Embedded Human Interface Device for Voice and Data Communication


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Abstract

The development of a proprietary profile that integrates the three wireless applications, mouse, headset and data port, into a single Bluetooth transceiver has not been exploited. In this paper, we propose a design solution of integrating both voice and data communications into a single device based on Bluetooth technology. The design solution presented in this paper is to integrate the primary functions of PC mouse, headset, laser pointer and data transfer unit into a single device targeted for all PC users. A new mouse design is introduced to reduce the data rate needed for the mouse through wireless link. We have successfully implemented that Bluetooth Human Interface Device with the integration of the above four functions into a single device and the device works properly.

Key words: Bluetooth, Wireless data, and Mobile devices.

1. Introduction

With the widespread of computerization and the increase in popularity of personal computer (PC) in our daily life, the demand for a practical and enhanced human interface device is ever increasing. The trend is steering towards the application of wireless technology in every human-computer interface device to offer better mobility and flexibility to the user.

One of the most widely used human interface devices is the PC mouse [1]. With the ever increasing demand of PC user, the standard wired PC mouse is facing obsolescence by the introduction its wireless counterpart. Furthermore, with the increase demand of PC applications, like power-point presentation, multimedia presentation, and PC telephony etc., several peripherals are needed simultaneously to be integrated into a single PC mouse [2]. Hence, the urge for a possible integration of these peripherals into a single device to improve the overall ergonomics has been strong, pending the availability of new technology to fulfill such application at a feasible market price.

In this paper, we propose a design solution of integrating both voice and data communications into a single device based on Bluetooth technology [2]. The device integrates the four unique functions and many ergonomic features in a single operating gadget at an affordable price. The four functions include wireless mouse, wireless headset, wireless data port and laser pointer. A new mouse design is also introduced to reduce the data rate needed for the mouse through wireless link. The gadget, with its remote transceiver that can support maximum 100 meters transmission distance, can operate as a PC mouse, laser pointer, transmit and receive both voice and data all wirelessly within ten meters. It can be used in multimedia presentation, Internet telephony, and wireless data communication, or other simpler application. This device is suitable for a wide range of PC users in the market.

We have successfully implemented that Bluetooth Human Interface Device with the integration of the above four functions into a single device and the device works properly.

2. Proposed Design Solution

This section presents the overview of the design solution and the description of each function module of integrating the four functions into a single device.

2.1 Overview of the Design

The general overview of the design is depicted in Fig. 1. Five modules are included in the handheld unit:

- The Bluetooth module has I/O Port, PCM interface and UART interface that are connected to the mouse module, audio module and data module respectively. The Bluetooth module can support the transmission of the PCM data signals simultaneously with either the I/O port or the UART’s signal. Since the audio function is not needed for data transmission, it is deactivated by our circuitry design in order to cut down power consumption. Audio and mouse signals are transmitted together to achieve the requirement for multimedia presentation as well as other application like home telephony that calls for wireless audio transmission together with remote mouse control functions.
3. Description of Firmware Solution

- Mouse module detects the input action by the user and converts it into the appropriate signal for transmission by the I/O port of the Bluetooth module.
- Audio module provides a duplex audio signal coding to PCM code from the audio input to the Bluetooth module’s PCM interface and vice versa, simultaneously.
- Data module provides handshake signal and the actual transmission and reception of serial data between the data inlet (from PC or PDA etc.) and the Bluetooth module’s UART port. It converts the RS-232 format data from external device into a UART signal (3 volts peak) before sending it to the Bluetooth module for transmission, or vice versa.
- Laser pointer is physically integrated into the handheld unit independently with a separate circuitry and battery. The function of the mouse module at the remote unit is to decode the mouse control signals received by the Bluetooth module and convert these signals into the suitable format for driving the USB mouse controller. The USB mouse controller communicates to the PC directly as a plug and play USB mouse. The functions and configurations of the audio, data and Bluetooth modules at the remote unit are similar to the handheld unit in the hardware aspects.

2.2 Functionality of Each Module

A new mouse design is proposed in this paper. The conceptual design of conventional mouse is shown Fig. 2. In our design, we reduce the data rate needed for the mouse through the wireless link by moving the mouse controller block to PC side instead of in the mouse side. In this implementation, the data rate needed for the wireless link to handle reduced tremendously. Hence, there is much spare capacity available for the Bluetooth transceiver to handle the functional needs of voice and data transmission simultaneously. The detail design of the mouse modules in handheld and remote units are illustrated in Figs. 4 and 5 respectively. The encoder implementation chart for mouse movement, mouse buttons, and function explanation is shown in Table 1.

These concepts are applicable to all wireless mice, especially for those that use digital transmission, including Bluetooth device. In this manner, some simple digital gates are needed to provide the encoding and decoding which tremendously reduce the data rate needed as compared to the conventional wireless mouse if digital transmission will to be used.

The voice module and data module are implemented conventionally in its hardware with the main challenge in the firmware implementation to integrate all the three wireless functions to operate simultaneously. Fig. 6 shows the design of the voice module and the data module.

Since the Bluetooth transceiver has limited capacity in term of its memory with only 4 Kbytes of memory available and processing power, we need to develop our own proprietary firmware to achieve code efficiency for our codes to support the 3 wireless functions, such as, mouse, voice and data, simultaneously. The firmware architecture overview is shown in Fig. 6. The BlueMouse/Dongle firmware is to integrate the functions into a single Bluetooth transceiver. The lower levels are the basic radio and link manager inbuilt in the Bluetooth transceiver module. Others are the general profiles to service and establish the link. These are provided by the software development kit provided by CSR Bluetooth transceiver vendor [3].

The handheld unit’s firmware algorithm is shown in Fig. 8. The handheld unit is the main gadget that the user will operate to realize the function of wireless mouse, wireless headset and wireless data port. Though simultaneous transmission is possible, it is not practically utilized. Hence, the firmware implementation segregates the function of mouse with audio and data into two operations. Hence, for normal presentation, the wireless mouse and wireless headset is activated together with the laser pointer. For wireless data transfer, only the data module is active and the transceiver is dedicated to transfer solely data from the serial port. In this manner, not only the data transfer rate is faster, the power consumption of the unit is also more efficient. The firmware in the remote unit is similar in design to the handheld. Its algorithm is shown in Fig. 9.

4. Conclusions

The development of a proprietary profile that integrates the three wireless applications, mouse, headset and data port, into a single Bluetooth transceiver has not been exploited. In this paper, we design and implement the 4-in-1 multi-function Bluetooth mouse, with mouse, headset, data port and laser pointer that would change the way human interface with computer. There are breakthroughs in restructuring the design concept of conventional mouse into one that need a much lower data rate.

The single multifunction device not only provides mobility and efficiency, it also reduces the number of devices needed in a normal presentation. There could be many other useful applications like wireless telephony and other simpler application

In conclusion, we have successfully developed the multifunction mouse with our new concepts and proprietary design which we think would revolutionized the way we do our presentation and interact with the PC.

References

[1] How does PC Mouse works?
http://www.4qdtc.com/meece.html
Fig. 1: Block diagram of 4-in-1 mouse.

Fig. 2: Conventional mouse design.

Fig. 3: Proposed mouse design to reduce data rate needed

Fig. 4: Detail of mouse module at handheld unit.

Fig. 5: Detail of mouse module at remote unit.
Table 1: Encoder implementation chart.

<table>
<thead>
<tr>
<th>Input Action</th>
<th>Switch activated</th>
<th>#Encoder Logic</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move Down-Left</td>
<td>SDL</td>
<td>000 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>Move Down-Right</td>
<td>SDR</td>
<td>001 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>Move Up-Left</td>
<td>SUL</td>
<td>010 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>Move Up-Right</td>
<td>SUR</td>
<td>011 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>Move Left</td>
<td>SL</td>
<td>100 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>Move Right</td>
<td>SR</td>
<td>101 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>Move Down</td>
<td>SD</td>
<td>110 (#1)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>No input</td>
<td>-</td>
<td>111 (#1)</td>
<td>No action</td>
</tr>
<tr>
<td>Function Shift</td>
<td>Fn button</td>
<td>000 (#2)</td>
<td>*Function Shift key</td>
</tr>
<tr>
<td>Data Function</td>
<td>Data select</td>
<td>001 (#2)</td>
<td>**Data Fn Select</td>
</tr>
<tr>
<td>Mouse Left Button</td>
<td>BL micro-switch</td>
<td>010 (#2)</td>
<td>Mouse Select</td>
</tr>
<tr>
<td>Mouse Right Button</td>
<td>BR micro-switch</td>
<td>011 (#2)</td>
<td>Menu</td>
</tr>
<tr>
<td>Scroll Down</td>
<td>BD micro-switch</td>
<td>100 (#2)</td>
<td>Screen scroll down</td>
</tr>
<tr>
<td>Scroll Up</td>
<td>BU</td>
<td>101 (#2)</td>
<td>Screen scroll up</td>
</tr>
<tr>
<td>Move Up</td>
<td>***SU</td>
<td>110 (#2)</td>
<td>Move mouse arrow</td>
</tr>
<tr>
<td>No input</td>
<td>-</td>
<td>111 (#2)</td>
<td>No action</td>
</tr>
</tbody>
</table>

* Function shift key is to multiplex the mouse buttons for other function or input key to the Bluetooth module as needed.
** Data Fn Select is to activate the Bluetooth module into serial data transmission mode, thereby deactivating the mouse function.
*** SU – scroll up was implemented in decoder #2 instead of #1 because #1 can only implement 7 useful state and one for no input.

![Audio and data module diagram](image-url)
Fig. 7: Firmware architecture overview.

Fig. 8: Handheld (or BlueMouse) unit’s firmware algorithm.
Fig. 9: Remore (or Dongle) unit’s firmware algorithm.