Automatic Voltage Regulator

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Abstract—*AVR (Automatic Voltage Regulator) plays a key role in generating stations. To maintain voltage stability of the generator the terminal voltage should remain constant all the times. In a large interconnected system manual regulation is much complicated and therefore automatic generation and voltage regulation is necessary. So, to maintain a constant voltage level, Automatic voltage regulators are used at each generating station. Generally the voltage fluctuation is mainly due to the variation in the load and if there is a variation in the voltage then it can damage the equipment so it is necessary to stabilize there voltage so automatic voltage regulator is used in the system to stabilize the voltage or to regulate the voltage.*

Keywords— *AVR, ATMEGA328.*

I. INTRODUCTION

In the power system it is necessary that system should be operate in steady state condition so most of the equipment's are designed to work in predetermined values of voltage and frequency of operation. So it is desirable that overall voltage profile must be within the permissible limit at all the times during the operation. The load on the system is not constant all the time, it's always varying and these load change requirement we can get through automatic excitation system, automatic excitation system in the sense that Automatic Voltage Regulator so it is used to stabilize the voltage in the power system. In case of any deviation from these values results in decrease in performance and lifetime of these equipment's. Hence for effective operation of the power system the Automatic Voltage Regulator (AVR) is installed at each generating plants. The main objective of AVR system is to maintain the terminal voltage of the alternator in the generating station. The Power system consist of generator it having Automatic Voltage Regulator to stabilize there voltage.

II. LITERATURE REVIEW

Yoshida et al. proposed PSO for reactive power and voltage control considering voltage stability. The results reveal that the proposed method generates a solution very near to the global optimum solution. Ying-Tung Hsiao presents an optimum approach for designing of PID controllers using ACO to minimize the integral absolute control error. The experiment results demonstrate that better control performance can be achieved in comparison with conventional PID method.[6] Ing-Tung Hsiao proposed a solution algorithm based on the ant colony optimization to determine the PID controller for getting a well performance. Simulation results demonstrate that better control performance can be achieved in controller in AVR system shows that minimize the maximum percentage overshoot, the rise time, the settling time and oscillation and step response of AVR system can be changed. Richa Singh (IEEE 2016)-ACO is popular technique which shows behavior of real ant colonies to find solutions to

discrete optimization problems.[13] Duan Hai-bin presented a parameter optimization strategy for PID controller using ACO Algorithm. The algorithm has been applied to the combinatorial optimization problem, and the results indicate high precision of control and quick response. Mohd. Rozely Kalil, Ismail Musirin proposed Ant Colony Optimization (ACO) technique for searching the optimal point of maximum loadability point at a load bus. Hamid Boubertakh, Mohamed Tadjine, Pierre-Yves Glorennec and Salim Labiod has proposed theory that although conventional PID controllers are the most used in the industrial process, their performance comparison with known methods.[4]

Hany M. Hasanien (2013) propose optimization of PID is often limited when it is poorly tuned and/or used for controlling highly complex processes with nonlinearities, complex dynamic behaviors.[3] Kiarash, Mehrdad Abedi, (2011) Shuffled frog leaping and particle swarm optimization this two algoritm are used to determine optimal PID controller in AVR system and also shows that for tuning PID controller using various optimization technique reduces complexity and find more realistic result than trial and error method.[4] Zwe-Lee Gaing (2004) presented PSO for optimum design of PID controller in AVR system. The simulation results proved the proposed method in improving the step response of an AVR system.[11] Rohit Kumar presented PSO based approach to solve the economic load dispatch with line flows and voltage constraints, and concluded that the proposed approach is computationally faster than GA.[12]

III. AUTOMATIC VOLTAGE REGULATOR

AVR (Automatic voltage regulator) is a system which mainly designed to automatically maintain a constant voltage level. It is used the power system to stabilize voltage which occurs because of variation the load also it is an instrument that adjusts voltage by means of automatic control device. The automatic voltage regulator is used to control the variation in the voltage. It sense the fluctuation in voltage and changes them into a stable voltage. The variation in the voltage occurs because of the variation in load. The variation in voltage is

harmful for the equipment of the power system. Generally, the AC automatic voltage regulator is a device designed to regulate voltage automatically that is, it sense variation in the voltage level and turn it into a stable voltage level. The automatic voltage regulators for generators were electromechanical systems, but a modern AVR uses solid-state devices. An AVR is work as feedback control system that measures the output voltage of the generator and compares that output to a set point, and generates an error signal that error signal controls the excitation of the generator. As the terminal voltage of the alternator increases as the excitation current in the field winding of the generator increases.

Why We Need AVR

It is very much necessary that the voltage of a supply system be maintained constant otherwise the performance of motors, lights etc. will be affected. The voltage of an A.C generator can vary 30% or more from no-load to full-load. Close control of generator voltage can only be achieved by regulating the voltage automatically by means of an AVR unit.

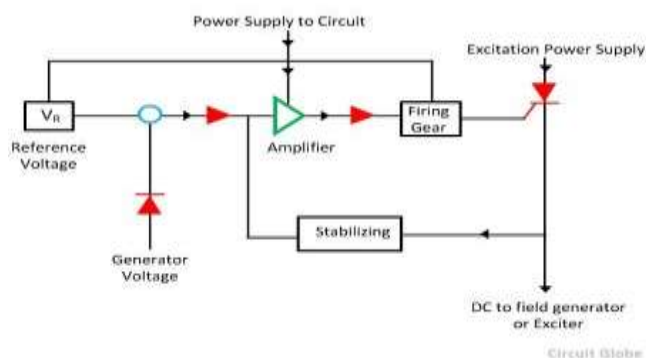*Working Principle of Automatic Voltage Regulator:*

Figure 1. Automatic Voltage Regulator

The working of an AVR is as follows:

(i)   It works on the principle of detection of error.
(ii) Output Voltage of Generator is sensed through a potential transformer.
(iii) This voltage is first rectified, filtered and compared with the reference voltage and produce a error signal.
(iv) Error signal is amplified by the Amplifier and then amplified error signal controls the excitation of main exciter.
(v)   Output of that exciter controls the terminal voltage of the Alternator.
(vi) Voltage Stabilizer used in the system to protect the equipment from high voltage or low voltage fluctuations.
(vii) Voltage Stabilizer regulates the fluctuating input voltage before it could be fed to the load.
(viii) By these ways Automatic Voltage Regulator works.

Excitation System: The system which is used to provide field current to the rotor winding of synchronous machine, such type of system is called as excitation system. The main requirement of excitation system is reliability under all condition and simplicity of control. The amount of excitation required is depend upon load power factor, load current and

speed of the machine. The excitation is more when load current of the system is large, power factor is lagging and speed of machine less.

Types of Excitation System:

- DC Excitation System
- AC Excitation System
  - Rotor Excitation System
  - Brushless Excitation System
  - Static Excitation System
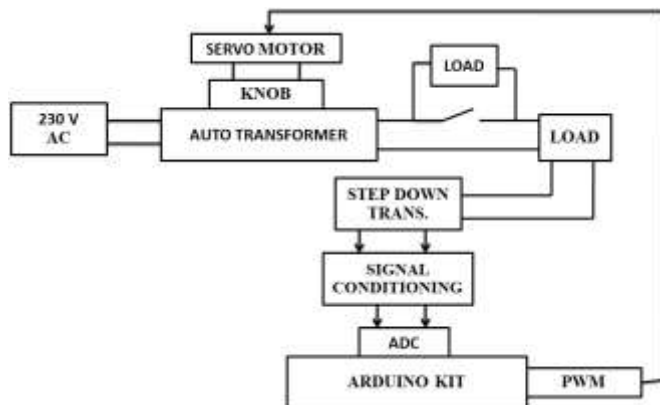
IV.   HARDWARE BLOCK DIAGRAM

Figure 2. Hardware Block Diagram

The Block Diagram Consist Of:

- Autotransformer
- Servomotor
- Step down transformer
- Signal conditioning unit
- Atmega328 IC
- Load

Single Phase Auto Transformer:

The single Phase Autotransformer having only one winding; part of this winding is common to both primary and secondary. Primary and secondary windings are electrically isolated in two winding transformer, but this is not in the case of autotransformer. As AVR is nothing but automatic voltage regulator. If voltage is increases then AVR sense that voltage and compare that voltage with the reference voltage and produce error signal and these error signal send to servo motor through PWM signal by Arduino.

Figure 3. Single Phase Auto Transformer

Servo motor is coupled to the Autotransformer so when servo sense the output of Arduino then it rotates and

automatically Autotransformer also rotate due to coupling.. As voltage decreases at the time also servo motor sense the error signals and due to their coupling it increases voltage level means that here Single phase Auto Transformer work as a BUCK BOOST system.

- *Advantages of Auto transformer:*
  - ➢ Only one winding is used in the auto-transformer, Therefore weight of the core material and volume of copper required reduces which results in low cost.
  - ➢ Power losses are less, So efficiency will be high.
  - ➢ Better voltage regulation.
- *Applications of Auto Transformer:*
- ➢ To give small boost to a transmission line to correct the voltage drop.
- ➢ To interconnect two grids which have different voltage ratings (3 phase autotransformers).
- ➢ As a starter for 3 phase induction motors.

Servo Motor:

A servo motor is like a DC motor, along with some other special purpose components that make a DC motor a servo. In a servo unit, it will find a small DC motor, a potentiometer, gear arrangement and an intelligent circuitry. The main circuitry along with the potentiometer makes the servo to rotate.

Figure 4: 5 V DC Servo Motor

Specifications:-
- Stall Torque   : 13 Kg/ cm
- Operating Speed   : 0.17 sec/ 60ia
  0.14 sec/ 60ia
- Operating Torque   : 4.8 V – 7.2 V
- Power Supply   :Through External
- Gear Type : Metal Gear
- Wire Length :   300 mm

A Servo Motor has an output shaft. This shaft positioned to some angular positions by sending the servo a coded signal. As the signal exists on the input line, the servo will maintain the angular position of the shaft. The angular position of the shaft changes, If the signal changes.

Step Down Transformer:

Figure 5. Single Phase Step down Transformer

In this prototype model step-down transformer is used, as signal conditioning unit requires small voltage level therefore 230V is converted into 5V. The transformer is used for step down the voltage level for rectification purpose.

Signal Conditioning Unit:

Signal conditioning is define as converting an analog signal such as it meets the requirements of the next stage for further processing. Most common use is in analog-to-digital converters. Operational amplifiers are employed to carry out the amplification of the signal in the signal conditioning stage.

Now we discuss this entire component one by one.

Full bridge rectifier:

Figure 6: Bridge Rectifier

The Full Bridge Rectifier is used for converting output voltage of step down transformer into 5 V DC. Then these supply pass to Arduino which s work on the 5 V supply and before passing these supply to Arduino it passed from Smoothing Capacitor for eliminating ripple in the supply.
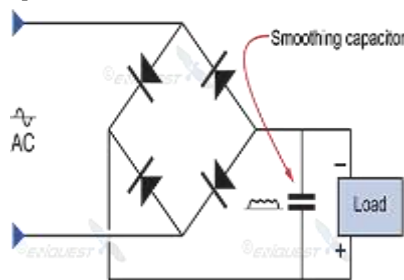
Smoothing Capacitor:

Figure 7: Smoothing Reactor

The main function of capacitor is for smoothing the wave of bridge rectifier. 470 micro farad capacitor is used here. After that the output is given to variable potentiometer. The smoothing capacitor converts the rippled output of the rectifier into a smooth DC voltage.

Variable Potentiometer:

Figure 8. Variable Potentiometer

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A potentiometer is a three-terminal rheostat with a rotating contact that forms an voltage divider. If there is only two terminals then one end and the wiper, it acts as a variable rheostat. The measuring instrument called a potentiometer is a voltage divider used for measuring voltage.

Arduino Kit:

Figure 9. Arduino

ATMEGA328 IC:

The ATMEGA328 provides the following features:
- 32 K bytes of In-System Programmable Flash Program memory with Read- While-Write capabilities.
- 1024 bytes EEPROM.
- 2 Kbytes RAM.
- 32 general purpose I/O lines.
- 32 general purpose working registers.
- Three Timer/Counters with compare modes.
- Internal and External Interrupts.

Load: Two Resistive loads are used.

Figure 10. 60 W, 100 W Load

V. EXPERIMENTAL SETUP OF HARDWARE:

Figure 11. Hardware Setup

In prototype design the autotransformer connects to servo motor by coupling. Autotransformer is used for buck and boost system voltage. When system voltage is reduced then servo motor senses the error value and it increases the system voltage with the help of autotransformer by changing the tapings of autotransformer. When system voltage is increased transformer changes its angle and reduces the voltage level; every time system has to maintain output voltage constant. Servo motor is used for feedback purpose; it gives feedback or senses the error value and accordingly changes their tappings. The PWM technique is used to send information to servo motor as servo motor understand the PWM signal. Later in the circuit, analog to digital converter is used because ATMEGA328 IC requires digital signal. ADC converter requires 5V DC supply for that purpose use of signal conditioning unit is used. ATMEGA328 IC is used for automatic voltage regulator.

In hardware implementation the hardware is connected to Arduino by using USB cable which continuously gives signal to servomotor causing the change in angle of autotransformer to buck and boost the system voltage. This helps to maintain terminal voltage at constant value. In this experiment, we will connect the power and ground pins directly to the Arduino 5V and GND pins. The PWM input will be connected to one of the Arduino's digital output pins. The best thing about a servo motor is that it can be connected directly to an Arduino. When the program starts running, the servo motor will rotate slowly from 0 degrees to 180 degrees, one degree at a time. When the motor has rotated 180 degrees, it will begin to rotate in the other direction until it returns to the home position.

VI. CONCLUSION

AVR (Automatic voltage regulator) is a system which mainly designed to automatically maintain a constant voltage level. It is used the power system to stabilize voltage which occurs because of variation the load also it is an instrument that adjusts voltage by means of automatic control device. Variation in the voltage ios mainly due to the fluctuation in the load in the supply system and variation in the voltage damage the equipment so it is necessary to stabilize that voltage so Automatic Voltage regulator is used in the system.

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