R&S®CMU, R&S®CBT, R&S®CBT32, R&S®SMU, R&S®SMJ, R&S®FSQ, R&S®FSU, R&S®FSP, R&S®FSL

Bluetooth® Basics at a Glance

Application Note 1MA108

This Application Note provides a brief look at the most important parameters and terms in Bluetooth®. It also covers new developments such as Enhanced Data Rate (version 2.0+EDR).

ROHDE&SCHWARZ

Contents

1 Overview 3
2 Brief Introduction to Bluetooth 3
- Frequency band and channel spacing 3
- Frequency hopping 3
- Packets 3
  - Single-slot und multislot packets 3
  - Basic rate packet format (< version 2.0) 3
  - EDR packet format (version 2.0+EDR) 4
  - Overview of packets 4
- Modulation 5
  - Basic rate modulation (< version 2.0) 5
  - EDR modulation (version 2.0+EDR) 5
- Transmit power 6
- Receiver sensitivity 6
- Time-division duplex scheme 6
- Links 7
  - Synchronous connection-oriented (SCO) link 7
  - Asynchronous connectionless (ACL) link 7
- States 8
  - Standby 8
  - Active 8
  - Sniff 8
  - Hold 8
  - Park 8
- Piconet 8
- Profiles 8

3 Attachment 9
- Tests 9
  - Basic rate 9
  - EDR 10
- List of figures 11
- List of tables 11
- References 11

4 Additional Information 11
5 Ordering Information 11

1 Overview

Bluetooth® is a short-range radio technology (approx. 10 m to 100 m) used instead of cabling. Bluetooth can already be found in a variety of devices such as mobile phones, hands-free equipment, PDAs, GPS receivers, printers, and many more.

This Application Note provides a brief look at the most important parameters and terms in Bluetooth. It also covers new developments such as Enhanced Data Rate (version 2.0+EDR).

2 Brief Introduction to Bluetooth

Frequency band and channel spacing

Bluetooth operates in the unlicensed industrial, scientific, and medical (ISM) band of 2.4 GHz, which it must share with other applications such as WLAN. Although channel allocations initially differed region by region, 79 channels with 1 MHz spacing have now been defined in the range from 2402 MHz (channel 0) to 2480 MHz (channel 78).

Frequency hopping

To take full advantage of the available spectrum and to prevent interferences of or by other applications, pseudorandom frequency hopping at a nominal rate of 1600 hops per second is used. The hopping sequence is based on the Bluetooth address of the master.

To further enhance coexistence with WLAN, adaptive frequency hopping (AFH) was introduced in specification V1.2. AFH does not use all 79 channels. Instead, it uses only a limited range, where channels with known interferences are excluded.

Packets

Single-slot und multislot packets

All Bluetooth products must support single-slot packets. These packets have a maximum length of 366 µs (AUX1 packets) and thus fit in a timeslot of 625 µs, i.e. the maximum frequency hopping rate is attained. The payload might include a payload header and/or CRC depending on different packets. In addition, products *may* also support three timeslots and/or five timeslots. The frequency is not changed during a packet.

Basic rate packet format (< version 2.0)

Every (data) packet consists of an access code, a header, and its payload:

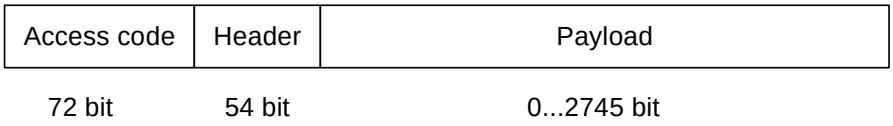

Fig. 1 - Packet format (basic rate)

The entire packet is GFSK-modulated.

EDR packet format (version 2.0+EDR)

An EDR packet contains the same access code and header (each GFSK) as a basic rate packet. In addition, a guard time area and a sync word area are inserted between the header and the payload. These two areas as well as the payload are DPSK-modulated.

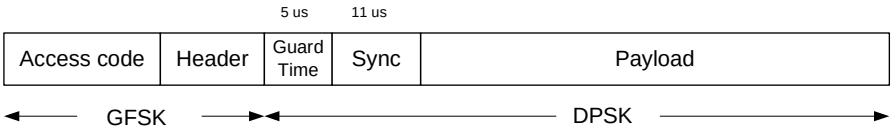

Fig. 2 - EDR packet format

Overview of packets

Table 1 provides a list of possible ACL packets. Rows 1 (DM1) to 7 (AUX1) are basic rate packets, and rows 8 (2DH1) to 13 (3DH5) are EDR packets.

Packet	Payload max. bytes	Max. rate (sym) kbps	Max. rate (asym) kbps	
			Forward	Reverse
DM1	17	108.8	108.8	108.8
DM3	121	258.1	387.2	54.4
DM5	224	286.7	477.8	86.4
DH1	27	172.8	172.8	172.8
DH3	183	390.4	585.6	86.4
DH5	339	433.9	723.2	57.6
AUX1	29	185.6	185.6	185.6
2DH1	54	345.6	345.6	345.6
2DH3	367	782.9	1174.4	172.8
2DH5	679	869.7	1448.5	115.2
3DH1	83	531.2	531.2	531.2
3DH3	552	1177.6	1766.4	235.6
3DH5	1021	1306.9	2178.1	177.1

Table 1 - ACL packets

Table 2 shows the possible SCO packets.

Packet	Payload bytes	Max. rate (sym) kbps
HV1	10	64.0
HV2	20	64.0
HV3	30	64.0
DV	10 + max. 9 for data	64.0 + 57.6 for data
EV3	30	196
EV4	120	192
EV5	180	288
2EV3	60	192
2EV5	360	576
3EV3	90	288
3EV5	540	864

Table 2 - SCO packets

Modulation

Basic rate modulation (< version 2.0)

For the basic rate, frequency modulation (Gaussian frequency shift keying) with a symbol rate of 1 Msymbol/s is used. This yields a gross data rate of 1 Mbps.

EDR modulation (version 2.0+EDR)

The data rate is enhanced by using two new types of modulation.

π/4-DQPSK

This type of modulation (two bits per symbol) makes it possible to increase the gross data rate to 2 Mbps. If a device is V2.0+EDR-compatible, this type of modulation must be supported.

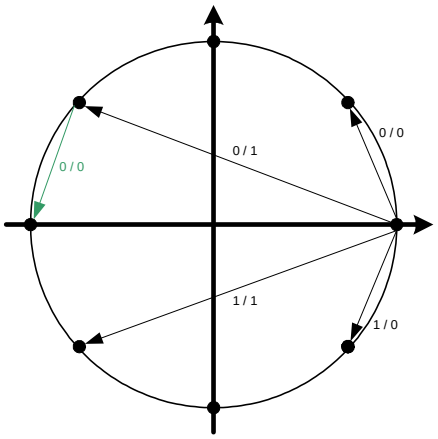

Fig. 3 - π/4-DQPSK

8DPSK

This type of modulation (three bits per symbol) makes it possible to increase the gross data rate to 3 Mbps. This type of modulation *may* also be supported in addition to π/4-DQPSK.

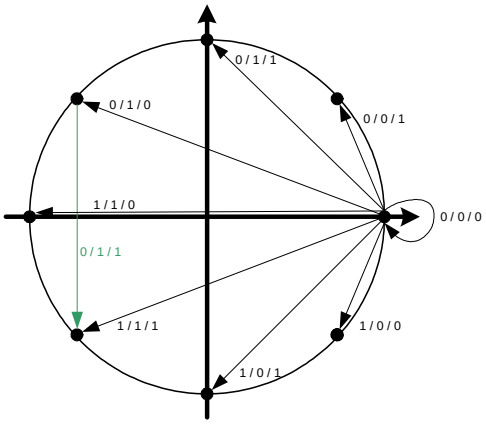

Fig. 4 - 8DPSK

Transmit power

Bluetooth products are divided into three power classes:

- Class 1: max. 20 dBm (100 mW)
- Class 2: max. 4 dBm (2.5 mW)
- Class 3: max. 0 dBm (1 mW)

In addition, a rough power control may be defined as an option, i.e. a specific command causes the device to respond with a positive (or negative) step between 2 dB and 8 dB. Moreover, the device issues a message when the maximum or minimum power is reached. However, this message does not have to be generated within a specific amount of time.

Receiver sensitivity

At a level of –70 dBm, a maximum bit error rate (BER) of 0.1 % is defined for the receiver. This level is called the "reference sensitivity level".

Time scheme

To provide master-and-slave communication in one channel, a time-division duplex (TDD) scheme has been defined. The frequency hopping (with a nominal rate of 1600 hops/s) yields a time division scheme of 625 µs.

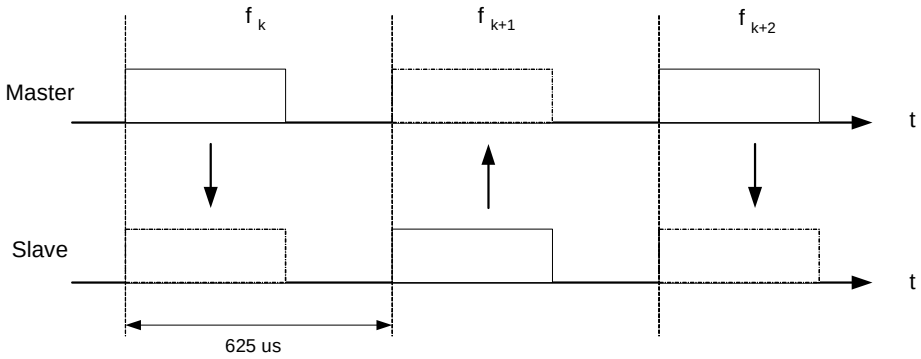

Fig. 5 - Timing scheme, single-slot

Fig. 5 shows the duplex scheme when using single-slot packets. Either the master or the slave transmits in each timeslot, and the frequency changes in every timeslot.

If longer packets are also used, the frequency is not changed until after the packet. The frequencies not used for transmitting the long packets are skipped (Fig. 6)

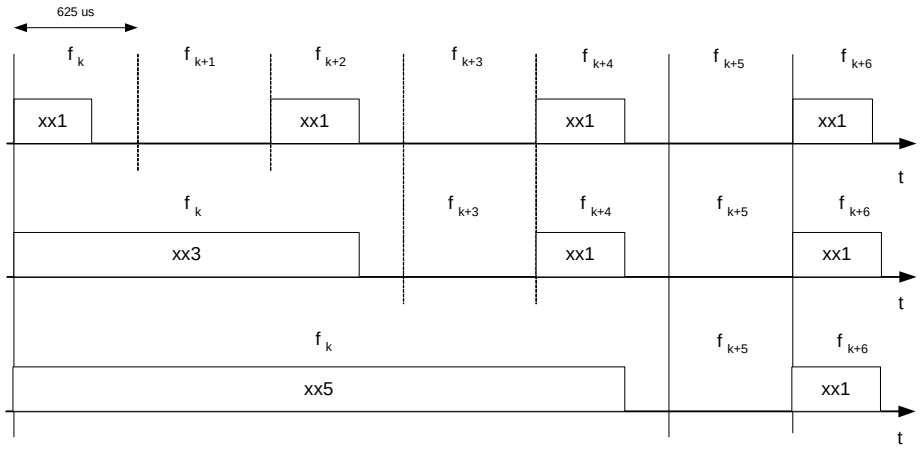

Fig. 6 - Timing scheme, multislot; xx1: single-slot packets, xx3/5: multislot packets

Links

Two link types are defined in Bluetooth.

Synchronous connection-oriented (SCO) link

The SCO link provides a point-to-point connection between the master and slave. Reserved, fixed timeslots with symmetric data rates are used for this purpose. SCO links are used for time-critical applications such as voice transmissions. The typical data rate is 64 kbps.

Asynchronous connectionless (ACL) link

The ACL link establishes a point-to-multipoint connection between a master and multiple slaves and uses timeslots that are not already occupied or reserved by SCO links. Both symmetric and asymmetric links are supported. If basic rate is used, the maximum net data rate is 433.9 kbps in symmetric operation and 723.2 kbps in asymmetric operation. If EDR is used, the corresponding values are 1306.9 kbps and 2178.1 kbps.

Bluetooth states

Standby

This is the default state in Bluetooth. A link is not set up.

Active

The device is part of an active link; packets are being exchanged.

Sniff

A link is present in which the master is transmitting to the slave but only on specific timeslots. The slave needs to be ready solely for these timeslots, thus saving energy (battery operating time).

Hold

In this connection mode, no more ACL packets are allowed. SCO packets can still be sent. This frees up time for other activities such as taking part in other piconets.

Park

In the park mode, a device does not actively participate in a piconet (see following description) but remains synchronized to the master. The device must wake up at regular intervals and resynchronize and "listen" for packets.

Piconet

A piconet consists of at least two and a maximum of eight Bluetooth products, where one device assumes the master role and thus defines the clock. All remaining devices are slaves. Each piconet has its own hopping sequence. A Bluetooth product can conduct an "inquiry", i.e. all remaining products (provided switched to visible) in the communications range respond by reporting their Bluetooth address and their capabilities. In a piconet, all devices must share the available resources (data rate!). Each link is initiated from the master. Up to three synchronous (SCO) links and one asynchronous (ACL) link can be held simultaneously for one slave.

Profiles

Two Bluetooth devices that want to exchange specific data must support the same profile. These profiles are implemented at the higher layers.

A large number of profiles are implemented, and the number is constantly increasing.

Examples:

- Advanced Audio Distribution Profile (A2DP): streaming of audio data
- Audio/Video Remote Control Profile (AVRCP): remote control for audio/video
- Basic Imaging Profile (BIP): transmission of image data
- Basic Printing Profile (BPP): printing
- Generic AV Distribution Profile (GAVDP): transmission of audio/video data
- Headset Profile (HSP) : voice output by means of a headset
- Hands-Free Profile (HFP): cordless telephone operation in an automobile

The CBT supports the following audio profiles:

- Headset Profile (HSP)
- Hands-Free Profile (HFP)

3 Attachment

Tests

The test specification [1] describes various RF tests. The following tables list these tests. The tables also indicate whether the CMU and/or the CBT support the individual tests. Some tests also require signal generators and spectrum analyzers.

Basic rate

Number	Name	CMU200/CBT
TRM/CA/01/C	Output power	yes
TRM/CA/02/C	Power density	yes
TRM/CA/03/C	Power control	yes
TRM/CA/04/C	TX output spectrum - frequency range	yes: remote only
TRM/CA/05/C	TX output spectrum - 20 dB bandwidth	yes
TRM/CA/06/C	TX output spectrum - adjacent channel power	yes
TRM/CA/07/C	Modulation characteristics	yes
TRM/CA/08/C	Initial carrier frequency tolerance	yes
TRM/CA/09/C	Carrier frequency drift	yes

Table 3 - Test specification, basic rate, transmitter

Number	Name	CMU200/CBT
RCV/CA/01/C	Sensitivity - single-slot packet	yes
RCV/CA/02/C	Sensitivity - multislot packet	yes
RCV/CA/03/C	C/I performance	yes, plus SMx
RCV/CA/04/C	Blocking performance	yes, plus SMx
RCV/CA/05/C	Intermodulation performance	yes, plus SMx + SMR
RCV/CA/06/C	Maximum input level	yes

Table 4 - Test specification, basic rate, receiver

EDR

Number	Name	CBT
TRM/CA/10/C	EDR relative transmit power	yes
TRM/CA/11/C	EDR carrier frequency stability and modulation accuracy	yes
TRM/CA/12/C	EDR dfferential phase encoding	yes
TRM/CA/13/C	EDR in-band spurious emissions	yes

Table 5 - Test specification, EDR, transmitter

Number	Name	CBT
RCV/CA/07/C	EDR sensitivity	yes
RCV/CA/08/C	EDR BER floor performance	yes
RCV/CA/09/C	EDR C/I performance	yes, plus SMx
RCV/CA/10/C	EDR maximum input level	yes

Table 6 - Test specification, EDR, receiver

List of figures

Fig. 1 - Packet format (basic rate) 3

Fig. 2 - EDR packet format 4

Fig. 3 - π/4-DQPSK 5

Fig. 4 - 8DPSK 6

Fig. 5 - Timing scheme, single-slot 7

Fig. 6 - Timing scheme, multislot; xx1: single-slot packets, xx3/5: multislot packets 7

List of tables

Table 1 - ACL packets 4

Table 2 - SCO packets 5

Table 3 - Test specification, basic rate, transmitter 9

Table 4 - Test specification, basic rate, receiver 10

Table 5 - Test specification, EDR, transmitter 10

Table 6 - Test specification, EDR, receiver 10

References

[1] Bluetooth Test & Interoperability Working Group: **RF Test Suite Structure and Test Purposes System Specification 2.0 + EDR Revision 2.0.E.3,** 03/2005, Bluetooth SIG, Inc.

[2] Rohde & Schwarz: **Measurements on Bluetooth Products Using R&S CMU200/CBT and R&S CMUgo/CBTgo**, 1CM50_2E, 10/2006

[3] Rohde & Schwarz: **Measurements on Bluetooth Products according to Testspecification (version 2.0 + EDR)**, 1MA106_0e, 12/2006

4 Additional Information

Please send any comments or suggestions concerning this Application Note to TM-Applications@rsd.rohde-schwarz.com.

5 Ordering Information

Communication tester		
R&S®CMU200		1100.0008.02
Option B53	Bluetooth extension	1100.5700.02
Option K53	Bluetooth test software	1115.5000.02
Option B41 (optional)	Audio generator and analyzer	1100.5300.02
Bluetooth tester		
R&S®CBT with display	CBT	1153.9000.35
R&S®CBT without display	CBT32	1153.9000.32
Option B55	Hardware option: EDR extension	1170.3006.02

Option U55	Hardware upgrade kit: EDR extension	1170.3106.02
Option K55	Software option: EDR	1170.3206.02
Vector signal generators		
R&S® SMU200A		1141.2005.02
R&S® SMU-B102	RF path A: 100 kHz to 2.2 GHz	1141.8503.02
R&S® SMU-B103	RF path A: 100 kHz to 3 GHz	1141.8603.02
R&S® SMU-B104	RF path A: 100 kHz to 4 GHz	1141.8703.02
R&S® SMU-B106	RF path A: 100 kHz to 6 GHz	1141.8803.02
R&S® SMU-B202	RF path B: 100 kHz to 2.2 GHz	1141.9400.02
R&S® SMU-B103	RF path B: 100 kHz to 3 GHz	1141.9500.02
R&S® SMU-B10	Baseband with ARB (64 Msamples)	1141.7007.02
R&S® SMU-B13	Baseband main module	1141.8003.02
R&S® SMU-K5	Bluetooth external PC software	1161.0466.02
Signal analyzers, spectrum analyzers and options		
R&S® FSP3	9 kHz to 3 GHz	1093.4495.03
R&S® FSP7	9 kHz to 7 GHz	1093.4495.07
R&S® FSP13	9 kHz to 13 GHz	1093.4495.13
R&S® FSP30	9 kHz to 30 GHz	1093.4495.30
R&S® FSP40	9 kHz to 40 GHz	1093.4495.40
R&S® FSQ3	20 Hz to 3.6 GHz	1155.5001.03
R&S® FSQ8	20 Hz to 8 GHz	1155.5001.08
R&S® FSQ26	20 Hz to 26.5 GHz	1155.5001.26
R&S® FSU3	20 Hz to 3.6 GHz	1166.1660.03
R&S® FSU8	20 Hz to 8 GHz	1166.1660.08
R&S® FSU26	20 Hz to 26.5 GHz	1166.1660.26
R&S® FSU46	20 Hz to 46 GHz	1166.1660.46
R&S® FS-K8	Bluetooth for R&S FSU, FSQ, FSP	1157.2568.02
R&S® FSL3	9 kHz to 3 GHz	1300.2502.03
R&S® FSL3	9 kHz to 3 GHz, incl. tracking generator	1300.2502.13
R&S® FSL6	9 kHz to 6 GHz	1300.2502.06
R&S® FSL6	9 kHz to 6 GHz, incl. tracking generator	1300.2502.16

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