A

PROJECT REPORT

On

PID CONTROLLER 96x48

Submitted to

Department of Electronics & Communication Engineering

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Techno India NJR Institute of Technology, Udaipur-313001

Certificate

This is to certify that project work titled "**PID CONTROLLER 96x48**" by **PRATIKSHA SISODIYA** and **MUSKAAN OJHA** was successfully carried out in the Department of Electronics and Communication Engineering, TINJRIT and the report is approved for submission in the partial fulfillment of the requirements for award of degree of Bachelor of Technology in Electronics and Communication.

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Designation:-Manager
Department & Organization :-R&D &
Pyrotech Electronics pvt.ltd.
Date...................

Name of HOD
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Dept. of E.C.E TINJRIT, Udaipur
Date..................25 MAY 2023....

Department of Electronics and Communication Engineering
Techno India NJR Institute of Technology, Udaipur-313001

Examiner Certificate

This is to certify that the following student

PRATIKSHA SISODIA & MUSKAAN OJHA

of final year B.Tech. (Electronics & Communication Engineering), was examined for the project work titled

"PID CONTROLLER 96X48"

during the academic year 2022 – 2023 at Techno India NJR Institute of Technology, Udaipur

Remarks:

Date:25 MAY 2023

Signature
(**Internal Examiner**)
Name :- ………………………
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Department: - ……………….
Organization:- ………………

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(**External Examiner**)
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Department: - ……………….
Organization:- ………………

Preface

PID controllers are found in a wide range of applications for industrial process control. Approximately 95% of the closed-loop operations of the industrial automation sector use PID controllers. PID stands for Proportional-Integral-Derivative. These three controllers are combined in such a way that it produces a control signal. As a feedback controller, it delivers the control output at desired levels. Before microprocessors were invented, PID control was implemented by the analog electronic components. But today all PID controllers are processed by the microprocessors. Programmable logic controllers also have the inbuilt PID controller instructions. Due to the flexibility and reliability of the PID controllers, these are traditionally used in process control applications.

In Chapter 1, we give an overview of the PID CONTROLLERS. Topics include what is PID CONTROLLER , block diagram , applications , working.

Chapter 2 discusses the hardware details of the product. Topics include different IC's used with their specifications.

Chapter 3 presents the software part of the product . Topics include cubesuite+, flash programmmer etc.

Chapter 4. Images of the project .

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR-313001

ACKNOWLEDGMENT

We take this opportunity to record our sincere thanks to all who helped us to successfully complete this work. Firstly, We are grateful to our **supervisor <LALIT SHARMA>** for his invaluable guidance and constant encouragement, support and most importantly for giving us the opportunity to carry out this work.

We would like to express our deepest sense of gratitude and humble regards to our

Head of Department for giving invariable encouragement in our endeavors and providing necessary facility for the same. Also a sincere thanks to all faculty members of ECE, TINJRIT for their help in the project directly or indirectly.

Finally, We would like to thank my friends for their support and discussions that have proved very valuable for us. We are indebted to our parents for providing constant support, love and encouragement. We thank them for the sacrifices they made so that we could grow up in a learning environment. They have always stood by us in everything we have done, providing constant support, encouragement and love

PRATIKSHA SISODIA & 19ETCEC012

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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ABSTRACT

The PID controller is the most common form of comments. It was a fundamental sanction for the first rulers and became the standard instrument when process observation arose in the 1940's. In today's process control, over 95% of PID control loops, most of the loops are actually a PI control. PID controllers are found today in all areas where the control is used. Controls come in different shapes. There are stand-alone systems in boxes for one or a few rings, which are manufactured by hundreds of thousands per year. PID control is an important component of a distributed control system. Control units are also included in many special purpose control systems. PID control is often combined with logical, sequential functions, parameters, and simple function blocks for building complex automation systems used to produce, transmit, and manufacture energy. Many advanced control strategies, such as typical predictive control, are organized hierarchically. PID control is used at the lowest level; The multivariate console gives tuning points for lower level control Thus it can be said that the PID controller is 'bread and butter' of control engineering. It is an important component of every control engineer's toolbox. PID controllers have survived many changes in technology, from mechanics and compressed air to microprocessors via electronic tubes, transistors and integrated circuits. The microprocessor has had a major impact on the PID controller. Practically all PID controllers made today rely on microprocessors. This has provided opportunities to provide additional features such as automatic tuning, gain scheduling, and continuous adjustment.

Conclusion-:The PID controller is the workhorse of modern process control systems. The proportional, integral, and derivative control modes each fulfill a unique function. Proportional and integral control modes are essential for most control loops, while derivative is useful only in some cases.

CHAPTER : 1

PID CONTROLLER

I. INTRODUCTION

PID controllers are found in a wide range of applications for industrial process control. Approximately 95% of the closed-loop operations of the industrial automation sector use PID controllers. PID stands for Proportional-Integral-Derivative. These three controllers are combined in such a way that it produces a control signal. As a feedback controller, it delivers the control output at desired levels. Before microprocessors were invented, PID control was implemented by the analog electronic components. But today all PID controllers are processed by the microprocessors. Programmable logic controllers also have the inbuilt PID controller instructions. Due to the flexibility and reliability of the PID controllers, these are traditionally used in process control applications.

WHAT IS PID CONTROLLER ?

The term PID stands for proportional integral derivative and it is one kind of device used to control different process variables like pressure, flow, temperature, and speed in industrial applications. In this controller, a control loop feedback device is used to regulate all the process variables.

This type of control is used to drive a system in the direction of an objective location otherwise level. It is almost everywhere for temperature control and used in scientific processes, automation & myriad chemical. In this controller, closed-loop feedback is used to maintain the real output from a method like close to the objective otherwise output at the fixe point if possible. In this article, the PID controller design with control modes used in them like P, I & D are discussed.

PID CONTROLLER BLOCK DIAGRAM:-

A closed-loop system like a PID controller includes a feedback control system. This system evaluates the feedback variable using a fixed point to generate an error signal. Based on that, it alters the system output. This procedure will continue till the error reaches Zero otherwise the value of the feedback variable becomes equivalent to a fixed point. This controller provides good results as compared with the ON/OFF type controller. In the ON/OFF type controller, simply two conditions are obtainable to manage the system. Once the process value is lower than the fixed point, then it will turn ON. Similarly, it will turn OFF once the value is higher than a fixed value. The output is not stable in this kind of controller and it will swing frequently in the region of the fixed point. However, this controller is more steady & accurate as compared to the ON/OFF type controller.

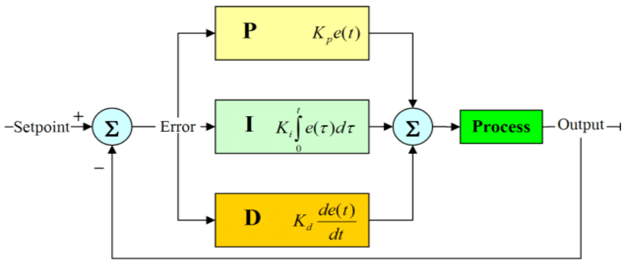


FIG.1.1

APPLICATIONS OF PROJECT:-

- Temperature Control of Furnace
- MPPT Charge Controller
- The Converter of Power Electronics
- Other process variables
- Temperature monitoring
- Industrial controls

WORKING OF PID CONTROLLER:-

With the use of a low cost simple ON-OFF controller, only two control states are possible, like fully ON or fully OFF. It is used for a limited control application where these two control states are enough for the control objective. However oscillating nature of this control limits its usage and hence it is being replaced by PID controllers.

PID controller maintains the output such that there is zero error between the process variable and setpoint/ desired output by closed-loop operations. PID uses three basic control behaviors that are explained below.

P- CONTROLLER

Proportional or P- controller gives an output that is proportional to current error e (t). It compares the desired or set point with the actual value or feedback process value. The resulting error is multiplied with a proportional constant to get the output. If the error value is zero, then this controller output is zero.

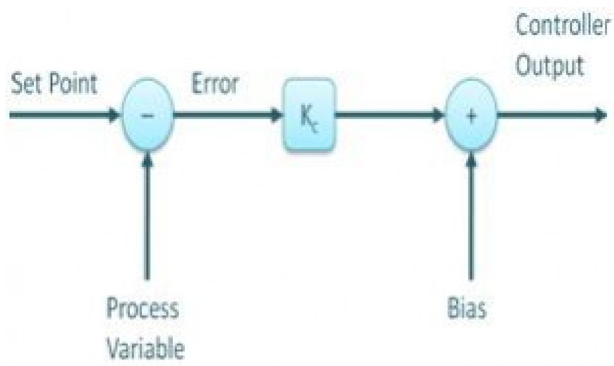


FIG.1.2

This controller requires biasing or manual reset when used alone. This is because it never reaches the steady-state condition. It provides stable operation but always maintains the steady-state error. The speed of the response is increased when the proportional constant Kc increases.

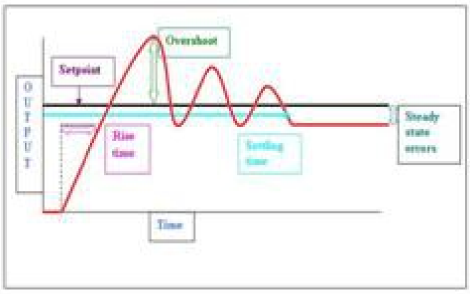


FIG.1.3

I-CONTROLLER

Due to the limitation of p-controller where there always exists an offset between the process variable and setpoint, I-controller is needed, which provides necessary action to eliminate the steady-state error. It integrates the error over a period of time until the error value reaches zero. It holds the value to the final control device at which error becomes zero.

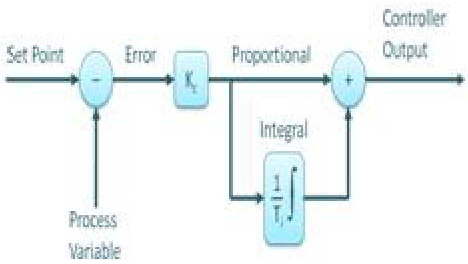


FIG.1.4

PI CONTROLLER

Integral control decreases its output when a negative error takes place. It limits the speed of response and affects the stability of the system. The speed of the response is increased by decreasing integral gain, Ki.

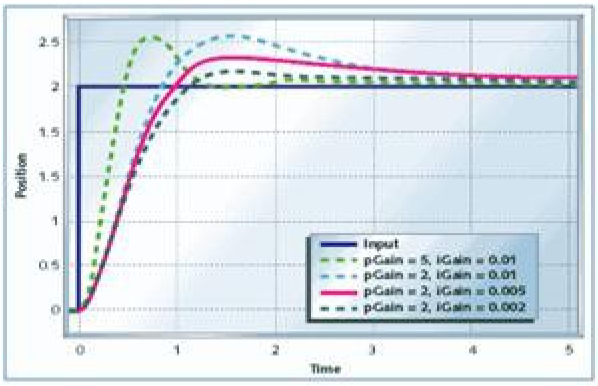


FIG.1.5

PI CONTROLLER RESPONSE

As the gain of the I-controller decreases, the steady-state error also goes on decreasing. For most of the cases, the PI controller is used particularly where the high-speed response is not required.

While using the PI controller, I-controller output is limited to somewhat range to overcome the integral wind up conditions where the integral output goes on increasing even at zero error state, due to nonlinearities in the plant.

D-CONTROLLER

I-controller doesn’t have the capability to predict the future behavior of error. So it reacts normally once the setpoint is changed. D-controller overcomes this problem by anticipating the future behavior of the error. Its output depends on the rate of change of error with respect to time, multiplied by derivative constant. It gives the kick start for the output thereby increasing system response.

PID CONTROLLER

In the above figure response of D, the controller is more, compared to the PI controller, and also settling time of output is decreased. It improves the stability of the system by compensating for phase lag caused by I-controller. Increasing the derivative gain increases the speed of response.

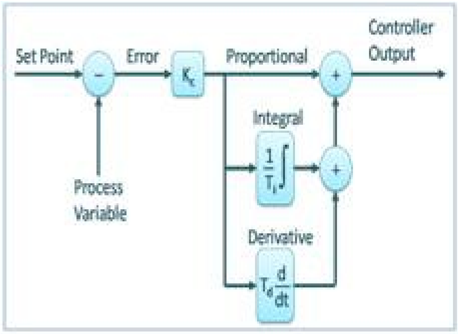


FIG.1.6

PID CONTROLLER RESPONSE

So finally we observed that by combining these three controllers, we can get the desired response for the system. Different manufacturers design different PID algorithms.

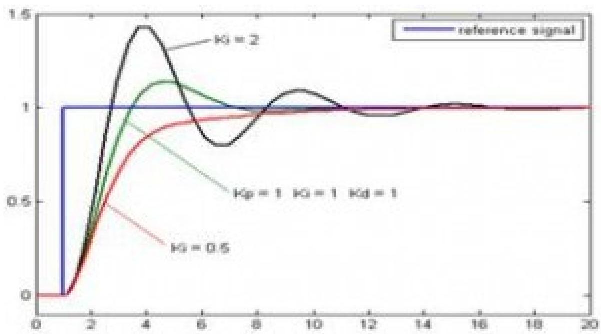


FIG.1.7

OVERVIEW

1) FEATURES:-

- **Universal Input** - 17 user selectable input types including signal inputs.
- **Display -** Dual 4 digit display, upper for process value and lower for set values & manual power value.
- **Input accuracy -** ±0.10% of span ±1digit.

- **Retransmission accuracy -** ±0.50% of span ±1digit .
- **Linearity -** ±0.10% of span ±1digit.
- Individual dead band for each set point.
- Individual delay for each relay.
- Power Consumption <10VA.
- Response time <250ms.
- Decimal point programmable for linear inputs.
- 10C/0.10C Resolution for sensor inputs.

OTHER FEATURES

- Square root, Cut off & range select for linear inputs.
- IO sensor breakdown up/down scale.
- Both software and hardware watchdog reset.
- Operating power supply as 90-270VAC/VDC.
- Auto/manual mode
- Heat/cool mode PID, ON-OFF control
- 4800/9600/14400 bps baud rate programmable

OPTIONAL FEATURES

- 4-20mA/1-5VDC Retransmission Output.
- RS232/RS485 Modbus Communication.
- +24/48VDC Power Supply.
- +24VDC Auxiliary output supply (Not in RTD input)

- Selectable re-transmission output for process
- value, control value & set value.

2) ORDERING INFORMATION:-

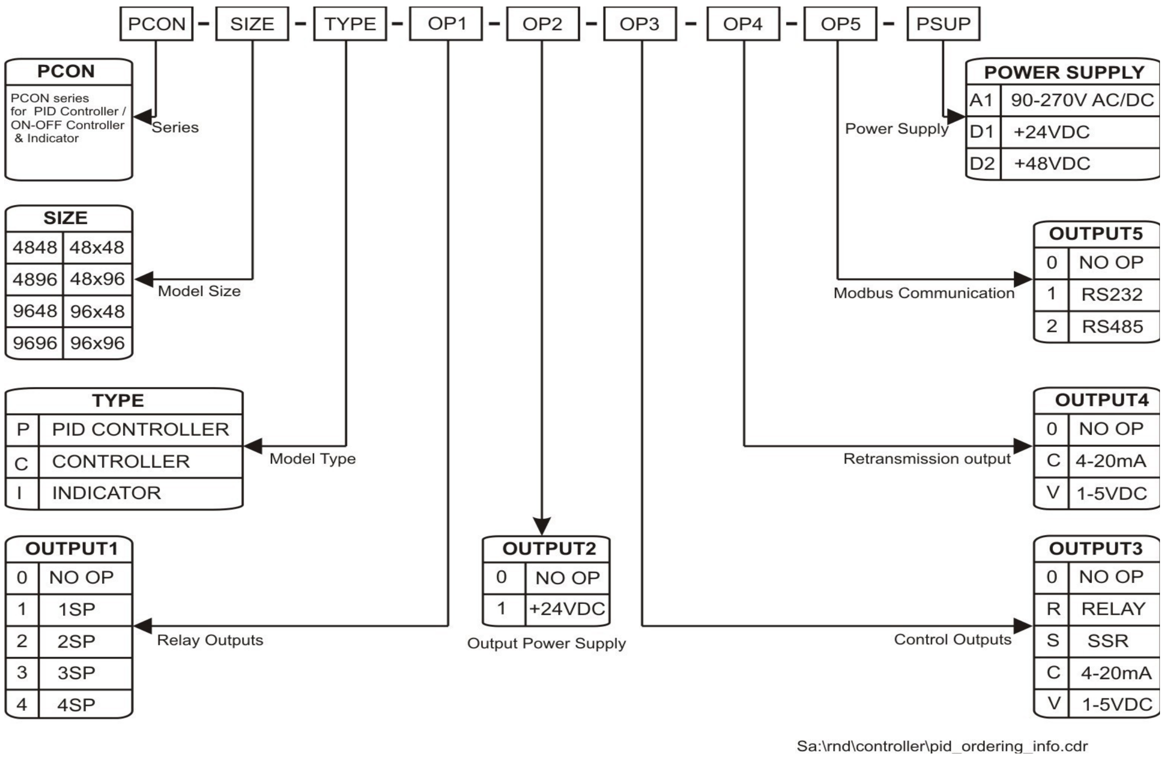


FIG.1.8

3) ORDERING EXAMPLE:- PCON-9696-P21-SM2A1

Note : 1) Input is user selectable.

2) Only output needs to be specified in the ordering code.

code	Deatail about code	Example code	Notes: For any type
PCON	SERIES		1. Output1 = 4SP Invalid for PID type.
9696	Size	96x96mm	
C	Type	PID controller	2. Output1>=3SP Invalid for PID type 48x48 size.
2	No. of set point	2 set points	
1	Output power supply	+24vdc output	3. Output1 & Output3

0	Control outputs	No output	Invalid for Indicator Type..
C	Retransmission output	4-20mA	4. Output2 Invalid for RTD(Pt-100) 3wire input for 96x96, 96x48, 48x96 sizes. 5. Output3 Invalid for Controller Type. 6. Output5=RS232 Invalid for 48x48 size.
2	Modbus commmunication	RS485	
A1	Input power supply	90-270V AC/DC	

INPUT/OUTPUT

Input

T/C : J,K,E,N,R,S,T,B

- RTD : Pt–100
- Resistance : 0-300
- mA : 0-20mA,4-20mA
- Volt : 0-10V, 1-10V, 0-5V, 1-5V
- mV : -10 to +50mV
- For Input Type Range
- J : -120 to 920 °C.
- K : -180 to 1300 °C.
- E : -120 to 700 °C.
- N : -200 to 1300 °C.

- R/S : 0 to 1760 °C.
- T : -200 to 400 °C
- B : 100 to 1800 °C.
- RTD : -150 to 850 °C.
- Linear Inputs : -1999 to 9999.(Display Range)
- **Display** :
  - 4 digit 7 Segment **Red** display for Process Value.
  - 4 digit 7 Segment **Green** display for Set Value.[1]
  - Individual **Red** LED to indicate relay status & control outputs.[1]
- OUTPUT :
  - Up to 4 set point with individual Relay output.[1](Rated for 5A/250VAC)
  - SSR/Relay/4-20mA/1-5VDC Control Output.[2]
  - Retransmission O/P 4-20 mA DC optional (Max load 500E).
  - Retransmission O/P 1-5 Volt DC optional (Min load 10K).
  - RS232/RS485 (RTU) Modbus Communication (Optional).[3]
  - +24VDC/40mA Auxiliary Supply (Optional).()
- CONTROLS : Mode, Up, Down, Exit keys for operation programming & calibration.

GENERAL SPECIFICATIONS

- ACJC : Inbuilt & Automatic for T/C I/P
- Calibration : Through Software.
- Hysteresis for each : 0.0 to 500.0 °C.

<10VA

Relay (Set Point) Power consumption

- Proportional band(2)
- Integral Time(2)
- Derivative time(2)
- Cycle Time(2)
- Control Algorithm(2)
- Range Select(4)
- CUT OFF(4)
- Digital Filter Level(4)
- Square Root(4)

: 1-999.9 °C

: 1-9999 second.

: 1-9999 second.

: 100ms to 60second.

: ON-OFF, PID.

: Forward/Reverse.

: OFF(0), 1 to 5.

: OFF(0), 1 to 5.

: No/Yes.

: Up Scale/Down Scale.

:

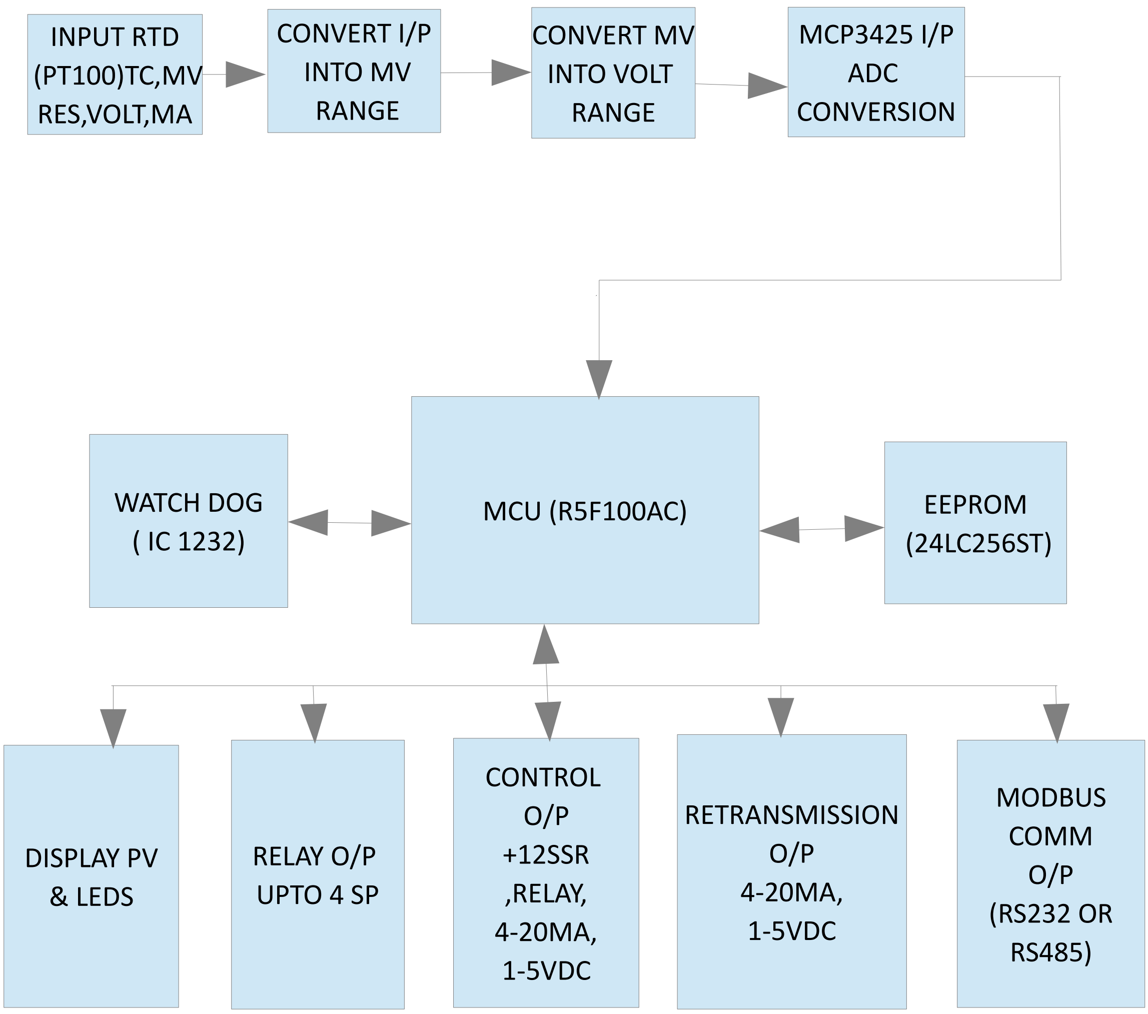
- Sensor open
- Input Accuracy : 0.1% of Span ±1 digit.
    - Analog o/p Accuracy : 0.5% of Span ±1 digit.

      : Up scale/Down scale
- Analog o/p Scaling
- Resolution (0.1°C for Limited Range, -199.9 to 999.9°C max.) : II. 0.1/1°C for Sensor Inputs.

  III.1/0.1/0.01/0.001 for Linear Inputs.

• Response time	:	Within 500ms.
• Insulation Strength or Isolation breakdown	:	1) All Relay outputs w.r.t. all inputs & primary at 2KVAC. 2) All inputs w.r.t. Primary inputs & outputs at 1KVAC.
• Watchdog timer	:	Both H/W & S/W provided.

HARDWARE BLOCK DIAGRAM
96x48 CONTROLLER



CHAPTER:-2

PID CONTROLLER HARDWARE

1. MICROCONTROLLER: R5F100AC (RL78/G13)

Ultra-low power consumption technology VDD = single power supply voltage of 1.6 to 5.5 V HALT mode STOP mode SNOOZE mode	**DMA (Direct Memory Access) controller** 2/4 channels Number of clocks during transfer between 8/16-bit SFR and internal RAM: 2 clocks
RL78 CPU core CISC architecture with 3-stage pipeline Minimum instruction execution time: Can be changed from high speed (0.03125 μs: @ 32 MHz operation with high-speed on-chip oscillator) to ultra-low speed (30.5 μs: @ 32.768 kHz operation with subsystem clock) Address space: 1 MB General-purpose registers: (8-bit register × 8) × 4	**Multiplier and divider/multiply-accumulator** 16 bits × 16 bits = 32 bits (Unsigned or signed) 32 bits ÷ 32 bits = 32 bits (Unsigned) 16 bits × 16 bits + 32 bits = 32 bits (Unsigned or signed)

banks On-chip RAM: 2 to 32 KB	
Code flash memory Code flash memory: 16 to 512 KB Block size: 1 KB Prohibition of block erase and rewriting (security function) On-chip debug function Self-programming (with boot swap function/flash shield window function)	**Serial interface** CSI: 2 to 8 channels UART/UART (LIN-bus supported): 2 to 4 channels I2C/Simplified I2C communication: 2 to 8 channels
Data Flash Memory Data flash memory: 4 KB to 8 KB Back ground operation (BGO): Instructions can be executed from the program memory while rewriting the data flash memory. Number of rewrites: 1,000,000 times (TYP.) Voltage of rewrites: VDD = 1.8 to 5.5 V	**Timer** 16-bit timer: 8 to 16 channels 12-bit interval timer: 1 channel Real-time clock: 1 channel (calendar for 99 years, alarm function, and clock correction function) Watchdog timer: 1 channel (operable with the dedicated low-speed on-chip oscillator)
High-speed on-chip oscillator	**A/D converter**

Select from 32 MHz, 24 MHz, 16 MHz, 12 MHz, 8 MHz, 6 MHz, 4 MHz, 3 MHz, 2 MHz, and 1 MHz High accuracy: +/- 1.0 % (VDD = 1.8 to 5.5 V, TA = -20 to +85°C)	8/10-bit resolution A/D converter (VDD = 1.6 to 5.5 V) Analog input: 6 to 26 channels Internal reference voltage (1.45 V) and temperature sensor
Operating ambient temperature TA = -40 to +85°C (A: Consumer applications, D: Industrial applications) TA = -40 to +105°C (G: Industrial applications)	**I/O port** I/O port: 16 to 120 (N-ch open drain I/O [withstand voltage of 6 V]: 0 to 4, N-ch open drain I/O [VDD withstand voltage Note 2/EVDD withstand voltage Note 3]: 5 to 25) Can be set to N-ch open drain, TTL input buffer, and on-chip pull-up resistor Different potential interface: Can connect to a 1.8/2.5/3 V device On-chip key interrupt function On-chip clock output/buzzer output controller
Power management and reset function	**Others** On-chip BCD (binary-coded decimal)

On-chip power-on-reset (POR) circuit On-chip voltage detector (LVD) (Select interrupt and reset from 14 levels)	correction circuit

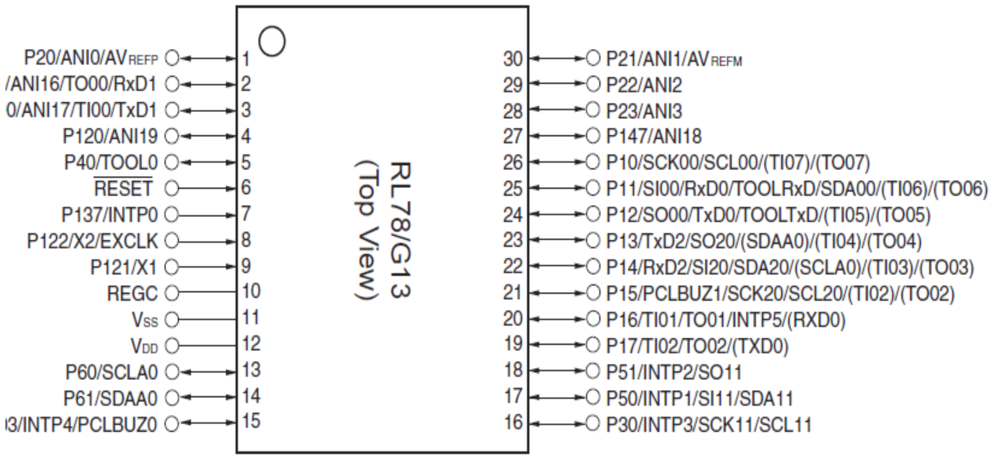


FIG.2.2

2.EEPROM : IC 24LC256ST

256K I2C™ CMOS Serial EEPROM

FEATURES:

• Low-power CMOS technology:

- Maximum write current 3 mA at 5.5V

- Maximum read current 400 μA at 5.5V

- Standby current 100 nA, typical at 5.5V

• 2-wire serial interface bus, I2C™ compatible

- Cascadable for up to eight devices
- Self-timed erase/write cycle
- 64-byte Page Write mode available
- 5 ms max. write cycle time
- Hardware write-protect for entire array
- Output slope control to eliminate ground bounce
- Schmitt Trigger inputs for noise suppression
- 1,000,000 erase/write cycles
- Electrostatic discharge protection > 4000V
- Data retention > 200 years
- 8-pin TSSOP
- Pb-free finishes available
- Temperature ranges:

- Industrial (I): -40°C to +85°C
    - Automotive (E): -40°C to +125°C

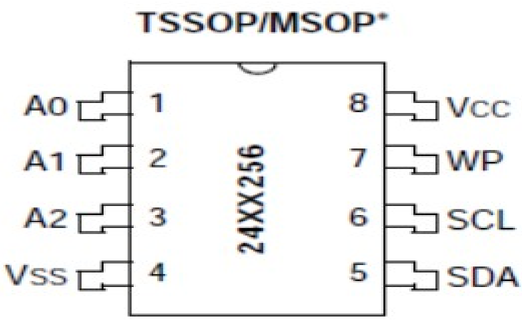


FIG.2.3

3. DISPLAY

1) **74LS145 IC** :- 1-of-10 decoder /driver open – collector

The SN74LS145, 1-of-10 Decoder/Driver, is designed to accept BCD inputs and provide appropriate outputs to drive 10-digit incandescent displays. All outputs remain off for all invalid binary input conditions. It is designed for use as indicator/relay drivers or as an open-collector logic circuit driver. Each of the high breakdown output transistors will sink up to 80 mA of current. Typical power dissipation is 35 mW. This device is fully compatible with all TTL families.

• Low Power Version of 74145

• Input Clamp Diodes Limit High Speed Termination Effects

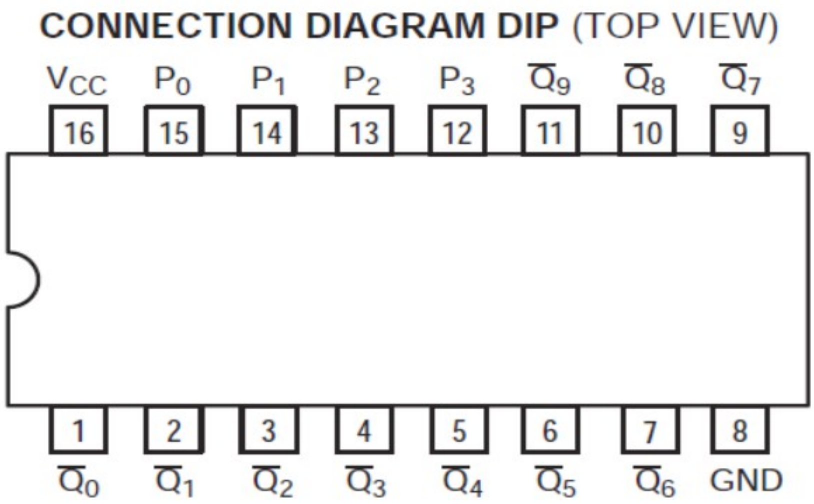


FIG.2.4

2) **74HC164 :-** 8-Bit Serial-in/Parallel-out Shift Register

- Typical operating frequency: 50 MHz
- Typical propagation delay: 19 ns (clock to Q)
- Wide operating supply voltage range: 2–6V
- Low input current: 1 mA maximum
- Low quiescent supply current: 80 mA maximum (74HC Series)
- Fanout of 10 LS-TTL loads

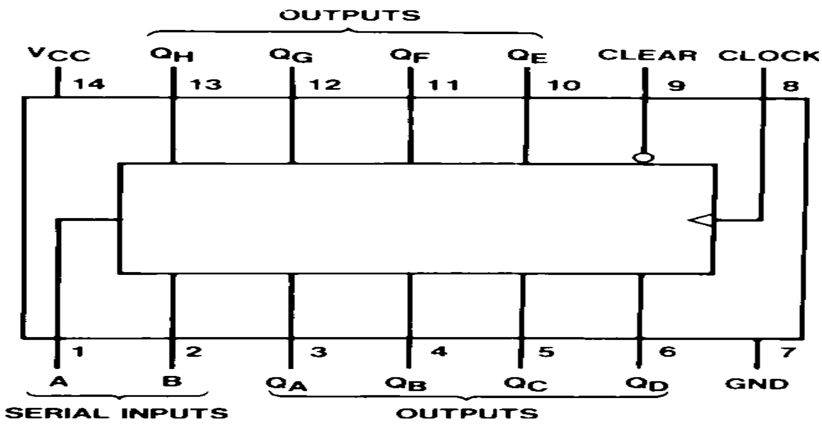


FIG.2.5

4.XRD5408/10/12

- 5V, Low Power, Voltage Output
- Serial 8/10/12-Bit DAC Family

FEATURES

- 8/10/12-Bit Resolution
- Operates from a Single 5V Supply
- Buffered Voltage Output: 13ms Typical Settling Time
- 240mW Total Power Consumption (typ)
- Guaranteed Monotonic Over Temperature
- Flexible Output Range: 0V to VDD

- 8 Lead SOIC and PDIP Package
- Power On Reset
- Serial Data Output for Daisy Chaining

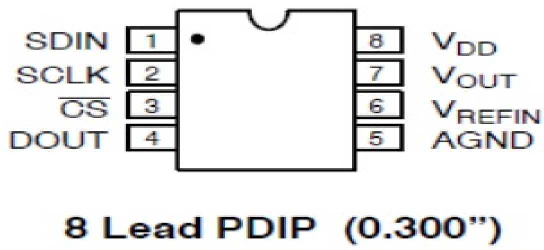


FIG.2.6

5.HEF4051B MSI

8-CHANNEL ANALOGUE MULTIPLEXER/DEMULTIPLEXER

FIG.2.7

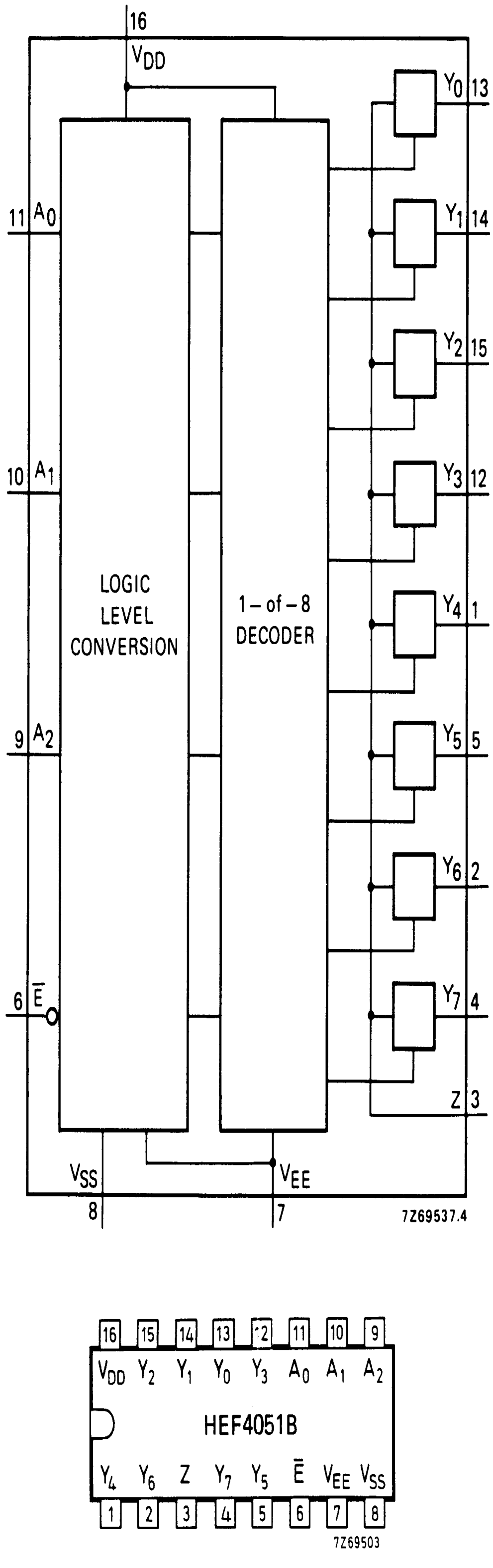

16
V_{DD}
11 A_0
10 A_1
9 A_2
6 $\bar{E}$
LOGIC
LEVEL
CONVERSION
1 – of – 8
DECODER
Y_0 13
Y_1 14
Y_2 15
Y_3 12
Y_4 1
Y_5 5
Y_6 2
Y_7 4
Z 3
V_{SS} 8
V_{EE} 7
7Z69537.4
16 15 14 13 12 11 10 9
V_{DD} Y_2 Y_1 Y_0 Y_3 A_0 A_1 A_2
HEF4051B
Y_4 Y_6 Z Y_7 Y_5 $\bar{E}$ V_{EE} V_{SS}
1 2 3 4 5 6 7 8
7Z69503

FIG.2.8

6.MCP3425

- 16-Bit Analog-to-Digital Converter
- with I2C Interface and On-Board Reference

FEATURES

• 16-bit ΔΣ ADC in a SOT-23-6 package

• Differential Input Operation

• Self Calibration of Internal Offset and Gain per

each conversion

• On-Board Voltage Reference:

- Accuracy: 2.048V ± 0.05%

• On-Board Programmable Gain Amplifier (PGA):

- Gains of 1, 2, 4 or 8

• On-Board Oscillator

• INL: 10 ppm of FSR (FSR = 4.096V/PGA)

• Programmable Data Rate Options:

- 15 SPS (16 bits)

- 60 SPS (14 bits)

- 240 SPS (12 bits)

• One-Shot or Continuous Conversion Options

• Low Current Consumption:

- 145 µA typical

(VDD= 3V, Continuous Conversion)

• One-Shot Conversion (1 SPS) with VDD = 3V:

- 9.7 µA typical with 16 bit mode

- 2.4 µA typical with 14 bit mode

- 0.6 µA typical with 12 bit mode

• Supports I2C Serial Interface:

- Standard, Fast and High-Speed Modes

• Single Supply Operation: 2.7V to 5.5V

• Extended Temperature Range: -40°C to 125°C

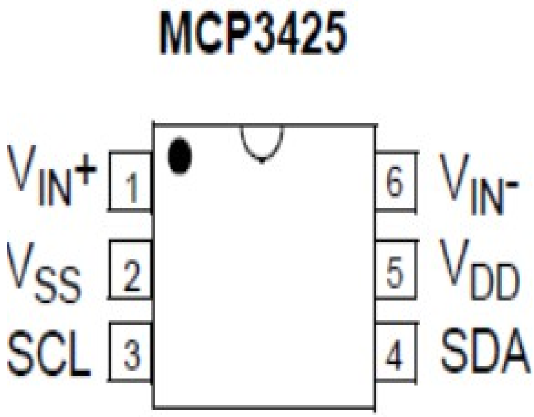


FIG.2.9

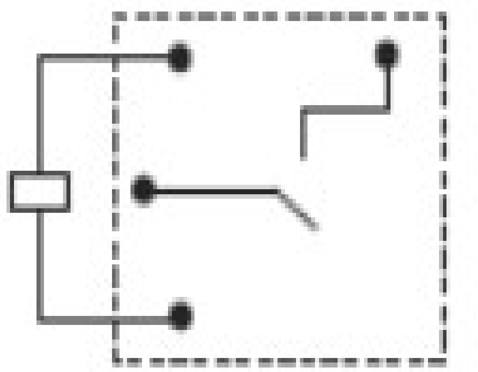
7.HF3FA

SUBMINIATURE HIGH POWER RELAY

FEATURES

- 15A switching capability
- Flammability class according to UL94,V-0
- CTI 250 available

- Product in accordance to IEC 60335-1 available
- 1Form A and 1Form C configuration
- Subminiature ,standard PCB layout
- UL insulation system: Class F
- Enviromental friendly product(RoHs compliant)
- outline dimensions:(19.0 x15.5x15.5)mm



WIRING DIAGRAM

FIG.2.10

CHAPTER : 3

PID CONTROLLER SOFTWARE

Now a days Renesas RL78 is becoming popular , and is being used by many known companies and is also a perfect microcontroller to make a strong base to understand theembedded programming concepts .It is helping the geeks to explore the power of microcontroller to do anything with a tiny black box packed in an inch sized chip .

FEATURES-

- Ultra-low power consumption technology
- VDD = single power s7upply voltage of 1.8 to 5.5 V which can operate at a low voltage
- HALT mode , STOP mode ,SNOOZE mode

RL78 CPU CORE

• CISC architecture with 3-stage pipeline

• Minimum instruction execution time: Can be changed from high speed (0.04167 ms: @ 24 MHz operation with high-speed on-chip oscillator) to ultra-low speed (1 ms: @ 1 MHz operation)

• Address space: 1 MB

• General-purpose registers: (8-bit register x 8) x 4 banks

• On-chip RAM: 256 B to 2 KB

CODE FLASH MEMORY

• Code flash memory: 2 to 16 KB

• Block size: 1 KB

• Prohibition of block erase and rewriting (security function)

• On-chip debug function

• Self-programming (with flash shieldwindow function)

DATA FLASH MEMORY

• Data flash memory: 2 KB

• Back ground operation (BGO): Instructions are executed from the program memory while rewriting the data flash memory.

• Number of rewrites: 1,000,000 times (TYP.)

• Voltage of rewrites: VDD = 1.8 to 5.5 V

HIGH-SPEED ON-CHIP OSCILLATOR

• Select from 24 MHz, 16 MHz, 12 MHz, 8 MHz, 6 MHz, 4 MHz, 3 MHz, 2 MHz, and 1 MHz

•High accuracy: +/- 1.0 % (VDD = 1.8 to 5.5 V, TA = -20 to +85 °C)

OPERATING AMBIENT TEMPERATURE

• TA = -40 to +85 °C (A: Consumer applications, D: Industrial applications)

• TA = -40 to +105 °C (G: Industrial applications)

POWER MANAGEMENT AND RESET FUNCTION

• On-chip power-on-reset (POR) circuit

• On-chip voltage detector (LVD) (Select interrupt and reset from 12 levels)

DMA (DIRECT MEMORY ACCESS) CONTROLLER

• 2 channels

• Number of clocks during transfer between 8/16-bit SFR and internal RAM: 2 clocks Multiplier and divider/multiply-accumulator

• 16 bits x 16 bits = 32 bits (Unsigned or signed)

• 32 bits x 32 bits = 32 bits (Unsigned)

• 16 bits x 16 bits + 32 bits = 32 bits (Unsigned or signed)

SERIAL INTERFACES

• CSI : 1 to 3 channels

• UART : 1 to 3 channels

• Simplified I2C communication : 0 to 3 channel

• I2C communication : 1 channel

TIMERS

• 16-bit timer : 4 to 8 channels

• 12-bit interval timer : 1 channel

WATCHDOG TIMER :1 channel (operable with the dedicated low-speed on-chip oscillator)

A/D CONVERTER

• 8/10-bit resolution A/D converter (VDD = 1.8 to 5.5 V)

• 8 to 11 channels, internal reference voltage (1.45 V), and temperature sensor

I/O PORTS

• I/O port: 18 to 26 (N-ch open drain I/O [withstand voltage of 6 V]: 2, N-ch open drain I/O

[VDD withstand voltage]: 4 to 9)

• Can be set to N-ch open drain, TTL input buffer, and on-chip pull-up resistor

• Different potential interface: Can connect to a 1.8/2.5/3 V device

•On-chip key interrupt function

• On-chip clock output/buzzer output controller

Others

• On-chip BCD (binary-coded decimal) correction circuit

Different version of RL78 are categorized on the below criteria

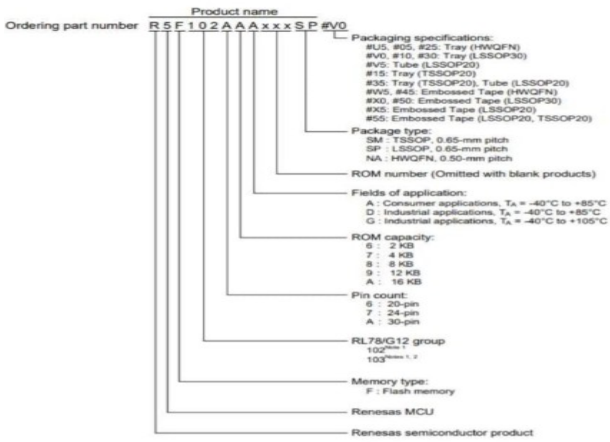


FIG.3.1

30 PIN PRODUCT :- 30-pin plastic LSSOP (7.62 mm (300), 0.65 mm pitch)

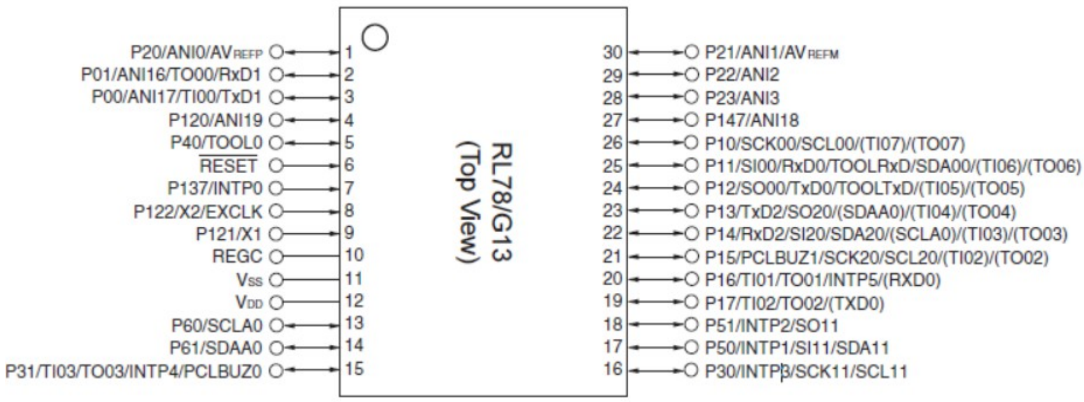


FIG.3.2

PIN IDENTIFICATION

- ✔ ANI0 to ANI14,
- ✔ ANI16 to ANI26: Analog input
- ✔ AVREFM: A/D converter reference

- ✔ potential (- side) input
- ✔ AVREFP: A/D converter reference
- ✔ potential (+ side) input
- ✔ EVDD0, EVDD1: Power supply for port
- ✔ EVSS0, EVSS1: Ground for port
- ✔ EXCLK: External clock input (Main
- ✔ system clock)
- ✔ EXCLKS: External clock input
- ✔ (Subsystem clock)
- ✔ INTP0 to INTP11: Interrupt request from
- ✔ peripheral
- ✔ KR0 to KR7: Key return
- ✔ P00 to P07: Port 0
- ✔ P10 to P17: Port 1
- ✔ P20 to P27: Port 2
- ✔ P30 to P37: Port 3
- ✔ P40 to P47: Port 4
- ✔ P50 to P57: Port 5
- ✔ P60 to P67: Port 6
- ✔ P70 to P77: Port 7
- ✔ P80 to P87: Port 8
- ✔ P90 to P97: Port 9
- ✔ P100 to P106: Port 10
- ✔ P110 to P117: Port 11
- ✔ P120 to P127: Port 12
- ✔ P130, P137: Port 13
- ✔ P140 to P147: Port 14
- ✔ P150 to P156: Port 15
- ✔ PCLBUZ0, PCLBUZ1: Programmable clock

- ✔ output/buzzer output
- ✔
- ✔ REGC: Regulator capacitance
- ✔ RESET: Reset
- ✔ RTC1HZ: Real-time clock correction clock
- ✔ (1 Hz) output
- ✔ RxD0 to RxD3: Receive data
- ✔ SCK00, SCK01, SCK10,
- ✔ SCK11, SCK20, SCK21,
- ✔ SCLA0, SCLA1: Serial clock input/output
- ✔ SCLA0, SCLA1, SCL00,
- ✔ SCL01, SCL10, SCL11,
- ✔ SCL20,SCL21, SCL30,
- ✔ SCL31: Serial clock output
- ✔ SDAA0, SDAA1, SDA00,
- ✔ SDA01,SDA10, SDA11,
- ✔ SDA20,SDA21, SDA30,
- ✔ SDA31: Serial data input/output
- ✔ SI00, SI01, SI10, SI11,
- ✔ SI20, SI21, SI30, SI31: Serial data input
- ✔ SO00, SO01, SO10,
- ✔ SO11, SO20, SO21,
- ✔ SO30, SO31: Serial data output
- ✔ TI00 to TI07,
- ✔ TI10 to TI17: Timer input
- ✔ TO00 to TO07,
- ✔ TO10 to TO17: Timer output
- ✔ TOOL0: Data input/output for tool
- ✔ TOOLRxD, TOOLTxD: Data input/output for external device

- ✔ TxD0 to TxD3: Transmit data
- ✔ VDD: Power supply
- ✔ VSS: Ground
- ✔ X1, X2: Crystal oscillator (main system clock)
- ✔ XT1, XT2: Crystal oscillator (subsystem clock)

INTRODUCTION TO CUBSUITE +

PROCESS DESCRIPTION : The process of whole software system proposed , to be developed, will ne as follows:

1. OPENING THE CUBESUITE+ :- This software must be intsalled in the computer of the user.The name of project should be copied in a suitable folder on user's PC.

2.LOADING THE SELECTED CODE PROJECT :-Select the project which ciontains the source files for the specific [eriphal sample code.Once the workspace is loaded into CS+ forCC the required sample project must be loaded before you can be open the source files:

From the menu the bar select Project>open Project....

CS+ for cc will open a dialog.Navigate to the unzipped CS folder.

A progress Status dialod will appear briefly whislist CS+ for CC loads the project.

3.OPENING CODE SOURCE FILES :- Once the project has been opened,the source code and all dependent files can be opened in editor by expanding the folders in the project tree window and diuble checking the files listedd, All fuiles have been grouped according to their file type.

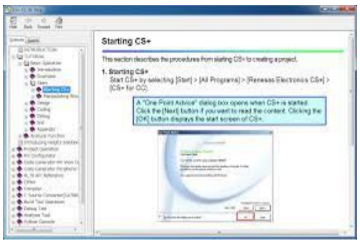


FIG.3.3

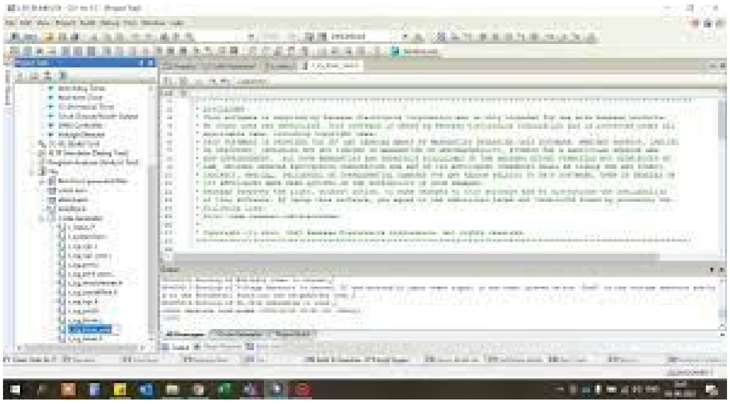
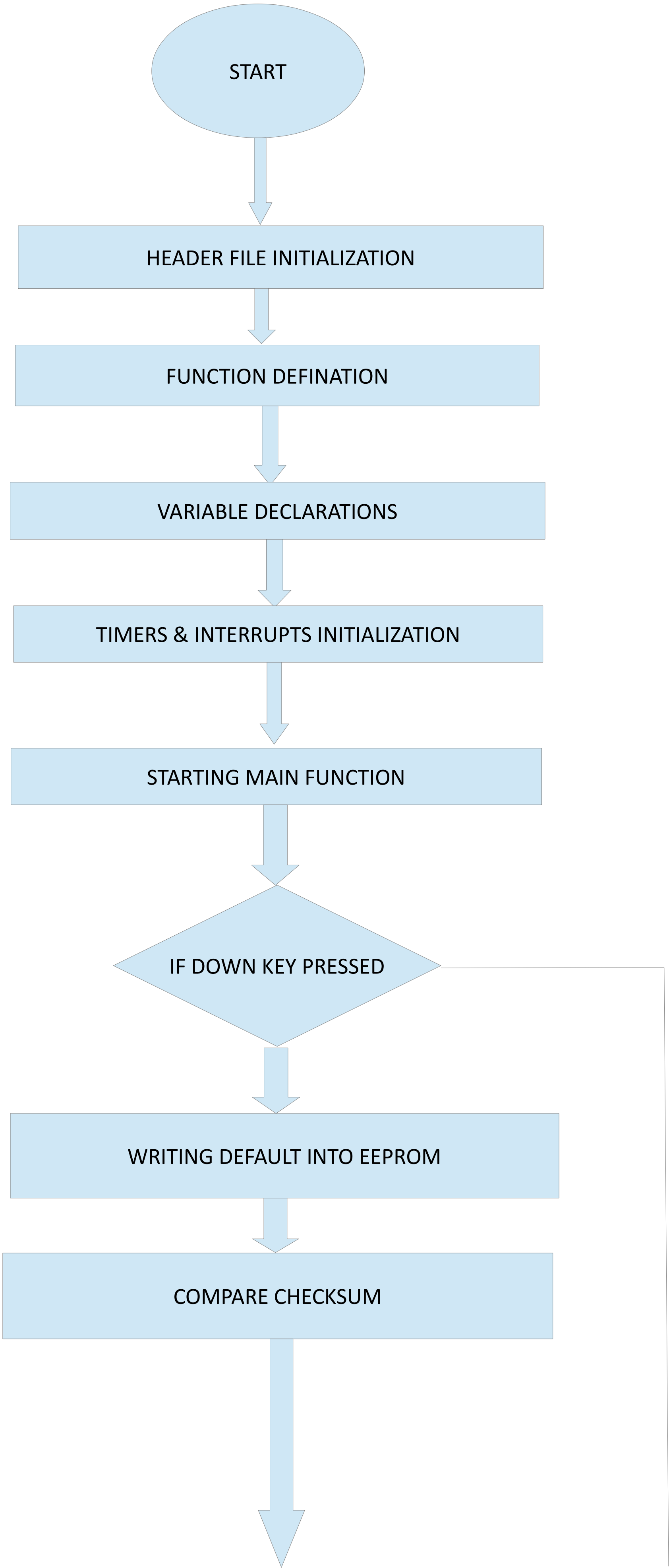
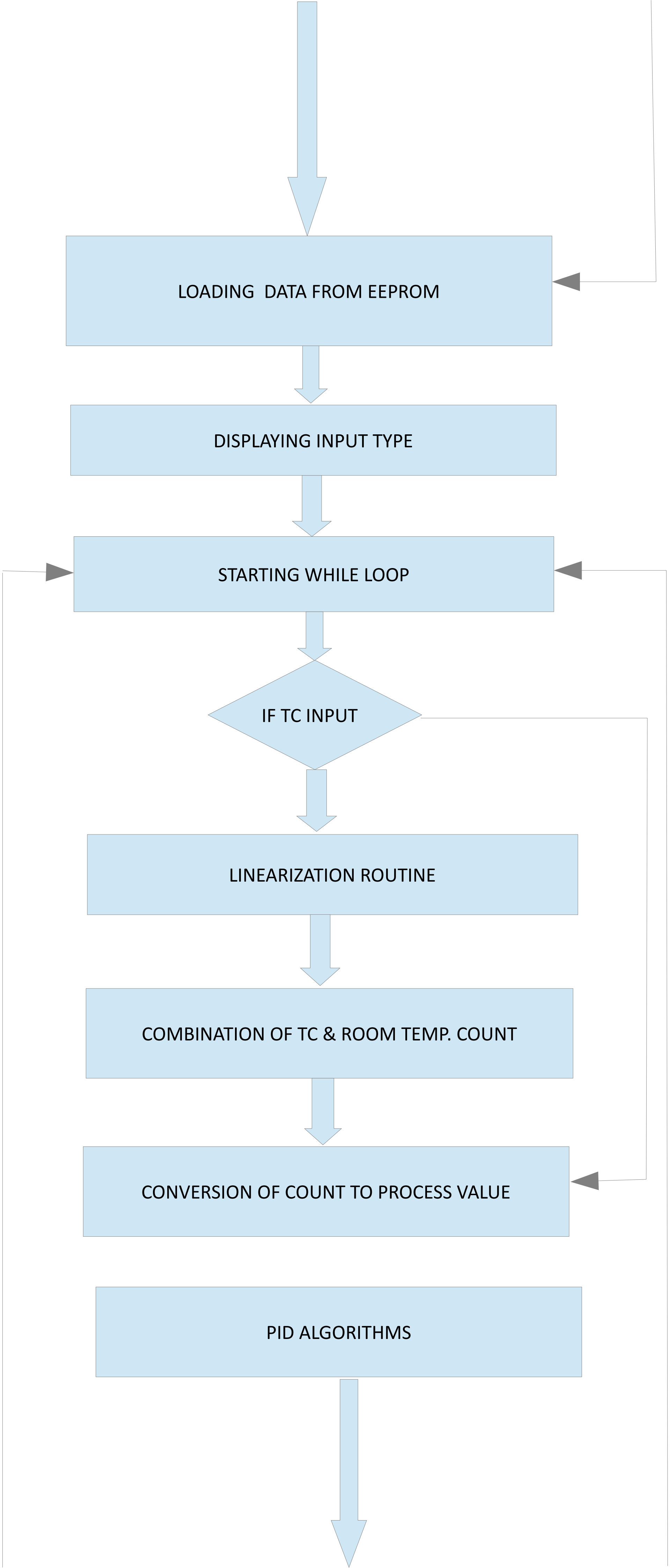


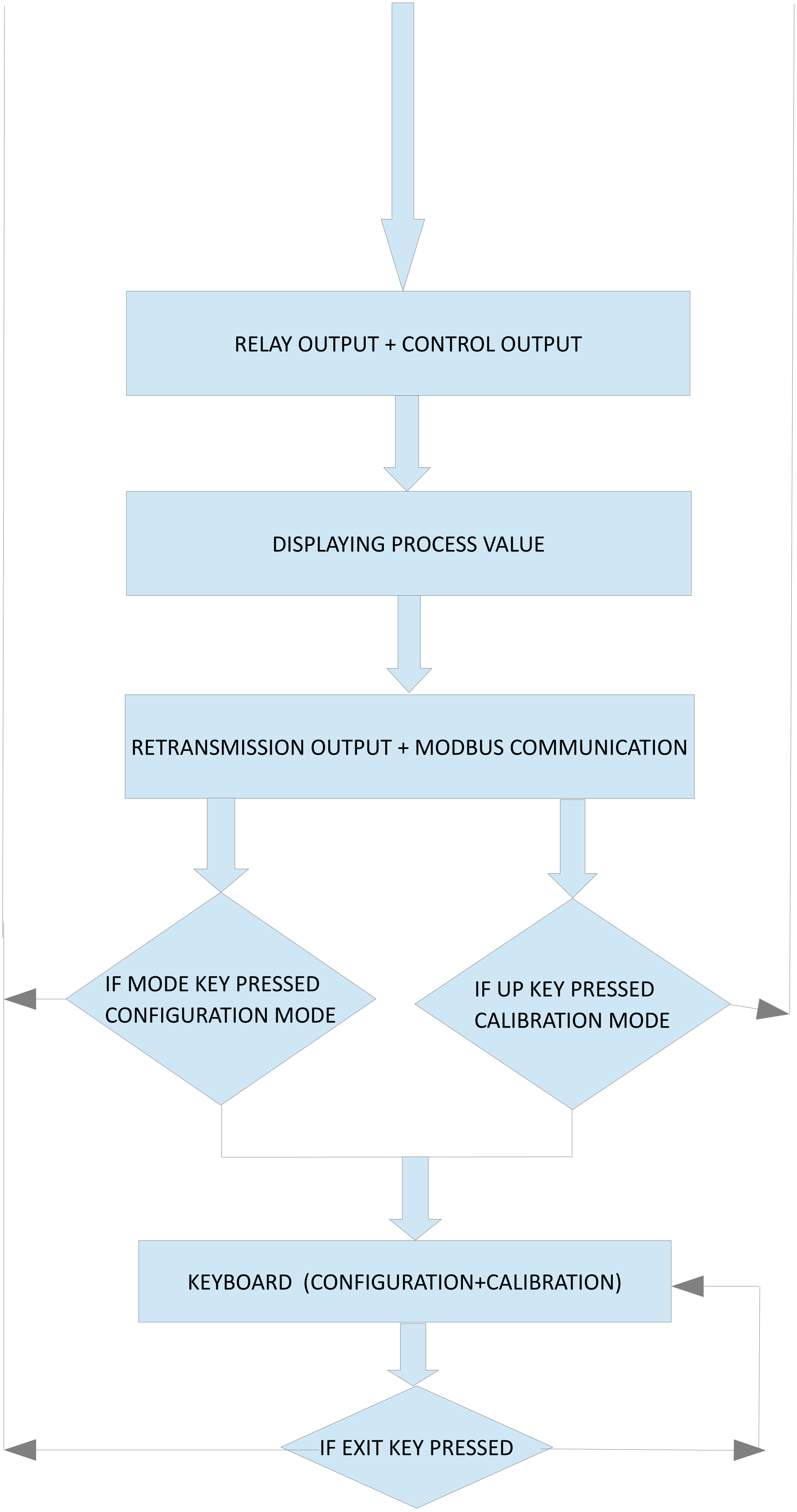
FIG.3.4

4.SOURCE CODE FUNCTION :- Each source codeproject is specifically written to run. Each project will contain a C source file that includes”r_main.c” in the name, for example”r_main.c”.This source file includes the C function main().All source files and dependent files whose filenames are prefixed with 'r_' were generated using Code Generator.

SOFTWARE LOGIC DEVELOPMENT FLOW CHART




LOADING DATA FROM EEPROM
DISPLAYING INPUT TYPE
STARTING WHILE LOOP
IF TC INPUT
LINEARIZATION ROUTINE
COMBINATION OF TC & ROOM TEMP. COUNT
CONVERSION OF COUNT TO PROCESS VALUE
PID ALGORITHMS


RELAY OUTPUT + CONTROL OUTPUT
DISPLAYING PROCESS VALUE
RETRANSMISSION OUTPUT + MODBUS COMMUNICATION
IF MODE KEY PRESSED
CONFIGURATION MODE
IF UP KEY PRESSED
CALIBRATION MODE
KEYBOARD (CONFIGURATION+CALIBRATION)
IF EXIT KEY PRESSED

KEYBOARD FLOWCHART

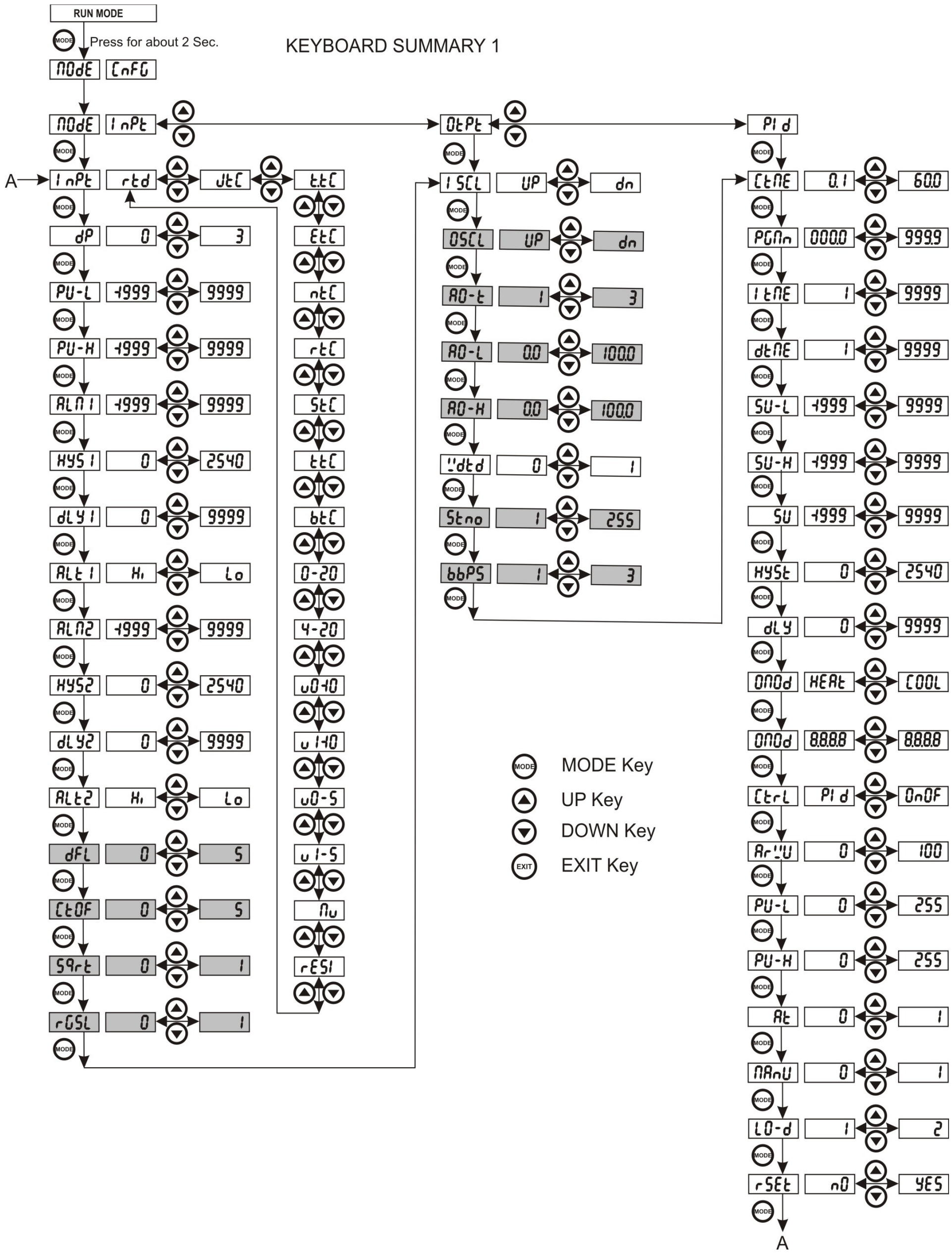
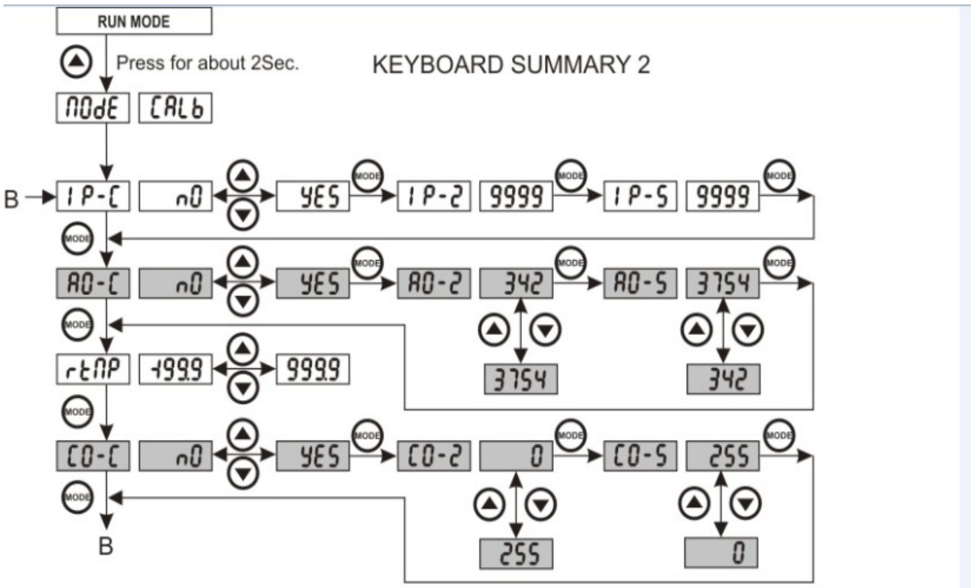


FIG.3.6



Note1:- At any time exit from keyboard press (EXIT) Key

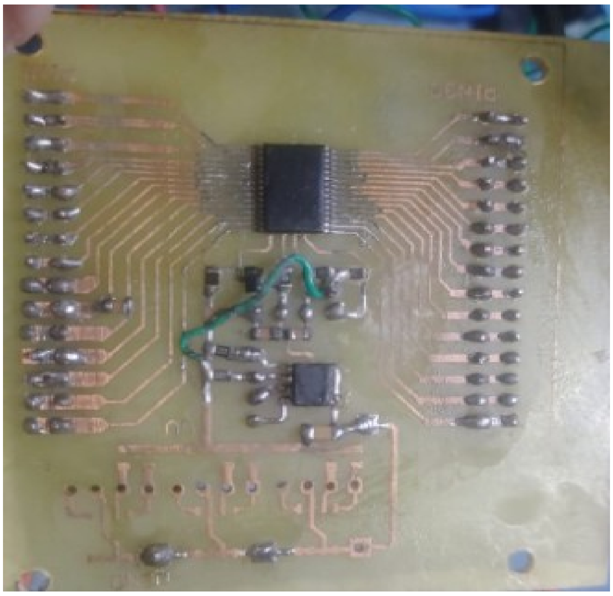
Note2:- The until will auto exit program mode after 60 seconds of inactivity.

Note2:-Appearance of all shaded menus dependent on selection of other parameter

FIG3.7

CHAPTER : 4

PID CONTROLLER IMAGE

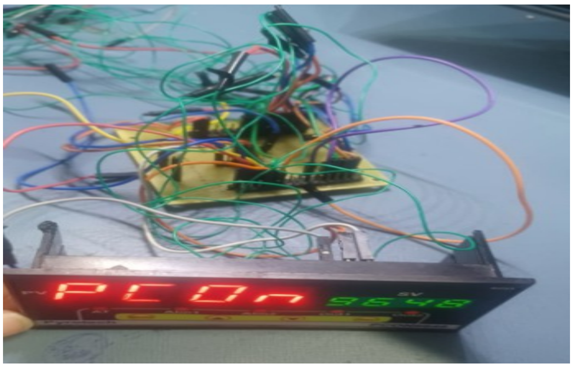


GP BOARD MCU (R5F100AC)& EEPROM (24LC256)

FIG.4.1

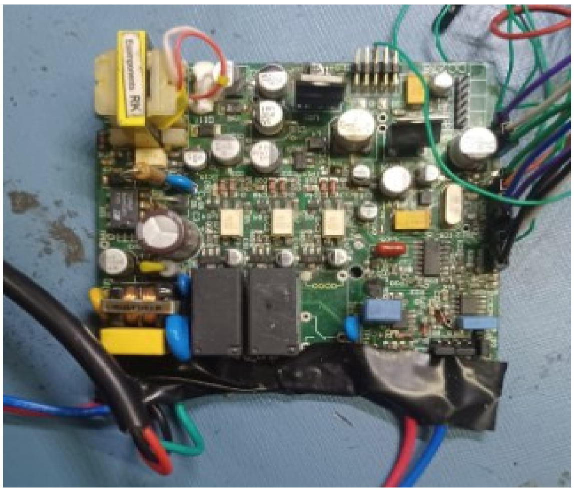
7 SEGMENT LED DISPLAY , LEDS & SWITCHES

FIG.4.2



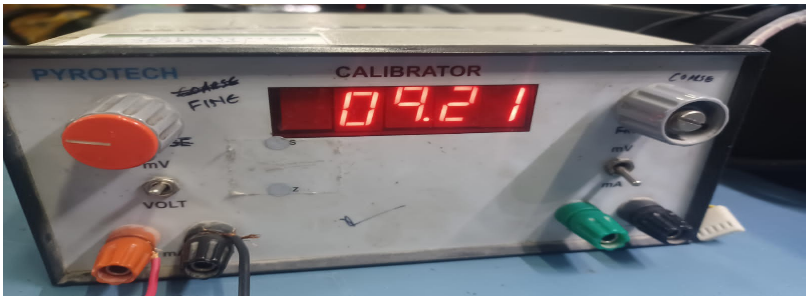
GP CONNECTION WITH DISPLAY & SWITCHES

FIG.4.3



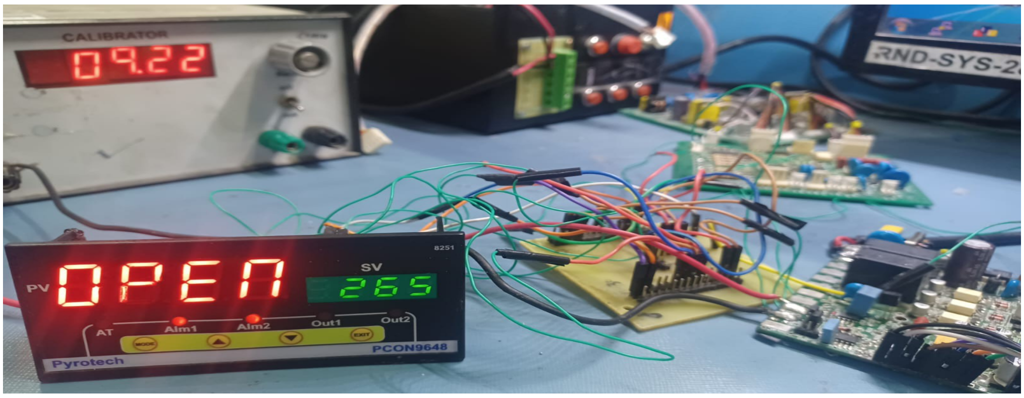
SMPS SECTION

FIG.4.4



MILIAMPERE & VOLTAGE SOURCE

FIG4.5



PROJECT SETUP

FIG4.6