# EXPERIMENT 1

**MOTOR CONTROL SYSTEM**

**OBJECTIVE**

**REFERENCE**

**EXPERIMENT EQUIPMENT**

**PRE-EXPERIMENT TASK**

**INTRODUCTION**

**The Components of the Motor Control System**

The Lab Exercises are completed with different types of motor for AC and DC. These can be loaded gradually with a magnetic powder brake. During the lab exercises studies are made of different control equipment that is used to run and control the motors. A few examples of control equipment are contactors, frequency converters, current rectifiers and PLC. These units are either assembled as a separate unit or as a module card that is fitted to the Base Unit 2000.

**Base Unit 2000**

The Base Unit is the centre for connecting different equipment. It is supplied by 230V AC and feeds the connected modules. These modules are inserted between two slides to a 64-pole socket.



Figure 1 Base Unit 2000

**Vs Motor**

The Vs motor is a 250W synchronous motor. It is connected to 3phase 400V supply voltage and can be connected in Y or D. (Star or delta). The supply to the Vs motors power circuit is via a 3-phase terminal that is connected to the 3-phase network. It can also be supplied from a frequency converter.



Figure 2 Vs Motor

**Ls Motor**

The Ls motor has a power of 250W and has a separately magnetised field winding. A current rectifier must be used when connecting to 230V AC, single phase.

A picture containing tool

Description automatically generated

Figure 3 Ls Motor

**Revolution Counter (rpm)**

To measure the rotation speed of the motor, a tachometer is attached to the motors axle.A picture containing device

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Figure 4 Revolution Counter (rpm)

**3-Phase Terminal**

The connection of the Vs motor to 3-phase is via a 3-Phase Terminal having a 5 pole 16A plug according to standards CEE17. On the terminal there is a control panel for three phases and a neutral. The three phases are fused and fed via an isolating transformer. The terminal is prepared for current and voltage measurement on all phases. It has also a phase rotation indicator with LEDs showing the rotation. Connection to the 3-phase terminal is via lab leads, either direct or via the Contactor Module. Only touch protected 4mm lab sockets are used.

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Figure 5 3 Phase Terminal

**Frequency Converter**

To be able to give a soft start and to regulate the speed, a frequency converter is used. This unit can be used for many other functions but in this exercise it is for soft start and stop, speed regulation and study of the overload protection.

A picture containing text, electronics

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Figure 6 Frequency Converter

**Current Rectifier Module**

The current rectifier is used to drive the DC motor. Different parameters are set such as speed, current limits, acceleration ramp etc.

A close-up of a computer

Description automatically generated with medium confidence

Figure 7 Current Rectifier Module

**EXPERIMENT**

**E1. Motors Nameplate**

1. **Operational Procedure**

Place the Vs motor on the workbench so that the nameplate is visible.

1. **Experimental Data**

Table 1 Experiment of Motors Nameplate

|  |  |
| --- | --- |
| **Type of Vs motor** | Sh 71-4A (Squirrel Cage 3-Phase Synchronous Motor) |
| **Frequency of Vs motor** | 50, 60 Hz |
| **Voltage when motor is connected Delta (D)** | 220-240 V (50 Hz) |
| **Voltage when motor is connected Star (Y)** | 380-420 V (50 Hz)  440-480 V (60 Hz) |
| **Rated current in delta** | 1.5-1.6 A (50 Hz) |
| **Rated current in star** | 0.85-0.93 A (50, 60 Hz) |
| **Rating speed motor** | 1380 rpm (50 Hz), 1660 rpm (60 Hz) |
| **Power factor** | 0.64 |
| **Slip (S)** | 1 |
| **IP rating** | 55 |

1. **Analysis and Experimental Task**
2. What is the stated axle power?

dadasdasdasd

1. What is the asynchronous speed of the motor?

The speed at which the rotor of the induction motor is rotating is called Asynchronous Speed. The rotor of the induction motor never rotates at the same speed as the stator rotating magnetic field. The speed of the rotor is always less than the synchronous speed.

Synchronous speed :

1. How many poles has this motor?

So, this motor has 4-5 poles

1. The relative slip s can be calculated by comparing **ns** with **na** = asynchronous speed. What is the percentage slip?

Slip refers to the difference between the shaft rotating speed (**na**) and the magnetic field's synchronous speed (**ns**), which is measured in frequency or RPM.

Because this motor is synchronous motor, the slip is 0

1. The power factor is given on the nameplate. What is the power factor of this motor?

Power Factor is the ratio of active power to total power (apparent power)

P = Power consumed in the load (active power)

S = Total power of generator (or used)

**E2. Motors Direction of Rotation**

1. **Objective**

An electric motor can be started and stopped in many different ways. It will be necessary to run the motor in different direction of rotation. These problems will be studied in this chapter.

1. **Operational Procedure**

**B.1 Connecting the Motor**

1. Place the Vs motor on the workbench so that the nameplate is visible.
2. Connect the motor in star.

Connect to the 3-phase terminal as shown in figure 2.1 below. i.e. L1-U1, L2-V2, L3-W3.

1. Start the motor using the switch on the 3-phase terminal.

Diagram, schematic

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Gambar xx 3-Phase terminal with star connected motor.

1. Switch off at the 3-phase terminal and study the direction of rotation when the speed is slow enough to see how the axle is turning.
2. State the direction of rotation seen from the axle end of the motor

The direction of rotation is always from the axle end.

1. Switch off the supply and let the motor stop completely. Change over any two phases, start up the motor and check the direction of rotation.
2. Sketch the motors direction of rotation seen from the other end.
3. By changing over any two phases on an asynchronous motor the direction of rotation will be reversed. The direction of rotation is dependent on the order in which the phases L1, L2 and L3 are connected to the motor windings. The  
   phases have an angle difference of 120 degrees. This means that the motor windings are supplied in rotation. See figure 2.2.

As the phases come in the order L1, L2 and L3, then according to 2.2 the motor will turn clockwise. If two of the phases are changed then the supply order is changed and the direction of rotation will change to anti-clockwise.

**B.2 Phase Rotation Meter**

A phase rotation meter can be used when the motor is at full speed and it is  
difficult to see which direction it is turning. This meter gives an optical indication  
of direction.

A motor that is connected L1-U1, L2-V2 and L3-W3  
will rotate clockwise.

1. Switch off the supply to the 3-phase terminal.
2. Connect the Vs motor and phase rotation meter as shown in figure 2.3.

Text

Description automatically generatedDiagram, schematic

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Gambar xx 3-Phase terminal with phase rotation meter and Vs motor.

1. Switch on the 3-phase terminal and check the phase rotation on the phase  
   rotation meter. Was it correct?
2. Check the motor rotation with different phase changes. Leave the phase rotation meter connected and change over the phases as shown in the table  
   below. Mark with rotation arrows the motors direction of rotation.
3. **Experimental Data**

|  |  |
| --- | --- |
| Motor connection | Direction of rotation |
| L1-U1L2-V1L3-W1 | Clockwise |
| L1-U1L2-W1L3-V1 | Counter-clockwise |
| L1-W1L2-U1L3-V1 | Clockwise |
| L1-V1L2-U1L3-W1 | Counter-clockwise |
| L1-V1L2-W1L3-U1 | Clockwise |
| L1-W1L2-V2L3-U3 | Counter-clockwise |

1. **Analysis and Experimental Task**
2. Why we connect L1-U1, L2-V2 and L3-W3? Determine type of connection!

Wye connection,

1. By changing any two phases to an asynchronous motor, the motor will change  
   direction of rotation. If the motor is connected to

Changing any phases and supply order (L1, L2, L3)

Summary

The direction of rotation is dependent on the order in which the phases L1, L2, and L3 that supplied in rotation

**E3. Overload Protection**

1. **Objective**
2. **Operational Procedure**
3. **Experimeental Data**

**E4. Motor Control with Current Rectifier**

1. **Objective**

In this exercise a motor shall be manoeuvred forward, reverse and from two stations.

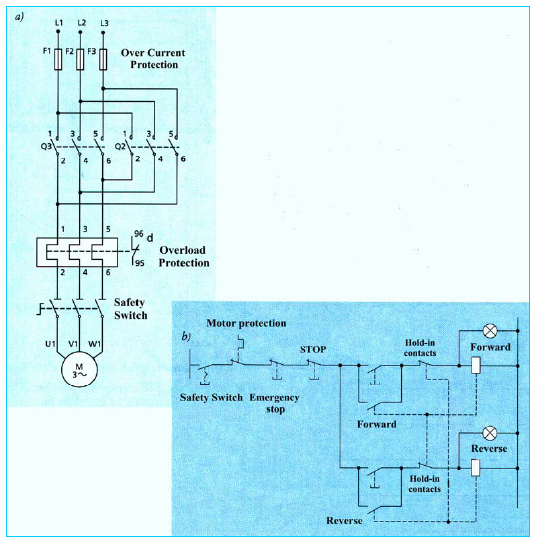
1. **Operational Procedure**

The first stage is to change the direction of rotation of the motor using a control circuit. Standards give the directions as *clockwise* or *anti-clockwise*. The terms *forward* and *reverse* are also used.

* + - 1. **Forward and Reverse Manoeuvres**

Place the equipment on the laboratory bench.

Study the circuit diagram in figure 4.1



*Figure 4.1 Diagram with forward and reverse of motor*

1. *Power circuit b) Control circuit*

The schematic diagram shows that the forward contactor makes the motor turn clockwise. This is easy to check as contactor **Q3** connects **L1-U1**, **L2-V2** and **L3-W3**. The upper part of the circuit diagram is a hold-in circuit when running the motor anticlockwise. Pressing the **STOP** button stops the motor.

The lower part of the circuit is connected when the motor is run in the anticlockwise direction; the hold-in circuit is broken by contacts **REVERSE**.

If the motor is run clockwise, a lock prevents the possibility of the motor being run in two directions at the same time. If this did happen then there would be a short circuit with a great strain on the motor and the load connected to the shaft. When contactor **Q3** is energised, the hold-in contacts in the lower hold-in circuit, are opened. It is then impossible for contactor **Q2** to be energised.

Explain in your words what happens when pushbutton **REVERSE** is pressed to run the motor in anticlockwise direction.

Switch reverse akan tertekan sehingga relay untuk menggerakkan motor dengan arah *reverse* juga akan hidup. Hal ini akan menghidupkan kontak *reverse* sehingga relay tersebut tetap akan hidup karena adanya *self holding circuit* pada loop *reverse*. Relay tadi juga akan menghidupkan lampu kedua atau lampu indikator *reverse*. Kontak *hold-in* pada relay *reverse* akan terbuka sehingga mencegah motor agar tidak bergerak *forward*.

Which motor winding will be connected to the phases when pushbutton **REVERSE** is pressed and contactor **Q2** is energized? Connect the phase by drawing a line between those marked below.

|  |  |
| --- | --- |
| **L1** | **U1** |
| **L2** | **V1** |
| **L2** | **W1** |

Switch off the supply to the 3-phase terminal.

Connect the control as shown in figure 4.1. Number the switches according to the control module and also give the connection number.

Test the connections ***without having the motor connected***.

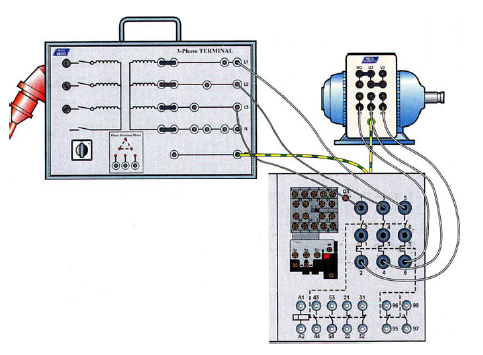
What happens when pushbutton **REVERSE** is pressed?

Sama kayak pertanyaan sebelumnya

Which set of contacts is used to break the hold-in circuit?

Kontak *forward* untuk menghentikan atau membuka *hold-in* pada rangkaian *reverse* dan kontak *reverse* untuk membuka *hold-in* pada rangkaian *forward*.

Figure 4.2 Below shows a simplified diagram of how the motors power circuit is connected to the 3-phase terminal and contactor module. Connect the power circuit as shown in figure 4.1

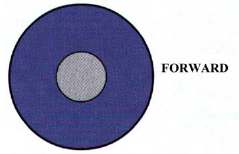


*Figure 4.1 Diagram for the connections between the motor and contactor module.*

Connect the control circuit as shown in figure 4.1

Switch on the supply to the 3-phase terminal. Start the motor by pressing the pushbutton **FORWARD**.

Sketch the direction of rotation in the round figure.

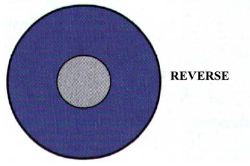


Stop the motor by pressing the **STOP** button.

Make sure the motor is completely still.

Press the pushbutton **REVERSE**.

Sketch the direction of rotation in the figure below.



Stop the motor by pressing the **STOP** button.

Make sure the motor is completely still.

The objective of interlocking the hold-in contacts is to prevent contacts Q2 and Q3 from closing at the same time. This would cause a short circuit as the phases are crossed in the power circuit.

* + - 1. **Time Controlled Motor**

1. **Experimeental Data**
2. **Analysis and Experimental Task**

**EXPERIMENT 2**

**ELECTRO-PNEUMATIC CONTROL**

**OBJECTIVE**

Fluid Power takes an important role as a technology in the performance of mechanical work. Industrial field nowadays turn their sight to these mechanism because of many advantages despite of its disadvantages. It is important for engineering student to learn and understand about this concept, so they know what to do in real system.

**REFERENCE**

Anonymous. Pneumatics Control Technology-Chungpa EMT. 2011.

Peter Crosser and Frank Ebel. Pneumatics Basic-Level. 2007

**EQUIPMENT REQUIRED**

PN-7050 Air Service Unit 1 piece

PN-7051 Air distributer 1 piece

PN-7100 3/2-way valve with push button (N.C) 1 piece

PN-7101 3/2-way valve with push button (N.O) 1 piece

PN-7400 Pneumatic single-acting cylinder 1 piece

PN-7602 3/2-Way Single Solenoid Valve(N.C) 1 piece

PN-7610 5/2-Way Double Solenoid Valve 1 piece

PN-7402 Double Acting Cylinder with Air Cushion 1 piece

PN-7570 Electrical Limit Switch module(Left) 1 piece

PN-7570 Electrical Limit Switch module(Right) 1 piece

PN-7302 Different pressure valve (AND) 1 piece

PN-7301 Shuttle valve (OR) 1 piece

PN-7400 Pneumatic single-acting cylinder 1 piece

- Power Supply Module 1 piece

- Switch Module 1 piece

- Relay Module 1 piece

- Compressor 1 piece

- Pneumatic Hose Sufficiently

- Electrical leads Sufficiently

**PRE-EXPERIMENT TASK**

1. What is the difference of Pneumatic and Hydraulic system?
2. Why do we need the valves in that System? Explain briefly!
3. How do the 3/2-way valve and 5/2-way valve works?

**INTRODUCTION**

A pneumatic system is a system that uses compressed air to transmit and control energy. The principles of pneumatics are the same as those for hydraulics, but pneumatics transmits power using a gas instead of a liquid. Compressed air is usually used, but nitrogen or other inert gases can be used for special applications. With pneumatics, air is usually pumped into a receiver using a compressor. The receiver holds a large volume of compressed air to be used by the pneumatic system as needed. Atmospheric air contains airborne dirt, water vapor, and other contaminants, so filters and air dryers are often used in pneumatic systems to keep compressed air clean and dry, which improve reliability and service life of the components and system. Pneumatic systems also use a variety of valves for controlling direction, pressure, and speed of actuators.

Most pneumatic systems operate at pressures of about 100 psi or less. Because of the lower pressure, cylinders and other actuators must be sized larger than their hydraulic counterparts to apply an equivalent force. For example, a hydraulic cylinder with a 2 in. diameter piston (3.14 sq. in. area) and fluid pressure of 1,000 psi can push with 3140 lbs. of force. A pneumatic cylinder using 100 psi air would need a bore of almost 6½ in. (33 sq. in.) to develop the same force. Even though pneumatic systems usually operate at much lower pressure than hydraulic systems do, **pneumatics holds many advantages that make it more suitable for many applications.** Because pneumatic pressures are lower, components can be made of thinner and lighter weight materials, such as aluminum and engineered plastics, whereas hydraulic components are generally made of steel and ductile or cast iron. Hydraulic systems are often considered rigid, whereas pneumatic systems usually offer some cushioning, or “give.” Pneumatic systems are generally simpler because air can be exhausted to the atmosphere, whereas hydraulic fluid usually is routed back to a fluid reservoir.

**Pneumatics also holds advantages over electromechanical power transmission methods.** Electric motors are often limited by heat generation. Heat generation is usually not a concern with pneumatic motors because the stream of compressed air running through them carries heat from them. Furthermore, because pneumatic components require no electricity, they don‟t need the bulky, heavy, and expensive explosion-proof enclosures required by electric motors. In fact, even without special enclosures, electric motors are substantially larger and heavier than pneumatic motors of equivalent power rating. Plus, if overloaded, pneumatic motors will simply stall and not use any power. Electric motors, on the other hand, can overheat and burn out if overloaded. Moreover, torque, force, and speed control with pneumatics often requires simple pressure- or flow-control valves, as opposed to more expensive and complex electrical drive controls. And as with hydraulics, pneumatic actuators can instantly reverse direction, whereas electromechanical components often rotate with high momentum, which can delay changes in direction.

**Factory automation is the largest sector for pneumatics technology**, which is widely used for manipulating products in manufacturing, processing, and packaging operations. **Pneumatics is also widely used in medical and food processing equipment**. Pneumatics is typically thought of as pick-and-place technology, where pneumatic components work in

**is much more.** Because compressed air can have a cushioning effect, it is often called on to provide a gentler touch than what hydraulics or electromechanical drives can usually provide. In many applications, pneumatics is used more for its ability to provide controlled pressing or squeezing as it is for fast and repetitive motion. Moreover, electronic controls can give pneumatic systems positioning accuracy comparable to that of hydraulic and electromechanical technologies.

|  |  |
| --- | --- |
| **1a. Automobile Production Lines** | **1b. Pneumatic system of an automatic machine** |

**Fig. 1(a,b) Common pneumatic systems used in the industrial sector**

Pneumatics is also widely used in chemical plants and refineries to actuate large valves. It‟s used on mobile equipment for transmitting power where hydraulics or electromechanical drives are less practical or not as convenient and in on-highway trucking for various vehicle functions. And of course, vacuum is used for lifting and moving work pieces and products. In fact, combining multiple vacuum cups into a single assembly allows lifting large and heavy objects. Following are the use of pneumatics in a variety of applications i.e. used in controlling train doors, automatic production lines, mechanical clamps, etc.

**Fluid power systems** consist of multiple components that work together or in sequence to perform some action or work. People well versed in fluid power circuit and system design may purchase individual components and assemble them into a fluid power system themselves. However, many fluid power systems are designed by distributors, consultants, and other fluid power professionals who may provide the system in whole or in part. The major components of any fluid power system include:

* **a pumping device** — a hydraulic pump or air compressor to provide fluid power to the system
* **fluid conductors** — tubing, hoses, fittings, manifolds and other components that distribute pressurized fluid throughout the system
* **valves** — devices that control fluid flow, pressure, starting, stopping and direction
* **Actuators** — cylinders, motors, rotary actuators, grippers, vacuum cups and other components that perform the end function of the fluid power system.
* **support components** — filters, heat exchangers, manifolds, hydraulic reservoirs, pneumatic mufflers, and other components that enable the fluid power system to operate more effectively.

Electronic sensors and switches are also incorporated into many of today‟s fluid power systems to provide a means for electronic controls to monitor operation of components. Diagnostic instruments are also used for measuring pressure, temperature and flow in assessing the condition of the system and for troubleshooting.

**EXPERIMENT**

**Experiment 1. Direct and Indirect Control**

Direct control of single acting cylinder using 3/2-way valve with push button.

1. **Operational Procedure**
2. Configure circuit in **Figure 1** for N.C circuit.
3. On the Air Service Unit, adjust the operating pressure in about 2-3 atm. Make sure to always check the pressure control valve in „open‟ or „closed‟ state.
4. Write initial condition of valve when it is depressed and released.
5. Whenever removing hose from device, make sure there isn‟t compressed air that flowing in the hose.
6. Configure circuit in **Figure 2** for N.O circuit.
7. Write initial condition of valve when it is depressed and released.

**EXPERIMENT 3**

**PROGRAMMABLE LOGIC CONTROLLER (PLC) – MITSHUBISHI**

**OBJECTIVE**

Understanding automation process in the industrial field is essential for an engineer. Engineering student have to be used to work and practice in industrial environment.therefore, they are ready with the real system. In this experiment, we will use PLC Mitshubishi

that shows basic automation command clearly and easy to understand. We would have introduced about basic instruction, counter, and timer.

**REFERENCE**

David W. Pessen, Industrial Automation: Circuit Design and Components, 2008.

**EQUIPMENT REQUIRED**

1. What kind of industries that use or apply PLC to their system? Why industries use them?
2. What is company that produces the PLC?

**PRE-EXPERIMENT TASK**

**INTRODUCTION**

**EXPERIMENT**

**EXPERIMENT 4 (Rayhan Haqi)**

**PROCESS CONTROL TRAINER (PCT-100)**