

STUDY AND DEVELOPMENT OF 3D ENTERTAINMENT CONSOLE

Major Project Report

*Submitted in fulfillment of the requirements
for the degree of*

Master of Technology
in
Electronics & Communication Engineering
(Embedded Systems)

By

Yash A. Trivedi
(16MECE24)



Electronics & Communication Engineering Department
Institute of Technology
Nirma University
Ahmedabad-382 481

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Under the guidance of

Industrial Project Guide:

Dr. Sharvari Dalal

Hardware Director
3D Ed Tech Pvt Ltd.
Ahmedabad

Internal Project Guide:

Prof. Jayesh Patel

Assistant. Professor, EC Department
Institute of Technology, Nirma University
Ahmedabad



Electronics & Communication Engineering Department
Institute of Technology
Nirma University
Ahmedabad-382 481

Declaration

This is to certify that

1. The thesis comprises my original work towards the degree of Master of Technology in Embedded Systems at Nirma University and has not been submitted elsewhere for a degree.
2. Due acknowledgment has been made in the text to all other material used.

- Yash A Trivedi
16MECE24

Disclaimer

“The content of this thesis does not represent the technology, opinions, beliefs, or positions of 3D Ed.Tech Pvt. Ltd. ,its employees,vendors, customers, or associates.”



Certificate

This is to certify that the Major Project entitled “**Study and Development of 3D Entertainment Console**” submitted by **Yash Trivedi (16MECE24)**, towards the partial fulfillment of the requirements for the degree of Master of Technology in Embedded Systems, Nirma University, Ahmedabad is the record of work carried out by him under our supervision and guidance. In our opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of our knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

Date:

Place: Ahmedabad

Prof. Jayesh Patel

Internal Guide

Dr. N.P. Gajjar

Program Coordinator

Dr. D. K. Kothari

HOD, EC Department

Dr. Alka Mahajan

Director, IT

Completion Certificate

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- Yash Trivedi
16MECE24

Abstract

People use his smart phone or tablet, not only for communication purpose, but, with the time and innovation, People start using his smart system in various application like, Home/ industry monitoring system, in medical system and use to manage so many appliances and IoT devices. In market, from last few years a new buzz word come across the market i.e. 3D Stereoscopic, 3D VR (virtual reality) and 3D AR (Augmented Reality). We live in the world where everything can easily describe in 3 dimensions rather than 2 dimension, even our mind precept any object in 3D manner. A 3D view can make system more attractive and efficient. In this thesis, main target is to design such portable laptop or tablet kind of console. We can use such a high-performance console in so many field. Such as gaming industry, automotive field, medical imagine, Educational etc. By creating the Two separate images (called image pairs) for left and right eye and pass this image in sequential manner at high frequency then we can realize the 3D effect called 3D VR. For that, required special type of Hardware (system) required. All conceptual as well designing information related to 3D visualization explains in this thesis.

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Chapter 1

Introduction

1.1 Motivation

With the time, as human necessary increase, day by day technology also improve. Initially persons can communicate via Land-line phone only which is not movable but as human needs increase, It's motivate the invention. After lots of evaluation , In 1973 first hand-held cell-phone design. Person can talk with anywhere at anytime. At that time cell phone is mostly used for calling, messaging and very few other functionality was there. In 2009-10 first time special mobile operating system i.e. Android OS was designed. After the Android, development of Smart phone and tablet was start and day by day users of smart phone / tablet increase in global market. This type of hand-held device easy to use and it's provide lots of functionality. Smart tablet and smart phone take place of Bulky Personal computer and laptop. From last few year android tablet/smart phone was not using only for calling/communication purpose, but peoples are using android based smart phone/ tablet for specific application like, smart tablet for home automation, Embedded Display for Industry monitoring and controlling, For health care monitoring and diagnostic system, For Gaming and educational console etc. This type of system called Android based embedded system.

Nowadays in international market, The smart high-end display or application specific android based embedded display are in very high demands, This technology covers almost all market area. There are one another cutting edge technology are nowadays used in Embedded system i.e. 3D stereoscopic and 3D VR. We can apply this technology in so many field health care domain, Gaming domain, Education domain.

1.2 Problem Statement

To reach the international market demand and competition, a system should be as possible as advance and should reach up to the satisfaction level of the persons. There are mainly two different objective of this project: (1) Prepare the embedded system which can interface with embedded Display and also interface with device which support USB 2.0/3.0 protocol and the main objective is (2) Design high performance movable smart embedded display which can deliver 3D stereoscopic vision (not 2.5D) and can communicate with space mouse.

The Project title “**Study and Develop hand-held mobile device for Entertainment Gaming Console**” can be divided into mainly three sub categories

1. Selection of Processor (and SBC for testing)
2. Prepare Application Processor and system for interfacing with eDP display (2D display)
3. Design 3D display and interface it with Application Processor

In this thesis, to reduce the complexity and too easy to understand, here used term “2D display” and “3D display”. Actually all display used in project or available in market are normal LCD/LED panel, according to application some parameter may be change, like Display interfacing protocol, size, Supportive frame rates, viewing angle etc.

1.3 Thesis Outline

The rest of thesis organized as follows.

Chapter 2 describe the selection of Processor. Its include details of Processor for mobile industry, Parameter consideration for selection of Processor and Performance testing of Processor/ CPU with benchmark testing. In this section, What is Benchmark Testing, Tools available in market for benchmark testing and Process of it.

Chapter 3 describe the details of Processor and SBC which we are choose for this project.

Chapter 4 describe about various display technology and protocol, Market review of Display technology and select the display based on application,

Interfacing the Display with Application processor.

Chapter 5 describe whole flow, ways and option for 3D vision. It's explain in detail, what is 3D, how we can realized 3D view of any physical object, Different between 2D,2.5D and 3D, Glasses technology and types, Various ways and options for 3D vision.

Chapter 6 is about Conclusion.

Chapter 7 is about future scope and Application of this thesis or project.

Chapter 2

Selection of Processor

Most embedded system require some type of processing unit, which can process the instruction/software/programs written by system developer or software engineer. This processing unit should be able to take in user inputs and provide appropriate outputs. In essence the processor is the brain of an embedded system. Nowadays different type of Processing unit available in market like Controller, Processor(CPU), Graphics processing unit (GPU), System on Chip (SoC) and System on Module(System on Module) etc. All of these processing units have their own advantages and disadvantages.

Processor: A processor has an ALU and a clock(as well as a Bus architecture, Instruction decode, Timing and Control unit). The processor doesn't have Memory or I/O or any other supporting elements which are a necessity for the type of embedded system that we are trying to design.

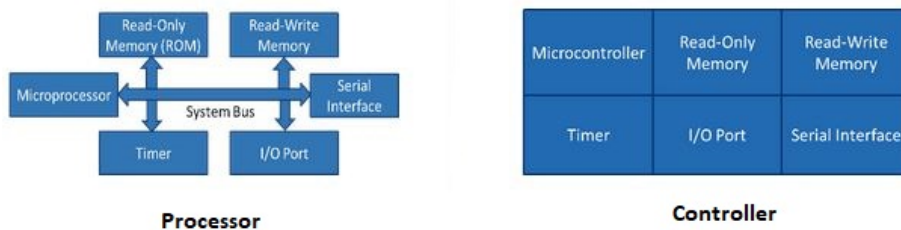


Figure 2.1: Micro controller V/s Microprocessor

Controller: Many smaller, simpler embedded systems are designed with a microcontroller instead of a larger microprocessor. A micro controller has an on chip processing unit(i.e. ALU and Instruction decode unit), Timing, Clock, Memory unit, Serial Interface, I/O port and other interfaces depend-

ing on which micro-controller is chosen. many more, Many advanced controllers such as the ARM based controllers have various modes of operation: Power saving modes (Normal mode operation, fast mode operation, Sleep mode operation).

System-On-Chip (SoC): A SoC is an Integrated Circuit, that integrate all all most components, which are required in an Embedded computing system. It may be able to take input and process on analog signal ,Digital signal, mixed-signal , all on a single silicon chip. The SoC integrates the controller or processor with essential components and advanced peripherals like GPU, Wifi bluetooth, DSP, Sensor core, Camera and Display etc.all integrated onto a single chip.

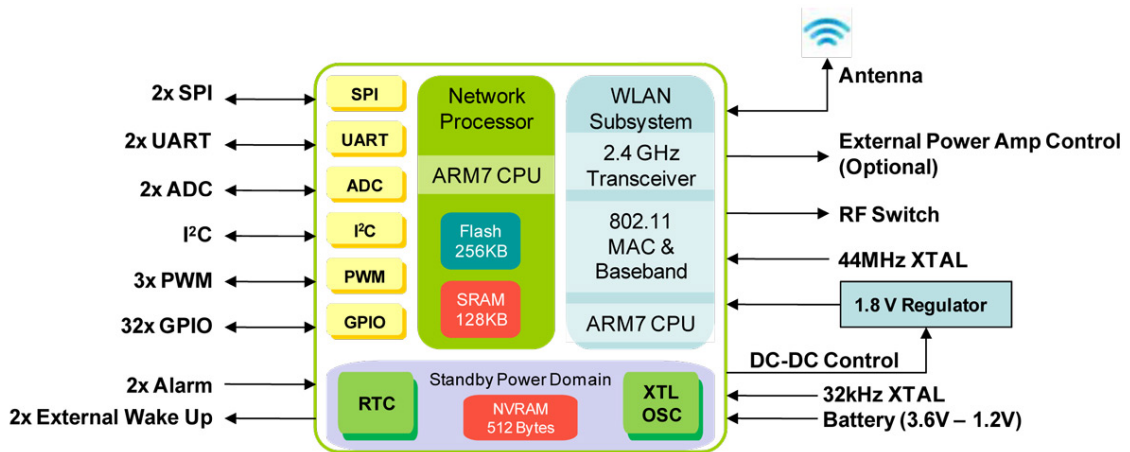


Figure 2.2: Soc

Because Soc integrates all required elements in a single chip and low power consumption SoCs are very popular in High performance Embedded application like mobile and portable computing, application specific mobile hand held device or embedded display

System On Module (SoM):System on Module is single board computer based on SoC.A **system on a module (SOM)** is a board-level circuit that integrates a system function in a single module with help of SoC. In general, all SBC based on SOM have two different PCBs, one is for SoM board and another one is the carrier board

One can use such SoC or SoM in high -end portable Embedded systems. An ARM based SoC is highly recommended in market especially for hand-held mobile devices. There are many vendors that provide ARM based SoC such as Qualcomm Snapdragon, Samsung Hummingbird , Samsung Exynos, Nvidia Tegra etc. The issue that we are trying to resolve is that from the various SoC vendors which SoC (or SoM) is appropriate for an application. We can choose the Processor either based on Comparison of Parameter or based on performance via Benchmark Testing. These Both ways are described below in detail.

2.1 Processor selection based on Parameter

To select an appropriate SoC for an application,one way is to comparison of several feature/ parameter. We can select the appropriate SoC / Processor based on below Parameter.[1].

Processing Power:

The first and foremost consideration in selecting the processor is its performance. The performance speed of a processor is dependent primarily on its architecture and its silicon design. There are few parameter which affect the performance,

- Fabrication Technology
- Multicore
- Cache Memory
- Pipeline Architecture
- Operating frequency
- Operating Voltage

Size:

Packaging size is also mattered in time of processor selection. In some application size of processor board is mattered, In such size constraint system, size of processor and package of SoC in Matter.

Power Consumption & Power Management:

Power consumption of system is very vital when we are going to design battery operated device and In market of Embedded system, most of the Embedded device is standalone battery operated device, in such a case power

consumption of Whole system is very crucial factor. To achieve good power performance matrix in battery operated system, we have to select such a Core/ CPU which support some kind of power management schema and have some operating mode like Full mode operation, Standby mode, sleep mode etc. ARM big-Little architecture is the best example of it.

Most of the ARM Soc Provide different Operating mode to achieve high power performance, such as Normal mode/ Active mode, Sleep mode, Standby mode etc. And because of this reason ARM core based Chip (Soc) highly recommended in Mobile industry as well in Portable system design.

Ecosystem:

When we are going to select the processor, the support provided by the SoC/chip manufacturer is important. The documentation level, Hardware description and Designing manual, Software development tools etc. are generally provide by manufacturer.

Like ST Microelectronics have STM32 based SoC is from ARM core and ST provide SW generation tool named CubeMX, with help of this tool we can generate a Embedded software according to Hardware configuration.

Peripheral / Interface Support:

International market moves toward the use of SoC rather than Processor/ Controller, A simple reason behind it is, SoC include all other peripheral with CPU/MCU in single chip. Like On-chip

- GPIO,I2C,SPI etc communication Protocol
- DSP Processor
- GPU
- Co-processor
- Wifi & Bluetooth
- Video Codec
- Audio codec

Availability in Market:

This parameter is also important, when we are going to use any SoC in our long term project or in Product design, in such case long term availability

and Support from the chip manufacturer are needed.

There are some other point that are also concern at some point when we are going to select the SoC / Processor

- Cost
- Available Driver, middleware
- Supported Operating system
- Supplier's Reputation

2.2 Comparison of Some SoC

2.2.1 Qualcomm Snapdragon 600 series and 800 series:

Qualcomm SoC highly used by mobile industry and specially these two Snapdragon processors was found in many of the Smartphone released during last two years. The Snapdragon 600 comes with Quad core Custom ARM IP core and it can run up to the maximum speed of 1.9 GHz and comes with Adreno GPU.

Qualcomm also provide another SoC which is very high performance and used in so many smart phone in last year.[2].The Qualcomm snapdragon 800 is 64 bit quad core processors designed based on ARMv8 Architecture and can operate at the maximum clock rate of 2.3GHz.It has high multimedia support, Its support ultra HD resolution video recording and Ultra HD streaming on the display, camera with up to 55 Megapixel resolution In last year its use in some of the high-end, big screen smart phone such as Sony xperia Z1 and Z1 Ultra, LG G2 and not only in smartphone but Nokia use this chip in it's Lumia 2520 tablet.

2.2.2 MediaTek 6592

MediaTek is not well known processor in the U.S. or Europe country but it is a low cost low-power, quad-core processor. It's Fabricate based on ARM core and Based on ARM's Big Little technology, it will also be able to run all eight cores simultaneously. An advanced MediaTek scheduling algorithm also monitors temperature and power consumption to ensure optimum performance at all times.MT6592 also features the quad-core ARM Mali™ graphics engine with a Full HD display controller and 16-megapixel

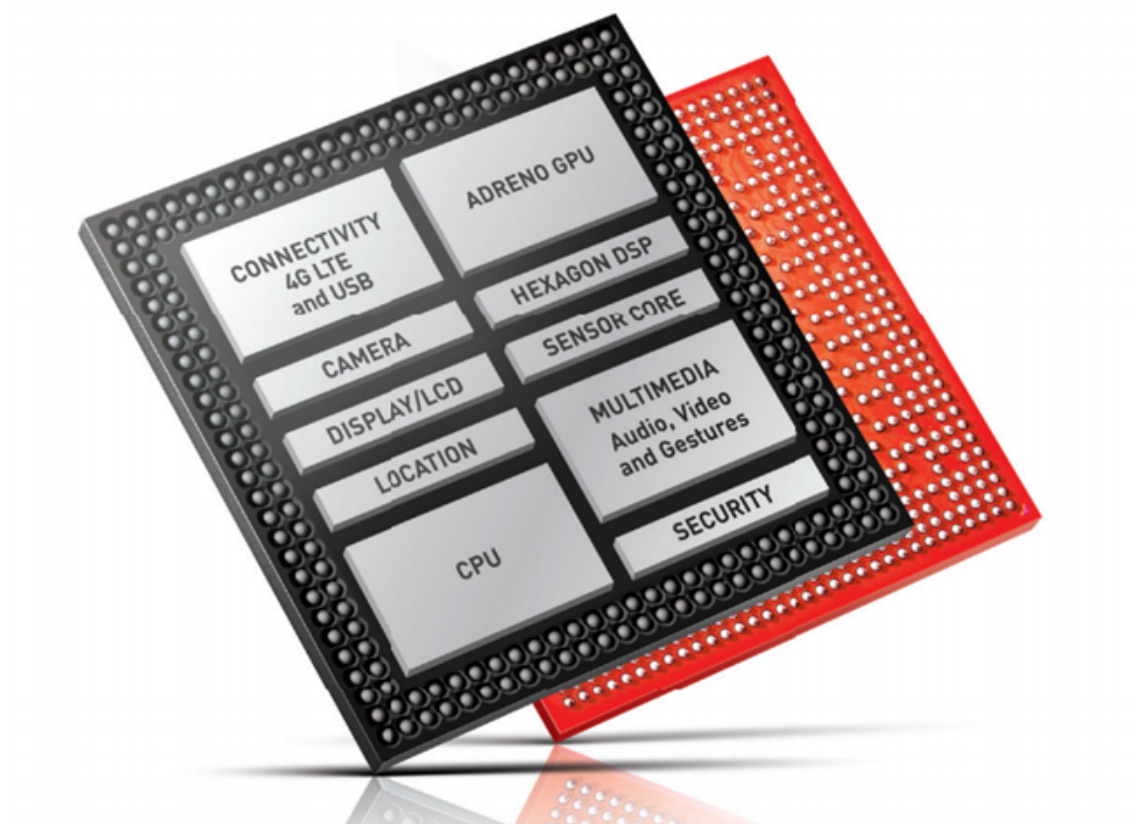


Figure 2.3: Snapdragon SoC

camera support. Comprehensive wireless connectivity includes an advanced multi-mode cellular modem and dual-band 801.11n Wifi.

2.2.3 Nvidia Tegra 4 And Tegra 4i

Nvidia's processors are well known in industry for its speed and for GPU. Nvidia Tegra series is also highly recommended in high end multimedia application. Nvidia Tegra 4 design from modifies the super advanced ARM Cortex A15 cores to produce speed up to 1.9GHz. The Nvidia Tegra 3, the Nvidia Tegra 4 has a companion core to take care of the easier tasks, that results in less energy consumption and longer battery life. It's capable of Ultra HD (4K) video streaming by the HDMI port, 4GB of RAM, and support screen resolution up to 3200 x 2000 pixels. The Nvidia Tegra 4i, is based on the ARM Cortex A9 core, it has some impressive specifications such as 2GB of RAM, 1080p resolution and can operate at maximum clock rate up to 2.3GHz. It also has Nvidia's new i500 4G LTE modem built-in, which is

very slim and more power efficient. Naturally, Nvidia's own Android-based Shield portable gaming machine also uses a the Nvidia Tegra 4.

2.2.4 Samsung Exynos 5 Octa

Most of the Samsung smart phone use Samsung's own Exynos SoC series. The Samsung's Exynos 4 Quad is a SoC using in many of the Samsung's high-end phones and tablets, such as the Galaxy S3 and the Galaxy Note 8.0. The Samsung Exynos 5 is octa core processor. While it's called an eight-core chip, the Samsung's Exynos 5 is effectively two quad-core chips nailed together using the ARM's Big Little concept. When demand on the processor is low, everything is handled by the "Small" 1.2GHz quad-core chip, but when high processing power needed a "Big" 1.8GHz quad-core chip based on the same ARM Cortex A15 architecture as the Nvidia Tegra 4 is start operation. The benefits of this Big-little concept is lower energy consumption when the system is performing basic or low performance tasks. At first, the Samsung Exynos 5 Octa could only use four cores at a time, but an updated version uses a new technique to enable all eight to work together. Samsung Exynos 5 Octa seen in: The i9500 Samsung Galaxy S4, and the N9500 Galaxy Note 3.

2.3 Benchmark Testing

Benchmark testing is act of running computer program, a set of programs, or other operations, in order to assess the relative performance of a Processor, normally by running a number of standard tests and trials against it.[1]. In Benchmark Testing a set of Program execute on Processor to test the Performance power of it. It is one of the very important stage at time of selection of processor.

Benchmark testing can be divide in to mainly 3 part based on the it's Part/application

- CPU Benchmarking
- GPU Benchmarking
- Memory Benchmarking

According to my/company application, I only required to check the power performance of CPU and GPU. After selecting the few SoC from the specs,

the next stage is Benchmark testing of each SoC/plateform. I perform benchmark testing on Eragon 820, Inforce 820,zSpace 300, Open Q835 etc. Fig (2.4) and Fig (2.5) show the result of Benchmark testing on different SoC.

	Lenovo Thinkpad W520	Inforce SBC 820	iWave 820 SBC	Open-Q 835	zSpace 300
<i>x cubes</i>	<i>FPS</i>	<i>FPS</i>	<i>FPS</i>	<i>FPS</i>	<i>FPS</i>
1001	60	49	49	60	120
2001	50	27.5	28	37	65
3001	33	19	19	26	42
4001	25	15	14	20	31
5001	20	11	11	16	25
6001	17	10	9	14	21
7001	15	8	8	12	18
8001	13	7	6	10	15
9001	12	7	5	10	14
10001	11	6	5	9	13
11001	10	5	4	8	12
12001	9	5	4	8	11
13001	8	5	4	7	10
14001	8	4	3	7	9
15001	7	4	3	6	9
16001	7	4	3	6	8
17001	6	4	3	6	7
18001	6	3	3	5	
19001	6	3	3	5	
20001	6	3	3	5	

Figure 2.4: Benchmark Report

2.4 Conclusion

From all market survey, comparison of the Parameter and with help of Benchmark testing result, we are come with some result, that Qualcomm snapdragon 820 SoC and 820 based SoM board is good enough to drive the High performance, battery operated Portable Embedded System. In next chapter, I describe the Feature and technical overview of That Sandragon 820 (APQ 8096 Soc).

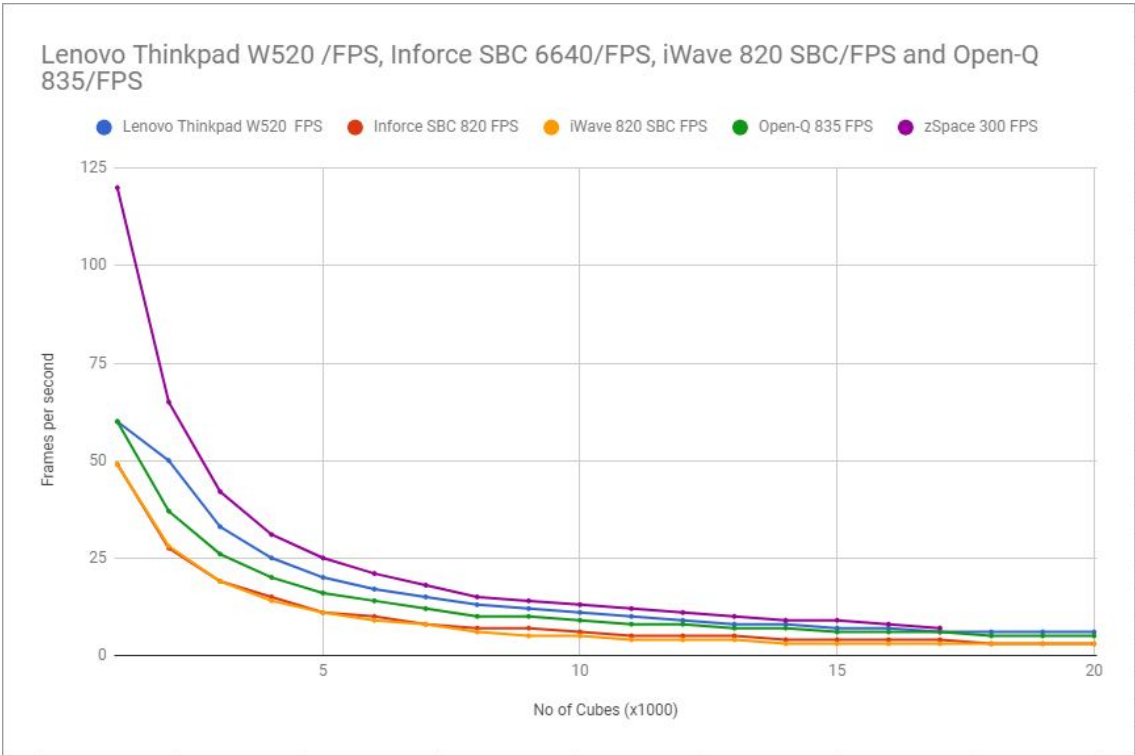


Figure 2.5: Benchmark Chart

Chapter 3

Qualcomm Snapdragon 820

Embedded computing devices have been continuously evolving since decades and so far been successful in performing complex functions without doubt. They support more functionality while increasing performance and reducing the board space and cost. All these demands are met by APQ 8096 (ERAGON 820).

ERAGON 820

APQ 8096 includes a customized 64-bit ARMv8 complaint quad core application processor(Qualcomm Kryo).The APQ 8096 has a high level of integration that reduces the bill of material, which delivers board area savings.All specification of this SOM is explained below.

PROCESSOR

Application Processor	64 bit ARMv8, quad-core application processor,Two High performance Kryo core (2.15GHz),Two low Power Kryo core(1.592GHz)
Digital signal Processing	Hexagon DSP with dual Hexagon vector Processor (825MHz)
RPM System	Cortex M3 (Manage: warm boot, bring up secure root of trust, APQ Power management, Coordinate shutdown/wakeup , clock rate)
Sensor Core	Dedicated low power snapdragon sensor core with DSP

Table 3.1: Processor Available in SOM

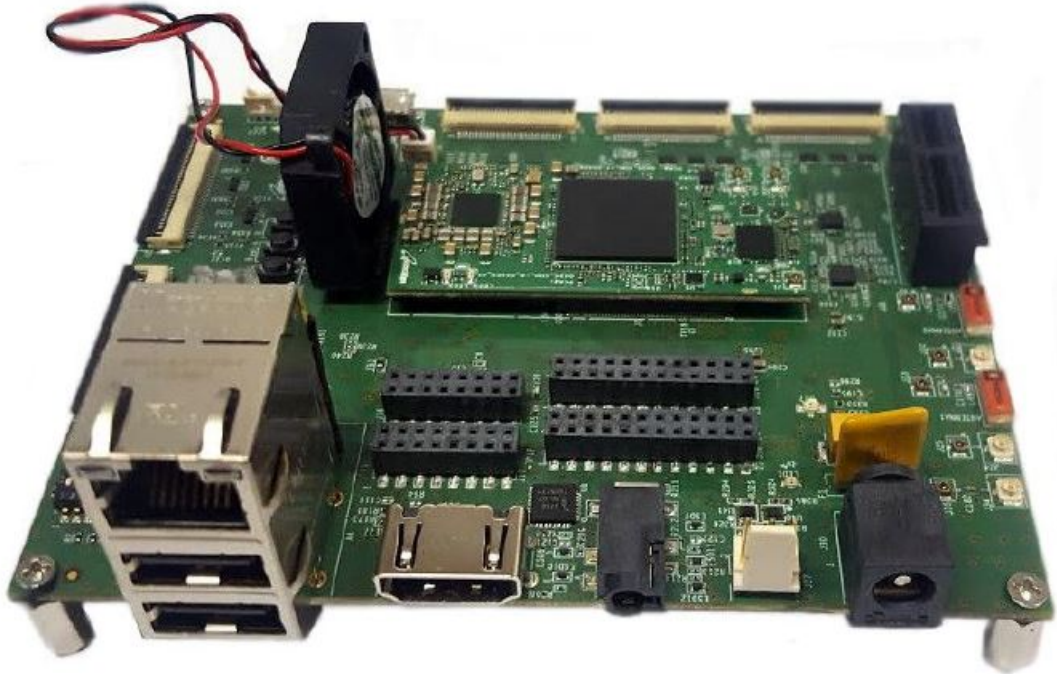


Figure 3.1: Eragon SoM

MEMORY SUPPORT

System memory	Dual channel PoP Memory - LPDDR4 SDRAM (1866MHz)
Other Internal memory	64GB UFS2.0 Flash 1 lane Gear 3 16GB eMMC 5.1 (Optional)

Table 3.2: Memory Available in SOM

Memory Interface	MicroSD card connector Push-push type connector (Max 32GB Supported)
WiFi / BlueTooth	Carrier board contain two Qualcomm RF chip QCA6174A-1 (Antenna chip) Provide two different wireless connectivity Also provision of integrating external antenna
Camera Interface	MIPI CSI interface Three(3) 4-lanes MIPI CSI
Display Interface	MIPI DSI Interface Two 4-lanes DSI Interface MIPI DSI As Primary Display supported upto 720p Both Display can work simultaneously
HDMI Interface	Carrier Board provide type A HDMI Output Connector. HDMI as Secondary Display supported upto 2160p
USB Interface	Three USB port: two USB2.0 and USB3.0, USB 2.0 as Host Mode, USB 3.0 as Device mode(Used For Programm the board using ADB Shell)
Ethernet Interface	Carrier board consist fifth generation Gigabit ethernet controller
GPS Interface	Externally GPS can be Interface using U.FL connector at J34 Note: GPS is validated with the GPS Antenna having the following specifications and vendor details: MFG Part: AP.17F.07.0064A MFG: Taoglas Limited Vendor: Digi key
JTAG Interface	20 pin JTAG connector Used for Programming and debugging purpose

Table 3.3: Peripheral Available in SoM

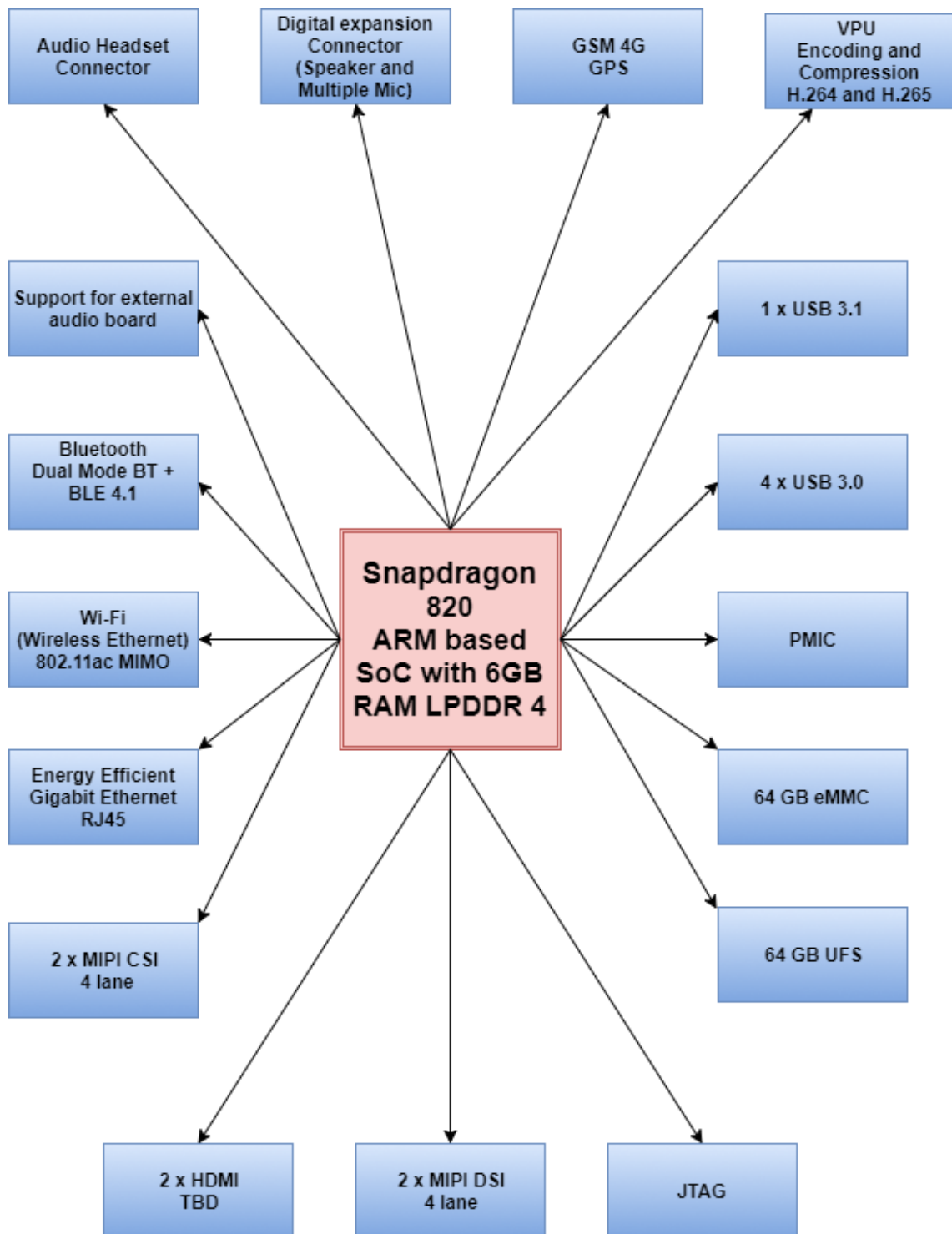


Figure 3.2: SOM Block Diagram

Chapter 4

2D Display

As i mentioned in chapter one, this whole project divide in two part, One is the find the available option of display for Embedded system and Interface that display with the application processor. Here in project Qualcomm snapdragon 820 based SoM I.e. Eragon 820 and another one part which is very important and prime part of this project is the Create 3D Stereoscopic view (3D VR) with help of this Qualcomm Soc. In this chapter, mainly discuss about Display protocol available in Eragon board, Market review for Display and Interface the display with Eragon.

4.1 Display Protocol on Eragon 820

As mentioned in chapter three, in eragon board, two display interface protocol are given,

1. MIPI Interface
2. HDMI Interface

MIPI INTERFACE

MIPI(Mobile Industry Peripheral Interface) protocol is sets or protocols use for the mobile industry for interfacing various components/ peripherals with mobile processor like For the display DSI (Display Serial Interface) is used, for Camera Interface (Camera Serial Interface) is used, and similar more like for smart battery interface,MIPI BIF etc. It's develop by MIPI Alliance Group. Qualcomm Snapdragon 820 Soc is use MIPI DSI and CSI protocol use for Display and Camera Interface.

ERAGON 820 provide two 4-lane MIPI (Mobile Industry Processor Interface) DSI port to connect the display. It's 40 pin interface. Display is connected to MIPI interface via Flexible flat cable(FFC). In MIPI DSI, Video data lanes is differential pair of 4 lane. Here no. of lane is for increase the transmission of Bit rate per second and differential pairs used for noise reduction in transmission. Eragon 820 has by default 4-lane for Video Data Line, So 8 signals for video data, 2 Signal pin for differential clock and other are for back light and for touch.

HDMI INTERFACE

ERAGON 820 provide HDMI output using standard type A connector for interfacing LCD panel which have HDMI connector. HDMI can support up to 3840 x 2160 resolution at 60fps. We can used non-touch LCD display with HDMI port. HDMI port has 19 pin. The pin out of HDMI is describe in Appendix A.

4.2 Market Survey

In market variety of LCD display interface technology available like, VGA Interface, RGB Interface, HDMI Interface, MIPI DSI interface, eDP Interface etc. Each display interface has their own merits and demerits. And mostly each Display interface protocol / video interface protocol has some application area.

Priority	Display Interface/Technology	Remark
1	eDP Display	Highly recommended in Embedded Application, Portable, High resolution(FHD), High Refresh rate
2	HDMI Display	Support High Resolution, High Refresh Rate, Used for TV and PC, not highly recommended in Embedded System
3	MIPI Display	Support FHD, Display come up to 7" inch size, Use in mobile industry

Table 4.1: Display Technology

All Display interface protocol develop for specific application and mainly used in that application only. VGA interface is used For TV or Personal computer, which is not movable in general, HDMI interface is used in so many application like TV, Personal computer, For mobile Industry (Specially for smart cellphone) MIPI Protocol is highly recommended. All most in all cell phone used MIPI Protocol for Interfacing Display, Camera, Wifi etc. Like MIPI DSI (Mobile Industry Peripheral Interface- Display serial Interface) is used for interfacing MIPI Display, similarly MIPI CSI (Camera Serial interface) is used for interfacing Camera sensor with application Processor. For an embedded display like, automotive display, industrial display, Gaming Display a special type of display is used called eDP (embedded display port), design and develop by VESA Organization.

4.2.1 *MIPI Display:*

In our ERAGON 820 board MIPI DSI interface is there, if we use 4 lane MIPI DSI Display then we can directly use display with eragon board without any convertor bridge. But the main limitation of MIPI display is the size of display. MIPI protocol is used or design for mobile industry as name suggest, so maximum size of available MIPI display is 7" inch. The main aim of this project is to design 2D Gaming Console and 3D Gaming Console. For that minimum 12" inch to 15" inch display required. So MIPI Display is not usable for such a product.

4.2.2 *HDMI Display:*

Eragon Provide HDMI interface, there are some advantage of HDMI interface, described below

- Global standard for connecting High definition equipment
- Higher resolution, like 1080p or 4K
- 3D support
- Faster refresh rate
- Transmit uncompressed audio - video data in full digital form

But as per our basic 2D Display requirements, we require touch support LCD display, while HDMI does not support touch.

4.2.3 eDP Display:

eDP Interface protocol design by VESA Organization. As name suggested, eDP (Embedded Display Port) is highly used Embedded Application accept from mobile phone. Such as Automobile Industry, Health care Industry etc. There are some benefits / Parameter Listed below

- Available in various size
- Portable
- Support High Resolution Like 720p or 1020p
- Support High refresh rate like 100Hz
- 30 pin and 40 pin interface available for Non-touch and Touch display

4.2.4 Conclusion:

From this analysis, We can say that, a LCD display with eDP electrical interface is the best solution for this project. In Eragon 820 board, MIPI and HDMI Interface available, As in this project we required capacities touch Supported 12" inch to 15" inch Display. So From Eragon side, MIPI DSI Interface is appropriate and For this application eDP Display required. So Here Video data conversion Required. The main task is to Design video Converter that convert MIPI video data to eDP Video data. A chapter 4.3 Discuss the Proposed system architecture and Design procedure of it and work carried out for this.

4.3 Video Conversion

As mentioned in previous chap 4.2, We want to drive touch eDP Display from Processor which have MIPI DSI Protocol (4 Lane DSI exists in current system). So for that we required ASIC (Proprietary Chip) which can convert MIPI DSI data signal and voltage to eDP signal. Below Fig(4.1) show the overview of the proposed architecture of Video Conversion.

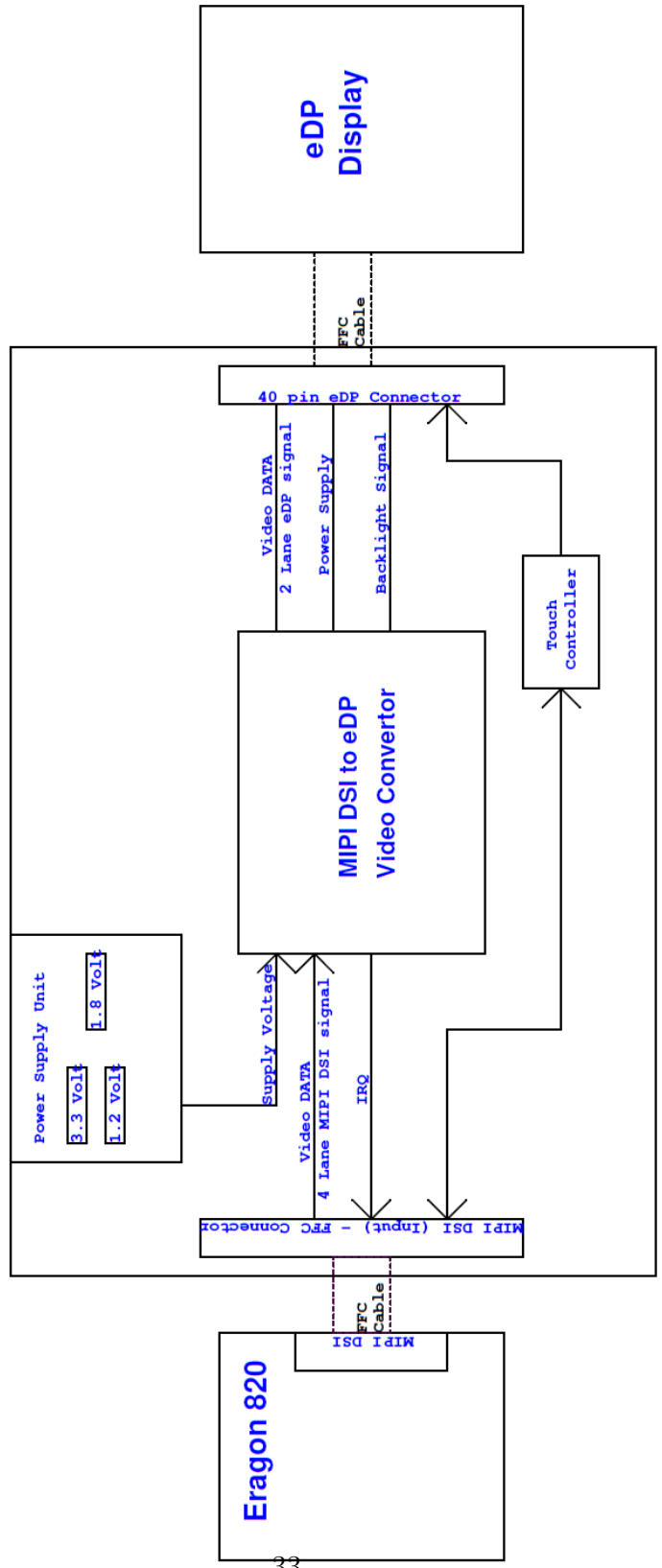


Figure 4.1: eDP Video Converter

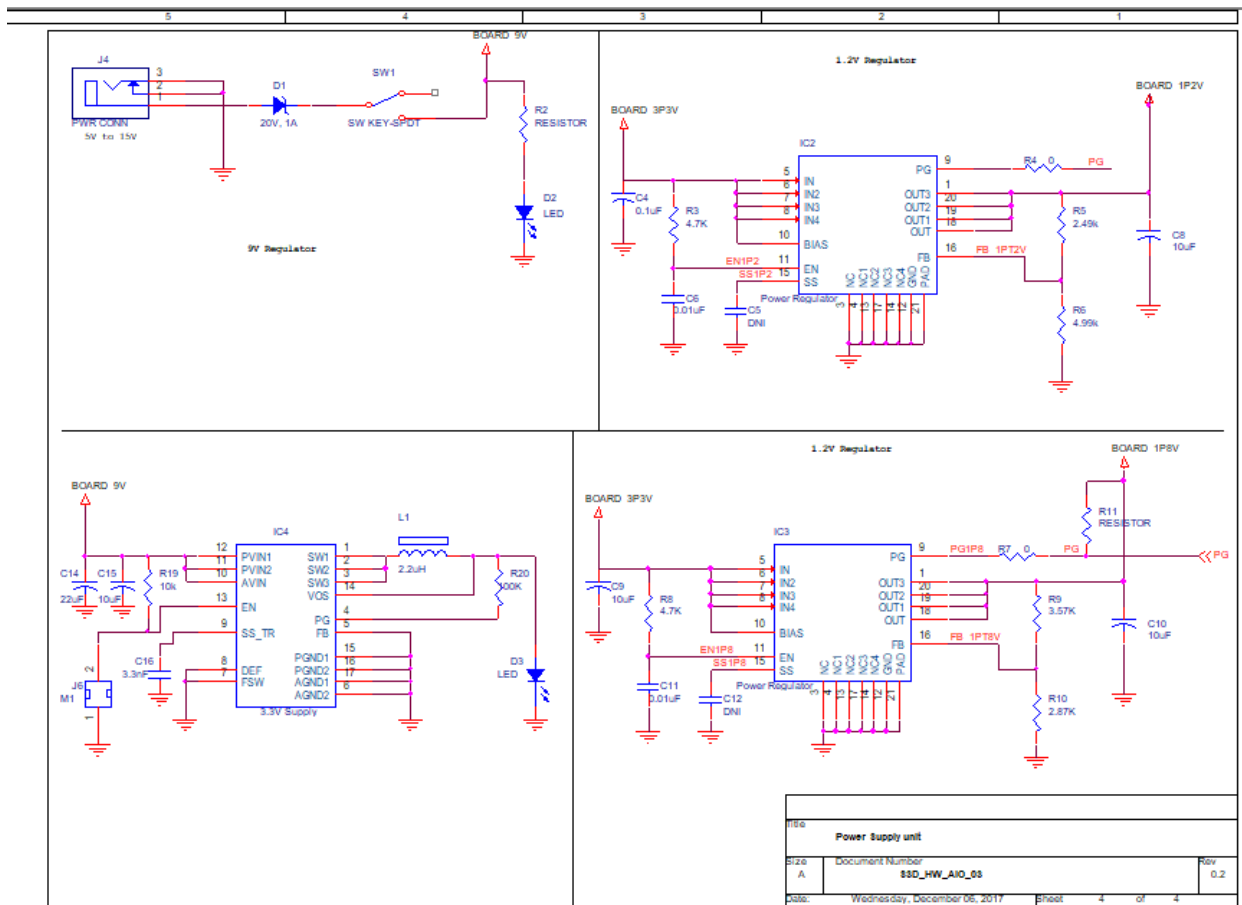


Figure 4.3: Schematic: Power Supply

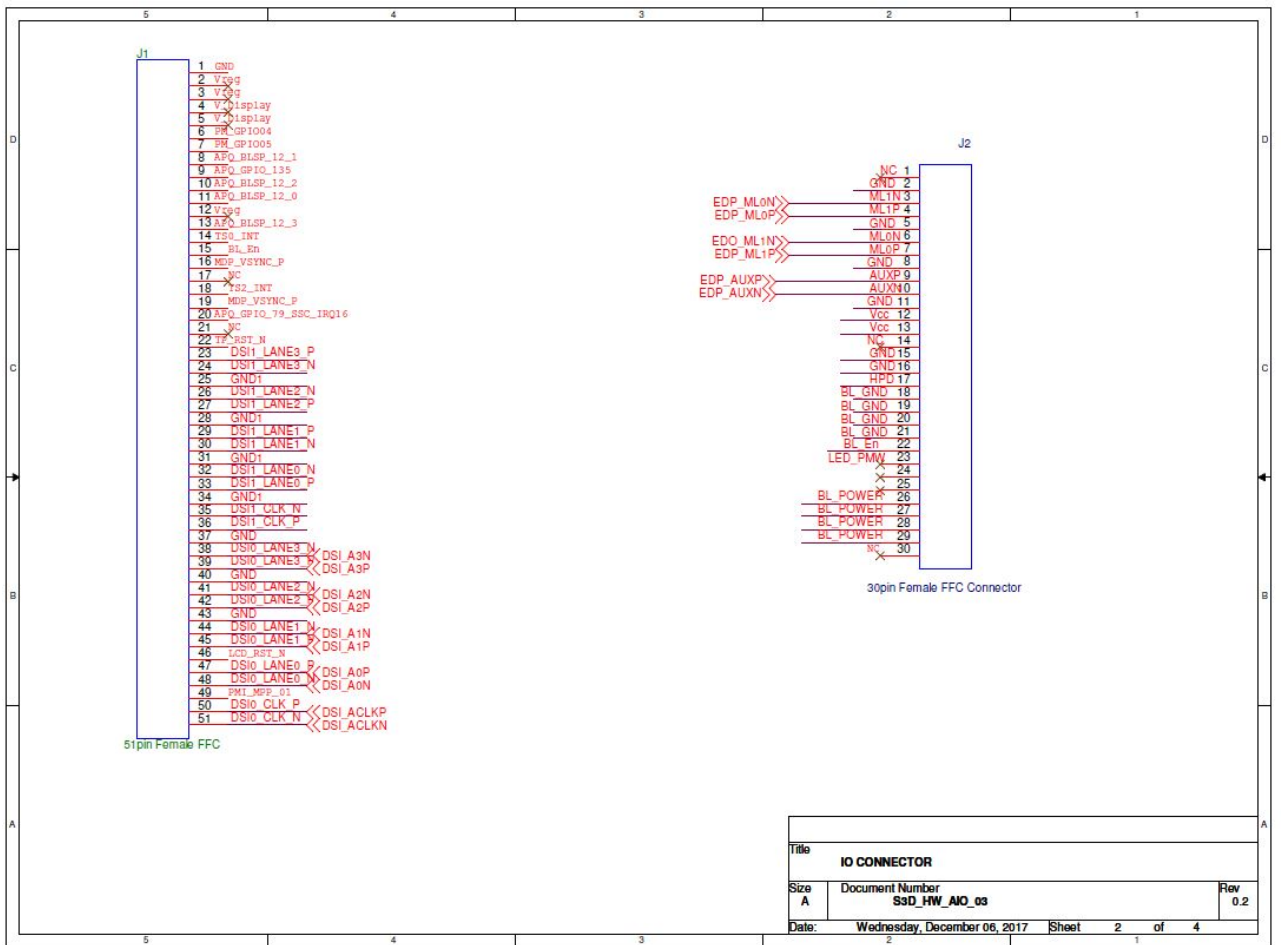


Figure 4.4: Schematic: IO

Chapter 5

3D Vision

5.1 Introduction

From last few year display technology evolving very fast. In 19's initially People was using CRT (Cathode ray tube) display to see the pictures and Video with standard VGA resolution. After that in 2000 CRT display is absolute and people are welcoming the LCD technology and LED Technology which is new in to market. People can see the normal 2D video at high high resolution. After That 2.5D (not pure 3D) was evaluate and nowadays Pure 3D visualization can be done on LCD display. With the large influx of new displays into market boasting '3D support'.

5.2 What is 3D Display?

[5]A modern 3D monitors or displays are capable of conveying a stereoscopic perception of 3D depth of the object to the viewer. This display has capacity to display to actual depth of normal 2D object. To visualize 3D view of any object, display should deliver actual depth of that object. From normal LCD screen, we can see only a top view of the object, we can't visualize the actual depth of it. The modern 3D display / technology are able to conveying stereoscopic perception of 3D depth to the user. The get the actual depth of 2D object, the basic requirements are create an two separate offset image of same object for separate left and right eyes and both image should pass in alternative form with very high frequency.

Before understand how 3D display work, i describe how mind can realized 3D

view or actual depth of any object. Our eyes are spaced apart at a certain distance (average 6.5 cm) so both left eye and right eye perceive two separate images of single object. Our brain combine these image and get depth of that object, this brain function called binocular function. To realized 3D view of an object by LCD display we have to do follow steps: Generate two different offset image pairs for left eye and right eye using install two cameras at certain distance and create an two separate image or creating an 3D image pair using different software, and then present left eye image at left eye and right eye image at right eye at very high frequency. The whole process of 3D visualization can be divided into mainly 3 stages. All these stage described below.

What is 3D TV?

A 3D TV is a new concept television that gives depth to the existing 2D image so that viewers can experience realistic and lifelike three-dimensional effects.

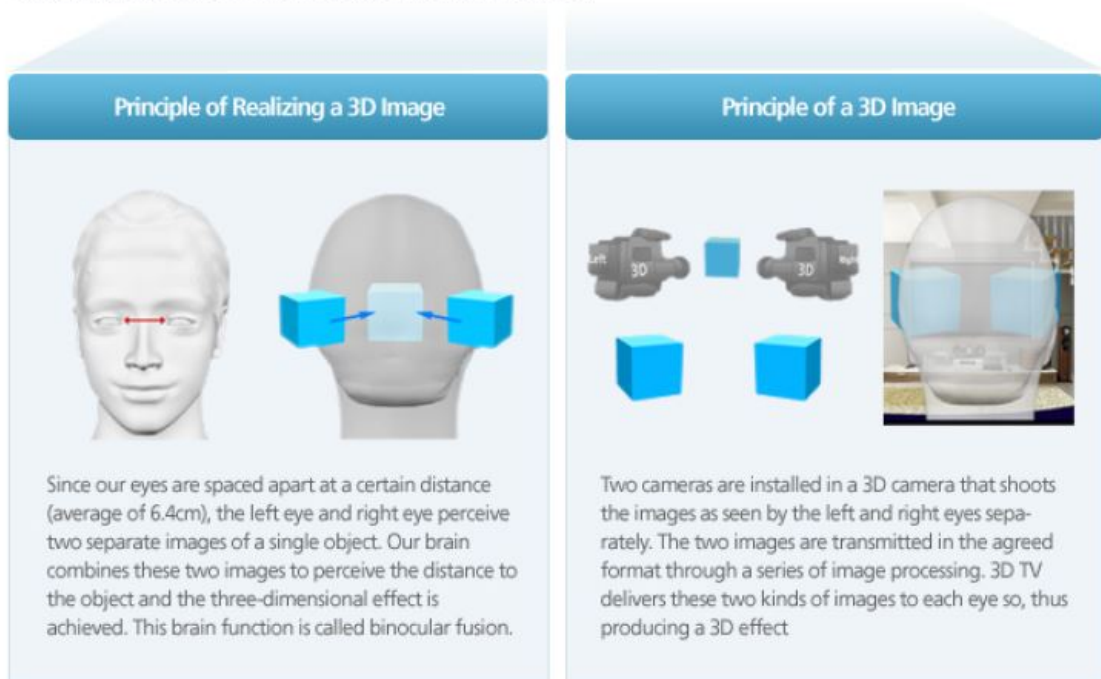


Figure 5.1: What is 3D TV

5.3 Stage Of 3D Presentation

There are mainly 3 stages of 3D visualizations named below:

- Source
- Preparation and Transmission
- Presentation



Figure 5.2: 3D Stages

Source

This stage is also called creation stage because in this section, create the actual 3D content either by the special 3D camera or create the image pair (separate image for left eye and right eye) using different software (like Blender and Unity) on a computer.

Preparation and Transmission:

After creating image pairs, we have to prepare in some format and transmit image pairs in such a manner so that viewer can see the left eye image in left eye only and right eye image in right eye only, and it should be done in alternative form, at very high frequency. Here Preparation and Presentation work together to realize 3D view of object. There are various technology used by market to realize 3D view of object, it will describe in below.

Presentation:

In this stage, We Present the 3D video / image pairs sequence in various display and maintain operation of Display and Glasses, as shown above Figure(3.2). Main purpose of this stage either shuttering of lens of glass or shuttering of display so views can realize the 3D view. We can use different display interface for viewing such 3D content, such as,

- HDMI standard 1.4a
- DP standard 1.2 / eDP

5.4 Basic Terminology

Few methods and terms are related with 3D console, like Side-By-Side 3D, Frame Sequential 3D, Active display, Passive display, Active Glasses, Passive

glass

Side-by-Side 3D: In side-by-side 3D, left eye and right eye image frame are scaled down horizontally and fit both respective left eye and right eye frame in same display at a time as shown in Fig (5.3).

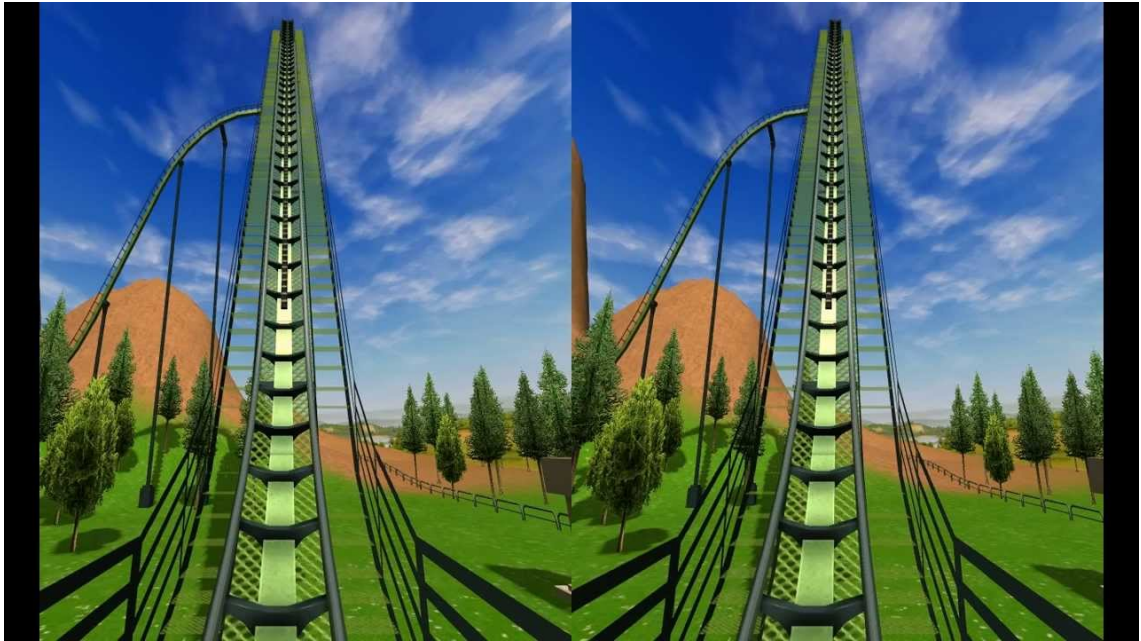


Figure 5.3: Side By Side 3D

Here in side-by-side 3D, Horizontal resolution of all image frame is scaled down like, 720p (1280x720) become 640x720.

Frame sequential: In frame sequential 3D, A stacked image pair display in sequential way as name suggest. A left image frame and right image frame comes in alternative way at high frequency. Below Image shows both method. (Fig 5.4).

Active display & Glass:To get 3D visualization shuttering of either display or glass is essential. When Shuttering is happens at side of display, then such display called active display and when shutting phenomenon happens

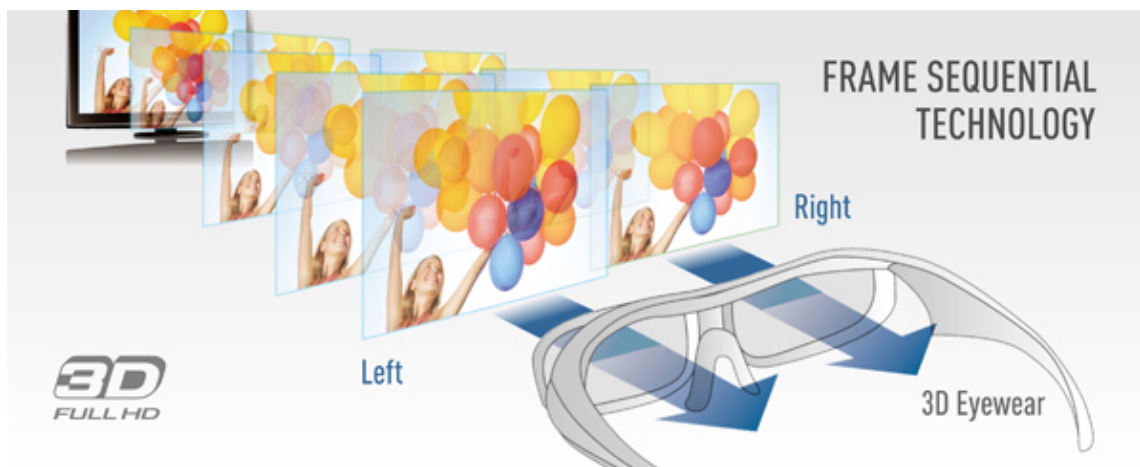


Figure 5.4: Frame Sequential 3D

at glass side then such glass called active glass.

5.5 Glasses Type

In 3D visualization, mainly two types of glasses are highly used in market,

- Polarized glasses (Passive Glasses)
- Active Shutter Glasses

Active Shutter Glass

The main aim of this glasses is to shutter ON/OFF the eye vision at very high rate (like 100Hz) with the synchronization of the Display so that when display sends the right eye signal, the left Lens of glass should black (Shutter OFF) and when Display sends the left eye signal, the right lens of glass should Black (Shutter OFF) and Left lens should open.

Note: The special glasses used (which is active glass, able to Shutter at high frequency) made up by Poly carbonate substrate, and manufacturing process is same as conventional LCD development process. Poly carbonate is one of the Thermoplastic (special type of polymer which is moldable above a specific temperature and solidifies upon cooling).

For the Synchronization with display, Special kind of signal should be sends

from the Display side and it's should be decode by the glass for the proper synchronization. For sync. signal Transmission mainly two protocol is highly used by market.

1. IR
2. Bluetooth

5.5.1 3D Sync. IR Protocol

In 3D market, There are few IR Transmission protocols are already design by few companies which is only can decode by their IR Glasses only. The whole set of IR 3D Sync. Signal can be classify based on no. of token used in transmission [8]. Here token is defined as a single pulse or group of pulses which define an action for the glasses to perform, e.g. 'open the left eye', or 'close the left eye'. Mainly 3 types of IR 3D Sync. Protocol used in industry.

- Single token Sync.
- Two token Sync.
- Four Token Sync.

As an example, here in Fig(5.5) show the Four token IR 3D Sync. Protocol, that means different four type of pulse / pulse train are used to determine the stage of operation. As mentioned earlier to get 3D visualization shuttering of right lens and left lens should be shuttered at proper manner. To get noise-less proper 3D visualization, duty cycle of shuttering phenomenon don't kept as 50% , like a 50% left lens open and another 50% Right lens open. if we kept as this way then we got very noisy 3D. To get as better as 3D, we have to maintain shuttering timing. We did experiment at company lab and set timing in such a way so we get very less noise. (**Timing details are confidential.**). Here in Fig(5.5) explain, we required 4 different types of signal for shuttering phenomenon. When glass get 1st signal ("Close Right Eye"), right lens will be OFF, and similar for all other 3.

Note: Here, token is not timing signal, this token is used by 3D Active shutter glasses, the controller of the glasses will interpret the token signal and take the decision of shuttering of the glasses

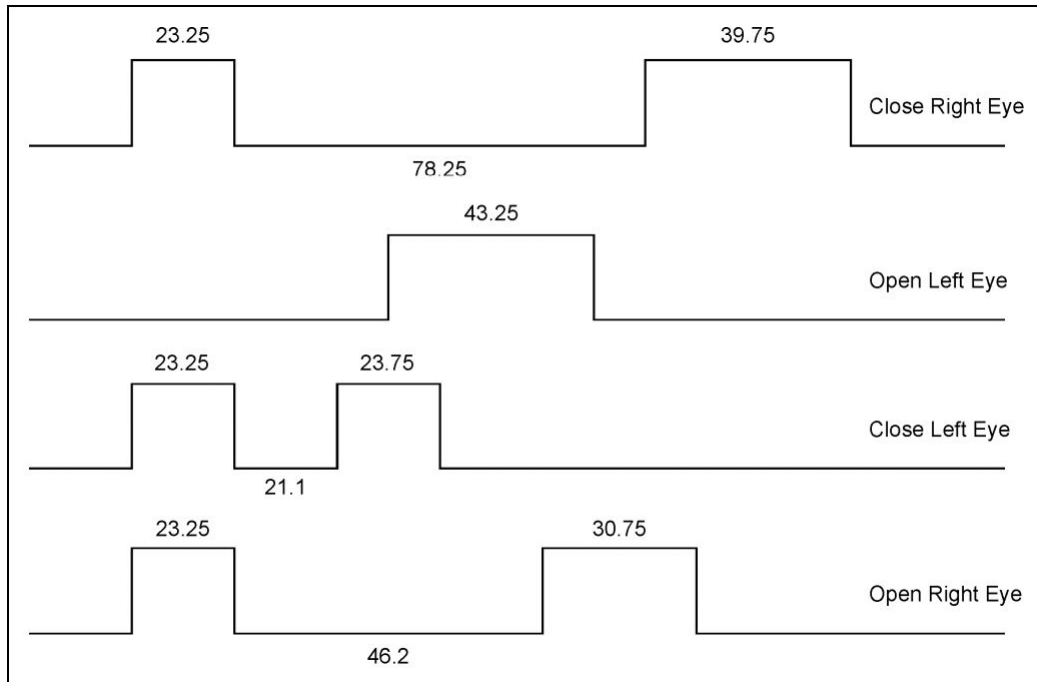


Figure 5.5: 4 Token IR 3D Sync. Protocol

5.5.2 3D Sync. Bluetooth Protocol

[9] Bluetooth SIG Group had design a new Bluetooth profile stack to control the Active shutter glass, called "Bluetooth 3D Synchronization profile". Here i give brief information of the operation of this profile.

BT 3D Synchronization Profile operates as follows:

1. 3DG select the 3DD using Proximity Association(Strongest Signal)
2. When Association / Pairing done, 3DG sends the information of pairing and battery status to 3DD via "3DG Connection Announcement" profile Operation
3. When Association / Pairing done, 3DG sends the information of pairing and battery status to 3DD via "3DG Connection Announcement" profile Operation
4. In 3DD Broadcast, mainly 3 types of signals. Frame Sync. Timing, Frame Periods and Lens shutter timing control 3DG receive the timing information from 3DD and manage the shuttering mechanism

5. If 3DG loses reception of 3D broadcast, 3DG continues synchronized lens shutter operation while lens shutter control timing error is in acceptable range, once timing error exceeds the threshold, 3D glass opens the both lens

Profile Operation

1. Frame Sync. Capture

The 3DD Frame Sync. Signal provide timing information about the displayed image Below Image show the implementation of frame sync signal. Rising edge of frame sync occurs at start of the left image display and falling edge of frame sync occurs at the start of the right image display. When the rising edge of Frame Sync occurs, the 3DD captures and stores the current value of its native Bluetooth clock (CLK[27:0]) and also the microsecond phase. The capturing of native bt clock value may be performed by Hardware (HW), interrupt driven firmware (FW) or combination of both. (The Bluetooth Controller will convert the external Frame Sync to its native Bluetooth clock and provide this information to the Bluetooth Host).

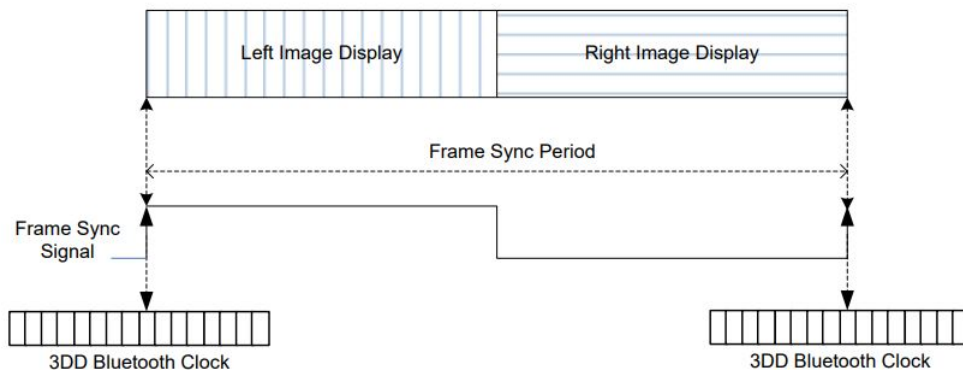


Figure 5.6: Bluetooth Native Clock

2. Proximity Association

Proximity Association is procedure by which 3DG discovers a nearby 3DD. Two type of data is used in proximity association, **Class of Device** and **EIR Data Type**.

Class Of Device: It's provide by 3DD in the response of Inquiry which generated by 3DG. (3DG shall not filter on class of device as part of proximity association)

EIR Data Types: 3DD send the three EIR data types as response of inquiry.

- 3D Information : providing 3D Synchronization Profile specific information (4 Byte of data)
- Legacy 3D Information : it's Manufacturer Specific Data type in EIR (This is necessary for backward compatibility)
- TX power level: 3DD shall include a TX Power Level data type in EIR data

Proximity Association Procedure:

- User interaction (Pressing the button or motion or touch sensors) triggers the proximity association on 3DG
- 3DG performs general inquiry (duration of 5.12 sec. but not more than 10min.)
- In Inquiry, 3GG will create a list of all nearby bluetooth device which satisfy some criteria and obtain the EIR receive power for each device
- correctly formatted EIR packet is received from 3DD that include 3D information data and TX power level (and Reference Protocol 3D information in case of Legacy 3DD)
- calculated path loss for the EIR packet of the responder (Path Loss = TX Power – RX EIR Power) is less than or equal to the Path Loss Threshold specified in the responder's EIR data
- Based on lowest path loss, 3DG will select the device (3DD)

3DG Connection Announcement:

The 3DG Connection Announcement is a message sent by the 3DG to a 3DD containing information about Association Notification and Battery Level Reporting.

Association Notification Transmission and Reception:

This operation is use by 3DG to notify the 3DD that 3DG will synchronize to the 3DD (3D Broadcast). 3DG deliver the information a part of 3DG connection Announcement and message sent over 3D Communication Channel.

Legacy Association Notification Transmission:

This operation is use By 3DG to notify the Legacy 3DD that 3DG will synchronize to 3DD's 3D Broadcast. (this operation is used when Legacy 3DD proximity association done).

Reference Protocol Association Notification Reception:

This operation is used by the 3DD to receive the Notification message that is sent by a Legacy 3DG to notify a Legacy 3DD (or in this case a 3DD) that it has successfully completed Proximity Association with it and will synchronize to its 3D Broadcast.

Battery Level Reporting:

This operation is used by 3DG to to deliver its current battery level to 3DD.

3D broadcast Message:

The 3DD transmit set of parameter that define Frame Sync. timing, Frame Rate, Lens shutter control timing signal to 3DG via 3D Broadcast Message. Total 19 Bytes (136 bit) information are sends in 3D Broadcast message.

5.6 Comparison of Sync. Protocol

As i says, in 3D market mainly two transmission protocol use in market for the 3D Sync. signal transmission. Both protocols have their own pros and cons.

IR 3D SYNC.:

Advantage

- IR Sync. protocol is easy as compare to Bluetooth 3D Sync., Easy to design hardware
- easy certification process
- To drive IT Active glass, just IR Emmiter with driver circuit is require, not any controller required for that
- Transmitter Design cost is low compare to BT based product

Disadvantage

- cross talk may possible

BLUETOOTH 3D SYNC..:

Advantage

- Standard protocol for controlling active shutter glass (used by many industry)
- No chance of cross talk

Disadvantage

- High complexity in designing
- Needed FCC and CE certification for product launching
- Bluetooth based controlling mechanism will more costly and complex design
- Bluetooth based active shutter glass control mechanism contain Bluetooth based SoC, at the end design will more complex

After the comparison of all parameter, in this thesis i will **go with IR 3D Sync. protocol** for the controlling the active shutter glass.

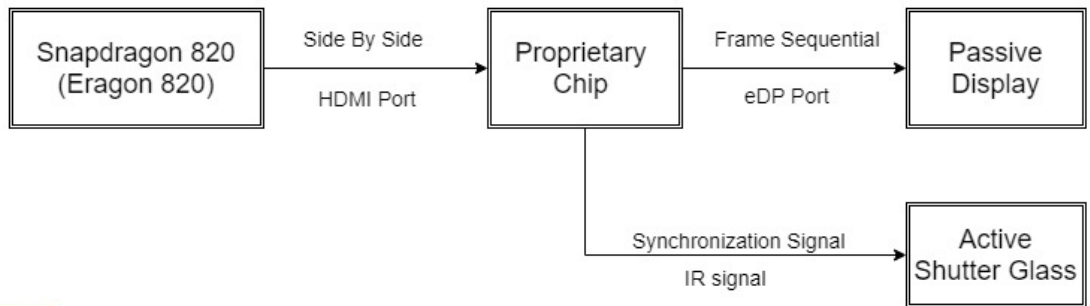
5.7 Option for 3D System

The Process of Preparation & presentation can be divided into two stage. One is Communication between Application processor(i.e. Eragon 820) and Proprietary chip and another one stage is Operate the Display and glasses using designed board(with help of Proprietary chip).

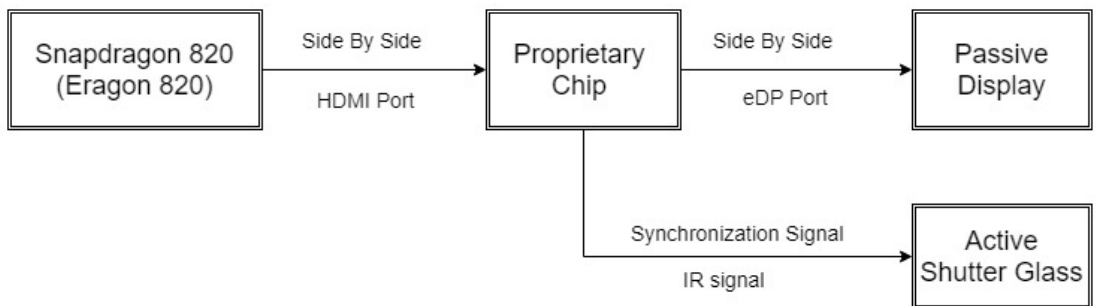
In snapdragon 820 based SBC, there are mainly two display interface , MIPI DSI and HDMI. We will mostly use HDMI port for sending the Video data to our design "3D Vision Board".

There are various option for Drive 3D display and Glasses using that chip. All possible option described below.

Option 1



Option 2



Option 3

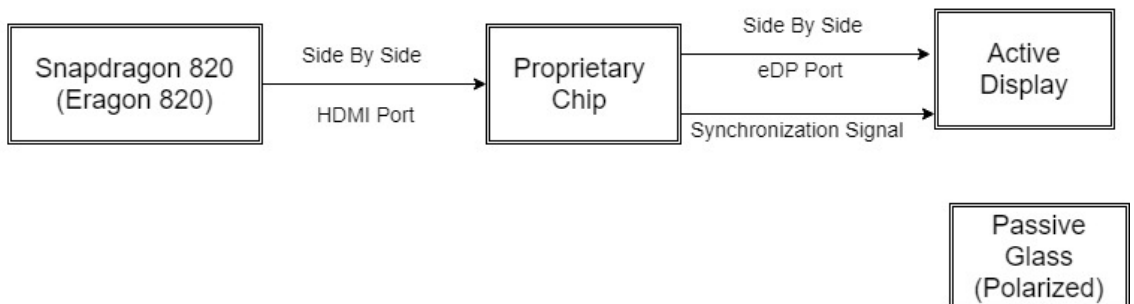


Figure 5.7: Option for 3D

5.8 3D Vision Board Design

Main aim of this project is to design Tablet/laptop kind of console system which can deliver the 3D content effectively. We can design such a system using any one option (Describe in Fig 5.7). In this thesis i am going with **Option 1**. To design such a battery operated system, i have to design proper Power tree with the Power management scheme. For Power Management scheme explain in Fig(5.10) and Power tree of board is explain in Fig(5.9). Here below Fig(5.8) shows the Block diagram of the 3D Vision board.

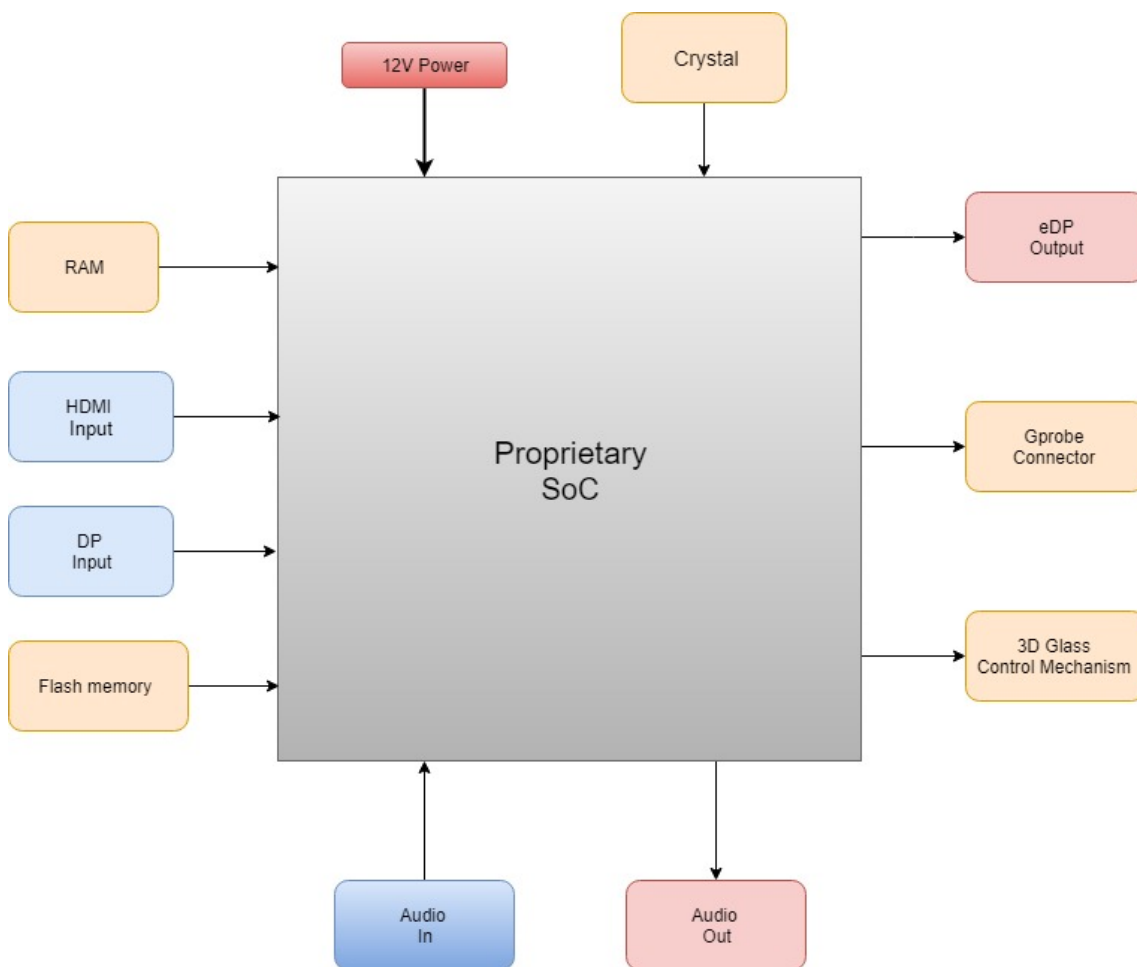


Figure 5.8: 3D Vision Board Block Diagram

According to Design Option 1, the Board will get Video input from HDMI, in side by side format and Process on it convert in Frame sequential 3D, and

3D FS. content display on eDP display using eDP port and IR based active shutter glass will manage the shuttering from on board 3D glass control mechanism.

Power Tree

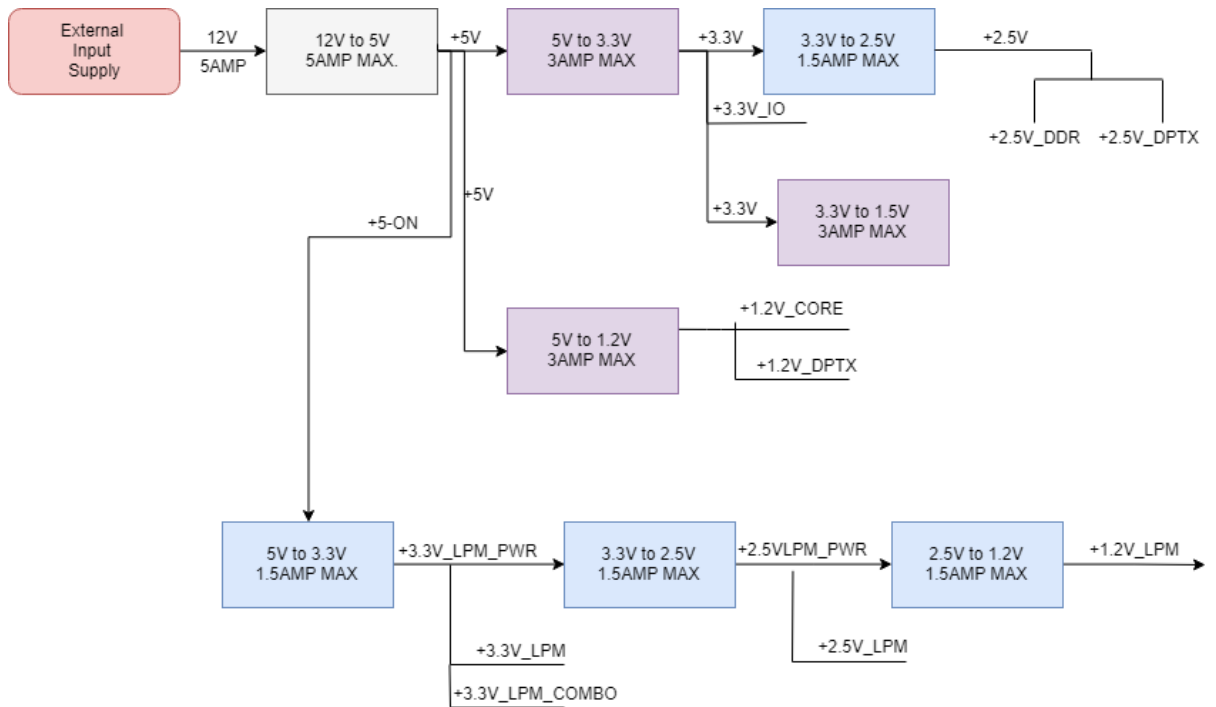


Figure 5.9: Power Tree

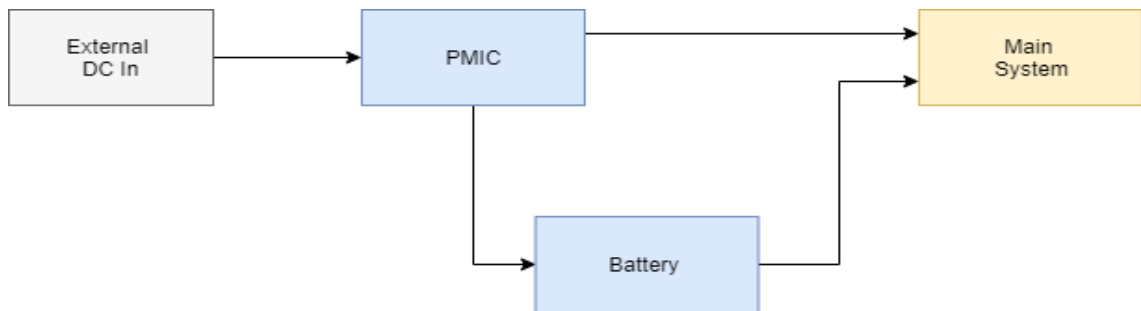


Figure 5.10: Power Management

HDMI Input:

HDMI (High definition multimedia interface) is standard protocol designed and develop by HDMI Org. which is use to interface HDMI display with the Application processor which have HDMI Out on chip. HDMI 1.4 protocol describe below.

HDMI 1.4 support maximum 1.4 Gbps bandwidth using three Differential video lines. HDMI 1.4 support several stereoscopic 3D formats such as field alternative, frame packing (Top to bottom 3D), line alternative full, side-by-side half, side-by-side full. HDMI 1.4 requires that 3D displays implement the frame packing 3D format at either 720p50 and 1080p24 or 720p60 and 1080p24

For core video data transmission, HDMI protocol used three differential Video lanes named Transition minimized differential Signaling And one differential clock lane. HDMI_PWR line is +5V for the SoC comes from HDMI Source. HDMI_HPD is used for the detection of HDMI Display. HDMI_DDC is Display data channel which used I2C protocol and gives the information of EDID. HDMI_CEC is an HDMI feature designed to allow user to command and control the CEC enable device (Up to 15 device)

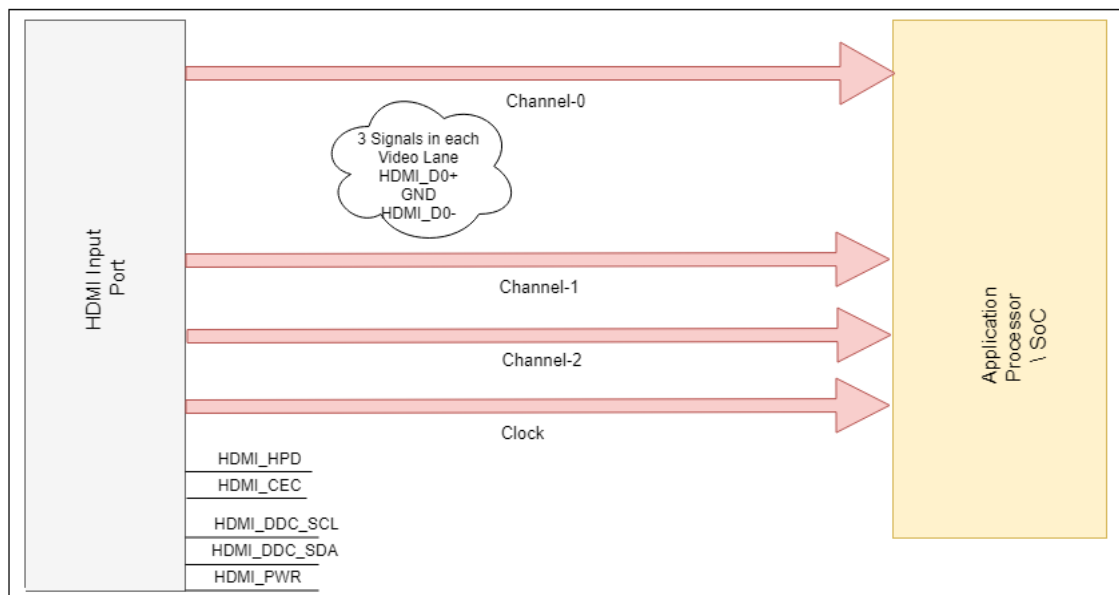


Figure 5.11: HDMI Input

eDP In Out:

eDP (Embedded Display port) is a standard DP protocol develop by VESA for the Digital video transmission, and highly used in Laptop, notebook, tablet, medical display or industrial display where display should be integrated with hardware. (Highly used in portable device).

DP protocol used Differential line for video transmission. Single eDP support up to 4 lanes. We can use 1lane or 2 lanes or 4 lanes according to our requirements. (Based on bandwidth requirements). It is based on resolution (i.e. 720p or 1080p) and display refresh rate (i.e. 50Hz or 60Hz or 100Hz). Differential Aux. lane is use for reference clock and handshaking.

eDP_HPD is use for display detection. And in eDP input, PWR pin gives power to SoC from the eDP source. At eDP output side, eDP display will interface, which required Back light power and Ground as well BL_PWM to manage the brightness of display and BL_En for the enable the Display.

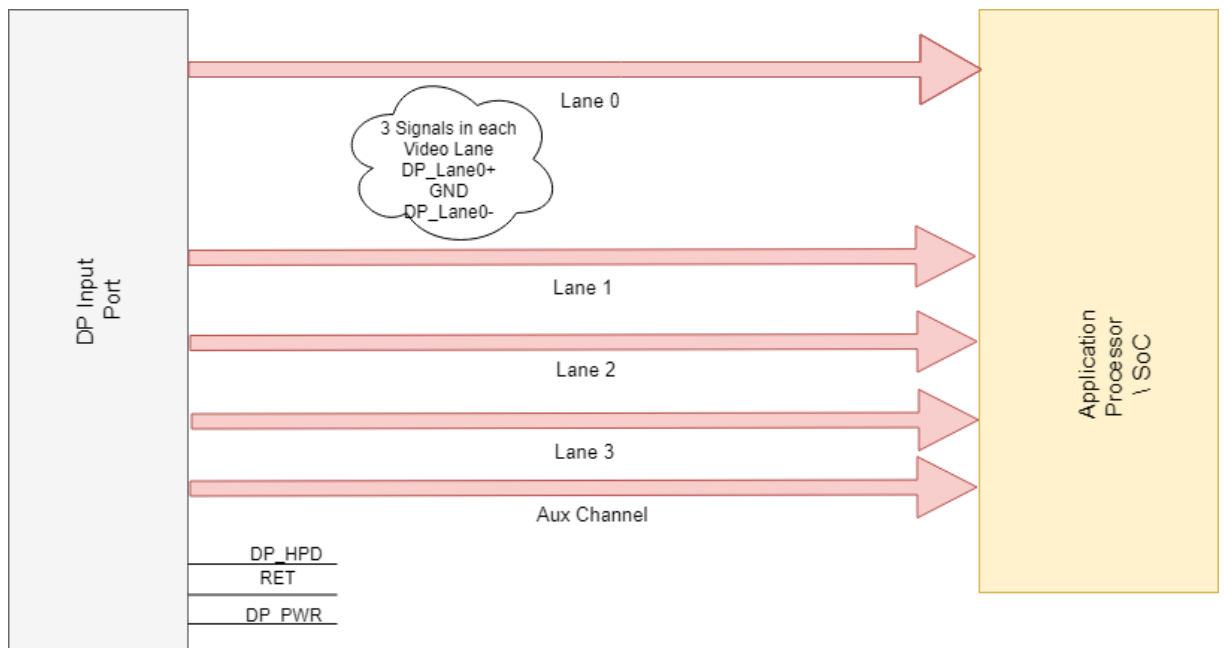


Figure 5.12: DP Input

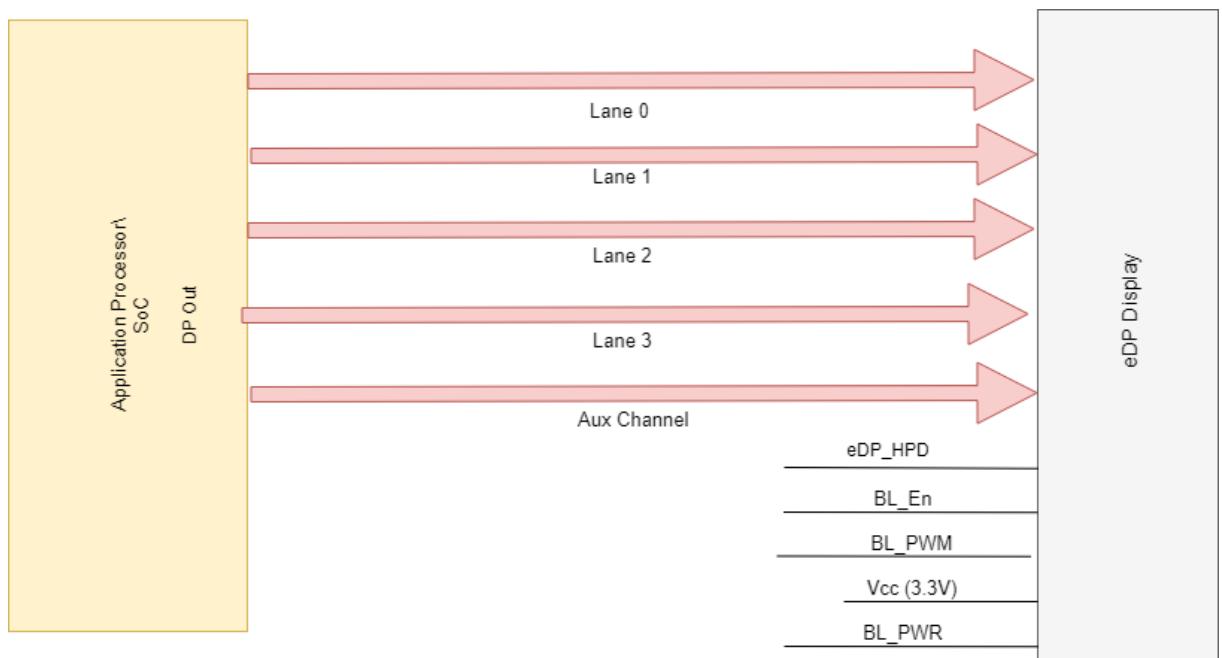


Figure 5.13: DP Output

Chapter 6

Conclusion

In this Project, main Aim is to design 3D Stereoscopic system or Tablet/ laptop kind of Battery operated system which can deliver 3D content/ output effectively. From chap 5,in my company i understood different electrical protocols, and about 3D stereoscopic. And i design a system which is deliver 3D content with very less timing noise and with very good quality.

Chapter 7

Future Scope

3D VR and AR is the latest technology and future of the technology. After creating 3D Content, we should have some kind of power full 3D console using any of way describe option in chap-5. This 3D system can use in so many field. The gaming industry is very big market where we can use 3D AR. As well in automobile sector, medical imagine and in educational Industry we can use concept of this project. 3D vision makes visual system more effective and attractive.

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.1 HDMI PINOUT

Pin No.	Pin function
1	HDMI Transmit - 2 High
2	Shield Ground
3	HDMI Transmit - 2 low
4	HDMI Transmit - 1 High
5	Shield Ground
6	HDMI Transmit - 1 Low
7	HDMI Transmit - 0 High
8	Shield Ground
9	HDMI Transmit - 0 Low
10	HDMI clock high
11	Shield Ground
12	HDMI clock low
13	HDMI CEC(Consumer electronics control) Signal
14	HDMI Ethernet Channel
15	HDMI DDC Clock lane
16	HDMI DDC Data lane
17	Digital ground
18	5V supply for ground
19	HDMI Hot plug detect pin

Table 1: HDMI Pinout