AN4356
Application note

Antenna desense on handheld equipment

Introduction

Mobile applications such as phones or tablets feature high-speed links to provide video with high definition or high data rate storage. The antennas used by the equipment to communicate with the base station become more and more wide band or smart, so are more sensitive to electro-magnetic interferences.

We will show in this note how the receiver sensitivity can be affected by this noise and how it is possible to maintain a correct reception.

1 EMI and noise issues

Inside handheld applications the different subsets talk together or with the exterior world using various links (*Figure 1*).

Figure 1. Handheld equipment schematic
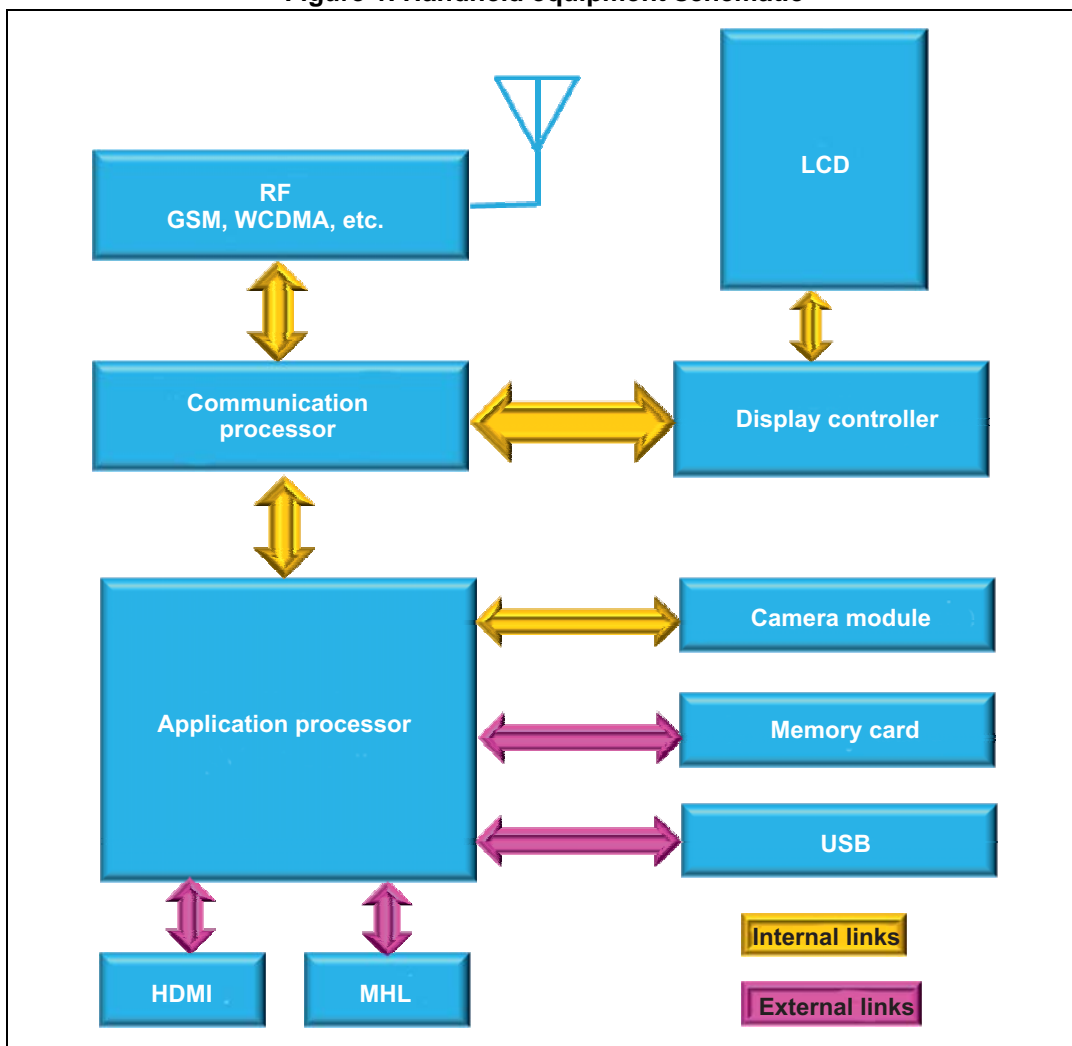
Standards used in mobile applications present high data rates. Here are some examples of speeds per data lane:

- MIPI D-PHY up to 1 Gbps
- HDMI 1.4 up to 3.35 Gbps
- MHL 1.0 up to 2.25 Gbps
- Display Port 1.2 up to 2.7 Gbps
- USB 2.0 up to 480 Mbps
- SD 4.0 up to 3.6 Gbps

Moreover, the data rates of new standards are even higher:

- MIPI M-PHY up to 5.4 Gbps
- USB 3.0 up to 5 Gbps
- MHL up to 6 Gbps

The frequencies used, and especially their harmonics, are in the same range as the mobile Rx frequencies, between 700 MHz and 2.7 GHz, and in the same range as the various RF frequencies used by FM, TV, GPS etc.

These high data rates involve clock and data signals with very fast transition times in the range of a hundred picoseconds and lower, inducing fast transitions and highly radiated fields. The effect of this is amplified by more complex sub-circuits using connectors and flex that can act like antennas, spreading unwanted frequencies and noise (*Figure 2*).

Figure 2. Radiated and conducted emissions

Internal links   **External links**
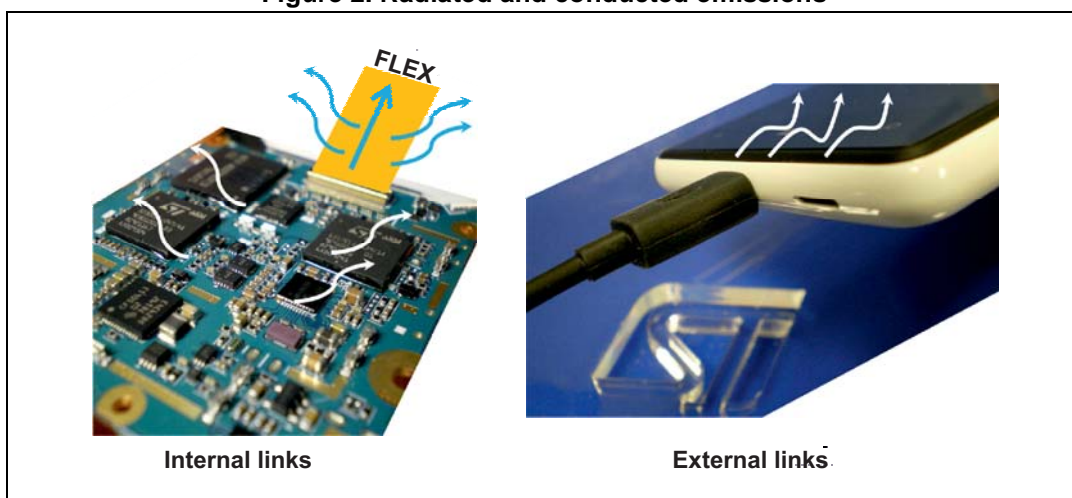
An important source of noise is the skew that can appear on a flexible PCB between interior and exterior traces on a differential link. (*Figure 3*).
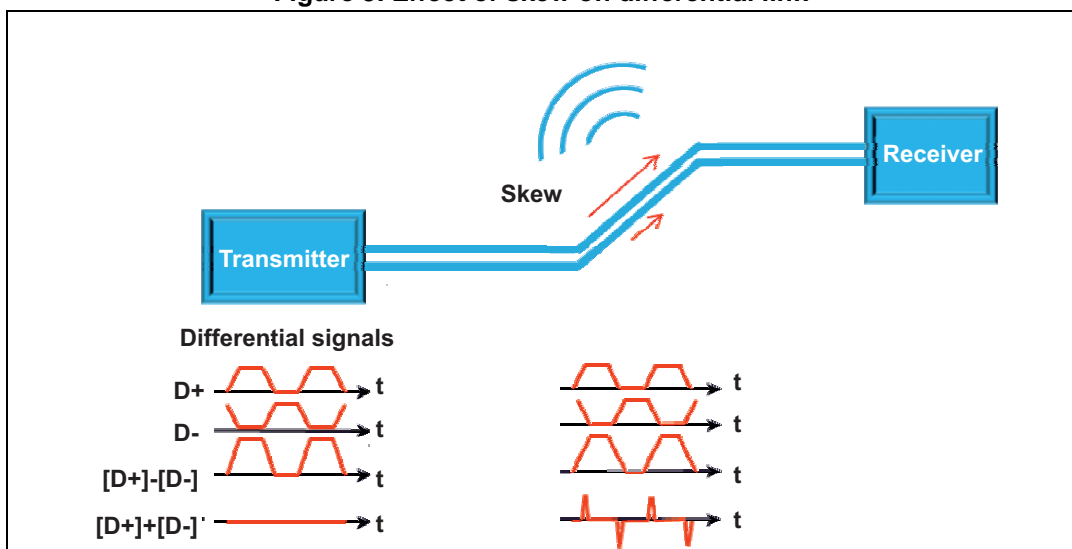
Figure 3. Effect of skew on differential link

Figure 4 shows the differential signals D+ and D- on a USB2.0 link where 150 ps of skew occur at 480 Mbps.

Figure 4. Noise brought by skew on a USB2.0 link in time domain: D+ and D- with 150 ps skew
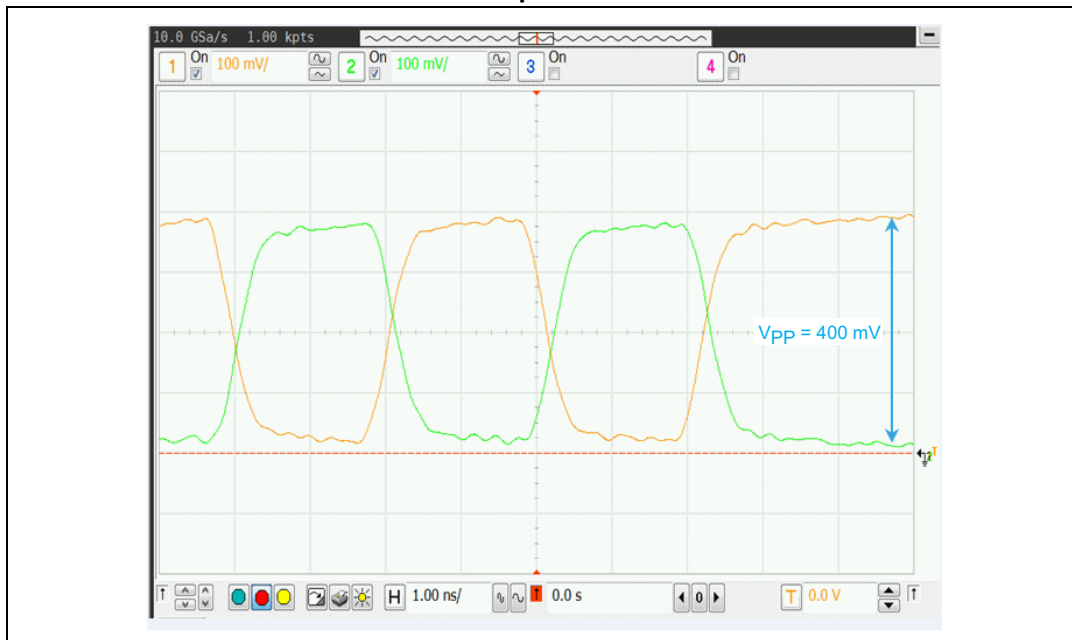

Figure 5 shows the common mode signal [D+] + [D-]. We can observe that its level is not negligible.

Figure 5. Noise brought by skew on a USB2.0 link in time domain: Common mode signal [D+] + [D-] noise introduced by skew
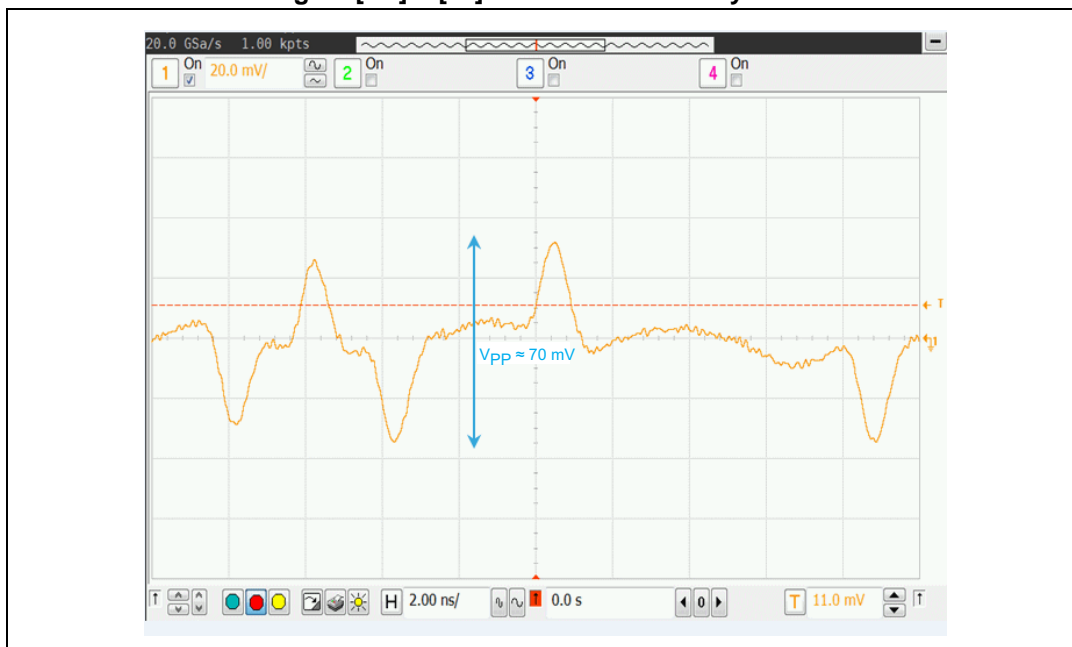
Figure 6 shows the spectral content of the USB2.0 signal. We can observe the carrier frequency and its harmonics. It is interesting to notice that the first one is in the range of frequencies used in mobile applications, such as 960 MHz, Rx band GSM960 (959.8 MHz). The second one is near GPS frequency at 1.575 GHz.

Figure 6. Spectral content of a USB2.0 link without and with skew
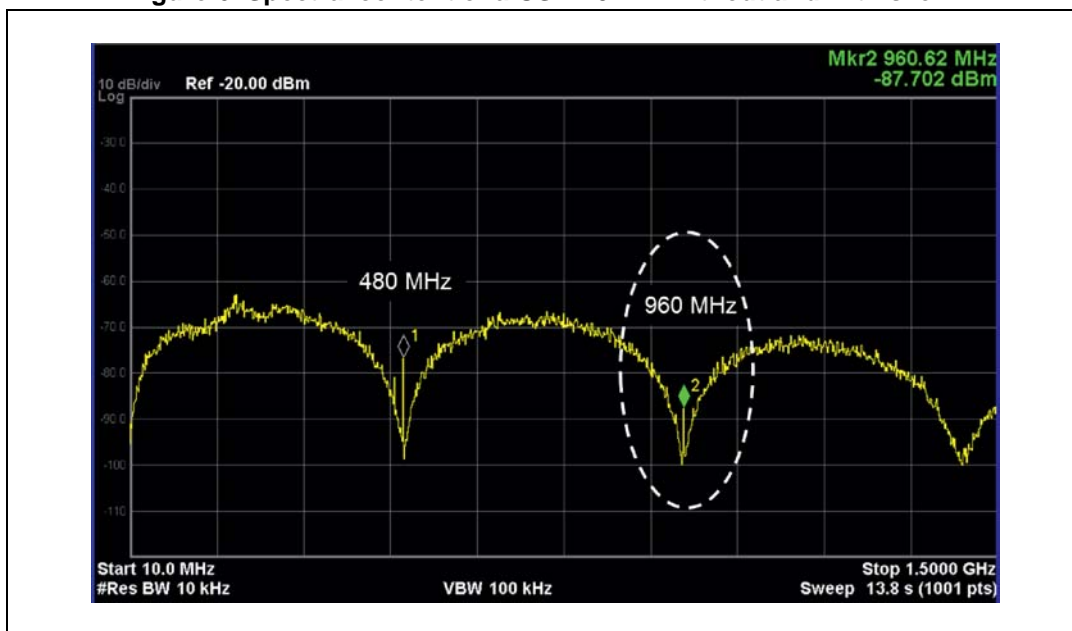
The noise amplitude, and therefore its bad effects on the equipment, will depend on the PCB layout and the proximity of the sensitive parts.

To evaluate the sensitivity losses due to this kind of noise, a TIS (total isotropic sensitivity) measurement on a standard cell phone has been done. *Figure 7* shows the sensitivity of the phone in the P-GSM 900 band and *Figure 8* in the WCDMA band (band VIII). Two measures have been done, one without USB traffic on the link and one with USB activity.

Figure 7. TIS measurement on P-GSM 900 band with and without USB activity on cell phone
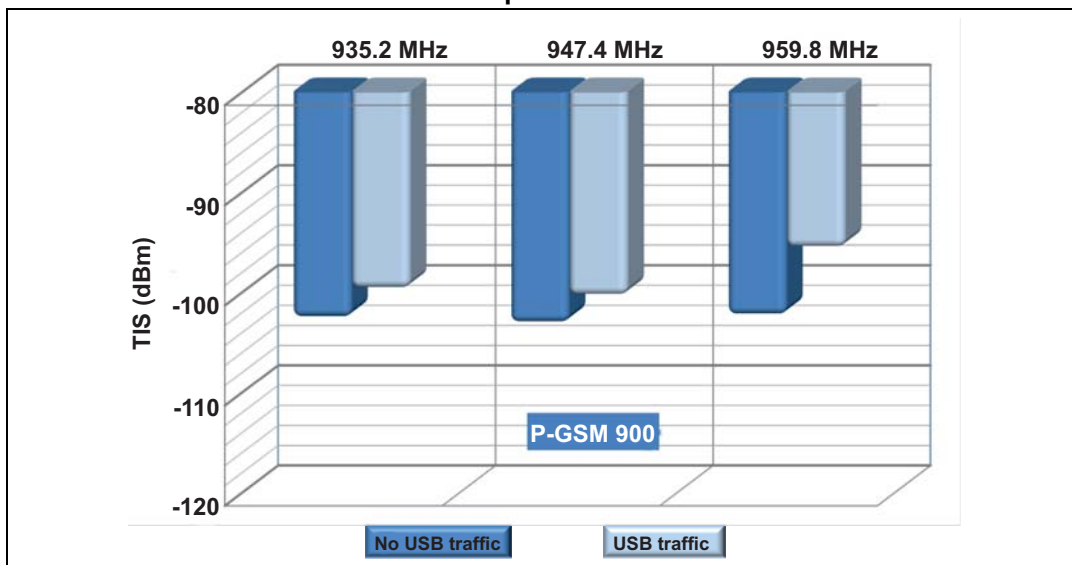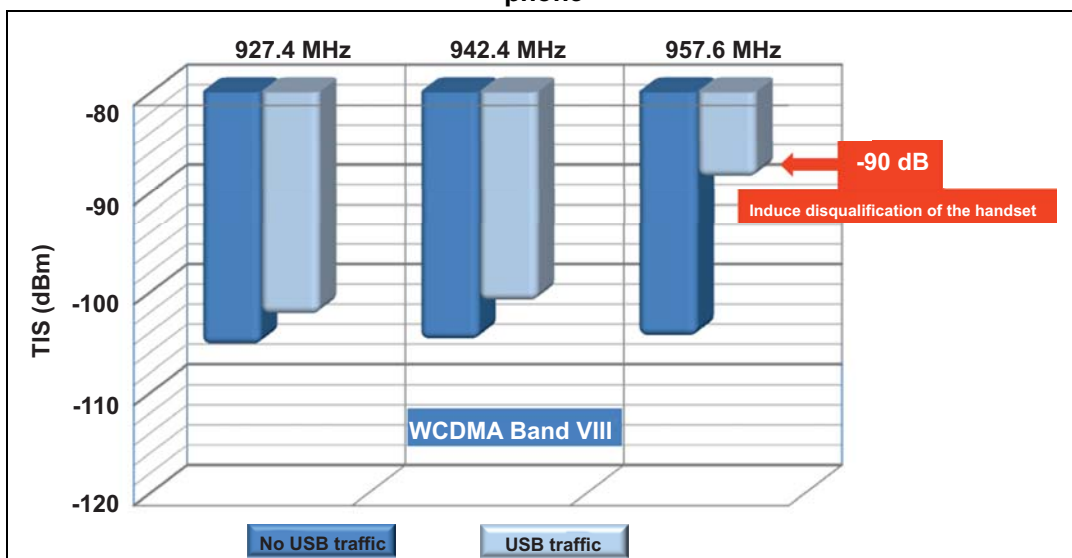

Figure 8. TIS measurement on WCDMA band VIII with and without USB activity on cell phone

We can observe an important loss of sensitivity from 3 dB and up to 15 dB in the worst case. Sensitivities better than -102 dBm to -105 dBm decrease to -90 dBm. These values are enough to disqualify the phone by an operator.
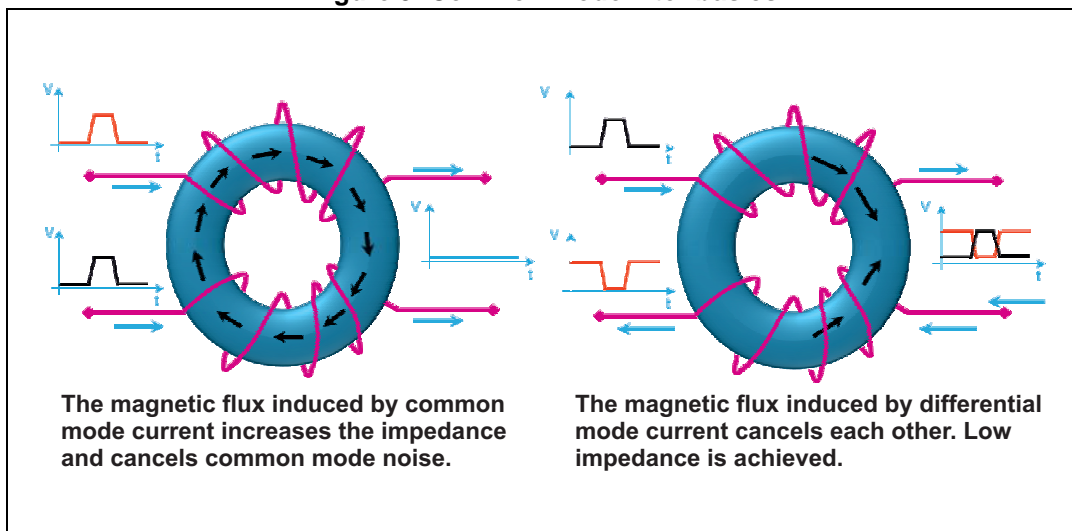
This phenomenon is called **antenna desense**.

The first way to prevent it is to shield all the subsets able to generate EMI. Most of the time it is not sufficient because unwanted frequencies are not precisely targeted.

2 Solution to avoid antenna desense

The best method to prevent antenna desense is to insert a common mode filter on the link. This device includes two coupled inductances acting like a subtracter for common mode noise thanks to the magnetic flux accumulation, inducing high impedance for it. The differential signal is not affected (*Figure 9*).

Figure 9. Common mode filter basics

The magnetic flux induced by common mode current increases the impedance and cancels common mode noise.

The magnetic flux induced by differential mode current cancels each other. Low impedance is achieved.

The common mode filter is efficient on all the common mode noise induced on the link:

- Conduction noise
- Radiated noise
- Noise induced by skew

Figure 10. Common mode filter against various noise sources
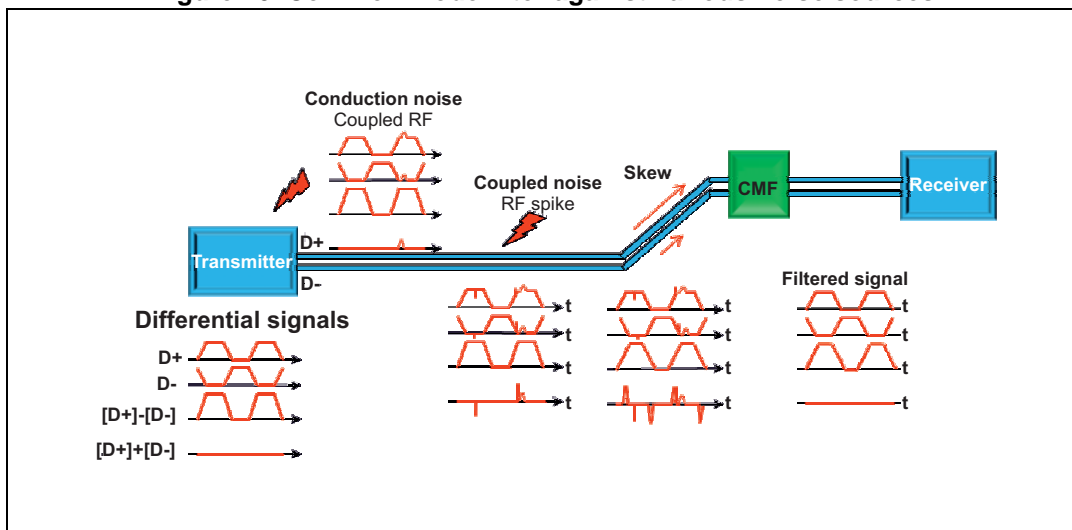
The key points on the selection criteria for a common mode filter are:

- High common mode rejection in the targeted frequency range; but at the same time, high common mode bandwidth to be invisible in case of embedded signals (clock signal for example in MHL standard)

- High differential bandwidth to drive the high data rate signals without distortion

- Low DC resistance to ensure lossless signal and impedance matching (TDR)

Another interesting characteristic is integrated ESD protection. The common mode filter is often close to digital devices sensitive to ESD surges or close to connectors in direct relationship with potential ESD strikes. This solution allows easier routing, space saving and reduced assembly cost.

STMicroelectronics provides a wide range of products dedicated for all high-speed links including all these features.

As an example, *Figure 11* shows the common mode rejection offered by an ECMF02-3HSM6. This device is dedicated to the MHL link and offers an integrated protection for the ID pin. The better rejection area is centered on 900 MHz

**Figure 11. ECMF02-3HSM6 common mode rejection versus frequency**
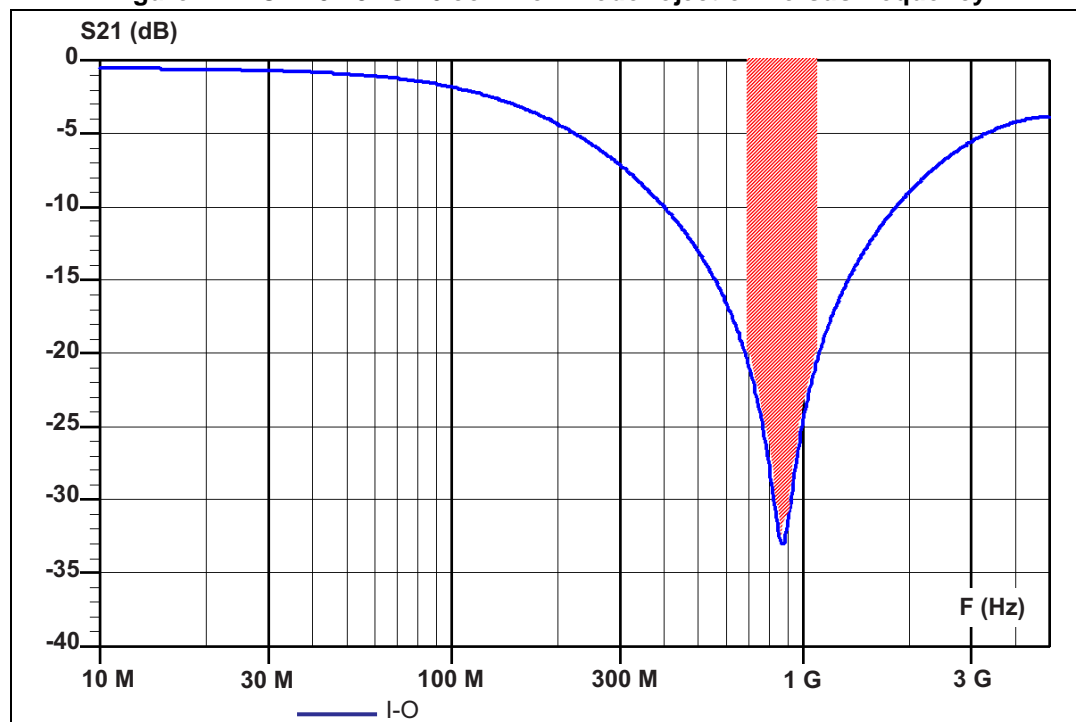
Other devices offer a higher common mode bandwidth and a wider rejection band (*Figure 12*). This one is suitable for example if there is some antenna desense issues at the GPS frequency (1.575 GHz).

Figure 12. ECMF02-2BF3 common mode rejection versus frequency
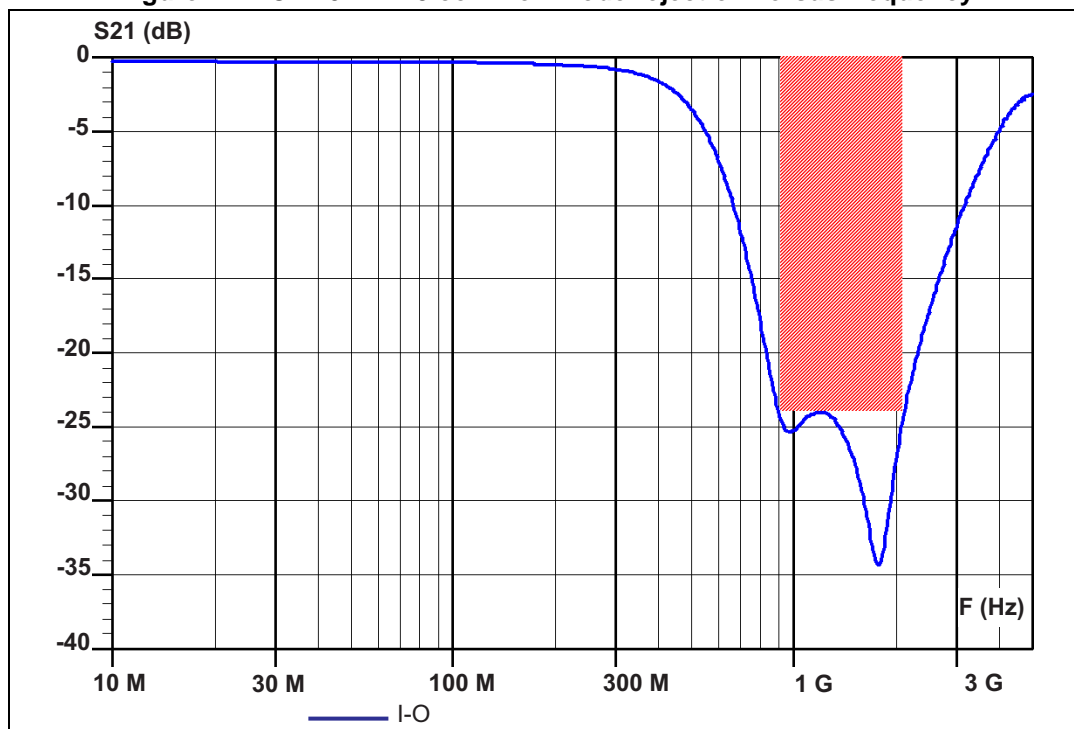
The device differential bandwidth is compliant with the eye diagram template of the standard. *Figure 13* shows the eye diagram compliance of an ECMF02-3HSM6 with MHL template.

Figure 13. ECMF02-3HSM6, MHL eye diagram compliance
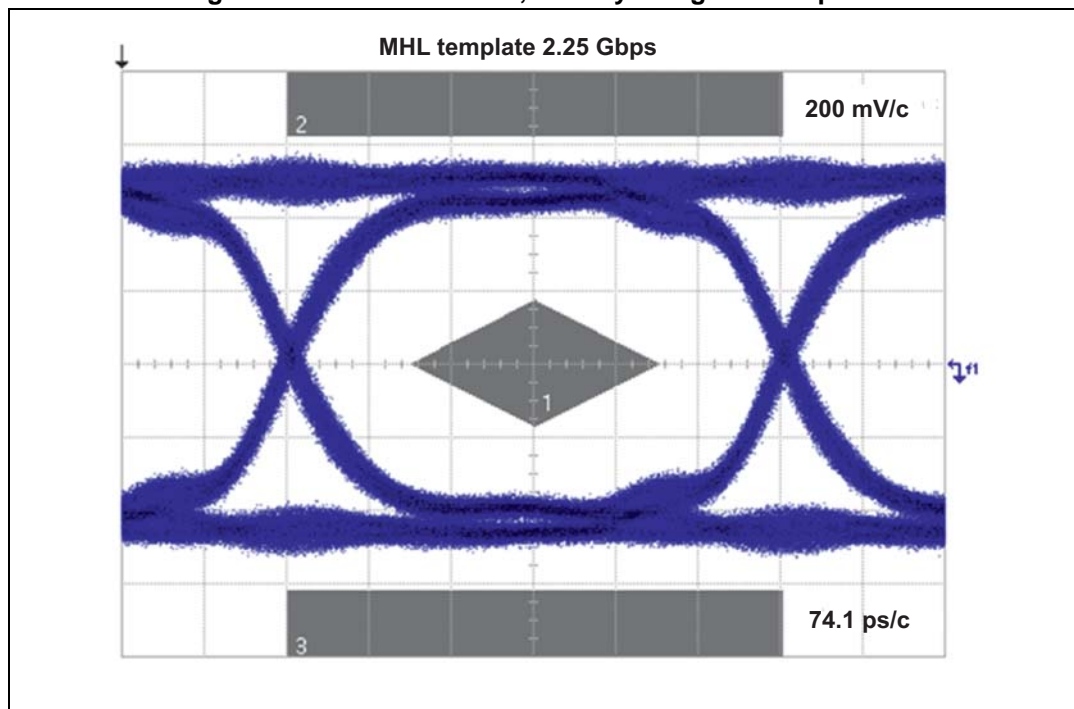
Let us see the benefit of these solutions on the USB example shown at the beginning of this note. *Figure 14* and *Figure 15* summarizes the results obtained in P-GSM 900 band and WCDMA band VIII.

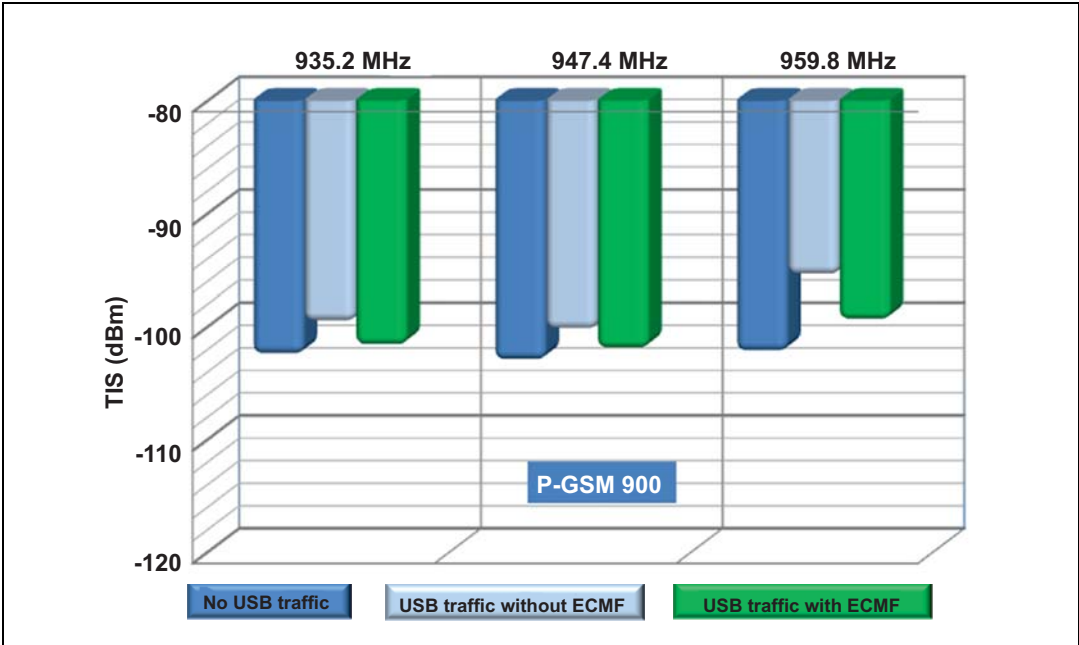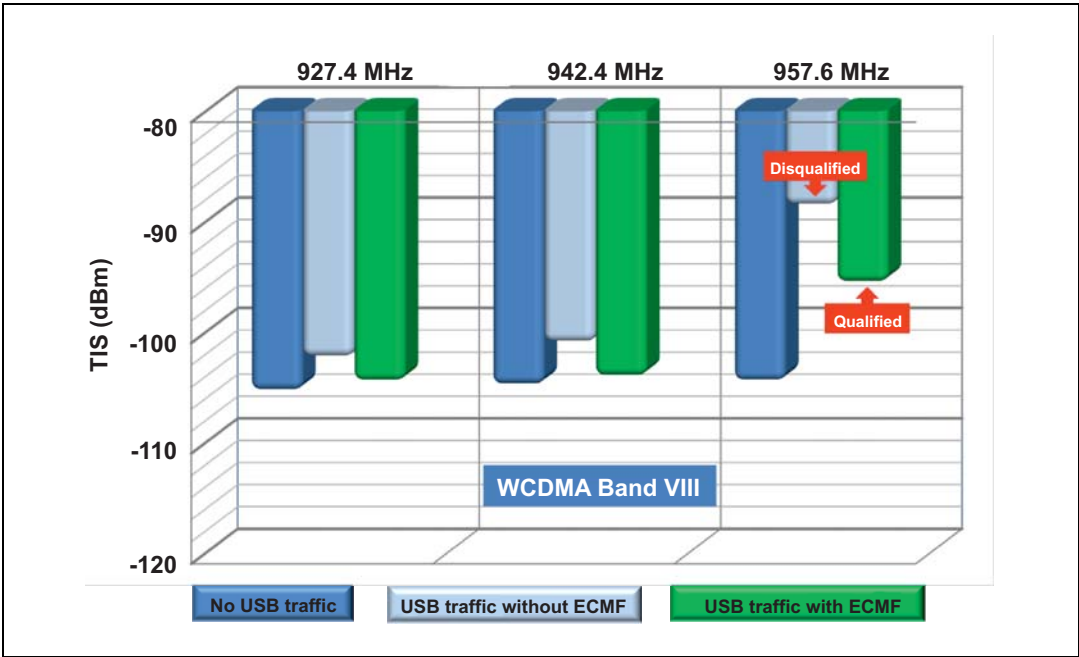**Figure 14. Effect of filtering during USB activity on TIS results in P-GSM 900 band**

Figure 15. Effect of filtering during USB activity on TIS results in WCDMA (band VIII)

The ECMF improves the TIS in each band up to -7 dBm. If the minimum sensitivity required is -103 dBm, 70% of the bands are recovered.

These trials have been done on the USB2.0 interface, but the same issues could be encountered on another links such as MIPI D-PHY, Display Port, MHL, HDMI, USB3.0, SD Card… related to the various Rx frequencies found in mobile equipments:

- GPS
- WLAN
- Bluetooth
- TV

A proper choice of ECMF device could help solve these kinds of problems.

The better place for the ECMF device is as close as possible to the connectors for the external links, and close to the connector flex for internal ones. For long flex, one ECMF at each end will be more efficient.

3 Conclusion

Losing sensitivity due to EMI is not unusual, especially in handheld device such as phones or tablets using long flex able to radiate a lot of noise.

Maintaining a low sensitivity level during reception is a key point on these applications to ensure their qualification and to keep good reliability results.

Common mode filters are the suitable devices to guard against this issue. But they must be chosen correctly regarding the various application constraints such as attenuation level in the right frequency bands, frequency bandwidth, even in common mode than in differential mode.

STMicroelectronics presents a wide range of devices dedicated to each application, allowing adaptation to the application needs, integrating functions not supported by discrete devices, reducing PCB surface and improving assembly costs.

4 Revision history

Table 1. Document revision history

Date	Revision	Changes
03-Oct-2013	1	Initial release.

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