COOLANT OIL CONTROL SYSTEM IN

VMC MACHINE

A PROJECT REPORT

Submitted by

RAJAGANAPATHY.S	**(13BEI111)**
GOWTHAMVEL.P	**(13BEI018)**
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in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

in

ELECTRONICS AND INSTRUMENTATION ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

(An Autonomous Institution, Affiliated to Anna University,Chennai)

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BONAFIDE CERTIFICATE

Certified that this project report **"COOLANT OIL CONTROL SYSTEM IN VMC MACHINE "**is the bonafide work of

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who carried out the project work under my supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

ACKNOWLDEGEMENT

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ABSTRACT

Most of the automation and precision machine tools industries are using automation systems for all kind of their operations. Although some simple and very most important operations are done by manually .By that way nowadays Coolants in VMC machine are controlled manually, in this project we are proposing an idea of automatic control of coolant oil in a VMC machine by measuring the level of coolant oil from its tank. Relating the level of coolant oil with the set point the controller will drain the coolant or fill the coolant in the machine.

In this project we are going to rectify the problems when doing the manual operations in coolant oil tank in VMC machine. During the precision machining operations the most of the automation machines are producing high temperature. So this will cause heavy damages in machine tools as well as decrease the production in precision machining industries.

So we are introducing the temperature monitoring system in VMC machine for displaying the operator by immersing the temperature sensor into the coolant oil tank. It can continuously monitor the temperature range of the coolant oil in the machine tank.

This coolant oil automation system will help to reduce the manual problems from the coolant oil transferring in precision machining industries and also increase the life time of the machine tools. By using the limit switches as the level sensor we have reduced the cost of the system.

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LIST OF ABBREVIATIONS

PIC	Peripheral Interface Controller
DC	Direct Current
PM	Permanent Magnet
EMF	Electro Magnetic Force
RAM	Random Access Memory
ALU	Arithmetic Logic Unit
CPU	Central Processing Unit
PVC	Poly Vinyl Chloride
ROM	Read Only Memory

1. INTRODUCTION

In this project we are going to rectify the problems when doing the manual operations in coolant oil tank in VMC machine. During the precision machining operations the most of the automation machines are producing high temperature. So this will cause heavy damages in machine tools as well as decrease the production in precision machining industries. So we are introducing the temperature monitoring system in VMC machine for displaying the operator by immersing the temperature sensor into the coolant oil tank. It can continuously monitor the temperature range of the coolant oil in the machine tank. This coolant oil automation system will help to reduce the manual problems from the coolant oil transferring in precision machining industries and also increase the life time of the machine tools.

2.HARDWARE DESCRIPTION

2.1 DC MOTOR

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

2.1.1 ELECTROMAGNETIC MOTORS

A coil of wire with a current running through it generates an electromagnetic field aligned with the center of the coil. The direction and magnitude of the magnetic field produced by the coil can be changed with the direction and magnitude of the current flowing through it.

A simple DC motor has a stationary set of magnets in the stator and an armature with one or more windings of insulated wire wrapped around a soft iron core that concentrates the magnetic field. The windings usually have multiple turns around the core, and in large motors there can be several parallel current paths. The ends of the wire winding are connected to a commutator. The commutator allows each armature coil to be energized in turn and connects the rotating coils with the external power supply through brushes. (Brushless DC motors have electronics that switch the DC current to each coil on and off and have no brushes.)

The total amount of current sent to the coil, the coil's size and what it's wrapped around dictate the strength of the electromagnetic field created. The sequence of turning a particular coil on or off dictates what direction the effective electromagnetic fields are pointed. By turning on and off coils in sequence a rotating magnetic field can be created. These rotating magnetic fields interact with the magnetic fields of the magnets (permanent or electromagnets) in the stationary part of the motor (stator) to create a force on the armature which causes it to rotate. In some DC motor designs the stator fields use electromagnets to create their magnetic fields which allow greater control over the motor. At high power levels, DC motors are almost always cooled using forced air.

Different number of stator and armature fields as well as how they are connected provide different inherent speed/torque regulation characteristics. The speed of a DC motor can be controlled by changing the voltage applied to the armature. The introduction of variable resistance in the armature circuit or field circuit allowed speed control. Modern DC motors are often controlled by power electronics systems which adjust the voltage by "chopping" the DC current into on and off cycles which have an effective lower voltage.

Since the series-wound DC motor develops its highest torque at low speed, it is often used in traction applications such as electric locomotives, and trams. The DC motor was the mainstay of electric traction drives on both electric and diesel-electric locomotives, street-cars/trams and diesel electric drilling rigs for many years. The introduction of DC motors and an electrical grid system to run machinery starting in the 1870s started a new second Industrial Revolution. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles and today's hybrid cars and electric cars as well as driving a host of cordless tools. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Large DC motors with separately excited fields were generally used with winder drives for mine hoists, for high torque as well as smooth speed control using thyristor drives. These are now replaced with large AC motors with variable frequency drives.

If external power is applied to a DC motor it acts as a DC generator, a dynamo. This feature is used to slow down and recharge batteries on hybrid car and electric cars or to return electricity back to the electric grid used on a street car or electric powered train line when they slow down. This process is called regenerative braking on hybrid and electric cars. In diesel electric locomotives they also use their DC motors as generators to slow down but dissipate the energy in resistor stacks. Newer designs are adding large battery packs to recapture some of this energy.

2.1.2 BRUSHED MOTOR

The Brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets.

Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high intensity uses. Maintenance involves regularly replacing the carbon brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor. Brushes consist of conductors.

2.1.3 BRUSHLESS MOTOR

Typical brushless DC motors use one or more permanent magnets in the rotor and electromagnets on the motor housing for the stator. A motor controller converts DC to AC. This design is mechanically simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. The motor controller can sense the rotor's position via Hall effectsensors or similar devices and can precisely control the timing, phase, etc., of the current in the rotor coils to optimize torque, conserve power, regulate speed, and even apply some braking. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost, and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

2.1.4 UNCOMMUTATED

- **Homopolar motor** – A homopolar motor has a magnetic field along the axis of rotation and an electric current that at some point is not parallel to the magnetic field. The name homopolar refers to the absence of polarity change. Homopolar motors necessarily have a single-turn coil, which limits them to very low voltages. This has restricted the practical application of this type of motor.

- **Ball bearing motor** – A ball bearing motor is an unusual electric motor that consists of two ball bearing-type bearings, with the inner races mounted on a common conductive shaft, and the outer races connected to a high current, low voltage power supply. An alternative construction fits the outer races inside a metal tube, while the inner races are mounted on a shaft with a non-conductive section (e.g. two sleeves on an insulating rod). This method has the advantage that the tube will act as a flywheel. The direction of rotation is determined by the initial spin which is usually required to get it going.

2.1.5 PERMANENT MAGNET STATORS

A PM motor does not have a field winding on the stator frame, instead relying on PMs to provide the magnetic field against which the rotor field interacts to produce torque. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. PM fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding. Most larger DC motors are of the "dynamo" type, which have stator windings. Historically, PMs could not be made to retain high flux if they were disassembled; field windings were more practical to obtain the needed amount of flux. However, large PMs are costly, as well as dangerous and difficult to assemble; this favors wound fields for large machines.

To minimize overall weight and size, miniature PM motors may use high energy magnets made with neodymium or other strategic elements; most such are neodymium-iron-boron alloy. With their higher flux density, electric machines with high-energy PMs are at least competitive with all optimally designed singly fed synchronous and induction electric machines. Miniature motors resemble the structure in the illustration, except that they have at least three rotor poles (to ensure starting, regardless of rotor position) and their outer housing is a steel tube that magnetically links the exteriors of the curved field magnets.

2.1.6 WOUND STATORS

There are three types of electrical connections between the stator and rotor possible for DC electric motors: series, shunt/parallel and compound (various blends of series and shunt/parallel) and each has unique speed/torque characteristics appropriate for different loading torque profiles/signatures.

Series connection - A series DC motor connects the armature and field windings in series with a common D.C. power source. The motor speed varies as a non-linear function of load torque and armature current; current is common to both the stator and rotor yielding current squared (I^2) behavior. A series motor has very high starting torque and is commonly used for starting high inertia loads, such as trains, elevators or hoists.This speed/torque characteristic is useful in applications such as dragline_excavators, where the digging tool moves rapidly when unloaded but slowly when carrying a heavy load. A series motor should never be started at no load. With no mechanical load on the series motor, the current is low, the counter-EMF produced by the field winding is weak, and so the armature must turn faster to produce sufficient counter-EMF to balance the supply voltage. The motor can be damaged by overspeed. This is called a runaway condition. Series motors called universal motors can be used on alternating current. Since the armature voltage and the field direction reverse at the same time, torque continues to be produced in the same direction.

However they run at a lower speed with lower torque on AC supply when compared to DC due to reactance voltage drop in AC which is not present in DC. Since the speed is not related to the line frequency, universal motors can develop higher-than-synchronous speeds, making them lighter than induction motors of the same rated mechanical output. This is a valuable characteristic for hand-held power tools. Universal motors for commercial utility are usually of small capacity, not more than about 1 kW output. However, much larger universal motors were used for electric locomotives, fed by special low-frequency traction power networks to avoid problems with commutation under heavy and varying loads.

Shunt connection - A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. This type of motor has good speed regulation even as the load varies, but does not have the starting torque of a series DC motor. It is typically used for industrial, adjustable speed applications, such as machine tools, winding/unwinding machines and tensioners.

Compound connection - A compound DC motor connects the armature and fields windings in a shunt and a series combination to give it characteristics of both a shunt and a series DC motor.[5] This motor is used when both a high starting torque and good speed regulation is needed. The motor can be connected in two arrangements: cumulatively or differentially. Cumulative compound motors connect the series field to aid the shunt field, which provides higher starting torque but less speed regulation. Differential compound DC motors have good speed regulation and are typically operated at constant speed.

2.2 LIMIT SWITCH

In electrical engineering a limit switch is a switch operated by the motion of a machine part or presence of an object. They are used for controlling machinery as part of a control system, as a safety interlocks, or to count objects passing a point. A limit switch is an electromechanical device that consists of an actuator mechanically linked to a set of contacts. When an object comes into contact with the actuator, the device operates the contacts to make or break an electrical connection.

Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the presence or absence, passing, positioning, and end of travel of an object. They were first used to define the limit of travel of an object; hence the name "Limit Switch". A limit switch with a roller-lever operator is installed on a gate on a canal lock, which indicates the position of a gate to a control system.

Standardized limit switches are industrial control components manufactured with a variety of operator types, including lever, roller plunger, and whisker type. Limit switches may be directly mechanically operated by the motion of the operating lever. A reed switch may be used to indicate proximity of a magnet mounted on some moving part. Proximity switches operate by the disturbance of an electromagnetic field, by capacitance, or by sensing a magnetic field.

Rarely, a final operating device such as a lamp or solenoid valve will be directly controlled by the contacts of an industrial limit switch, but more typically the limit switch will be wired through a control relay, a motor contactor control circuit, or as an input to a programmable logic controller.

Miniature snap-action switch may be used for example as components of such devices as photocopiers, computer printers, convertible tops or microwave ovens to ensure internal components are in the correct position for operation and to prevent operation when access doors are opened. A set of adjustable limit switches are installed on a garage door opener to shut off the motor when the door has reached the fully raised or fully lowered position. A numerical control machine such as a lathe will have limit switches to identify maximum limits for machine parts or to provide a known reference point for incremental motions.

Fig.no 2.1

2.3 PIC MICROCONTROLLER

PIC (usually pronounced as "pick") is a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Peripheral Interface Controller. The first parts of the family were available in 1976; by 2013 the company had shipped more than twelve billion individual parts, used in a wide variety of embedded systems. Early models of PIC had read-only memory (ROM) or field-programmable EPROM for program storage, some with provision for erasing memory. All current models use flash memory for program storage, and newer models allow the PIC to reprogram itself. Program memory and data memory are separated. Data memory is 8-bit, 16-bit, and, in latest models, 32-bit wide. Program instructions vary in bit-count by family of PIC, and may be 12, 14, 16, or 24 bits long. The instruction set also varies by model, with more powerful chips adding instructions for digital signal processing functions.

The hardware capabilities of PIC devices range from 6-pin SMD, 8-pin DIP chips up to 144-pin SMD chips, with discrete I/O pins, ADC and DAC modules, and communications ports such as UART, I2C, CAN, and even USB. Low-power and high-speed variations exist for many types.

The manufacturer supplies computer software for development known as MPLAB, assemblers and C/C++ compilers, and programmer/debugger hardware under the MPLAB and PICKit series. Third party and some open-source tools are also available. Some parts have in-circuit programming capability; low-cost development programmers are available as well as high-production programmers. PIC devices are popular with both industrial developers and hobbyists due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, serial programming, and re-programmable Flash-memory capability.

Various older (EPROM) PIC microcontrollers

The original PIC was intended to be used with General Instrument's new CP1600 16-bit central processing unit (CPU). Whilst most people considered the CP1600 a good CPU, it had poor I/O performance, and the 8-bit PIC was developed in 1975 to improve performance of the overall system by offloading I/O tasks from the CPU.

The PIC used simple microcode stored in ROM to perform its tasks, and although the term RISC was not used at the time, it shares some common features with RISC designs. In 1985, General Instrument sold their microelectronics division and the new owners cancelled almost everything which by this time was mostly out-of-date. The PIC, however, was upgraded with an internal EPROM to produce a programmable channel controller. In 2001, Microchip introduced Flash programmable devices, with full production commencing in 2002. Today, a huge variety of PICs are available with various on-board peripherals (serial communication modules, UARTs, motor control kernels, etc.) and program memory from 256 words to 64K words and more (a "word" is one assembly language instruction, varying in length from 8 to 16 bits, depending on the specific PIC micro family).

PIC and PICmicro are registered trademarks of Microchip Technology. It is generally thought that PIC stands for Peripheral Interface Controller, although General Instruments' original acronym for the initial PIC1640 and PIC1650 devices was "Programmable Interface Controller". The acronym was quickly replaced with "Programmable Intelligent Computer". The Microchip 16C84 (PIC16x84), introduced in 1993, was the first Microchip CPU with on-chip EEPROM memory. By 2013, Microchip was shipping over one billion PIC microcontrollers every year.

2.3.1 DEVICE FAMILIES

PICmicro chips are designed with a Harvard architecture, and are offered in various device families. The baseline and mid-range families use 8-bit wide data memory, and the high-end families use 16-bit data memory. The latest series, PIC32MZ is a 32-bit MIPS-based microcontroller. Instruction words are in sizes of 12-bit (PIC10 and PIC12), 14-bit(PIC16) and 24-bit (PIC24 and dsPIC). The binary representations of the machine instructions vary by family and are shown in PIC instruction listings.

Within these families, devices may be designated PICnnCxxx (CMOS) or PICnnFxxx (Flash). "C" devices are generally classified either "End-Of-Life" (no longer available), or "Not suitable for new development" (not actively promoted by Microchip). The program memory of "C" devices is variously described as OTP, ROM, or EEPROM. As of October 2016, the only OTP product classified as "In production" is the pic16HV540. "C" devices with quartz windows (for erasure), are in general no longer available.

PIC10 and PIC12

These devices feature a 12-bit wide code memory, a 32-byte register file, and a tiny two level deep call stack. They are represented by the PIC10 series, as well as by some PIC12 and PIC16 devices. Baseline devices are available in 6-pin to 40-pin packages. Generally the first 7 to 9 bytes of the register file are special-purpose registers, and the remaining bytes are general purpose RAM. Pointers are implemented using a register pair: after writing an address to the FSR (file select register), the INDF (indirect f) register becomes an alias for the addressed register. If banked RAM is implemented, the bank number is selected by the high 3 bits of the FSR. This affects register numbers 16–31; registers 0–15 are global and not affected by the bank select bits. Because of the very limited register space (5 bits), 4 rarely read registers were not assigned addresses, but written by special instructions (OPTION and TRIS).

The ROM address space is 512 words (12 bits each), which may be extended to 2048 words by banking. CALL and GOTO instructions specify the low 9 bits of the new code location; additional high-order bits are taken from the status register. Note that a CALL instruction only includes 8 bits of address, and may only specify addresses in the first half of each 512-word page. Lookup tables are implemented using a computed GOTO (assignment to PCL register) into a table of RETLW instructions.

This "baseline core" does not support interrupts; all I/O must be polled. There are some "enhanced baseline" variants with interrupt support and a four-level call stack. PIC10F32x devices feature a mid-range 14-bit wide code memory of 256 or 512 words, a 64-byte SRAM register file, and an 8-level deep hardware stack. These devices are available in 6-pin SMD and 8-pin DIP packages (with two pins unused). One input only and three I/O pins are available. A complex set of interrupts are available. Clocks are an internal calibrated high-frequency oscillator of 16 MHz with a choice of selectable speeds via software and a 31 kHz low-power source.

PIC16

These devices feature a 14-bit wide code memory, and an improved 8-level deep call stack. The instruction set differs very little from the baseline devices, but the two additional opcode bits allow 128 registers and 2048 words of code to be directly addressed. There are a few additional miscellaneous instructions, and two additional 8-bit literal instructions, add and subtract. The mid-range core is available in the majority of devices labeled PIC12 and PIC16.The first 32 bytes of the register space are allocated to special-purpose registers; the remaining 96 bytes are used for general-purpose RAM. If banked RAM is used, the high 16 registers (0x70–0x7F) are global, as are a few of the most important special-purpose registers, including the STATUS register which holds the RAM bank select bits. (The other global registers are FSR and INDF, the low 8 bits of the program counter PCL, the PC high preload register PCLATH, and the master interrupt control register INTCON.) The PCLATH register supplies high-order instruction address bits when the 8 bits supplied by a write to the PCL register, or the 11 bits supplied by a GOTO or CALL instruction, is not sufficient to address the available ROM space.

PIC17

The 17 series never became popular and has been superseded by the PIC18 architecture. The 17 series is not recommended for new designs, and availability may be limited to users. Improvements over earlier cores are 16-bit wide opcodes (allowing many new instructions), and a 16-level deep call stack. PIC17 devices were produced in packages from 40 to 68 pins.

The 17 series introduced a number of important new features:

- a memory mapped accumulator
- read access to code memory (table reads)
- direct register to register moves (prior cores needed to move registers through the accumulator)
- an external program memory interface to expand the code space
- an 8-bit × 8-bit hardware multiplier
- a second indirect register pair
- auto-increment/decrement addressing controlled by control bits in a status register (ALUSTA)

A significant limitation was that RAM space was limited to 256 bytes (26 bytes of special function registers, and 232 bytes of general-purpose RAM), with awkward bank-switching in the models that supported more.

PIC18

In 2000, Microchip introduced the PIC18 architecture. Unlike the 17 series, it has proven to be very popular, with a large number of device variants presently in manufacture. In contrast to earlier devices, which were more often than not programmed in assembly, C has become the predominant development language. The 18 series inherits most of the features and instructions of the 17 series, while adding a number of important new features:

- call stack is 21 bits wide and much deeper (31 levels deep)
- the call stack may be read and written (TOSU:TOSH:TOSL registers)
- conditional branch instructions
- indexed addressing mode (PLUSW)
- extending the FSR registers to 12 bits, allowing them to linearly address the entire data address space
- the addition of another FSR register (bringing the number up to 3)

The RAM space is 12 bits, addressed using a 4-bit bank select register and an 8-bit offset in each instruction. An additional "access" bit in each instruction selects between bank 0 (a=0) and the bank selected by the BSR (a=1).

A 1-level stack is also available for the STATUS, WREG and BSR registers. They are saved on every interrupt, and may be restored on return. If interrupts are disabled, they may also be used on subroutine call/return by setting the s bit (appending ", FAST" to the instruction).

The auto increment/decrement feature was improved by removing the control bits and adding four new indirect registers per FSR. Depending on which indirect file register is being accessed it is possible to postdecrement, postincrement, or preincrement FSR; or form the effective address by adding W to FSR. In more advanced PIC18 devices, an "extended mode" is available which makes the addressing even more favorable to compiled code:

- a new offset addressing mode; some addresses which were relative to the access bank are now interpreted relative to the FSR2 register
- the addition of several new instructions, notable for manipulating the FSR registers.

These changes were primarily aimed at improving the efficiency of a data stack implementation. If FSR2 is used either as the stack pointer or frame pointer, stack items may be easily indexed – allowing more efficient re-entrant code. Microchip's MPLAB C18 C compiler chooses to use FSR2 as a frame pointer.

PIC24 and dsPIC

In 2001, Microchip introduced the dsPIC series of chips, which entered mass production in late 2004. They are Microchip's first inherently 16-bit microcontrollers. PIC24 devices are designed as general purpose microcontrollers. dsPIC devices include digital signal processing capabilities in addition. Although still similar to earlier PIC architectures, there are significant enhancements:

- All registers are 16 bits wide
- Program counter is 22 bits (Bits 22:1; bit 0 is always 0)
- Instructions are 24 bits wide
- Data address space expanded to 64 KiB
- First 2 KiB is reserved for peripheral control registers
- Data bank switching is not required unless RAM exceeds 62 KiB
- "f operand" direct addressing extended to 13 bits (8 KiB)
- 16 W registers available for register-register operations. (But operations on f operands always reference W0.)

- Instructions come in byte and (16-bit) word forms
- Stack is in RAM (with W15 as stack pointer); there is no hardware stack
- W14 is the frame pointer
- Data stored in ROM may be accessed directly ("Program Space Visibility")
- Vectored interrupts for different interrupt sources

Some features are:

- (16×16)-bit single-cycle multiplication and other digital signal processing operations
- hardware multiply–accumulate (MAC)
- hardware divide assist (19 cycles for 32/16-bit divide)
- barrel shifting
- bit reversal
- hardware support for loop indexing
- direct memory access

dsPICs can be programmed in C using Microchip's XC16 compiler (formerly called C30) which is a variant of GCC. Instruction ROM is 24 bits wide. Software can access ROM in 16-bit words, where even words hold the least significant 16 bits of each instruction, and odd words hold the most significant 8 bits. The high half of odd words reads as zero. The program counter is 23 bits wide, but the least significant bit is always 0, so there are 22 modifiable bits.

Instructions come in two main varieties, with most important operations (add, xor, shifts, etc.) allowing both forms.The first is like the classic PIC instructions, with an operation between a specified f register (i.e. the first 8K of RAM) and a single accumulator W0, with a destination select bit selecting which is updated with the result. (The W registers are memory-mapped. so the f operand may be any W register.)

The second form is more conventional, allowing three operands, which may be any of 16 W registers. The destination and one of the sources also support addressing modes, allowing the operand to be in memory pointed to by a W register.

PIC32M MIPS-based line

The PIC32M processors, despite the name, are a completely different architecture from earlier PIC microcontrollers. Their instruction set is nothing like the Microchip-designed single-operand instruction sets of earlier PIC processors, but use the MIPS instruction set, with 32 registers, 3-operand instructions, and a Von Neumann architecture.

PIC32MX

In November 2007, Microchip introduced the PIC32MX family of 32-bit microcontrollers, based on the MIPS32 M4K Core.[11] The device can be programmed using the Microchip MPLAB C Compiler for PIC32 MCUs, a variant of the GCC compiler. The first 18 models currently in production (PIC32MX3xx and PIC32MX4xx) are pin to pin compatible and share the same peripherals set with the PIC24FxxGA0xx family of (16-bit) devices allowing the use of common libraries, software and hardware tools. Today, starting at 28 pin in small QFN packages up to high performance devices with Ethernet, CAN and USB OTG, full family range of mid-range 32-bit microcontrollers are available. The PIC32 architecture brought a number of new features to Microchip portfolio, including:

- The highest execution speed 80 MIPS (120+[12] Dhrystone MIPS @ 80 MHz)
- The largest flash memory: 512 kB
- One instruction per clock cycle execution
- The first cached processor

- Allows execution from RAM
- Full Speed Host/Dual Role and OTG USB capabilities
- Full JTAG and 2-wire programming and debugging
- Real-time trace

PIC32MZ

In November 2013, Microchip introduced the PIC32MZ series of microcontrollers, based on the MIPS M14K core. The PIC32MZ series include:

- 252 Mhz core speed, 415 DMIPS
- Up to 2 MB Flash and 512KB RAM
- New peripherals including high-speed USB, crypto engine and SQI

In September 2015, Microchip updated the MIPS core of the PIC32MZ to the MIPS M5150 Warrior M-class processor.

PIC32MM

In June 2016, Microchip introduced the PIC32MM family, specialized for low-power and low-cost applications. The PIC32MM features core-independent peripherals, sleep modes down to 500 nA, and 4 x 4 mm packages.

2.3.2 CORE ARCHITECTURE

The PIC architecture is characterized by its multiple attributes:

- Separate code and data spaces (Harvard architecture).
- A small number of fixed-length instructions
- Most instructions are single-cycle (2 clock cycles, or 4 clock cycles in 8-bit models), with one delay cycle on branches and skips
- One accumulator (W0), the use of which (as source operand) is implied (i.e. is not encoded in the opcode).

- All RAM locations function as registers as both source and/or destination of math and other functions.
- A hardware stack for storing return addresses
- A small amount of addressable data space (32, 128, or 256 bytes, depending on the family), extended through banking
- Data-space mapped CPU, port, and peripheral registers
- ALU status flags are mapped into the data space
- The program counter is also mapped into the data space and writable (this is used to implement indirect jumps).

There is no distinction between memory space and register space because the RAM serves the job of both memory and registers, and the RAM is usually just referred to as the register file or simply as the registers.

Data space (RAM)

PICs have a set of registers that function as general-purpose RAM. Special-purpose control registers for on-chip hardware resources are also mapped into the data space. The addressability of memory varies depending on device series, and all PIC devices have some banking mechanism to extend addressing to additional memory. Later series of devices feature move instructions, which can cover the whole addressable space, independent of the selected bank. In earlier devices, any register move had to be achieved through the accumulator.

To implement indirect addressing, a "file select register" (FSR) and "indirect register" (INDF) are used. A register number is written to the FSR, after which reads from or writes to INDF will actually be to or from the register pointed to by FSR. Later devices extended this concept with post- and pre- increment/decrement for greater efficiency in accessing sequentially stored data. This also allows FSR to be treated almost like a stack pointer (SP). External data memory is not directly addressable except in some PIC18 devices with high pin count.

Code space

The code space is generally implemented as on-chip ROM, EPROM or flash ROM. In general, there is no provision for storing code in external memory due to the lack of an external memory interface. The exceptions are PIC17 and select high pin count PIC18 devices.

Word size

All PICs handle (and address) data in 8-bit chunks. However, the unit of addressability of the code space is not generally the same as the data space. For example, PICs in the baseline (PIC12) and mid-range (PIC16) families have program memory addressable in the same word size as the instruction width, i.e. 12 or 14 bits respectively. In contrast, in the PIC18 series, the program memory is addressed in 8-bit increments (bytes), which differs from the instruction width of 16 bits. In order to be clear, the program memory capacity is usually stated in number of (single-word) instructions, rather than in bytes.

Stacks

PICs have a hardware call stack, which is used to save return addresses. The hardware stack is not software-accessible on earlier devices, but this changed with the 18 series devices. Hardware support for a general-purpose parameter stack was lacking in early series, but this greatly improved in the 18 series, making the 18 series architecture more friendly to high-level language compilers.

Instruction set

PIC's instructions vary from about 35 instructions for the low-end PICs to over 80 instructions for the high-end PICs. The instruction set includes instructions to perform a variety of operations on registers directly, the accumulator and a literal constant or the accumulator and a register, as well as for conditional execution, and program branching. Some operations, such as bit setting and testing, can be performed on any numbered register, but bi-operand arithmetic operations always involve W (the accumulator), writing the result back to either W or the other operand register. To load a constant, it is necessary to load it into W before it can be moved into another register. On the older cores, all register moves needed to pass through W, but this changed on the "high-end" cores.

PIC cores have skip instructions, which are used for conditional execution and branching. The skip instructions are "skip if bit set" and "skip if bit not set". Because cores before PIC18 had only unconditional branch instructions, conditional jumps are implemented by a conditional skip (with the opposite condition) followed by an unconditional branch. Skips are also of utility for conditional execution of any immediate single following instruction. It is possible to skip skip instructions. The 18 series implemented shadow, registers which save several important registers during an interrupt, providing hardware support for automatically saving processor state when servicing interrupts.

In general, PIC instructions fall into five classes:

1. Operation on working register (WREG) with 8-bit immediate ("literal") operand. E.g. movlw (move literal to WREG), andlw (AND literal with WREG). One instruction peculiar to the PIC is retlw, load immediate into WREG and return, which is used with computed branches to produce lookup tables.

2. Operation with WREG and indexed register. The result can be written to either the Working register (e.g. `addwf reg,w`). or the selected register (e.g. `addwf reg,f`).
3. Bit operations. These take a register number and a bit number, and perform one of 4 actions: set or clear a bit, and test and skip on set/clear. The latter are used to perform conditional branches. The usual ALU status flags are available in a numbered register so operations such as "branch on carry clear" are possible.
4. Control transfers. Other than the skip instructions previously mentioned, there are only two: `goto` and `call`.
5. A few miscellaneous zero-operand instructions, such as return from subroutine, and `sleep` to enter low-power mode.

Performance

The architectural decisions are directed at the maximization of speed-to-cost ratio. The PIC architecture was among the first scalar CPU designs and is still among the simplest and cheapest. The Harvard architecture, in which instructions and data come from separate sources, simplifies timing and microcircuit design greatly, and this benefits clock speed, price, and power consumption.

The PIC instruction set is suited to implementation of fast lookup tables in the program space. Such lookups take one instruction and two instruction cycles. Many functions can be modeled in this way. Optimization is facilitated by the relatively large program space of the PIC (e.g. 4096 × 14-bit words on the 16F690) and by the design of the instruction set, which allows embedded constants. For example, a branch instruction's target may be indexed by W, and execute a "RETLW", which does as it is named – return with literal in W.

Interrupt latency is constant at three instruction cycles. External interrupts have to be synchronized with the four-clock instruction cycle, otherwise there can be a one instruction cycle jitter. Internal interrupts are already synchronized. The constant interrupt latency allows PICs to achieve interrupt-driven low-jitter timing sequences. An example of this is a video sync pulse generator. This is no longer true in the newest PIC models, because they have a synchronous interrupt latency of three or four cycles.

Advantages

- Small instruction set to learn
- RISC architecture
- Built-in oscillator with selectable speeds
- Easy entry level, in-circuit programming plus in-circuit debugging PICkit units available for less than $50
- Inexpensive microcontrollers
- Wide range of interfaces including I²C, SPI, USB, USART, A/D, programmable comparators, PWM, LIN, CAN, PSP, and Ethernet[21]
- Availability of processors in DIL package make them easy to handle for hobby use.

Limitations

- One accumulator
- Register-bank switching is required to access the entire RAM of many devices
- Operations and registers are not orthogonal; some instructions can address RAM and/or immediate constants, while others can use the accumulator only.

The following stack limitations have been addressed in the PIC18 series, but still apply to earlier cores:

- The hardware call stack is not addressable, so preemptive task switching cannot be implemented
- Software-implemented stacks are not efficient, so it is difficult to generate reentrant code and support local variables

With paged program memory, there are two page sizes to worry about: one for CALL and GOTO and another for computed GOTO (typically used for table lookups). For example, on PIC16, CALL and GOTO have 11 bits of addressing, so the page size is 2048 instruction words. For computed GOTOs, where you add to PCL, the page size is 256 instruction words. In both cases, the upper address bits are provided by the PCLATH register. This register must be changed every time control transfers between pages. PCLATH must also be preserved by any interrupt handler.

Compiler development

While several commercial compilers are available, in 2008, Microchip released their own C compilers, C18 and C30, for the line of 18F 24F and 30/33F processors. As of 2013, Microchip offers their XC series of compilers, for use with MPLAB X. Microchip will eventually phase out its older compilers, such as C18, and recommends using their XC series compilers for new designs. The easy-to-learn RISC instruction set of the PIC assembly language code can make the overall flow difficult to comprehend. Judicious use of simple macros can increase the readability of PIC assembly language. For example, the original Parallax PIC assembler ("SPASM") has macros, which hide W and make the PIC look like a two-address machine. It has macro instructions like `mov b, a` (move the data from address a to address b) and `add b, a` (add data from address a to data in address b). It also hides the skip instructions by providing three-operand branch macro instructions, such as `cjne a, b, dest` (compare a with b and jump to dest if they are not equal).

2.3.3 HARDWARE FEATURES

PIC devices generally feature:

- Flash memory (program memory, programmed using MPLAB devices)
- SRAM (data memory)
- EEPROM memory (programmable at run-time)
- Sleep mode (power savings)
- Watchdog timer
- Various crystal or RC oscillator configurations, or an external clock

Variants

Within a series, there are still many device variants depending on what hardware resources the chip features:

- General purpose I/O pins
- Internal clock oscillators
- 8/16/32 bit timers
- Synchronous/Asynchronous Serial Interface USART
- MSSP Peripheral for I²C and SPI communications
- Capture/Compare and PWM modules
- Analog-to-digital converters (up to ~1.0 MHz)
- USB, Ethernet, CAN interfacing support
- External memory interface
- Integrated analog RF front ends (PIC16F639, and rfPIC).
- KEELOQ Rolling code encryption peripheral (encode/decode)

Trends

The first generation of PICs with EPROM storage are almost completely replaced by chips with Flash memory. Likewise, the original 12-bit instruction set of the PIC1650 and its direct descendants has been superseded by 14-bit and 16-bit instruction sets. Microchip still sells OTP (one-time-programmable) and windowed (UV-erasable) versions of some of its EPROM based PICs for legacy support or volume orders. The Microchip website lists PICs that are not electrically erasable as OTP. UV erasable windowed versions of these chips can be ordered.

Part number

The F in a PICMicro part number generally indicates the PICmicro uses flash memory and can be erased electronically. Conversely, a C generally means it can only be erased by exposing the die to ultraviolet light (which is only possible if a windowed package style is used). An exception to this rule is the PIC16C84 which uses EEPROM and is therefore electrically erasable. An L in the name indicates the part will run at a lower voltage, often with frequency limits imposed. Parts designed specifically for low voltage operation, within a strict range of 3 - 3.6 volts, are marked with a J in the part number. These parts are also uniquely I/O tolerant as they will accept up to 5 V as inputs.

2.3.4 DEVELOPMENT TOOLS

Microchip provides a freeware IDE package called MPLAB, which includes an assembler, linker, software simulator, and debugger. They also sell C compilers for the PIC18, PIC24, PIC32 and dsPIC, which integrate cleanly with MPLAB. Free student versions of the C compilers are also available with all features. But for the free versions, optimizations will be disabled after 60 days. The cheapest compiler for the most common PIC18 series and commercial use starts at around $500. Several third parties develop C language compilers for PICs, many of which integrate to MPLAB and/or feature their own IDE. A fully featured compiler for the PICBASIC language to program PIC microcontrollers is available from meLabs, Inc. Mikroelektronika offers PIC compilers in C, Basic and Pascal programming languages.

A graphical programming language, Flowcode, exists capable of programming 8- and 16-bit PIC devices and generating PIC-compatible C code. It exists in numerous versions from a free demonstration to a more complete professional edition. The Proteus Design Suite is able to simulate many of the popular 8 and 16-bit PIC devices along with other circuitry that is connected to the PIC on the schematic. The program to be simulated can be developed within Proteus itself, MPLAB or any other development tool.

2.3.5 DEVICE PROGRAMMERS

Devices called "programmers" are traditionally used to get program code into the target PIC. Most PICs that Microchip currently sells feature ICSP (In Circuit Serial Programming) and/or LVP (Low Voltage Programming) capabilities, allowing the PIC to be programmed while it is sitting in the target circuit. Microchip offers programmers/debuggers under the MPLAB and PICKit series. MPLAB ICD and MPLAB REAL ICE are the current programmers and debuggers for professional engineering, while PICKit is a low-cost programmer-only line for hobbyists and students.

Bootloading

Many of the higher end flash based PICs can also self-program (write to their own program memory), a process known as bootloading. Demo boards are available with a small bootloader factory programmed that can be used to load user programs over an interface such as RS-232 or USB, thus obviating the need for a programmer device. Alternatively there is bootloader firmware available that the user can load onto the PIC using ICSP. After programming the bootloader onto the PIC, the user can then reprogram the device using RS232 or USB, in conjunction with specialized computer software.

The advantages of a bootloader over ICSP is faster programming speeds, immediate program execution following programming, and the ability to both debug and program using the same cable.

Third party

There are many programmers for PIC microcontrollers, ranging from the extremely simple designs which rely on ICSP to allow direct download of code from a host computer, to intelligent programmers that can verify the device at several supply voltages. Many of these complex programmers use a pre-programmed PIC themselves to send the programming commands to the PIC that is to be programmed. The intelligent type of programmer is needed to program earlier PIC models (mostly EPROM type) which do not support in-circuit programming.Third party programmers range from plans to build your own, to self-assembly kits and fully tested ready-to-go units. Some are simple designs which require a PC to do the low-level programming signalling (these typically connect to the serial or parallel port and consist of a few simple components), while others have the programming logic built into them (these typically use a serial or USB connection, are usually faster, and are often built using PICs themselves for control).

In-circuit debugging

All newer PIC devices feature an ICD (in-circuit debugging) interface, built into the CPU core, that allows for interactive debugging of the program in conjunction with MPLAB IDE.MPLAB ICD and MPLAB REAL ICE debuggers can communicate with this interface using the ICSP interface. This debugging system comes at a price however, namely limited breakpoint count (1 on older devices, 3 on newer devices), loss of some I/O (with the exception of some surface mount 44-pin PICs which have dedicated lines for debugging) and loss of some on-chip features.

In-circuit emulators

Microchip offers three full in-circuit emulators: the MPLAB ICE2000 (parallel interface, a USB converter is available); the newer MPLAB ICE4000 (USB 2.0 connection); and most recently, the REAL ICE (USB 2.0 connection). All such tools are typically used in conjunction with MPLAB IDE for source-level interactive debugging of code running on the target.

2.3.6 OPERATING SYSTEMS

PIC projects may utilize Real time operating systems such as FreeRTOS, AVIX RTOS, uRTOS, Salvo RTOS or other similar libraries for task scheduling and prioritization. An open source project by Serge Vakulenko adapts 2.11BSD to the PIC32 architecture, under the name RetroBSD. This brings a familiar Unix-like operating system, including an onboard development environment, to the microcontroller, within the constraints of the onboard hardware.

2.3.7 CLONES

ELAN Microelectronics

ELAN Microelectronics Corp. produce a series of PICmicro-like microcontrollers with a 13-bit instruction word.[29] The instructions are mostly compatible with the mid-range 14-bit instruction set, but limited to a 6-bit register address (16 special-purpose registers and 48 bytes of RAM) and a 10-bit (1024 word) program space. The 10-bit program counter is accessible as R2. Reads access only the low bits, and writes clear the high bits.

An exception is the TBL instruction, which modifies the low byte while preserving bits 8 and 9.

The 7 accumulator-immediate instructions are renumbered relative to the 14-bit PICmicro, to fit into 3 opcode bits rather than 4, but they are all there, as well as an additional software interrupt instruction. There are a few additional miscellaneous instructions, and there are some changes to the terminology (the PICmicro OPTION register is called the CONTrol register; the PICmicro TRIS registers 1–3 are called I/O control registers 5–7), but the equivalents are obvious. Some models support multiple ROM or RAM banks, in a manner similar to other PIC microcontrollers.

Holtek

Holtek produce a large number of PICmicro-like microcontrollers, in the HT37, HT4x, HT56, HT6x, HT82 and HT95 families. They are most similar to the 14-bit mid-range PICmicro processors, but not exact clones. The STATUS register contains an arithmetic overflow flag, they include several additional instructions, and many include two pointer/indirect registers.

They come in three instruction widths:

- 14-bit instructions, with 11-bit ROM addresses (2K×14 bit) and 7-bit RAM addresses,
- 15-bit instructions, with 12-bit ROM addresses (4K×15 bit) and 8-bit RAM addresses, and
- 16-bit instructions, with 13-bit ROM addresses (8K×16 bit) and 8-bit RAM addresses. Some further extend ROM and RAM by banking.

Instructions not in the basic 14-bit PIC instruction set are:

- Add and subtract with carry
- Left and right rotate not through carry
- Test and skip if zero (no increment or decrement)

- Set byte to all-ones (like CLR sets to all-zeros)
- Table read from ROM
- CLRWDT1 and CLRWDT2 instructions which must be used alternately to reset the watchdog timer

Notable differences from the original PICmicro:

- The subtract instructions subtract the operand from the accumulator,
- There is no TRIS/OPTION instruction; all registers are addressable, and
- Software may use the full subroutine stack depth; interrupts are masked while the stack is full, and will be taken as soon as a return instruction is executed.

Hycon

Hycon Technology, a Taiwanese manufacturer of mixed-signal chips for portable electronics (multimeters, kitchen scales, etc.), has a proprietary H08 microcontroller series with a 16-bit instruction word very similar to the PIC18 family. (No relation to the Hitachi/Renesas H8 microcontrollers.) The H08A is most like the PIC18; the H08B[32] is a subset. Although the available instructions are almost identical, their encoding is different, as is the memory map and peripherals. For example, the PIC18 allows direct access to RAM at 0x000–0x07F or special function registers at 0xF80–0xFFF by sign-extending an 8-bit address. The H08 places special function registers at 0x000–0x07F and global RAM at 0x080–0x0FF, zero-extending the address.

Parallax

Parallax produced a series of PICmicro-like microcontrollers known as the Parallax SX. It is currently discontinued. Designed to be architecturally similar to the PIC microcontrollers used in the original versions of the BASIC Stamp, SX microcontrollers replaced the PIC in several subsequent versions of that product. Parallax's SX are 8-bit RISC microcontrollers, using a 12-bit instruction word, which run fast at 75 MHz (75 MIPS). They include up to 4096 12-bit words of flash memory and up to 262 bytes of random access memory, an eight bit counter and other support logic. There are software library modules to emulate I²C and SPI interfaces, UARTs, frequency generators, measurement counters and PWM and sigma-delta A/D converters. Other interfaces are relatively easy to write, and existing modules can be modified to get new features.

PKK Milandr

Russian PKK Milandr produces microcontrollers using the PIC17 architecture as the 1886 series. Program memory consists of up to 64kB Flash memory in the 1886VE2U (Russian: 1886ВЕ2У) or 8kB EEPROM in the 1886VE4U (1886ВЕ4У). The 1886VE5U (1886ВЕ5У) through 1886VE7U (1886ВЕ7У) are specified for a temperature range of -60 °C to +125 °C. Hardware interfaces in the various parts include USB, CAN, I2C, SPI, as well as A/D and D/A converters. The 1886VE3U (1886ВЕ3У) contains a hardware accelerator for cryptographic functions according to GOST 28147-89. There is even a radiation-hardened chip with the designation 1886VE10 (1886ВЕ10).

Fig. no 2.2

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

2.4 POWER SUPPLY

A power supply is an electronic device that supplies electric energy to an electrical load. The primary function of a power supply is to convert one form of electrical energy to another. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are discrete, stand-alone devices, whereas others are built into larger devices along with their loads. Examples of the latter include power supplies found in desktop computers and consumer electronics devices.

Every power supply must obtain the energy it supplies to its load, as well as any energy it consumes while performing that task, from an energy source. Depending on its design, a power supply may obtain energy from various types of energy sources, including electrical energy transmission systems, energy storage devices such as a batteries and fuel cells, electromechanical systems such as generators and alternators, solar power converters, or another power supply. All power supplies have a power input, which receives energy from the energy source, and a power output that delivers energy to the load. In most power supplies the power input and output consist of electrical connectors or hardwired circuit connections, though some power supplies employ wireless energy transfer in lieu of galvanic connections for the power input or output. Some power supplies have other types of inputs and outputs as well, for functions such as external monitoring and control.

2.4.1 DC POWER SUPPLY

A DC power supply is one that supplies a constant DC voltage to its load. Depending on its design, a DC power supply may be powered from a DC source or from an AC source such as the power mains.

2.4.2 AC-TO-DC SUPPLY

Schematic of basic AC-to-DC power supply, showing (from L-R) transformer, full-wave bridge rectifier, filter capacitor and resistor load. Some DC power supplies use AC mains electricity as an energy source. Such power supplies will sometimes employ a transformer to convert the input voltage to a higher or lower AC voltage. A rectifier is used to convert the transformer output voltage to a varying DC voltage, which in turn is passed through an electronic filter to convert it to an unregulated DC voltage.

The filter removes most, but not all of the AC voltage variations; the remaining AC voltage is known as ripple. The electric load's tolerance of ripple dictates the minimum amount of filtering that must be provided by a power supply. In some applications, high ripple is tolerated and therefore no filtering is required. For example, in some battery charging applications it is possible to implement a mains-powered DC power supply with nothing more than a transformer and a single rectifier diode, with a resistor in series with the output to limit charging current.

2.4.3 LINEAR REGULATOR

The function of a linear voltage regulator is to convert a varying DC voltage to a constant, often specific, lower DC voltage. In addition, they often provide a current_limiting function to protect the power supply and load from overcurrent (excessive, potentially destructive current).

A constant output voltage is required in many power supply applications, but the voltage provided by many energy sources will vary with changes in load impedance. Furthermore, when an unregulated DC power supply is the energy source, its output voltage will also vary with changing input voltage. To circumvent this, some power supplies use a linear voltage regulator to maintain the output voltage at a steady value, independent of fluctuations in input voltage and load impedance. Linear regulators can also reduce the magnitude of ripple and noise on the output voltage.

2.4.4 AC POWER SUPPLY

An AC power supply typically takes the voltage from a wall outlet (mains supply) and lowers it to the desired voltage. Some filtering may take place as well.

In modern use, AC power supplies can be divided into single phase and three phase systems. The primary difference between single phase and three phase AC power is the constancy of delivery.AC power Supplies can also be used to change the frequency as well as the voltage, they are often used by manufacturers to check the suitability of their products for use in other countries. 230V 50 Hz or 115 60 Hz or even 400 Hz for avionics testing.

2.4.5 SWITCHED MODE POWER SUPPLY

In a switched-mode power supply (SMPS), the AC mains input is directly rectified and then filtered to obtain a DC voltage. The resulting DC voltage is then switched on and off at a high frequency by electronic switching circuitry, thus producing an AC current that will pass through a high-frequency transformer or inductor. Switching occurs at a very high frequency (typically 10 kHz - 1 MHz), thereby enabling the use of transformers and filter capacitors that are much smaller, lighter, and less expensive than those found in linear power supplies operating at mains frequency. After the inductor or transformer secondary, the high frequency AC is rectified and filtered to produce the DC output voltage. If the SMPS uses an adequately insulated high-frequency transformer, the output will be electrically isolated from the mains; this feature is often essential for safety.

Switched-mode power supplies are usually regulated, and to keep the output voltage constant, the power supply employs a feedback controller that monitors current drawn by the load. The switching duty cycle increases as power output requirements increase.

SMPSs often include safety features such as current limiting or a crowbar circuit to help protect the device and the user from harm.[2] In the event that an abnormal high-current power draw is detected, the switched-mode supply can assume this is a direct short and will shut itself down before damage is done. PC power supplies often provide a power good signal to the motherboard, the absence of this signal prevents operation when abnormal supply voltages are present.

Some SMPSs have an absolute limit on their minimum current output. They are only able to output above a certain power level and cannot function below that point. In a no-load condition the frequency of the power slicing circuit increases to great speed, causing the isolated transformer to act as a Tesla coil, causing damage due to the resulting very high voltage power spikes. Switched-mode supplies with protection circuits may briefly turn on but then shut down when no load has been detected. A very small low-power dummy load such as a ceramic power resistor or 10-watt light bulb can be attached to the supply to allow it to run with no primary load attached.

The switch-mode power supplies used in computers have historically had low power factors and have also been significant sources of line interference (due to induced power line harmonics and transients). In simple switch-mode power supplies, the input stage may distort the line voltage waveform, which can adversely affect other loads (and result in poor power quality for other utility customers), and cause unnecessary heating in wires and distribution equipment. Furthermore, customers incur higher electric bills when operating lower power factor loads. To circumvent these problems, some computer switch-mode power supplies perform power factor correction, and may employ input filters or additional switching stages to reduce line interference.

2.4.6 PROGRAMMABLE POWER SUPPLY

A programmable power supply is one that allows remote control of its operation through an analog input or digital interface such asRS232 or GPIB. Controlled properties may include voltage, current, and in the case of AC output power supplies, frequency. They are used in a wide variety of applications, including automated equipment testing, crystal growth monitoring, semiconductor fabrication, and x-ray generators.

Programmable power supplies typically employ an integral microcomputer to control and monitor power supply operation. Power supplies equipped with a computer interface may use proprietary communication protocols or standard protocols and device control languages such as SCPI.

2.4.7 UNINTERRUPTIBLE POWER SUPPLY

An uninterruptible power supply (UPS) takes its power from two or more sources simultaneously. It is usually powered directly from the AC mains, while simultaneously charging a storage battery. Should there be a dropout or failure of the mains, the battery instantly takes over so that the load never experiences an interruption. In a computer installation, this gives the operators time to shut down the system in an orderly way. Other UPS schemes may use an internal combustion engine or turbine to continuously supply power to a system in parallel with power coming from the AC. The engine-driven generators would normally be idling, but could come to full power in a matter of a few seconds in order to keep vital equipment running without interruption. Such a scheme might be found in hospitals or telephone central offices.

2.4.8 HIGH VOLTAGE POWER SUPPLY

A 30 kV high voltage power supply with Federal Standard connector, used in electron microscopes. A high voltage power supply is one that outputs hundreds or thousands of volts. A special output connector is used that prevent sarcing, insulation breakdown and accidental human contact. Federal Standard connectors are typically used for applications above 20 kV, though other types of connectors (e.g., SHV connector) may be used at lower voltages. Some high voltage power supplies provide an analog input that can be used to control the output voltage. High voltage power supplies are commonly used to accelerate and manipulate electron and ion beams in equipment such as x-ray generators, electron microscopes, and focused ion beam columns, and in a variety of other applications, including electrophoresis and electrostatics.

High voltage power supplies typically apply the bulk of their input energy to a power inverter, which in turn drives a voltage multiplier or a high turns ratio, high voltage transformer, or both (usually a transformer followed by a multiplier) to produce high voltage. The high voltage is passed out of the power supply through the special connector, and is also applied to a voltage divider that converts it to a low voltage metering signal compatible with low voltage circuitry. The metering signal is used by a closed-loop controller that regulates the high voltage by controlling inverter input power, and it may also be conveyed out of the power supply to allow external circuitry to monitor the high voltage output.

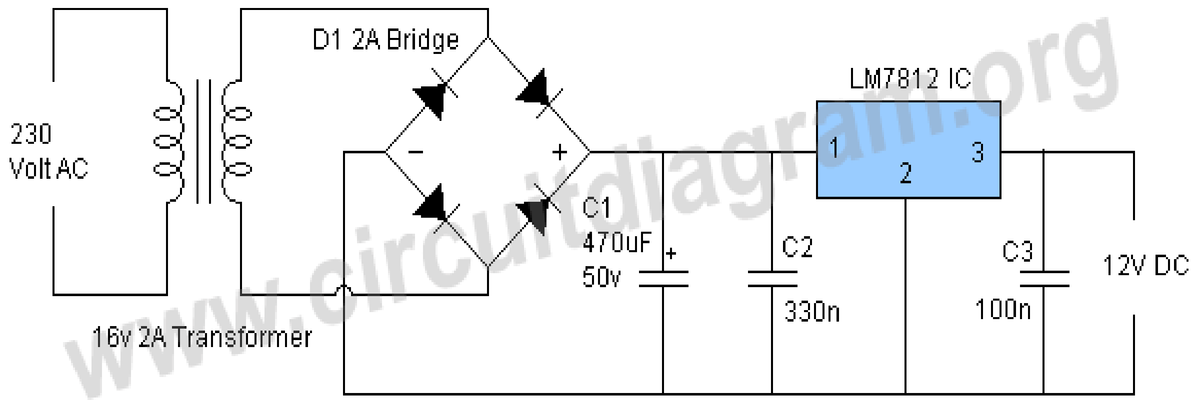

Fig.no 2.3

2.5 PUMP

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps. Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

Single stage pump - When in a casing only one impeller is revolving then it is called single stage pump.

Double/ Multi stage pump - When in a casing two or more than two impellers are revolving then it is called double/ multi stage pump. In biology, many different types of chemical and bio-mechanical pumps have evolved, and biomimicry is sometimes used in developing new types of mechanical pumps.

TYPES

Mechanical pumps may be submerged in the fluid they are pumping or be placed external to the fluid.

Pumps can be classified by their method of displacement into positive displacement pumps, impulse pumps, velocity pumps, gravity pumps, steam pumps and valveless pumps. There are two basic types of pumps: positive displacement and centrifugal. Although axial-flow pumps are frequently classified as a separate type, they have essentially the same operating principles as centrifugal pumps.

2.5.1 POSITIVE DISPLACEMENT PUMP

A positive displacement pump makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe. Some positive displacement pumps use an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant through each cycle of operation.

Positive displacement pumps, unlike centrifugal or roto-dynamic pumps, theoretically can produce the same flow at a given speed (RPM) no matter what the discharge pressure. Thus, positive displacement pumps are constant flow machines. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate.

A positive displacement pump must not operate against a closed valve on the discharge side of the pump, because it has no shutoff head like centrifugal pumps. A positive displacement pump operating against a closed discharge valve continues to produce flow and the pressure in the discharge line increases until the line bursts, the pump is severely damaged, or both. A relief or safety valve on the discharge side of the positive displacement pump is therefore necessary. The relief valve can be internal or external. The pump manufacturer normally has the option to supply internal relief or safety valves. The internal valve is usually only used as a safety precaution. An external relief valve in the discharge line, with a return line back to the suction line or supply tank provides increased safety.

Positive displacement types

A positive displacement pump can be further classified according to the mechanism used to move the fluid:

- **Rotary-type positive displacement**: internal gear, screw, shuttle block, flexible vane or sliding vane, circumferential piston, flexible impeller, helical twisted roots (e.g. the Wendelkolben pump) or liquid-ring pumps
- **Reciprocating-type positive displacement :** piston pumps, plunger pumps or diaphragm pumps
- **Linear-type positive displacement**: rope pumps and chain pumps.

Rotary positive displacement pumps

Rotary vane pump

These pumps move fluid using a rotating mechanism that creates a vacuum that captures and draws in the liquid.

***Advantages**:* Rotary pumps are very efficient because they naturally remove air from the lines, eliminating the need to bleed the air from the lines manually.

***Drawbacks**:* The nature of the pump requires very close clearances between the rotating pump and the outer edge, making it rotate at a slow, steady speed. If rotary pumps are operated at high speeds, the fluids cause erosion, which eventually causes enlarged clearances that liquid can pass through, which reduces efficiency.

Rotary positive displacement pumps fall into three main types:

- **Gear pumps** - a simple type of rotary pump where the liquid is pushed between two gears
- **Screw pumps -** the shape of the internals of this pump is usually two screws turning against each other to pump the liquid

- **Rotary vane pumps -** similar to scroll compressors, these have a cylindrical rotor encased in a similarly shaped housing. As the rotor orbits, the vanes trap fluid between the rotor and the casing, drawing the fluid through the pump.

Reciprocating positive displacement pumps

Reciprocating pumps move the fluid using one or more oscillating pistons, plungers, or membranes (diaphragms), while valves restrict fluid motion to the desired direction.

Pumps in this category range from simplex, with one cylinder, to in some cases quad (four) cylinders, or more. Many reciprocating-type pumps are duplex (two) or triplex (three) cylinder. They can be either single-acting with suction during one direction of piston motion and discharge on the other, or double-acting with suction and discharge in both directions. The pumps can be powered manually, by air or steam, or by a belt driven by an engine. This type of pump was used extensively in the 19th century—in the early days of steam propulsion—as boiler feed water pumps. Now reciprocating pumps typically pump highly viscous fluids like concrete and heavy oils, and serve in special applications that demand low flow rates against high resistance. Reciprocating hand pumps were widely used to pump water from wells. Common bicycle pumps and foot pumps for inflation use reciprocating action.

These positive displacement pumps have an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pumps as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant given each cycle of operation.

Typical reciprocating pumps are:

- **Plunger pumps** - a reciprocating plunger pushes the fluid through one or two open valves, closed by suction on the way back.
- **Diaphragm pumps** - similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder. Diaphragm valves are used to pump hazardous and toxic fluids.
- **Piston pumps** displacement pumps - usually simple devices for pumping small amounts of liquid or gel manually. The common hand soap dispenser is such a pump.
- **Radial piston pumps**

Various positive displacement pumps

The positive displacement principle applies in these pumps:

- Rotary lobe pump
- Progressive cavity pump
- Rotary gear pump
- Piston pump
- Diaphragm pump
- Screw pump
- Gear pump
- Hydraulic pump
- Rotary vane pump
- Peristaltic pump
- Rope pump
- Flexible impeller pump

GEAR PUMP

This is the simplest of rotary positive displacement pumps. It consists of two meshed gears that rotate in a closely fitted casing. The tooth spaces trap fluid and force it around the outer periphery. The fluid does not travel back on the meshed part, because the teeth mesh closely in the center. Gear pumps see wide use in car engine oil pumps and in various hydraulic power packs.

SCREW PUMP

A screw pump is a more complicated type of rotary pump that uses two or three screws with opposing thread e.g., one screw turns clockwise and the other counterclockwise. The screws are mounted on parallel shafts that have gears that mesh so the shafts turn together and everything stays in place. The screws turn on the shafts and drive fluid through the pump. As with other forms of rotary pumps, the clearance between moving parts and the pump's casing is minimal.

PROGRESSIVE CAVITY PUMP

Widely used for pumping difficult materials, such as sewage sludge contaminated with large particles, this pump consists of a helical rotor, about ten times as long as its width. This can be visualized as a central core of diameter *x* with, typically, a curved spiral wound around of thickness half *x*, though in reality it is manufactured in single casting. This shaft fits inside a heavy duty rubber sleeve, of wall thickness also typically *x*. As the shaft rotates, the rotor gradually forces fluid up the rubber sleeve. Such pumps can develop very high pressure at low volumes.

ROOTS TYPE PUMPS

Named after the Roots brothers who invented it, this lobe pump displaces the liquid trapped between two long helical rotors, each fitted into the other when perpendicular at 90°, rotating inside a triangular shaped sealing line configuration, both at the point of suction and at the point of discharge. This design produces a continuous flow with equal volume and no vortex. It can work at low pulsation rates, and offers gentle performance that some applications require.

Applications include:

- High capacity industrial air compressors
- Roots superchargers on internal combustion engines.
- A brand of civil defense siren, the Federal Signal Corporation's Thunderbolt.

PERISTALTIC PUMP

A peristaltic pump is a type of positive displacement pump. It contains fluid within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A number of rollers, shoes, or wipers attached to a rotor compresses the flexible tube. As the rotor turns, the part of the tube under compression closes (or occludes), forcing the fluid through the tube. Additionally, when the tube opens to its natural state after the passing of the cam it draws (restitution) fluid into the pump. This process is called peristalsis and is used in many biological systems such as the gastrointestinal tract.

PLUNGER PUMPS

Plunger pumps are reciprocating positive displacement pumps. These consist of a cylinder with a reciprocating plunger. The suction and discharge valves are mounted in the head of the cylinder. In the suction stroke the plunger retracts and the suction valves open causing suction of fluid into the cylinder. In the forward stroke the plunger pushes the liquid out of the discharge valve. Efficiency and common problems: With only one cylinder in plunger pumps, the fluid flow varies between maximum flow when the plunger moves through the middle positions, and zero flow when the plunger is at the end positions. A lot of energy is wasted when the fluid is accelerated in the piping system. Vibration and water hammer may be a serious problem. In general the problems are compensated for by using two or more cylinders not working in phase with each other.

TRIPLEX-STYLE PLUNGER PUMPS

Triplex plunger pumps use three plungers, which reduces the pulsation of single reciprocating plunger pumps. Adding a pulsation dampener on the pump outlet can further smooth the pump ripple, or ripple graph of a pump transducer. The dynamic relationship of the high-pressure fluid and plunger generally requires high-quality plunger seals. Plunger pumps with a larger number of plungers have the benefit of increased flow, or smoother flow without a pulsation dampener. The increase in moving parts and crankshaft load is one drawback.

Car washes often use these triplex-style plunger pumps (perhaps without pulsation dampeners). In 1968, William Bruggeman significantly reduced the size of the triplex pump and increased the lifespan so that car washes could use equipment with smaller footprints. Durable high pressure seals, low pressure seals and oil seals, hardened crankshafts, hardened connecting rods, thick ceramic plungers and heavier duty ball and roller bearings improve reliability in triplex pumps. Triplex pumps now are in a myriad of markets across the world.

Triplex pumps with shorter lifetimes are commonplace to the home user. A person who uses a home pressure washer for 10 hours a year may be satisfied with a pump that lasts 100 hours between rebuilds. Industrial-grade or continuous duty triplex pumps on the other end of the quality spectrum may run for as much as 2,080 hours a year.

The oil and gas drilling industry uses massive semi trailer-transported triplex pumps called mud pumps to pump drilling mud, which cools the drill bit and carries the cuttings back to the surface. Drillers use triplex or even quintuplex pumps to inject water and solvents deep into shale in the extraction process called fracking.

COMPRESSED AIR POWERED DOUBLE-DIAPHRAGM PUMPS

One modern application of positive displacement pumps is compressed-air-powered double-diaphragm pumps. Run on compressed air these pumps are intrinsically safe by design, although all manufacturers offer ATEX certified models to comply with industry regulation. These pumps are relatively inexpensive and can perform a wide variety of duties, from pumping water out of bunds, to pumping hydrochloric acid from secure storage (dependent on how the pump is manufactured – elastomers / body construction). Lift is normally limited to roughly 6m although heads can reach almost 200 psi (1.4 MPa).

ROPE PUMPS

Devised in China as chain pumps over 1000 years ago, these pumps can be made from very simple materials: A rope, a wheel and a PVC pipe are sufficient to make a simple rope pump. Rope pump efficiency has been studied by grass roots organizations and the techniques for making and running them have been continuously improved.

2.5.2 IMPULSE PUMPS

Impulse pumps use pressure created by gas (usually air). In some impulse pumps the gas trapped in the liquid (usually water), is released and accumulated somewhere in the pump, creating a pressure that can push part of the liquid upwards.

Conventional impulse pumps include:

- **Hydraulic ram pumps** – kinetic energy of a low-head water supply is stored temporarily in an air-bubble hydraulic accumulator, then used to drive water to a higher head.
- **Pulser pump*s*** – run with natural resources, by kinetic energy only.
- **Airlift pumps** – run on air inserted into pipe, which pushes the water up when bubbles move upward

Instead of a gas accumulation and releasing cycle, the pressure can be created by burning of hydrocarbons. Such combustion driven pumps directly transmit the impulse form a combustion event through the actuation membrane to the pump fluid. In order to allow this direct transmission, the pump needs to be almost entirely made of an elastomer (e.g. silicone rubber). Hence, the combustion causes the membrane to expand and thereby pumps the fluid out of the adjacent pumping chamber. The first combustion-driven soft pump was developed by ETH Zurich.

HYDRAULIC RAM PUMPS

A hydraulic ram is a water pump powered by hydropower. It takes in water at relatively low pressure and high flow-rate and outputs water at a higher hydraulic-head and lower flow-rate. The device uses the water hammer effect to develop pressure that lifts a portion of the input water that powers the pump to a point higher than where the water started.

The hydraulic ram is sometimes used in remote areas, where there is both a source of low-head hydropower, and a need for pumping water to a destination higher in elevation than the source. In this situation, the ram is often useful, since it requires no outside source of power other than the kinetic energy of flowing water.

2.5.3 VELOCITY PUMPS

Rotodynamic pumps (or dynamic pumps) are a type of velocity pump in which kinetic energy is added to the fluid by increasing the flow velocity. This increase in energy is converted to a gain in potential energy (pressure) when the velocity is reduced prior to or as the flow exits the pump into the discharge pipe. This conversion of kinetic energy to pressure is explained by the First law of thermodynamics, or more specifically by Bernoulli's principle. Dynamic pumps can be further subdivided according to the means in which the velocity gain is achieved.

These types of pumps have a number of characteristics:

1. Continuous energy
2. Conversion of added energy to increase in kinetic energy (increase in velocity)
3. Conversion of increased velocity (kinetic energy) to an increase in pressure head

A practical difference between dynamic and positive displacement pumps is how they operate under closed valve conditions. Positive displacement pumps physically displace fluid, so closing a valve downstream of a positive displacement pump produces a continual pressure build up that can cause mechanical failure of pipeline or pump. Dynamic pumps differ in that they can be safely operated under closed valve conditions (for short periods of time).

RADIAL FLOW PUMPS

Such a pump is also referred to as a centrifugal pump. The fluid enters along the axis or center, is accelerated by the impeller and exits at right angles to the shaft (radially); an example is the centrifugal fan, which is commonly used to implement a vacuum cleaner. Generally, a radial-flow pump operates at higher pressures and lower flow rates than an axial- or a mixed-flow pump.

AXIAL FLOW PUMPS

These are also referred to as all fluid pumps. The fluid is pushed outward or inward and move fluid axially. They operate at much lower pressures and higher flow rates than radial-flow (centripetal) pumps.

MIXED FLOW PUMPS

Mixed-flow pumps function as a compromise between radial and axial-flow pumps. The fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0 and 90 degrees from the axial direction. As a consequence mixed-flow pumps operate at higher pressures than axial-flow pumps while delivering higher discharges than radial-flow pumps. The exit angle of the flow dictates the pressure head-discharge characteristic in relation to radial and mixed-flow.

EDUCTOR-JET PUMP

This uses a jet, often of steam, to create a low pressure. This low pressure sucks in fluid and propels it into a higher pressure region.

2.5.4 GRAVITY PUMPS

Gravity pumps include the syphon and Heron's fountain. The hydraulic ram is also sometimes called a gravity pump; in a gravity pump the water is lifted by gravitational force.

2.5.5 STEAM PUMPS

Steam pumps have been for a long time mainly of historical interest. They include any type of pump powered by a steam engine and also pistonless pumps such as Thomas Savery's or the Pulsometer steam pump. Recently there has been a resurgence of interest in low power solar steam pumps for use in smallholder irrigation in developing countries. Previously small steam engines have not been viable because of escalating inefficiencies as vapour engines decrease in size. However the use of modern engineering materials coupled with alternative engine configurations has meant that these types of system are now a cost effective opportunity.

2.5.6 VALVELESS PUMPS

Valveless pumping assists in fluid transport in various biomedical and engineering systems. In a valveless pumping system, no valves (or physical occlusions) are present to regulate the flow direction. The fluid pumping efficiency of a valveless system, however, is not necessarily lower than that having valves. In fact, many fluid-dynamical systems in nature and engineering more or less rely upon valveless pumping to transport the working fluids therein. For instance, blood circulation in the cardiovascular system is maintained to some extent even when the heart's valves fail. Meanwhile, the embryonic vertebrate heart begins pumping blood long before the development of discernible chambers and valves. Ink jet printers operating on the Piezoelectric transducer principle also use valveless pumping. The pump chamber is emptied through the printing jet due to reduced flow impedance in that direction and refilled by capillary action.

Fig.no 2.4

2.6 SOLENOID VALVE

A Solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports. Multiple solenoid valves can be placed together on a manifold.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design. Besides the plunger-type actuator which is used most frequently, pivoted-armature actuators and rocker actuators are also used.

2.6.1 OPERATION

There are many valve design variations. Ordinary valves can have many ports and fluid paths. A 2-way valve, for example, has 2 ports; if the valve is open, then the two ports are connected and fluid may flow between the ports; if the valve is closed, then ports are isolated. If the valve is open when the solenoid is not energized, then the valve is termed normally open (N.O.). Similarly, if the valve is closed when the solenoid is not energized, then the valve is termed normally closed. There are also 3-way and more complicated designs. A 3-way valve has 3 ports; it connects one port to either of the two other ports (typically a supply port and an exhaust port).

Solenoid valves are also characterized by how they operate. A small solenoid can generate a limited force. If that force is sufficient to open and close the valve, then a direct acting solenoid valve is possible. An approximate relationship between the required solenoid force F_s, the fluid pressure *P*, and the orifice area *A* for a direct acting solenoid value is: where *d* is the orifice diameter. A typical solenoid force might be 15 N (3.4 lb_f). An application might be a low pressure (e.g., 10 psi (69 kPa)) gas with a small orifice diameter (e.g.,⅜ in (9.5 mm) for an orifice area of 0.11 in^2 (7.1×10^{-5} m^2) and approximate force of 1.1 lbf (4.9 N)).

2.6.2 INTERNALLY PILOTED

While there are multiple design variants, the following is a detailed breakdown of a typical solenoid valve design. A solenoid valve has two main parts: the solenoid and the valve. The solenoid converts electrical energy into mechanical energy which, in turn, opens or closes the valve mechanically. A direct acting valve has only a small flow circuit, shown within section E of this diagram (this section is mentioned below as a pilot valve). In this example, a diaphragm piloted valve multiplies this small pilot flow, by using it to control the flow through a much larger orifice.

Solenoid valves may use metal seals or rubber seals, and may also have electrical interfaces to allow for easy control. A spring may be used to hold the valve opened (normally open) or closed (normally closed) while the valve is not activated. When high pressures and large orifices are encountered, then high forces are required. To generate those forces, an internally piloted solenoid valve design may be possible. In such a design, the line pressure is used to generate the high valve forces; a small solenoid controls how the line pressure is used. Internally piloted valves are used in dishwashers and irrigation systems where the fluid is water, the pressure might be 80 pounds per square inch (550 kPa) and the orifice diameter might be ¾ in (19 mm). In some solenoid valves the solenoid acts directly on the main valve. Others use a small, complete solenoid valve, known as a pilot, to actuate a larger valve. While the second type is actually a solenoid valve combined with a pneumatically actuated valve, they are sold and packaged as a single unit referred to as a solenoid valve. Piloted valves require much less power to control, but they are noticeably slower. Piloted solenoids usually need full power at all times to open and stay open, where a direct acting solenoid may only need full power for a short period of time to open it, and only low power to hold it.

A direct acting solenoid valve typically operates in 5 to 10 milliseconds. The operation time of a piloted valve depends on its size; typical values are 15 to 150 milliseconds. Power consumption and supply requirements of the solenoid vary with application, being primarily determined by fluid pressure and line diameter. For example, a popular 3/4" 150 psi sprinkler valve, intended for 24 VAC (50 - 60 Hz) residential systems, has a momentary inrush of 7.2 VA, and a holding power requirement of 4.6 VA.[5] Comparatively, an industrial 1/2" 10000 psi valve, intended for 12, 24, or 120 VAC systems in high pressure fluid and cryogenic applications, has an inrush of 300 VA and a holding power of 22 VA.[6] Neither valve lists a minimum pressure required to remain closed in the un-powered state.

Fig.no 2.5

2.7 FLOW CHART

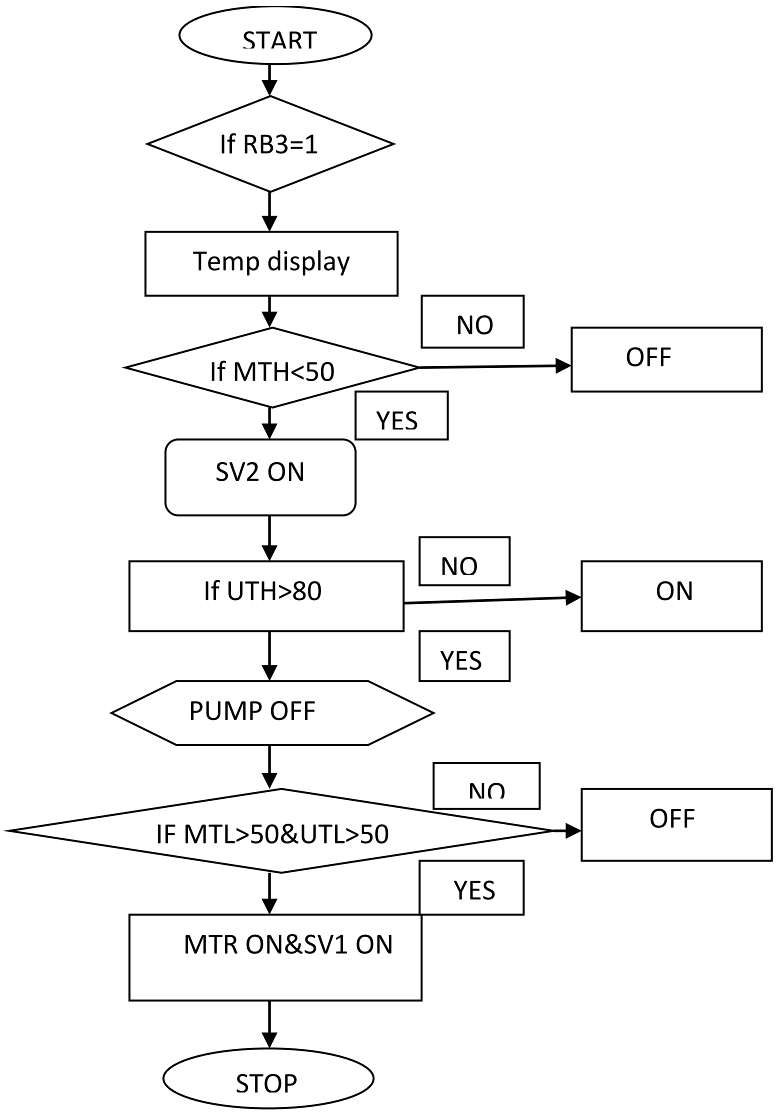

Fig.no 2.6

3. RESULTS

3.1 PUMP ON

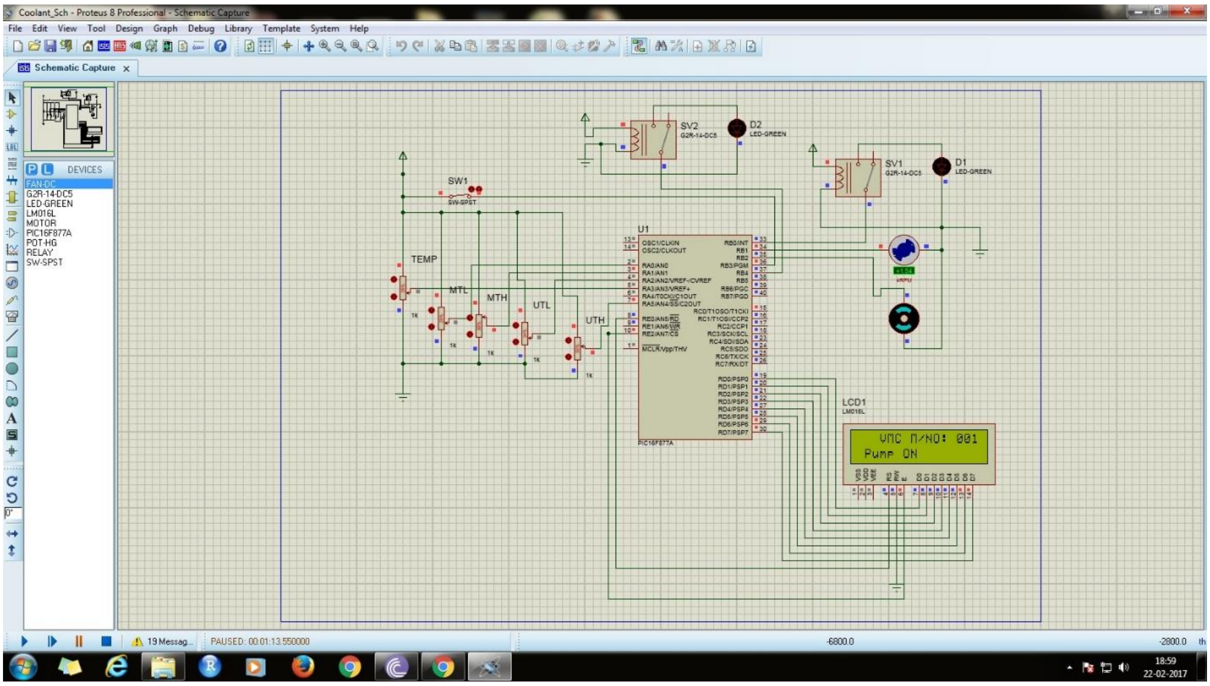

Fig.no 3.1

3.2 PUMP OFF

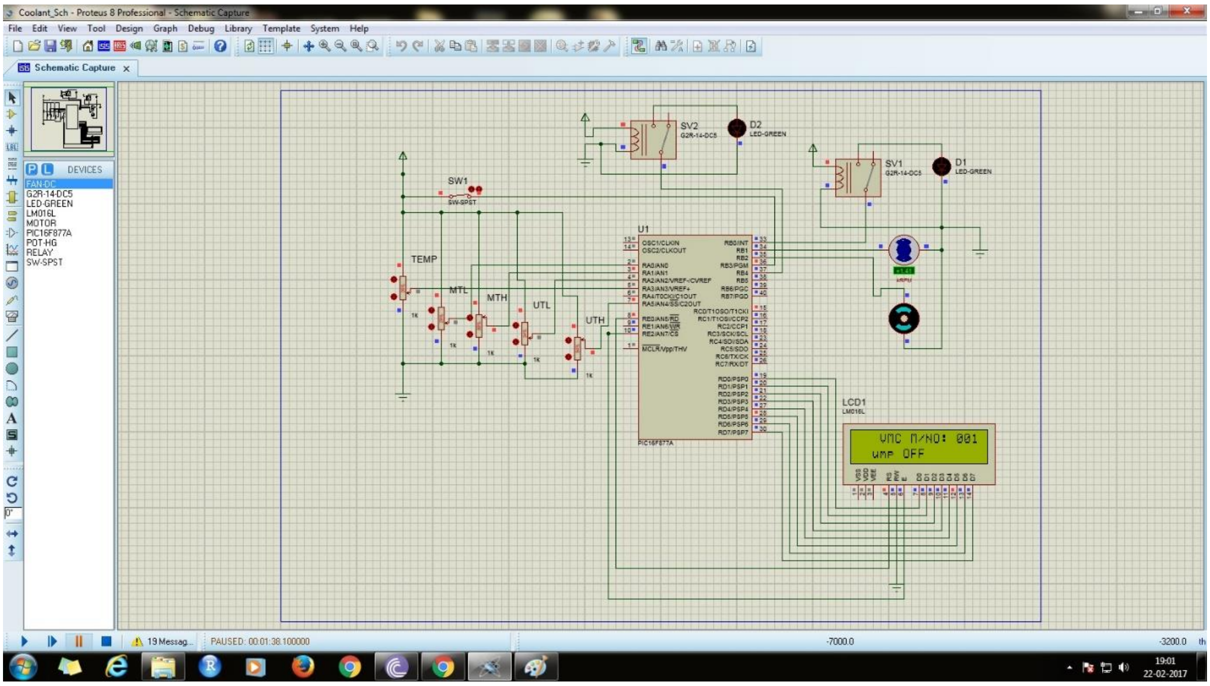

Fig.no 3.2

3.3 SV2 ON

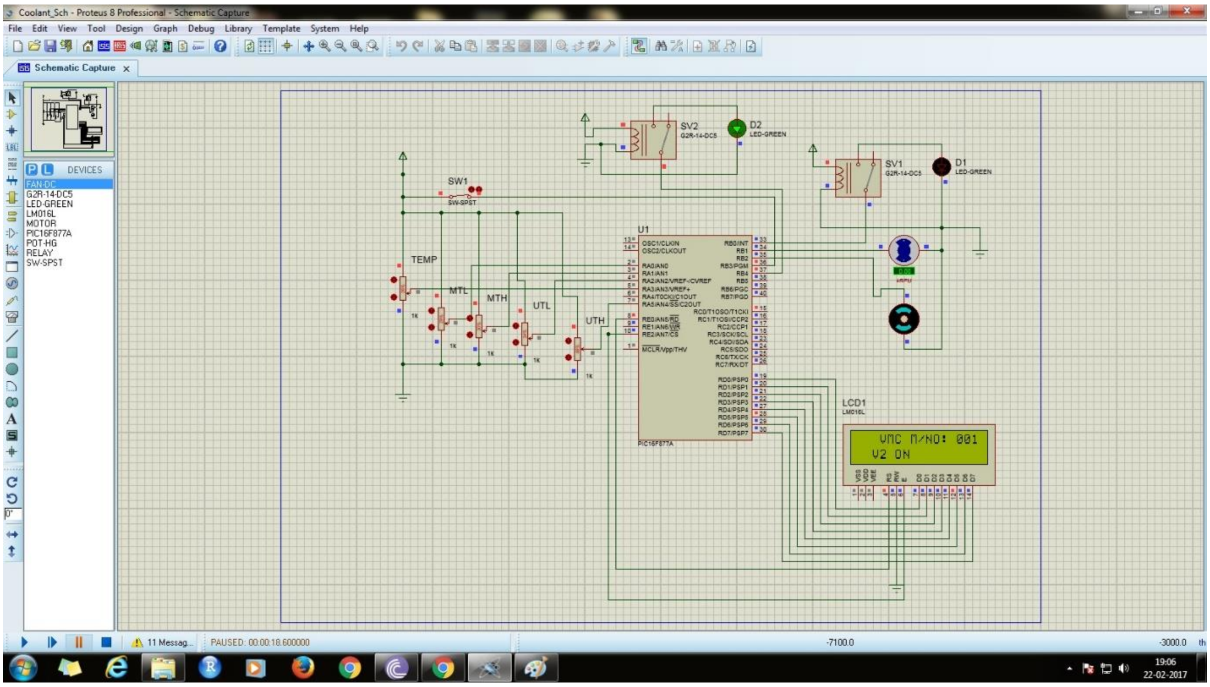

Fig.no 3.3

3.4 SV2 OFF

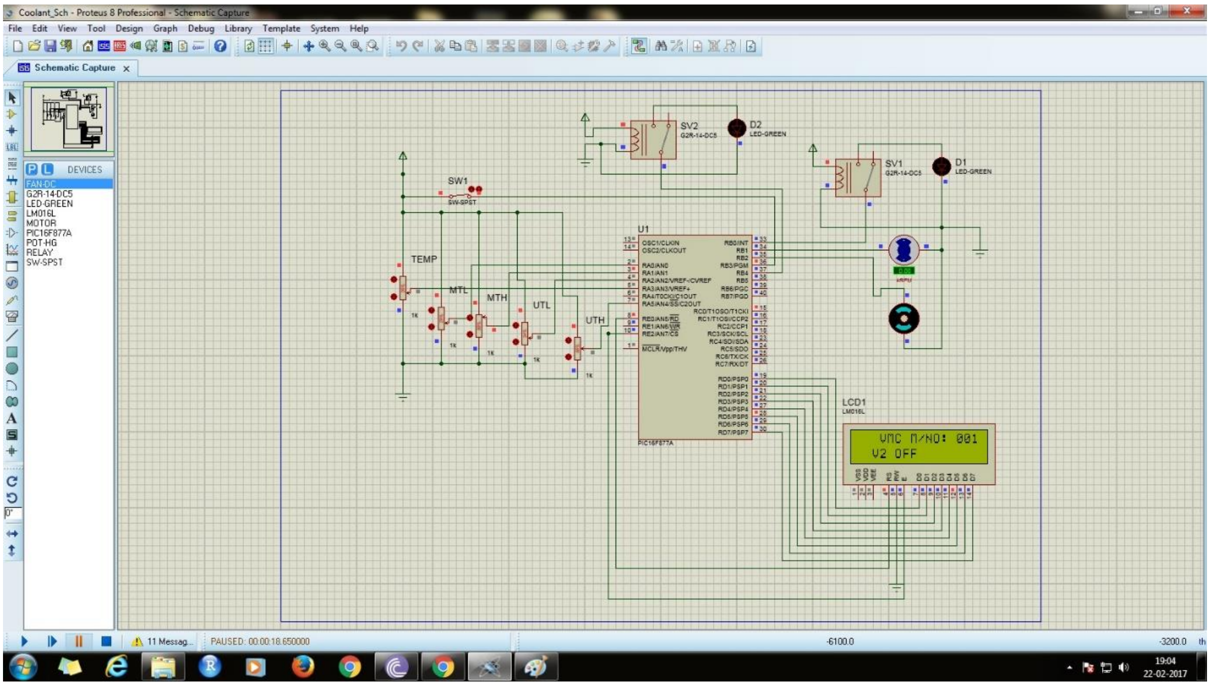

Fig.no 3.4

3.5 MILLING STOP

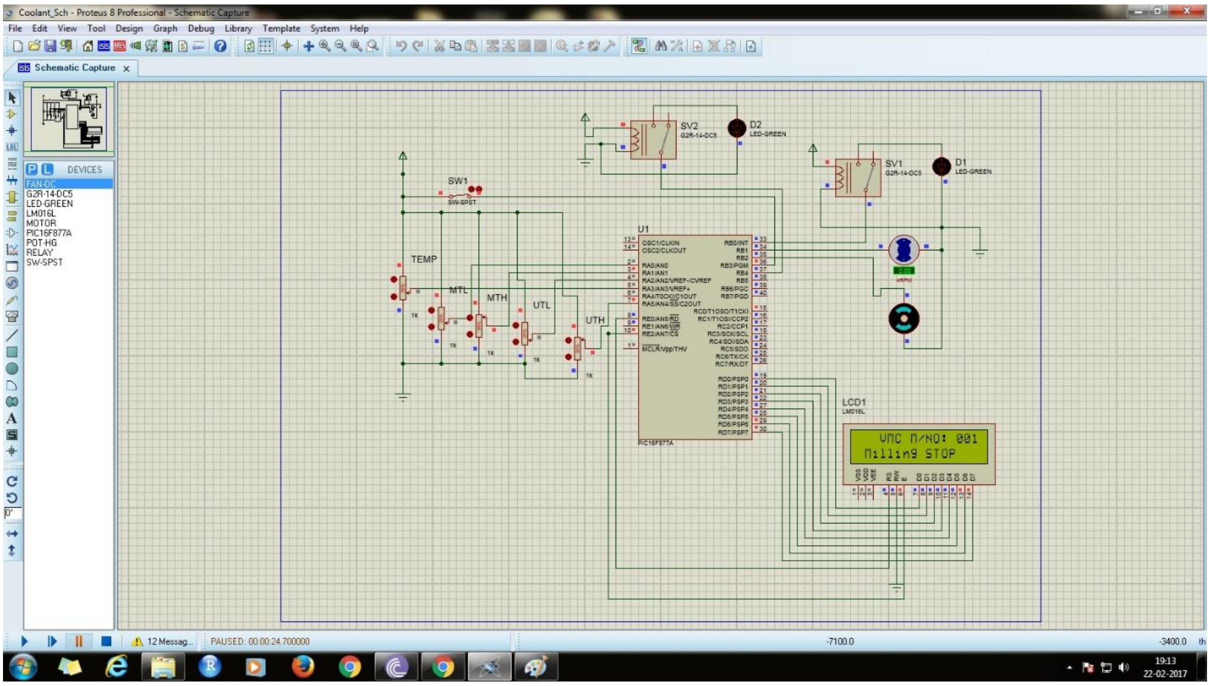

Fig.no 3.5

4. CONCLUSION

Thus the idea of automatic control of coolant oil in a VMC machine is controlled and implemented successfully by measuring the level of coolant oil from its tank.

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