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Report On

FCC Testing of the
The Boeing Company Black Smartphone
In accordance with FCC CFR 47 Part 2 and FCC CFR 47 Part 22
(GSM)

COMMERCIAL-IN-CONFIDENCE

FCC ID: H8V-BLK1

Document 75923267 Report 04 Issue 3

January 2014



Product Service

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COMMERCIAL-IN-CONFIDENCE

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FCC Testing of the
The Boeing Company Black Smartphone
In accordance with FCC CFR 47 Part 2 and FCC CFR 47 Part 22
(GSM)

Document 75923267 Report 04 Issue 3

January 2014

PREPARED FOR

The Boeing Company
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Springfield
VA 22153

PREPARED BY

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Senior Administrator (Technical)

APPROVED BY

Simon Bennett
Authorised Signatory

DATED

23 January 2014

This report has been up issued to Issue 3 to include additional test results.

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 CFR 47 Part 2 and FCC CFR 47 Part 22. The sample tested was found to comply with the requirements defined in the applied rules.

Test Engineer(s);

A Galpin

G Lawler

N Rousell

T Guy





CONTENTS

Section	Page No
1	REPORT SUMMARY 3
1.1	Introduction 4
1.2	Brief Summary of Results 5
1.3	Application Form 6
1.4	Product Information 7
1.5	Test Conditions 7
1.6	Deviations from the Standard 7
1.7	Modification Record 7
2	TEST DETAILS 8
2.1	Spurious Emissions at Band Edge 9
2.2	Effective Radiated Power 14
2.3	Maximum Peak Output Power - Conducted 21
2.4	Emission Limitations for Cellular Equipment 23
2.5	Conducted Spurious Emissions 34
2.6	Occupied Bandwidth 43
2.7	Modulation Characteristics 50
2.8	Frequency Stability 53
3	TEST EQUIPMENT USED 57
3.1	Test Equipment Used 58
3.2	Measurement Uncertainty 61
4	ACCREDITATION, DISCLAIMERS AND COPYRIGHT 62
4.1	Accreditation, Disclaimers and Copyright 63



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SECTION 1

REPORT SUMMARY

FCC Testing of the
The Boeing Company Black Smartphone
In accordance with FCC CFR 47 Part 2 and FCC CFR 47 Part 22 (GSM)



Product Service

1.1 INTRODUCTION

The information contained in this report is intended to show verification of the FCC Testing of the The Boeing Company Black Smartphone to the requirements of FCC CFR 47 Part 2 and FCC CFR 47 Part 22.

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	The Boeing Company
Model Number(s)	Black Smartphone
Serial Number(s)	XCV23200852 XCV23200791
Number of Samples Tested	2
Test Specification/Issue/Date	FCC CFR 47 Part 2 (2012) FCC CFR 47 Part 22 (2012)
Incoming Release Date	Application Form 13 December 2013
Disposal Reference Number Date	Held Pending Disposal Not Applicable Not Applicable
Order Number Date	48774 01 July 2013
Start of Test	21 July 2013
Finish of Test	23 January 2014
Name of Engineer(s)	A Galpin G Lawler T Guy N Rousell
Related Document(s)	ANSI C63.4: 2009



1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with FCC CFR 47 Part 2 and FCC CFR 47 Part 22 is shown below.

Section	Spec Clause		Test Description	Result	Comments/Base Standard
	Pt2	Pt22			
GSM 850 - GMSK Modulation					
2.1	2.1051	22.905	Spurious Emissions at Band Edge	Pass	
2.2	-	22.913 (a)	Effective Radiated Power	Pass	
2.3	2.1046	22.913 (a)	Maximum Peak Output Power - Conducted	Pass	
2.4	-	22.917	Emission Limitations for Cellular Equipment	Pass	
2.5	2.1051	22.917 (a)	Conducted Spurious Emissions	Pass	
2.6	2.1049 (h)	22.917 (b)	Occupied Bandwidth	Pass	
2.7	2.1047 (d)	-	Modulation Characteristics	-	Customer Declaration
2.8	2.1055	22.355	Frequency Stability	Pass	
GSM 850 - 8PSK Modulation					
2.1	2.1051	22.905	Spurious Emissions at Band Edge	Pass	
2.2	-	22.913 (a)	Effective Radiated Power	Pass	
2.3	2.1046	22.913 (a)	Maximum Peak Output Power - Conducted	Pass	
2.4	-	22.917	Emission Limitations for Cellular Equipment	Pass	
2.5	2.1051	22.917 (a)	Conducted Spurious Emissions	Pass	
2.6	2.1049 (h)	22.917 (b)	Occupied Bandwidth	Pass	
2.7	2.1047 (d)	-	Modulation Characteristics	-	Customer Declaration
2.8	2.1055	22.355	Frequency Stability	Pass	



Product Service

1.3 APPLICATION FORM

APPLICANT'S DETAILS			
COMPANY NAME : The Boeing Company ADDRESS : 7700 Boston Blvd. Springfield, VA 22153			
NAME FOR CONTACT PURPOSES : Brian Chapman			
TELEPHONE NO: 703.270.6714		FAX NO:	
E-MAIL: brian.s.chapman@boeing.com			

EQUIPMENT INFORMATION			
<u>Equipment designator:</u>			
Model name/number	Identification number		
<u>Supply Voltage:</u>			
<input type="checkbox"/> AC mains	State AC voltage	V	and AC frequency Hz
<input type="checkbox"/> DC (external)	State DC voltage	V	and DC current A
<input checked="" type="checkbox"/> DC (internal)	State DC voltage ...3.8	V	and Battery type... Li-polymer
<u>Frequency characteristics:</u>			
Frequency range	824.2MHz to 848.8.8 MHz		Channel spacing 200kHz (if channelized)
Designated test frequencies:			
Bottom: 824.2 MHz	Middle: 836.6MHz	Top: 848.8MHz	
<u>Power characteristics:</u>			
Maximum transmitter power	2W(33dBm)		Minimum transmitter power W (if variable)
<input type="checkbox"/> Continuous transmission	State duty cycle 12.5%		
<input checked="" type="checkbox"/> Intermittent transmission	If intermittent, can transmitter be set to continuous transmit test mode? N		
<u>Antenna characteristics:</u>			
<input type="checkbox"/> Antenna connector	State impedance		ohm
<input checked="" type="checkbox"/> Temporary antenna connector	State impedance		50 ohm
<input checked="" type="checkbox"/> Integral antenna	State gain (peak)		-1.5dBi
<u>Modulation characteristics:</u>			
<input type="checkbox"/> Amplitude	<input type="checkbox"/> Other		
<input type="checkbox"/> Frequency	Details:		
<input checked="" type="checkbox"/> Phase			
Can the transmitter operate un-modulated?		N	
ITU Class of emission:			
<u>Extreme conditions:</u>			
Maximum temperature	55 °C		Minimum temperature
Maximum supply voltage	4.2 V		Minimum supply voltage
			-10 °C
			3.6 V

I hereby declare that I am entitled to sign on behalf of the applicant and that the information supplied is correct and complete.

Signature :

Name :

Position held :

Date :

Brian Chapman
Program Manager
12/13/13



Product Service

1.4 PRODUCT INFORMATION

1.4.1 Technical Description

The Equipment Under Test (EUT) was a The Boeing Company Black Smartphone. 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 3.8 V DC supply.

FCC Accreditation
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.



Product Service

SECTION 2

TEST DETAILS

FCC Testing of the
The Boeing Company Black Smartphone
In accordance with FCC CFR 47 Part 2 and FCC CFR 47 Part 22 (GSM)



2.1 SPURIOUS EMISSIONS AT BAND EDGE

2.1.1 Specification Reference

FCC CFR 47 Part 2, Clause 2.1051
FCC CFR 47 Part 22, Clause 22.905

2.1.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200852 - Modification State 0

2.1.3 Date of Test

28 August 2013

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

In accordance with 22.917(b), any emissions outside of the block edges shall be attenuated by at least $43 + 10 \log (P)$. The measurements are shown to ± 1 MHz from the block edges. The plots shown under the Spurious Emissions sections covers the required range of 9 kHz to 9 GHz.

The reference power and path losses of all channels used for testing in each frequency block were measured. Having entered the reference level offset, a limit line was displayed, showing the $-13 \text{ dBm } (43 + 10 \log (P))$, limit. The EUT was operated at maximum power on GMSK and 8PSK modulation schemes.

2.1.6 Environmental Conditions

Ambient Temperature	22.7 - 23.7°C
Relative Humidity	49.3%



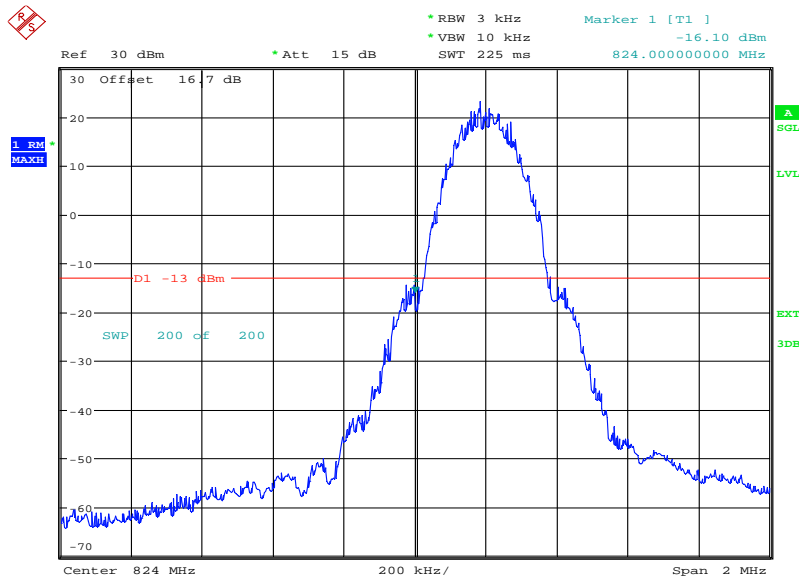
2.1.7 Test Results

GSM 850 - 8PSK Modulation

3.8 V DC Supply

Frequency Block (MHz)	Mode	Lower Block Edge Test Channels/Frequencies	Upper Block Edge Test Channels/Frequencies
A : (824.0 – 835.0)	GSM 850	Channel : 128 Frequency : 824.2 MHz	N/A
B : (846.5 – 849.0)	GSM 850	N/A	Channel : 251 Frequency : 848.8MHz

Frequency Block A

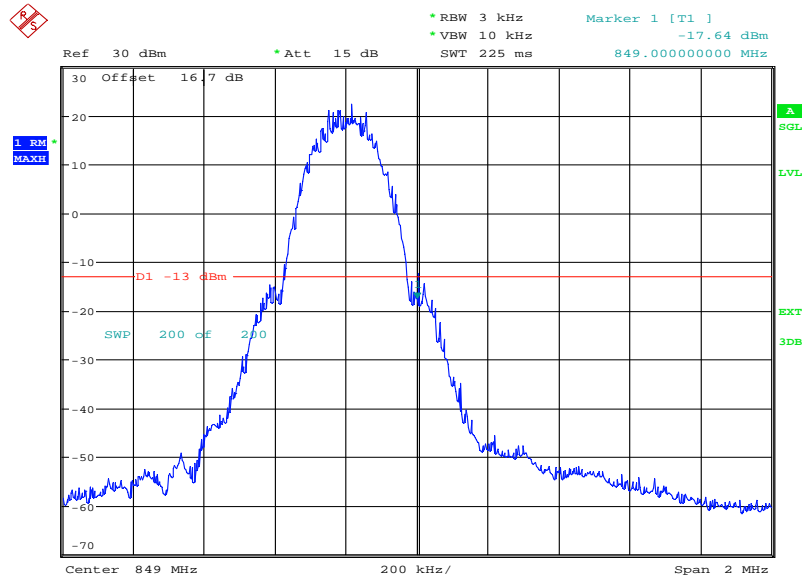


Date: 28.AUG.2013 09:50:57



Product Service

Frequency Block B



Date: 28.AUG.2013 09:52:28

Limit Clause

-13 dBm at block edge.

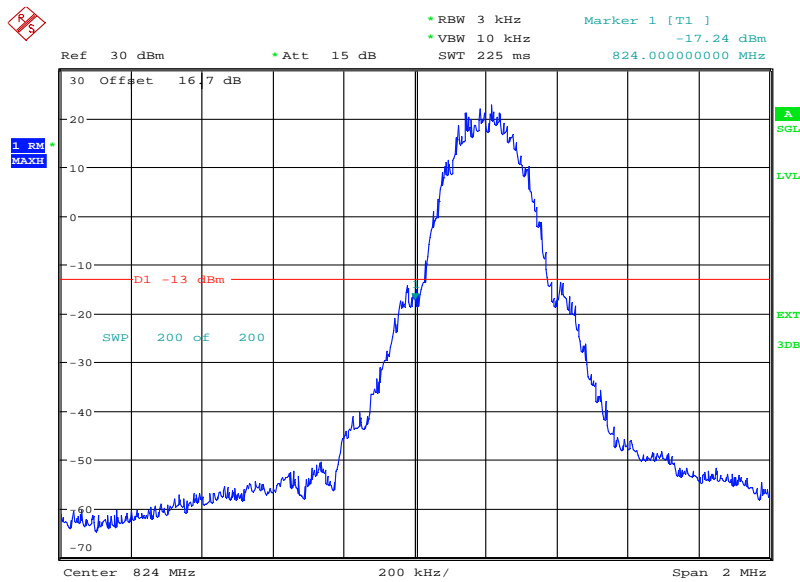


GSM 850 - GMSK Modulation

3.8 V DC Supply

Frequency Block (MHz)	Mode	Lower Block Edge Test Channels/Frequencies	Upper Block Edge Test Channels/Frequencies
A : (824.0 – 835.0)	GSM 850	Channel : 128 Frequency : 824.2 MHz	N/A
B : (846.5 – 849.0)	GSM 850	N/A	Channel : 251 Frequency : 848.8MHz

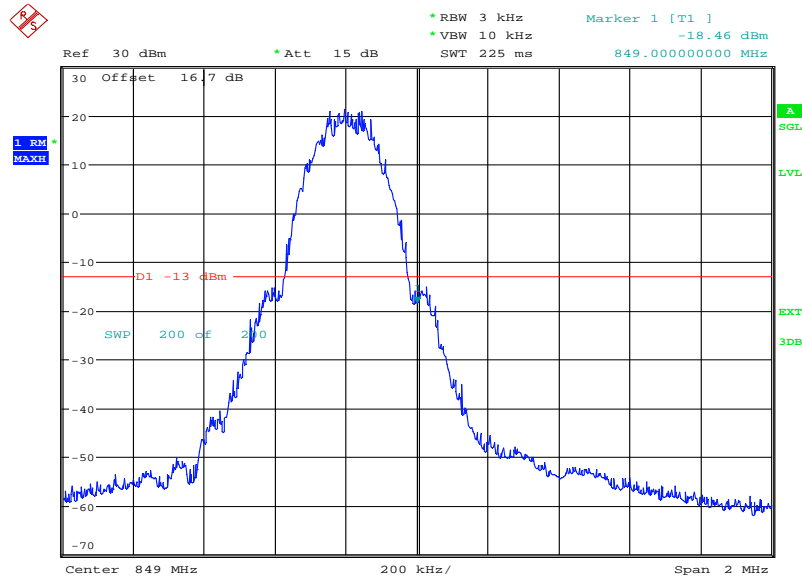
Frequency Block A



Date: 28.AUG.2013 09:48:53



Frequency Block B



Date: 28.AUG.2013 09:47:01

Limit Clause

-13 dBm at block edge.



2.2 EFFECTIVE RADIATED POWER

2.2.1 Specification Reference

FCC CFR 47 Part 22, Clause 22.913 (a)

2.2.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200791 - Modification State 0

2.2.3 Date of Test

21 July 2013 & 22 January 2014

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

Measurements of the fundamental from the EUT were obtained with the Measurement Antenna in both Horizontal and Vertical Polarisations. The fundamental frequency was maximised by adjusting the antenna height, antenna polarisation and turntable azimuth. A peak detector was used with the trace set to max hold. The maximum result was recorded.

The EUT was then removed from the chamber and replaced with a substitution antenna. Using a signal generator the level was adjusted to achieve the same value on the measuring instrument as previously recorded with the EUT. The final result (ERP) was determined by a calculation using the signal generator level, antenna gain and cable loss.

The measurements were performed at a 3m distance unless otherwise stated.

2.2.6 Environmental Conditions

Ambient Temperature	18.9 - 23.4°C
Relative Humidity	28.0 - 39.0%



Product Service

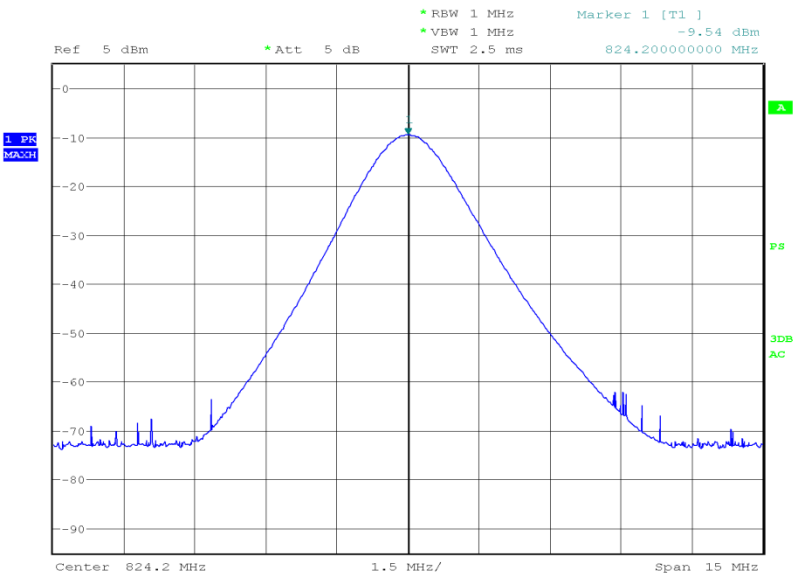
2.2.7 Test Results

GSM 850 - 8PSK Modulation

3.8 V DC Supply

824.2 MHz

Result (dBm)	Result (W)
23.07	0.203



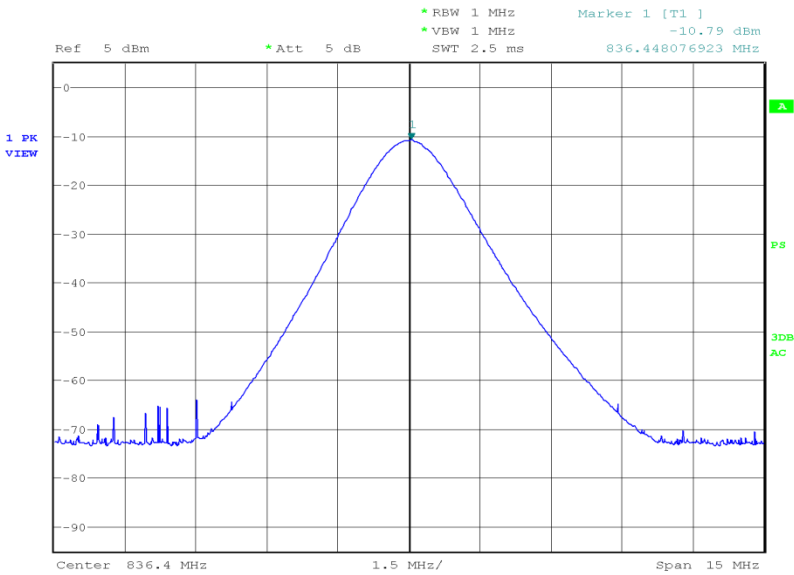
Date: 22.JAN.2014 19:51:28



Product Service

836.4 MHz

Result (dBm)	Result (W)
21.93	0.156



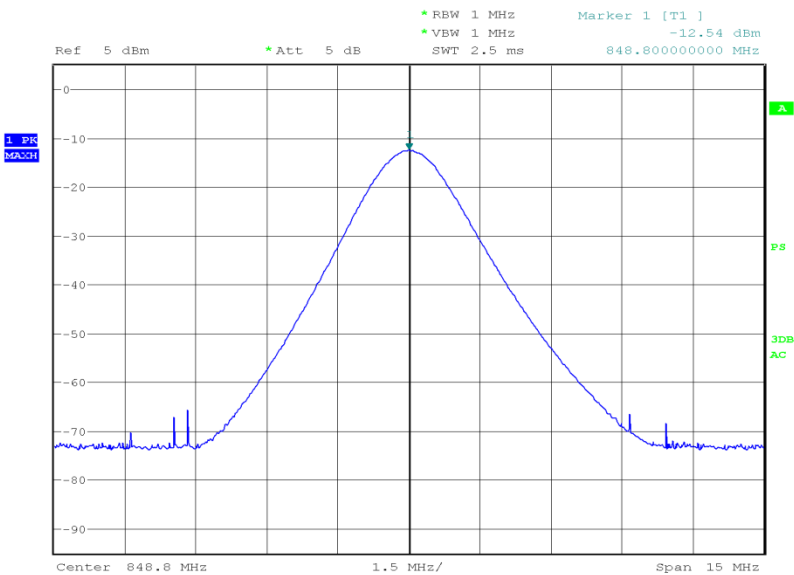
Date: 22.JAN.2014 19:49:13



Product Service

848.8 MHz

Result (dBm)	Result (W)
19.83	0.096



Date: 22.JAN.2014 19:55:59

Limit Clause

Mobile – 7 W or 38.45 dBm
Base Stations – 500 W or 57 dBm



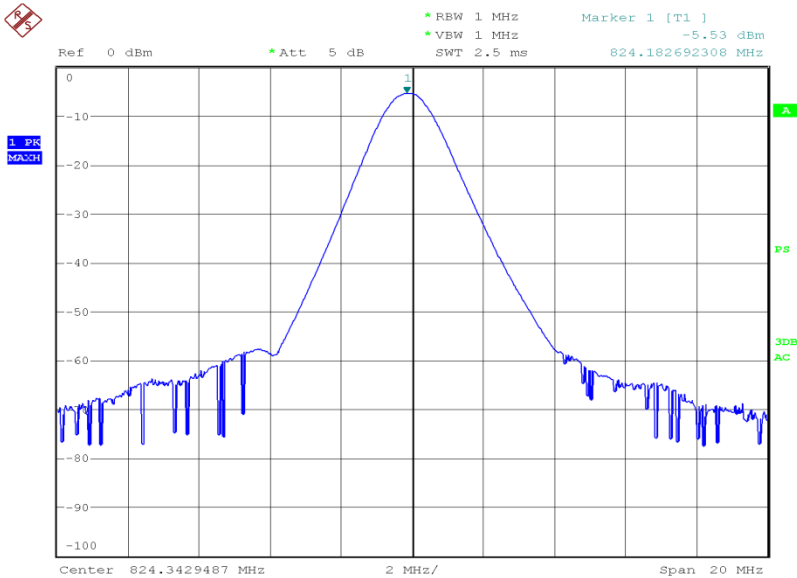
Product Service

GSM 850 - GMSK Modulation

3.8 V DC Supply

824.2 MHz

Result (dBm)	Result (W)
26.29	0.426



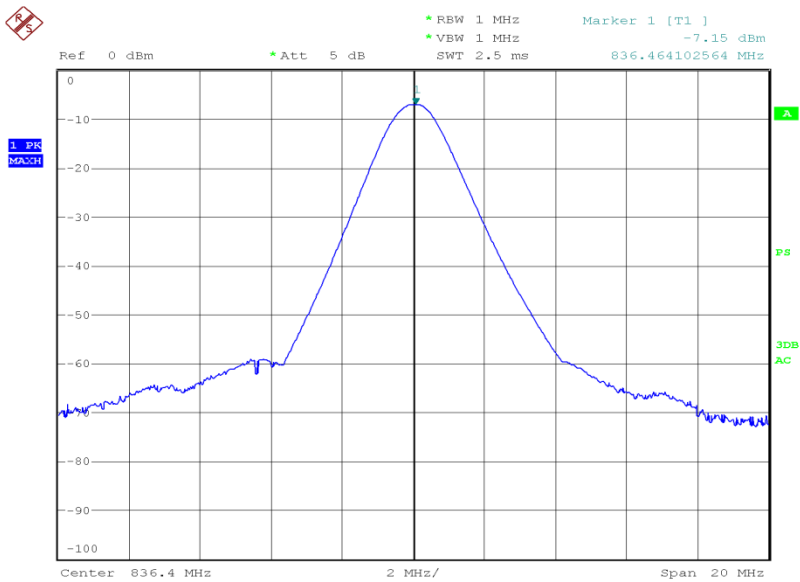
Date: 21.JUL.2013 07:59:58



Product Service

836.4 MHz

Result (dBm)	Result (W)
24.96	0.313



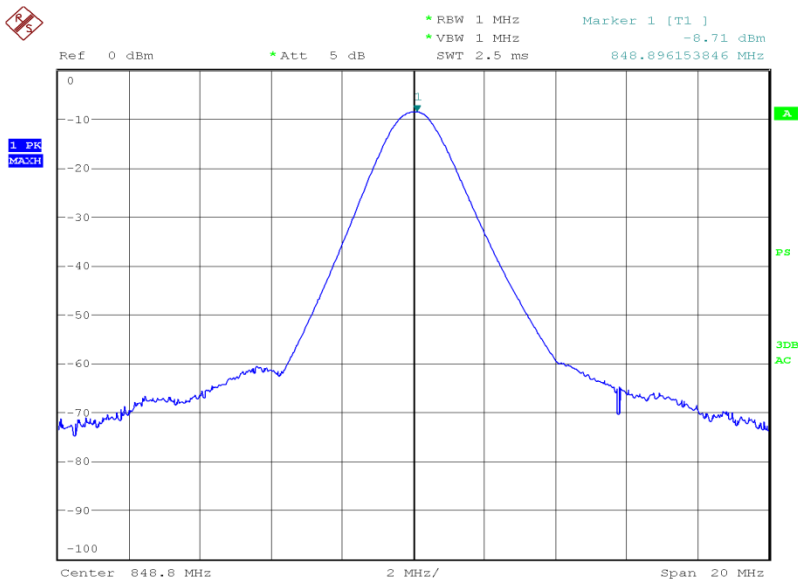
Date: 21.JUL.2013 08:31:40



Product Service

848.8 MHz

Result (dBm)	Result (W)
23.11	0.205



Date: 21.JUL.2013 08:41:45

Limit Clause

Mobile – 7 W or 38.45 dBm



2.3 MAXIMUM PEAK OUTPUT POWER - CONDUCTED

2.3.1 Specification Reference

FCC CFR 47 Part 2, Clause 2.1046
FCC CFR 47 Part 22, Clause 22.913 (a)

2.3.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200852 - Modification State 0

2.3.3 Date of Test

21 August 2013 & 22 August 2013

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

Using a spectrum analyser and attenuator(s), the output power of the EUT was measured at the antenna terminal.

The EUT supports GMSK and 8PSK modulation schemes and was tested in these modes of operation.

The spectrum analyser RBW and VBW were set to 1 MHz and the path loss measured and entered as a reference level offset.

2.3.6 Environmental Conditions

Ambient Temperature	22.9°C
Relative Humidity	55.1%



2.3.7 Test Results

GSM 850 - 8PSK Modulation

3.8 V DC Supply

824.2 MHz

Mode	Result (dBm)	Result (W)
GSM 850	32.52	1.786

836.4 MHz

Mode	Result (dBm)	Result (W)
GSM 850	32.43	1.75

848.8 MHz

Mode	Result (dBm)	Result (W)
GSM 850	32.32	1.706

Limit Clause

Mobile – 7 W or 38.45 dBm

GSM 850 - GMSK Modulation

3.8 V DC Supply

824.2 MHz

Mode	Result (dBm)	Result (W)
GSM 850	32.48	1.77

836.4 MHz

Mode	Result (dBm)	Result (W)
GSM 850	32.33	1.71

848.8 MHz

Mode	Result (dBm)	Result (W)
GSM 850	32.29	1.694

Limit Clause

Mobile – 7 W or 38.45 dBm



2.4 EMISSION LIMITATIONS FOR CELLULAR EQUIPMENT

2.4.1 Specification Reference

FCC CFR 47 Part 22, Clause 22.917

2.4.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200791 - Modification State 0

2.4.3 Date of Test

21 July 2013, 22 July 2013, 22 January 2014 & 23 January 2014

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

A preliminary profile of the Spurious Radiated Emissions was obtained up to the 10th harmonic by operating the EUT on a remotely controlled turntable within a semi-anechoic chamber. Measurements of emissions from the EUT were obtained with the Measurement Antenna in both Horizontal and Vertical Polarisations. The profiling produced a list of the worst-case emissions together with the EUT azimuth and antenna polarisation.

Using the information from the preliminary profiling of the EUT, the list of emissions was then confirmed or updated under Alternative Open Site conditions. Emission levels were maximised by adjusting the antenna height, antenna polarisation and turntable azimuth.

The EUT was set to transmit on maximum power with modulation. The EUT was tested on bottom, middle and top channels at maximum power.

For any emissions found the EUT was then removed from the chamber and replaced with a substitution antenna. Using a signal generator the level was adjusted to achieve the same value on the measuring instrument as previously recorded with the EUT. The final result was determined by a calculation using the signal generator level, antenna gain and cable loss.

The measurements were performed at a 3m distance unless otherwise stated.

2.4.6 Environmental Conditions

Ambient Temperature	18.9 - 23.6°C
Relative Humidity	27.0 - 43.0%



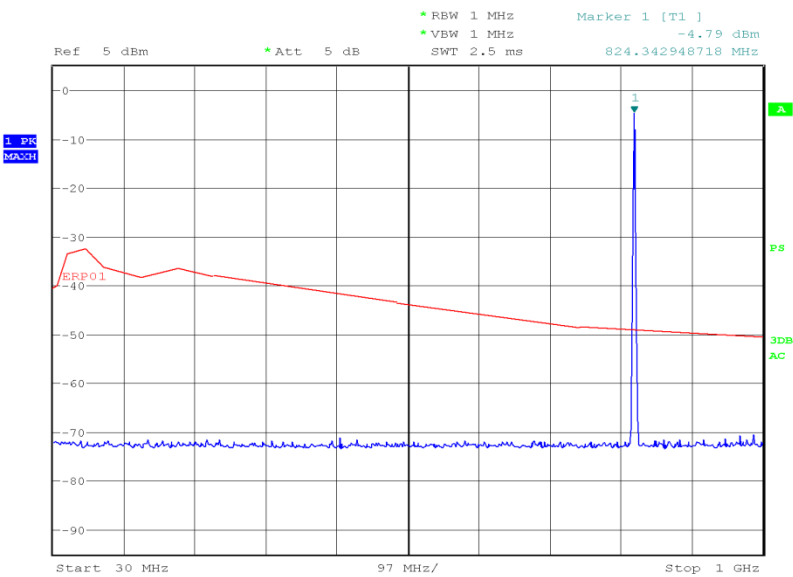
Product Service

2.4.7 Test Results

GSM 850 - 8PSK Modulation

824.2 MHz

30 MHz to 1 GHz

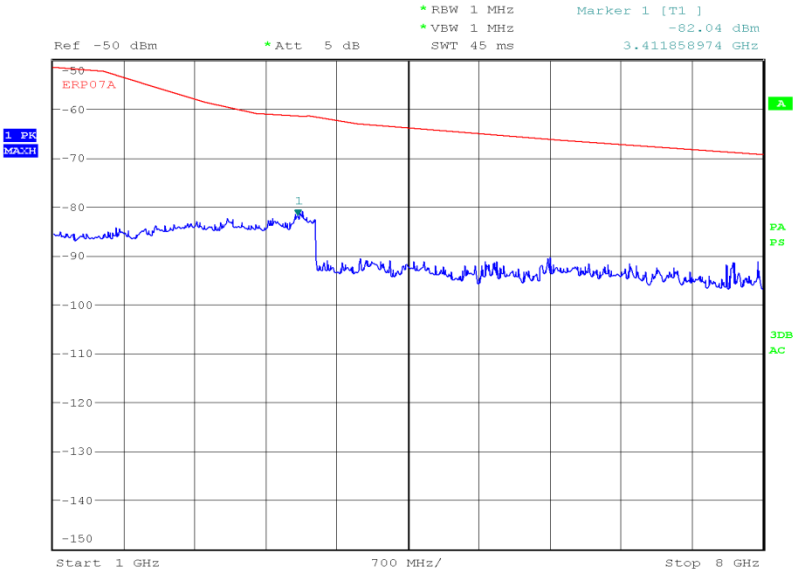


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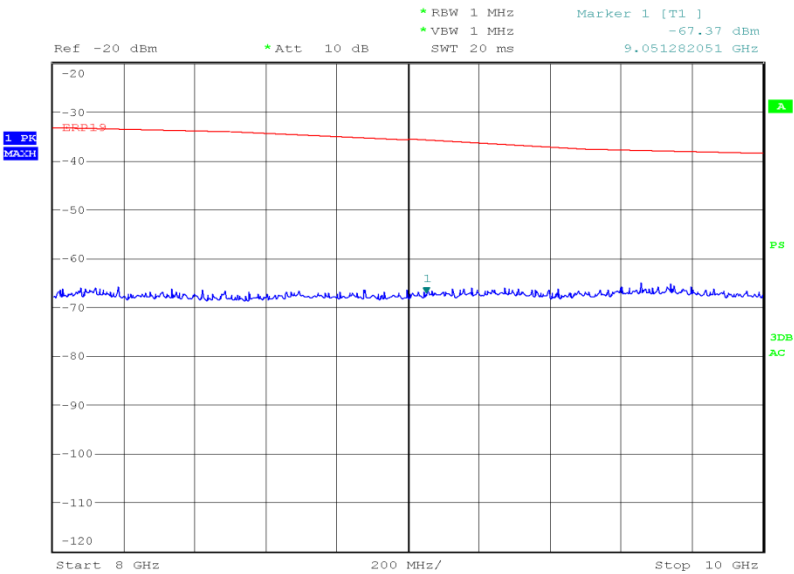
Product Service

1 GHz to 8 GHz



Date: 22.JAN.2014 20:09:08

8 GHz to 10 GHz



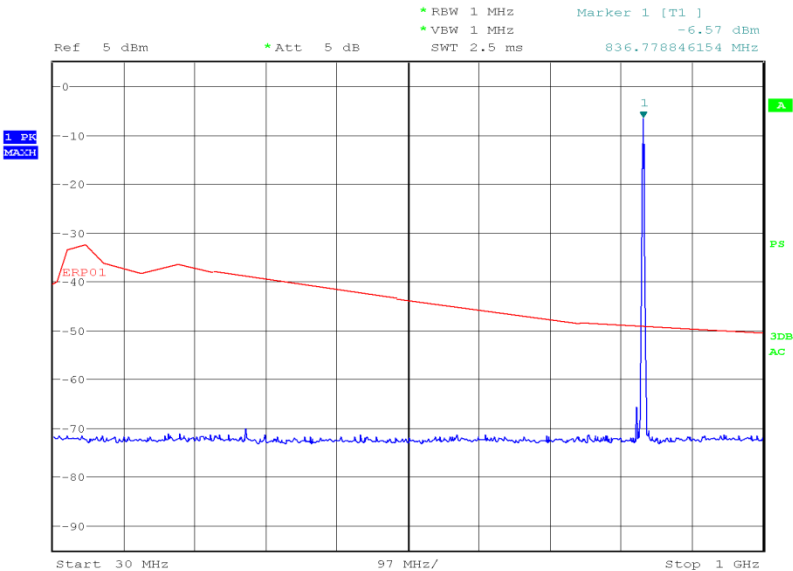
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Product Service

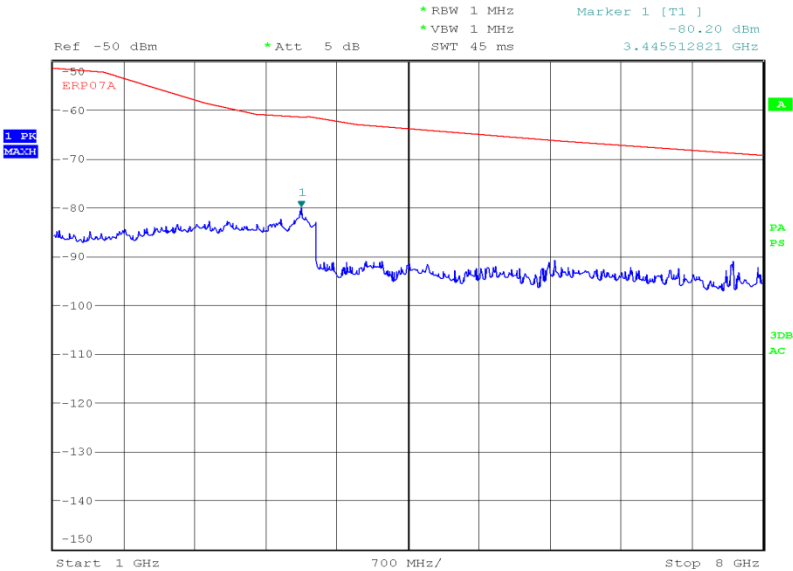
836.4 MHz

30 MHz to 1 GHz



Date: 22.JAN.2014 19:17:39

1 GHz to 8 GHz

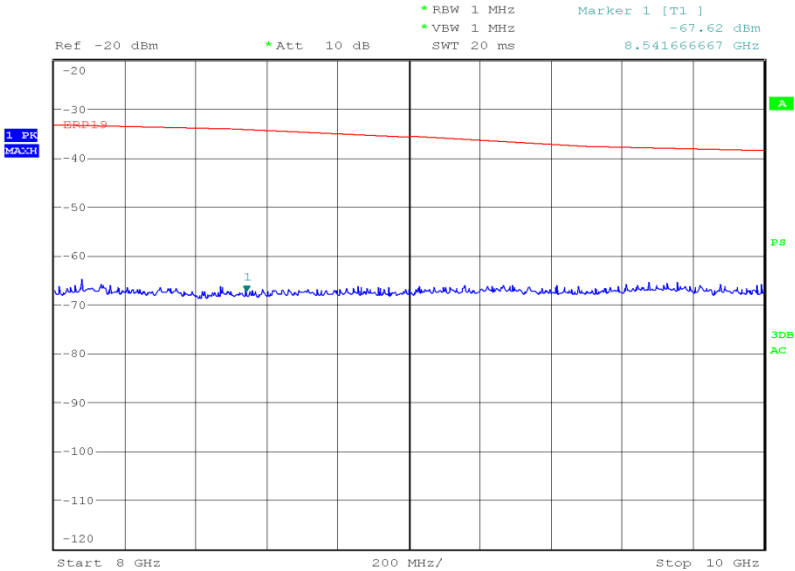


Date: 22.JAN.2014 20:05:37



Product Service

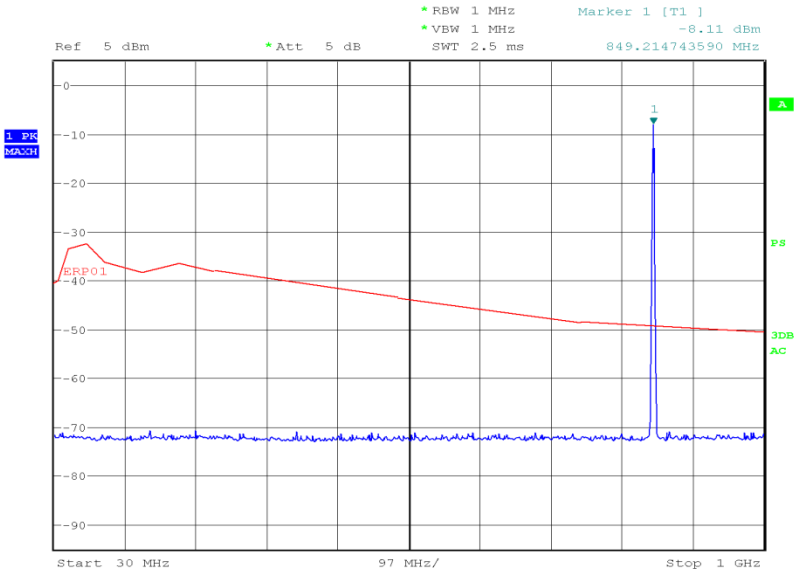
8 GHz to 10 GHz



Date: 23.JAN.2014 00:17:03

848.8 MHz

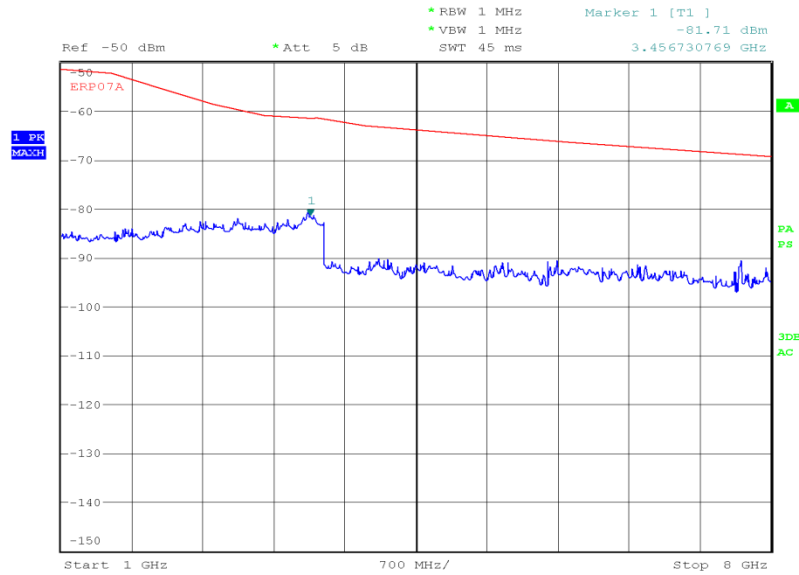
30 MHz to 1 GHz



Date: 22.JAN.2014 19:15:05

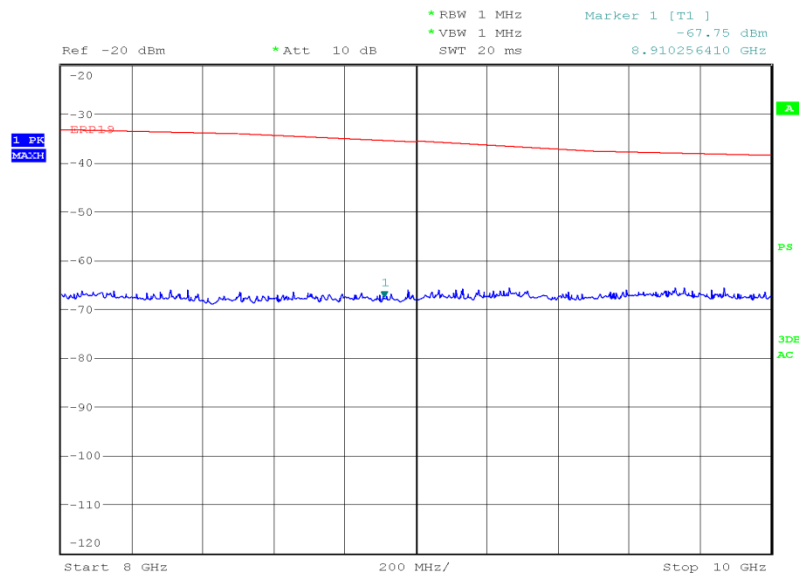


1 GHz to 8 GHz



Date: 22.JAN.2014 20:02:07

8 GHz to 10 GHz



Date: 23.JAN.2014 00:14:32

Limit Clause

$$43 + 10 \log(P) \text{ or } -13 \text{ dBm}$$

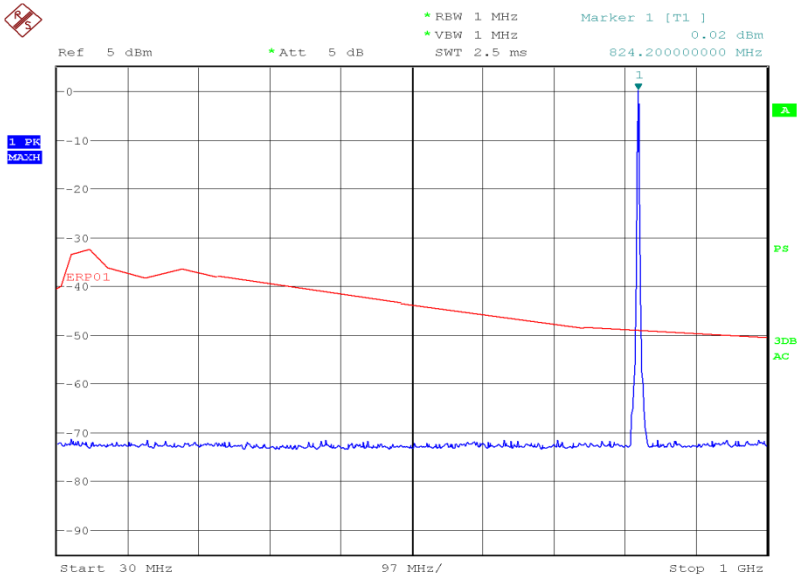


Product Service

GSM 850 - GMSK Modulation

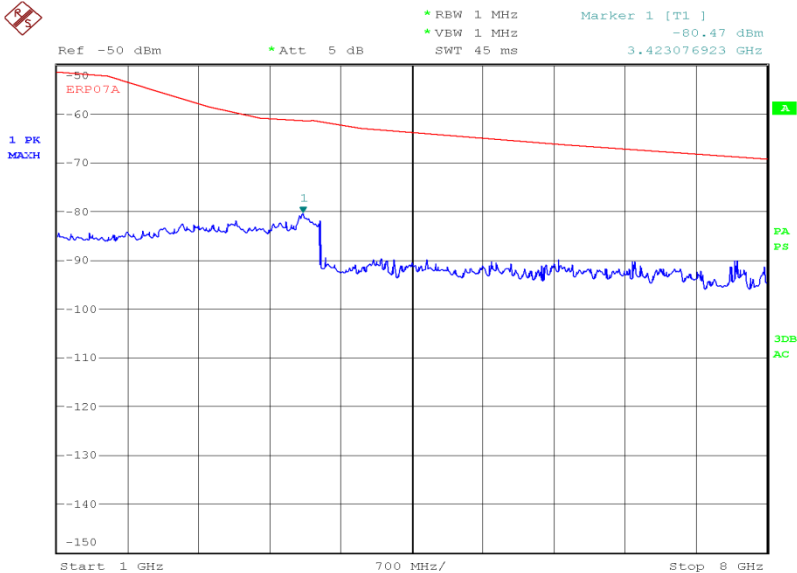
824.2 MHz

30 MHz to 1 GHz



Date: 22.JUL.2013 19:26:33

1 GHz to 8 GHz

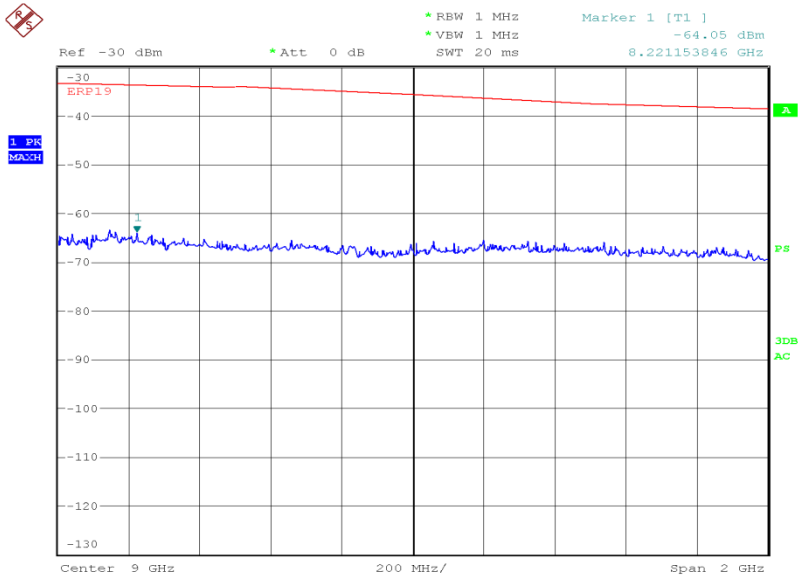


Date: 21.JUL.2013 08:09:32



Product Service

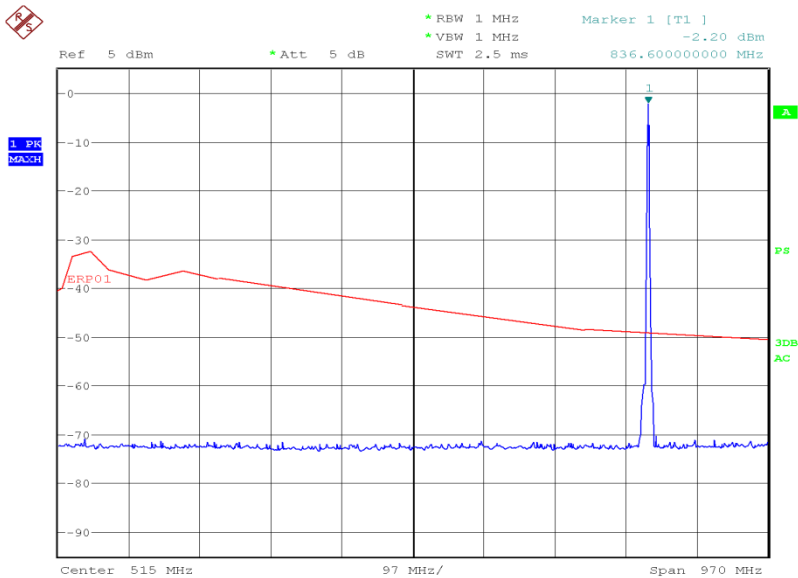
8 GHz to 10 GHz



Date: 21.JUL.2013 14:57:27

836.4 MHz

30 MHz to 1 GHz

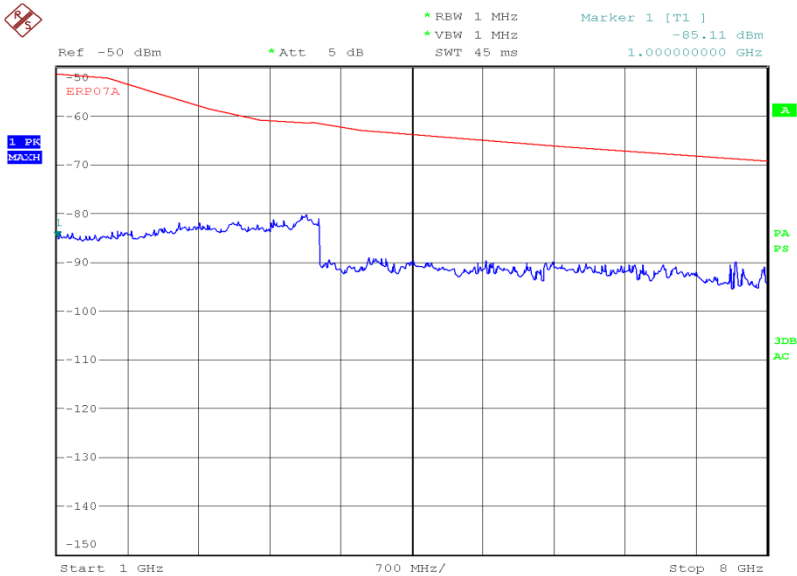


Date: 22.JUL.2013 19:29:31



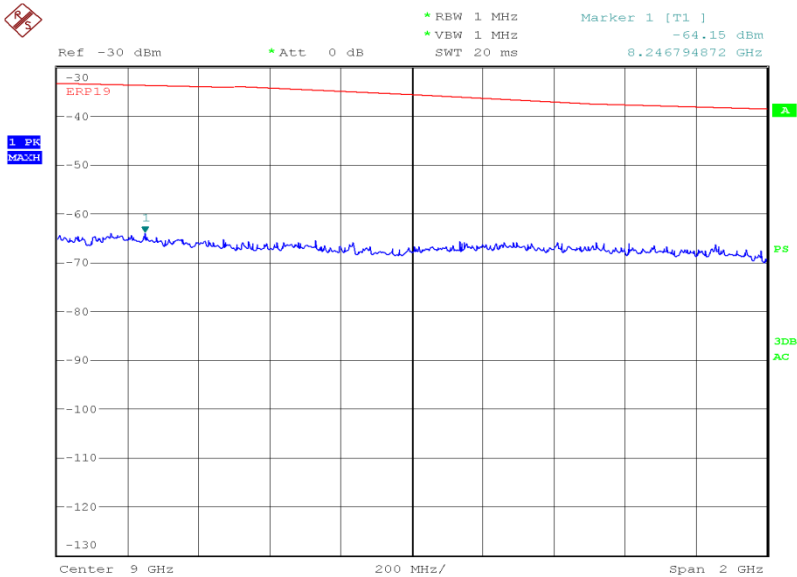
Product Service

1 GHz to 8 GHz



Date: 21.JUL.2013 08:20:24

8 GHz to 10 GHz



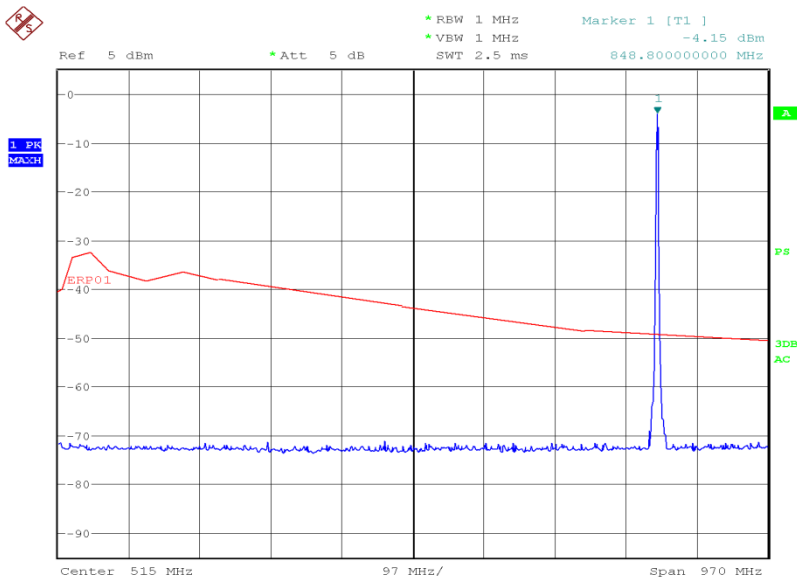
Date: 21.JUL.2013 14:59:02



Product Service

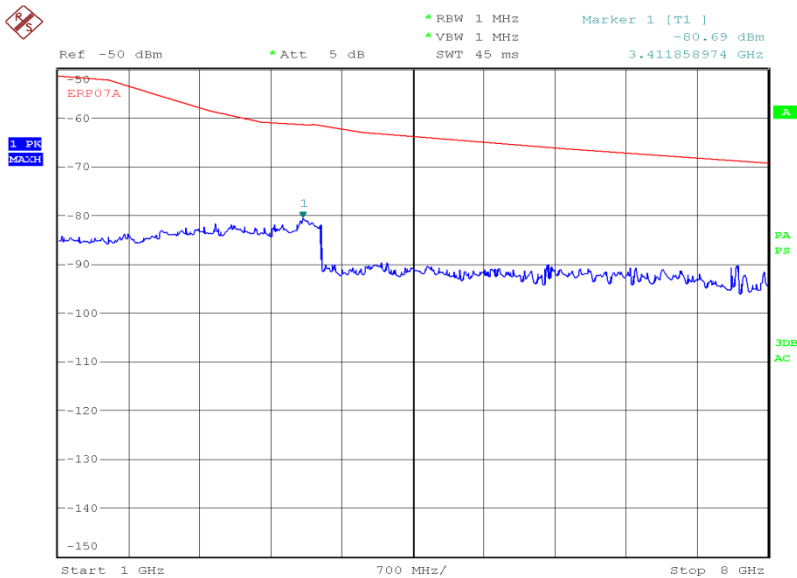
848.8 MHz

30 MHz to 1 GHz



Date: 22.JUL.2013 19:31:26

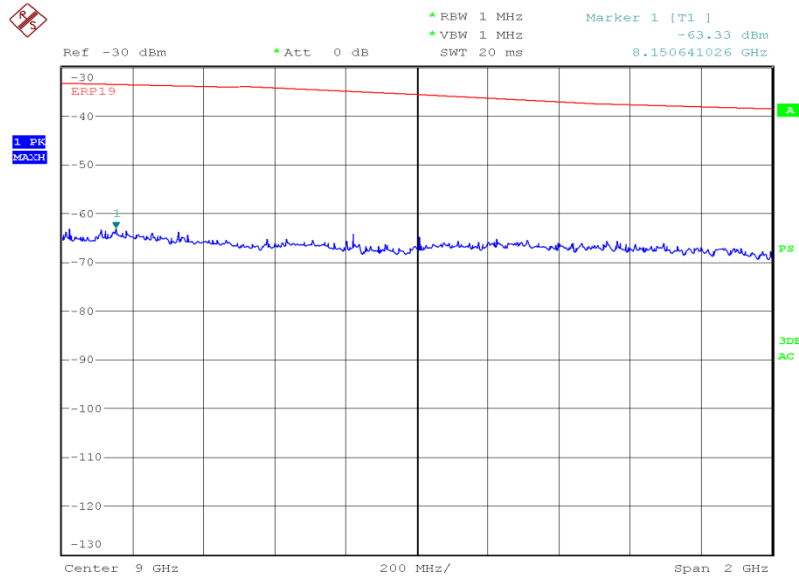
1 GHz to 8 GHz



Date: 21.JUL.2013 08:52:27



Product Service

8 GHz to 10 GHz

Date: 21.JUL.2013 15:03:00

Limit Clause

43+10log(P) or -13 dBm



2.5 CONDUCTED SPURIOUS EMISSIONS

2.5.1 Specification Reference

FCC CFR 47 Part 2, Clause 2.1051
FCC CFR 47 Part 22, Clause 22.917 (a)

2.5.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200852 - Modification State 0

2.5.3 Date of Test

21 August 2013 & 22 August 2013

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

In accordance with Part 2.1051, the spurious emissions from the antenna terminal were measured. The transmitter output power was attenuated using a combination of filters and attenuators and the frequency spectrum investigated from 9 kHz to the 10th harmonic. The EUT was set to transmit on full power with modulation. The EUT was tested on Bottom, Middle and Top channels for maximum power. The resolution and video bandwidths were set to 1 MHz and 3 MHz thus meeting the requirements of Part 22.917(b). The spectrum analyser detector was set to max hold.

From 9 kHz to 4 GHz, an attenuator was used. For measuring the range 1.5 GHz to 9 GHz an attenuator and high pass filter were used. This was to reduce saturation effects in the spectrum analyser.

The maximum path loss across the measurement bands were used as reference level offsets to ensure worst case.

2.5.6 Environmental Conditions

Ambient Temperature	22.9°C
Relative Humidity	55.1%



Product Service

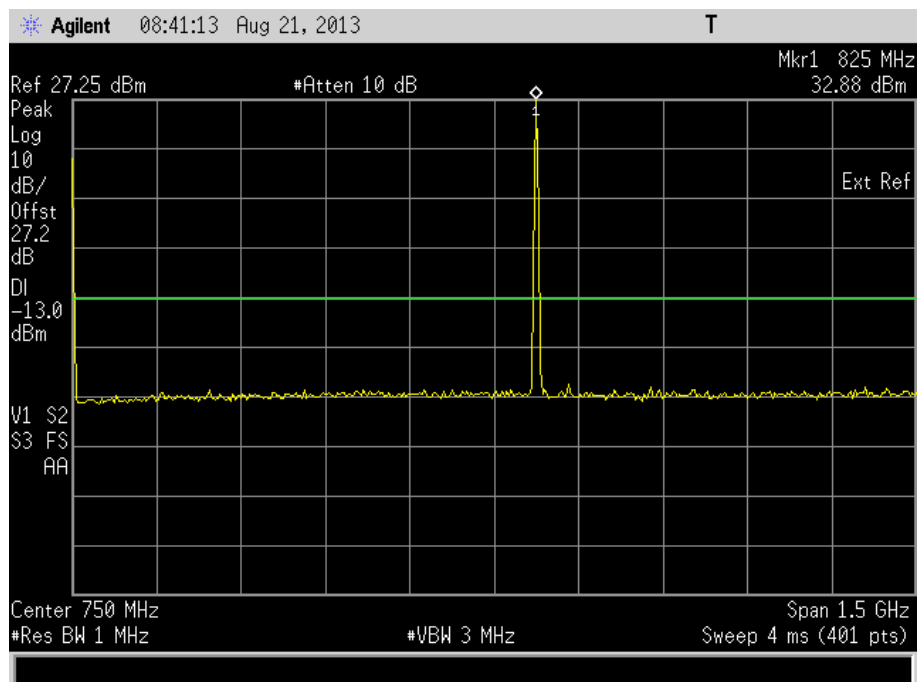
2.5.7 Test Results

GSM 850 - 8PSK Modulation

3.8 V DC Supply

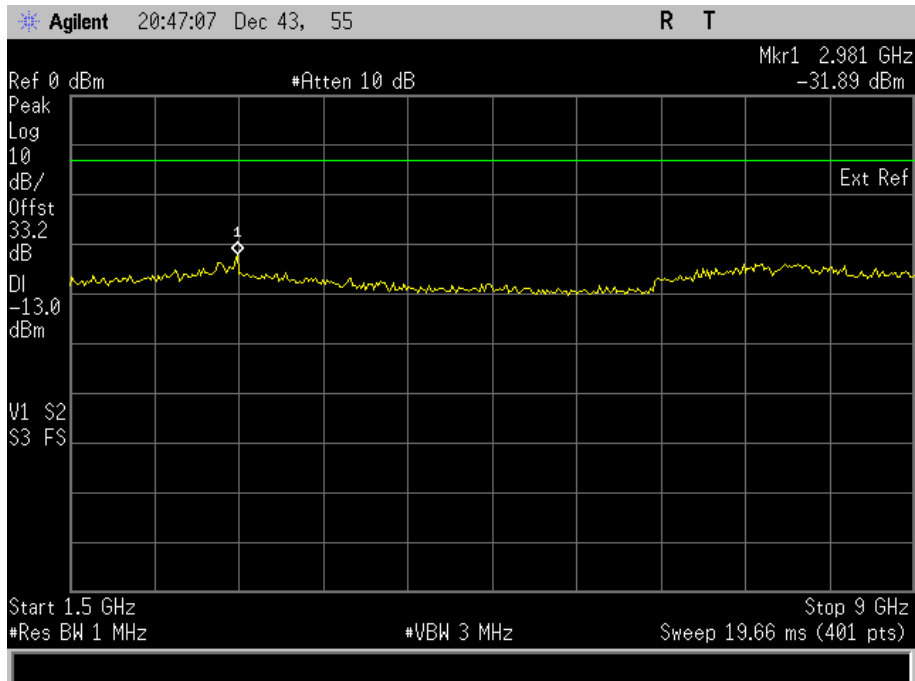
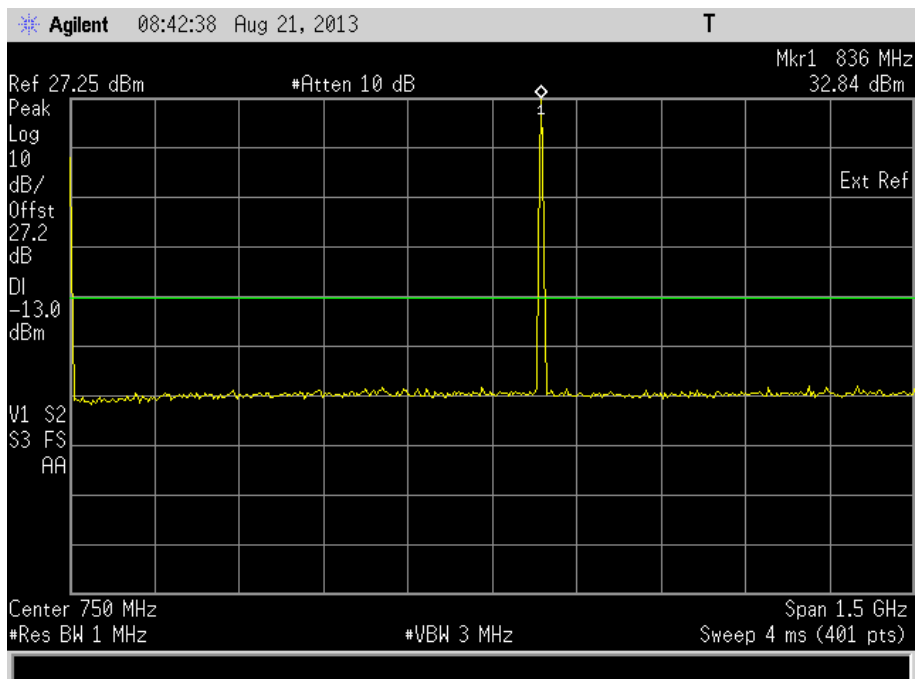
824.2 MHz

9 kHz to 1.5 GHz



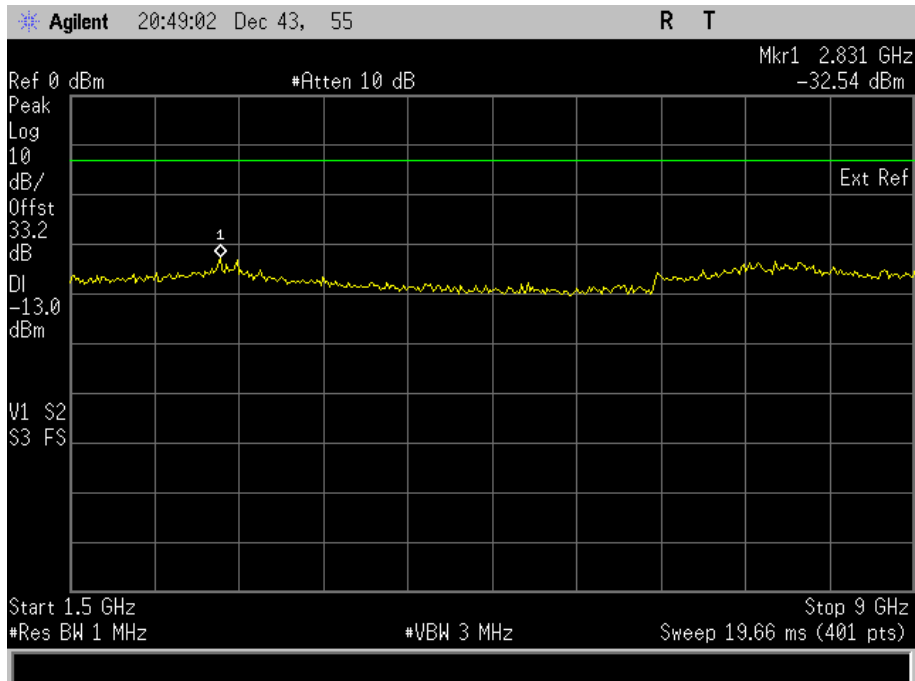
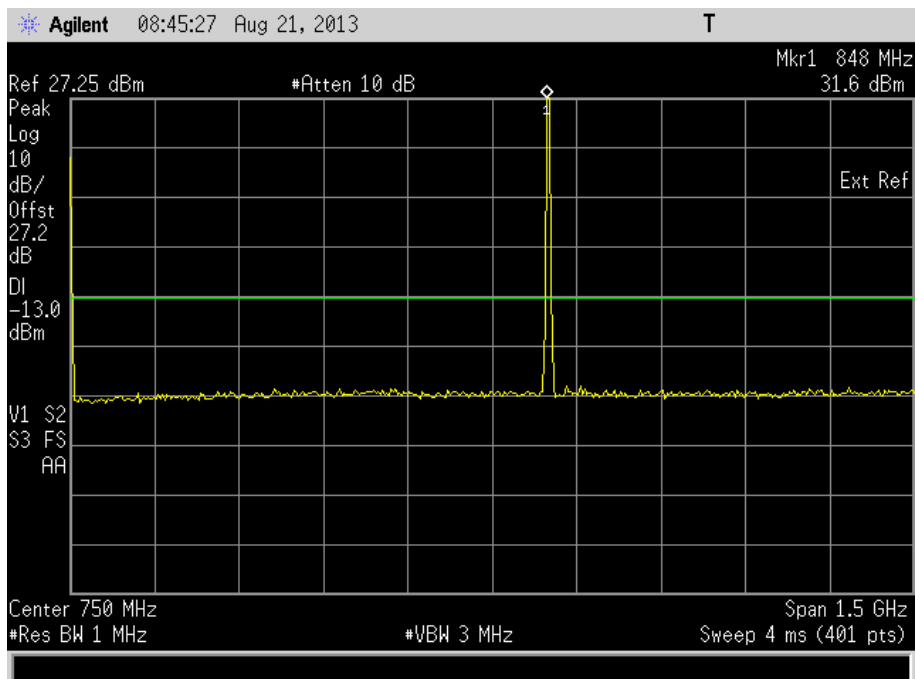


Product Service

1.5 GHz to 9 GHz836.4 MHz9 kHz to 1.5 GHz



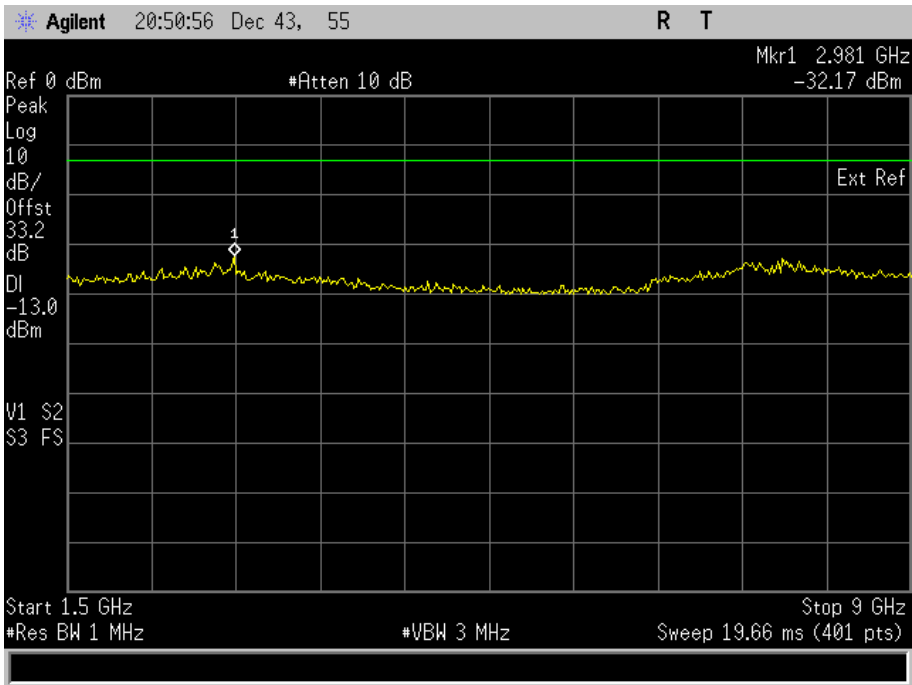
Product Service

1.5 GHz to 9 GHz848.8 MHz9 kHz to 1.5 GHz



Product Service

1.5 GHz to 9 GHz



Limit Clause

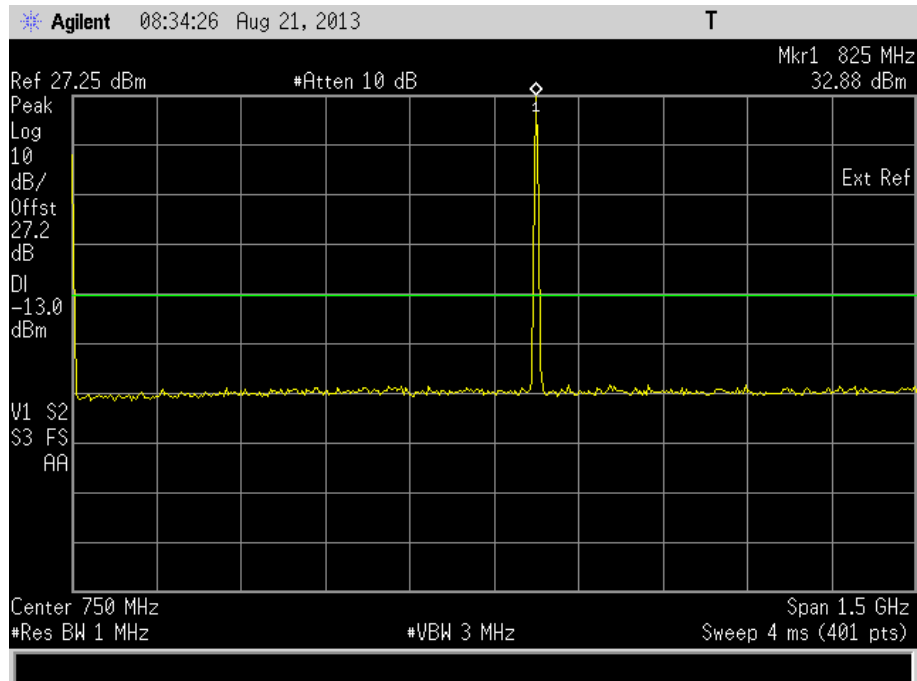
43+10log(P) or -13 dBm



Product Service

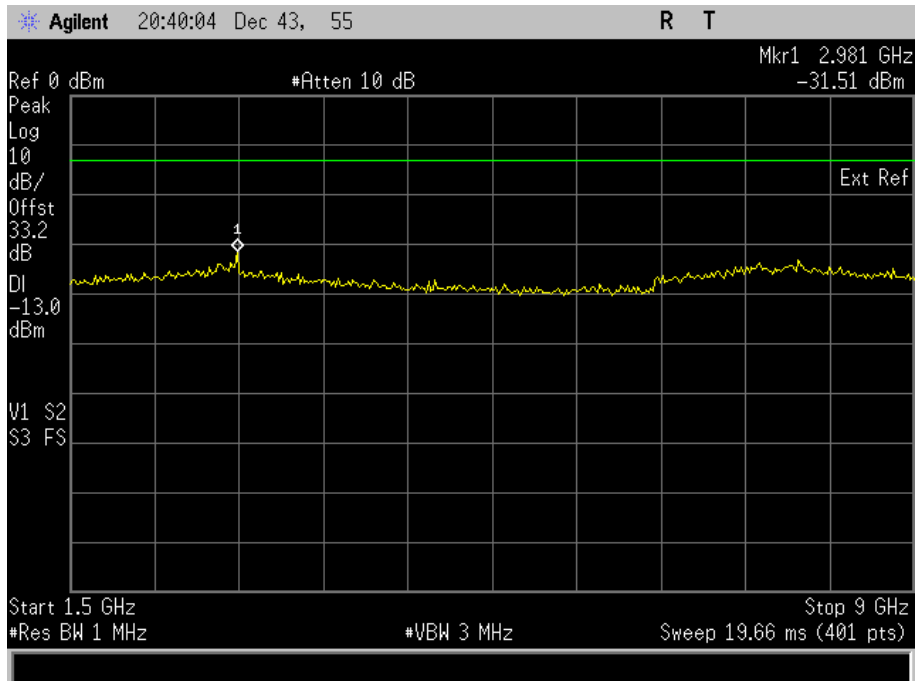
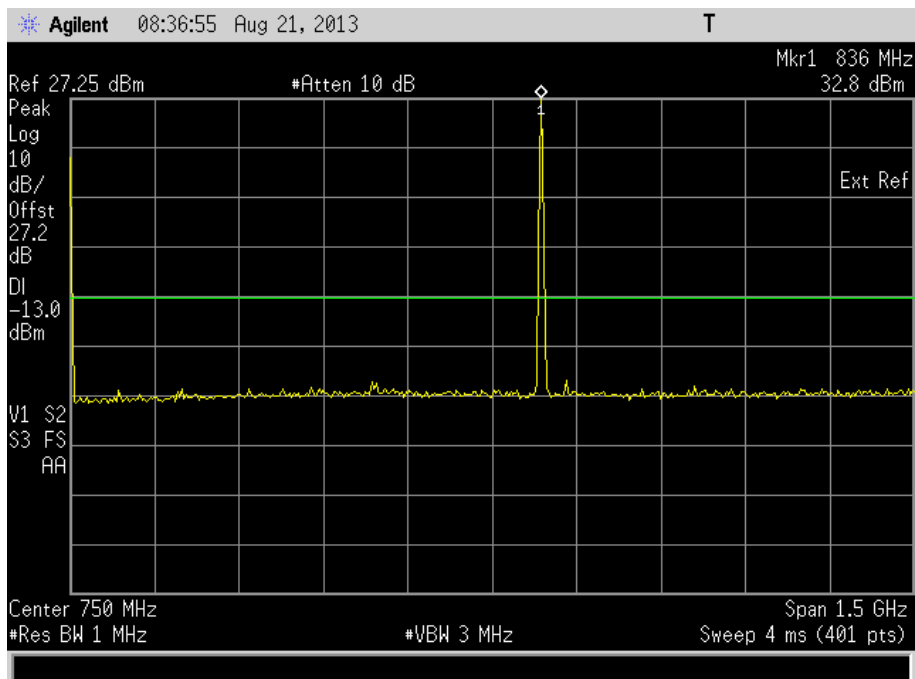
GSM 850 - GMSK Modulation

3.8 V DC Supply

824.2 MHz9 kHz to 1.5 GHz

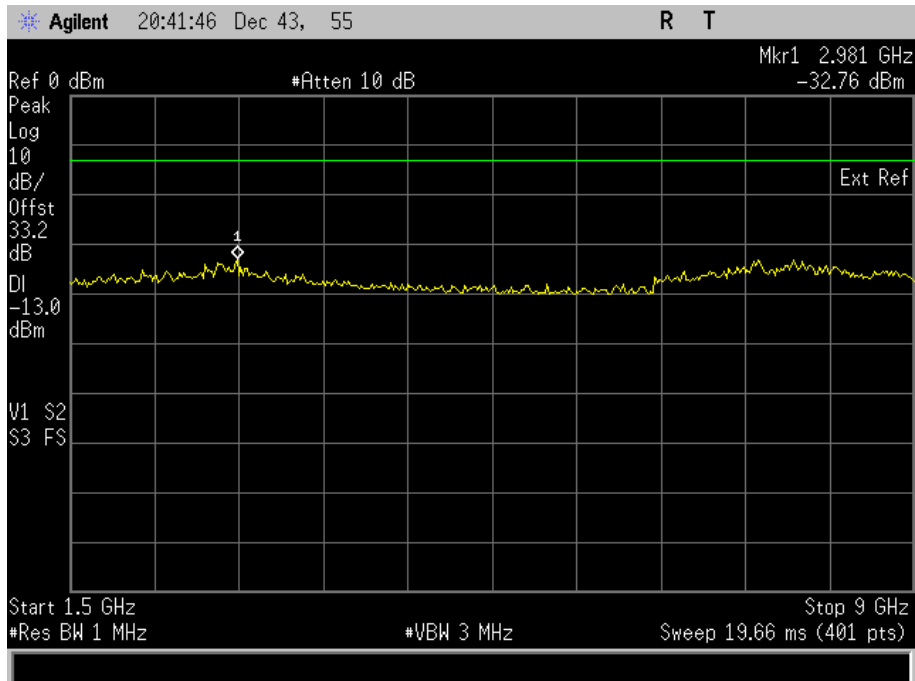
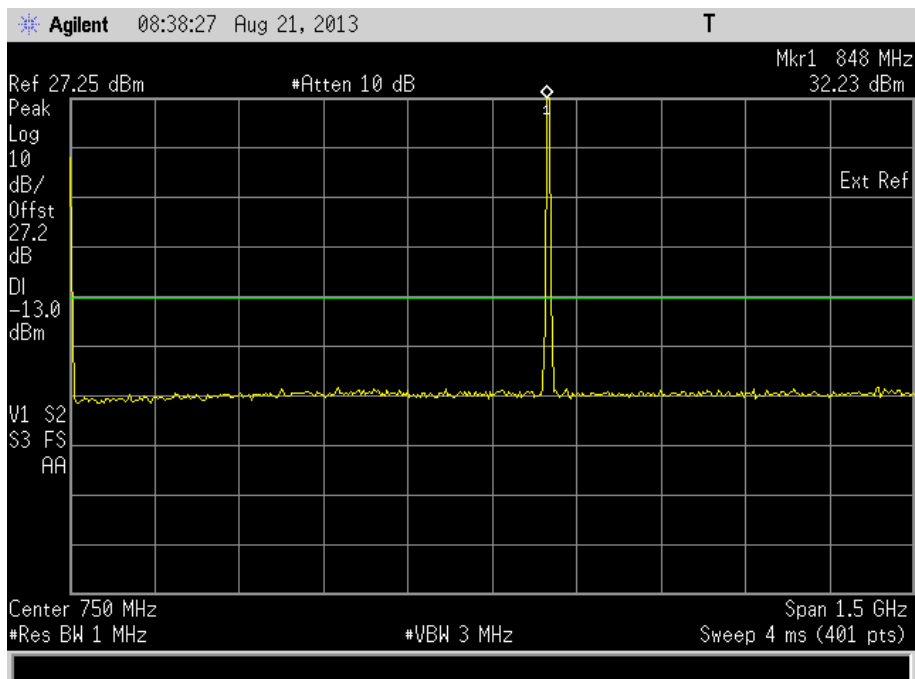


Product Service

1.5 GHz to 9 GHz836.4 MHz9 kHz to 1.5 GHz



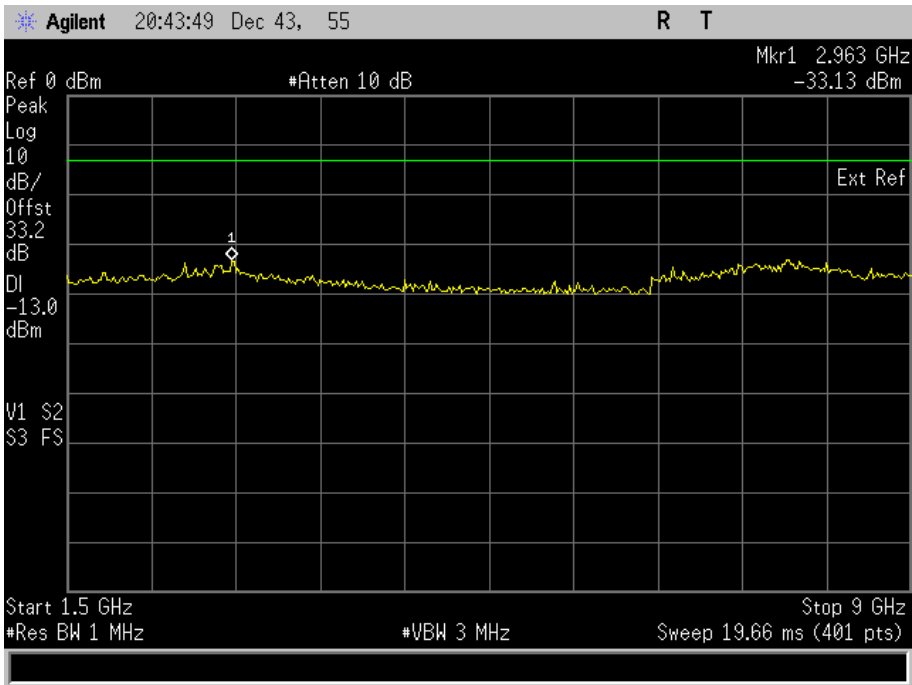
Product Service

1.5 GHz to 9 GHz848.8 MHz9 kHz to 1.5 GHz



Product Service

1.5 GHz to 9 GHz



Limit Clause

43+10log(P) or -13 dBm



Product Service

2.6 OCCUPIED BANDWIDTH

2.6.1 Specification Reference

FCC CFR 47 Part 2, Clause 2.1049 (h)
FCC CFR 47 Part 22, Clause 22.917 (b)

2.6.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200852 - Modification State 0

2.6.3 Date of Test

20 August 2013 & 22 August 2013

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 EUT was transmitting at maximum power, with modulation. Using a resolution bandwidth of 10 kHz and a video bandwidth of 30 kHz, the -26 dBc points were established and the emission bandwidth determined.

The plot of the following pages shows the resultant display from the Spectrum Analyser.

2.6.6 Environmental Conditions

Ambient Temperature	22.9°C
Relative Humidity	55.1%



Product Service

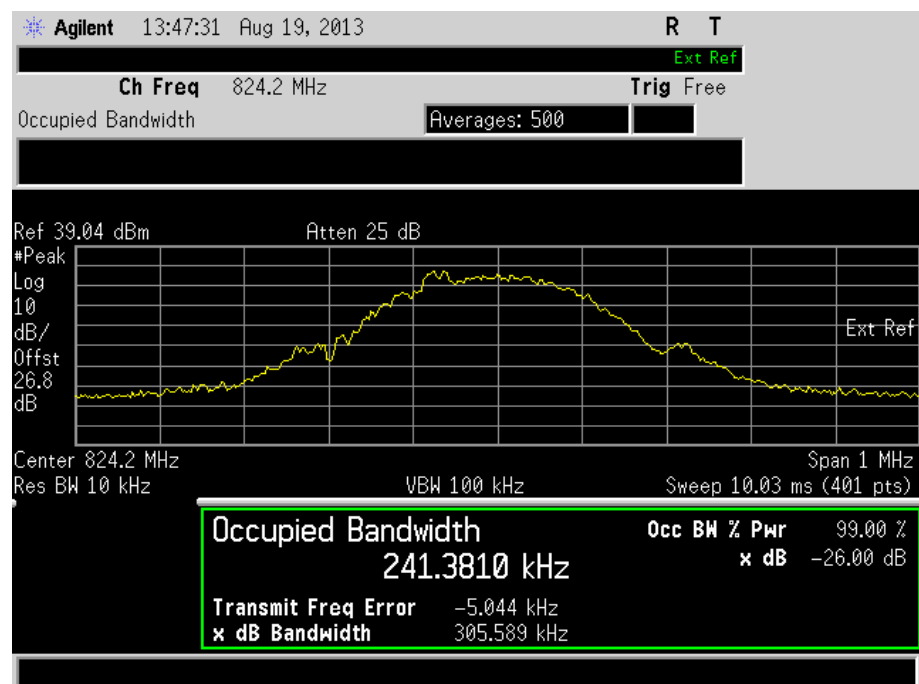
2.6.7 Test Results

GSM 850 - 8PSK Modulation

3.8 V DC Supply

824.2 MHz

Mode	Occupied Bandwidth (kHz)
GSM 850	241.381

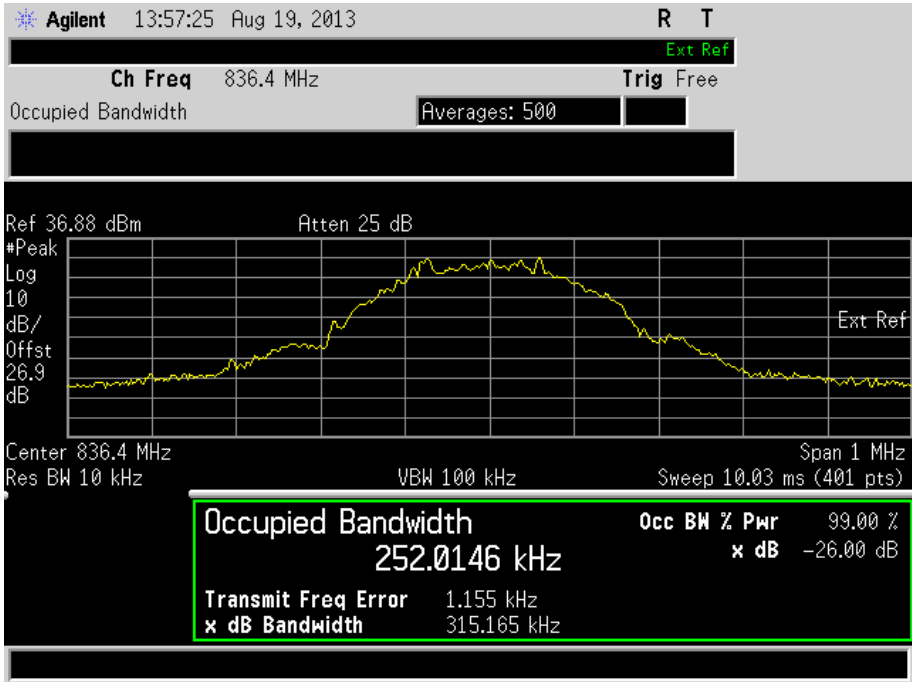




Product Service

836.4 MHz

Mode	Occupied Bandwidth (kHz)
GSM 850	252.0146

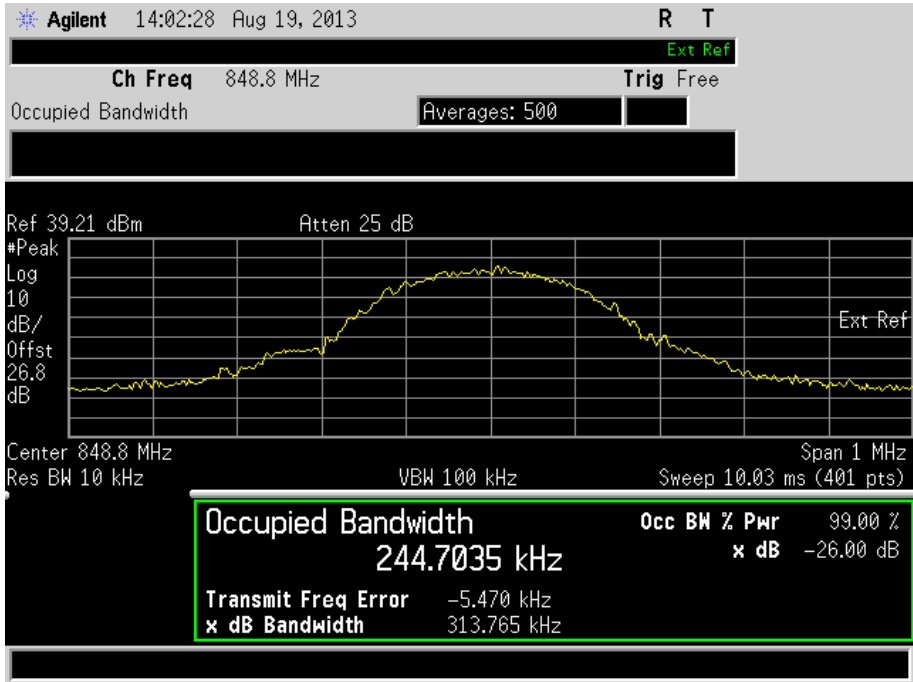




Product Service

848.8 MHz

Mode	Occupied Bandwidth (kHz)
GSM 850	244.7035



Limit Clause

The occupied bandwidth, that is the frequency bandwidth such that, below is lower and above is upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission.



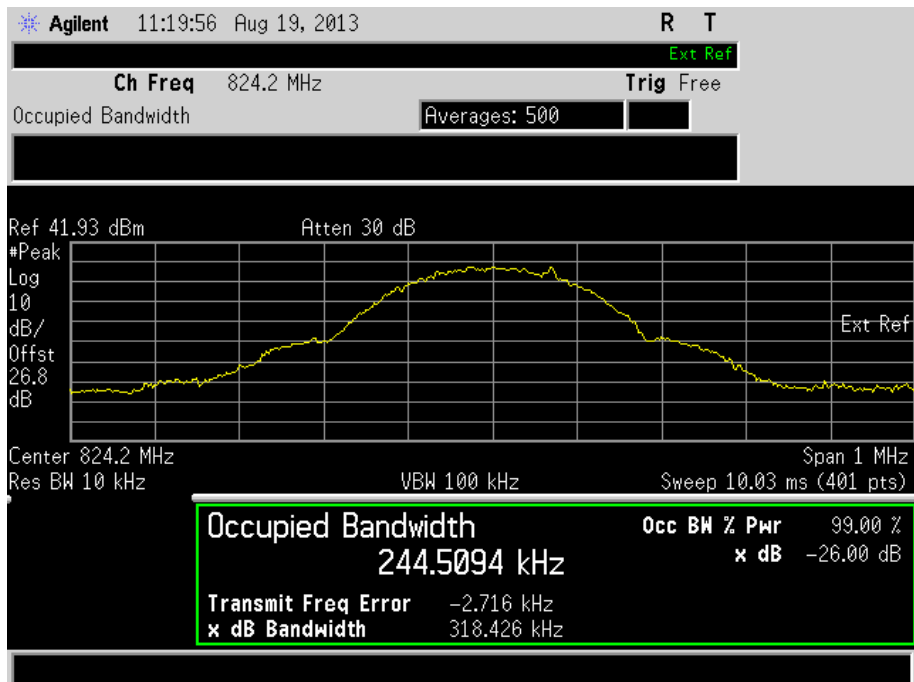
Product Service

GSM 850 - GMSK Modulation

3.8 V DC Supply

824.2 MHz

Mode	Occupied Bandwidth (kHz)
GSM 850	244.5094

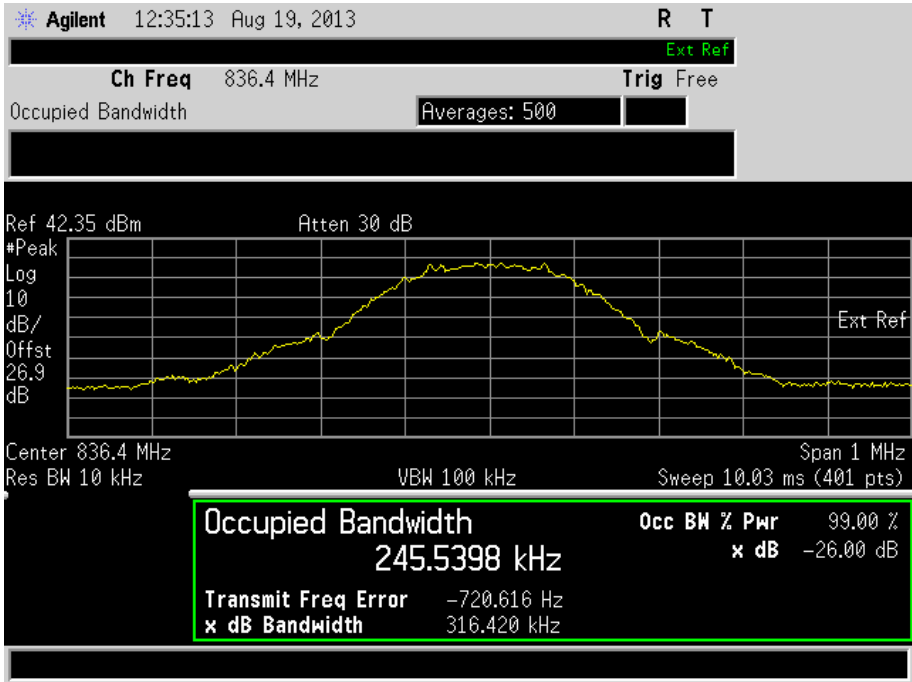




Product Service

836.4 MHz

Mode	Occupied Bandwidth (kHz)
GSM 850	245.5398

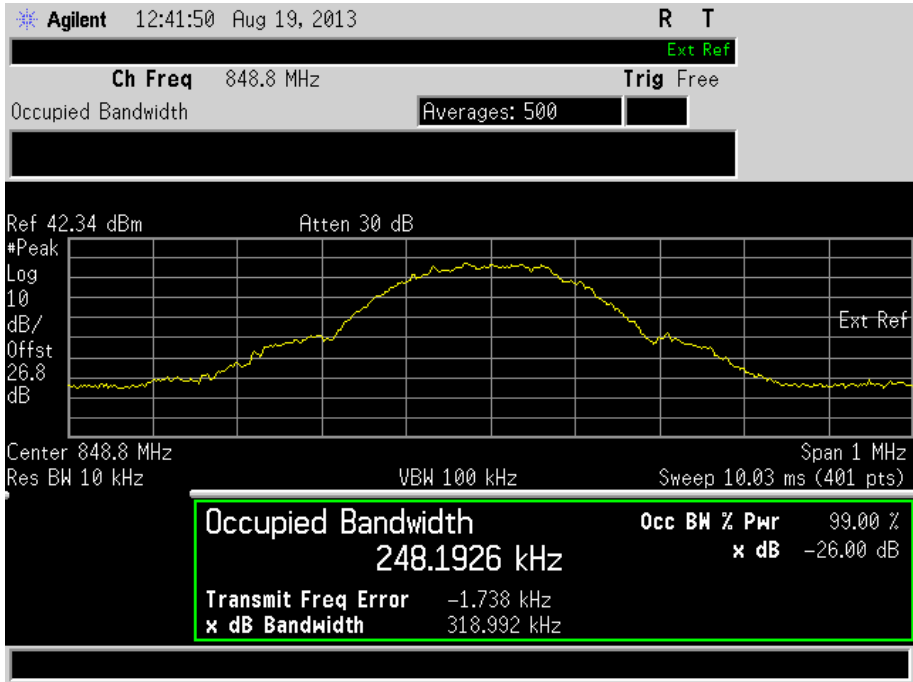




Product Service

848.8 MHz

Mode	Occupied Bandwidth (kHz)
GSM 850	248.1926



Limit Clause

The occupied bandwidth, that is the frequency bandwidth such that, below is lower and above is upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission.



2.7 MODULATION CHARACTERISTICS

2.7.1 Specification Reference

FCC CFR 47 Part 2, Clause 2.1047 (d)

2.7.2 Equipment Under Test

Black Smartphone

2.7.3 Test Results

GSM 850 - 8PSK Modulation and GSM 850 - GMSK Modulation

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

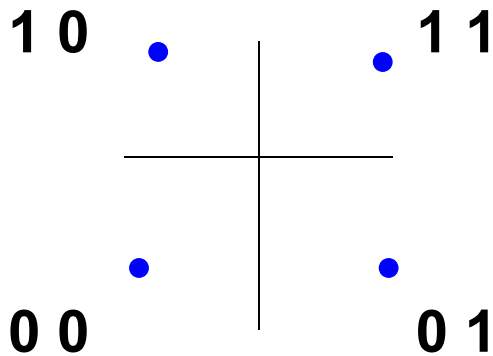
GMSK OVERVIEW

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 (Quadrature Phase Shift Keying)

However

There is a problem with QPSK: transition from e.g. 00 to 11 gives phase shift of 180° (π 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)

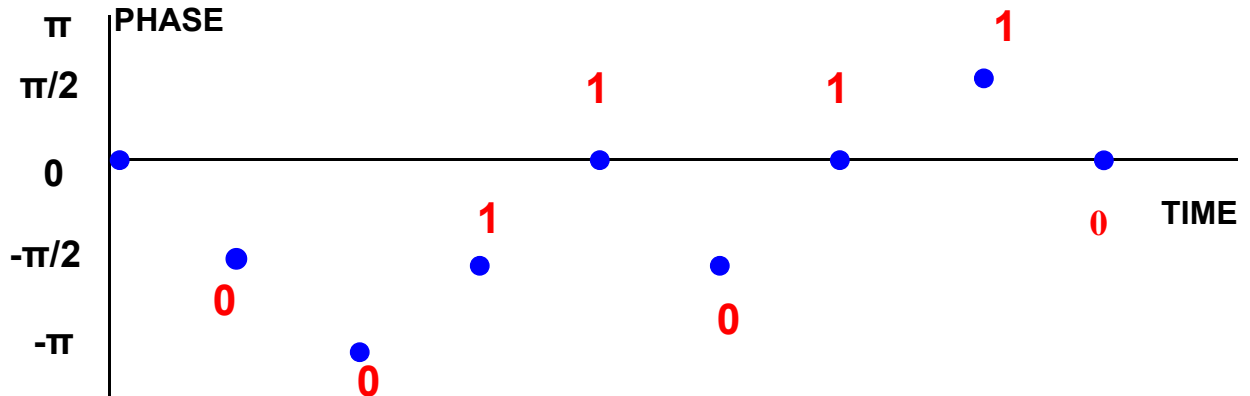
I Stream	0		1		0		1	
	$-\pi/2$		$-\pi/2$		$-\pi/2$		$\pi/2$	
Q stream		0		1		1		0
		$-\pi/2$		$\pi/2$		$\pi/2$		$-\pi/2$



3. Combine (add) the two PSK signals:

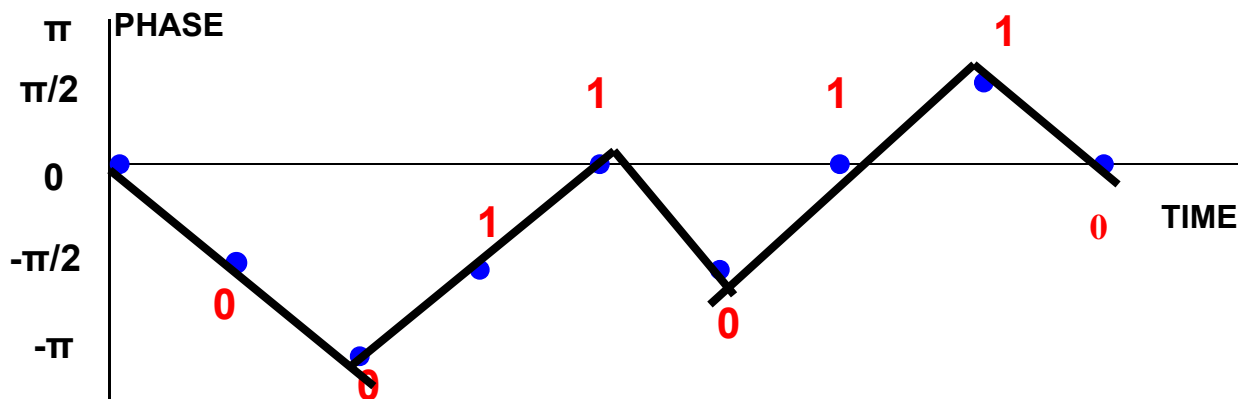
Combined Phase	$-\pi/2$	$-\pi$	$-\pi/2$	0	$-\pi/2$	0	$\pi/2$	0
----------------	----------	--------	----------	---	----------	---	---------	---

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.

Limit Clause

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

2.8 FREQUENCY STABILITY

2.8.1 Specification Reference

FCC CFR 47 Part 2, Clause 2.1055
FCC CFR 47 Part 22, Clause 22.355

2.8.2 Equipment Under Test and Modification State

Black Smartphone S/N: XCV23200852 - Modification State 0

2.8.3 Date of Test

8 August 2013 & 27 August 2013

2.8.4 Test Equipment Used

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

2.8.5 Test Procedure

The EUT was set to transmit on maximum power with modulation. A CMU200 communication analyser, was used to measure the frequency error. The maximum result was taken over 200 bursts. The temperature was adjusted between -30°C and +50°C in 10° steps as per 2.1055 and the frequency error was measured at each temperature.

2.8.6 Environmental Conditions

Ambient Temperature	22.5 - 24.9°C
Relative Humidity	47.9 - 50.2%



Product Service

2.8.7 Test ResultsGSM 850 - 8PSK Modulation

3.8 V DC Supply

Under Temperature Variations836.4 MHz

Temperature Interval (°C)	Mode	Modulation	Deviation (ppm)
-30	GSM 850	8PSK	0.057388809
-20	GSM 850	8PSK	-0.046628407
-10	GSM 850	8PSK	-0.050215208
0	GSM 850	8PSK	-0.054997609
+10	GSM 850	8PSK	0.06217121
+20	GSM 850	8PSK	0.06097561
+30	GSM 850	8PSK	-0.057388809
+40	GSM 850	8PSK	-0.05978001
+50	GSM 850	8PSK	0.077714012

Limit Clause

Frequency Range (MHz)	Base, Fixed (ppm)	Mobile ≤ 3 watts (ppm)	Mobile ≤ 3 watts (ppm)
25 to 50	20	20	50
50 to 450	5	5	50
450 to 512	2.5	5	5
821 to 896	1.5	2.5	2.5
928 to 929	5.0	-	-
929 to 960	1.5	-	-
2110 to 2220	10	-	-

Under Voltage Variations836.4 MHz

DC Voltage (V)	Mode	Modulation	Deviation (ppm)
3.8 V DC	GSM 850	8PSK	0.06097561
3.6 V DC	GSM 850	8PSK	0.054997609
4.2 V DC	GSM 850	8PSK	-0.06336681

Limit Clause

Frequency Range (MHz)	Base, Fixed (ppm)	Mobile \leq 3 watts (ppm)	Mobile \leq 3 watts (ppm)
25 to 50	20	20	50
50 to 450	5	5	50
450 to 512	2.5	5	5
821 to 896	1.5	2.5	2.5
928 to 929	5.0	n/a	n/a
929 to 960	1.5	n/a	n/a
2110 to 2220	10	n/a	n/a

GSM 850 - GMSK Modulation

3.8 V DC Supply

Under Temperature Variations836.4 MHz

Temperature Interval (°C)	Mode	Modulation	Deviation (ppm)
-30	GSM 850	GMSK	N/T*
-20	GSM 850	GMSK	N/T*
-10	GSM 850	GMSK	0.0056
0	GSM 850	GMSK	0.0012
+10	GSM 850	GMSK	0.0012
+20	GSM 850	GMSK	0.0012
+30	GSM 850	GMSK	0.0012
+40	GSM 850	GMSK	0.0024
+50	GSM 850	GMSK	0.0012

Remark

*The EUT did not operate at -20°C and -30°C.

Limit Clause

Frequency Range (MHz)	Base, Fixed (ppm)	Mobile \leq 3 watts (ppm)	Mobile \leq 3 watts (ppm)
25 to 50	20	20	50
50 to 450	5	5	50
450 to 512	2.5	5	5
821 to 896	1.5	2.5	2.5
928 to 929	5.0	-	-
929 to 960	1.5	-	-
2110 to 2220	10	-	-

Under Voltage Variations836.4 MHz

DC Voltage (V)	Mode	Modulation	Deviation (ppm)
3.8 V DC	GSM 850	GMSK	0.0012
3.6 V DC	GSM 850	GMSK	0.0012
4.2 V DC	GSM 850	GMSK	NT

Limit Clause

Frequency Range (MHz)	Base, Fixed (ppm)	Mobile \leq 3 watts (ppm)	Mobile \leq 3 watts (ppm)
25 to 50	20	20	50
50 to 450	5	5	50
450 to 512	2.5	5	5
821 to 896	1.5	2.5	2.5
928 to 929	5.0	n/a	n/a
929 to 960	1.5	n/a	n/a
2110 to 2220	10	n/a	n/a



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
Section 2.1 - Spurious Emissions at Band Edge					
Antenna (Bilog)	Schaffner	CBL6143	287	24	18-Jan-2014
Attenuator (20dB/ 2W)	Pasternack	PE7004-20	489	12	18-Oct-2013
GPS Frequency Standard	Rapco	GPS-804/3	1312	6	24-Jan-2014
Screened Room (5)	Rainford	Rainford	1545	36	25-Dec-2013
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Power Supply	Hewlett Packard	6104A	1948	-	TU
Spectrum Analyser	Rohde & Schwarz	FSU26	2747	12	30-Nov-2013
High Pass Filter (4GHz)	RLC Electronics	F-100-4000-5-R	2773	12	1-Feb-2014
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	11-Oct-2013
'2.92mm' - '2.92mm' RF Cable (2m)	Rhophase	KPS-1503-2000-KPS	3694	12	25-Oct-2013
'2.92mm' - '2.92mm' RF Cable (2m)	Rhophase	KPS-1503-2000-KPS	3695	12	15-Oct-2013
9m RF Cable (N Type)	Rhophase	NPS-2303-9000-NPS	3791	-	TU
Tilt Antenna Mast	matur GmbH	TAM 4.0-P	3916	-	TU
Mast Controller	matur GmbH	NCD	3917	-	TU
Dc-40GHz Power Splitter	Aeroflex / Weinschel	1534	3986	-	TU
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	26-Oct-2013
Section 2.2 - Effective Radiated Power					
Antenna (Double Ridge Guide)	EMCO	3115	34	12	9-Nov-2013
Antenna (Double Ridge Guide, 1GHz-18GHz)	EMCO	3115	234	12	3-Apr-2014
Antenna (Double Ridge Guide, 1GHz-18GHz)	EMCO	3115	235	12	9-Nov-2013 9-Nov-2014
Communications Tester	Rohde & Schwarz	CMU 200	442	12	1-Nov-2013 8-Nov-2014
Signal Generator (10MHz to 40GHz)	Rohde & Schwarz	SMR40	1002	12	7-Aug-2013 06-Sep-2013
Screened Room (5)	Rainford	Rainford	1545	36	25-Dec-2013 25-Jan-2014
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
Antenna (Log Periodic)	Schaffner	UPA6108	3108	12	5-Apr-2014
Antenna (Log Periodic)	Schaffner	UPA6108	3109	12	3-Apr-2014
Antenna (DRG Horn)	ETS-LINDGREN	3115	3125	12	17-Jul-2014
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	11-Oct-2013 22-Oct-2014
9m RF Cable (N Type)	Rhophase	NPS-2303-9000-NPS	3791	-	TU
Tilt Antenna Mast	matur GmbH	TAM 4.0-P	3916	-	TU
Mast Controller	matur GmbH	NCD	3917	-	TU
Wideband Radio Communication Tester	Rohde & Schwarz	CMW 500	4144	12	17-Jul-2014



Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Due
Section 2.3- Maximum Peak Output Power - Conducted					
Attenuator (20dB/ 2W)	Pasternack	PE7004-20	489	12	18-Oct-2013
Power Supply	Hewlett Packard	6104A	1948	-	TU
Radio Communications Test Set	Rohde & Schwarz	CMU 200	3035	12	6-Dec-2013
ESA-E Series Spectrum Analyser	Agilent Technologies	E4402B	3348	12	13-Jun-2014
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	31-Aug-2013
Combiner/Splitter	Weinschel	1506A	3877	12	19-Mar-2014
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	26-Oct-2013
Section 2.4 – Emission for Broadband Cellular Equipment					
Antenna (Double Ridge Guide, 1GHz-18GHz)	EMCO	3115	234	12	3-Apr-2014
Antenna (Double Ridge Guide, 1GHz-18GHz)	EMCO	3115	235	12	9-Nov-2013
Antenna (Bilog)	Schaffner	CBL6143	287	24	18-Jan-2014
Dual Power Supply Unit	Thurlby	PL320	288	-	TU
Communications Tester	Rohde & Schwarz	CMU 200	442	12	1-Nov-2013 08-Nov-2014
Filter (High Pass)	Lorch	SHP7-7000-SR	566	12	20-Feb-2014
Antenna (Double Ridge Guide)	Q-Par Angus Ltd	QSH 180K	1511	24	7-Nov-2014
Pre-Amplifier	Phase One	PS04-0086	1533	12	27-Sep-2013 19-Dec-2014
Pre-Amplifier	Phase One	PS04-0087	1534	12	30-Sep-2014
Screened Room (5)	Rainford	Rainford	1545	36	25-Dec-2013 25-Jan-2014
Turntable Controller	Inn-Co GmbH	CO 1000	1606	-	TU
High Pass Filter (4GHz)	RLC Electronics	F-100-4000-5-R	2773	12	1-Feb-2014
Antenna (Bilog)	Chase	CBL6143	2904	24	10-Jun-2015
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	22-Oct-2014
Amplifier (1 - 8GHz)	Phase One	PS06-0060	3175	-	O/P Mon
Amplifier (8 - 18GHz)	Phase One	PS06-0061	3176	-	O/P Mon
EMI Test Receiver	Rohde & Schwarz	ESU40	3506	12	11-Oct-2013
3 GHz High Pass Filter	K&L Microwave	11SH10-3000/X18000-O/O	3552	12	1-Feb-2014
9m RF Cable (N Type)	Rhophase	NPS-2303-9000-NPS	3791	-	TU
Tilt Antenna Mast	maturo GmbH	TAM 4.0-P	3916	-	TU
Mast Controller	maturo GmbH	NCD	3917	-	TU
Section 2.5 - Conducted Spurious Emissions					
Attenuator (20dB/ 2W)	Pasternack	PE7004-20	489	12	18-Oct-2013
Spectrum Analyser	Agilent Technologies	E7405A	1410	12	11-Sep-2013
Power Supply	Hewlett Packard	6104A	1948	-	TU
High Pass Filter (4GHz)	RLC Electronics	F-100-4000-5-R	2773	12	1-Feb-2014
Filter	Daden Anthony Ass	MH-1500-7SS	2778	-	O/P Mon
Radio Communications Test Set	Rohde & Schwarz	CMU 200	3035	12	6-Dec-2013
ESA-E Series Spectrum Analyser	Agilent Technologies	E4402B	3348	12	13-Jun-2014
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	31-Aug-2013
Combiner/Splitter	Weinschel	1506A	3877	12	19-Mar-2014
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	26-Oct-2013
1 Metre K Type Cable	Rhophase	KPS-1501A-1000-KPS	4106	12	25-Oct-2013



Product Service

Instrument	Manufacturer	Type No.	TE No.	Calibration Period (months)	Calibration Due
Section 2.6- Occupied Bandwidth					
Attenuator (20dB/ 2W)	Pasternack	PE7004-20	489	12	18-Oct-2013
Power Supply	Hewlett Packard	6104A	1948	-	TU
Radio Communications Test Set	Rohde & Schwarz	CMU 200	3035	12	6-Dec-2013
ESA-E Series Spectrum Analyser	Agilent Technologies	E4402B	3348	12	13-Jun-2014
Network Analyser	Rohde & Schwarz	ZVA 40	3548	12	31-Aug-2013
Combiner/Splitter	Weinschel	1506A	3877	12	19-Mar-2014
1 Metre SMA Cable	Rhophase	3PS-1801A-1000-3PS	4099	12	26-Oct-2013
Section 2.8 - Frequency Stability					
Multimeter	White Gold	WG022	190	12	30-Oct-2013
Temperature Chamber	Montford	2F3	467	-	O/P Mon
Power Supply Unit	Farnell	D302T	609	-	O/P Mon
Radio Communications Test Set	Rohde & Schwarz	CMU 200	3035	12	6-Dec-2013
Thermocouple Thermometer	Fluke	51	3173	12	23-Aug-2013
Attenuator (10dB, 20W)	Lucas Weinschel	1	3225	12	11-Dec-2013
1 Metre N Type Cable	Rhophase	NPS-1601A-1000-NPS	4103	12	11-Jun-2014

TU – Traceability Unscheduled

O/P MON – Output Monitored with Calibrated Equipment

Note: Some items of equipment are shown as having two calibration dates due to testing being carried out at two different times. The latter calibration dates refer to 8PSK test cases for ERP and Radiated Spurious Emission performed in January 2014



3.2 MEASUREMENT UNCERTAINTY

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

Test Discipline	MU
Maximum Peak Output Power - Conducted	± 0.70 dB
Emission Limitations for Cellular Equipment	30MHz to 1GHz: ± 5.1 dB 1GHz to 40GHz: ± 6.3 dB
Conducted Spurious Emissions	± 3.454 dB
Effective Radiated Power	30MHz to 1GHz: ± 5.1 dB 1GHz to 40GHz: ± 6.3 dB
Spurious Emissions at Band Edge	30MHz to 1GHz: ± 5.1 dB 1GHz to 40GHz: ± 6.3 dB
Occupied Bandwidth	± 16.74 kHz
Modulation Characteristics	-
Frequency Stability	± 46.70 Hz



Product Service

SECTION 4

ACCREDITATION, DISCLAIMERS AND COPYRIGHT



Product Service

4.1 ACCREDITATION, DISCLAIMERS AND COPYRIGHT



This report relates only to the actual item/items tested.

Our UKAS Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our UKAS Accreditation.

Results of tests not covered by our UKAS Accreditation Schedule are marked NUA
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TÜV SÜD Product Service

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