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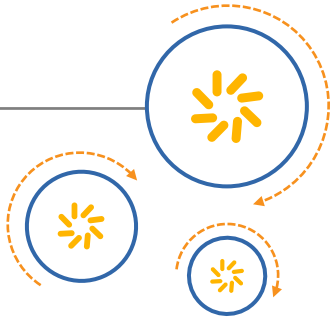

IPQ4019/IPQ4029 AP.DK04 USB3.0 and 2.4 GHz Wi-Fi Coexistence

Application Note

80-Y9700-11 Rev. A

November 17, 2015

For additional information or to submit technical questions go to https://createpoint.qti.qualcomm.com/

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Revision history

Revision	Date	Description
A	November 2015	Initial release

1 Introduction

1.1 Purpose

USB3.0 and 2.4 GHz Wi-Fi coexistence is an industry-wide problem because USB3.0 operates in the 2.4 GHz band, which is the same frequency band as that of 802.11/b/g/n Wi-Fi. USB3.0 emits tremendous amount of energy to the entire 2.4−2.5 GHz band when the USB3.0 port is in operation. Due to this huge amount of USB3.0 energy in the Wi-Fi band, the noise floor observed by the radio chip is increased by more than 20 dB.

The noise elevation in the spectrum directly hurts the link budget/receive sensitivity of 2.4 GHz Wi-Fi radio, which in turn affects the uplink throughput across the range. This document describes the best PCB layout practice for IPQ4019/IPQ4029 chipset to mitigate USB3.0 signal interference with 2.4 GHz Wi-Fi band.

1.2 Issue description

The USB3.0 coexistence with 2.4 GHz Wi-Fi issue is not observed in cabled setup and is visible only during noise floor over the air (OTA). This is due to the coupling of radiation from the USB device to the Wi-Fi antennas since the USB ports are placed close to the 2.4 GHz Wi-Fi antennas.

Level of emission or degradation of 2.4 GHz Wi-Fi signal varies from one USB device to another. For example, Kingston USB3.0 disk with plastic enclosure degrades 2.4 GHz NF max. 22 dB and SanDisk USB3.0 disk with metal shielding degrades 2.4 GHz NF max. 4~5 dB.

2 Mitigation Techniques

The design recommendations to minimize the impact of USB3.0 signal interference with the 2.4 GHz Wi-Fi radio signal are:

- Connect USB GND directly with system GND, then can supply low-impedance return path for USB3.0 signal. See Figure 1.

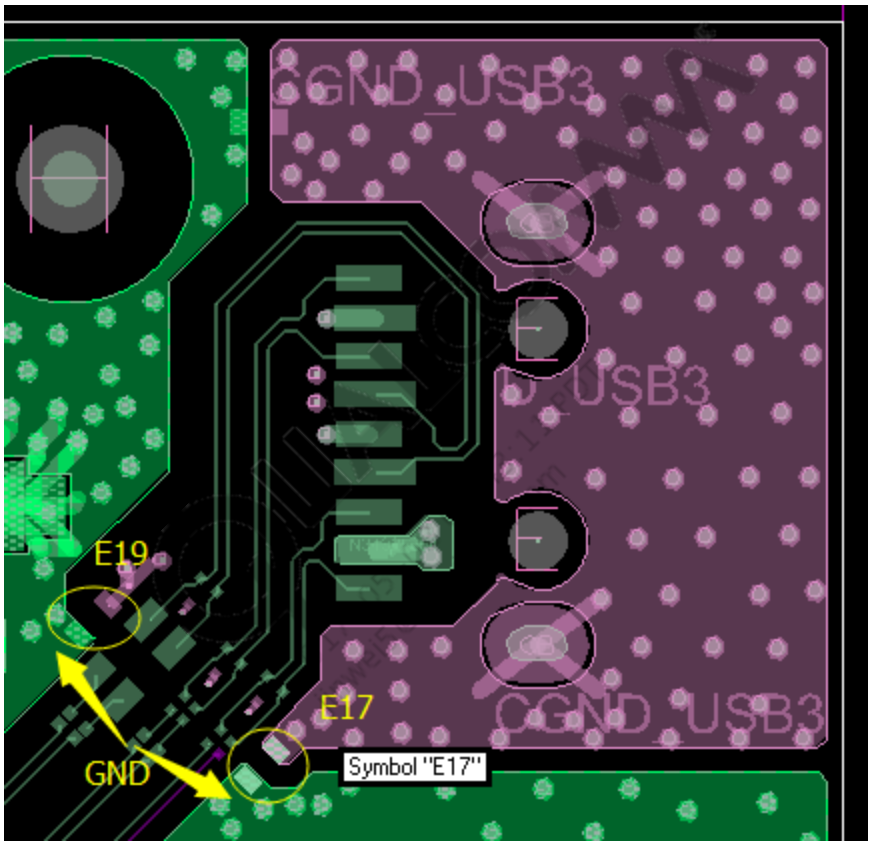

Figure 1 Connecting USB shield/chassis pins directly to board's GND

- UFL cable routing to the antenna elements plays a big part in noise pickup and consequently in 2.4 GHz Wi-Fi signal degradation. UFL cables should be routed away from the board. See Figure 2 and Figure 3.

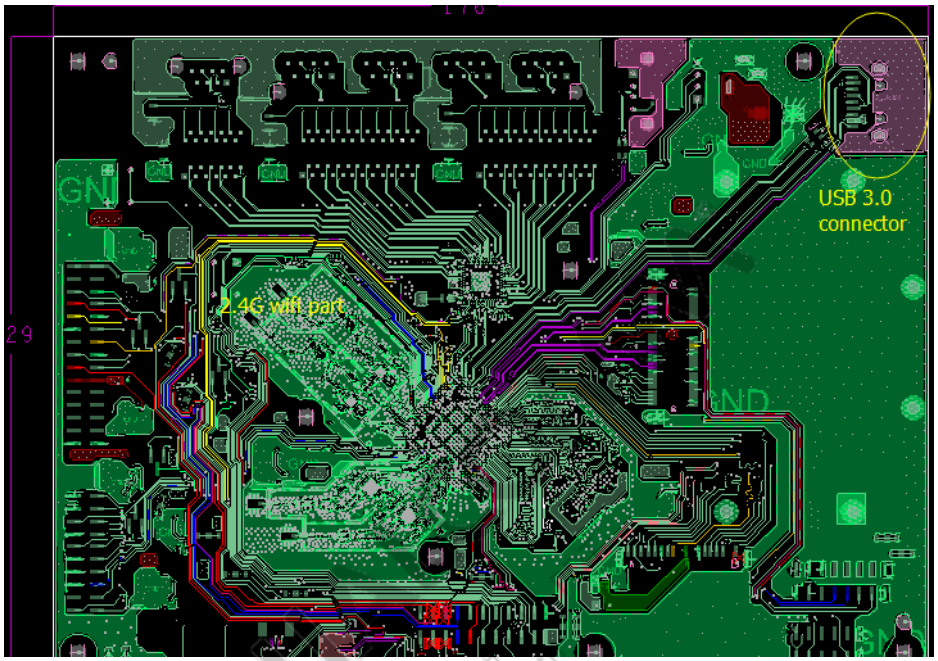

Figure 2 Placing USB connectors away from RF part

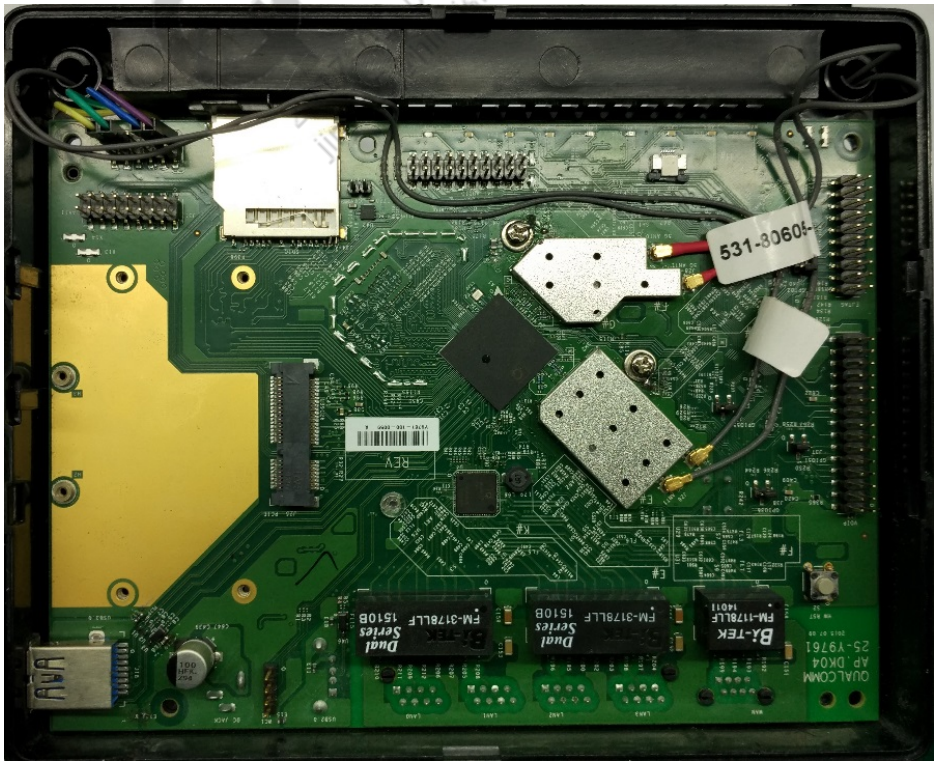

Figure 3 Placing USB connectors away from antenna cable

- Choose SMD fully shielded USB3.0 connector on board. See Figure 4.

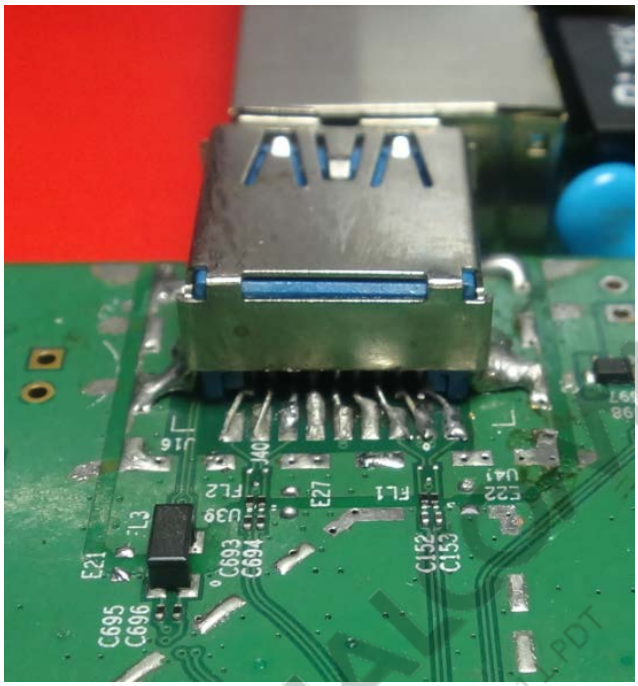

Figure 4 Fully shielded USB3.0 connector

Figure 5 Partially shielded USB3.0 connector

- Shielding the USB3.0 device.

  Properly shielding the USB 3.0 device can help reduce the amount of noise emitted in the 2.4 GHz band. To illustrate this point, different material U disk including plastic and metal shielding to plug in AP.DK04 to run noise floor test; max degrade to 22 dB with plastic enclosure and just 4~5 dB with metal shielding.

- Add common mode chokes on the USB Tx and Rx lines as shown in Figure 6.

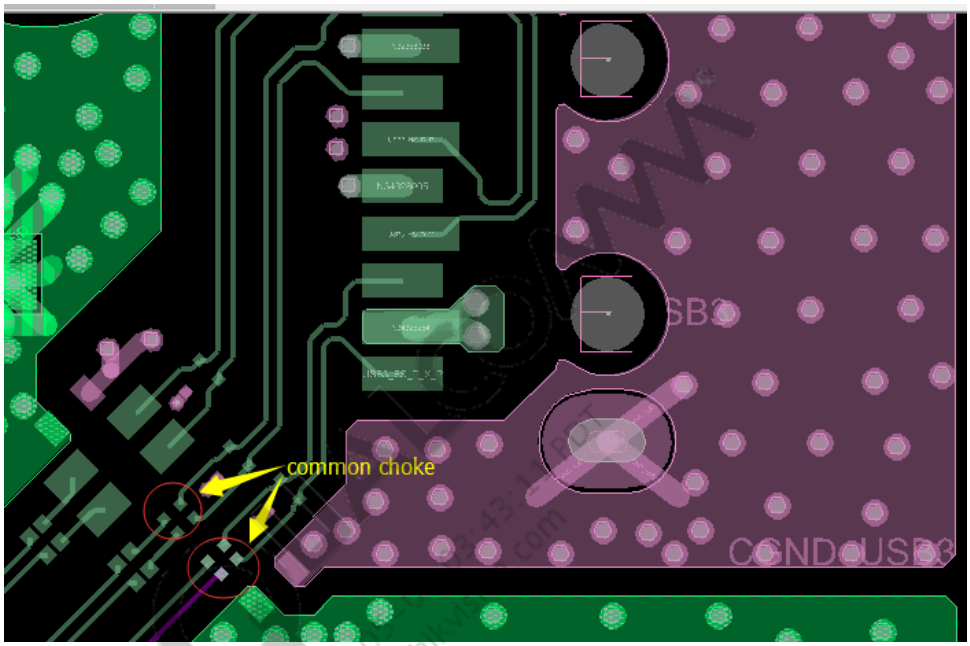

Figure 6 Common mode chokes on USB Tx and Rx

3 Performance Improvement

AP.DK04 based board designed with all the improvements outlined in section 2 will be able to achieve better noise immunity, test with noise floor and find that can achieve 20 dB improvement. With all the improvements outlined in section 2, the impact will be greatly mitigated.

The noise generated due to the USB3.0 data spectrum can have an impact on radio receivers if antenna is placed close to a USB3.0 device and/or USB3.0 connector. The noise is a broadband noise that cannot be filtered out, but if follow this application note and noise floor will not be degraded much.

Below is noise floor test result.

- Clean NF level for reference (without USB3.0 disk)

```
The number of channels scanned for acs report is:  11
Channel | BSS  | minrssi | maxrssi | NF | Ch load | spect load | sec_chan
-------------------------------------------------------------------------
2412(  1)    0         0         0   -100       9            0          0
2417(  2)    0         0         0    -99       6            0          0
2422(  3)    0         0         0    -99       3            0          0
2427(  4)    0         0         0    -99       1            0          0
2432(  5)    0         0         0    -99       1            0          0
2437(  6)    0         0         0    -99       1            0          0
2442(  7)    0         0         0    -99       1            0          0
2447(  8)    0         0         0   -100       2            0          0
2452(  9)    0         0         0    -99       2            0          0
2457( 10)    0         0         0    -99       1            0          0
2462( 11)    0         0         0    -99       2            0          0
root@OpenWrt:/# wifitool ath1 acsreport
The number of channels scanned for acs report is:  24
Channel | BSS  | minrssi | maxrssi | NF | Ch load | spect load | sec_chan
-------------------------------------------------------------------------
5180( 36)    0         0         0   -104       0            0          0
5200( 40)    0         0         0   -105       0            0          0
5220( 44)    0         0         0   -105       0            0          0
5240( 48)    0         0         0   -105       0            0          0
5260( 52)    0         0         0   -106       0            0          0
5280( 56)    0         0         0   -106       0            0          0
5300( 60)    0         0         0   -106       0            0          0
5320( 64)    0         0         0   -106       0            0          0
5500(100)    0         0         0   -105       1            0          0
5520(104)    0         0         0   -105       0            0          0
5540(108)    0         0         0   -105       0            0          0
5560(112)    0         0         0   -105       0            0          0
5580(116)    0         0         0   -105       0            0          0
5600(120)    0         0         0   -105       0            0          0
5620(124)    0         0         0   -105       0            0          0
5640(128)    0         0         0   -105       0            0          0
5660(132)    0         0         0   -105       1            0          0
5680(136)    0         0         0   -105       0            0          0
5700(140)    0         0         0   -105       0            0          0
5745(149)    0         0         0   -105       0            0          0
5765(153)    0         0         0   -105       0            0          0
5785(157)    0         0         0   -105       0            0          0
5805(161)    0         0         0   -105       0            0          0
5825(165)    0         0         0   -105       0            0          0
```

- Change E17/E19=0 Ohm, remove E13, change E3/E4 from bead to 0 Ohm, use fully enclosure USB3.0 connector, 2.4 GHz NF degrade max. 4~5 dB.

```
root@OpenWrt:/# wifitool ath0 acsreport
The number of channels scanned for acs report is:  11
Channel | BSS  | minrssi | maxrssi | NF | Ch load | spect load | sec_chan
-------------------------------------------------------------------------
2412( 1)    0        0         0    -96       1           0          0
2417( 2)    0        0         0    -96       1           0          0
2422( 3)    0        0         0    -96       1           0          0
2427( 4)    0        0         0    -96       1           0          0
2432( 5)    0        0         0    -97       0           0          0
2437( 6)    0        0         0    -96       1           0          0
2442( 7)    0        0         0    -95       1           0          0
2447( 8)    0        0         0    -95       1           0          0
2452( 9)    0        0         0    -95       0           0          0
2457( 10)    0        0         0    -96       0           0          0
2462( 11)    0        0         0    -96       0           0          0
root@OpenWrt:/#
root@OpenWrt:/#
root@OpenWrt:/# wifitool ath1 acsreport
The number of channels scanned for acs report is:  24
Channel | BSS  | minrssi | maxrssi | NF | Ch load | spect load | sec_chan
-------------------------------------------------------------------------
5180( 36)    0        0         0   -104       1           0          0
5200( 40)    0        0         0   -105       0           0          0
5220( 44)    0        0         0   -105       0           0          0
5240( 48)    0        0         0   -105       0           0          0
5260( 52)    0        0         0   -105       0           0          0
5280( 56)    0        0         0   -106       0           0          0
5300( 60)    0        0         0   -106       0           0          0
5320( 64)    0        0         0   -106       0           0          0
5500(100)    0        0         0   -105       1           0          0
5520(104)    0        0         0   -105       0           0          0
5540(108)    0        0         0   -105       0           0          0
5560(112)    0        0         0   -105       0           0          0
5580(116)    0        0         0   -105       0           0          0
5600(120)    0        0         0   -105       0           0          0
5620(124)    0        0         0   -105       0           0          0
5640(128)    0        0         0   -104       0           0          0
5660(132)    0        0         0   -105       1           0          0
5680(136)    0        0         0   -105       0           0          0
5700(140)    0        0         0   -105       0           0          0
5745(149)    0        0         0   -105       0           0          0
5765(153)    0        0         0   -105       0           0          0
5785(157)    0        0         0   -104       0           0          0
5805(161)    0        0         0   -105       0           0          0
5825(165)    0        0         0   -105       0           0          0
root@OpenWrt:/#
```