USB-MSD-RD

USB MASS STORAGE DEVICE REFERENCE DESIGN KIT USER'S GUIDE

1. Kit Contents

- CF, SD, MMC Memory Expansion Board (AB5)
- 256 MB SD Card
- Straight DB9 serial cable (RS-232 cable)
- Quick-start Guide
- Reference Design Kit CD-ROM containing the following items:
  - USB Mass Storage Device Reference Design Programmer's Guide (AN282), and associated software (AN282SW.zip)
  - Keil Software 8051 Development Tools (evaluation assembler, 2 kB limited compiler, and linker)
  - All C8051F340 and USB MSD related documentation in PDF format

2. Requirements

The USB MSD Reference Design Kit has been designed for use with a C8051F340DK Development Kit. The development kit can be purchased separately from Silicon Laboratories (www.silabs.com). The following are the requirements to use this Reference Design Kit as described in this User's Guide.

- C8051F340DK Development Kit (contents shown below):
  - C8051F340-TB Target Board
  - USB Debug Adapter
  - 6' USB Cable
  - AC to DC Power Adapter
- PC with the following features:
  - Operating system: Windows 2000/XP/Server2003
  - Available ports: One serial port (RS232) and one USB port

Note: A full version of the Keil tool chain is required in order to modify and recompile the code provided with this reference design because the code size is greater than evaluation tool chain's code size limits. No tool chain is required for the demonstration or for debugging because an object file (*.OMF) is provided with the reference design.

3. USB Mass Storage Device Reference Design Kit Overview

The USB Mass Storage Device (MSD) Reference Design Kit includes the AB5 Expansion Board (shown in Figure 1) that can be connected directly to the expansion connector of a C8051F340-TB Target Board. The connected setup with a SD memory card is shown in Figure 2. This hardware and the included 'F340 firmware fully demonstrate how an application can benefit from implementing the USB MSD device class. The firmware is described in Section "4. USB MSD RD Firmware". Step-by-step demonstration instructions are provided in Section "5. USB MSD Reference Design Kit Demonstration". Detailed descriptions of the components and API functions are included in "AN282: USB Mass Storage Device Reference Design Programmer's Guide". The board hardware is described in sections 6, 7, and 8.

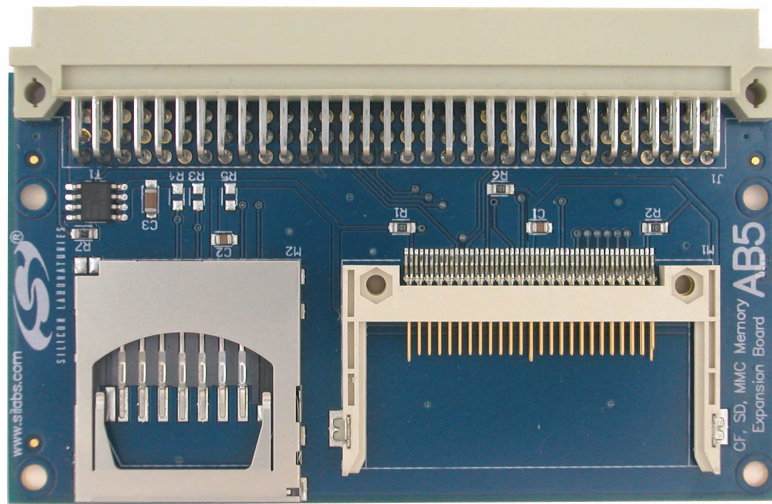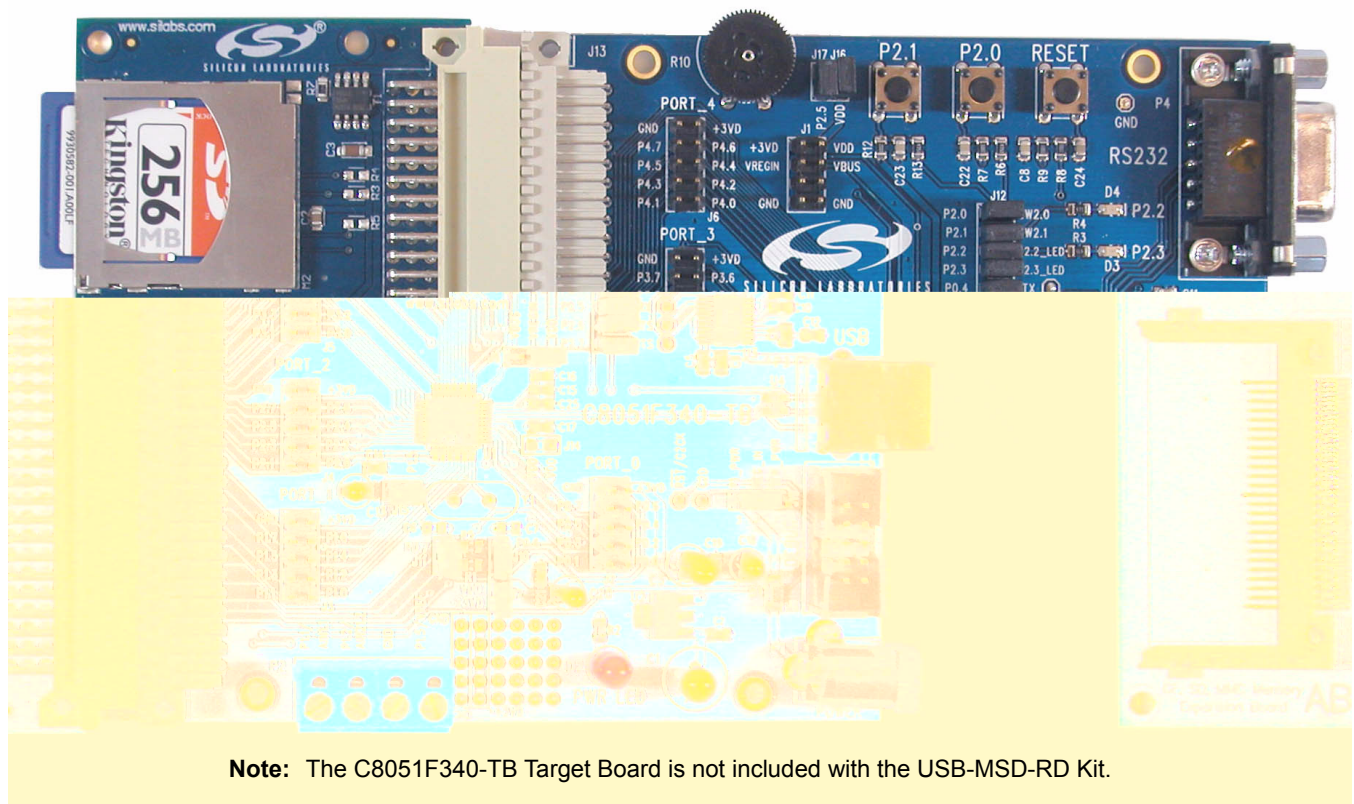Copyright © 2006 by Silicon Laboratories

Figure 1. CF, SD, MMC Memory Expansion Board (AB5)

Note: The C8051F340-TB Target Board is not included with the USB-MSD-RD Kit.

Figure 2. C8051F340-TB connected to AB5 Expansion Board with SD Card

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4. USB MSD RD Firmware

The USB MSD RD includes all the 'F340 firmware necessary to handle the following:

- USB enumeration and standard requests
- MSD class requests
- SCSI command set
- Media access - SD, MMC and CompactFlash card formats
- FAT16 file system support

Also included is an example application that can perform the following tasks:

- Present an interactive command shell via the UART
- Measure temperature using the on-chip temperature sensor and ADC
- Monitor the state of the two push-button switches on the target board
- Log the temperature and button state information to log files in the memory card

The USB MSD RD System Architecture shown in Figure 3 gives an overview of the various components that constitute the USB MSD RD firmware. The code space usage chart in Figure 4 shows the amount of code space used by the firmware components. Detailed descriptions of the components and API functions are included in "AN282: USB Mass Storage Device Reference Design Programmer's Guide".

To implement your own application based on this USB MSD Reference Design, you can customize the blocks labeled 'Application', 'Other HW Peripherals', and 'App. Specific Hardware' (all shown in blue in Figure 3). Source code for all the other firmware blocks is also provided, but typically there is no need to customize these blocks.
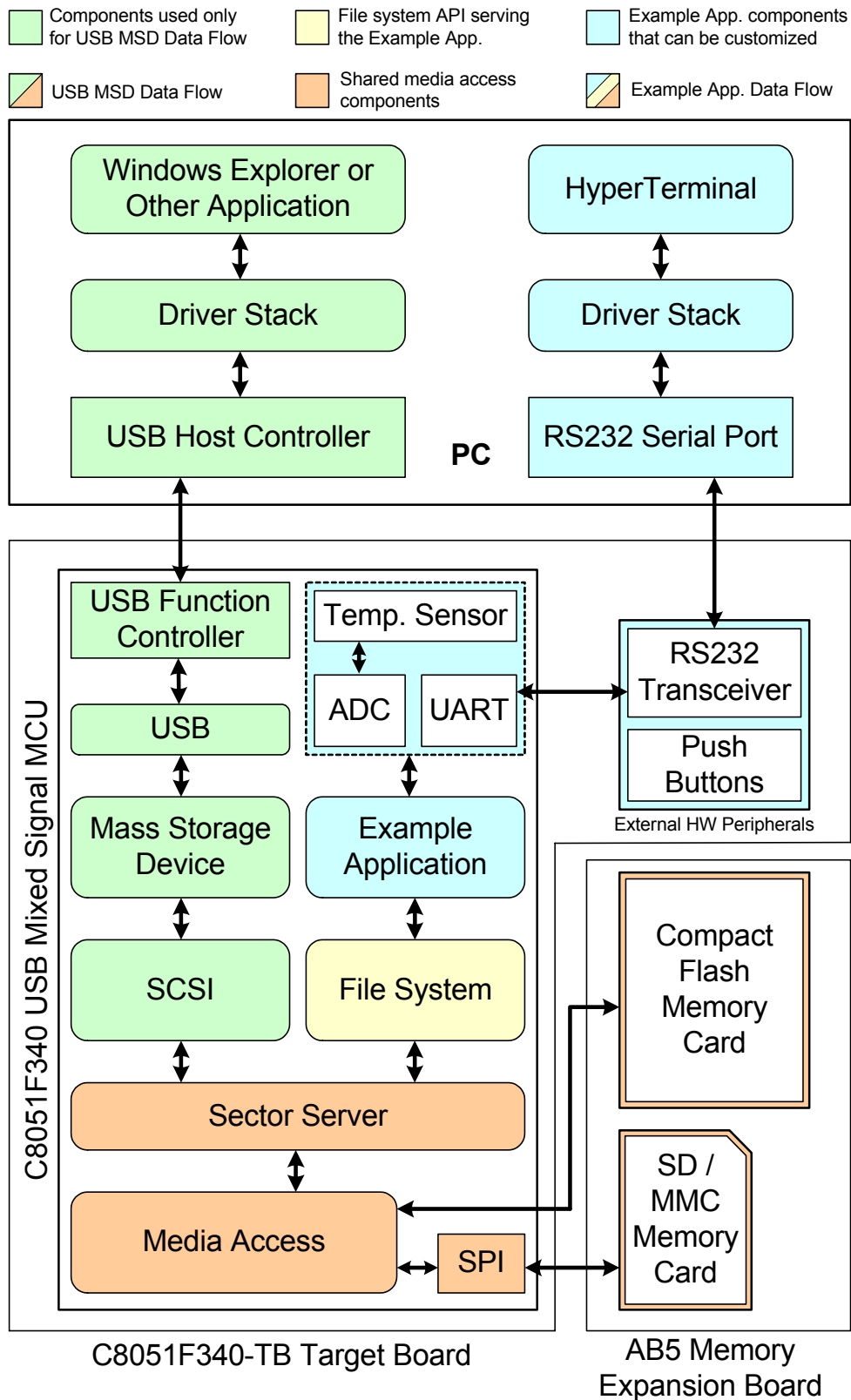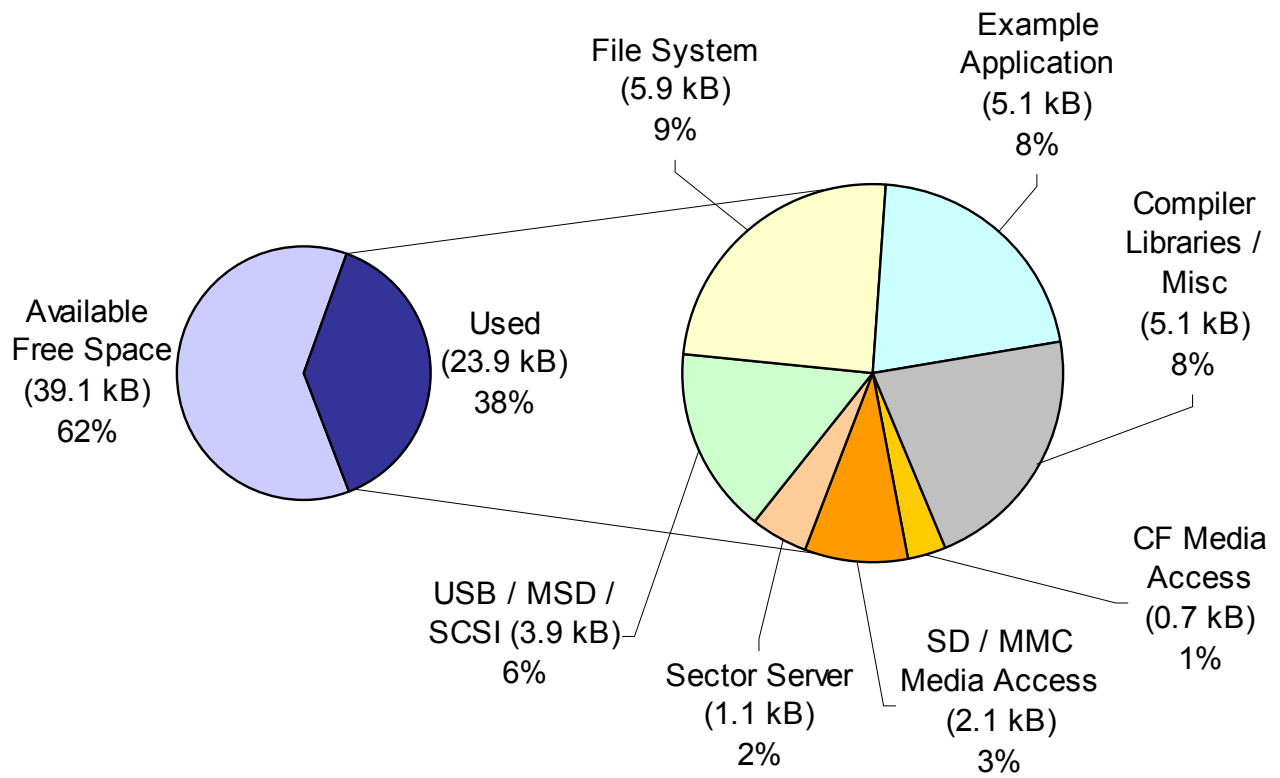
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Components used only for USB MSD Data Flow

File system API serving the Example App.

Example App. components that can be customized

USB MSD Data Flow

Shared media access components

Example App. Data Flow

PC

Windows Explorer or Other Application

Driver Stack

USB Host Controller

HyperTerminal

Driver Stack

RS232 Serial Port

C8051F340 USB Mixed Signal MCU

USB Function Controller

USB

Mass Storage Device

SCSI

Temp. Sensor

ADC

UART

Example Application

File System

Sector Server

Media Access

SPI

RS232 Transceiver

Push Buttons

External HW Peripherals

Compact Flash Memory Card

SD / MMC Memory Card

C8051F340-TB Target Board

AB5 Memory Expansion Board

Figure 3. USB MSD RD System Architecture

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Figure 4. USB MSD Firmware Code Space Usage on the C8051F340

5. USB MSD Reference Design Kit Demonstration

The following step-by-step demonstration will walk you through the various features and capabilities of this reference design. There are three parts to this demonstration: Firmware Download, Example Application Demonstration, and Mass Storage Device Demonstration.

Note: The demonstration instructions assume that a PC running Windows 2000/XP/Server2003 is being used.

5.1. Firmware Download

The steps in this section will guide you in downloading the USB MSD Reference Design firmware to the C8051F340-TB target board.

1. Follow the 'Software Setup' instructions in the C8051F340DK User's Guide to install the Silicon Laboratories IDE. This document is available at the following web page: http://www.silabs.com/tgwWebApp/public/web_content/products/Microcontrollers/USB/en/C8051F340DK.htm.

2. Depending on which type of debug adapter you have, set up the hardware as shown in one of the two diagrams below (Figure 5, Figure 6). Consult the C8051F340DK User's Guide for detailed instructions.
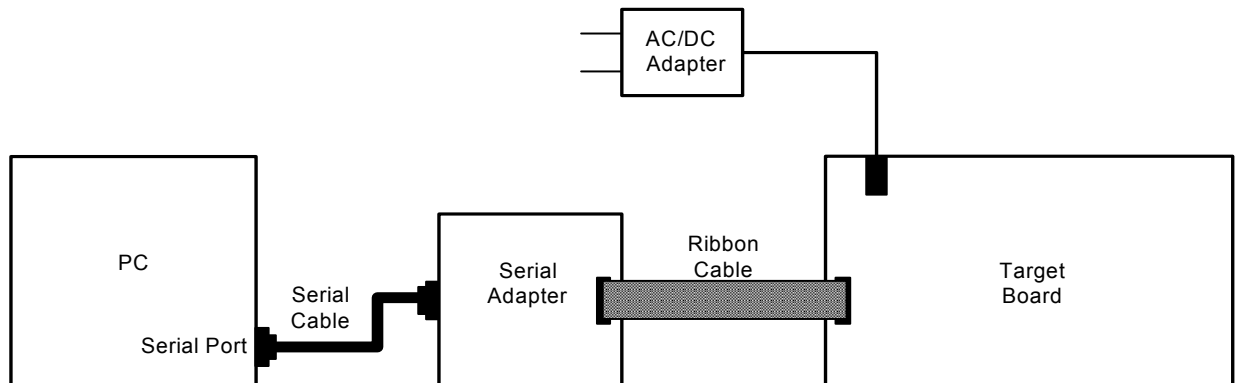
Figure 5. Hardware Setup using a Serial Debug Adapter
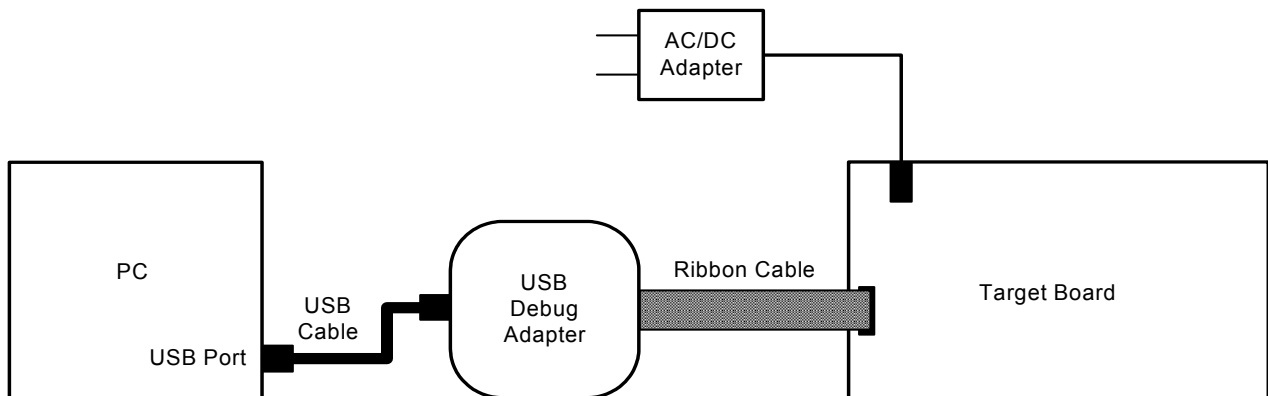
Figure 6. Hardware Setup using a USB Debug Adapter

3. Launch the Silicon Labs IDE using the icon from your Start Menu: 'Start Menu → Programs → Silicon Laboratories → Silicon Laboratories IDE'

4. Before connecting to the target device, several connection options may need to be set. Open the 'Connection Options' window by selecting 'Options → Connection Options...' in the IDE menu. First, select the adapter that was included with the kit in the "Serial Adapter" section. Next, the correct "Debug Interface" must be selected. C8051F34x family devices use the Silicon Labs 2-wire (C2) debug interface. Once these selections are made, click the OK button to close the window.

5. Click the 'Connect' button in the toolbar or select 'Debug → Connect' from the menu to connect to the device. You will see the text "Target: C8051F340" in the status bar of the IDE if the connection was successful.

6. Choose the 'Project → Download Object File…' option. This shows a 'Download' dialog. Click the 'Browse' button and select the USB MSD RD firmware pre-linked OMF file from this path: C:\Silabs\MCU\USB_MassStorageDevice_RD\Firmware\F34x_MSD.OMF

7. Click the 'Download' button to download this firmware to the 'F340 device. You will see the text "Download successful" in the Build window if the firmware was downloaded successfully.

8. Disconnect the dc power adapter and the ribbon cable from the target board.

5.2. Example Application Demonstration

The Example Application demonstrates how the reference design can be used as an independent embedded system while it is not connected to a PC via USB. In this configuration, the embedded system is able to perform various tasks based on user commands via a UART-based interactive command shell.

5.2.1. PC Software Setup

On the PC, set up HyperTerminal to use the COM port at 115200 baud, 8-N-1, and no flow control as shown in Figure 7. Detailed setup instructions are shown below.

1. Launch HyperTerminal from your Start Menu: 'Start Menu → Programs → Accessories → Communications → HyperTerminal'.

2. Type any name for the new connection, and click OK.

3. In the 'Connect using:' drop-down list, Choose 'COM1', or if you have multiple COM ports, choose the one you want to use.

4. Set up the COM1 Properties dialog as shown in Figure 7, and click OK.
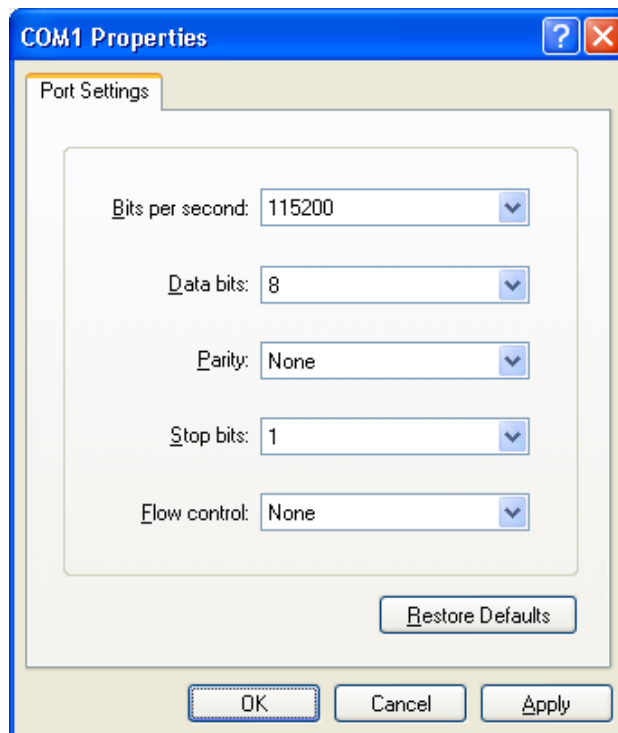
Figure 7. Example Application - HyperTerminal Settings

5.2.2. Hardware Setup

1. Connect the C8051F340-TB target board connector J13 to the AB5 expansion board connector J1.

2. Insert the SD card provided with the reference design kit into the SD card slot (M2) in the expansion board.

3. Connect a straight DB9 serial cable (RS-232 cable) between the PC's serial port and C8051F340-TB.

4. Make sure that the jumpers on the 'F340 TB are as shown in Figure 8.

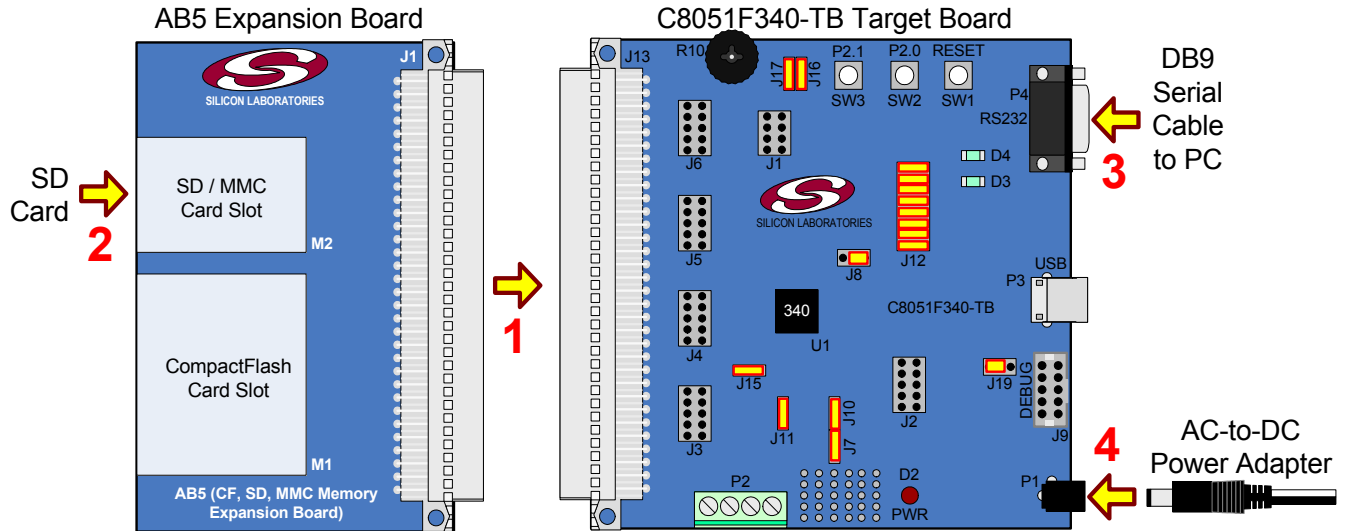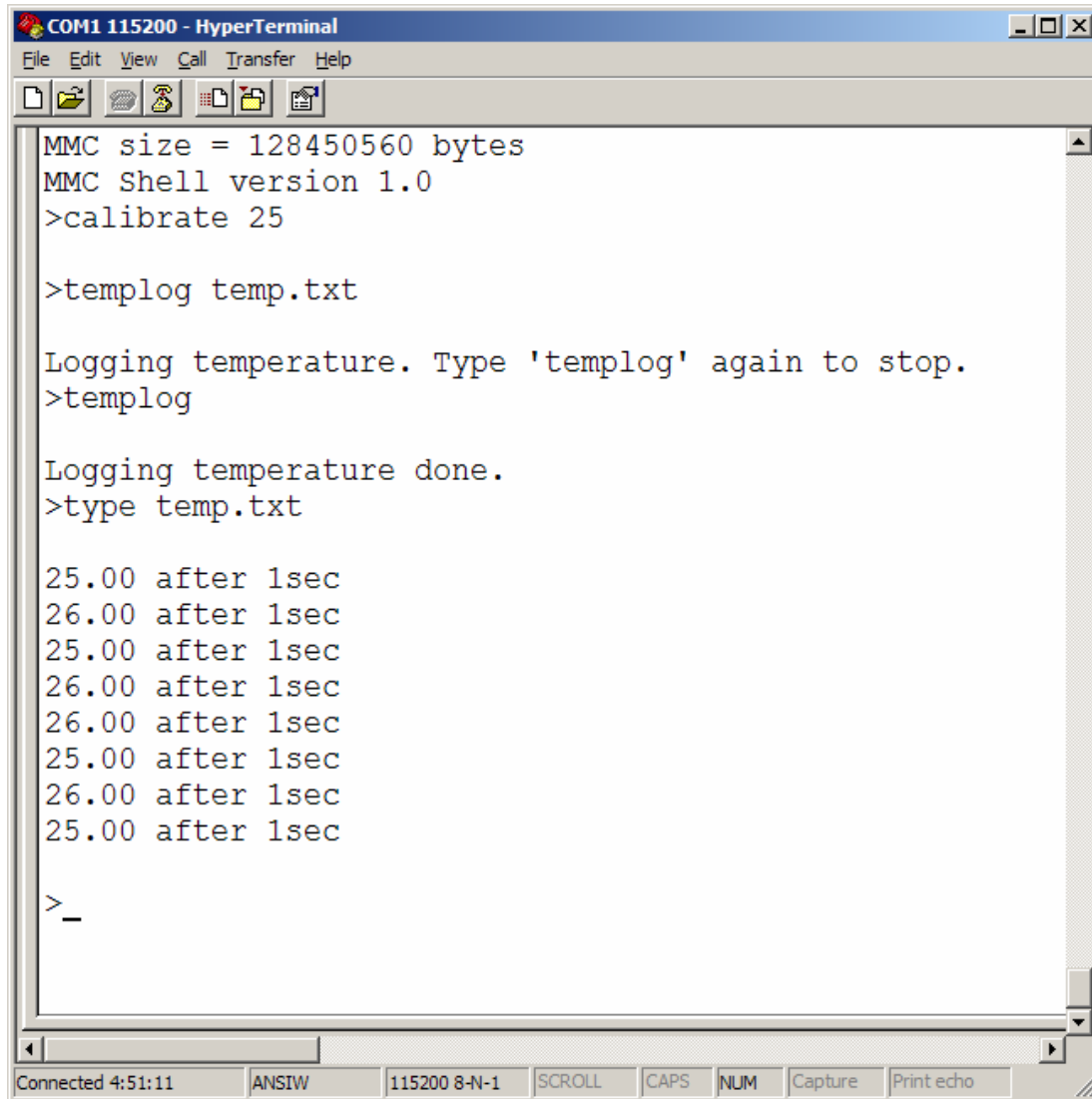5. Apply power to the target board using a dc power adapter.

Figure 8. Demonstration Connections

5.2.3. Interacting with the Example Application

1. A command interpreter shell is presented via HyperTerminal. Use this to interact with the device firmware to record a temperature log. Follow the steps below referring to screenshot in Figure 9.

Note: If the text "USB Active; UART Disabled" is displayed even when a USB cable is not plugged into the USB connector on the board, it most likely is because of error(s) in jumper settings. See Figure 8 for the correct jumper settings.

  a. Type "calibrate 25" to calibrate the device to room temperature (25 ºC).

  b. Type "templog temp.txt" to initiate temperature logging to a file that is updated every second. This is an example of periodic logging, where the interval between logs is known in advance. The 'F340 ADC0 measures the temperature using the on-chip temperature sensor, which is then logged to a file.

  c. Wait for a few seconds to collect some temperature data in the file.

  d. Type "templog" to stop the log.

  e. Type "type temp.txt" to view the contents of the log file.

```
COM1 115200 - HyperTerminal                                          _ □ ×
File  Edit  View  Call  Transfer  Help

MMC size = 128450560 bytes
MMC Shell version 1.0
>calibrate 25

>templog temp.txt

Logging temperature. Type 'templog' again to stop.
>templog

Logging temperature done.
>type temp.txt

25.00 after 1sec
26.00 after 1sec
25.00 after 1sec
26.00 after 1sec
26.00 after 1sec
25.00 after 1sec
26.00 after 1sec
25.00 after 1sec


>_


Connected 4:51:11      ANSIW       115200 8-N-1   SCROLL   CAPS   NUM   Capture   Print echo
```

Figure 9. Example Application - Temperature logging

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2. Continue to use the command interpreter shell to log press/release events for the buttons P2.0 and P2.1 on the C8051F340 target board. Follow the steps below and also refer to Figure 10.

    a. Type "log button.txt" to initiate button press/release logging to a file that is updated every time a button press or release event occurs. This is an example of asynchronous logging, where the interval between logs is not known in advance. The events are logged with the time value in milliseconds that shows the time since the last event.

    b. Press buttons labeled "P2.0" and "P2.1" repeatedly for a few times in any order you wish.

    c. Type "log" to stop the log.

    d. Type "type button.txt" to view the contents of the log file.

Figure 10. Example Application - Button state logging

3. In addition to the above commands, you can also try other commands supported by the command interpreter shell. An index of all commands supported by the example application is available in "Appendix A—Command Interpreter Shell Reference".

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5.3. Mass Storage Device Demonstration

This demonstrates the 'F340 device firmware support for the standard USB Mass Storage Device class. The HyperTerminal interactive command shell is deactivated whenever the device is plugged into the PC via a USB cable. This is to protect against simultaneous access of the file system by the PC and the example application.

1. Connect a USB cable between the PC and the C8051F340-TB target board.

2. The operating system will detect the new hardware, recognize it as a standard USB Mass Storage Device, and install appropriate drivers. There should be no need for any user interaction during this phase. At the end of this process, you will see three entries in Device Manager, and you should also see a Removable Disk in Windows Explorer. See Figures 11 and 12.
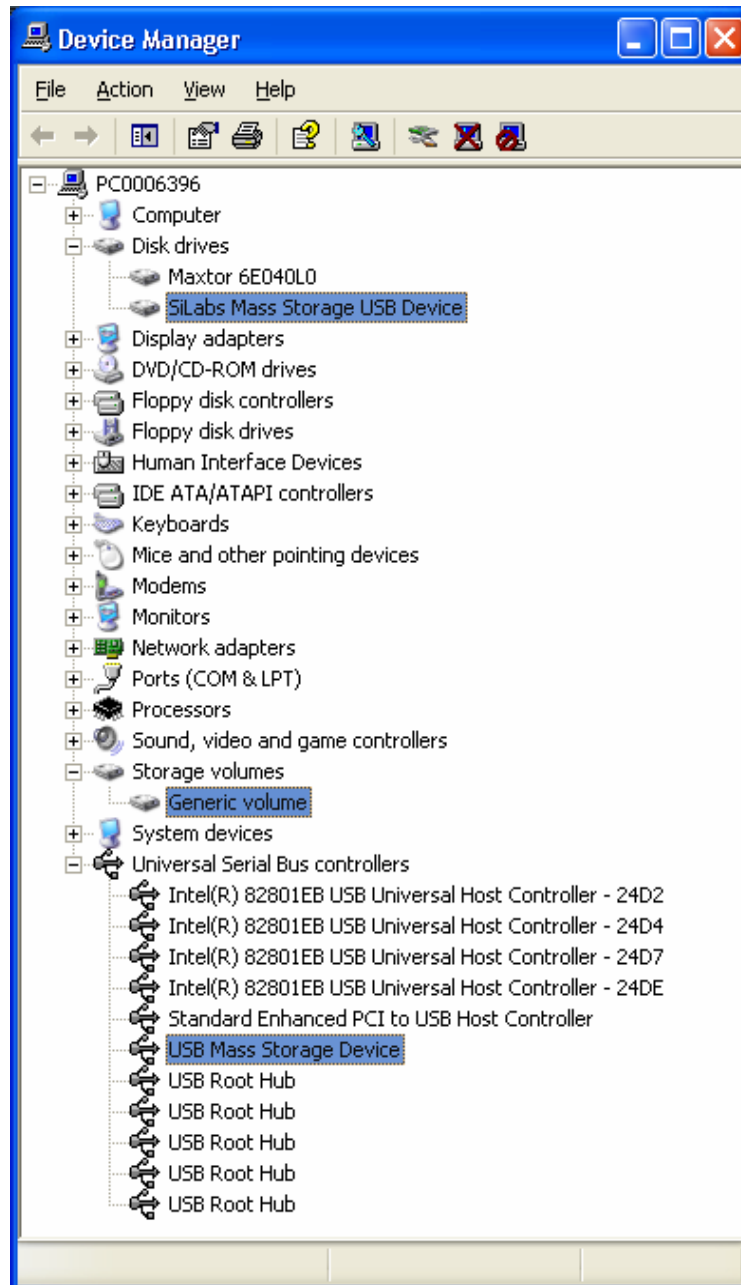
Figure 11. USB Mass Storage Device - Device Manager
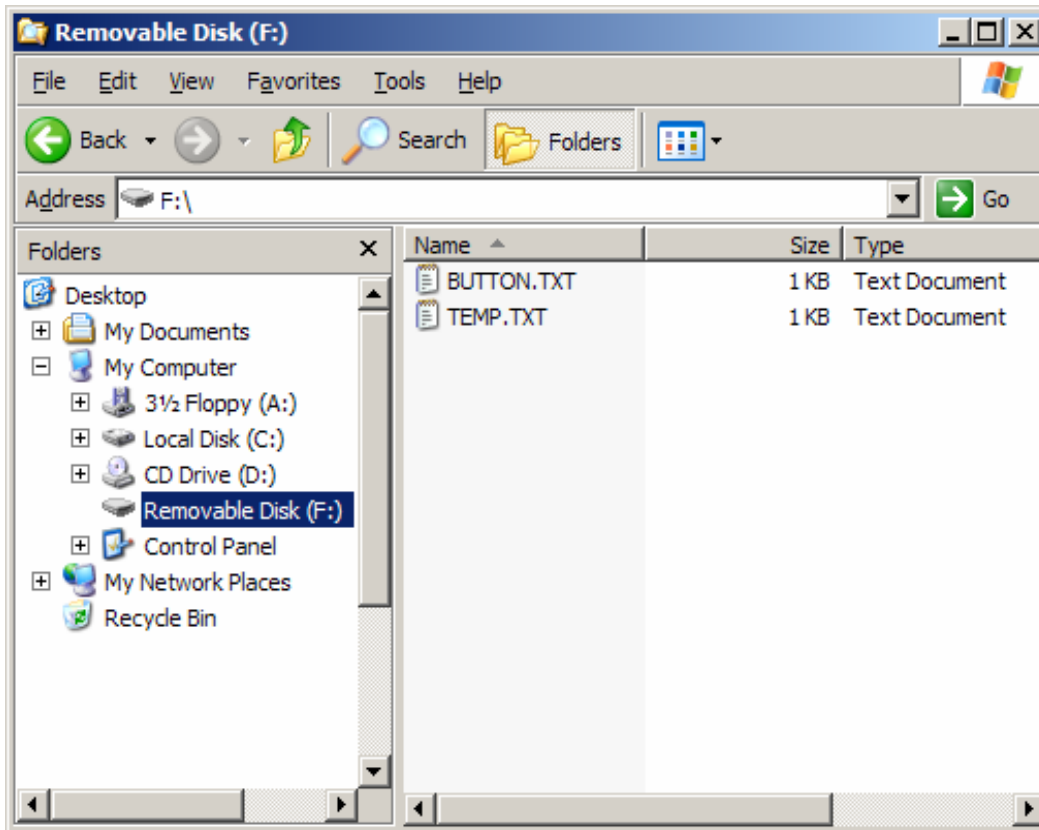
Figure 12. USB Mass Storage Device - Windows Explorer

3. The files created during the previous example application demonstration will be visible. Files can be viewed, added, deleted, copied or moved using Windows Explorer.

4. To disconnect the device, click on the icon with the green arrow in the system tray and select "Safely Remove USB Mass Storage Device". See Figure 13. You can unplug the USB cable from the C8051F340-TB Target Board after you see a message informing you that it is safe to do so. Unplugging the USB cable will restore control to the HyperTerminal-based command interpreter shell.
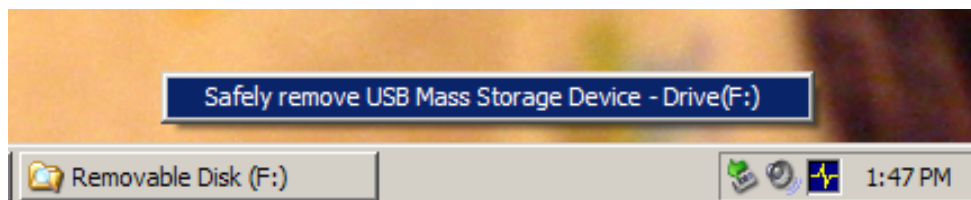
Figure 13. USB Mass Storage Device - Safe Device Removal

6. CF, MMC, SD Memory Expansion Board (AB5)

The CF, MMC, SD Memory Expansion Board contains a SD/MMC card slot, a CompactFlash card slot, and a power gating FET that allows control of power to the expansion board via software. The pin connections are shown in Table 1. The board schematic is shown in Figure 14.

Table 1. CF, SD, MMC Memory Expansion Board Pin Connections

| Signal Name	Connector Pin	C8051F340-TB Connection	Description
POWER	A1	+3VD	Digital Power
GND	B1	GND	Digital Ground
ADD0	B16	P3.5	CF Address bit 0
ADD1	A16	P3.6	CF Address bit 1
ADD2	C15	P3.7	CF Address bit 2
DA0	B15	P4.0	CF Data bit 0
DA1	A15	P4.1	CF Data bit 1
DA2	C14	P4.2	CF Data bit 2
DA3	B14	P4.3	CF Data bit 3
DA4	A14	P4.4	CF Data bit 4
DA5	C13	P4.5	CF Data bit 5
DA6	B13	P4.6	CF Data bit 6
DA7	A13	P4.7	CF Data bit 7
SCK	C12	P0.0	SD/MMC SPI Clock
MISO	B12	P0.1	SD/MMC SPI Master In, Slave Out
MOSI	A12	P0.2	SD/MMC SPI Master Out, Slave In
NSS	C11	P0.3	SD/MMC SPI Slave Select
OE	A23	P1.1	CF Output Enable
CE1	C22	P1.2	CF Card Enable
CD1	B22	P1.3	CF Card Detect
RDY	A22	P1.4	CF Ready Signal
RESET	C21	P1.0	CF Reset Signal
WE	B21	P1.6	CF Write Enable
PWR_ON	A21	P1.7	Expansion board global power control

7. Schematic
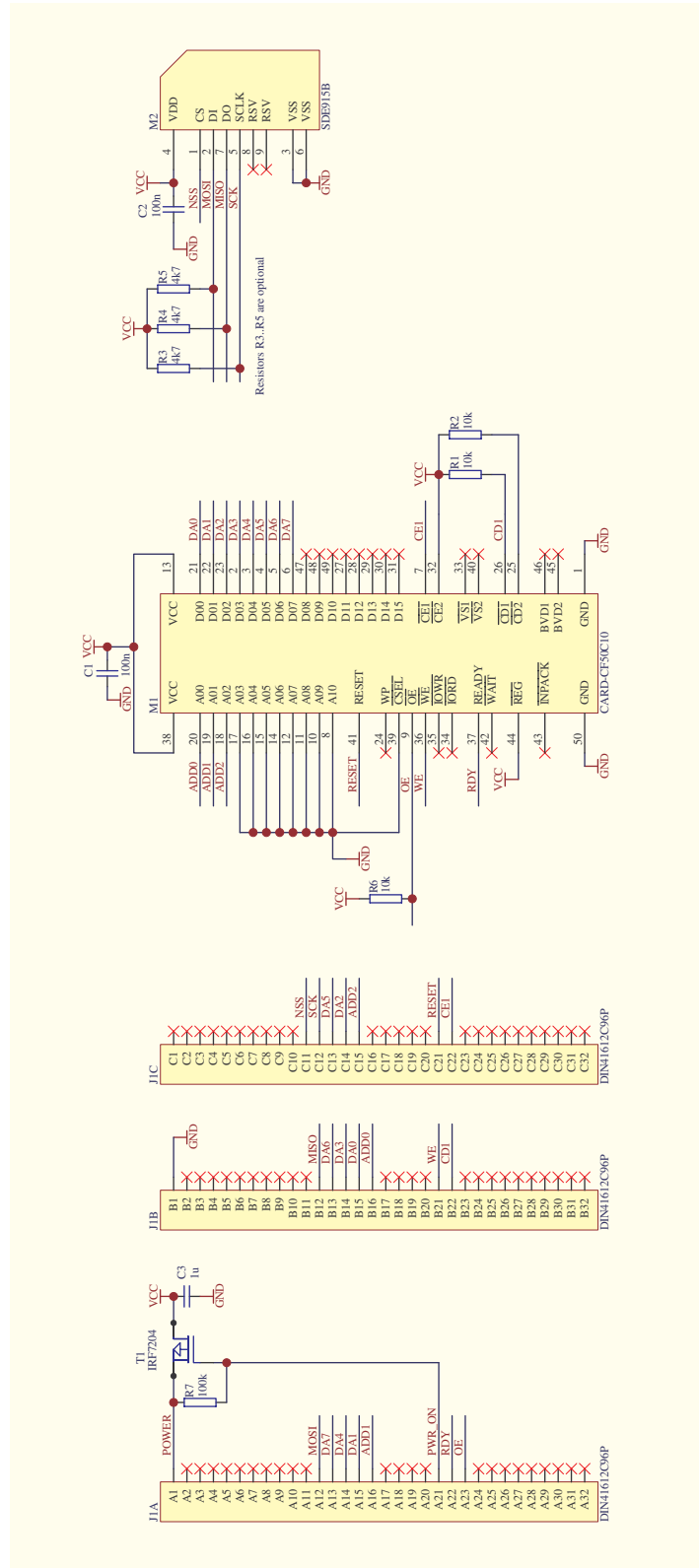
Figure 14. CF, MMC, SD Memory Expansion Board (AB5) - Schematic

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8. Bill of Materials

Pos.	Reference Designator	Description	Value/Type	Tolerance	Voltage /Power	Dielectric	Qty per unit	Manufacturer	Manufacturer Part #	Supplier	Supplier Part #	PCB Footprint
10	R1 R2	RES 10K OHM 1/8W 5% 0805 SMD	10k	5%	1/8W		2	Yageo America	RC0805JR-0710KL	Digi-Key	311-10KARCT-ND	0805
20	R7	RES 100K OHM 1/8W 5% 0805 SMD	100k	5%	1/8W		1	Yageo America	RC0805JR-07100KL	Digi-Key	311-100KARCT-ND	0805
30	C1 C2	CAP .10UF 50V CERAMIC X7R 0805	100n	10%	50V	X7R	2	Yageo America	CC0805KRX7R9BB104	Digi-Key	311-1140-1-ND	0805
40	C3	CAP 1.0UF 16V CERAMIC X7R 1206	1u	10%	16V	X7R	1	Yageo America	CC1206KKX7R7BB105	Digi-Key	311-1181-1-ND	1206
50	J1	Connector	DIN41612C96P				1			Maritex	DIN41612C96P;LF	DIN41612C96P
60	M1	CF Card Connector	CARD-CF50C10				1			Maritex	CARD-CF50C10;LF	CARD-CF50C10
70	M2	SD Card Connector	CARD-MMCE715B-LF			1			Maritex	CARD-MMCE715B-LF	SDE915B	
80	T1	MOSFET P-CH 20V 5.3A 8-SOIC	IRF7204				1	International Rectifier	IRF7204PBF	Digi-Key	IRF7204PBF-ND	SO-8
90	Memory Card	MEMORY CARD 256MB SECURE DIGITAL	256MB				1				Secure Digital 256MB Kingston	

DO NOT POPULATE

Pos.	Reference Designator	Description	Value/Type									
1000	R3 R4 R5	4k7										
1010												

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APPENDIX A—COMMAND INTERPRETER SHELL REFERENCE

Command Interpreter Shell - Communication Parameters

- Baud rate: 115200 bps
- Data format: 8 data bits, 1 stop bit, no parity
- Flow control: None

Command Interpreter Shell - Supported Commands

The interactive command interpreter shell presented by the example application via the UART supports a set of MS-DOS-like commands. Table 2 lists the supported commands along with explanations.

Table 2. Command Interpreter Shell - Supported Commands

Command	Explanation
CLS	Clear the screen.
DIR	Show the contents of the current directory.
MD <dirname>	Make "dirname"directory. If "dirname" is incorrect or already exists, an error message is returned.
CD <dirname>	Change to "dirname" directory. If "dirname" is incorrect or does not exist in the present directory, an error message is returned.
RD <dirname>	Remove "dirname" directory. If "dirname" is incorrect, an error message is returned. <u>IMPORTANT:</u> No check is done on "dirname" directory contents before removal.
TYPE <filename>	Show the ASCII contents of a file in the current directory.
DEL <filename>	Delete a file in the current directory.
FORMAT	Format the existing FAT16 partition. Note: This will not work properly if the existing file system is of a format other than FAT16. See "Appendix B—Formatting a Memory Card" for instructions on how to format a new disk.
S <nnnnn>	Show the contents of the nnnnn-th 512-byte block. Calling "S" without a parameter will print the valid range of sectors.
CHKDSK	Show info about the formatting used.
CALIBRATE <val>	Sets offset for temperature sensor. 'val' should be current ambient temperature in degrees C.
TEMPLOG <filename>	Start background logging of ambient temperature. The logging is appended at the end of the specified file in the current directory. Calling "TEMPLOG" without a parameter will stop current logging, if any, and close that file.
LOG <filename>	Start background logging of the state of the two buttons (P2.1 and P2.2). The logging is appended at the end of the specified file in the current directory. Calling "LOG" without a parameter will stop current logging, if any, and close that file.

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Command Interpreter Shell - Notes

1. The commands are not case-sensitive.

2. Wild cards (*,? etc) are not supported by the shell.

3. Long file names are not supported by the shell. They are abbreviated to 8.3 format by removing unsupported characters, truncating when longer than 8 characters, and adding a numbered suffix. This is done as described in the following Microsoft Knowledge Base article: http://support.microsoft.com/?kbid=142982
   Example: If two files named 'abcdefghi.txt' and 'abcdefghk.txt' are placed in the one folder when the device is in PC mode, the "dir" command in Example Application mode will list them as 'abcdef~1.txt' and 'abcdef~2.txt', respectively.

4. The 'dir' command shows the volume label as a separately entry, with the tag "<LABEL>" shown in the extension column.

5. File creation/modification date and time stamps are not supported when the device is in Embedded System Mode.

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APPENDIX B—FORMATTING A MEMORY CARD

The USB MSD RD firmware supports the FAT16 file system. Memory cards formatted with other file systems cannot be used with this firmware. If the disk is already formatted as FAT16, and you want to reformat the disk, you can do so using the "FORMAT" command available through the Example Application's Command Interpreter Shell. See "Appendix A—Command Interpreter Shell Reference" for details.

Formatting using Windows Explorer:

If the disk is formatted with a file system other than FAT16, or if you are not sure what file system is currently on the disk, you can perform a new format on the disk using the "Format" command available in Windows Explorer.

WARNING: Using the Format command will erase all data from the target disk, and is irreversible.

Connect the system as described in Section "5.3. Mass Storage Device Demonstration". After the device has enumerated and shows up as a removable disk, open 'My Computer', right-click on the removable disk, and choose 'Format'. In the following dialog, choose 'FAT' as the file system and click the 'START' button to start the formatting process. Optionally, you can enter a volume label as well.

Limitations:

■ Memory card sizes should be greater than 16 MB, up to a maximum of 4 GB.

■ Windows formats memory card sizes up to 16 MB as FAT12, which is not supported by the USB MSD RD firmware.

■ The FAT16 file system supports memory sizes up to 4 GB.

Troubleshooting:

If the memory card does not appear as a valid USB Mass Storage Device when connected, it is most likely formatted in a way that is not readable by the firmware (for example, a custom digital camera format). In this case, the card should be formatted using a dedicated memory card reader or other specialized device.

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NOTES:

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