A study of frequency and pulses for stepper motor controller system by using programmable logic controller

S Hassan¹, M S Yusof¹, Z Embong², Q E Kamarudin¹, R H A Haq¹, M Ibrahim¹, K R Khairilhijra¹, O M F Marwh¹, N Sa'ude¹, M Ismon¹ and M A Madlan¹

¹Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia
²Faculty of Science, Technology and Human Development, Universiti Tun Hussein Onn Malaysia, 86400 Batu Pahat, Johor, Malaysia

Abstract. The stepper motor movement process produced different frequency and pulses. This research explained about the frequency and pulses for the stepper motor movement by using Programmable Logic Controller (PLC) as research method. The study was done to find the suitable frequency and pulses for stepper motor movement by developing a prototype stepper motor controller system. The pulse frequency used did not affected the distance of moving load in the stepper motor operations. The increasing number of pulse frequency only will affect the time taken for the stepper motor to complete its operations. The result showed that number of pulse frequency at high operation was 5000 Hz. Pulse number reacted as a manipulated variable that affected both factor which is time taken of stepper motor operation and the distance of moving load.

1. Introduction
The stepper motor has been used in various applications such as CNC table, printer, laser machine, rapid prototyping, sorter and others [1]. It is a brushless electric motor and electromagnetic device that uses magnetic field for movement with the aid of digital pulses. It is precise and accurate in producing discrete stationary angular rotations [2]. Digital pulses for stepper motor can be obtained by using different controller such as microcontroller or Programmable Logic Control (PLC). Every stepper motor has different frequency. The uses of controller system was helped a lot to find the best frequency for the stepper motor movement. This was happen because by using CX-Programmer software in the stepper motor controller system, it produced high program readability. Programmable logic controllers had been widely used for sequential logic control in manufacturing environments. PLC system was used to integrate materials handling and processes in automated manufacturing systems. By using PLC in the stepper motors controller system, the suitable frequency and pulses were identified for stepper motor movement [3].

Recently, researchers have shown that PLC is an electronic device controller which is functioning as a leader for a process system. PLC also used for special purpose industrial computers designed in term of control a wide variety of manufacturing machines and systems [4]. Three kind of parameter which is a rotational direction, an angle of the rotation and the speed of the rotor to rotate had been discussed in study of Stepper Motor Controller using PIC 18F4520. The project consists of stepper motor driver circuit, motor speed controller circuit, the circuit start or stop, the oscillator circuit and power supply circuit to solve the problem statement. From the project, it has three control functions which is rotate
the stepper motor (clockwise or counter clockwise), stop the stepper motor and control the speed of rotating stepper motor [5].

Stepper motor that use in colour sorting application by using PLC system is an extraordinary research on how to control the stepper motor in advanced function programming of PLCs. There are three parameters were studied in the experiment which is OMRON CQM1H CPU-43(PIC16F84A), OMRON CX-programmer and RGB digital colour sensor. From the study, it is proved that colour sensor device used to differentiate various colours [6]. The principles of operation in the stepper motor begin with stacks [7]. Stacks is a magnetically isolated sections which is the multi-stack variable-reluctance stepping motor is divided along its axial length into it [8]. A successful multi-stack design is often produced with additional stacks so that it has a choice of step length but motor with higher stack numbers have no real performance advantages over a three-stack motor. The capability of torque produced in hybrid was greater than in the variable-reluctance motor.

The study about direct load control using PLC describes the function of PLC. The function of PLC in this process is to convert the incoming signal be a warning signal. The process begins with a programmable logic controller which gets an input signal from the computer and then converts to become warning signal. From the warning signal, it goes through a customer responds. The number of load was shut off and the alarm also shut off [9]. Other research that was done by Ramazan and Yucel which is about water pumping control system with PLC and IWLAN. The study was explained another function of the PLC system in the control system. From the study, the PLC sends a digital signal to the water pump to turn it on or off, based on the tank level of the water in the tank. IWLAN stand for industrial wireless local area network. IWLAN was used as a communication connection in the process [10].

2. Research methodology
The experimental process was started by developing prototype stepper motor controller system. The development process was involved designing circuit, PLC programming, installing and experimental testing as shown in table 1 and figure 1. Push button was used as input component to connect and break an electrical circuit. Push button switch was an electrical component that directly manipulated by a human as a control signal to a system. To run the electrical circuit, it used 24V power supply for a low voltage application.

| Table 1. Label and Function of the Controller System |
|-----------|---------------------------------|
| Label     | Function                        |
| A         | Switch Box                      |
| B         | 24 VDC power supply             |
| C         | CP1L programmable logic controller |
| D         | Wire Connector                  |
| E         | Driver for stepper motor        |
| F         | Stepper motor                   |

A selection of stepper motor was done to get the suitable part. The function of stepper motor is to generate a force and apply to the load. This study was a used stepper motor which is type Autonics A2K-M24. Then, the actuator type Misumi LX20 was connected with the motors. A stepping motor can move with only one way moving part. It provided an alternative to automatically complex assemblies [11] that require regular maintenance and develop inaccuracies over time.
In controlling the system, this study had decided to use Omron CP1L Programmable Logic Controller. CP1L provides an option of three programming languages which are function blocks, ladder diagram and structure text. This programming helps in reducing development and troubleshooting time. The added function block memory (10K steps) improves reusability of user program assets and supports design standardization. The function blocks aid efficient creation of reusable programs used in various devices such as ladder programs used for ethernet communications.

Other important input device is limit switch. It uses is to control a machine, as safety interlocks or to count objects passing a point. In addition, this device typically was wired through a control relay, a motor contactor control circuit and as an input to a programmable logic controller. The limit switch can be operated simply with a light touch because the type of limit switch is lower limit switch category.

3. Result and analysis

Ladder diagram was used as a programming language for the stepper motor controller system liked showing in figure 2. After the pulse frequency was set up, Push Button 1 (0.00) represented the clockwise movement of stepper motor. After that, the load touches the Limit Switch 1 (0.02) and the motor was stopped. In different direction of stepper motor rotation, the motor rotated counter-clockwise after Push Button 2 (0.01) was pressed. Then, the load moved and only will stop until it touched the Limit Switch 2 (0.03). For the safety purpose, an emergency switch (0.04) was installed for both direction and it acted as a circuit breaker.

Based on tables 2, 50,000 and 100,000 pulses are used as constant variables. Figure 3 shows the relationship between different values of pulse frequency (Hz) with time taken of stepper motor operations. The pulse frequency is inversely proportional to the time taken of stepper motor operations. It means that whatever factor of pulse frequency changes, time taken of stepper motor operations also changes by the inverse of that factor.

Besides that, the relationship between different pulse frequencies at 50,000 and 100,000 number of pulses with the distance of stepper motor movement was shown in figure 4. The result was showed that any changing or improving on the pulse frequency, the distance of moving load will remain the same.
Figure 2. Ladder Diagram design for stepper motor controller system

Table 2. Relationship between numbers of pulse frequency (Hz) with time and distance

| No. of Pulse | Pulse Frequency [Hz] | Time [s] | Distance [mm] |
|--------------|----------------------|----------|---------------|
| 50,000       | 1000                 | 50.6     | 12.1          |
| 50,000       | 2000                 | 25.4     | 12.2          |
| 50,000       | 3000                 | 17.0     | 12.2          |
| 50,000       | 4000                 | 12.6     | 12.2          |
| 50,000       | 5000                 | 10.2     | 12.3          |
| 100,000      | 1000                 | 100.0    | 25.1          |
| 100,000      | 2000                 | 50.5     | 25.2          |
| 100,000      | 3000                 | 33.7     | 25.1          |
| 100,000      | 4000                 | 25.0     | 24.7          |
| 100,000      | 5000                 | 20.3     | 24.7          |

Figure 3. Relationship between Different Pulse Frequencies [Hz] and Time [s]  
Figure 4. Relationship between Different Pulse Frequencies [Hz] and Distance [mm]
The main operation of the ladder diagram that was showed in figure 2 before which represent the clockwise rotating of the stepper motor. The experiment was done by setting the pulse frequency as the manipulated variable in order to obtain the time and distance of stepper motor movement. The experiment showed that the value of distance was not affected by pulse frequency at constant number of pulse but for the time, the value was directly proportional.

4. Conclusion
From the research, number of pulse and frequency pulse of the stepper motor movement has been studied for motor controller system. The best result for number of pulse frequency at high operation is 5000 Hz. The high operation is referred to the number of pulses which is 100,000.

As a conclusion, the pulse frequency does not affected the distance of moving load for the stepper motor operations at constant number of pulse. The increasing number of pulse frequency was affected the time for the stepper motor movement. Then, the number of pulse was directly proportional with time and distance for motor movement at constant frequency pulse value.

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