CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF MECHANICAL ENGINEERING

Department of Instrumentation and Control Engineering

Master's Thesis

Control and Vizualization of the

Special Pneumatic Drive Application

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FACULTY
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MASTER THESIS ASSIGNMENT

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II. MASTER THESIS SPECIFICATION

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1. Study materials to TP 220 set - pneumatic drives
2. Design control by PLC for semirotary drive application
3. Design visualization of the application in the SCADA system
4. Compare tacts time for variant types of the loads

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Pneumatic Drives, Workbook TP220, 559880, Festo
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III. THESIS ASSIGNMENT RECEIVED

The student is aware that the thesis has to be accomplished through an independent and unassisted student's work, supported only by recognized consultations. Literature and other information resources as well as consultants' names have to be acknowledged in the thesis.

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ANNOTATION LIST

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STATEMENT

I declare that I have worked out this thesis independently assuming that the results of the Thesis can also be used at the discretion of the supervisor of the thesis as its co-author. I also agree with the potential publication of the results of the thesis or its substantial part, provided I will be listed as the co-author.

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ABSTRACT

This master thesis work mainly involves of the tact time measurements of the pneumatic actuator, with various types of load. The manual data are measured from the experiments done with using FESTO TP220 set. Aimed to gain knowledge about various types of actuators and compared those with TP220 supplements and know the actuators involved in the industries for transportation applications. Targeted to design a control by using PLC SIMATIC S7-200 also virtual control with GRAPHCET language.

To prepare visualization of the semi-rotary drive using Reliance 4 Design SCADA software. The SCADA software design is used to monitor the process and to calculate the time of the semi-rotary drive.

The entire process involves the communication between field level, PLC control and SCADA system. The communication is achieved from a low level to high levels of automation.

CONTENTS

1   INTRODUCTION

Nowadays, pneumatics is popular in various industries, particularly in automation technology. The pneumatic drive plays a dominant role in many automated, materials handling tasks. It is due to the following reason: low cost, safe and compact positioning system.

It is well suited for light and medium-duty applications. Furthermore, they are fast acting, clean and require little maintenance. They are widely used in industry to perform simple pick-and-place fixed set point tasks. However, pneumatic systems are not widely used for servo applications (variable set point) because of their poor dynamic response as compared to electric or hydraulic systems. Air compressibility can cause spongy operation and delays in signal transmission, affecting both response time and positioning accuracy.

This thesis work will give a clear idea about the time calculations about the linear and semi-rotary drive actuators, which is suited for the above-mentioned problem.

1.1   ACTUATORS

The System (Drives or Actuators) which converts the energy into mechanical motion. Basically, it is divided into two major parts based on the type of motion and based on energy source used.

There are five types of energy source used in the system in the form of pneumatic, hydraulic, mechanical, thermal or magnetic (shape memory alloys) and electrical.

Actuators can create mechanical motions which include linear, rotary or oscillatory and swivel motion which is most commonly used in manufacturing and assembly processes.

The following topic consists of a brief explanation of above actuators types.

1.1.1 PNEUMATIC ACTUATORS [10]

Pneumatic actuators are the devices used for converting pressure energy of compressed air into the mechanical energy to perform useful work. In other words, actuators are used to perform the task of utilising the required force at the end of the stroke or used to create displacement by the movement of the piston. The pressurised air from the compressor is supplied to the reservoir. The pressurised air from storage is supplied to

pneumatic actuator to do work. Pneumatic cylinders can be used to get linear, rotary and oscillatory motion. Pneumatic actuators are used in the area where the purity is important.

For example, pneumatic actuators are used to clamping, transfer, positioning of work piece in handling technology.

Fig. 1: Fluidic Muscle [1]

1.1.2 HYDRAULIC ACTUATORS

Hydraulic actuators are used in industrial process control, employ hydraulic pressure to drive an output member. These are used where high speed and large forces are required. The fluid used in the hydraulic actuator is highly incompressible so that pressure applied can be transmitted instantaneously to the member attached to it. [10]
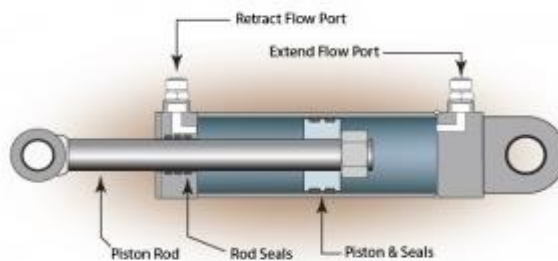
Fig. 2: Section view of Hydraulic Drive [10]

1.1.3 MECHANICAL ACTUATORS

Mechanical linear actuators typically operate by conversion of rotary motion into linear motion. Conversion is commonly made via a few simple types of mechanism: screw, cam and gear. For example, rack and pinion steering system which is used in traditional automobiles.

Fig. 3: Ball and screw actuator

1.1.4 ELECTRICAL ACTUATORS

This type of actuators converts electrical energy into mechanical torque. It is one of the cleanest and readily available actuators basically used in multi-turn valves. Electric motors are best examples for this type of actuators.
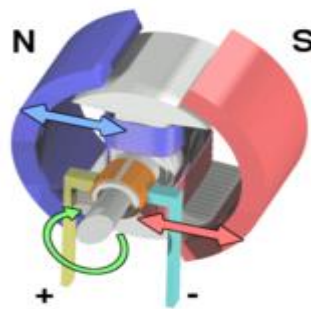
Fig. 4: Structure of electric motor assembly [10]

1.1.5 SHAPE MEMORY ALLOYS

Shape-memory actuators are used where a large force and stroke are required and thermodynamic efficiency is not essential. Since the discovery of shape memory in titanium-nickel, a number of inventions have been made having applications in medicine, aerospace, automotive, and consumer products. These devices range in size from meters to micrometres. Shape memory alloy have the capability to retain their original form when subjected to heat or a magnetic field. These unique properties are used in various fields including transportation, aerospace, and biomedical.
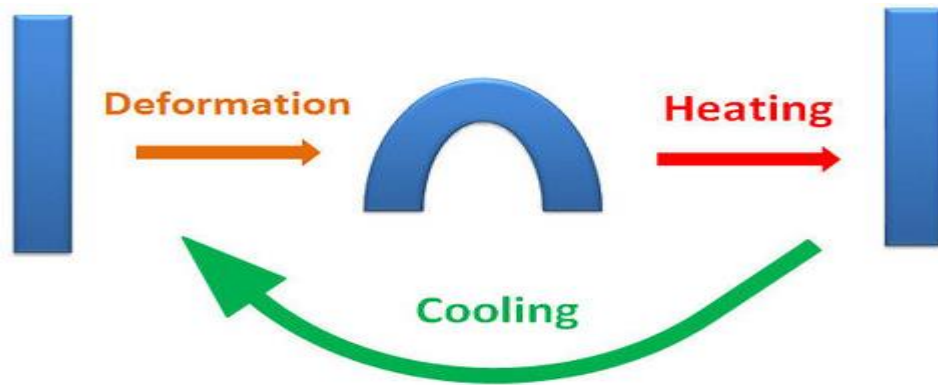
Fig. 5: Process of shape memory alloy

1.2 PRINCIPLES USED IN ACTUATORS

Operating principles are one of the most important considerations among materials, sizing and performance parameters of the drive. To achieve in the proper working and condition of operation.

As straightforward as most drives seem external, the multitude of parameters crucial for its reliable use, require the user to be aware of the technologies and criteria.

1.3 PRINCIPLE USED IN LINEAR DRIVES [1]

A rod less air cylinder differs from a basic air cylinder in that no piston rod extends outside the cylinder body. Instead, the internal piston is connected to an external carriage, by means of a magnetic or mechanical coupling system. Three different operating principles are used for the design of rod less cylinders:

- Cable cylinder
- Linear-type cylinders with slotted cylinder barrel
- Cylinders with magnetically coupled slide

1.3.1 BAND CYLINDER

Cable cylinder also is known as band cylinder. In the case of band cylinders, the piston force is transmitted to a slide via a circulating band. The band runs through a seal as it leaves the piston chamber. In the cylinder caps, the band is returned by means of guide rollers. Wipers ensure that contamination does not reach the guide rollers via the band.
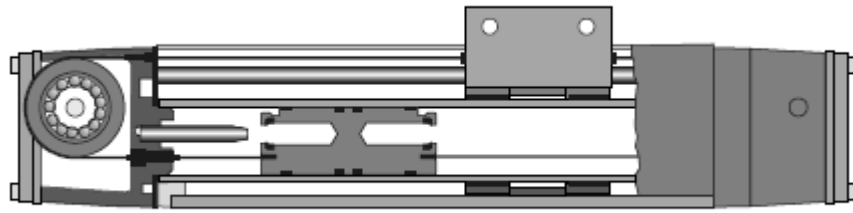
Fig. 6: Cable cylinder [1]

1.3.2 LINEAR-TYPE CYLINDER

With this type, the cylinder barrel is provided with a slot over its entire length. Force is available on a slide that is permanently connected to the piston. The connection from the piston to the slide is effected externally via the slotted cylinder barrel. The slot is sealed by means of a steel band which covers the inside of the slot. The band is deflected between the piston seals and guided underneath the slide. A second band covers the slot externally to prevent the ingress of dirt.
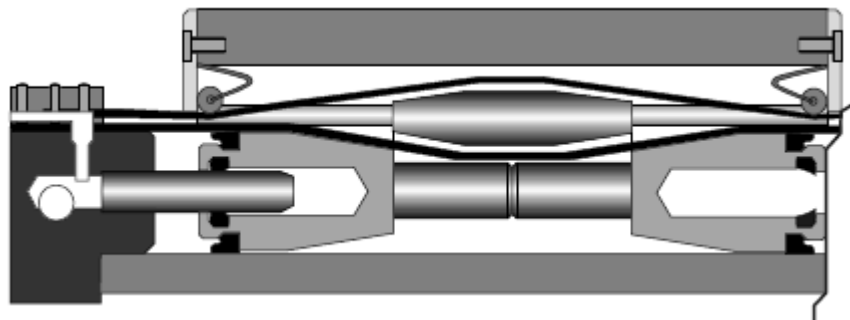
Fig. 7: Linear-type cylinder [1]

1.3.3 CYLINDER WITH MAGNETIC COUPLING

This double-acting pneumatic linear drive consists of a cylinder drum, piston and moving outer slide on the cylinder drum. The piston and outer slide are equipped with permanent magnets. Motion is transmitted from the piston to the outer slide via the force-locking of the magnetic coupling. As soon as the piston is forced, the slide moves synchronously with the piston. The cylinder chamber is hermetically sealed against the outer slide as there is not mechanical connection. This prevents any leakage loss.
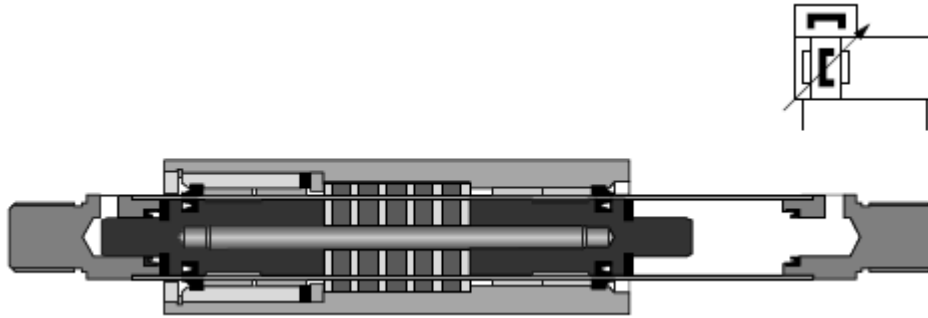
Fig. 8: Cylinder with magnetic coupling [1]

1.4   PRINCIPLE OF ROTARY DRIVE

Two main operating principles for pneumatic semi-rotary actuators are known:

• The semi-rotary vane drive principle

• The rack and pinion drive principle

1.4.1 SEMI-ROTARY VANE DRIVE

A semi-rotary vane rotary actuator is shown in Fig.9. A semi-rotary actuator allows only a partial revolution. A vane-type semi-rotary actuator consists of a vane connected to an output shaft. When pneumatic pressure is applied to one side of the vane, it rotates. A stop prevents the vane from rotating continuously. Compared to their size, semi-rotary vane drives are able to generate very high torques and are therefore highly effective. Typical swivel or rotary angles are 90° and 180° for transferring or passing on workpieces in production or assembly.
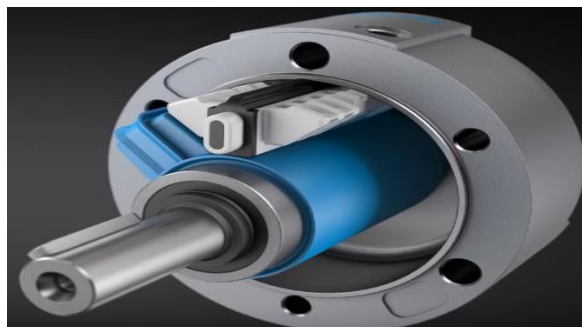
Fig. 9: Semi-rotary vane drive [8]

1.4.2 RACK AND PINION DRIVE

A rack and pinion rotary actuator are a commonly used design for obtaining partial revolution actuation. This consists of a pneumatic cylinder with a rack and pinion gear mechanism. The rack gear on the piston rod turns the pinion gear, thereby converting the linear motion of the piston into rotary motion, which is transmitted to the load through the output shaft.
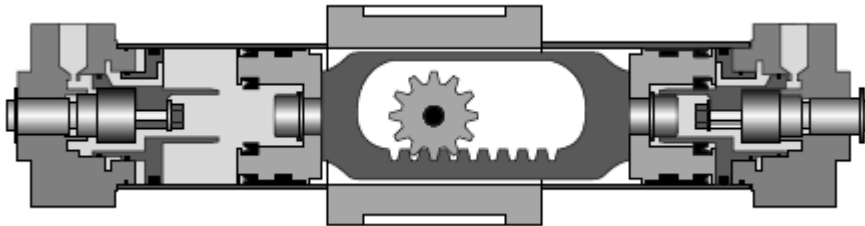
Fig. 10: Rack and Pinion Drive [1]

The main advantage of the rack and pinion principle compared to semi-rotary vane drives is the possibility of a larger rotary angle possible. The longer the gear rack and as such the piston stroke, the greater is the rotary angle possible. A rack and pinion drive of 360° or more is therefore perfectly feasible.

1.4.3 APPLICATION OF ROTARY DRIVES

Rotary actuators are used for mixing, dumping, intermittent feeding, and clamping, continuous rotation, turning over, automated transfer, providing constant tension, and material handling. They are also suitable for turning, toggle clamping, indexing, positioning, oscillating, lifting, opening, closing, pushing, pulling, and lowering.

2   TECHNOLOGIES USED

2.1   PLC

A Programmable Logic Controller (PLC) is a digital computer widely used in the field of automation. PLCs are designed for multiple arrangements of digital and analogue input and outputs. PLC continuously monitors the input and makes decisions based on a program to control the output. PLC is the replacement of the complex relay control systems.

Nowadays, many industrial production processes, machine function enhanced this type of control system. The biggest benefits of PLC are the ability to change and replicate the process while collecting and communicating vital information. Another advantage of a PLC system is that it can be modular. It is possible to mix and match the types of Input and Output devices to best suit your application.

Some producers of PLC are Siemens, Rockwell Automation, Mitsubishi, Schneider Electric, Omron, GE Fanuc, B7R Industrial, ABB, Sharp, Moeller and Hitachi IES.

2.2   BASIC OF PLC
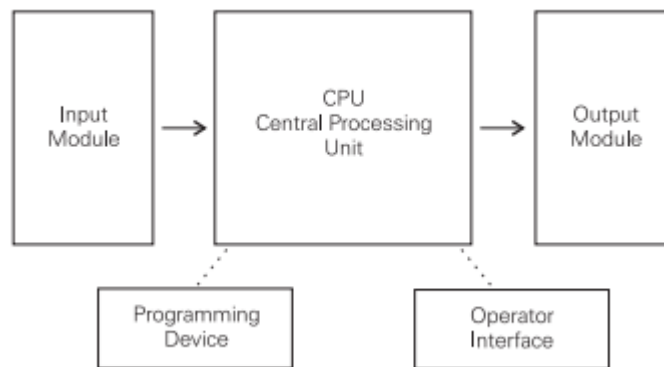
Fig. 11: PLC architecture

2.3   PLC OPERATE

There are four basic steps in the operation of all PLCs. These steps continually take place in a repeating loop. Four steps in the PLC operations are:

1. Input Scan
2. Program Scan
3. Output Scan
4. Housekeeping

INPUT SCAN

Detects the state of all input devices that are connected to the PLC.

PROGRAM SCAN

Executes the user created program logic.

OUTPUT SCAN

Energizes or de-energizes all output devices that are connected to the PLC

HOUSEKEEPING

This step includes communications with programming terminals, internal diagnostics, etc...

2.3.1 INPUTS

Input devices can consist of digital or analog devices. A digital input card handles discrete devices which give a signal that is either on or off such as a pushbutton, limit switch, sensors or selector switches. An analog input card converts a voltage or current into a digitally equivalent number that can be understood by the CPU. Examples of analog devices are pressure transducers, flow meters and thermocouples for temperature readings Condition Sensors.

2.3.2 OUTPUTS

Output devices can also consist of digital or analog types. A digital output card either turns a device on or off such as lights, LEDs, small motors, and relays. An analog output card will convert a digital number sent by the CPU to its real-world voltage or current. Typical outputs signals can range from 0-10 VDC or 4-20mA and are used to drive mass flow controllers, pressure regulators and position controls.

2.4   PROGRAMMING LANGUAGES USED IN PLC

2.4.1 IMPORTANCE OF IEC 61131

IEC 61131-3 is the most important standard in the industry. 80% of all PLCs support it, all new developments are based on it. Depending on the country, some languages are more popular than others. Fig. 12 shows types of IEC 61131 languages.
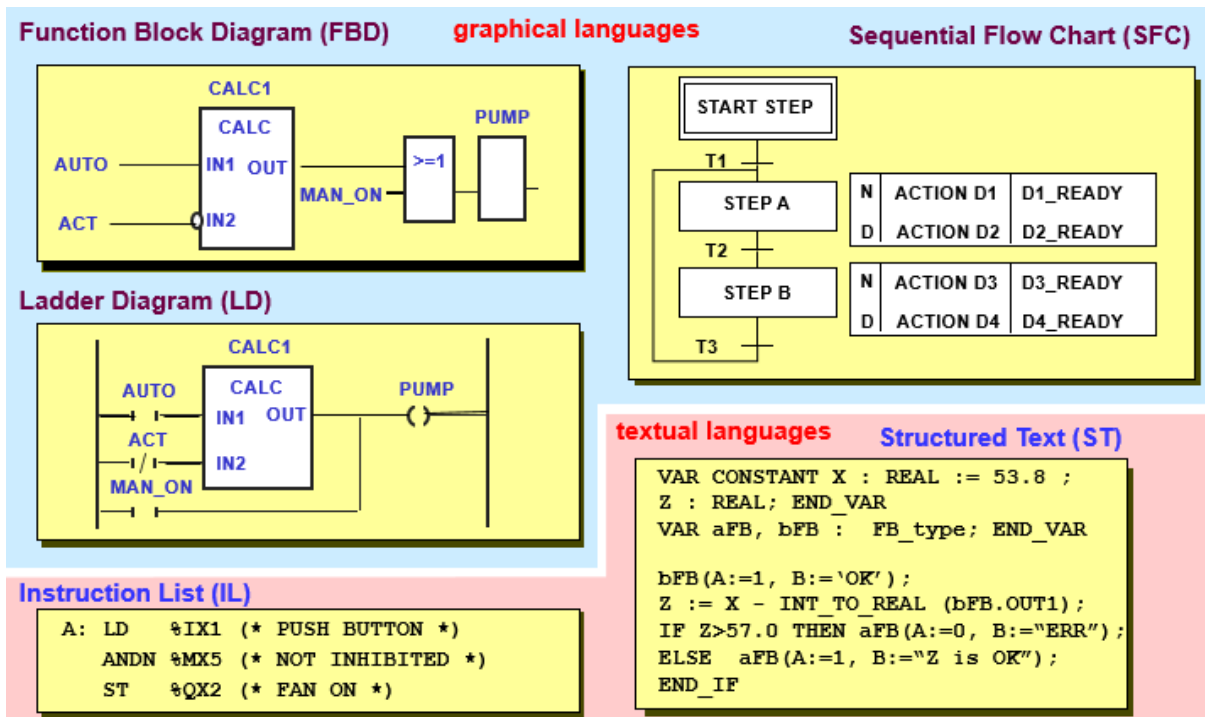
Fig. 12: Programming language of IEC 61131 [3]

2.4.2 LADDER DIAGRAM (LD)

Ladder Diagram (LD) traditional Ladder logic is a graphical programming language. Initially programmed with simple contacts that simulated the opening and closing of relays, Ladder Logic programming has been expanded to include such functions as counters, timers, shift registers, and math operations.

2.4.3 STRUCTURED TEXT (ST)

Structured Text is a commanding language similar to Pascal (If, While, etc...) The variables defined in ST can be used in other languages and supports a wide range of standard functions and operators.

2.4.4 INSTRUCTION LIST (IL)

A low level "assembler like" language that is based on similar instructions list languages found in a wide range of today's PLCs.

2.4.5 SEQUENTIAL FUNCTION CHART (SFC)

A method of programming complex control systems at a more highly structured level. An SFC program is an overview of the control system, in which the basic building blocks entire program files. Each program file is created using one of the other types of

programming languages. The SFC approach coordinates large, complicated programming tasks into smaller, more manageable tasks.

Describes sequences of operations and interactions between parallel processes.

Derived from Grafcet and SDL (Specification and Description Language, used for communication protocols), mathematical foundation lies in Petri Nets.

2.4.6 FUNCTION BLOCK DIAGRAM (FBD)

Function Block Diagrams (FBDs) are another language from of the IEC 61131-3 standard. Graphical language for depicting signal and data flows through reusable function blocks. In these types of programs, the values flow from the inputs to the outputs, through function blocks. FBD is very useful for expressing the interconnection of control system algorithms and logic.

2.5 BENEFITS OF USING PLC

- Increasing productivity
- Increasing quality
- Reducing process cost
- High level of safety in working condition

2.6 ADVANTAGES OF PLC CONTROL

- Programming languages are an easy program and understood.
- PLC's are reprogrammable.
- Less space and maintenance required.
- Inputs and outputs can monitor easily.
- Great life and reliability
- Multiple devices are embedded with a single PLC-like timer and memory and multiple sensors can be attached.

2.7 DISADVANTAGES OF PLC CONTROL

- Cost is high.
- Finding errors is difficult and need more skilled workers.
- Challenging Process with replacement or changes.
- Complicated with connecting wires.
- Debugging is complicated and indefinite time process.

2.8 PLC APPLICATION EXAMPLES

- Automotive Industry: Reducing Time-To-Customer and Other Costs.

- Beverage Industry: Improving Production Flexibility and Agility.

- Entertainment Industry: Increasing the Safety, Reliability and Profitability.

- Marine Industry: Optimise Equipment Performance and Improve Reliability.

- Packaging Industry: Deliver Greater Speed and Accuracy to Meet Urgent Demands

2.9 SCADA

SCADA (supervisory control and data acquisition) is a software program for process control. The SCADA system consists of a master control station with one or more PC-based human machine interfaces (HMIs). Human-Machine Interface: If done on PC or operator interface that allows a person to interact with a control system. It may contain trends, alarm summaries, pictures, or animation. The SCADA system may also contain other secondary control stations with HMIs, and large substations may also have local HMIs. The front end of the SCADA is Graphic User Interface (GUI).
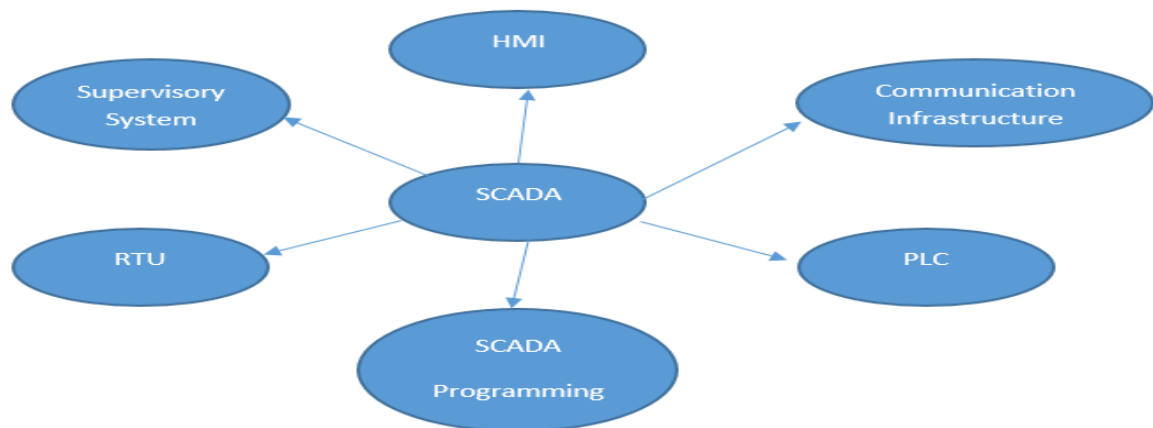
Fig. 13: SCADA

2.9.1 SCADA SYSTEM

SCADA (**supervisory control and data acquisition**) is a system operating with coded signals over communication channels so as to provide control of remote equipment (using typically one communication channel per remote station). The control system may be combined with a data acquisition system by adding the use of coded signals over communication channels to acquire information about the status of the remote equipment

for display or for recording functions. It is a type of industrial control system (ICS). Industrial control systems are computer-based systems that monitor and control industrial processes that exist in the physical world. SCADA systems historically distinguish themselves from other ICS systems by being large-scale processes that can include multiple sites and large distances. These processes include industrial, infrastructure, and facility-based processes, as described below:

- Industrial processes include those of manufacturing, production, power generation, fabrication, and refining, and may run in continuous, batch, repetitive, or discrete modes.

2.9.2 SYSTEM COMPONENTS

An SCADA system usually consists of the following subsystems:

- Remote terminal units (RTUs) are connected to sensors in the process and convert sensor signals to digital data. They have telemetry hardware capable of sending digital data to the supervisory system, as well as receiving digital commands from the supervisory system. RTUs often have embedded control capabilities such as ladder logic in order to accomplish boolean logic operations.

- Programmable logic controller (PLC) are connected to sensors and actuators in the process and convert sensor signals to digital data. PLCs have more sophisticated embedded control capabilities (typically one or more IEC 61131-3 programming languages) than RTUs. PLCs do not have telemetry hardware, although this functionality is typically installed alongside them. PLCs are sometimes used in place of RTUs as field devices because they are more economical, versatile, flexible, and configurable.

- A telemetry system is typically used to connect PLCs and RTUs with control centres, data warehouses, and the enterprise. Examples of wired telemetry media used in SCADA systems include leased telephone lines and WAN circuits. Examples of wireless telemetry media used in SCADA systems include satellite (VSAT), licensed and unlicensed radio, cellular and microwave.

- A data acquisition server is a software service which uses industrial protocols to connect software services, via telemetry, with field devices such as RTUs and PLCs. It allows clients to access data from these field devices using standard protocols.

- A human–machine interface or HMI is the apparatus or device which presents processed data to a human operator, and through this, the human operator monitors and interacts with the process. The HMI is a client that requests data from a data acquisition server.

- A historian is a software service which accumulates time-stamped data, Boolean events, and Boolean alarms in a database which can be queried or used to populate graphic trends in the HMI. The historian is a client that requests data from a data acquisition server.

- A supervisory (computer) system, gathering (acquiring) data on the process and sending commands (control) to the SCADA system.

Reliance, WinCC, Eclipse SCADA, Stuxnet, PROMOTIC SCADA are some list of SCADA system.

2.9.3 APPLICATIONS OF SCADA

SCADA systems are used for monitoring a variety of data like fluid flows, currents, pressures, temperatures, water levels, and etc. If the system detects any abnormal conditions from any monitoring data, then the alarms at the central or remote sites will be triggered for alerting the operators through HMI.

2.10 OPC COMMUNICATION

OPC is a software interface standard that allows Windows programs to communicate with industrial hardware devices. The acronym "OPC" comes from "OLE (Object Linking and Embedding) for Process Control".
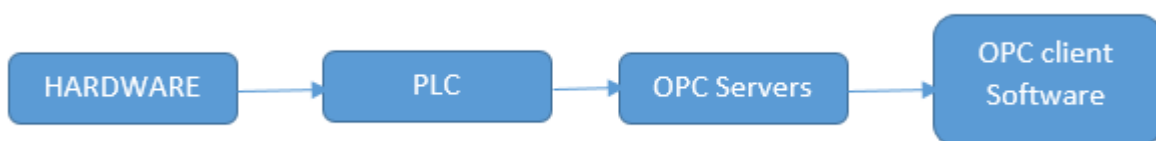

Fig. 14: single server-client connection

OPC is the interoperability standard for the secure and reliable exchange of data in the industrial automation space and in other industries. It is platform independent and ensures the seamless flow of information among devices from multiple vendors. The OPC Foundation is responsible for the development and maintenance of this standard. [2]

3   SOFTWARE DESCRIPTION

3.1   FLUIDSIM® PNEUMATICS V5.0

FluidSIM is a comprehensive software for the creation, simulation, instruction and study of electro-pneumatic, electrohydraulic, digital and electronic circuits. All the program functions interact smoothly, combining different media forms and sources of knowledge in an easily accessible fashion. FluidSIM unites an intuitive circuit diagram editor with detailed descriptions of all components, component photos, sectional view animations and video sequences. The new simulation core need not fear a comparison with more expensive special programs. Despite complex physical models and precise mathematical procedures simulation is amazingly fast. FluidSIM also provides a whole range of possibilities for communication with other software via OPC/DDE.

Therefore, alongside some common part designs in the component library, configurable and representative components. Pneumatic components for simulation are selected from the Library on the left side to the workspace or new project space. And play button starts the movement of the actuators according to how it is being simulated as shown in Fig. 15.
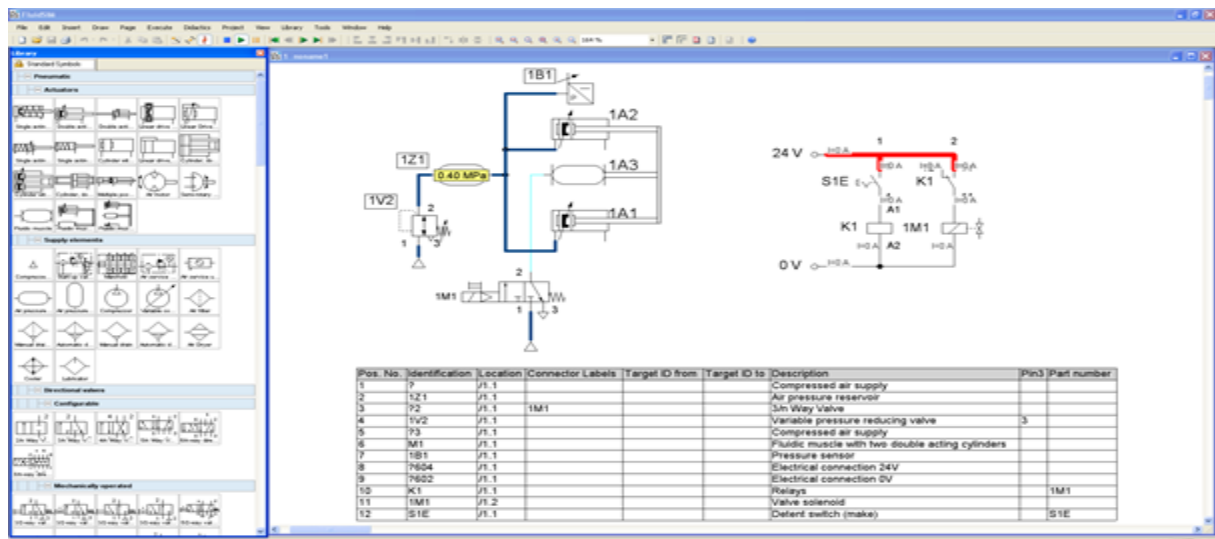
Fig. 15: FluidSIM V5.0 work simulation environment

3.2   SIEMENS SIMATIC S7-200 AND STEP 7-MICRO/WIN32

Siemens makes several PLC product lines in the SIMATIC S7 family. They are S7-200, S7-300, and S7-400.
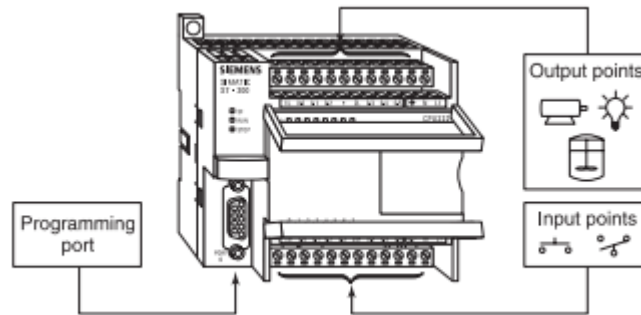
Fig. 16: SIEMENS PLC [3]

The S7-200 is referred to as a micro PLC because of its small size. The S7-200 has a brick design which means that the power supply and I/O are onboard. The S7-200 can be used on smaller, stand-alone applications, such as elevators, car washes, or mixing machines, etc. It can also be used on more complex industrial applications such as bottling and packaging machines.
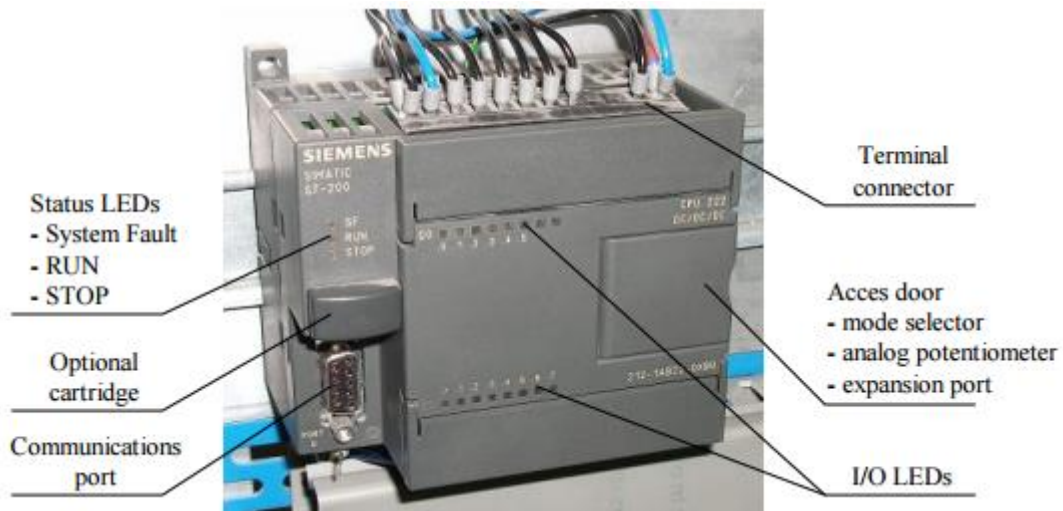
Fig. 17: PLC S7-200 [3]

A software program is required in order to tell the PLC what instructions it must follow. Programming software is typically PLC specific. A software package for one PLC, or

one family of PLCs, such as the S7 family, would not be useful on other PLCs. The S7-200 uses a Windows-based software program called STEP 7-Micro/WIN32.
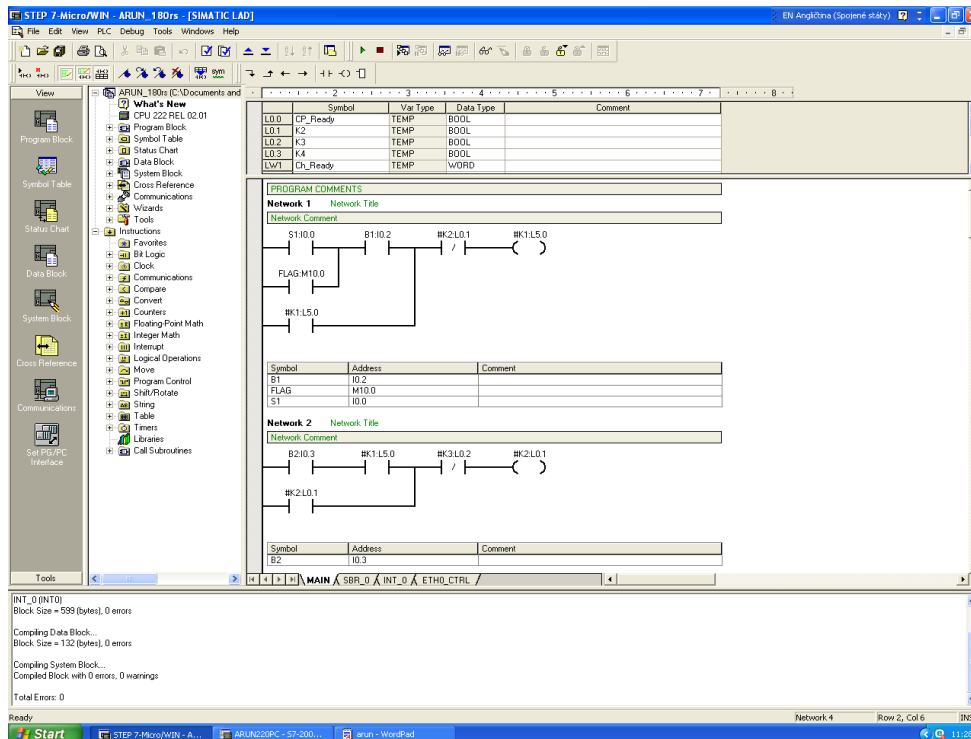
Fig. 18: STEP 7-Micro/WIN32

The programming software can be run Off-line or On-line. Offline programming allows the user to edit the ladder diagram and perform a number of maintenance tasks. The PLC does not need to be connected to the programming device in this mode. On-line programming requires the PLC to be connected to the programming device. In this mode, program changes are downloaded to the PLC. In addition, the status of the input/output elements can be monitored. The CPU can be started, stopped, or reset. [4]

3.3   PC ACCESS

Using Siemens PC Access SMART tool, it is possible to read/ write the data from S7-200 PLC on to the host computer. This can be used for simple GUI requirements for data monitoring or data archiving. (PC Access SMART is an OPC server protocol specifically developed for S7-200 series PLC, an OPC software dedicatedly developed for interaction between the S7-200 SMART PLC and host computer)

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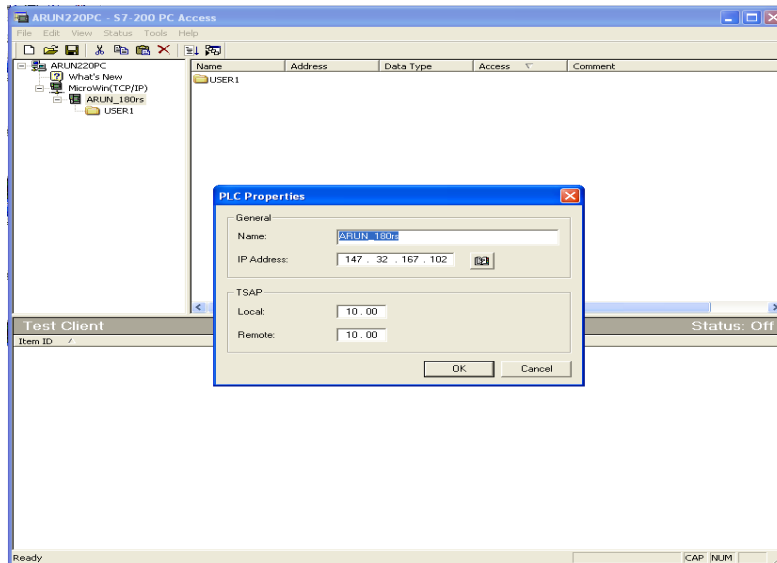
Fig. 19: PC Access S7-200 window

3.4   RELIANCE SCADA

Reliance SCADA system is modern HMI system which allows to visualise and control industrial and automation processes. Reliance SCADA system project consists of reports, scripts, access rights, OPC, SMS, and Email messages. Also, Process can monitor and control from a remote location through mobile and other control devices.
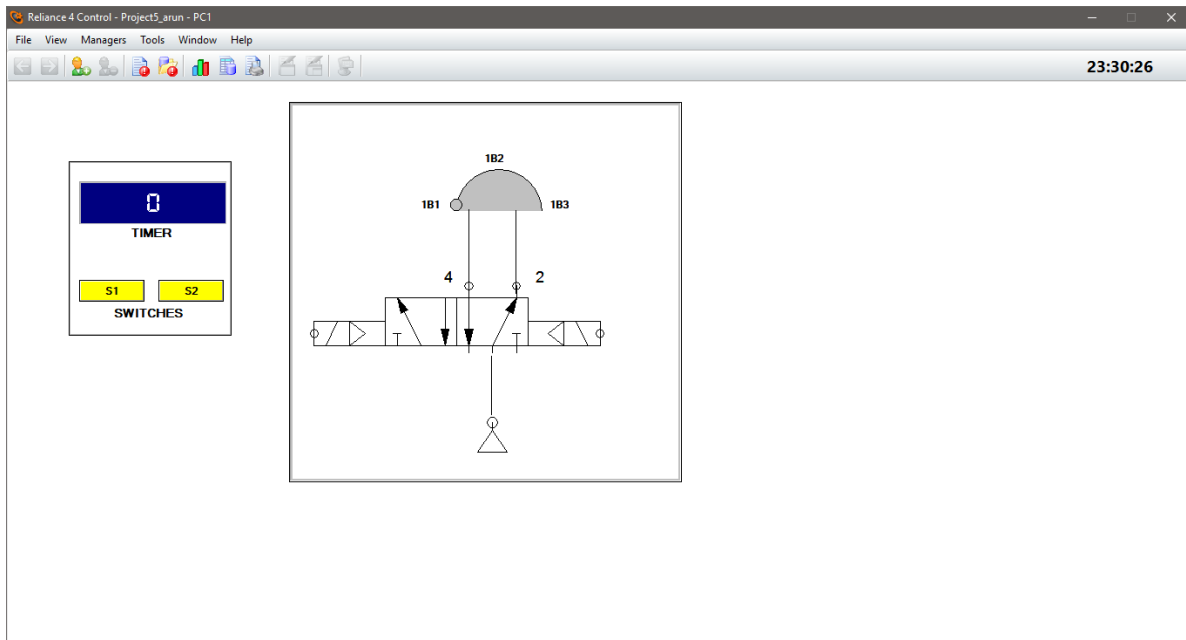
Fig. 20: SCADA runtime environment

Reliance SCADA system consist of following software modules

- Development Environment

- Runtime Software

- Reliance Control Server

- Web client

During thesis work, we have experienced mainly about development environment and runtime software.

The development environment is used to create and edit visualisation projects. It consists of several windows like main menu, toolbars, and components menu. Each window can be edited and set up through Window Manager.

Runtime software is a designed to run and visualise project process for users. Different users can log on/off and also can control and monitor process according to their own rights. It displays like to change language, trends, reports and alarm/events.

4   COMPONENT DESCRIPTIONS

The following components are used for this diploma work which is shown in Table 1.

Table 1: Components used

Part no.	Description	Quantity
1	Linear Drive	1
2	Semi-rotary drive	1
3	Function generator	1
4	Proximity sensor, electronic	3
5	Air reservoir	1
6	One-way flow control valve, 2 off	2
7	5/2-way solenoid valve	1
8	On/off valve with filter regulator	1
9	Loading weight, 2 kg	1
10	Loading weight, 0.175 kg	2

4.1   LINEAR DRIVE

The rod less cylinder is mechanically coupled to the slide unit, which directly supports loads. It is working in the same manner as conventional type cylinder. When the compressed air passed alternately the outer slid moves forward and backwards which is coupled to the piston. Operating pressure is between 2-8 bars. The drive has flexibly cushioning at both ends.

Fig. 21: Linear Drive [1]

The DGC-GF, with plain-bearing guide linear drive has been designed for space saving transport of masses shown in Fig. 21. The maximum stroke length and piston diameter of the drive are 5000 mm and 63 mm. The main technical data are used for the experiment in laboratory shown in Table 2.

Table 2: Technical data of linear drive

Description	Details
Stroke length	170mm
Piston diameter	80mm
Mode of operation	Double-acting
Driver principle	Slotted cylinder, mechanically coupled
Max. speed	3m/s
Position sensing	For proximity sensor

4.2   SEMI-ROTARY DRIVE

In a semi-rotary drive, the force is transmitted directly to the drive shaft via a rotary vane. The swivel angle is freely adjustable from 0 to 180°. It has three adapters for placing the magnetic proximity sensors. Operating pressure is between 2-8 bars and it has flexibly cushioning at both ends.

Table 3: Technical data of semi-rotary drive

Description	Details
Stroke length	170mm
Piston diameter	10mm
Mode of operation	Double-acting
Driver principle	Semi-rotary actuator with vane drive
Max. swivel angle	0-181 °
Position sensing	Electrical, pneumatic, inductive.

Construction of Rotating plate has four holes for mount the weights in order to simulate the loads. The main technical data are used for experiment in laboratory shown in Table 3.

Fig. 22: Semi-rotary drive [8]

4.3 FUNCTION GENERATOR

The functional generator is the multi-function device and acts as a pulse generator, counter and stopwatch. The type of function generator shown in Fig. 23 encloses of a microcontroller circuit, a selector switch, LCD display, pushbuttons, signal inputs, signal outputs and two bus bars for the power supply.
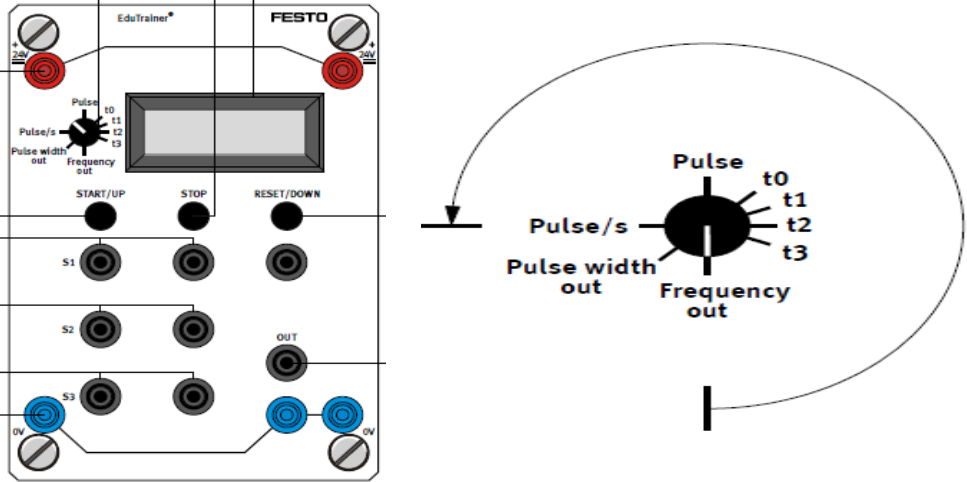

Fig. 23: Functional generator

The following five modes of operation are available via the function generator:

1. Impulse - Pulse

2. Frequency measurement - Pulse/s

3. Time measurement - t0, t1, t2, t3

4. Square-wave signal output - Frequency out

5. Voltage output - Pulse width out

The modes of operation are set via a selector switch shown in Fig. 23. During the experiment selection of time measurement is used

Time measurements

The selector switch is set to the settings "t0, t1, t2, t3". t0: The function generator operates in the same way as a manually operated stopwatch. The times can be measured with the help of the START and STOP pushbuttons.

t1, t2, t3: 3 times can be measured simultaneously. The currently displayed time can be selected via the selector switch. The input sockets S1 measure the time t1, the input sockets S2 measure the time t2 and the input sockets S3 measure the time t3. The times are stored until cancelled via the RESET socket or RESET pushbutton. [1]

4.4 PROXIMITY SENSOR, ELECTRONIC

Fig. 24: Magnetic proximity sensor [8]

The contactless magnetic proximity sensor electronically operated is mounted on drives through holder with T-slot, with the help of connecting cable and LED operating status indicator shown in the Fig. 24. Switch that closes when magnetic field is brought nearby. Protected against polarity reversal, overload and short circuit.

4.5   AIR RESERVOIR

Fig. 25: Air pressure reservoir, 0.4 l [8]

The air reservoir stores the pressurised air used to operate the pneumatic circuit components. It acts like a pneumatic battery. Air reservoir used for experiment has 400ml volume and pressure range of 0-16bar.

Functions of Air pressure reservoir:

1. It is used to generate static pressure combined with one-way flow control valve.
2. Used as accumulator when the sudden pressure drops occurs and compensates the pressure fluctuation.
3. The long-time delay is possible with using time-delay and flow control valve.

4.6   ONE-WAY FLOW CONTROL VALVE

Fig. 26: One-way flow control valve, 2 off [8]

One-way flow control valve is one of the combinations of a flow control valve and non-return valve. Air flow adjustment can be done through knurled screw. Pressure range can be set between 0.2-10bar. It is used to adjust the flow of pressurised air.
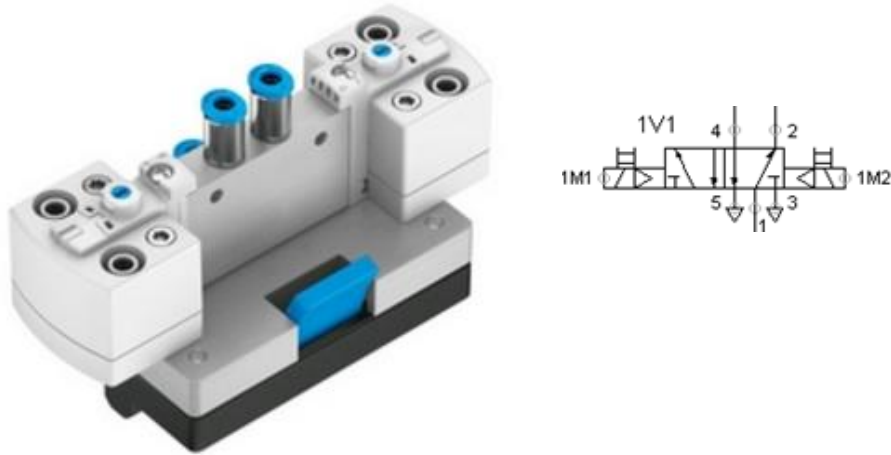
4.7   5/2-WAY SOLENOID VALVE

Fig. 27: 5/2-way solenoid valve [8]

The Fig. 27 is shown Pilot actuated, double solenoid piston spool valve with non-detention and detention manual override, and LED. Operating pressure of this kind valve is basically from 1.5 – 8 bar.

4.8   AIR SERVICE UNIT WITH FILTER REGULATOR

On-off valve is actually a normally opened 3/2 valve to exhaust the system when necessary. The 3-2 hand valve performs exactly like the 3-2 solenoid. This valve is manually (hand) operated and used as an on/off valve for the entire circuit. So, it is possible to disconnect from energy source also used to reduce energy in the system in order to prevent unexpected start-up. In pneumatic systems, this can, for example, be done by disconnecting the system from the energy supply and dissipating the pressure in the system. The suitable shut-off device, which features a pressure relief mechanism, must be lockable.
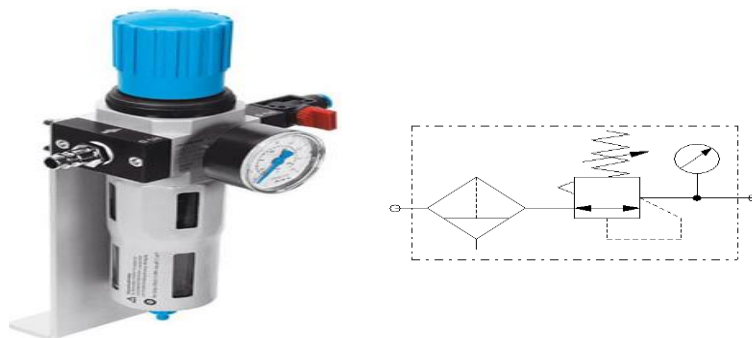

Fig. 28: Air service unit

4.9 LOADING WEIGHT, 2 KG

Fig. 29: Loading weight, 2 kg [8]

The Fig. 29 shows the steel weight of two kilogrammes which gives a load to the linear drive. The hand knob screw helps to fix loading weight above the sliding guide which has mounted in the linear drive.

4.10 LOADING WEIGHT, 0.175 KG

Fig. 30: Brass Loading weight, 0.175 kg [8]

The loading weight is made up of the brass material. It weights 0.175kg with a screw which is used to mount the load to the semi-rotary drive plate. The construction of the aluminium plate has 200mm diameter with four holes for loading weight connection. The four holes threads are equally divided or it is placed exactly 90-degree angle.

5   EXPERIMENTAL WORK

The section involves various experiment carried out for operating behaviour of the Linear and Semi-Rotary Drives. All these tasks are prepared as classical electro-pneumatic method in the laboratory.

5.1   ANALYSING THE TIME OF TRAVEL OF LINEAR DRIVES

5.1.1 AIM OF THE EXPERIMENT

The main aim of this experiment is to check about the influence of the connectors, tubing length and diameter of the time travel of the linear drive.

### 5.1.2 PROBLEM IDENTIFICATION

Basically, several machine cycles are very high in most of the industrial automation process. This can be done by fast drives. So, according to the study and previous experiment that drives should be configured properly to achieve proper machine cycle. So, mostly this can be compensated using flow control valve. Even though flow control valve can rectify the problem only in some level. [1]

5.1.3 WORKING PROCEDURE

Table 4: Part description of linear and semi-rotary drive

Part No.	Identification	Description
1	S1	Push button 1
2	S2	Push button 2
3	1B1, 1B2, 1B3	Proximity sensors
4	1F1,1F2	Stop watch
5	1A1	Linear drive
7	1V1	5/3-way valve
8	1V2, 1V3	Flow control vales
9	1Z1,1Z3	Pressure gauge
10	1Z2	Air reservoir
11	1M1,1M2	Solenoid valve
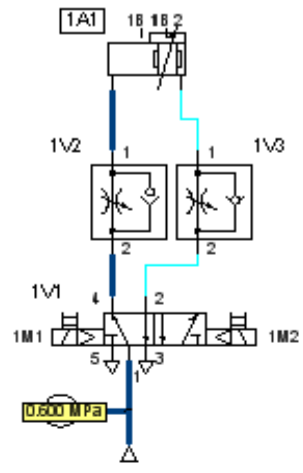
State Diagram
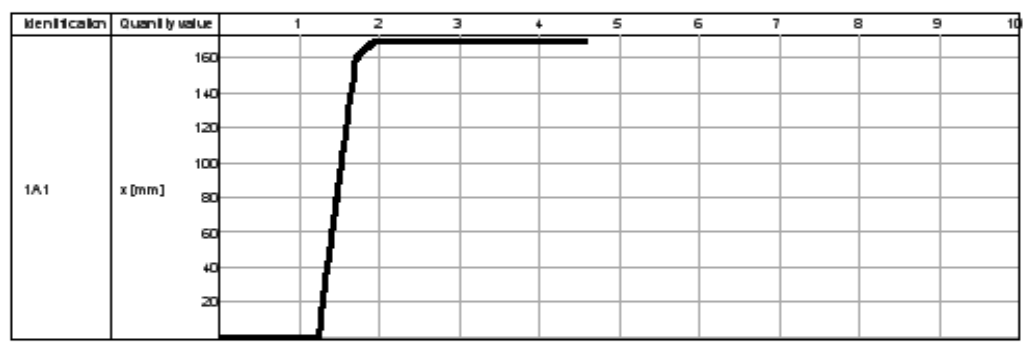
Electric Circuit Diagram
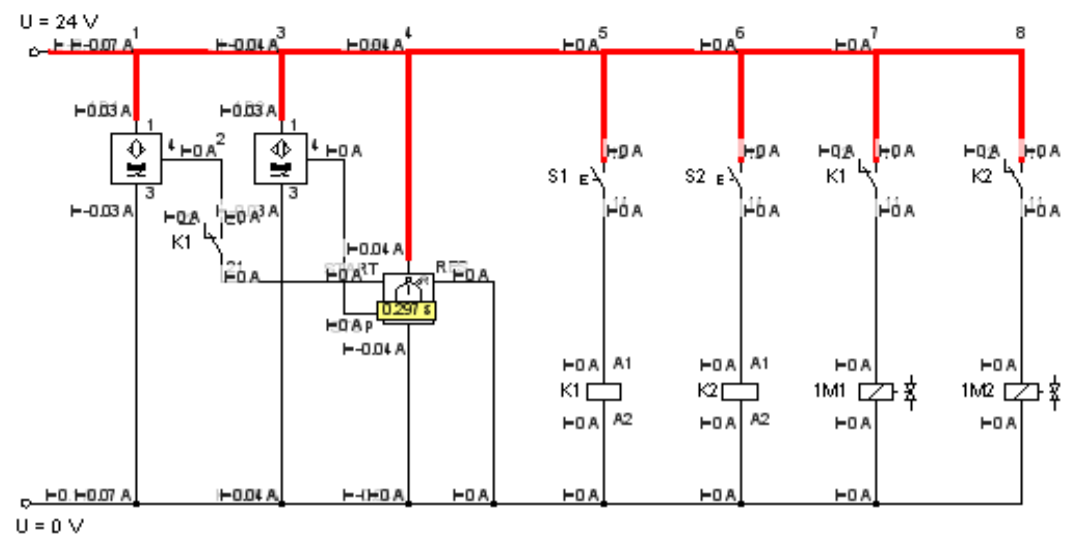
Fig. 31: Linear drive without counter force

The working of the linear drive is simple. The Fig. 31 and 32 shows classical electro-pneumatic circuit of the linear drive with and without using counterforce. These circuits are

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designed using FluidSIM® V5.0 and basic parameters are set from the technical data of linear drive from Table 2. Part description of linear drive shown in Table 4.
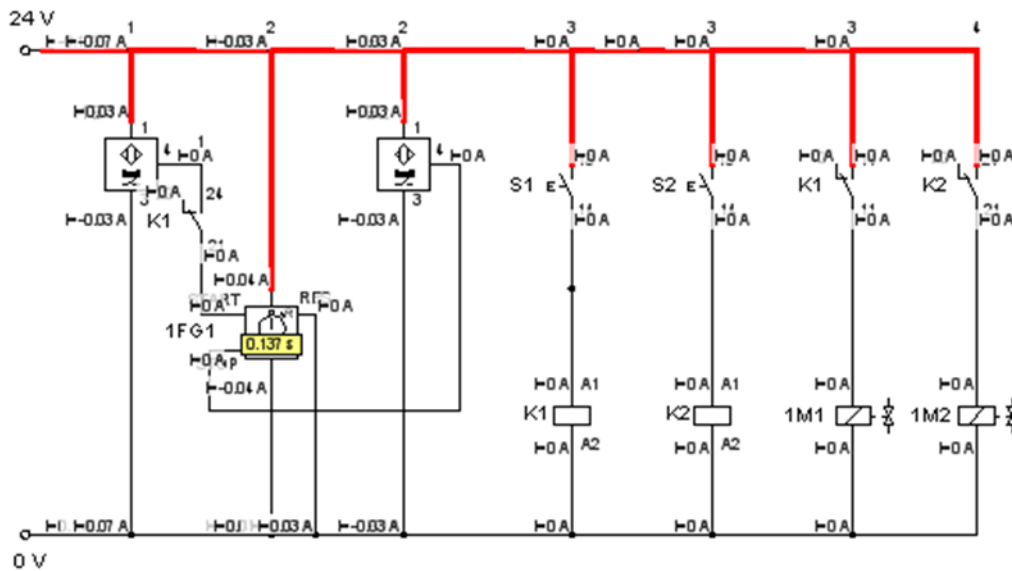

Fig. 32: Linear drive with counter force

In the electrical circuit, initially magnetic proximity sensor 1B1 is activated and when push button S1 is pressed relay K1 activates, correspondingly the state of K1 is changed to closed contact from open contact. So, K1 activates the solenoid valve 1M1. Hence the 5/3-way pneumatic valve 1V1 changes its position. It pressurised air to flow alternately, so slid moves from one position to another position. In this circuit proximity sensor, 1B1 and 1B2 output is connected to stopwatch 1F1. So, it is possible to measure time in between 1B1 and 1B2 when output gets a signal. Time measurement is taken out and tabulated and push button S2 helps slid move its initial position when it has activated through relay K2. Reset of the time is done by manual reset button. The function generator is used to measure the speed of travel of the cylinder.

5.1.4 WORK DONE

Working was carried out in the laboratory as per the circuit and examined the influence of tubes length, counterforces and supply pressure.

Table 5: Measurement for tubing length 0.5m

Operating pressure (bar)	Travel time for a distance of 100 mm (s)		Measurements
	Without counterforce	With counterforce	
4	0.102	0.48	Cylinder DGC-18-170-GF-PPV-A Counterforce 62 N (2.5 bar) Connector QSM-4
6	0.067	0.146	Tubing PUN 4x0.75 Tubing length **0.5 m**

Table 6: Measurement for tubing length 1m

Operating pressure (bar)	Travel time for a distance of 100 mm (s)		Measurements
	Without counterforce	With counterforce	
4	0.1	0.48	Cylinder DGC-18-170-GF-PPV-A Counterforce 62 N (2.5 bar) Connector QSM-4
6	0.067	0.163	Tubing PUN 4x0.75 Tubing length **1 m**

Table 7: Measurement for tubing length 2m

Operating pressure (bar)	Travel time for a distance of 100 mm (s)		Measurements
	Without counterforce	With counterforce	
4	0.118	0.582	Cylinder DGC-18-170-GF-PPV-A
			Counterforce 62 N (2.5 bar)
			Connector QSM-4
6	0.086	0.164	Tubing PUN 4x0.75
			Tubing length **2 m**

From the graph, it is clear that the travel time is less when the tubing length is minimum. Also, pressure plays a major role in time travel taken. When the pressure is at 6 bar the time taken was reduced to 20-30 % compared with 4 bar for without counterforce.
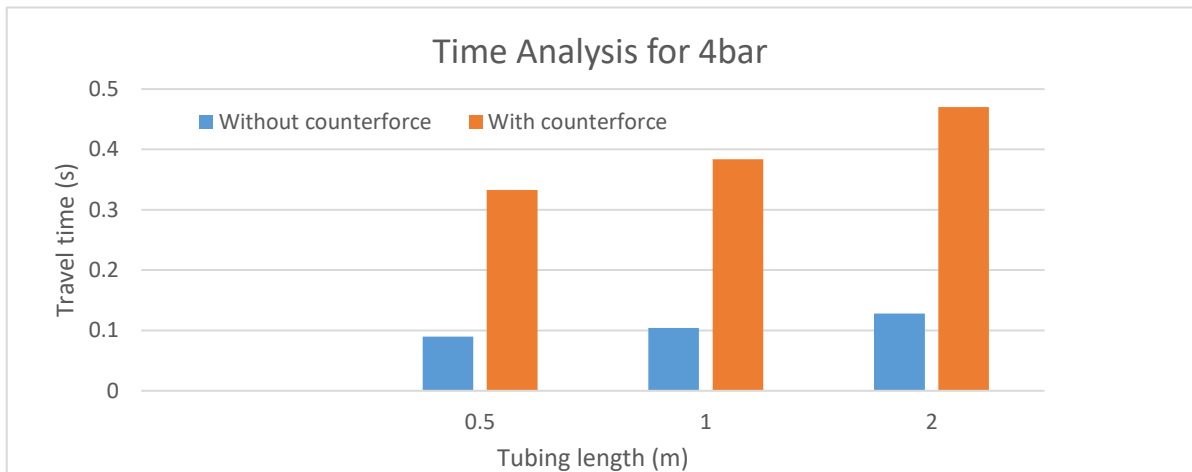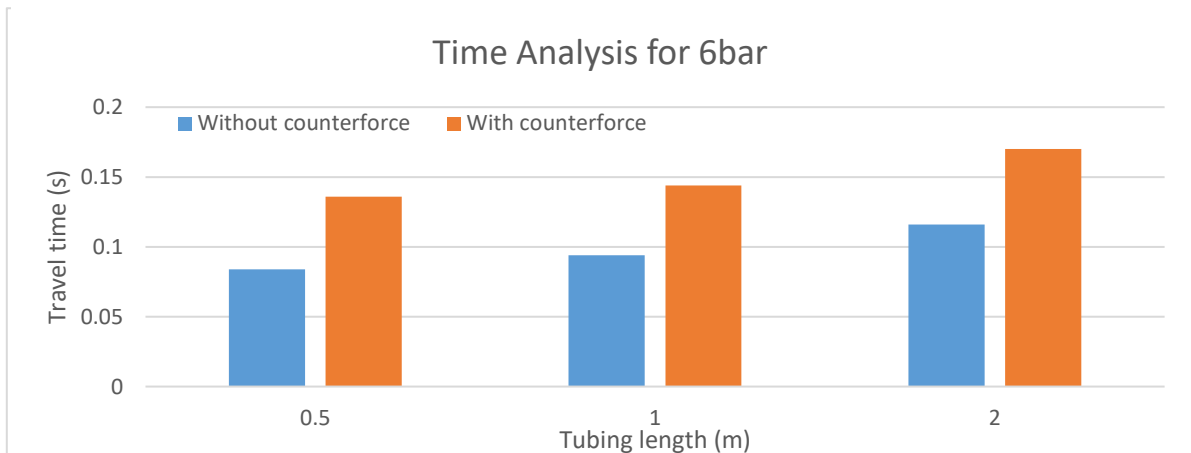

Fig. 33: Time Analysis for 4bar

Fig. 34: Time Analysis for 6bar

5.2   ANALYSING THE OPERATING BEHAVIOUR OF SEMI-ROTARY DRIVES

5.2.1 AIM OF THE EXPERIMENT

The aim of calculating torque and moment of inertia is to reduce the malfunction. Based on the calculation for a moment of inertia for different types of loads is to be carried out theoretically and selection of the semi-rotary accordingly. Kinetic energy is also taken into consideration for section drive.

5.2.2 PROBLEM IDENTIFICATIONS

Compared to Linear drive semi-rotary drives are slow in process and malfunction is happening frequently for dynamic loading when the object is transferred from one place to another [1].

5.2.3 MASS MOMENT OF INERTIA CALCULATION

Moment of inertia has a major conclusive effect than torque for a rotary drive. Even small amount of the moment will cause the big damage to the semi-rotary drive though the kinetic energy is more. Because Moment of inertia has square the radius whereas torque has just radii. Torque causes some delay in the rotary motion. Mass moment of inertia calculation is tabulated for some loads below.

Table 8: Mass Moment of Inertia for some loads

Load	Mass(kg)	Torque (N-m)	Force (N)	Radius(m)	Moment of Inertia(kgm2)
A	0.2	2	1.962	1.02	0.208
B	2	2	19.62	0.102	0.021
C	0.175	2	1.71675	1.165	0.238
D	1	2	9.81	0.204	0.042

5.2.4 EXPERIMENT OF SEMI-ROTARY DRIVE

The working procedures of semi-rotary are much similar to linear drive mentioned section 5.1.3 Working procedure. But only different is semi-rotary drive needs one more proximity sensor 1B3. The electro-pneumatic circuit is shown in Fig. 34.

Semi-Rotary Drive Pneumatic Circuit Diagram
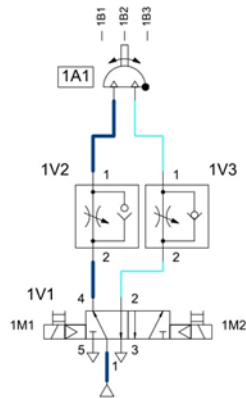
State Diagram

Electric Circuit Diagram
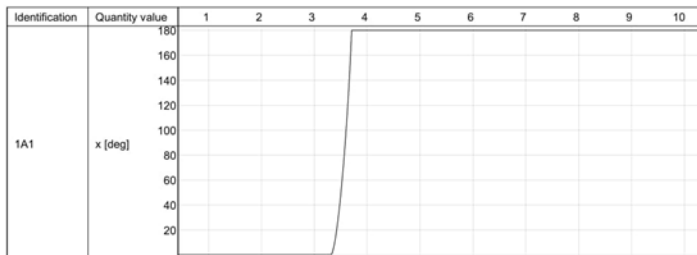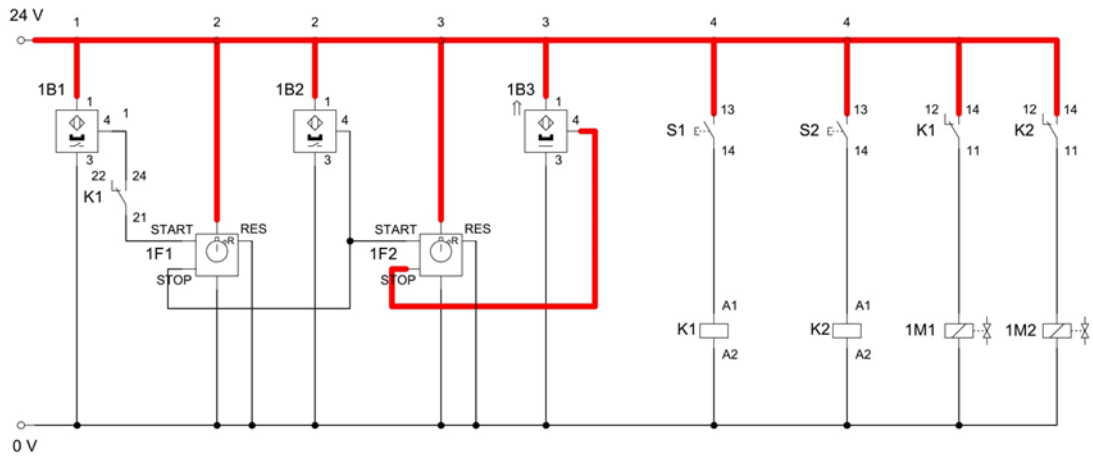
Part Discription

Pos. No.	Identification	Location	Connector Labels	Description
1	1V2	/1.2		Throttle check valve
2	1V3	/1.2		Throttle check valve
3	1V1	/1.2	1M1, 1M2	5/n Way Valve
4	1A1	/1.2		Semi-rotary actuator
5	1F1	/1.2		Stopwatch
6	1F2	/1.3		Stopwatch

Fig. 34: Semi-rotary Drive circuit

The experimental procedure as followed:

- Semi-rotary drive mounted on the table and three electronic proximity sensors 1B1, 1B2 and 1B3 are placed in the corresponding slot which is in the drive rotary table.

- Flow control valve is adjusted approximately to set a swivel time 1 sec.

- The out of proximity sensors is connected with the function generator equipment for measuring the time.

- Using the selector switch of functional generator time travel has been observed between 1B1-1B2 in t1 and 1B2-1B3 in t2 simultaneously.
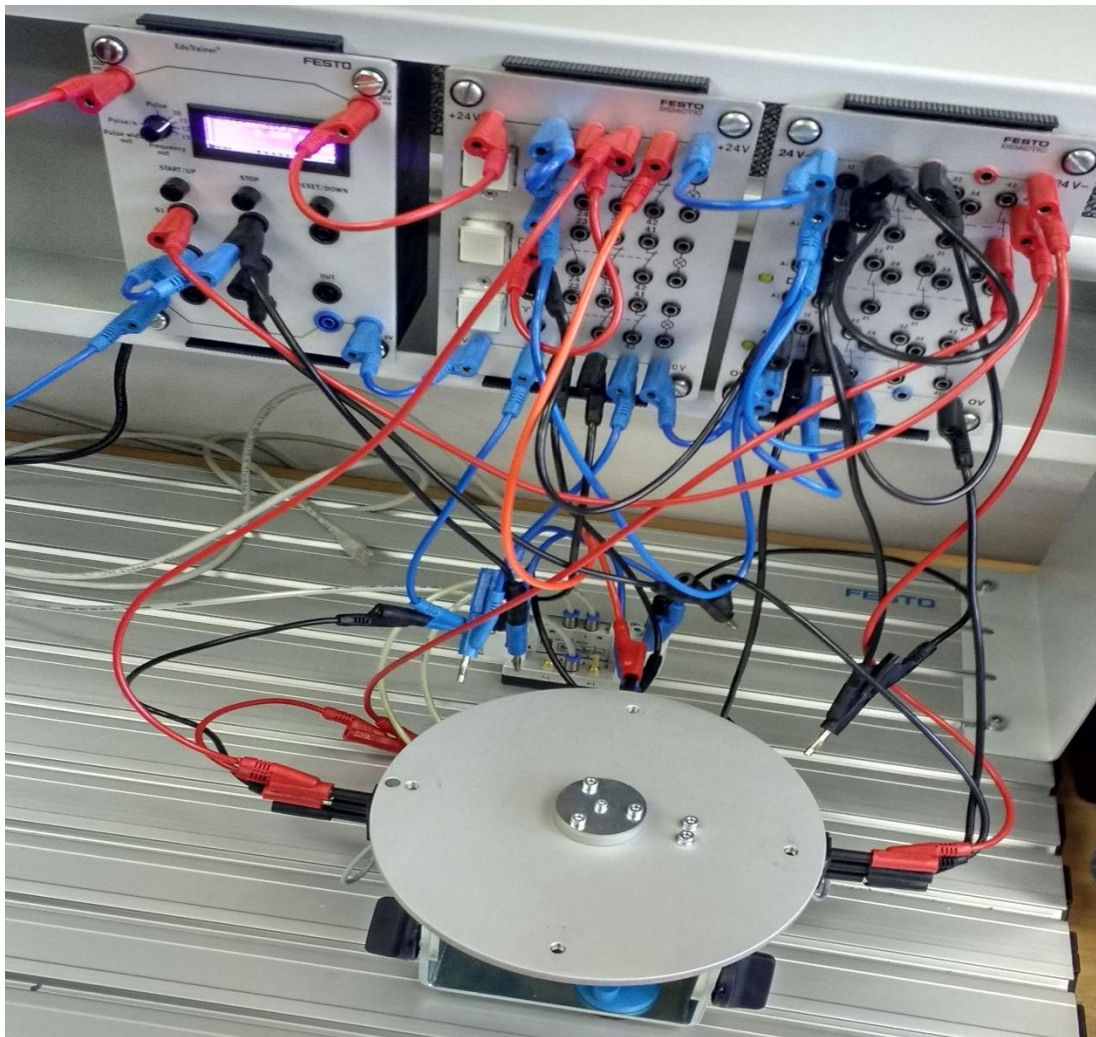

Fig. 35: Connections of semi-rotary drive at lab109

5.2.5 WORK DONE

The motion behaviour of semi-rotary drive has been done and measured time period are tabulated. The measurements are taken without mounting load in the rotary plate and time measurement analysed parallel and perpendicular to the working table. The values are tabulated in Table 9 and 10.

There is no difference in operating behaviour assembly position to the parallel and perpendicular to the worktable without load. Because load acts symmetrically to the drive.

Table 9: Measured value without load

Start	Stop	Measurement Period (s)	
		Parallel	Perpendicular
1B1	1B2	0.190	0.186
1B2	1B3	0.171	0.163

Table 10: Measured value with load

Start	Stop	Measurement Period (s)			
		Perpendicular			
		Lower	Upper	Left	Right
1B1	1B2	0.212	0.194	0.220	0.190
1B2	1B3	0.098	0.207	0.086	0.094

The time between 1B1 and 1B2 clearly extended for the load at a lower position. The load acts completely against the gravity. If the load is mounted left, the weight acts against the movement till 90◦ and acts due to the direction of movement for the next 180◦. The pressure drop on the exhausted side needs to be the maximum to enable the movement to begin.

During the time measurement of right side load mount, the force acts in the direction of movement the rotational movement starts sooner than the first.

For the parallel and perpendicular position in profile plate, the mass should be accelerated and then decelerate it for without load condition.

For with load condition, a perpendicular position to profile plate in the lower position of that mass acts downwards throughout the entire movement and as such against the movement.

The pressure difference must be high enough to raise the mass but in the case of parallel position, it supports the drive movement.

5.2.6 PROBLEMS ENCOUNTERED AND RESOLVED

During the experiment, some problems have been realised. It has pointed below with the solution.

Linear Drive

- In linear drive placement of the proximity sensor is very important though it has not any exact position available in the slot for fix it where exactly it should be. Because time measurement is carried out at some length. For example, the sensor first (1B1) and second (1B2) is placed in 20mm and 120mm correspondingly in the total length of 170mm.

- Due to the vibration caused by the linear drive sliding moment sensor position has changed.

The above problems cannot be fixed fully unless otherwise, some fixing knob set either in the sensor or in the drive slot. This need to be developed during manufacturing.

Semi-rotary drive

- The problem comes same as in the linear drive sensor placement in the semi-rotary drive but in the little different way. Semi-rotary drive has fixed slot for the sensor 1B1, 1B2 and 1B3 correspondingly in 0°, 90° and 180°.

- Based on the actual circuit which has mentioned in the TP220 exercise, time measurement taken to be done between starting push button S1 to 1B1, IB1 to 1B2 and 1B2 to 1B3. But, the sensor 1B1 is in the position 0°, exactly same as in the starting position. So, it is not possible to calculate the time between S1 to 1B1.

Common problems

- Other than individual drive problem some common problems happened. First things are work combined with other processes which are common in the industries. For example, working with vacuum technology has created a problem like pressure difference and flow control is needed for vacuum technology, not for the drive. Hence, the problem has been resolved using one more ON/OFF valve between two processes.

- In this project, supply air and exhaust air flow control are used. Picture is shown in Fig. 35. The speed of the piston can be an influence on the both side. So it was difficult to know which screw knob has to be adjusted for corresponding forward and backwards moment of the piston. Finally, I have resolved it by simulation done by using FluidSim.
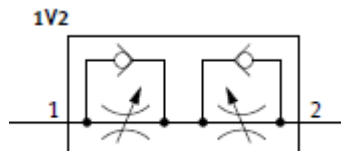

Fig. 36: Flow control valve

Stopwatch:

- Time measurement is the important function in the thesis work, Simulation has done by using the manual stopwatch in the FluidSIM® 5.0. The Fig. 37 shows the stopwatch used in the software. It measures the time in-between two proximity sensors. It was working same like the experimental work. If we set all the parameters acceding to the real data. The simulation gives the same result as the experimental result.
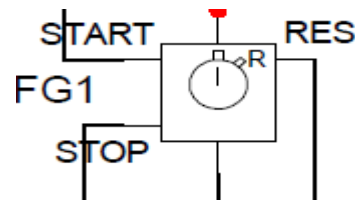

Fig. 37: Stopwatch

All the above problem has been resolved and experiment is done for the drives manually.

Considering these problem semi-rotary drive has many malfunctions and improvement need to be done. So, then choosing semi-rotary as the main task and manual calculation is taken and tabulated it to further references. By using the values and signals next level of automation process is done using PLC coding and visualisation is done by SCADA.

6   PLC FOR SEMI-ROTARY DRIVE APPLICATIONS

6.1   PLC LADDER PROGRAMMING FOR LINEAR AND SEMI-ROTARY DRIVE

Programming a PLC is simply constructing a set of instructions. There are several ways to look at a program such as a ladder logic, statement lists, or function block diagrams.

Ladder Logic (LAD) is one programming language used with PLCs. Ladder logic uses components that resemble elements used in a line diagram format to describe hard-wired control. The ladder diagram is read from left to right and top to bottom.

In this diploma thesis work, as a tool to create a program for executing our task, we used Ladder Diagram programming language. And to do so systematically, we used the Moving Chain method.

The ladder program has been done by using moving chain algorithm. Reason for Using Moving Chain

- It is a more common method while programming the real PLC.

- While using bistable valves, it is more suitable because the type of signal generated by this method is impulse.

Reason for Using Standing Chain

- It is a more suitable method for using monostable. Because it is spring return.

6.2   KEY TO SOME ELEMENTS USED IN PROGRAM

Bit logic instructions:

---| |--- **Normally Open Contact (Address)** is closed when the bit value stored at the specified <address> is equal to "1".

---| / |--- **Normally Closed Contact (Address)** is closed when the bit value stored at the specified <address> is equal to "0".

--- ( ) **Output Coil** works like a coil in a relay logic diagram. If there is power flow to the coil.

6.3   GRAFCET LANGUAGE

The GRAFCET (Functional Graph of Control Step Transition) or SFC (Sequential Function Charts) is a formal model being used to specify and also to control reactive systems of the type "all or nothing" (Boolean inputs and outputs).
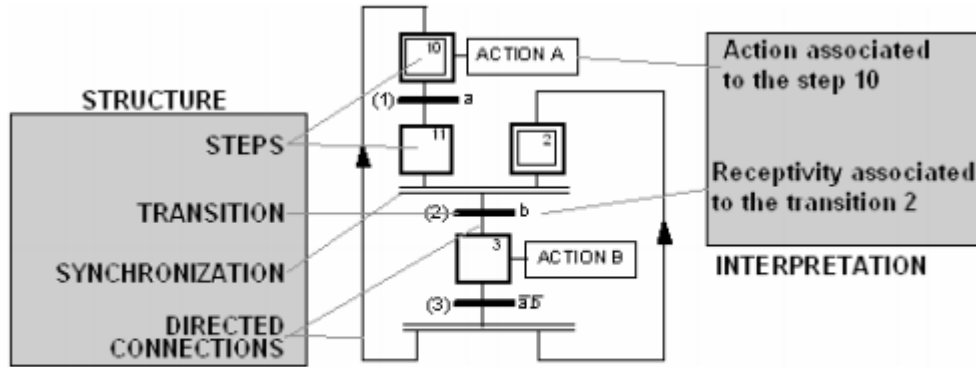
Structure of a Grafcet and interpretation
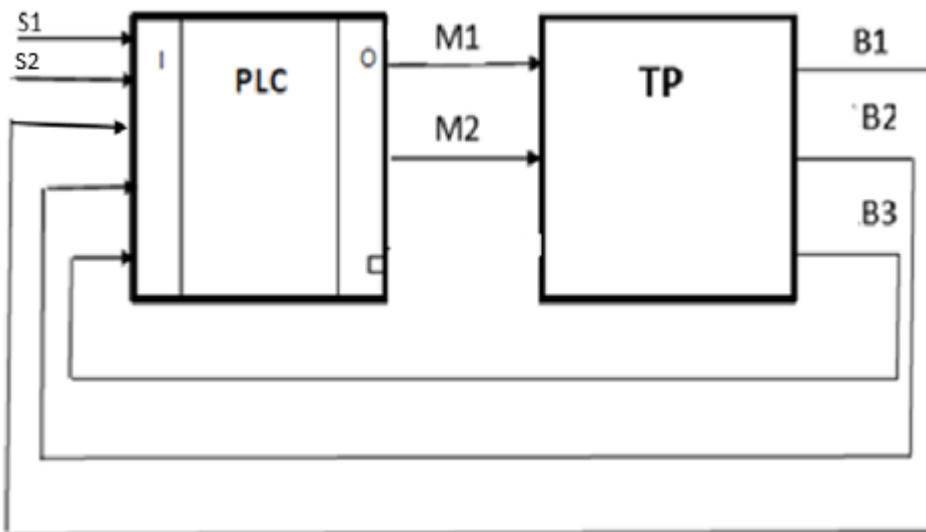
6.4   PLC BLOCK DIAGRAM

Fig. 38: Block Diagram of semi-rotary drive

TP: TECHNOLOGICAL PROCESS

PLC: PROGRAMMABLE LOGIC CONTROLLER

Signals	Symbols	Description
Input	S1	Drive forward
Input	S2	Drive backward
Inputs	1B1, 1B2, 1B3	Position sensor
Output	1M1,1M2	Output valve

As shown in the block diagram above, there is some operating panel with a start button (S1, S2) to start the whole process. PLC will use this start button signal as an input as well as the signals of the position sensors (B1, B2, and B3). PLC controls the coils through its output signals (M1, M2) which make the semi-rotary drive backwards or forward. In addition to that there also two outputs to control the solenoids which control the moving speed of the drive through flow control valves.
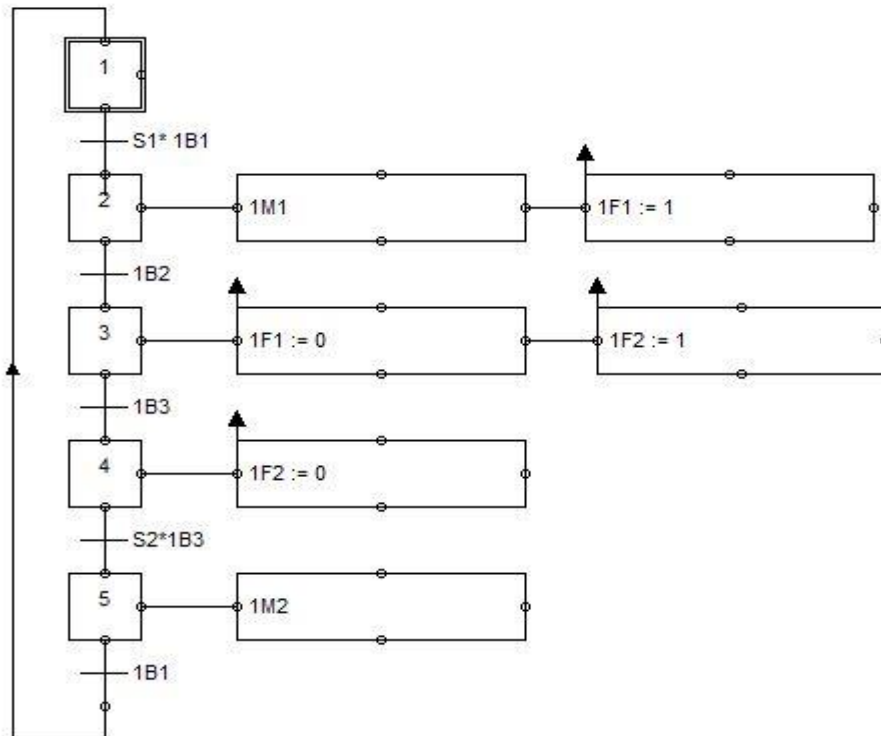
6.5   GRAPFCET

Fig. 39: GRAFCET for semi-rotary drive

The GRAFCET for semi-rotary drive consists of 5 steps which are represented by a square which a unique number is associated. A step can be initially represented by a double square. The step is either active or inactive. A transition represents a possibility of the change of the system which has represented by a horizontal line. Each directed arcs links a step to a transition or a transition to a step which is shown in Fig. 39.

At the start of the program, the token is in the initial state. When the S1 and proximity sensor 1B1 is activated the output valve 1M1 activated simultaneously timer 1F1 starts to measure the time. In transition 1B2, timer 1F1 stops and timer 1F2 starts and so on.

When the signal reaches to sensor 1B3, the timer 1F2 stops to measure the time. In the final state when S2 activated the signal passes to the valve 1M2, so signal transfer to next state and the final state of transition connected to the initial state and process continuous in the loop.

6.6   TIMER

Beginning Interval Time

The Beginning Interval Time (BGN_ITIM) instruction reads the current value of the built-in 1 millisecond counter and stores the value in OUT. The maximum timed interval for a DWORD millisecond value is 2 raised to the 32 power or 49.7 days.
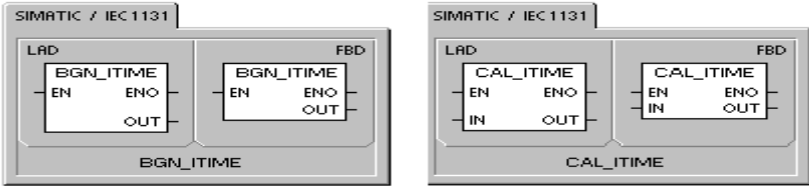

Fig. 40: Timers

Calculate Interval Time

The Calculate Interval Time (CAL_ITIM) instruction calculates the time difference between the current time and the time provided in IN. The difference is stored in OUT. The maximum timed interval for a DWORD millisecond value is 2 raised to the 32 power or 49.7 days. CITIM automatically handles the one millisecond timer rollover that occurs within the maximum interval, depending on when the BITIM instruction was execute

Block: MAIN
Author:
Created: 05/24/2017 02:26:09 pm
Last Modified: 06/16/2017 10:40:37 am

	Symbol	Var Type	Data Type	Comment
L0.0	CP_Ready	TEMP	BOOL	
L0.1	K2	TEMP	BOOL	
L0.2	K3	TEMP	BOOL	
L0.3	K4	TEMP	BOOL	
LW1	Ch_Ready	TEMP	WORD	
LW3	Error	TEMP	WORD	
L5.0	K1	TEMP	BOOL	
LD6	TM	TEMP	DINT	
LD10	TM1	TEMP	DINT	
LD14	TM2	TEMP	DINT	
LD18	TM3	TEMP	DINT	
LD22	TM4	TEMP	DINT	
LD26	TM5	TEMP	DINT	
		TEMP		

PROGRAM COMMENTS
Network 1   Network Title
Network Comment

Symbol	Address	Comment
B1	I0.2	
FLAG	M10.0	
S1	I0.0	

Network 2   Network Title
Network Comment

Symbol	Address	Comment
B2	I0.3	

Network 3   Network Title
Network Comment

Symbol	Address	Comment
B3	I0.4	
FLAG1	M10.1	
S2	I0.1	

Network 4

Symbol	Address	Comment
M1	Q0.0	
M2	Q0.1	

Network 5

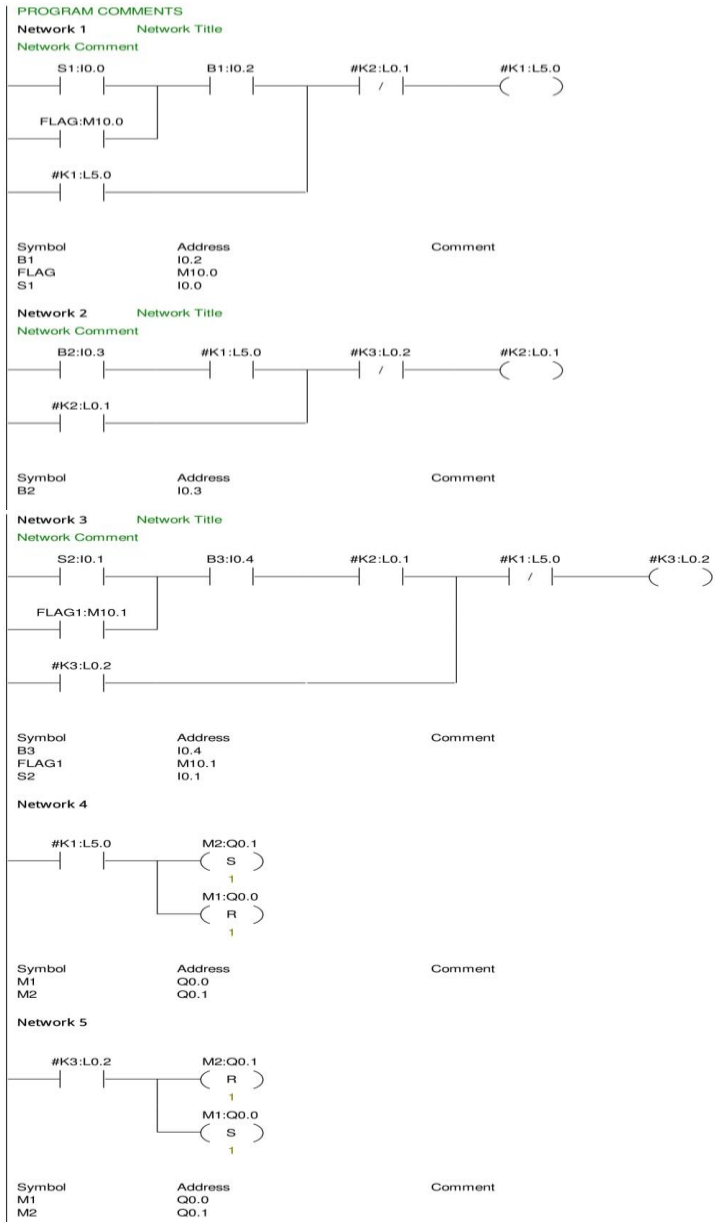| Symbol	Address	Comment
M1	Q0.0	
M2	Q0.1	

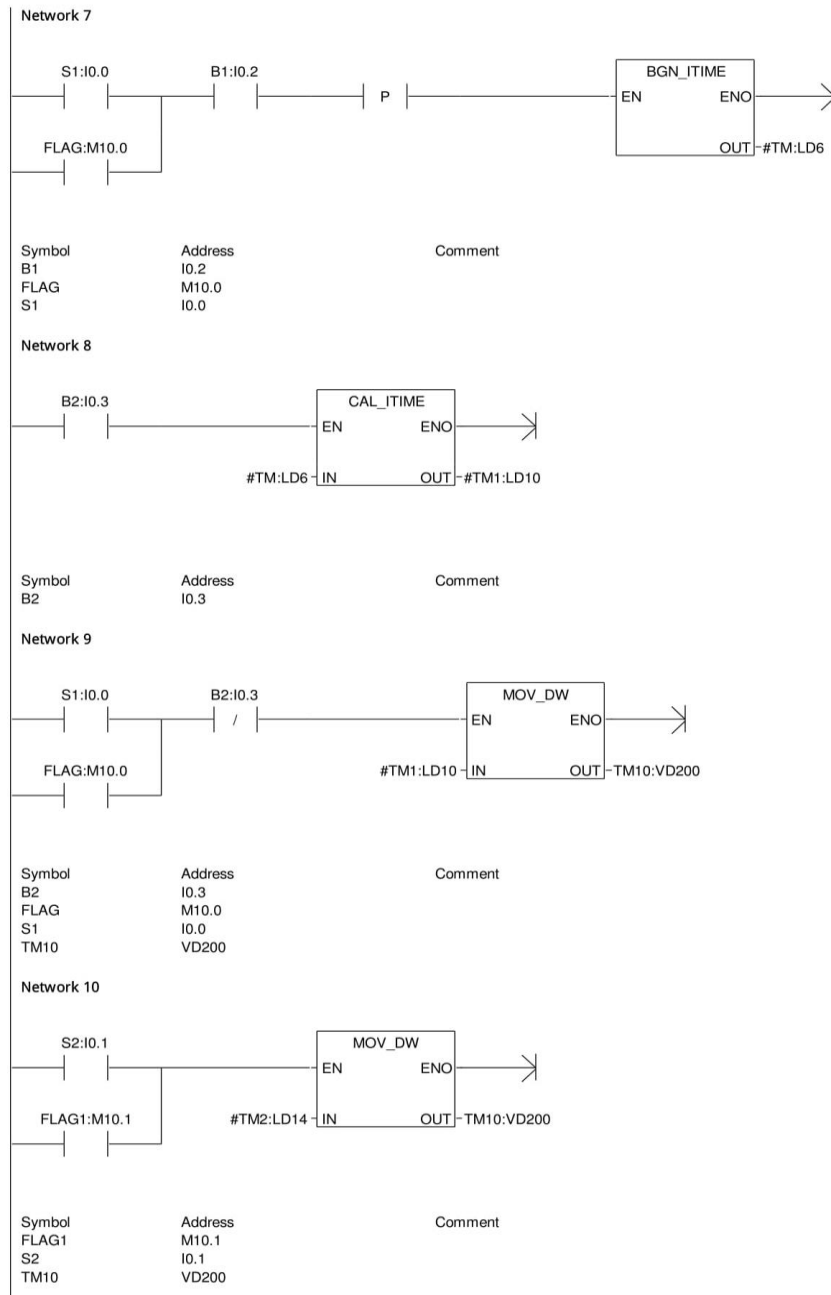*Fig. 41: PLC coding for semi rotary drive - 1*

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Fig. 42: PLC coding for semi-rotary drive - 2

Block Move Instructions:

Block Move Double Word instructions move a specified amount of data to a new memory location at the input address IN to a new block starting at the output address OUT. The data type can be Double word or integers.
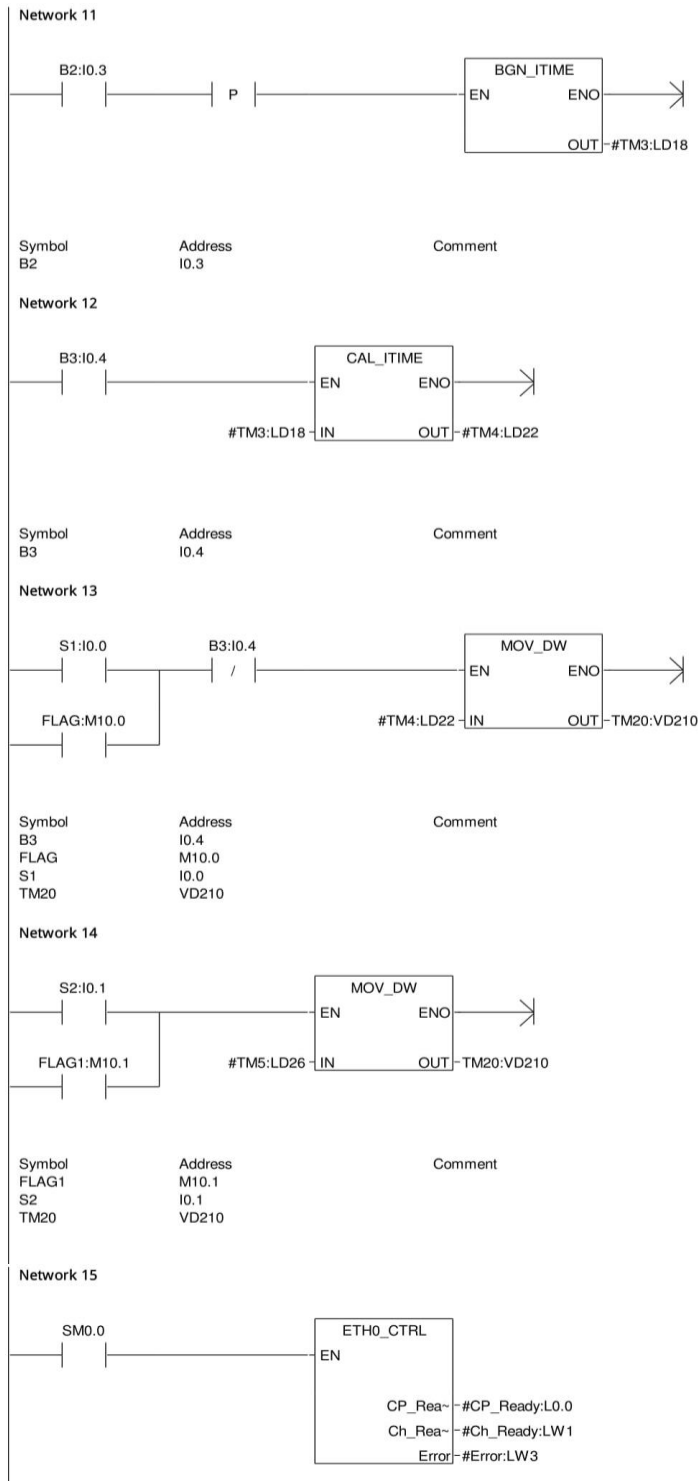
Fig. 43: PLC coding for semi rotary drive - 3

- SM0.0 is Special Memory Byte SMB0. The bit is always ON.

- Symbol TM0-TM5: Double Integer.(Milliseconds)

- Symbol TM10 and TM20 : Double Integer.(Milliseconds)

```
Block:          ETH0_CTRL
Author:         Ethernet Wizard
Created:        06/13/2017  11:33:25 am
Last Modified:  06/13/2017  11:33:26 am


          Symbol              Var Type        Data Type       Comment
          EN                  IN              BOOL

                              IN

                              IN_OUT
L0.0      CP_Ready            OUT             BOOL            CP 243-1 Module is ready
LW1       Ch_Ready            OUT             WORD            Channel ready bits
LW3       Error               OUT             WORD            Error word

                              OUT

                              TEMP
```

This POU was generated by the Ethernet Wizard for use with a CP 243-1 module at position 0. The ETHx_CTRL (Control) instruction is used to enable and initialize the CP 243-1 module. This instruction should be called on every program scan, and only be used once in your program. The command byte for this module was specified as QB4.

The following connections have been configured for this module:
Connection 0 is a Server: Local TSAP: 10.00   Remote TSAP: 10.00 Client Addresses: 0.0.0.0

Fig. 44: PLC coding for semi rotary drive - 4

6.7   ETHx_CTRL (CP243-1 MODULE CONTROL SUBROUTINE) [4]

The ETHx_CTRL subroutine initializes and performs error checking for the Ethernet module. The subroutine should be called at the beginning of every scan and should only be used once per module.

This instruction commands the CP243-1 Ethernet module to check the V memory area for a new configuration each time the CPU changes to RUN mode. If the configuration is different or the CRC protection is disabled, then the module is reset with the new configuration.

CP_Ready becomes active when the Ethernet module is ready to receive commands from the other instructions. Ch_Ready has a bit assigned to each channel to show the status of the connection for that particular channel. For example, bit 0 is ON when channel 0 has established a connection.
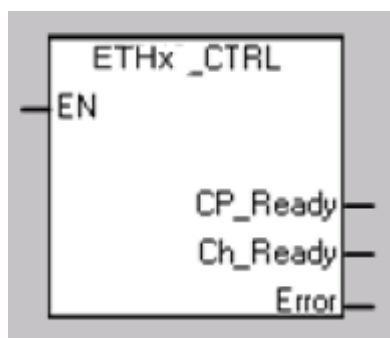

Fig. 45: Block of ETHx_CTRL

6.8   PC ACCESS

PC Access is an OPC server protocol specifically developed for S7-200 series PLC, an OPC software dedicatedly developed for interaction between the S7-200 PLC and host computer. Using PC Access tool performs to read/write the data from S7-200 on to the host computer. This is used for simple Graphical User Interface (GUI) requirements for data monitoring and data archiving. We can get the step followed by the PC access.

- Once the ladder coding is downloaded to the S7-200, then symbols from Micro/WIN software is imported to the PC Access. This is done by the following procedure.

- The crucial thing should be noted here is the setting the configuration of the TSAP properties.

- In the PC Access clicking PLC properties tool we can write IP addresses and TSAP (Transport Service Access Point). It is a rather more important step because it gives Information about the PLC and its communication panel location which is connected to the network.

6.9   PROBLEM FACED

During the coding of PLC, I have faced a lot of problems which is based on calculating time and store the time in the memory location. This was my crucial part of the thesis.

It was more time-consuming process. Because we do not have any experience with calculating time-based project and work during my studies. So, understanding the working of the timer and storing calculated time to the memory and transferring it was the bit difficult process. We have studied about the various basic timers and functionality of it.

It helps to reach the solution and final result was achieved. The types of the timer used in the ladder programming have been mentioned section 6.6. Time measurement has been calculated and it has been moved to memory location using the Move double word block. The measured values are in terms of the milliseconds (Double Integers).

7 SCADA

7.1 STEPS IN CREATING A PROJECT IN SCADA

Reliance 4 SCADA software is used in this project for the visualization and control of semi-rotary drive automation. The Reliance 4 Design development environment is future for creating and editing visualization projects. The runtime software is a program designed to run a visualization project on the end user's computer. It is used to control and monitor the visualized semi-rotary drive.
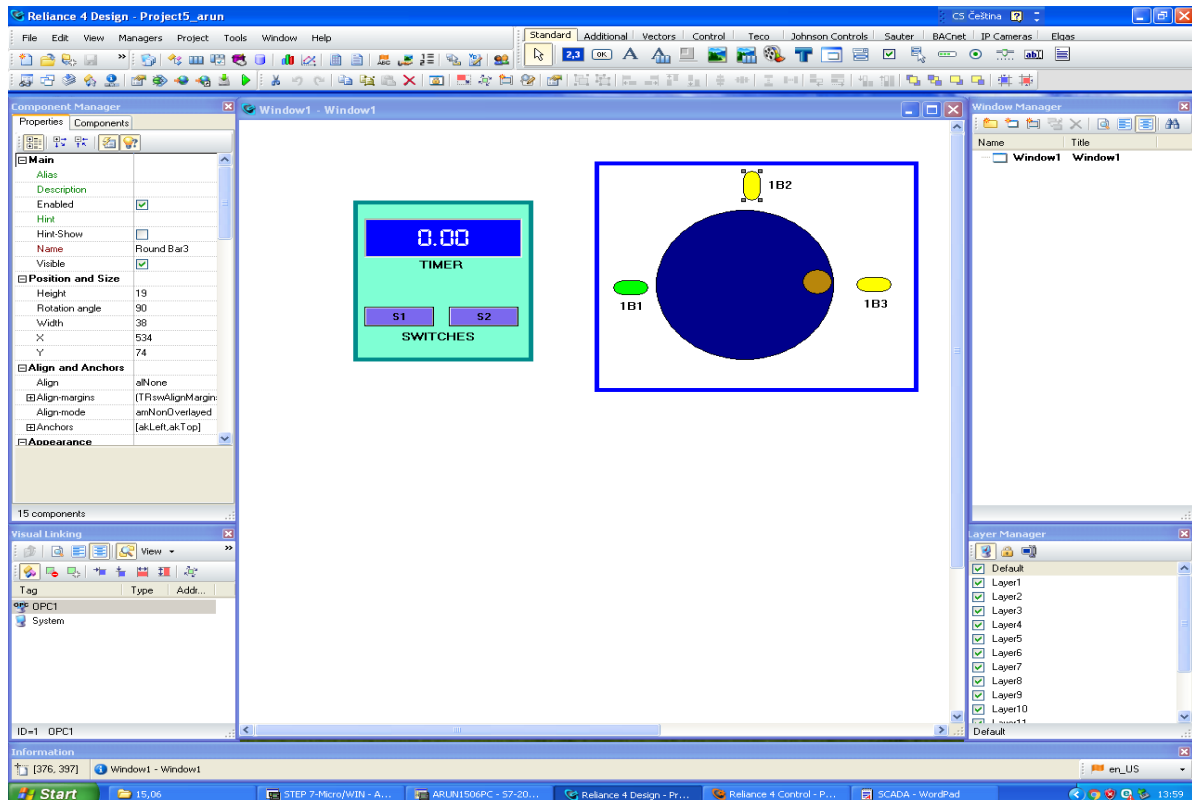

Fig. 46: Reliance 4 design development environment

7.1.1 DEVICE MANAGER

Device Manager is one of most important part of design environment which gives details about devices, tags and alarms/events. It is also divided into physical and virtual. The physical device is PLC type controller which tag values are stored in the memory of the device. Data transmission of this type device is done by communication Drive Manager or commonly known as OPC and DDE servers.

Virtual devices are designed for internal tags of the visualization project. This type of tags is exist only in computer memory so that we can work with freely. Tags are set and commend their names according to their working then tags are linked with modules which we build in windows.

7.1.2 SCRIPTS MANAGER

Script Manager is a tool that is used to define and configure scripts. It is a code which is a control for a run time. The main task is to read the values from the tags to scripts variables and to write the values from scripts variable to tag variables. The script code using VB script writing method for variables and logics defined from tags. Then the system of the code checked and analysis of error causing syntaxes.

Due to the insufficient time scripts are not used for this thesis work. Further study is needed for display and stores the calculated tact time of semi-rotary drive to display in run time.

7.1.3 DATA TABLE MANAGER

The data table is also known as database. Data sampling and logging: Sampling time is Interval given to actual time and logging is saved data like monthly, weekly and yearly. Physical data can export to excel file. It is saved in Reliance history data in.XXX file.

7.1.4 TREND MANAGER

Two types of the trend are in Reliance known as Real-time trend and trend. Real-time trend is used to show the actual data which stored in PC memory and trends are used to display historical data which created and stored from data table manager. Trend parameters are created and it has changed for a particular user.

7.1.5 USER MANAGER

User manager is an important feature in Reliance design which is used to define a different kind of users. The main part of user manager is to give access rights to the different user. The user's rights can set according to their purposes like to view, changes parameters and design changes and control. The password can be set for each user. Customise runtime module is possible.

7.1.6 REPORT MANAGER

Analysed report displaying and compared it with a data table. Then tested and exported values to excel file. The report is the Trend with all the following commands: Navigate, Filter, Compute, Evaluate, and Editing. The report can be viewed during the Runtime and it can also export to external memory.

7.1.7 ALARMS/EVENTS

Alarms/Event is known as an acknowledgement of the process. In control system operation it is used for warnings and for safety purpose. Also, we can introduce filters to view and resolve the particular issue finally it has checked in run time working on complete process and verified for working limits. It has duplicated to link another device.

7.1.8 DUPLICATIONS

In some cases, we have to do the same process again in different locations, here the technological process and PLC variable is similar to what we did in the past.

For this, we use duplications to save time. Following things can be duplicated: Device, users, Tags, alarms/event, trends, report, script and widows. Also, new window is set for switching different windows. Different type of languages prepared for different native users for doing problem free operations for various location.

7.2 PROJECT CREATION FOR SEMI-ROTARY DRIVE

The above procedures help to design the visualisation environmental of the semi-rotary drive.

- The basic design window is created using component palette in the Reliance 4 design environment. Component palette has standard, additional, vectors and much more tabs. Such types of tabs are used for complete design project successfully.
- After successfully created the project window. Device manager is used to adding a new OPC device with the new device command. On the *Basic* page define the OPC server identifier OPC server Prog ID). The identifier can be entered either manually, or selected from the list of OPC servers installed on your system (after clicking the OPC icon).
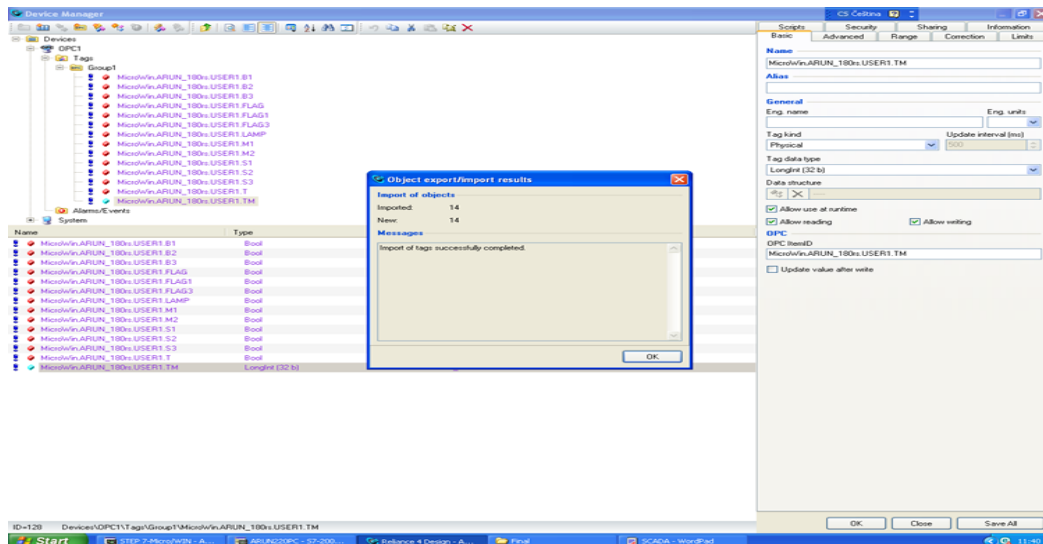
Fig. 47: Adding the tags to OPC

- Then, Via Import from OPC Server command import tags (OPC Items) from the OPC server – installed OPC server should automatically start to provide the list of tags defined in its configuration. It was added under the group1 under the OPC tree.

- Newly added display component have to be linked to a tag to show a value. Open the Display Properties dialogue.

- The runtime software display component shows the real-time value of the OPC tag. It is shown in Fig.48. (The Value are in terms of integer milliseconds)
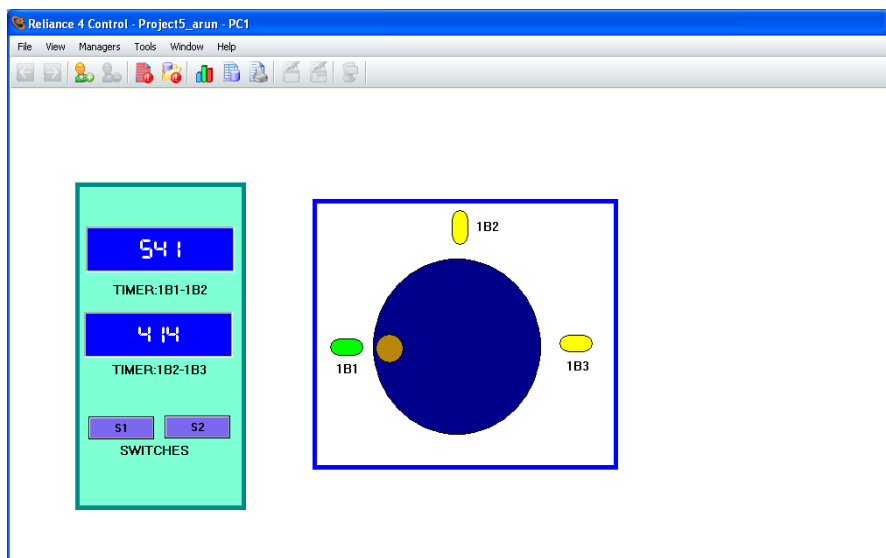
Fig. 48: Reliance 4 Runtime environmental of semi-rotary drive

8   COMPARISION OF TACT TIME FOR TYPES OF LOADS

Table 12: Tact time comparison

| Start | Stop | Rotary table perpendicular to the work table | | | |
| | | Manual time measurement (s) | | Measurements from SCADA(s) | |
		Without load	with load	Without load	with load
1B1	1B2	0.186	0.220	0.326	0.541
1B2	1B3	0.163	0.086	0.292	0.414

The measurement time taken from the value is almost similar to the value which value obtained from the SCADA runtime environment shown in table 12.

The measurement values are taken for the arrangement of the rotary table perpendicular to the working table. The ratio of the values is almost similar.

The measurement of the values difference happened because of the flow control value adjustment varies from the both the cases.

The further work is needed for the store the values which we got from the SCADA runtime environment. I know it has done by the script manager option and the data table creation.

By creating the data table, we can export the data to the excel files. It helps to analysis behaviour of the semi-rotary drive. Depending on the data we can choose the semi-rotary drive specification corresponding to the load and application more reliability.

So, that operation and delays in signal transmission, affecting both response time and positioning accuracy of the semi-rotary drive can be improved.

9   CONCLUSION

My first task was to study and to describe the functionality of the special type of the pneumatic drives of the FESTO TP220 set. The particular type of linear and semi-rotary drive have been simulated in FluidSIM® V5.0 using classical electro-pneumatic and using virtual PLC in GRAFCET language. Learnt the importance of setting parameters for drive. Experiment have been done for the linear and semi-rotary drive manually by using FESTO components in the Czech Technical University laboratory-109. I have done it and described in section 4 and 5.

The second task was to design control by PLC for semi-rotary drive application. It has been done successfully by using Ladder Diagram (LD) Programming in PLC SIMATIC S7-200 and described in section 6.

The third task was to design visualisation of application in the SCADA system of the semi-rotary drive. I have done it and it is described in section 7.

My last task compared tact time for variant types of the loads. Manual measured data has been analysed for various types of loads and compared with time measurement taken from the runtime environment. The result was good. I have described it in section 8.

Finally, I have to store the measured time values for future comparison with the actual value which I have got from the laboratory experiment. I know how it has to be done using Reliance 4 SCADA software. Due to time limitation, I could not complete it. Further work and deep knowledge in reliance software help to achieve the best result.

In conclusion through this thesis, I have learnt about the special type of drives. And fulfilled the defined guidelines of my thesis work. It was such a great learning. I am sure that it helps me for my future study and career.

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ABBREVIATIONS

PLC	Programmable Logic Controllers
SCADA	Supervisory Control And Data Acquisition
HMI	Human-Machine Interface
LED	Light Emitting Diode
PC	Personal Computer
RTU	Remote Terminal Units
GUI	Graphic User Interface
LD	Ladder Diagram
SFC	Sequential Functional Block
FBD	Functional Block Diagram
ST	Structural Text
IL	Instructional List
CPU	Central Processing Unit
TSAP	Transport Services Access Point
OLE	Object Linking and Embedding

TABLE OF FIGURES
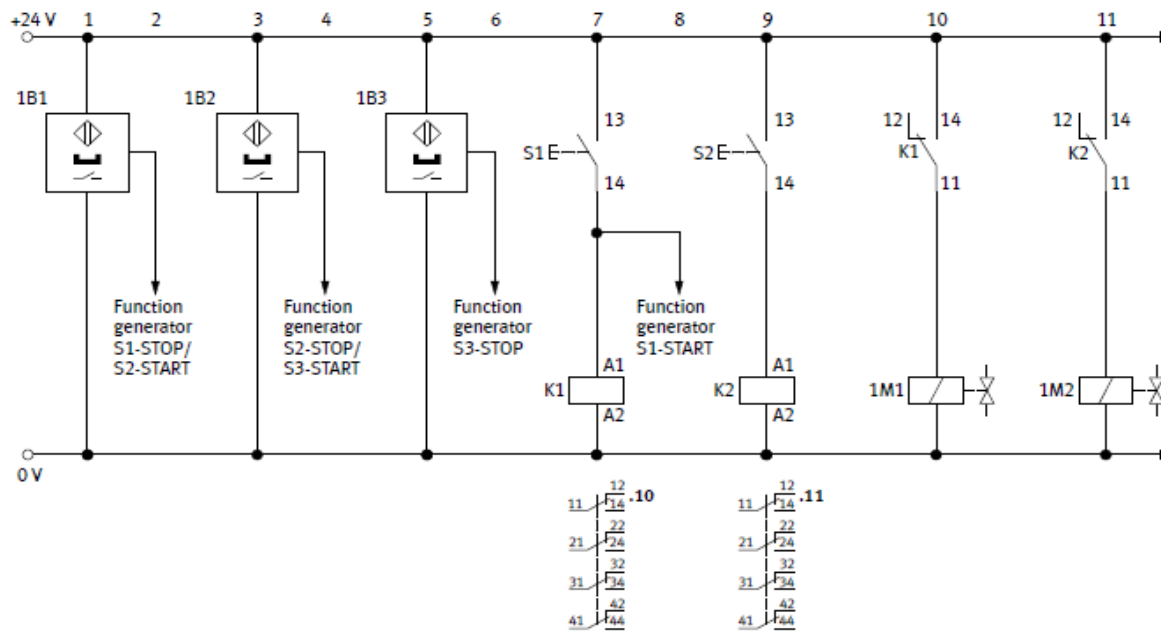
LIST OF TABLES

APPENDIX

Other supporting documents related to thesis work is attached in the Compact Disc (CD).
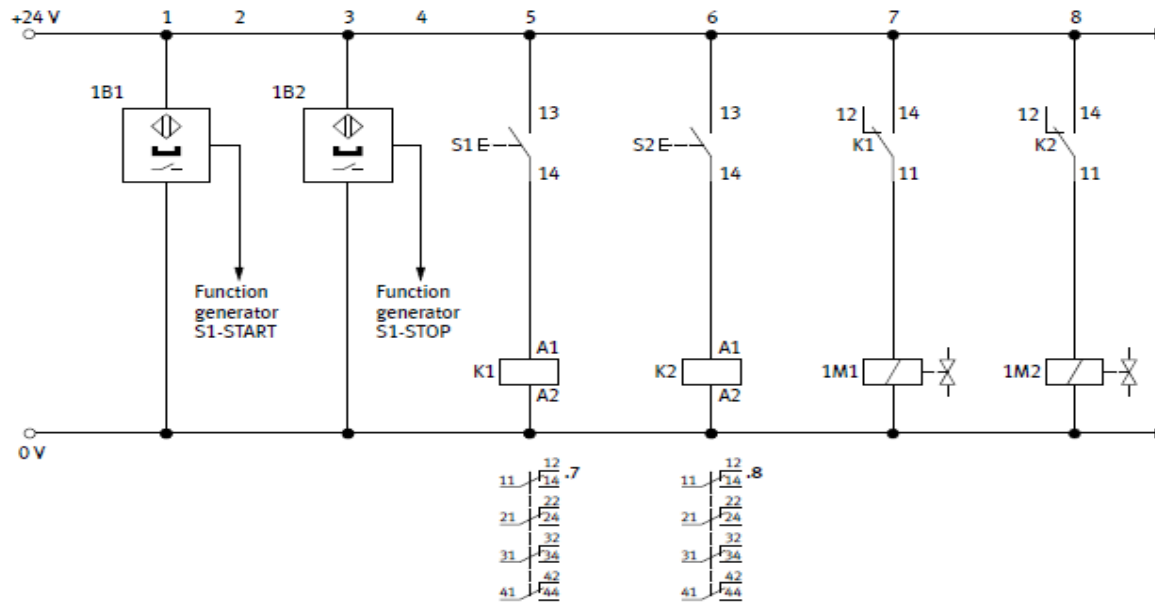
Electrical circuit diagram

Fig. 49: Electrical circuit diagram of Linear Drive [1]

Electrical circuit diagram

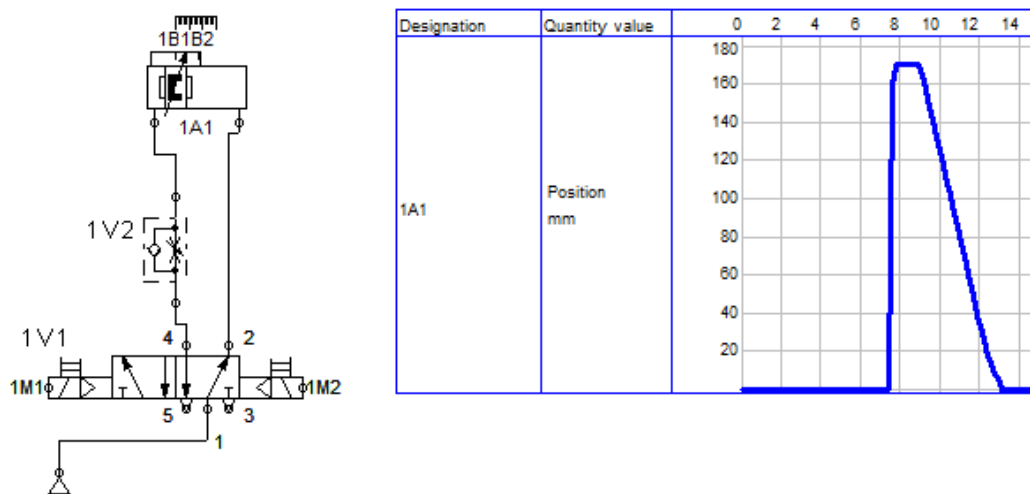Fig. 50: Electrical circuit diagram of Semi-Rotary Drive [1]

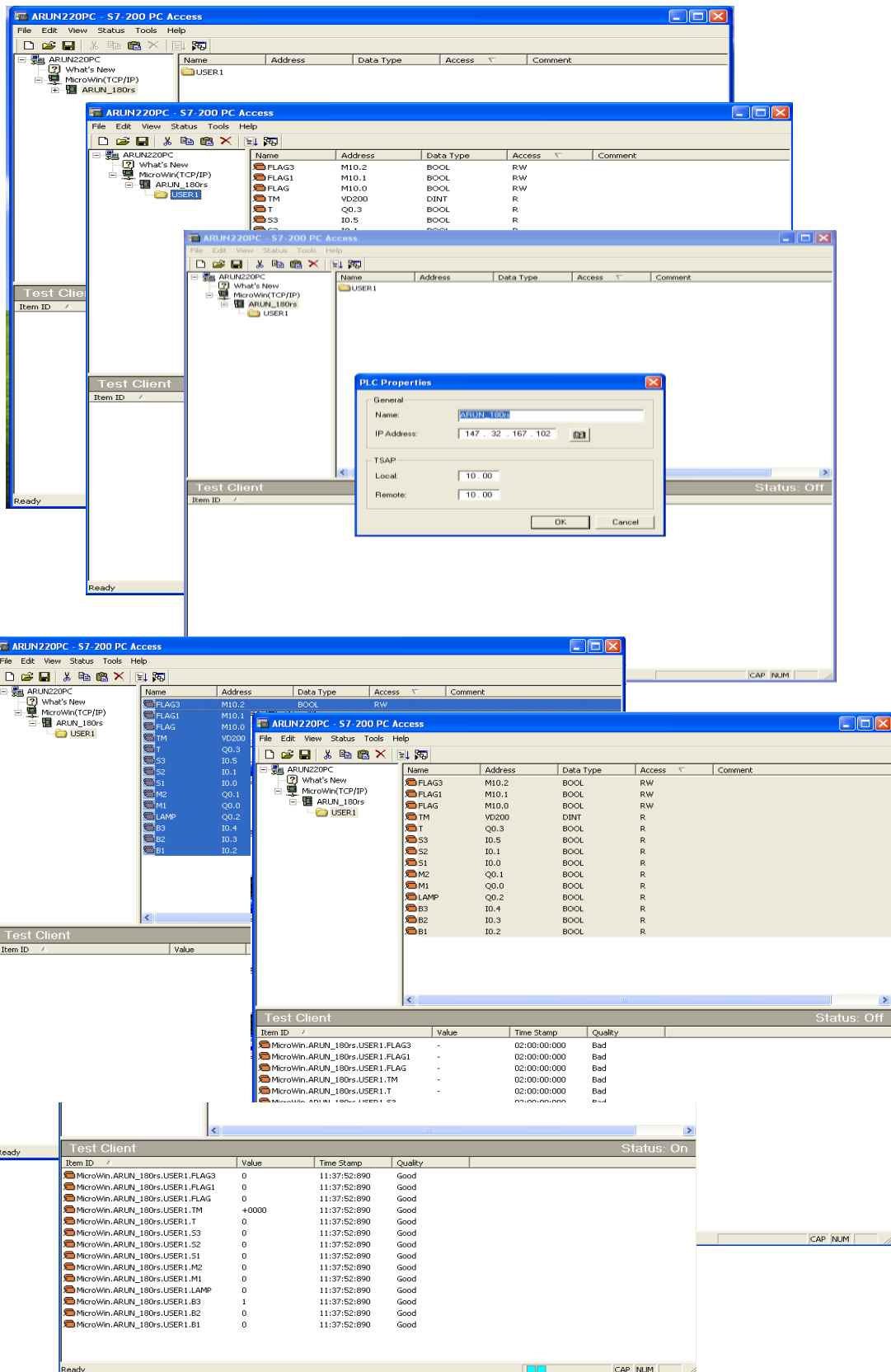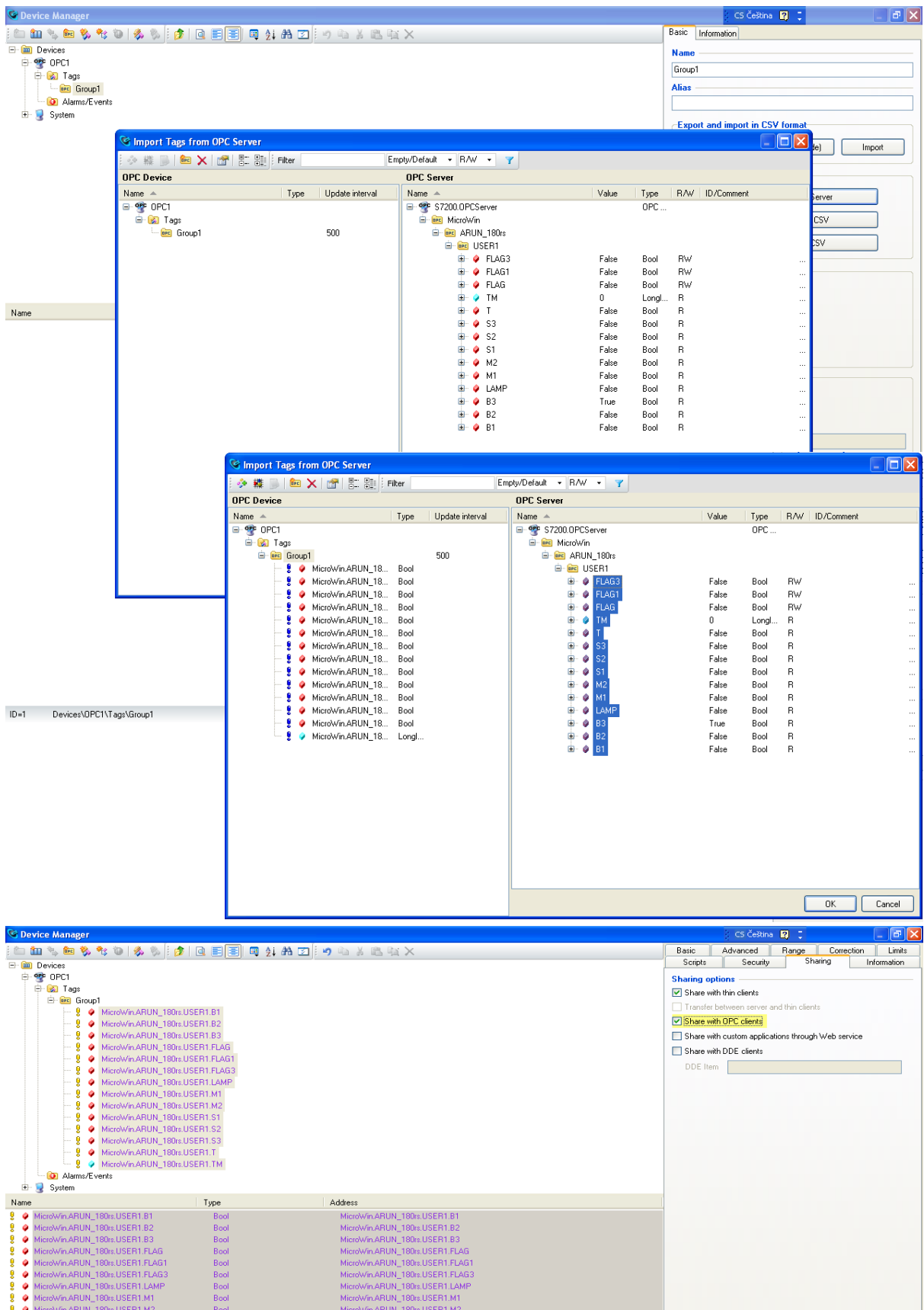Fig. 51: Flow control valve simulation circuit

Fig. 52: PC Access step flow

Fig. 53: Import tags from OPC server to SCADA