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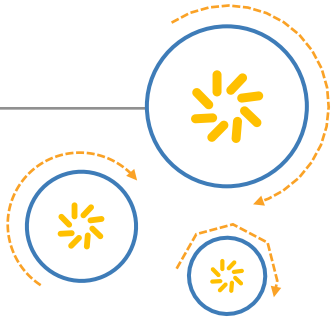

QM8626 Simultaneous Transmission and Collocated RF Exposure Calculations

80-KA570-17 Rev. C

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Revision history

Revision	Date	Description
A	July 2015	Initial release
B	August 2015	Edit to add IC reference
C	August 2015	• Significant changes for IC requirements, calculations, etc. • Revised power and gain values for combined compliance to FCC and IC limits • Consideration to ETSI EIRP limits included • Document title change

Contents

Tables

1 Introduction

The purpose of this document is to:

1. Demonstrate that the QM8626 module meets RF exposure requirements for mobile applications, even at transmit powers greater than what was used for other regulatory testing, per FCC and IC RF exposure requirements.
2. Provide QM8626 module integrators with information that can be used for determining maximum antenna gains and/or cable losses in mobile applications without the need for additional RF exposure analysis.

The conducted powers and antenna gains provided in the tables and calculations were derived to simultaneously comply with all three of the major regulatory bodies, i.e., FCC, IC and ETSI, although ETSI calculations are not included in this report.

This maximum permissive exposure report demonstrates compliance with Federal Communications Commission (FCC) CFR 47 §1.1310 and 2.1091 and Industry Canada (IC) RSS-102 Issue 5 for collocated transmitters used in simultaneous conditions with the QM8626 module installed in a *mobile* host platform. The *mobile* classification applies when 20 cm or more separation distance is maintained between the transmission antennas and the end user.

The module is a QM8626 module authorized with FCC ID J9CQM8626 and IC ID 2723A-QM8626. The module includes WWAN (GSM, WCDMA, CDMA), WLAN (802.11) and Bluetooth (BT) transmitters. This document also includes calculations for generic unlicensed transmitters for three different bands of operation.

1.1 Acronyms and definitions

Table 1-1 lists terms used in this document.

Table 1-1 Acronyms and definitions

Term	Definition
BT	Bluetooth
CDMA	Code Division Multiple Access
FCC	Federal Communications Commission
GPRS	General Packet Radio Service
GSM	Global System for Mobile
MPE	Maximum Permissible Exposure
OET	Federal Communications Commission Office of Engineering & Technology
RF	Radio Frequency
UMTS	Universal Mobile Telecommunications System

Term	Definition
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network

2 Transmitter Summary

Table 2-1 summarizes transmitter parameters associated with this application.

The WWAN modes of operation reflect the QM8626 module's parameters associated with FCC ID J9CQM8626 and IC ID 2723A-QM8626.

The WLAN transmit power and antenna gain parameters represent the highest transmit power for a given frequency.

Integration of a WLAN module that exceeds the parameters requires new FCC and IC authorizations or permissive change applications. A worst-case antenna gain of 2 dBi is used for 2.4 GHz WLAN and 6 dBi is used for 5 GHz WLAN and BT antennas.

Table 2-1 WWAN and collocated transmitter declared parameters

Technology	Frequency (MHz)	Maximum conducted power (dBm)	Conducted power (W)	Maximum antenna gain (dBi)
GPRS 2 UL	824 - 848	33.28	2.13	3.1
CDMA2000	826 - 846	23.90	0.2455	3.1
UMTS	824 - 848	24.10	0.257	3.1
GPRS 2 UL	1850 - 1909	32.50	1.78	5
CDMA2000	1852 - 1907	24.00	0.251	5
UMTS	1851 - 1908	23.70	0.2345	5
WLAN	2412 - 2462	18.00	0.063	2
WLAN	5180 - 5240	15.55	0.036	6
WLAN	5725 - 5850	14.74	0.030	6
WLAN	5755 - 5795	15.05	0.032	6
BT	2402 - 2480	10.53	0.011	6

3 Simultaneous Transmission

Table 3-1 provides a matrix of simultaneous transmission scenarios that are possible with the QM8626 module.

Table 3-1 Simultaneous transmission scenarios

Simultaneous transmission case scenario		
Transmitter 1	Transmitter 2	Simultaneously transmit?
WWAN	WLAN	Yes
WWAN	BT	Yes
WLAN	BT	No

4 RF Exposure Limits and Equations

4.1 FCC

According to FCC CFR 47 §1.1310, the criteria listed in Table 4-1 are used to evaluate the environmental impact of human exposure to Radio Frequency (RF) radiation as specified in 1.1307(b). Table 4-1 shows the limits for RF exposure.

Table 4-1 FCC Limits for RF exposure

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	*900/f^2	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f^2	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

The Friis transmission formula is:

$$P_d = \frac{P_{out} \times G}{4\pi R^2}$$

Where:

P_d = power density (mW/cm2)

P_{out} = output power to antenna (mW)

G = gain of antenna in linear scale

R = distance between observation point and center of the radiator (cm)

4.2 Industry Canada (IC)

According to IC RSS-102 Issue 5, the criteria listed in Table 4-2 are used to evaluate the environmental impact of RF exposure to Radio Frequency (RF) radiation. Table 4-2 shows the limits for RF Exposure.

Table 4-2 IC Limits for RF exposure (General Public)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m^2)	Reference Period (minutes)
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	$0.73/f$	-	6**
1.1-10	$87/f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	$58.07/f^{0.25}$	$0.1540/f^{0.25}$	$8.944/f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	$3.142f^{0.3417}$	$0.008335f^{0.3417}$	$0.02619f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	$616000/f^{1.2}$
150000-300000	$0.158f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000/f^{1.2}$

Note: f is frequency in MHz.
*Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

5 RF Exposure Calculations

5.1 Standalone RF exposure calculations

The RF exposure calculations for standalone transmitters at a separation distance of 20 cm are shown in Table 5-1 for FCC and Table 5-2 for IC per the transmit power and antenna gain values declared in Table 2-1.

For frequency dependent limits, the lowest transmitter frequency was used to represent the lowest RF exposure limit (e.g., 824 MHz = 0.549 mW/cm^2).

Table 5-1 and Table 5-2 also include calculations for generic unlicensed radios for three operating bands that may be collocated with the module in its host device. Any combination of conducted power, maximum antenna gain and duty cycle may be used as long as average Effective Isotropic Radiated Power (EIRP) is less than or equal to the value given.

Table 5-1 FCC WWAN and unlicensed standalone RF exposure calculations

Technology	Frequency (MHz)	Maximum Conducted Power (dBm)	Conducted Power (W)	Maximum Antenna Gain (dBi)	Duty Cycle	Average EIRP (dBm)	Average EIRP (W)	Power Density @ 20cm (mW/cm^2)	FCC MPE Limit (mW/cm^2)	Verdict	Technology Power density/ Exposure limit[1]
GPRS 2 UL	824 - 848	33.28	2.13	3.1	0.25	30.36	1.09	0.216	0.549	Pass	0.394
CDMA2000	826 - 846	23.90	0.2455	3.1	1.00	27.00	0.50	0.100	0.549	Pass	
UMTS	824 - 848	24.10	0.257	3.1	1.00	27.20	0.52	0.104	0.549	Pass	
GPRS 2 UL	1850 - 1909	32.50	1.78	5.0	0.25	31.48	1.41	0.280	1.000	Pass	0.280
CDMA2000	1852 - 1907	24.00	0.251	5.0	1.00	29.00	0.79	0.158	1.000	Pass	
UMTS	1851 - 1908	23.70	0.2345	5.0	1.00	28.70	0.74	0.148	1.000	Pass	
WLAN	2412 - 2462	18.00	0.063	2.0	1.00	20.00	0.10	0.020	1.000	Pass	0.020
WLAN	5180 - 5240	15.55	0.036	6.0	1.00	21.55	0.14	0.028	1.000	Pass	0.028
WLAN	5725 - 5850	14.74	0.030	6.0	1.00	20.74	0.12	0.024	1.000	Pass	0.024
WLAN	5755 - 5795	15.05	0.032	6.0	1.00	21.05	0.13	0.025	1.000	Pass	0.025
BT	2402 - 2480	10.53	0.011	6.0	1.00	16.53	0.04	0.009	1.000	Pass	0.009
Generic unlicensed radio	902 - 928	-	-	-	-	21.00	0.13	0.025	1.000	Pass	0.025
Generic unlicensed radio	2400 - 2484	-	-	-	-	21.00	0.13	0.025	1.000	Pass	0.025
Generic unlicensed radio	5725 - 5875	-	-	-	-	21.00	0.13	0.025	1.000	Pass	0.025

Notes:

1. Fraction of power density for the corresponding wireless technology divided by exposure limit.

Table 5-2 IC WWAN and unlicensed standalone RF exposure calculations

Technology	Frequency (MHz)	Freq.(MHz) for calculations	Maximum Conducted Power (dBm)	Conducted Power (W)	Max Antenna Gain (dBi)	Duty Cycle	Average EIRP (dBm)	Average EIRP (W)	Power Density @ 20cm (W/m^2)	IC RF Exposure Limit[1] (W/m^2)	Verdict	Technology Power density/ Exposure limit[2]
GPRS 2 UL	824 - 848	830	33.28	2.13	3.1	0.25	30.36	1.09	2.163	2.588	Pass	0.836
CDMA2000	826 - 846	830	23.90	0.2455	3.1	1.00	27.00	0.50	0.997	2.588	Pass	
UMTS	824 - 848	830	24.10	0.257	3.1	1.00	27.20	0.52	1.044	2.588	Pass	
GPRS 2 UL	1850 - 1909	1880	32.50	1.78	5.0	0.25	31.48	1.41	2.800	4.526	Pass	0.619
CDMA2000	1852 - 1907	1880	24.00	0.251	5.0	1.00	29.00	0.79	1.579	4.526	Pass	
UMTS	1851 - 1908	1880	23.70	0.2345	5.0	1.00	28.70	0.74	1.475	4.526	Pass	
WLAN	2412 - 2462	2412	18.00	0.063	2.0	1.00	20.00	0.10	0.199	5.366	Pass	0.037
WLAN	5180 - 5240	5180	15.55	0.036	6.0	1.00	21.55	0.14	0.284	9.047	Pass	0.031
WLAN	5725 - 5850	5725	14.74	0.030	6.0	1.00	20.74	0.12	0.236	9.687	Pass	0.024
WLAN	5755 - 5795	5755	15.05	0.032	6.0	1.00	21.05	0.13	0.253	9.722	Pass	0.026
BT	2402 - 2480	2460	10.53	0.011	6.0	1.00	16.53	0.04	0.089	5.439	Pass	0.016
Generic unlicensed radio	902 - 928	910	-	-	-	-	21.00	0.13	0.250	2.756	Pass	0.091
Generic unlicensed radio	2400 - 2484	2460	-	-	-	-	21.00	0.13	0.250	5.439	Pass	0.046
Generic unlicensed radio	5725 - 5875	5800	-	-	-	-	21.00	0.13	0.250	9.774	Pass	0.026

Notes:

1. IC RF Exposure calculated per RSS-102 Issue 5 for frequencies 300 MHz – 6 GHz: 0.02619 x f (MHz)$^{0.6834}$, where the lowest frequency is selected from the given band.
2. Fraction of power density for the corresponding wireless technology divided by exposure limit.

5.2 Collocated/simultaneous transmission RF exposure calculations

5.2.1 FCC Calculations

According to the OET Bulletin 65, when RF sources have different frequencies the fraction of the FCC power density limited should be determined and the sum of all fractional components should be < 1. The values in the fraction columns are calculated from the highest power density and lowest RF exposure limit values (worst case) derived from Table 5-1 (FCC) or Table 5-2 (IC). That is,

$$\frac{PowerDensity(WWAN)}{Limit} + \frac{PowerDensity(WLAN)}{Limit} + \frac{PowerDensity(Generic)}{Limit} < 1$$

Table 5-3 shows summations of all of the iterations of the Power Density per FCC Limit Fractions calculated in Table 5-1 for 850 MHz WWAN. Table 5-4 shows summations of all of the iterations of the Power Density per FCC Limit Fractions calculated in Table 5-1 for 1900 MHz WWAN.

Table 5-3 FCC Collocated Transmitter Calculations for 850 MHz WWAN

WLAN Band	(WLAN Pd) / (RF exposure limit)	(WWAN 850 MHz) / (RF exposure Limit)	(Generic unlicensed) / (RF exposure Limit)	(850 MHz WWAN fraction) + (WLAN fraction) + (generic unlicensed fraction)	Limit	Verdict
2412 - 2462	0.020	0.394	0.025	0.439	1	Pass
5180 - 5240	0.028			0.447	1	Pass
5725 - 5850	0.024			0.443	1	Pass
5755 - 5795	0.025			0.444	1	Pass

Table 5-4 FCC Collocated Transmitter Calculations for 1900 MHz WWAN

WLAN Band	(WLAN Pd) / (RF exposure limit)	(WWAN 1900 MHz) / (RF exposure Limit)	(Generic unlicensed) / (RF exposure Limit)	(850 MHz WWAN fraction) + (WLAN fraction) + (generic fraction)	Limit	Verdict
2412 - 2462	0.020	0.280	0.025	0.325	1	Pass
5180 - 5240	0.028			0.333	1	Pass
5725 - 5850	0.024			0.329	1	Pass
5755 - 5795	0.025			0.330	1	Pass

5.2.2 IC Calculations

Table 5-5 shows summations of all of the iterations of the Power Density per IC Limit Fractions calculated in Table 5-2 for 850 MHz WWAN. Table 5-6 shows summations of all of the iterations of the Power Density per IC Limit Fractions calculated in Table 5-2 for 1900 MHz WWAN.

Table 5-5 IC Collocated Transmitter Calculations for 850 MHz WWAN

(WWAN 850 MHz) / (RF exposure limit)	Generic unlicensed band	(Generic unlicensed) / (MPE Limit)	WLAN Band	(WLAN Pd) / (MPE Limit)	(850 MHz WWAN fraction) + (WLAN fraction) + (generic fraction)	Limit	Verdict
0.836	902 - 928	0.091	2412 - 2462	0.037	0.964	1	Pass
			5180 - 5240	0.031	0.958	1	Pass
			5725 - 5850	0.024	0.951	1	Pass
			5755 - 5795	0.026	0.953	1	Pass
	2400 - 2484	0.046	2412 - 2462	0.037	0.919	1	Pass
			5180 - 5240	0.031	0.913	1	Pass
			5725 - 5850	0.024	0.906	1	Pass
			5755 - 5795	0.026	0.908	1	Pass
	5725 - 5875	0.026	2412 - 2462	0.037	0.898	1	Pass
			5180 - 5240	0.031	0.893	1	Pass
			5725 - 5850	0.024	0.886	1	Pass
			5755 - 5795	0.026	0.887	1	Pass

Table 5-6 IC Collocated Transmitter Calculations for 1900 MHz WWAN

(WWAN 1900 MHz) / (RF exposure limit)	Generic unlicensed band	(Generic unlicensed) / (MPE Limit)	WLAN Band	(WLAN Pd) / (MPE Limit)	(850 MHz WWAN fraction) + (WLAN fraction) + (generic fraction)	Limit	Verdict
0.619	902 - 928	0.091	2412 - 2462	0.037	0.747	1	Pass
			5180 - 5240	0.031	0.741	1	Pass
			5725 - 5850	0.024	0.734	1	Pass
			5755 - 5795	0.026	0.736	1	Pass
	2400 - 2484	0.046	2412 - 2462	0.037	0.702	1	Pass
			5180 - 5240	0.031	0.696	1	Pass
			5725 - 5850	0.024	0.689	1	Pass
			5755 - 5795	0.026	0.691	1	Pass
	5725 - 5875	0.026	2412 - 2462	0.037	0.681	1	Pass
			5180 - 5240	0.031	0.676	1	Pass
			5725 - 5850	0.024	0.669	1	Pass
			5755 - 5795	0.026	0.670	1	Pass