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# SPEED ADJUSTMENT SIMULATION USING VOLTAGE DIVIDER CIRCUIT

IDA HAMIDAH[1,*], IN MUSTAGISIN[2], DONI FAJAR RAMADHAN[1], SRIYONO[1], ADE GAFAR ABDULLAH[2], AGUS SOLEHUDIN[1]

[1]Departemen Pendidikan Teknik Mesin, Universitas Pendidikan Indonesia
Jl. Dr. Setiabudi No. 229 Bandung, 40154, Indonesia
[2]Departemen Pendidikan Teknik Elektro, Universitas Pendidikan Indonesia
Jl. Dr. Setiabudi No. 229 Bandung, 40154, Indonesia
*Corresponding author: idahamidah@upi.edu

**Abstract**

The purpose of this study is to make a motor speed control circuit using a voltage regulator circuit. Making this series follows several steps as follows: (1) making a voltage regulator circuit using the gating block in the PSIM application (2) giving a load to the resistor voltage regulator circuit to analyze the output voltage generated (3) the voltage regulator circuit connected to the motor so that it can analyze motor speed. From the experiments that have been done, the increasing limiting angle given to the gating block will make the motor rotation decrease. Motor speed reduction results in a significant and less significant decrease in speed. this is caused by the gating block which limits the voltage out of the circuit. So that from this experiment it can be implemented into a simple circuit in regulating load speed.

Keywords: Gating block, Induction motor, Voltage limiting.

## 1. Introduction

Induction motor is one type of electric motor that works through the electromagnetic induction process. The stator side of this motor is connected to an electrical energy source [1, 2]. For the rotor side it is induced through an air gap from the stator with the electromagnet media [3, 4]. Induction motors are widely used in industry and international production [3, 4]. The use of this motor inductance increases significantly every year. However, there are obstacles in the use of this motor, which is instability in motor rotation when given a load [1, 4]. This can be overcome by using a frequency regulator, voltage regulator, cycloconverter and voltage driver [1, 5-9].

Voltage driver circuit is a device that functions the same as the current booster [10, 11]. This tool has a working system to strengthen the voltage on the device such as an induction machine [11, 12]. It has an adapter circuit which uses a power supply that has a low power [11, 12]. This voltage amplifier can also be used to increase the voltage and can provide a greater supply of voltage [12, 13]. In the use of induction motors speed adjustment is needed for efficient motor performance [14].

The use of voltage drivers is more efficient than using cycloconverter and voltage regulation in adjusting the speed of an induction motor [10, 15]. Controlling an induction motor will be easier when using a voltage driver than not using it [16, 17]. Voltage drivers must be considered in controlling an induction motor. Therefore, the researcher will conduct an analysis of the control of the induction machine with speed adjustments using the voltage driver circuit. This method has been believed by previous researchers in controlling induction machines [12, 14, 16, 17]. In this study, researchers will use the PSIM application as a simulation of the voltage driver circuit. The results of this study also can be used to compare the performance of voltage regulator that had been done by our group [18].

## 2. Method

Changing motor speed can be done in several ways. Among them is by adjusting the input voltage or by changing the frequency. The range of voltage converters used will function to change the input voltage of the induction motor. Changing the input voltage can regulate the speed of the motor something with needs.

Making this voltage reduction circuit will be done using the PSIM application. In this application there is a block item that will make the circuit easier so that the circuit becomes simpler. In addition, this application will also make it easier to analyze because it can display output waves and the value of waves. Figure 1 shows the circuit of motor speed control.

This voltage limitation can be done by gating blocks. the working principle of a gating block is the opening of a voltage at a certain angle so that the voltage generated will be regulated. In the circuit there are two gating blocks in each phase. Gating block will open the width of the angle that can be traversed by a positive voltage at angle 0-180 degrees. another gating block will open the width of the angle that can be passed by a negative voltage at angle of 180-360 degrees. this opening applies to phase R, while phase S will start at an angle of 120 and phase T will start at an angle of 240.

Figure 2 is a picture of a circuit to see the output voltage produced by a voltage reduction circuit. In the picture of circuit is connected with a resistor to illustrate it as a load. But without using a resistor even the still generated circuit can still be seen.

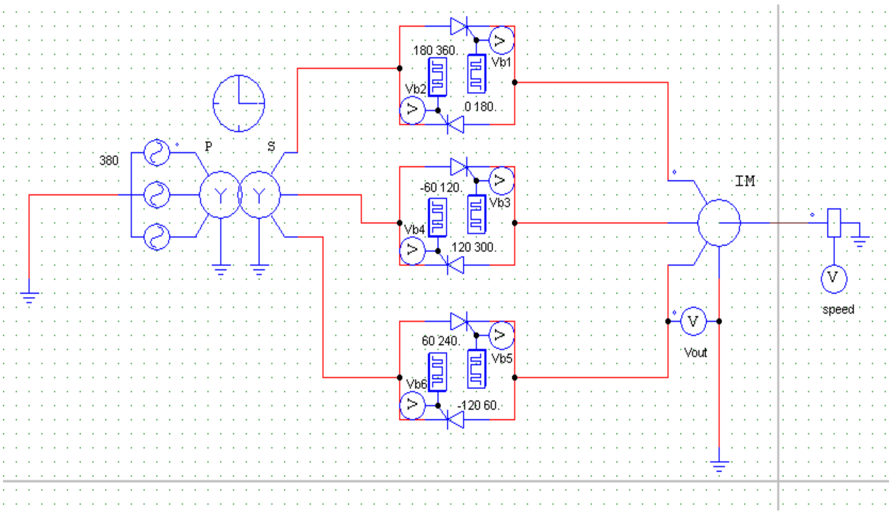


**Fig. 1. Motor speed controller circuit.**

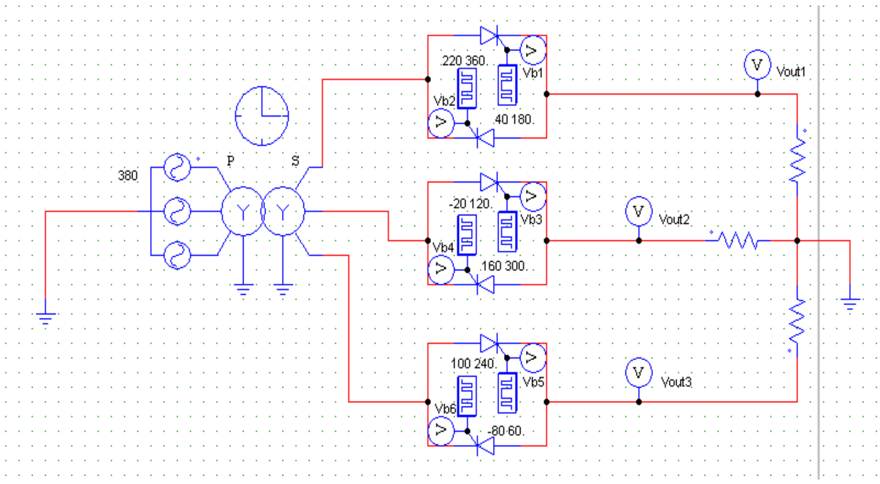


**Fig. 2. Voltage reduction circuit.**

Figure 3 it describes the input voltage on a motor when using block gating 0-180. Without using the gating block also, the voltage that comes out will be like this wave. Figure 3 can be compared with Fig. 4 to find out how the gating block is used.

The voltage coming out of the voltage limiting circuit will be like Fig. 4. when compared between Figs. 3 and 4 it can be noted that there are some waves lost when we give a limiting gating block that only opens at certain voltage sections. These missing waves cause the voltage to decrease. But in this circuit, the voltage reduction does not affect the incoming frequency.

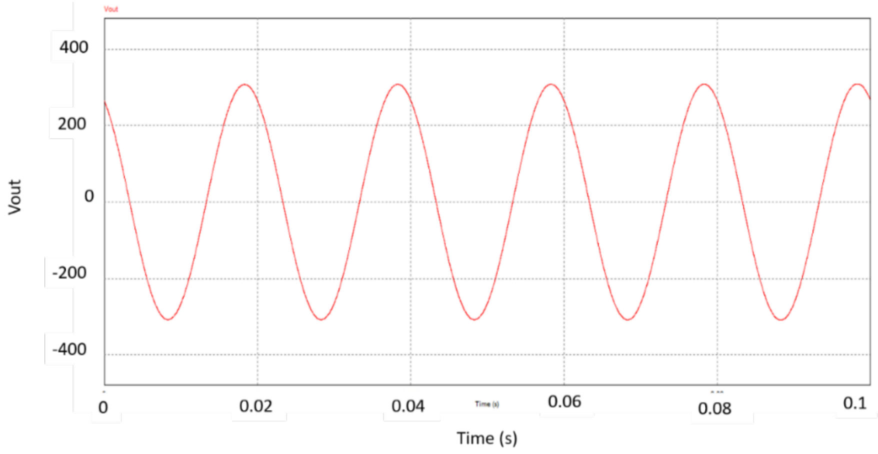


**Fig. 3. voltage signal during normal conditions.**

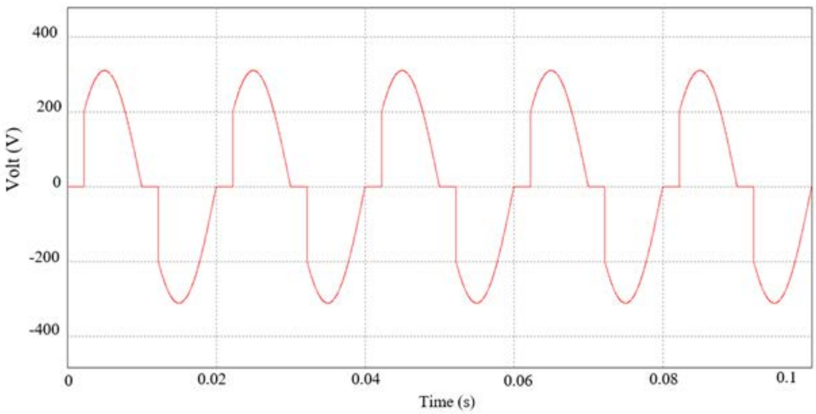


**Fig. 4. Voltage reducing circuit output voltage signal.**

To calculate the output voltage that has been limited by the gating block can use the following equation;

$$Vout = \sqrt{\frac{1}{T}\int_0^T Vmax^2\, Sin^2\, t\, dt} \tag{1}$$

In Eq. (1), *Vout* means the voltage that will be transfer into the motor, this voltage is the rms voltage, while the *Vmax* in question is the peak stress of Fig. 4. The integral boundary will change according to the angle closure performed by the gating block. Thus, that in this case the voltage to be generated will depend on these restrictions. Thus, in this circuit it will depend on the gating block that will open and close the phase as desired.

The induction motor that will be used in this series is squirrel-cage induction machine. Changing the angle at the gating block will affect the input voltage. so that it can change the speed of the induction motor. This concept will be used to change the speed of the induction motor.

Reducing speed with the Reduction method does not only reduce motor speed. But according to Eq. (2), it can also reduce the torque produced by the motor too.

$$\tau_{max} = \frac{3V^2{}_{TH}}{2\omega_{sync}(R_{TH}+\sqrt{R_{TH}{}^2+(X_{TH}+X_2)^2}} \quad (2)$$

where $\tau_{max}$ = Torsi maximum motor, $V_{TH}$ = Thevenin voltage, $\omega_{sync}$ = Synchron speed, $R_{TH}$ = Thevenin resistance, $X_{TH}$ = Thevenin reactance, and $X_2$ = reactance

Thevenin approved in equation 2 is a theory that is used to facilitate range. For Fig. 5 is a picture of a replacement circuit using Thevenin method to make calculations easier. And this is the maximum torque equation where, $\boldsymbol{V_{TH}}$ is Voltage Thevenin which has a relationship with the input voltage as in Eq. (3):

$$V_{TH} = V_{\varphi}\frac{X_M}{\sqrt{R_1{}^2+(X_1+X_M)^2}} \quad (3)$$

where $V_{\varphi}$ = Voltage input, $X_M$ = Magnetic reactance, $R_1$ = Resistance stator, and $X_1$ = Reactance stator

By looking at Eq. (3), it can be concluded that Thevenin voltage is proportional to the input voltage. So that the reduction in the input voltage will cause the torque on the motor to be reduced.

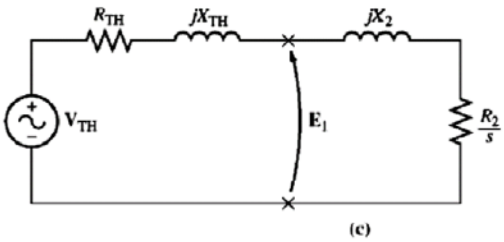


**Fig. 5. Induction motor replacement circuit using Thevenin theory.**

For the angle to be tried is 20-180, 40-180, 60-180, 80-180, 100-180, 120-180, 140-180. This is because if the change is too small the speed change is not too significant unless at a certain angle. And the final limitation angle is 140-180 because the motor has stopped when the restriction is on 140-180. The angles that have been applied to the circuit will give rise to the output voltage of the voltage regulator circuit and also the motor speed produced.

## 3. Results and Discussion

From the results of the experiment, limiting the angle on the gating block can affect the motor speed (see Table 1). Because when the angular rise in the gating barrier will reduce the voltage produced, thus can affecting the motor speed. This result can also be seen in Fig. 6 which shows a decrease in motor speed.

Significant changes occur during 100-180 towards 120-180. The motor speed recorded in Table 1 is the speed between the normal work of the motor. At some angles such as 80-180 the motor speed produced is not stable. However, in limiting gating blocks at 40-180 (in Fig. 8) the motor will run normally. And when the gating block opens at 140-180 degree, the motor stop.

In Fig. 7 it can be seen that motor speed tends to be not constant. The motor speed at the time of gating block 80-180 (in Fig. 7) is delivered between 1104.8531-934.59972 rpm. While in setting the block from an angle of 40-180 the graph of the motor speed will be normal as in Fig. 8.

**Table 1. Simulation results.**

| No. | Corner Limitation on Gating Block | Motor Speed | Input Voltage |
|---|---|---|---|
| **1** | **20-180** | 1000 | 219.2188 |
| **2** | **40-180** | 1000 | 219.2188 |
| **3** | **60-180** | 999.7 | 218.2908 |
| **4** | **80-180** | 955.8 | 198.9372 |
| **5** | **100-180** | 940.1 | 183.0666 |
| **6** | **120-180** | 24 | 134.8197 |
| **7** | **140-180** | -8.14E-07 | 71.44334 |

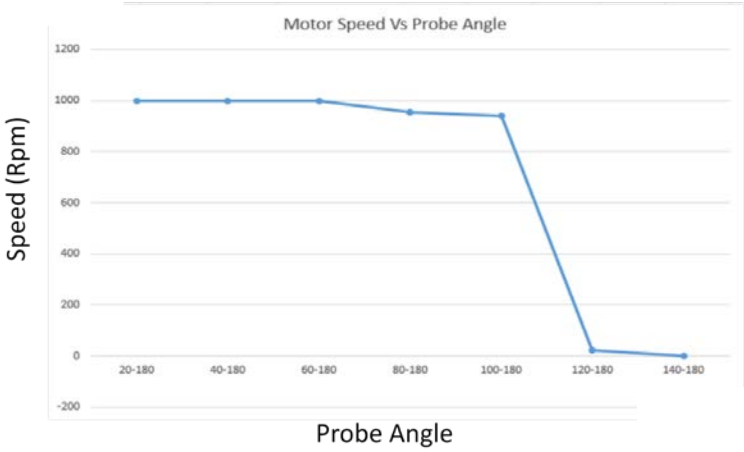


**Fig. 6. Changes in motor speed against the angle of gating block.**

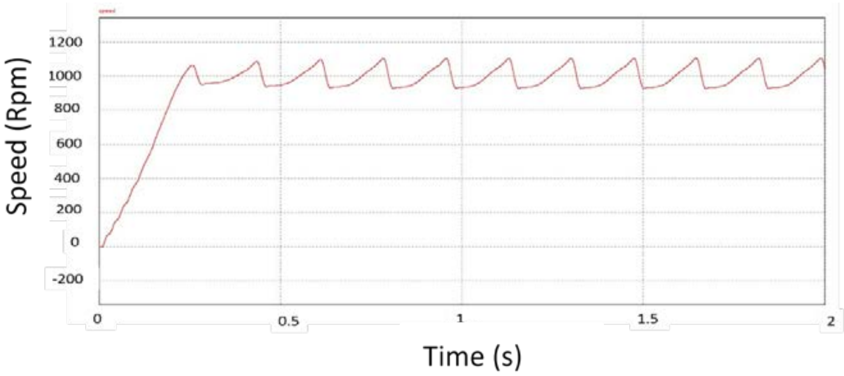


**Fig. 7. Motor speed at 80-180 angle**.

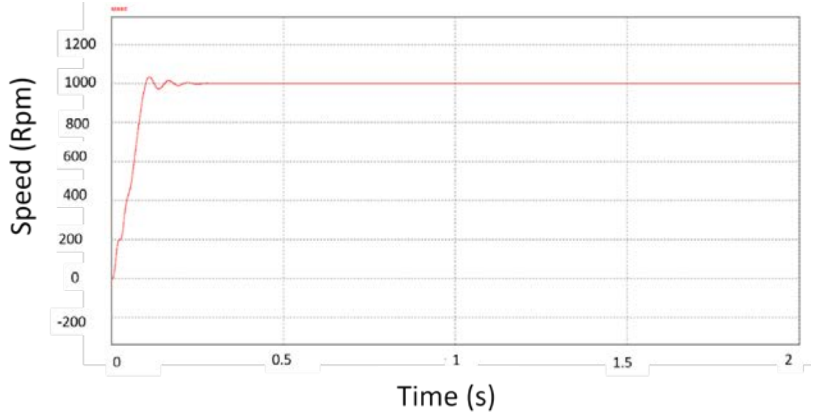


**Fig. 8. Motor speed at 40-180 angles.**

Figure 9 is the voltage generated after entering the induction motor. The image of this voltage is different from the voltage before the induction motor is installed. This change in the graph of the voltage image is influenced by the inductive load on the motor. This change only occurs at the beginning of time. Then it will turn into a sinusoidal wave and return to another form. Next the voltage will continue to change to the second and third forms. But this change indicates that the voltage referred to in Fig. 9 is not stable. Unstable voltage can damage electronic devices.

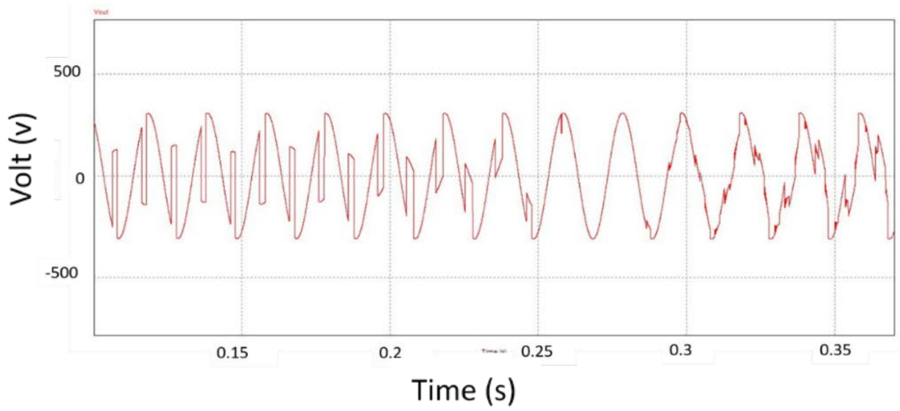


**Fig. 9. Input Voltage Chart to Motor at Angle 80-180.**

## 4. Conclusions

In this simulation, it can be concluded that changing the input voltage of the motor will change the motor turns. However, at certain phase restrictions the motor speed is unstable and the most significant speed changes occur at 100-180 to 120-180. And by changing the motor speed on the circuit the torque produced also changes. If the motor speed is reduced then the torque produced will also decrease.

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