GR551x FCC RSE Certification Note

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Preface

Purpose

This document describes the requirements and considerations for getting GR551x FCC (Federal Communications Commission) RSE (Radiated Spurious Emission) certification at a third-party lab, and aims to help users pass the certification smoothly.

Audience

This document is intended for:

- Technical support engineer
- Reseller
- Customer engineer
- Certification engineer

Release Notes

This document is the second release of *GR551x FCC RSE Certification Note*, corresponding to GR551x SoC series.

Revision History

Version	Date	Description
1.0	2021-10-28	Initial release
1.1	2023-04-20	Updated the "Certification Notes" section.

Contents

1 FCC RSE Certification Introduction

Devices with Bluetooth module, such as cell phones, notebooks, mice, keyboards and speakers, need to follow the FCC PART 15 rules when applying for FCC (Federal Communications Commission) certification.

This document describes the requirements and considerations for getting GR551x FCC RSE (Radiated Spurious Emission) certification, and aims to help users pass the certification smoothly.

The RSE frequency range described in the document is 1 GHz – 25 GHz. Unless otherwise stated, other certification items like the Hopping Sequence and Band Edges Measurement, can be certified in accordance with the regular process.

1.1 Certification Requirements

The RSE restrictive requirements excerpted from FCC PART 15 Subpart C 15.209 are as follows:

§ 15.209 Radiated emission limits; general requirements.

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009–0.490	2400/F(kHz)	300
0.490–1.705	24000/F(kHz)	30
1.705–30.0	30	30
30–88	100 **	3
88–216	150 **	3
216–960	200 **	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54–72 MHz, 76–88 MHz, 174–216 MHz or 470–806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§ 15.231 and 15.241.

Figure 1-1 Excerpt from FCC PART 15 Subpart C 15.209

Note:

- 40.0 dBμV/m: 30 MHz – 88 MHz
- 43.5 dBμV/m: 88 MHz – 216 MHz
- 46.0 dBμV/m: 216 MHz – 960 MHz
- 54.0 dBμV/m: 960 MHz +

1.2 Certification Notes

FCC RSE certification has both peak and average value requirements. RSE average value must be obtained by DCCF (Duty Cycle Compensation Factor) conversion. The operating instructions are briefly described below.

1. Set GRDirect Test Mode Tool as required to make the Bluetooth LE module output power based on preconfigured conditions.

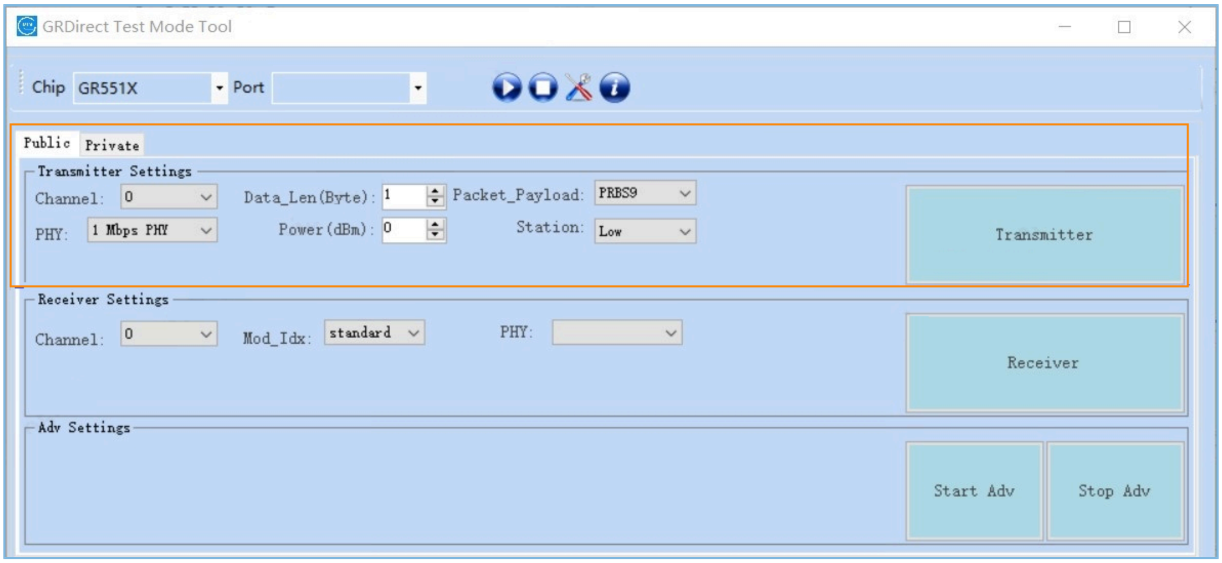
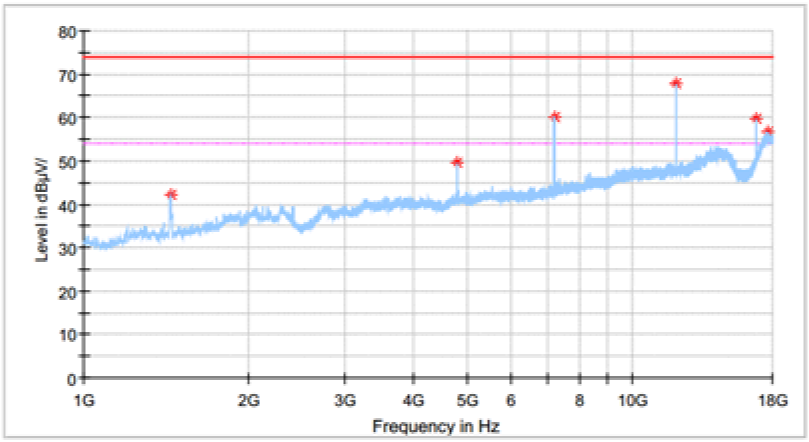


Figure 1-2 GRDirect Test Mode Tool configuration reference

- **Channel**: Select the channel to be tested (0 – 39).
- **Data_Len (Byte)**: Byte length setting; select **255** (maximum).
- **Packet_Payload**: Data type setting; select **PRBS9**.
- **PHY**: Options include 2 M/1 M/500 K/125 K; select **1 Mbps PHY**.
- **Power (dBm)**: Power setting (unit: dBm); selecting **0** means TX power is 0 dBm.
- **Station**: Select **Low**. Setting **PHY** to **1 Mbps PHY** corresponds to a duty cycle at 11%; setting **PHY** to **2 Mbps PHY** corresponds to a duty cycle at 8%.

2. Measure RSE peak value. For details, refer to "Chapter 2 FCC RSE Peak Value Measurement".

3. According to RSE peak value test result and DCCF conversion, the RSE average value (refer to "Chapter 3 FCC RSE Average Value Measurement") and calculation description should be written into the lab certification report, examples are as follows.



Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1440.300000	42.18	74.00	31.82	200.0	H	265.0	1.2
4802.900000	49.67	74.00	24.33	200.0	H	151.0	11.8
7206.700000	60.08	74.00	13.92	150.0	H	44.0	15.3
12010.900000	67.71	74.00	6.29	150.0	H	36.0	21.1
16813.400000	59.62	74.00	14.38	150.0	H	226.0	24.5
17646.400000	56.79	74.00	17.21	150.0	H	113.0	29.2

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1440.300000	23.34	54.00	30.66	200.0	H	265.0	1.2
4802.900000	30.83	54.00	23.17	200.0	H	151.0	11.8
7206.700000	41.24	54.00	12.76	150.0	H	44.0	15.3
12010.900000	48.87	54.00	5.13	150.0	H	36.0	21.1
16813.400000	40.78	54.00	13.22	150.0	H	226.0	24.5
17646.400000	37.95	54.00	16.05	150.0	H	113.0	29.2

Calculate Duty Cycle Value:
T_{on}=144.23µs=0.144ms
T_p= 1.26 ms

Duty Cycle Corrected Factor =20*log(T_{on}/T_P)=20*log(0.144/1.26)= -18.84 dB
Average value = Peak value+ Duty Cycle Corrected Factor

Figure 1-3 Test report sample

2 FCC RSE Peak Value Measurement

Directly measure the RSE peak value as described in Section 11.12.1, 6.4, 6.5 and 6.6 of *ANSI C63.10-2020 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices*.

Detailed instrument settings are provided in Section 11.12.2.4, as shown below.

11.12.2.4 Peak measurement procedure

Peak emission levels are measured by setting the instrument as follows:

a) RBW = as specified in Table 16

b) VBW ≥ [3 × RBW].

c) Detector = peak.

d) Sweep time = No faster than coupled (auto) time.

e) Trace mode = max-hold.

f) Allow sweeps to continue until the trace stabilizes. (Note that the required measurement time and number of sweep points may be lengthened for low duty cycle applications.)

Table 16—RBW as a function of frequency

Frequency	RBW
9 kHz to 150 kHz	200 Hz to 300 Hz
0.15 MHz to 30 MHz	9 kHz to 10 kHz
30 MHz to 1000 MHz	100 kHz to 120 kHz
>1000 MHz	1 MHz

If the peak detected amplitude can be shown to comply with the average limit, then it is not necessary to perform a separate average measurement.

Figure 2-1 Instrument setting reference

3 FCC RSE Average Value Measurement

FCC RSE average value measurement is available in two ways.

- Direct measurement: Suitable for most wireless devices.
- FCC RSE average value measurement: Recommended for GR551x-enabled wireless devices, suitable for DTS (Data Transmission Service) devices.

3.1 Direct Measurement

Perform direct measurement on instruments as described in chapter 11.12.2.5.3 of *ANSI C63.10-2020 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices*.

11.12.2.5.2.3 Reduced VBW averaging across ON and OFF times of the EUT transmission with max-hold

If continuous transmission of the EUT ($D \geq 98\%$) cannot be achieved and the duty cycle is not constant (duty cycle variations exceed ±2%), then the following procedure shall be used:

a) RBW = 1 MHz.

b) VBW $\geq 1 / T$, where T is defined in 11.6. When the device operates with a protocol-limited duty factor the average value may be measured using VBW=1Hz provided that the device is being exercised at or above the maximum operational duty cycle during the measurement.

c) Video bandwidth mode or display mode:

  1) The instrument shall be set so that video filtering is applied in the power domain. Typically, this requires setting the detector mode to Power averaging (rms) and setting the average-VBW type to power (rms).

  2) As an alternative, the instrument may be set to linear detector mode. Ensure that video filtering is applied in linear voltage domain (rather than in a log or dB domain). Some instruments require linear display mode to accomplish this. Others have a setting for average-VBW type, which can be set to “voltage” regardless of the display mode.

d) Detector = peak.

e) Sweep time = No faster than coupled (auto) time.

f) Trace mode = max-hold.

g) Allow max-hold to run for at least [$50 \times (1 / D)$] traces.

Figure 3-1 Excerpt from ANSI C63.10-2020

3.2 DCCF Conversion

The following sections describe the source, method, and example of DCCF conversion.

3.2.1 Basis and Source

The official FCC document KDB558074 "*Guidance for Compliance Measurements on Digital Transmission System, Frequency Hopping Spread Spectrum System, and Hybrid System Devices Operating under Section 15.247 of the FCC Rules*" clearly states that DTS device can use DCCF conversion to obtain RSE results.

c) Test procedures for DTS device EMC and radio parameters, such as power, OBW, radiated and band-edge measurements, are described in the following subclauses, including cross-references to Clause 11 of ANSI C63.10.

In addition the following clarifications relative to ANSI C63.10 are also applicable.

1) Concerning 11.13 (Band-edge measurements) of ANSI C63.10:

The requirement in 11.13.1 that the DTS bandwidth (or EBW) edge falls within 2 MHz of the band edge applies only for use of the marker-delta method; use of the integration method is not subject to the same limitation.

2) For measuring output power of a device transmitting a wide-band noise-like signal (*i.e.,* digitally-modulated) where the peak power amplitude is a statistical parameter, the preferred methodology is to use integrated average power measurements, as described in 11.9.2 and 11.13.3 of ANSI C63.10. The peak integrated band power methods of 11.9.1.2 and 11.13.3.2 of ANSI C63.10 are not applicable for FCC compliance testing purposes.

3) Additional measurement procedures and the allowance for duty cycle for DTS device out-of-band measurements in a restricted band for protocol-limited devices is described in FAQ #3 in Section 11 of this document.

Figure 3-2 Excerpt from KDB558074 (1)

Question 3: What measurement methods are available for making average measurements on devices with protocol-limited duty cycles such as ZigBee devices (DTS devices certified under Section 15.247)?

Answer 3: Several measurement methods are available for making average measurements for radiated and antenna-port conducted spurious emissions provided that: (i) the spurious emissions fall in restricted bands, (ii) emission are temporally related to the fundamental, (iii) the maximum duty cycle used in determining the reduction factor is hardwired such that under no condition can it be changed or modified by either the device or end user, (iv) a documented justification for use of Section 15.35(c) including the measurements used to determine the worst-case duty cycle must be included in the test report, and (v) the duty cycle correction factor is the worst case operational duty cycle based on the maximum transmission time in any 100 msec period. If the above criteria are satisfied, one of the following measurement techniques may be used:

a) Applying a duty cycle correction to the Peak measurement – First, a Peak measurement is made using the Peak detector function of a spectrum analyzer. The spectrum analyzer settings should be such that it meets the requirements of 11.12.2.4 in ANSI C63.10 for making a Peak measurement. Then the operational duty cycle of the EUT may be subtracted from the Peak reading to derive the RMS average value. If the EUT supports more than one operational duty cycle the worst-case value should be used, *i.e.*, the highest operational duty cycle.

Figure 3-3 Excerpt from KDB558074 (2)

In November 2019, Telecommunication Certification Body (TCB) Council held a workshop where it further explained the DCCF applicability among DTS devices. It is an update to Q#3 in KDB558074.

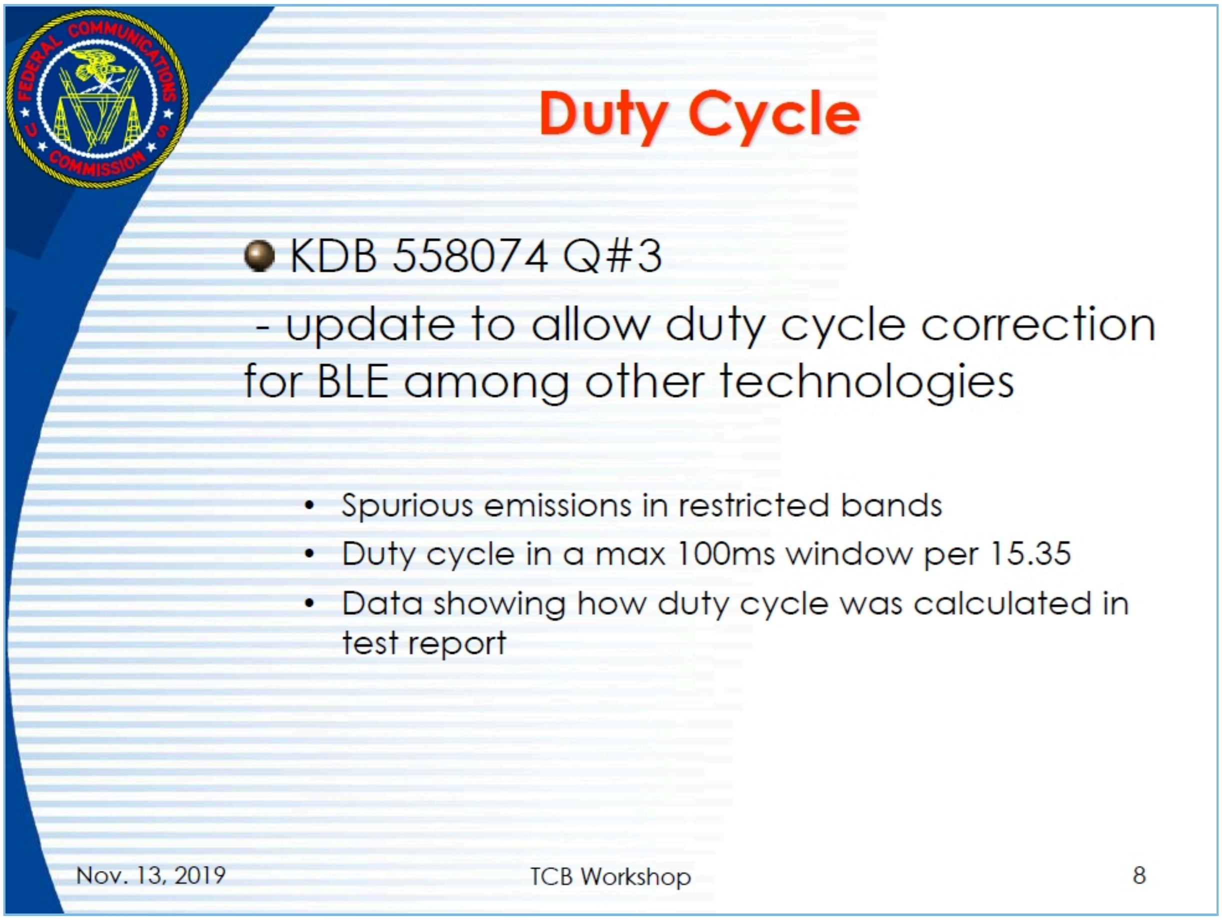


Figure 3-4 Excerpt from TCBC conference materials

3.2.2 Conversion Method

For DCCF calculation formula, refer to Section 7.5 of *ANSI C63.10-2020 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* or the calculation instructions in test report sample from "Section 1.2 Certification Notes".

7.5 Procedure for determining the average value of pulsed emissions

Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval.[62] The following procedure is an example of how the average value may be determined. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown in Equation (10):

$$\delta(\mathrm{dB}) = 20\log(\Delta) \tag{10}$$

where

δ is the duty cycle correction factor (dB)
Δ is the duty cycle (dimensionless)

This correction factor may then be subtracted from the peak pulse amplitude (in dB) to find the average emission. This correction may be applied to all emissions that demonstrate the same pulse timing characteristics as the fundamental emission (e.g., the fundamental and harmonic emissions). In cases where the pulse train is truly random or pseudo random, some regulatory agencies might accept a declaration by the manufacturer of the worst-case value of t_{ON}. The duty cycle correction is determined as follows:

[61] See 47 CFR 15.231 and 15.240(b).
[62] See 47 CFR 15.35(c).

Figure 3-5 Excerpt from ANSI C63.10-2020 (1)

For duty cycle (#) description and instrument settings, please refer to Section 11.6 of ANSI C63.10-2020 American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices, as shown in the figure below.

Measurements of duty cycle and transmission duration shall be performed using one of the following techniques:

a) A diode detector and an oscilloscope that together have a sufficiently short response time to permit accurate measurements of the ON and OFF times of the transmitted signal.

b) The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the ON and OFF times of the transmitted signal:

  1) Set the center frequency of the instrument to the center frequency of the transmission.
  2) Set RBW ≥ OBW if possible; otherwise, set RBW to the largest available value.
  3) Set VBW ≥ RBW. Set detector = peak or average.
  4) The zero-span measurement method shall not be used unless both RBW and VBW are > $50/T$ and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring the duty cycle shall not be used if $T \leq 16.7$ µs.)

Figure 3-6 Excerpt from ANSI C63.10-2020 (2)

3.2.3 Measurement Example

Suppose that in a certain FCC certification test, Ton = 144.23 µs = 0.144 ms, Tp = 1.26 ms, then Duty Cycle Value = 11.43% is calculated according to the formula: Duty Cycle Value = Ton/Tp. The test diagram for transmitted duty cycle value is shown below.

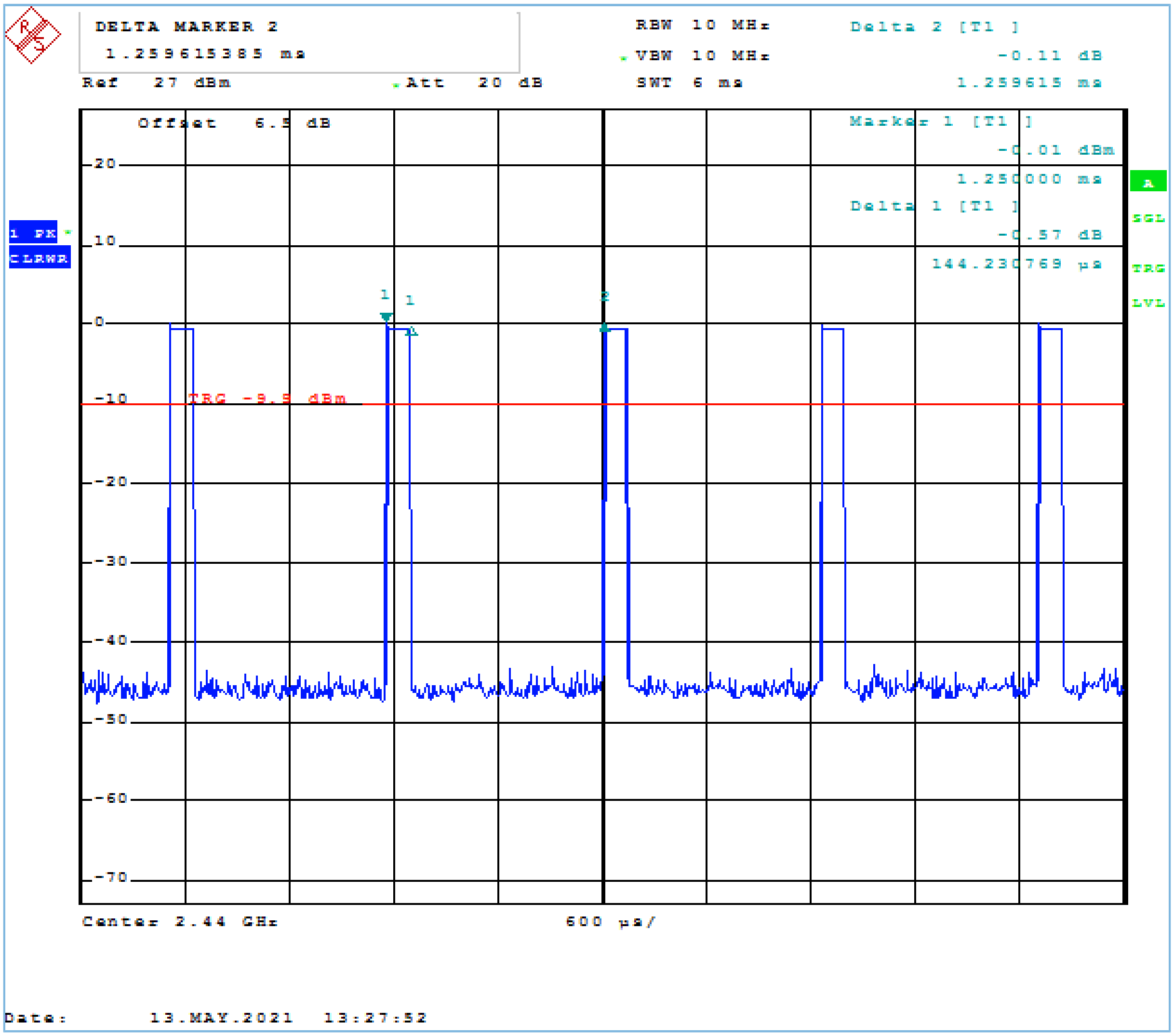


Figure 3-7 Test diagram for transmitted duty cycle value

Then the FCC RSE average value is computed as follows.

1. Measure the RSE MaxPeak values directly.

Table 3-1 Peak value reference

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1440.300000	42.18	74.00	31.82	200.0	H	265.0	1.2
4802.900000	49.67	74.00	24.33	200.0	H	151.0	11.8
7206.700000	60.08	74.00	13.92	150.0	H	44.0	15.3
12010.900000	67.71	74.00	6.29	150.0	H	36.0	21.1

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
16813.400000	59.62	74.00	14.38	150.0	H	226.0	24.5
17646.400000	56.79	74.00	17.21	150.0	H	113.0	29.2

2. Calculate DCCF: DCCF =20 * log(Ton/Tp) = 20 * log (0.144/1.26) = -18.84 dB
3. Calculate average value: Average value = Peak value + DCCF
4. The average values obtained through conversion are shown below, obtained by subtracting 18.84 dB from the MaxPeak values presented in the table above.

Table 3-2 Average value reference

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1440.300000	23.34	54.00	30.66	200.0	H	265.0	1.2
4802.900000	30.83	54.00	23.17	200.0	H	151.0	11.8
7206.700000	41.24	54.00	12.76	150.0	H	44.0	15.3
12010.900000	48.87	54.00	5.13	150.0	H	36.0	21.1
16813.400000	40.78	54.00	13.22	150.0	H	226.0	24.5
17646.400000	37.95	54.00	16.05	150.0	H	113.0	29.2

4 Third-Party Lab Candidates

The EMC (Electromagnetic compatibility) labs and TCBs available for RSE DCCF measurement are listed below.

4.1 EMC Labs

Table 4-1 EMC lab list

Name	Location	Description
Micrometer	Shenzhen	Tests RSE Peak/Average separately and accepts Peak-DCCF conversion
MRT	Suzhou	
GRGTEST	Chengdu, Shenzhen, Wuxi , Shanghai	
BACL	Chengdu, Shenzhen, Dongguan, Kunshan	

4.2 TCB

Table 4-2 TCB list

Short Name	Full Name	Description
ACB	American Certification Body, Inc.	Clearly support: Certified by RSE Peak-DCCF conversion
Aplus	APlus Labtech Co., Ltd.	
Timco	Timco Engineering Inc.	
BACL (Chengdu)	Bay Area Compliance Laboratories (Chengdu)	

5 Glossary

Table 5-1 Glossary

Abbreviation	Description
ANSI	American National Standards Institute
DCCF	Duty Cycle Compensation Factor
DTM	Direct Test Mode
DTS	Data Transmission Service
EMC	Electromagnetic Compatibility
FCC	Federal Communications Commission
RSE	Radiated Spurious Emission
TCB	Telecommunication Certification Body
TCBC	Telecommunication Certification Body Council