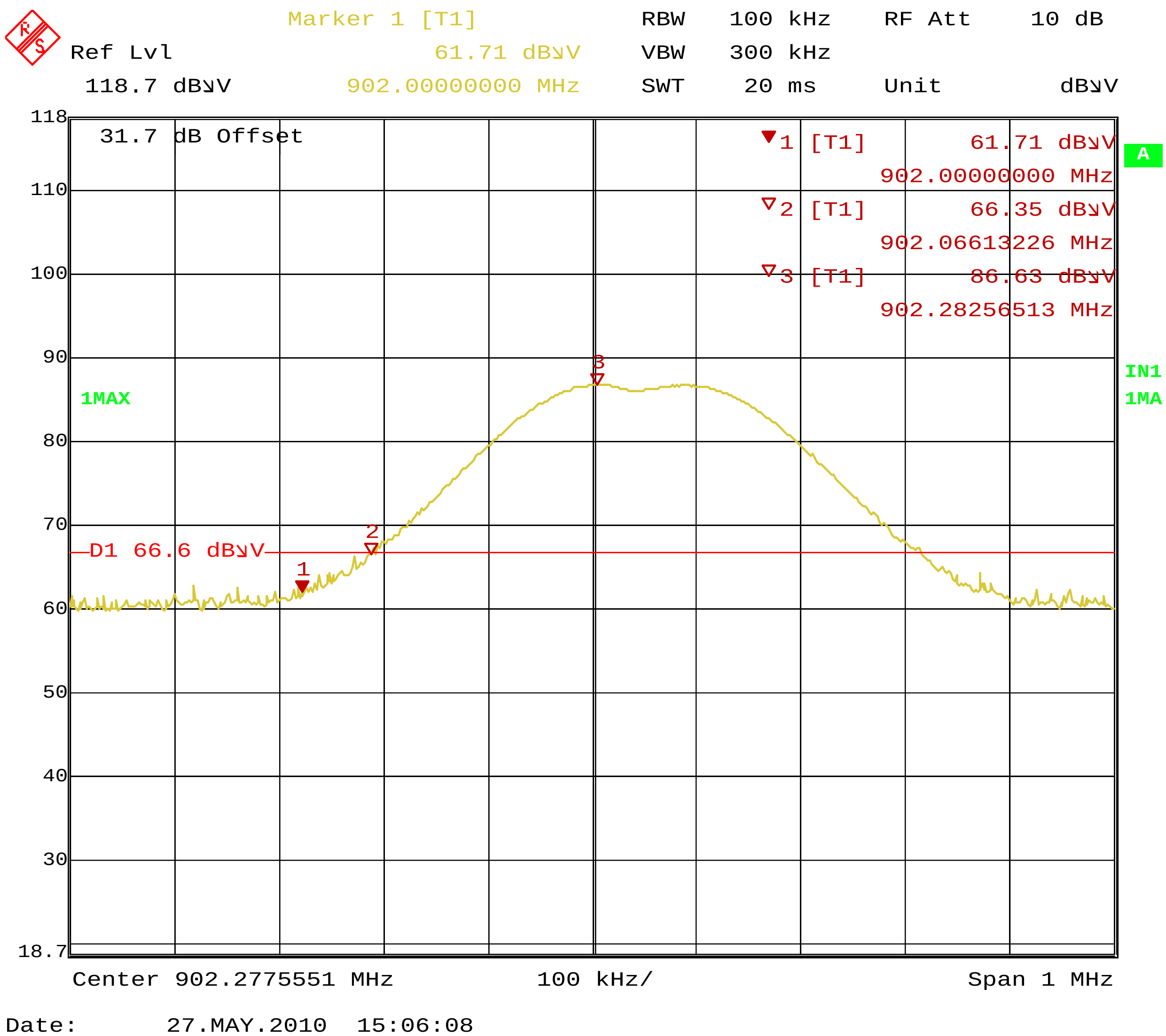


Figure 8 – Band edge Results at 902.33 MHz (Horizontal)

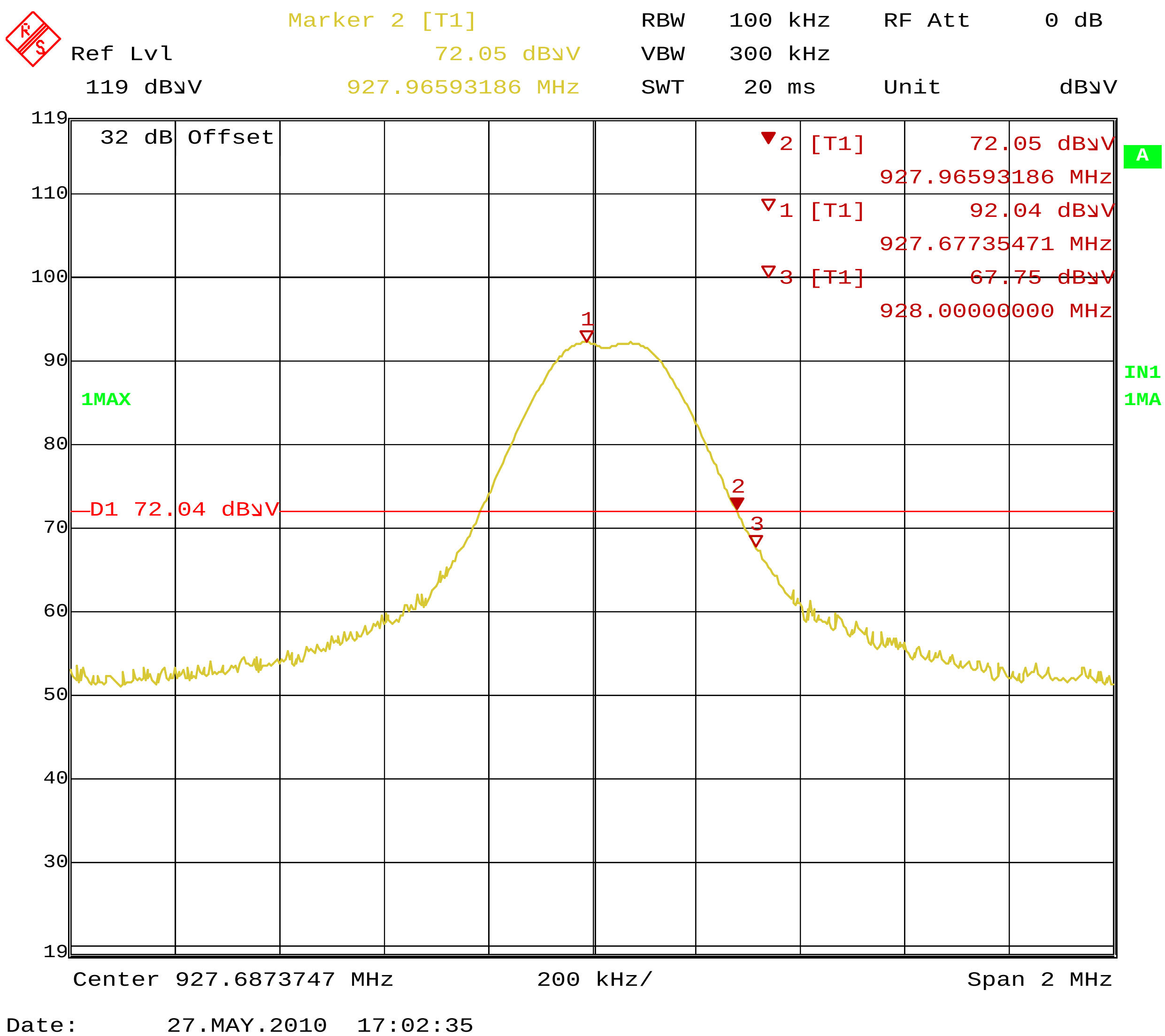


Figure 9 – Band edge Results at 927.93 MHz (Horizontal)

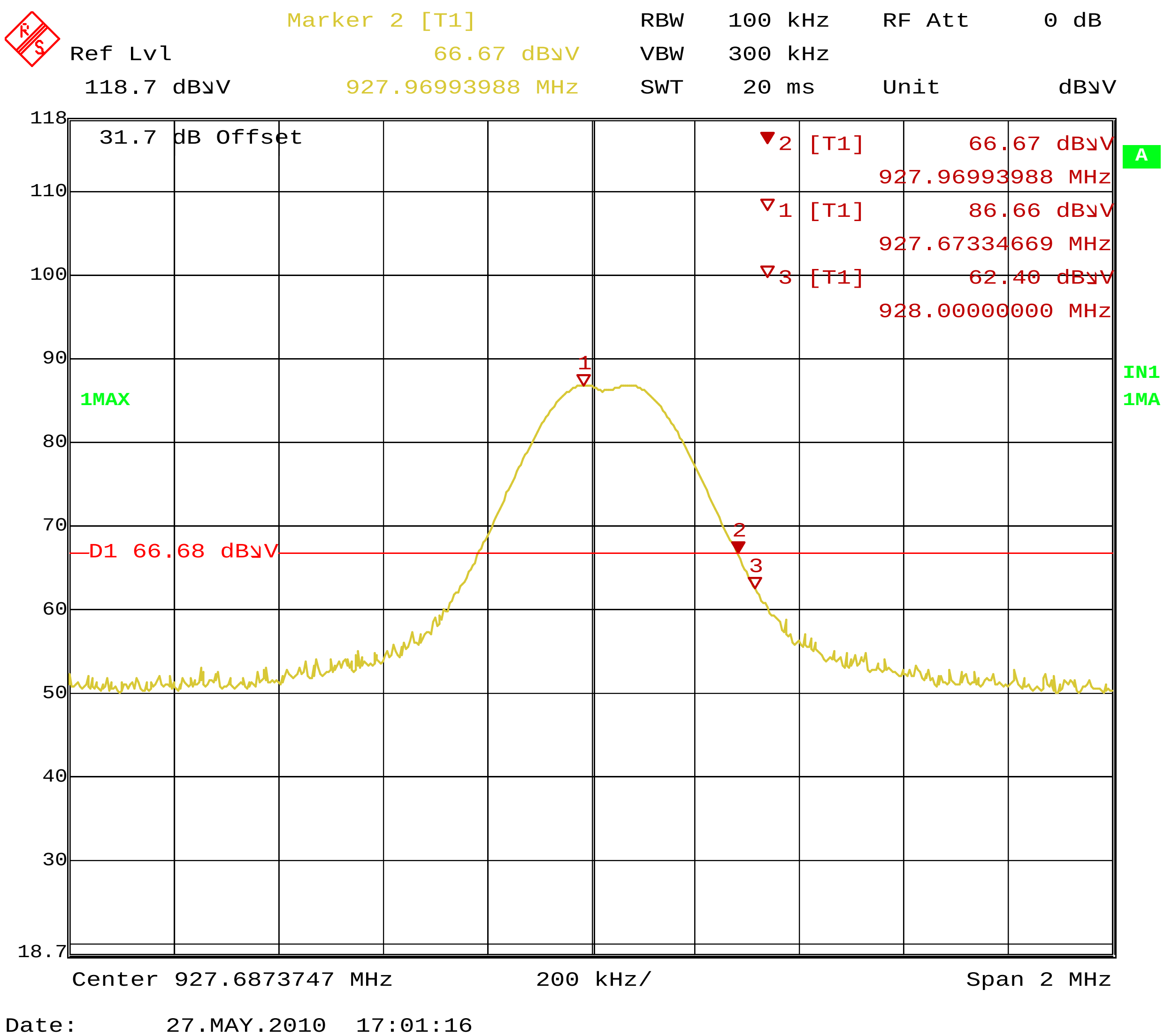


Figure 10 – Band edge Results at 927.93 MHz (Vertical)

4.4 Occupied Bandwidth per CFR47 Part 15.215 (c)

The occupied bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency.

The 99% bandwidth is the bandwidth in which 99% of the transmitted power occupied.

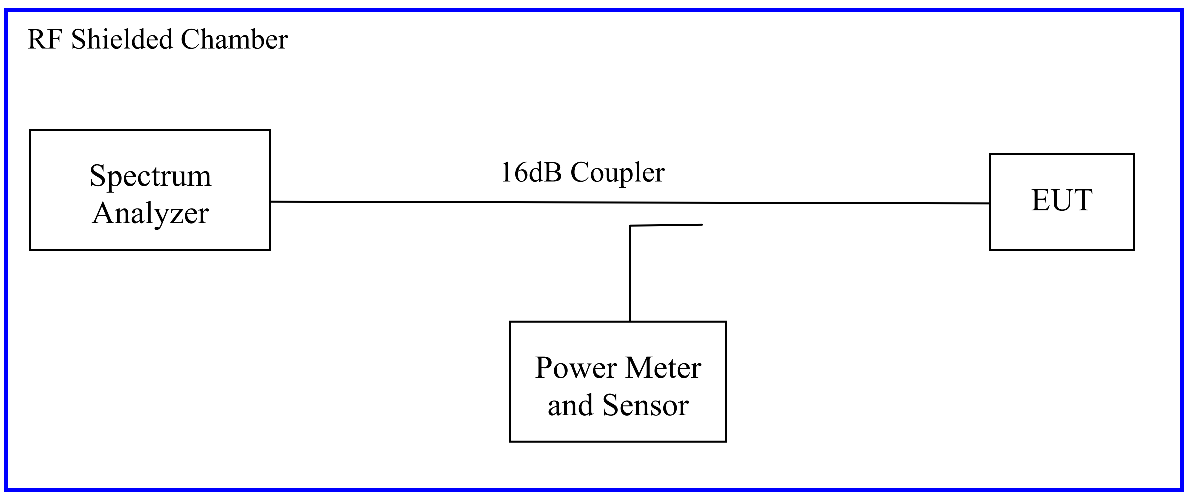
The 20 dB bandwidth is defined the bandwidth of 20 dBr from highest transmitted level of the fundamental frequency.

The bandwidth shall be documented per Section CFR47 15.215(c) 2010 and RSS Gen Sect. 4.4.1.

4.4.1 Test Method

The conducted method was used to measure the occupied bandwidth. The measurement was performed with GFSK modulation. This test was conducted on 3 channels of Sample, S/N 48311A925N0345. The worst sample result is indicated below.

Test Setup:



4.4.2 Results

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

Table 6: Occupied Bandwidth – Test Results

Test Conditions: Normal Temperature and Voltage only				
Antenna Type: Capacitive		**Power Setting:** -5 dBm		
Signal State: Modulated (GFSK)		**Data Rate:** 125 kBps		
Ambient Temp.: 23° C		**Relative Humidity:**33%		
Bandwidth Measurement				
Operating Channel	**Limit**	**99% Bandwidth (MHz)**	**20 dB Bandwidth (kHz)**	**Results**
902.33 MHz	NA	258.51702407	272.54509018	NA
914.934 MHz	NA	260.52104208	270.56112224	NA
927.93 MHz	NA	258.51702407	271.04208417	NA
Note: 20 dB bandwidth was measured using radiated method at 3 meter distance				

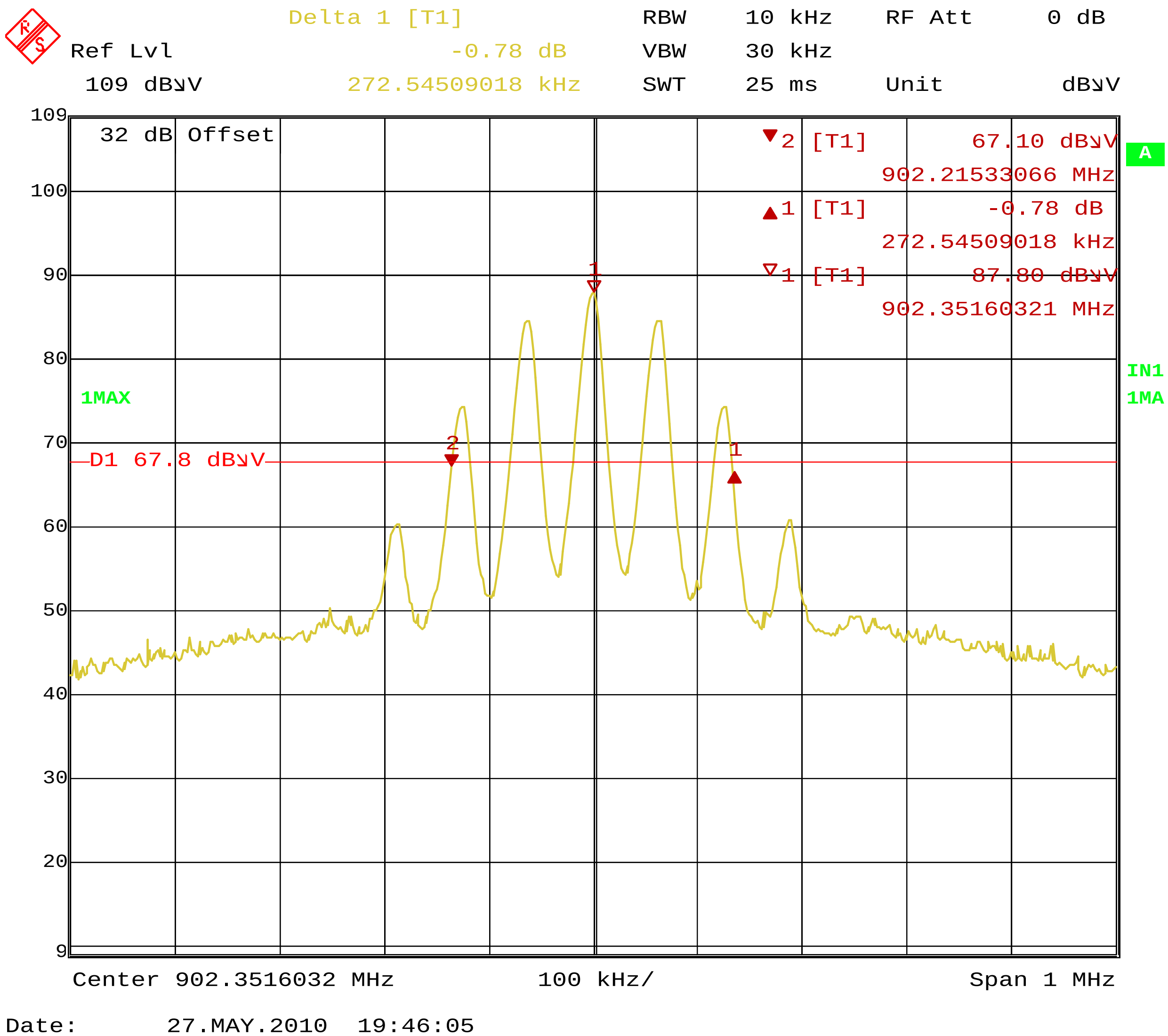


Figure 11 – 20 dB Bandwidth at Channel 3

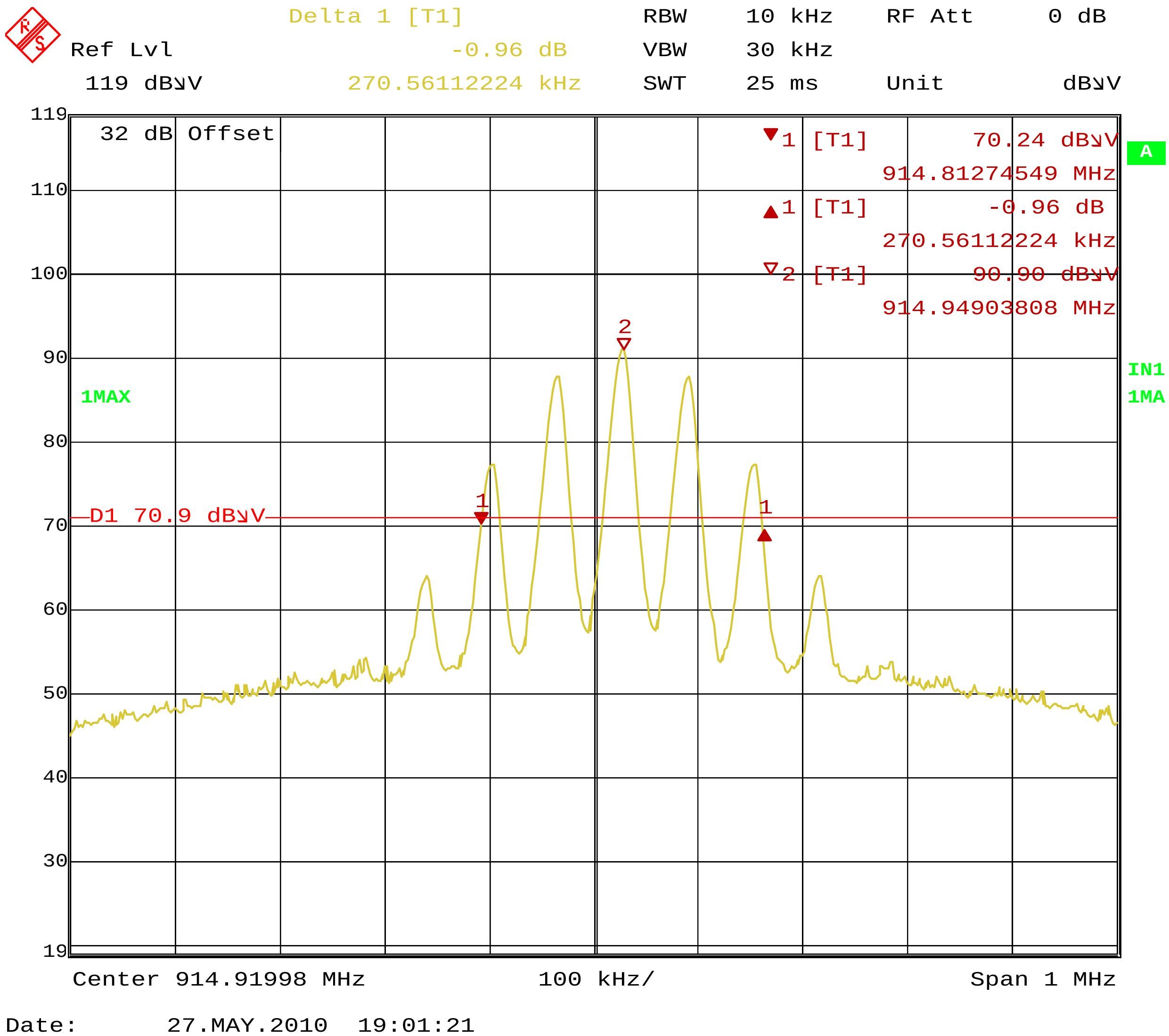


Figure 12 – 20 dB Bandwidth at Channel 7

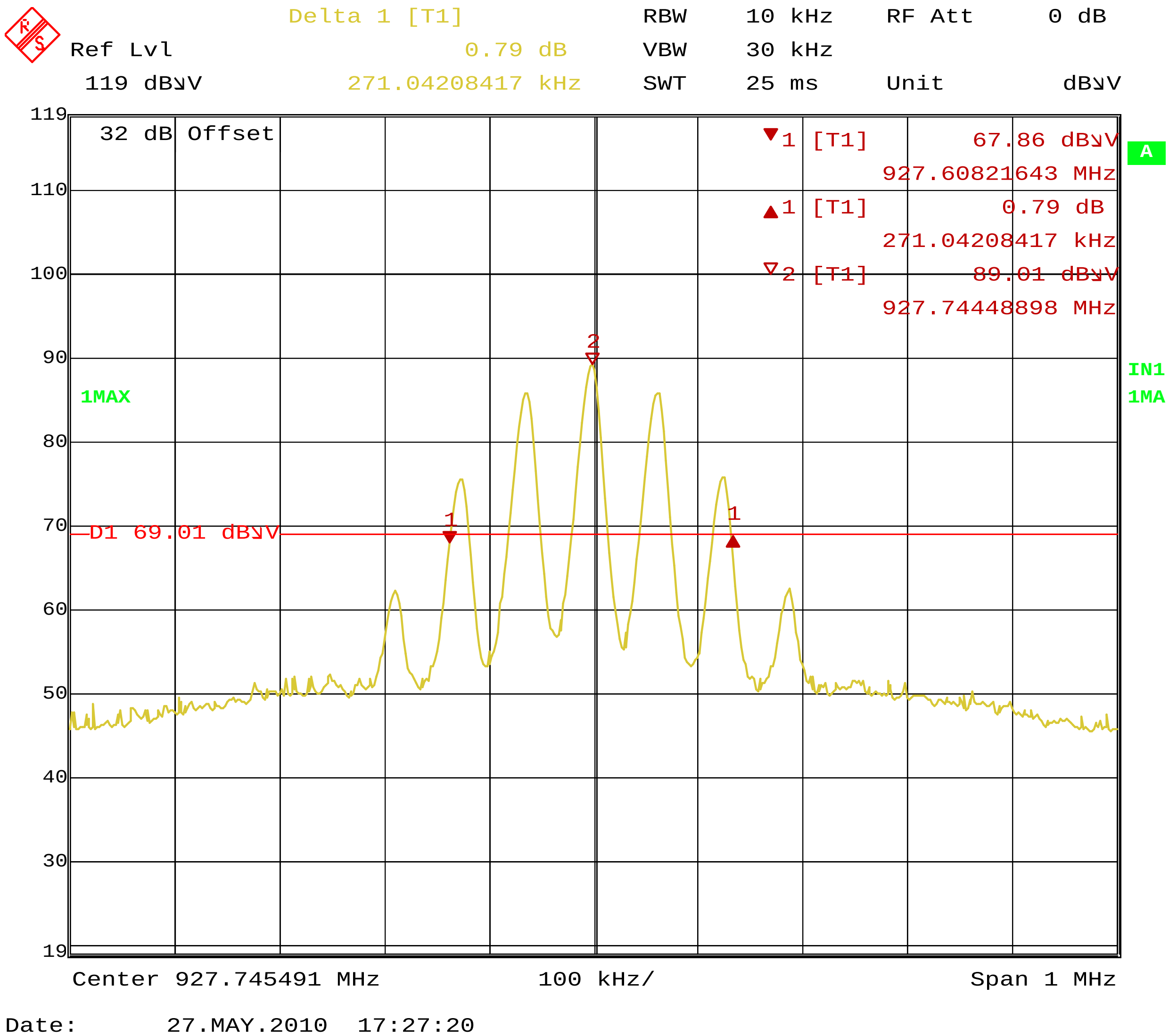


Figure 13 – 20 dB Bandwidth at Channel 12

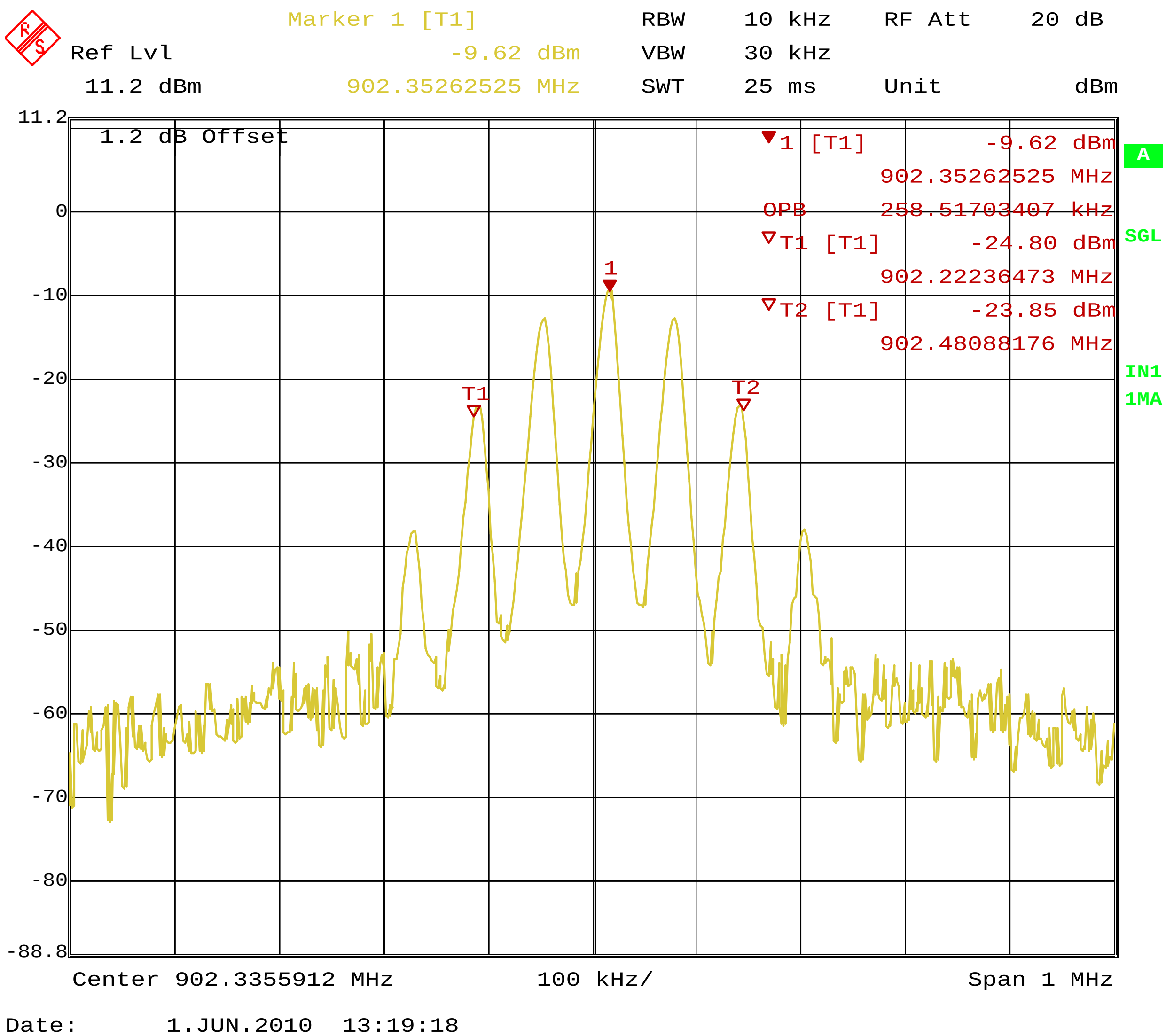


Figure 14 – 99% Bandwidth of Channel 3

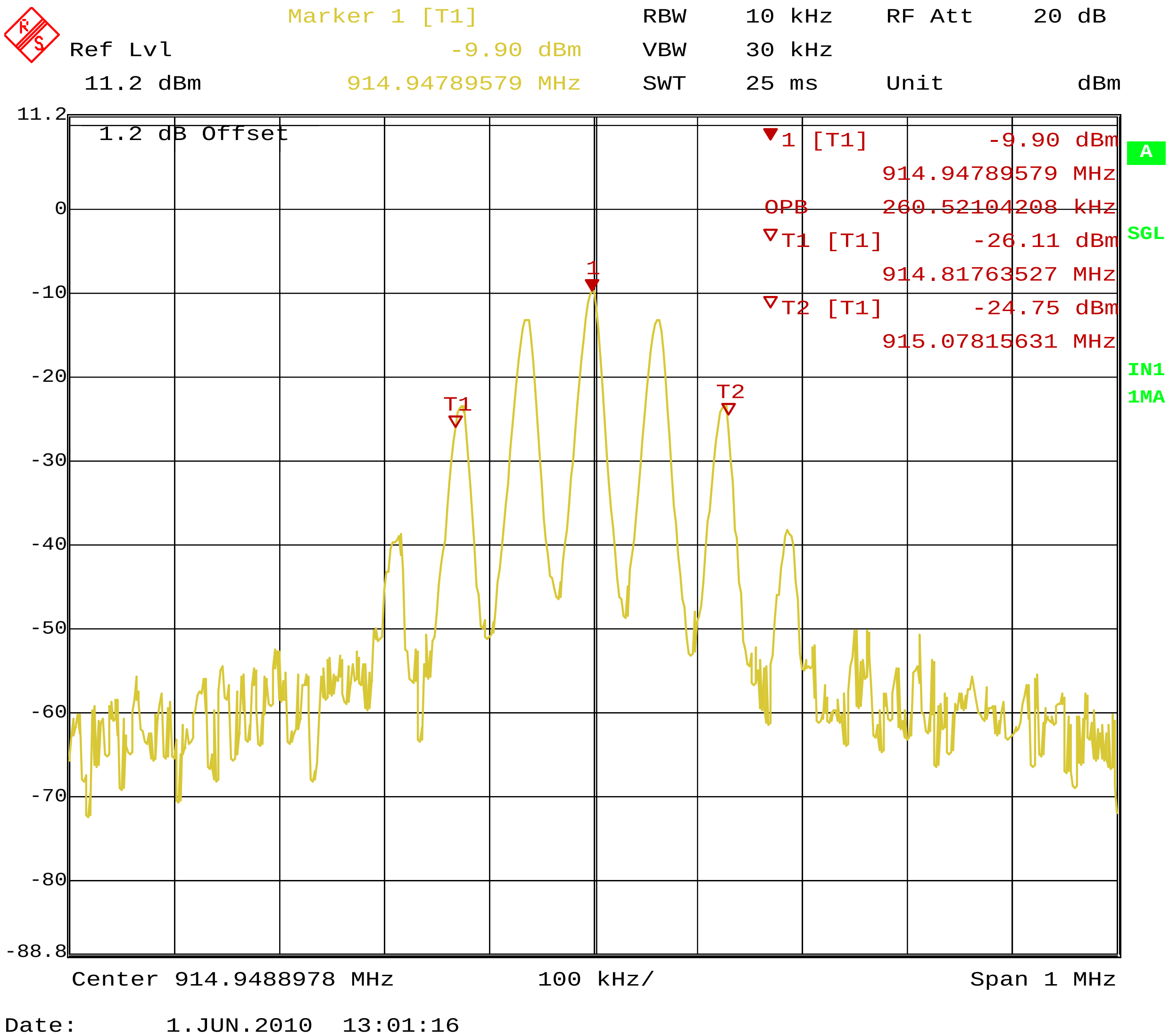


Figure 15 – 99% Bandwidth of Channel 7

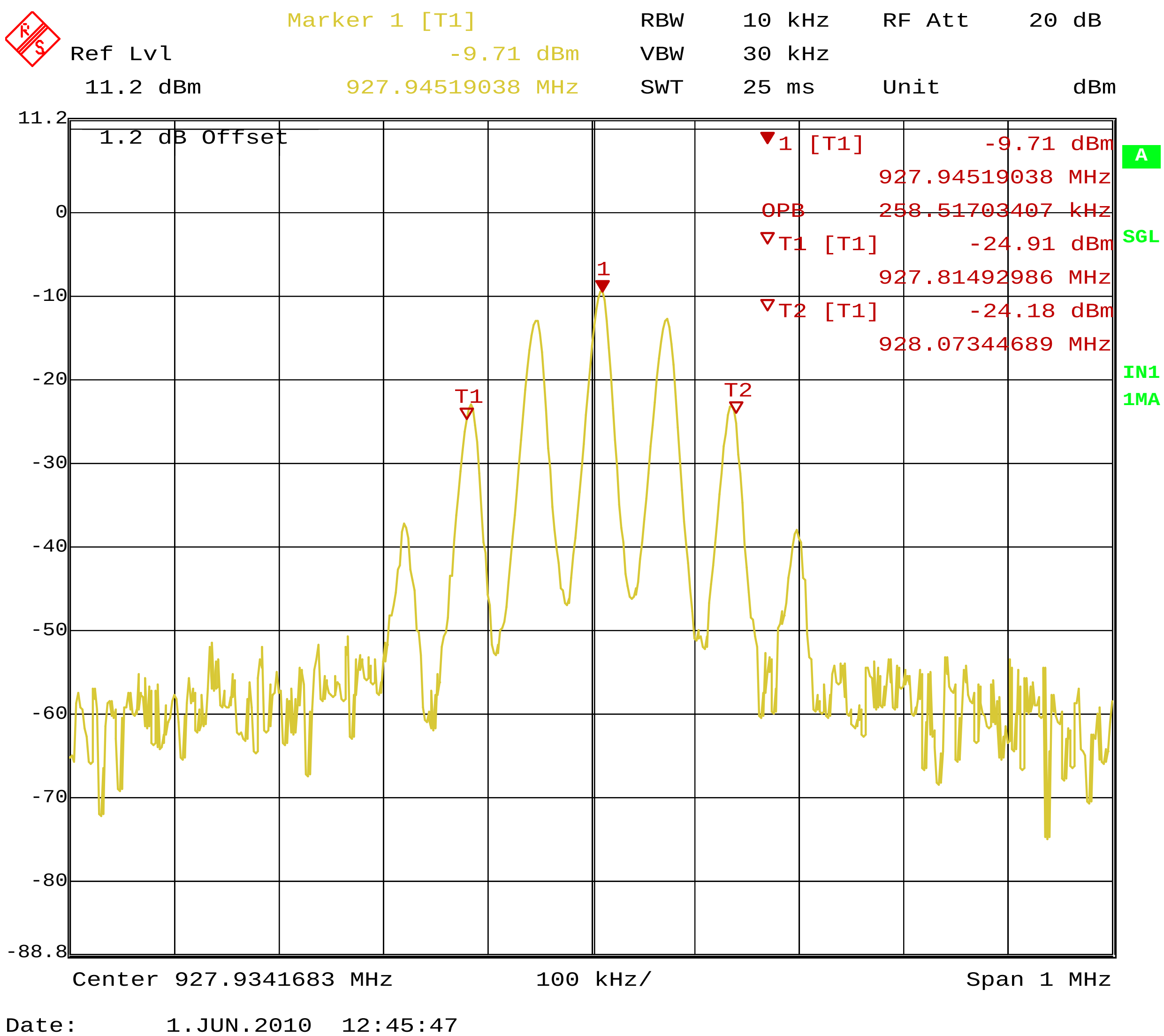


Figure 16 – 99% Bandwidth of Channel 12

4.5 Transmitter Spurious Emissions per CFR47 Part 15.209, 15.249 (d)

Transmitter spurious emissions are emissions outside the frequency range of the equipment when the equipment is in transmit mode; per requirement of CFR47 15.205, 15.209, 15.249(d), RSS 210 Sect. A.2.9

4.5.1 Test Methodology

4.5.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization’s.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

The preliminary tests performed to determine the worst positions. The worst position was on Z-Axis.

4.5.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final scans performed for three operating channels; 902.33 MHz, 914.934 MHz, and 927.93 MHz at 125 kbps on Z-Axis.

4.5.1.3 Deviations

None.

4.5.2 Transmitter Spurious Emission Limit

The spurious emissions of the transmitter shall not exceed the values in CFR47 Part 15.205, 15.209: 2010 and RSS 210 A1.1.2 2007.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100 **	3
88-216	150 **	3
216-960	200 **	3
Above 960	500	3

All harmonics and spurious emission which are outside of the restricted band shall be 20 dB below the in-band emission.

4.5.3 Test Results

The final measurement data was taken under the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and 1.5.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

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EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line / Freq**	12 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP/Ave (dBuV/m)	Total CF dBuV	E-Field QP/Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
Transmit Mode at Ch 3, 902.33 MHz.										
41.88	V	113	123	35.41	30.98	-11.98	19.00	40.00	-21.00	Spurious
117.30	V	212	246	34.62	30.90	-10.12	20.78	43.52	-22.74	Spurious
117.84	H	245	351	33.19	30.02	-10.06	19.96	43.52	-23.56	Spurious
144.03	H	258	189	30.64	26.70	-10.77	15.93	43.52	-27.59	Spurious
Transmit Mode at Ch 7, 914.934MHz.										
202.95	H	150	22	38.11	35.00	-10.96	24.04	43.52	-19.48	Spurious
251.95	H	119	6	37.08	34.32	-10.39	23.93	46.02	-22.09	Spurious
41.55	V	131	156	35.05	29.75	-11.68	18.07	40.00	-21.93	Spurious
143.95	V	107	133	35.79	33.61	-10.76	22.85	43.52	-20.67	Spurious
Transmit Mode at Ch 12, 927.93 MHz.										
114.70	H	323	352	31.16	26.93	-10.51	16.42	43.52	-27.10	Spurious
117.95	H	239	330	30.72	26.80	-10.04	16.76	43.52	-26.76	Spurious
32.45	V	125	77	33.81	29.11	-4.51	24.60	40.00	-15.40	Spurious

Spec Margin = E-Field QP/Ave - Limit, E-Field QP = FIM QP/Ave+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 1.6dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Tested on the Z-Axis.
No spurious emission was observed above 1GHz; only harmonics.

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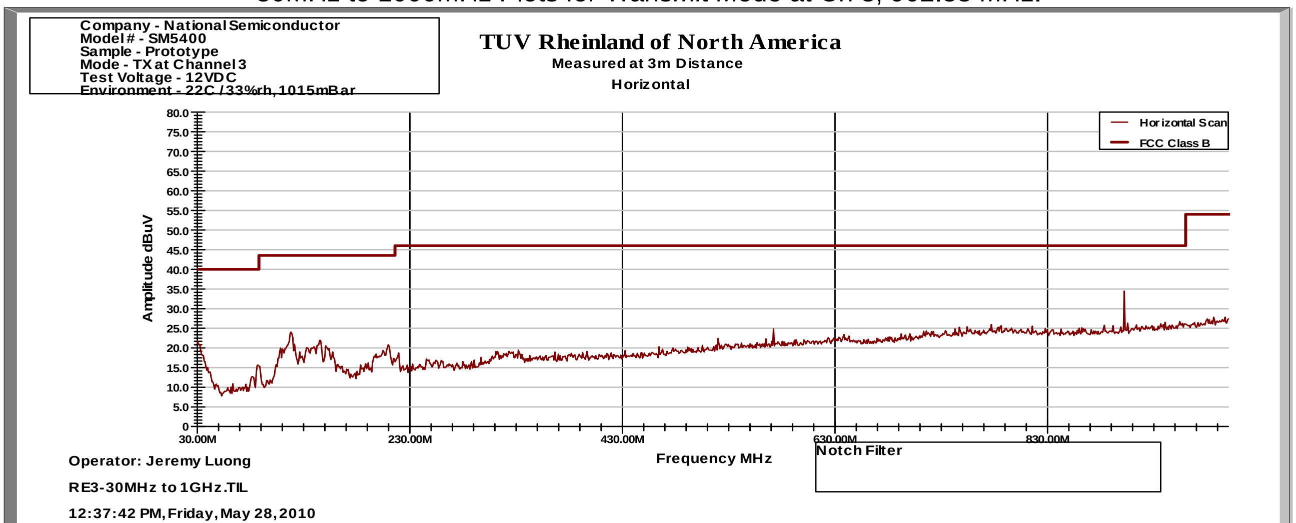
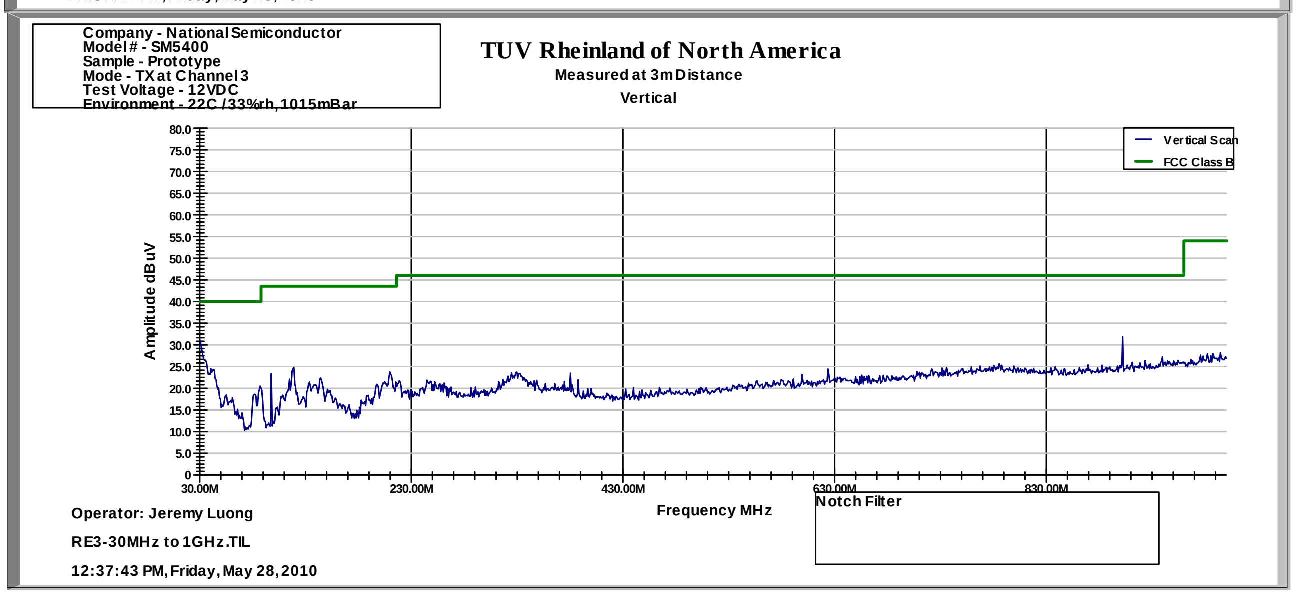
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line DC**	12 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz Plots for Transmit Mode at Ch 3, 902.33 MHz.





Notes: None.

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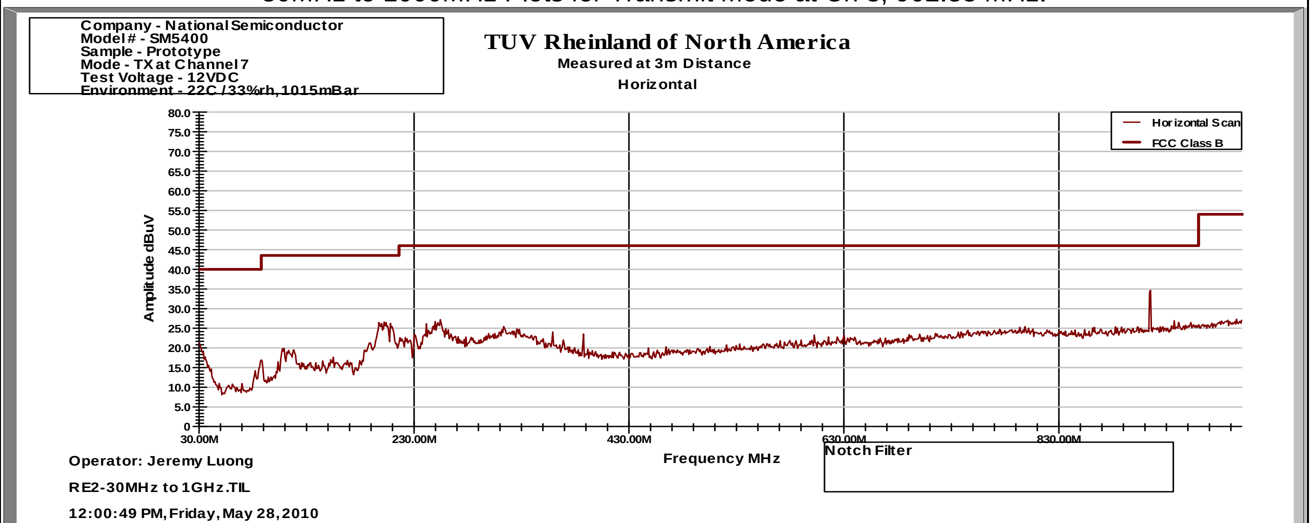
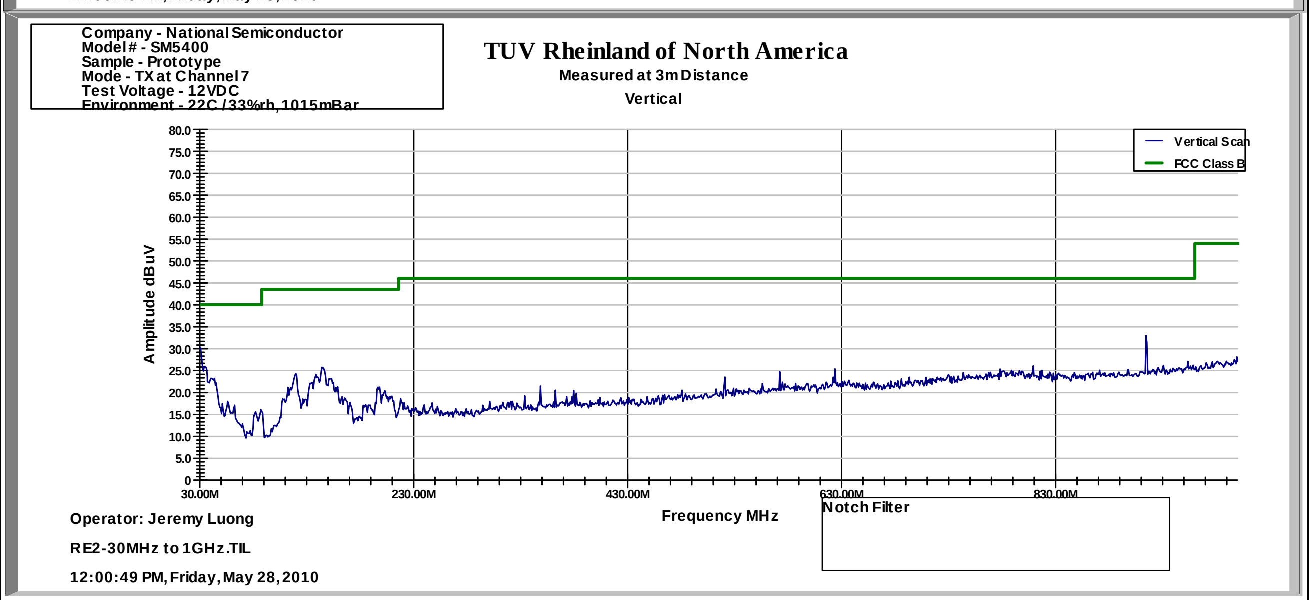
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	21° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line AC**	120 Vac 60 Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1MHz / 3 MHz
Dist/Ant Used	3m / EMCO3115	**Performed by**	Jeremy Luong

30MHz to 1000MHz Plots for Transmit Mode at Ch 3, 902.33 MHz.





Notes: None

SOP 1 Radiated Emissions

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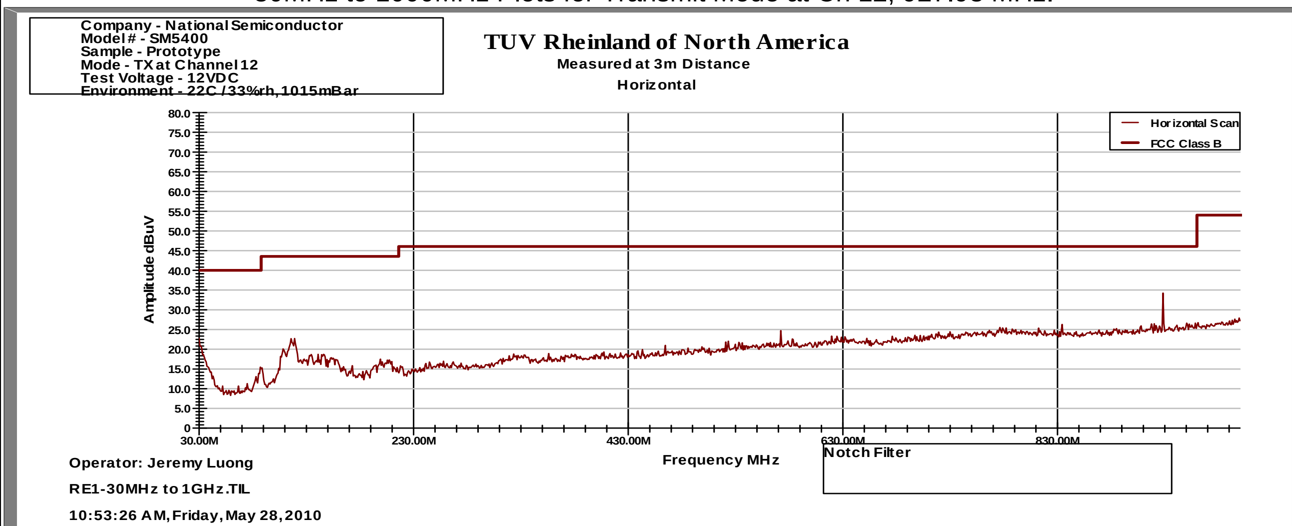
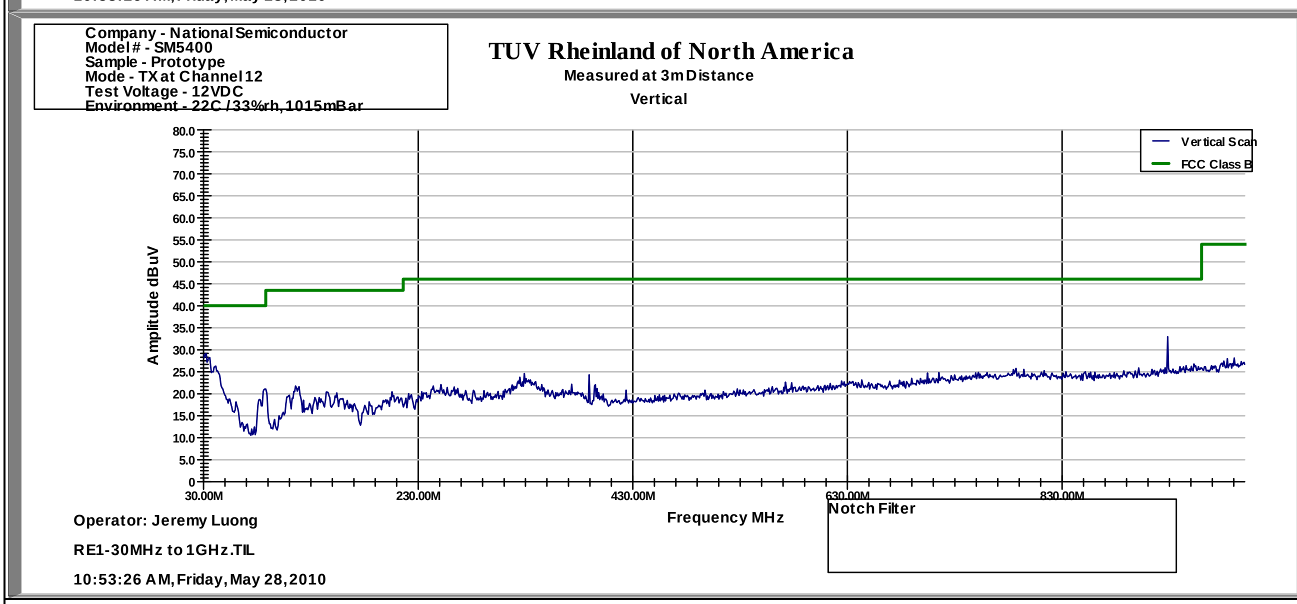
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	21° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line AC**	120 Vac 60 Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1MHz / 3 MHz
Dist/Ant Used	3m / EMCO3115	**Performed by**	Jeremy Luong

30MHz to 1000MHz Plots for Transmit Mode at Ch 12, 927.93 MHz.





Notes: None

4.6 Receiver Spurious Emissions

Receiver spurious emissions are emissions at any frequency when the equipment is in receive mode.

The spurious emissions of the receiver shall not exceed the values in CFR47 15.109, RSS-GEN Sect.7.2.3

4.6.1 Test Methodology

4.6.1.1 Preliminary Test

A test program that controls instrumentation and data logging was used to automate the preliminary RF emission test procedure. The frequency range of interest was divided into sub-ranges to yield a frequency resolution of approximately 120 kHz and provide a reading at each frequency for no more than 12° of turntable rotation. For each frequency sub-range the turntable was rotated 360° while peak emission data was recorded and plotted over the frequency range of interest in horizontal and vertical antenna polarization's.

Preliminary emission profile testing was performed inside the anechoic chamber. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the floor. The EUT was positioned as shown in the setup photographs. The receiving antenna was placed at a distance of 3m at a fixed height of 1m. Measurement equipment was located outside of the chamber. A video camera was placed inside the chamber to view the EUT.

Preliminary scans performed with EUT positioned in 3 orthogonal axes: Z-Axis was worst.

4.6.1.2 Final Test

For each frequency measured, the peak emission was maximized by manipulating the receiving antenna from 1 to 4 meters above the ground plane and placing it at the position that produced the maximum signal strength reading. The turntable was then rotated through 360° while observing the peak signal and placing the EUT at the position that produced maximum radiation. The six highest emissions relative to the limit were measured unless such emissions were more than 20 dB below the limit. If less than six emissions are within 20 dB of the limit, than the noise level of the receiver is measured at frequencies where emissions are expected. Multiples of all oscillator and microprocessor frequencies were also checked.

Final testing was performed on an NSA compliant test site. The EUT was placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane. The placement of EUT and cables were the same as for preliminary testing and is shown in the setup photographs.

The final scans performed on Channel 6: 914.934 MHz with EUT positioned along Z-Axis.

4.6.1.3 Deviations

None.

4.6.2 Receiver Spurious Emission Limit

The spurious emissions of the receiver shall not exceed the values in CFR47 15.109: 2010 and RSS 210:2007 Section 2.6.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490......................	2400/F(kHz)	300
0.490-1.705......................	24000/F(kHz)	30
1.705-30.0.......................	30	30
30-88............................	100 **	3
88-216...........................	150 **	3
216-960..........................	200 **	3
Above 960........................	500	3

4.6.3 Test Results

The final measurement data indicates the worst case operating modes, configurations, and/or cable positions. It also reflects the results including any modifications and/or special accessories listed in Sections 1.4 and 1.5.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.6.3.1 Final Data

The data recorded in this section contains the final results under the worst-case conditions and without any modifications or special accessories implemented as the manufacturer intends.

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EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line / Freq**	12 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3 and EMCO3115	**Performed by**	Jeremy Luong

Emission Freq (MHz)	ANT Polar (H/V)	ANT Pos (cm)	Table Pos (deg)	FIM (Pk) Pk (dBuV/m)	FIM QP/Ave (dBuV/m)	Total CF dBuV	E-Field QP/Ave (dBuV/m)	Spec Limit (dBuV/m)	Spec Margin (dB)	Type
Receive Mode at Ch 7, 914.934 MHz.										
42.15	V	107	20	34.54	31.19	-12.15	19.04	40.00	-20.96	Spurious
117.34	V	125	19	28.82	25.45	-10.11	15.34	43.52	-28.18	Spurious
389.14	V	112	77	25.54	19.48	-7.14	12.34	46.02	-33.68	Spurious
117.22	H	392	326	32.22	27.86	-10.13	17.73	43.52	-25.79	Spurious
5487.45	V	92	20	42.69	39.72	6.81	46.52	53.98	-7.46	Spurious
5487.46	H	151	0	38.94	30.68	6.81	37.49	53.98	-16.49	Spurious

Spec Margin = E-Field QP/Ave - Limit, E-Field QP = FIM QP/Ave+ Total CF ± Uncertainty
Total CF= Amp Gain + Cable Loss + ANT Factor

Combined Standard Uncertainty $u_c(y)$ = ± 1.6dB Expanded Uncertainty $U = ku_c(y)$ k = 2 for 95% confidence

Notes: Tested on the Z-Axis.

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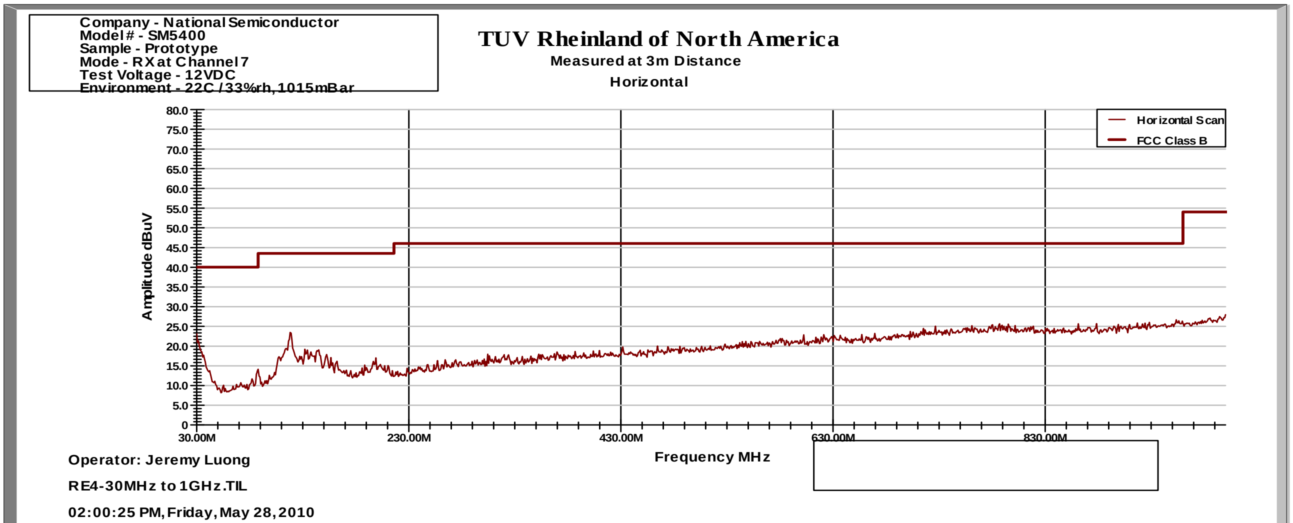
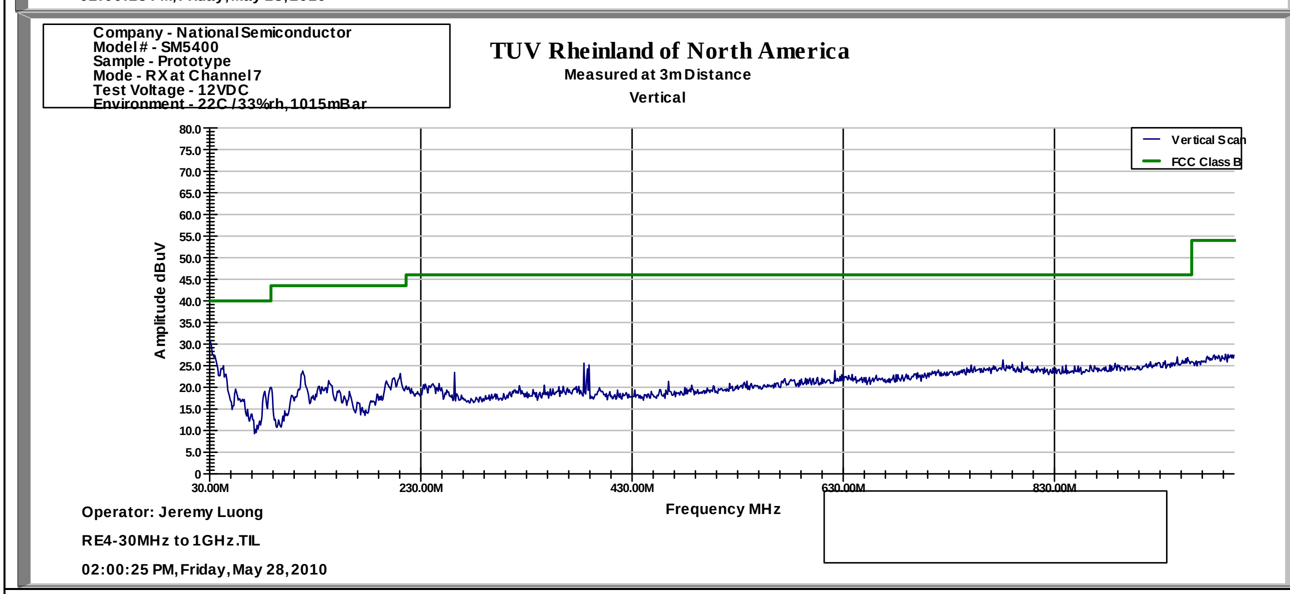
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	22° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line DC**	12 Vdc
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	120kHz / 300kHz
Dist/Ant Used	3m / JB3	**Performed by**	Jeremy Luong

30MHz to 1000MHz Plots for Receive Mode

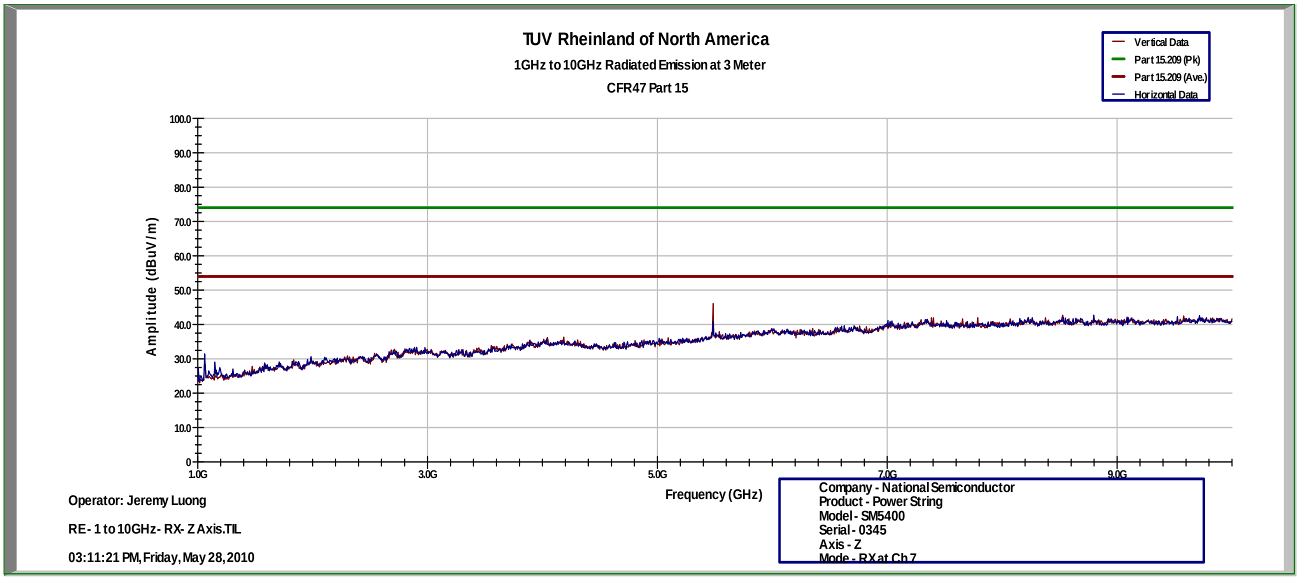




Notes: None.

SOP 1 Radiated Emissions		Tracking # 31051011.001 Page 3 of 3	
EUT Name	SolarMagic ™ PowerString Optimizer	**Date**	May 28, 2010
EUT Model	SM5400	**Temp / Hum in**	21° C / 33% rh
EUT Serial	48311A925N0345	**Temp / Hum out**	N/A
EUT Config.	Attached Antenna on Z-Axis	**Line AC**	120 Vac 60 Hz
Standard	CFR47 Part 15 Subpart C	**RBW / VBW**	1MHz / 3 MHz
Dist/Ant Used	3m / EMCO3115	**Performed by**	Jeremy Luong

Above 1GHz Plot for Receive Mode



Notes: None

4.7 Conducted Emissions per CFR47 Part 15.207

Testing was performed in accordance with ANSI C63.10:2009, RSS-210:2007. These test methods are listed under the laboratory's NVLAP Scope of Accreditation.

This test measures the levels emanating from the EUT, thus evaluating the potential for the EUT to cause radio frequency interference to other electronic devices.

4.7.1 Test Methodology

A test program that controls instrumentation and data logging was used to automate the AC Power Line Conducted emission test procedure. The frequency range of interest was divided into sub-ranges such as to yield a frequency resolution of 9 kHz. For each frequency sub-range, each phase and neutral of the AC power line were measured with respect to ground. Measurements were performed using a set of 50μH / 50Ω LISNs.

Testing is either performed in the semi-anechoic chamber or in EMC Lab 5. The setup photographs clearly identify which site was used. The vertical ground plane used in the semi-anechoic chamber is a 2m x 2m solid aluminum frame and panel and is bonded to the horizontal ground plane.

In the case of tabletop equipment, the EUT is placed on a 1.0m x 1.5m non-conductive table 80cm above the ground plane and 40cm from a vertical ground reference plane. The rear of the EUT was positioned flush with the backside of the table and directly over the LISNs. The power and I/O cables were routed over the edge of the table and bundled approximately 40cm from the ground plane. Support equipment was powered from a separate LISN.

4.7.1.1 Deviations

There were no deviations from this test methodology.

4.7.2 Test Results

The EUT is compliant to the requirements of the test standard(s) since it does not connect to the public utility network.

4.8 Maximum Permissible Exposure

4.8.1 Test Methodology

In this document, we try to prove the safety of radiation harmfulness to the human body for our product. The limit for Maximum Permissible Exposure (MPE) specified in FCC 1.1310 is followed. The Gain of the antenna used in this product is measured in a Semi-Anechoic Chamber, and also the maximum total power input to the antenna is measured. Through the Friis transmission formula and the maximum gain of the antenna, we can calculate the distance, away from the product, where the limit of MPE is reached.

Although the Friis transmission formula is a far field assumption, the calculated result of that is an over-prediction for near field power density. We will take that as the worst case to specify the safety range.

4.8.2 RF Exposure Limit

According to FCC 1.1310 table 1: The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in 1.1307(b)

LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm^2)	Average Time (minutes)
(A)Limits For Occupational / Control Exposures				
300-1500	…	…	F/300	6
1500-100,000	…	…	5	6
(B)Limits For General Population / Uncontrolled Exposure				
300-1500	…	…	F/1500	6
1500-100,000	…	…	1.0	30

F = Frequency in MHz

4.8.3 EUT Operating Condition

The software provided by Manufacturer enabled the EUT to transmit data at lowest, middle and highest channel individually.

4.8.4 Classification

The antenna of the product, under normal use condition, is at least 20cm away from the body of the user/ operator. Warning statement to the user for keeping at least 20cm or more separation distance with the antenna should be included in users manual.

4.8.5 Test Results

4.8.5.1 Antenna Gain

The transmitting antenna was integrated. The antenna gain was +0.23 dBi or 1.05 (numeric).

4.8.5.2 Output Power into Antenna & RF Exposure value at distance 20cm:

Calculations for this report are based on highest power measurement.

Limit for MPE (from FCC part 1.1310 table1) is 1.0 mW/cm^2

The highest measured field strength at 3 meter distance is +93.8 dBuV/m.

The calculated EIRP is -1.4287dBm or 0.7196mW

Using the Friss transmission formula, the EIRP is Pout*G, and R is 20cm.

Pd = (0.7196) / (1600π) = 0.000143mW/cm2, which is 0.99985 mW/cm2 below to the limit.

As originally tested, the EUT was found to be compliant to the requirements of the test standard(s).

4.8.6 Sample Calculation

The Friis transmission formula: $Pd = (Pout*G) / (4*\pi*R^2)$

Where;

Pd = power density in mW/cm2
Pout = output power to antenna in mW
G = gain of antenna in linear scale
π ≈ 3.1416
R = distance between observation point and center of the radiator in cm

Ref. : David K. Cheng, *Field and Wave Electromagnetics*, Second Edition, Page 640, Eq. (11-133).

5 Test Equipment Use List

Equipment	Manufacturer	Model #	Serial/Inst #	Last Cal dd/mm/yy	Next Cal dd/mm/yy
Bilog Antenna	Sunol Science	JB3	A102606	02/18/10	02/18/11
Antenna Bilog	Sunol Science	JB3	A061907	05/14/10	05/14/12
Tuned Dipole Antenna	A.H Systems, Inc.	TDS-200/535-1	154	01/09/09	01/09/11
Tuned Dipole Antenna	A.H Systems, Inc.	TDS-200/535-2	154	01/09/09	01/09/11
Tuned Dipole Antenna	A.H Systems, Inc.	TDS-200/535-3	154	01/09/09	01/09/11
Tuned Dipole Antenna	A.H Systems, Inc.	TDS-200/535-4	154	01/09/09	01/09/11
Antenna Horn (1-18GHz)	EMCO	3115	9602-4676	07/03/08	07/03/10
Antenna Horn (1-18GHz)	EMCO	3115	9710-5301	07/03/08	07/03/10
EMI Receiver	Hewlett Packard	8546A	3325A00168	10/29/09	10/29/10
Preselector	Hewlett Packard	85460A	3330A00174	10/29/09	10/29/10
Amplifier	Hewlett Packard	8447D	2944A07996	01/21/10	01/21/11
Spectrum Analyzer	Rhode&Schwarz	ESIB	100180	08/19/09	08/19/10
Amplifier	Rhode&Schwarz	TS-PR18	100019	06/14/08	09/14/10
Amplifier	Rhode&Schwarz	TS-PR26	100011	06/14/08	09/14/10
Signal Generator	Anritsu	MG3694A	42803	09/19/09	09/19/10
Thermo Chamber	Associated Environmental	SK-3102	5999	01/22/10	01/22/11
Notch Filter	Micro-Tronics	BRM50706	001	01/22/10	01/22/11
Power Supplier	Kikosui	PCR8000W	CM000912	01/18/10	01/18/11
Digital Multimeter	Fluke	83 III	84590116	01/21/10	01/21/11
Thermometer	Fluke	52II	88650033	10/16/09	10/16/10

6 EMC Test Plan

6.1 Introduction

This manufacturer-supplied document provides a description of the Equipment Under Test (EUT), configuration(s), operating condition(s), and performance acceptance criteria. It is intended to provide the test laboratory with the essential information needed to perform the requested testing.

6.2 Customer

The information in the following tables is required, as it should appear in the final test report.

Table 7 – Customer Information

Company Name	National Semiconductor
Address	2900 Semiconductor Drive
City, State, Zip	Santa Clara, CA 95051
Country	USA
Phone	(408) 721-2857
Fax	(408) 736-8503

Table 8 – Technical Contact Information

Name	Steven Kim
E-mail	Steven.Kim@nsc.com
Phone	(408) 721-2857
Fax	(408) 736-8503

6.3 Equipment Under Test (EUT)

The information provided in the following table should be listed as it should appear in the final report. For those products that have only a model name, list the model number as *non-applicable* and vice-versa.

Table 9 – EUT Designation

Product Name	SolarMagic ™ PowerString Optimizer
Model Number	SM5400
System Name	NA
Product Description	The SolarMagic PowerString optimizer is designed to address real-world problems facing PV arrays. These include shading and module-to-module mismatching which could adversely affect the performance and efficiency of the array. PowerString optimizers provide power optimization and monitoring/management for a string level solution.

6.3.1 Product Specifications

The information provided in the following table should be listed as it should appear in the final report.

Table 10 – EUT Specifications

Dimensions	5.9"H 25"W 9.4"D
Power Rating	Operating Voltage: 150 - 1000Vac Current Rating: 9.3A RF Circuit Operating Voltage: 12 Vdc
Environment	Outdoor
Operating Temperature Range:	-20 to +55 degrees C
Multiple Feeds:	☐ Yes and how many ☒ No
Operating Frequency	902.33 MHz, 910.49 MHz, 914.934 MHz, 927.93 MHz.
Transmitter Frequency Band	902 MHz to 928 MHz (GFSK)
Rated Power Output	+13.98 dBm
Nos. of Channel	4
Antenna Type	Capacitive (Attached)

Antenna Gain	0.23 dBi
Modulation Type	☐ AM ☐ FM ☐ Phase ☒ Other describe: GFSK
Firmware Version	Production – V3.0.10313 Manufacturing Test – V3.0.10326 Serializer – V3.0.10326 LinkServer and LinkClient – V2.2.10326
Type of Equipment	☐ Table Top ☒ Wall-mount ☐ Floor standing cabinet ☒ Other *describe :roof/pole-mount*

6.3.2 Interface Specifications

Table 11 – Interface Specifications

Interface Type	Cabled with what type of cable?	Is the cable shielded?	Maximum potential length of the cable?	Metallic (M), Coax (C), Fiber (F), or Not Applicable?
Array -	PV	☒ No	☒ Metric: 10m	☒ M
Array +	PV	☒ No	☒ Metric: 10m	☒ M
String +	PV	☒ No	☒ Metric: 10m	☒ M
String -	PV	☒ No	☒ Metric: 10m	☒ M

6.3.3 Configuration(s)

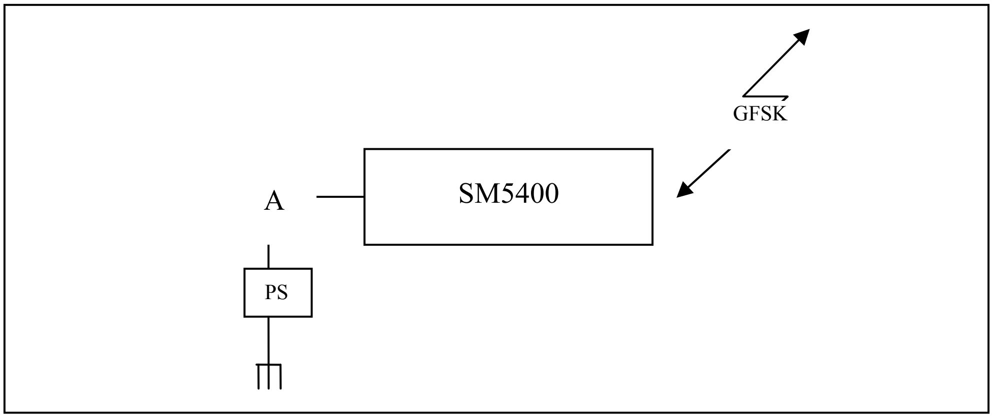


Figure 17 - Block Diagram of EUT Set-Up

Table 12 – Equipment Shown in Block Diagram

Equipment	Manufacturer	Model	Serial	Used for
Power String Optimizer	National Semiconductor	SM5400	48311A925N0345	Device under test
DC Power Supply	Agilent	RS-15-5	RA93067939	Supply DC Voltage

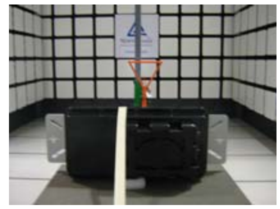
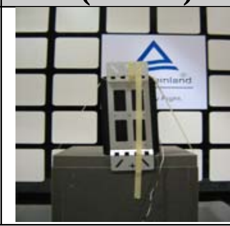
Table 13 – Cables Shown in Block Diagram

Des.	Cable Name	Port Reference
A	DC Power	2-conductor DC cable

Table 14: Description of Sample used for Testing

Device	Serial	Configuration	Used For
SM5400	48311A925N0345	Sample (w/ UFL Connector)	All applicable tests in the standard

Table 15: Description of Test Configuration used for Radiated Measurement.

Device	Antenna	Mode	Setup Photo (X-Axis)	Setup Photo (Y-Axis)	Setup Photo (Z-Axis)
SM5400	Attached	Transmit & Receive			

6.4 Test Specifications

The information provided in the following table should be provided as you would like the product to be evaluated if different from the requirements of the standard.

Table 16 – EUT Designation

Emissions and Immunity	
Standard	Requirement
CFR47 Part 15.249:2010	All