

# The Bluetooth wireless technology

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## Abstract

*The Bluetooth wireless technology comprises hardware, software and interoperability requirements. It is a global standard that eliminates wires and cables between devices, facilitates both data and voice communication and offers the possibility of ad hoc networks. Bluetooth technology is not limited to point-to-point connections and does not require a clear line-of-sight. Bluetooth technology is used by all major players in the telecom, computer and home entertainment industry and also in such diverse areas as the automotive industry, health care, automation etc.*

## 1. Introduction

Bluetooth wireless technology is a wireless standard that defines short-range radio link between devices (for example between mobile phones, pagers, PDAs, computers, etc.) without wires or cables. More than just a replacement for cables, Bluetooth provides a wireless way to connect computers with all types of portable, electronic devices, forming small, private networks often referred to as PANs (personal area networks).

## 2. A history of Bluetooth

The idea that resulted in the Bluetooth wireless technology was born in 1994 when Ericsson, a Swedish telecommunications company, decided to develop a low-power, low-cost radio interface between mobile phones and their accessories to replace wires and cables used today to connect the two devices. In February 1998, the Special Interest Group (SIG) was formed. The group was organized by nine Bluetooth promoters: 3Com, Ericsson, IBM, Intel, Lucent Technologies, Microsoft, Motorola, Nokia, Toshiba. The purpose of the group was to monitor the development of Bluetooth, making it a global, open, short-range radio standard that would permit interoperability between all Bluetooth-enabled devices.

The first Bluetooth specification was released in July 1999 and Bluetooth-enabled devices became widely available in 2000.

Why is this technology called Bluetooth? Harald Bluetooth was a Viking and King of Denmark between 940 and 981. One of his skills was getting people to talk to each other, and during his rule Denmark and Norway were united. And according to King Harald new technology is called Bluetooth.

### 3. The Bluetooth frequency band and transmitter characteristics

The Bluetooth Specification defines a short range (around 10 meters) or optionally a medium range (around 100 meters) radio link capable of voice or data transmission to a maximum capacity of 720 kilobits per second (kb/s) per channel. Radio frequency operation is in the unlicensed industrial, scientific and medical (ISM) band at 2.40 to 2.48 GHz (but some countries can have national limitations in the frequency range – see Table 1.), The ISM band is divided into 79 channels, each of which has a bandwidth of 1MHz.

**Table 1. Operating frequency bands**

Geography	Regulatory Range	RF Channels
USA, Europe and most other counties <sup>1)</sup>	2,400 – 2,4835 GHz	$f = 2405 + k$ MHz $k = 0, \dots, 78$

Note 1. The Bluetooth Specification includes a special frequency hopping pattern to provide provisions for compliance with national limitations like in France. The frequency range for France is 2.4465 - 2.4835 GHz and the corresponding RF channels are  $f = 2454 + k$  MHz,  $k = 0, \dots, 22$ .

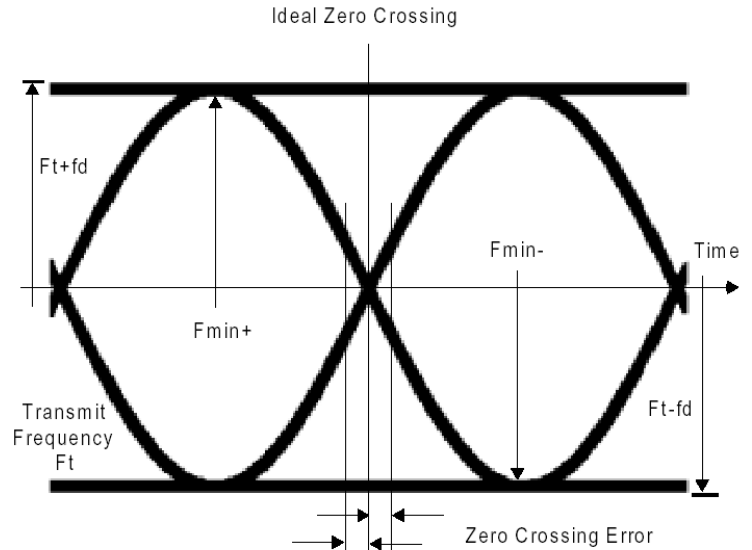
Bluetooth technology uses a spread spectrum, frequency hopping and full-duplex signal at a nominal rate of 1600 hops/sec. The signal hops among 79 frequencies at 1 MHz intervals because of a high degree of interference immunity. The equipment is classified into three power classes according to RF Output (Table 2.).

**Table 2. Power classes**

Power Class	Max. Output Power	Nominal Output Power	Min. Output Power
1	100 mW (20 dBm)	N/A	1 mW (0 dBm)
2	2,5 mW (4 dBm)	1 mW (0 dBm)	0,25 mW (-6 dBm)
3	1 mW (0 dBm)	N/A	N/A

The Modulation is GFSK (Gaussian Frequency Shift Keying) with a BT=0.5. The Modulation index must be between 0.28 and 0.35. A binary one is represented by a

positive frequency deviation and a binary zero is represented by a negative frequency deviation (see Figure 1.).



**Figure 1. Actual transmit modulation**

Because the ISM band is free and unlicensed, one potential problem with using it is the possibility of interference from other devices and appliances that also operate in this band. Good solution is reducing interference by frequency hopping. The signal hops among 79 frequencies at 1 MHz intervals to give a high degree of interference immunity with a nominal rate of 1600 hops/sec (Figure 2.).

### 4. Voice and data communication

The Bluetooth technology uses up to three simultaneous synchronous voice channels or a channel that simultaneously supports asynchronous data and synchronous voice. Each voice channel supports a 64 kb/s synchronous (voice) channel in each direction.

The asynchronous data channel can support maximal 723.2 kb/s asymmetric (and up to 57.6 kb/s in the return direction) or 433.9 kb/s symmetric.

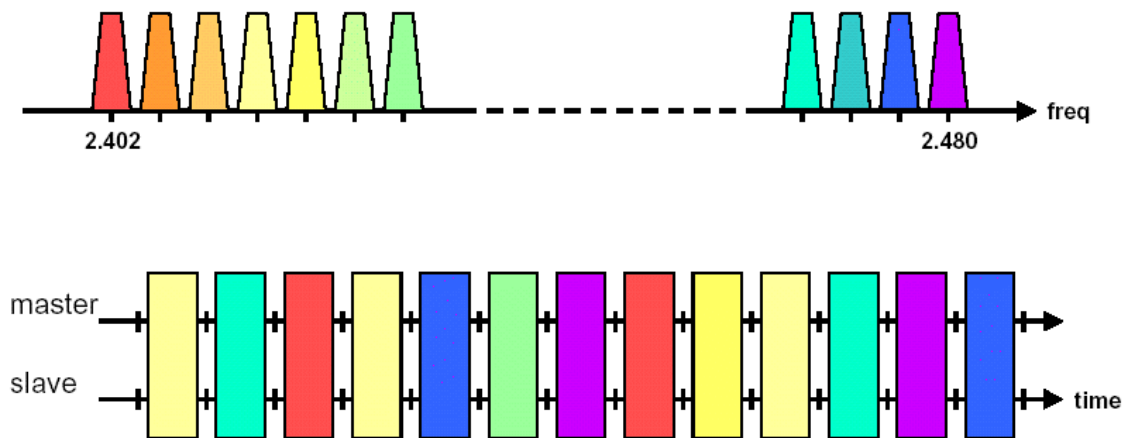


Figure 2. Frequency hopping

## 5. Network Topology

Bluetooth units that come within range of each other can set up ad hoc point-to-point and/or point-to-multipoint connections. Units can dynamically be added or disconnected to the network. Two or more Bluetooth units that share a channel form a piconet. Several piconets can be established and linked together in ad hoc scatternets to allow communication and data exchange in flexible configurations. As many as 10 piconets within a range can form a scatternet.

After two devices have established a connection, one is set as the “master” and the other becomes the “slave” because of control traffic of each piconet’s hopping scheme (Figure 3.).



Figure 3. Typical piconet

In a piconet, a single master device controls up to seven active slave devices. Each piconet is established with a different frequency-hopping scheme, determined by the master, and all devices in the same piconet are synchronized to this hopping scheme. Each piconet works independently and has access to full bandwidth. The piconet can also include as many as 255 parked slaves, which are devices synchronized with the piconet but not actively sending or receiving signals.

## 6. Bluetooth security

Radio signals can be easily intercepted, so security is a concern with Bluetooth. Bluetooth devices have built-in security to prevent eavesdropping or falsifying the origin of messages (spoofing). Firstly, FHSS provides basic protection by requiring that each data transmission use a specific sequence of channel hopping and only the sending and receiving devices know that sequence. Secondly, Bluetooth has a challenge-response authentication routine that verifies the receiving unit is valid. Thirdly, the Bluetooth standard supports 128-bit key encryption to ensure a secure transmission between devices.

Three entities are used in the security algorithms - the Bluetooth device address (48 bits, public entity unique for each device), a private user key (128 bits, secret

entity that is derived during initialization and is never disclosed) and a random number (128 bits, different for each new transaction).

## 7. Conclusion

Certainly, Bluetooth is growing in popularity; statistics (<http://www.instat.com>) indicate that Bluetooth chip sales have surpassed those of 802.11 wireless technology. Other competing standards such as IrDA (Infrared Data Association), Wireless LANs based on the IEEE 802.11 standard, Home RF (radio frequency) and UWB (ultra-wideband radio) exist, but Bluetooth technology has lot of advantages. The Bluetooth technology is not limited to point-to-point connections and doesn't require a clear line-of-sight like IrDA. Wireless LANs have high transmission capacity and also the number of simultaneous users. On the other hand it is, compared to Bluetooth wireless technology, more expensive, power consuming and the hardware requires more space and it is

therefore not suited for small mobile devices.

But the future of Bluetooth depends upon companies continuing to incorporate Bluetooth chips into their devices. This seems to be happening, as reported by Cahners In-Stat, which estimates that Bluetooth chip sales will reach 780 million by 2005.

## 7. References

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