Operational description

Bluetooth frequency	2402-2480MHz
Bluetooth version	2.0
Modulation	GFSK
Charging Voltage	110-240V
Operation Voltage	4.2V
Charging period	4 hours
Duration of charged battery	45 days
Weight	478g
Transmitter Power	0.0017W
RF IC	BCM2042
Crystal	24MHz

BCM2042

PRODUCT Brief

SINGLE-CHIP BLUETOOTH® MOUSE AND KEYBOARD

FEATURES

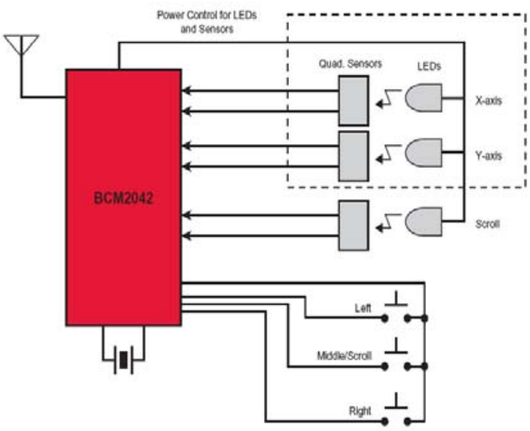
- Single-chip Bluetooth® device with fully integrated Human Interface Device (HID) profile and full Bluetooth stack
- On-board 8051 processor and RAM/ROM memory
- Custom-integrated Bluetooth core processor has been optimized to support the HID v1.0 profile and minimize power consumption
- Bluetooth version 2.0 compliant including support for adaptive frequency hopping and fast connect
- Integrated 8 Kbytes of non-volatile flash memory for storing Bluetooth address and configuration data
- Fully integrated radio eliminates all filters and matching components and features a single-pin interface directly to antenna
- Direct interface to keyboard scan matrix with full support for up to 8 x 20 keys and user-customizable hot keys
- Integrated quadrature signal decoder to support both ball and optical mouse designs
- Direct interface to LED and LCD displays
- Drive capability to power external optoelectronics
- ROM-based design eliminates external flash memories
  - Flash option offered to support feature development
- Fully integrated low dropout (LDO) regulator provides direction interface to batteries
- Integrated switching regulator to support external sensor and more to further reduce BOM cost
- Available in 88-pin fpBGA and 120-pin fpBGA packages

SUMMARY OF BENEFITS

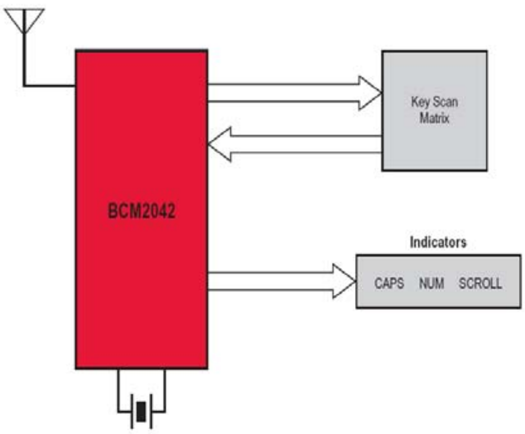
- Cost-optimized solution for mouse and keyboard applications
  - Achieves lowest possible cost through the integration of all external components
  - Direct interface to key scan matrix or ball/optical mouse encoders
- Replaces existing mouse or keyboard processor and memory and adds Bluetooth functionality
- Lowest power consumption solution provides greater than six-month battery life
- Adaptive frequency hopping support ensures full interoperability and coexistence with WLAN enabled personal computers
- Optimized radio provides long-range, interference-free operation in high-interference environments
  - Transmitter provides +4 dBm output power and satisfies Class 2 operation
  - Receiver provides -85 dBm receiver sensitivity
- Single monolithic bulk CMOS device providing low cost and high availability of manufacturing supply

APPLICATIONS

- Bluetooth mouse
- Bluetooth keyboard
- Combination mouse/keyboard
- Remote control HID devices
- Game controllers



BCM2042 Mouse Block Diagram



BCM2042 Keyboard Block Diagram

The BCM2042 is a major breakthrough in the design of low-cost Bluetooth mouse and keyboard devices. The BCM2042 is a true single chip that integrates the entire profile, application, and Bluetooth protocol stack and is fully compliant with the Bluetooth SIG specification for human interface devices. The BCM2042 is fully compliant with the version 2.0 Bluetooth specification, including adaptive frequency hopping and fast connection, which are essential to mouse and keyboard applications in personal computers.

Integration is key to achieving the system cost targets of today's PC OEMs. By integrating all components within today's mouse and keyboard into the BCM2042, low system costs can be achieved to approach the price points of legacy-wired mice and keyboards. The BCM2042 can interface directly to mouse optical or ball encoders and keyboard scan matrices.

Two key integrated components enable the BCM2042 to reach extremely low system BOM costs and dramatically extend battery life. The BCM2042 integrates 8 KB of non-volatile memory on-chip. Because of this, the BCM2042 does not require external flash or EEPROM when designing bluetooth mice or keyboards. Also, the BCM2042 integrates a high-performance boost regulator enabling direct connection with mice electronics. The integration of non-volatile RAM and the boost regulator enable extremely low system costs.

The Bluetooth baseband core has been optimized to maximize the battery life and functionality required for a mouse or keyboard application. Battery life has been optimized in the BCM2042 to meet greater than 6 months for the typical user using standard battery technology.

The BCM2042 integrates a high-performance radio implemented in standard bulk CMOS. It incorporates a proprietary self-calibrating VCO structure for both excellent phase noise and fast frequency hopping covering the entire band. All filters have been fully integrated into the device and are also self-calibrating to automatically compensate for changes in temperature and any process variation during manufacturing. The RF interface to the device fully integrates the T/R switch and its associates matching circuits, enabling direct interface with the antenna.

The block diagrams show how the BCM2042 can be used in either a mouse or keyboard application.

Rating	*Symbol*	*Value*	*Unit*
DC supply voltage for RF (VDD_RF)	–	1.65	V
DC supply voltage for Core (VDD_CORE)	–	1.65	V
DC supply voltage for I/O (VDD_IO or VDD_R3V)	–	4.1	V
DC supply voltage for Switching Regulator (1 cell)	–	1.6	V
DC supply voltage for Switching Regulator (2 cells in serial)	–	3.63	V
Voltage on the switching regulator #1 output pin	SW1_HI	3.3	V
Voltage on the switching regulator #2 output pin	SW2_HI	1.8	V
Voltage on input or output pin	–	V_{SS} – 0.3 to V_{DD} + 0.3	V
Storage temperature range	Tstg	–40 to 125	°C

Parameter	*Minimum*[1]	*Typical*	*Maximum*[1]	*Unit*
DC supply voltage for RF (VDD_RF)	1.4	1.5	1.65	V
DC supply voltage for Core (VDD_CORE)	1.35	1.5	1.65	V
DC Supply voltage for VDD_IO	1.62	–	3.6	V
DC supply voltage for VDD_MEM or VDD_R3V	1.71	1.8	3.63	V
DC supply voltage for switching regulators (1 cell)	0.80	1.45	1.60	V
DC supply voltage for switching regulators (2 cells in series)	1.8	2.9	3.6	V
Voltage on the switching regulator #1 output pin SW1	2.7	3	3.3	V
Voltage on the switching regulator #2 output pin SW2	1.5	1.6	1.8	V

1. Overall performance degrades beyond Minimum and Maximum supply voltages.

Characteristics	*Symbol*	*Min*	*Typ*	*Max*	*Unit*
Input low voltage (3.3V I/O supply)	V_{IL}	–	–	0.8	V
Input high voltage (3.3V I/O supply)	V_{IH}	2.0	–	–	V
Input low voltage (1.8V I/O supply)	V_{IL}	–	–	0.6	V
Input high voltage (1.8V I/O supply)	V_{IH}	1.1	–	–	V
Output low voltage	V_{OL}	–	–	0.4	V
Output high voltage	V_{OH}	V_{DD} – 0.4	–	–	V
Input low current	I_{IL}	–	15	–	µA
Input high current	I_{IH}	–	15	–	µA
Output low current (3.3V I/O supply)	I_{OL}	–	–	2.0	mA
Output high current (3.3V I/O supply)	I_{OH}	–	–	2.0	mA
Input capacitance	C_{IN}	–	0.12	–	pF

Operational Mode	*Minimum*	*Typical*	*Maximum*
Transmit[a]	–	43 mA	–
Receive[b]	–	38 mA	–
DM1 (TX mode)	–	28 mA	–
DM1 (RX mode)	–	25 mA	–
Sniff mode, 10 ms	–	2.35 mA	–
Sniff mode, 60 ms	–	0.39 mA	–
Sniff mode, 100 ms	–	0.24 mA	–
Sniff mode, 1.28 s	–	0.018 mA	–
Sleep (disconnected or Inter-Sniff, state preserved)	–	50 µA	–
Deep sleep (disconnected, wake on interrupt)	–	16 µA	–

a. Max current when receiver and baseband are both operating, 100% on.
b. Max current when transmitter and baseband are both operating, 100% on.

Parameter	*Minimum*	*Typical* [3]	*Maximum*	*Unit*
Receiver Section				
Frequency range	2402	–	2480	MHz
Overall Rx sensitivity[1]	–	-85	-80	dBm
Input IP3	–	-10	–	dBm
Maximum input	-20	-10	–	dBm
Input impedance	–	50	–	Ω
Input impedance for RF_IO:	–	|S11| < -10 dB	–	–
Interference Performance				
Co-Channel interference, $C/I_{co\text{-}channel}$	–	9	11 [2]	dB
Adjacent (1 MHz) interference, $C/I_{1\ MHz}$	–	-5	0	dB
Adjacent (2 MHz) interference, $C/I_{2\ MHz}$	–	-35	-30	dB
Adjacent ($\geq$3 MHz) interference, $C/I_{\geq 3\ MHz}$	–	-43	-40	dB
Image frequency interference, C/I_{Image}	–	-20	-9 [2]	dB
Adjacent (1 MHz) interference to in-band image frequency, $C/I_{Image\pm 1\ MHz}$	–	-35	-20 [2]	dB

1. The receiver sensitivity is measured at a BER of 0.1% on the device interface.
2. The maximum value represents the actual Bluetooth specification required for Bluetooth qualification as defined in the version 1.2 specification.
3. Typical operating conditions are 1.8V operating voltage and 25°C ambient temperature.

Parameter	*Minimum*	*Typical*	*Maximum*	*Unit*
Transmitter Section				
Frequency range	2402	–	2480	MHz
Output power—at max power setting[3]	-2	0	4	dBm
Output power—at minimum power setting[3]	-26	–	-18	dBm
Output power step size	–	2	–	dB
Output impedance [3]	–	50	–	Ω
Output impedance for RF_IO:	–	|S11| < -10 dB	–	–
In-Band Spurious Emission	–	–	–	–
$\pm$ 500 kHz	–	–	-20	dBc
20 dB bandwidth	–	900	1000	kHz
|M-N| = 2	–	–	-20 [1]	dBm
|M-N| $\geq$ 3	–	–	-40 [1]	dBm
Out-of-Band Spurious Emission	–	–	–	–
30 MHz – 1 GHz	–	–	-36 [1,2]	dBm

30 MHz – 1 GHz	–	–	-36 [1,2]	dBm
1 GHz – 12.75 GHz	–	–	-30 [1,2]	dBm
1.8 GHz – 1.9 GHz	–	–	-47 [1]	dBm
5.15 GHz – 5.3 GHz	–	–	-47 [1]	dBm
LO Performance				
Lock time	–	180	–	μs
Initial carrier frequency tolerance	–	±25	±75	kHz
Frequency drift	–			
DH1 packet	–	±20	±25	kHz
DH3 packet	–	±20	±40	kHz
DH5 packet	–	±20	±40	kHz
Drift rate	–	10	20	kHz/50 μs
Frequency deviation	–			
00001111 sequence in payload[4]	140	–	175	kHz
10101010 sequence in payload[5]	115	–	–	kHz
Channel spacing	–	1	–	MHz

1. Maximum value represents the actual Bluetooth specification required for Bluetooth qualification as defined in the version 1.2 specification.
2. The spurious emissions during Idle Mode are the same as specified in Table 1: Receiver RF Specifications.
3. The RF characteristics are measured at the chip interface.

1.Frequency Range of a Bluetooth Device

The maximum frequency of the device is 2402MHz - 2480 MHz. This is according the Bluetooth Core Specification V 2.0

2. 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 maximum 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.

3. 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

4. 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) is 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 312.5IJs. The clock has a cycle of about one day (23h30). In most case it is implemented as a 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 ms). The hopping sequence will always differ from the first one.

5. 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 section 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.

6. Dwell Time in Data Mode

The dwell time of 0.3797s within a 30 seconds period in data mode is independent from the packet type (packet length). The calculation for a 30 seconds period is as follows:

*Dwell time = time slot length * hop rate / number of hopping channels *30s*

Example for a DH1 packet (with a maximum length of one time slot) Dwell time = 625 IJs * 1600 1/s /79 * 30s = 0.3797s (in a 30s period)

For multi-slot packet the hopping is reduced according to the length of the packet.

Example for a DH5 packet (with a maximum length of five time slots)

Dwell time = 5 * 625 ms * 1600 * 1/5 *1/s / 79 * 30s = 0.3797s (in a 30s period)

This is according the Bluetooth Core Specification V 2.0 for all Bluetooth devices. Therefore, all Bluetooth devices comply with the FCC dwell time requirement in the GSM mode. This was checked during the Bluetooth Qualification tests. The Dwell time in hybrid mode is measured and stated in the test report.

7. Channel Separation in Hybrid Mode

The nominal channel spacing of the Bluetooth system is 1 MHz independent of the operating mode. The maximum “initial carrier frequency tolerance” which is allowed for Bluetooth is fcenter = 75 kHz.

This was checked during the Bluetooth Qualification tests (Test Case: TRM/CA/07-E) for three frequencies (2402MHz, 2441MHz, 2480 MHz).

8. Derivation and Examples for a Hopping Sequence in Hybrid Mode

For the generation of the inquiry and page hop sequences the same procedures as described for the data mode are used (see section 5), but this time with different input vectors:

• For the inquiry hop sequence, a predefined fixed address is always used. This result in the same 32 frequencies used by all devices doing an inquiry but every time with a different start frequency and phase in this sequence.

• For the page hop sequence, the device address of the paged unit is used as the input vector. This results in the use of a subset of 32 frequencies, which is specific for that initial state of the connection establishment between the two units. A page to different devices would result in a different subset of 32 frequencies.

So it is ensured that also in hybrid mode, the frequency is used equally on average.

Example of a hopping sequence in inquiry mode:

48, 50, 09, 13, 52, 54, 41, 45, 56, 58, 11, 15, 60, 62, 43, 47,00, 02, 64, 68, 04, 06, 17, 21,08, 10, 66,70, 12, 14,19, 23

Example of a hopping sequence in paging mode:

08, 57, 68, 70, 51, 02, 42, 40, 04, 61, 44, 46, 63, 14, 50, 48, 16, 65, 52, 54, 67, 18, 58, 56, 20, 53, 60, 62, 55, 06, 66, 64

9. Receiver Input Bandwidth and Synchronization in Hybrid Mode

The receiver input bandwidth is the same as in the GSM mode (1 MHz). When two Bluetooth devices establish contact for the first time, one device sends an inquiry access code and the other device is scanning for this inquiry access code. If two devices have been connected previously and want to start a new transmission, a similar procedure takes place. The only difference is, instead of the inquiry access code, a special access code, derived from the BD-ADDRESS of the paged device will be, will be sent by the master of this connection. Due to the fact that both units have been connected before (in the inquiry procedure) the paging unit has timing and frequency information about the page scan of the paged unit. For this reason the time to establish the connection is reduced.

10. Spread Rate I Data Rate of the Direct Sequence Signal

The spread rate / data rate in inquiry and paging mode can be defined via the access code. The access code is the only criterion for the system to check if there is a valid transmission or not. If you regard the presence of a valid access code as one bit of information, and compare it with the length of the access code of 68 bits, the spread rate / data rate will be 68/1.