

Operational description

General

Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz, using a spread spectrum, frequency hopping, full-duplex signal at a nominal rate of 1600 hops/sec. Bluetooth uses Gaussian Frequency Shift Keying. The signal hops among 79 frequencies at 1 MHz intervals to give a high degree of interference immunity. The physical channel is sub-divided into time units known as slots. A slot is 625usec. Data is transmitted between Bluetooth enabled devices in packets that are positioned in these slots. To operate Bluetooth communication, there must be at least two Bluetooth devices. One device provides the synchronization reference and is known as the master. All other devices are known as slaves. A group of devices synchronized in this fashion form a piconet. Any time a Bluetooth wireless link is formed, it is within the context of a piconet. A piconet consists of two or more devices that occupy the same physical channel (which means that they are synchronized to a common clock and hopping sequence). The common (piconet) clock is identical to the Bluetooth clock of one of the devices in the piconet, known as the master of the piconet, and the hopping sequence is derived from the master's clock and the master's Bluetooth device address. All other synchronized devices are referred to as slaves in the piconet. A Bluetooth enabled device that is a member of two or more piconets is said to be involved in a scatternet. Within a common location a number of independent piconets may exist. Each piconet has a different physical channel (that is a different master device and an independent piconet clock and hopping sequence). A Bluetooth enabled device may participate concurrently in two or more piconets. It does this on a time-division multiplexing basis. A Bluetooth enabled device can never be a master of more than one piconet. (Since the piconet is defined by synchronization to the master's Bluetooth clock it is impossible to be the master of two or more piconets.) A Bluetooth enabled device may be a slave in many independent piconets. Mag uses a 3.7V Li-Ion battery. An AC adaptor is used to charge the battery. The all input power is from the battery. LDO is used to separate 3V, 2V, and 1.8V to the hardware circuits from the battery. The regulator uses TC1017_3.0VCTTR, TC1017_1.8VCTTR and TC1071_2V. The antenna used by Mag is a SMD type Multilayer chip.

Co-ordination of the hopping sequence in data mode to avoid simultaneous occupancy by multiple transmitters:

Bluetooth units which want to communicate with other units must be organized in a structure called piconet. This piconet consist of max. 8 Bluetooth units. One unit is the master the other seven are the slaves. The master co-ordinates frequency occupation in this piconet for all units. As the master hop sequence is derived from it's BD address which is unique for every Bluetooth device, additional masters intending to establish new piconets will always use different hop sequences.

Example of a hopping sequence in data mode:

Example of a 79 hopping sequence in data mode:

40, 21, 44, 23, 42, 53, 46, 55, 48, 33, 52, 35, 50, 65, 54, 67, 56, 37, 60, 39, 58, 69, 62, 71, 64, 25, 68, 27, 66, 57, 70, 59, 72, 29, 76, 31, 74, 61, 78, 63, 01, 41, 05, 43, 03, 73, 07, 75, 09, 45, 13, 47, 11, 77, 15, 00, 64, 49, 66, 53, 68, 02, 70, 06, 01, 51, 03, 55, 05, 04

Equally average use of frequencies in data mode and short transmissions:

The generation of the hopping sequence in connection mode depends essentially on two input values:

1. LAP/UAP of the master of the connection
2. Internal master clock

The LAP (lower address part) are the 24 LSB's of the 48 BD_ADDRESS. The BD_ADDRESS is an unambiguous number of every Bluetooth unit. The UAP (upper address part) are the 24 MSB's of the 48 BD_ADDRESS. The internal clock of a Bluetooth unit is derived from a free running clock which is never adjusted and is never turned off. For synchronization with other units, only the offsets are used. It has no relation to the time of the day. Its resolution is at least half the RX/TX slot length of 312.5 μ s. The clock has a cycle of about one day (23h30). In most case it is implemented as 28 bit counter. For the deriving of the hopping sequence the entire LAP (24 bits), 4 LSB's (4 bits) (Input 1) and the 27 MSB's of the clock (Input 2) are used. With this input values different mathematical procedures (permutations, additions, XOR-operations) are performed to generate the sequence. This will be

done at the beginning of every new transmission.

Regarding short transmissions, the Bluetooth system has the following behavior:

The first connection between the two devices is established, a hopping sequence is generated. For transmitting the wanted data, the complete hopping sequence is not used and the connection ends. The second connection will be established. A new hopping sequence is generated. Due to the fact that the Bluetooth clock has a different value, because the period between the two transmission is longer (and it cannot be shorter) than the minimum resolution of the clock (312.5 μ s). The hopping sequence will always differ from the first one.

Receiver input bandwidth, synchronization and repeated single or multiple packets:

The input bandwidth of the receiver is 1 MHz. In every connection, one Bluetooth device is the master and the other one is the slave. The master determines the hopping sequence (see chapter 5). The slave follows this sequence. Both devices shift between RX and TX time slot according to the clock of the master. Additionally the type of connection (e.g. single or multi-slot packet) is set up at the beginning of the connection. The master adapts its hopping frequency and its TX/RX timing is according to the packet type of the connection. Also, the slave of the connection uses these settings. Repeating of a packet has no influence on the hopping sequence. The hopping sequence generated by the master of the connection will be followed in any case. That means, a repeated packet will not be send on the same frequency, it is send on the next frequency of the hopping sequence.
