DESIGNING OF EMBEDDED SOLUTION FOR SERIAL ASYNCHRONOUS TO ANALOG RESOLVER FORMAT CONVERSION

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

VLSI DESIGN & EMBEDDED SYSTEMS

Submitted by:

VIJENDRA KUMAR SINGH
2K19/VLS/23

Under the supervision of

Dr. YASHNA SHARMA
Assistant Professor

ELECTRONICS & COMMUNICATION ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

2019-2021

Yashna 31/7/2021

ELECTRONICS &COMMUNICATION ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

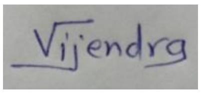
(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

CANDIDATE'S DECLARATION

I, Vijendra Kumar Singh, Roll No. 2K19/VLS/23 student of M.Tech (VLSI & Embedded Systems), hereby declare that the work presented in this thesis designated "**Designing of Embedded Solution for Serial Asynchronous to Analog Resolver Format Conversion"** is done by me and submitted to the Department of Electronics and Communication Engineering, Delhi Technological University, Delhi in fractional fulfillment of the prerequisite for the award of the degree of Master of Technology.

This is an original research work and not copied from any source without acknowledge them with proper citation and has not previously published anywhere for the award of any Degree, Diploma Associate ship, Fellowship or other similar title or recognition.



Place: New Delhi **(Vijendra Kumar Singh)**

Date:

ELECTRONICS & COMMUNICATION ENGINEERING

DELHI TECHNOLOGICAL UNIVERSITY

(Formerly Delhi College of Engineering)

Bawana Road, Delhi-110042

CERTIFICATE

I hereby certify that the Project Dissertation titled "**Designing of Embedded Solution for Serial Asynchronous to Analog Resolver Format Conversion**" which is submitted by **Vijendra Kumar Singh, 2K19/VLS/23**, to the Department of Electronics & Communication Engineering, Delhi Technological University, Delhi in partial fulfillment of the prerequisite for the award of the degree of Master of Technology, is a record of the project work carried out by the student under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: New Delhi

Date: 31st July. 2021

Dr. YASHNA SHARMA

Assistant Professor

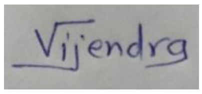
Department of ECE

Delhi Technological University

ACKNOWLEDGMENTS

It gives me immeasurable pleasure to express my deepest sense of gratitude and sincere appreciation to my supervisor, Assistant Professor Dr. Yashna Sharma, who has the substance of an intellect. She persuasively encouraged and guided me to be professional and do the work in a proper manner. The objective of this project would not have been completed without her persistent help. Her useful suggestions during this whole work and supportive behavior are sincerely acknowledged.

I would like to acknowledge the support of my family and friends. They helped me a lot directly and indirectly during this project work.



Date: **VIJENDRA KUMAR SINGH**

2K19/VLS/23

ABSTRACT

A marine vessel platform is fitted with sensors and equipments of diverse origin which are required to work in tandem in order to enhance its operation capability. However, due to incompatibilities in respect of data formats and protocols that are used, these equipments/ sensors cannot be interfaced directly. Presently, some systems are digital type, and some are analog type. Therefore, this project focuses on the design and development of embedded solution for Serial Asynchronous (Digital) to Analog Resolver format conversion for transmission of Roll and Pitch Angle and it also provides interfacing of digital and analog Resolver systems. An embedded board was designed using Cadence OrCAD proprietary software and it was developed using microcontroller 8051, Digital to Resolver converter modules, Low power operational amplifiers and some other required components. This electronic interfacing embedded board converts the Digital input contains Roll and Pitch angle into Analog Resolver types of output. It was tested using simulated Roll and Pitch angle created with the help of COM Port Toolkit application software and the output of this embedded interfacing solution was measured on Angle Position Indicator (API) and on an oscilloscope.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

API – Angle Position Indicator

VLL – Line to Line Voltage

RLG – Ring Laser Gyro

UART – Universal asynchronous receiver transmitter

PCB – Printed Circuit Board

OrCAD – Oregon (Oregon, United States) + CAD (Computer Aided Design)

I/P – Input

O/P – Output

MCC – Micro Controller

DSC – Digital to Synchro Converter

TTL – Transistor Transistor Logic

GND – Ground

IDE – Integrated Development Environment

DDC – Data Device Corporation

CSI – Control Sciences, Inc.

CCC – Computer Conversion Corporation

b/w – Between

Ref – Reference

CHAPTER-1

INTRODUCTION

1.1 Background

It is well known that during the year 1980, most of the marine vessels were fitted with analog equipments, systems and sensors on its platform, and during around year 1995, the marine vessels were started to get modernization to digital platform. The gyroscope is the main equipment which is required to support the navigation of the vessel. During the year 1980, the gyroscope fitted onboard vessel was analog resolver or synchro type. Now, India has entered in the 21st Century and there is a need to digitalize their systems because everywhere in the world, every country has started to use digital systems on its marine vessel's platform.

The analog gyroscope, or the mechanical gyroscope which is fitted onboard old marine vessels sends Roll and Pitch angular information in Analog Resolver format to the various sink equipments, spread across the platform of the marine vessels. But, as the part of renovation and modernization, old mechanical Gyroscopes were replaced by latest Digital Gyroscope i.e. Ring Laser types [1]. Ring Laser types Gyroscope sends Roll and Pitch data in serial asynchronous [2] format on RS422A electrical standard.

The major challenge here, in interfacing of these two types of equipments or systems is that, the latest Digital Gyroscope [3] is not compatible with the old mechanical Gyroscope. The format in which the various sink equipments accept the Roll and Pitch angular information is not available in same format as in latest Digital Gyroscope. Therefore, an embedded interface solution has been designed and developed to interface the latest Digital Gyroscope to [4] analog Resolver types various sink equipments.

1.1.1 Initial Setup of Equipments onboard marine vessel

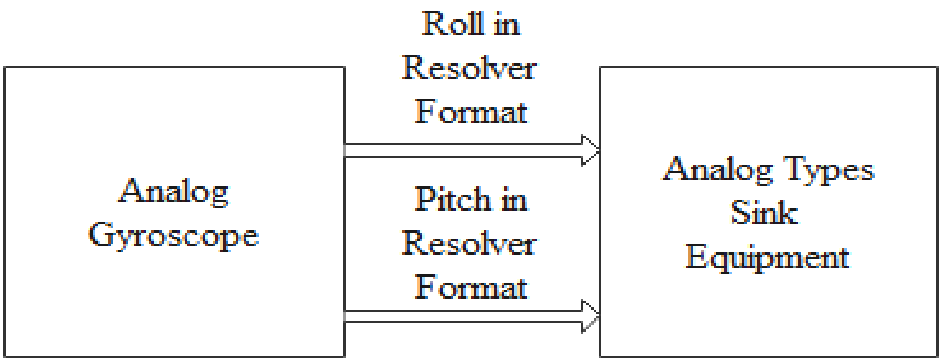


Fig.1.1 Initial Setup of Analog Gyroscope and Sink Equipment.

The block diagram mentioned at Figure-1.1 shows the initial setup between mechanical Gyroscope and Sink Equipment onboard marine vessels. As part of upgradation the Mechanical Gyroscope was replaced by Digital Gyroscope as the old Mechanical Gyroscope was no longer supportable as shown in Fig.1.2. The Digital Gyroscope provides the Roll and Pitch in a serial asynchronous packet structure format. Therefore, a requirement came up to design an embedded interfacing solution, which interfaces these two different domain systems.

1.1.2 Setup after the replacement of Mechanical Gyroscope

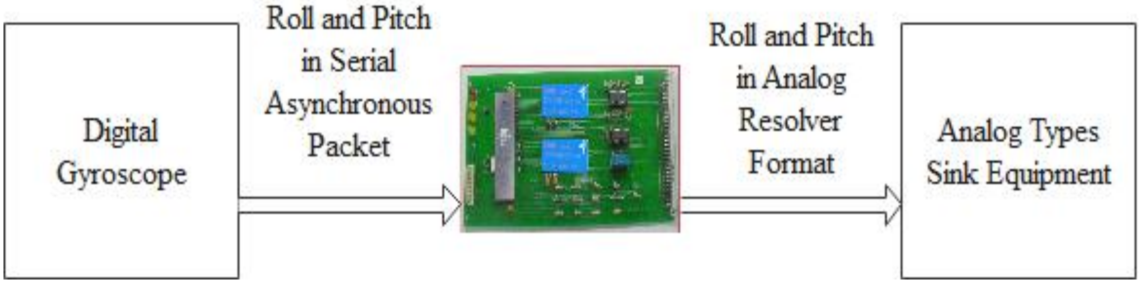


Fig.1.2 New Setup after installation of Digital Gyroscope.

The Embedded Interfacing solution, which is mentioned in Figure-1.2 gets digital packet from the Digital Gyroscope and extracts the Roll and Pitch information from the serial packet and converts these values in analog Resolver format which is required by the sink equipment.

1.1.3 Brief description about following technical points:-

(a) Roll and Pitch angles
(b) Electrical interface between Digital Gyroscope and Embedded interface board
(c) Resolver Signal

1.1.3.1 Roll and Pitch Angles of marine vessel

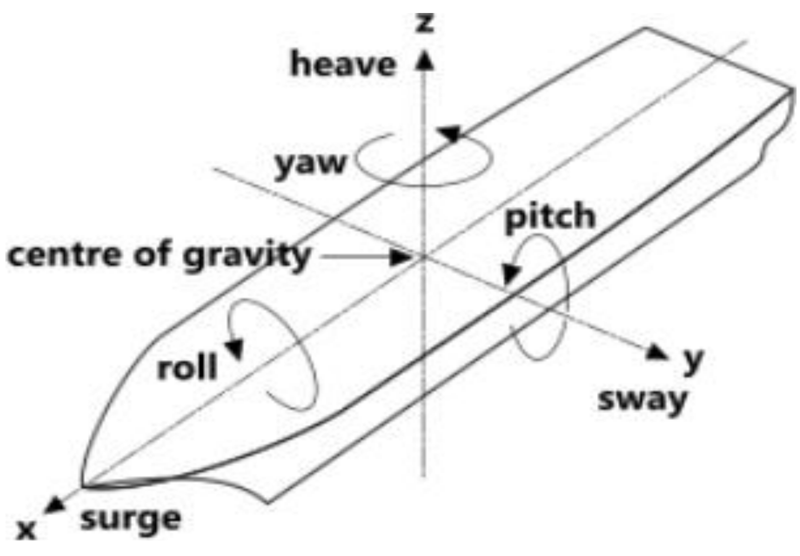


Fig.1.3 Roll and Pitch Angles

Roll angle is the movement of a marine vessel around its longitudinal axis and Pitch angle is movement of marine vessel around lateral axis as shown in Figure-1.3. The range of Roll and Pitch angle is ±90º. The left side of marine vessel is called as port and right side is called as starboard. The Roll angle is measured as positive in the clockwise direction at the starboard across the longitudinal axis and negative in anticlockwise direction at the port side, in the forward direction of marine vessel. The forward side of marine vessel is called as bow and backward side is called as aft. The Pitch angle is measured as positive at the bow side across the lateral axis when bow is moving down and negative at the aft side across the lateral axis when aft is moving down.

1.1.3.2 Electrical interface between Digital Gyroscope and Embedded board

The I/P of embedded interface board is in the form of serial asynchronous [2-5] RS422A standard format. RS-422A (known as EIA RS422A) is a suggested standard provided by Electronics Industry Association (EIA) for serial communication. RS422A uses differential lines for transmission of data as shown in Figure-1.4. Therefore it provides best noise immunity and longer distance of data transmission that is up to 1500 meter. These advantages make RS422A standard, a better fit for military and industrial applications.

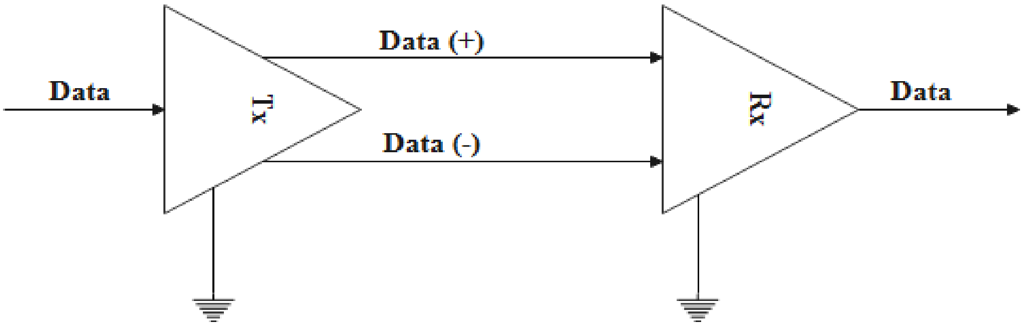


Fig.1.4 Data Transmission on differential line in RS-422A Standard

1.1.3.2.1 Serial Asynchronous Communication

Serial transmission of data is the standard of transmission of the data, only one bit at one moment and consecutively, across of a channel communication. In the serial asynchronous communication the number of bit of a character or word could be sent at a invariable rate. When, no character will be sent then the line remains at logic high called as Mark or Stop. The logic Low on the line called as Space or Start. The starting of a character or word is represented by a start bit which remains at all times low. This is utilized for synchronizing the transmitter and receiver. When the start bit received, the data bits are transmitted with Least Significance Bit first and then one or more stop bits are sent. The grouping of start bit, character and stop bits is called as frame. The clock pulse is not used for transmission of the data between the Tx (Transmitter) and Rx (Receiver).

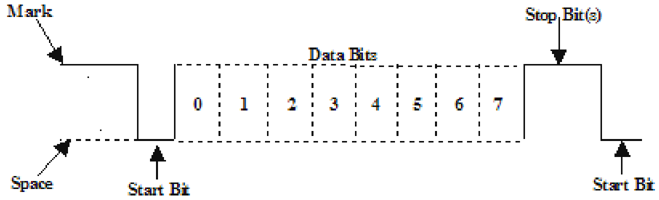


Fig.1.5 Serial Asynchronous Communication Format

1.1.3.3 Resolver Signal

Resolver signal is sinusoidal analog signal and it travels on four windings called as S1, S2, S3 and S4. There are one primary and two secondary windings with 90º out of the phase. It is the phase difference b/w the signal at secondary windings S2, S4 /S3, S1 and the primary winding R1, R2. It has two wire rotor terminals R1 and R2 which are excited by AC Ref. supply and provides output across the two separated stator windings. There are two line to line voltages called as VLL, whose amplitude is directly proportional to sine (S1,S3) and cosine (S2,S4) of the shaft angle. The VLL voltages produced across the stator windings measured as K(cosθ)(sinω(t)) and K(sinθ)(sinω(t)) respectively for cosine and sine windings. where transformation ratio is K, shaft angle is θ with respect to the from some Ref 0º position, and ω = 2πf carrier frequency.

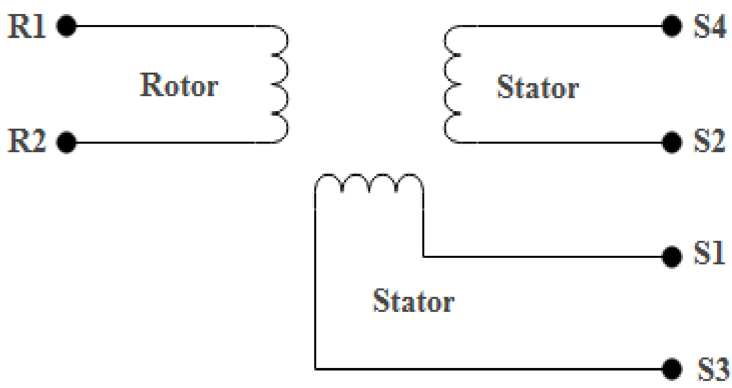


Fig.1.6 Electrical representation of Resolver Signal

AC Reference supply voltage:

A Sin wt.

The voltage appears across the stator windings:

S1 to S3 = K Sin wt Sin θ

S2 to S4 = K Sin wt Sin θ

1.2 Objective

The objective of this work is the conversion of the Serial Asynchronous data into Analog Resolver format.

1.2 Organization

The work in this thesis is organized in nine chapters including this chapter is describes as below:-

Chapter–1 gives the detailed introduction and background of project and tells about the objective of the same. This gives a detailed idea about the design and development of the Embedded Solution.

Chapter-2 tells about the literature reviews of the topics. It describes the previous work done by different companies.

Chapter-3 discussed about the proposed detailed block diagram of the embedded solution. It tells about I/P, O/P, MCC and the Reference supply used.

Chapter-4 describes about the schematic diagram and the software used for designing the circuit diagram.

Chapter-5 gives information for printed circuit board and its designing steps.

Chapter-6 describes about the software /IDE (Integrated Development Environment) used for programming and it gives information about the code.

Chapter-7 gives detailed information about the testing, simulation methodology and testing equipment used.

Chapter-8 shows a detailed result and discussion.

Chapter-9 gives conclusions.

CHAPTER-2

Literature Review

2.1 Introduction

Various companies already made the Digital to resolver/synchro converter modules; the details are mentioned in succeeding paragraphs. Data Device Corporation (DDC), US based company, Control Sciences, Inc. (CSI), UK based company and Computer Conversions Corporation (CCC), US based company design and developed the digital to resolver converter modules.

These all three modules will not accept the input data in a serial asynchronous format. These modules need data in 14 or 16 bit in parallel bits form in hexadecimal.

A serial asynchronous packet received from Ring Laser Gyro is on RS422A differential standard lines, and this serial packet has various other parameters. This data could not be fed directly to Digital to Resolver Converter modules. First the required data was extracted from serial packet and then the value of data was changed with the help of required resolution. Then the processed data was fed on 16 bits parallel lines in hexadecimal format.

2.1.1 Digital to resolver converter module made by Data Device Corporation (DDC)

The DSC11524 is a majorly used D to A converter as shown in Fig.2.1. The digital input shows the angle, and the output is pin programmable for resolver, sine/cosine O/P. The reference supply I/P will accept any type of waveform, if it is a sawtooth waveform for CRT drive. Because of the reference supply is DC coupled to the O/P, the DSC11524-303 can be used in various configurations, such as: a digital to synchro/resolver converter by using the sinusoidal reference supply as an I/P; a digital to sine/cosine DC converter using the DC reference supply; a polar to rectangular converter by using the reference supply I/P proportional to the radius vector; a rotating cart. Because, it is highly reliable, small in size, low power consumption and hybrid DSC11524 is ideal for the most stringent and sever military applications. Digital to Resolver / Synchro DDC electronic components are accurate, smallest converters. These single chips and hybrid converters are contains monolithic custom designing.

The conversion of the signal in DSC11524 is done by a digital to resolver converter which is having very high accuracy. Whose sine and cosine O/Ps have a low range factor variation as a function of the I/P angle. The resolver O/P is amplified by scaling amplifiers for resolver O/P, or both got amplified and then converted to the synchro O/P by the electronic Scott-T transformer. The O/P line currents in the both cases could be 15 mA (rms), which is adequate for driving S/D converters. The O/P power amplifiers are required for driving EM devices that are synchro and resolver. Reference conditioner has the differential I/P with AC and DC CMMR. The two number of reference I/Ps are available. The RH and RL I/P provide the max synchro or resolver O/P voltage for the 26V rms standard reference I/P. The RH´ and RL´ I/Ps are used to scale the O/P for the some other reference supply voltage levels. The series resistors will be included to the reference supply I/P is explained below, either to accommodate higher reference supply voltage levels, or to reduce the O/P voltage level. The reference conditioner O/P -R is planned for the testing purpose. The signal voltage between 6V to 7.5V at -R represents that the reference supply I/P signal is present.

The converter consists three I/P latches. The I/P is restricted by LM or LL. The 8-bit bus has been enabled by each of these pins of the converter for interfacing with an. LM controls the bits 1 to 8 and LL controls the bits 9 to 16. The data to be stabled for 50ns before enabling one of the latches (LL, LM) and permit 100ns for the latch to I/P the data.

The DSC11524 module works as a multiplying D to A converter in that the voltage level of each O/P line is proportional to the reference supply. The max. line to line voltage levels are figured out by the O/P amplifiers and are nominally 11.8V for synchro O/P and 6.81V / 11.8V for resolver O/P. The RH and RL reference supply I/P is designed and developed to give this nominal O/P for a standard 26V reference supply voltage level. The scaling adjustments are done by 02 internal resistors of 100k ohm with the reference conditioner in series. The RH´ and RL´ reference supply I/P has only internal resistors of 5k ohm with the reference conditioner in series. So that the line to line nominal O/P is obtained for a reference input of 1.3 V. Two resistors, R’, will be added in series for higher reference supply voltages, with the inputs.

This module has following features:-

(a) It gives 15 mA (RMS) output current.

(b) It works in two modes, in first mode output is 11.8 VL-L Resolver and in second mode output is 6.81 VLL Resolver.

(c) There are Byte 8 Bit/2 Double Buffered Latches.

(d) It is pin programmable for Resolver o/p.

(e) It has 16-Bit Resolution.

(f) It is complete D/S and D/R Converter

(g) It accepts DC (Direct Current) coupled Ref. for Any types of Waveform.

(h) It generates Rotating PPI Sweep or Sine/Cosine DC.

(i) It is high reliable CMOS Digital to Resolver Chip

(j) It does not require No +5 V Supply Required

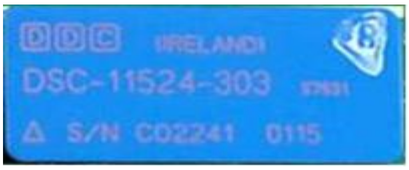


Fig.2.1 Data Device Corporation DSC11524-303 Module

DSC11524 module specifications

S. No.	Parameter	Unit	Value
i.	Resolution	bit	16
ii.	Accuracy	Minutes	±4 to ±2min
iii.	Output settling time	µA	less than 20 for any digital step change
iv.	Logic type		Positive logic, Natural binary, CMOS compatible. I/Ps are transient CMOS protected. Logic zero = 0.0 to 1.00V Logic one = 2.20 to 5.00 V
v.	Load Current	µA	20 max to GND (bits 1-16)
vi.	Reference I/P Type		Two differential inputs: one for standard +26 Volt, one for programmable
vii.			

2.1.2 Digital to synchro/resolver converter made by Control Sciences Inc. (CSI)

Control Science Inc. Digiyal to Resolver conversion modules, contains low to mediam rage power designed and developed on printed circuit board and mounted on bulkhead of high power. The binary parallel data is converted to accurately to either 04 wire resolver format or 03 wires synchro format signal. The range of output power available across the modules is around 1.50VA to 125.00VA. CSI company already made different types of modules with different electrical characteristics for resolution of 12,14 and 16bits.

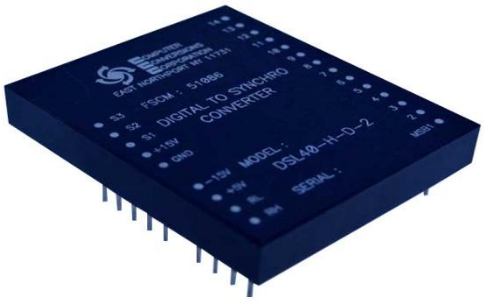


Fig.2.2 Control Sciences, Inc. (CSI), Digital to Synchro/Resolver Converter

2.1.3 Computer Conversions Corporation (CCC), digital to resolver converter module

Fort the Series of HDRCK, the size is hybrid, accuracy is high and it is highly power D to R Converter module, designed and developed for industrial and stringent, applicable for army, navy and air force and has very high performance, control of motion, transmission of data, simulation and in the field of radar applications. DRCK gives better than 31 arc second accuracy with 16 Bit of Resolution, when, delivering the O/P drive greater then 2VA, in a compact hybrid sized thermally optimized package. The DRCK Converter facilitates very high speed performance; able to facilitate speeds of up to 965 RPS without any distortion and the O/Ps maintain both ratio and absolute accuracy for suitability in the application use of the O/Ps independently: complex firing and tracking system, PPI radar display, system performs polar & rectangular coordinates and conversions. A converter is capable of operating across the wideband carrier frequency of 47 to 22KHz, while providing dynamic performance of greater then 150 revolutions per second at 16 Bit of resolution. DRCK converter is the highest accuracy Digital to Resolver converter. AC Reference supply input is internally transformer isolated, reference supply input option includes 115, 40, 26, 7 VRMS user scalable. The isolation gives freedom from ground loops, DC Offsets, or loading, meets the requirements of MIL-T-27, and reference power compliance to MIL-STD-1399. The models of ±15VDC powered, provide an o/p choice of 0 to 6.8VLL or 7VLL sine/cosine and ±12VDC power of units give 5.6VLL sine/cosine. The output gradient may be changed by adding a single resistor in series with the AC reference I/P. External transformer is available here, that may be provided for higher voltage O/Ps or synchro format. DRCK model is offered in a standard converter format having built in o/p transformers integrated within. HDRCK Series is sub-miniature modules that are; size comparable, low cost yet powerful performing alternatives to Hybrid Digital to Resolver and Digital to synchro converters. This module has following features:-

(a) It has 16 Bits Resolution
(b) It has accuracy of 30 arc seconds
(c) It has Comparable to Hybrids Lower Cost/Size
(d) The Slew Rate is to 960.00 RPS
(e) The Internal Isolated Reference I/P O/Ps: 7VAC/1.3VAC/115VAC/40VAC/26VAC
(f) It has 5.0V and 3.30V compatible logic
(g) It has Wide Band Ref. Freq: 47.00 to 20000Hz.
(h) It has High power 2.0VA O/P Drive
(i) It has Virtually Indestructible o/ps: Short Circuit Proof with thermal cutoff and drives high power with current limitation
(j) It has Thermally conductive metal top heat sink
(k) It requires +/-12 and +/-15 Volt power supply
(l) It can operates between -40ºC to +85ºC
(m) It has Short circuit protected o/ps
(n) It is Buffered 16 Bit Transparent Latch Input
(o) It has CMOS and TTL Compatible i/ps

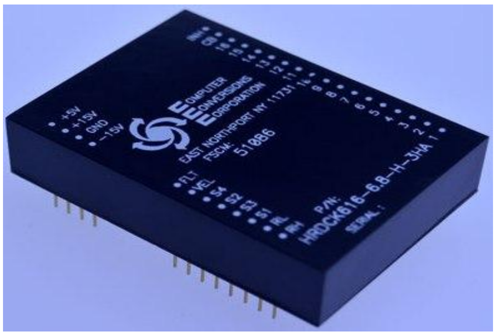


Fig.2.3 CCC Digital to Synchro/Resolver Converter

2.2 Conclusion

The embedded solution for serial asynchronous to resolver converter has been designed and developed using Data Device Corporation (DDC) digital to resolver converter module and physically implemented on a two layer board. Here, all the processing have been done on board which could not be done by DDC module and the buffer amplifiers have been added in the output of board.

CHAPTER-3

DESCRIPTION OF COMPONENTS

3.1 Block Diagram of Proposed Embedded Interfacing Solution

A typical interfacing arrangement for the proposed embedded interfacing solution is shown in Figure-2.1. This diagram represents the top level functionality of the embedded interfacing solution and descriptions of modules were used in design and development [6]. The driver IC AM26LS32 [7] was used for conversion of the RS422A standard input into TTL format [8]. The microcontroller 8051 [9] is used to extracts the Roll and Pitch angular information from the Serial Asynchronous input packet [10-11] and fed the Roll and Pitch angles to DSC11524 Modules [12]. These modules convert the Roll and Pitch angular information into Analog Resolver format [13] and further this output fed to low power operational amplifiers [14]. The low power amplifiers are used as buffer.

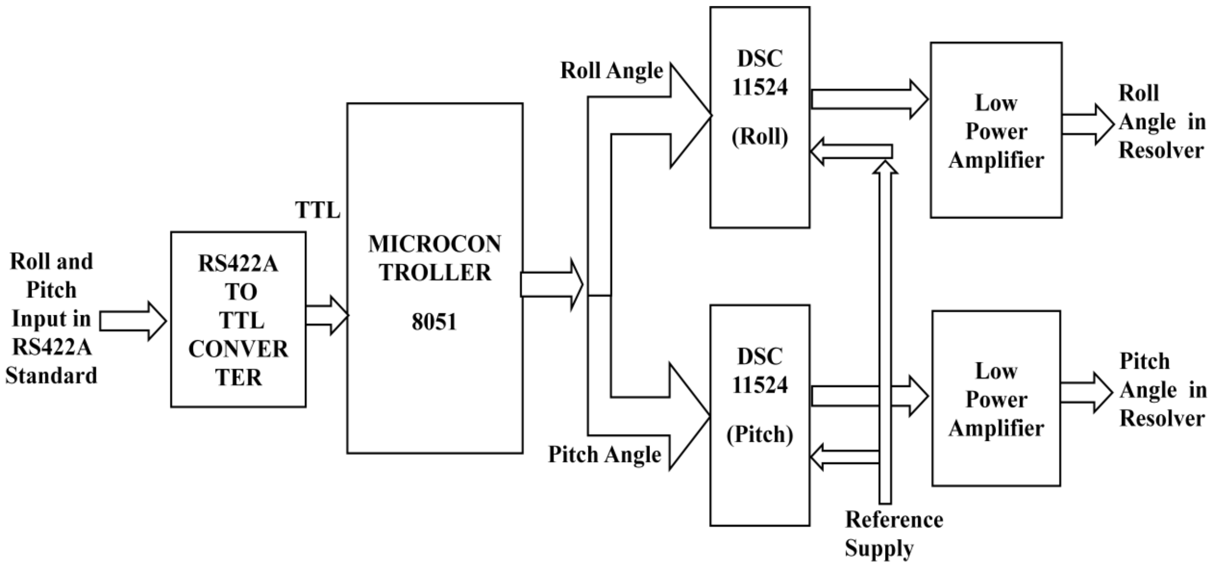


Fig.3.1 Block Diagram of Proposed Embedded Interface Solution.

3.1.1 Input of the Interface Solution

The latest gyroscope provides Roll and Pitch in the digital serial Asynchronous packet format on RS422A communication standard. This standard signal format fed to RS422 to TTL converter and then it fed to Microcontroller 8051.

3.1.2 Microcontroller

The 8051 microcontroller was used which extracts the Roll and Pitch values of the marine vessel from the packet and fed to DSC i.e. DRC module (Digital to Resolver Converter module).The microcontroller 8051 has 16 bit address bus and 8 bit data bus. Because of it has 8bit of data bus, therefore it is called 8bit microcontroller. The address bus of 16 bit can be addressed to 64K byte of ROM or code memory space. The 8051 microcontroller has the 4kilo bytes of ROM memory space and 128 bytes of RAM memory space. This microcontroller unit has many SFR called as special function registers e.g A called as accumulator, B register and some control registers. It contains thirty eight The 8051 MCU contains 02 , 16bit counters or times and three internal interrupts and two external hardware interrupt. It has one UART for serial asynchronous communication and four I/P and O/P ports called as P0,P1,P2 AND P3.

3.1.3 DSC (Digital to Synchro Converter) Modules

The DSC11524-303 is a multi applicable digital to analog converter. The digital input represents angle information and the output is pin programmable for four winding resolver, sine/cosine, or three winding synchro type output. The reference input supply will accept any waveform, even a sawtooth for CRT drive. Because of the reference supply is DC coupled to the output, the DSC11524-303 can be used in many configurations, such as: a digital to synchro/resolver converter using a sinusoidal reference supply as an input; a digital to sine/cosine and DC converter using a DC reference supply.

3.1.4 Reference Supply

A reference supply of 26, 400Hz is required for DSC modules. This is supplied by the reference system onboard marine vessel. A common Reference supply should be used for interfacing board and sink equipment. If we used two different Reference supplies then the sink equipment calculate the wrong angle value.

CHAPTER-4

DESIGN METHODOLOGY

4.1 Schematic Diagram

The schematic diagram mentioned at Figure-3.1 was designed using OrCAD Capture cadence proprietary software tool suite [15-16]. OrCAD Capture is a powerful schematic drawing tool for implementing the design intent of an electronic circuit. The major components used in designing of circuit diagram are the Microcontroller 8051 IC AT89C55, Digital to Resolver Converter IC DSC11524-303 (Two modules were used, one for Roll Angle and another for Pitch angle), One IC for RS422 standard to TTL conversion AM26LS32, Four Low Power Operational amplifiers LM324 and some other driver IC,s.

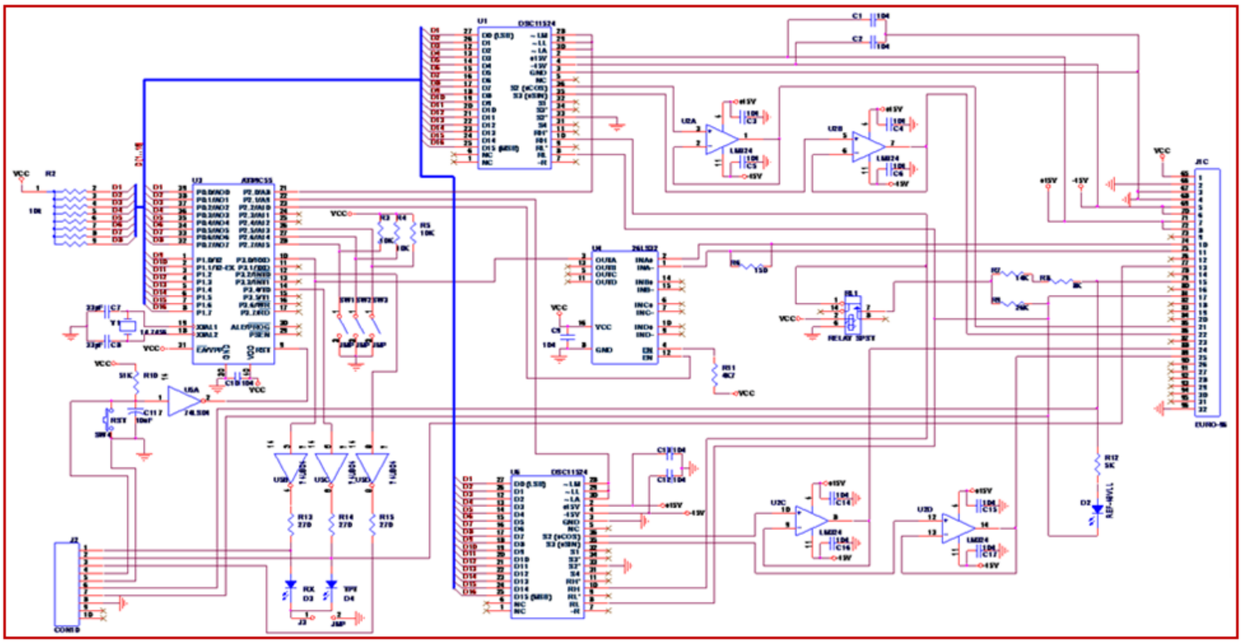


Fig. 4.1 Circuit Diagram of Proposed Interface Solution.

The steps of designing the schematic are as (i) Launch Capture (ii) and then select new project from menu (iii) write down the name of project from new project menu (iv) Select the types of project is is analog or mixed types (v) Decide the project location where the project will be saved in PC/System and then click on ok button (vi)In the software in PSPICE menu or dialogue box blank project will be created. After the creation of blank project the project can be simulated in software. But libraries to be configured manually (vii) For Creation of new project click on Ok button.

4.1.1 Bill of Material

Item	Qty	Part	Ref
1	14	104	C1 to C17 Capacitors
2	2	33pF	C7, C8
3	1	10uF	C11
4	1	PWR	D1
5	1	REF-48VLL	D2
6	1	RX	D3
7	1	TPT	D4
8	1	EURO-96	J1
9	1	CON10	J2
10	4	JMP	SW1, SW2, SW3, J3
11	1	RELAY SPST	RL1
12	4	270	R1, R13, R14, R15
13	4	10k	R2, R3, R4, R5
14	1	150	R6
15	1	14K	R7
16	1	8K	R8
17	1	26K	R9
18	1	51K	R10
19	1	4K7	R11
20	1	5K	R12
21	1	RST	SW4
22	2	DSC11524	U1, U6
23	1	LM324	U2
24	1	AT89C55	U3
25	1	26LS32	U4
26	1	74LS04	U5
27	1	11.0592	Y1

CHAPTER-5

Printed Circuit Board

5.1 The Interface Solution Card

The PCB (Printed Circuit Board) of interface solution is mentioned at Figure-3. This PCB was designed by using the OrCAD PCB Editor Cadence software [17]. Two layer PCB is used for designing the required PCB. These are the basics steps used in PCB designing i.e. Draw the Outline of PCB, assign the Foot prints of all components, creating a netlist, automatic or manual Routing, selection of Top or Bottom layer, selection of constraints, generating the Artwork (Gerber file). A Gerber file keeps format of ASCII vector files that gives information of every physical board layer of PCB designing. Schematic board objects e.g. solder mask, vias, copper traces, silkscreen images and pads are shown by a flash or draw code, and defined by the series of coordinates of vector. These all files are utilized by manufacturer to generate the details of design in the physical form of the Printed Circuit Board.

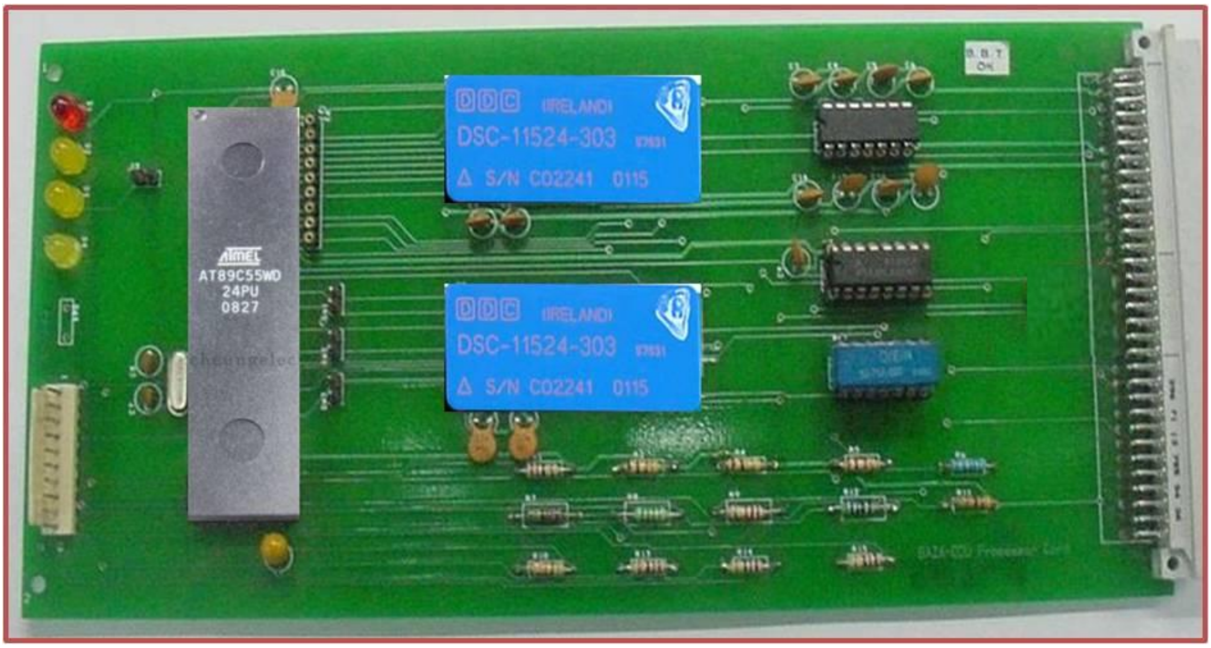


Fig. 5.1 Interface Card of Proposed Interface Solution

5.2 Basics of the Printed Circuit Board

The Printed circuit card is a stiff arrangement which consists of an electrical circuit which is made by copper wires and that are called as traces of the PCB and on which the traces are developed that area is called as planes. The components are mounted or soldered on top, bottom or both sides of PCB as per requirements and design with the help of pads. These pads help in connecting components on traces and connect top and bottom traces as per requirements. The PCB board can have only one layer on one side of PCB or two layer on both sides of CB or it may have multiple layers as per requirements and these all layer are connected to each others. The board is made of dielectric material which has very poor electrical conduction. The layer of copper on PCB card is isolated by very poor dielectric material. The material used for PCB card manufacturing is fire resistant and known as FR4 material and the traces and planes are made of copper metal.

5.3 The Design Process of Printed Circuit Board

For the physical design and development of PCB, any design tool like OrCAD is required. First I design a schematic circuit on OrCAD capture. In the designing of the PCB card first schematic design done then circuit implemented on PCB board. First the library has been developed which has circuits symbols simulation models, foot prints etc. After the developing or adding the library the components symbols have been placed on the schematic. This software is used, first paced the components symbols and connects each other. The circuit simulation will be conducted. The all the data related to connection send to layout. The designer or engineer keeps components footprints inside layout. After footprints arrangement routing has been done manually or automatically as per requirements. DRC checks also have been done. Bill of material generated for PCB card development.

5.4 Steps of making Printed Circuit Board

All the steps are described in details in the succeeding paragraphs:-

5.4.1 Designing of Schematic on OrCAD Capture using Symbols of Electronic Components

Before starting the design of the PCB board on the OrCAD cadence tool, it is to be make sure that the library part work to be completed initially. For designing the circuits, the logical symbols are to be created for resistors, inductors, capacitors, connectors and connected components and modules. Now, the components placed as per circuit requirements on OrCAD tool page. All the components are connected to each other as per circuit design by a wire. These wires are called as nets.

5.4.2 Use of PSPICE with Demo Circuit and Netlist for Simulation of the Circuit

With the components and nets arranged on the schematic, the next step is to make sure that the circuit as drawn would work the way, it is intend. To make sure this, simulation would be done of the circuits in a Simulation Program with Integrated Circuits Emphasis tool otherwise known as PSPICE. These tools permit PCB engineers to examine the circuits that are designed before building the real hardware. As such, they could save time and funds building these tools a necessary part of the PCB design method.

5.4.3 PCB Design Grids, DRCs for Routing Verification and Other OrCAD Tool Setups

When the components has been placed and connected by nets. The DRC checks have been done and then footprints of components have been placed in a layout and the routing has been done manually or automatically.

5.4.4 Accurate Component Placement Layout for the Highest Performance of PCB

All the components are to be placed within the layout boundary and the routing to as like a rubber band. So that no more noise and heat produced. For highest performance of circuit we should care about every feature of circuits.

5.4.5 The appropriate PCB Routing Angles shell Connect Circuitry simultaneously

The routing nets should not cross each other and placed routing in best way otherwise it may degrade the performance of the circuit. The routing should be used automatically or manually it depends upon for case to case, which one will be better.

5.4.6 Power and the Ground Planes, the Significance of a High-Quality PCB Return Current Path

The PCB has power and ground planes, which are used to connect the components. So many holes inside the planes may cause noise and power loss. These holes played important role for returning currents.

5.4.7 Using the Tools for Manufacturing Cost Estimation, Fabrication and Assembly Drawing Creation

PCB designer did cost estimation after the placement of components, routing and finishing the power and ground planes. DRC checks have been done. The final marking, copyright have been indicated on PCB card.

5.4.8 Making the PCB Board, Fabrication of Multilayer PCB and Method of Soldering

In this case the PCB card is prepared and sends the O/P data file to manufacturer/ fabricator for fabrication of PCB. Etchings have been done. The required components have been loaded and soldering has been done for different components as per requirements. After these steps the PCB card has been ready by inspection and testing.

CHAPTER-6

Programming

6.1 Development Environment (IDE)

Programming for 8051 microcontroller is written in c-language on Keil µVision4 IDE (Integrated Development Environment) as shown in Figure-5.1. Microcontroller receives a serial packet in TTL format on its UART (Universal asynchronous receiver-transmitter) [11] and on pin number 10. It extracts the Roll and Pitch angle from serial packet and keeps these values on port P0 and P1 of microcontroller. The digital to resolver converter module [12] is connected on port P0 and P1, which converts this Roll and Pitch angle in TTL into Resolver format [18] and sends further to low power operational amplifier [14].

6.2 How to write a program in Keil IDE

First click on the Keil application software and open it. Click on the Project > New Project then choose a location in PC to save the program, write down the name and Save it. In the next click select the microcontroller of various componies. Select the Atmel, and then by expanding select AT89C55 device and click on ok. After this go to the New in the menu and select New. It will open a new editor to write the program. Further, move to the save option and save the program/code file with .c extension. Write down the program for the Microcontroller 8051. Now from the left side, select Source Group1 and Add Existing Files to Group 'Source Group1'. After it select the code (c file) then add and close it. Further, move to the Project > Build Target to build the project. If there are some errors, the building will be failed, after the doing the correction in the errors, it will be build. Further, click on the Target1 from the left side and select Options for Target 'Target1'. Then set the crystal values to 11.0592MHz and check mark on the use On Chip ROM. Further move to the o/p tab. In this tab check Create Hex File, and click on OK. Further, build it again. Burn the hex file in the microcontroller 8051, now it will work.

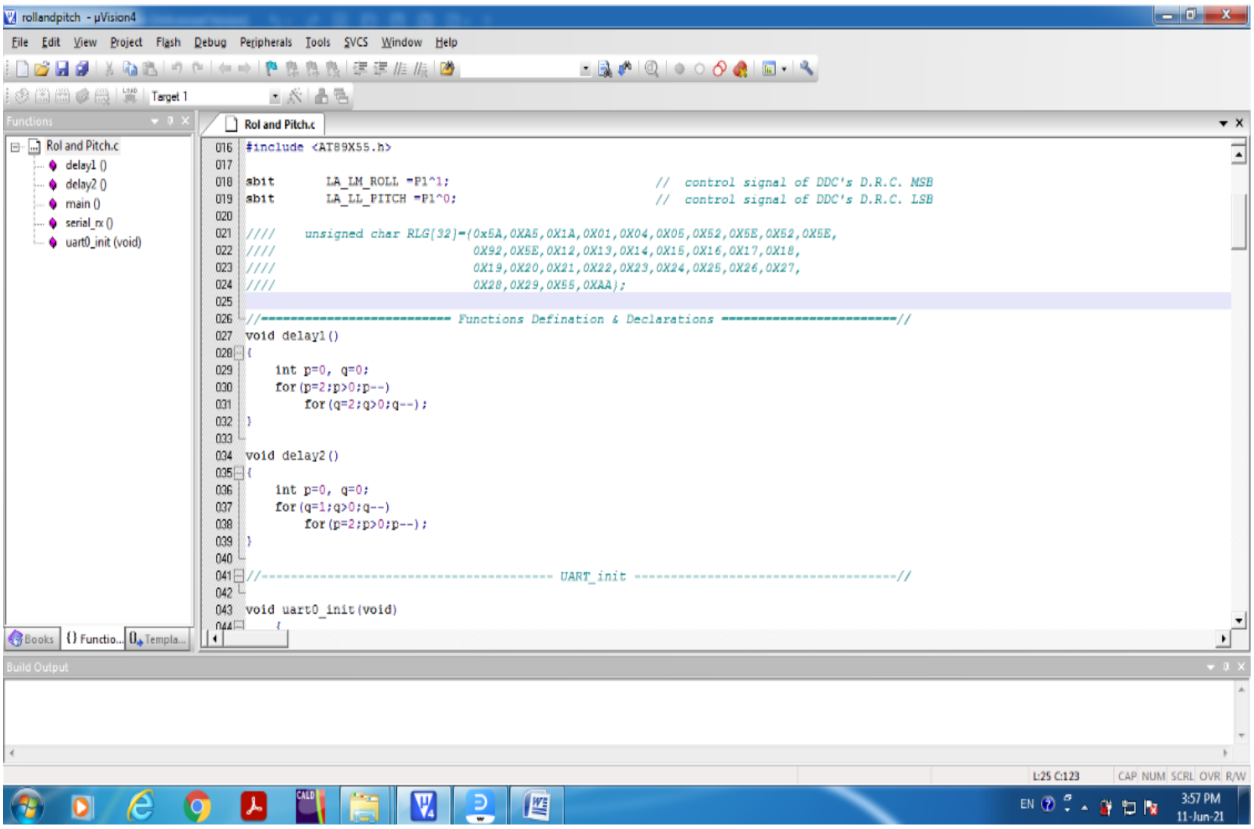


Fig. 6.1 Keil µVision4 Integrated Development Environment.

6.3 Program Written

```
//======= Library Declarations and Macros ==========//
#include <AT89X55.h>
sbit    LA_LM_ROLL =P2^0;    //    control signal of DDC's D.R.C. MSB
sbit    LA_LL_PITCH =P2^1;   //    control signal of DDC's D.R.C. LSB
//================= Functions Defination & Declarations ================//
void delay1()
{
        int p=0, q=0;
        for(p=2;p>0;p--)
                for(q=2;q>0;q--);
}
void delay2()
{
        int p=0, q=0;
        for(q=1;q>0;q--)
```

```
		for(p=2;p>0;p--);
}
//-------------------------- UART_init --------------------------------//

void uart0_init(void)
	{
		TMOD=0x20;		//  SETTING OF TIMER2 FOR TRANSMIT AND
RECEIVE
		SCON=0xD0;	//  SERIAL MODE 1, 10-BIT DATA, NO PARITY , UART0

		TH1=0xFD;
		TR1=1;			//  TIMER 2 SET FOR BAUDRATE GENERATION
	}
//--------------------------- UART_Rx -------------------------------//
	unsigned char serial_rx()
	{
		 unsigned char x;
			while(RI==0);
			x=SBUF;
			RI=0;
			return(x);
	}
//------------------------- main body -----------------------------//
void main()
{
	unsigned int i=0;
	unsigned int final_roll_val,final_pitch_val;
	unsigned char Rx_flag1=0,Rx_flag=0,Rx_Data,Rx_Header1,Rx_Header2;
	unsigned char GYRO[78]={0};
	short roll, pitch;
	float roll_value,pitch_value;
```

```
P0=0x00;
P2=0x00;
P1=0x00;
P3=0x03;

LA_LM_ROLL=1;               // LA' & LM' = 1 (active low)
LA_LL_PITCH=1;    // LA' & LL' = 1 (active low)

uart0_init();
P0=0x00;                    // LSB
P2=0x00;                    // MSB
                }
while(1)
        {
//=============== receive packet =============================//

Rx_Header1 = serial_rx();
Rx_Header2 = serial_rx();

if((Rx_Header1 == 0x5A)&&(Rx_Header2 == 0xA5))
{
        Rx_flag = 1;
}
else
{
        Rx_flag = 0;
}
if (Rx_flag)
{
        Rx_flag = 0;
        for(i=2;i<78;i++)
        {
```

```
                    Rx_Data = serial_rx();
                    GYRO[i] = Rx_Data;
                    if((Rx_Data == 0xAA)&&(i == 77))
                    {
                        Rx_flag1 = 1;
                        break;
                    }
                     else if((Rx_Data != 0xAA)&&(i == 31))
                     {
                       Rx_flag1 = 0;
                       RLG[16]      = 0;
                       GYRO[17]   = 0;
                       GYRO[18]   = 0;
                       GYRO[19]   = 0;
                       break;
                     }
                }
        }       }
        if(Rx_flag1)
        {
                    Rx_flag1 = 0;

                    roll = ((GYRO[17]) | (GYRO[16]<<8));
                    pitch = ((GYRO[19]) | (GYRO[18]<<8));
//--**************===== load the I/O Ports ===============//
                    if(roll<0)
                    {
                        roll=~roll;
                        roll+=1;
                        roll_value = (roll * 0.00274658203125);
                        roll_value = (360-(roll_value));
                    }
```

```
else
{
        roll_value = (roll * 0.00274658203125);
}
final_roll_val = roll_value/0.0054931;
P0 = final_roll_val;                // LSB
final_roll_val = final_roll_val >> 8;
P1 = final_roll_val;                // MSB

delay1();
LA_LM_ROLL=0 ;   // when logic of LA,LM
delay2();
LA_LM_ROLL=1;

if(pitch<0)
{
        pitch=~pitch;
        pitch+=1;
        pitch_value = (pitch * 0.00274658203125);
        pitch_value = (360-(pitch_value));
}
else
{
        pitch_value = (pitch * 0.00274658203125);
}
final_pitch_val     = pitch_value/0.0054931;

P0= final_pitch_val;                // LSB
final_pitch_val = final_pitch_val >> 8;
P1 = final_pitch_val;               // MSB

delay1();
```

```
        LA_LL_PITCH=0 ;                // when logic of LA,LM
        delay2();
        LA_LL_PITCH=1;

         Rx_Header1 = 0;
        Rx_Header2 = 0;

        GYRO[16]     = 0;
        GYRO[17]     = 0;
        GYRO[18]     = 0;
        GYRO[19]     = 0;
}
```

CHAPTER-7

Testing and Simulation

7.1 Roll Pitch Angular Information Simulation for Testing

The embedded interfacing solution has been tested with the help of simulated Roll and Pitch angle created by COM Port Toolkit [19-11]. This COM Port Toolkit is PC based application that mimics the output behaviour of the latest digital Gyroscope (Ring Laser Types) [17]. This application software provides a user friendly interface to configure latest Gyroscope data [3]. When I want to simulate the latest Gyroscope data then I write down the packet structure of latest Gyroscope in this application and set the required serial parameters and then click on send button then this serial asynchronous packet with initially set serial parameters, can get from any USB output port of PC. A commercial USB to RS422A converter has been utilized in this simulation [19] because of the embedded interfacing card needs the input data in RS422A standard. This RS422A standard data fed to input of card and output of card was checked and then the performance of the interface card was evaluated. A snapshot of the COM Port Toolkit with simulated values is shown in Figure-5. This kind of validation philosophy helps to capture error/ discrepancies, if present, at an early stage of the design and development of embedded interfacing solution, and thus saves a lot of time during the actual interfacing stage [17].

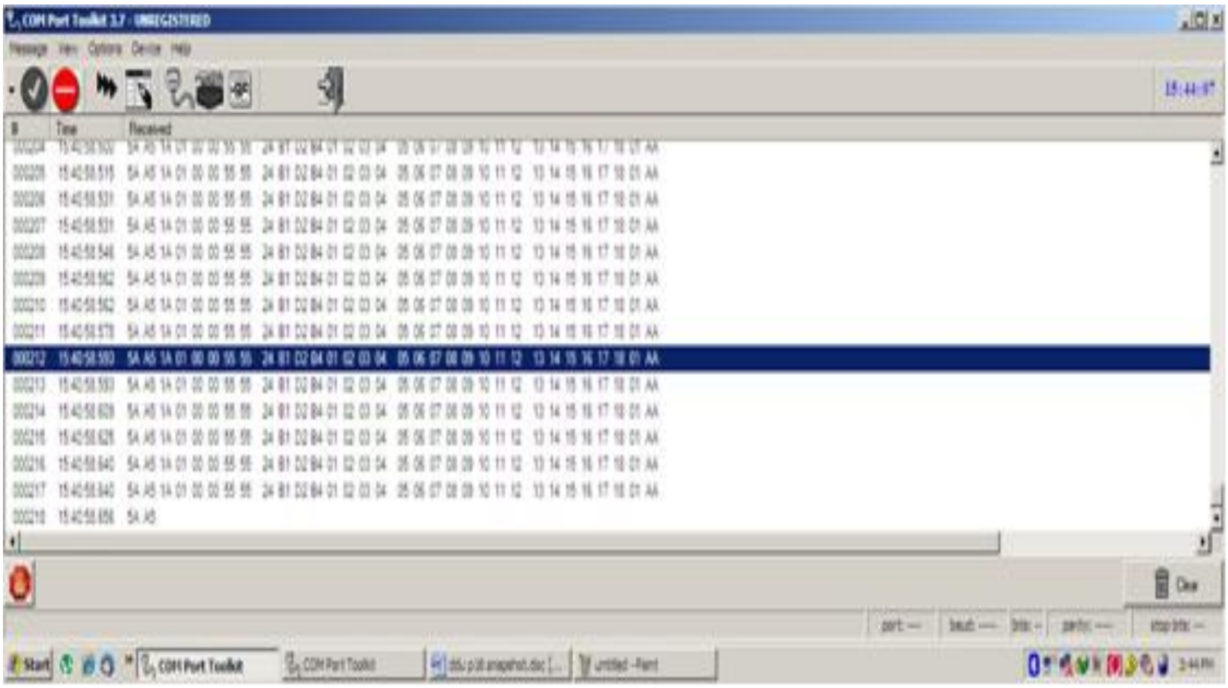


Fig.7.1 Screenshot of COM Port Toolkit with simulated Roll and Pitch Angle.

7.2 Serial asynchronous 10Hz packet

Roll and Pitch angles are generated in serial asynchronous packet format [20]. This serial packet is tested with the help of oscilloscope and the waveform found on oscilloscope is shown in Figure-6.2.

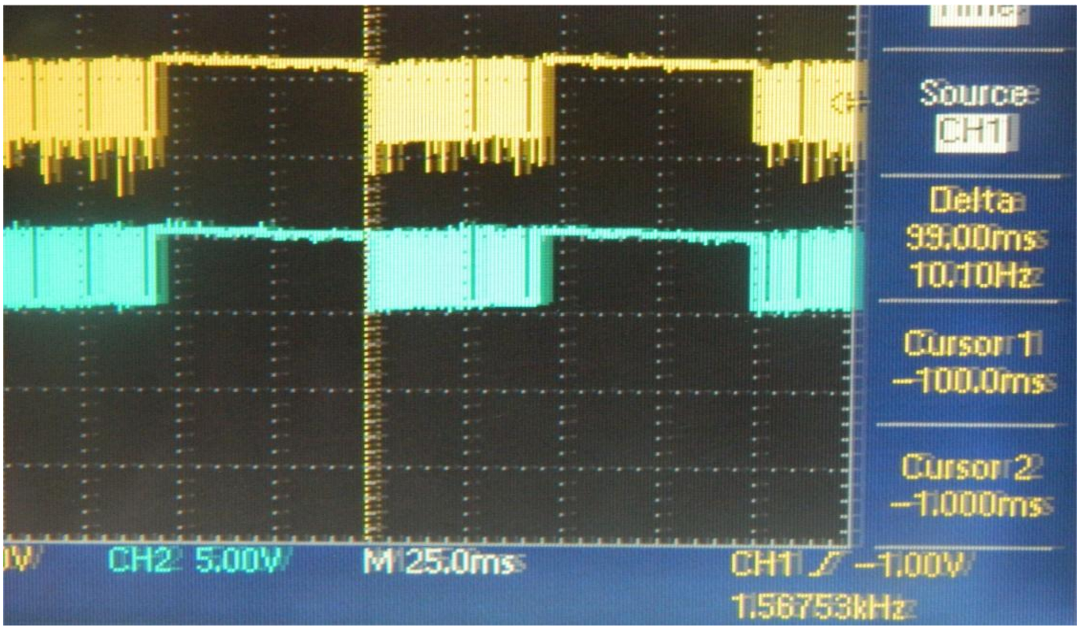


Fig.7.2 Serial Asynchronous 10Hz Packet waveform.

7.3 Testing Setup and Testing

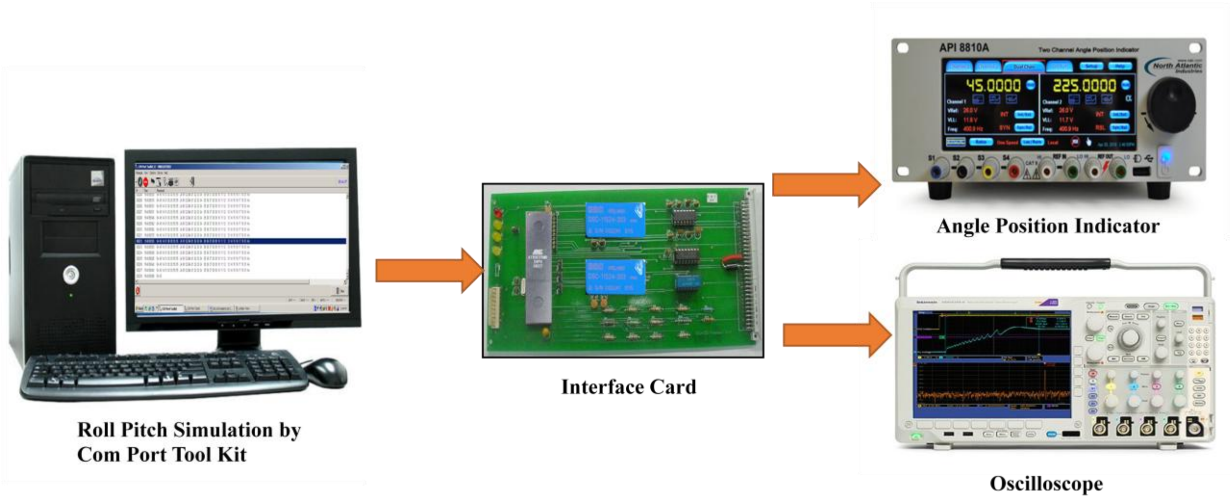


Fig.7.3 Testing Setup for Embedded Interfacing Card.

The testing setup for embedded interfacing solution is mentioned at Figure-6.3. The simulated values of Roll and Pitch angle have been generated with the help of PC based COM Port Toolkit application [196] and fed to input of embedded interfacing card with the help of an USB to RS422A standard serial converter as shown in Figure-6.4. It is plug and play type device. The outputs of embedded interfacing card have been measured on Angle Position Indicator instrument and Oscilloscope electronic instruments.

Fig.7.4 USB to Serial RS422 standard converter.

7.4 Reference Supply

A reference supply of 115V and 400Hz was generated with the help of Reference power supply generator as shown in Figure-6.4. But the Digital to resolver convertor module DSC-11524 required the 26V and 400Hz reference power supply. Therefore, a voltage divider was used to reduced the voltage.

Fig.7.5 Reference Supply Generator.

7.5 Tools used in Design and Development

7.5.1 OrCad Cadence tool for circuit Designing

Orcad capture is used for circuit designing. This OrCAD cadence is one of the most widely used schematic design tool for the creation of electrical circuits, with the integrated flows supporting the engineering process, coupled with the optional OrCAD product for management of component data, OrCAD cadence capture is the more powerful tool for design and product development.

7.5.2 Proteus Software for simulation

The Proteus software is software that is proprietary tool which is used primarily for circuit design and simulation. This software is used by designing and development by the engineer and technician for making circuit and used for prints for manufacturing PCB (Printed Circuit Board).

7.5.3 Keil µVision4 IDE for code writing

Keil uVision4 is a software tool, which help to embedded programmer and developer for writing the code. This software tool is an integrated development environment (IDE), it has a text editor for writing the code, a compiler and it will convert your source code file to hex files.

7.5.4 Galep Programmer

Fig.7.6 Galep Burner.

This Galep burner is used for burning/ flashing of code in hex file into the microcontroller. The Galep-5 is self powered universal device programmer for 8051 microcontroller. Due to the physical structure and power supply independence, the Galep-5 is the best device for burning the code. Its high speed makes it as a production programmer and with its JTAG debugging capabilities it could also be utilized for microcontroller based project development activities.

7.5.5 API (Angle Position indicator) for Roll and Pitch angle measurement

Angular position indicators are the electrical devices that are frequently used for the measurement of changes in the angular position of some certain object with respect to a fixed preferred position. API is used to get Resolver analog input and display the angle values on its display.

7.5.6 Oscilloscope for waveform capturing and VLL measurement

Oscilloscope is used for viewing the waveforms of the signals in the wire in electrical format and waveform can print and snapshots with the help of it. Here, I am measuring the VLL voltages for different Roll and Pitch angles.

7.5.7 Comport Tool Kit

COM Port Toolkit is a data, protocol and timing parameter analysis tool specially to support to segregate the issues with serial RS232, RS422 and RS485 data transmission control networks.

7.5.8 Roll Pitch Simulation

COM Port Toolkit is used for generation of Roll and Pitch angles in serial asynchronous in a packet format, when the actual Digital Gyro equipment is not available for testing.

CHAPTER-8

Results and Discussion

8.1 Results

The testing setup was arranged as mentioned in Figure-6. The application software, COM Port Toolkit application was installed on Window operating system based PC. In this application, the value of Roll and Pitch angle was fed in required packet format with initially set serial communication parameters i.e. start bit, stop bit baud rate and refresh rate etc [11]. The Range of Roll and Pich angle keeps within 0 to ±90º. The simulated Roll and Pitch angle in serial asynchronous format was taken from USB port of PC and an USB to RS422A standard converter was utilized for conversion. This serial packet in RS422A standard was fed to input of embedded card and this card converts the Roll and Pitch angle in serial asynchronous to Resolver format. Analog Resolver has sinusoidal signal in four windings S1, S2, S3 and S4 [18]. This Resolver output of card fed to Angle Position Indicator Instrument (API). The API displays the Roll and Pitch angle values on its display. These Roll and Pitch values were matched with input Roll and Pitch angles values and found correct with minute deviation, reading are mentioned for different Roll and Pitch angles values in Table-1 and 2.

The Range of Roll and Pitch angle is ±90º, The clockwise angle measured as positive angle and in anticlockwise direction angle will be measured as negative. The angle measured at the output of interface solution will be measured by using 2X factor. It means the 90º angle displays on Dial in 180º scale. The 1º angle will be displayed in 2º scale, just double. So it is called as 2X factor. It is explained below:-

a) As per 2X factor, for positive angle like +45º will be represented on Dial as +45º*2=+90º, it means +45º will be represented as +90º on Dial.

b) As per 2X factor for negative angle like -45º will be represented on Dial as +360-45º*2=+270º, it means -45º will be represented as +270º on Dial.

The output of card is in Analog Resolver format. The voltage measured at the output of interface card will be measured between line to Line, therefore it is called as VLL. It is RMS value. These voltage values for different Roll and Pitch angles were measured with the help of oscilloscope and mentioned in Table 1 and 2.

8.2 Line to line Voltage (VLL) measurement for different Roll Angle with the help of Oscilloscope at the output of embedded interfacing board.

Sink equipments have a motor which needs four winding Resolver input signal and when it gets the resolver input signal then it starts moving. How much angel it will move, it depends upon the values of Line to Line Voltage (VLL). It is RMS value. Oscilloscope is used for measurement of output waveform and Line to line voltages (VLL). VLL voltage is a RMS value. Three channels are used for measurement of two Resolver outputs and one Reference.

- Channel1 (Yellow Colour): Used for Reference signal measurement

- Channel2 (Blue Colour): Used for Sine windings (S1,S3) measurement

- Channel3 (Pink Colour): Used for Cosine windings (S2,S4) measurement

Voltage Calculation

- VLL(S1,S3)=Vmax(VLL) Sin(Roll angle)
- VLL(S2,S4)=Vmax (VLL)*Cos(Roll angle)

S. No.	Simulated Input Roll Angle	Voltage (VLL)	
		S2,S4 Cos Winding	S1,S3 Sin Winding
i.	0	12.15	0.003
ii.	1	12.14	0.218
iii.	5	11.95	2.085
iv.	7.5	11.72	3.107
v.	10	11.40	4.105
vi.	15	10.51	6.005
vii.	22.5	8.6	8.52
viii.	30	6.044	10.44
ix.	45	0.003	12.07
x.	60	6.040	10.43
xi.	75	10.51	6.003
xii.	90	12.15	0.002
xiii.	3.75	12.03	1.567
xiv.	1.875	12.11	0.788
xv.	-1	12.13	0.416
xvi.	-7.5	11.72	3.105
xvii.	-11.25	11.21	4.593
xviii.	-15	10.51	6.004
xix.	-22.5	8.59	8.54
xx.	-30	6.039	10.44
xxi.	-45	0.003	12.06
xxii.	-60	6.04	10.44
xxiii.	-75	10.52	6.004
xxiv.	-90	12.14	0.003

Table 8.1 VLL voltages measured for different angles of Roll at the output of Embedded Interfacing Solution.

8.2.1 Case1: When Roll angle is 30º

In this case, we feed Roll value=30º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1, S3 Sin Winding

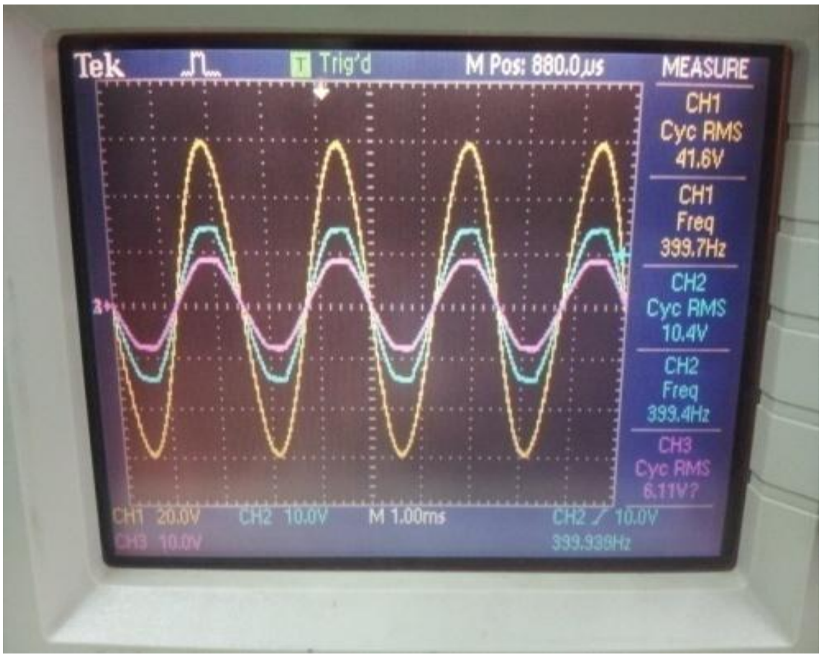


Fig.8.1 Waveform at 30º Roll

8.2.2 Case2: When Roll angle is 45º

In this case, we feed Roll value=45º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1, S3 Sin Winding. In this Fig.10, there no Cos winding is displaying, because of Cos 90º=0. Therefore, here, the Cos winding value is zero.

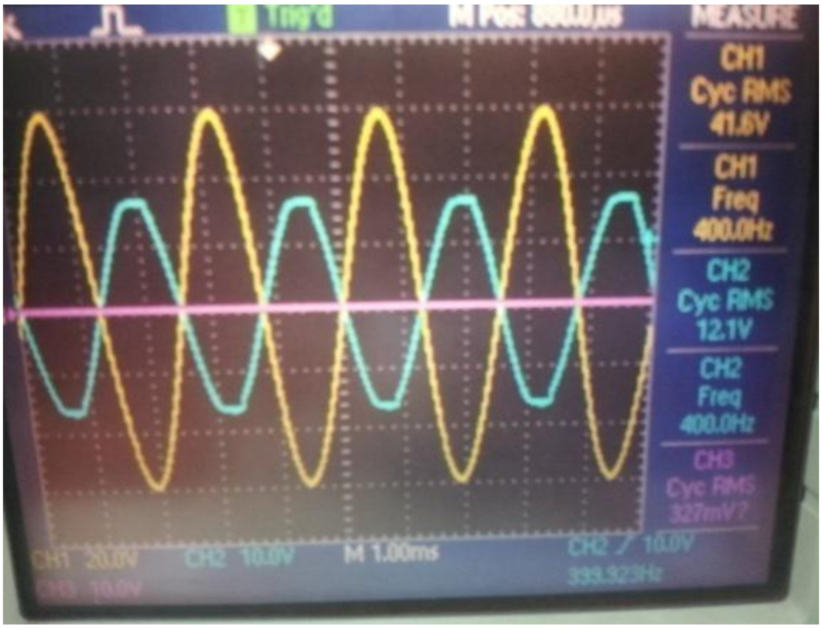


Fig.8.2 Waveform at 45º Roll

8.2.3 Case3: When Roll angle is 60º

In this case, we feed Roll value=60º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1,S3 Sin Winding

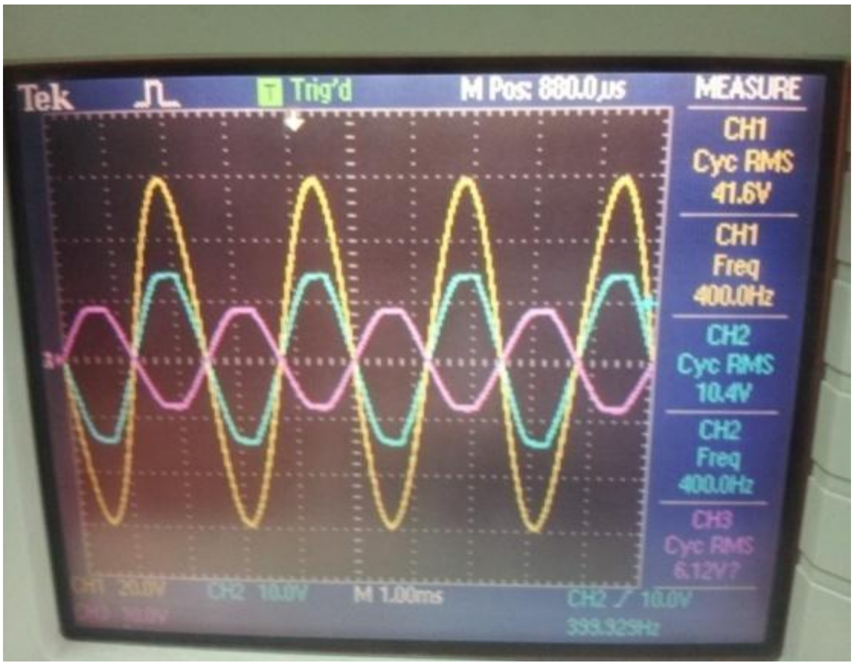


Fig.8.3 Waveform at 60º Roll

8.2.4 Case4: When Roll angle is 90º

In this case, we feed Roll value=90º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1, S3 Sin Winding. In this case the Sin winding is not displaying, because Sin 180º=0. Therefore, the voltage across sine winding is zero.

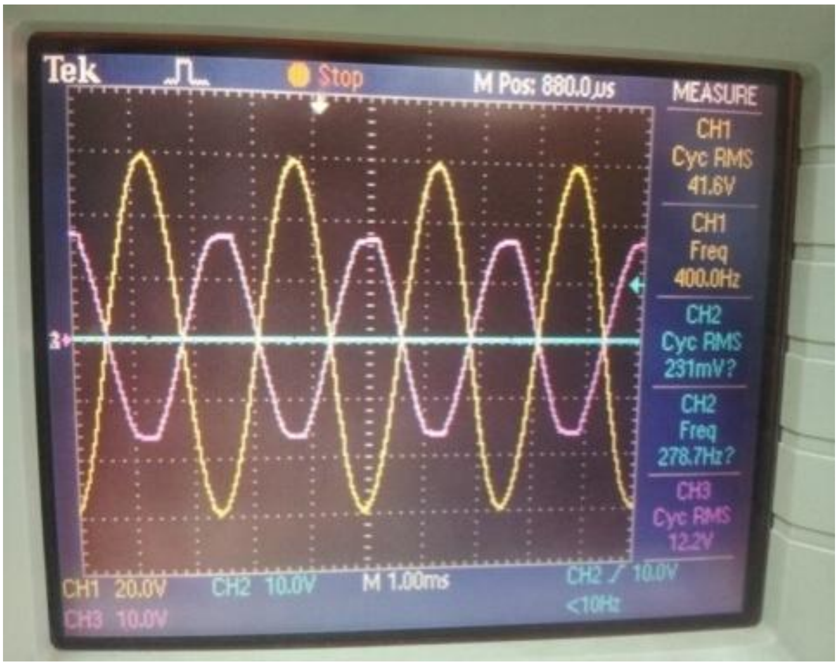


Fig.8.4 Waveform at 90º Roll

8.3 Line to line Voltage (VLL) measurement for different Pitch Angle with the help of Oscilloscope at the output of embedded interfacing board.

S. No.	Simulated Input Pitch Angle	Voltage (VLL)	
		S2,S4 Cos Winding	S1,S3 Sin Winding
i.	0	12.12	0.002
ii.	1	12.12	0.415
iii.	2.813	12.06	1.174
iv.	5	11.94	2.079
v.	5.625	11.89	2.335
vi.	10	11.39	4.098
vii.	11.25	11.20	4.585
viii.	15	10.50	5.995
ix.	22.5	8.58	8.52
x.	30	6.035	10.42
xi.	45	0.0025	12.04
xii.	60	6.035	10.42
xiii.	75	10.50	5.999
xiv.	90	12.12	0.0045
xv.	-1	12.12	0.419
xvi.	-1.1	12.12	0.460
xvii.	-10	11.40	4.103
xviii.	-15	10.50	6.501
xix.	-22.5	8.59	8.53
xx.	-30	6.037	10.43
xxi.	-45	0.005	12.05
xxii.	-60	6.037	10.42
xxiii.	-75	10.50	5.997
xxiv.	-90	12.13	0.003

Table 8.2 VLL voltages measured for different angles of Pitch at the output of Embedded Interfacing Solution.

8.3.1 Case1: When Pitch angle is 30º

In this case, we feed Pitch value=30º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1, S3 Sin Winding.

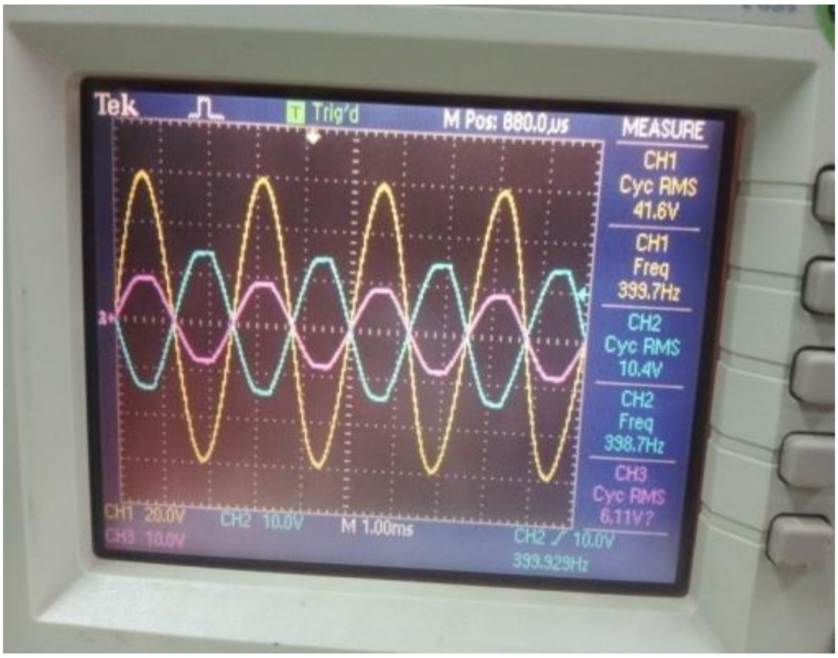


Fig.8.5 Waveform at 30º Pitch

8.3.2 Case2: When Pitch angle is 45º

In this case, we feed Pitch value=45º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1, S3 Sin Winding. In this case, the cosine winding is absent because of Cos 90º=0. Therefore, the voltage across cosine winding is zero.

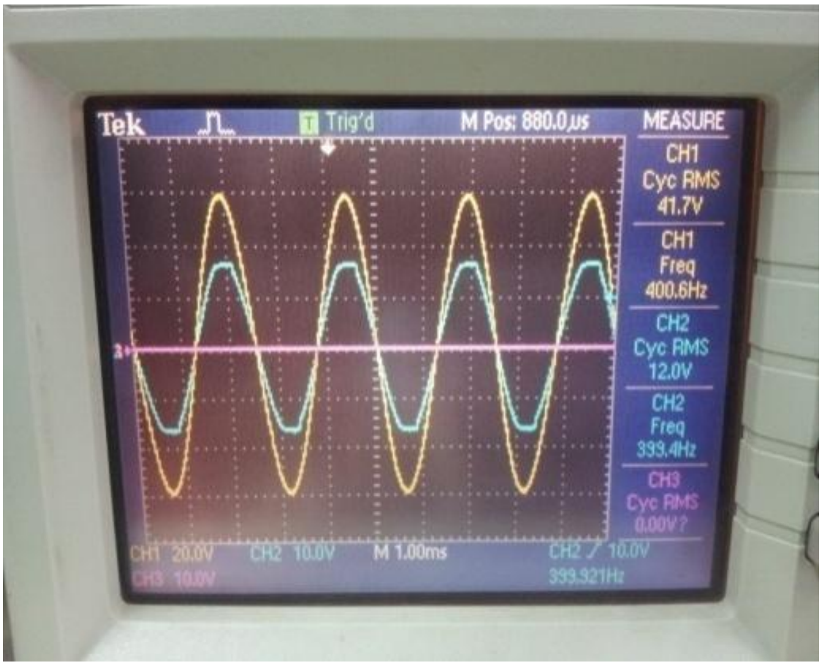


Fig.8.6 Waveform at 45º Pitch

8.3.3 Case3: When Pitch angle is 60º

In this case, we feed Pitch value=60º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2, S4 Cos Winding, S1, S3 Sin Winding

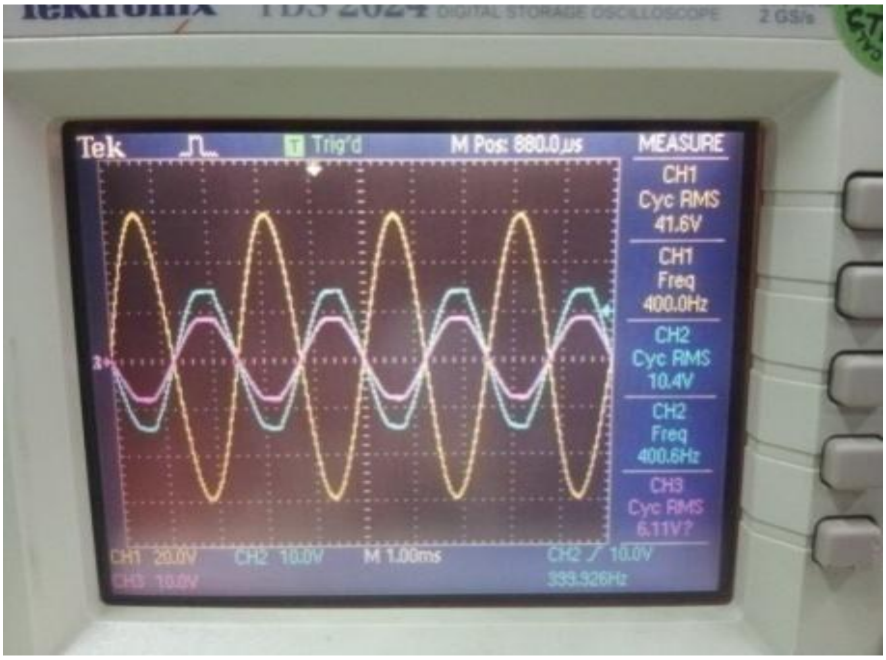


Fig.8.7 Waveform at 60º Pitch

8.3.4 Case4: When Pitch angle is 90º

In this case, we feed Pitch value=90º with the help of Digital Gyro emulator. The emulator will generate a 100Hz, 32 byte packet, and at the output of interface solution we measure the Roll angle value between S2,S4 Cos Winding, S1,S3 Sin Winding Here the blue sin winding is absent because of Sin 2x90º=0. Therefore, the voltage across sine windings is zero.

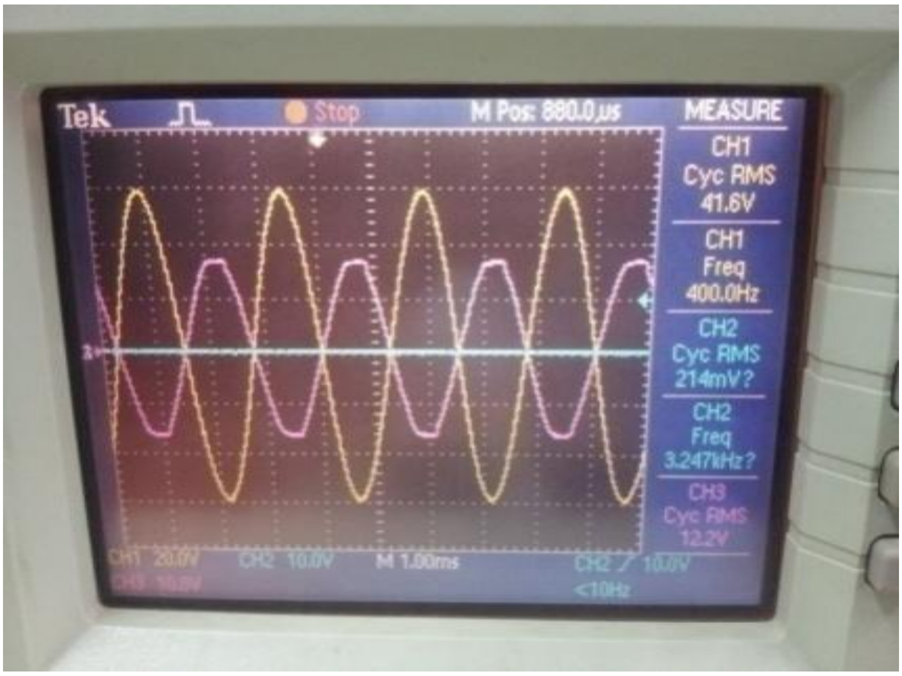


Fig.8.8 Waveform at 90º Pitch

8.4 Roll Angle Measured on API and on Oscilloscope at the Output of Embedded Interfacing Solution

S. No.	Simulated Input Roll Angle	Output Roll Angle on API
i.	0	0
ii.	1	1.94
iii.	5	9.91
iv.	7.5	14.07
v.	10	19.84
vi.	15	29.83
vii.	22.5	44.76
viii.	30	59.83
ix.	45	89.98
x.	60	120.16
xi.	75	150.17
xii.	90	180
xiii.	3.75	7.41
xiv.	1.875	3.69
xv.	-1	358.02
xvi.	-7.5	345.11
xvii.	-11.25	337.63
xviii.	-15	330.13
xix.	-22.5	315.18
xx.	-30	300.13
xxi.	-45	270
xxii.	-60	239.80
xxiii.	-75	209.81
xxiv.	-90	180

Table 8.3 Roll angle measured at the output of Embedded Interfacing Solution.

8.5 Pitch Angle Measured on API and on Oscilloscope at the Output of Embedded Interfacing Solution

S.No.	Simulated Pitch Angle	Output Pitch Angle on API
i.	0	359.98
ii.	1	1.94
iii.	2.813	5.54
iv.	5	9.89
v.	5.625	11.12
vi.	10	19.84
vii.	11.25	22.33
viii.	15	29.81
ix.	22.5	44.80
x.	30	59.82
xi.	45	89.98
xii.	60	120.16
xiii.	75	150.15
xiv.	90	180.00
xv.	-1	358
xvi.	-1.1	357.81
xvii.	-10	340.11
xviii.	-15	330.13
xix.	-22.5	315.15
xx.	-30	300.16
xxi.	-45	269.98
xxii.	-60	239.80
xxiii.	-75	209.78
xxiv.	-90	179.96

Table 8.4 Pitch angle measured at the output of Embedded Interfacing Solution.

CHAPTER-9

Conclusion

An embedded interfacing solution has been designed, developed and tested with the help of simulated Roll and Pitch Angle in serial asynchronous packet, created by COM Port Toolkit application software on Window operating system based PC. The output angles Roll and Pitch have been measured on API (Angle Position Indicator) and Oscilloscope Electronics Instruments. The Roll and Pitch angles values have been found correct with some minute deviation as mentioned in Table-8.3 and Table 8.4 respectively. The output VLL voltages for different angles values for Roll and Pitch have been measured on oscilloscope as mentioned in Table 8.1 and Table 8.2 respectively.

This embedded interfacing solution will allow seamless interfacing of equipment, sensors and weapon systems from diverse origin to work in tandem to enhance operation capability of a marine vessel platform. Here, the major module used for conversion of Serial Asynchronous to Resolver format has 16 bit resolution and ±4minutes accuracy and it can operate from 0 to 70ºC wide temperature range. The Embedded interfacing Solution also could be utilized to interface various Digital and Resolver types of systems and allows distribution of important navigational Roll and Pitch angle parameters to various sink equipments, spread across the platform of the marine vessel.

The embedded solution for serial asynchronous to resolver converter has been designed and developed using digital to resolver converter module of Data Device Corporation (DDC) and whole circuit physically implemented on Printed Circuit Board.

The DDC, CSI and CCC digital to resolver converter modules could not directly accept the angle values in serial asynchronous packet structure format and they need angle values in 16 parallel binary bits by considering full scale value of both angles for 16 bit as 360°. Therefore, this embedded solution designed and developed here, sorted out this problem. It accepts the angle values in serial asynchronous format also. The serial asynchronous packet received from Ring Laser Gyro contains many other parameters at different locations in packet. Therefore, this developed solution extracts the required angle values from specific location of packet and after some internal calculations and processing; it sends the angle value to digital to resolver converter module.

References

[1] R. G. Satheesh and Saraswat, V.K. “Advanced navigation system for aircraft applications”, Def. Sci. J., 2013, 63(2), 131-137. doi: 10.14429/dsj.63.4254.

[2] G. Ashok Kumar, R. Ashish, K. Naveen and R. Ravi, IEEE 2020 “7th International Conference on Signal Processing and Integrated Networks” (SPIN) - Noida, India (2020.2.27-2020.2.28)] “Design and Implementation of High-Speed Universal Asynchronous Receiver and Transmitter (UART), 295–300. doi:10.1109/SPIN48934.2020.9070856.

[3] R. Nishanthan, “A Study of Ring Laser Gyroscopes”, “a thesis submitted in partial fulfillment of the requirements for the degree of master of science”, University of Canterbury, New Zealand.

[4] Del Amo, A., Montero, J., & Gomez, D. (2006). Fuzzy Logic Applications to Fire Control Systems. 2006 IEEE International Conference on Fuzzy Systems. doi:10.1109/fuzzy.2006.1681877.

[5] S. Sheetal and D. Rajeshwar, IEEE 2020 “7th International Conference on Signal Processing and Integrated Networks “ (SPIN) - Noida, India (2020.2.27-2020.2.28)] 2020 “Design & Implementation of Low Power Delta Sigma ADC.” 193–197. doi:10.1109/SPIN48934.2020.9070852.

[6] H. Ngocdung, Jenkins M. and Karangelen N, “Data integration for military systems engineering”.In Proceedings of the IEEE Symposium and Workshop on Engineering of Computer Based Systems, 1996. pp. 11-15. doi:10.1109/ecbs.1996.494504

[7] Texas Instruments datasheet “onAM26LS32AC, AM26LS32AI, AM26LS32AM AM26LS33AC, AM26LS33AM” SLLS115F – October 1980 – Revised September 2016.

[8] Jie Liang and Ran Duan, “Design of the Embedded Serial and Parallel Communication Protocol Controller”, IEEE, pp. 436-439, 2010.

[9] M. Muhammad Ali, Book “8051 Microcontroller and Embedded Systems using assembly and c, second edition”.

[10] Jan Axelson, “Serial Port Complete, 2nd Ed”.

[11] S. Naveen Prakash and Shrotriya S, “Asynchronous Message Transmission Technique for Latency Requirements in Time Critical Ship-borne System”, Defence Science Journal, Vol. 66, No. 1, January 2016, pp. 26-29, DOI : 10.14429/dsj.66.8502 ©2016, DESIDOC.

[12] Datasheet of ©1995, 1999 DDC (Data Device Corporation) module, DSC-11524, 16-Bit Hybrid D/S and D/R converter pin programmable for Synchro or Resolver output.

[13] Bhagiratharao, E. Real time information fusion in military systems. Def. Sci. J., 1990, 40(1), 71-82.

[14] Datasheet of Texas Instruments “LMx24-N, LM2902-N Low-Power, Quad-Operational Amplifiers”, SNOSC16D –March 2000–revised January 2015.

[15] O. Steven and S. Katia, “Augmenting ad hoc networks for data aggregation and dissemination”. In Proceedings of the 28th IEEE Conference on Military Communications, 2009, pp. 2346-2352. doi:10.1109/milcom.2009.5379977.

[16] A. Shubham and Indu S., IEEE 2020 “7th International Conference on Signal Processing and Integrated Networks” (SPIN) - Noida, India (2020.2.27-2020.2.28) “A Low Power and High Speed 8-bit ALU Design using 17T Full Adder.”, 514–519. doi:10.1109/SPIN48934.2020.9070844.

[17] C. Kishor and K. Ashok, “Designing Integration Unit to Integrate Navigational and Tactical Equipment onboard Naval Platforms”. Defence Science Journal, Vol.64, No.5”, September 2014, pp.445-450, DOI:10.14429/dsj.64.5035.

[18] Data Device Corporation “Synchro/Resolver conversion handbook” fourth edition, updated 03/2009, 105 Wilbur Place, Bohemia, New York, USA.

[19] Popa M., Popa A. S., Cretu, V. and Micea M., “Monitoring Serial Communications in Microcontroller Based Embedded Systems”. 2006 International Conference on Computer Engineering and Systems. doi:10.1109/icces.2006.320425.

[20] Yongjian Tang, Lenian He and Xiaolang Yan, “A novel data processing in high speed serial communication”, IEEE, pp. 1228-1231, 2005.

List of Publications of the Candidate's Work

Two Scopus Indexed conference papers have been accepted based on the candidate's work. These are listed below:

1. "Designing of Serial Asynchronous to Analog Resolver Format Converter", Vijendra Kumar Singh, Yashna Sharma, "6th International Conference on Communication and Electronics Systems (ICCES 2021)", Coimbatore, India - 8-10, July 2021.

2. "Interfacing of Digital and Resolver Type Systems for Transmission of Heading Angle", Vijendra Kumar Singh, Yashna Sharma, "8th International Conference on Signal Processing and Integrated Networks (SPIN 2021)", 26-27 August 2021.