32-bit Development Platform for Graphical Interfaces

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Abstract – **In this paper is examined the technology behind 32 bit embedded system with touch screen interface. A key focus of the study is on development of a hardware device based on a Cortex-M3 microprocessor. A printed circuit board (PCB) is designed with Cadence OrCAD and achieved results are examined.**

Keywords – **CORTEX-M3, 32-bit, LCD, Touch screen.**

I. Introduction

Today's embedded systems are built upon 8/16 bit microcontroller architecture. With the availability of new low-power 32-bit architectures, there is an opportunity to increase performance, improve accuracy, and achieve greater power efficiency in these applications. It's also important that, higher processing capability makes it possible to implement new and effective features, including advanced control algorithms and next-generation interfaces such as GUI-based displays, rapid signal processing and capacitive touch sensing.

With the expansion of the Smart phone and personal data assistants their significance is rapidly increasing into the modern-day life.

The wide spread of open source platforms don't have even slightly the capabilities of those devices. And most of the multimedia devices which exist are just too expensive for the average user. Therefore this low cost, graphical interface unit is introduced. Taking full advantage of the 32-bit microprocessors.

Allowing creation of simple graphical applications, and helping understand the principles of graphical interface development. Easy to use pre-developed graphical library are introduced.

The major goals of designing one such system are reviewed and basic conception is introduced in Section II. Key considerations in developing PCB for the hardware with Cadence OrCAD software are shown in Section III.

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II. Conceptions and Overview

The 32-bit ARM Cortex M3 processor offers superior code density to 8-bit and 16-bit architecture (Fig.1) [1]. This has significant advantages in terms of reduced memory requirements and maximizing the usage of precious on-chip flash memory. The ARM Cortex-M3 processors utilize the ARM Thumb-2 technology which provides excellent code density. Code size comparison can be seen on Fig. 2. The comparison is created using relative EEMBC Caremark test size [2].

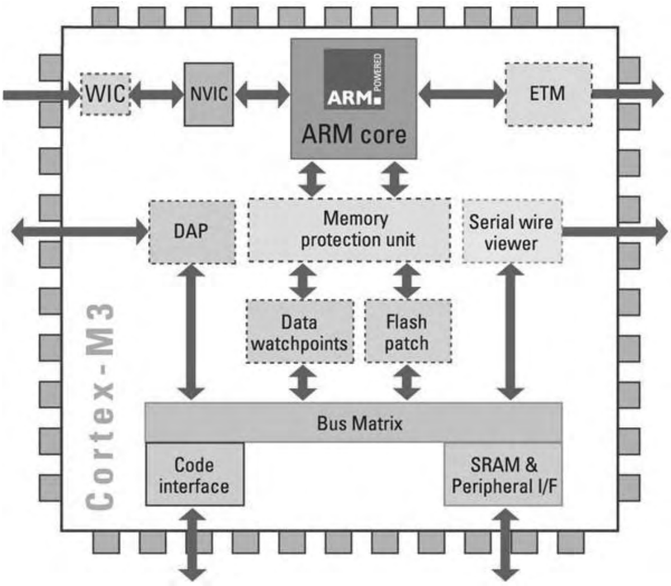

Fig. 1. Cortex-M3 architecture.

The whole picture is not complete without also considering that ARM Cortex-M3 processor instructions are more powerful. There are many circumstances where a single Thumb instruction equates to several 8/16-bit microcontroller instructions. This means that Cortex-M devices have smaller code and achieve the same task at lower bus speed. Comparison between different architecture is shown on Fig. 3. [3].

The demand for ever lower-cost products with increasing connectivity (e.g. USB, Bluetooth, IEEE 802.15) and sophisticated analog sensors (e.g. accelerometers, touch screens) has resulted in the need to more tightly integrate analog devices with digital functionality to pre-process and communicate data. Most 8-bit devices do not offer the performance to sustain these tasks without significant increases in MHz and therefore power and so embedded developers are required to look for alternative devices with more advanced processor technology.

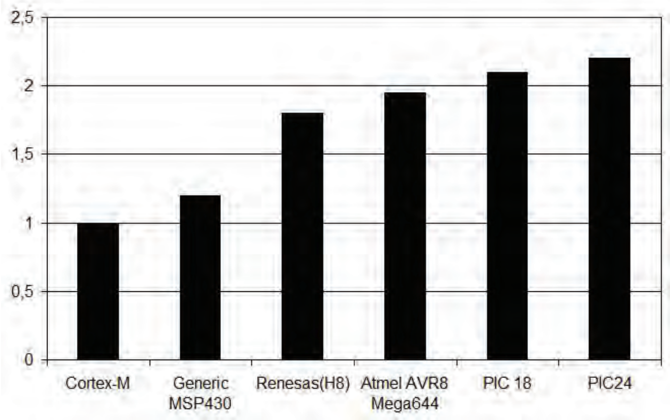

Fig. 2. Code size comparison.

The 16-bit devices have previously been used to address energy efficiency concerns in microcontroller applications. However, the relative performance inefficiencies of 16-bit devices mean they will generally require a longer active duty cycle or higher clock frequency to accomplish the same task as a 32-bit device [3]. The comparison for energy utilization can be seen Fig.4.

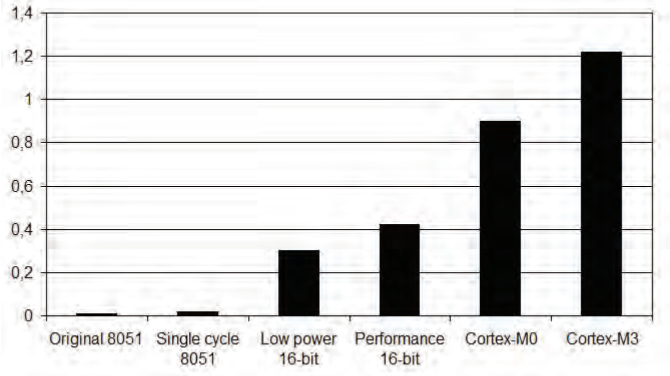

Fig. 3. Performance DMPIS/MHz.

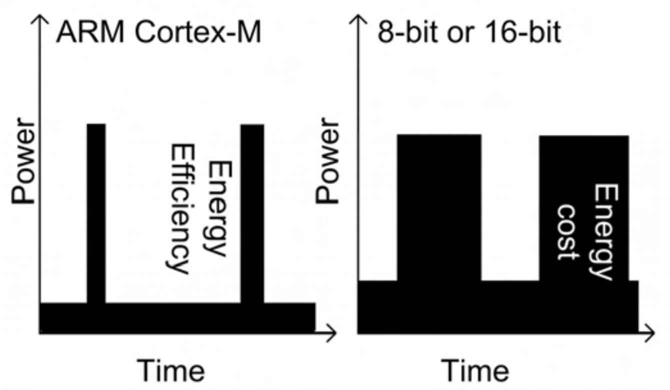

Fig.4 Energy utilization.

A. Device Concept

The designed system must have basic set of hardware needed for development. A simple Quarter Video Graphics Array (QVGA) with embedded LCD controller is chosen mainly on cost measure. The wide variety of low cost displays introduces the opportunity for one cheap and intended for open source communities' device. Resistive touch screens don't offer accuracy, and stylus must be used in order high accuracy to be achieved. Most of the popular developing platforms don't offer mobility. That's why the device must allow autonomous power supply. The device must feature connectivity, in order to be able to be manipulated with. The tendency in microelectronics is miniaturization. Therefore mini USB is suitable for one such system, because of its low volume and size. External memory must be accessible by the user, that's why micro SD connector is available.

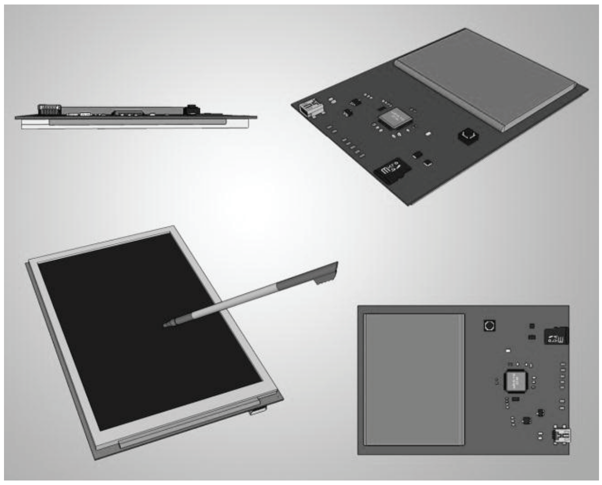

Fig. 5. Device Concept.

A basic conception of the device is designed before PCB creation and manufacturing process. The 3-dimensional view is shown on Fig. 4. The platform is handheld autonomous device that resembles modern cutting edge smart devices.

B. Software overview

In order to achieve high efficiency, image bit-blitting is used. Basicly, area called "window" is defined in the Graphic Display Data RAM (GDDRAM) and the incoming bit stream of filling data which is with predefined direction from the initialization of the display. This means that before graphic data sending, the microcontroller must calculate and store it into an intermediate buffer. Thus smooth frame rates are achieved. This way is much faster than sending first data for the designated pixel, and then its color value. An example of defined window is shown on Fig. 6.

The touch panel will be driven by a special touch controller. The incoming data read by the controller is prescaled and inserted into reasonable range of the display resolution. In order to be achieved accurate reading it is used a median count filter.

On Fig. 7 software conception is proposed. The Main function carries the initialization and functionality of the hardware and Shell functions manage the user applications, developed for graphical interfacing.

Initialization of the display consists in writing specific values to the LCD register. Manufacturers recommended are used.

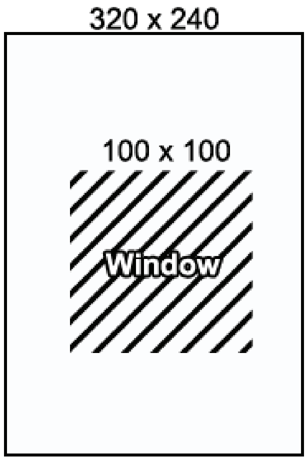

Fig. 6. Defined window area.

Users have a pre-developed graphics library on their disposal, which allows them displaying different shapes or images from the internal or external memory. The performance of the device allows manipulation with compressed or large files, thus introducing many possibilities to the application developers.

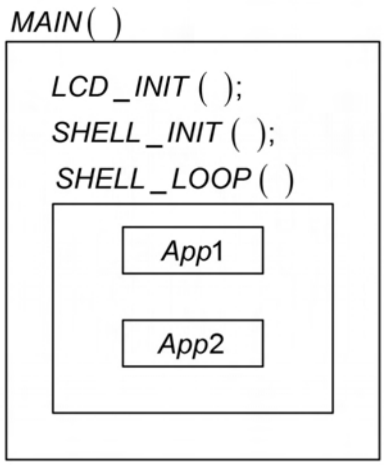

Fig. 7. Software structure.

III. Development Platform for Graphical Interfaces

All the parts chosen for the platform are mainly picked by intense research criteria or experimental

There is a LPC1343 microcontroller unit (MCU) provided on the board which belongs to the 32-bit CORTEX-M3 family from NXP [4]. The microcontroller alone interfaces everything on the board (Fig.8). Being effective in data processing, the LPC1343 is the right choice for development of devices with multimedia content. The MCU uses external 16 MHz quartz crystal oscillator, which is PPL-ed to 72 MHz clock speed. The LPC1343 MCU features 32KB flash memory and 8 KB RAM memory. It provides other integrated modules such as SSP controller with multi-protocol capabilities and fast-mode plus I2C bus interface communication, UART, up to 42 general purpose I/O pins, on chip PHY, 10-bit ADC.

The device features a 320x240 resolution TFT display covered with a resistive touch panel sensitive to touch. The TFT and touch panel together form a functional unit called a touch screen (Fig.8). The touch screen can be used to show images, videos and other graphic content, menu navigation etc. It makes it possible for the user to make interactive apps such as virtual keyboards and tablet inputs. Touch panel itself eliminates the need for additional buttons on the board.

Touch screen backlight is powered with switching transistor and can be adjusted via software with Pulse-Width Modulation (PWM). Thereby power consumption can be reduced when needed.

SSD1289 is an all in one TFT LCD Controller Driver that integrated the RAM, power circuits, gate driver and source driver into a single chip. It can drive up to 262k color amorphous TFT panel with resolution of 240 RGB x 320.

It also integrated the controller function and consists of 172,800 bytes (240 x 320 x 18) GDDRAM such that it interfaced with the MCU through 16-bit parallel interface and stored the data in the GDDRAM.

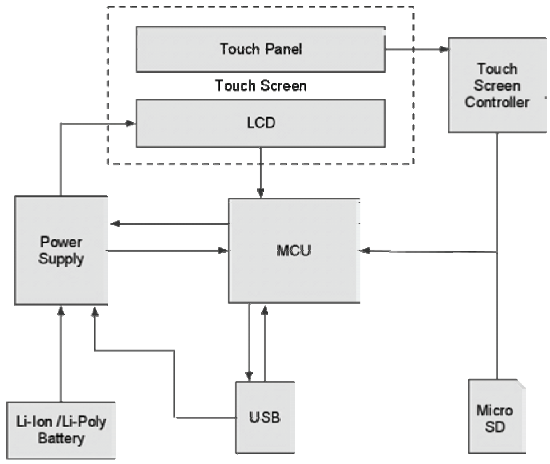

Fig. 8. Device Block Diagram.

SSD1289 embeds DC-DC Converter and Voltage generator to provide all necessary voltage required by the driver with minimum external components. A Common Voltage Generation Circuit is included to drive the TFT-display counter electrode.

An Integrated Gamma Control Circuit is also included that can be adjusted by software commands to provide maximum flexibility and optimal display quality.

SSD1289 can be operated down to 1.4V and provide different power save modes. It is suitable for any portable battery driven applications requiring long operation period and compact size.

An ADS7843 touch screen controller manages the touch panel and is interfaced also via SPI. This multi slave configuration reduces the pin count used on the MCU.

Since multimedia applications are getting increasingly demanding, it is necessary to provide additional memory. There is a build-in Micro SD connector for inserting micro SD card provided for the board. It enables the system to additionally expand memory space. SPI serial interface is used for communication between the MCU and the micro SD card.

There is a 5-pin LDO (Low-dropout regulator) which provides stable 3,3Volts for the device. The LDO with the battery charging unit and 2 Shottky diodes for the turn-on switch represent dynamic power supply, which makes possible, software to control power down of the device, monitoring the charging process of the battery via ADC, and taking full advantages of the power saving options of the LPC1343 MCU. The board may use one of three power supply sources:

- +5V from the USB-VBUS from the USB
- Li ion/li-poly battery connected to a designated connector provided on the board.
- +3.3V from the JTAG connector.

Battery charging unit has status pin. LED is connected to it and indicates when charging is complete.

The Shottky diodes are used for switch debouncing from the initial turn-on. Their absence may cause brown out voltage loops,

There is a mini USB connector provided on the board which is used for connecting to a PC. It allows stable 5 V source for charging. And also allows the device to enumerate as mass storage device (MSD) [5].

Debugging of the MCU can be performed via specially designated JTAG connector.

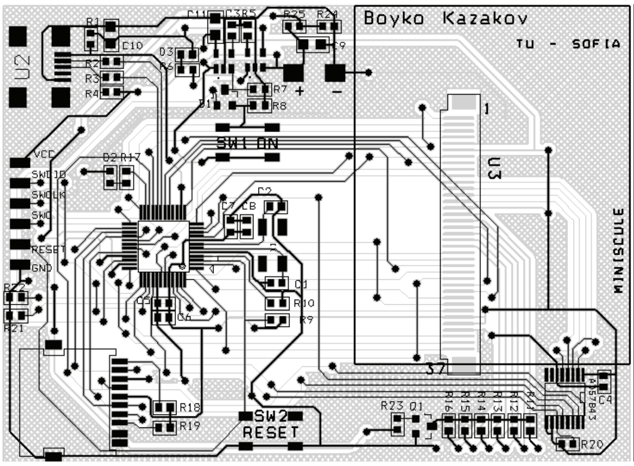

Fig. 9. PCB of the Device

The PCB is created for the device with Cadence Orcad [7] software and follows basic surface mounted technology (SMT) considerations. It features:

- Double layer PCB
- 10 mill tracks /12 mill for tracks involving the power supply, 50 mill via
- Main consideration for the board size and dimension is to fit on the back of the Touch screen. Thus 59x90 mm. is the optimal size for the most 3.2” modules there are.
- 6 pin 100mill SMD footprint is created for the JTAG debugger.

Footprints for the most of the parts are designed with the datasheet recommended dimensions. Special attention is given to routing of data buses, to reduce noise and cross talk influence. Also low via count is abide. A decoupling capacitors are placed also for reducing the noise. Connector for the touch screen is place with accuracy of a millimeter in order the display to be precisely centered on the bottom layer of the board. There is an area on the top layer, left unplaced with components for the battery installation.

IV. Conclusion

In this paper is examined the technology behind 32 bit embedded system with touch screen interface. A printed circuit board (PCB) is designed. The Cortex-M3 microprocessor is proven as suitable choice for such kind of a device. The developed platform can be used for creating of graphical user applications. With its simplicity the system is intended for the beginning of firmware developers.

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