Kvaser Air Bridge Installation Guide

https://www.kvaser.com

Printed Friday 5th May, 2023

(This page is intentionally left blank.)

Contents

1 About this document

This document provides guidance for installing the Kvaser Air Bridge units in different physical environments. It consists of an introduction to Kvaser Air Bridge, followed by radio guidelines and more detailed considerations that aim to give you a complete understanding of how to maximize the Kvaser Air Bridge's radio performance. Use Section 3, Radio guidelines, on Page 7, as a quick reference for any stationary installation or as a valuable tip for use of the Kvaser Air Bridge in general.

The Air Bridge System Integration Guide, provides design-in advice for system integrators who use Kvaser Air Bridge as a system component and want to make the most of its data bridging capability.

2 Introduction

2.1 What is Kvaser Air Bridge?

The Kvaser Air Bridge is a CAN system bridge that can be used to transfer messages wirelessly between two CAN systems.

Kvaser Air Bridge consists of a pair of preconfigured radio transceivers operating in the so-called 2.4 GHz ISM band. This is an unlicensed frequency band open for applications in industry, science and medical sectors. Equipment using this frequency band includes mobile phones, computers, wireless access points, car alarms, garage door openers, remote-controlled machinery etc.

2.2 How does Kvaser Air Bridge work?

The Kvaser Air Bridge can be used in many situations to bridge two CAN systems. All that's required is to connect the two preconfigured radio transceivers to each of the systems.

All Kvaser Air Bridge units include a radio transceiver with a power amplifier that provides the maximum allowed transmit power, ensuring a robust connection and maximizing the communication distance potential. The omni-directional antennas enable transmission and reception in any direction. Provided that the Kvaser Air Bridge unit is mounted in an upright position, 360-degree coverage can be obtained.

2.3 Spectrum availability and co-existence

As the 2.4 GHz ISM band is made available for many different radio technologies, it is subject to various rules that aim to establish co-existence in areas that are densely populated with transmitters and receivers using the same frequency band. Such rules include spreading the radio energy across the frequency band and preventing simultaneous transmission by radio equipment in close vicinity of each other. It's important to note that although the 2.4 GHz ISM band serves to promote co-existence between radio transceivers, there may be situations where degraded radio communication is experienced.

The Kvaser Air Bridge employs special features to make it a robust radio link, most notably a frequency hopping approach that uses around 40 frequencies. Besides frequency hopping, a special 'Listen Before Transmit' mechanism invokes a 'Clear Channel Assessment' before every transmission. If another radio is located nearby the Kvaser Air Bridge unit and transmits on the designated frequency, then the data will not be transmitted on that frequency but rather on the next available frequency. This latter mechanism is not mandatory in the United States and is therefore not implemented in units sold there.

2.4 CAN connection

The Kvaser Air Bridge provides a simple approach that preserves many CAN bus features, and it automatically adapts to the CAN bus bit rates.

As the transfer of messages over radio always introduces a certain latency, it cannot support arbitration between the CAN systems. This means that a message sent on one CAN bus will be subject to a second arbitration on the other CAN bus after being transferred over the radio link. On the other hand, all messages received on the Kvaser Air Bridge's own CAN bus interface will be directly acknowledged according to the CAN standard, i.e. even before they are transmitted to its paired Kvaser Air Bridge unit.

Autobaud is the process of automatically selecting the correct bus parameters for communication on the connected CAN bus based on received CAN traffic.

2.5 Transmission and reception of messages over radio

As with any radio-based system, a careful and sound installation approach will ensure optimal communication. This concerns the surrounding structures, in addition to other emitters that may disturb the radio communication. Near-by devices may also be using the 2.4 GHz ISM band, or there may be apparatus unintentionally emitting energy in this band.

The Kvaser Air Bridge units take turns in transferring messages over the 2.4 GHz ISM band. The transfer is based on a Time Division Duplex protocol with a fixed cycle length of 4.8 ms of which each Kvaser Air Bridge unit is allocated 50%. The 2.4 ms transmit interval in each direction provides adequate time for the transmitter and receiver to reliably synchronize and transfer the messages at short latency. For each transmit interval, a new frequency is selected according to a frequency hopping scheme that ensures equal use of the available frequencies. The Kvaser Air Bridge automatically establishes the radio link between Kvaser Air Bridge units and has the ability to avoid transmitting on frequencies presently used by other nearby radio devices.

In scenarios involving multiple pairs of Kvaser Air Bridge units, it is recommended that all units use the same firmware version to optimize performance. Please contact Kvaser support for more information.

3 Radio guidelines

Radio signals often “compete” with interfering radio waves or noise. It is the relationship between signal and interference that determines a radio link’s performance, but there’s much that can be done to optimize performance. Different use cases may require alternative approaches that are based to a greater or lesser degree on the rules of thumb given below. In most cases, following just one or two of the rules of thumb will be sufficient. The Kvaser Air Bridge design is based on a robust radio protocol that copes well with interference.

Please note that mobile use cases are subject to slightly different considerations regarding performance and that the rules of thumb might not always be possible to follow.

Rule 1.
Minimize distance between units while keeping line-of-sight

Keep the distance between the Kvaser Air Bridge units (transceivers) as short as possible (however avoid placing them closer to each other than 0.5 m) and make sure that they are in line-of-sight of each other. If this is not possible, the radio signal will be weakened, limiting the maximum practical distance. The attenuation of a wall, for example, depends on its material and thickness.

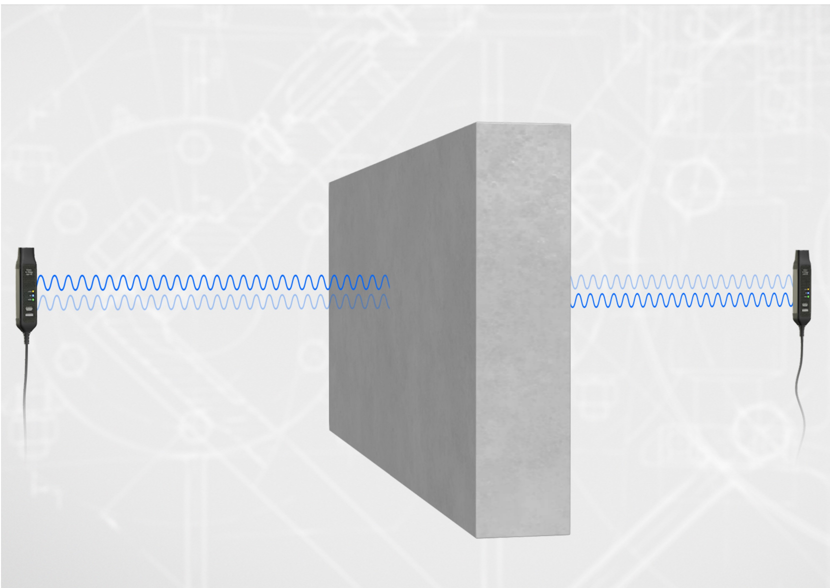

Figure 1: Radio signals are weakened if units are not in direct line-of-sight.

Try to avoid having obstacles very close to the line-of-sight path as this too may result in a weakened signal.

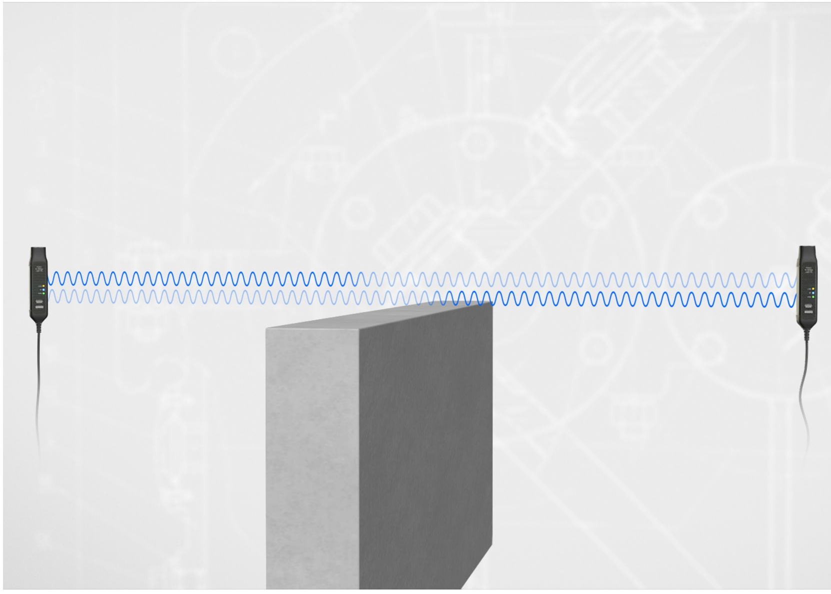

Figure 2: Obstacles should be kept away from the line-of-sight path.

A very short distance between Kvaser Air Bridge units may result in disturbance to the radio link.

Rule 2. Align units with each other

Ensure that the Kvaser Air Bridge units are mounted parallel to each other. In most cases, when the line-of-sight path is horizontal, the Kvaser Air Bridge units should be positioned vertically.

Figure 3: Radio units aligned in parallel is preferable.

Where the Kvaser Air Bridge units are placed at a height that is greater than the distance between them, it may be an advantage to tilt them.

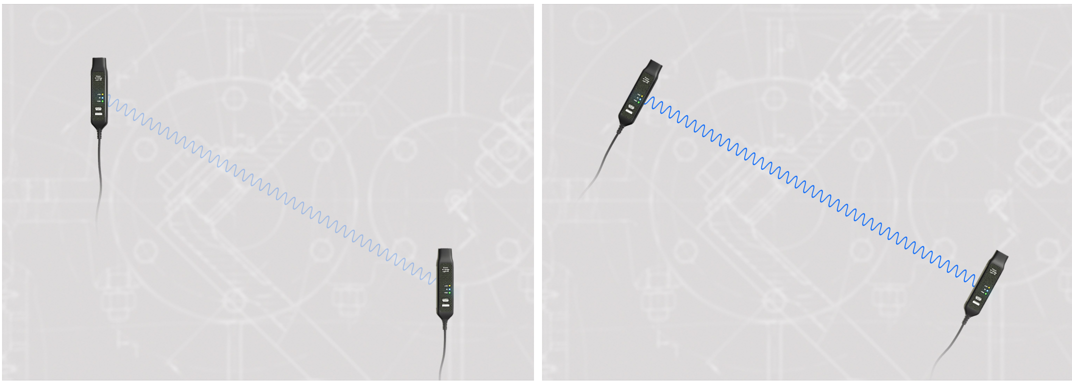

Figure 4: Tilting may improve signal when height difference is obvious.

Rule 3. Keep units away from walls

Maximize distance between the Kvaser Air Bridge units and nearby vertical structures, such as walls. If possible, position the Kvaser Air Bridge units so that signals reflected in these structures will have less impact on the transmissions. The impact of reflections depends on the extension of the walls and on the distances from it.

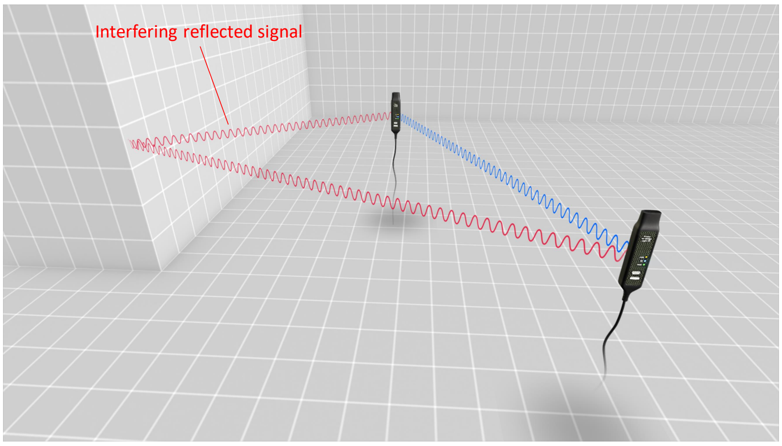

Figure 5: Signals reflected in walls may have an impact on transmissions.

Preferably, the mean (or average) distance from the units to a wall should be at least one tenth of the line-of-sight distance. If the units, for example, are deployed 30 m apart, then the mean distance to a wall/s should be 3 m or more.

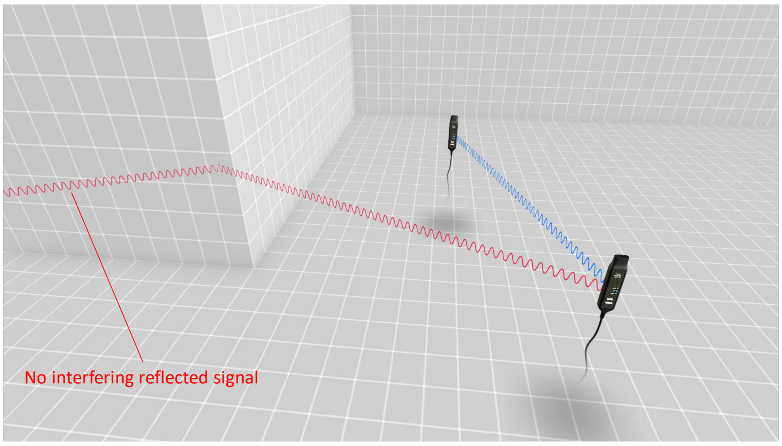

Figure 6: Not all walls cause interference reflections.

The maximum distance will depend on the installation and on the physical environment in which the Kvaser Air Bridge is used, i.e. structures, emitters etc. The Kvaser Air Bridge is designed for maximum range with an 18 dBm output power and a low noise amplifier for high sensitivity. Adhering to the presented rules of thumb will enable the system to make the most of the Kvaser Air Bridge's characteristics in order to obtain communication distances well exceeding the 30 m mentioned above. If you require further assistance on the subject, please contact Kvaser Support.

Rule 4. Optimize Kvaser Air Bridge unit heights

Radio signals reflected in the ground are important but generally cannot be avoided. Whilst you can't change ground reflections, altering the height of the Kvaser Air Bridge units can result in a positive impact on the transmission. This fact opens up an interesting opportunity for optimizing the performance.

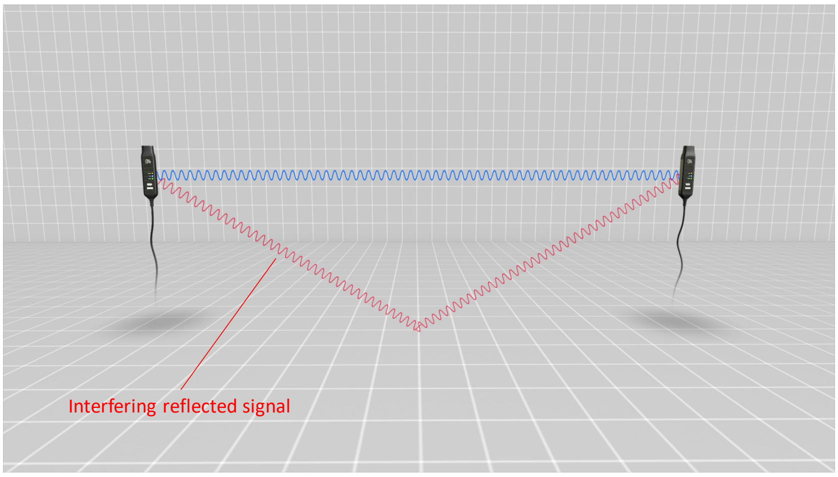

Figure 7: Signal reflected in ground or floor.

For indoor use, optimizing performance becomes more complicated but may still be worthwhile in situations involving interfering emitters. Of course, walls may have an impact too if they are at close range.

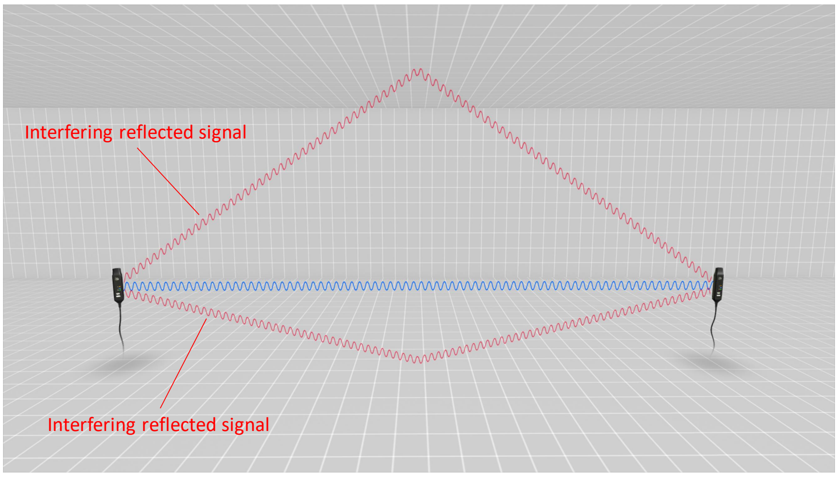

Figure 8: Signal reflected in floor and ceiling.

In theory, based on the distance between units, an antenna height that accords with the red line in Figure 9 on Page 12 would be worth experimenting with in order to optimize performance.

The heights in the graph can be applied for distances between Kvaser Air Bridge units above 10 m. For indoor use, the example in the graph can be applied up to a distance of approximately six times the ceiling height.

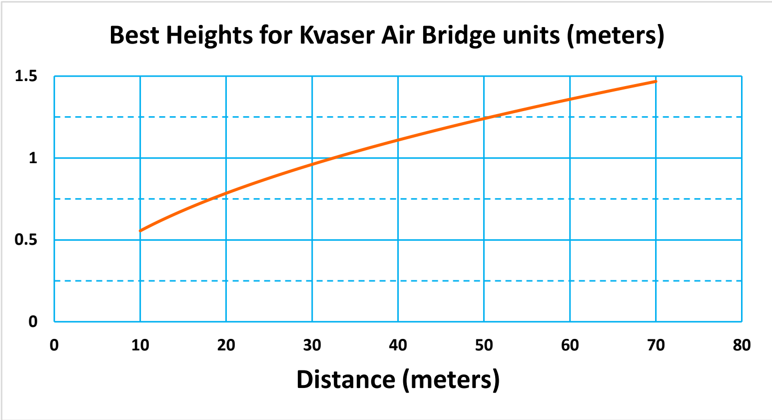

Figure 9: Examples of antenna heights that may optimize performance.

If the Kvaser Air Bridge units are installed at different heights, then, in order to apply this rule, it's best to calculate the square root of the two heights multiplied by each other. For example, a recommended height of 1.4 m can be met with two different heights at 1 and 2 m. Often, simply the average height will be close enough.

Reflections from the ceiling generally only merit consideration when the line-of-sight distance is greater than six times the ceiling height. If you require tailored advice on this topic, please contact Kvaser Support.

Rule 5. Reduce interference from other emitters

Other equipment that uses the 2.4 GHz ISM band should not normally interfere with Kvaser Air Bridge. Should you have doubts, you could try temporarily turning them off or try to place the Kvaser Air Bridge unit further away from the suspected source of interference.

Wi-Fi hotspots may be reconfigured to use other Wi-Fi modes or another frequency band, e.g. the 5 GHz ISM band.

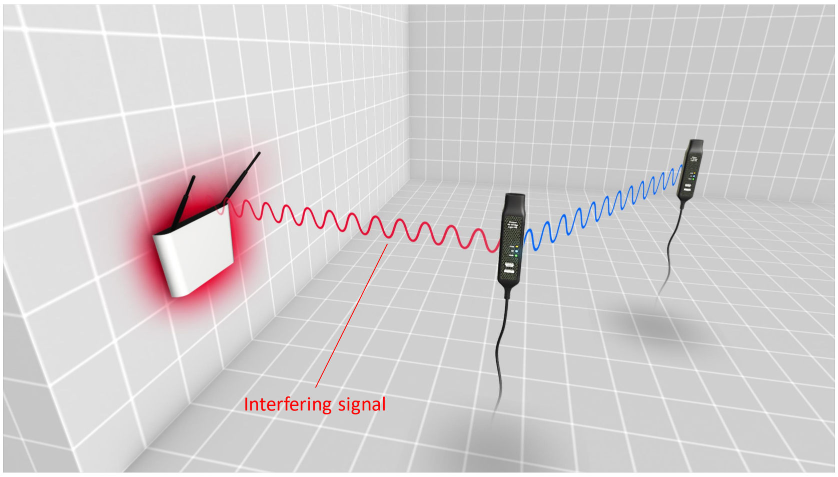

Figure 10: Possible interference from nearby radio emitters.

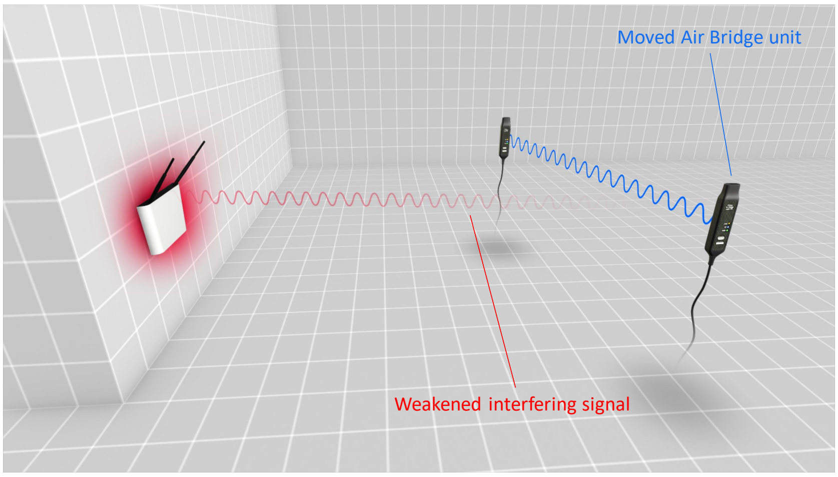

Figure 11: Reduction of radio interference by increased distance.

Note that microwave ovens and motors may also emit energy that interferes with radio devices.

Rule 6. Adjust location or heights

There may be locations where the signal level is weakened due to interference caused by reflected radio waves in the ground, floor, walls and ceiling, so-called multi-path interference. This may be overcome by changing the location of one of the Kvaser Air Bridge units or both.

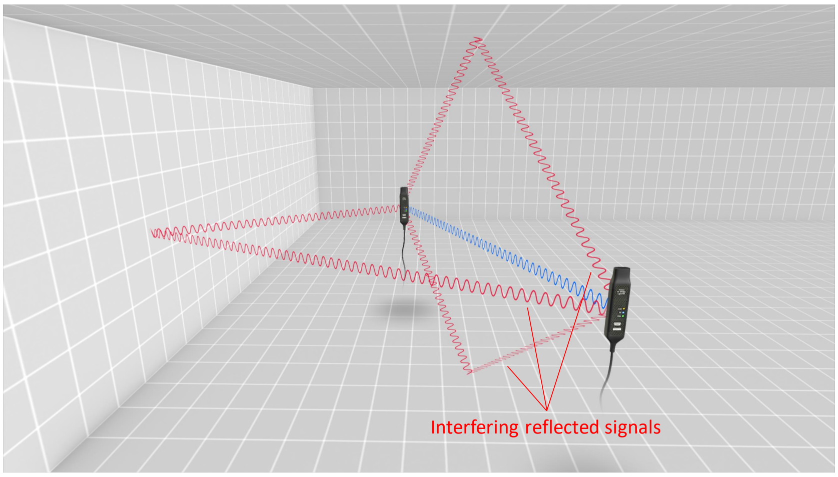

Figure 12: Multipath interference caused by ground, floor, walls and ceiling.

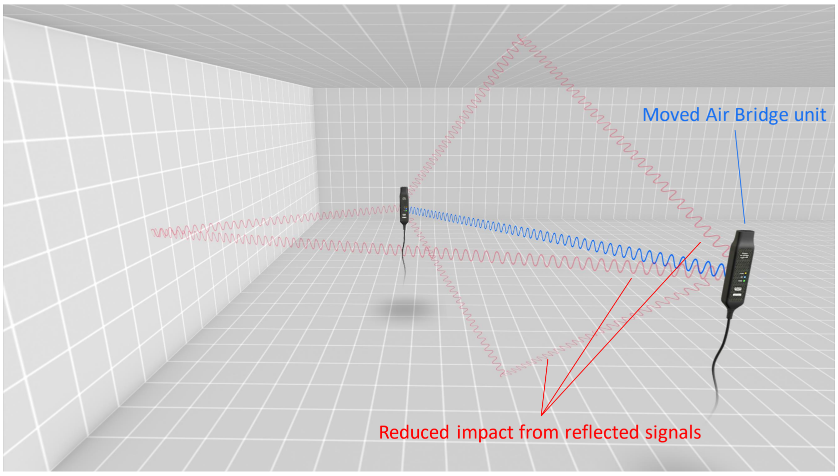

Figure 13: A slight adjustment in location may improve signal conditions.

4 Radio propagation considerations

4.1 Antenna radiation

One of the most common antennas used for radio communication is the dipole antenna. An ordinary dipole antenna has an antenna pattern which is “omnidirectional”, meaning a horizontal 360 degree coverage when it is mounted vertically, which is normally the case. The dipole antenna, however, does not exhibit a fully spherical coverage. In fact, a vertically mounted dipole antenna radiates less in upwards and downwards directions and most along the horizontal plane. The radiation pattern of the Kvaser Air Bridge is pretty much like that of a dipole antenna and the corresponding pattern for a receiving antenna is more or less identical. See Figure 14 for a depiction of the radiation intensity around a dipole antenna.

4.2 Polarization

All radio waves are in some way polarized and the dipole antennas always emit linearly polarized radio waves. If a dipole antenna is mounted vertically, the radio waves that propagate along the horizontal plane are said to be vertically polarized, regardless of the azimuth in which they propagate. The best reception of radio signals in this case is obtained if the receive dipole antenna is oriented vertically as well. Normally, the orientation is not all that critical, but may be worth while considering. In essence, the orientation of a dipole antenna should be perpendicular to the three-dimensional direction of propagation (dashed line in Figure 14), and the one-dimensional extension of the dipole should be in the same plane (pink plane in Figure 14, representing the polarization of the electrical field component of the radio wave) as the other dipole antenna with which it is intended to communicate. Dipoles are depicted as black rods in Figure 14.

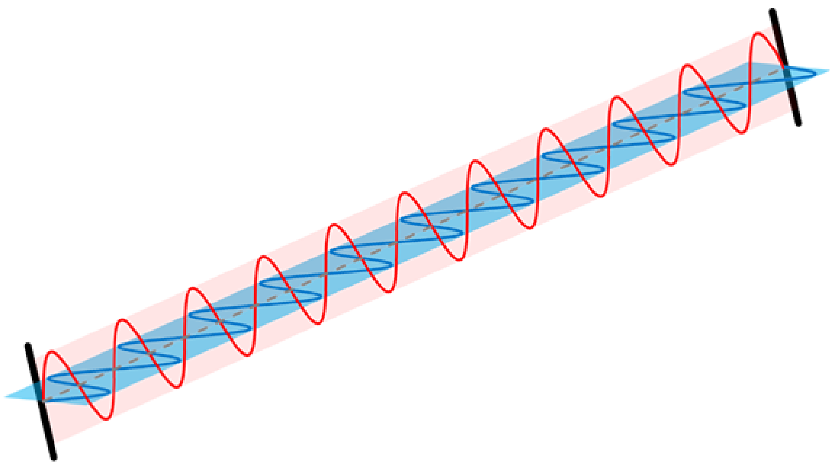

Figure 14: Electromagnetic wave and dipole antenna orientation.

4.3 Free space propagation

Radio signals as they travel through space have a power level that decreases with distance. This reduction in power level is often referred to as free space loss, even though it in fact is a result of spreading the power over a greater area or cross section. The power level is hence reduced by a factor four if the distance is increased by a factor two. The same applies to emitted interference. Therefore, increasing the distance to a source of interference may be just as relevant as reducing the distance between communicating radios.

4.4 Attenuation

Radio signals may pass through different materials but will then experience an attenuation or weakening of the power level, partly due to energy absorption. Besides thickness, the attenuation depends heavily on material. Non-metallic materials such as wood and plastic, e.g. cause relatively limited attenuation whereas metals may essentially block the radio waves. Also, denser materials such as concrete walls generally cause more attenuation than wood or plastics. Also, grids and meshes will cause attenuation depending on the wavelength of the radio waves. Sheet metals and meshes of metal wires are also commonly used as shields to protect from unwanted radio waves.

4.5 Reflection

Radio waves that encounter an object may to an extent pass through that object or be absorbed in the object. This depends on the electrical and magnetic properties of the object's material. The energy that doesn't pass through or becomes absorbed will be reflected. Hence, a reflected radio wave may be reduced in strength but not necessarily that much. This also depends on the incident angle between the radio wave and the object's surface. The angle of reflection is always equal to the incident angle and the reflected radio wave will experience a certain phase shift that depends on incident angle and material properties.

4.6 Multipath interference

A transmitted radio signal may reach a receive antenna in multiple ways. Normally, in line-of-sight conditions there will be a direct wave from the transmitter. But there may also be several indirect radio waves that are the result from reflections in the floor, walls etc. These waves combine in the receiving end which will have an impact on the signal level. The resulting signal may be either strengthened or weakened depending on the strengths of the reflected radio waves and their phase in relation to the direct wave. This phenomenon is commonly known as multipath interference. The strength and phase shifts depend on the traversed length of the radio wave and the strength and phase shift of the reflections.

5 Radio performance considerations

This section describes the underlying physical phenomena behind the ‘rules of thumb’. It provides a detailed look at considerations related to interference and radio link performance.

5.1 Signal to noise ratio

For optimal communication, a radio signal needs a certain advantage over noise in the receiver: a minimum signal-to-noise ratio (SNR). Figure 15 shows the power level of a radio signal in the presence of noise that a receiver needs to cope with.

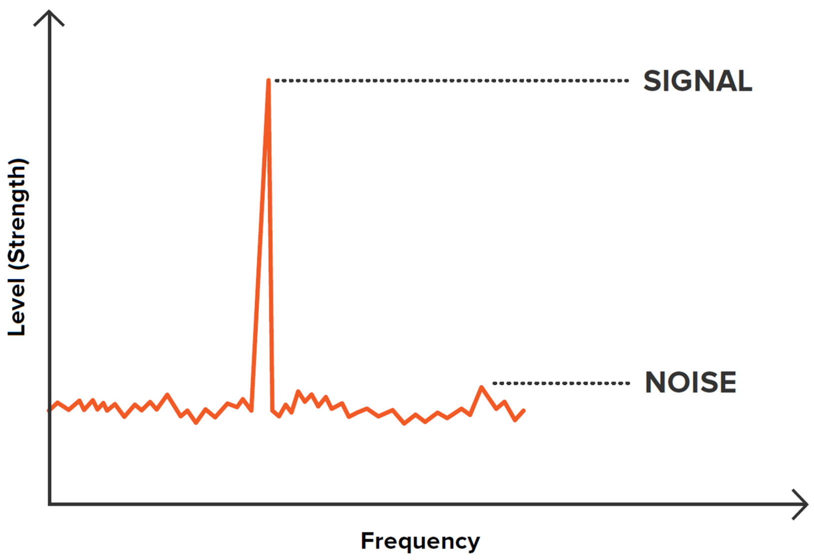

Figure 15: A radio signal in the presence of noise.

Noise in the receiver consists of internal noise in the receiver circuitry and external noise that is picked up by the antenna. The noise may hence emanate from any interfering emitter.

5.2 Link margin

In practice, further advantage is required to counter the effects of signal strength variation and radio interference. This additional advantage is often referred to as “link margin”. The link margin corresponds to the longest practical communication distance. This includes consideration of interference and other negative effects on the radio signal propagation that may be caused by the surrounding physical structures and atmospheric conditions such as rain. For this reason, the link margin may need to take into account both the negative impact of interfering emitters in the nearby area and the negative effects on the radio wave propagation. These negative effects combine, and the appropriate link margin may well be different depending on use cases and scenarios. Also, the desired performance level of the radio link, usually capacity and packet error rate, will greatly influence the determination of what is an adequate link margin and what is an insufficient link margin.

5.3 Interference by other emitters

Emitters close to the Kvaser Air Bridge units can affect the reception of the radio signal and the transmitter function of the Kvaser Air Bridge units.

Emitters may interfere in such a way that noise from emitters adds to the internal noise of the receiver within the Kvaser Air Bridge unit, resulting in a reduced link margin.

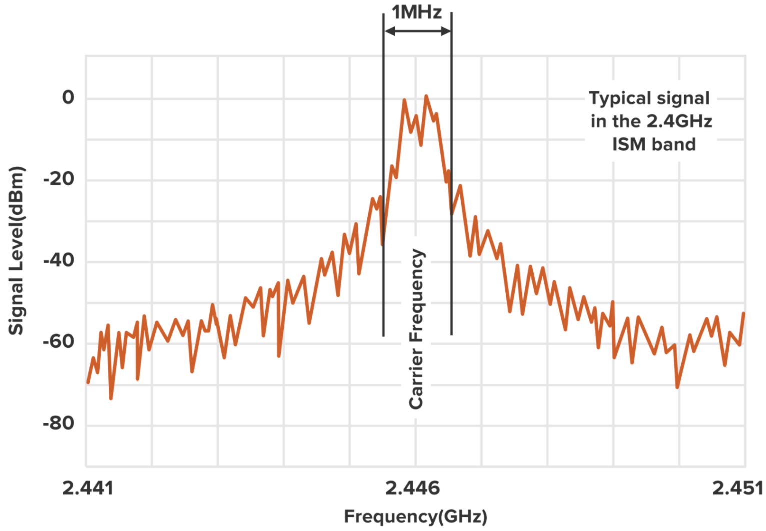

Figure 16: A typical radio signal from a 2.4 GHz transmitter.

Figure 16 shows an example of the spectrum of a transmitted signal with a 1 MHz occupied bandwidth. The elevated power level near the carrier frequency, shows clearly that the transmitted energy may have an impact on nearby receivers being tuned to a frequency close to that of the transmitter.

In the case of very close emitters, the signal itself can block the receiver circuitry in any radio device.

Emitters may also interfere in such a way that a radio device regards the presence of radio energy as if that particular frequency is occupied and therefore choses to transmit on the next available frequency.

5.4 Interference countermeasures

As all emitters certified for use in the 2.4 GHz ISM band do not simultaneously occupy the whole frequency band, an emitter within interfering distance of a Kvaser Air Bridge unit will not normally interfere with all of the frequencies employed by a Kvaser Air Bridge. The frequency hopping approach used by the Kvaser Air Bridge waveform is designed to provide the best combination of throughput and latency, especially in the presence of interfering emitters. Kvaser Air Bridge provides a retransmission procedure to reduce the impact of packet errors and thereby to secure the transfer of messages.

As demanded by the relevant standards, the Kvaser Air Bridge's frequency hopping approach ensures the coexistence of other radio transceivers in the same band. Nevertheless, these other transceivers may experience a degraded throughput when used in very close proximity to a Kvaser Air Bridge unit.

6 Version history

Version history for document IN_98234_air_bridge_installation_guide:

Revision	Date	Changes
1.0	2021-03-16	Initial revision