Abstract—DM3730 processor is fabricated on single chip Texas Instrument’s advanced 45-nm technology with improved performance. ARM architecture provides best Graphics with less power consumption. DM3730 1GHz processor comes in 0.4mm pitch POP (Package on Package) with memory mounted on top of the processor. Debugging at the hardware/software level is necessary for developing an efficient system. Image Processing application requires, Camera, Speakers, GSM module, keyboard, mouse, internet connection for installing required software’s, hence hardware debugging is must to test and know the working of these peripherals properly. The hardware/software debugging is the need of the today’s industry for proper deliver of the system. In this paper, DM3730 Processor is tested for different peripherals on Linux Platform. This paper is a part of research work on the project “Development of Non-Intrusive Driver Fatigue Detection & Warning System to avoid on road Accidents” sanctioned under Early Career Research Award sponsored by Science & Engineering Research Board ,Govt. of India ,New Delhi at Vignan Institute of Technology & Science, Vignan Hills, Hyderabad.

Keywords— DM3730; GS;, Camer;, Image.

I. INTRODUCTION

DM3730 Processor functional block diagram consists main blocks of the processor such as; Camera ISP image capture hardware, Host USB OTG, Dual output 3-layer display processor, System control, Stacked and External memories, ARM Cortex A8 MPU subsystem , DSP imaging Audio Video Processor-TMS320DM64x+, External Peripheral interfaces. The board has 32KB on-chip ROM and 64KB on-chip RAM. The board also supports other memory such as Flash memory (NAND/NOR), Static RAM (SRAM)[1].

A. Board Specifications

There are different types of specifications which are needed to avoid the errors due to lack of compatibility. In brief, board specifications refer to a type of technical standard. Table I gives Mechanical specifications of the board.

| Parameter         | Specifications |
|-------------------|---------------|
| Size              | 82.55 mm by 82.55mm |
| Height Maximum    | Total Board Mass (TBM) |
| Layers on board   | Six |
| Thickness (PCB)   | 0.062 inches |
| Complaint RoHS    | Yes |
| Weight of Board   | Total Board Weight (TBW) |
| USB Ports         | 4 |
| Camera Port       | Yes |

B. Board Features

The The board has a faster CPU clocked at 1GHz, 512MB RAM, and onboard Ethernet jack and has 4 USB ports. The other important feature is addition of Camera port makes it easy to import video through Leopard imaging cameras.

The board with all its parts labelled is shown in Figure 1.

![Figure 1. Types of Driver Fatigue Detection System](image-url)
**LED Indicators:** The board provides 5 green LEDs which are controlled by user

- TPS65950 has one LED programmed via I2C interface.
- GPIO pins control two LEDs on the processor.
- One Power LED to indicate power is applied to board.
- One LED indicates power to USB HUB.

The RED LED on board indicates that the applied voltage exceeds the maximum limit of board. To protect the board from damage, the power connectors are removed immediately and look for alternate power.[8]

**RS232 connector:** This board supports RS232 via UART3 to access onboard transceiver through DB9 connector.

**Operating System:** The open source hardware design brings ‘laptop’ like performance while adhering hand-held power levels. It supports following open source OS which is ported on the microSD card of minimum 4GB memory: Angstrom Linux, Ubuntu, Fedora, Android, Arch Linux, Windows CE, XBMC, FreeBSD.

II. STEPS TO PORT OPERATING SYSTEM

Board supports Angstrom Linux, Ubuntu, Fedora, android, Arch Linux, Windows CE, XBMC and FreeBSD open source OS. Ubuntu has released many versions, during this research work, the latest version was Ubuntu 11.10. Ubuntu is selected due to its user friendly Graphical User Interface (GUI), popularity. Following are the steps followed to install Ubuntu 11.10 on to the formatted 8GB microSD card:

**Hardware required:** 8GB microSD card, Laptop with Linux OS and internet facility.

**Step (i):** Before porting OS onto the card, the system requires few packages, which are installed using the command through terminal

**Install Pre-requisites:** sudo apt-get install uboot.mkimage_btrfs_tools_pv

**Step (ii):** Download latest version of Ubuntu image for the board using the command

```
www.rcn_ce.net-deb-roots-oneirie-ubuntu-11.10-r10_minimal_armel
```

**Step (iii):** Checksum_md5sumUbuntu-11.10-r10_minimal_armel

**Step (iv):** Unzip the files onto the folder using

```
tar xjf ubuntu-11.10-r10_console-armel
```

**Step (v):** Enter into the folder where the unzip files are stored using

```
cd/ ubuntu-11.10-r10_console-armel.tar.xz
```

The folder has a script file named ‘setup_sdcard.sh’, which partitions the SD card otherwise the steps discussed in the previous section can be used.

**Step (vi):** Insert 8GB microSD card into the board, connect USB keyboard, mouse, DVI-D monitor to the board through HDMI cable and also connect the Ethernet cable as shown in Figure 3.

Fig. 3. Board Setup after Porting OS onto the MicroSD Card

From Step 7 onwards, the OS installation on SD card are explained, make sure that SD card name is correctly used otherwise other device gets formatted.

**Step (vi):** Porting of OS onto the card is done using script file and command

```
sudo ./setup-sdcard.sh_mmc /dev/sdb_uboot beagle_xm
```

This step may take approximately 15min to install all the packages onto the SD card. After successful completion, it gives message everything complete, unmount the SD card.

**Default user name/password:** ubuntu/temppwd

After this message, take out the SD card and insert it into the Board.

III. HARDWARE DEBUGGING

In the previous section, Ubuntu 11.10 is ported successfully onto the 8GB microSD card. This section deals with connecting all the peripherals needed to develop DFD system and testing.

**Hardware required:** Board, 5V power supply, DVI-D monitor, HDMI cable, 8GB Ubuntu 11.10 ported microSD card, camera, USB 2.0 supported keyboard and mouse, Ethernet cable, GSM module and speakers. Insert the 8GB microSD card onto the board, connect USB keyboard, mouse, connect DVI-D monitor to the board through HDMI cable and also connect the Ethernet cable as shown in Figure 3.
A. Testing of Ethernet Connection

After powering the board, the SD card boots and the login screen appears as shown in Figure 4.6. Username and Password are entered as mentioned earlier, the console window appears which is not user friendly because it lacks GUI. In order to get the GUI, first the board is configured for internet connection using steps shown below:

```
arm@ubuntu:~ $ sudo ifconfig a
arm@ubuntu:~ $ sudo dhclient eth0
arm@ubuntu:~ $ sudo ifconfig a
```

arm@ubuntu shows the user details at the terminal prompt. The above three command configures the internet connection through Ethernet cable. Once the internet is configured, before installing GUI packages, it is must to update and upgrade the Ubuntu version with following two steps:

```
arm@ubuntu:~ $ sudo apt-get update
arm@ubuntu:~ $ sudo apt-get upgrade
```

GUI packages are two types, first one takes more memory and second type is light weight version. To save the memory on SD card, light weight version of Ubuntu lxde is installed using command:

```
arm@ubuntu:~ $ sudo apt-get install_xfce4
```

This takes around an hour to install all packages and after completion, reboot the board and Ubuntu GUI appears on monitor.

B. Testing of Camera

Driver Fatigue is estimated using eye blink rate, where the face of the driver is monitored continuously and captured through camera. In this research work, Logitech Pro 9000 USB Camera is used to capture the images of a driver. The camera and its specifications are shown in Table 4.5.

The Logitech Camera has USB cable, hence connected through USB onto the board. To check working of camera, firstly an additional package needs to be installed using:

```
arm@ubuntu:~ $ sudo apt-get install luvcview
```

This package helps to check the camera working and also helps in changing its properties. After installing package, the following command is typed:

```
arm@ubuntu:~ $ sudo apt-get install xfile4
```

This takes around an hour to install all packages and after completion, reboot the board and Ubuntu GUI appears on monitor.

C. Testing of Audio Device

Driver fatigue is estimated using image and vision based approach by continuously capturing the frames as discussed in previous section. After fatigue is detected, it is needed to alert the driver through warning system. In most of the existing DFD system, warning system fails. In this research work, the board has inbuilt audio jacks where speakers can be connected as shown in Figure 5 and the required Audio CODEC are available in TPS65950. Testing audio is done by connecting the speakers to audio output jack has shown in Figure 4.8 by using following command:

```
arm@ubuntu:~ $ sudo apt-get install gstreamer-properties
```

First gstreamer installed, which is open source multimedia framework capable of handling audio & video playing, recording, and editing. To test audio and video, simply type the following command in terminal:

```
ubuntu@arm:~ $ gstreamer-properties
```

GStreamer is used as multimedia framework and is developed using C programming language based on GObject. It permits programmer to develop variety of media applications such as audio playback, video streaming, recording and editing. The following window opens for testing connected audio and video signals.
D. Testing of GSM Module

Communication between GSM module and Serial Port of the board is achieved using Minicom which is a text-based communications program. Minicom helps to communicate between external devices like mobile phones, routers through RS232. Minicom is free application software available for different OS. The GSM Module is connected to board through Serial Port as shown in Figure 6.

Minicom is a program in Linux used to communicate through serial port. Before using Minicom, it needs to be configured. To configure Minicom super user privileges are required and the connected serial device. Figure 6 shows, Serial port Settings through Minicom. The communication between GSM modem and Board is done by writing Python code using AT Commands.

IV. PERFORMANCE MEASUREMENT

The DM3730 processor is a high performance, applications processors are based on the enhanced device architecture. This architecture is designed to provide best in class ARM and graphics performance while delivering low power consumption. A 1.5GHz floating and fixed point DSP is capable of analysing these images in real-time with high performance. This high-performance processor comes with set of peripherals such as PCI express, Ethernet, two 32-bit DDR3 memory interface operating at 1600MHz makes this DFD System a High Performance. Integra DSP+ARM can replace a discrete microprocessor, FPGA and DSP. The memories associated with these are consolidated to a single set of chips, converting nine distinct parts to only three parts. This result in 50% of cost reduction and system power requirements are potentially reduced which makes this system Low Power.

REFERENCES

[1] Daniel Allred, Gustavo Martinez,” Maximizing the Power of ARM ® with DSP”, White paper Texas Instruments, (October 2010).
[2] Toscani,L., Gangemi,P.F., Parigi,A., Silipo,R., Ragghianti, P., Sirabella,E., Morelli, M.,Bagnoli,L., Vergassola,R., and Zaccara,G., “Human heart rate variability and sleep stages,” The Italian Journal of Neurological Sciences, Volume 17, pp. 437-439, (1996).
[3] Bonnet,M.H., and Arand, D.L.,“Heart rate variability: sleep stage, time of night, and arousal influences”, Electroencephalography and Clinical Neurophysiology, Volume 102, pp.390-396, (1997).
[4] Martin Gallagher, “Development of a driver alert system for road safety”, in (2006-07).
[5] Stonham,T.J., “Practical face recognition and verification with wizard”, In H. D. Ellis, editor, Aspects of face processing. Kluwer Academic Publishers, (1986).
[6] Ji,Q., Yang, S., “Real time visual cues extraction for monitoring driver vigilance”, Proceedings of International Workshop on Computer Vision Systems, Vancouver, Canada, (2001).
[7] Yammamoto K, Higuchi S, “Development of a drowsiness warning system”, J Soc Automated Engineering Japan, 46(9), pp.127–133,(2009).
[8] TMS320DM647/TMS320DM648 Digital Media Processor, Copyright © 2007-2012 Texas Instruments Incorporated.
[9] Choi, J. S.; Lim J. K.; Nam J. Y.; Ho Ha Y.,(2006) Image capture and storage system for digital TV without degrading image quality, IEEE Transactions on Consumer Electronics, vol.52, Issue 2, pp:467 – 471.
[10] Diaz, J.; Ros, E.; Mota, S.; Pelayo, F.; Ortigosa, E. M.(2006), Subpixel motion computing architecture, IEEE Proceedings - Vision, Image and Signal Processing, Volume 153, Issue 6, pp:869 – 880.
[11] Marsh, P., (2005) High performance horizons [High performance computing], Computing & Control Engineering Journal, Volume 15, Issue 6, Page(s):42- 48.
[12] Vijayalaxmi, Performance Analysis of DSP & ARM Processor for Image Processing, Advances in Computer Science and Engineering © 2016 Pushpa Publishing House, Allahabad, India Published Online: August 2016 Volume 16, Numbers 1-2, 2016, Pages 39-48.