Application Note : Wireless Product Certification Guide

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Brief:

In this document, FCC certification is taken as an example to provide guide on how to prepare and apply for wireless product certification.

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1 Necessity of Product Certification

Before wireless electronic product is ready for sale and use in a country or an area, it must pass product certification of local regulation committee to prove it does conform to local electromagnetic compatibility requirement.

Common product certifications include:

- FCC: Federal Communications Commission in the USA
- CE: Conformity with European demand
- SRRC (SRMC): State Radio Regulation Committee (State Radio Monitoring Center)

Test items for product certification in various countries are largely identical but with some minor differences in threshold. In this document, FCC certification is taken as an example to provide guide on how to prepare and apply for wireless product certification.

2 FCC Brief Introduction

FCC supervises import and usage of Radio Frequency (RF) Devices in the USA, such as computers, fax machines, electronic devices, radio receiving and transmitting devices, wireless remote control toys, phones and other products which may harm personal body safety. In order to export to the USA, these products must pass test and approval by a government-authorized lab based on FCC technical standard. Importers and customs broker must declare that each RF device conforms to FCC standard, i.e. each device must have FCC license and FCC flag.

Common FCC flag is shown as below:

FCC, mandatory certification of the USA, mainly test EMI part, and has no requirements to EMS part such as its own anti-interference and anti-radiation performances.

FCC includes the following three certification methods:

1) FCC VERIFICATION (FCC-VOC):

   Applied to products such as AV products, corded telephones, common household appliances, commercial PCs, and etc.

   Manufacturer only needs to prove its product conforms to FCC regulations via self-verification or entrusted lab verification, without the need to submit FCC certification.

2) Declaration of conformity (FCC-DOC):

   Applied to products such as home computers and peripherals, civil broadcast receivers, other receivers and TV interface devices as specified in FCC Part15, Industrial, scientific and medical devices for mass consumers as specified in FCC Part 18.

   Manufacturer does not need to submit FCC certification, but must verify its product conforms to FCC regulations via one of FCC registered and licensed labs which are mainly in Taiwan and abroad.

3) FCC CERTIFICATION (FCC-ID):

   Applied to as low-voltage transmitter products, such as cordless telephones, automatic door remote controllers, wireless remote control toys, security alarm systems, initiative RF transmitter devices, and etc.

   Certification method: First submit product samples to FCC licensed test houses and get test report, then send product technical materials (detailed photos, block diagrams, user manuals, and etc.) and test report to FCC TCB test house. FCC TCB test house will check the submitted materials, issue the certificate and authorize a FCC ID number. New FCC-ID applicant must apply for a number from FCC first. After test and certification, product with FCC ID number can be sold to the US market.

3 Product Certification Materials

For product certification, applicant needs to provide the following materials:

1. Detailed communication materials of manufacturer.
2. Schematic and brief introduction of working principle of the product to be certified.
3. Detailed descriptions of the product to be certified, including working frequency, modulation method, occupied bandwidth, Tx power, whether frequency tuning is needed, and etc.

4 Certification Test Items

Certification is to test whether a wireless product conforms to electromagnetic compatibility items, i.e. whether it will interfere other devices when in Tx and Rx state. Common test items include:

1. In-band Tx power: To avoid interfering other devices, in-band power cannot be too large.
2. 2^{nd} and 3^{th} harmonic power: To avoid interfering other devices, out-of-band harmonics cannot be too large.
3. Occupied bandwidth: To avoid influencing other devices, occupied bandwidth should conform to regulation and cannot be too large.
4. Clutter in Rx mode: Ensure clutter radiated in Rx mode is not too strong.
5. Carrier accuracy: Ensure frequency offset is not too large.

Generally each certification institute will test the items above, but the threshold may differ with local regulations.

In North America, 802.15.4 devices are required to conform to Part 15 of the FCC Rules. Canada has their own standard, but the test requirements for Canada and the USA are virtually identical, so we only focus on FCC in this document.

Within FCC Part 15, the relevant rule parts applicable to 802.15.4 devices are 15.35, 15.205, 15.207, 15.209, 15.247 and possibly 15.249 which may be used if power output is low enough. Product evolution, rated output power, test cost, relaxed limits and measurement uncertainty are the main drivers which would determine which rule part is best applied. Having a baseline measurement based on the 15.247 requirements may be advantageous if the output power is high, so our tests focus on the 15.247 rules.

Under 15.247, the device is classed as a Digital Transmission System (DTS device). The following requirements from 15.247 are applicable to DTS devices and in this case 802.15.4 application.

Table 1 Requirements from 15.247

FCC Rule Part	Test Case Description	Measurement Type	Applicable Limit
15.247 (a) (2)	6dB Bandwidth	Conducted	Min 500 KHz
15.247 (b) (3)	Peak Power Output	Conducted	30 dBm peak conducted power, max antenna gain 6dbi
15.247 (e)	Power Spectral Density	Conducted	8 dbm/3 kHz
15.247 (d)	Conducted Spurious Emissions	Conducted	20 db below fundamental in 100 kHz band
15.247 and 15.249 /15.205/15.209	Radiated Spurious Emissions	Radiated	Restricted band requirements as per general radiated emission limits

5 How to Prepare DUT

1. Labs support two methods to test RF performance: wired test, wireless test.

   For the former, it's needed disconnect on-board antenna, and solder semi-steel cable connector. For the latter, the wireless product to be tested must keep intact. So it's needed to check this point with the lab before submitting DUT samples.
2. It's needed to solder out Power, GND and SWS pin for DUT board.
3. DUT samples should be burned with corresponding test firmware, which need to contain the following functions:
   a) Can control product to switch TX and RX mode.
   b) Can control product to switch frequency point.
   c) Can control product to change power.
   d) Can control product to switch debug mode, e.g. single carrier, modulated wave.
4. It's needed to provide necessary PC control tools, e.g. WTCDB.

6 How to Ensure Certification Pass

In all test items, harmonic and clutter test are the mostly likely to exceed limits and thus fail. Product modification takes time and effort, and may not solve the problem. Compared with this, it's better to focus on initial product design to ensure product performance. A good PC design can simplify product certification a lot.

For PCB design requirements and suggestions, please refer to Telink hardware design guides:

1) AN_16101001_Telink Hardware Design Guide
2) AN_TLSR8263ET24-15092200_TLSR8263ET24 Single-layer PCB Design Guideline

7 RF Tuning Sample

7.1 FCC RF tuning

In all of Telink RF chips, a Pi-type filter can be used to tune for FCC compliance.

The figure below shows a PI-type filter connected between the RF pin (ANT) of the TLSR8646 chip and antenna. The filter is used to tune FCC/CE items.

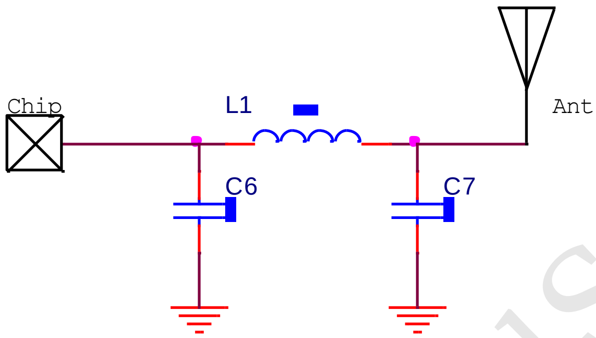


Figure 1 Matching network

7.1.1 Filter Simulation

The first step in RF tuning is obtaining the initial values, various EDA tools can be used to simulate the filter and obtain the initial value.

For example, the working band is 2.45GHz, while the 2^{nd} and 3^{rd} harmonic are 4.9GHz and 7.35GHz respectively. The in-band attenuation of the 2.45GHz band should be decreased, and the stop-band rejection should be increased, i.e. the power of 2^{nd} and 3^{rd} harmonic should be decreased.

If L1 = 2.2nH, C6=C7=3.3pF, the simulation result is shown as below.

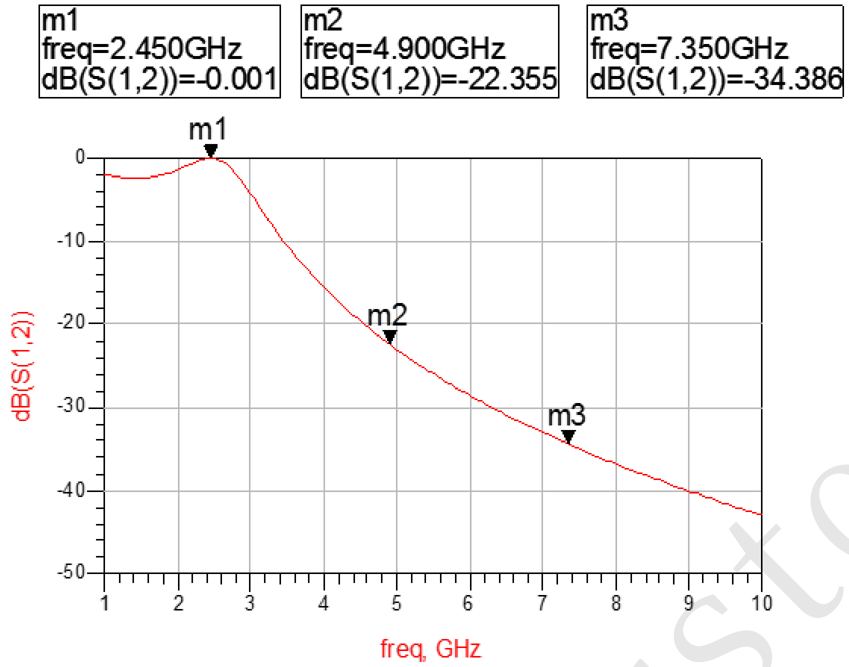


Figure 2 Filter simulation result sample

The figure above shows the initial value as the tuning reference. The tendency can be available by observing other results.

7.2 Sample Tuning and Test Result

In this example, we use a TLSR8646 module to show how the RF is tuned to comply with the FCC requirements.

To test the DUT, first connect the DUT with Telink EVK via Swire, power and GND lines, then connect the EVK with PC via an USB cable, finally connect the DUT with a spectrum analyzer via RF connector, as shown below.

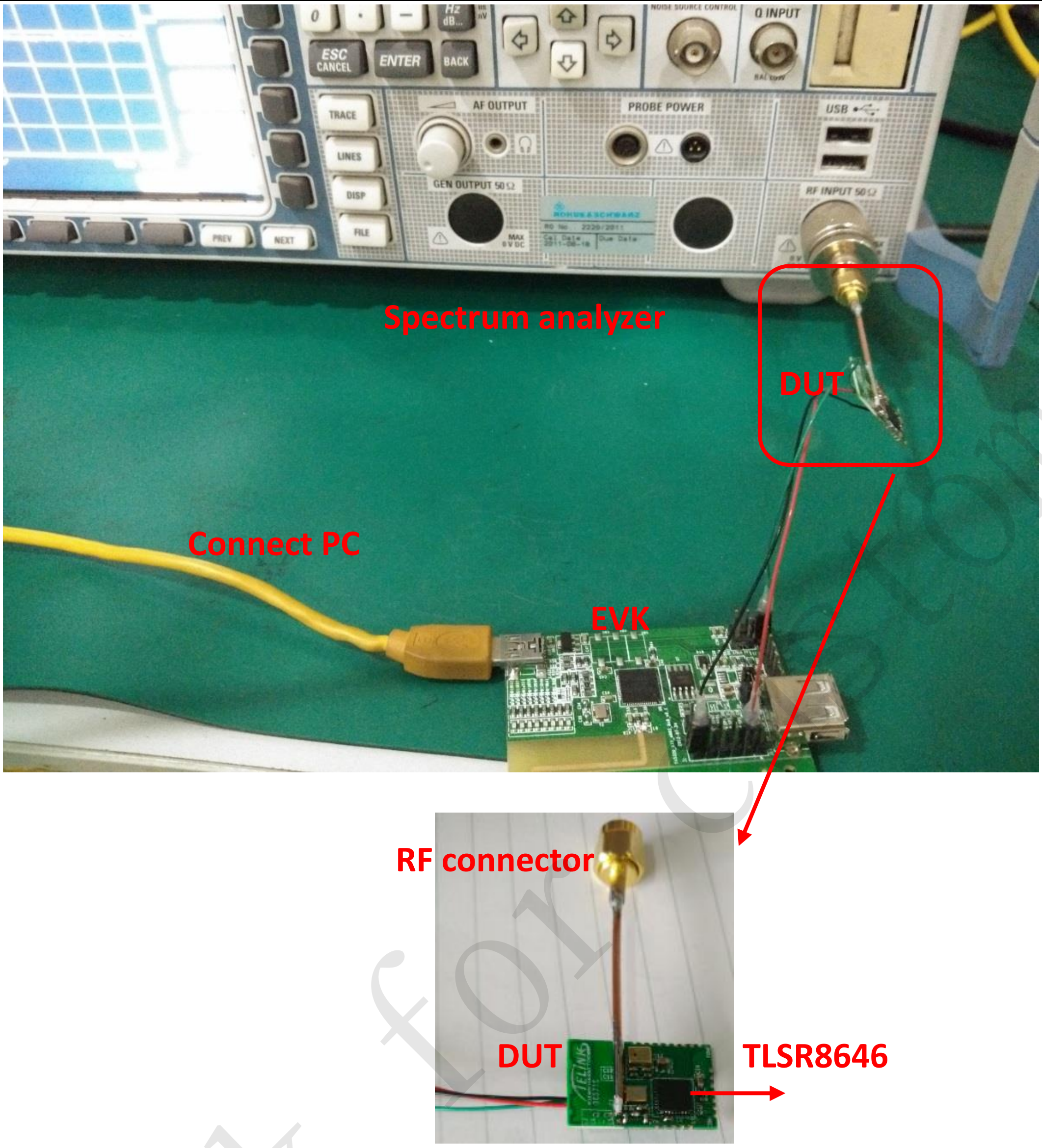
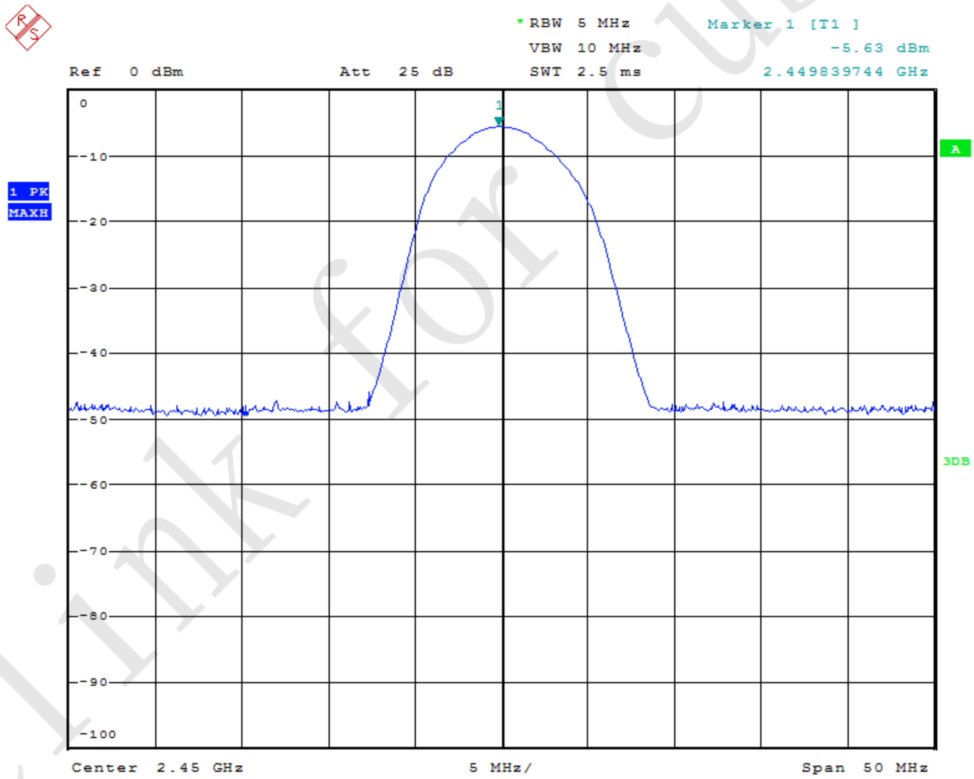


Figure 3 Hardware connection chart

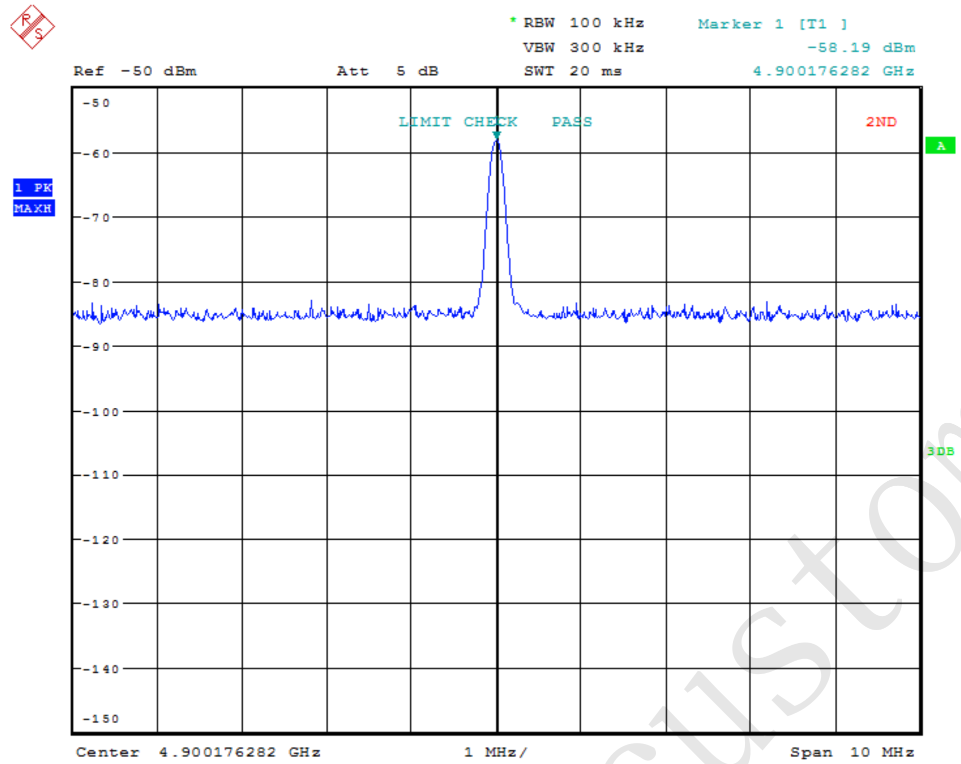
Table 2 Test result overview

Case	L1	C6, C7	Tx Power	2nd harmonic Power	3rd harmonic power
1	2.2nH	3.3pF	-5.63dBm Figure 4 (a)	-58.19dBm Figure 4 (b)	-64.78dBm Figure 4 (c)
2	2.2nH	1pF	4.79dBm Figure 5 (a)	-42.80dBm Figure 5 (b)	-73.72dBm Figure 5 (c)
3	1nH	1.5pF	1.29dBm Figure 6 (a)	-49.43dBm Figure 6 (b)	-66.46dBm Figure 6 (c)
4	3.3nH	1.5pF	5.64dBm Figure 7 (a)	-51.94dBm Figure 7 (b)	-68.64dBm Figure 7 (c)
5	2.2nH	1.5pF	4.32dBm Figure 8 (a)	-51.85dBm Figure 8 (b)	-67.83dBm Figure 8 (c)

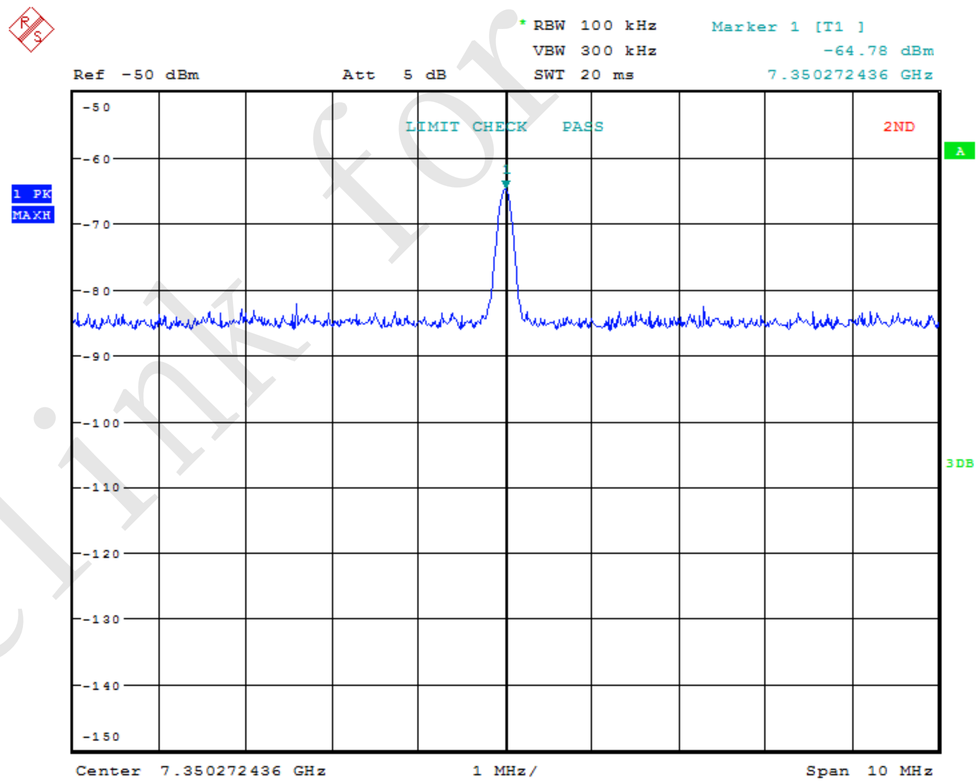
7.2.1 Test case 1: L1 = 2.2nH, C6=C7=3.3pF



(a) Tx power



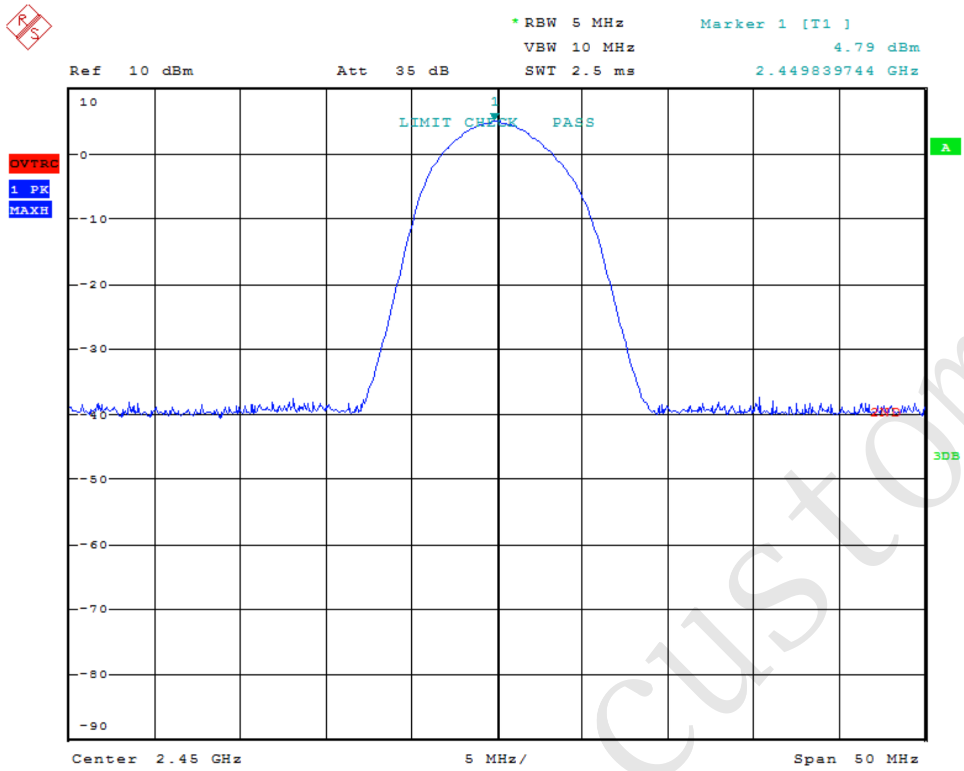
(b) 2nd harmonic power



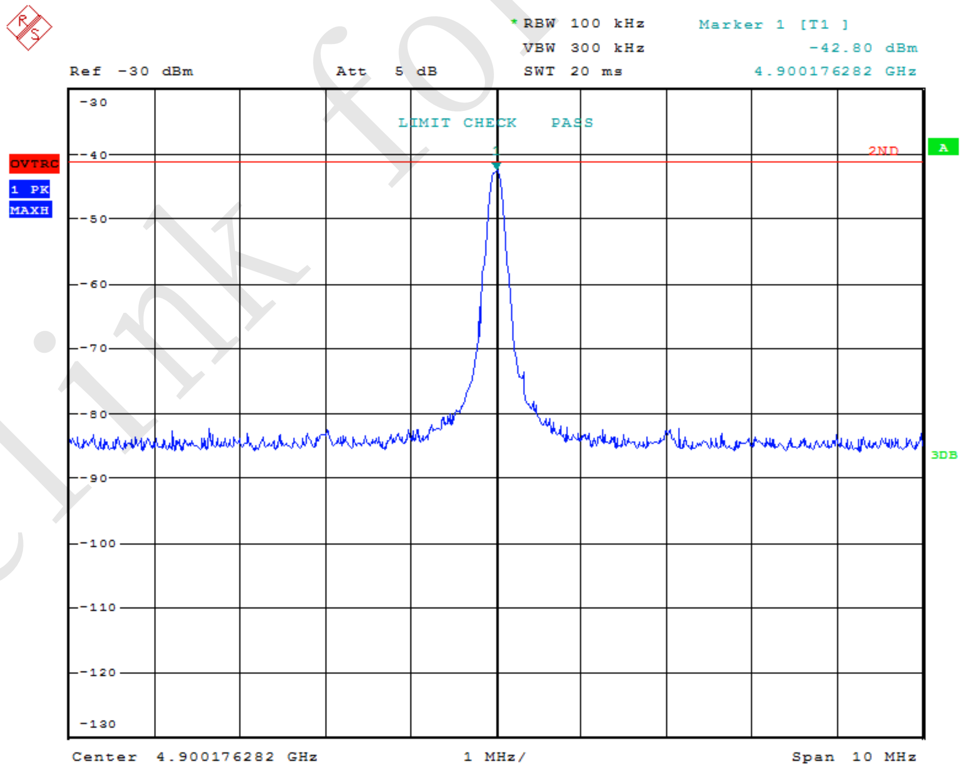
(c) 3rd harmonic power

Figure 4 Test result of case 1 (L1 = 2.2nH, C6=C7=3.3pF)

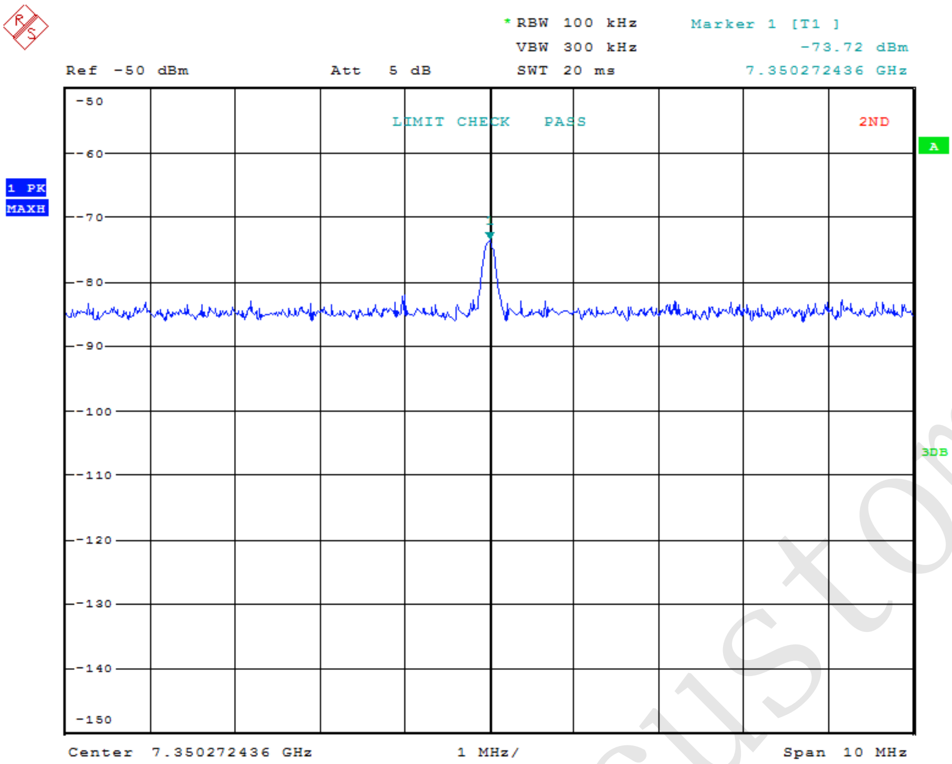
7.2.2 Test case 2: L1 = 2.2nH, C6=C7=1pF



(a) Tx power



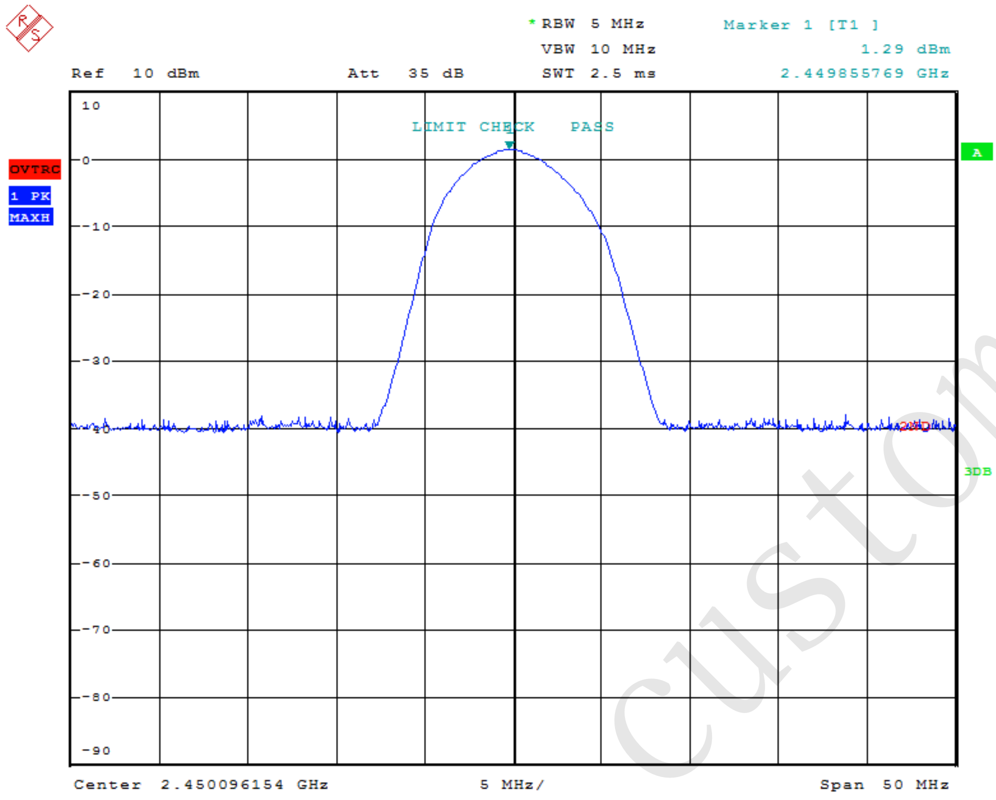
(b) 2nd harmonic power



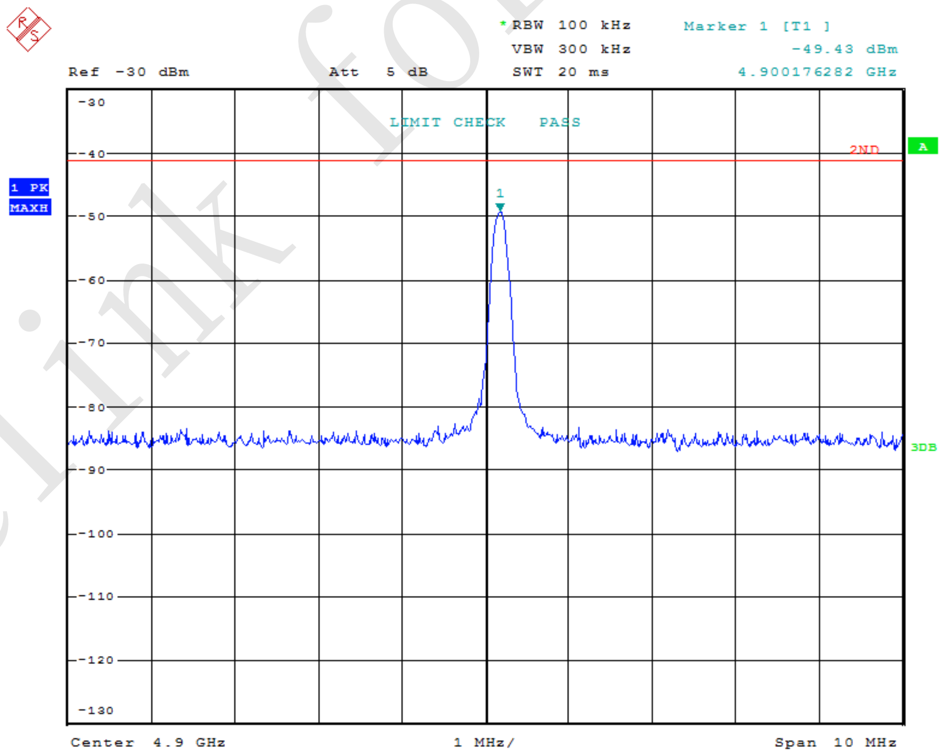
(c) 3rd harmonic power

Figure 5 Test result of case 2 (L1 = 2.2nH, C6=C7=1pF)

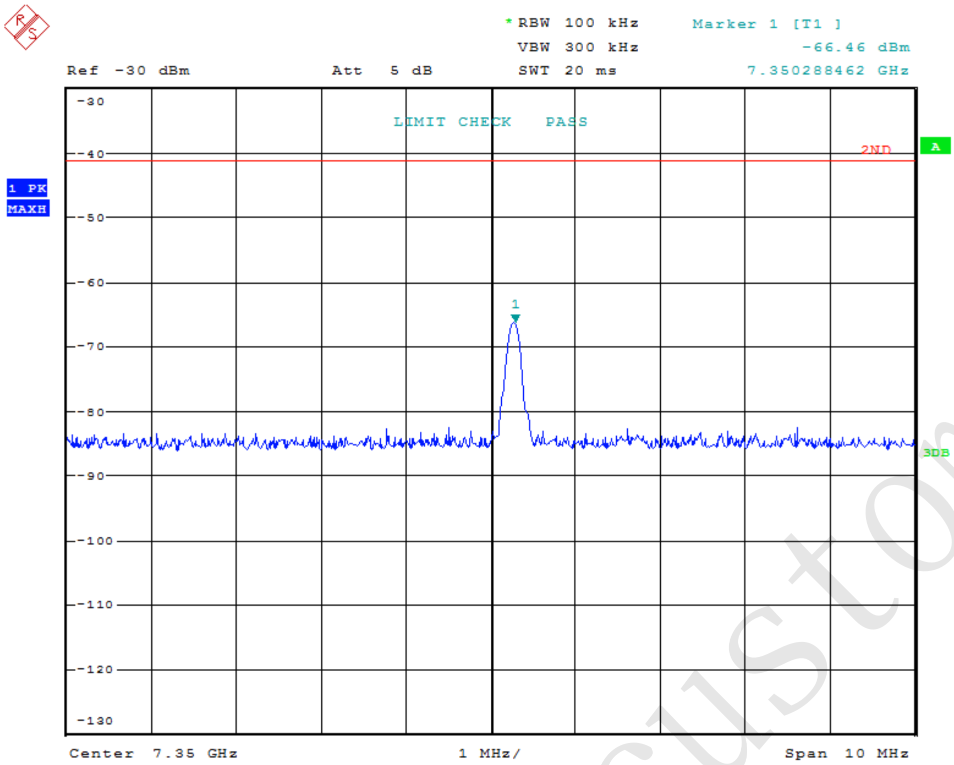
7.2.3 Test case 3: L1 = 1nH, C6=C7=1.5pF



(a) Tx power



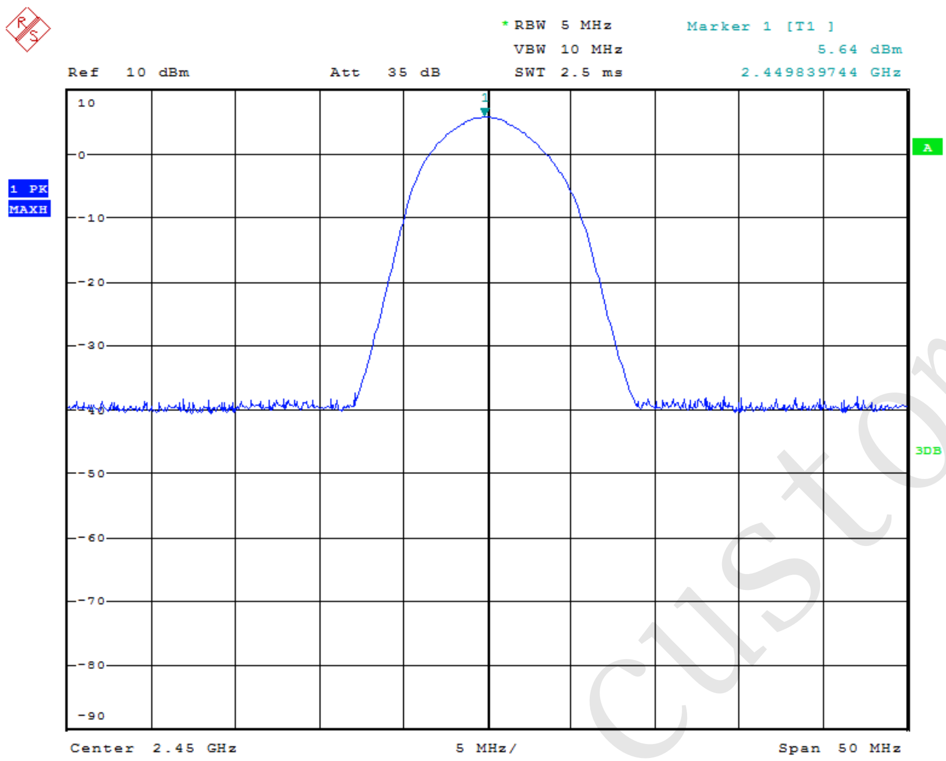
(b) 2nd harmonic power



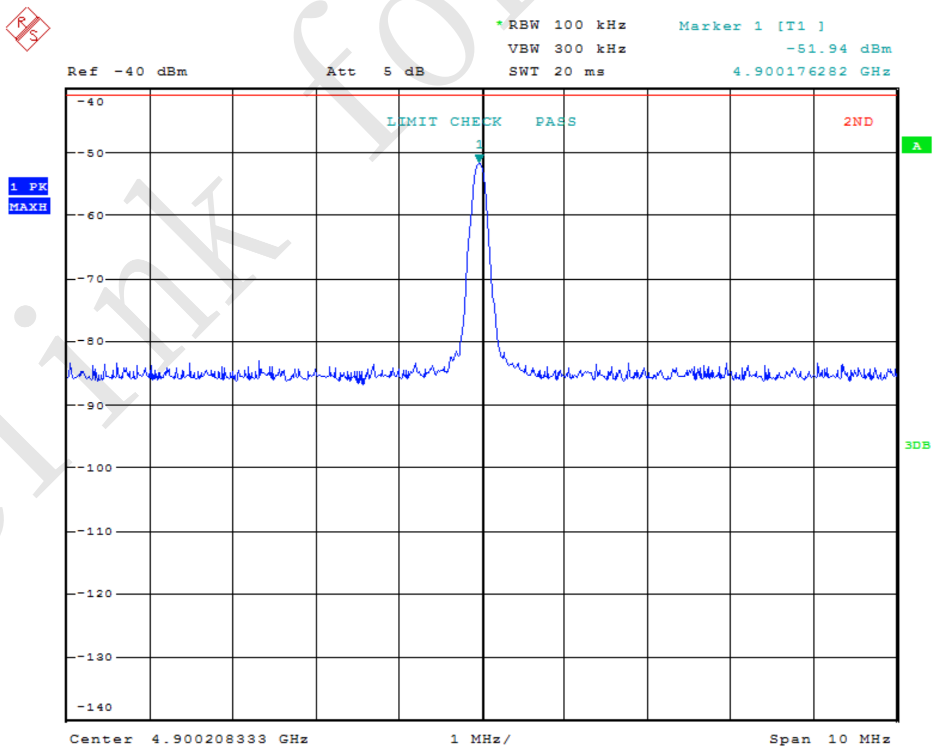
(c) 3rd harmonic power

Figure 6 Test result of case 3 (L1 = 1nH, C6=C7=1.5pF)

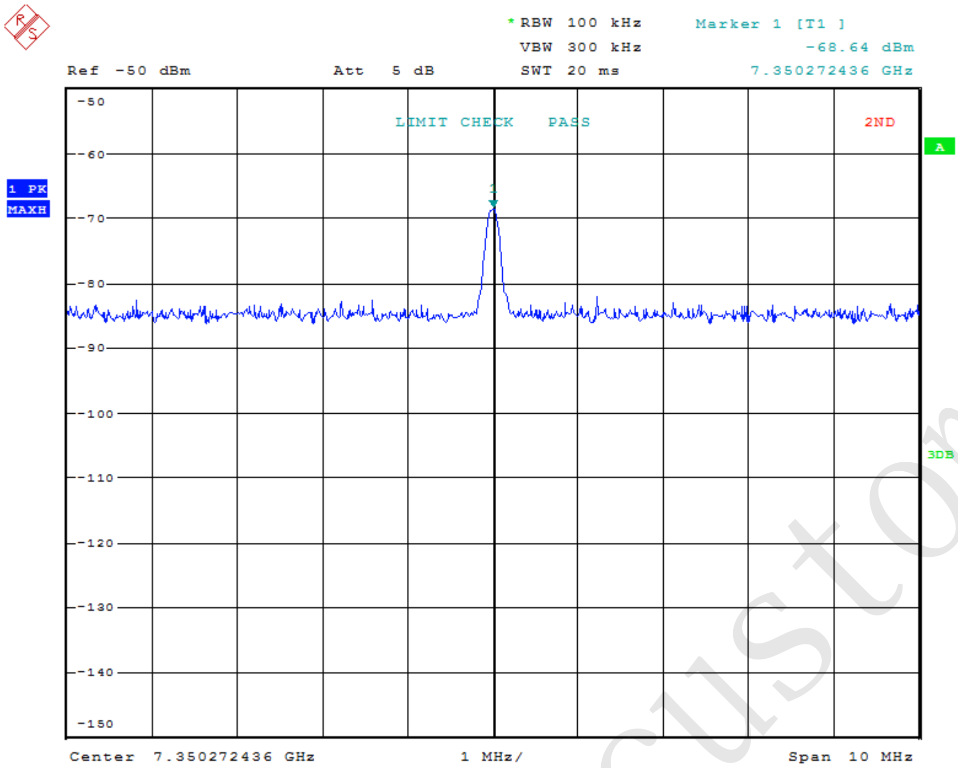
7.2.4 Test case 4: L1 = 3.3nH, C6=C7=1.5pF



(a) Tx power



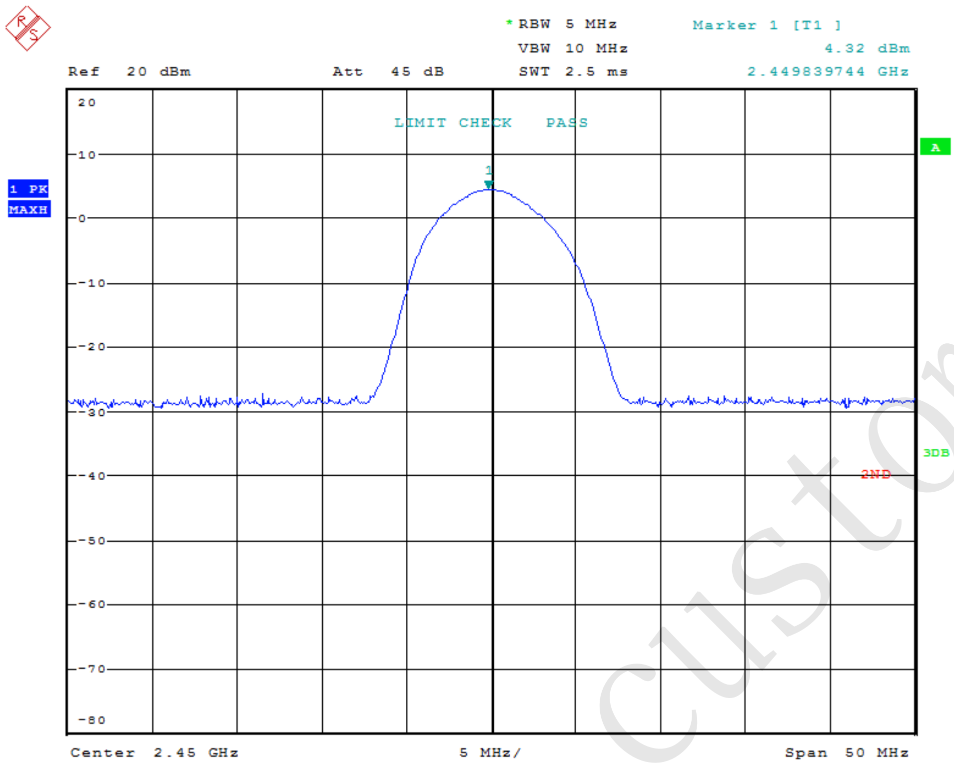
(b) 2^{nd} harmonic power



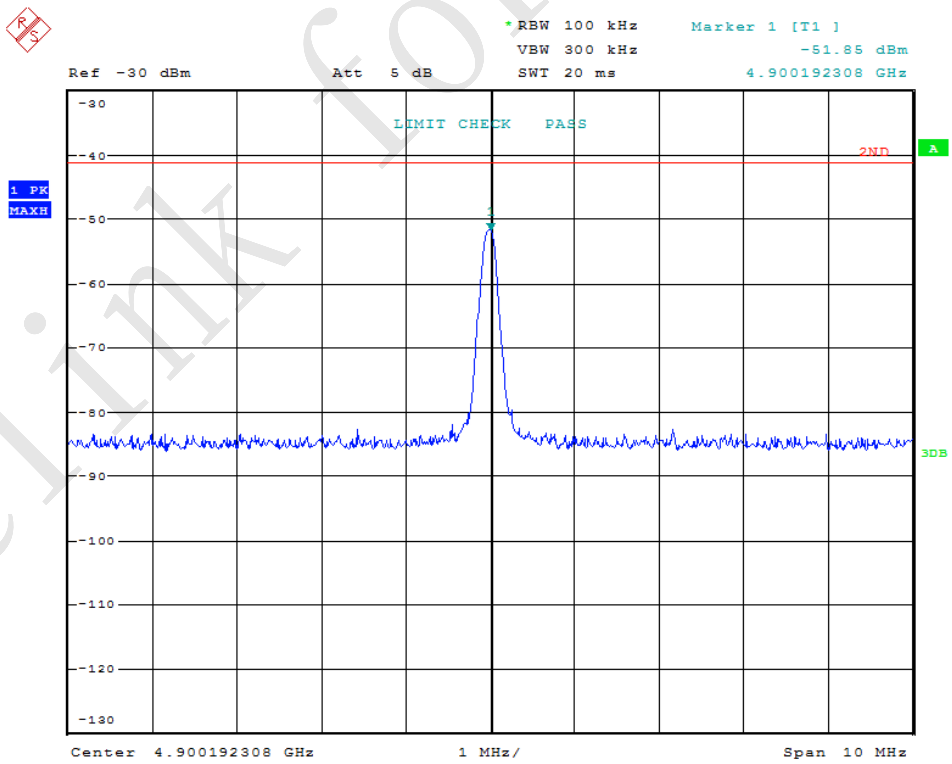
(c) 3rd harmonic power

Figure 7 Test result of case 4 (L1 = 3.3nH, C6=C7=1.5pF)

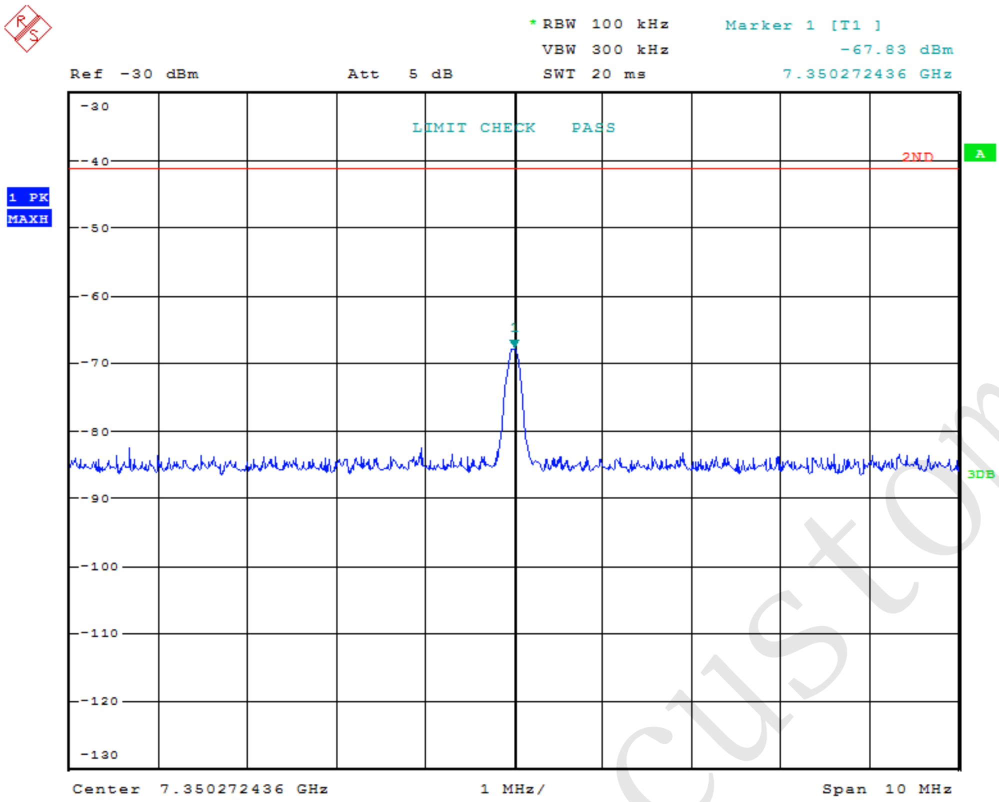
7.2.5 Test case 5: L1 = 2.2nH, C6=C7=1.5pF



(a) Tx power



(b) 2nd harmonic power



(c) 3rd harmonic power

Figure 8 Test result of case 5 (L1 = 2.2nH, C6=C7=1.5pF)

7.2.6 Conclusion

As test result above shows, it's recommended to select 3.3nH/2.2nH and 1.5pF as the L1, C6 and C7 values of the matching network for this DUT. The values can ensure in-band loss low enough to pass all FCC items.

The filter component values recommended for FCC certification may vary depending on the DUT used. Customers can follow similar steps to tune their own boards correspondingly.