TECHNICAL NOTE TN 1203.04

XE1203 TO XE1203F MIGRATION AT 915 MHz

1 Table of Contents

2 Index of Figures

3 Index of Tables

4 Introduction

This document describes the migration of a XM1203-C915 FCC pre-certified reference design module from the XE1203 transceiver to XE1203F transceiver. The document shows that it is possible to achieve this migration as a Class 1 Permissive Change.

It is recommended that this technical note is read in conjunction with the following documentation:

Semtech XE1203F Low-Power Integrated UHF Transceiver Datasheet
(http://www.semtech.com/pc/downloadDocument.do?navId=H0,C193,C196,P2614&id=774)
Semtech TN1203.02 XE1203 to XE1203 TrueRF Migration
(http://www.semtech.com/pc/downloadDocument.do?navId=H0,C193,C196,P2614&id=869)

4.1 FCC Requirements[1]

FCC rules and regulations state that for a change made to previously certified equipment to be considered as a Class 1 Permissive Change, and hence that does not require filing with the Commission, modifications made must not degrade the characteristics reported by the manufacturer and accepted by the Commission when certification is granted.

To ensure compliance with both Semtech product specifications and FCC rules and regulations, the following parameters were measured:

1. PLL Tuning Range and Loop Filter Voltage, V_{LFB}
2. Receiver Sensitivity
3. Transmitter Output Power
4. Transmitter Harmonic and Spurious Emissions
5. Receiver Spurious Emissions

A Semtech XM1203-C915MHz module (PCB revision e054v05a, BOM revision v05a) was used as an example of chip migration on an existing circuit.

5 XM1203-C915MHz Module

5.1 Reference Module Build Standard

The XME1203 module is a single-sided, 4-layer PCB of 1.6mm thickness. The PCB material is FR4 and the layer build up is as described below in Table 1:

Layer	Description
1	Signal
FR4	0.6mm
2	Ground Plane
FR4	0.4mm
3	Power Plane
FR4	0.4mm
4	Signal/Ground Plane

Table 1: XM1203 PCB Build-Up

The circuit schematic is illustrated below in Figure 1 and Bill of Material in Table 2.

[1] CFR47 Chapter 1,Part 2.1043: Changes in Certified Equipment (October 2005)

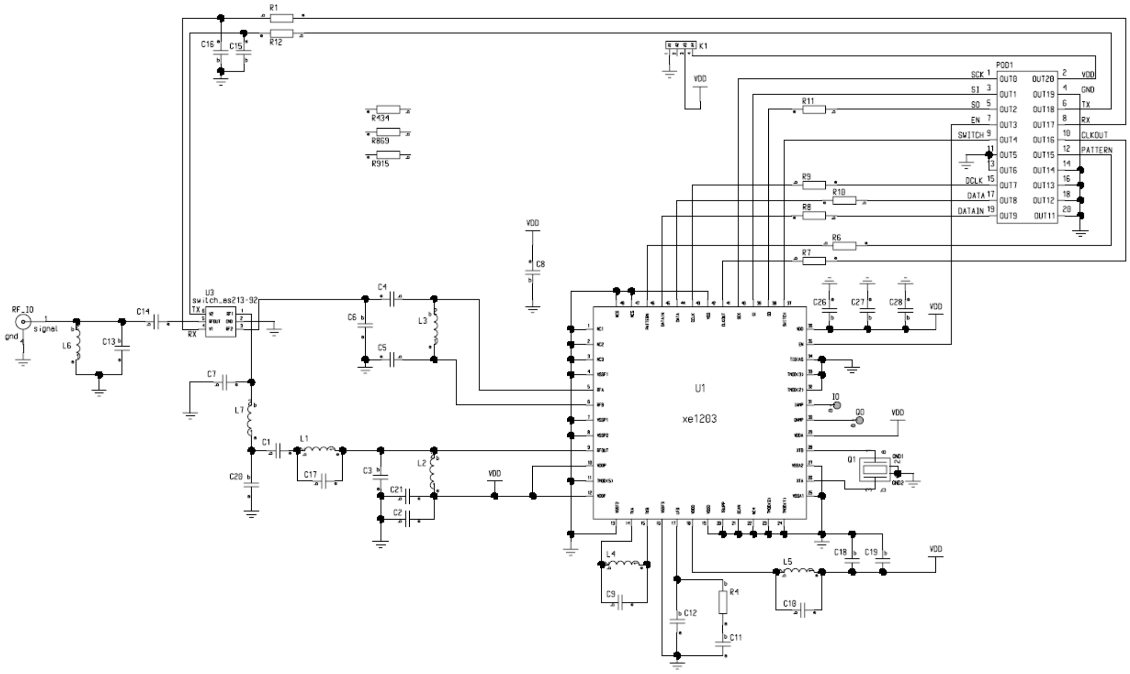

Figure 1: XM1203 Circuit Schematic

Ref Des	Value	Qty	Description	Manufacturer
U1	XE1203	1	RF Transceiver	XEMICS
C1	15pF	1	Capacitor COG (+/-5%)	Epcos
C2, C20	3.3pF	2	Capacitor COG (+/-5%)	Epcos
C3	33pF	1	Capacitor COG (+/-5%)	Epcos
C4	3.3pF	1	Capacitor COG (+/-5%)	Epcos
C5, C8	1.5pF	2	Capacitor COG (+/-5%)	Epcos
C6	6.8pF	1	Capacitor COG (+/-5%)	Epcos
C15,C16,C19	22pF	3	Capacitor COG (+/-5%)	Epcos
C11	22nF	1	Capacitor COG (+/-5%)	Epcos
C12	220pF	1	Capacitor COG (+/-5%)	Epcos
C18,C28	1nF	2	Capacitor COG (+/-5%)	Epcos
C7,C29,C30,C32,C33	NC	5	NC	-
C27	10nF	1	Capacitor COG (+/-5%)	Epcos
C26	1uF	1	Capacitor X7R (+/-10%)	Murata
R3 **Capacitor**	33pF	1	Capacitor COG (+/-5%)	Epcos
R1,R2,R12	0ohms	3	Resistor (+/-1%)	Multicomp
R4	2.7k	1	Resistor (+/-1%)	Multicomp
R5	33	1	Resistor (+/-1%)	Multicomp
R6,R7,R8,R9,R10,R11	1k	6	Resistor (+/-1%)	Multicomp
R13	270 ohm	1	Resistor (+/-1%)	Multicomp
C9 **Inductor**	12nH	1	LQG18HN12NJ00D	Murata
C10	NC	1	NC	-
L1	8.2nH	1	LQG18HN8N2J00D	Murata
L2	22nH	1	LQG18HN22NJ00D	Murata
L3	22nH	1	LQW18AN22NG00D	Murata
L4	NC	1	NC	-
Q2	C3XM5-1S8-39M00	1	Crystal 39MHz	C3
U3	AS213-92	1	RF-Switch GaAs SPDT	Skyworks
POD1	2x10 pole	1	Connector 2 x 10 Pole	FCI
RF1	SMA Connector	1	PC Mount Rt. Angle	Huber & Suhner
J1	1x4 pole	1	Connector 1 x 4 Pole	FCI
U5	TMX S110	1	SAW-Filter 915MHz	Temex

Table 2: XM1203-C915MHz BOM revision v05a

A Semtech XM1203-C915MHz module of PCB revision e054v05a and BOM revision v05a (Module #1) was characterized.

For an identical build standard module the XE1203 transceiver was subsequently replaced with a XE1203F and modifications made to passive component values to optimize transceiver performance whilst ensuring that the regulatory characteristics did not degrade (Module #2).

5.2 XE1203F Migration

5.2.1 VCO Tank

For operation in the 902 - 928 MHz ISM band the VCO tank inductor value is optimized to center the loop filter voltage at Pin 17 (LFB). The tank circuit modifications are detailed below.

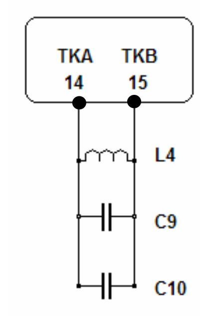

Figure 2: XE1203F VCO Tank Circuit

Ref Des	Value	Description	Manufacturer
C9 **Inductor**	6.8nH	LQG18HN6N8J00	Murata
C10	NC	NC	-
L4	NC	NC	-

Table 3: VCO Tank Circuit BOM

5.2.2 LNA

The modifications to the LNA circuit and subsequent BOM are documented below. It should be noted that L3 is a multi-layer type.

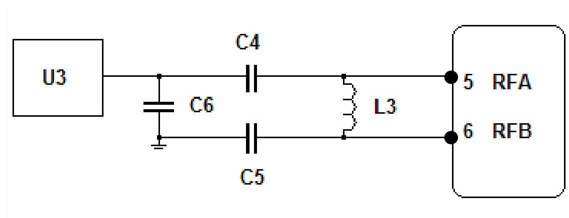

Figure 3: XE1203F LNA Matching Network

Ref Des	Value	Description	Manufacturer
C4	1pF	Capacitor COG (+/-0.25pF)	Murata
C5	1pF	Capacitor COG (+/-0.25pF)	Murata
C6	NC	NC	-
L3	27nH	LQG18HN27NJ00	Murata

Table 4: XE1203F LNA Matching Network BOM

5.2.3 Frequency Synthesizer Loop Filter

The loop filter circuit modifications are documented below. As the VCO gain of the XE1203F (k_{VCO}) is increased in comparison with the XE1203, the loop filter component values are modified accordingly. Circuit values for data rates up to 38.4 kB and for greater than 38.4 kB are tabulated below.

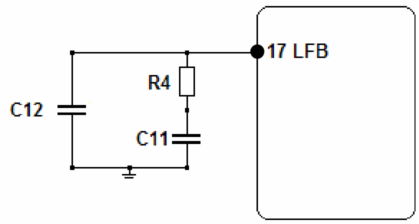

Figure 4: XE1203F Loop Filter Schematic

Ref Des	Value	Description	Manufacturer
C11	22nF	Capacitor X7R (+/-5%)	Murata
C12	1.2nF	Capacitor X7R (+/-5%)	Murata
R4	470Ω	Resistor 0.125W	Multicomp

Table 5: Loop Filter BOM for Data Rates up to 38.4 kB

Ref Des	Value	Description	Manufacturer
C11	4.7nF	Capacitor X7R (+/-5%)	Murata
C12	330pF	Capacitor COG (+/-5%)	Murata
R4	1kΩ	Resistor 0.125W	Multicomp

Table 6: Loop Filter BOM for Data Rates Greater than 38.4 kB

5.2.4 Transmitter Matching Network

The optimum load impedance presented at the RFOUT Pin of the XE1203F at 915 MHz for each output power modes are provided in the following table:

Mode	Nom. Output Power (dBm)	Opt. Load Impedance (Ω)
00	0	133 + j11
01	5	133 + j103
10	10	107 + j59
11	15	83 + j18

Table 7: Optimum PA Load Impedance

The PA matching network and optimized BOM are illustrated below:

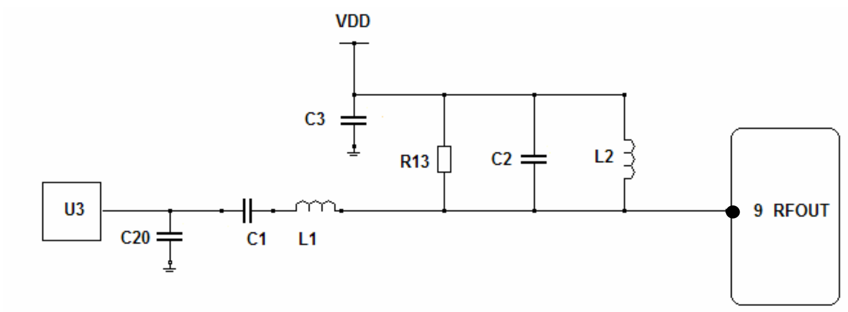

Figure 5: XE1203 PA Matching Network

Ref Des	Value	Description	Manufacturer
C1	15pF	Capacitor COG (+/-5%)	Murata
C2	4.7pF	Capacitor COG (+/-0.25pF)	Murata
C3	10pF	Capacitor COG (+/-5%)	Murata
C20	2.2pF	Capacitor COG (+/-0.25pF)	Murata
L1	8.2nH	LQG18HN8N2J00	Murata
L2	15nH	LQG18HN15NJ00	Murata
R13	NC	NC	-

Table 8: XE1203 PA Matching Network BOM

5.2.5 Digital Block Power Supply Filtering

Since the VCO gain is increased, the VCO is more susceptible to common mode noise on the supply rails, especially the digital supply, VDDD. To minimize spurious emissions generated within the fractional-N PLL block, the power supply filtering is modified as detailed below:

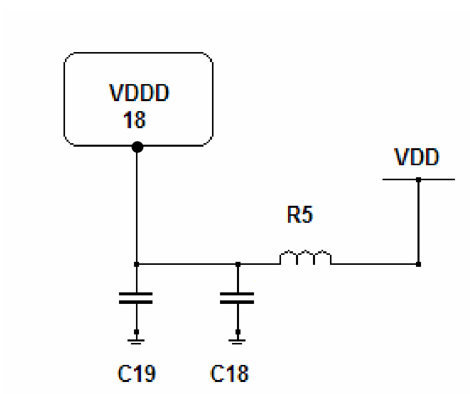

Figure 6: Digital Supply Filtering

Ref Des	Value	Description	Manufacturer
C18	NC	NC	Murata
C19	NC	NC	Murata
R5 **Inductor**	47nH	LQG18HN47NJ00	Murata

Table 9: Digital Supply Filtering BOM

6 Results

The results are tabulated below in Table 10:

Unless otherwise specified, all measurements were performed at VDD = 3.3 V, t = t_{amb}.

Parameter	Conditions		Module		Units
			#1	#2	
PLL Tuning Range	f_{LO}(min		898.575	869.590	MHz
	f_{LO}(ctr)		914.996	915.034	MHz
	f_{LO}(max)		928.590	931.434	MHz
V_{LFB}	f_{LO}(min)		1.59	1.34	V
	f_{LO}(ctr)		2.30	1.60	V
	f_{LO}(max)		3.10	1.92	V
TX Output Power	0dBm Mode		-3.9	-3.7	dBm
	5dBm Mode		-0.4	1.2	dBm
	10dBm Mode		4.4	5.6	dBm
	15dBm Mode		12.3	11.3	dBm
TX Spurious @ P_{MAX}	902 MHz - 928 MHz		-55	-59	dBm
	< 1 GHz		-67	-79	dBm
TX Harmonics @P_{MAX}	2nd Harmonic	1830 MHz	-72	-77	dBm
	3rd Harmonic	2745 MHz	-70	-78	dBm
	4th Harmonic	3660 MHz	-59	-74	dBm
	5th Harmonic	4575 MHz	-68	-80	dBm
	6th Harmonic	5490 MHz	-48	-	dBm
	7th Harmonic	6405 MHz	-49	-	dBm
	8th Harmonic	7320 MHz	-	-	dBm
	9th Harmonic	8235 MHz	-	-	dBm
	10th Harmonic	9150 MHz	-	-	dBm
RX Sensitivity	902 MHz		-111.6	-111.7	dBm
	915 MHz		-112.5	-112.0	dBm
	928 MHz		-112.1	-112.5	dBm
RX Spurious	f_{LO}(ctr)		-73	-75	dBm

Table 10: Test Results

7 Conclusions

The laboratory analysis indicates that for the Semtech XM1203-C915 Reference Design, the migration from XE1203 to XE1203F with only passive component value modifications results in reduced harmonic and spurious emissions whilst conducted transmitter output power and receiver sensitivity meets Semtech's published specifications taking into account that a SAW filter is added in series with both the transmitter and receiver paths.

Note that these results are only valid for the Semtech XM1203 reference design module and is a representative example of chip migration from XE1203 to XE1203F.

Since the XE1203F will be integrated in to a final application, it is this application that must be measured to ensure technical compliance with FCC rules and regulations. For further information please contact your local Semtech sales representative: (http://www.semtech.com/contact/)

END OF DOCUMENT