HART COMMUNICATION FOUNDATION

TECH NOTE

Co-Existence of WirelessHART with other Wireless Technologies

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Synopsys:

The IEEE 802.15.4 radios specified by the WirelessHART specification use the same 2.4 GHz Industrial, Scientific, and Medical (ISM) non-licensed frequency band as several other wireless technologies. There have been several studies on how these technologies may interfere with one another however; this research has focused on the use of a single wireless channel of operation. WirelessHART utilizes new advancements such as channel hopping and mesh networking to ensure co-existence with other wireless networks.

Co-Existence

Co-existence is defined as "The ability of one system to perform a task in a given shared environment where other systems have an ability to perform their task and may or may not be using the same set of rules."[i] Successful co-existence is measured by the reliability of each network to deliver its messages to the desired destination. Therefore, each network must be able to accomplish its objective while not disrupting the ability of another network to complete its objective.

Problems can occur when two or more packets of information are transmitted at the same time and frequency such that they "collide" in the same physical space. If networks aren't designed to minimize or avoid these occurrences, unreliable communications will result.

There are several techniques that can be used to minimize network interference:

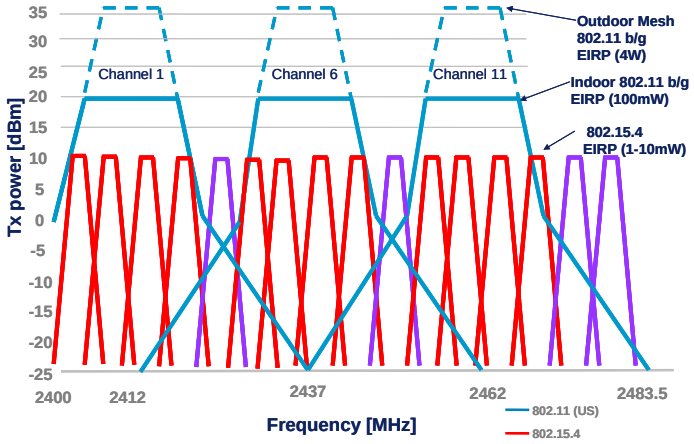
- Channel hopping – changing the frequency channel
- Time Division Multiplexing – varying the time of communications
- Power Modulation – low power transmission
- Direct Sequence Spread Spectrum
- Mesh networking supports large physical space with low power instruments
- Blacklisting and channel assessment

In the data link layer of the WirelessHART protocol, packet acknowledgment with automatic retry assures data is not lost if interference does happen to occur.

Channel Hopping

As specified by IEEE802.15.4, the 2.4 GHZ ISM frequency band is divided into 16 non-overlapping frequency channels. WirelessHART instruments use a pseudo-random channel hopping sequence to reduce the chance of interference with other networks, such as IEEE802.11b/g (Wi-Fi) which operates in the same ISM frequency band.

The figure below shows the potential of overlap between IEEE802.11g and IEEE802.15.4 radios. Since the 802.11b/g channels are wider, there are only 3 non-overlapping channels for Wi-Fi networks. A given IEEE802.11 Wi-Fi access point will only use 1 of the 3 non-overlapping channels and will only broadcast periodically, so the channel is not in continuous use. Pseudo-random channel hopping inherent to WirelessHART instruments ensures that they do not fix on using a channel being used by an IEEE802.11b/g network for any lengthy period of time. Together with the other techniques listed above, the probability of interference is minimal either way.



Time Division Multiplexing

A WirelessHART network utilizes Time Division Multiple Access (TDMA) technology to ensure that only one instrument is talking on a channel at any given time. This prevents message collisions within the WirelessHART network. A network is provided with an overall schedule which is divided into 10 msec timeslots. At any time, only one pair of instruments are communicating on the same frequency channel, however, it is possible that more than one pair of instruments can communicate at the same time using different channels. In most cases, only one pair of instruments is communicating in a given timeslot so the WirelessHART network will not monopolize the frequency spectrum that is shared with other wireless networks.

Power Modulation

The IEEE802.15.4 radios were chosen because they are relatively low power instruments suited to wireless process control applications, as well as being readily available at a reasonable cost. The radios are used with 10dB amplifiers to allow communication of up to 200m to the next instrument, which in turn can serve as a router to pass the message along. In cases where the full distance is not required, WirelessHART instruments can transmit at a lower power to reduce the chance of interfering with other networks in the ISM frequency band. The lower transmit power of WirelessHART instruments also means that any chance of interfering with a IEEE802.11b/g Wi-Fi network is small.

Direct Sequence Spread Spectrum

Direct Sequence Spread Spectrum (DSSS) technology provides about 8dB of additional gain utilizing unique coding algorithms. The transmission is spread over the entire frequency of the selected 802.15.4 channel. Devices with the correct decoding information can receive the data while others see the transmissions as white noise and disregard it. This allows multiple overlapping radio signals to be received and understood only by other devices in their own networks.

Mesh Networking

The use of mesh networking technology complements the use of the low power IEEE802.15.4 radios. With mesh networking, instruments do not need to have a direct transmission path to the network gateway. It is only required that any instrument be able to communicate to any other instrument in the mesh network. Each WirelessHART field instrument is capable of routing the message of other instruments along a route that will ensure the message is received at its ultimate gateway destination. Mesh networks also provide path redundancy and thus achieve better reliability than if each instrument were required to have a direct line of sight path to the gateway. The mesh network can adapt to changing communication and other environmental conditions to find a reliable communication path to the gateway.

Physical separation of >1m between WirelessHART instruments and Wi-Fi access points is all that is required for peaceful coexistence between the two types of wireless networks.

Blacklisting and Channel Assessment

In conjunction with channel hopping the WirelessHART network can be configured to avoid specific channels that are highly utilized by other networks and therefore likely to provide interference. However because most networks are not loaded continuously this is rarely required.

To further avoid any conflict with other neighboring networks a WirelessHART instrument listens to the frequency channel prior to transmitting data. If other transmissions are detect the WirelessHART instrument will back off and attempt the communication in another timeslot on a different frequency.

Summary

The WirelessHART technology was designed specifically to work in the 2.4GHz ISM band in an environment where other wireless networks are expected to be found. Using techniques such as channel hopping, time division multiple access, low power, mesh networking, and direct sequence spread spectrum coding allow a WirelessHART network to maintain high data reliability and at the same time minimize, if not eliminate, any effect it has on other overlapping networks.

[i] IEEE Std 802.15.2-2003, Part 15.2: Coexistence of Wireless Personal Area Networks with Other Wireless Instruments Operating in Unlicensed Frequency Bands, 28 August 2003.