# Star-delta starting of induction motor stages visualisation using Arduino and LabVIEW

# Star-delta starting of induction motor stages visualisation using Arduino and LabVIEW

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**Abstract.** This paper presents a lab module in learning of star-delta starting induction motor using Arduino and LabVIEW. Current, voltage and speed sensors using current transformer, voltage transformer and photo coupler respectively are implemented in this module and connected to Arduino. LabVIEW then processes those inputs from Arduino via USB for making visualisation of speed, current, and voltage for both stage at star and delta connections. The speed is used to set the timer in proper value at 75 – 80 percent of the full load speed of the motor. This module has been tested using a standard instrument and the results show that the error values of voltage was 0.39 percent.

## 1. Introduction

The use of electric motors in the industry, especially in the hotel industry is increasing along with the increasing number of hotels in Bali. The type of motors that generally used are induction motors for pumps, elevator drives or for other purposes. The common starting method for motor induction uses Direct-On Line method. For large capacity of induction motor, a Star-Delta starting method is needed due to a large amount of the starting current. The star stage will reduce the amount of current by 58% and the voltage down to once per square 3 compare to delta stage. The changes between star stage to delta stage is crucial in this operation especially for the time between those two stages. If the change is too fast, the speed of the motor is not enough to produce torque to spin the rotor, on the other hand, if the changeover is to slow, the circuit breaker will identify the current as a fault condition. So, for this purpose it is essential to set the timer in the correct ones. Photocoupler is also used to detect the speed of the rotor. It needs to ensure that the speed of the rotor is not lower than 80% of the normal speed operation of the motor. By setting this condition, it will be adequate to produce a torque to rotate the rotor. One of strategy to produce this result is by using Arduino [1], [2] and LabVIEW. Current and Voltage of the starting stages is able to be detect by using sensor then connected to Arduino. LabVIEW is applied for calculations process and for plotting the signal of the starting period both for current and voltage. This result can be used for further investigation and control in starting stage of induction motor such as improving the starting performance of induction motor using a fuzzy logic controller [3], self-exited induction generator with dynamic load [4], or using a new design of the starting winding of the induction motor [5] - [7]. Another research in starting stages of the induction motor are also for limiting starting current using adaptive fuzzy PID [8] or a magnetic energy recovery switch (MERS) [9]. Visualization of the starting stage of induction motor to investigate the firing angle value of the thyristorized voltage controller [10] or to investigate the varies values of stator and rotor leakage

impedance during the start stage of induction motor then making a new accurate calculation strategy on this stage [11].

## 2. Methodology

In this research, an application of the microprocessor Arduino and LabVIEW are applied for measuring and visualizing current and voltage of induction motor in the starting star-delta mode. Figure 1 shows the system that were built for star-delta starting of induction motor.

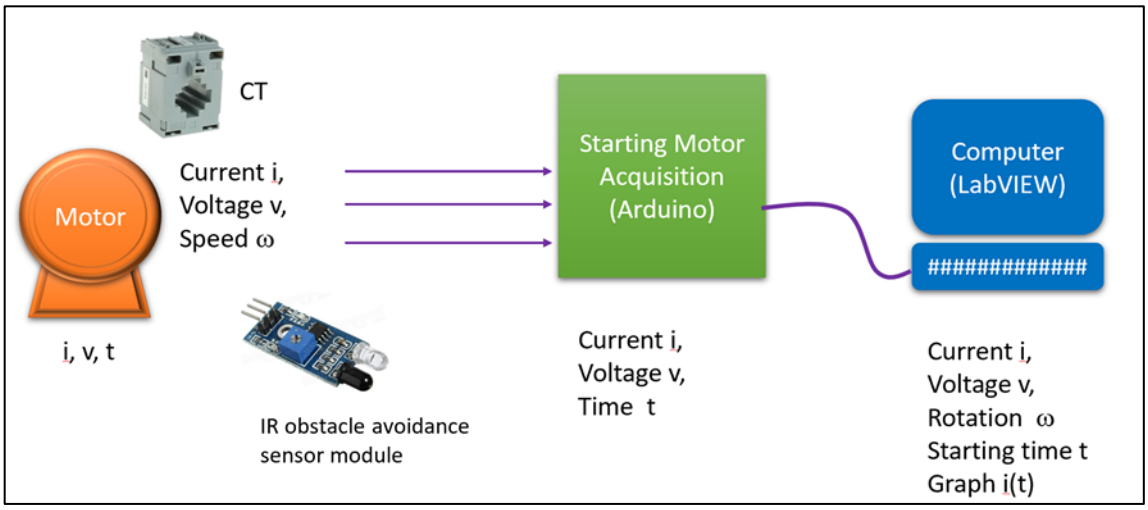


**Figure 1.** Circuit for calculating the circuit.

The parameters of induction motor in starting stages are collected using some sensor such as, 3 current transformer (CT) are used for detecting the three phases of current, 3 voltage transformers for detecting three phases of voltage. An IR obstacle avoidance sensor module is applied in order to measure speed of the motor. The Arduino then process these parameters for producing the result values of current, voltage, speed and time, followed by displaying them in 4 x 20 LCD. The values from the sensor also go to Personal Computer, then using LabVIEW these values can be processing to visualise the starting stages of the induction motor.

### *2.1. Sensor and dc regulator*

In this research, 3 current sensors are used for measuring the currents flow in the 3-phase induction motor. Some additional resistors and a 10□□F capacitor are added to make the system able to handle a high current. This current sensor circuit can be seen in Figure 2.

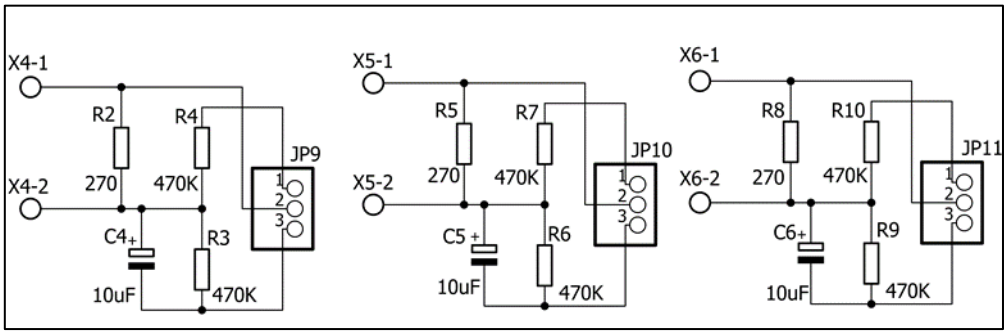


**Figure 2.** Current sensor circuit.

There are 3 voltage sensors in this module using voltage transformer as shown in Figure 3. These transformers will reduce the value of the three-phase voltage of the induction motor to the value that can be handled by Arduino. Power supply is made separated with Arduino to make it independent from Arduino's supply of power. A dc regulator is used for producing 5 and 9 volts of voltage to these sensors and circuit as shown in Figure 3.

Value of power factor also can be calculated as the difference phase between current and voltage and can be seen in Figure 4.

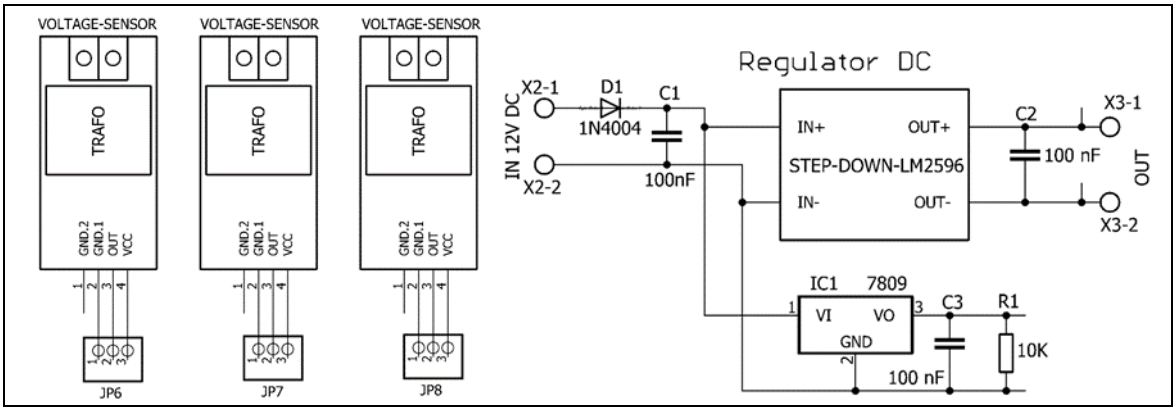


**Figure 3.** Voltage sensor and DC Regulator circuit diagram.

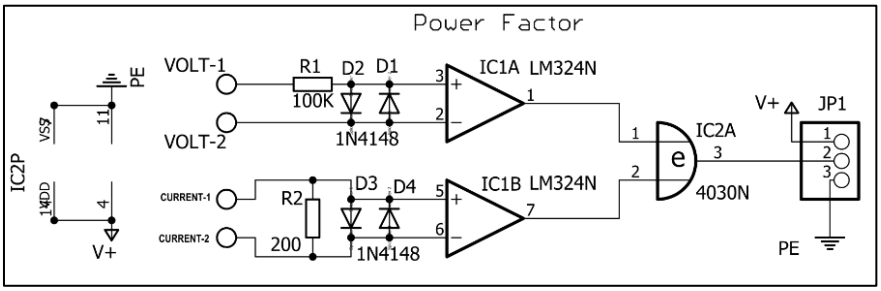


**Figure 4.** Power Factor circuit diagram.

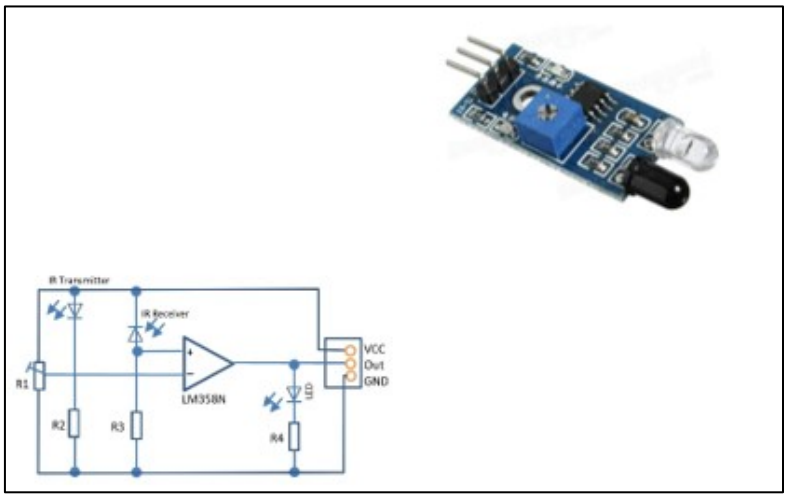


**Figure 5.** Sensor circuit for tacho meter.

Tacho meter was built using IR obstacle avoidance sensor module that has two main parts: an IR transmitter and an IR receiver. This tachometer will operate based on the light reflection. The distance of the sensor to the object can be set using R1.

*2.2. Arduino Nano*

The Arduino nano is based on the ATmega328P. This type of Arduino has a small board with 8 analog input pins and it can be seen in Figure 6.

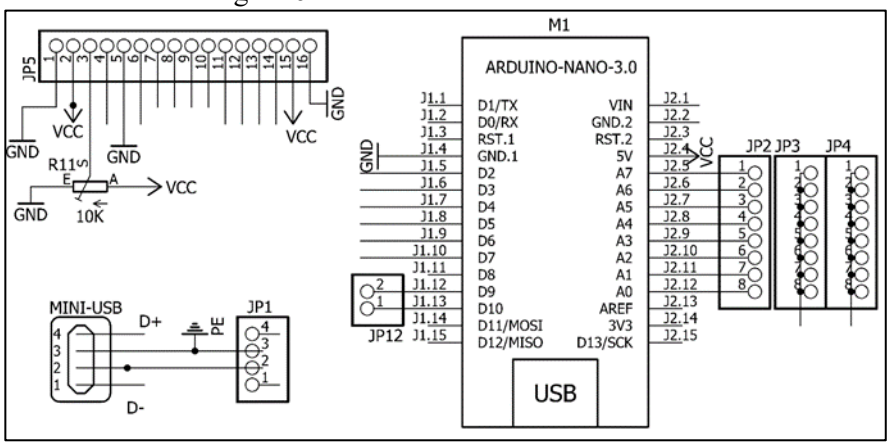


**Figure 6.** Arduino Nano 3.0.

## 3. Results and discussion

All of circuit is then connected together to become as a module. This starting motor acquisition module can be seen in Figure 7 and the front panel in Figure 8. On this front panel of the module the connection can be made for Lab activities where there are 3 connectors for current sensor, 3 connectors for voltage sensor, and 1 pin connector that can be connected to the speed sensor. USB to PC port is used for connection to computer and LabVIEW.

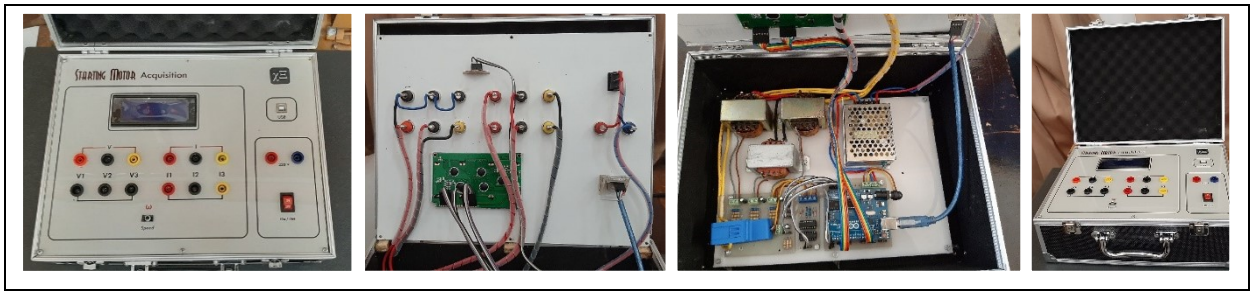

**Figure 7.** Starting motor acquisition module.

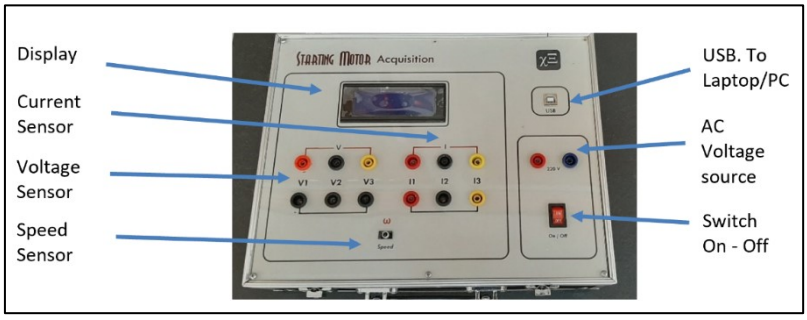


**Figure 8.** Front panel of starting motor acquisition module.

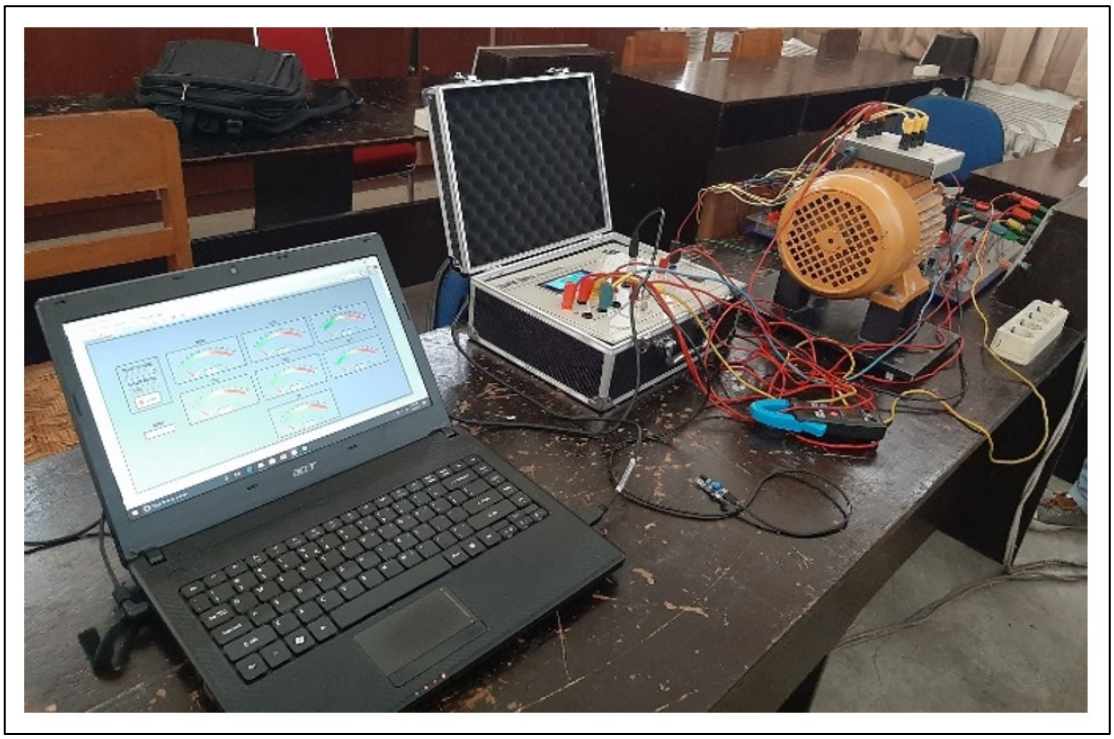

**Figure 9.** Connection setup for starting star-delta 3 phase induction motor.

Connection setup is made using this module to measure all parameter on the starting of 3 phase induction motor as shown in Figure 9. The USB port is connected to laptop that is running in LabVIEW software. In this operation, programs from LabVIEW could be changed and adjusted as needed. It will be a simple circuit or a complex one.

*3.1. Stages visualization*

One of the advantages of this module is this module can be operated using flexible program from LabVIEW. For examples, this can be operated for measuring voltage and current in one phase as shown in Figure 10, or for measuring 3 phases voltage and power factor as Figure 11.

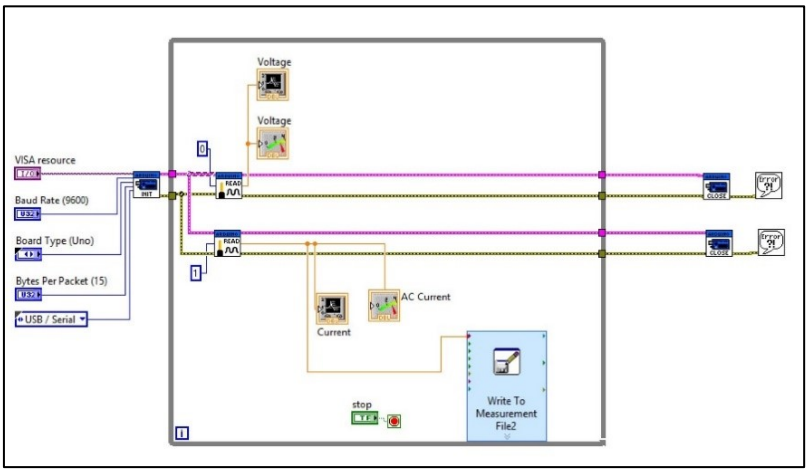


**Figure 10.** LabVIEW schematic for showing voltage, current in one phase.

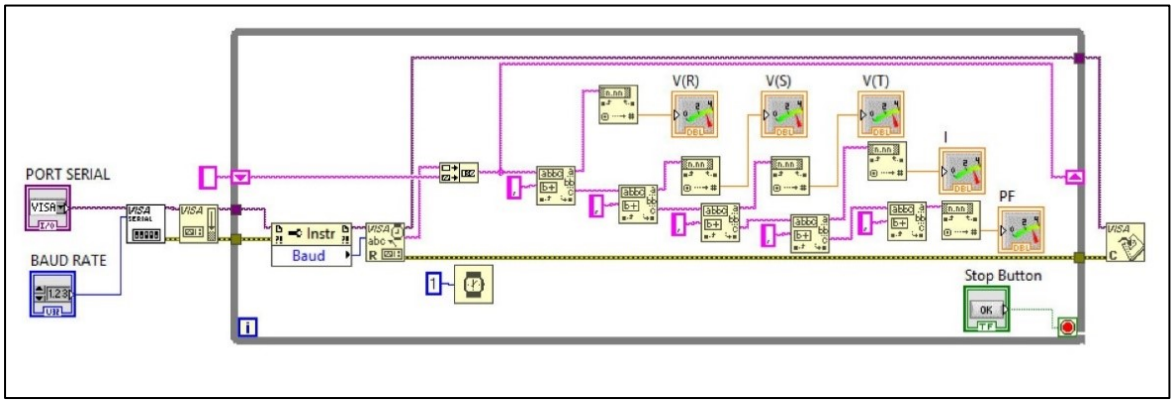


**Figure 11.** LabVIEW schematic for showing 3 phase of voltage, current and power factor of the induction motor.

Results of the current measurement using LabVIEW circuit in Figure 10 can be seen in Figure 12. The motor firstly is started in star connection and then after a few second, the winding connection become delta configuration. The visualization of this stage for the current measurements in LabVIEW can be seen in Figure 12.

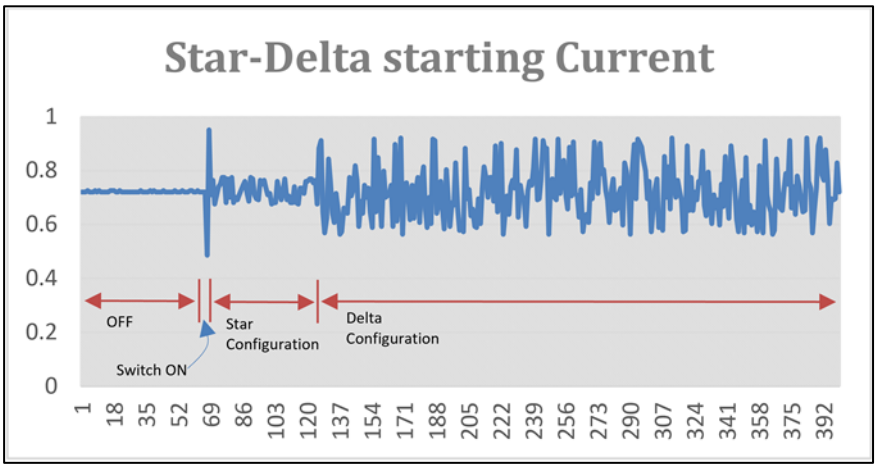


**Figure 12.** Visual result of the current during star to delta configuration stage.

At start stage, the current increases very quickly for a moment and drops to a certain value when connected in star configuration. After a while the coil turns to delta configuration as shown in the data at point 127. As it is known, the current when the motor coil is connected to the delta increases.

*3.2. Measurement result*

The measurement results of this module have been checked and compared with a standard instrument in electrical Laboratory at Bali State Polytechnic shown on the Table 1. The average error in voltage measurement is only 0.39%.

**Table 1.** Result for voltage measurement between standard meter and module.

| No | Voltage- Using Standard Meter | | | Voltage - Using Module | | | Error (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | R | S | T | R | S | T | R | S | T |
| 1 | 30 | 30 | 30 | 30.2 | 30.1 | 30.5 | 0.67% | 0.33% | 1.67% |
| 2 | 40 | 40 | 40 | 40.2 | 40.1 | 40 | 0.50% | 0.25% | 0.00% |
| 3 | 50 | 50 | 50 | 50.1 | 50 | 50.1 | 0.20% | 0.00% | 0.20% |
| 4 | 60 | 60 | 60 | 60.3 | 60.2 | 60.5 | 0.50% | 0.33% | 0.83% |
| 5 | 70 | 70 | 70 | 70.4 | 70.1 | 70.2 | 0.57% | 0.14% | 0.29% |
| 6 | 80 | 80 | 80 | 80.2 | 80.4 | 80 | 0.25% | 0.50% | 0.00% |
| 7 | 90 | 90 | 90 | 90.1 | 90.2 | 90.1 | 0.11% | 0.22% | 0.11% |
| 8 | 100 | 100 | 100 | 100.2 | 100.3 | 100.4 | 0.20% | 0.30% | 0.40% |
| 9 | 110 | 110 | 110 | 110.4 | 110.2 | 110.1 | 0.36% | 0.18% | 0.09% |
| 10 | 120 | 120 | 120 | 120.3 | 120.2 | 120.1 | 0.25% | 0.17% | 0.08% |
| 11 | 140 | 140 | 140 | 140.7 | 140.8 | 140.5 | 0.50% | 0.57% | 0.36% |
| 12 | 150 | 150 | 150 | 151.2 | 151.1 | 150.8 | 0.80% | 0.73% | 0.53% |
| 13 | 160 | 160 | 160 | 160.5 | 161.1 | 161.2 | 0.31% | 0.69% | 0.75% |
| 14 | 170 | 170 | 170 | 170.8 | 170.7 | 170.7 | 0.47% | 0.41% | 0.41% |
| 15 | 180 | 180 | 180 | 180.2 | 181.5 | 180.3 | 0.11% | 0.83% | 0.17% |
| 16 | 190 | 190 | 190 | 190.5 | 190.7 | 190.8 | 0.26% | 0.37% | 0.42% |
| 17 | 200 | 200 | 200 | 201.1 | 201.3 | 200.6 | 0.55% | 0.65% | 0.30% |
| 18 | 210 | 210 | 210 | 210.2 | 210.5 | 210.6 | 0.10% | 0.24% | 0.29% |
| 19 | 220 | 220 | 220 | 221.3 | 220.6 | 221 | 0.59% | 0.27% | 0.45% |
| | | | | **Average error:** | | | **0.38%** | **0.38%** | **0.39%** |

## 4. Conclusions

A module for the star-delta starting of 3 phase induction motor was built using an Arduino Uno and Arduino Nano. The current sensor section uses a current transformer, while the voltage sensor uses a voltage transformer with added voltage divider circuit. The tacho meter uses the IR obstacle avoidance sensor module which works on the principle of light reflection. This module can handle some various LabVIEW circuit to make it more flexible as a Lab module. In general, this tool can display changes in current when there is a change in the motor coil from the star to delta configuration. Average error in voltage measurement is about 0.39%.

## 5. References

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