DESIGN AND IMPLEMENTATION OF INDUCTION MOTOR WITH VARIABLE FREQUENCY DRIVE

Bimantoro Sardoyo Putro; Agus Supardi, S.T.,M.T.
Program Studi Teknik Elektro,
Fakultas Teknik,
Universitas Muhammadiyah Surakarta

Abstract

Induction motor is the kind of electric motor that widely used. The advantages of induction motor is the price is low and easy to maintain. Induction motor is an asynchronous motor where the rotational speed can change according with the change of speed. The asynchronous characteristic is expressed by slip that is the relative difference about the synchronous speed of rotating field and the speed of rotor that follow. For industrial utilization, the certain load need precision speed and because of that the change of speed should be avoided. Induction motor speed control is required to ensure the induction motor remain in constant rotating even if there is a load change. The speed of induction motor is determined by several factors such as input motor frequency. Frequency modulation can be done by electric power device. Variable Frequency Drive (VFD) is a induction motor controlling scheme that use to manipulate frequency input on induction motor. In this research would be implemented VFD to control single-phase induction motor. Tests are carried by the change of load and the feedback system to keep the speed remain same.

Keyword: Induction Motor, Variable Frequency Drive, Load

Abstrak

Motor induksi merupakan motor listrik yang sering digunakan. Keuntungan dari motor induksi yaitu harganya murah dan mudah dalam perawatan. Motor induksi adalah motor asinkron dimana kecepatan putarnya sesuai dengan perubahan kecepatan. Karakteristik asinkron ditunjukan dengan slip yang merupakan perbedaan antara kecepatan sinkron motor dengan kecepatan putaran rotor. Untuk kebutuhan industri, beberapa beban membutuhkan kecepatan yang presisi sehingga perubahan kecepatan sebisa mungkin dihindari. Kecepatan motor induksi ditentukan oleh beberapa faktor salah satunya frekuensi masukan. Modulasi frekuensi dapat dilakukan dengan alat elektronik.Variable Frequency Drive (VFD) adalah skema control motor induksi yang digunakan untuk memanipulasi nilai tegangan input motor. Pada penelitian ini, VFD digunakan untuk mengontrol motor induksi satu fasa. Pengujian dilakukan dengan beban yang berbeda dan menganalisa system untuk menjaga kestabilan kecepatannya

Keyword: Motor Induksi, Variable Frequency Drive, Beban

1. INTRODUCTION

Most of the industrial equipment uses electric motor as the prime mover. Induction motor are the most widely used because it has simple construction, low prices, high efficiency, and easy

to maintain (Evalina, 2018). The industrial production process use induction motor for example for milling the raw material from solid become smooth shape. The industrial distribution process use induction motor for example for move the product from one place to another place with conveyor that use induction motor as mover. The industrial finishing process also use induction motor for example for packing the product.

An induction motor generally has rotation speed nearly it constant speed, it speed veryclose to its synchronous speed (Haryanto, 2011). When there are a load of motor, the speed of motor would be decrease according to the load. The greater load of motor, the speed also would be lower. It means if the load of the motor is increase, so the rotation speed of induction motor is decrease. Whereas the change of load in the industrial world is very common thing.

There are some way to set the speed of induction motor such as voltage control and frequency control which known by V/f constant control. V/f constant control is one of the ways to control the speed of induction motor by change the value of voltage and frequency, but still keep the constant ratio of both (Haryanto, 2011)

1.1 Single-Phase Induction Motor

Induction motor is a kind of electric motor that used. It mostly used because has several advantages such as:

1. It has simple construction
2. Low Price
3. Easy for maintenance
4. High Reliability

Induction motor work based on electromagnetic induction principle. Stator winding given by voltage and made the iron core became a magnet, and would inducted into rotor. rotor winding is a close loop, so that the current would be through on rotor winding. It rotor current would be interacted with magnetic field on stator and generate a rotation force on rotor. stator winding generate rotation field in synchronous speed. (Emidiana, 2017)

Stator is the stationary part of induction motor. It is a frame that laminated by aluminium alloy. The stator has a tapered groove shape with the parallel sided. The grooves of the stator is place where main coil and auxiliary coil are located.

Single-phase induction motor has characteristic that explained by Double Field Theory. This theory use ideas where a single rotating axis can be assumed to be a rotating vector of half magnitude. Sine wave can presented by two rotation flux, that has synchronous rotation of (Ns = 120 f / P)

1.2 Variable Frequency Drive

Variable frequency drive (VFD) is an electronic device that has function to setting the speed of induction motor by changing the input frequency (Kale, 2017). To control the torque and speed of induction motor, it control the power of main supply through the motor shaft. VFD is most widely use in industry, previously use the mechanical system, and change to motor slip / braking system, hence currently use of semiconductor system. VFD provides more flexibility if compared with the traditional method of speed control (Dorjee, 2014). VFD use frequency to set the speed of induction motor. When the frequency input is change, so the rotation speed of motor is also change.

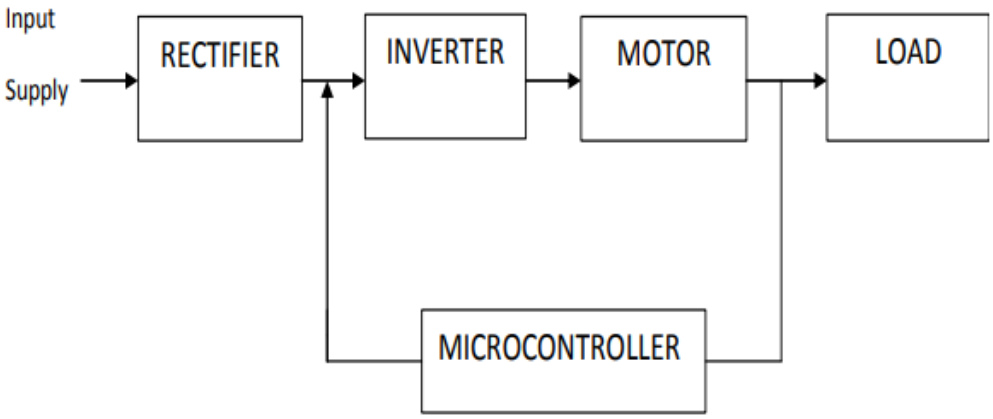


Figure 1. Block Diagram of VFD

The work principle of VFD is when voltage come in from 50 Hz frequency through board rectifier and contained on capacitor bank, so from the AC into DC. Then the DC voltage is distributed into board inverter in order to convert into AC again with the frequency as needed.

2. METHOD

The first method that used in this research is study the literature about the single-phase induction motor principle and about variable frequency drive. Study is done by studying the electronic book, international and local journal, and consultation with the supervisor in order to get the information about this project.

The next step is make the design of variable frequency drive that include DC power supply (rectifier), frequency generator, and inverter. For the induction motor, it provided with a framework to coupled between motor pulley and load pulley that connected with belt. The first practice is to know how the frequency initial setting is work. After it work, it try to give the load of the induction motor and observe the ability of induction motor to keep it constant speed.

The research is following by several part such as:

1. Creating the circuit design of every part of device.
2. Install every component of every part.
3. Doing experiment without load and with load to know the performance of device.
4. Analysis the result of experiment.
5. Make the result data and discuss that.

The step of experiment are shown in figure 1.

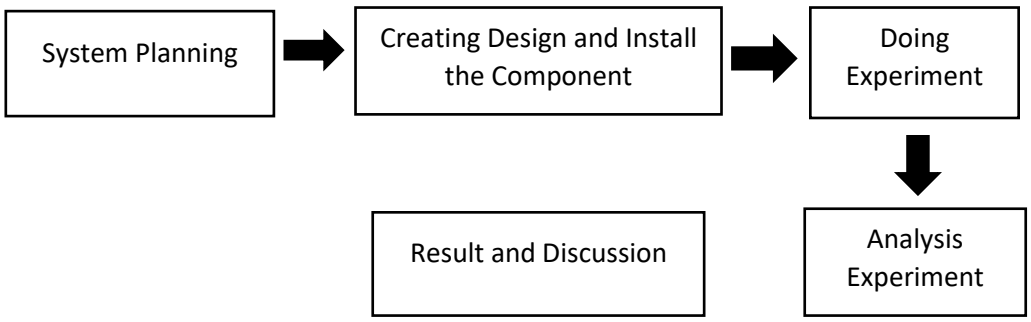
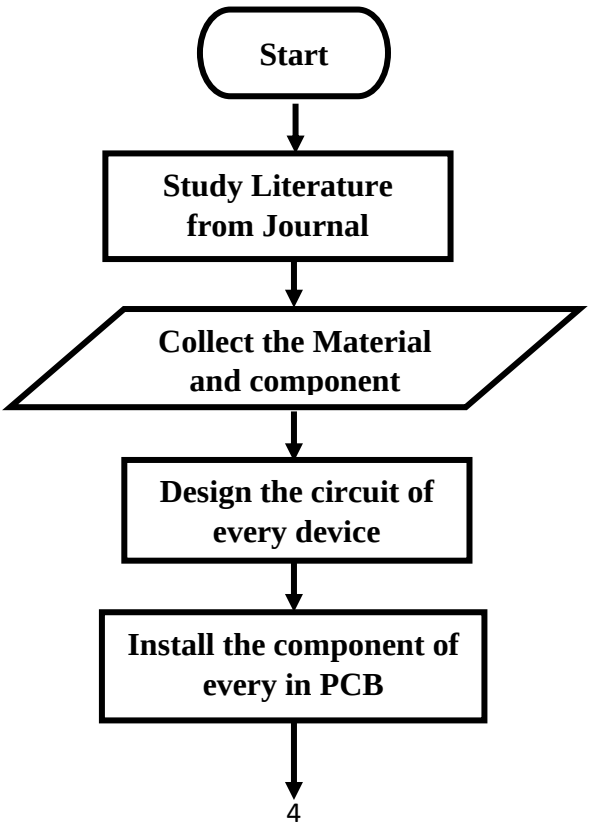


Figure 2. Research Step

2.1 System Planning

The step of this research would be displayed in this following flowchart in order to explain the flow sequence of this research :

Flowchart System



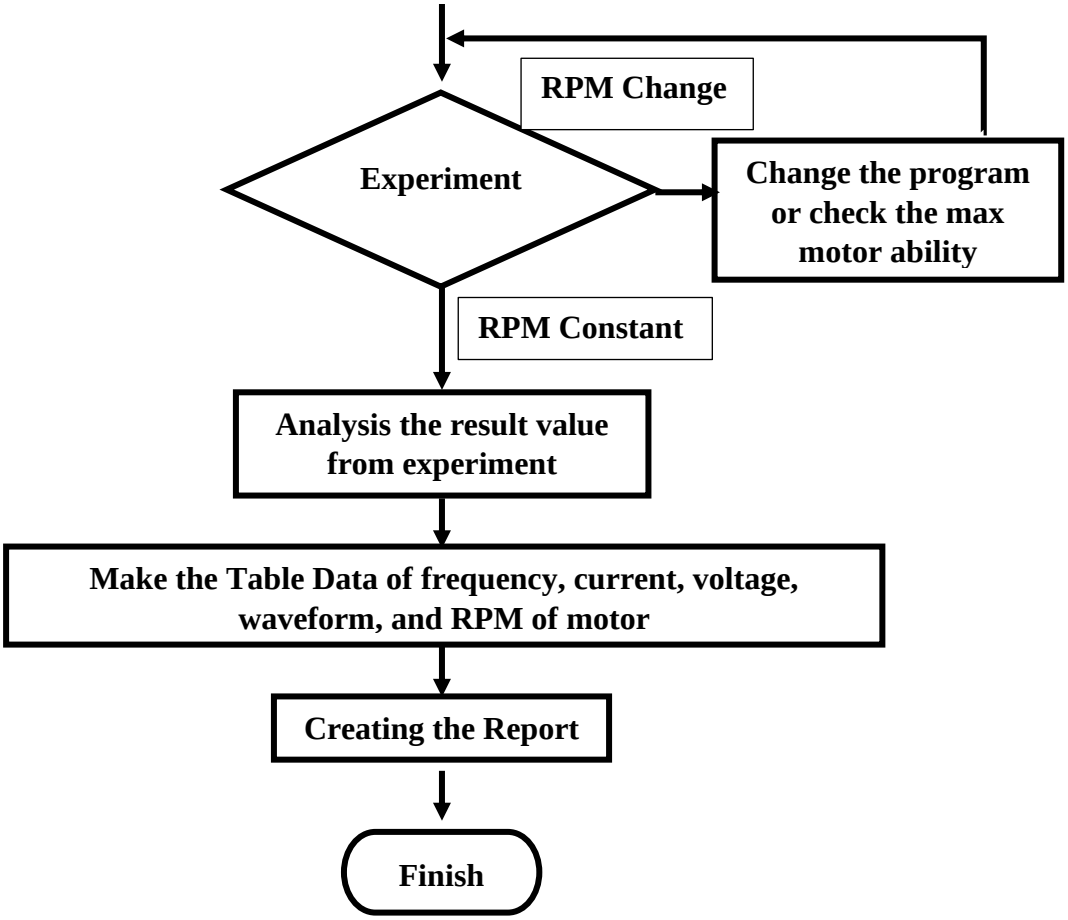


Figure 3. Flowchart

2.2 Device Analysis

This device use two kinds of power supply. The first power supply has 12 V of voltage and 22 A of current that use to supply the inverter. The second power supply has 12 V of voltage and 5 A of current that use to supply the controller device. The controller of this research use microcontroller STM32 and in this controller has 3 button as a selection button. And there is 16x2 LCD to show the RPM setting of motor and real RPM of Motor. In the controller also has an inverter to produce PWM wave an setting frequency. To read the real RPM of motor use IR sensor. The transformer use to increase the voltage of inverter. And the object of this research is a single-phase induction motor 220V as an output and would be coupled with the load that connected with belt.

The work principle of this device is users provide RPM input value which are desired through push button on controller. Then the controller would be run the induction motor according the input RPM value, and IR sensor would be monitored. When the induction motor reach the input RPM value, controller would be keep the speed. If the load of induction motor

is increase and RPM of motor is decrease, so the controller would be increasing the motor RPM by increase the voltage frequency output.

3. RESULT AND DISCUSSION

3.1 Device Part

This research has several part of device including:

3.1.1 Power Supply 1

Figure 4. Power Supply 1

Power supply 1 has 12V and 22A to supply the inverter. It also as a rectifier to change the AC voltage into DC voltage in order to manipulate the value of frequency

3.1.2 Power Supply 2

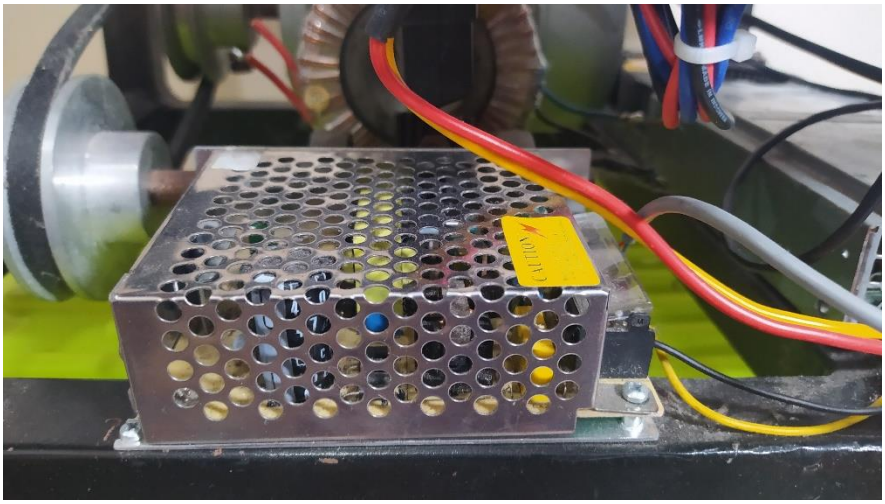


Figure 5. Power Supply2

Power supply 2 has 12V and 5A that used to supply a controller

3.1.3 Controller

Figure 6. Controller

It consist of three buttons and LCD 16x2 that use to setting initial RPM and show the real RPM of motor. It use STM32 as microcontroller. The function of controller is to generate PWM wave and control the frequency.

3.1.4 Inverter

Figure 7. Inverter

Inverter use to change the DC current into AC current

3.1.5 IR Sensor

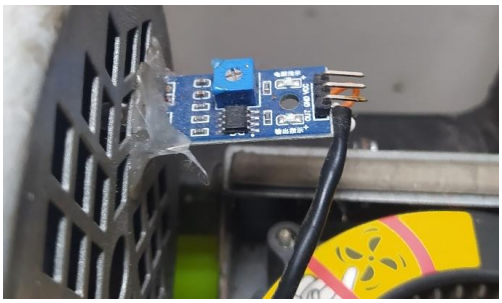


Figure 8. IR Sensor

IR sensor use to read the real RPM of motor. It work like a tachometer. It transmit a infra red light into the part that rotate (coupled with rotor) and calculate the light that received and loses.

3.1.6 Transformer

Figure 8. Transformer

Transformer use to increase voltage from inverter

3.1.7 Single Phase Induction Motor

Figure 9. Single Phase Induction Motor

It is a single-phase induction motor 220V as an output of this research

3.1.8 Overall Device

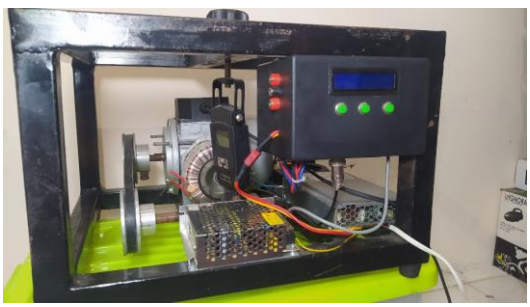


Figure 10. Overall Device

It is a full view of device

3.2 Device Explanation

The work principle of this device is expressed in this diagram:

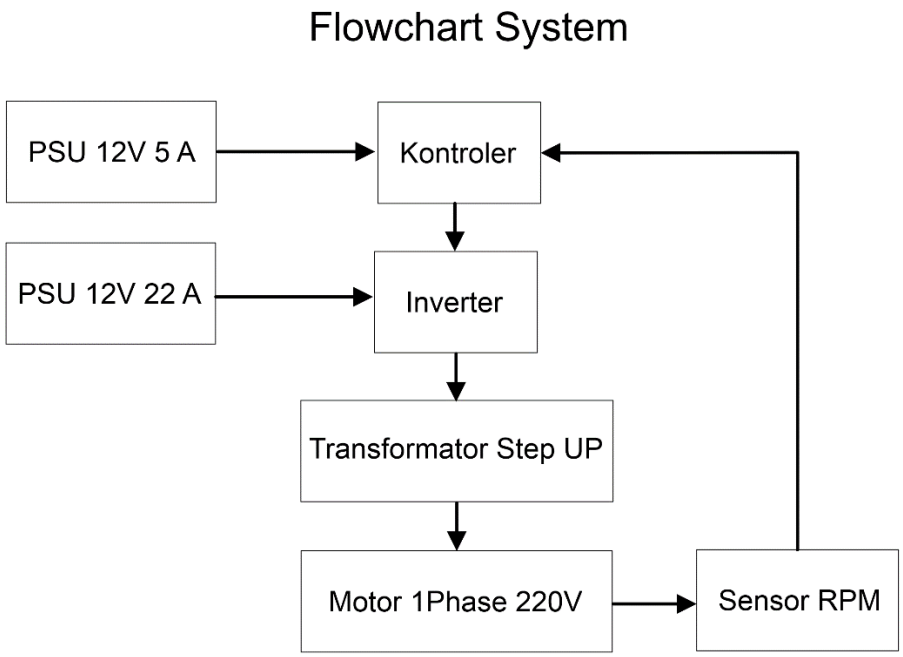


Figure 11. Flowchart system of device

The first step is, user input the initial RPM that wanted. Then, the controller would be run the motor and IR Sensor read the real speed of motor and monitored on LCD. If there is a load that given on the induction motor, the RPM the motor would be decrease. the controller would be keep the RPM of motor by increase the value of frequency input of motor until the speed are same with the initial setting speed.

The script of this device use library I2C (wire.h) and library Liquid Crystal Display I2C (LiquidCrystal_I2C.h) and then initiation for library LCD I2C using script “LiquidCrystal_I2C lcd(0x27,16,2);” that is mean Lcd address located in 0x27 and with the size Lcd 16x2 (16 columns and 2 rows). The initial input and output variable with “define” on the void setup use “pinMode()” for control the pin would be as an input or output.

On the microcontroller STM32 should be resulted wave SPWM (sine pulse width modulation) that would be resulting sine wave that can setting it amplitude and frequency. There are 2 timer hardware on STM32, so it can resulting 2 PWM signals in the same time (PWM inside PWM). Script hardware timer as a interrupt, so the hardware timer program is separate with void loop so that not disturb the program on void loop.

Program on the void loop consist of reader input push button that showing to Lcd I2C. input read push button use “digitalRead” and use lock function on the script reader push button. Lock function in order to when the first read is success, so the program would be wait the next change condition of push button, in order to script would be executed in one time

3.3 Result Experiment

No	RPM Input	Freq. Out (Hz)	DC Output (V)	AC Output (V)	Motor Current (A)	Transformer Current (A)	RPM Output
1	500	43	12.4	180.4	0.2	9.29	498
2	1000	45	12.4	183.6	0.2	9.34	9980
3	1500	51	12.4	186.1	0.2	9.85	1490
4	2000	53	12.4	189.4	0.2	10.35	2050
5	2500	59	12.4	196.7	0.2	11.48	2490

Table 1. Result Experiment

3.4 Explanation

There are 5 times of experiment that doing with a different value of initial input RPM setting. Every input has 500 RPM difference value with input value before. In the experiment, there are several parameter that measured such as Frequency output, DC voltage output (from power supply/rectifier), AC voltage output (from inverter), Motor current, Transformer current, and RPM output.

The frequency output is increase when the RPM input value also increase. The DC output is still constant because it only change the voltage from source into DC voltage. The AC voltage output value is also increase when RPM input value is also increase. Motor current output is in constant value. Transformer current value is increase when the value of RPM initial setting is increase too. The RPM output value is very close with the initial RPM setting.

4. CLOSING

4.1. Conclusion

Based on the experiment that doing, there are so many parameter that known from the initial RPM setting value. The speed or RPM that input from this device is controlled by the frequency value. When the initial RPM setting value is high, so the value of frequency output is also high. Same with it, the value of AC voltage and current is also high when the initial

RPM setting value is high. The real speed of motor is same with the initial speed setting of motor. It means this device is work according to the program that applied in this device.

4.2 Suggestion

This device can work based on the power of motor. If the load is high until the motor can not carry it. So this device is can not work. the best way to operate the device system is to accordance between the load and the motor.

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