

STUDY AND IMPLEMENT OF AN EMBEDDED SYSTEM BASED ON USB HOST

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Abstract

Aiming at the application limitation of the USB device of Embedded Systems, this article carried out a scheme which can help to make use of MCU+USB master chip directly. In this scheme, a kind of common embedded USB host system module was designed and achieved based on the interface chip SL811HS of the USB host and can communicate with USB device, the widely used and easily debugged AT89C55 microcontroller was chose as the MCU, and then the entire module was designed and verified. At the same time, the interrupt task scheduling mechanism was used for designing the software system. Also we designed a set of API to improve the versatility of whole module that could be transplanted into the different Embedded System of different processors conveniently.

Keywords: Embedded USB host, AT89C55, SL811HS

Introduction

With the development and popularization of computer technology and USB technology, the Embedded USB System consisted of all kinds of Microcontroller Unit and had been widely applied in areas of industrial automation, office automation, building automation and etc. To achieve the function of data collection, removable storage, plug and play and etc, the integrated USB technology has become an important trend of the development of new generation Embedded Systems. At present, they must use PC as host and take themselves as external device instead of working independently from PC. As USB has characteristics such as standardization of the hardware

structure, rapid communication and Plug and Play, as well as in general application area, embedded devices has advantages which general-purpose computer is not matched for low-cost, small-size, low-consumption and real-time etc. So, if function of USB host in Embedded Systems has been achieved, we could store and move data among Embedded Systems conveniently and low-costly. Therefore, the research for achieving the functions of USB host in Embedded Systems has important significance and practical value[1~2].

As the present situation of using the USB embedded system in industrial control, this article proposed a scheme which can be achieved by using MCU+USB master chip directly; the 8-bit MCU was used to achieve the function of USB host. The drive of the control chip of USB host was completed by MCU, while the data was packed on the basis of the USB agreement, and then accessed the class of Mass Storage of USB devices, created, read and revised files in USB flash disk at the same time. The 8-bit MCU's utilization in this scheme has merits such as simplified hardware circuit, less peripherals and low system cost. By the way of executing virtual software modules, CPU droved normal I/O interfaces to achieve the function of hardware peripherals. In MCU, USB agreement stack and the class agreement of Mass Storage was load and the file system of FAT was built. Then with a external control chip of USB host, the function of USB host was accomplished independently from PC, and controlling and operating directly to USB devices. This can create significant application values in the field of mobile data storage and exchange, and play a more important role in other Embedded Systems when it was integrated.

The Overall Scheme Design

The design was divided into two parts: hardware design and software design. The hardware design is mainly considering the peripheral circuit design of controlling chip of USB host. While the key technique and difficulty is the software design of embedded USB host, as aiming at the common property of embedded USB host system and control platform. The software design could offer common interface to the drive programs of USB devices so that the control platform had the function of offering host service aimed at different USB devices simultaneously[3].

The Hardware of usb host system

To achieve the USB agreement, first of all, the hardware, namely the physical layer of agreement, must be solved. It can be solved by choosing proper control chip of USB host. This system chose the SL811HS[4] chip of CYPRESS Corporation. Because of advantages of the chip such as convenient interface, simple drive, less resources and calibration, the start package of frame was treated by hardware automatically etc, and the chip was suitable for being used in Embedded System, it was chosen for achieving the physical layer of USB agreement. There is no doubt that it is a superiority that CYPRESS Corporation, one of the earliest companies who concentrated in making USB control chip, owned mature technology and much reference information for a new development direction.

In addition, the system chose AT89C55 [5] as a system controlling MCU which was made by ATMEL Corporation, U.S. The AT89C55 is a product of low-voltage, high-performance CMOS 8-bit microcontroller, and compatible with the standard MCS-51. The chip contains 20Kbytes of Erasable Programmable Read-Only Memory (EPROM), the 256bytes of random access data memory (RAM), 4 8-bit I / O ports, three 16-bit counter, two Enhanced Full Double industrial serial communication interface and dual data pointers. The devices take the ATMEL

Corporation's high-speed, non-volatile memory technology, and the processor core has been redesigned, so its performance has been greatly improved comparing to the standard 89C52.

The system schematic shown in Figure1. The major chips used by system hardware circuit also include a serial communication level converter MAX232, 8D latch 74HC373, to program conveniently, reach faster transmission speed and achieve more complex applications, 32KB of 62256 was chose as the extended RAM.

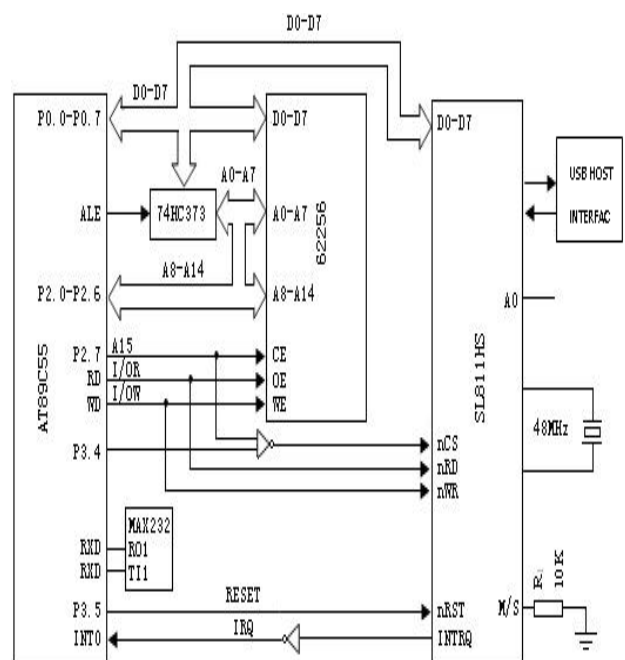


Figure 1. System circuit diagram

The software design of usb host system

For the versatility of the designed embedded USB host system, the software design should not depend on any operating system. The programming style of each task can meet the need of USB system perfectly through dispatching of interrupt, because when entire USB bus was moving, the system could still running according to given sequence and agreement. Simply, the USB system includes two parts: USB host and USB



peripherals. The communication of USB system was controlled by USB host. There are differences between USB host and host of Ethernet in concept. The USB host didn't simply mean hardware, but included software of embedded PC system and hardware. When the embedded USB host was been designed, we should understand and hold the communication process between USB devices and USB host system. The part of software contained mainly USB host and USB devices function module. They were independent and utilized from each other, and accomplished the function of USB host together.

After establishing corresponding hardware connection, we can chose different hardware features and exploitation languages to accomplish the design work of USB host. Software based on features of different hardware. The implementation process of USB host system was bottom-up:

- The communication between AT89c55 and SL811HS was the base of USB software system. It contained interface function, which defines reading, writing and setting address to SL811HS, and operating function of standard device interface. Because signal wire of data and address of external bus of SL811HS is multiplex, when AT89C55 reads and writes data to the memory of SL811HS, sending address first, and then the data. Besides, thank to SL811HS adopted the address automatically added mechanism, if we need to read or write the data of consequent address, only we do is that sending primary address. Then while we reads or writes data, SL811HS will add 1 to addressing address.
- The sending and receiving the lowest data packet of USB host. According to the different need of transmissions and the affairs of SETUP, IN and OUT, these packets transit between host and device. While the combination of three affairs built up the four transmission way (control transmission, interrupt transmission, bulk transmission, and synchronous transmission) of USB. In embedded USB Host Demo, we need

only to achieve basic control transmission and bulk transmission of USB. This is a function of sending data package; its parameters consist of length, address pointer and endpoint type of sending data package.

- The achievement of request command of USB standard device. The mission of this section is that achieving the all kinds of request commands of standard device defined by USB agreement.
- The construction of USB class of Mass Storage[6]. What was supported in embedded USB Host Demo is USB device which is USB class device of Mass Storage. The Mass Storage class adopted the transmission agreement of Bulk-Only, while subclass adopted UFI command set. So, the achievement of Mass Storage Class contained the two sections which established Bulk-Only (contained the definition of package of CBW and CSW) firstly, and second supported the specific request command of UFI to achieve the reading and writing of Flash of USB flash disk.
- From the perspective of software, the achievement of Bulk-Only transmission agreement needs exactly the bulk transmission functions of Bulk_Transfer_OUT() and Bulk_Transfer_IN().The same as the CBW and CSW. While UFI commands send specific request command based on the agreement of Bulk-Only.

The following is the definition of CBW and CSW:

```
typedef struct_CBW
{
    unsigned long dCBWsignature;
    unsigned long dCBWTag;
    unsigned char dCBWDataTransferLength;
    unsigned char bmCBWFlags;
    unsigned char bCBWLUN;
    unsigned char bCBWCBLLength;
    unsigned char CBWCB[16];
}CBW, *pCBW;

typedef struct_CSW
{
```

```

unsigned long dCBWSignature;
unsigned long dCBWTag;
unsigned long dCSWDataResidue;
unsigned char bCSWStatus;
}CSW, *Pcsw;
    
```

EFI defined a series of commands to achieve the read/write and control the disk. In the inspect of software, the main assignment of EFI is to write the content of CBWCB of corresponding EFI command, then call the function of BULK-ONLY(). The detailed programme inventory is no longer given there. Through the achievement of EFI command of subclass of Storage, the file system could call all kinds of operation of EFI in disk to achievement of file management after the construction of FAT[7] file system.

- The construction of simple FAT file system. The key of achievement of FAT file system is to build the data structure of file system. The USB flash disk used by system consists of MBR, DBR, FAT, FDT and DATA. For the convenience of reading the message of USB flash disk, we build up the data structure of each section first, and then define the data structure of FDT. After that, system programme inquiries the relative information of files of USB flash disk, then defines a function to achieve the read of information and data of files. Because of the information of FAT file system is stored in a regular place, we can read the file information based on known info. Then we read the detailed data of file through the size and storage address of file we have read. Besides, system can write into USB flash disk through the write command of EFI.

The software flowchart of whole system showed as figure 2:

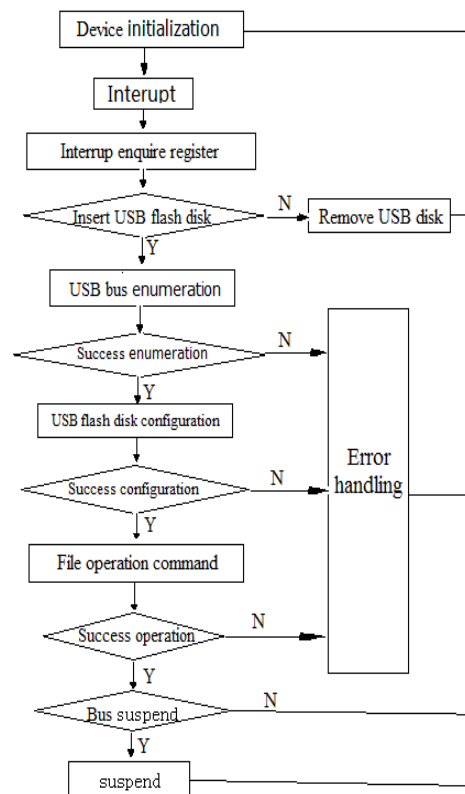


Figure 2. The software flowchart of USB host

The enumeration and configuration are the key steps and processes, and every USB host system must experience. Before USB device has not been configured, its default address and control endpoint are 0. Only through control transmission, getting the relative information of device, configuring device again based on requirement and distributing new address, can we carry out the next step of development of USB system.

Application of embedded usb host in the series of hp desk printer

Because it is an embedded application problem of printer, the device driver is related to the printer's support, including the system service, print environment, fonts and task management. Due to the industry status and market share of HP, referring to its development manual, technical guidelines and content about printer equipment in USB agreement, it will mainly develop its

USB ink-jet printer of HP DeskJet series , doing actual operation in HP DeskJet D2368 C9080D inkjet printer .

Function HP Print () gives a specific printing application. Guaranteed. The printer has access to system and go through device enumeration before print, device address being 1. Program need to inquire the current state of the printer at first by calling printer equipment request . For abnormal situation, such as offline, paper out and error ,it will solve this situation correspondingly. if printer has no error, it will be ready to print. Having used SOFT_RESET to reset printer, after the printer initialize, it setups page and sets print environment for printer mission. If we complete the printing preparation work above, we can output print text to the printer . the flow

diagram of function HP Print () is shown in figure 3:

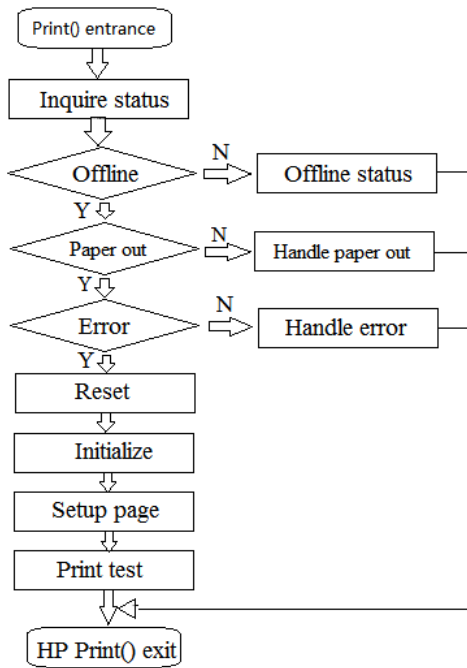


Figure 3. The flow diagram of function HP printer

The following is the source table of function HPPrint():

```

//HP PCL command sequence
unsigned char codo PCLCmd1[]={
//EscE-Reset Printer.
    0x1b,' E' ,
};
unsigned char codo PCLCmd2[]={

```

```

//Esc&12A-Set Paper Size,Selects U.S. Letter size
paper 8 1/2 × 11 in.

```

```
0x1b,' &' , ' 1' , ' 2' , ' 6' ,
```

```
//Esc&10O-Set Portrait Orientation.
```

```
0x1b,' &' , ' 1' , ' o' , ' O' ,
```

```
//Esc&11L-Enable Perforation Skip Mode,Default top
margin is 1/2 in.
```

```
0x1b,' &' , ' 1' , ' L' ,
```

```
//Esc&8D_Set Spacing,8 LPI is used for page length
and margin circulation.
```

```
0x1b,' &' , ' 1' , ' 8' , ' D' ,
```

```
//Esc&188P_Specify Page Length,11 in .x 8 lpi = 88
lines
```

```
0x1b,' &' , ' 1' , ' 8' , ' 8' , ' P' ,
```

```
//Esc&172F_Set Text Length,
```

```
0x1b,' &' , ' 7' , ' 2' , ' F' ,
```

```
//Esc(sOp12H-Specify Fixed 12 cpi,12 cpi is used to
set columns for side margin circulations.
```

```
0x1b,' &' , ' ( ' , ' s' , ' c' , ' p' , ' 1' , ' 2' ,
H' ,
```

```
//Esc&a 6L _Set Left Margin.
```

```
0x1b,' &' , ' a' , ' G' , ' L' ,
```

```
//Esc &a 90M_Set Left Margin.
```

```
0x1b,' &' , ' a' , ' 9' , ' C' , ' M' ,
```

```
//Esc*p-95y+475x_Position CAP for Header.
```

```
, Cx1b,' *' , ' p' , ' - ' , ' 9' , ' 5' , ' y' , ' +' ,
4' , ' 7' , ' 5' , ' x' ,
```

```
//Esc(12U_Select Character Set.Select PC-850
character set.
```

```
0x1b,' ( ' , ' 1' , ' 2' , ' U' ,
```

```
//Esc(s612vOs3b6T_Select Header Font,Sets font to
Letter Gothic 6 cpi 12 point bold.
```

```
0x1b,' )' , ' s' , ' 6' , ' h' , ' 1' , ' 2' , ' v' ,
O' , ' s' , ' 3' , ' b' , ' 6' , ' T' ,
```

```
//Header Text “Embedded USB HOST System”
```

```
'E' , ' m' , ' b' , ' e' , ' d' , ' d' , ' e' , ' d' ,
U' , ' S' , ' B' , ' H' , ' O' , ' S' , ' T' , ' S' ,
y' , ' s' , ' t' , ' e' , ' m' ,
```

```
//Esc&19C_Set VMI to 9/48 in.Provides a
desriable(desirable) line for 12 point font used in main
text.
```

```
0x1b,' &' , ' 1' , ' 9' , ' C' ,
```

```
};
//The print content
Unsigned char code Prn Text[]=" The Universal
Serial Bus is a new technology for connecting
peripheral devices to computer.Compared with the
traditional PC interfaces such as serial and parallel
port,the USB combines the advantages of higher data
transform throughput,plug-and-play,hot
swapping ,expandability and low-cost.It' s
not long before the USB has become the requisite
standard interface in PC after the USB specification was
issued." ;
.....
```

```
Int HPPrint < void >
{
BYTE PrinterStatus;
If ( 1GetPortStatus<1,0,&PrinterStatus> )
{
IF( PrinterStatus & PRN_EPP)
Printf ( " Printer Error !\n" );
Return PRN_ERR;
}
IF (PrinterStatus & PRN_SEL)
{
Printf( " Printer Not Select !\n" );
Return PRN_SEL;
}
If (PrinterStatus & PRN_PE)
{
Printf( " Printer Paper Empty !\n" );
Return PRN_PE;
}
}
Else
{
SoftReset (1,0);
//Esce_Reset Printer ,Returns the printer to its default
sottings.

DataRW(1,uDev[1].bEPAddr[2],Ox40,(int)size,of(PCL
Cmd1),PCLCmd1);
//Send HP PCL command sequence
```

```
DataRW(1,uDev[1].bEP Addr[2],Ox40,(int)size
of(PCLCmd2),PCLCmd2);
DataRW(1,uDev[1].bEPAddr[2],Ox40,(int)size of (Prn
Text),Prn Text);
//Send the print content
Esce_Reset Printer,Clears partially composed pages,
returns printer to default settings.
DataRW(1,uDev[1].bERAddr[2],Ox40,(int)size of
(PCLCmd1),PCLCmd1);
Return FALSE;
}}
```

Test results and maintenance

the flow diagram of test is shown in figure 4:

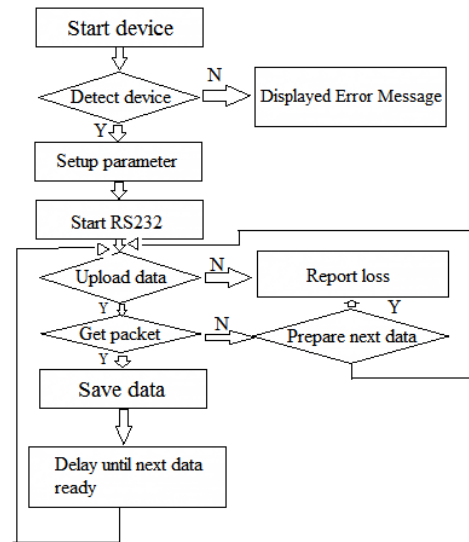


Figure 4 .system diagram

Test results

On the basis of the theory ,by the connection of USB flash disk and the module , at the same time the printer connects the module .Connecting the power, this module run the USB enumeration process and a series of initial program. Finally the working process of the module will be shown in figure 6-5. At last, it will transfer U data to the printer successfully in theory, and will print out the data file. It can be run successfully in the program running software, so this system



basically resolves the initial task of requirement expected to be completed and realize the function module.

Module maintenance

This system meets expected requirements basically, but this system still has many defects and deficiencies, such as:(1)there is not selective in the data conversion. This system can only transfer the USB flash disk data of testing cases to the module, then it connects the data to the printer to print ;(2)This module function is simple. There is not selective in data transmission. In this paper, the USB flash disk data of testing cases must be set up in word document or TXT notepad document. Then the data can be transferred to the printer, and printed successfully;(3)The system fails to make a graphic print output function available and so on.

conclusion

The embedded USB host system in this article provides host port of stable signal transmission in hardware and provides common interface of USB device drive programme. This makes it possible for achieving the function of USB host in Embedded System and we can store and move the information among Embedded Systems with lower cost and more convenience. The application of this technology can make it easy for connecting with USB peripherals. At the same time, the system function gets extended and the flexibility of instrument gets improved. The system adopts module design, so the achieved embedded USB host system has much space for increasing function.

At present, there attaches great importance to the study and application of USB host all around the world .The full utilization of simple and easy feature of USB and high speed data transmission performance

supplied by USB 2.0 agreement(480Mb/s),will bring a broaden market to the application of USB. With setting the appearance of USB OTG[8] (additional agreement of USB 2.0 agreement), the study of embedded USB host will attract more developer to concentrate on it in the future.

References

- [1] Frank. USB Project Technical Report [R]. [http:// www.driverdevelop.com](http://www.driverdevelop.com)
- [2] Zeng Chunnian, Study of Vehicle USB Host Based on The SL811HS Chip [J]. Journal of Wuhan University of Technology..2008(02).P125-128
- [3] Jan Axelson. USB Complete[M]. Translated by Chen Yi. Peking: China Electric Power Press .
- [4] Cypress Semiconductor Corporation. SL811HS/SL811HST Embedded USB Host/Slave Controller. March 14, 2002
- [5] Wei Yingqin, Chen Liankun. USB High-speed Data Transmission Based on PDIUSBD12 [J]. The Application of The CSM and Embedded Systems, 2006,(09).P74-76
- [6] USB Implementer's Forum. USB Mass Storage Class UFI Command Specification Rev1.0 [EB/OL]. <http://www.usb.org>. 2006-11-22
- [7] Microsoft. Microsoft Extensible Firmware Initiative FAT32 File System Specification.
- [8] USB IF. Universal Serial Bus Special Revision 2.0[R] .2000-04-2.

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