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# ARM Soc Based Enotebook

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**ABSTRACT**

In recent years, electronic media has grown very fast replacing papers, tape devices, books, etc. The new technologies provide large number of data into single device, fast searching options and more readability than ever. As eBooks are replacing books; we are proposing ENotebook system in which user can write as he did in notebook, save, searches and then reread content. This paper presents design and development of ENotebook using ARM7. The system uses touch screen to get input data and operations like save, delete, open & close of data file. All data sensed by touch screen is digitized by internal ADCs of LPC2148 microcontroller which gives low power platform with fast execution. The output is shown on graphical LCD. Whatever user writes on screen it may need to save for future use. The content of such hand written data will be in graphical/pictorial form hence required large of memory for storage. We can provide external memory using pen drive, memory card, EEPROM etc. in this system we are using SD card interfacing through SPI port.

***Key Words:*** ARM7, Graphical LCD LPC 2148, SD Cards ,Touch Screen.

## I. INTRODUCTION

Touch screens have been used as an input in many applications, ranging from ATMs to public kiosks to travel information desks. But it wasn’t until touch screens came in the hands of the public, in the form of smart phones or music players, did the thought of it replacing paper came into the mind of people. The result was smart phones with the application ‘Touch Notes’.Touch notes, an application created by Laboratories For Computer Nicety Inc., Chicago, Illinois, USA, is a very common application in all windows, android, and java phones supporting touch. It allows the user to scribble, write anything like on paper and to save it. Also the user can access the previously created pages and edit them anytime. The popularity of smart phones, PDAs, portable game consoles and many types of information appliances is driving the demand for, and acceptance of, touch screens.Also with time global warming is an issue about which everyone is worried. Growing plants is the only solution to this issue. So to save trees we have to save paper and for this paperless work is the best solution. Switching to 100% post-consumer recycled paper would more than triple those impacts, saving over 14,000 trees a year!! And avoiding over 630 tonnes of greenhouse gas!

## II. LITERATURE SURVEY AND TECHNOLOGICAL SURVEY

The Pocket PC was a small, portable IBM PC–compatible computer, introduced in 1989 by Poqet Computer Corp. with a price of $2000. It was the first subnotebook form factor IBM-PC-compatible computer that ran MS-DOS [1]. The Poqet PC was powered by two AA-size batteries. Early products included the PenPad 200 handwriting-only computer terminal, with a digitizing tablet and electronic pen and no keyboard. With the advent of the IBM personal computer, later products such as the PenPad 320 focused particularly on graphics and CAD/CAM applications for DOS, as well as on data-entry and data-editing applications.

In early 80s and 90s we get a new platform called PDA (Personnel Digital Assistant) to have an option to pcs to carry everywhere. A personal digital assistant (PDA), also known as a palmtop computer, or personal data assistant [2], [3], [4] is a mobile device that functions as a personal information manager.

With invent of touch technology and embedded Operating System (OS) a new era begins. PDAs are largely considered obsolete with the widespread adoption of smartphones [5]. Nearly all current PDAs have the ability to connect to the Internet. A PDA has an electronic visual display, enabling it to include a web browser. All current models also have audio capabilities enabling use as a portable media player, and also enabling most of them to be used as mobile phones. Most PDAs can access the Internet, intranets or extranets via Wi-Fi or Wireless Wide Area Networks.

Apple Computers launched the Apple Newton stylus based computer in 1993. It utilized Apple's own new Newton OS, initially running on hardware manufactured by Motorola and incorporating an ARM CPU and era of iPhones and iPads starts [7].After 2007 with the access to capacitive screens and the success of the iPhone, multi-touch and other natural user interface features, as well as flash memory solid state storage and "instant on" warm-booting; external USB and Bluetooth keyboards defined tablets. Some have 3G mobile telephony applications. Most tablets released since mid-2010 use a version of an ARM processor for longer battery life. The ARM Cortex family is powerful enough for tasks such as internet browsing, light production work and mobile games [8].

Why eNotebook? With above all hand held devices, the most important factor to select is a cost for students and researchers. It is cost that matters and also time to type and capture an image. But, if we go with e notebook, it will be a great solution to cost and time. It is developed using an ARM core. So you can add any feature to system to increase connectivity, accessibility and storage.

Recently "Sony" introduced a revolutionary new way to work. Digital Paper from "Sony", in conjunction with a document management solution, gives you the power to annotate, share, and save your documents – all from a handy device that's light enough to carry anywhere and costing U.S. $ 1,100.00 only [9]!

## III. OVERVIEW OF SYSTEM

Fig. 1 shows the block diagram for proposed ENotebook system. The heart of a system is an arm controller which will get handwritten input from touch screen and provide it to GLCD to display.

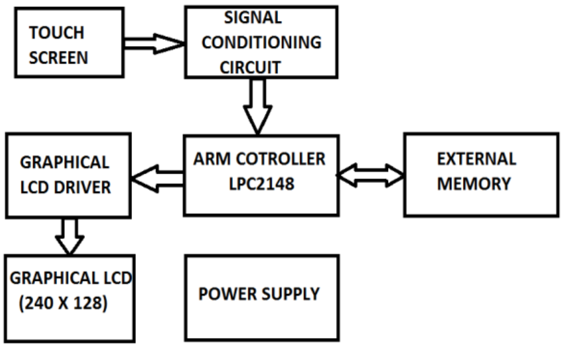


**Fig -1**: System Block Diagram

As ARM is used instead of using external signal conditioning and ADC, we will have onchip ADC. Input captured will be saved on external memory.

### 3.1 Touchscreen

3.1.1 Principle of Operation

A resistive touch screen is constructed with two transparent layers coated with a conductive material stacked on top of each other. When pressure is applied by a finger or a stylus on the screen, the top layer makes contact with the lower layer. When a voltage is applied across one of the layers, a voltage divider is created. The coordinates of a touch can be found by applying a voltage across one layer in the Y direction and reading the voltage created by the voltage divider to find the Y coordinate, and then applying a voltage across the other layer in the X direction and reading the voltage created by the voltage divider to find the X coordinate.

3.1.2 Detecting a Touch

To know if the coordinate readings are valid, there must be a way to detect whether the screen is being touched or not. This can be done by applying a positive voltage (VCC) to Y+ through a pull-up resistor and applying ground to X–. The pull-up resistor must be significantly larger than the total resistance of the touch screen, which is usually few hundred ohms. When there is no touch, Y+ is pulled up to the positive voltage. When there is a touch, Y+ is pulled down to ground as shown in Fig. 2. This voltage-level change can be used to generate a pin-change interrupt [10].

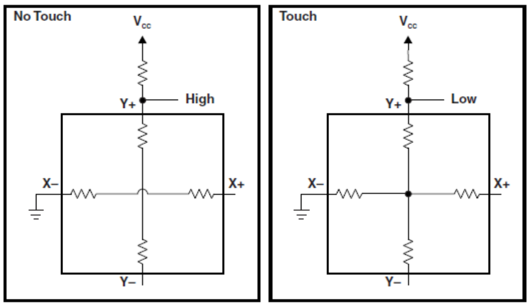


**Fig-2:** Detecting a touch

3.1.3 Excitation and Measurement Method

The method for measuring the pressure point is based upon a preferably homogenous resistive surface (ITO). When applying a voltage to the electrode pair in the resistive surface a uniform voltage gradient appears across the surface. A second ITO layer is necessary to do a high-resistance voltage measurement. A resistive touch screen can thus be seen as an electrical switch requiring a small amount of pressure (0.1 – 1.5 Newton) to close.

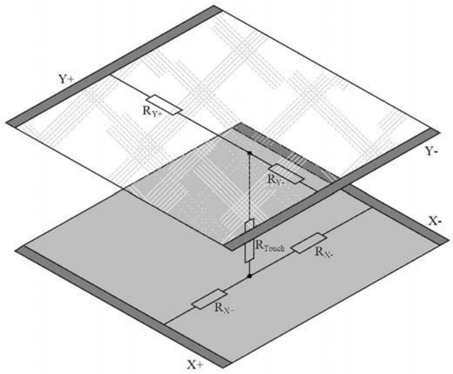


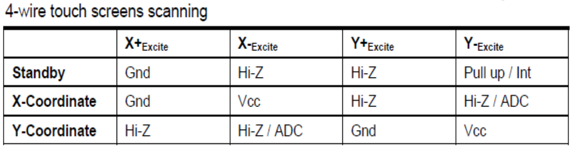
**Fig-3:** Schematic of a 4-wire touch screen when pressure is applied.

The point of contact *divides* each layer in a series resistor network with two resistors (see Fig. 2), and a connecting resistor between the two layers. By measuring the voltage at this point the user gets information about the position of the contact point orthogonal to the voltage gradient. To get a complete set of coordinates, the voltage gradient must be applied once in vertical and then in horizontal direction: first a supply voltage must be applied to one layer and a measurement of the voltage across the other layer is performed, next the supply is instead connected to the other layer and the opposite layer voltage is measured. In stand-by mode one of the lines are connected to a level triggered interrupt in order to detect touch activity.

The X and Y coordinates of a touch on a 4-wire touch screen can be read in two steps. First, Y+ is driven high, Y– is driven to ground, and the voltage at X+ is measured. The ratio of this measured voltage to the drive voltage applied is equal to the ratio of the y coordinate to the height of the touch screen. The x coordinate can be similarly obtained by driving X+ high, driving X– to ground, and measuring the voltage at Y+. The ratio of this measured voltage to the drive voltage applied is equal to the ratio of the X coordinate to the width of the touch screen.

The table below shows connections while measuring the coordinates.

**Table -1:**4-Wire Touch Screens Scanning



4-wire touch screens scanning

| | $X+_{Excite}$ | $X-_{Excite}$ | $Y+_{Excite}$ | $Y-_{Excite}$ |
|---|---|---|---|---|
| **Standby** | Gnd | Hi-Z | Hi-Z | Pull up / Int |
| **X-Coordinate** | Gnd | Vcc | Hi-Z | Hi-Z / ADC |
| **Y-Coordinate** | Hi-Z | Hi-Z / ADC | Gnd | Vcc |

### 3.2. The Arm Controller

The analog values received from the touchscreen are then input to the controller and the co-ordinates for the touchscreen are calculated and this in turn acts as an input to the graphic LCD driver which further drives the LCD to turn the particular pixel ON.

#### 3.2.1 Advanced Risc Machine (ARM7)

The ARM7TDMI is a member of the Advanced RISC Machines (ARM) family of general purpose 32-bit microprocessors, which offer high performance for very low power consumption and price [11].

The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of micro programmed Complex Instruction Set Computers. This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small & cost effective chip. Pipelining is employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory [11],[13]. The ARM memory interface has been designed to allow the performance potential to be realised without incurring high costs in the memory system. Speed-critical control signals are pipelined to allow system control functions to be implemented in standard low-power logic, and these control signals facilitate the exploitation of the fast local access modes offered by industry standard dynamic RAMs. The CPU has two instruction sets, the ARM and the Thumb instruction set. The ARM7TDMI is a 3-stage pipeline, 32-bit RISC processor. The processor architecture is Von Neumann load/store architecture, which is characterized by a single data and address bus for instructions and data. The CPU has two instruction sets, the ARM and the Thumb instruction set [13].

The ARM instruction set has 32-bit wide instructions and provides maximum performance. Thumb instructions are 16-bits wide and give maximum code density. Instructions operate on 8-, 16-, and 32-bit data types. The CPU has seven operating modes. Each operating mode has dedicated banked registers for fast exception handling. The processor has a total of 37, 32-bit registers, including 6 status registers [11],[12].

#### 3.2.1.1 3- stage Pipeline structure

The pipeline has three stages; FETCH, DECODE and EXECUTE. The hardware of each stage is designed to be independent so up to three instructions can be processed simultaneously. The pipeline is most effective in speeding up sequential code [10].

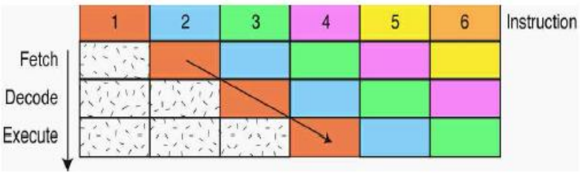


**Fig- 4**: 3-Stage Pipeline structure

#### 3.2.1.2 Concept of Thumb

The ARM7TDMI processor employs a unique Architectural strategy known as THUMB, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue The key idea behind THUMB is that of a super reduced instruction set. Essentially, the ARM7TDMI processor has two instruction sets:

- The standard 32-bit ARM set
- A 16-bit THUMB set [12]

The THUMB set's 16-bit instruction length allows it to approach twice the density of standard ARM code while retaining most of the ARM's performance advantage over a traditional 16-bit processor using 16-bit registers. This is possible because THUMB code operates on the same 32- bit register set as ARM code. THUMB code is able to provide up to 65% of the code size of ARM, and 160% of the performance of an equivalent ARM processor connected to a 16-bit memory system [11], [12].

This allows instruction to be stored in 16 bit format, expanded into ARM instruction & then executed. Although the THUMB instruction, they will achieve a much higher code density. So in order to build a reasonably sized application that will fit on a small single chip microcontroller, it is vital to compile code as a mixture of ARM & THUMB function. This process is called interworking & is easily supported on all ARM compilers. By compiling code in THUMB instruction set we can get a space saving of 30%, while same code compiled as ARM code will run 40% faster [11], [13].

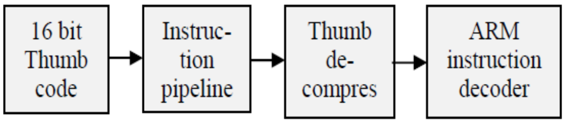


**Fig- 5**: THUMB instruction concept

### 3.3. Signal Conditioning and ADC

Signal conditioning circuit is used to amplify the incoming signal from touch screen. Since output of touch screen is analog, we need to convert it in digital signal because microcontroller is digital onchip 10 bit ADC [11], [12], [13].

### 3.4. Graphical LCD

Graphical LCD contains Dot matrix for display. To store the ON / OFF values of this dot matrix requires large memory and also it needs to refresh content of LCD screen after a particular interval. Since microcontroller might busy in to the other stuffs like sampling, processing, and saving, retrieving data from memory hence LCD driver is required which does all these operations [15].

**Figure 6:** Graphical LCD

### 3.5. External Memory

Whatever user writes on screen it may need to save for future, using pen drive, memory card, EEPROM etc. Content of such hand written data will be in graphical / pictorial form hence requires large memory for storage. We can provide external memory as well. Here in this system SD card is used as external memory and interfaced using SPI protocol [14][16][17].

**Fig- 7**: SD card and reader**.**

### 3.6. Power Supply

The system required different power supply as follows;

- 3.3V for ARM microcontroller.
- 5V for signal conditioning circuit and graphical LCD [11], [13].

### 3.7. Flow of working

Graphic LCD and Touchscreen are initialized when we switch on the Digital Paper. Then, a welcome message on LCD is displayed once the device is ON and then it checks for the presence of a memory card, then a message is shown accordingly if card is successfully detected or not. Once the device is successfully initialized we can do *calibration* of the touchscreen by selecting proper co-ordinates through the touch input and by checking if touch input for calibration is within specified limits or not, then a message is displayed accordingly. Once calibration is done successfully, the menu page is shown which consists of four options namely WRITE, OPEN, SAVE and CLEAR. We can select one of these tasks to perform an operation. The controller detects continuously for a valid touch, and if detected, checks the pixel touched is in the blank space or if it is inside the menu block. If touch is in blank space, then the corresponding co-ordinates generate a voltage which is transmitted to the controller to perform the operation on the LCD. Depending on the actual values of touch point the corresponding pixels are lit on LCD (as our LCD is placed right below the touchscreen). It shows four pixels for a touch detected at one point, so the drawn line is thick enough to be visible.

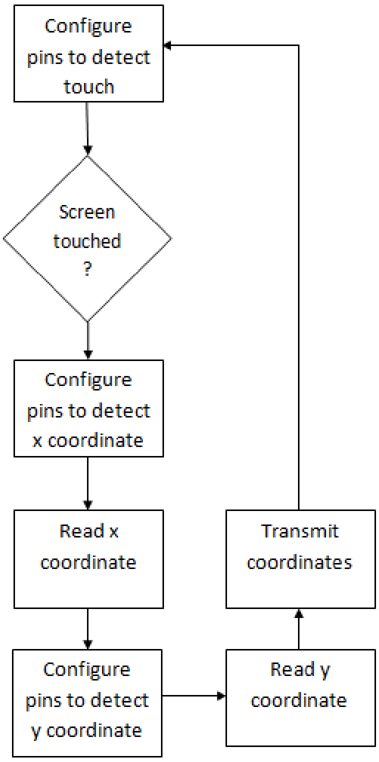
Now if one of the MENU options is selected, then the corresponding operations are performed.

- If OPEN – it opens all files in the memory card, shows cancel option in menu, and keeps on detecting for a touch to select a file, or the cancel option. If cancel is selected go to starting screen, else if a file name is selected, it opens the corresponding file. Nothing happens if any clear part of the screen is touched.If SAVE – then it saves the current display as a new file.

- If CLEAR – then it clears the complete drawing portion, refreshes LCD and displays menu again
- WRITE/ERASE – initially when the screen is touched, the corresponding pixels are lit up, and Erase option is available on the menu. On selecting the 'Erase' option, the touching of screen will erase the corresponding pixels on the screen, and in place of the erase option, 'Write' option is displayed. This can be clicked and used to return to write mode.

## IV. SOFTWARE DESIGN

### 4.1 Flowchart


Configure pins to detect touch
Screen touched ?
Configure pins to detect x coordinate
Read x coordinate
Configure pins to detect y coordinate
Read y coordinate
Transmit coordinates

The software platforms used for completion of tasks in flowchart are as follows-

### 4.2 Keil µVision4

µVision is a window-based software development platform that combines a robust and modern editor with a project manager and make facility tool. It integrates all the tools needed to develop embedded applications including a C/C++ compiler, macro assembler, linker/locator, and aHEX file generator. µVision helps expedite the development process of embedded applications by providing the Integrated Development Environment. KEIL can be used to create source files; automatically compile, link and covert using options set with an easy to use user interface and finally simulate or perform debugging on the hardware with access to C variables and memory. Unless you have to use the tolls on the command line, the choice is clear. KEIL Greatly simplifies the process of creating and testing an embedded application [19].

### 4.3 Flash Program Utility

For downloading the application program into FlashROM, this utility tool is necessary. The program code generated in C language after processing produces object code in hex form. It is referred as .hex file. To dump this hex code in the flash ROM of the controller the facility is provided with Keil version 4. For programming with older versions, the same task is completed with the help of software called Flash Magic [20].

## V. RESULT

Fig.8, 9, 10, shows images of ENotebook screen implemented using this paper concept. Fig 8 shows the 1st screen when power is on. In fig 9 shows all the menus are initialised. When we are writing or drawing at that time ERASE menu is displayed this means by default it is WRITE menu. But when we are erasing whatever we have written then WRITE menu get initialised on screen as fig10.

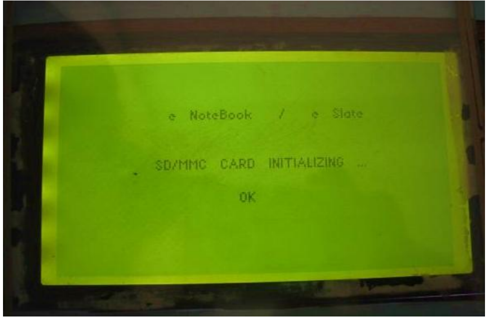


**Fig. 8**- Initializing Screen

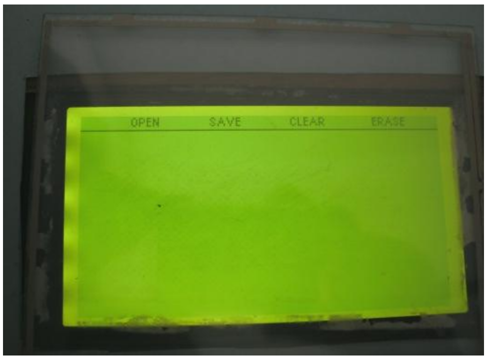


**Fig. 9**- Showing All Menus

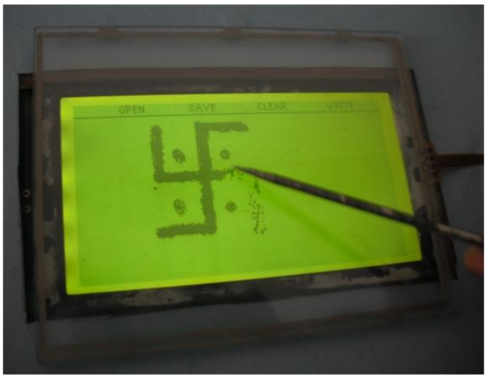


**Fig. 10**: erasing an image

## VI. CONCLUSION

The system prescribed here is the one with Touch screen interface which made it more interactive to user. Data drawn on touch screen is displayed on LCD and saved on SD card. The file stored is only of BMP monochrome format. Memory expansion is also possible. It provides a User friendly GUI User can store data in one's own handwriting. We can connect such systems together using *wi-fi* or any other communication protocol and can share data. Most importantly the data can be retrieved any time especially for researchers, students it makes their work paperless and saves paper

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