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Warrior-X PDA

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Table of Contents:

Introduction

Road warriors once dreamed of a miracle device which could more than adequately replace their cell phone, gaming unit, PDA, and GPS unit. The technology of today has made this a reality and many manufacturers are rushing to come out with a device which could do it all. Currently most of these "miracle devices" use either the Motorola Dragon Ball processor and Palm OS or an Intel processor and the Windows CE OS. SysCore would like to create a PDA-Cell Phone-GPS unit tentatively titled Warrior-X built with the Fujitsu MB91302A 32-bit RISC microcontroller. A picture of the external design can be seen in Figure 2.

Description of the Complete System

Introduction

The Warrior-X is composed of many components including: the Main Microcontroller, the FPGA, the DSP, the LCD Screen Module, the GPS Module, and the USB Microcontroller. A block diagram of the Warrior-X System, which states the component interfaces, can be seen in Figure 1. Figure 3 describes the rough internal component placement.

Main Microcontroller

The heart of the Warrior-X consists of the Fujitsu MB91302A microcontroller. For simplicity the MB91302A will be referred to as the main microcontroller. The main microcontroller's responsibilities include: processing high level data and user input, running the Application code, and communicating with various components such as the Direct Memory Access (DMA) Slave Controller, SDRAM memory, the USB microcontroller, GPS module, and the DSP. The MB91302A has three UARTS, two I^2C Buses, and a five channel Direct Memory Access (DMA) Controller. These interfaces are used to provide high speed communication to external components.

The main microcontroller is connected to the USB microcontroller through the I^2C bus, which operates at 100 KHz. The main microcontroller connects to the GPS module through a UART operating at 9600 Baud. The MB91302A connects to the DSP and flash memory through the built-in DMA controller. The first channel is reserved for the main compact flash drive, which is 128MB. The second and third channels are reserved for the two auxiliary compact flash drives. The user can use these ports to add more memory or a peripheral such as a camera or Wi-Fi card. The maximum flash memory size supported is four Gigabytes. The fourth and fifth DMA channels are connected to the DSP. The main microcontroller is connected to 64MB of SDRAM memory, through the MB91302A's built-in SDRAM interface. The other interfaces (two UARTs and one I^2C Bus) are reserved for future use.

FPGA (DMA Slave Controller)

A Field Programmable Gate Array (XILINX FPGA XC2S50) is used to create a DMA slave controller for channel one (Main Flash Drive), channel two (Auxiliary Flash Drive 1), and channel three (Auxiliary Flash Drive 2). The DMA slave controller's purpose is to translate the DMA protocol into the parallel Compact Flash protocol used to access flash memory. For example, if the main microcontroller requests to read 500 bytes from the Main Flash Drive, the DMA slave controller turns on the Chip Select for the Main Flash Drive. Then it outputs the request on the parallel bus, retrieves the bytes, and sends them out to the main microcontroller using DMA channel one.

DSP

The DSP (Texas Instruments TMS320VC5502) is broken into several modules which include: Audio Processing Module, Video Processing Module, Cell Phone Processing Module, LCD Processing Module, DMA Interface Module, and Memory Interface Module. The DSP includes an I^2C Bus, a UART, and 6 Channel DMA Controller, which it utilizes for communicating with external components.

The DSP is connected to 64MB of SDRAM to accommodate the memory needs for the various modules. The Memory Interface Module coordinates how this memory is used and accessed. It also is the only way the SDRAM can be accessed. This offers some protection and prevents data corruption. For instance, the Memory Interface Module would prevent the Audio Processing Module from overwriting the LCD Processing Module memory.

The DMA Interface Module handles the DMA requests from the main microcontroller. The main microcontroller treats the DSP as a memory device. DMA communication provides a fast communication link between two devices, which usually does not involve interaction of the processor. The Warrior-X requires this quick communication for creating the video output, decoding video, and decoding audio. The main microcontroller retrieves and writes blocks of memory through DMA channels four and five which are physically connected to the DSP's built-in DMA interface. The DMA Module communicates with the Memory Interface Module to transfer blocks of memory back and forth between the DSP and main microcontroller.

The LCD Processing Module acts as a LCD controller. Its main purpose is to transfer the LCD screen image, which is stored in the DSP SDRAM memory, and send it to the LCD Screen. It does this by communicating with the Memory Interface Module. The image on the LCD screen must be refreshed often and can be a very time intensive process. The LCD Processing Module offloads the main microcontroller by performing this task. The LCD support chips are connected to the DSP using a parallel bus interface.

The Cell Phone Processing Module coordinates the compression and

decompression of audio streams and does the processing necessary to transmit a packet to the cellular network. The audio stream, which originated from the microphone, must be compressed before it is sent out. At the same time the audio stream, originating from the Cell Phone receiver must be decompressed before it reaches the speaker. The Cell Phone Processing Module performs these operations in collaboration with the Audio Processing Module. In addition the Cell Phone Processing Module also contains the Speech Transcoder and Channel Codec which are required for cellular phone network transmission.

The Video Processing Module decodes video streams for playback on the LCD Screen. In order to do this, it must grab a frame from the video stream in memory, decode it, and replace the LCD image memory. The LCD Processing Module will update the LCD image automatically when it goes to refresh the screen. The Video Processing Module can decode mpeg1, mpeg2, DivX, and avi video.

The Audio Processing Module is split into two sections. There is a Decode and an Encode section. The Encode section takes in an audio stream from the microphone which is connected to an analog-to-digital (A/D) converter. The A/D converter is connected to the DSP through the serial port. Then the Audio Processing Module encodes the digitized audio stream into the mp3 format. The result is stored in the SDRAM memory where it can be fetched by the main microcontroller. The Decode section takes an audio stream stored in SDRAM memory, decodes it, and sends it to the digital-to-analog (D/A) converter. The D/A converter is connected to the DSP through the I^2C Bus. The Decode section supports mpeg1, mpeg2, mpeg3, and wav format. The Encode section supports the mp3 format only. The Audio Processing Module can handle various bit rates for mpegs.

The DSP operation varies based on the application running on the main microcontroller. The majority of DMA transfers between the main microcontroller and DSP are related to updating the LCD image, transferring video, or transferring audio streams. DSP interaction with the main microcontroller is limited, when the phone application is running. Similarly if an audio application is running the LCD image is not updated frequently. When a video application is running, such as DivX file, the LCD image is not being updated at all. In all applications the real bottleneck for DSP operation will be the DMA Processing Module and the Memory Interface Module.

LCD Screen Module

The LCD Screen Module (Sharp LQ035Q7DB02) consists of a TFT-LCD panel, driver ICs, a back light, and a touch panel, which are all sealed together. The LCD screen is connected directly to the DSP. The touch panel can be used to select items on the touch screen. The pins are directly connected to the DSP. The DSP stores the values in the memory. If these values change then the main microcontroller is notified by an interrupt.

GPS Module

The GPS Module (Tyco A1025) is a fully functional GPS receiver, which is used to collect coordinate information. It is connected to the main microcontroller through a UART operating at 9600 Baud. It tries to limit its interaction with the main microcontroller by only reporting valid GPS data to the main microcontroller. It will also report information such as almanac data, accuracy, when it lost the GPS signal, the number of satellites tracked, the calculated moving time, and the calculated path. The accuracy of the GPS module is approximately three meters when using differential mode and slightly more if a differential signal is not detected. The coordinate system used will be UTM (Universal Transverse Mercator). The GPS antenna is connected directly to the GPS module.

USB Microcontroller

The USB microcontroller Cypress (CY7C64013-PC) connects to an external computer through the USB port and handles the buttons pressed on the Warrior-X. The main microcontroller does not have a USB port so the USB microcontroller provides this feature. By connecting to a computer the Warrior-X software can be updated; new programs can be added; avi files, mpeg1s, mpeg2s, mpeg3s, DivX files, jpegs, GPS maps, phone lists, calendar appointments, contact list, and reading material can be transferred back and forth to the computer. The USB module is connected to the main microcontroller through the I^2C Bus which operates at 100 KHz. The Warrior-X keypad is connected directly to the USB microcontroller. This keypad design scheme is chosen to reserve the main microcontroller's pins for future development.

Initialization

Main Microcontroller

The Warrior-X main microcontroller program and DSP program are stored on the main flash drive. When the main microcontroller boots up, the internal ROM will be running a low level OS. The low level OS will retrieve the high level OS which is stored on the main flash drive, and load it into the SDRAM. It will also request the DSP program and save it temporarily in SDRAM. Then the main microcontroller will begin running the high level OS.

DSP

When the DSP loads up, it too will be running a low level OS. It will request its program from the main microcontroller. The main microcontroller will ignore the request until it begins running the high level OS and has a copy of the DSP program. When the main microcontroller has the DSP program, it will send it to the DSP over DMA Channel 4. The DSP will load up its program in SDRAM and begin running. The DSP will notify the main microcontroller that it is operational. The main microcontroller will then create the LCD image for either the main screen or password screen depending on the user configurations.

USB Microcontroller

The USB microcontroller is a one time programmable (OTP) chip. The internal ROM contains the program. As soon as the USB microcontroller receives power it will begin running its program. When the main microcontroller OS is operational, it will communicate with the USB microcontroller to make sure it is working properly.

GPS Module

The GPS Module contains its own internal program as well; however the firmware can be updated through the serial port. As soon as it is operational, the GPS Module will begin collecting GPS data from the satellites. The main microcontroller will communicate with the GPS module once the high level OS is operational. The GPS Module may or may not have the GPS data initialized properly at this time depending on how current the satellite information is. The GPS module will notify the main microcontroller when it has its information.

Operating System / Firmware

Main Microcontroller

The low level operating system for the main microcontroller MB91302A will use a Real-Time OS uITROM3.0 which is installed in the built-in ROM. This operating system supports 16/32-bit SDRAM along with other memory interfaces. Minor modifications will be made to the OS to support flash drives. The Real Time OS supports task management, synchronization, time management, and interrupts. The high level operating system will be created in C. This will make calls to the Real-Time OS and communicate with the Application Layer. The Warrior-X will run a LINUX light version for the high level OS. Red Hat has created several versions of LINUX which run on FUJITSU microcontrollers. If Red Hat creates a version for the MB91302A, then the Warrior-X will use it otherwise more development time will be required to develop the OS. All of the applications will be written in C.

USB Microcontroller

The USB Microcontroller code will be written in C using the Keil C51 Compiler. This is a one time programmable chip, so developers will use an emulator supplied by Cypress in place of the CY764013PC. The extra pins will be used for debugging since there is no serial port on the USB microcontroller.

GPS Module

The GPS module code will be written in C using the Keil C51 Compiler. The microcontroller used in the design is the ST20-GP7 by ST microelectronics. Tyco provides libraries which can be integrated into the project design. The code can be uploaded through the serial port. There are two serial ports in this design. One can be used for debugging the code.

FPGA

XILINX has its own set of tools for programming the FPGA: ISE Web-Pack and Web-Fitter. The FPGA code will be written in VHDL which is supported by these tools.

DSP

The DSP firmware can be written in C using the following tools: eXpress DSP, Code Composer Studio, Integrated Development Environment, DSP/BIOS, and third-party software. Code Composer Studio will be used for writing the firmware. This is an IDE code generation tool that includes a C Compiler, Visual Linker, and simulator. There will be access to the C55x DSP Library which includes various math functions, filters and support libraries.

Example Applications

The application possibilities for the Warrior-X are endless. Initial support will include all the current applications that road warriors have come to expect. There will be cell phone capabilities, web access, voice mail, voice dialing, instant messaging, appointment calendar, address book, games, GPS capabilities, audio player, video player, word processor, email, PDF reader, graphing calculator, paint program, JPEG viewer, and voice memo.

The GPS Program: FindMe, will allow Warrior-X users to transmit their location, (optional) picture, (optional) audio, and (optional) text message to another user through the cell phone network. When the receiving user gets the message, the GPS application Locate-X will load up and show where the user is along with the (optional) picture, (optional) audio, and (optional) text message. This can be used in conjunction with the instant messaging program.

The main GPS program called Locate-X will contain many innovative features, which will only be limited by the loaded base map detail. A simplistic menu will allow users to find what they need. For example if they need to find a gas station, the map screen will focus down to a 5 square mile block and show the user where all the gas stations are within a 5 mile radius of the present location. If there are none, then Locate-X will increase by 5 miles until it finds one.

A user can also locate points by inputting address information. Locate-X can even create driving directions if the user inputs a starting address and destination address. Locate-X will then create step by step directions. If the driver misses a turn, Locate-X will change the directions so that the final destination could still be reached. Locate-X will also collect valid data such as speed, average moving time, and trip time.

Locate-X can save an unlimited number of way points. The storage is only limited by the flash drive memory. Locate-X also allows users to create their own symbols for waypoints by using jpegs or creating icons using the included

paint program.

Marketing Data

The Warrior-X will be targeted to road warriors and techies specifically focusing on how Warrior-X simplifies the lives of those who use it. The promotional flyer will center on a character named Jane who uses the Warrior-X for both entertainment and business purposes.

Jane works for a pharmaceutical company, which has locations throughout the United States. Her job duties include visiting the various sites and meeting with clients. Jane often finds herself waiting for airplanes, and sitting in hotel rooms with little to do. She used to carry around a PDA, GPS, mp3 player, a game boy, and a cell phone until she discovered the Warrior-X. The Warrior-X is the first device, which can do it all without sacrificing reliability or features. Now Jane can watch the latest video releases, answer all of her emails, find that great restaurant in Cincinnati, listen to her favorite Beatles track, and talk to her aunt with just one device.

Main Features

- 32-Bit RISC Microcontroller operating at 68 MHz
- Built-in GPS
- Built-in Cell Phone
- QVGA TFT-LCD Display with built-in Touch Screen supporting 18 bit color
- Backlight for Night Reading
- Low Power Consumption
- Built-in 128MB Flash Memory
- 64MB SDRAM memory dedicated to Video and Audio Processing
- 64MB SDRAM memory dedicated to OS and Applications
- 2 Compact Flash Connectors to support more Compact Flash Memory, Camera, or WI-FI Card. *Up to 4 Gigabytes of Compact Flash Memory can be added.*
- MP3 playback Support
- MPEG-1, MPEG-2, DivX, AVI playback video support
- High Speed USB support
- Upgradeable OS
- Bundled with many exciting programs

GPS Features

- Unlimited Waypoints
- 3 meter accuracy
- Compatible with GARMIN Map Datum
- Supports up to 16MB of Maps (*More if Auxiliary Compact Flash is added.)

Cell Phone Features

- Voice Mail
- Voice Dialing

Included Applications:

- Password Protection
- Locate-X GPS Software
- FindMe GPS Software
- Word Processor
- Video Player
- Audio Player
- Voice Memo
- Web Browser
- Instant Messenger
- Email
- PDF Reader
- Appointment Calendar
- Address Book
- JPEG Viewer
- Paint Program
- Scientific Graphing Calculator
- Many Included Games

Games:

- Solitaire
- Mine Sweep
- Poker
- Qbert
- Donkey Kong
- Super Breakout
- Frogger
- Pac-Man
- Dig Dug

Advertisement Campaign

Early versions of Warrior-X will be demonstrated at trade shows. Evaluation units will be sent to different publications. Full page ads will be taken out in business, technical, music, and travel magazines. Free units will be delivered to prominent business people, actors, actresses, and musicians in exchange for endorsement.

Approximate Cost of Warrior-X

The approximate cost for the Warrior-X is $600.00. This will include all the ICs, packaging, labor, marketing, and engineering costs. The initial engineering samples will cost $500.00 to create. It has been forecasted that the Warrior-X can be created for under $300.00 once it goes into full production and it will be sold for $800.00. The target customer will be people between the age of 20 and 40.

Time Estimate for the Construction of Warrior-X

SysCore has positioned a team of two hardware engineers and twelve software engineers to work on the project. One hardware engineer will test and develop the Printed Circuit Board. One hardware engineer will test and develop the FPGA code and help with the overall design. Four software engineers will test and develop the DSP Module. One software engineer will test and develop the GPS Module. One software engineer will test and develop the USB Microcontroller firmware. Two software engineers will test and develop the main microcontroller OS firmware. Four software engineers will test and develop the applications. SysCore has reached an agreement with Activision and Atari for creating the pre-packaged games on the Warrior-X. The project will take 10 months of development and 2 months of testing.

Future Enhancements

The Warrior-X is built to be upgraded for future use. It is expected that the Operating System will be changed to support new types of devices such as Wi-Fi Cards and Cameras. Eventually there will be Wi-Fi support and a camera built into the Warrior-X.

The Warrior-X will be enhanced so that it can have Bluetooth support and an infrared communication port. An Infrared port is extremely crucial to the future success of the product. This would allow customers to use the Warrior-X as a universal remote. Now the DVD player, TV, CD player, and stereo can be controlled with one device. Data from the computer can also be accessed easier without the use of a cord. Bluetooth offers some of the same exciting possibilities of infrared. Bluetooth is often used to transmit data between two devices. Many networked home appliances are being created which use Bluetooth. These two features will be available in future versions of the Warrior-X.

Detailed Specifications

Main Microcontroller: MB91302A

- 32 Bit RISC CPU Core (5 stage Pipeline)
- 68MHz Clock (PLL support the max base frequency is 17 MHz)
- 32 bits *16 General Purpose Registers
- 16-bit fixed length instructions (basic Instructions)
- Average one instruction per cycle
- Instruction set optimized for embedded applications and high level languages
- Branch Instructions with Delay slot
- Built-in multiplier with instruction level support Signed 32-Bit Multiplication takes 5 cycles
- Built-in Pre-fetch buffer
- Support Flash Memory
- SDRAM interface
- Bus Cycle averages 2 cycles
- 5 Channel DMA Controller supports 32 bit addressing mode, demand transfer, burst transfer, step transfer, and block transfer. Supports fly by transfer and data size ranging from 8, 16, or 32 bit.
- 4KB Data RAM
- 4KB RAM (Instruction cache)
- 3 Channel UART
- Interrupt controller
- 2 Channel I^2C Bus Interface
- Power Save Mode
- CMOS Technology .25um
- 3.3V +-.3V Operation
- 144 Pins

Main Drive Wintec W7B6128M1XG-S8

- Compact Flash
- 128MB
- Connected to Parallel Bus of Slave DMA Controller
- Must Enable Chip Select to use.
- Burst mode from/to host interface 8.3MB/sec
- Burst mode from/to flash interface 20MB/sec
- Read speed up to 2MB/sec
- Write speed up to 1.2MB/sec
- Operating Current: 40mA (typical)
- Transient Current: 120mA (typical)

Aux Drive 1

- Compact Flash or Peripheral
- Connected to Parallel Bus of Slave DMA Controller
- Must Enable Chip Select to use.

Aux Drive 2

- Compact Flash or Peripheral
- Connected to Parallel Bus of Slave DMA Controller
- Must Enable Chip Select to use.

Slave DMA Controller: XILINX FPGA XC2S50

- 1,728 Logic Cells
- 200 MHz Operating Speed
- 50,000 Logic and Ram
- 176 User I/O Pins
- 24,576 Distributed RAM Bits
- 32K Total Block RAM Bits

DSP: Texas Instruments TMS320VC5502

- 300 MHz Operation
- 3.3 IO Supply (Volts)
- 1.26 Core Supply Volts
- 3.33ns Instruction Cycle Time
- One/Two Instructions Executed Per Cycle.
- 6 Channel DMA Int/Ext
- 64K Bytes RAM
- 32K Bytes ROM
- 16K Bytes Instruction Cache
- 2 ALU
- Dual Multipliers (Up to 600 Multiply-Accumulates per Second)
- UART
- I^2C Bus
- Asynchronous SRAM, EPROM,
- Synchronous SDRAM, SBRAM support
- Emulation/Debug Trace Capability
- 126 Pins

USB Microcontroller: Cypress CY7C64013-PC

- 48 MHz Internal Operating Speed through PLL Clock Generator
- 6 MHz External ceramic resonator
- Harvard Architecture
- 8 Bit RISC microcontroller
- Conforms to USB and USB HID Specification Version 1.1
- Integrated USB transceivers

- 256 Bytes RAM
- 8 Kbytes of EPROM
- Integrated Master/Slave I^2C Compatible Controller operating at 100 KHz
- Operating Voltage from 4.0 to 5VDC
- Watch Dog Timer
- Full-Speed USB 12Mbps
- 28 pin PDIP package

GPS Module: Tyco A1025- Miniaturized 3.3V GPS Module

- 4Mbit flash standard, 8Mbit flash optional
- Dedicated ST Microelectronics ST20GP7 6 MIPS microcontroller
- Stand alone Accuracy: 3m CEP, SA off
- Differential Accuracy: <2m CEP
- ANSI C compiler/linker and libraries, debugging profiling and simulation tools
- 4800, 9600, 19200, 38400, 57600, 115200 Baud modem
- Message Output: NMEA: GGA, GSA, GSV, RMC, VTG; WGS84 Standard; 258 map datums; UTM projection
- Low Power- Wakeup, standby, lower power mode
- Included Bootloader for easy firmware update through serial port.
- 12 parallel tracking
- Support for backup battery for fast time to first fix
- Time to first fix: Cold 60s
- Time to first fix Warm 32s
- Time to first fix Hot start <3s
- Obstruction recovery 1s
- Dimensions: 29.9mm * 29.5mm * 7mm

LCD Module / Touch Screen: Sharp LQ035Q7DB02

- 240 (H)*320(V) viewing area
- QVGA 18 color bits for each pixel (262,144 colors)
- 3.5 inch screen
- 5V Input Voltage
- Advanced Thin Film Transistor
- Includes Back Light
- Includes Driver ICs
- Includes a Touch Panel

Data Memory: Wintec Industries W9V308647PA-333

- 64MB SDRAM
- 133MHz speed

Phone Circuit

- LMV248 Dual Band GSM Power Controller supports GSM/DCS/PCS and

mobile phone
- MAX2264EUE Power Amplifier supports CDMA,TDMA, PDC Cellular Phones

Stereo D/A Converter and headphone amp: Texas Instruments TLV320DAC23

- Connects to I^2C Port of DSP
- 8 to 96 KHz Output
- 2.7 V – 3.6 V analog supply
- 16/20/24/32-bit word lengths
- Audio master/slave timing capability optimized for TI DSPs (250/272 f_s)
- Stereo line outputs
- Highly efficient linear headphone amplifier

A/D Converter: Texas Instruments TLC2578IDW

- Connects to Serial Port of DSP up to 25 MHz
- 12 Bit Resolution
- Hardware-Controlled, Programmable Sampling Period
- Single 5-V Analog Supply; 3-/5-V Digital Supply
- Built-In Conversion Clock and 8x FIFO

Component Description and Justification

MB91302A Microcontroller

The MB91302A was chosen for the external interfaces (DMA Controller, I^2C Bus, SDRAM interface, and UART) and for the 32-bit RISC CPU architecture. It will handle all the various applications and external communications. The MB91302A only operates at 68 MHz, but this will be sufficient for the applications running on the Warrior-X. The early versions of Palm Pilots operated at a much slower speed and were capable of running most of the applications that can run on the Warrior-X. Another advantage is that the MB91302A has 3 UARTs. The first edition Warrior-X only uses one UART to connect to the GPS Module. The next edition of the Warrior-X will make use of the two UART ports to connect to a Bluetooth port and an infrared port.

Main Drive Wintec W7B6128M1XG-S8

The main drive is big enough to hold the High Level OS for the main-microcontroller and the DSP. It has enough room to hold the application programs, map data, cell phone codes, and user data. Since Flash memory is dropping in price it was decided that it would be an advantage to offer 128MB now. Many PDAs are pre-packaged with smaller amounts of flash. A main complaint of many PDA users is that their PDA does not have enough built-in storage memory.

AUX Drive 1 and 2

Compatibility and expandability are important to the success of the Warrior-X. AUX Drive 1 and 2 allow customers to add more memory, a camera, Bluetooth support, or Infrared support to their Warrior-X.

Slave DMA Controller: XILINX FPGA XC2S50

The DMA controller is being built using a FPGA to provide fast access to the flash drives. This allows pins to be reserved on the main microcontroller for future use. The FPGA has enough pins to create a 32-bit shared parallel bus to all of the flash drives. The FPGA operates at 200 MHz which ensures that the data transfer will be fast enough to be transparent to the main microcontroller.

DSP Texas Instruments TMS320VC5502

This DSP was chosen for its low power consumption, wide availability, support, and recognition in the field. This DSP operates at 300 MHz and has all the necessary interfaces required for the design (DMA Controller, I^2C Bus, SDRAM interface, and UART.) It is currently being used in many cell phone and PDA designs performing similar functions.

USB Microcontroller: Cypress CY7C64013-PC

The main microcontroller does not have a USB port. In order to make Warrior-X future upgradeable and to provide a means to transport data, this chip was added. The microcontroller is cheap, yet provides full speed communication with the PC. It also has an I^2C Bus which can provide high speed communication with the main microcontroller. In addition to providing USB support, some of the extra pins are used to monitor the keyboard interface.

GPS Module: Tyco A1025- Miniaturized 3.3V GPS Module

There are many GPS Modules on the market. This one was chosen because the firmware can be modified to fit the design. Tyco has been known to have many support libraries for this module and it operates at 3.3V. The accuracy is less than 3 meters and there is a dedicated microcontroller operating at 6 MIPS.

LCD Module: Sharp LQ035Q7

Many LCD modules were evaluated for this design. This model was chosen because it had a built-in touch screen interface and a backlight. It also supports the QVGA format which is becoming very popular. There are 262,144 colors per pixel and a resolution of 320*240. This will provide sharp output for games and video.

Data Memory: Wintec Industries W9V308647PA-333

There will be 64MB of SDRAM for the main microcontroller and DSP to ensure that there will be enough memory to run applications on the Warrior-X now and in the future. SDRAM Memory is extremely critical for speeding up applications because flash memory access is much slower than SDRAM access. Most of the programs will be loaded into SDRAM to ensure fast performance. It

is also becoming hard to find smaller memory modules and the price difference does not provide much savings.

Phone Circuit

The Phone circuit encompasses what is required for cellular transmission. To date not all of the components needed for cellular transmission have been identified. The components, which were chosen, operate at 3.3V.

Stereo D/A Converter and headphone amp: Texas Instruments TLV320DAC23

This component was chosen, because it is widely found in mp3 players and has a built-in headphone amp. Also the interface to the DSP is I^2C and it operates at 3.3V.

A/D Converter: Texas Instruments TLC2578IDW

This component was chosen, because it will provide an adequate sampling rate and the interface to the DSP is serial. This component operates at 3.3V.

Power Circuit

The power circuit includes all the components needed to provide power to the Warrior-X. To date not all of the components needed for the power circuit have been identified. The unit will run on 5 4AA NICAD batteries. This will provide enough power for the unit. The power circuit will output 3.3V and 5V to be used by the various components on the board.

Microphone

The microphone will be used for voice input. It is connected to a Maxim Preamp (MAX4466EUK-T), which interfaces to the A/D converter.

Speaker and Headphone Jack

The Speaker and Headphone Jack will be used to output audio to the user. These ports are connected to the D/A converter which has a built-in preamp.

Component Price List

Component	Manufacturer	Model Number	Cost
Microcontroller	Fujitsu	MB91302A	$15.00 Digi-Key
LCD Screen Module	Sharp	LQ035Q7DB02	$225.45 All American Direct
DSP	Texas Instruments	TMS320VC5502	$14.16 Arrow
FPGA	XILINX	XC250-TQ144	$17.10 Digi-Key
USB Microcontroller	Cypress	CY7C64013-PC	$6.30 Digi-Key
Compact Flash 128MB	Wintec Industries	W7B6128M1XG-S8	$57.50 Digi-Key
Compact Flash Connector	AVX Corporation	305610000006000	3*$3.50 Digi-Key
64MB SDRAM 133MHz	Wintec Industries	W9V308647PA-333	2*$33.75 Digi-Key
Stereo D/A Converter and headphone amp	Texas Instruments	TLV320DAC23	$4.50 Digi-Key
A/D Converter	Texas Instruments	TLC2578IDW	$9.66 Digi-Key
Speaker	CUI Inc	GA0501	2* $3.25 Digi-Key
Microphone	Horn Industrial Co.	EM9725U-474	$3.14 Digi-Key
GPS Module	Tyco	A1025	$16.70 Digi-Key
CONN 3.5MM AUDIO JACK SMT	CUI	SJ-3513SMT	$.59 Digi-Key
Fast Charge Management IC	Texas Instruments	BQT2000T	$3.83 Digi-Key
IC DC/DC CONV SINGLE CELL 8-SOIC	Linear Technology	LT1307IS8	$2.80 Digi-Key
BATTERY NICAD 5/4AA SIZE W/TAB	Panasonic	P-120AAS/A2	$3.26 Digi-Key
IC AMP 2.7V CELLBAND 16-TSSOP	Maxim	MAX2264EUE	$6.06 Digi-Key
Dual Band GSM Power Controller	National Semiconductor	LVM248	$1.08 Dig-Key
GPS Antenna	Aromat	GPS-F-26-TNC-01C	$4.47 Arrow
IC Preamp Microphone SOT23-5	Maxim	MAX4466EUK-T	$.40 Digi-Key

Figure 1: Block Diagram of Warrior-X System

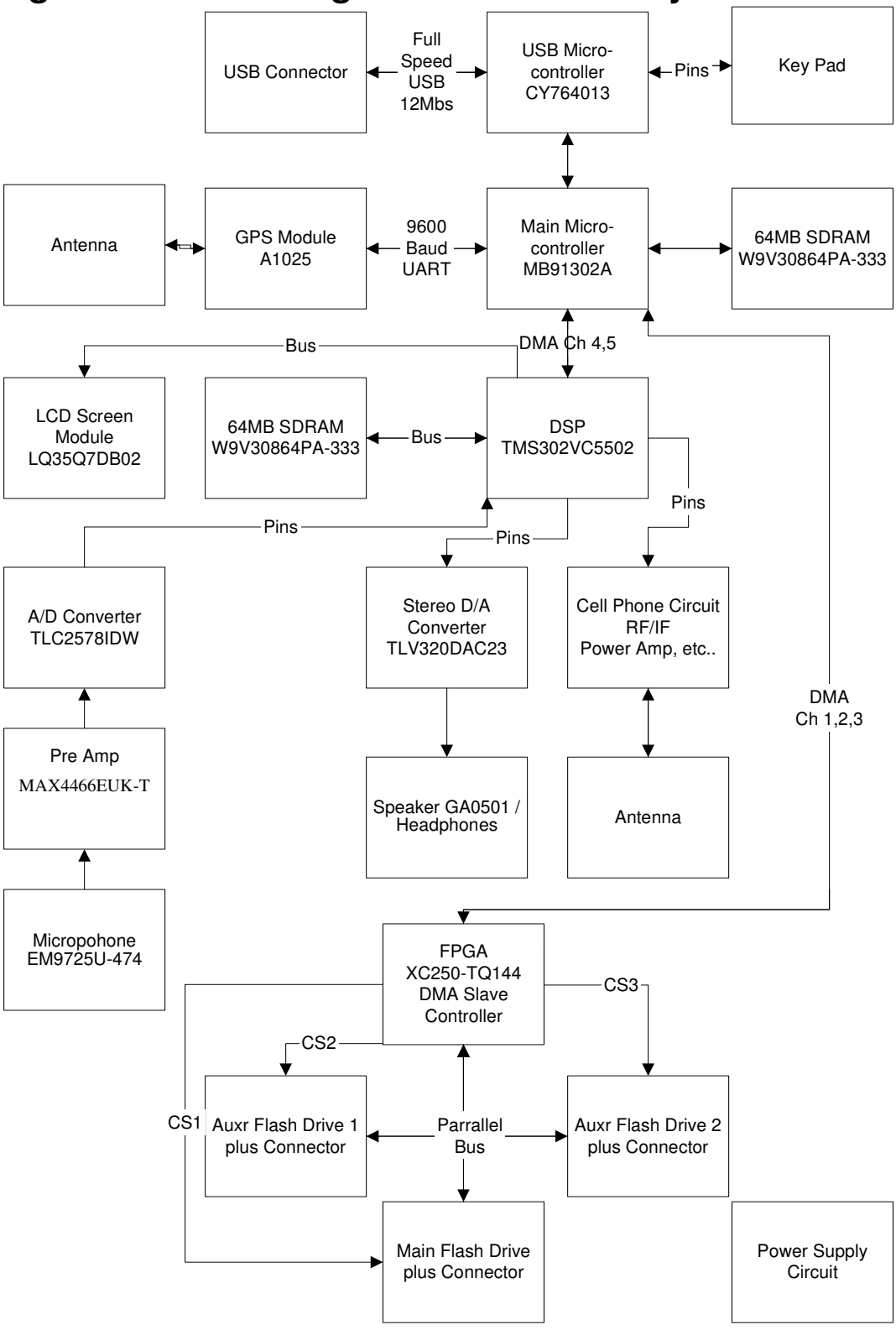


Figure 2: External Design

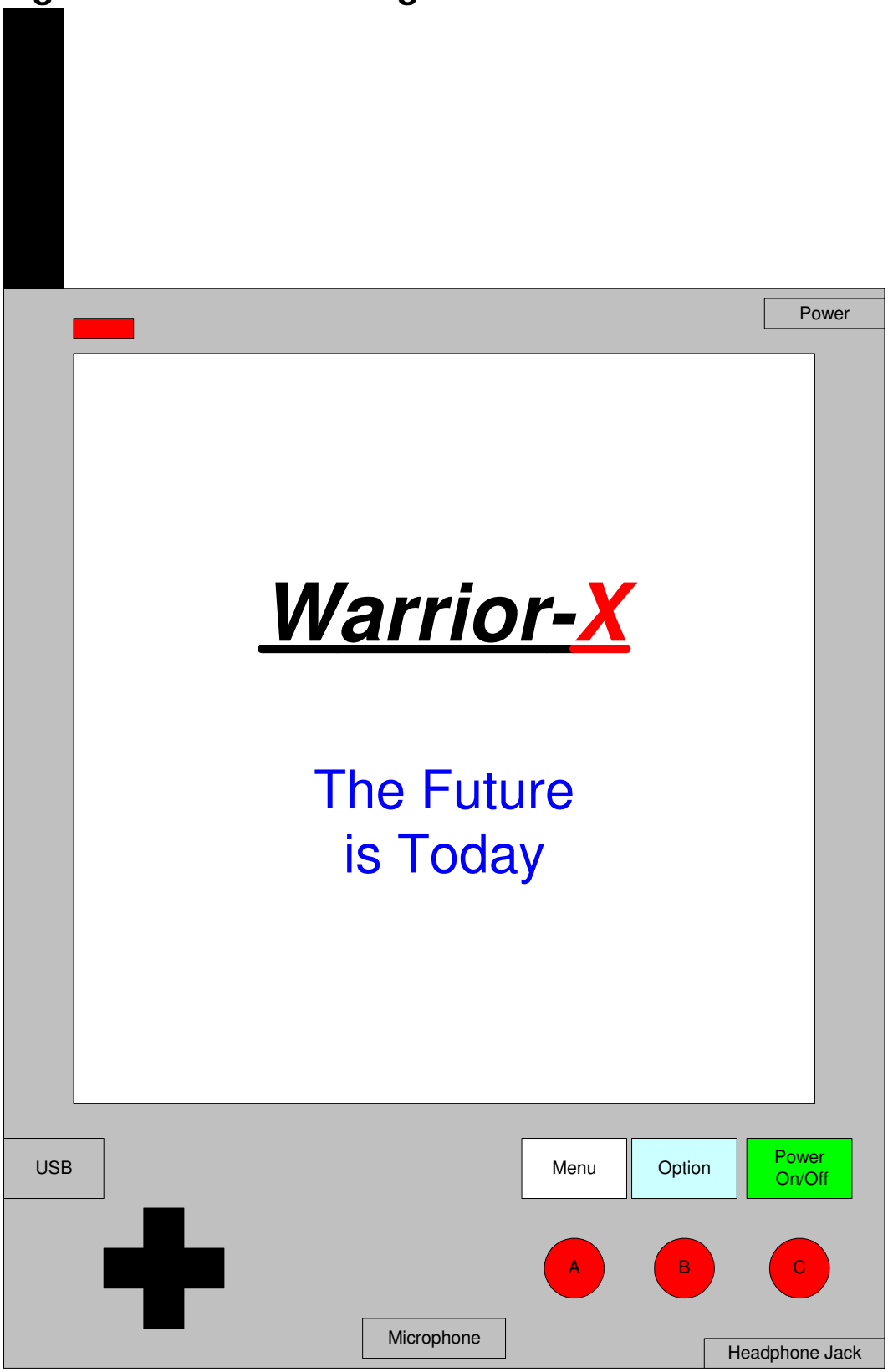
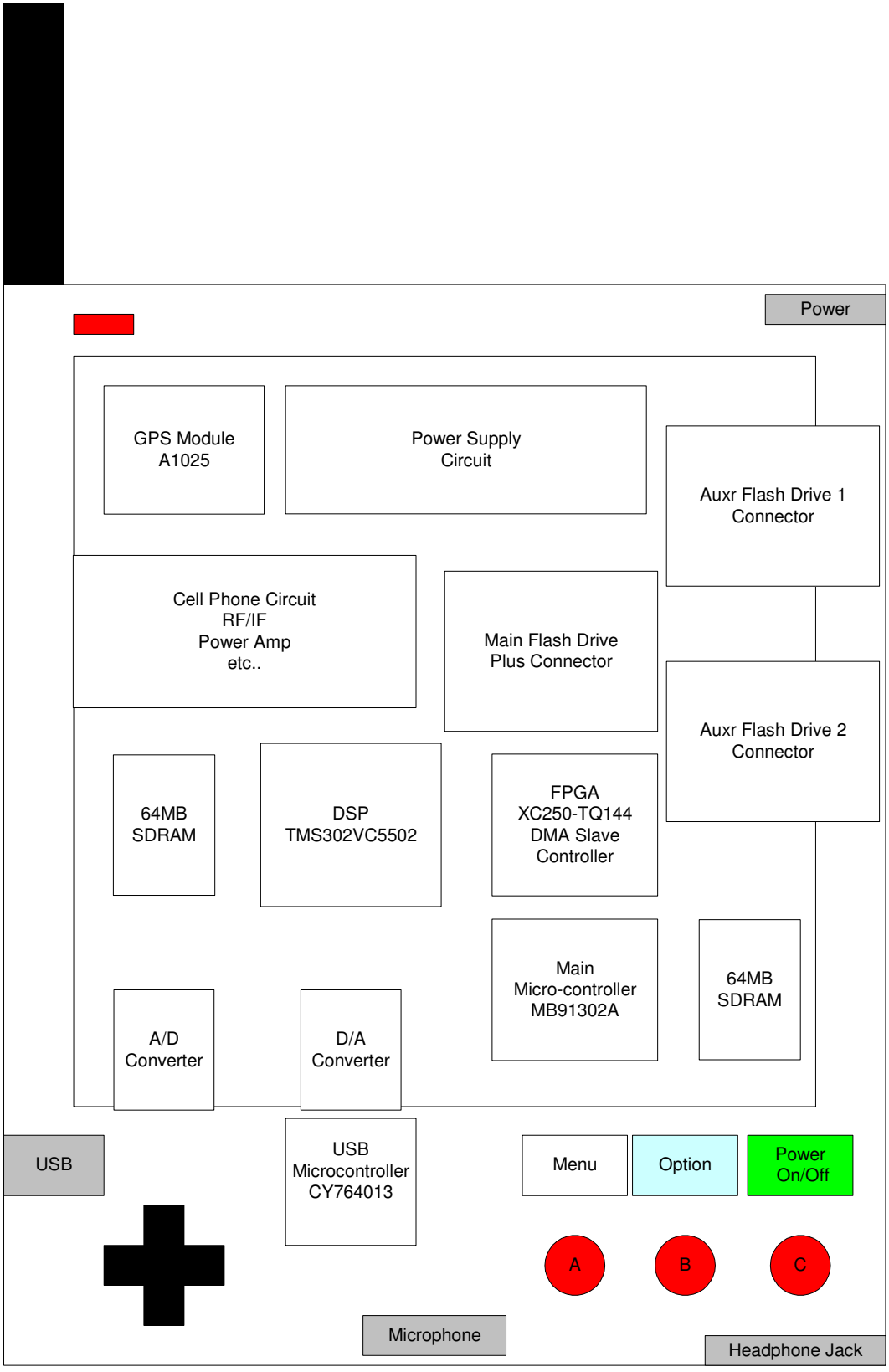


Figure 3: Internal Component Placement



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