Test result analysis,

colocation test report,

G0M-2401-2381-TFCCOLOC-V02

Product description: Tracker TR4111000

Model No. :   4111000

FCC ID: 2AR86-TR41

Customer: Treon Oy

Address: Visiokatu, 3 33720 Tampere, Finland

Contents

Document Version History	Date of issue	Comments	Approved by
v0.1	23.08.2024	Initial version	
v1.0	23.08.2024	Approved version	Jukka Rauma
v2.0	16.12.2024	Corrected model and FCC ID for Quectel cellular module. Updated results accoding co-location test report, G0M-2401-2381-TFCCOLOC-V02.	Jukka Rauma
v3.0	30.1.2025	Corrected references to correct co-location test report version V02.	Jukka Rauma

1. General Information

Analysis in this Annex are based on following test report.

Test report name: G0M-2401-2381-TFCCOLOC-V02.pdf
Test report dated: 2024-12-13
Version: 02
Eurofins Product Service GmbH
Storkower Str. 38c, D-15526 Reichenwalde, Germany

2. Configuration and Operation Modes

Test modes – Applied for both EUT 1 and EUT2

Operation Mode(s)	Description
WLAN-DT (IEEE 802.11n)	Mode = Transmit Modulation = BPSK Bandwidth = 20 MHz Power setting = 16 dBm (software setting) Channel = 6 (2437 MHz) Data rate = 6.5 Mbit/s (MCS0) Streams = 1 Duty cycle = 100%
BLE 1	Mode = Transmit Modulation = GFSK Bandwidth = 1 MHz Power setting = 4.7 dBm (software setting) Channel = 18 (2442 MHz) Data rate = 1 Mbit/s Packet type = PRBS9 Packet length = 193 Duty cycle = 87,5%
BLE 2	Mode = Transmit Modulation = GFSK Bandwidth = 1 MHz Power setting = 4.7 dBm (software setting) Channel = 18 (2442 MHz) Data rate = 1 Mbit/s Packet type = PRBS9 Packet length = 193 Duty cycle = 87,5%
Comment: Above worst case scenarios are based on average transmitter output power and were found by evaluation of the module test reports: F160785E3 issued by Phoenix TESTLAB on 2016-06-27 and 3955RER001/3955RER002 issued by Eurofins Electric & Electronics Finland Oy on 2024-06-26.	

1.7 Test Modes – (EUT 1)

Mode	Description
GSM850 / GMSK	Channel = 190 Mode = Transmit Power = 3 Modulation = GMSK Number of time slots = 1 Duty cycle = 12.5 %
GSM1900 / GMSK	Channel = 512 Mode = Transmit Power = 3 Modulation = GMSK Number of time slots = 1 Duty cycle = 12.5 %
LTE FDD4 / QPSK	Channel = 19965 Mode = RMC TPC = All 1 Modulation = QPSK Bandwidth = 3 MHz Number of resource blocks = 1 Resource block offset = 0 Duty cycle = 100 %
LTE FDD7 / QPSK	Channel = 21350 Mode = RMC TPC = All 1 Modulation = QPSK Bandwidth = 20 MHz Number of resource blocks = 1 Resource block offset = 0 Duty cycle = 100 %
LTE FDD12 / QPSK	Channel = 23060 Mode = RMC TPC = All 1 Modulation = QPSK Bandwidth = 10 MHz Number of resource blocks = 1 Resource block offset = 24 Duty cycle = 100 %
LTE FDD13 / QPSK	Channel = 23230 Mode = RMC TPC = All 1 Modulation = QPSK Bandwidth = 5 MHz Number of resource blocks = 1 Resource block offset = 24 Duty cycle = 100 %
LTE FDD26 / QPSK	Channel = 26740 Mode = RMC TPC = All 1 Modulation = QPSK Bandwidth = 10 MHz Number of resource blocks = 1 Resource block offset = 24 Duty cycle = 100 %

LTE TDD41 / QPSK	Channel = 40620 Mode = RMC TPC = All 1 Modulation = QPSK Bandwidth = 15 MHz Number of resource blocks = 1 Resource block offset = 37

Comment:

The test modes for GSM850 / GMSK, GSM1900 / GMSK, LTE FDD4 / QPSK, LTE FDD12 / QPSK, LTE FDD13 / QPSK, LTE FDD26 / QPSK are based on worst case evaluation of the conducted output power from module reports GSM-HR/2019/10016E-0101, LTE HR/2019/10016E-0101 issued by SGS-CSTC Standards Technical Services Co., Ltd. Shenzhen, Date of issue: 2019-05-22

The test modes for LTE FDD7 / QPSK, LTE TDD41 / QPSK are based on the worst case evaluation of the spurious emission results from module reports 2212RSU048-U1(V01), 2212RSU048-U2(V01), 2212RSU048-U3(V01) issued by MRT Technology (Suzhou) Co., Ltd. Shenzhen, Date of issue: 2023-03-05

The test modes for GSM850 / GMSK, GSM1900 / GMSK, LTE FDD4 / QPSK, LTE FDD12 / QPSK, LTE FDD13 / QPSK, LTE FDD26 / QPSK are based on the module reports of module EG21-G.

The test modes for LTE FDD7 / QPSK, LTE TDD41 / QPSK are based on the module reports of module EG21-GL. Both modules are from same series but not identical.

The test mode selection for GSM850, GSM1900, LTE FDD4, LTE FDD12, LTE FDD13, LTE FDD26 is based on customer module declaration. Evaluation of module reports for EG21-GL has shown, that spurious emission results have usually a margin between measured emission and 47 CFR § 24.238 limit of > 30 dB for low/mid/high channel. In some cases the margin is > 20 dB. In those cases the selected test frequency was still close enough to the real worst case channel regarding spurious emission. In some cases the margin is < 20 dB, affected modes (LTE FDD7 / QPSK, LTE TDD41 / QPSK) are retested.

1.8   Test Modes – (EUT 2)

Mode	Description
NB-IoT FDD5 / PMAX	Channel = 20648 TPC = Power max Modulation = π/4 - QPSK Bandwidth = 15 kHz Number of tones = 3 Tone offset = 6 Duty cycle = 19.9 %
NB-IoT FDD12 / PMAX	Channel = 23012 TPC = Power max Modulation = π/4 - QPSK Bandwidth = 15 kHz Number of tones = 3 Tone offset = 6 Duty cycle = 17.8 %
NB-IoT FDD13 / PMAX	Channel = 23278 TPC = Power max Modulation = π/4 - QPSK Bandwidth = 15 kHz Number of tones = 3 Tone offset = 6 Duty cycle = 17 %
NB-IoT FDD25 / PMAX	Channel = 26688 TPC = Power max Modulation = π/4 - QPSK Bandwidth = 15 kHz Number of tones = 3 Tone offset = 6 Duty cycle = 17 %
NB-IoT FDD26L / PMAX	Channel = 26790 TPC = Power max Modulation = π/4 - QPSK Bandwidth = 15 kHz Number of tones = 1 Tone offset = 11 Duty cycle = 33 %
NB-IoT FDD66 / PMAX	Channel = 132670 TPC = Power max Modulation = π/4 - QPSK Bandwidth = 15 kHz Number of tones = 3 Tone offset = 6 Duty cycle =17 %
Comment: Above worst case scenarios are based on average transmitter output power and were found by evaluation of the module test reports: NIE: 59675RRF.002, Date of issue: 2019-06-03 and NIE: 59675RRF.004 Date of issue: 2019-05-15 by DEKRA Testing and Certification S.A.U Parque Tecnologico de Andalucia.	

3. Combined test modes

EUT 1

- test modes 1-8 are for following modules

    o   FCC ID: XMR202212EG21GL, Quectel cellular
    o   FCC ID: XPYLILYW1: u-blox, WiFi

Mode	Description of combined test modes	Mode	Result
1	GSM850 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_GSM850, Pmax, BLE1 2442 MHz, BLE2: 2442 MHz	No emissions detected closer than 10 dB from the limit (-13 dBm)
2	GSM1900 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_GSM1900, Pmax, BLE1 2442 MHz, BLE2: 2442 MHz	No emissions detected closer than 10 dB from the limit (-13 dBm)
3	LTE FDD4 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_LTE FDD4, 3 MHz, CH 19965, RB1#0	No emissions detected closer than 10 dB from the limit (-13 dBm)
4	LTE FDD7 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_LTE FDD7, 20 MHz, CH 21350, RB1#0	No emissions detected closer than 10 dB from the limit (-13 dBm)
5	LTE FDD12 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_LTE FDD12, 10 MHz, CH 23060, RB1#24	No emissions detected closer than 10 dB from the limit (-13 dBm)
6	LTE FDD13 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_LTE FDD13, 5 MHz, CH 23230, RB1#24	No emissions detected closer than 10 dB from the limit (-13 dBm)
7	LTE FDD26 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_LTE FDD26, 10 MHz, CH 26740, RB1#24	No emissions detected closer than 10 dB from the limit (-13 dBm)
8	LTE FDD41 / WLAN-DT / BLE 1&2	IEEE 802.11n, HT20, 2462 MHz, MCS 1, P=16dBm_LTE TDD38/41, 15 MHz, CH 40620, RB1#37	No emissions detected closer than 10 dB from the limit (-13 dBm)

EUT 2
- test modes 8-13 are for following modules

  - o FCC ID: 2ANPO00NRF9160, Nordic cellular
  - o FCC ID: XPYLILYW1: u-blox, WiFi

Mode	Description of combined test modes	Mode	Result
9	NB-IoT FDD5 / PMAX, WLAN-DT / BLE 1&2	WLAN-DT (IEEE 802.11n), NB-IoT FDD5_PMAX, BLE 1_P=4.7 dBm, BLE2_P=4 dBm	No emissions detected closer than 10 dB from the limit (-13 dBm)
10	NB-IoT FDD12 / PMAX, WLAN-DT / BLE 1&2	WLAN-DT (IEEE 802.11n), NB-IoT FDD12 / PMAX, BLE 1_P=4.7 dBm, BLE2_P=4 dBm	No emissions detected closer than 10 dB from the limit (-13 dBm)
11	NB-IoT FDD13 / PMAX, WLAN-DT / BLE 1&2	WLAN-DT (IEEE 802.11n), NB-IoT FDD13 / PMAX, BLE 1_P=4.7 dBm, BLE2_P=4 dBm	No emissions detected closer than 10 dB from the limit (-13 dBm)
12	NB-IoT FDD25 / PMAX, WLAN-DT / BLE 1&2	WLAN-DT (IEEE 802.11n), NB-IoT FDD25 / PMAX, BLE 1_P=4.7 dBm, BLE2_P=4 dBm	No emissions detected closer than 10 dB from the limit (-13 dBm)

13	NB-IoT FDD26L / PMAX, WLAN-DT / BLE 1&2	WLAN-DT (IEEE 802.11n), NB-IoT FDD26L / PMAX, BLE 1_P=4.7 dBm, BLE2_P=4 dBm	No emissions detected closer than 10 dB from the limit (-13 dBm)
14	NB-IoT FDD66 / PMAX, WLAN-DT / BLE 1&2	WLAN-DT (IEEE 802.11n), NB-IoT FDD66 / PMAX, BLE 1_P=4.7 dBm, BLE2_P=4 dBm	No emissions detected closer than 10 dB from the limit (-13 dBm)

4. Result tables and comments

Test results – Combined test mode 1							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
1	1673	-35.9	pk	Ver	-13 dBm	-22.95	PASS

Test results – Combined test mode 2							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
2	2467	-18.4	pk	Ver	-13 dBm	-05.41	PASS
Comment: Marker2 (this result above) in graph is for WLAN carrier							

Test results – Combined test mode 3							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
3	973.454	-23	pk	Ver	-13 dBm	-10.04	PASS

Test results – Combined test mode 4							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
4	965.08	-23.9	pk	Ver	-13 dBm	-10.88	PASS
4	7326.467	-42.9	pk	Ver	-13 dBm	-29.89	PASS
4	9766.767	-39.5	pk	Ver	-13 dBm	-26.51	PASS
4	26025.7	-33.2	pk	Ver	-13 dBm	-20.53	PASS

Test results – Combined test mode 5							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
5	734.22	-20.6	pk	Ver	-13 dBm	-07.55	PASS
Comment: Marker2 (this result above) in graph is for LTE system simulator downlink signal							

Test results – Combined test mode 6							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
6	750.613	-17.7	pk	Ver	-13 dBm	-04.66	PASS
Comment: Marker2 (this result above) in graph is for LTE system simulator downlink signal							

Test results – Combined test mode 7							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
7	733.347	-19.5	pk	Ver	-13 dBm	-06.53	PASS
Comment: Marker2 (this result above) in graph is for LTE system simulator downlink signal							

Test results – Combined test mode 8							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
8	950.53	-24.6	pk	Ver	-13 dBm	-11.59	PASS
8	7326.85	-41.5	pk	Ver	-13 dBm	-28.53	PASS
8	9767.15	-38.5	pk	Ver	-13 dBm	-25.45	PASS
8	26006.15	-33.5	pk	Ver	-13 dBm	-20.53	PASS

Test results – Combined test mode 9							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
9	9769	-41.4	pk	Ver	-13 dBm	-28.45	PASS

Test results – Combined test mode 10							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
10	1399	-27.3	pk	Hor	-13 dBm	-14.27	PASS
10	9769	-40.5	pk	Hor	-13 dBm	-27.49	PASS

Test results – Combined test mode 11							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
11	9769	-42.2	pk	Ver	-13 dBm	-29.22	PASS

Test results – Combined test mode 12							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
12	1387	-32.3	pk	Hor	-13 dBm	-19.32	PASS
12	9767	-40.3	pk	Ver	-13 dBm	-27.30	PASS

Test results – Combined test mode 13							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
13	9769	-42	pk	Ver	-13 dBm	-28.99	PASS

Test results – Combined test mode 14							
Mode	Frequency [MHz]	Level [dBm]	Detector	Polarization	Limit [dBm]	Margin [dB]	Result
14	9767	-41.7	pk	Ver	-13 dBm	-28.72	PASS

5. Analysis result

Verification tests were performed on the following 3 integrated, certified modules due to the modification of the microstrip reference traces. The tests were performed because the certification of the modules was restricted to use only with reference traces as defined by the manufacturer. The verification tests were intended to ensure the modules were still in compliance with spurious emissions requirements with the modified microstrip reference traces that are specific to this host device.

According to results, all emissions (coming from EUT) have margin more than 10 dB against used (47 CFR 24.238) limit (-13 dBm).

Based on results, also FCC part 15 subpart C, 15.247(d) requirement for radiated emissions is fulfilled. 15.209(a) General radiated emission requirement for restricted bands is most stringest limit (eg. 15.209 Peak limit for frequencies above 1 GHz is 74 dBuV/m = -24 dBm).

15.247(d):
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

Therefore minor changes in reference design microstrip traces for Quectel EG21-GL module (FCC-ID: XMR202212EG21GL), Nordic Semiconductor module nRF9160 (FCC ID: 2ANPO00NRF9160) and u-blox LILY-W131 (FCC ID: XPYLILYW1) does not have affect for compliance of these modules, when integrated to EUT.