



M68HC08 *Microcontrollers*

*2.4-GHz Wireless
Optical Mouse and
Multimedia Keyboard
Solution*

*Designer Reference
Manual*

*DRM050/D
Rev. 0, 09/2003*

MOTOROLA.COM/SEMICONDUCTORS

Freescale Semiconductor, Inc.

Freescale Semiconductor, Inc.

**For More Information On This Product,
Go to: www.freescale.com**

2.4-GHz Wireless Optical Mouse and Multimedia Keyboard Solution Designer Reference Manual — Rev 0

**By: Dennis Lui
Ernest Chan
W.S. Wong
Applications Engineering
Microcontroller Division
Hong Kong**

To provide the most up-to-date information, the revision of our documents on the World Wide Web will be the most current. Your printed copy may be an earlier revision. To verify you have the latest information available, refer to:

<http://motorola.com/semiconductors>

The following revision history table summarizes changes contained in this document. For your convenience, the page number designators have been linked to the appropriate location.

Motorola and the Stylized M Logo are registered trademarks of Motorola, Inc.
DigitalDNA is a trademark of Motorola, Inc.
This product incorporates SuperFlash® technology licensed from SST.

© Motorola, Inc., 2003

Revision History**Revision History**

Section	Page	Description of Change
Throughout	NA	Initial Release

Table of Contents

Section 1. System Overview

1.1	Introduction	7
1.2	Features	7
1.3	System Overview	8
1.4	Transmit and Receive	9

Section 2. RF Front End

2.1	Introduction	11
2.2	Functional Description	11
2.3	RF Transceiver Module RFW102	12
2.4	Interface IC RFW-D100	14
2.5	Antenna and PCB Specification	15

Section 3. Optical Mouse Transmitter

3.1	Introduction	17
3.2	System Overview	17
3.2.1	Microcontroller JB8	18
3.2.2	Optical Mouse Sensor	18
3.2.3	RF Transmission	19
3.2.4	DC/DC Converter	19

Section 4. Mouse Transmitter Firmware

4.1	MAC Layer Protocol	21
4.2	Application Firmware Flow	22
4.3	Power Management for the Mouse	23
4.4	Output Buffer Format for the RF Packet	24

Section 5. Multimedia Keyboard Transmitter

5.1	Introduction	27
5.2	System Overview	27
5.2.1	Microcontroller LK24	28
5.2.2	RF Transmission	28
5.2.3	DC/DC Converter	29

Section 6. Keyboard Transmitter Firmware

6.1	Firmware Structure	31
6.2	Output Buffer Format for Keyboard RF Packet.	32

Section 7. USB Receiver

7.1	Introduction	35
7.2	System Overview	35
7.2.1	Microcontroller JB16.	36
7.2.2	RF Transmission	36
7.2.3	Voltage Regulator.	37

Section 8. Receiver Firmware

8.1	Receiver Firmware Structure	39
8.2	USB Report.	41
8.2.1	Input Report Example.	43
8.3	Remote Wakeup.	44

Section 9. Testing and Customization

9.1	Testing	45
9.2	Customization.	45
9.2.1	Hardware	45
9.2.1.1	Optical Mouse Transmitter.	45
9.2.1.2	Keyboard Transmitter	46
9.2.1.3	USB Receiver	46
9.2.1.4	RF Circuitry	46
9.2.2	Firmware	46
9.2.2.1	Mouse Transmitter	46
9.2.2.2	Keyboard Transmitter	46
9.2.2.3	Receiver.	46

Section 1. System Overview

1.1 Introduction

This manual describes a reference design of a 2.4-GHz Universal Serial Bus Wireless Optical Mouse and Multimedia Keyboard solution by using the MC68HC908JB8, MC68HC908LK24, and MC68HC908JB16.

The whole system consists of a wireless mouse, a wireless keyboard and a USB receiver. The wireless communication link is developed in the worldwide unlicensed Industrial, Scientific, and Medical (ISM) band of 2400–2483 MHz. All hardware schematic diagrams and firmware source codes are available as reference materials.

1.2 Features

- High speed RF link in 2.4-GHz ISM band
- Windows 98™, Windows 2000™, and Windows XP™ Compatible¹
- USB 2.0 Low Speed Compliance
- 1 Mbps transmission data rate
- 10 to 20 meter communication distance
- RF front end and Media Access Control (MAC) designs are based on RFWaves chipset and protocol

1. Windows 98, Windows 2000 and Windows XP are trademarks of Microsoft Corporation in the U.S. and other countries.

System Overview

1.3 System Overview

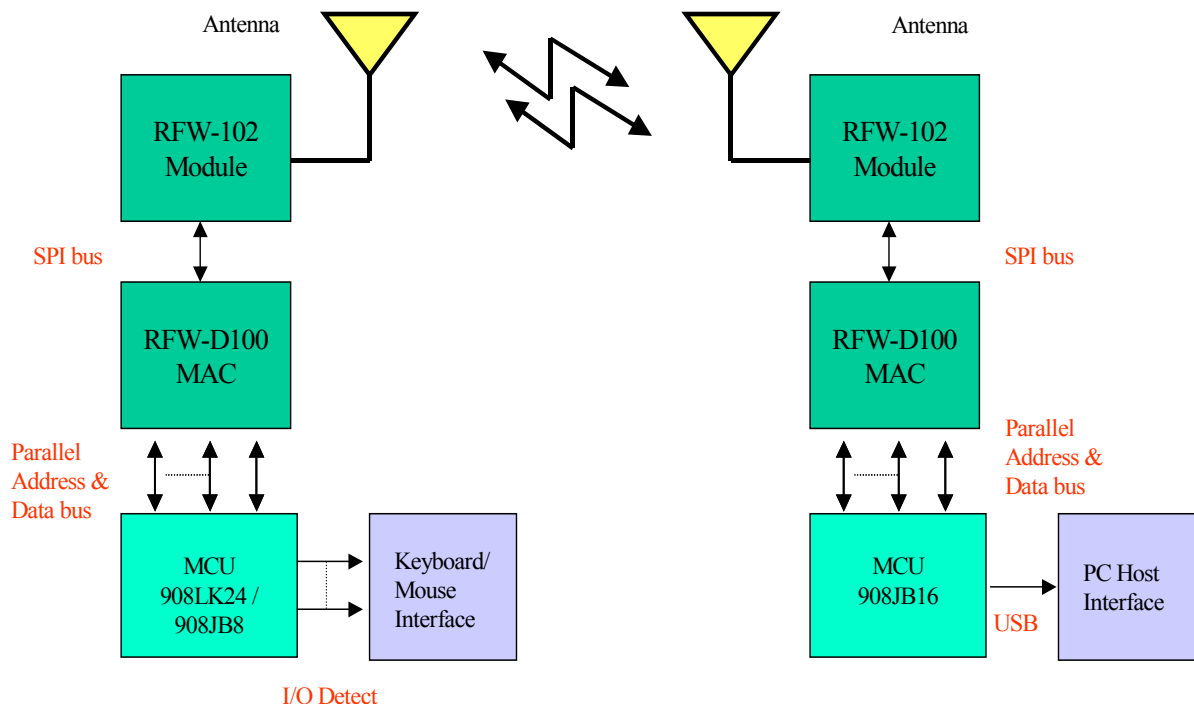


Figure 1-1. System Overview

The system consists of three functional devices, a wireless optical mouse using the MC68HC908JB8 (hereafter referred as JB8, production version uses the low voltage MC68HC08JT8), a wireless multimedia keyboard using the MC68HC908LK24 (hereafter referred as LK24), and the wireless receiver using the MC68HC908JB16 (hereafter referred as JB16).

The basic structure and functional blocks for each device are similar and consist of a RF transceiver module for half duplex transmission in 2.4-GHz frequency band, a baseband IC for link layer access control and protocol handling. The overall system operation, I/O interface, and power management are controlled by MCU.

Based on the number of I/O pins, voltage operation, and memory size requirements, the JB8 and LK24 are chosen for wireless mouse and

keyboard designs. The JB16 is specially designed for USB wireless application. It has high processing power and large memory size to handle overall data traffic control for multiple input devices.

1.4 Transmit and Receive

In data transmission, the data generated from the key matrix in a keyboard or displacement detection/button status data in mouse application is detected by MCU and sent to the baseband IC in a parallel format. All kinds of media access, link layout control, and data conversion in serial format are handled by the baseband IC. The final data in serial format is transmitted by the RF module at 2.4 GHz.

In data reception, the data received from RF module is decoded with corresponding protocol, and the serial packet data will be converted into parallel format again in baseband processing. The final data in parallel format will be captured by MCU and sent to the PC host through the USB interface.

Section 2. RF Front End

2.1 Introduction

2.4-GHz RF links are designed for wireless communication media for this application. The RF front end of the USB receiver, mouse, and keyboard are the same. The front end is a half duplex direct sequence spread spectrum (DSSS) radio transceiver chipset, intended for use in the world wide unlicensed Industrial, Scientific, and Medical (ISM) band of 2400–2483.5MHz. The front end chipset mainly consist of two parts, the transceiver module RFW102 and the interface IC RFW-D100. CSMA is used as the communication protocol in between the USB receiver, the keyboard, and mouse.

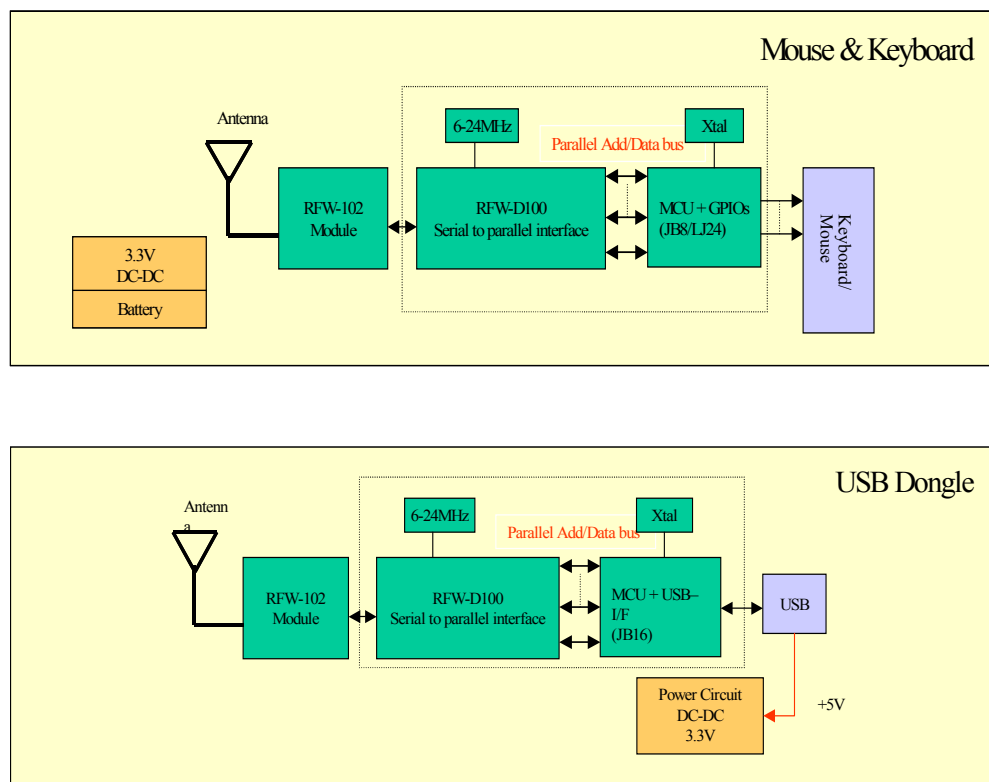
2.2 Functional Description

The complete solution of the RF transceiver consists of an RF transceiver module RFW102 and a link interface IC RFW-D100. The RFW-D100 links the MCU and the transceiver module. When data is being transmitted from the mouse or keyboard, the transmit data from the MCU is passes into the interface IC. In the interface IC, the data will be converted from parallel type to serial type. Also it will be coded with packet address and error checking.

The serial data will then pass to the RF transceiver and ASK modulates into IF frequency 488 MHz. The modulated data will be DSSS spreading and up-converts into 2.4 GHz RF signal for transmission.

When the RF signal is received by the USB receiver, it is down-converted into IF frequency and DSSS de-spreading into ASK IF signal. Then, the ASK IF signal will demodulate into serial data out of the RF transceiver module RFW102.

The received serial data will pass into the interface IC RFW-D100, in which it will be converted to parallel data for the MCU.



2.3 RF Transceiver Module RFW102

The RFW102 transceiver module is a short-range, half-duplex wireless radio transceiver. The transceiver is intended for use in the unlicensed ISM band of 2400–2483.5 MHz.

The transceiver module provides a peak output power of 2 dBm and data rate up to 1Mbps. Power consumption during transmit is extremely low, (21 mA in 1Mbps, 28 mA in 1 kbps), which is directly dependent on the bit transfer rate. During standby mode, the transceiver consumes almost no power and features an extremely short wake up time of 20 ms.

The communication link between the transceivers is a Direct Sequence Spread Spectrum (DSSS) pulse pipe. The modulation scheme is 100%

Amplitude Shift Keying (ASK). The spreading modulation scheme is a Bi-Phase modulation where each bit has a 13-bit Barker series.

Below are the key features of the transceiver module:

- 2.4-GHz unlicensed ISM band operation
- 1 Mbps data rate
- Sample 3 line digital interface
- Low power consumption
- +2 dBm typical peak output transmission power
- -80 dBm typical sensitivity
- Typical standby current of 2.6 mA
- Complies with FCC regulation
- Wide range operating voltage (2.7 V–3.6 V)
- Direct Sequence Spread Spectrum (DSSS) 11 dB processing gain
- Short signal acquisition time (1.2 ms)

The transceiver has a fully digital serial I/O interface providing a simple 3-line interface. Tx/Rx is for controlling of the transceiver work in transmit or receive mode. Act is used for switching the transceiver between working mode and sleep mode. Data IO is the data transfer channel.

The transceiver chipset includes three chips.

- RFW24 — An RFIC performs all of the timing, amplifying, switching, transmitting, and receiving functions.
- RFW488C — A 4-pin SAW correlator, which is used as a direct sequence spread spectrum spreading and de-spreading element.
- RFW488R — A 1-port SAW resonator, which serves as the system oscillation source.

For detailed information on the internal implementation of the transceiver module, please refer to the data sheet about the RFW102 from RFWaves website:

<http://www.rfwaves.com>

2.4 Interface IC RFW-D100

The RFW-D100 is a complimentary IC to the RFW-102 module. It provides an MCU with a parallel interface to the RFW-102 transceiver module and other features that enable implementing a protocol suitable for wireless communication with a small burden on the MCU.

In HID application, the MCU is in charge of the MAC layer protocol. The RFW-D100 is used to reduce the real-time demands of the MCU handling the MAC protocol. It converts the fast serial input to 8-bit words, which are much easier for 8-bit MCUs to work with. Also, it buffers the input through a 16-byte FIFO, giving the MCU access the RFW-D100 efficiently. Instead of reading one byte per interrupt, the MCU can read up to 16 bytes in each interrupt.

Below are the features of the RFW-D100 interface IC:

- Provides parallel interface with the RFW102 modem
- Serial to parallel conversion of the RFW102 interface
- Input FIFO (RX_FIFO)
- Output FIFO (TX_FIFO)
- Preamble Correlation
- Packet Address Filter
- CRC calculation
- Watchdog Timer driven by internal RC oscillator
- Power saving mode: Idle, Power-down.
- Receiver signal strength indication (RSSI)

For detailed information on the RFW-D100, please refer to the data sheet about the RFW-D100 from the RFWaves website:

<http://www.rfwaves.com>

2.5 Antenna and PCB Specification

The antenna interface of the RFWaves module RFW102 is 200 Ω differential. For matching and placement of different antenna, refer to the data sheet of the specific antenna you are using.

The reference antenna of the RFWaves transceiver module RFW102-M used here is a special design printed circuit board differential loop antenna. The purpose of this design is aimed at low cost, small form factor, and high directivity design.

For the dimension and PCB specification of the antenna board, please refer to documents which can be download from RFWaves website:
<http://www.rfwaves.com>

Section 3. Optical Mouse Transmitter

3.1 Introduction

The JB8 has 8K Flash memory, 3-MHz bus processing power, 16-bit 2-channel timer module, and appropriate number of I/O pins makes this MCU suited for this 2.4-GHz Wireless Optical Mouse application. The main features of the reference design include:

- 2.4-GHz RF Link
- 1 Mbps data rate
- 800 DPI Resolution
- Smart Power Management

3.2 System Overview

The optical mouse consists of the JB8, the Agilent optical mouse sensor ADNS-2030, the baseband IC and RF Module from RFWaves, and DC/DC converter. **Figure 3-1** shows the block diagram of the system.

Optical Mouse Transmitter

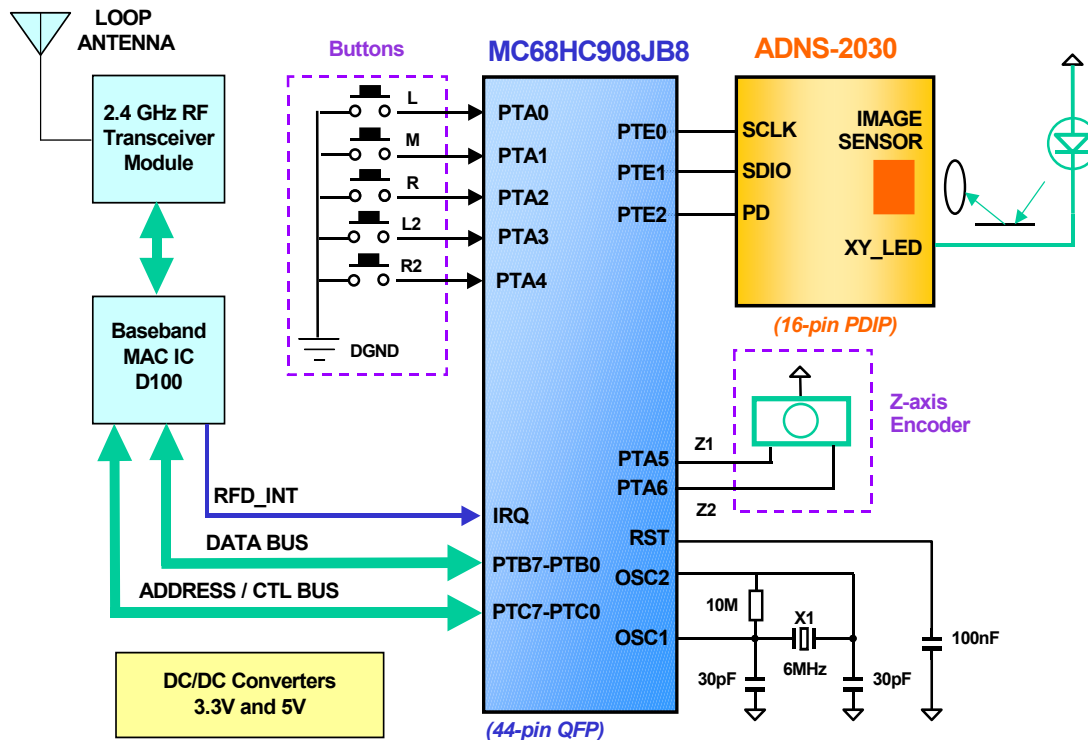


Figure 3-1. Mouse Block Diagram

3.2.1 Microcontroller JB8

The functions of the JB8 are to get the XY displacement from the sensor, detect the Z displacement, check button status, control the baseband IC to sending out data, and perform the overall power management.

Three standard left, middle, and right buttons (and two additional buttons reserved for future development) are implemented.

3.2.2 Optical Mouse Sensor

The AN2030 is a 3-V supply sensor specially design for wireless optical mouse. The communication between the sensor and the JB8 is through Serial Peripheral Interface with clock input at the SCLK pin and bidirection data interface at SDIO pin. The Power Down (PD) pin is used to power down the sensor when it's not in use.

3.2.3 RF Transmission

The data from the MCU will be transferred to the baseband IC for parallel to serial packet conversion as well as error checking. The encoded data will be passed to the RF module for ASK modulation in IF band and frequency spreading with DSSS scheme. The modulated signal will be further up-converted into 2.4-GHz ISM band for final transmission.

3.2.4 DC/DC Converter

The power supply for a handheld device should be able to keep the DC voltage output at a constant level even though the input battery voltage is continuously dropping down. There are two DC/DC converters; the 3.3-V supply is used for the baseband IC and RF module. The 5-V supply is only used for the JB8, but it would be eliminated in the final product when the low-voltage version JT8 is used.

Section 4. Mouse Transmitter Firmware

4.1 MAC Layer Protocol

Each piece of firmware on the mouse, keyboard, or dongle consists of a MAC layer implementing the RFWaves Carrier Sense Multiple Access (CSMA) protocol. In CSMA protocol, every device in the network uses the same physical channel for communication. Each device will first detect whether the channel is being used by others before it initiates its own transmission.

The MAC layer manages the wireless communication between the mouse/keyboard and the dongle through the baseband RFW-D100 IC.

The MAC layer implements two interrupt functions from each of the MCUs. The IRQ and one Timer Channel are used by the MAC.

Interface functions have been built for the application to access the MAC. For example, the application layer can invoke these functions:

- Initiate the MAC layer and the RF hardware
- Initiate transmission of a new packet
- Initiates a packet receiving by the MAC layer
- Check and locate any newly received packet in the MAC buffer
- Sets the MAC and RF hardware to low power mode, or resume from it

The “MACAPI.H” header file in each of the firmware contains more details about these functions and their uses.

Mouse Transmitter Firmware

4.2 Application Firmware Flow

Figure 4-1 shows the main application firmware flow of the wireless optical mouse. One of the main challenges in wireless optical mouse design is the power management to minimize the power consumption and maximize the performance.

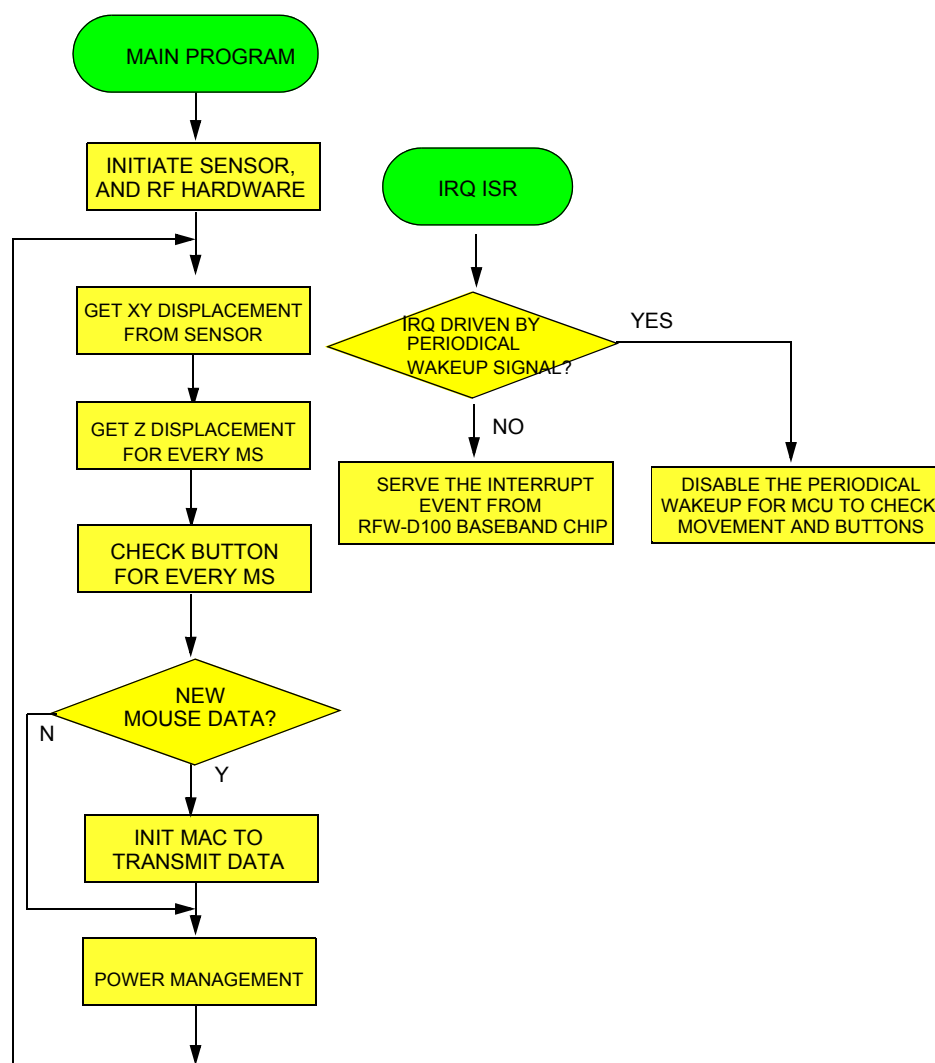


Figure 4-1. Firmware Structure

The main program continually checks the registers of the sensor to see if any XY movement happened. If any XY movement is detected, it gets the X and Y displacements from the sensor registers, puts them in the FIFO buffer and sets the corresponding flags. For every ms timer tick, it checks the Z movement and the buttons' status. If new mouse data has been detected, JB8 will initiate the RF data transmission through the baseband RFW-D100 IC.

Apart from serving the interrupt events from the baseband D100 IC during normal operation, IRQ serves as the periodical wakeup signal when JB8 is in sleep mode. The JB8 must check whether there is any new movement or if the buttons' status changed. IRQ ISR firmware will determine what appropriate actions must be taken.

4.3 Power Management for the Mouse

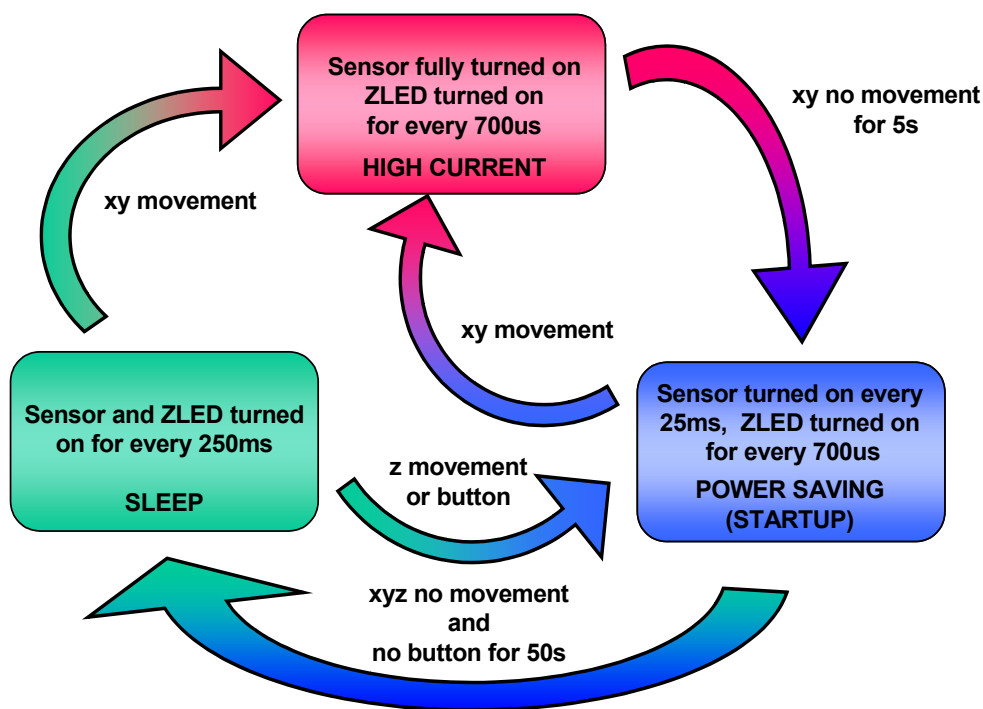


Figure 4-2. Power Management

Figure 4-2 shows the flow of the power management. There are three defined stages — Power Saving, High Current, and Sleep stage.

After power up, the mouse is put in Power Saving stage. In this stage, the sensor is only turned on for every 25 ms to see if any XY movement occurred. The Z movement and buttons are sensed for every ms.

If no activity happens in 50 seconds, it enters the Sleep stage. In this stage, the JB8 is put in stop mode and will be woken up every 250 ms to monitor any activity. The RFW-D100 and RFW-D102 IC are in idle mode (not in power down mode). Their power consumption will be reduced because the system CLK to RFW-D100 has been stopped (JB8 and RFW-D100 share the same crystal CLK source).

Any XY movement will cause the mouse to enter the High Current stage. At this stage, the sensor is powered on and XY movement is continually monitored. The Z movement and buttons' activities are still monitored for every ms. If no XY movement happens in 5 seconds, it then enters Power Saving Stage.

Except for the 1 ms timer tick, all the above mentioned timings can be configured by changing their constant values.

4.4 Output Buffer Format for the RF Packet

Users may refer to the RFWaves RFW-D100 IC data sheet for more detail about the RFWaves Packet Structure (Rev 1.3, Appendix B).

Figure 4-3 shows the output buffer format for the mouse RF packet. The contents of this will be transmitted when invoking the transmission function. Users can refer to the "TransmitData" function in "main.c" of the reference firmware as an example.

The first byte is the total size of the buffer data (equal to 11 here). Bytes 2 through 5 are the Network ID which is used to distinguish different RFWaves Networks. Byte 6 is the node ID which is used for identification of different device within the network. The last four bytes are the mouse data.

The contents of the output buffer will be received by the JB16 dongle and dongle can extract the mouse data and send to the host through USB.

**Output Buffer Structure
For for Mouse RF Packet**

Packet Size
Network ID byte1
Network ID byte2
Network ID byte3
Network ID byte4
Node ID
Reserved for Sequence
Packet Size
Button Status
X-Displacement
Y-Displacement
Z-Displacement

Figure 4-3. Output Buffer Format for the Mouse Packet

Section 5. Multimedia Keyboard Transmitter

5.1 Introduction

The LK24 has a built-in PLL with a low frequency crystal (32.768 kHz) and is able to operate as fast as 4 MHz bus speed at 3.3 V. It contains enough I/O pins for key matrix scanning. The main features of the keyboard include:

- 2.4-GHz RF Link
- 1 Mbps data rate
- Power management keys (power, wake and sleep) support
- Multimedia keys support

5.2 System Overview

The keyboard transmitter consists of the LK24, the baseband IC and RF Module from RFWaves, and DC/DC converter. **Figure 5-1** shows the block diagram of the system.

Multimedia Keyboard Transmitter

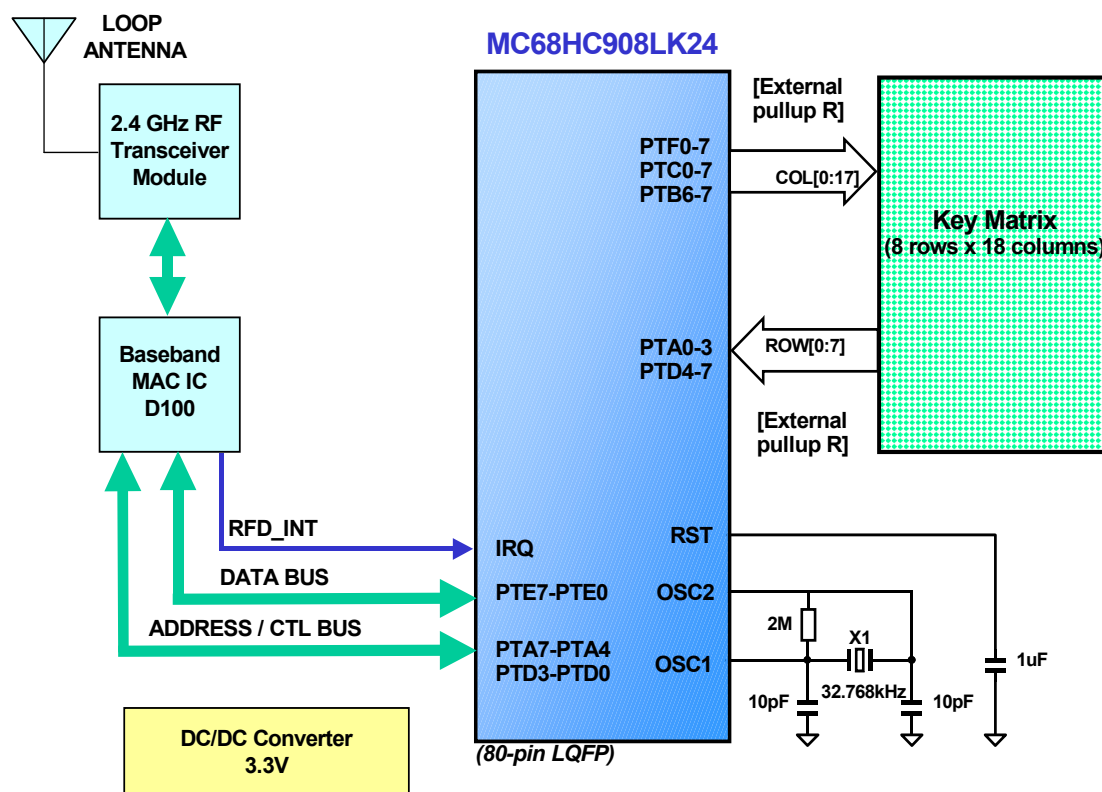


Figure 5-1. Keyboard Block Diagram

5.2.1 Microcontroller LK24

The functions of the LK24 are to scan the key matrix and determine what keys are pressed and released, control the baseband IC to sending out data, and perform the overall system control.

5.2.2 RF Transmission

The data from MCU will be transferred to the baseband IC for parallel to serial packet conversion as well as error checking. The encoded data will be passed to the RF module for ASK modulation in IF band and frequency spreading with DSSS scheme. The modulated signal will be further up-converted into the 2.4-GHz ISM band for final transmission.

5.2.3 DC/DC Converter

The power supply for a handheld device should be able to keep the DC voltage output at a constant level even though the input battery voltage is continuously dropping down, so a 3.3 V DC/DC converter is designed for the whole system, including the MCU and the baseband IC and RF module.

Section 6. Keyboard Transmitter Firmware

6.1 Firmware Structure

The firmware structure consists of two main parts:

- MAC Layer protocol
- Main Application routine

The MAC layer also implements the RFWaves CSMA protocol. Please refer to the section [4.1 MAC Layer Protocol](#) for a description of this layer.

Figure 6-1 shows the flow of the main program. The main tasks are to detect any key being pressed or released and then send the key code by RF signal through the control of baseband RFW-D100 IC.

If no key is pressed within 10 seconds, LK24 will put the baseband IC into power down mode, LK24 will also enter lower power mode. The MCU will be woken up when any key is pressed.

Keyboard Transmitter Firmware

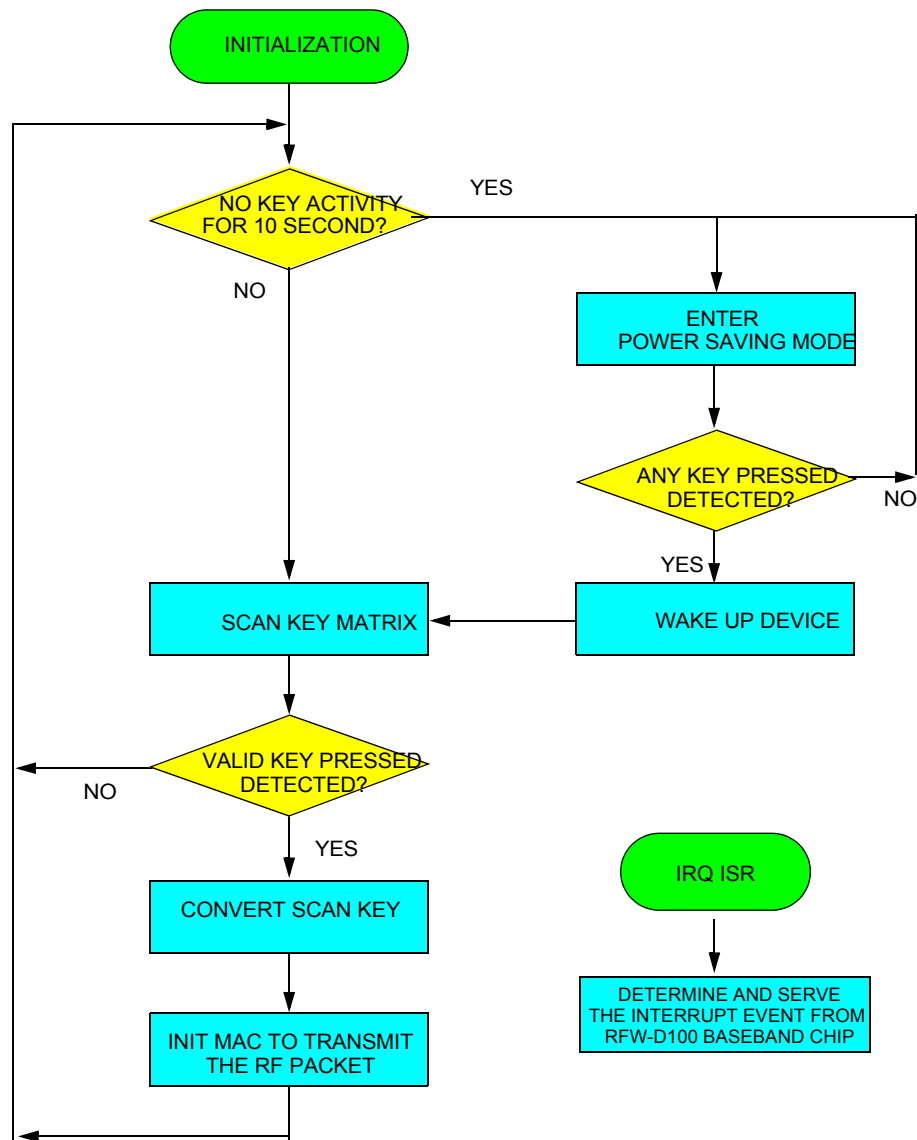


Figure 6-1. Firmware Flow

6.2 Output Buffer Format for Keyboard RF Packet

Figure 6-2 shows the output buffer format for the keyboard RF packet. It is similar to that of the mouse, except for the last two bytes. Break/Make byte indicates whether the packet represents a Make key

(the key has been pressed) or a Break key (the key has been released).
The last byte is the scan code of the key.

Output Buffer Structure
For for Keyboard RF Packet

Packet Size
Network ID byte1
Network ID byte2
Network ID byte3
Network ID byte4
Node ID
Reserved for Sequence
Packet Size
Break/Make Byte
Scan Code

Figure 6-2. Packet Format

Section 7. USB Receiver

7.1 Introduction

The features of JB16 include a Universal Serial Bus (USB) interface, 16K Flash memory, 6-MHz bus clock and two timer modules, which makes this MCU suited for personal computer Human Interface Devices (HID) applications, such a mouse and keyboard. The main features of the receiver include:

- 2.4-GHz RF Link
- 1 Mbps data rate
- Fully USB specification 2.0 low speed compliant
- Windows 98, 2000 and XP compatible

7.2 System Overview

The receiver consists of the JB16, the baseband IC and RF Module from RFWaves and a 3.3-V voltage regulator. [Figure 7-1](#) shows the block diagram of the system.

USB Receiver

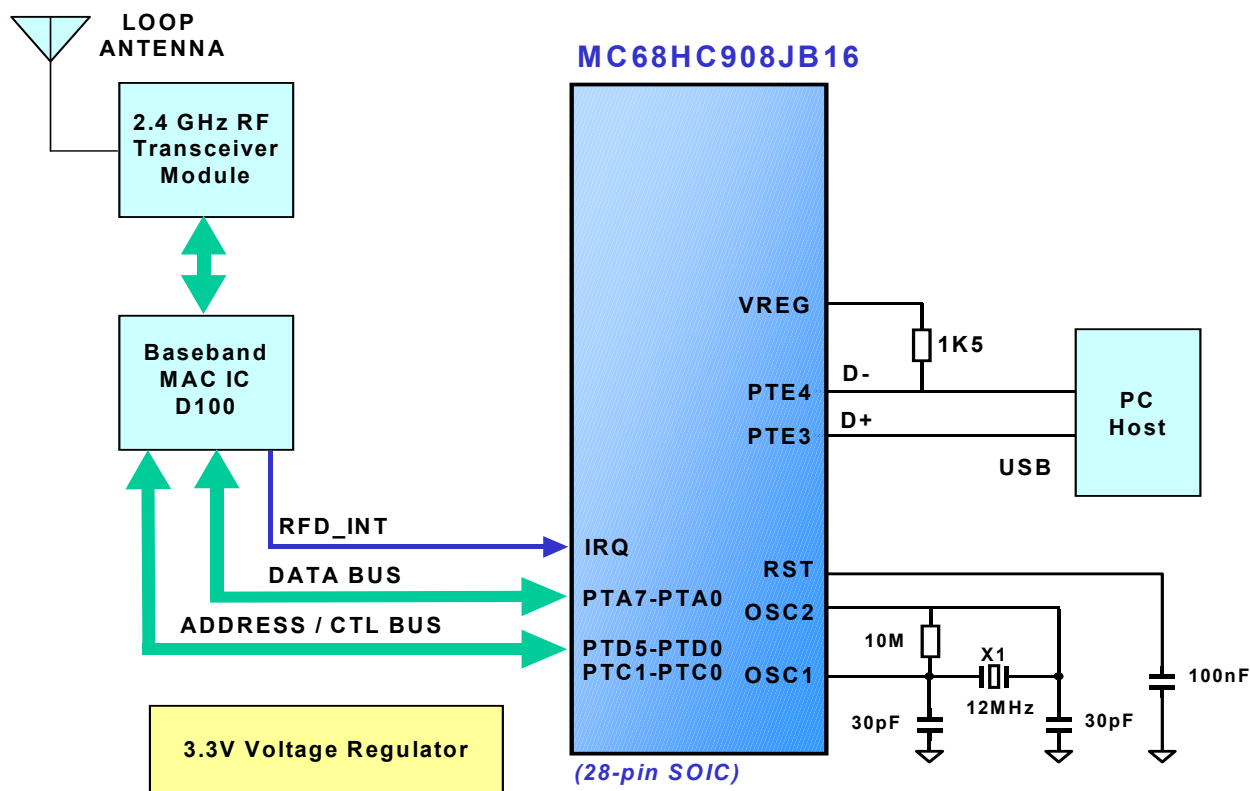


Figure 7-1. USB Receiver Block Diagram

7.2.1 Microcontroller JB16

The functions of the JB16 are to handle the USB transactions, control the baseband IC to receiving input data, and perform the overall system control. The processed data is converted into USB report format and sent to the host.

7.2.2 RF Transmission

The receiving RF signal will be down-converted into IF band for de-spreading with DSSS scheme and ASK demodulation. The demodulated data in serial packet format will be converted back to parallel data and sent to the MCU for USB report generation.

7.2.3 Voltage Regulator

The bus power voltage from USB interface is 5 V, so a 3.3-V regulator is added to provide a correct voltage 3.3 V for baseband IC and RF module. The JB16 is specially design for USB application, so external regulated supply input is not necessary.

Section 8. Receiver Firmware

8.1 Receiver Firmware Structure

The firmware consists of three main parts:

- MAC Layer protocol
- Application layer routines
- USB interrupt routine

The MAC layer implements the RFWaves CSMA protocol. Please refer to the section [4.1 MAC Layer Protocol](#) for a description of this layer.

Figure 8-1 shows the flow of the main application program. The USB interrupt routine is not shown here. You may refer to another reference design called *USB and PS2 Multimedia Keyboard by using the MC68HC908JB8* for more detail.

The main routine continually checks if there is any valid mouse or keyboard data from the MAC layer. If so, the data will be converted to USB report format and sent to the host via the endpoint 1 and endpoint 2.

IRQ serves for different interrupt events from the RFW-D100 chip when USB is not in suspend mode. The IRQ ISR firmware will determine which interrupt source caused the IRQ. It could be done by checking the IIR register from RFW-D100 Baseband chip and then the corresponding action can be taken by the interrupt service routine. During USB suspend, the periodical wake-up trigger at IRQ can wake up MCU to detect incoming packets and return to the host computer.

Receiver Firmware

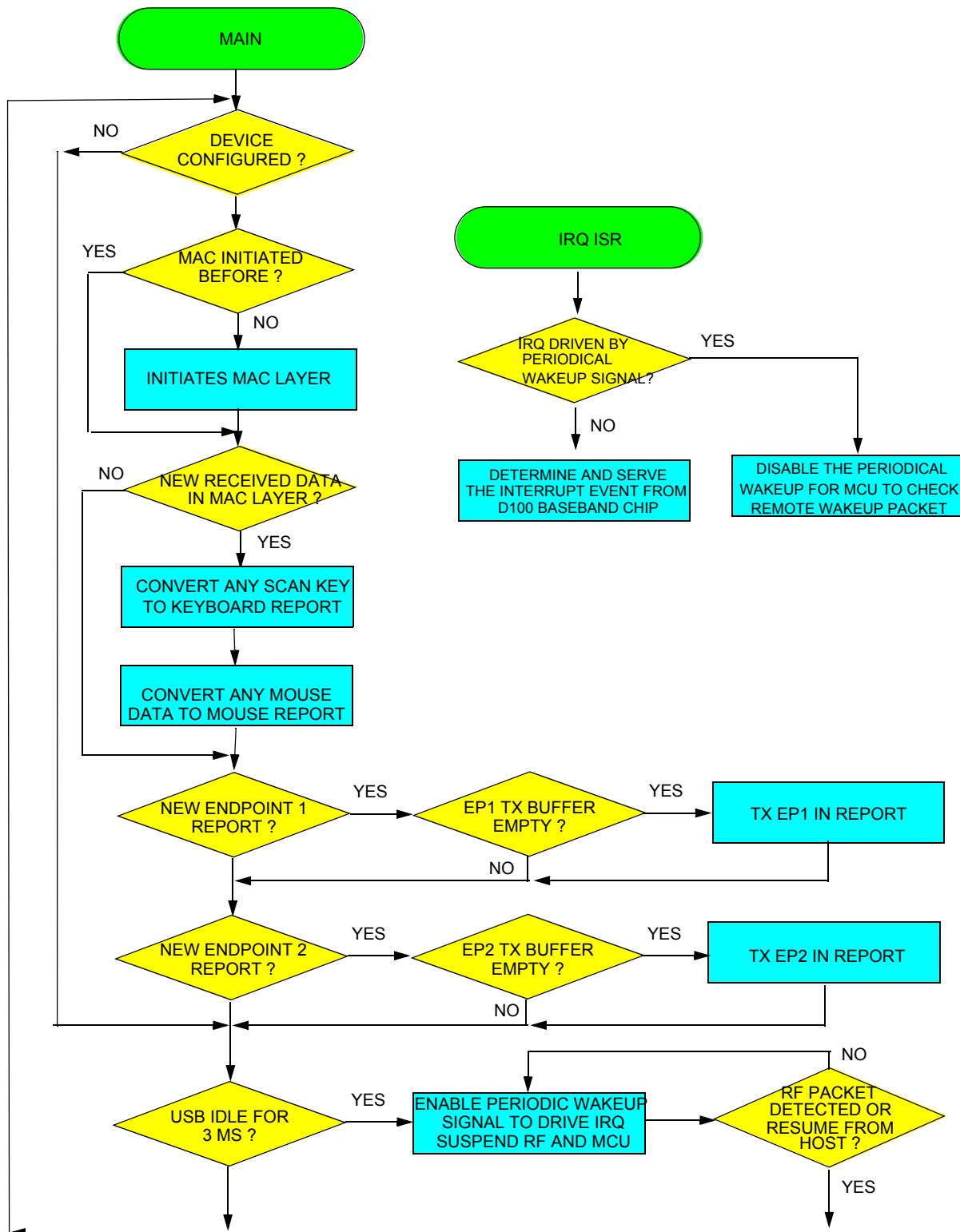


Figure 8-1. Firmware Flow

8.2 USB Report

The mouse and keyboard implement two HID interfaces on endpoint 1 and endpoint 2 in a USB composite-device fashion. HID interface 0 (endpoint 1) implements a standard HID keyboard with identical report and boot protocols. HID interface 1 (endpoint 2) implements multimedia and power management keys and mouse data. This implementation ensures that the keyboard works in BIOS setup and in DOS mode.

Interface 0 will issue 8-byte input reports that are identical to the standard keyboard boot protocol report (see [Table 8-1](#)) as documented in the Device Class Definition for Human Interface Device (HID) version 1.1. This interface also allows the host system to send the CAP/NUM/SCROLL lock status to JB16, as specified by the 1-byte output report (see [Table 8-2](#)). It can be used to turn on and off the respective LED state indicators if LEDs have been implemented in the hardware. These LEDs are not included in the reference JB16 receiver hardware.

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Right GUI	Right ALT	Right Shift	Right Control	Left GUI	Left ALT	Left Shift	Left Control
1	Reserved							
2	Keyboard Usage ID (Key Code)							
3	Keyboard Usage ID (Key Code)							
4	Keyboard Usage ID (Key Code)							
5	Keyboard Usage ID (Key Code)							
6	Keyboard Usage ID (Key Code)							
7	Keyboard Usage ID (Key Code)							

Table 8-1. Interface 0 Input Report

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0						Scroll Lock	Caps Lock	Num Lock

Table 8-2. Interface 0 Output Report

Interface 1 report contains the power management key report, multimedia key input report, or mouse input report, which is distinguished by a unique Report ID. The power management key uses Report ID number 1 (see Table 8-3); the multimedia key uses Report ID number 2 (see Table 8-4); and the mouse report uses Report ID number 3 (see Table 8-5).

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Report ID = 1							
1						Power	Wake	Sleep

Table 8-3. Interface 1 Power Key Input Report

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Report ID = 2							
1	M7	M6	M5	M4	M3	M2	M1	M0
2	M15	M14	M13	M12	M11	M10	M9	M8
3	M23	M22	M21	M20	M19	M18	M17	M16
4	Reserved for M24 - M31							

Table 8-4. Interface 1 Multimedia Key Input Report

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Report ID = 3							
1						Middle button	Right button	Left button
2	X Displacement							
3	Y Displacement							
4	Z Displacement							

Table 8-5. Interface 1 Mouse Input Report

8.2.1 Input Report Example

Table 8-6 shows some input report examples. Report ID is not used in interface 0. The first byte is the modifier byte and is set on bit base. Whenever a modifier key is pressed, the corresponding bit is set to 1. For example, if the Left Control and the character 'A' keys are pressed, the first byte of the report equals \$01, the second byte is reserved, the third byte equals \$04, and the forth through the eighth bytes equal \$00.

Power Management keys are reported through interface 1 with report ID 1. For example, if the Wake key is pressed, the first byte equals \$01 (ID = 1), and the second byte equals \$02 (corresponding bit equals 1) since Wake key is defined as the bit 2 of the second byte.

Hot keys are reported through interface 1 with reported ID 2. For example, if the hot key 0 and the hot key 17 are pressed, the first byte equals \$02 (ID = 2); the second byte equals \$01 since hot key 0 is pressed; the third byte equals \$00 since hot keys 8 to 16 are not pressed; and the forth byte equals \$02 since the hot key 17 is pressed.

Keys Pressed	Endpoint	In Report Data
Left Control, 'A'	1	\$01,\$00,\$04,\$00,\$00,\$00,\$00,\$00
Left Control, Right Alt, 'A', 'B'	1	\$41,\$00,\$04,\$05,\$00,\$00,\$00,\$00
Wake	2	\$01,\$02
Hot Key 0 & Hot Key 17	2	\$02,\$01,\$00,\$02

Table 8-6. Input Report Examples

8.3 Remote Wakeup

The JB16 receiver supports remote wakeup function that can wake up the host computer during USB suspend.

During suspend, the MCU will be periodically woken up by the IRQ driven by the external RC charging and discharging circuit. The MCU then turns on the RF circuit (both RFW-D100 and RFW-D102) for a short period of time, detect whether a valid mouse or keyboard RF packet arrived for waking up the host. During this short period, the IRQ will serve for RFW-D100 interrupt events again.

If no valid packet has been detected in this period, the receiver will sleep again. The MCU will initiate the charging and discharging cycle again before it enters power saving mode.

The mouse or keyboard can re-transmit an RF packet again if there is no acknowledgment from the JB16 receiver. The maximum number of such re-transmissions can be adjusted through the MAC application interface transmission function.

For the JB16 receiver to be able to detect the incoming packet, some timing parameters needed to be considered.

The first is the small wakeup duration at each IRQ wakeup. For example, if the receiver is sleeping while a packet arrives, the transmitter will send out a second packet because there is no acknowledge from the receiver. If the IRQ wakeup period longer than the interval between the first and next re-transmitted packet, the re-transmitted packet can be detected by the receiver.

Another timing is the interval between two IRQ interrupts. Consider a single key has been pressed on the keyboard. If an IRQ wakeup detection duty in the receiver has just elapsed before the arrival of the first RF keyboard packet, the receiver cannot detect that packet. The next wakeup duty will start at the next IRQ interrupt.

It can be seen that for a smaller number of re-transmission setting in the keyboard, all re-transmission may have taken place before the next wakeup duty start. This means the receiver will fail to detect the pressed key and cannot wake up the host. Therefore, the interval between two IRQ interrupts should be shorter for a relative small re-transmission setting in the transmitter. This time interval can be adjusted by the external RC values, C22, and R45.

Section 9. Testing and Customization

9.1 Testing

The solution was tested under different Windows Operating Systems on several different PCs.

- USB compliance test using Command Verifier version 1.2
- Compatibility tests under Windows 98SE, 2000, and XP
- Compatibility tests of ¹AMD[®] 750, Intel[®] 810 and 845 chip set desktops, IBM Thinkpad[®] T23, and Dell Latitude[®] NoteBook C640

9.2 Customization

9.2.1 Hardware

9.2.1.1 Optical Mouse Transmitter

The DC/DC converters/regulators used in this reference design are for reference only, customers can choose any converters/regulators they prefer. The LEDs for the sensor can be connected to the DC/DC converter output or connected to the batteries output. The advantage of connecting to the DC/DC converter output is that the system can work in a lower voltage, but the drawback is higher current consumption. The advantage of connecting to the batteries output is the lower power consumption but the system will not work properly if battery voltage is below 2.5 V.

1. Trademarks are owned by their respective companies.

9.2.1.2 Keyboard Transmitter

Left the unused pin open.

9.2.1.3 USB Receiver

The diodes connected in series at JB16 VDD can be removed if resistor networks are added in the data/address bus between JB16 and baseband IC as a 5-V to 3.3-V voltage divider.

9.2.1.4 RF Circuitry

The RF transceiver module, the baseband IC, and the CSMA protocol are developed by RFWaves. Please refer to RFWaves website for details and recommendations on RF circuitry customization.

<http://www.rfwaves.com>

9.2.2 Firmware

9.2.2.1 Mouse Transmitter

- Set the timing parameters for power management.

9.2.2.2 Keyboard Transmitter

- Modify the key matrix tables in “KEY-MAP.ASM” according to customized key matrix.

9.2.2.3 Receiver

- Modify the “KEYMAPTx.H” and USB “KEY-USB.ASM” files according to customized key matrix.
- Change vendor ID, product ID, and product revision number in the device descriptor table in “KBD-MSE.H”.
- Change the report descriptor in “KBS-MSE.H” if necessary.

Freescale Semiconductor, Inc.

Freescale Semiconductor, Inc.

**For More Information On This Product,
Go to: www.freescale.com**

Freescale Semiconductor, Inc.

HOW TO REACH US:

USA/EUROPE/LOCATIONS NOT LISTED:

Motorola Literature Distribution;
P.O. Box 5405, Denver, Colorado 80217
1-303-675-2140 or 1-800-441-2447

JAPAN:

Motorola Japan Ltd.; SPS, Technical Information Center,
3-20-1, Minami-Azabu Minato-ku, Tokyo 106-8573 Japan
81-3-3440-3569

ASIA/PACIFIC:

Motorola Semiconductors H.K. Ltd.;
Silicon Harbour Centre, 2 Dai King Street,
Tai Po Industrial Estate, Tai Po, N.T., Hong Kong
852-2668334

TECHNICAL INFORMATION CENTER:

1-800-521-6274

HOME PAGE:

<http://motorola.com/semiconductors>

Information in this document is provided solely to enable system and software implementers to use Motorola products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Motorola reserves the right to make changes without further notice to any products herein. Motorola makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Motorola assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Motorola data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Motorola does not convey any license under its patent rights nor the rights of others. Motorola products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Motorola product could create a situation where personal injury or death may occur. Should Buyer purchase or use Motorola products for any such unintended or unauthorized application, Buyer shall indemnify and hold Motorola and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Motorola was negligent regarding the design or manufacture of the part.



Motorola and the Stylized M Logo are registered in the U.S. Patent and Trademark Office. digital dna is a trademark of Motorola, Inc. All other product or service names are the property of their respective owners. Motorola, Inc. is an Equal Opportunity/Affirmative Action Employer.

© Motorola, Inc. 2003

DRM050/D

**For More Information On This Product,
Go to: www.freescale.com**