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## Report On

FCC Testing of the Sharp Quad-band LTE (B1/B3/B17/B26), Dual-band WCDMA (FDD I / V), Quad-band GSM (850/900/1800/1900) & WiMAX2+ (TDD41) multi mode Smart phone with Bluetooth, WLAN, and GPS in accordance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2 (PCS 1900)

COMMERCIAL-IN-CONFIDENCE

FCC ID: APYHRO00238

Document 75934711 Report 15 Issue 1

June 2016



Product Service

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COMMERCIAL-IN-CONFIDENCE

REPORT ON

FCC Testing of the Sharp Quad-band LTE (B1/B3/B17/B26), Dual-band WCDMA (FDD I / V), Quad-band GSM (850/900/1800/1900) & WiMAX2+ (TDD41) multi mode Smart phone with Bluetooth, WLAN, and GPS in accordance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2 (PCS 1900)

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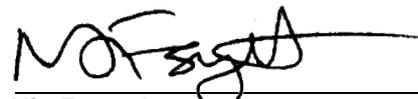
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Authorised Signatory

DATED

24 June 2016

ENGINEERING STATEMENT

The measurements shown in this report were made in accordance with the procedures described on test pages. All reported testing was carried out on a sample equipment to demonstrate limited compliance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2. The sample tested was found to comply with the requirements defined in the applied rules.

Test Engineer(s);

  
M Russell

  
G Lawler





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## **SECTION 1**

### **REPORT SUMMARY**

FCC Testing of the  
Sharp Quad-band LTE (B1/B3/B17/B26), Dual-band WCDMA (FDD I / V), Quad-band GSM  
(850/900/1800/1900) & WiMAX2+ (TDD41) multi mode Smart phone with Bluetooth, WLAN, and  
GPS

In accordance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2 (PCS 1900)



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## 1.1 INTRODUCTION

The information contained in this report is intended to show the verification of FCC Testing of the Sharp Quad-band LTE (B1/B3/B17/B26), Dual-band WCDMA (FDD I / V), Quad-band GSM (850/900/1800/1900) & WiMAX2+ (TDD41) multi mode Smart phone with Bluetooth, WLAN, and GPS to the requirements of FCC 47 CFR Part 24 and FCC 47 CFR Part 2.

|                               |   |
|-------------------------------|---|
| Objective                     | To perform FCC Testing to determine the Equipment Under Test's (EUT's) compliance with the Test Specification, for the series of tests carried out. |
| Manufacturer                  | Sharp Corporation   |
| Serial Number(s)              | IMEI 004401115813228<br>IMEI 004401115813517  |
| Number of Samples Tested      | 2   |
| Test Specification/Issue/Date | FCC 47 CFR Part 24 (2015)<br>FCC 47 CFR Part 2 (2015)   |
| Disposal                      | Held Pending Disposal   |
| Reference Number              | Not Applicable  |
| Date                          | Not Applicable  |
| Order Number                  | 10829   |
| Date                          | 31 May 2016   |
| Start of Test                 | 31 May 2016   |
| Finish of Test                | 6 June 2016   |
| Name of Engineer(s)           | M Russell<br>G Lawler   |
| Related Document(s)           | ANSI C63.4 (2014)<br>ANSI TIA-603-C (2004)<br>ANSI C63.26 (2015)  |



## 1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2 is shown below.

| Section  | Specification Clause |            | Test Description                                 | Result | Comments/Base Standard |
|----------|----------------------|------------|--|--------|------------------------|
|          | Part 24              | Part 2     |  |        |                        |
| PCS 1900 |                      |            |  |        |                        |
| 2.1      | 24.229 and 24.238    | 2.1051     | Spurious Emissions at Band Edge                  | Pass   |                        |
| 2.2      | 24.232               | 2.1046     | Maximum Conducted Output Power                   | Pass   |                        |
| 2.3      | 24.235               | 2.1055     | Frequency Stability                              | Pass   |                        |
| 2.4      | 24.238               | 2.1053     | Emission Limitations for Broadband PCS Equipment | Pass   |                        |
| 2.5      | 24.238               | 2.1049 (h) | 26 dB Bandwidth                                  | Pass   |                        |
| 2.6      | 24.238 (a)           | 2.1051     | Spurious Emissions at Antenna Terminals          | Pass   |                        |
| 2.7      | -                    | 2.1047 (d) | Modulation Characteristics                       | -      | Customer Declaration   |



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### **1.3 PRODUCT TECHNICAL DESCRIPTION**

Refer to Model Description APYHRO00238 Rev 4.0 document.

### **1.4 PRODUCT INFORMATION**

#### **1.4.1 Technical Description**

#### **1.4.2 Technical Description**

The Equipment Under Test (EUT) was a Sharp Quad-band LTE (B1/B3/B17/B26), Dual-band WCDMA (FDD I / V), Quad-band GSM (850/900/1800/1900) & WiMAX2+ (TDD41) multi mode Smart phone with Bluetooth, WLAN, and GPS. A full technical description can be found in the manufacturer's documentation.

### **1.5 TEST CONDITIONS**

For all tests the EUT was set up in accordance with the relevant test standard and to represent typical operating conditions. Tests were applied with the EUT situated in a shielded enclosure.

The EUT was powered from a 4.0 V DC supply.

FCC Measurement Facility Registration Number  
90987 Octagon House, Fareham Test Laboratory

### **1.6 DEVIATIONS FROM THE STANDARD**

No deviations from the applicable test standard were made during testing.

### **1.7 MODIFICATION RECORD**

Modification 0 - No modifications were made to the test sample during testing.



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## **SECTION 2**

### **TEST DETAILS**

FCC Testing of the  
Sharp Quad-band LTE (B1/B3/B17/B26), Dual-band WCDMA (FDD I / V), Quad-band GSM  
(850/900/1800/1900) & WiMAX2+ (TDD41) multi mode Smart phone with Bluetooth, WLAN, and  
GPS  
In accordance with FCC 47 CFR Part 24 and FCC 47 CFR Part 2 (PCS 1900)



Product Service

## **2.1 SPURIOUS EMISSIONS AT BAND EDGE**

### **2.1.1 Specification Reference**

FCC 47 CFR Part 24, Clause 24.229 and 24.238  
FCC 47 CFR Part 2, Clause 2.1051

### **2.1.2 Equipment Under Test and Modification State**

S/N: IMEI 004401115813228 - Modification State 0

### **2.1.3 Date of Test**

31 May 2016

### **2.1.4 Test Equipment Used**

The major items of test equipment used for the above tests are identified in Section 3.1.

### **2.1.5 Test Procedure**

The test was performed in accordance with KDB 971168 D01 v02 r02, clause 6.

### **2.1.6 Environmental Conditions**

|                     |        |
|---------------------|--------|
| Ambient Temperature | 23.6°C |
| Relative Humidity   | 47.5%  |



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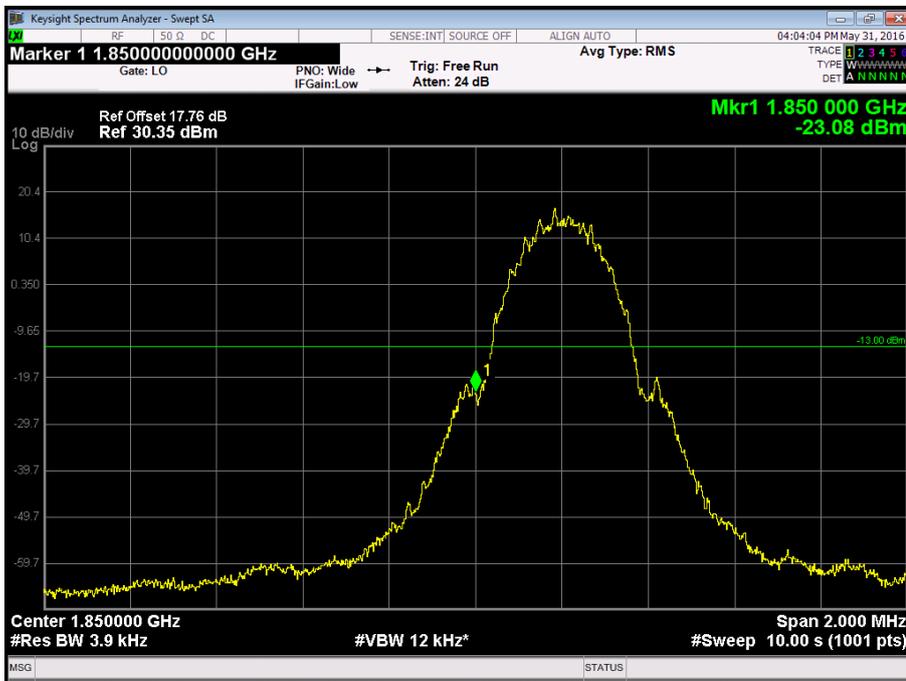
2.1.7 Test Results

4.0 V DC Supply

PCS 1900, Circuit-Switched, GMSK, Spurious Emissions at Band Edge Results

| Block Edge | Frequency Block (MHz)      |                            |
|------------|----------------------------|----------------------------|
|            | A :1850 MHz – 1865 MHz     | C :1895 MHz – 1910 MHz     |
| Lower      | Channel: 512<br>1850.2 MHz | -                          |
| Upper      | -                          | Channel: 810<br>1909.8 MHz |

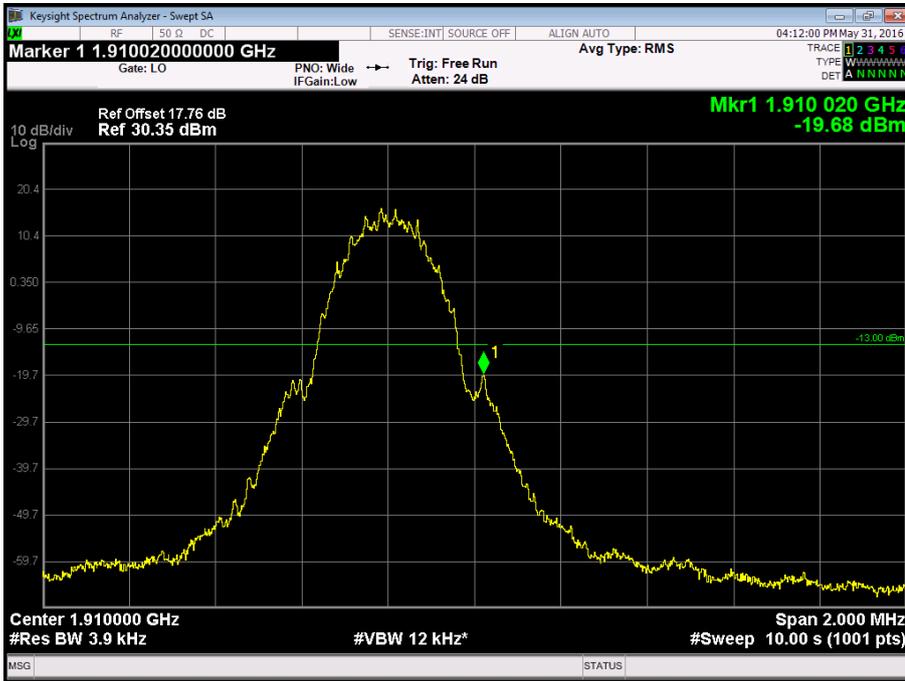
PCS 1900, Circuit-Switched, GMSK, Frequency Block A, Spurious Emissions at Band Edge Plot





Product Service

PCS 1900, Circuit-Switched, GMSK, Frequency Block C, Spurious Emissions at Band Edge Plot



FCC 47 CFR Part 24, Limit Clause 24.229 (a)

Mobile Transmitters:

Block A: 1850 to 1865 MHz paired with 1930 to 1945 MHz

Block B: 1870 to 1885 MHz paired with 1950 to 1965 MHz

FCC 47 CFR Part 24, Limit Clause 24.238 (a)

43 + 10 log (P) dB or -13 dBm.



Product Service

## 2.2 MAXIMUM CONDUCTED OUTPUT POWER

### 2.2.1 Specification Reference

FCC 47 CFR Part 24, Clause 24.232  
FCC 47 CFR Part 2, Clause 2.1046

### 2.2.2 Equipment Under Test and Modification State

S/N: IMEI 004401115813228 - Modification State 0

### 2.2.3 Date of Test

31 May 2016

### 2.2.4 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

### 2.2.5 Test Procedure

The test was performed in accordance with KDB 971168 D01 v02r02, clause 5.2.3.

#### Remarks

The EUT could not be configured to transmit continuously therefore the power meter was gated so that the measurement was only performed over the active transmission burst.

The antenna gain was declared by the manufacturer as 2.0 dBi. EIRP was then calculated using the following formula:

$$\text{EIRP} = \text{Pout (dBm)} + \text{ANT Gain (dBi)}$$

### 2.2.6 Environmental Conditions

|                     |        |
|---------------------|--------|
| Ambient Temperature | 23.6°C |
| Relative Humidity   | 47.5%  |



Product Service

**2.2.7 Test Results**

4.0 V DC Supply

PCS 1900, Circuit-Switched, Maximum Peak Conducted Output Power Results

| Frequency  | Conducted Power (dBm) | Antenna Gain | EIRP (dBm) | EIRP (W) |
|------------|-----------------------|--------------|------------|----------|
| 1850.2 MHz | 30.05                 | 2.0 dBi      | 32.05      | 1.60     |
| 1880.0 MHz | 29.97                 | 2.0 dBi      | 31.97      | 1.57     |
| 1909.8 MHz | 29.87                 | 2.0 dBi      | 31.87      | 1.54     |

FCC 47 CFR Part 24, Limit Clause 24.232 (c)

Mobile and portable stations: 2 Watts.



Product Service

## **2.3 FREQUENCY STABILITY**

### **2.3.1 Specification Reference**

FCC 47 CFR Part 24, Clause 24.235  
FCC 47 CFR Part 2, Clause 2.1055

### **2.3.2 Equipment Under Test and Modification State**

S/N: IMEI 004401115813228 - Modification State 0

### **2.3.3 Date of Test**

6 June 2016

### **2.3.4 Test Equipment Used**

The major items of test equipment used for the above tests are identified in Section 3.1.

### **2.3.5 Test Procedure**

This test was performed in accordance with FCC 47 CFR Part 2, clause 2.1055.

#### Remarks

A radio communications test set frequency measurement function was used to measure the frequency error. The radio communications test set was configured for an uplink frequency of 1880.0 MHz and the frequency reference was set to an external 10MHz rubidium frequency standard.

### **2.3.6 Environmental Conditions**

|                     |        |
|---------------------|--------|
| Ambient Temperature | 23.5°C |
| Relative Humidity   | 39.8%  |



### 2.3.7 Test Results

#### PCS 1900, 1880.0 MHz, Circuit-Switched, GMSK, Frequency Stability Under Temperature Variations Results

| Temperature | Fundamental Measured Frequency (MHz) |
|-------------|--------------------------------------|
| -30 °C      | -0.022                               |
| -20 °C      | -0.021                               |
| -10 °C      | -0.020                               |
| 0 °C        | -0.016                               |
| +10 °C      | -0.015                               |
| +20 °C      | -0.016                               |
| +30 °C      | -0.017                               |
| +40 °C      | -0.014                               |
| +50 °C      | -0.014                               |

#### PCS 1900, 1880.0 MHz, Circuit-Switched, GMSK, Frequency Stability Under Voltage Variations Results

| Voltage  | Fundamental Measured Frequency (MHz) |
|----------|--------------------------------------|
| 4.0 V DC | -0.016                               |
| 3.7 V DC | -0.014                               |

#### Remark

The measured frequency error over temperature and voltage extremes does not cause the fundamental emission to go outside the authorised frequency block.

#### FCC 47 CFR Part 24, Limit Clause 24.235

The frequency stability shall be sufficient to ensure that the fundamental emission stays within the authorised frequency block.



Product Service

## **2.4 EMISSION LIMITATIONS FOR BROADBAND PCS EQUIPMENT**

### **2.4.1 Specification Reference**

FCC 47 CFR Part 24, Clause 24.238  
FCC 47 CFR Part 2, Clause 2.1053

### **2.4.2 Equipment Under Test and Modification State**

S/N: IMEI 004401115813517 - Modification State 0

### **2.4.3 Date of Test**

5 June 2016

### **2.4.4 Test Equipment Used**

The major items of test equipment used for the above tests are identified in Section 3.1.

### **2.4.5 Test Procedure**

Testing was performed in accordance with ANSI C63.26, clause 5.5.

### **2.4.6 Environmental Conditions**

|                     |        |
|---------------------|--------|
| Ambient Temperature | 16.9°C |
| Relative Humidity   | 70.0%  |



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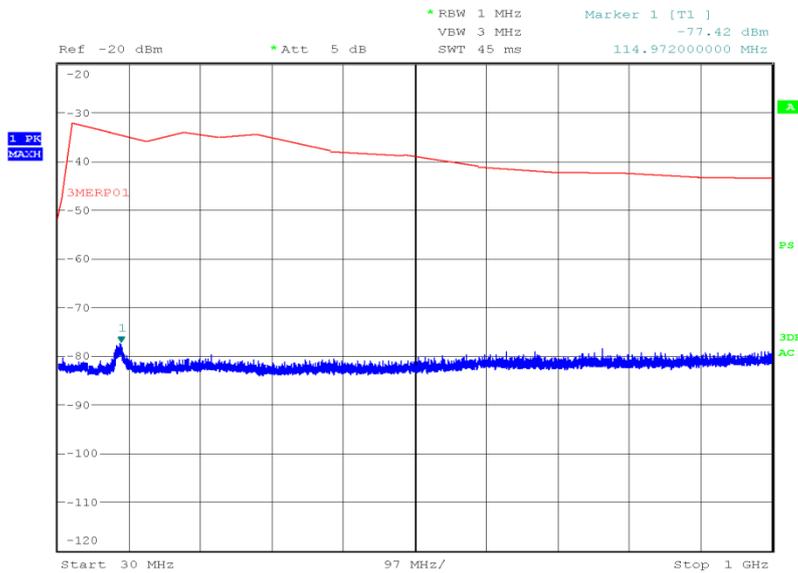
**2.4.7 Test Results**

PCS 1900, 1850.2 MHz, 30 MHz to 20 GHz, Emission Limitations for Broadband PCS Equipment Results

| Frequency (MHz) | Emission Results (dBm) |
|-----------------|------------------------|
| *               |                        |

\*No emissions were detected within 10 dB of the limit.

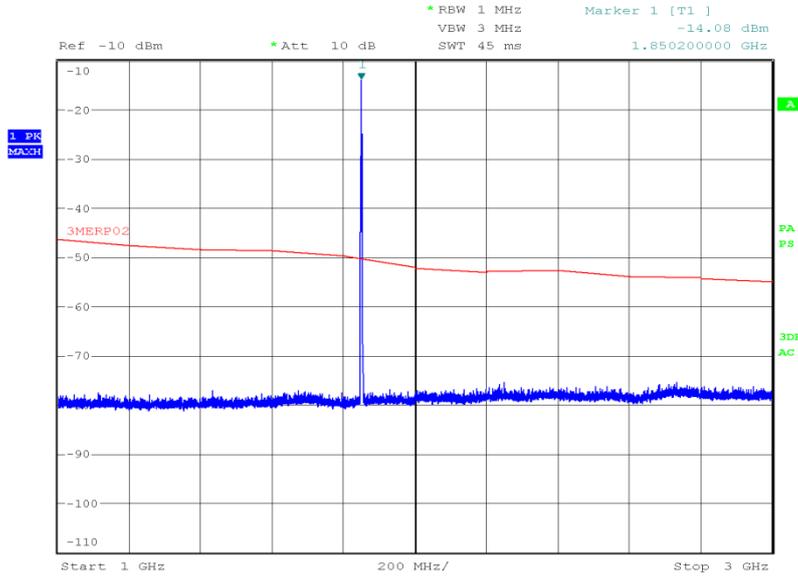
PCS 1900, 1850.2 MHz, 30 MHz to 1 GHz, Emission Limitations for Broadband PCS Equipment Results



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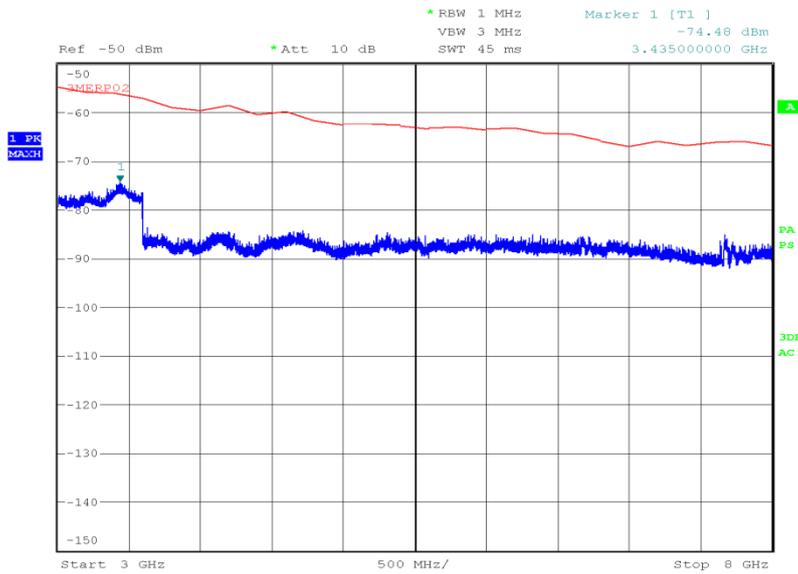


PCS 1900, 1850.2 MHz, 1 GHz to 3 GHz, Emission Limitations for Broadband PCS Equipment Plot



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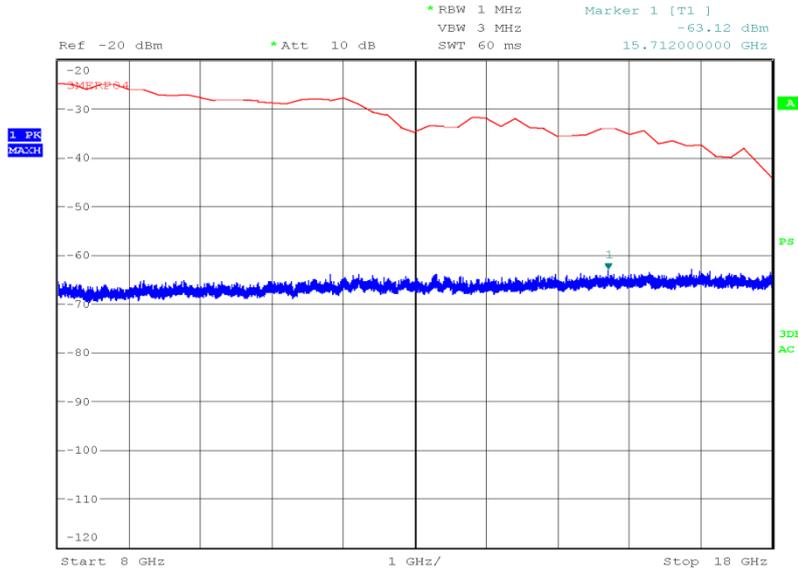
PCS 1900, 1850.2 MHz, 3 GHz to 8 GHz, Emission Limitations for Broadband PCS Equipment Plot



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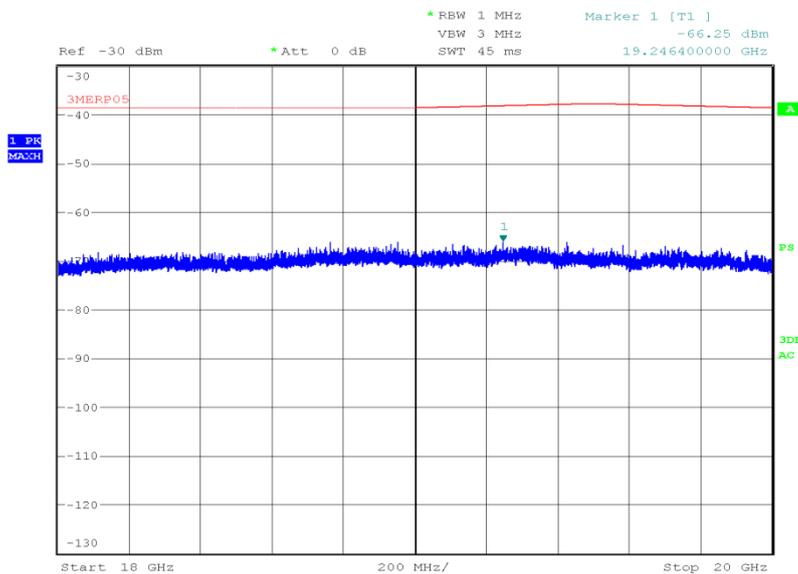


PCS 1900, 1850.2 MHz, 8 GHz to 18 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 13:22:04

PCS 1900, 1850.2 MHz, 18 GHz to 20 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 14:03:53



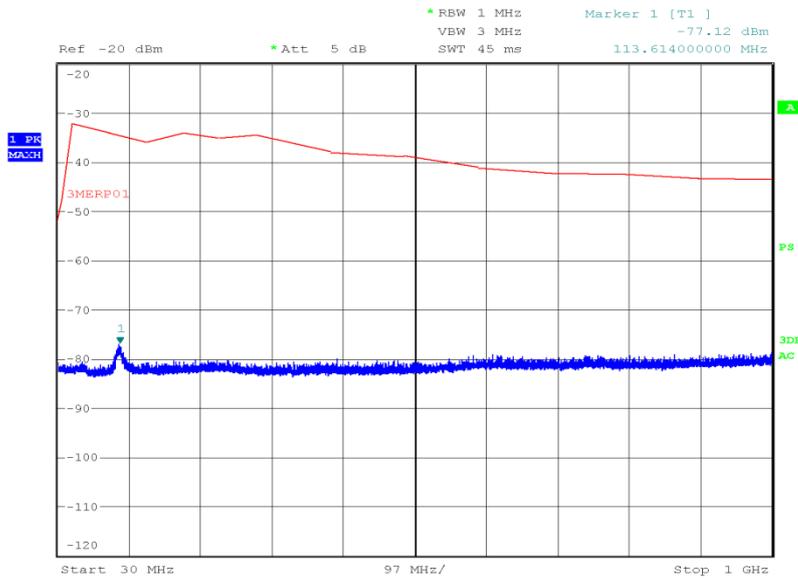
Product Service

PCS 1900, 1880.0 MHz, 30 MHz to 20 GHz Emission Limitations for Broadband PCS Equipment Results

| Frequency (MHz) | Emission Results (dBm) |
|-----------------|------------------------|
| *               |                        |

\*No emissions were detected within 10 dB of the limit.

PCS 1900, 1880.0 MHz, 30 MHz to 1 GHz, Emission Limitations for Broadband PCS Equipment Results

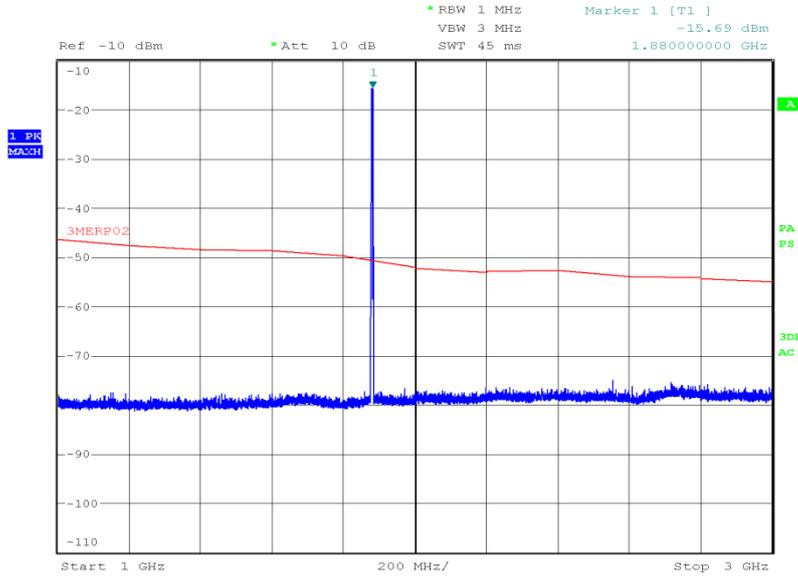


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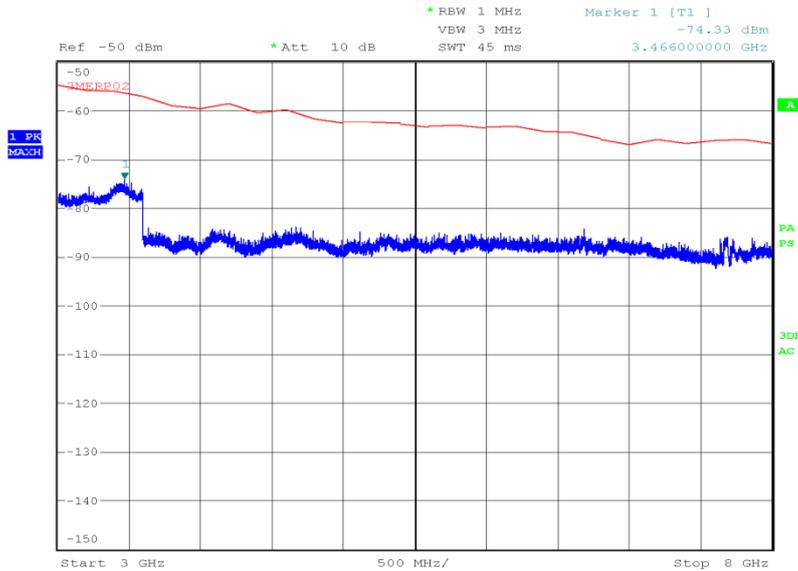
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PCS 1900, 1880.0 MHz, 1 GHz to 3 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 12:55:54

PCS 1900, 1880.0 MHz, 3 GHz to 8 GHz, Emission Limitations for Broadband PCS Equipment Plot

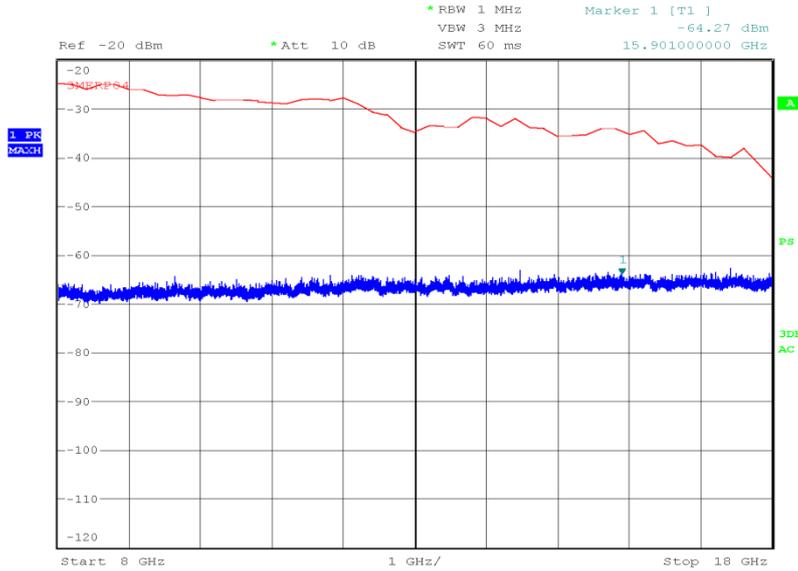


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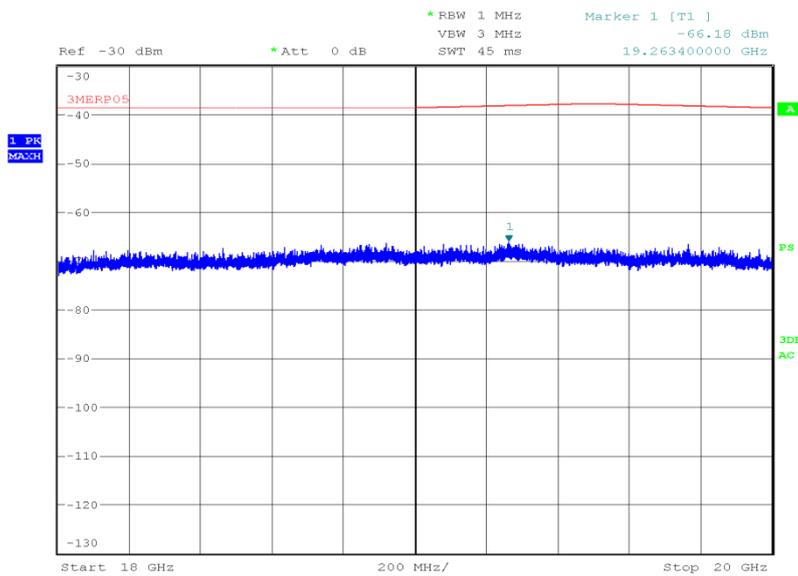
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PCS 1900, 1880.0 MHz, 8 GHz to 18 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 13:33:13

PCS 1900, 1880.0 MHz, 18 GHz to 20 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 14:04:51



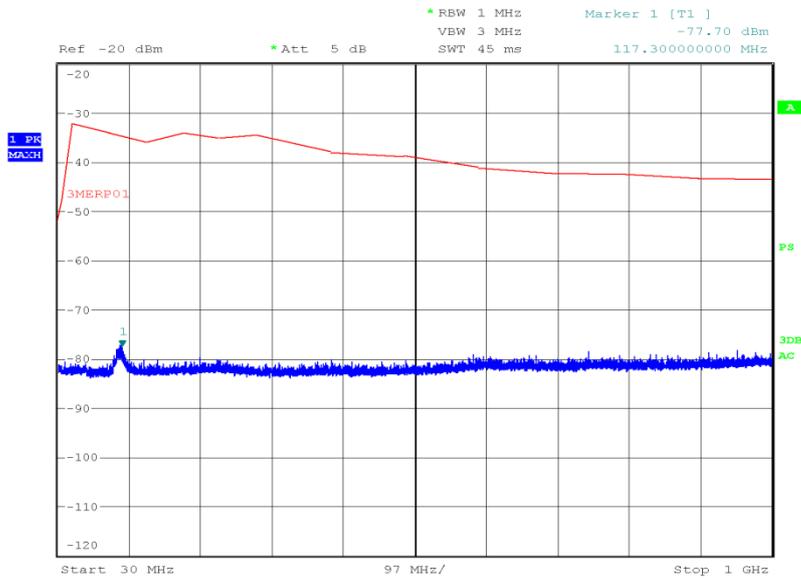
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PCS 1900, 1909.8 MHz, 30 MHz to 20 GHz Emission Limitations for Broadband PCS Equipment Results

| Frequency (MHz) | Emission Results (dBm) |
|-----------------|------------------------|
| *               |                        |

\*No emissions were detected within 10 dB of the limit.

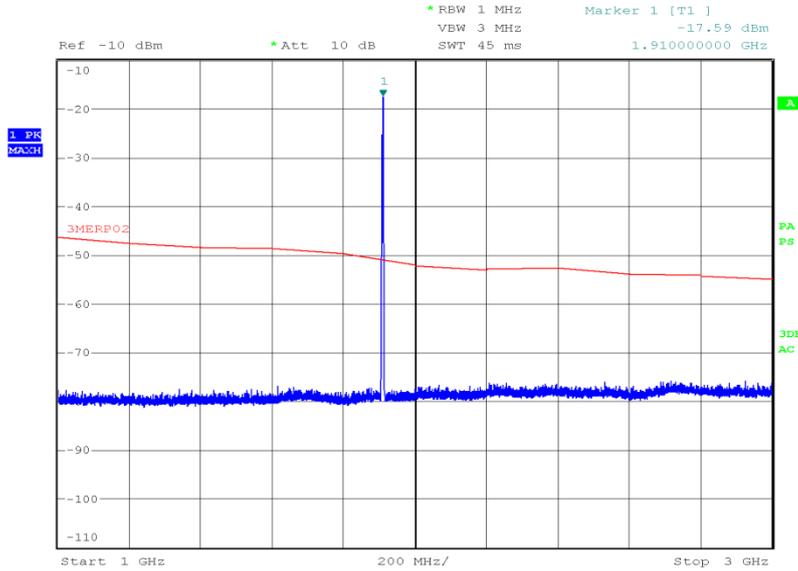
PCS 1900, 1909.8 MHz, 30 MHz to 1 GHz, Emission Limitations for Broadband PCS Equipment Results



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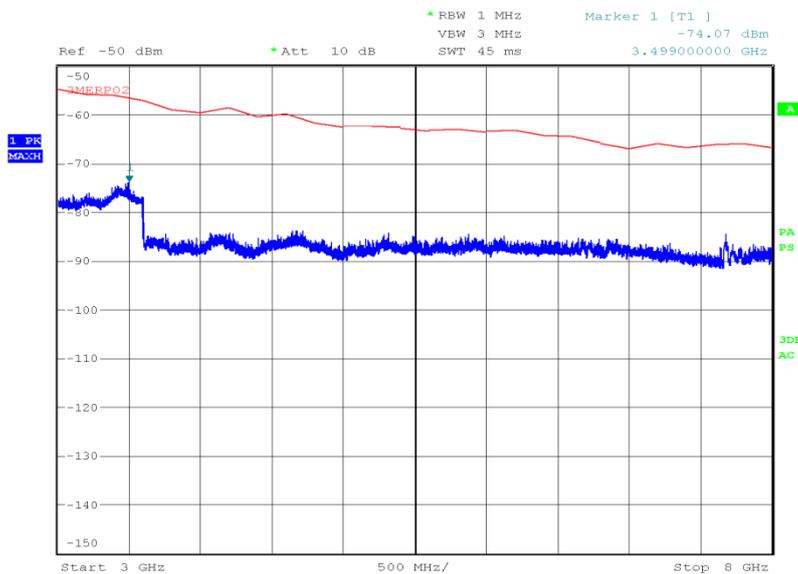


PCS 1900, 1909.8 MHz, 1 GHz to 3 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 13:00:59

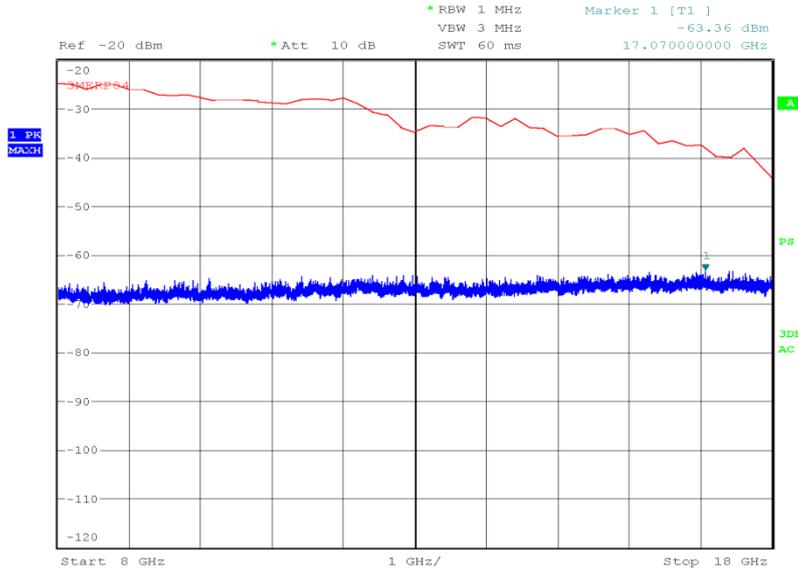
PCS 1900, 1909.8 MHz, 3 GHz to 8 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 13:05:38

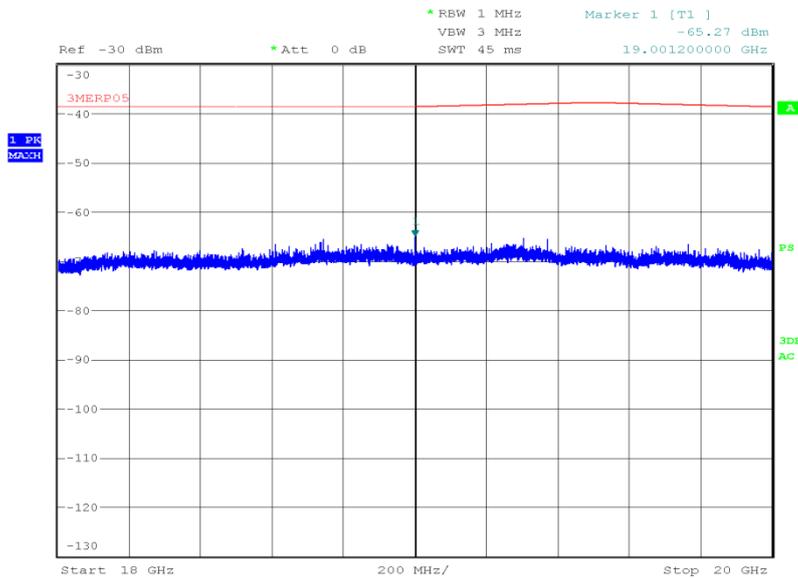


PCS 1900, 1909.8 MHz, 8 GHz to 18 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 13:34:18

PCS 1900, 1909.8 MHz, 18 GHz to 20 GHz, Emission Limitations for Broadband PCS Equipment Plot



Date: 5.JUN.2016 14:05:47

FCC 47 CFR Part 24, Limit Clause 24.238 (a)

43 + 10 log (P) dB or -13 dBm.



Product Service

**2.5 26 dB BANDWIDTH****2.5.1 Specification Reference**

FCC 47 CFR Part 24, Clause 24.238  
FCC 47 CFR Part 2, Clause 2.1049 (h)

**2.5.2 Equipment Under Test and Modification State**

S/N: IMEI 004401115813228 - Modification State 0

**2.5.3 Date of Test**

1 June 2016

**2.5.4 Test Equipment Used**

The major items of test equipment used for the above tests are identified in Section 3.1.

**2.5.5 Test Procedure**

The test was performed in accordance with KDB 971168 D01 v02 r02, clause 4.1.

**2.5.6 Environmental Conditions**

|                     |        |
|---------------------|--------|
| Ambient Temperature | 23.1°C |
| Relative Humidity   | 47.8%  |



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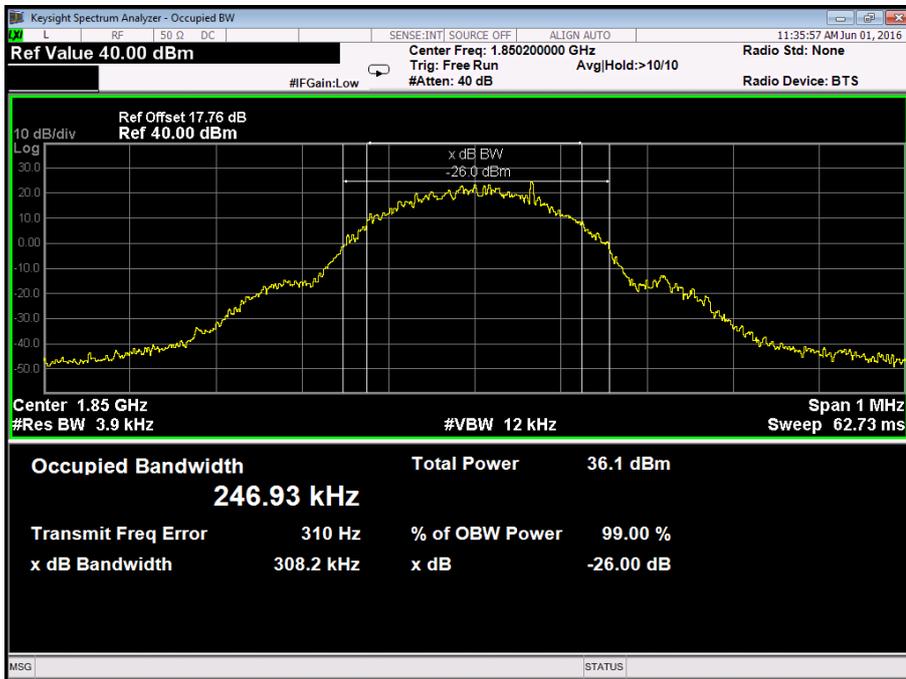
**2.5.7 Test Results**

4.0 V DC Supply

PCS 1900, Circuit-Switched, 26 dB Bandwidth Results

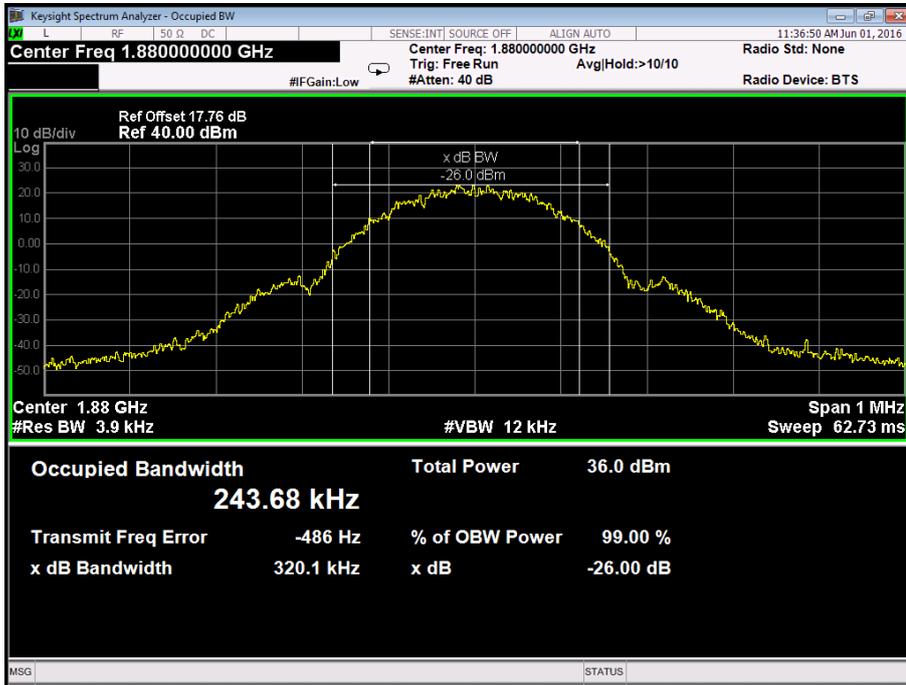
|            |            |            |
|------------|------------|------------|
| 1850.2 MHz | 1880.0 MHz | 1909.8 MHz |
| kHz        | kHz        | kHz        |
| 308.2      | 320.1      | 312.2      |

PCS 1900, 1850.2 MHz, Circuit-Switched, 26 dB Bandwidth Plot

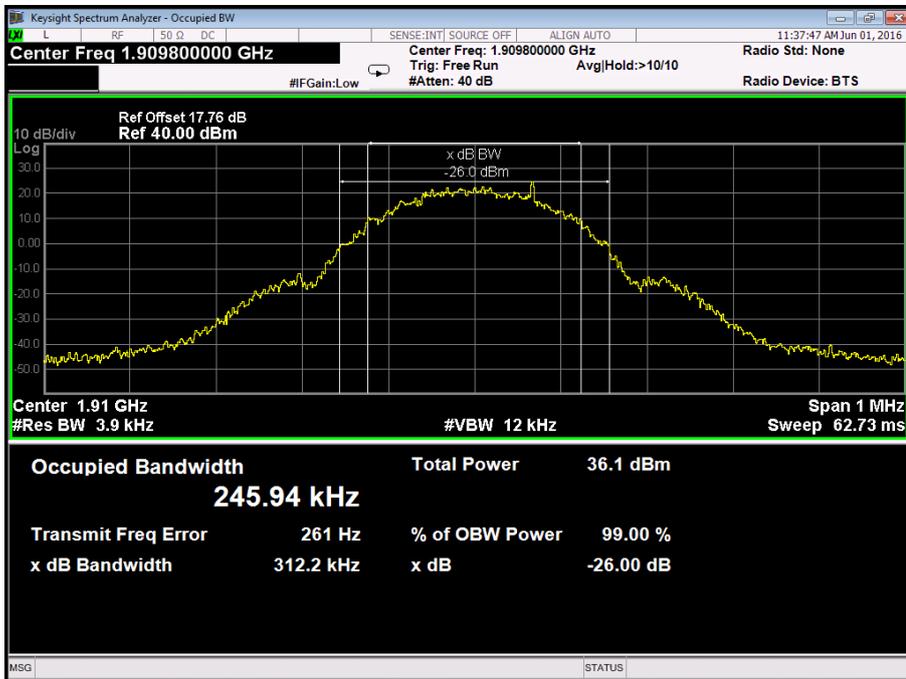




PCS 1900, 1880.0 MHz, Circuit-Switched, 26 dB Bandwidth Plot



PCS 1900, 1909.8 MHz, Circuit-Switched, 26 dB Bandwidth Plot



FCC 47 CFR Part 24, Limit Clause 24.238

The emission bandwidth is defined as the width of the signal between two points, one below the carrier centre frequency and one above the carrier centre frequency, outside of which all emissions are attenuated at least 26 dB below the transmitter power.



Product Service

## **2.6 SPURIOUS EMISSIONS AT ANTENNA TERMINALS**

### **2.6.1 Specification Reference**

FCC 47 CFR Part 24, Clause 24.238 (a)  
FCC 47 CFR Part 2, Clause 2.1051

### **2.6.2 Equipment Under Test and Modification State**

S/N: IMEI 004401115813228 - Modification State 0

### **2.6.3 Date of Test**

1 June 2016

### **2.6.4 Test Equipment Used**

The major items of test equipment used for the above tests are identified in Section 3.1.

### **2.6.5 Test Procedure**

The test was performed in accordance with KDB 971168 D01 v02 r02, clause 6.

### **2.6.6 Environmental Conditions**

|                     |        |
|---------------------|--------|
| Ambient Temperature | 23.1°C |
| Relative Humidity   | 47.8%  |



Product Service

**2.6.7 Test Results**

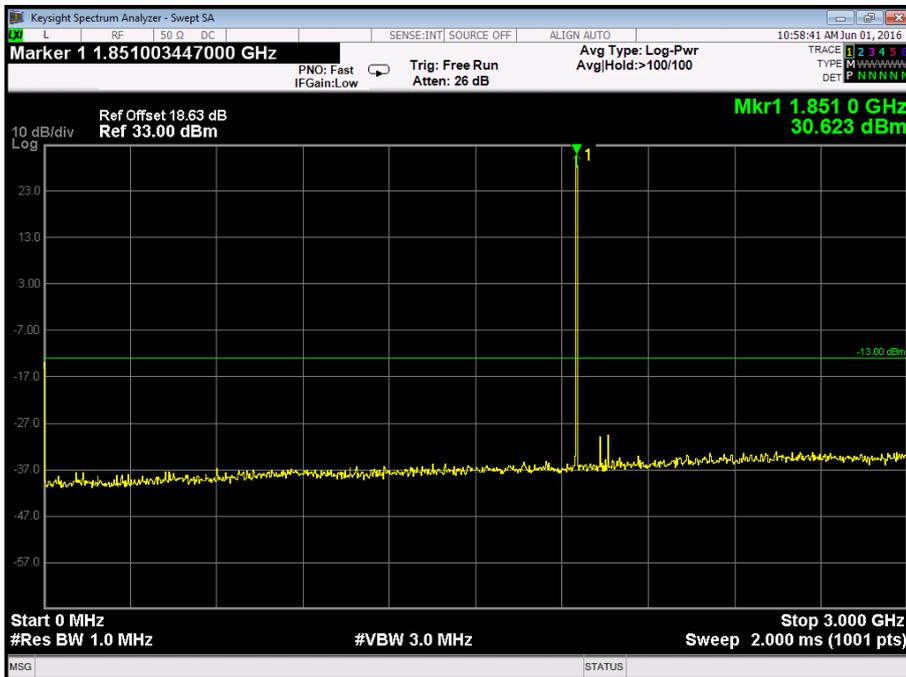
4.0 V DC Supply

PCS 1900, 1850.2 MHz, Spurious Emissions at Antenna Terminals Results

| Frequency (MHz) | Emission Results (dBm) |
|-----------------|------------------------|
| *               |                        |

\*No emissions were detected within 10 dB of the limit.

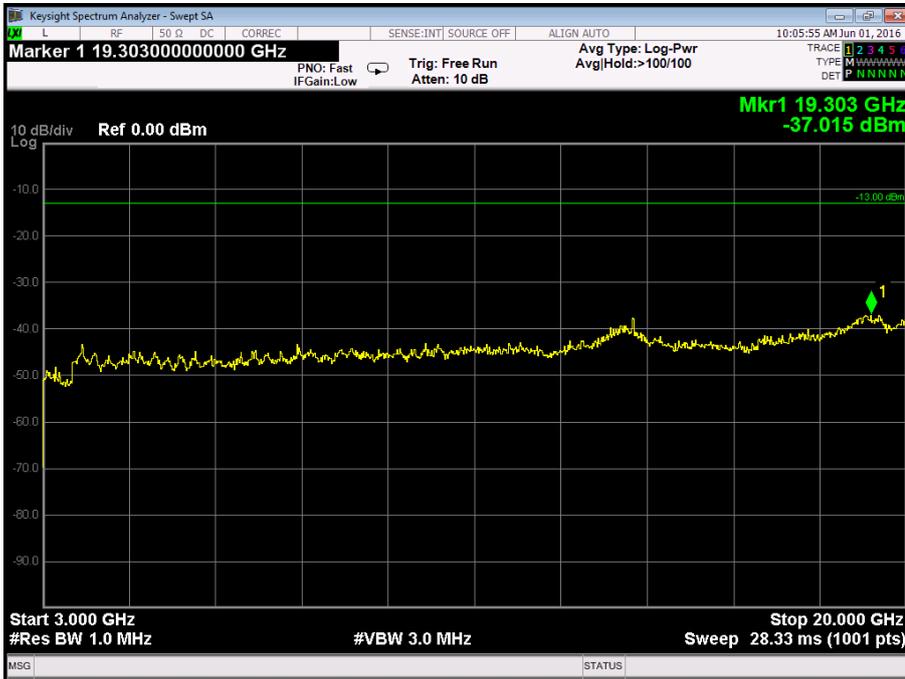
PCS 1900, 1850.2 MHz, 9 kHz to 3 GHz, Spurious Emissions at Antenna Terminals Plot





Product Service

PCS 1900, 1850.2 MHz, 3 GHz to 20 GHz, Spurious Emissions at Antenna Terminals Plot





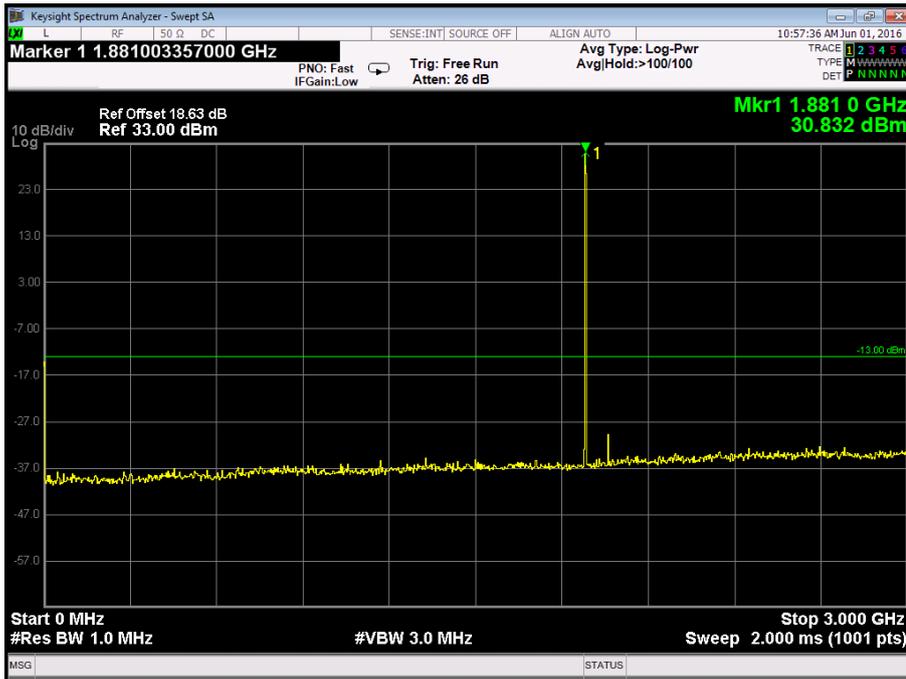
Product Service

PCS 1900, 1880.0 MHz, Spurious Emissions at Antenna Terminals Results

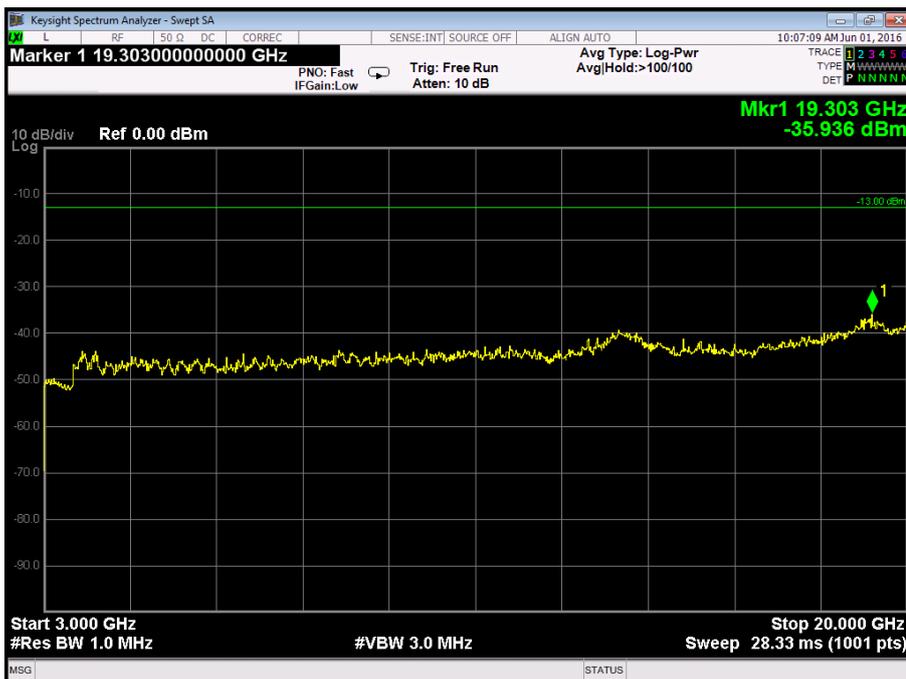
| Frequency (MHz) | Emission Results (dBm) |
|-----------------|------------------------|
| *               |                        |

\*No emissions were detected within 10 dB of the limit.

PCS 1900, 1880.0 MHz, 9 kHz to 3 GHz, Spurious Emissions at Antenna Terminals Plot



PCS 1900, 1880.0 MHz, 3 GHz to 20 GHz, Spurious Emissions at Antenna Terminals Plot





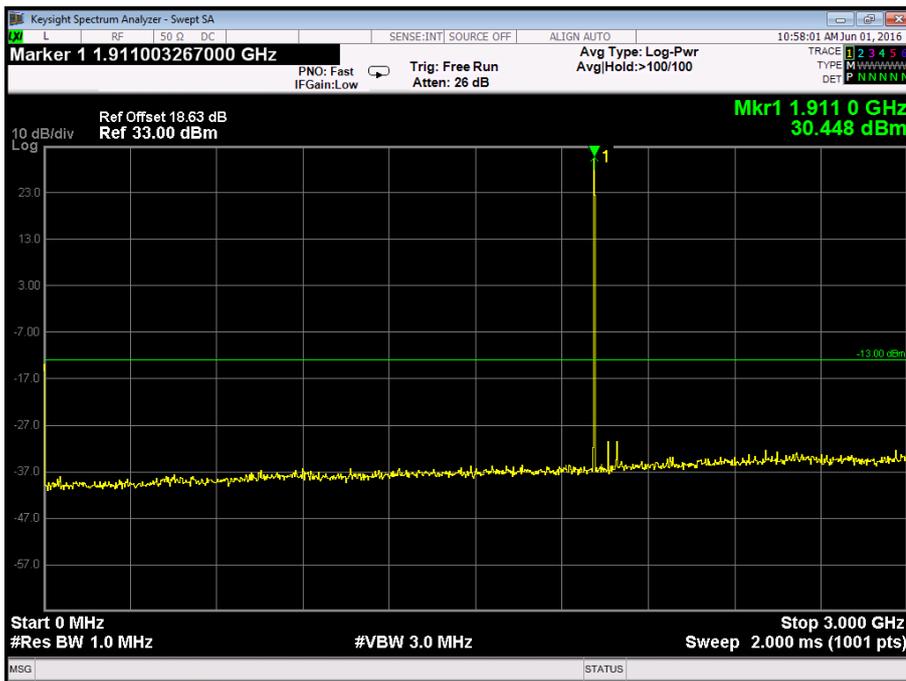
Product Service

PCS 1900, 1909.8 MHz, Spurious Emissions at Antenna Terminals Results

| Frequency (MHz) | Emission Results (dBm) |
|-----------------|------------------------|
| *               |                        |

\*No emissions were detected within 10 dB of the limit.

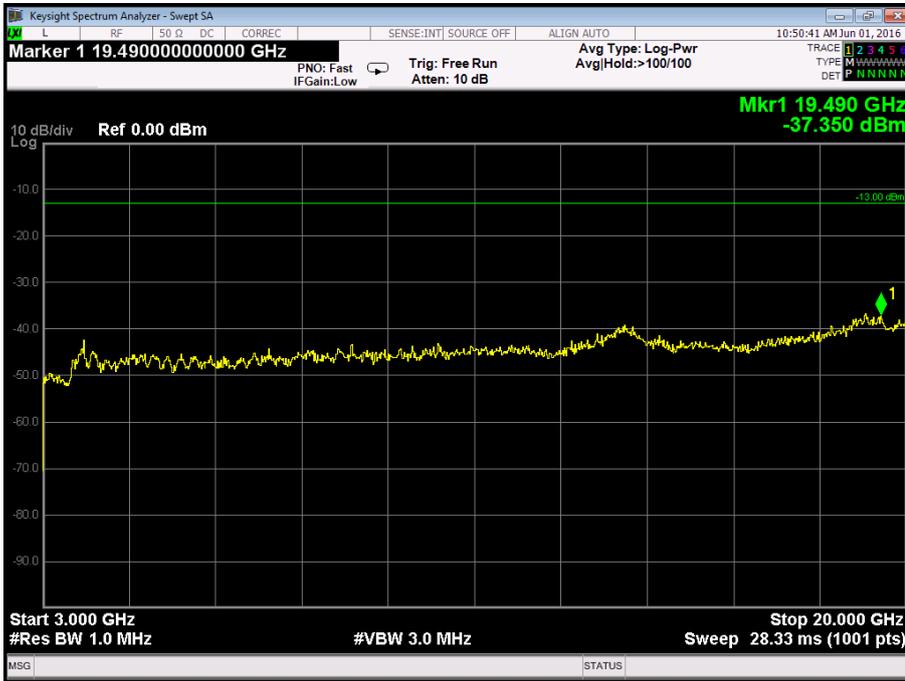
PCS 1900, 1909.8 MHz, 9 kHz to 3 GHz, Spurious Emissions at Antenna Terminals Plot





Product Service

PCS 1900, 1909.8 MHz, 3 GHz to 20 GHz, Spurious Emissions at Antenna Terminals Plot



FCC 47 CFR Part 24, Limit Clause 24.238 (a)

43 + 10 log (P) dB or -13 dBm.



## 2.7 MODULATION CHARACTERISTICS

### 2.7.1 Specification Reference

FCC 47 CFR Part 2, Clause 2.1047 (d)

### 2.7.2 Test Results

PCS 1900, Modulation Characteristics, Customer Description

#### Description of Modulation Technique

The modulation scheme used in GSM is called Gaussian Minimum Shift Keying (GMSK). GMSK facilitates the use of narrow bandwidth and allows for both coherent and non coherent detection capabilities. It is a scheme in which the transitions from One to Zero or Zero to One do not occur quickly, but over a period of time. If pulses are transmitted quickly harmonics are transmitted. The power spectrum for a square wave is rich in harmonics, and the power within the side lobes is wasted, and can be a cause of potential interference.

A method to reduce the harmonics is to round off the edges of the pulses thus lowering the spectral components of the signal. In GSM this is done by using a Gaussian pre-filter which typically has a bandwidth of 81.25kHz. The output from the Gaussian filter then phase modulates the carrier. As there are no dramatic phase transitions of the carrier this gives a constant envelope and low spectral component output from the transmitter.

The spectral efficiency is calculated by

$\text{bit rate} / \text{Channel bandwidth} = 270.83333 \text{ kbit/s} / 200 \text{ kHz} = 1.354 \text{ bit/s/Hz}$ .

The bandwidth product  $BT = \text{Bandwidth} \times \text{bit duration} = 81.25 \text{ kHz} \times 3.6923 \text{ micros} = 0.3$

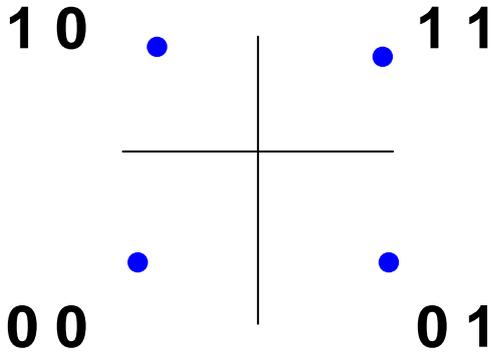
#### **GMSK OVERVIEW**

The modulation scheme used for the EUT is GMSK.

A brief overview of how GMSK works is shown below.

#### **GMSK (Gaussian Minimum Shift Keying)**

The fundamental principal behind GMSK is Phase shift keying. This splits a data stream into a series of 2-digit phase shifts, using the following phase shifts to represent data pairs.



Therefore for the BIT sequence 0 0 1 1 1 0 0 1 The corresponding phase shift will be used

|              |      |     |      |      |
|--------------|------|-----|------|------|
| BIT SEQUENCE | 0 0  | 1 1 | 1 0  | 0 1  |
| PHASE        | 225° | 45° | 135° | 315° |

This is called QPSK (Quadratic Phase Shift Keying)

**However**

There is a problem with QPSK: transition from e.g. 00 to 11 gives phase shift of 180° ( $\pi$  radians). This has the effect of inverting the carrier waveform and this can lead to detection errors at the receiver.

Solution: restrict phase changes to  $\pm 90^\circ$

1. Split bitstream into 2 streams e.g.

|          |     |   |     |   |     |   |     |   |
|----------|-----|---|-----|---|-----|---|-----|---|
|          | 0 0 |   | 1 1 |   | 0 1 |   | 1 0 |   |
| I Stream | 0   |   | 1   |   | 0   |   | 1   |   |
| Q stream |     | 0 |     | 1 |     | 1 |     | 0 |

2. Modulate each stream with PSK (1 = 90° or  $\pi/2$ , 0 = -90° or  $-\pi/2$  phase shift)

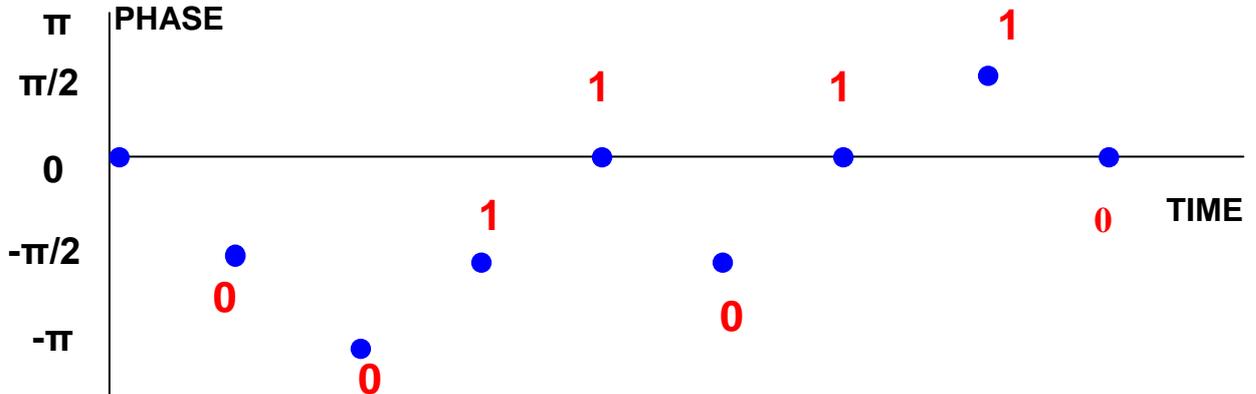
|          |          |          |          |         |          |         |         |          |
|----------|----------|----------|----------|---------|----------|---------|---------|----------|
| I Stream | 0        |          | 1        |         | 0        |         | 1       |          |
|          | $-\pi/2$ |          | $-\pi/2$ |         | $-\pi/2$ |         | $\pi/2$ |          |
| Q stream |          | 0        |          | 1       |          | 1       |         | 0        |
|          |          | $-\pi/2$ |          | $\pi/2$ |          | $\pi/2$ |         | $-\pi/2$ |



3. Combine (add) the two PSK signals:

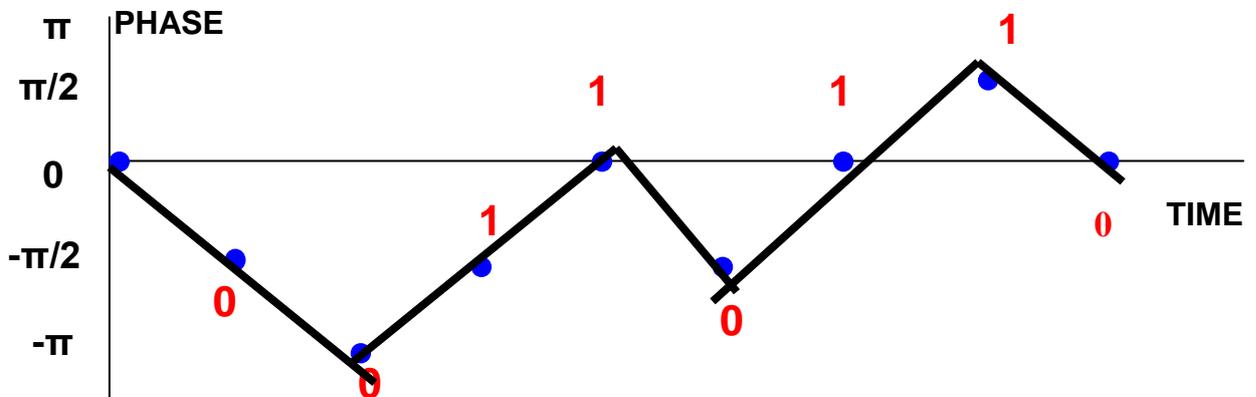
|                |          |        |          |   |          |   |         |   |
|----------------|----------|--------|----------|---|----------|---|---------|---|
| Combined Phase | $-\pi/2$ | $-\pi$ | $-\pi/2$ | 0 | $-\pi/2$ | 0 | $\pi/2$ | 0 |
|----------------|----------|--------|----------|---|----------|---|---------|---|

Result: offset – QPSK, phase change is restricted to  $\pm \pi/2$  radians:



It would be preferable to have “gradual” changes in phase between each pair of bits (Continuous-phase modulation). Replacing each “rectangular” shaped pulse (for 1 or 0) with a sinusoidal pulse can do this:

Result: Minimum Shift Keying (MSK):



**Gaussian Minimum Shift Keying**

MSK has high sidebands relative to the main lobes in the frequency domain – this can lead to interference with adjacent signals.

If the rectangular pulses corresponding to the bitstream are filtered using a Gaussian-shaped impulse response filter, we get Gaussian MSK (GMSK) – this has low sidelobes compared to MSK.

**FCC 47 CFR Part 2, Limit Clause 2.1047 (d)**

A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.



Product Service

### **SECTION 3**

#### **TEST EQUIPMENT USED**



### 3.1 TEST EQUIPMENT USED

List of absolute measuring and other principal items of test equipment.

| Instrument   | Manufacturer          | Type No.                   | TE No. | Calibration Period (months) | Calibration Due |
|--|-----------------------|----------------------------|--------|-----------------------------|-----------------|
| <b>Section 2.1 - Spurious Emissions at Band Edge</b> |                       |                            |        |                             |                 |
| Radio Communications Test Set                        | Rohde & Schwarz       | CMU 200                    | 442    | 12                          | 18-Jan-2017     |
| Power Splitter                                       | Weinschel             | 1506A                      | 606    | 12                          | 24-Mar-2017     |
| Rubidium Standard                                    | Rohde & Schwarz       | XSRM                       | 1316   | 6                           | 3-Sep-2016      |
| Programmable Power Supply                            | Iso-tech              | IPS 2010                   | 2435   | -                           | O/P Mon         |
| Hygrometer   | Rotronic              | I-1000                     | 3220   | 12                          | 19-Aug-2016     |
| Attenuator (10dB, 20W)                               | Lucas Weinschel       | 1                          | 3225   | 12                          | 16-Dec-2016     |
| Network Analyser                                     | Rohde & Schwarz       | ZVA 40                     | 3548   | 12                          | 2-Sep-2016      |
| TRUE RMS MULTIMETER                                  | Fluke                 | 179                        | 4006   | 0                           | 9-Dec-2016      |
| Calibration Unit                                     | Rohde & Schwarz       | ZV-Z54                     | 4368   | 12                          | 7-Sep-2016      |
| Frequency Standard                                   | Spectracom            | Secure Sync 1200-0408-0601 | 4393   | 6                           | 3-Sep-2016      |
| Wideband Radio Test Set                              | Rohde & Schwarz       | CMW500                     | 4546   | 12                          | 3-Feb-2017      |
| PXA Signal Analyser                                  | Keysight Technologies | N9030A                     | 4654   | 12                          | 8-Oct-2016      |
| <b>Section 2.2 - Maximum Conducted Output Power</b>  |                       |                            |        |                             |                 |
| Radio Communications Test Set                        | Rohde & Schwarz       | CMU 200                    | 442    | 12                          | 18-Jan-2017     |
| Power Splitter                                       | Weinschel             | 1506A                      | 606    | 12                          | 24-Mar-2017     |
| Programmable Power Supply                            | Iso-tech              | IPS 2010                   | 2435   | -                           | O/P Mon         |
| Hygrometer   | Rotronic              | I-1000                     | 3220   | 12                          | 19-Aug-2016     |
| Attenuator (10dB, 20W)                               | Lucas Weinschel       | 1                          | 3225   | 12                          | 16-Dec-2016     |
| Network Analyser                                     | Rohde & Schwarz       | ZVA 40                     | 3548   | 12                          | 2-Sep-2016      |
| P-Series Power Meter                                 | Agilent Technologies  | N1911A                     | 3981   | 12                          | 25-Sep-2016     |
| 50 MHz-18 GHz Wideband Power Sensor                  | Agilent Technologies  | N1921A                     | 3983   | 12                          | 25-Sep-2016     |
| TRUE RMS MULTIMETER                                  | Fluke                 | 179                        | 4006   | 0                           | 9-Dec-2016      |
| Fan Heater   | Master                | B 3 EPB                    | 4363   | -                           | TU              |
| Calibration Unit                                     | Rohde & Schwarz       | ZV-Z54                     | 4368   | 12                          | 7-Sep-2016      |
| Wideband Radio Test Set                              | Rohde & Schwarz       | CMW500                     | 4546   | 12                          | 3-Feb-2017      |
| PXA Signal Analyser                                  | Keysight Technologies | N9030A                     | 4654   | 12                          | 8-Oct-2016      |
| <b>Section 2.3 - Frequency Stability</b>             |                       |                            |        |                             |                 |
| Attenuator 10dB/25W                                  | Weinschel             | 46-10-43                   | 400    | 12                          | 18-Jun-2016     |
| Temperature Chamber                                  | Montford              | 2F3                        | 467    | -                           | O/P Mon         |
| Rubidium Standard                                    | Rohde & Schwarz       | XSRM                       | 1316   | 6                           | 3-Sep-2016      |
| Radio Communications Test Set                        | Rohde & Schwarz       | CMU 200                    | 2809   | 12                          | 9-Jul-2016      |
| Thermocouple Thermometer                             | Fluke                 | 51                         | 3174   | 12                          | 9-Dec-2016      |
| Hygrometer   | Rotronic              | I-1000                     | 3220   | 12                          | 19-Aug-2016     |
| Attenuator (10dB, 20W)                               | Lucas Weinschel       | 1                          | 3225   | 12                          | 16-Dec-2016     |
| TRUE RMS MULTIMETER                                  | Fluke                 | 179                        | 4006   | 0                           | 9-Dec-2016      |
| Wideband Radio Communication Tester                  | Rohde & Schwarz       | CMW 500                    | 4144   | 12                          | 16-Nov-2016     |
| Frequency Standard                                   | Spectracom            | Secure Sync 1200-0408-0601 | 4393   | 6                           | 3-Sep-2016      |



| Instrument  | Manufacturer             | Type No.                   | TE No. | Calibration Period (months) | Calibration Due |
|---|--------------------------|----------------------------|--------|-----------------------------|-----------------|
| <b>Section 2.4 - Emission Limitations for Broadband PCS Equipment</b> |                          |                            |        |                             |                 |
| Antenna 18-40GHz (Double Ridge Guide)                                 | Link Microtek Ltd        | AM180HA-K-TU2              | 230    | 24                          | 12-Feb-2018     |
| Radio Communications Test Set   | Rohde & Schwarz          | CMU 200                    | 442    | 12                          | 18-Jan-2017     |
| Power Splitter  | Weinschel                | 1506A                      | 606    | 12                          | 24-Mar-2017     |
| Rubidium Standard   | Rohde & Schwarz          | XSRM                       | 1316   | 6                           | 3-Sep-2016      |
| Pre-Amplifier   | Phase One                | PS04-0086                  | 1533   | 12                          | 30-Jul-2016     |
| 18GHz - 40GHz Pre-Amplifier   | Phase One                | PS04-0087                  | 1534   | 12                          | 23-Dec-2016     |
| Screened Room (5)   | Rainford                 | Rainford                   | 1545   | 36                          | 20-Dec-2017     |
| Turntable Controller  | Inn-Co GmbH              | CO 1000                    | 1606   | -                           | TU              |
| Programmable Power Supply   | Iso-tech                 | IPS 2010                   | 2435   | -                           | O/P Mon         |
| Antenna (Bilog)   | Chase                    | CBL6143                    | 2904   | 24                          | 11-Jun-2017     |
| Hygrometer  | Rotronic                 | I-1000                     | 3220   | 12                          | 19-Aug-2016     |
| Attenuator (10dB, 20W)  | Lucas Weinschel          | 1                          | 3225   | 12                          | 16-Dec-2016     |
| EMI Test Receiver   | Rohde & Schwarz          | ESU40                      | 3506   | 12                          | 2-Nov-2016      |
| Network Analyser  | Rohde & Schwarz          | ZVA 40                     | 3548   | 12                          | 2-Sep-2016      |
| 9m RF Cable (N Type)  | Rhophase                 | NPS-2303-9000-NPS          | 3791   | -                           | TU              |
| Tilt Antenna Mast   | maturu GmbH              | TAM 4.0-P                  | 3916   | -                           | TU              |
| Mast Controller   | maturu GmbH              | NCD                        | 3917   | -                           | TU              |
| TRUE RMS MULTIMETER   | Fluke                    | 179                        | 4006   | 0                           | 9-Dec-2016      |
| Calibration Unit  | Rohde & Schwarz          | ZV-Z54                     | 4368   | 12                          | 7-Sep-2016      |
| Frequency Standard  | Spectracom               | Secure Sync 1200-0408-0601 | 4393   | 6                           | 3-Sep-2016      |
| Hygropalm Temperature and Humidity Meter                              | Rotronic                 | HP21                       | 4410   | 12                          | 27-Apr-2017     |
| Suspended Substrate Highpass Filter                                   | Advance Power Components | 11SH10-3000/X18000-O/O     | 4412   | 12                          | 23-Mar-2017     |
| PXA Signal Analyser   | Keysight Technologies    | N9030A                     | 4654   | 12                          | 8-Oct-2016      |
| Double Ridged Waveguide Horn Antenna                                  | ETS-Lindgren             | 3117                       | 4722   | 12                          | 29-Dec-2016     |
| <b>Section 2.5 - 26 dB Bandwidth</b>                                  |                          |                            |        |                             |                 |
| Radio Communications Test Set   | Rohde & Schwarz          | CMU 200                    | 442    | 12                          | 18-Jan-2017     |
| Power Splitter  | Weinschel                | 1506A                      | 606    | 12                          | 24-Mar-2017     |
| Programmable Power Supply   | Iso-tech                 | IPS 2010                   | 2435   | -                           | O/P Mon         |
| Hygrometer  | Rotronic                 | I-1000                     | 3220   | 12                          | 19-Aug-2016     |
| Attenuator (10dB, 20W)  | Lucas Weinschel          | 1                          | 3225   | 12                          | 16-Dec-2016     |
| Network Analyser  | Rohde & Schwarz          | ZVA 40                     | 3548   | 12                          | 2-Sep-2016      |
| TRUE RMS MULTIMETER   | Fluke                    | 179                        | 4006   | 0                           | 9-Dec-2016      |
| Calibration Unit  | Rohde & Schwarz          | ZV-Z54                     | 4368   | 12                          | 7-Sep-2016      |
| PXA Signal Analyser   | Keysight Technologies    | N9030A                     | 4654   | 12                          | 8-Oct-2016      |



Product Service

| Instrument   | Manufacturer             | Type No.                   | TE No. | Calibration Period (months) | Calibration Due |
|--|--------------------------|----------------------------|--------|-----------------------------|-----------------|
| <b>Section 2.6 - Spurious Emissions at Antenna Terminals</b> |                          |                            |        |                             |                 |
| Radio Communications Test Set                                | Rohde & Schwarz          | CMU 200                    | 442    | 12                          | 18-Jan-2017     |
| Power Splitter   | Weinschel                | 1506A                      | 606    | 12                          | 24-Mar-2017     |
| Rubidium Standard  | Rohde & Schwarz          | XSRM                       | 1316   | 6                           | 3-Sep-2016      |
| Programmable Power Supply                                    | Iso-tech                 | IPS 2010                   | 2435   | -                           | O/P Mon         |
| Filter   | Daden Anthony Ass        | MH-1500-7SS                | 2778   | 12                          | 5-Feb-2017      |
| Hygrometer   | Rotronic                 | I-1000                     | 3220   | 12                          | 19-Aug-2016     |
| Attenuator (10dB, 20W)                                       | Lucas Weinschel          | 1                          | 3225   | 12                          | 16-Dec-2016     |
| Network Analyser   | Rohde & Schwarz          | ZVA 40                     | 3548   | 12                          | 2-Sep-2016      |
| TRUE RMS MULTIMETER  | Fluke                    | 179                        | 4006   | 0                           | 9-Dec-2016      |
| Calibration Unit   | Rohde & Schwarz          | ZV-Z54                     | 4368   | 12                          | 7-Sep-2016      |
| Frequency Standard   | Spectracom               | Secure Sync 1200-0408-0601 | 4393   | 6                           | 3-Sep-2016      |
| Suspended Substrate Highpass Filter                          | Advance Power Components | 11SH10-3000/X18000-O/O     | 4412   | 12                          | 23-Mar-2017     |
| Wideband Radio Test Set                                      | Rohde & Schwarz          | CMW500                     | 4546   | 12                          | 3-Feb-2017      |
| PXA Signal Analyser  | Keysight Technologies    | N9030A                     | 4654   | 12                          | 8-Oct-2016      |

TU – Traceability Unscheduled

O/P MON – Output Monitored with Calibrated Equipment



### 3.2 MEASUREMENT UNCERTAINTY

For a 95% confidence level, the measurement uncertainties for defined systems are:-

| Test Discipline                                  | MU   |
|--|--|
| Maximum Conducted Output Power                   | $\pm 0.70$ dB  |
| 26 dB Bandwidth                                  | $\pm 9.18$ kHz   |
| Spurious Emissions at Antenna Terminals          | $\pm 3.454$ dB   |
| Modulation Characteristics                       | -  |
| Spurious Emissions at Band Edge                  | $\pm 17.6$ kHz   |
| Emission Limitations for Broadband PCS Equipment | 30 MHz to 1 GHz: $\pm 5.1$ dB<br>1 GHz to 40 GHz: $\pm 6.3$ dB |
| Frequency Stability                              | $\pm 99.54$ Hz   |



Product Service

## **SECTION 4**

### **ACCREDITATION, DISCLAIMERS AND COPYRIGHT**



Product Service

#### 4.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT



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