

# RF EMISSIONS FROM SMART GRID ELECTRIC METERS, HAN DEVICES, AND THEIR RELATIONSHIP TO THE FCC MAXIMUM PERMISSIBLE EXPOSURE LIMIT (MPE)

PREPARED FOR



BY



Gordon W. Hudson  
20<sup>th</sup> September 2012

## Table of Contents

1. Executive Summary.....	4
a) Summary Table for Residential Location .....	5
b) Summary Table for Commercial Location .....	5
2. Scope & Purpose .....	6
3. RF Restrictions .....	6
4. Radiation.....	6
5. Maximum Permissible Exposure (MPE) %.....	7
a) FCC Table on Radio Frequency Radiation Exposure Limits .....	7
6. Test Equipment.....	8
7. Common RF Emitters – Spectrum Analysis Mode .....	9
8. Common RF Emitters – Safety Evaluation Mode .....	11
9. PSO gridSMART® MPE Test Details .....	12
c) Locations.....	12
d) Test Criteria .....	12
e) PSO Test Locations & Modes Overview.....	12
10. PSO gridSMART® MPE Test Results .....	13
a) Commercial Location.....	13
b) Residential Location .....	17
11. Comparative Results .....	22
a) Overall MPE results graph summary (logarithmic).....	22
b) Overall MPE results graph summary (linear) .....	23
12. Conclusions .....	24
13. Other Resources .....	25
a) Technical References .....	25
b) Similar Reports .....	25
14. Equipment Certification & Calibration Information .....	26
a) 3-Axis Antenna Calibration Documentation .....	27
b) Antenna Cable Calibration Documentation .....	29
c) SRM-3000 Selective Radiation Meter Calibration Documentation .....	31

## Table of Figures

Figure 1 - FCC MPE limits.....	7
Figure 2 - Narda SRM-3000, Stock Photo.....	8
Figure 2 - Cell Phone Emission, Max Hold mode @ 1cm distance. ....	9
Figure 3 - Microwave Oven, Full Power, Max Hold mode @ 1cm. ....	10
Figure 4 - SRM-3000 Example Screenshot in Safety Eval mode.....	11
Figure 5 - Common RF Emitters, % of MPE .....	11
Figure 6 - Commercial Location Layout ( <i>not to scale</i> ) .....	13
Figure 7 - Commercial Location MPE levels .....	13
Figure 8 - Commercial Location "A", Meter Rear .....	14
Figure 9 - Commercial Location "B", in store .....	15
Figure 10 - Commercial Location "C", Meter Front .....	16
Figure 11 - Residential Location Layout ( <i>not to scale</i> ) .....	17
Figure 12 - Residential Location MPE levels .....	18
Figure 13 - Residential Location "B", at thermostat.....	19
Figure 14 - Residential Location "C", Meter Rear .....	20
Figure 15 - Residential Location "D", Meter Front .....	21
Figure 16 - Overall MPE results, logarithmic.....	22
Figure 17 - Overall MPE results, linear .....	23

## 1. Executive Summary

This report was prepared with certified, calibrated National Institute of Standards equipment using techniques similar, where practical, with FCC best practices for measuring RF Emissions. The standard for comparison is the FCC Maximum Exposure Limit for the General Population Exposure FCC 47 CFR 1.1301-1.1310.

Testing indicates RF emissions from PSO's Smart Grid systems are from hundreds to thousands of times lower than the FCC Maximum Permissible Exposure limit (MPE) when in normal use. The emissions measured inside residences or businesses equipped with the Smart Grid system are over 100 times less than a standard cell phone, over 1000 times less than exposure standing in front of a microwave oven, and are often so low they cannot be discerned from common background RF emission sources such WiFi and cordless phones.

To gain useful data, two test modes were used.

- Regular (normal use) transmission mode
  - Units were measured over a 30 minute period with no system intervention, as per the FCC MPE limits for the general population.
- Worst case transmission mode
  - Units were forced into constant activity by repeatedly requiring a firmware upgrade, which creates excessive data traffic, which in turn creates higher than normal RF emission levels to determine the maximum possible level of RF emissions. Tests were performed for 30 minutes.

Again, for the thermostats or HAN devices, two similar test modes were employed.

- Regular (normal use) transmission mode
  - Units were measured over a 30 minute period with no system intervention, as per the FCC MPE limits for the general population.
- Worst case transmission mode
  - Thermostat was continually accessed, creating excessive data traffic, which in turn creates higher than normal RF emission levels to determine the maximum possible level of RF emissions. Tests were performed for 30 minutes.

The tests were conducted in both residential and commercial locations to measure a variety of ambient conditions. The Maximum Permissible Exposure levels, established by the FCC, noted below in Figure 1, are relative to 100%. For example, an individual standing in residential location "A", for 900 MHz, would experience 0.0033632% of the Maximum Permissible Exposure. The summary of all results noted on the following page.

**a) Summary Table for Residential Location**

Residential Location	Meter Mode	MPE Level (%)	SRM-3000 Mode
Ambient Testing 2.4GHz band at Location "A", living area.	Normal Use Mode	0.04232	AVERAGE 30m
Ambient Testing 900MHz band at Location "A", living area.	Normal Use Mode	0.0033632	AVERAGE 30m
2.4GHz at Thermostat, at Location "B"	Querying Thermostat	0.056284	MAX (PEAK) HOLD
2.4GHz at Thermostat, at Location "B".	Querying Thermostat	0.042471	AVERAGE 1m
2.4GHz at Meter, at Location "D".	Querying Thermostat	0.043705	AVERAGE 1m
2.4GHz at Meter, at Location "D".	Querying Thermostat	1.5727	MAX (PEAK) HOLD
900MHz at Meter while FW upgrade at Location "D"	Firmware Upgrade Mode	1.3348	AVERAGE 30m
900MHz behind Meter while FW upgrade at Location "C".	Firmware Upgrade Mode	0.004229	AVERAGE 30m
900MHz while FW upgrade at Location "A".	Firmware Upgrade Mode	0.0034023	AVERAGE 30m

**b) Summary Table for Commercial Location**

Commercial Location	Meter Mode	MPE Level (%)	SRM-300 Mode
QuickTrip Location "A" - behind meter.	Normal Use Mode	0.0002667	AVERAGE 30m
QuickTrip Location "A" - behind meter.	Firmware Upgrade Mode	0.0034668	AVERAGE 30m
QuickTrip Location "B" - middle of store.	Firmware Upgrade Mode	0.0033571	AVERAGE 30m
QuickTrip Location "C" - Outside, close to meter.	Firmware Upgrade Mode	0.10847	AVERAGE 30m
QuickTrip Location "C" - Outside, close to meter.	Normal Use Mode	0.0038079	AVERAGE 30m

## 2. Scope & Purpose

So-called “*smart grid*” meters read the amount of electric consumption per customer and communicate that information back to the utility on a regular basis, often in real time.

In addition to Automatic Meter Reading (AMR) these devices perform as part of an Advanced Metering Infrastructure (AMI) network, capable of bidirectional communication with the utility and customer’s equipment via HAN (Home Area Network) devices, such as room thermostat controls.

The scope & purpose of this document is to provide RF emission data from real-world testing of these devices against the FCC Maximum Permissible Exposure Limit, or MPE, and compare it to data collected from other common RF devices.

## 3. RF Restrictions

The Federal Communications Commission (FCC) has established restrictions on exposure to Radio Frequency (RF) radiation to protect the public and the environment. One of these restrictions is known as the MPE, or Maximum Permissible Exposure limit. This is measured in percent, with 100% being the maximum. Anything over 100% of the Maximum Permissible Exposure limit is in violation of this restriction and will not be granted an FCC license to operate.

## 4. Radiation

This word is unnerving to most, but it is very important to distinguish between the different types, and clarify this term.

*Non-Ionizing Radiation* – These are electromagnetic waves of a relatively low frequency, such as radio waves, infra-red rays, and microwaves which do not possess enough energy to remove electrons from atoms. No health risks are known from non-ionizing radiation.

*Ionizing Radiation* – These are electromagnetic waves of relatively high frequency, such as particles and rays emitted by radioactive materials, and x-rays, which possess enough energy to strip electrons from atoms (ionize them), can damage DNA structure and can contribute to cancer, and other adverse health effects.

## 5. Maximum Permissible Exposure (MPE) %

The FCC has two different limits imposed for MPE. Occupational, or Controlled exposure and General Population, or Uncontrolled Exposure. Formulae for calculating Power Density, and therefore MPE, are frequency-dependent. The lowest frequency of operation is always used.

For the purposes of this paper, we are concerned with two frequency bands – 900MHz (Power Density limit of  $[902/300]\text{mW}/\text{cm}^2$ ) and 2.4GHz (Power Density Limit of  $5\text{mW}/\text{cm}^2$ ) – and the General Population, or Uncontrolled exposure limit, which is averaged over a 30 minute time span.

### a) FCC Table on Radio Frequency Radiation Exposure Limits

#### (A) Limits for Occupational/Controlled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) ( $\text{mW}/\text{cm}^2$ )	Averaging Time $ E ^2$ , $ H ^2$ or S (minutes)
0.3-3.0	614	1.63	(100)*	6
3.0-30	$1842/f$	$4.89/f$	$(900/f^2)^*$	6
30-300	61.4	0.163	1.0	6
300-1500	--	--	$f/300$	6
1500-100,000	--	--	5	6

#### (B) Limits for General Population/Uncontrolled Exposure

Frequency Range (MHz)	Electric Field Strength (E) (V/m)	Magnetic Field Strength (H) (A/m)	Power Density (S) ( $\text{mW}/\text{cm}^2$ )	Averaging Time $ E ^2$ , $ H ^2$ or S (minutes)
0.3-1.34	614	1.63	(100)*	30
1.34-30	$824/f$	$2.19/f$	$(180/f^2)^*$	30
30-300	27.5	0.073	0.2	30
300-1500	--	--	$f/1500$	30
1500-100,000	--	--	1.0	30

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

Figure 1 - FCC MPE limits.

## 6. Test Equipment

The equipment used to detect RF emissions from equipment in this case is the SRM-3000 Selective Radiation Meter from Narda Safety Test Solutions (<http://www.narda-sts.us/>). Narda STS is a global leader in EM (Electromagnetic) Field test and measurement.

The equipment consists of an isotropic, three-axis antenna for pickup of radiated fields, and a base unit which houses the electronics to process the received fields and display them in a range of different formats, including spectrum analyzer displays and numbers in percent of MPE.

For these tests we are purely interested in the level of the emissions displayed in % MPE.

A remote antenna cable for the antenna is used for the tests. The signal loss created by using this cable is calculated out of the measurements automatically by the SRM-3000.



Figure 2 - Narda SRM-3000, Stock Photo



## 7. Common RF Emitters – Spectrum Analysis Mode

To create a point of reference, some common household RF emitting devices were scanned. This allows us to compare everyday existing RF emissions with RF emissions from AMI infrastructure. Spectrum Analyzer mode was used in these tests to give a graphic representation of the emissions.

### iPhone 4S, Full RX Signal @ 1 centimeter.

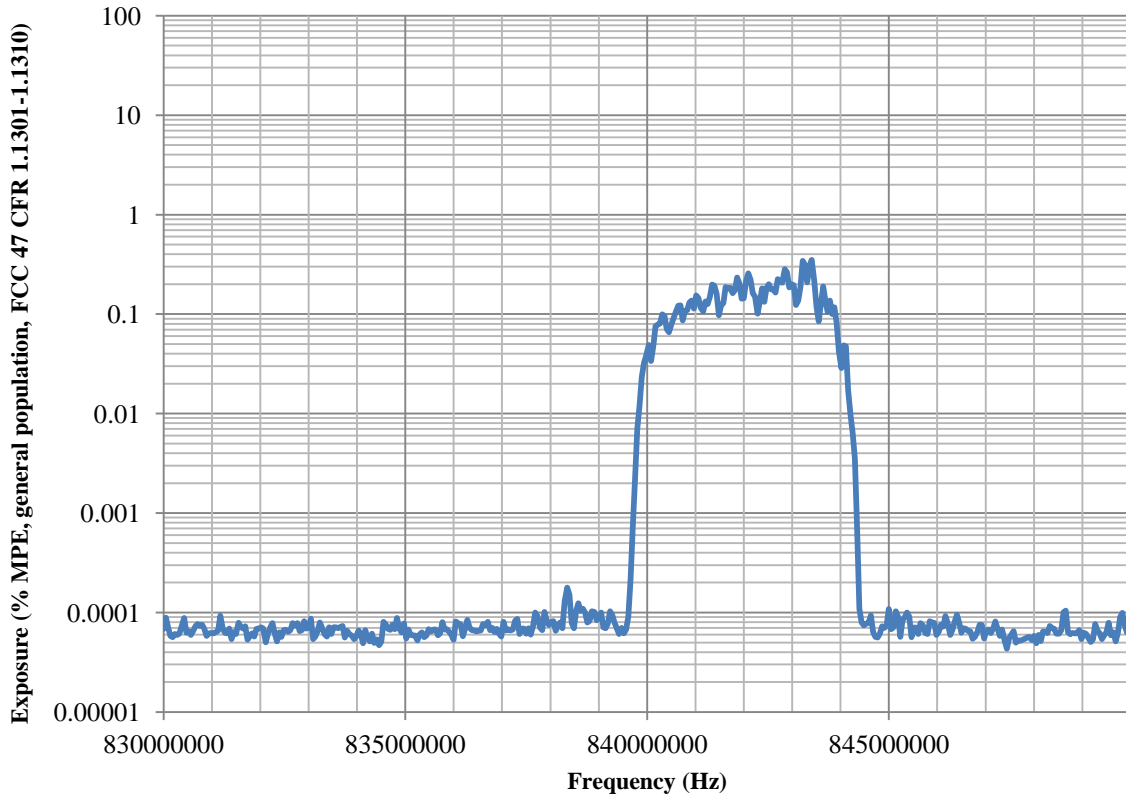


Figure 2 - Cell Phone Emission, Max Hold mode @ 1cm distance.

The above graph shows % MPE on the y-axis in a logarithmic scale, and frequency in Hz along the x-axis. The SRM-3000 was in MAX mode, which continuously monitors the frequencies selected and displays the maximum value detected at any given time or frequency.

As we can see, a common cell phone (iPhone 4S in this case) reaches around 0.35% of the MPE at its peak emission. This would be an invalid result, since the SRM-3000 was used in MAX mode, not Safety Evaluation Mode which detects MPE averaged over time. The cell phone had maximum receive signal (5 bars) at the time, so the transmitted emission should have been relatively low since cell phones vary their power in relation to receive signal.

### Microwave Oven, Full Power @ 1 centimeter.

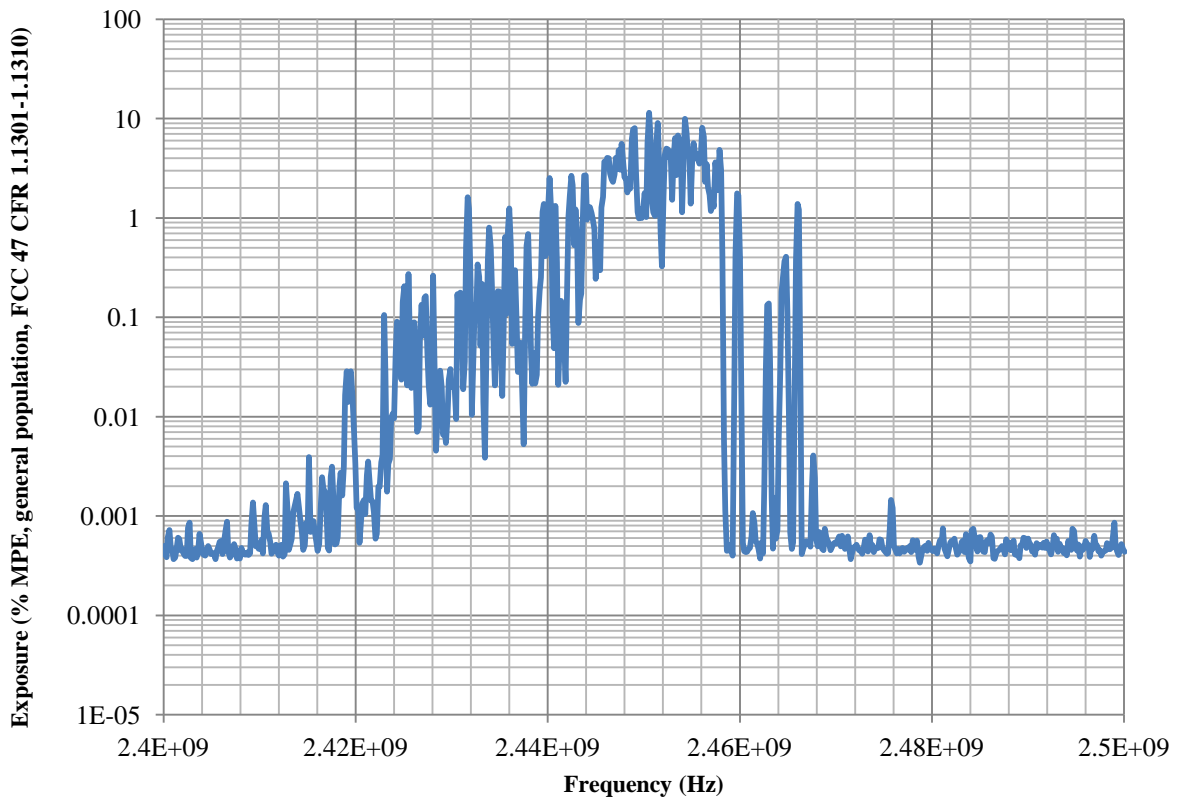


Figure 3 - Microwave Oven, Full Power, Max Hold mode @ 1cm.

In the same MAX mode, the peak emission from a microwave oven is very “dirty” compared to a cell phone, and it reaches almost 11.5% of the MPE at 1cm distance, which is similar to someone looking inside the oven to check on their food. Other MAX measurements around the door of the microwave oven yielded up to 20% of MPE. The oven was heating 1 standard cup of water during the test.

## 8. Common RF Emitters – Safety Evaluation Mode

The SRM-3000 Safety Evaluation mode is the most “meaningful” mode, since it gives MPE results in a simple percentage of the maximum (100%).

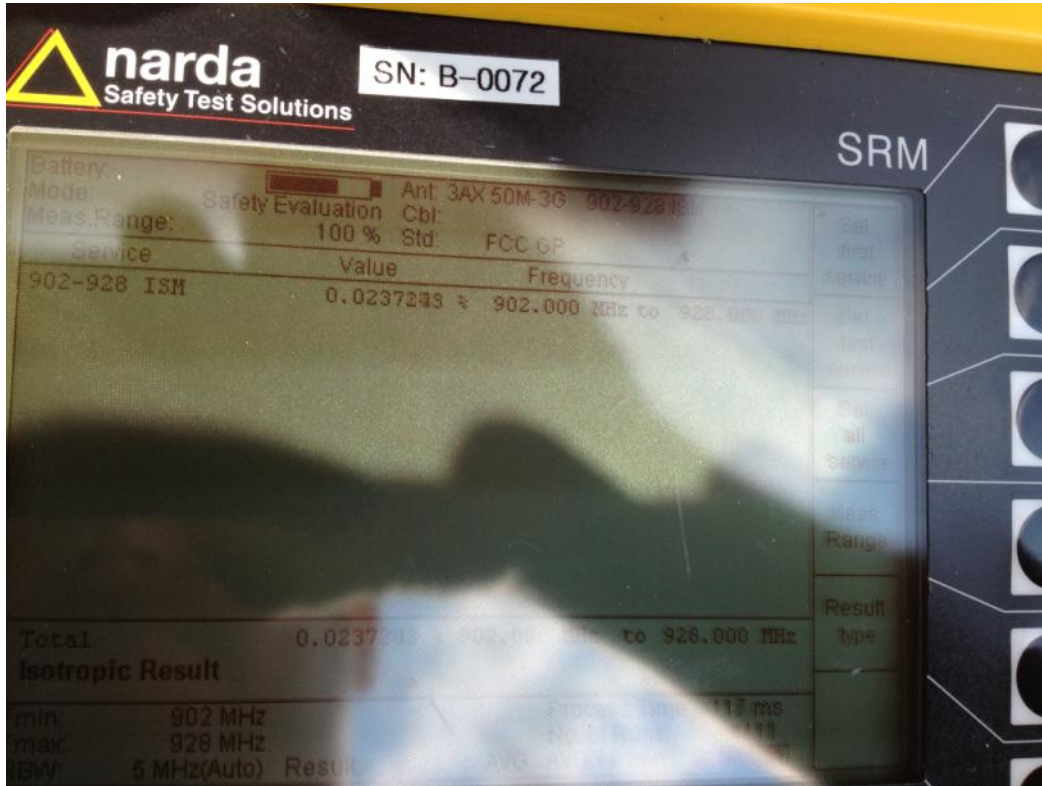


Figure 4 - SRM-3000 Example Screenshot in Safety Eval mode

Device	Distance	Averaging Time	% MPE
iPhone 4S Cell Phone	1 cm	2 minutes	0.23
Microwave Oven	1 cm	2 minutes	22.78
Microwave Oven	1 m	2 minutes	2.03

Figure 5 - Common RF Emitters, % of MPE

In Figure 5, the same devices were tested as in the “Common RF Emitters – Spectrum Analysis Mode” section, but now we are using the SRM-3000 in Safety Evaluation mode.

The FCC MPE limit for General Population specifies that the RF emissions be averaged over 30 minutes. These measurements were averaged over 2 minutes. However, this was enough time to gain a realistic result, since the cell phone is transmitting during the entire duration of a call, and the microwave oven cycled its magnetron on and off several times during the 2 minute cook time of 1 standard cup of water.

## 9. PSO gridSMART® MPE Test Details

### c) Locations

#### Commercial location:

QuikTrip, 11590 N 140th E Ave Owasso, OK 74055

Google Maps link: <http://goo.gl/maps/cJmHN>

#### Residential location:

PSO employee. Address withheld for privacy.

### d) Test Criteria

For close or near-field scans, the directions and angles around the equipment were scanned to find the direction of peak emission.

There is no practical way for us to measure peak emission locations in far-field areas (in areas occupied with people, for example) so the omnidirectional characteristic of the SRM-3000 antenna was utilized in these cases.

### e) PSO Test Locations & Modes Overview

#### Commercial locations:

The commercial location did not have a gridSMART thermostat control, and therefore no HAN. Only the meter emissions were tested at this location.

900MHz Test. SRM-3000 at Meter Rear, Meter in Normal Use mode.

900MHz Test. SRM-3000 at Meter Rear, Meter in Firmware Update mode.

900MHz Test. SRM-3000 in Store, Meter in Firmware Update mode.

900MHz Test. SRM-3000 at Meter Front, Meter in Firmware Update mode.

900MHz Test. SRM-3000 at Meter Front, Meter in Normal Use mode.

#### Residential locations:

The residence had the full gridSMART system – meter and thermostat control. Both the meter and thermostat emissions were tested at this location.

2.4GHz Test. SRM-3000 in living area, ambient 2.4GHz.

900MHz Test. SRM-3000 in living area, ambient 900MHz.

2.4GHz Test. SRM-3000 at Thermostat, 1 min max peak while being queried.

2.4GHz Test. SRM-3000 at Thermostat, 1 min average while being queried.

2.4GHz Test. SRM-3000 at Meter Front, 1 min average while querying thermostat.

2.4GHz Test. SRM-3000 at Meter Front, 1 min max peak while querying thermostat.

900MHz Test. SRM-3000 at Meter Front, Meter in Firmware Update mode.

900MHz Test. SRM-3000 at Meter Rear, Meter in Firmware Update mode..

900MHz Test. SRM-3000 in living area, Meter in Firmware Update mode.

## 10. PSO gridSMART<sup>®</sup> MPE Test Results

### a) Commercial Location

Three locations were chosen. Location “A” is the closest point anyone in the store would be to meter. This is a staff-only location in the storage area. Location “B” is a general location within the store. Location “C” is the meter location itself.

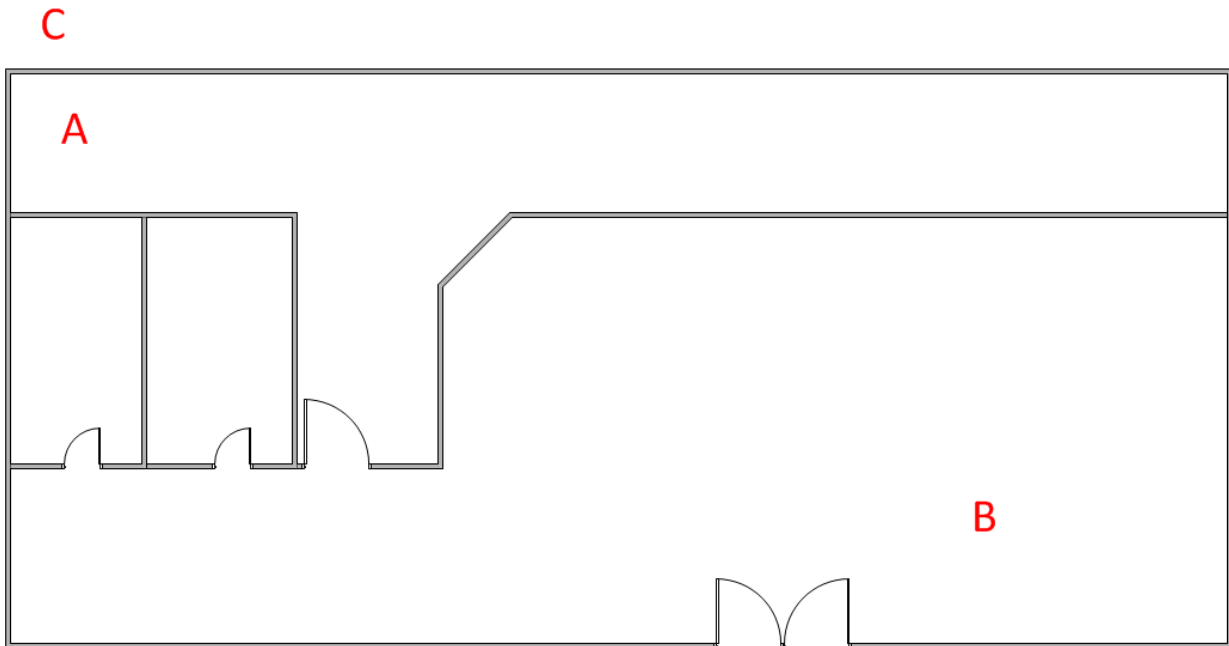


Figure 6 - Commercial Location Layout (*not to scale*)

Commercial Location	Meter Mode	MPE Level (%)	SRM-300 Mode
QuickTrip Location "A" - behind meter.	Normal Use Mode	0.0002667	AVERAGE 30m
QuickTrip Location "A" - behind meter.	Firmware Upgrade Mode	0.0034668	AVERAGE 30m
QuickTrip Location "B" - middle of store.	Firmware Upgrade Mode	0.0033571	AVERAGE 30m
QuickTrip Location "C" - Outside, close to meter.	Firmware Upgrade Mode	0.10847	AVERAGE 30m
QuickTrip Location "C" - Outside, close to meter.	Normal Use Mode	0.0038079	AVERAGE 30m

Figure 7 - Commercial Location MPE levels

Using the FCC guidelines for exposure (% MPE, general population, FCC 47 CFR 1.1301-1.1310) we can see that exposure in the store (Location “B”) is very low, at around three thousandths of one percent. The exposure level at worst case was around one tenth of one percent. The “worst case” scenario was created by finding the maximum emission level right at the meter and having the meter in “firmware upgrade” mode, which causes it to continuously receive and transmit on all channels in the FHSS mode. This is the highest possible emission the meter will create during its lifetime and testing all angles allows us to capture that emission.

The readings taken behind the meter are lower, most likely because of the RF shielding effect caused by the meter back, meter housing and brick wall.

*Commercial Test Location Photographs*

Location "A"



**Figure 8 - Commercial Location "A", Meter Rear**



Location "B"



Figure 9 - Commercial Location "B", in store



Location "C"



Figure 10 - Commercial Location "C", Meter Front



## b) Residential Location

Four locations were chosen. Location “A” in the living area, Location “B” at the HAN thermostat, Location “C” behind the meter, and Location “D” at the meter front. The plan of the residence is purely diagrammatic in order to show these locations.

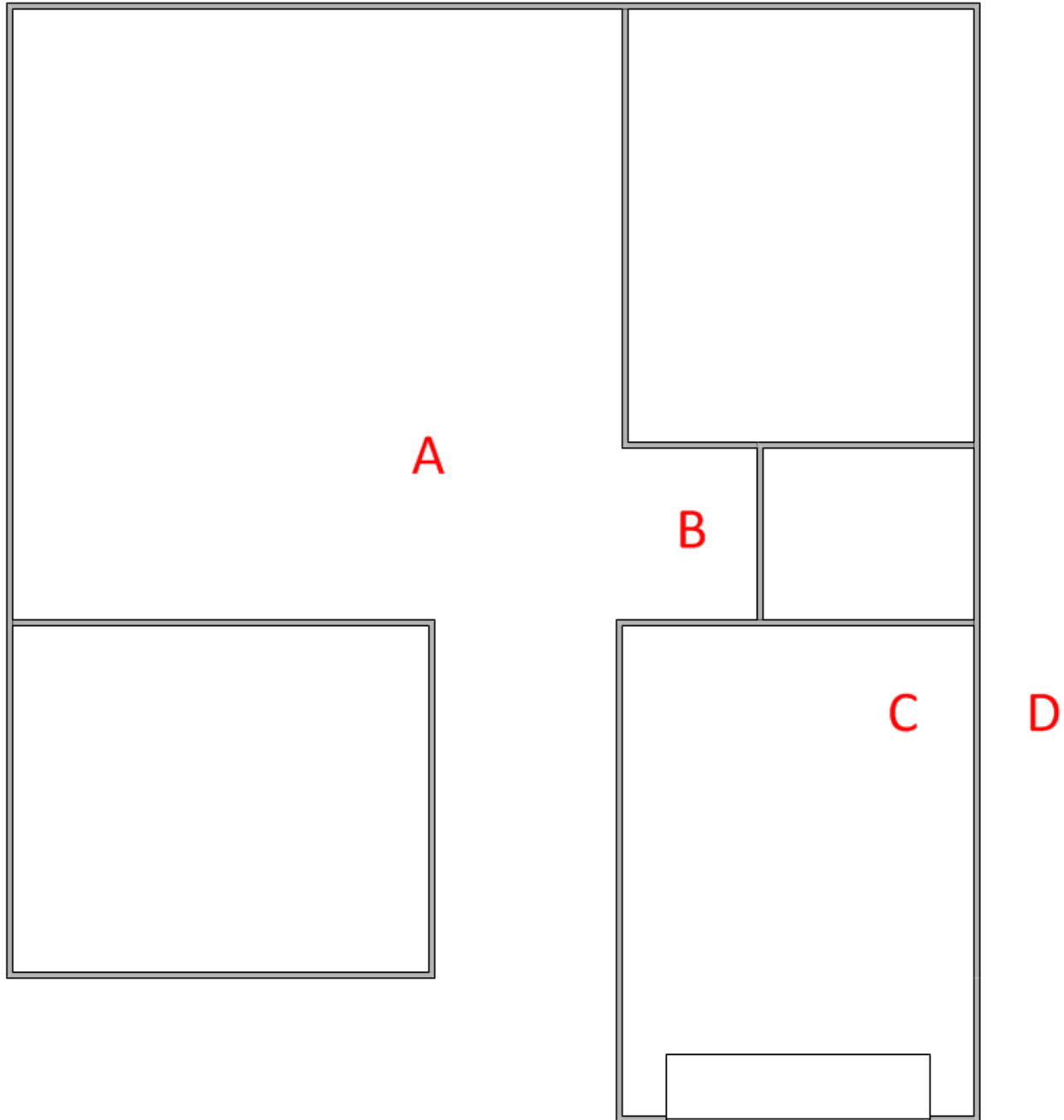


Figure 11 - Residential Location Layout (*not to scale*)

Residential Location	Meter Mode	MPE Level (%)	SRM-3000 Mode
Ambient Testing 2.4GHz band at Location "A", living area.	Normal Use Mode	0.04232	AVERAGE 30m
Ambient Testing 900MHz band at Location "A", living area.	Normal Use Mode	0.0033632	AVERAGE 30m
2.4GHz at Thermostat, at Location "B"	Querying Thermostat	0.056284	MAX (PEAK) HOLD
2.4GHz at Thermostat, at Location "B".	Querying Thermostat	0.042471	AVERAGE 1m
2.4GHz at Meter, at Location "D".	Querying Thermostat	0.043705	AVERAGE 1m
2.4GHz at Meter, at Location "D".	Querying Thermostat	1.5727	MAX (PEAK) HOLD
900MHz at Meter while FW upgrade at Location "D"	Firmware Upgrade Mode	1.3348	AVERAGE 30m
900MHz behind Meter while FW upgrade at Location "C".	Firmware Upgrade Mode	0.004229	AVERAGE 30m
900MHz while FW upgrade at Location "A".	Firmware Upgrade Mode	0.0034023	AVERAGE 30m

**Figure 12 - Residential Location MPE levels**

Using the FCC guidelines for exposure (% MPE, general population, FCC 47 CFR 1.1301-1.1310), the ambient RF background is 0.0033%, which is around three thousandths of one percent in the 900MHz band. It is over an order of magnitude higher in the 2.4GHz band in this residential area, at around four hundredths of one percent, mainly because of the proliferation of Wi-Fi in residential areas. Wireless routers most commonly operate in the 2.4GHz band, although this is changing somewhat with migration to the 5.8GHz band, driven by the demand for higher throughput.

### *Crowded Band*

Many other devices operate in this 2.4GHz ISM band. ISM (Industrial Scientific and Medical) bands were originally allocated and intended for just those applications. However, the main use of these ISM bands in recent decades has been for communications, wireless internet, Wi-Fi, cordless phones, etc. Microwave Ovens also operate in this 2.4GHz band. Some years ago, the 900MHz band was more popular than the 2.4GHz band, but there has been a migration to 2.4GHz and 5.8GHz, leaving the 900MHz band relatively quiet.

### *Disappearing HAN transmission?*

Since the 2.4GHz band is heavily used in populated areas and residential Wi-Fi is pervasive, it was impossible to discern any HAN signal between the meter and the thermostat from the ambient noise floor. For this reason, attempts to catch a transmission on the air, some "Max (Peak) Hold" measurements were performed, taken while the meter ← → thermostat communication was active. These measurements do not follow the FCC 30 minute averaging guidelines, and will be artificially high. Nevertheless, it was important to verify that the communications link was active, and that the signal levels were obliterated when detected using the averaging process.

*Residential Location Photographs*

Location "A" was not photographed, for privacy reasons.



**Figure 13 - Residential Location "B", at thermostat**



Figure 14 - Residential Location "C", Meter Rear





Figure 15 - Residential Location "D", Meter Front

# 11. Comparative Results

## a) Overall MPE results graph summary (logarithmic)

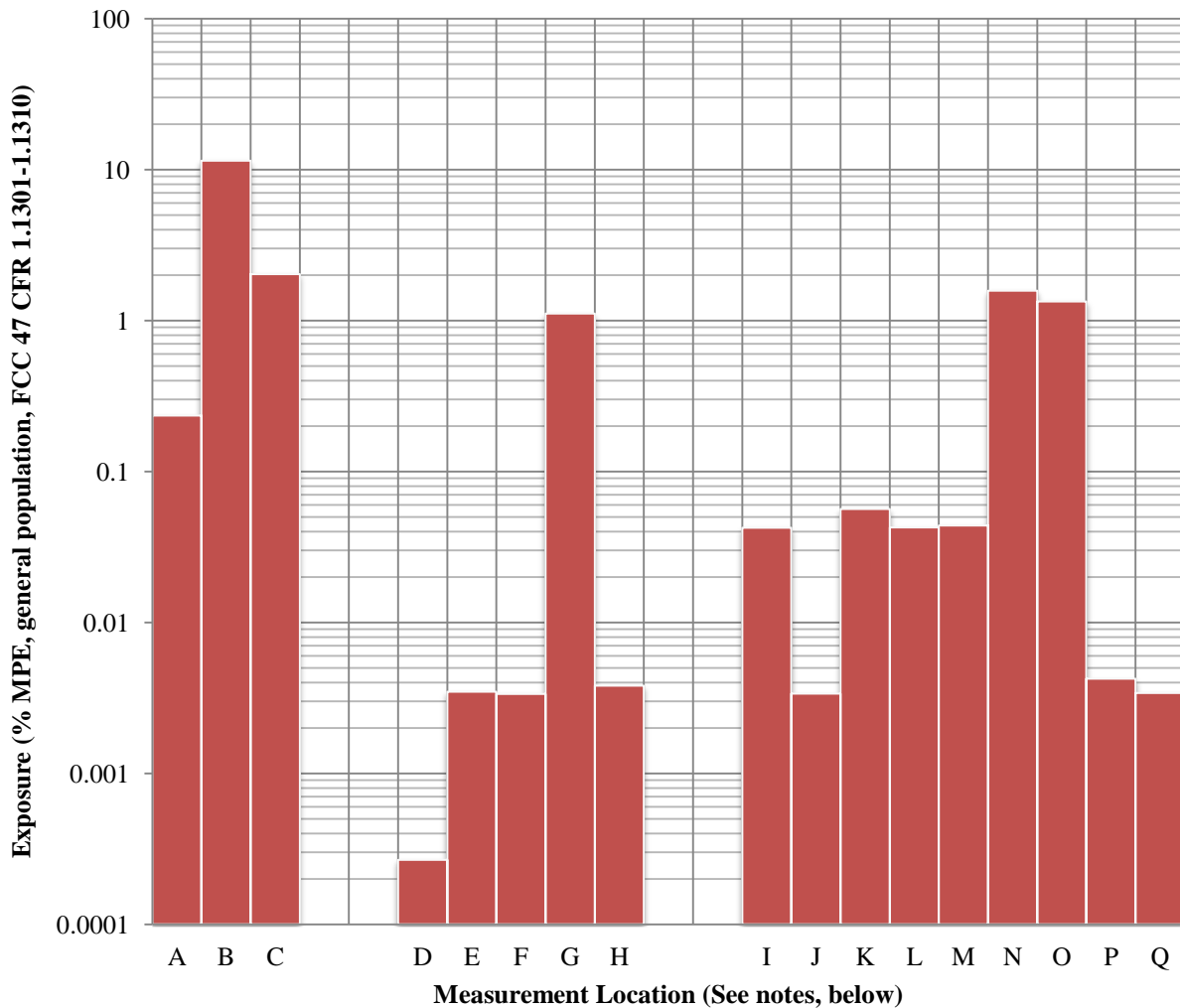


Figure 16 - Overall MPE results, logarithmic

- A iPhone 4S Cell Phone in a good (5 bar) signal area, measured at 1cm.
- B Microwave Oven, full power setting, heating 1 cup of water. Measured at 1cm.
- C Microwave Oven full power setting, heating 1 cup of water. Measured at 1000cm.
- D Commercial location "A", at meter rear, normal mode.
- E Commercial location "A", at meter rear, update mode.
- F Commercial location "B", in store, update mode.
- G Commercial location "C", at meter, update mode.
- H Commercial location "C", at meter, normal mode.
- I Residential location, Ambient Noise Floor Testing 2.4GHz band at Location "A", living area.
- J Residential location, Ambient Noise Floor Testing 900MHz band at Location "A", living area.
- K Residential location, 2.4GHz at Thermostat, at Location "B". Max (Peak) Hold.
- L Residential location, 2.4GHz at Thermostat, at Location "B".
- M Residential location, 2.4GHz at Meter, at Location "D".
- N Residential location, 2.4GHz at Meter, at Location "D". Max (Peak) Hold.
- O Residential location, 900MHz at Meter while FW upgrade at Location "D".
- P Residential location, 900MHz behind Meter while FW upgrade at Location "C".
- Q Residential location, 900MHz while FW upgrade at Location "A".

**b) Overall MPE results graph summary (linear)**

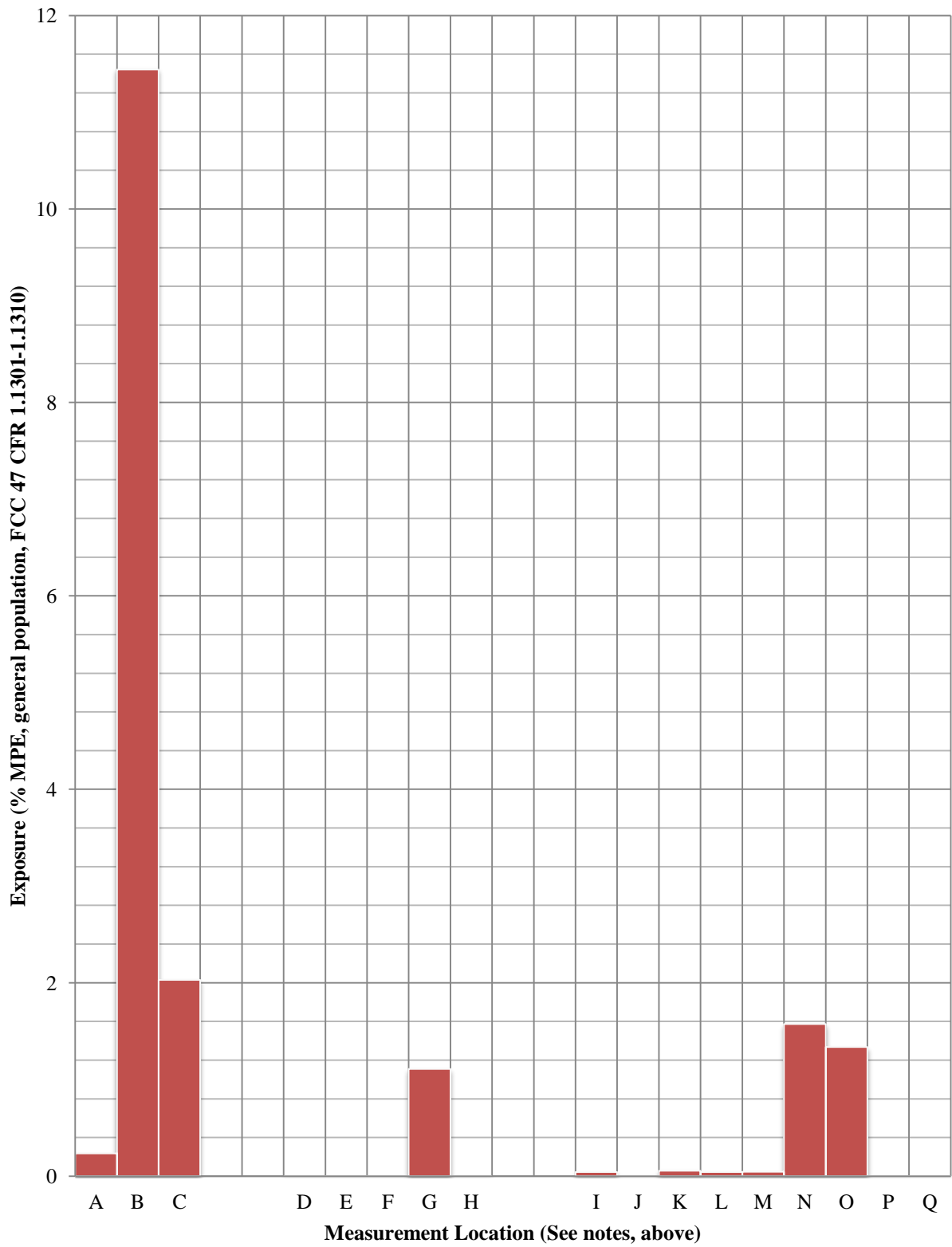


Figure 17 - Overall MPE results, linear

## *Logarithmic vs. Linear*

To make the lowest and highest result values visible on the graph above, Figure 16, a logarithmic (base 10) format for the y-axis was chosen. Each tick mark on the y-axis represents 10 times more than the previous tick mark.

To turn the values into a more “real world” number format, we use a linear graph, as in Figure 17. The highest emission we measured in the overall results was 11.44% from the Microwave Oven at 1 centimeter distance. In Figure 17, the y-axis is in a common linear number series, with zero at the bottom and 12 at the top, to include the highest emission.

Figure 17 more clearly illustrates the level of emissions from AMI infrastructure compared to emissions from cell phones, microwave ovens, etc, with most levels much smaller (with the exception of the close-in tests) and some levels not visible due to their low magnitude.

## **12. Conclusions**

Emissions from gridSMART<sup>®</sup> AMI infrastructure, given worst case scenarios and abnormally small detection distances do not come anywhere close to approaching the FCC’s Limit for Maximum Exposure.

Shown in these tests:

- Emissions from gridSMART<sup>®</sup> and similar AMI meters, when active, are lower than common background RF levels in every case except when measured in the near-field of the meter antenna.
- Near-field emissions from an active meter, in a “worst-case” scenario, were found to be around 1.5% or less of the FCC’s Maximum Permissible Exposure limit for the general public.
- Emissions from HAN thermostats are barely detectable over common Wi-Fi router interference when in a residential area.
- Overall emissions from HAN and AMI network infrastructure are anywhere from 1,000 to 10,000 times less than the FCC’s Maximum Permissible Exposure limit for the general public when measured in a building equipped with AMI infrastructure.



## **13. Other Resources**

### **a) Technical References**

FCC CFR Title 47, Volume 1, Section 1.1310 – Radiofrequency Radiation Exposure Limits.

FCC OET Bulletin 56, Fourth Edition – Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency and Electromagnetic Fields.

FCC OET Bulletin 65, Edition 97-01 – Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency and Electromagnetic Fields.

IEEE C.95-1, 2005 – IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency and Electromagnetic Fields, 3kHz to 300GHz.

Sensus – MPE Calculations for FlexNet Endpoint-Equipped Electric and Gas Meters.

Narda STS – A Practical Guide for Establishing an RF Safety Program.

### **b) Similar Reports**

EMC Technologies AMI Meter Electromagnetic Field Survey, Document Number M110736, 20 October 2011.

Health Impacts of Radio Frequency from Smart Meters – California Council on Science and Technology, January 2011.

Silver Spring Networks – Whitepaper: Radio Frequency Emissions, Analysis of Radio Frequency Exposure Associated with Silver Spring Networks' Advanced Metering Devices.

Edison Electric Institute – A discussion of Smart Meters and RF Exposure Issues, March 2011.

## **14. Equipment Certification & Calibration Information**

All equipment used in the collection of RF emissions data for this report were both certified and had valid current NIST traceable calibration.

The following pages contain the certificate images and sticker images from the actual equipment. Narda calibration is valid for two (2) years from the date of calibration.

## a) 3-Axis Antenna Calibration Documentation

Narda Safety Test Solutions GmbH  
Sandwiesenstrasse 7 - 72793 Pfullingen - Germany  
Phone: +49 7121 9732 0 - Fax: +49 7121 9732 790



# Calibration Certificate

Narda Safety Test Solutions hereby certifies that the object referred to in this certificate has been calibrated by qualified personnel using Narda's approved procedures. The calibration was carried out in accordance with a certified quality management system which conforms to ISO 9001

OBJECT	Three-Axis-Antenna, E-Field, 50 MHz to 3 GHz
MANUFACTURER	Narda Safety Test Solutions GmbH
PART NUMBER (P/N)	P/N 3501/02
SERIAL NUMBER (S/N)	A-0013
CUSTOMER	
CALIBRATION DATE	25-Aug-2011
RESULT ASSESSMENT	within specifications
AMBIENT CONDITIONS	Temperature: (23 ± 3) °C Relative humidity: (20 to 60) %
CALIBRATION PROCEDURE	3000-8702-00A

ISSUE DATE: 2011-08-25

  
CALIBRATED BY  
Kretschmann

  
AUTHORIZED SIGNATORY

MANAGEMENT  
SYSTEM



Certified by DQS against  
ISO 9001:2008  
(Reg.-No. 099379 QM08)

This calibration certificate may not be reproduced other than in full except with the permission of the issuing laboratory. Calibration certificates without signature are not valid.

ADVANCED TEST EQUIPMENT  
(858) 558-6500

**CALIBRATED**

I.D. NO

A-0013

DATE

8/25/11

BY

DUE

8/25/13

MWD

QSV  
narda  
Quality Test Solutions

**3-AXIS-ANTENNA**

50MHz - 3GHz

E-Field

P/N 3501/02

Germany

S/N A-0013

## b) Antenna Cable Calibration Documentation

Narda Safety Test Solutions GmbH  
Sandwiesenstrasse 7 - 72793 Pfullingen - Germany  
Phone: +49 7121 9732 0 - Fax: +49 7121 9732 790



# Calibration Certificate

Narda Safety Test Solutions hereby certifies that the object referred to in this certificate has been calibrated by qualified personnel using Narda's approved procedures. The calibration was carried out in accordance with a certified quality management system which conforms to ISO 9001

OBJECT	RF-cable SRM, 100 kHz to 3 GHz, N 50 Ohms, Length 1.5 m
MANUFACTURER	Narda Safety Test Solutions GmbH
PART NUMBER (P/N)	3601/01
SERIAL NUMBER (S/N)	B-0057
CUSTOMER	
CALIBRATION DATE	2011-08-30
RESULT ASSESSMENT	within specifications
AMBIENT CONDITIONS	Temperature: (23 ± 3) °C Relative humidity: (20 to 60) %
CALIBRATION PROCEDURE	3000-8703-00A

ISSUE DATE: 2011-08-30

  
CALIBRATED BY  
Kretschmann

  
AUTHORIZED SIGNATORY



Certified by DQS against  
ISO 9001:2008  
(Reg.-No. 099379 QM08)

This calibration certificate may not be reproduced other than in full except with the permission of the issuing laboratory. Calibration certificates without signature are not valid.



TEST EQUIPMENT  
558-6500

**CALIBRATION**

B-0057

8-30-11

BY

NARU

8-30-13

## c) SRM-3000 Selective Radiation Meter Calibration Documentation

Narda Safety Test Solutions GmbH  
Sandwiesenstrasse 7 - 72793 Pfullingen - Germany  
Phone: +49 7121 9732 0 - Fax: +49 7121 9732 790



# Calibration Certificate

Narda Safety Test Solutions hereby certifies that the object referred to in this certificate has been calibrated by qualified personnel using Narda's approved procedures. The calibration was carried out in accordance with a certified quality management system which conforms to ISO 9001

OBJECT	Selective Radiation Meter, Basic Unit, SRM-3000
MANUFACTURER	Narda Safety Test Solutions GmbH
PART NUMBER (P/N)	3001/01
SERIAL NUMBER (S/N)	B-0072
CUSTOMER	
CALIBRATION DATE	25-Aug-2011
RESULT ASSESSMENT	within specifications
AMBIENT CONDITIONS	Temperature: (23 ± 3)°C Relative humidity: (20 to 60) %
CALIBRATION PROCEDURE	3000-8701-00A

ISSUE DATE: 2011-08-25

  
CALIBRATED BY  
M. Budim

  
AUTHORIZED SIGNATORY

MANAGEMENT  
SYSTEM



Certified by DQS against  
ISO 9001:2008  
(Reg.-No. 099379 QM08)

This calibration certificate may not be reproduced other than in full except with the permission of the issuing laboratory. Calibration certificates without signature are not valid.

ADVANCED TEST EQUIPMENT  
(858) 558-6500 **CALIBRATED**

I.D. NO **B0072**

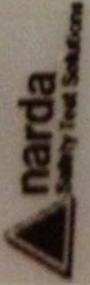
DATE **8/25/11**

BY

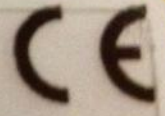
DUE **8/25/13**

**MMP**

**SRM**



**BASIC UNIT**  
100kHz - 3GHz  
P/N 3001/01  
S/N B-0072



Germany