Telink Semiconductor

Tuning TLSR8355 Matching Network

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V1.0

Overview

- The document describes how to tune matching network of the TLSR8355 radio. And it also can be used to tune the matching network of the TLSR827x series radios.

- A spectrum analyzer, a vector network analyzer are used to monitor output power and tune matching in receive mode.

How it works

- The right Figure is a block diagram of RF part, including RF front-end on the chip and RF matching Network on the PCB as well as Antenna.

  - Impedance seen from ANT (Port2) towards chip should be 50ohm.

  - Rx is disable when TX mode(port1 to LNA is high Z), TX is disable when Rx mode as well .

  - The impedance of TX from port1 to ANT side is about 300ohm.

  - When the impedance from ANT (Port2) towards the chip is 50ohm, thus every point on the matching network will be a conjugate match, so the left and right sides of the dotted line will be conjugated impedance,. We get PA output impedance (on the right side of the dotted line) is 300+jX, so on the left side of the dotted line will be 300-jX.
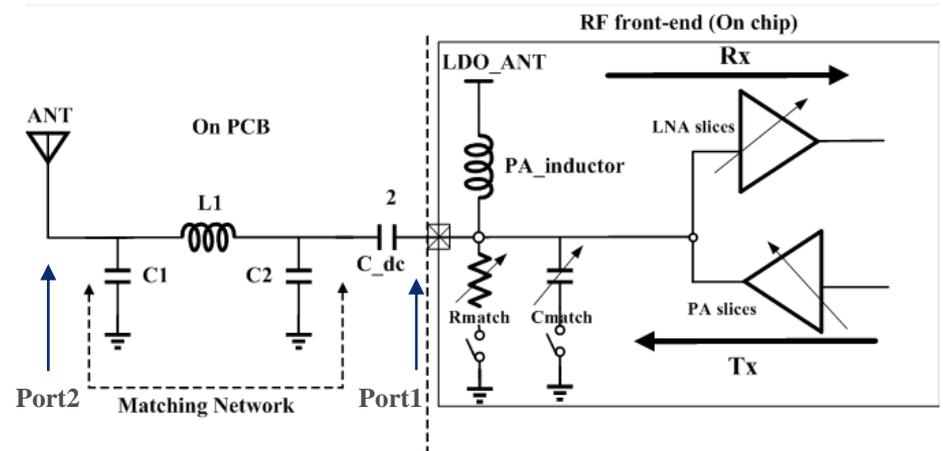
How it works - 2

- C_dc is used as DC blocker.
  - For the capacitors, using NP0 is good choice.

- The matching network has 3 main tasks:
  - Transform the output impedance of the radio to 50 ohm antenna.
  - Suppress harmonics to meet the requirement of the regulations level.

- Harmonic suppression is good because the matching network forms a low pass filter.
  - A low pass filter insists of C1, L1 and C2.
  - For the capacitors, using NP0 is good choice.

- The LO leakage in RX mode is very low on TLSR8355.

- All components have parasitic effects. For example, an inductor will have series R and shunt C. a capacitor will have a series L and shunt C. Different circuit board will also have different parasitic effects. So please use the same type inductor and capacitor are recommended to use in tuning stage and in MP stage. And if it is possible, please follow the reference design.

How to Tune the board - 1

- To tune the performance of the matching network, EMI tool, spectrum analyzer and vector network analyzer are needed.

  - EMI tool can be downloaded from telink wiki. User can use EMI tool to change channel, change power, change mode and so on. For TLSR8355, it is easy to communicate with telink burning evk through SWS bus.

  - The frequency range of the spectrum analyzer must be higher than the highest harmonic of interest. A spectrum analyzer is recommended if the frequency range can be up to 12.5Ghz.

- The first step is tuning in RX mode.

  - Set TLSR8355 into RX mode using EMI tool and vector network analyzer.

  - Modify the parameters of L and C to make sure that S11 is lower than -10dB.

- The second step is testing on spectrum analyzer in TX mode.

  - Set TLSR8355 into TX mode using EMI tool and spectrum analyzer.

  - Record the power of fundamental frequency, 2nd harmonic till 5th harmonic.

- If harmonic is not lower than limit, redo the two steps and modify the parameters of L and C.

How to Tune the board - 2

- Both spectrum analyzer and vector network analyzer should be connected to the 50ohm output of the matching network. PCB antenna is usually used in real case, then the trace must be cut. A semi-rigid cable is usually used to solder to the board. The outer of the semi-rigid cable must be firmly soldered to the ground plane of the board. The inner of the semi-rigid cable is soldered to the 50ohm point. And please make sure that solder the outer to the ground plane close to the 50ohm point.

- Setting spectrum analyzer and vector network analyzer to cover the measurement items.

  - Set center frequency, frequency range based on the frequency to be measured on the vector network analyzer and spectrum analyzer.

  - The RBW should be 1MHz on spectrum analyzer.

- Always start with recommended component values on the reference layout.

How to Tune the board - 3

- Follow the flow chart in the figure. If the performance is not very good, please adjust the components. Even only one component is adjusted, it will affect the performance fro all parameters. It is an iterative process. Never change more than one component at a time. otherwise, it is impossible to observe the effect of each component.

- If the value of L or C is too high, the power will be affected.

```
        Set DUT into RX mode
                 │
                 ▼
   Measure on vector network analyzer ◄──────────────┐
                 │                                     │
                 ▼                                     │
          S11<-10dB ──NO──► Adjust L1/C1/L2 ──────────┤
                 │                                     │
                YES                                    │
                 ▼                                     │
        Set DUT into TX mode                           │
                 │                                     │
                 ▼                                     │
     Measure on Spectrum analayzer                     │
                 │                                     │
                 ▼                                     │
     Harmonic meets the limit ──NO──► Adjust L1/C1/L2 ─┘
                 │
                YES
                 ▼
             Finished
```
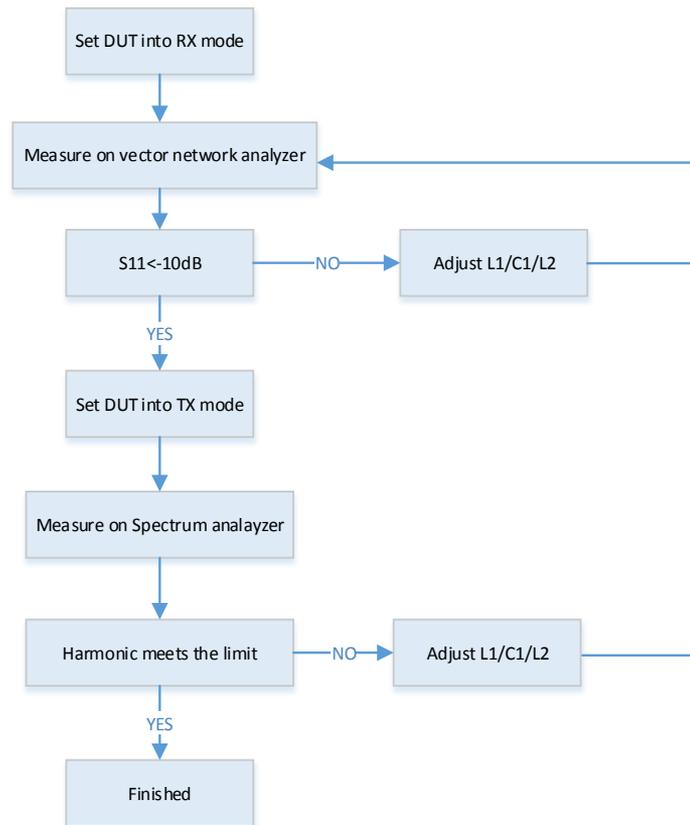
How to Tune the board - 4

- The component value showed on the recommended layout on telink wiki can be used if the reference layout on telink wiki is used. But if the layout is changed, some of the components must be changed because of the parasitic effects.

  - Thickness of board

  - Component size

  - Vendor

- The LO leakage frequency in RX mode can be known with the equation:

  - LO leakage = RF-1

  - All frequencies are in MHz. RF = Receiving frequency.

- Check output power on low/middle/high channel.

How to Tune the board – 5

- Please record the changed component value in the same row. It makes it easy to observe the effects of the change. Please note that change only one component at one time and record all the measurement when every component is changed.

NO.	C1	L1	C2	S11	TX Low CH	TX Middle CH	TX High CH	2nd Harm	3th Harm	4th Harm	5th Harm	RX LO

- Some mark is marked in one end, such as inductor. Please make sure the component is kept to the same direction.

- Since chip inductor is more cheaper, it is often used in mass production. But if using wire wound inductor, better RF performance can be had, but at a higher cost and a higher Q-value.

- The inductor used in telink reference design is chip inductor.

- Please always use the same vendor as in the production. Even the value is the same, different component from different vendor is a little different. Hence, the effect of the component on the vector network analyzer will be different.