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Technical Whitepaper - October 2020

LoRaWAN® Gateways
Radio coexistence
Description of usual Challenges and Solutions For Carrier-Grade Installation and Performances

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1 Introduction

When deploying a LPWAN, as any radiocommunications network, the choice of the gateway installation site is critical. An optimized site provides to the operator several benefits such as a better coverage area, a better QoS, an optimized number of deployed gateways. This is finally a cost reduction for the deployment itself and an improved QoS during the exploitation of the network.

In a defined area, the number of available sites, offering the best coverage, is obviously limited. Site sharing is often favoured in urban and suburban areas where there is a shortage of available sites or complex radio planning requirements. These sites are, in most of the uses cases, already used by other radio systems such as cellular base stations (GSM/UMTS/LTE) or TV emitters for instance.

In many use cases, the LoRaWAN® gateways are therefore colocalized with those emitters and special care must be taken during the installation to avoid any interferences. More generally, when deploying LoRaWAN® gateways, especially in urban areas, it is necessary to consider all the radio systems in the near environment.

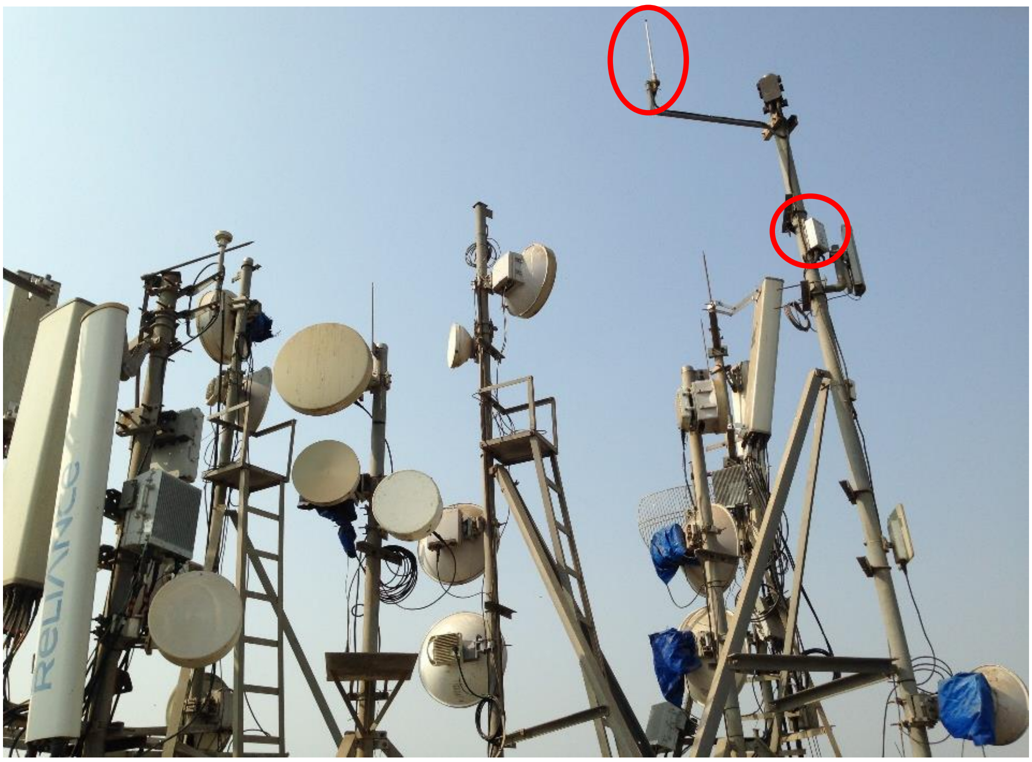

Figure 1 : Example of KERLINK® Wirnet® iBTS Compact gateway deployed in Mumbai (India)

This White Paper provides some clues to understand the phenomenon which could cause desensitization of the LoRaWAN® gateways because of the colocalized transmitters. Deeper analysis, calculations and recommendations are provided in the White Paper “Outdoor LoRaWAN® Gateways – Radio coexistence issues and solutions” (see [1]).

2 LoRaWAN® coexistence issues due to cellular networks

LoRaWAN® end-devices and gateways communicates in unlicensed frequency bands. This is a benefit for the operator or customer that do not need license, and associated fees, from government or state, to transmit on these frequencies.
The most common LoRaWAN® frequency bands used worldwide are the following:

- 433 MHz (EMEA)
- 868-870 MHz (EMEA)
- 902-915 MHz (North America)
- 915-928 MHz (LATAM, APAC)

However, it is important to note that unlicensed frequencies are country specific. Although some zones share similar frequency bands, some countries may have specific usage. This could relate to the allowed frequencies but also time on air, duty cycle, EIRP, etc.

The LoRaWAN® gateway may be colocalized with 3G or 4G base stations, sharing the same tower or mast. In the past years, the number of 3G bands and moreover the 4G bands have significantly increased. At the beginning of 2020, the number of LTE bands used worldwide exceeded 70 as detailed in [2]. The bands are mainly spread from 400MHz to 3800MHz.
So, considering the overall picture of LoRaWAN® bands and LTE bands, we have then a few LoRaWAN® bands among a large amount of LTE bands. When scrutinizing the bands, we can see that some LTE bands and LoRaWAN® bands are very close to each other. The guard band is sometimes very limited (few MHz) or even reduce to null. Some examples are provided below, for different continents or countries:

Zone / Countries	Unlicensed bands	LTE UL bands	LTE DL bands
Europe	868 - 870MHz	832 – 862MHz (B20)	791 – 821MHz (B20)
	863 - 873MHz		
	915 - 918MHz	880 – 915MHz (B8)	925 – 960MHz (B8)
	915 - 921MHz		
North America	902 - 928MHz	824 – 849MHz (B5)	869 – 894MHz (B5)
Australia / New-Zealand	915 - 928MHz	880 – 915MHz (B8)	925 – 960MHz (B8)
		825 – 845MHz (B5)	870 – 890MHz (B5)
Asia / Thailand, Taiwan and Singapore	920 - 925MHz	885 – 915MHz (B8)	930 – 960MHz (B8)
Asia / Malaysia	919 - 924MHz	880 – 915MHz (B8)	925 – 960MHz (B8)

Colocalizing LoRaWAN® gateways with LTE (or 3G, 2G) Base Stations may cause some issues if the RF filters and the installation are not carefully considered. The main issues to be faced are:

- Out-of-band spurious generated by LTE transmitter falling in the LoRaWAN® unlicensed band causing desensitization of the LoRaWAN® gateway
- Out-of-band spurious generated by LoRaWAN® transmitter falling in the LTE UL band causing desensitization of the LTE base station

- LTE transmitter acting as an out-of-band blocker causing desensitization of the LoRaWAN® gateway
- LTE transmitter intermodulation in the LoRaWAN® receiver, causing desensitization of the LoRaWAN® gateway
- LTE transmitter intermodulation in the LoRaWAN® transmitter causing desensitization of the LTE Base Station or any other receiver
- Total amount of radiated power by LTE BS in the installation site may damage the LoRaWAN® receiver.

To mitigate these potential issues, colocalization of LoRaWAN® gateways with LTE BS imposes several constraints on the gateway installation and design:

- At least 45dB isolation is required between LTE BS antenna and LoRa® antenna to minimize impact of LTE BS out-of-band spurious.
- A minimum attenuation of 60dB of LTE BS DL band is expected from RX RF filters of the LoRaWAN® gateways, to mitigate LTE BS blocking.
- A minimum IIP3 of -33dBm for the LoRaWAN® receiver to mitigate LTE BS intermodulation.
- A minimum attenuation of 40dB of LTE BS UL/DL band is expected of the LoRaWAN® Tx path, between PA and antenna port, to reduce transmitted out-of-band spurious and minimize the transmit intermodulation.

The minimum separation distance between LTE BS (Wide Area BS and Medium Range BS) and LoRaWAN® gateways are summarized in the following table:

Gateway type (LoRaWAN Regional Parameter)	Min Vertical separation for Wide Area BS (48dBm)	Min Vertical separation for Medium Range BS (38dBm)	Min Horizontal separation for Wide Area BS (48dBm)	Min Horizontal separation for Medium Range BS (38dBm)
EU868-870 version	1m	1m	150m	150m
US902-928 version	1m	1m	150m	40m
AU915-928 version	1.5m	1m	200m	150m
AS923 version Guard band <2MHz	**100m**	**40m**	**10km**	**7km**
AS923 version Guard band <5MHz	7m	2.5m	1500m	400m
AS923 version Guard band <10MHz	1.5m	1m	200m	150m

A cavity filter is recommended in all the above use cases.

For “AS923” versions of the gateway it is also recommended to increase the guard band between the LoRaWAN® channels and the edge of the LTE UL band. A guard band of 2MHz or less must be avoided unless accepting huge desensitization of the LoRaWAN® gateway and significant reduction of the coverage area.

3 Colocalization with high-power transmitters

LoRaWAN® gateways may be colocalized with high power transmitters. These transmitters could be either radio broadcasting equipment's (FM radio, TV), radars, satellite stations, military applications, etc. All the different uses cases cannot be treated in this document but any LoRaWAN® deployment must consider all the high-power transmitters in the area.
One of the most critical high-power transmitters are Digital Terrestrial TV Transmitters:

- DVB-T/T2 in EMEA and APAC regions
- ATSC in North America
- ISDB-T in Japan and LATAM

DVB-T/T2 transmitters are critical due to the high radiated power but also due to the operating UHF band (470-694MHz) which is close to the unlicensed bands used by LPWAN gateways.

The DVB-T/T2 transmitters may degrade the LoRaWAN® gateways receiver performance due to:

- Out-of-band spurious falling in the unlicensed band
- High power carrier causing out of band blocking

If not sufficiently protected by RF filtering, the DVB-T/T2 transmitters may also damage the gateways and especially the radio front-end.

Considering the essential requirements of the Digital Terrestrial TV Transmitters as detailed in the ETSI EN 302 296 documents (see [6]), the antenna isolation between the LoRaWAN® gateway RF port and the DVB-T emitter RF port, shall be greater than 50dB.
When translating this isolation into distance separation, then the minimum antenna separation of LoRaWAN® gateways with DVB-T/T2 transmitters is:

Min Vertical separation	Min Horizontal separation
2m	150m

Considering to the very high power in the vicinity, that could cause damages to the gateway, KERLINK® recommends usage of cavity filters to mitigate the risk. The cavity filter may provide about 40dB attenuation in the UHF band, ensuring no damage of the gateway during the installation.

4 Colocalization with other LPWAN gateways

Nowadays, colocalization of LPWAN gateways on a shared site is rare but as massive IoT deployment is approaching, the probability is increasing significantly. LPWAN gateways could then share the same site or eventually could be installed on close roof tops for instance. LPWAN gateways could be LoRaWAN® gateways but also SigFox gateways, Qowisio gateways or any other LPWAN gateways sharing the same unlicensed band.

The issue when colocalizing LPWAN on the same site or on a close site is due to the fact they use the same bands and, most of the time, the same channels. Therefore, RF filtering cannot be used to avoid interferences. Of course, if gateways are configured in receive mode only (no transmission), no issue are encountered. Issues are observed when a gateway transmits on a dedicated channel, causing desensitization of the other gateways, as in-band blockers.

It must be noted that in case of colocalization of full-duplex LoRaWAN® gateways (North America use case), there is no in-band blocking issue. This is because the US902-928 regional parameter (see [8]) defines separated bands for UL and DL frequencies as follows:

- UL: 902-915MHz
- DL: 923-928MHz

The duplexer used to separate UL and DL bands prevents any desensitization of the receiver while transmitting. This is valid for full-duplex gateways and therefore for all the gateways located on the same site. However, transmit intermodulation may occur when two full-duplex gateways are transmitting at same time. IM3 products may be generated in the ISM band or outside the ISM band.

In case of half-duplex gateways, the probability of issues is more stringent. The transmitted gateway is considered as an in-band blocker for the other gateway's receivers. Different use cases must be considered depending on:

- The gateway EIRP, according to the local regulation. It may vary from 16dBm EIRP to 36dBm EIRP
- The frequency separation between the DL (TX)and the UL (RX) channels frequencies. We may consider the following uses cases: co-channel, adjacent and alternate channels, 2MHz offset.
- The sensitivity and acceptable desensitization of the gateways.

The required isolation for adjacent channels, alternate channels (up to 2MHz offset) can be translated into distance separation. Based on these calculations, we can provide the following recommendations regarding antenna separation of LPWAN gateways:

Gateway type (LoRaWAN Regional Parameter)	Min Vertical separation	Min Horizontal separation
EU868-870 version	5m	200m
US902-928 version	1m	20m
AU915-928 version	10m	300m
AS923 version	**50m**	**1500m**

For deployments in LATAM (AU915-928) it is recommended to use UL channels from 915 to 922MHz rather than 922 to 928MHz.
For deployments in APAC (AS923), colocalization is therefore not recommended unless using separate channelization.

The probability of interferences may be, however, mitigated by the duty cycle of the LPWAN gateway transmitter (1% to 10%). The probability is therefore low.

5 LoRaWAN® gateway design

Knowledge of the LoRaWAN® gateway performance is a prerequisite before colocalizing the gateway with other transmitters. The radio performances of the LoRaWAN® gateway would help to understand the potential issues and the relevant solutions to prevent interferences. The key parameters to be considered are:

- The architecture of the front-end
- The band-pass of the RF filters
- The minimum SNR required
- The sensitivity performance
- The out-of-band rejection
- The in-band rejection
- The receiver linearity
- The transmit intermodulation performance
- The maximum input power

From the beginning of the LoRa Alliance, Semtech has proposed several Reference Designs to support gateways manufacturers. Each gateway manufacturer may have its own proprietary architecture but most of the architectures available in the LoRaWAN® ecosystem are a direct application of Semtech Reference Design or a derivative version.

The Reference Designs architecture may be convenient for some installation sites but has some weaknesses in harsh environments i.e. when colocalized with high power transmitters:

- Close out-of-band signals may generate intermodulation products that could fall into the LoRaWAN® unlicensed band. The level of the intermodulation products would obviously depend on the IIP3 of the receiver.
- Close out-of-band may generate TX intermodulation products that could fall into the LoRaWAN® unlicensed band or in the LTE uplink bands for instance, causing desensitization of the LoRaWAN® gateway or cellular Base Stations.
- TX noise generated by the PA has no, or very limited, out-of-band spurious rejection. These spurious or noise could fall into the LTE uplink bands for instance, causing desensitization of the cellular Base Stations.
- The gateway may be sensitive to lightning surges which could cause damages of the front-end chipsets.
- Maximum input power may be limited.

To fix the potential issues of Semtech Reference Design in harsh environment, then a band-pass cavity filter shall be added at the antenna port. The cavity filter may be embedded in the gateway or connected outside the gateway.

Also, when designing a LoRaWAN® gateway, the choice of the band-pass RF filters must be carefully investigated. This is often a trade-off between contradictory requirements. The main specifications to be considered are:

- Band-pass, driven by:
  - The usable unlicensed band according to the local regulation (country specific)
  - The LoRaWAN® Regional Parameters that can be used for a LoRaWAN® deployment in a dedicated country (see [8]).
  - The number of LoRaWAN® channels which can be used or needed.
- The out-of-band rejection, driven by
  - LTE UL and DL bands used in the dedicated country
  - Guard band between the LoRaWAN® unlicensed band and LTE bands
- The maximum input power which is often neglected but must be chosen as high as possible to reinforce the robustness of the receiver.

Increasing the RF filters bandwidth leads to lower rejection of the close LTE bands and therefore the gateways immunity is degraded.
Increasing the RF filter rejection lead to increase the insertion losses of the RF filters and the bandwidth may be sacrificed to get the expected immunity.

Cavity filters offer the best option for RF filters as this is the ideal tradeoff between maximum input power, out of band rejection, insertion losses and largest bandwidth.

6 Cavity filters

6.1 Main requirements of cavity filters

Previous chapters demonstrated that cavity filters are required when colocalizing LoRaWAN® gateways with high power emitters.

Cavity filters improve performance of the LoRaWAN® gateways regarding:

- Out-of-band blockers
- Transmit intermodulation
- Intermodulation of LTE BS emitters in the LoRaWAN® receiver
- Out-of-band spurious emissions generated by the LoRaWAN® transmitter
- Out-of-band maximum input power

However, cavity filters do not improve performance of the gateways regarding:

- In-band blockers
- Linearity of the receiver
- In-band maximum input power
- Out-of-band spurious generated by other transmitters in the unlicensed band

When selecting a cavity filter, the gateway manufacturer or must consider:

- The usable unlicensed band for LoRaWAN®
- The Regional Parameters to be used for LoRaWAN®
- The cellular (LTE) bands colocalized with LoRaWAN® gateway
- Guard band between unlicensed band (LoRaWAN®) and LTE DL bands
- Attenuation of the main interfering bands i.e. the colocalization issues to be solved
- Outdoor or indoor (embedded) versions depending on the gateways
- Typical Insertion Losses to evaluate impact on the budget link
- Dimensions
- Weight
- Connectors type
- Operating temperature range

The following table summarizes the main common characteristics of cavity filters when using unlicensed band in the 860-928MHz range (EMEA, North America, LATAM, APAC areas):

Characteristic	Specification
Power Handling	10W CW Min
Impedance	50Ω@I/O
Operating Temperature	-40℃～+85℃
Attenuation 10-800MHz	60dB min
Attenuation 1000-2000MHz	60dB min
Attenuation 2000-3000MHz	50dB min
Attenuation in LTE DL bands	40dB min if guard band greater than 10MHz 50dB min if guard band greater than 5MHz 60dB min if guard band greater than 2MHz
Attenuation in LTE UL bands	40dB min

Some examples are provided in [1] for specific unlicensed bands and targeted countries. Contact sales@kerlink.com for more information.

6.2 Embedded or external cavity filters?

Gateways manufacturers, or operators, must face the choice of using embedded cavity filters or use external cavity filters.
Using an embedded cavity filter is a seducing choice as it offers several advantages:

- Lower price of the cavity filter:
  - External cavity filters require specific powder coating to meet IP67.
  - Embedded cavity filter does not require such coating.
- Easier installation:
  - The installer just needs to connect a coaxial cable between the gateway RF port and the antenna.
  - External cavity filter mounting must be considered by the installer.

However, external cavity filters must be also considered as they offer a lot of flexibility for the operators and installers. An embedded cavity filter is supposed to address all the possible interferences uses cases in a specific country. This could be true in a dedicated country but untrue in another country or in another installation site. The external cavity filter would allow the installer to meet all the specificities of an installation site.

If we consider, for example, the EMEA zone. The unlicensed bands may vary depending on the countries as follows:

- 868 – 870 MHz in Ivory Coast, Kenya, Nigeria, South-Africa, Greece, Sweden, etc.
- 863 – 870 MHz in Belgium, France, Germany, Italy, Netherlands, Lebanon, Oman, etc.
- 863 – 873 MHz in Denmark, Finland, Hungary, United-Kingdom, Iran, Somalia, etc.
- 863 – 876 MHz in Kuwait, Qatar, Saudi Arabia, UAE, etc.
- 862 – 873 MHz in Albania, Moldova, Slovenia
- 862 – 876 MHz in Comoros
- 864 – 870 MHz in Belarus
- 864 – 869.2 MHz in Russia

It could be understood that a gateway manufacturer would avoid producing 8 different versions of EMEA gateways to accommodate all the different above unlicensed band. A unique gateway supporting 863-876MHz band would be suitable for all the EMEA countries. One or more external cavity filters could be envisaged to accommodate each country specificities regarding out-of-band emissions or out-of-band blocker rejection.

In North America, both LTE (band 5 mainly) and unlicensed bands (902-928MHz) are clearly defined and harmonized across countries (USA, Canada, Mexico, Bahamas, Panama, etc.). Using embedded filters make fully sense in this zone.

The situation is even more stringent in APAC zone, as we have different unlicensed band in the 915-928MHz range but moreover different usages of the LTE bands 8, 5 and 20 as detailed in the table below:

Unlicensed band (MHz)	LTE DL band (MHz)	Countries	LoRaWAN® Regional Parameters
915–928MHz	870-890MHz 935–960MHz	Australia New-Zealand, Tonga	AS923-1 AU915
915–918MHz	870-880MHz 925–960MHz	Philippines	AS923-3
917–923.5MHz	864-894MHz 950–960MHz	South Korea	KR920
918–923MHz	869-880MHz 925–960MHz	Vietnam	AS923-2
918–925MHz	869-894MHz 925–960MHz	Solomon Islands	AS923-1
919–924MHz	870-880MHz 925–960MHz	Malaysia Myanmar	AS923-1
920–923MHz	869-880MHz 925–960MHz	Indonesia	AS923-2
920–924MHz	925–960MHz	Sri Lanka	AS923-1
920–925MHz	870-890MHz 869-894MHz 930–960MHz	Brunei Darussalam Hong-Kong, Macao Singapore, Taiwan Thailand	AS923-1

920–928MHz	860–890MHz 935–960MHz	Japan New-Zealand	AS923-1
922–925MHz	870-885MHz 930–960MHz	Bangladesh	AS923-1
923–925MHz	870-880MHz 927–960MHz	Cambodia Laos	AS923-1

It could be therefore difficult for a gateway manufacturer to accommodate all the specific requirements of each country regarding unlicensed bands vs. LTE DL bands (12 configurations). A unique gateway supporting 915 – 928 MHz band would be suitable for all the APAC countries. Several external cavity filters could be envisaged to accommodate each country specificities regarding out-of-band emissions or out-of-band blocker rejection.

In LATAM, 915-928MHz unlicensed bands are mostly harmonized across countries (Brazil, Argentina, Chile, Colombia, Honduras, Paraguay, Peru, Uruguay, etc.) but there are some exceptions:

- Bolivia: 915 – 930 MHz
- Costa-Rica: 920.5 – 928 MHz
- Curaçao: 920 – 925 MHz
- Venezuela: 922 – 928 MHz

Moreover, LTE deployments (bands 5 and 8) may vary depending on the countries.
Using embedded filters (915 – 928 MHz band) would be convenient for most of the LATAM countries but external cavity filters would be more convenient for Venezuela, Costa-Rica and Curaçao.

6.3 Impact of cavity filters on budget link

Cavity filters losses must be included in the feeder losses in the budget link calculation. The losses have obviously an impact on both uplink and downlink budget.
Depending on the used unlicensed band and country specificities, the cavity filters insertion losses could vary from 0.5dB to 4.0dB. It is quite obvious that a 4.0dB insertion losses cavity filter could have a huge impact on the coverage area. It is however possible to mitigate the impact of the cavity filter insertion losses by using an appropriate antenna gain. The choice of the antenna (gain) and the feeder losses are therefore a tradeoff that must be considered before the installation of the gateway.

Also, when considering the LoRaWAN® DL budget, we need to ensure the gateway is able to transmit at the maximum allowed EIRP, according to the local regulation. The antenna gain must be therefore adjusted depending on:

- The gateway maximum conducted power.
- The feeder losses including coaxial cable, lightning surge insertion losses and cavity filter losses.
- The maximum allowed EIRP, according to the local regulation.

7 Gateway GNSS receiver

Like any other receiver of the LoRaWAN® gateway, the GNSS receiver, when colocalized with other emitters, can be desensitized due to:

- Out-of-band spurious generated by emitters falling in the GNSS band causing desensitization of the GNSS gateway
- High power emitters acting as out-of-band blockers causing desensitization of the LoRaWAN® gateway

Fortunately, GNSS antennas have narrow bandwidth which increases significantly the isolation with high power emitters such as LTE BS and DVB-T/T2 emitters. Separation distance can be then lowered but still must be considered.

Issues may occur when adding an external active GNSS antenna due to potential linearity issues of the LNA or poor out-of-band rejection, causing desensitization of the GNSS receiver. Best architectures of GNSS antennas are therefore:

- Passive antenna
- Active antenna with SAW-LNA-SAW (Figure 2) or SAW-LNA architecture.
  The LNA gain shall be also minimized (15dB for instance instead of usual 30dB) to optimize linearity performance.

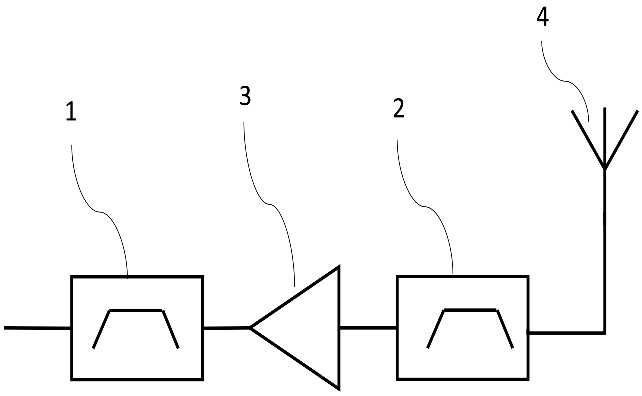

Figure 2 : Recommended GNSS active antenna block diagram

Other types of GNSS antenna are not recommended.

8 Gateway cellular backhaul

The outdoor LoRaWAN® gateways usually embeds a cellular 3G or 4G modem for backhauling. The global market trend is cellular modem to support a maximum of LTE bands to reach a worldwide coverage. The performance of this cellular modem inside the gateway is obviously critical as the backhauling must be reliable to ensure connectivity with the Network Server.

The cellular modem is also subject to the environmental interferences. In case of colocalization with LTE BS, the main causes of desensitization are:

- The LoRaWAN® transmitter of the gateway which may:
    - Generate out-of-band spurious in the LTE DL band
    - Acts as an out-of-band blocker for the LTE UE receiver
- The LTE BS transmitter (LTE BS DL) which may:
    - Generate out-of-band spurious in the LTE DL band
    - Acts as an out-of-band blocker for the LTE UE receiver
    - Generate intermodulation products in the LTE UE receiver
    - Cause damages to the cellular modem due to high LTE BS power at backhaul RF port
- Any other high-power emitter (DVB-T/T2 or other) which may:
    - Generate out-of-band spurious in the LTE DL band
    - Acts as an out-of-band blocker for the LTE UE receiver

Adequate cellular backhaul front-end design, minimum isolation and separation distances are therefore required to mitigate desensitization.

9 Gateway enclosure and shields

In the previous chapters, it was demonstrated that RF filtering is a key factor to ensure a LoRaWAN® gateway would not suffer from desensitization due to the colocalized emitters. A huge amount of attenuation is therefore expected in the receiver path.
The LoRaWAN® gateway, when colocalized with other emitters, is surrounded by electromagnetic fields. The strength of these fields depends obviously on the proximity to these emitters and to their radiated powers. These electromagnetic fields may leak directly into the electronic components of the LoRaWAN® receiver.
For example, we may experience a direct electromagnetic fields leakage between LTE BS transmitter and the LoRa® transceiver. In this case, the effects of RF filters and cavity filters are reduced to null! Electromagnetic interferences (EMI) effects must be therefore carefully considered when designing an outdoor gateway.

In Europe, as part of the CE marking, LoRaWAN® gateway must be compliant to ETSI EN 301 489-1 (see [7]), ensuring EMC compliance. Electromagnetic field immunity of the gateways is tested according to EN 61000-4-3 procedure. A 3 V/m field is applied from 80MHz to 6GHz. This test may guarantee a good EMI performance of the gateway, but in case of colocalization with high power emitters, this test is not sufficient, as stronger fields can be reached.

To optimize the EMC performance of the LoRaWAN® gateway, effective shielding is required in colocalized sites. The shields of can be used at different levels:

- Enclosure:
  Using metal enclosure is an easy and efficient way to improve EMC performance. Some precautions must be however considered to avoid degradation of the performance:
    - Avoid or reduce apertures size
    - Use EMI gaskets
    - Connect all metal parts together (cover, frame, etc.)

  Plastic enclosure (ABS, Polycarbonate) could be also envisaged but internal shielding shall be reinforced in this case.
- Module: a modular conception is especially convenient when using a plastic enclosure. Each module is inserted in a metal box, providing the required EMC protection.
- PCB: effective PCB cans must be used to cover radio chipsets to avoid internal coupling inside the gateway and protect them from external interferences.
- Cables: efficient shielded cables must be sued to interconnect PCB.

Finally, the enclosure and the associated mounting kit, antennas brackets, etc., must be connected to the installation site grounding system for an effective EMI protection.

10 Conclusion

When colocalizing a LoRaWAN® gateway with high power transmitters and / or Wide Area LTE Base Stations or Medium Range LTE Base Stations, usage of cavity filters is recommended to mitigate blocker effects, intermodulation effects and moreover transmit intermodulation. This recommendation is driven by technical aspects as shown in this application note but also because the environment is not under control of the installer. LTE emitters or DVB-T emitters may be located close to the LoRaWAN® gateways site without any possibility to modify it. Using a cavity filter may fix a lot of potential issues. The additional cost of the cavity filter is finally very low compared to the QoS improvement and intervention costs on the installation site.

However, cavity filters do not fix all the possible issues. In particular, out-of-band spurious generated by high power transmitters and / or Wide Area LTE Base Stations or Medium Range LTE Base Stations may cause desensitization of the LoRaWAN® gateways if minimum vertical and horizontal separation are not respected. These distances are detailed in this White Paper and can be roughly summarized, depending on the regions:

- Europe: 2m vertical separation, 300m horizontal separation.
- North America: 2m vertical separation, 150m horizontal separation.
- LATAM (AU915-928): 2m vertical separation, 300m horizontal separation.
  It is recommended to use UL channels from 915 to 922MHz rather than 922-928MHz.
- APAC (AS923): 7m vertical separation, 1500m horizontal separation.
  Selection of the channels must be carefully considered to optimize the frequency separation with LTE DL band and mitigate potential desensitization.

Moreover, when installing a LoRaWAN® gateway with other LPWAN gateway, minimum vertical separation distance is required, depending on the regions:

- Europe: 5m vertical separation, 200m horizontal separation.
- North America: 1m vertical separation, 30m horizontal separation.
- LATAM (AU915-928): 10m vertical separation, 300m horizontal separation.
  It is recommended to use UL channels from 915 to 922MHz rather than 922-928MHz.
- APAC (AS923): 50m vertical separation, 1500m horizontal separation.
  Colocalization is therefore not recommended unless using separate channelization.

The focus is usually put on the LoRa® link but the GNSS receiver and the LTE backhauling must be also considered. Choice of the antenna is key to have the better GNSS performance. Separation distance and front-end design improvements may be considered to optimize the LTE link.

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About Kerlink® Group

Founded in 2004, Kerlink® is a fast-growing, global and publicly traded provider of Internet of Things (IOT) solutions helping telecom operators, public authorities and private businesses to design, launch and operate public and private IOT networks. Kerlink® is a founding and Board member of the LoRa Alliance® and of the uCiFi Alliance™.

Based in France, with subsidiaries in the US, Singapore, India and Japan, Kerlink® offers a comprehensive portfolio of industrial-grade premium network equipment, best-of-breed neb.vork operations and management software, value-added applications— like geolocation, device management and reference design - and expert professional services to design, orchestrate and monetize tailored IoT networks.

In just over 10 years, more than 200,000 Kerlink® installations have been rolled out for more than 350 clients in 70 countries, with major deployments in Europe, South Asia, South America and Oceania, for tier-one telecom operators, major transportation companies and large utility players.

Kerlink® crystalizes a strong ecosystem of partners leveraging its connectivity solutions best-in-class building blocks not only to design innovative connected device and conceive smart applications but also to unlock the real potential of IoT to improve the lives of people around the world.

Kerlink® is also constantly improving its efficiency, operations control and processes through its Quality Program and has been certified ISO 9001-2015 by AFNOR for its IoT network solutions overall design, development, and sales processes.