FCC Test Report

FOR
Synapse Product Development

Marketing name
Bike Interface Module

Model Name/Number
BIT-01-0-9

Product Description
The Lyft BIM is an LTE connectivity, location, and NFC card reader module for use on battery powered shared electric vehicles.

FCC ID: 2ASMP0109

Applied Rules and Standards
Title 47 CFR: Part 15.225

REPORT #: EMC_SYNAP_035_19001_FCC_15.225_NFC

DATE: 05/16/2019

A2LA Accredited

IC recognized # 3462B-1

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1 Assessment

The following device as further described in section 3 of this report was evaluated for unlicensed radio according to criteria specified in Code of Federal Regulations Title 47 CFR: Part 15.225.

No deviations were ascertained.

According to section 5 of this report, the overall result is PASS.

Company	Description	Model #
Synapse Product Development	The Lyft BIM is an LTE connectivity, location, and NFC card reader module for use on battery powered shared electric vehicles.	BIT-01-0-9

Responsible for Testing Laboratory:

Date	Section	Name	Signature
05/16/2019	Compliance	Cindy Li (Lab Manager)	Cindy Li Digitally signed by Cindy Li DN: cn=Cindy Li, o=Cetecom Inc., ou=EMC, email=cindy.li@cetecom.com, c=US Date: 2019.05.16 16:05:56 -07'00'

Responsible for the Report:

Date	Section	Name	Signature
05/16/2019	Compliance	Issa Ghanma (EMC Engineer)	Digitally signed by: Issa Ghanma DN: CN = Issa Ghanma email = issa.ghanma@cetecom.com C = US O = CETECOM INC. OU = EMC Date: 2019.05.16 15:24:05 -07'00'

2 Administrative Data

2.1 Identification of the Testing Laboratory Issuing the EMC Test Report

Company Name:	CETECOM Inc.
Department:	Compliance
Street Address:	411 Dixon Landing Road
City/Zip Code	Milpitas, CA 95035
Country	USA
Telephone:	+1 (408) 586 6200
Fax:	+1 (408) 586 6299
Lab Manager:	Cindy Li
Responsible Project Leader:	Cathy Palacios

2.2 Identification of the Client

Applicant's Name:	Synapse Product Development
Street Address:	640 Bryant St
City/Zip Code	San Francisco, CA 94107
Country	USA

2.3 Identification of the Manufacturer

Manufacturer's Name:	Lyft, Inc.
Manufacturers Address:	185 Berry St Suite 5000
City/Zip Code	San Francisco, CA 94107
Country	USA

3 Equipment Under Test (EUT)

3.1 EUT Specifications

Module Name:	NFC Module
Frequency Range / number of channels:	13.56 MHz / 1 Channel
Type(s) of Modulation:	ASK
Modes of Operation:	RFID
Antenna Information as declared:	This antenna is composed of 4 loops of 300µm copper traces in a rectangle of size 37mm x 42mm. There is a 100µm thick ferrite sheet bonded to the bottom side of the PCB (Laird MHLL12060-200) This antenna is tuned to couple with a similarly tuned 13.56 MHz NFC card antenna.
Max. Output Powers as declared:	15 dBm (low power) 18 dBm (high power)
Power Supply/ Rated Operating Voltage Range:	Low 30 VDC, Nominal 36 VDC, High 42 VDC
Operating Temperature Range:	Low -20º C, Nominal 25º C, High 50º C
Sample Revision:	☐Prototype Unit; ■Production Unit; ☐Pre-Production
EUT Dimensions [mm]:	270 x 70 x 40
EUT Diameter:	■ < 60 cm ☐ Other _____
Other Radios included in the device:	❖ Cellular 4G LTE CAT-1 • Module name: Digi XBee Cellular LTE Cat 1 • Module number: XBC-V1-UT-001 • FCC ID: RI7LE866SV1 • IC ID: 5131A-LE866SV1 ❖ WLAN(Wi-Fi): 802.11 b/g/n (Receive only) • Module name & number: Stand-alone Wi-Fi uBlox NINA-W132 • FCC ID: XPYNINAW13 ❖ GPS: • Module name: uBlox M8 GNSS Antenna Module • Model number: uBlox SAM-M8Q

3.2 EUT Sample details

EUT #	Serial Number	NFC board lable	HW Version	SW Version	Notes / Comments
1	B1M40098	1SP0569	1.0	1.0	Normal / End user mode
2		1SP0526	1.0	1.0	CW mode
3		1SP0535	1.0	1.0	Protocol loop mode
4		NFC TX S3	1.0	1.0	Test mode Always read / High duty cycle

3.3 Accessory Equipment (AE) details

AE #	Comments
-	According to the User Manual, No accessories are to be used with this device.

3.4 Test Sample Configuration

Set-up #	Combination of AE used for test set up	Comments
-	-	-

3.5 Mode of Operation details

Mode of Operation	Description of Operating modes	Additional Information
Op. 1	RFID ASK	Client provided a test laptop and instructions to get the ability to configure the radio to: • CW mode. • Normal mode. • Protocol loop. • Select protocol. • Highest possible duty cycle. Instructions and commands provided by the client will not be available to the end user. For Radiated measurements: The internal antenna was connected.

3.6 Justification for Worst Case Mode of Operation

During the testing process the EUT was tested with transmitter sets the highest duty cycle, maximum output power and worst case of protocols supported.

For radiated measurements, all data in this report shows the worst case between horizontal and vertical antenna polarizations and for all orientations of the EUT.

4 Subject of Investigation

The objective of the measurements done by CETECOM Inc. was to assess the performance of the EUT according to the relevant requirements specified in Code of Federal Regulations Title 47 CFR: Part 15.225.

This test report is to support a request for new equipment authorization under the:

- FCC ID: 2ASMP0109

4.1 Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus, with 95% confidence interval (in dB delta to result), based on a coverage factor k=1.

Radiated measurement

9 kHz to 30 MHz	±2.5 dB (Magnetic Loop Antenna)
30 MHz to 1000 MHz	±2.0 dB (Biconilog Antenna)
1 GHz to 40 GHz	±2.3 dB (Horn Antenna)

According to TR 102 273 a multiplicative propagation of error is assumed for RF measurement systems. For this reason the RMS method is applied to dB values and not to linear values as appropriate for additive propagation of error. Also used: http://physics.nist.gov/cuu/Uncertainty/typeb.html. The above calculated uncertainties apply to direct application of the Substitution method. The Substitution method is always used when the EUT comes closer than 3 dB to the limit.

4.2 Environmental Conditions During Testing:

The following environmental conditions were maintained during the course of testing:

- Ambient Temperature: 20-25° C
- Relative humidity: 40-60%

4.3 Dates of Testing:

04/01/2019 – 04/04/2019

5 Measurement Results Summary

Test Specification	Test Case	Temperature and Voltage Conditions	Mode	Pass	NA	NP	Result
§15.225 (a), (b), (c)	Field Strength (Fundamental)	Nominal	ASK	■	☐	☐	Complies
§15.225 (d) §15.209 (a)	TX Spurious emissions-Radiated	Nominal	ASK	■	☐	☐	Complies
§15.225(e)	Frequency stability	Extreme temperature and voltage conditions	CW	■	☐	☐	Complies

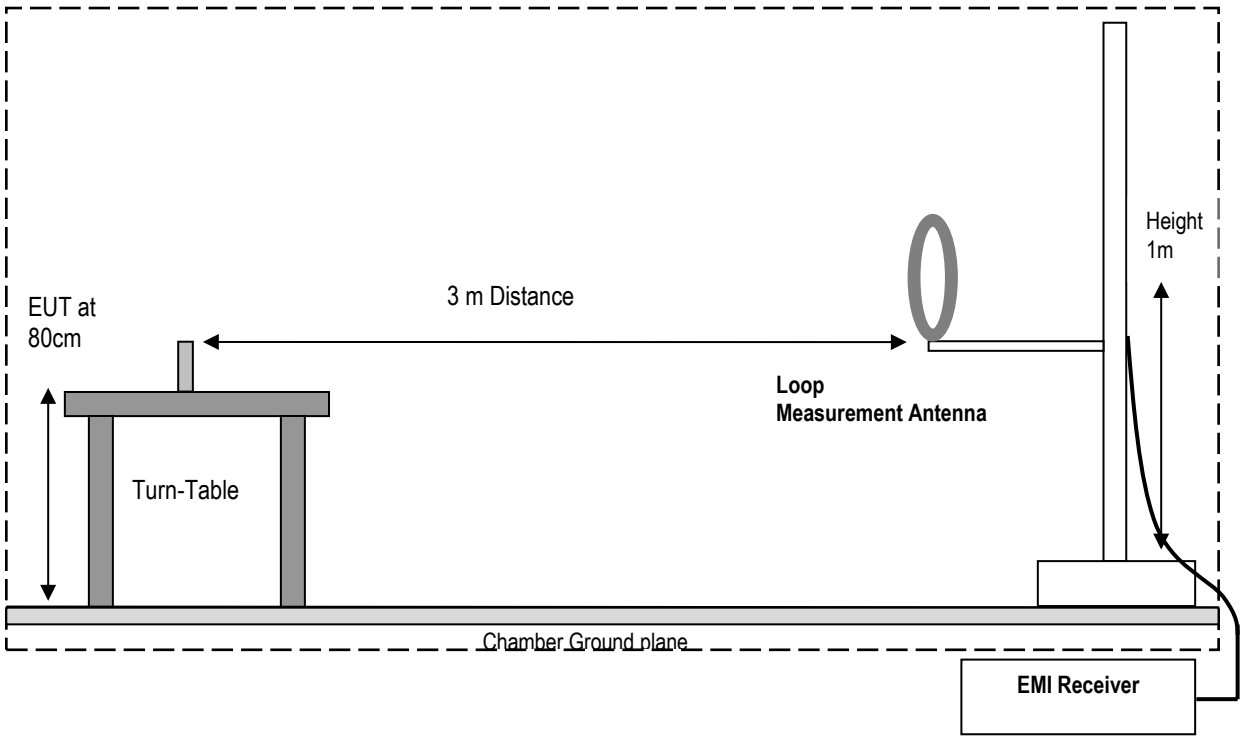
6 Measurement Procedures

6.1 Radiated Measurement

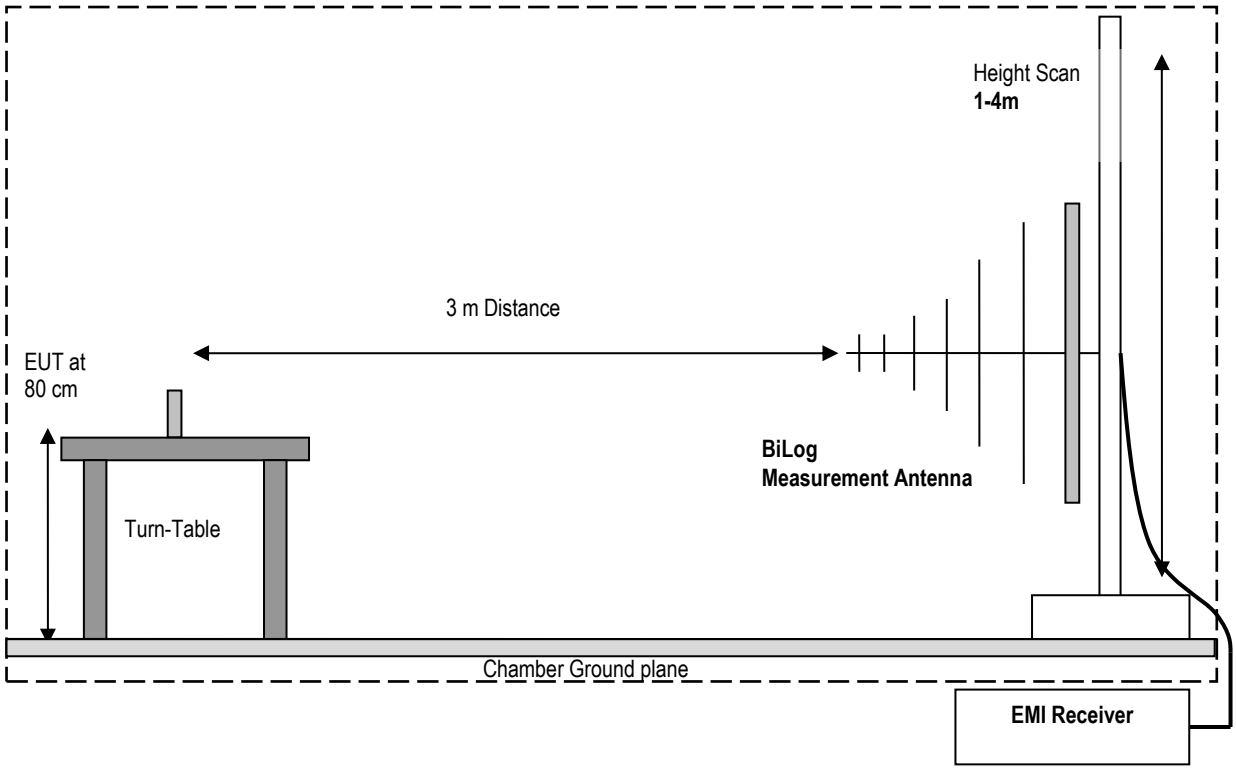
The radiated measurement is performed according to ANSI C63.10 (2013)

- The exploratory measurement is accomplished by running a matrix of 16 sweeps over the required frequency range with R&S Test-SW EMC32 for 360º continuous measurement of the turntable, two orthogonal positions of the EUT and both antenna polarizations. This procedure exceeds the requirement of the above standards to cover the 3 orthogonal axis of the EUT. A max peak detector is utilized during the exploratory measurement. The Test-SW creates an overall maximum trace for all 12 sweeps and saves the settings for each point of this trace. The maximum trace is part of the test report.
- The 10 highest emissions are selected with an automatic algorithm of EMC32 searching for peaks in the noise floor and ensuring that broadband signals are not selected multiple times.
- The maxima are then put through the final measurement and again maximized in a 90deg range of the turntable, fine search in frequency domain and height scan between 1m and 4m.
- The above procedure is repeated for all possible ways of power supply to EUT and for all supported modulations.
- In case there are no emissions above noise floor level only the maximum trace is reported as described above.
- The results are split up into up to 4 frequency ranges due to antenna bandwidth restrictions. A magnetic loop is used from 9 kHz to 30 MHz, a Biconilog antenna is used from 30 MHz to 1 GHz, and two different horn antennas are used to cover frequencies up to 40 GHz.

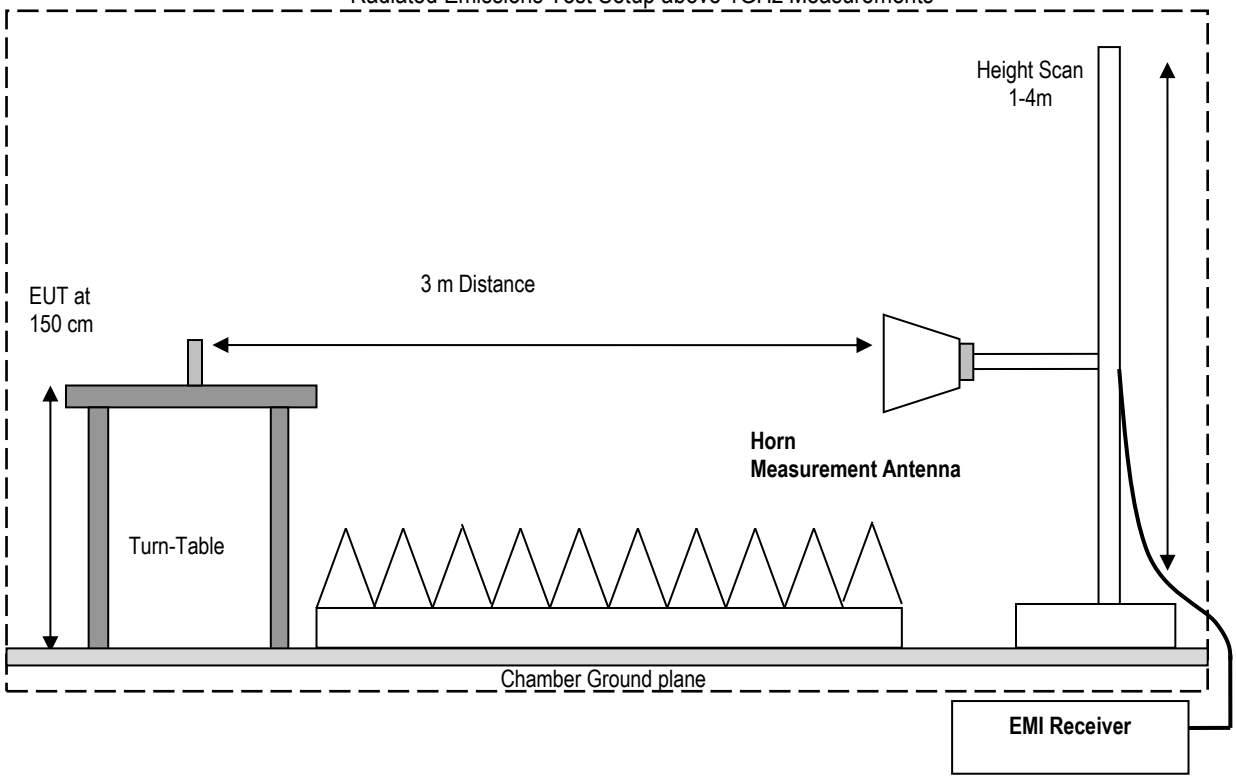
Radiated Emissions Test Setup below 30MHz Measurements



Radiated Emissions Test Setup 30MHz-1GHz Measurements



Radiated Emissions Test Setup above 1GHz Measurements



6.1.1 Sample Calculations for Field Strength Measurements

Field Strength is calculated from the Spectrum Analyzer/ Receiver readings, taking into account the following parameters:

1. Measured reading in dBµV
2. Cable Loss between the receiving antenna and SA in dB and
3. Antenna Factor in dB/m

All radiated measurement plots in this report are taken from a test SW that calculates the Field Strength based on the following equation:

FS (dBµV/m) = Measured Value on SA (dBµV) - Cable Loss (dB) + Antenna Factor (dB/m)

Example:

Frequency (MHz)	Measured SA (dBµV)	Cable Loss (dB)	Antenna Factor Correction (dB)	Field Strength Result (dBµV/m)
1000	80.5	3.5	14	98.0

7 Test Result Data

7.1 Field strength

7.1.1 References

- **FCC Part 15 Subpart C-Intentional Radiators**
  §15.225 Operation within the band 13.110-14.010 MHz

(a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.
(b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.
(c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

7.1.2 Limits

According to ANSI C63.10-2013 Section 6.4.4

- Equation (1):
  $\mathbf{d}_{\text{near field}} = 47.77 / f_{\text{MHz}}$
  $\mathbf{d}_{\text{near field}} \approx 3.5$ meters

- Equation (2)
  $\mathbf{FS}_{\text{limit}} = \mathbf{FS}_{\text{max}} - 40\log(\mathbf{d}_{\text{near field}} / \mathbf{d}_{\text{measure}}) - 20\log(\mathbf{d}_{\text{limit}} / \mathbf{d}_{\text{near field}})$

  The limit applied to the measurement result, is converted to 3 meters, by using:
  - 40 dB/decade extrapolation factor for distance < λ/2π and;
  - 20 dB/decade extrapolation factor for distance > λ/2π

  Where:
  - $\mathbf{FS}_{\text{limit}}$: is the calculation of field strength at the limit distance, expressed in dBµV/m
  - $\mathbf{FS}_{\text{max}}$: is the measured field strength, expressed in dBµV/m ≈ 84 dBµV/m (See note 1)
  - $\mathbf{d}_{\text{near field}}$: is the λ/2π distance ≈ 3.5 meters
  - $\mathbf{d}_{\text{measure}}$: is the distance of the measurement point from the EUT = 3 meters
  - $\mathbf{d}_{\text{limit}}$: is the reference limit distance = 30 meters

Note 1: The maximum allowed field strength; 15.848 mV/m (84 dBµV/m), were used as $\mathbf{FS}_{\text{max}}$ to adjust the mask limit at the measured distance, so equation (2) will be:

$\mathbf{FS}_{\text{limit}} = \mathbf{FS}_{\text{max}} + 40\log(\mathbf{d}_{\text{near field}} / \mathbf{d}_{\text{measure}}) + 20\log(\mathbf{d}_{\text{limit}} / \mathbf{d}_{\text{near field}})$

- Within the band 13.553-13.567 MHz

$\mathbf{FS}_{\text{limit}} = 84 + 18.7 + 2.7$
$\mathbf{FS}_{\text{limit}} = 105.1$ dBµV/m at 3 meters

- Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz

$\mathbf{FS}_{\text{limit}} = 70.47 + 18.7 + 2.7$
$\mathbf{FS}_{\text{limit}} = 91.87$ dBµV/m at 3 meters

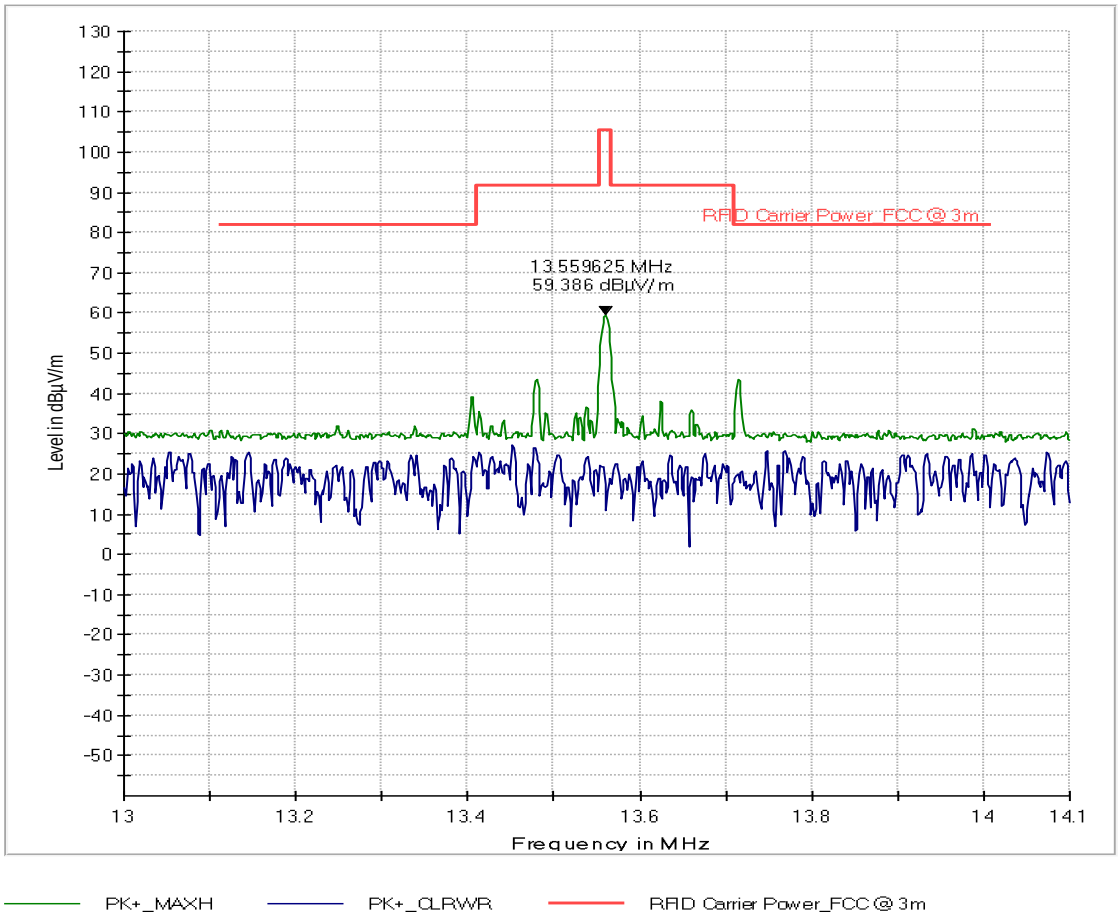
- Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz

$\mathbf{FS}_{\text{limit}} = 60.51 + 18.7 + 2.7$
$\mathbf{FS}_{\text{limit}} = 81.91$ dBµV/m at 3 meters

7.1.3 Test conditions and setup:

Ambient Temperature	EUT operating mode	Power Input
22° C	Op.1	DC 36V

7.1.4 Measurement plots:



7.2 Frequency Stability

7.2.1 References and limits

- **FCC Part 15 Subpart C-Intentional Radiators**

  §15.225 Operation within the band 13.110-14.010 MHz

  (e) The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of −20 degrees to + 50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

7.2.2 Measurement procedure

Measurements were done according to ANSI C63.10-2013 Section 6.8 Frequency stability tests

The EUT was configured to operate in CW mode. Small loop antenna connected to a spectrum analyzer was used as a test fixture- See photos in the "Test setup photos file" Section 8

7.2.3 Measurement results

The following formula used for PPM calculation:

PPM = ((MCF / ACF) – 1) * 10^6

Where:
MCF : Measured Center Frequency.
ACF : Assigned Center Frequency.
Variation = MCF – ACF

Frequency stability when varying supply voltage				
Voltage	**Temperature [ºC]**	**MCF [MHz]**	**Variation (MCF-ACF) [MHz]**	**PPM (+-)100**
30	50	13.5594	-0.0005	-38.7718
42	50	13.5605	0.0006	42.3496
30	**-20**	**13.5609**	**0.0010**	**71.8483**
42	-20	13.5605	0.0006	42.3496

Frequency stability with respect to ambient temperature						
Time [min]	**Temperature [ºC]**	**Voltage**	**MCF [MHz]**	**ACF [MHz]**	**Variation [MHz]**	**PPM (+-)100**
0	50	36	13.559876	13.559926	-0.000050	-3.7
2	50	36	13.559678	13.559926	-0.000248	-18.3
5	50	36	13.559233	13.559926	-0.000693	-51.1
10	50	36	13.559629	13.559926	-0.000297	-21.9
0	40	36	13.560074	13.559926	0.000149	11.0
2	40	36	13.559728	13.559926	-0.000198	-14.6
5	40	36	13.559926	13.559926	0.000000	0.0
10	40	36	13.560025	13.559926	0.000099	7.3
0	30	36	13.558936	13.559926	-0.000990	-73.0
2	30	36	13.558738	13.559926	-0.001188	-87.6
5	30	36	13.560421	13.559926	0.000495	36.5
10	30	36	13.560223	13.559926	0.000297	21.9
0	**20**	**36**	**13.561262**	**13.559926**	**0.001337**	**98.6**
2	20	36	13.558787	13.559926	-0.001139	-84.0
5	20	36	13.559629	13.559926	-0.000297	-21.9
10	20	36	13.559777	13.559926	-0.000149	-11.0
0	10	36	13.560074	13.559926	0.000149	11.0
2	10	36	13.560322	13.559926	0.000396	29.2
5	10	36	13.559777	13.559926	-0.000149	-11.0
10	10	36	13.560223	13.559926	0.000297	21.9
0	0	36	13.560619	13.559926	0.000693	51.1
2	0	36	13.559579	13.559926	-0.000347	-25.6
5	0	36	13.559827	13.559926	-0.000099	-7.3
10	0	36	13.560668	13.559926	0.000742	54.7
0	-10	36	13.559629	13.559926	-0.000297	-21.9
2	-10	36	13.559381	13.559926	-0.000545	-40.2
5	-10	36	13.559480	13.559926	-0.000446	-32.9
10	-10	36	13.561213	13.559926	0.001287	94.9
0	-20	36	13.560718	13.559926	0.000792	58.4
2	-20	36	13.560074	13.559926	0.000149	11.0
5	-20	36	13.559629	13.559926	-0.000297	-21.9
10	-20	36	13.559777	13.559926	-0.000149	-11.0

7.3 Transmitter Spurious Emissions and Restricted Bands

7.3.1 Measurement according to ANSI C63.10

Analyzer Settings:

- Frequency = 9 KHz – 30 MHz
- RBW = 9 KHz
- Detector = Peak

- Frequency = 30 MHz – 1 GHz
- Detector = Peak / Quasi-Peak
- RBW = 120 KHz (<1 GHz)

- Frequency > 1 GHz
- Detector = Peak / Average
- RBW = 1MHz

Plots reported here represent the worst case emissions for horizontal and vertical antenna polarizations and for three orientations of the EUT. Unless mentioned otherwise, the emissions outside the limit lines in the plots are from the transmit signal.

7.3.2 Limits: FCC 15.247(d)/15.209(a)

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
[1]0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	Above 38.6
13.36-13.41			

- Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).
- PEAK LIMIT= 74dB µV/m
- AVG. LIMIT= 54dB µV/m

- Except as shown in CFR 47 Part 15.205 paragraph (d), only spurious emissions are permitted in any of the frequency bands listed below

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

Radiated spurious emissions shall be measured for the transmit frequencies, transmit power, and data rate for the lowest, middle and highest channel in each frequency band of operation and for the highest gain antenna for each antenna type, and using the appropriate parameters and test requirements described in 5.4.
The highest (or worst-case) data rate shall be recorded for each measurement.

For testing at distance other than the specified in the standard, the limit conversion is calculated by using 40 dB/decade extrapolation as follow:

Conversion factor (CF) = 40 log (D/d) = 40 log (300 m / 3 m) = 80 dB

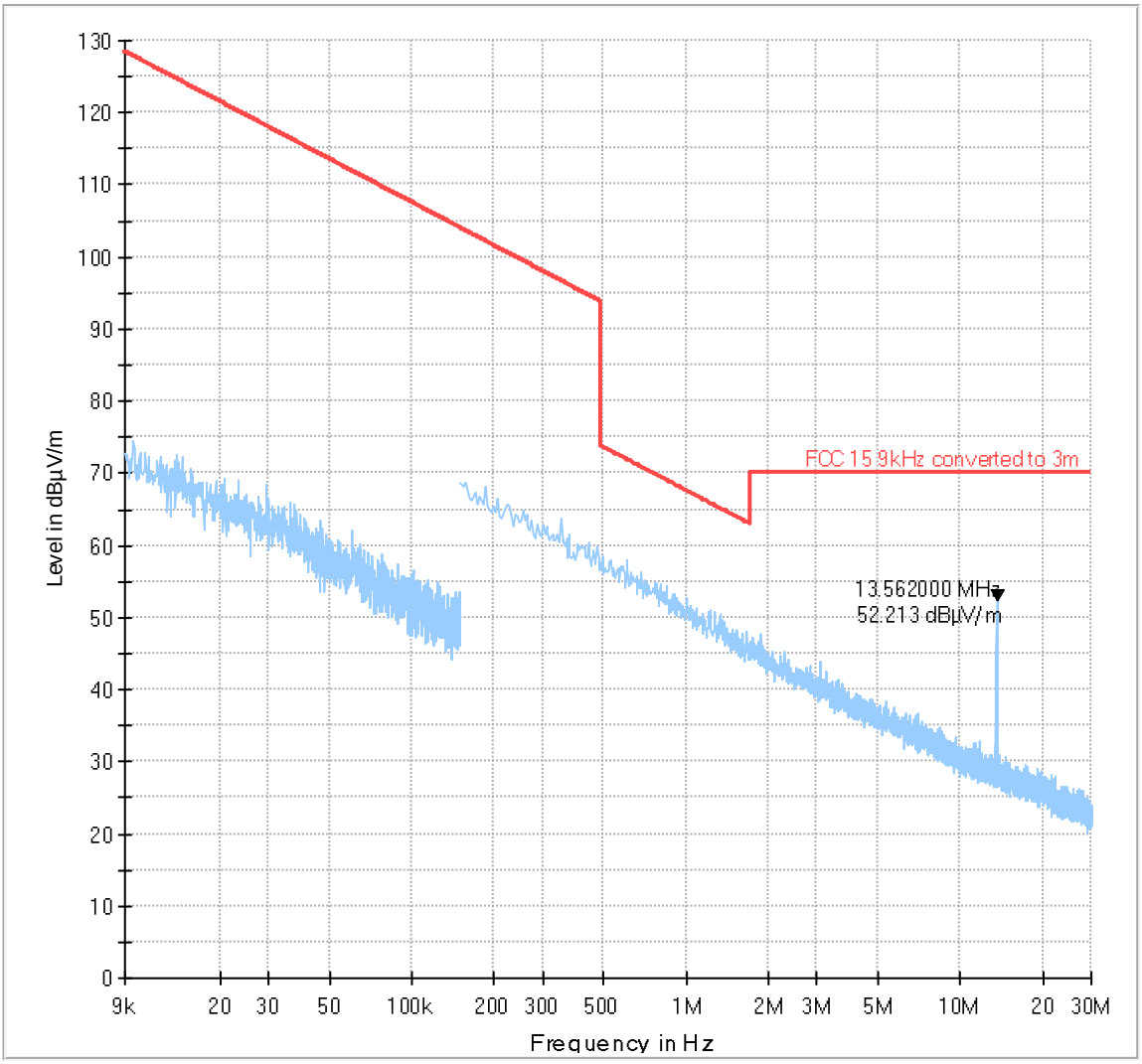
7.3.3 Test conditions and setup:

Ambient Temperature	EUT operating mode	Power Input
22° C	Op.1	DC 36V

7.3.4 Measurement Plots:

Plot # 1 Radiated Emissions: 9KHz – 30MHz

NFC 13.56 MHz

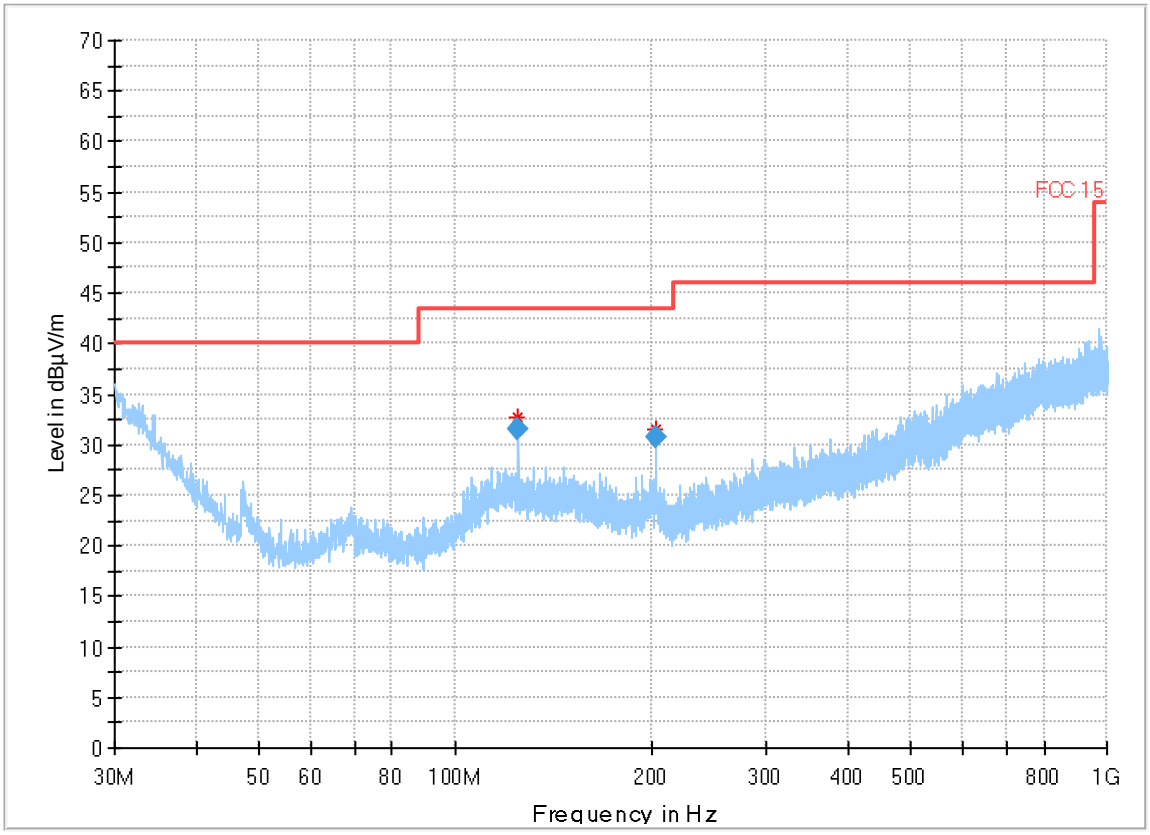


Plot # 2 Radiated Emissions: 30MHz – 1GHz

NFC 13.56 MHz

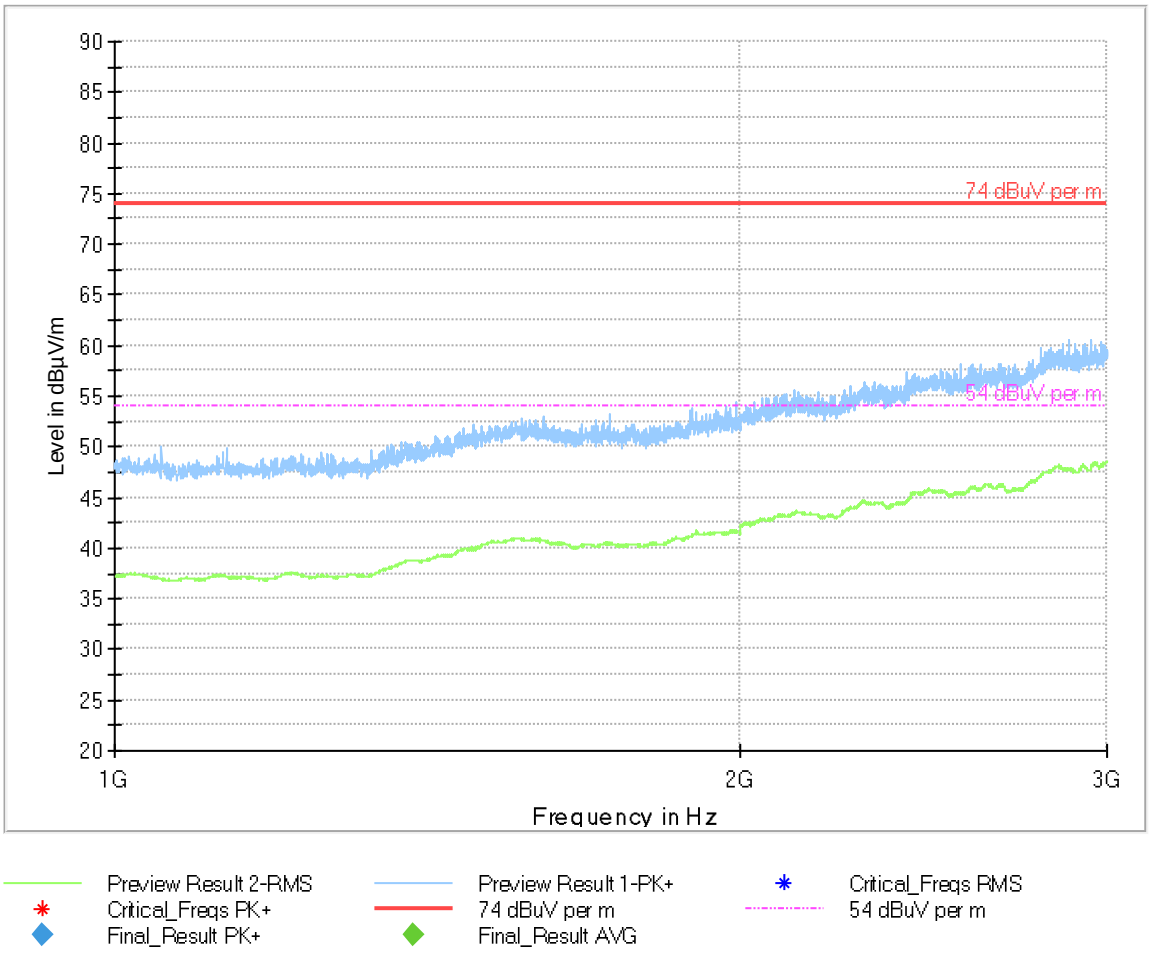
Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)	Comment
125.001399	31.57	43.52	11.95	200.0	120.000	152.0	H	208.0	22.9	1:28:03 PM - 4/2/2019
203.385563	30.78	43.52	12.74	200.0	120.000	152.0	H	81.0	21.4	1:25:56 PM - 4/2/2019



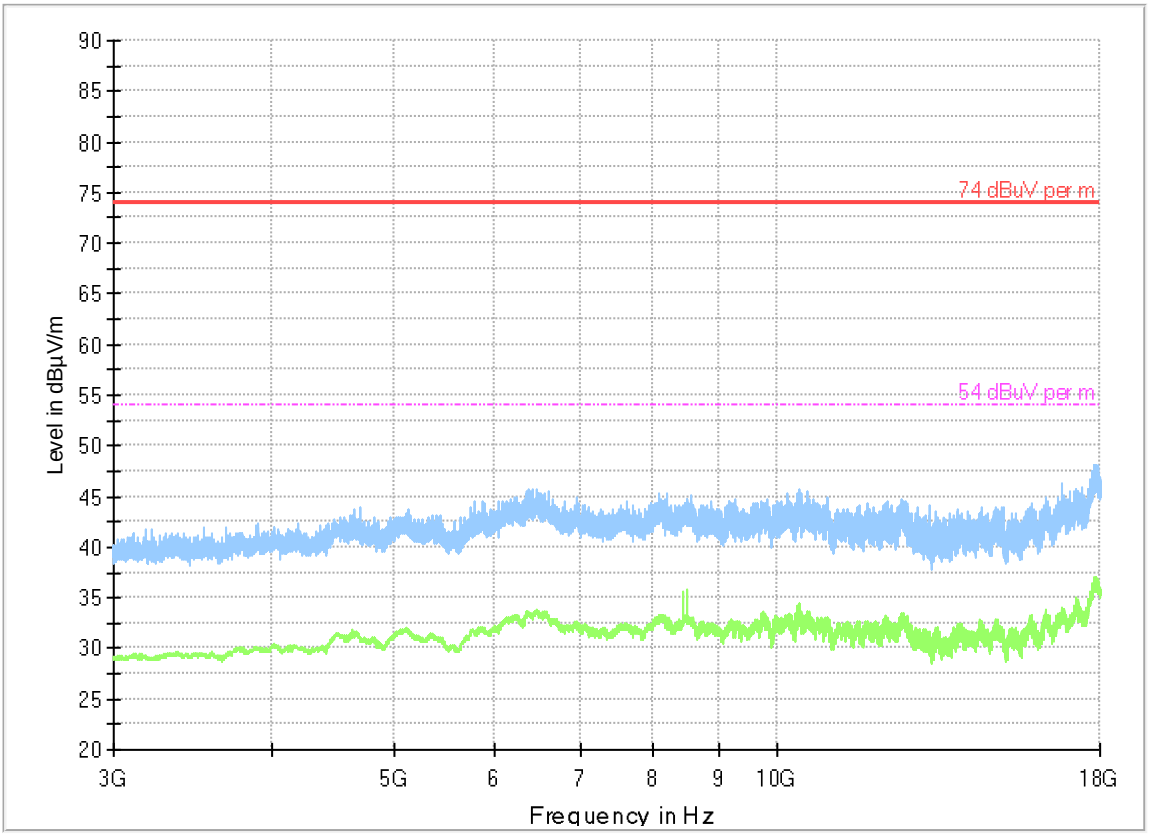
Plot # 3 Radiated Emissions: 1 – 3GHz

NFC 13.56 MHz



Plot # 4 Radiated Emissions: 3 – 18GHz

NFC 13.56 MHz



8 Test setup photos

Setup photos are included in supporting file name: "EMC_SYNAP_035_19001_FCC_Setup_Photos.pdf"

9 Test Equipment And Ancillaries Used For Testing

Equipment Type	Manufacturer	Model	Serial #	Calibration Cycle	Last Calibration Date
ACTIVE LOOP ANTENNA	ETS LINDGREN	6507	00161344	3 YEARS	10/26/2017
BICONILOG ANTENNA	EMCO	3142E	166067	3 YEARS	6/27/2017
HORN ANTENNA	ETS.LINDGREN	3115	00035114	3 YEARS	07/31/2017
HORN ANTENNA	ETS.LINDGREN	3117	00245984	3 YEARS	01/26/2018
EMI RECEIVER / ANALYZER	ROHDE&SCHWARZ	ESU 40	100251	3 YEARS	1/31/2018
VWR THERMOMETER	CONTROL COMPANY	36934-164	191871994	2 YEARS	01/10/2019

Note: Equipment used meets the measurement uncertainty requirements as required per applicable standards for 95% confidence levels.
Calibration due dates, unless defined specifically, falls on the last day of the month. Items indicated "N/A" for cal status either do not specifically require calibration or is internally characterized before use.

10 Revision History

Date	Report Name	Changes to report	Report prepared by
05/16/2019	EMC_SYNAP_035_19001_FCC_15.225_NFC	Initial Version	Issa Ghanma