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Implementation of Video Capture and Playback in Mobile Systems

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ABSTRACT

Mobile phones are backbone of the mobile communications and have experienced fastest growing segment in the consumer market. In the 3G and 4G mobiles, video recording is an essential entertainment features so the user can record and play the video within the mobile phone. In this paper, video capture and playback implementation had been carried out by integrating the camera module to the GSM phone. An alaysis of the video processing had been carried out. Image sensor and LCD module had been interfaced with the base band processor through the video processor. To interface the different module necessary PCB schematic diagram had been arrived. Software implementation had been carried out for the Human Machine Interface for various settings of the camera module, which is integrated with the video processor. The developed playback system had been tested for the various senerious. In this video has been captured through the camera sensor and at the time of playback measured the resolution, power consumption and image transfer rates of the various modules used in the developed camera phone.

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1. INTRODUCTION

Mobile phones are the backbone of mobile communications and have experienced explosive growth. “Mobile phones are a hugely popular form of communication among young people, and we wanted to bridge the gap between youth culture and the church,” the Reverend Stefan Heinze told The Guardian newspaper [1].Generations of mobile phone are divided into four as of today based on communication system between base stations. They are

First Generation Mobiles

TACS was the technology used by vodafone and cellnet when they first launched their UK networks. The service offered were mainly voice calls, which were prone to eavesdropping and cloning. This was due to analogy, technology limitations. UK networks now use digital technology, which utilize complex encryption techniques.

Second Generation Mobiles

All four UK operators to provide their national mobile service are currently using GSM. This is also known as 2G in the industry. The services include voice, e-mail, SMS. The level of coverage varies from region to region. WAP is feature that enables mobile access to the Internet but this service has not been successful due to its capacity limitations. There is a GPRS service currently being offered and is known as 2.5G in the industry. GPRS is geared towards offering better data services and is a migration step to third generation mobiles.

Third Generation Mobiles

UMTS is said to be the future of mobile communications, which is currently being planned by four existing network operators along with a fifth operator called Hutchinson 3G. This is known as 3G in industry & is aiming to provide new services utilizing voice, data, video, multimedia etc at a capacity up to 2Mbps. The packages initially will be aimed at business users due to high license and deployment cost.

Fourth Generation Mobiles

As the more number of user starting rising within the cell using high end multimedia application, the industry realized sortage of the bandwidth of 3G wireless technology.3G was never built to deliver the streaming media services.The industry need to look for data optimized fourth generation technologies which can fulfill the shortage of bandwidth.Today LTE is the standard for the 4G technologies and researechers are moving ahead to improve the data rates.

1.1. Components of Mobile System

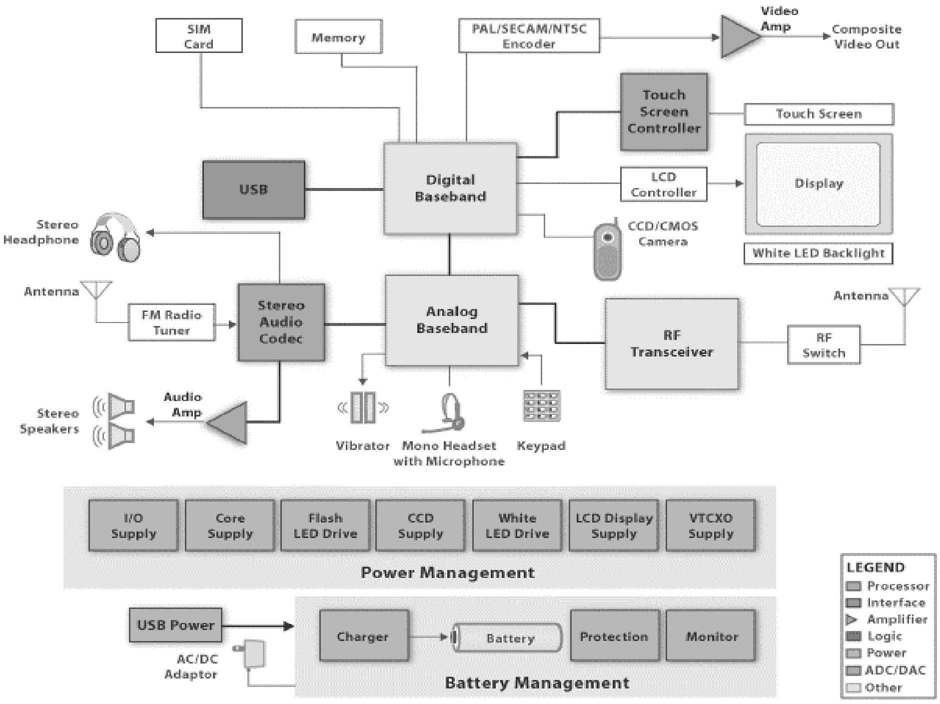

Figure 1. Blocks Diagram with Functionalities of Typical Mobile (cell phone) [1]

Figure 1, represents the various blocks used in the typical cell phone system. The blocks are described as follows:

Microphone: Captures voice for conversion from analog to digital mode.

Speaker: Allows monitoring of remote phone.

LCD Display: Shows Call, Phone, Signal & Network Information.

Keypad: Allows access to specific remote locations of the phone.

Battery and Meter: While battery housings on cell phones are standard input designs. Some cell phones also have some “battery processing” intelligence built in. For example, they will check the charge level to start or stop the charge when the phone is connected to a desktop, car or quick charger and even automatically discharge the battery for you when necessary. This is usually linked to the LCD display and to an audible beep to warn you of the battery charge status.

LED Lights: Status information, Usually Green, white & Red.

Digital Signal Processor: The DSP chipset is a critical component which is used to co-ordinates the voice, SMS and data/fax features of a cell phone. It processes speech, handles voice activity detection, as well as discontinuous GSM transmission and reception. One section amplifies the input signal received from the microphone, while another converts this.

CODEC: Microphone voice signal from “analogue” to “digital”. The digital conversion is necessary because the GSM cellular standard is a completely digital system. This DSP’s voice processing is done with highly sophisticated compression technique mediated by the “CODEC” portion of the cell phone.

RF Unit: The CODEC chipset instantly transfers this “compressed” information to the cell phone’s Radio Frequency (RF) unit. RF Unit is essentially to perform the transmitter and receiver section of the cell phone. It sends out the voice or data information via the cell phone antenna, over the air and on to the nearest cellular base station and ultimately to your call destination. The incoming voice also travels much the same route, although it is first uncompressed from incoming digital from into an audible analogue form, which is then piped out as sound through the cell phone’s speaker. This analogue-to-digital and digital-to-analogue voice conversion via the CODEC is done at very high speeds, so that you never really experience any delay between talking and the other person hearing you and vice versa.

SIM Card Reader: When you switch on your phone with a “live” SIM card inside, the subscriber information on the chip inside the SIM card is read by the SIM card reader and then transmitted digitally to the network via the RF unit. The same route is followed when it hit the call button on the cell phone. The number you have inputted is instantly and digitally transferred to the network for processing.

External Connectors: At the bottom of most cell phones there is an external connector system. You can usually plug in a data/fax adapter or a battery charger, or a personal hands free device, or car-kit with external antenna connections. You will also find many with separate “speaker” and LED lights that are activated when the phone rings and/or when the battery is low. Many phones also have tiny LED lights under the keypad that light up when u presses a key and/or when the phone rings.

On-Board Memory: Many cell phones also have a certain amount of on-board memory chip capacity available for storing outgoing telephone numbers, your own telephone number, as well as incoming and outgoing SMS messages. Some allow copying between the (limited) memory on the SIM card and the phones own internal memory.

Antenna System: Cell phone manufactures are implementing many wonderful permutations of antenna system designs. While some are stubby, fixed types. The most predominant designs though are those with thin, pullout steel rods all of whom usually fit snugly into a special antenna shaft. These antenna designs, be they the stubby or pull-out types, all conform to the same circa 900 MHz frequency transmit and receive range required by the GSM specification.

2. HARDWARE DESIGN AND IMPLEMENTATION

In this project, CMOS sensor module is integrated with the video processor in the existing GSM mobile handset. This was done by implementing the schematic diagram and designed the PCB for these modules. The software code is developed for the integrating of sensor module with the existing system.

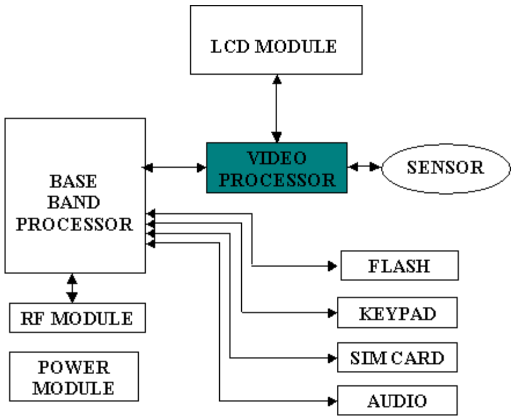

Figure 2. Camara Phone Higher-level Block Diagram

As shown in Figure 2, this video processor is acting as bridge among base band processor, LCD controller, and image sensor. This video processor allows the direct interface with CMOS/CCD sensor and LCD display. This video processor can capture still images as well as video clips and send them to mobile phone baseband processors, or receive any size of JPEG image or MJPEG video from base band processor for LCD display and also this can provide high-quality, low-latency video stream to LCD panels with desired resolution and color depth. Most of the display and camera functions are conducted by video processor, which will greatly reduce the burden on host CPU for computation-intensive image and graphics processing. The camera sensor used in this implementation, which will support the CCIR 656 compatible 8-bit serial interfacing or YCbCr interfacing. This sensor module is connected with the video processor using the I2C bus. This sensor technology improves image quality by reducing or eliminating common lighting/electrical sources of image contamination, such as fixed pattern noise, smearing, etc., to produce clean, fully stable color image. Blade profiles of pump, turbine and stator.

2.1. Video Processor Interface Design

The hosts CPU can read/write the control registers and on-chip SRAM of Video Processor via host interface unit. Video Processor supports most popular CPUs such as ARM, Xscale and other 68/80-series CPUs. The data bus is 8 bit/16 bit (synchronous or asynchronous). The internal control bus is AMBA.

CPU Interface: Video Processor supports three kinds of CPU interfaces: Separate 8-bit, Multiplex 8-bit and multiplex 16-bit. There are 24 pins used to connect to host CPU: CPU_A0~A7, CPU_A8, CPU_RS, CPU_D0~D7, CPU_CS1N, CPU_CS2N, CPU_OEN, CPU_WEN, CPU_WBEN0, CPU_WBEN1.

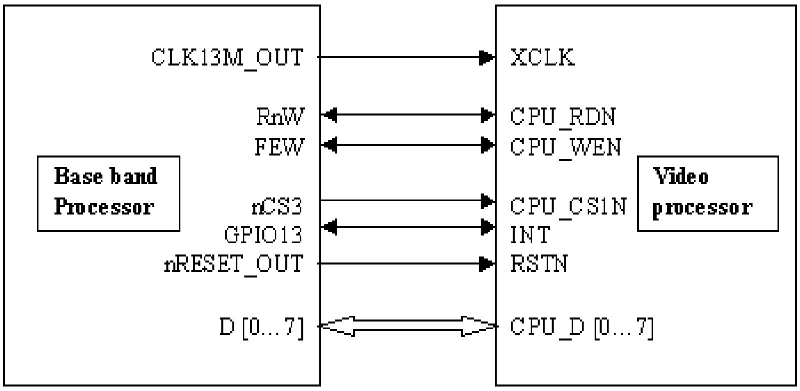

Figure 3. Interfacing Base-Band Processor with Video Processor

Figure 3, represents the Base band processor is interfaced with the video processor. This CPU processor supports the three types of Bus interfaces. They are:

a) **Separate 8-bit:** 8-bit data bus, data lines and address line are separate. Under this mode, CPU must support 10 address lines and 8 data lines. 10 address lines should connect to CPU_A0~A7, CPU_A8, CPU_RS. 8 data lines should connect to CPU_D0~CPUD7.
b) **Multiplex 8-bit:** 8-bit data bus, data lines and address lines are multiplex on the same 8 lines. Under this mode, CPU must support 2 address lines and 8 data lines. 2 address lines should connect to CPU_A8, CPU_RS. 8 data lines should connect to CPU_D0~CPUD7.
c) **Multiplex 16-bit:** 16-bit data bus, data lines and address lines are multiplex on the same 16 lines. Under this mode, CPU must support 2 address lines and 16 data lines. 2 address lines should connect to CPU_A8, CPU_RS. 16 data lines should connect to CPU_D0~CPUD7 (lower 8-bit), CPU_A0~A7 (upper 8-bit).

In this design camera sensor supports the 8- bit data transfer. With the 8-bit data transfer a better performance and speed of data transfer rate have been achived. The pins used for interfacing the host processor are as follows:

a) **CPU_A8** is used as the address or data selection signal. Under bypass mode, the CPU controls the LCD directly;
b) **CPU_RS** is used as the RS pin of the CPU.
c) **CPU_CS1N** is used as the chip select of Video Processor under normal working mode. Under bypass mode, it can be used as the chip select of the LCD. It can be switched between the chip select of the main panel and chip select of sub panel by setting the register of Video Processor. So, Video Processor supports one chip select signal (CPU_CS1N) to control a dual panel LCD. The CPU_CS2N can be pull-up.
d) **CPU_WEN:** The write enable signal
e) **CPU_WBEN0:** The lower byte write enable signal

f) **CPU_WBEN1:** The upper byte write enable signal

The common CPU provides these three signals. The connections should be based on the timing of the CPU and the configuration of video processor.

a) **INT pin:** should connect to the external interrupt pin of CPU.
b) **XCLK pin:** 5MHz – 20MHz clock input
c) **RSTN pin:** reset pin, connect to one GPIO of CPU, low active
d) **TEST pin:** this pin must be connected to the ground.

2.2. LCD Interface

The LCD interface pins are matched with the LCD module pins. Here we are interfacing the LCD module pins with the video processor.

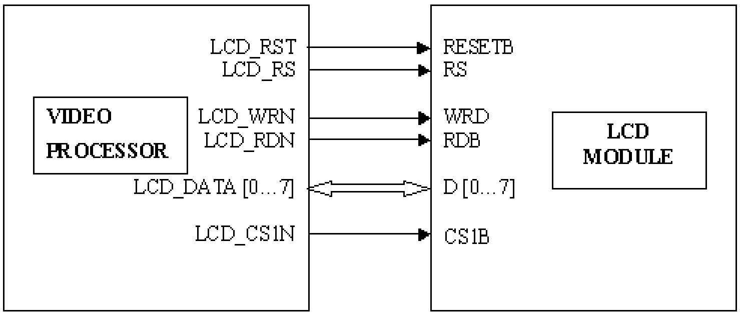

Figure 4. Interfacing LCD with Video Processor

As shown in Figure 4, these pins LCD_RST, LCD_RS, LCD_WRN, LCD_RDN, LCD_CS1N, LCD_CS2N and LCD_DATA [0…7] are the video processor pins, which are used for the interfacing with LCD module. Since single panel LCD module is used, LCD_CS1N is connected and LCD_CS2N is left connected. This LCD module maximum image size is supports up to 352 x 288 pixels and it supports the 4/8/12/16/18/24 bit transfers.

2.3. Sensor Module Interface

As shown in Figure 5, the pin interface between the camara module and the video processor is as follows:

a) **CS_D0 ~ D7:** 8-bit data bus, matched with the sensor module's data lines.
b) **CS_VSYNC, CS_HSYNC:** vertical, horizontal synchronizing signal.
c) **CS_SDA, CS_SCK:** I2C data line and clock signal.
d) **CS_RSTN, CS_PWDN, and CS_ENB:** reset, power down, and enable signal. These three pins are output pins. The internal register of Video Processor can control the output signal. These pins are connected to the matched pins of the sensor module.
e) **CS_CLK:** the clock signal Video Processor outputs to sensor module.

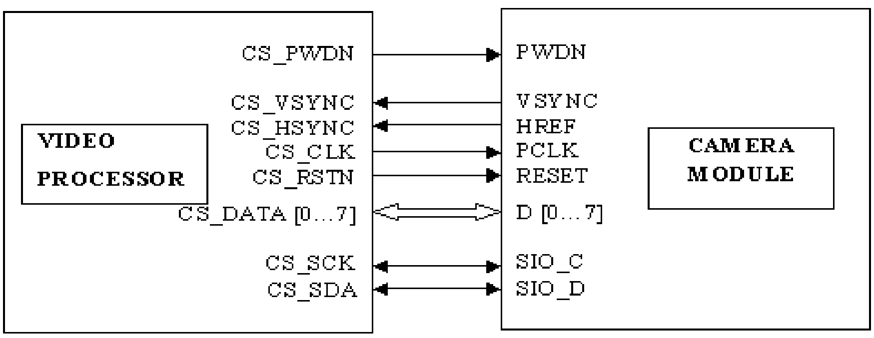

Figure 5. Interfacing Camara Module with Video Processor

The next task after the schematic preparation was the PCB designing. A net list was generated from the schematic and exported to the layout and the PCB was designed. In the PCB design three factors are mainly followed while development. They are as follows:

a) The address and data lines are always routed in parallel and they are in same layer
b) To avoid the noise generation which affects the data losses, the clock signal cannot cross the address and data lines because the signal frequency is high compared to the data lines.
c) The VCC signal also cannot cross the address and data lines because these power signals are high frequency signals. For this transmission losses will arise and sometimes short circuit will cause the total damage of the board.
d) After completion of the design, all the blocks of the design were tested and tuned in the satisfactory working conditions, which completes the hardware implementation part of project.

3. SOFTWARE DESIGN AND IMPLEMENTATION

The section describes the software architecture, the software operation and flow charts, and the low-level control software for the video processor. The features and functions, using the video processor had been described as follows:

3.1. Software Architecture

The control software divided into three cooperative layers for integration into the GSM cellular phone control software. The layers are:

a) User interface
b) Protocol layer
c) Operational layer

Each of these layers as follows.

User Interface: The user interface layer is responsible for the all aspects of activation and selection for the various features and functions of the video processor circuitry. The user interface layer provides the routines, menu readouts, selections and control settings/selections for programming the video processor. The specific details of the user interface functions and routines are as follows.

Protocol Layer: The protocol layer includes all functions that are integrated into the GSM protocol routines of the cellular phone control software. The protocol layer is generally responsible for activating the operation of the video processor when specific events occur. This ensures that the operation of the video processor flows smoothly, and the desired features and functions of the video processor are integrated closely and seamlessly with the GSM protocol.

Operational Layer: The operational layer contains all of the low-level control routines and drivers for the video processor circuitry. The most essential routines in this layer control the basic video processor functions: Preview, Capture and Display. These low-level control routines are called from the appropriate places in the higher-level routines so that the Video processor is controlled and activated at the appropriate times. Other control reviewed in this section will handle the all of the message management functions. These functions manage the capture storing and displaying of the pictures. These routines also manage storage tables or other mechanisms that keep track of the individual pictures in the storage array so that a specific picture can be displayed.

Figure 6 shows the software flow for integration of the camera module to the video processor. In this software design it creates a separate camera entity that will be interfaced using the software flow. After that developed of the user interface, the interface flow need to be understands by user for the operation of the playback functionalities. To configure software control between the baseband memory and the video processor, reset the chip to activate the all the functions in the baseband processor. After this initialize the bus type which can be used for the interfacing with video processor. Set the clock signal for the video processor to activate internal functions in video processor. The clock frequency for the video processor is 13MHz. After set the clock signal that is required to install the interrupt service program to send out an interrupt. Then checks that all the blocks are activated are not. If all the functions are activated, then initialize the video processor hardware. After the initialization was done then implement the camera block using the APIs (Application program Interface) supported by the video processor. Once the camera is integrated with the video processor it needs to develop the user interface functions. Figure 6, explained the APIs that are used in the initialization of all the components.

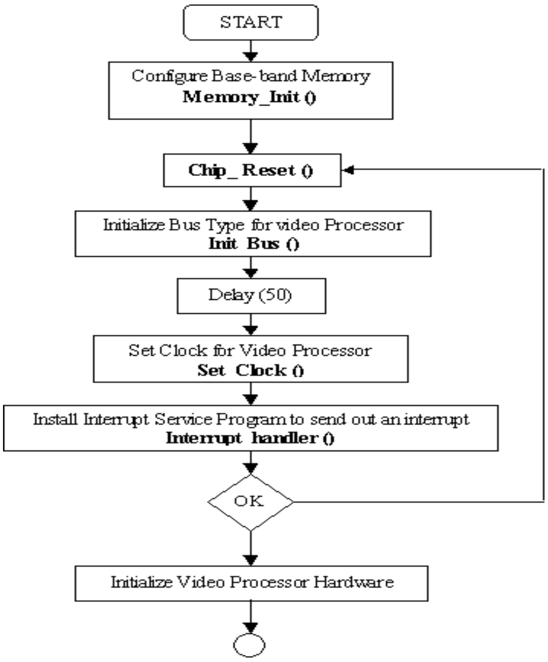

Figure 6. Software Flow represents the Camara Integration with Video Processor

3.2. Initialisation and Device Control

After power on, Video processor must be initialized; the following procedure has to be followed.

a) USER_InitBUS(); // Initialize the bus type of Video Processor.
b) USER_SetCLK(0x8, 0x02); // Set Video Processor clock.
c) USER_SetInterrupt(1,1,3); // Set Video Processor interrupt output.
d) DrvInitInt(); // Install the interrupt service program
e) USER_Init(); //Hardware initialization
f) USER_CamOpen();
g) USER_CamClose();

Controls the open and close of the modules related to the camera. Operations cannot be done unless the camera is open. When camera is open, only graphic function and Bypass functions are operational.

3.3. Capture Software

The Video Processor can capture the still image (capture still: single still image, JPEG format) and capture video (capture video: Capture the image continually, motion JPEG format), as Figure 7. Both of them have two modes: capture sensor and capture LCD. Capture sensor means to capture the image signal from the sensor module. LCD Capture means the capture the image that are displaying on the LCD. To develop the fuctionlalites of the software module for the video playback the necessary software APIs had been developed.

Capture Video: Video size and quality control

a) Video size: void SetVideoParameter (UNIT8 Ratio);
b) Video quality: SetCaptureQuality (UNIT8 rate);

The size and quality of the video must be configured prior to capturing the video. After the configuration has been done, it will be always valid unless re-initialize.The API functions provided by the API to capture video are:

a) CaptureVideo_start (CallBack pUCallBack); // Capture Sensor
b) CaptureLCDVideo_Start (CallBack pUCallBack); //Capture LCD
c) CaptureVideo_Stop (void); //stop capture Video

The user has to write the corresponding callback functions:

UNIT8* (* CallBack)(UNIT8 Status, UNIT16 Byte_Length, UNIT32 *BufLen);

The API for JPEG display and video display is provided.

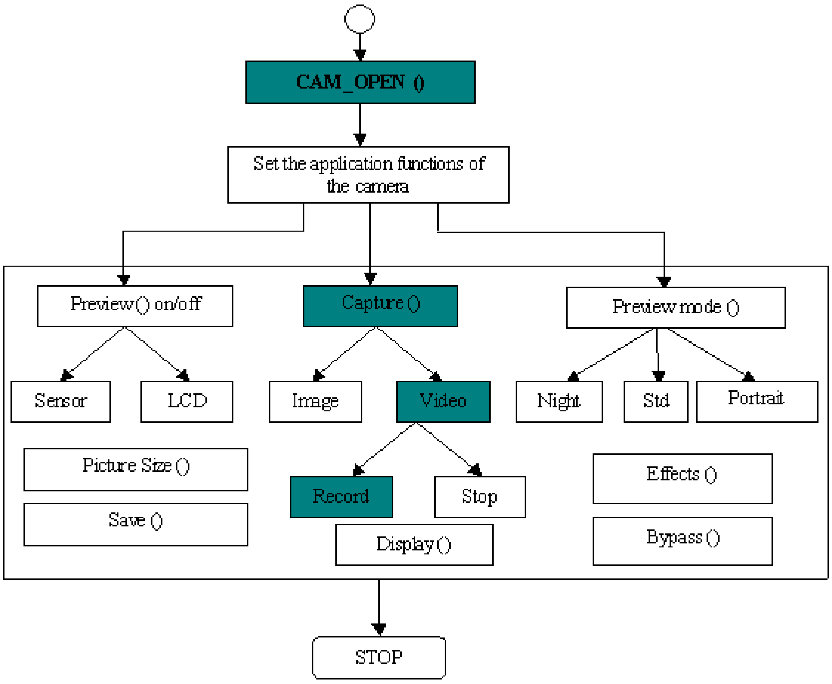

Figure 7. Software Flow represents the Opening and Capturing of the Still Images

JPEG Display: This API function is called, and the pointer that points to the JPEG image is given out, and the image will be displayed on the LCD.

Display JpegFile (UNIT8 *jpegBuf, UNIT16 Lcd_OffsetX, UNIT16 Lcd_OffsetY, UNIT16 Display_W, UNIT16 Display_H);

Video Display: The API function for displaying video is as follows. It is required that the video format is motion JPEG (as same as the captured video).

a) Start: DisplayVideo (UNIT8 FrameRate, User558_CallBack pUCallBack);
b) Stop: DisplayVideoStop (void);
c) Pause: DisplayVideoPause (void);

The corresponding callback function has to be written:

UNIT8* (*CallBack)(UNIT8 Status, UNIT16 Byte_Length,UNIT32 *BUFLen

It gives an explanation on the User Interface (UI) aspect of the camera phones that forms an important aspect of the overall design. The various API functions for previewing, capturing and displaying of the images is also explained which gives a fair idea about the software architecture of the camera phone.

4. RESULTS

Figure 8, shows the implemented hardware setup for the camera module. Testing and verification of each modules power consumptions, input voltages and clock frequency had been carried out. Video processing with the clock frequency of 13MHz and the input voltage supplied to the processor is 3.3V. From the camera sensor the input voltage required was 2.6V. The power consumption of the sensor is 20mA. The maximum image size is 640 x480 pixels (0.3Mpixels). The video image transfer rate for the camera sensor is 30 fps. The clock frequency of the camera module is 24MHz. From the LCD module the input voltage required is 2.8v. Power consumption of the LCD module is 3mA. The resolution of the LCD module is 352 x 288 pixels. These are the things observed from the designed camera phone.

Figure 8. Hardware System with Camara Mobile

5. CONCLUSION

The project work carried out aims at integrating a CMOS camera module into a GSM mobile phone. The schematic generation and the PCB designing were made. A test board was designed and was tested to check the accuracy of the design. The result was fully functional Camera phone with a VGA resolution.

a) The developed prototype was compared with existing camera phones. Experimental results show that the proposed new design achieved equal or better efficiency than the existing camera phonesThe image transfer rate of the captured video can be achieved by 30 frames/sec through the image sensor, which was interfaced with the video processor.
c) The developed prototype is indeed a good trade-off among power consumption, playback quality, cost, and playback latency.
d) The cost of the designed camera phone is 15% less compared to the existing mobile phone.

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