

# FACTORS OF BLUETOOTH TECHNOLOGY TO MITIGATE INTERFERENCE WITH WIFI

## TECHNICAL BRIEF

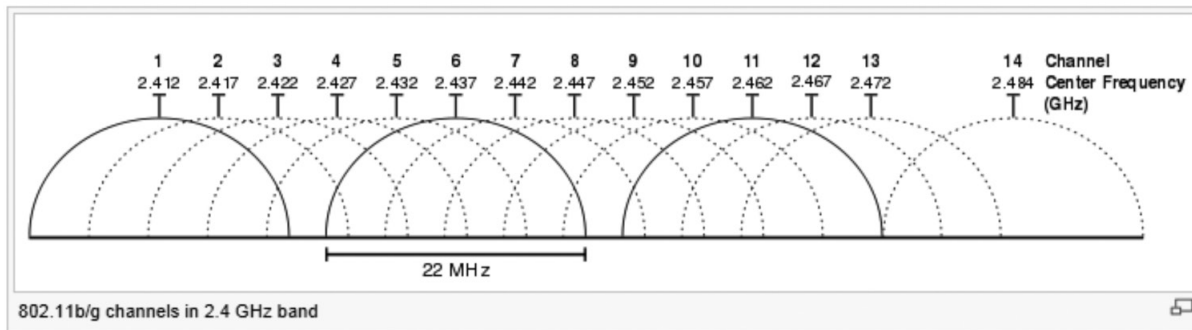
### FACTORS OF BLUETOOTH TECHNOLOGY TO MITIGATE INTERFERENCE WITH WIFI

## BLUETOOTH

Bluetooth wireless technology (BT) operates in the unlicensed Industrial, Scientific, Medical (ISM) band in the 2.4GHz frequency range. It randomly uses 79 1Mhz wide channels ranging from 2.402MHz to 2.480MHz. Each channel is occupied for a maximum time slot of 625us. During this time the radio must change the operating frequency, receive or transmit data, and provide enough off time before switching to the next hop frequency. In reality, the time the radio is actually transmitting on a given channel is much less and is dependent on the amount of data being transmitted.

## WIFI

WiFi or 802.11 b/g, also operates in the same ISM band as BT. Due to complicated modulation techniques, 802.11g channels are 20MHz wide while 802.11b channels are 22MHz wide. This means a common WiFi channel can occupy from 20 to 22 BT channels.



COURTESY: [HTTP://EN.WIKIPEDIA.ORG/WIKI/IEEE\\_802.11B-1999](http://en.wikipedia.org/wiki/IEEE_802.11B-1999)

## INTERFERENCE

For an RF signal to be received by the radios receiver, the RF signal must contain enough energy to be detected by the receiver circuit. The minimum receive level is known as the receivers sensitivity. This is similar to the lowest whisper that a human ear can detect. What if there happens to be two signals present at the same time and both are greater than the receiver's sensitivity? Which signal will the radio detect? One would think that it would not be able to correctly detect either signal. That would be true if both signals are close to the same power level. If one signal had a higher power level than the other signal by a specific amount, the radio would be able to detect the more powerful signal. This is similar to a human ear being able to clearly understand members at a dinner table while there are many others talking at tables that are further away. The minimum ratio of power level for two signals when a radio can correctly detect the desired signal is known as the carrier/interferer ratio, or C/I. This means that two RF signals can exist on the same frequency at the same time without causing interference if the ratio of their power levels meet the radios C/I specification.

## INTERFERENCE AVOIDANCE

There are several ways to avoid interference. One would be to use different radio frequencies such as assigning one WiFi access point (AP) to a specific channel and a neighboring AP to a different channel. This is commonly done using WiFi channels 1, 6, 11. This is known as frequency division. With only 3 channels to choose from, how do you fill a manufacturing floor with APs? As long as APs that are using the same channel are spaced far enough away so that the power level from the next closest same channel AP is much less than the power level of the nearer AP then both devices and APs will have no issues detecting the correct signal. This can be applied to BT devices as well. Motorola's BT devices transmit much less power than WiFi devices. Therefore if a WiFi device and BT scanner are the same distance from an AP, the AP will have no problem detecting the WiFi device. However if the BT device and WiFi device are close to each other, the WiFi device may detect the BT signal periodically and cause interference. This would depend on the distance from the AP. As the distance increases the signal from the AP decreases and may be the same level or lower than the BT devices signal. This was identified as a problem early on by Symbol Technologies with version 1.1 of the BlueTooth Specification, where a proprietary avoidance mechanism was put in place on early BT devices. This concept has since been adopted and is now mandatory in all BT devices.

## TECHNICAL BRIEF

### FACTORS OF BLUETOOTH TECHNOLOGY TO MITIGATE INTERFERENCE WITH WIFI

## ADAPTIVE FREQUENCY HOPPING

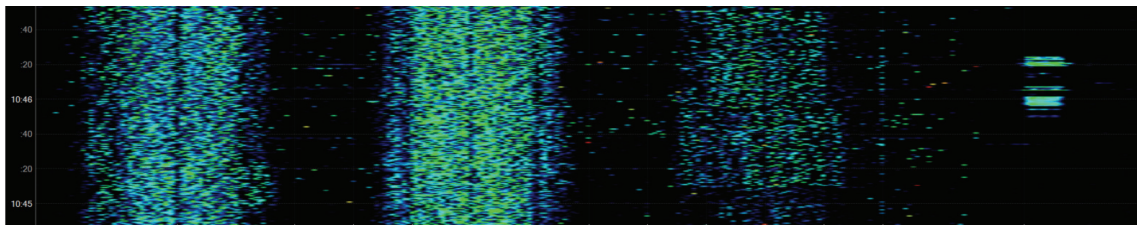
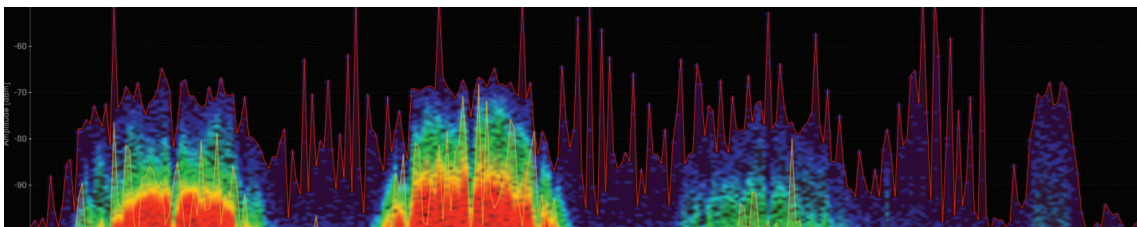
The BT Special Interest Group, the group which governs over the BT specification, addressed this interference issue in BT version 1.2 late in 2003 by adding adaptive frequency hopping to the standard. In adaptive frequency hopping, the BT radio must listen to all BT channels and detect radio energy. Once RF energy is detected it marks the channel as 'active' and communicates this to the device that it is communicating with. Together, they remove all channels that either radio has detected energy on and no longer use them in their hop sequence. All Motorola Solution barcode scanners employ Adaptive Frequency Hopping. This means that in the case where the BT scanner and WiFi device are in close proximity, the BT device will hear the WiFi device communicating to the AP and mark the channels that correspond to WiFi channel being used. With the BT channels that overlap on top of the WiFi channels removed from the hop sequence, interference has been eliminated. As the number of channels is reduced there is an increased risk of BT channel collisions. Each collision causes the transmit time to increase by 625us. As you will see later, the use of sniff mode and the earlier C/I discussion limits the risk of collisions. There are still enough channels remaining in the hop sequence for BT to operate properly.

## OTHER OPERATING PRACTICES

There are other modes of operation that Motorola's scanners use to further limit RF interference. To both improve battery life and limit RF energy, Motorola scanners use a lower power mode defined in the BT specification called Sniff Mode. In this mode the scanner and cradle stop communicating for a period of time. This time is chosen so the scanner can still transmit data after a good decode quickly but can remain off the air by a factor of 100. To further reduce power and save energy, Motorola scanners also use a power control scheme. The radio measures the incoming signal from the device that it is communicating with and if the signal is beyond the radios sensitivity level with enough margin, the radio pair will communicate with each other to lower the transmit power. Both of these concepts improve all neighboring devices C/I ratio and further reduces interference with other BT piconets and WiFi devices. Motorola barcode scanners are defaulted out of the box as non-discoverable. This removes the risk of an employee finding our device during a search and attempting to create a connection to the device. Another positive behavior of Motorola barcode scanners is how they behave when they either go out of range or loose communication with the device that it is communicating with. They do not continuously try to re-connect. They go to a low power state and transmissions stop. They try to re-connect only upon a trigger pull or when placed back into the cradle. This eliminates interference issues seen on other BT products that continuously attempt to reconnect which causes continuous interference with all 2.4GHz devices. These operating features make Motorola scanners a wise choice compared to other BT scanners as they help to eliminate interference in several ways.

## RF SPECTRUM SURVEY RESULTS

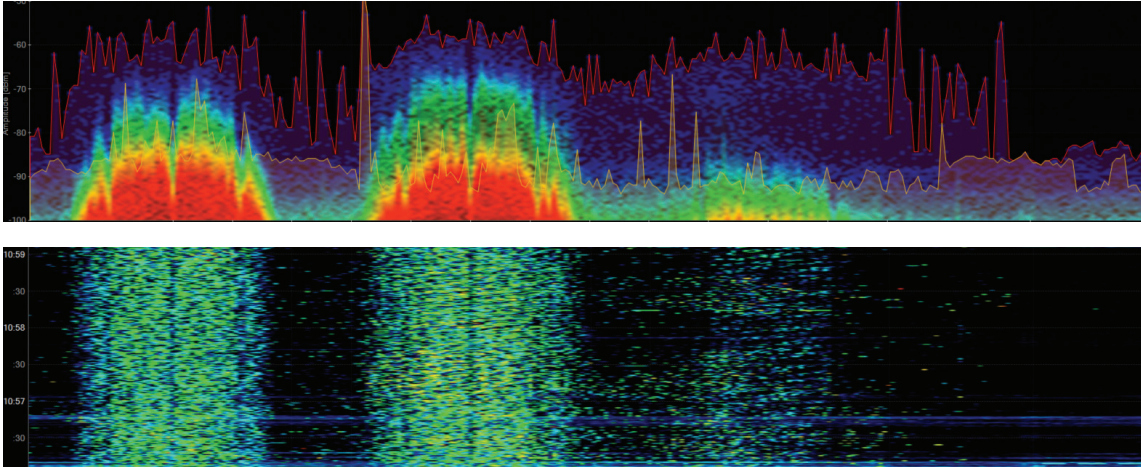
The figures below show two different RF spectrum traces in the 2.4GHz band obtained in two different locations in a manufacturing plant.



IT OFFICE AREA

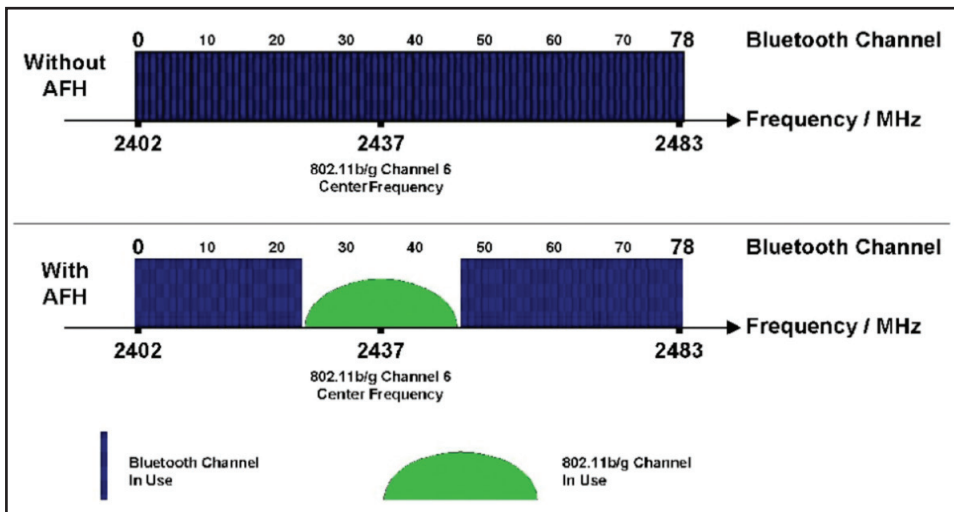
## TECHNICAL BRIEF

### FACTORS OF BLUETOOTH TECHNOLOGY TO MITIGATE INTERFERENCE WITH WIFI



ASSEMBLY AREA

In the IT office area, WiFi channel 6 is in use. Channel 1 is also in use but appears to be further away from this area and the received power level is much less. The BT channels associated with the frequencies used for WiFi channel 6 need to be removed from the BT hop sequence. The BT channels associated with WiFi channel 1 may not have much impact on the WiFi since the AP is a considerable distance away, but the BT channels are likely to be removed as well. The BT channels associated with WiFi channel 11 do not need to be marked as active since the energy level is weak. The space between the WiFi channels will be used by BT. In the assembly area, both WiFi channel 1 and 6 need to be removed from the hop sequence. Channel 11 has very low energy. An illustration of the removal of BT channels associated with WiFi channel 6 is shown below.



COURTESY: EETIMES.COM

## CONCLUSION

Use of Motorola's Bluetooth Barcode Scanners in a WiFi environment will not interfere with WiFi devices. Making use of Adaptive Frequency Hopping, Automatic Power control, and intelligent link management all play together to assure that both technologies play nice together without interference.

To view a wide selection wireless barcode scanners visit: [motorolasolutions.com/wlan](http://motorolasolutions.com/wlan).

Part number TB-BT-WIFI. Printed in USA 12/13. MOTOROLA, MOTO, MOTOROLA SOLUTIONS and the Stylized M Logo are trademarks or registered trademarks of Motorola Trademark Holdings, LLC and are used under license. All other trademarks are the property of their respective owners. ©2013 Motorola Solutions, Inc. All rights reserved.