

# Alternator Performance Testing Using PLC and SCADA

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**Abstract:** Alternator is an electromechanical device when it is driven at high speed it generates an electromotive force. In order to test the alternator in bulk amount, it is impossible manually. To overcome the above disadvantage, the testing machine is automated using Programmable Logic Controller (PLC) and Supervisory Control and Data Acquisition System (SCADA). PLC controls the entire process in the testing machine and SIEMENS WINCC SCADA is used for data monitoring. PLC used in this work is SIEMENS with 24 inputs and 16 outputs. Alternator is picked from the conveyor and placed on the test bench using cylinders. Alternator is driven at a particular speed by Servo motor. The advantage of servo motor is accuracy in positioning. The output current from the alternator is given to the PLC, where the desired output for the given input is already programmed. The programming of PLC depends on analyzing the performance characteristics between speed Vs torque and voltage Vs current. The parameters such as repeatability and linearity are checked for improved efficiency. If the component matches the desired performance then it is unloaded to the conveyor else it is send to the rejection chamber.

**Keywords:** PLC, SCADA, Alternator, servo motor, Performance Testing.

## I. INTRODUCTION

The existing method of testing the performance of alternator involves analysing it under various speed conditions. In this method part load and full load tests are conducted. It is identified that the above tests does not provide required characteristics of alternator. In this project, testing of alternator involves measuring and analysing the parameters such as voltage, current and speed to provide reliable alternators. The various components used for testing the alternator includes,

- PLC (Programmable Logic Controller)
- SCADA (Supervisory Control And Data Acquisition System)
- Profibus
- Servo Drive

Operation involves loading the alternator at the receiver ring assembly on the test bench which is then indexed to an angle of 180° to the testing point by means of induction motor. At the testing point, various speed inputs are given to the alternator for conducting tests such as charge lamp test, critical speed test, etc. Alternator is driven at a particular speed by servo motor which is controlled by servo drive. Servo motor is chosen for its accurate positioning capability.

Various parameters such as Speed, Voltage and Current are measured under various testing conditions. The desired characteristics of the alternator are already fed in the PLC. If the component satisfies the specified criteria's it is unloaded to the conveyor, else it is picked and placed in the rejection chamber for further modifications. This system provides supplying alternators satisfying customer requirements by verifying its linearity, repeatability and reliability.

## II. ALTERNATORS

A.C Generators or alternators are electromechanical device when it is driven at high speed it generates an e.m.f. It uses on the principle of Electromagnetic Induction which states that “When the magnetic field is cuts by current carrying conductor, e.m.f is induced”. The important components are

- Stationary Armature
  - Stator
  - Rotor
- Rotating Magnetic Field

### A. Stator Winding

The stator winding has three sets of windings. Each is formed into a number of evenly spaced coils around the stator core. As the rotor assembly rotates within the stator winding as shown in Figure 1. The alternating magnetic field from spinning rotor induces an alternating voltage into the stator winding.

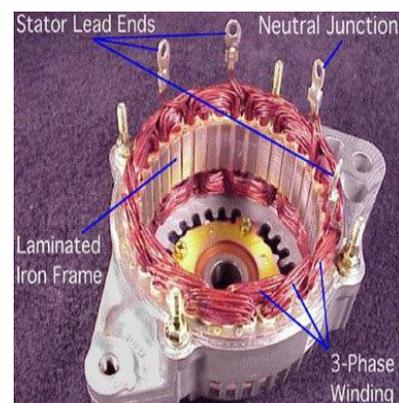


Figure 1: Stator Winding

The magnetic field saturates the iron touch poles. One finger pole becomes a north pole and the other a south pole. The rotor spins creating an alternating captivating field, North, South, North, South, etc. The vigor of the magnetic field and the speed of the rotor impinge on the amount of voltage induced into the stator. The induced voltage is stored in the charging system.

### B. Charging System Circuit

Four wires bond the alternator to the break of the charging system. 'B' is the alternator yield wire that supplies current to the battery. 'IG' is the explosion input that turns on the alternator/regulator assembly. 'S' is used by the regulator to scrutinize charging voltage at the battery. 'L' is the wire the regulator uses to ground the charge forewarning lamp.

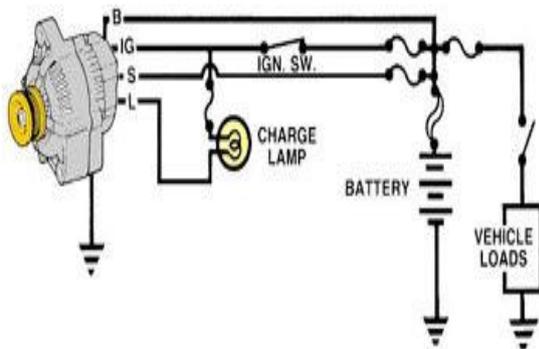


Figure 3: Charging System Circuit

### C. SIMENS S7 300 PLC

The SIMATIC S7-300 has been designed for innovative system solutions with the focus on manufacturing engineering, and as a universal automation system, it represents an optimal solution for applications in centralized and distributed configurations. Siemens S7 PLCs are byte orientated tackle. In the encoding language Step7, input bytes can be addressed as IB0, IB1, productivity bytes as QB0, QB1 and recollection Bytes as MB0, MB1, etc. However, the Siemens PLCs also recognizes words, double words. The corresponding words are

- MW0 (Memory Word 0) consists of MB0 (Memory Byte 0) and MB1, MB0 being the low byte of MW0
- MW1 consists of MB1 and MB2
- MW2 consists of MB2 and MB3

Generally MWn consists of MBn and MB(n+1) with MBn creature the low byte of MWn. In this simple application, the Siemens PLC receives the data on input bytes IB0 and IB1 and maps them to recall Word M0. Next, MW10, MW12,... are derived as MW0 plus offset. In the end, these Memory Words are copied to the output byte.

## III. SYSTEM OVERVIEW

A.C Generators or alternators are electromechanical device which converts when it is driven at high speed it generates an electromotive force. It works on the principle of Electromagnetic Induction which states that “When a current carrying conductor cuts the force is induced”.

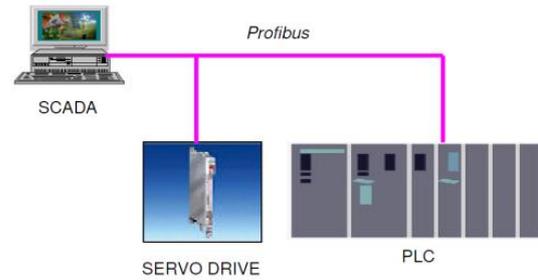


Figure 5: Human Machine Interface

In this machine, operator will load the alternator in the receiver ring assembly of the test bench. If the component is not clamped properly or anything goes wrong, it is notified from the SCADA monitor then pressing of emergency stop button is advised. Induction motor is used to rotate the test bench at desired positions. The alternator to be tested will move to the test probe engaging assembly after 180° rotation. Then the following tests are performed in the alternator.

- L and R continuity test
- Charge lamp test
- Critical speed test
- Blocking diode test
- Reg. volt test
- Full load test
- Part load test

Alternator is driven at a particular speed by servo motor. Servo motor is chosen for its ability of accurate positioning since it is a closed loop system. Stepper motor is an open loop system, therefore accurate positioning cannot be obtained. The alternator is coupled with the tool bit of servo motor. The servo motor is controlled by servo drive. The servo drive gets 3Φ supply via current transformer, fuse, choke, filter, Motor Protection Circuit Breaker (MPCB) and contactor. In this, the current transformer is used to limit the current flow, filter to remove the noise from the supply, MPCB to protect servo motor in case of over load and contactor for switching the servo drive.

#### Specifications of Servo Drive

Voltage level	: 480 V
Frequency	: 50/60 Hz
Supply	: 3Φ supply
Peak current	: 54.4 A
Constant current	: 34 A

The power supply and the encoder which is used to control the servo motor is the output from the servo drive. Servo motor runs at 6000 rpm which in turn rotate the alternator shaft and the generated voltage is measured using Aplab. PROFIBUS is used for the communication between servo drive and PLC. PROFIBUS is the only field bus which works on higher baud rate up to 12 Mbps. Length can be increased by using repeaters or fiber optic interface. The electrostatic effect on the PROFIBUS network can be reduced by

- Using shielded twisted pair cable
- Grounding the shield at multiple points
- Assuring that the ground wire is as thick as possible

PLC is used for controlling the entire process. The output current of the alternator is given as input for the PLC. SIEMENS PLC is used to control the entire process. This PLC consists of 24 inputs and 16 outputs. It has the following advantages

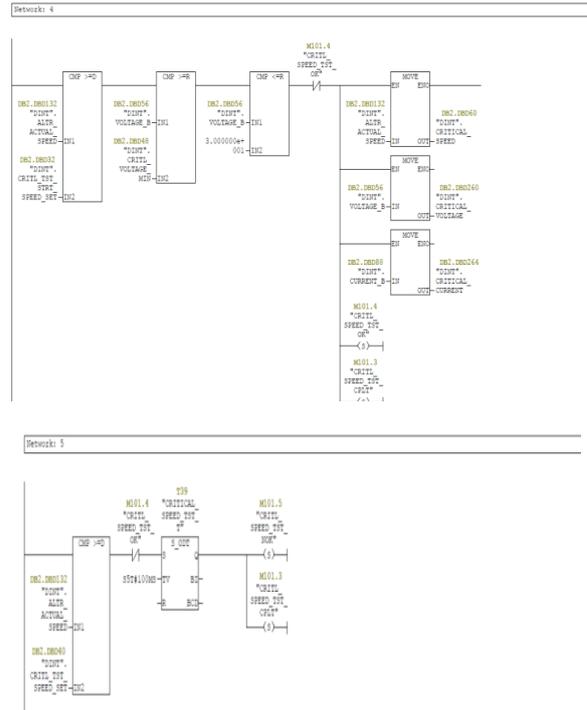
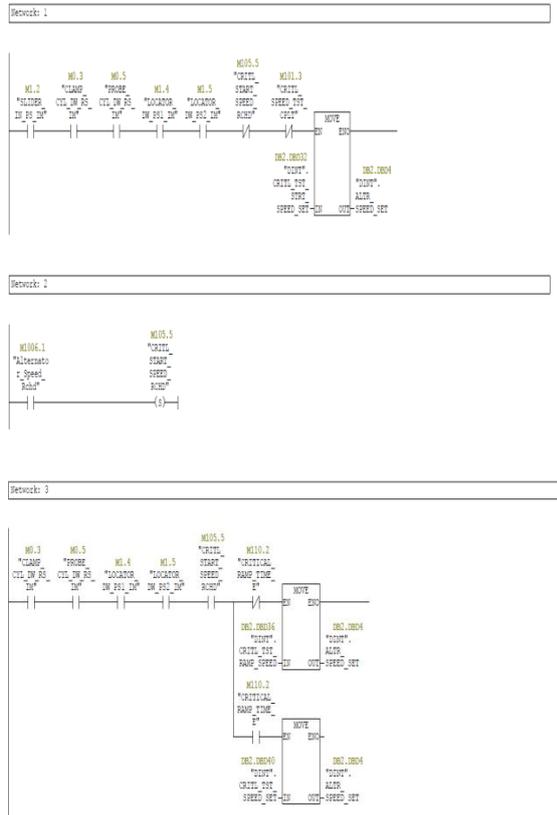
- High speed inputs
- High Data Storage Capacity
- High speed Data Capturing
- Memory – 64 K

The output current from the alternator is given to PLC, where the desired output for the given input is already programmed. The programming of PLC depends on analyzing the performance characteristics between speed vs. torque and voltage vs. current.

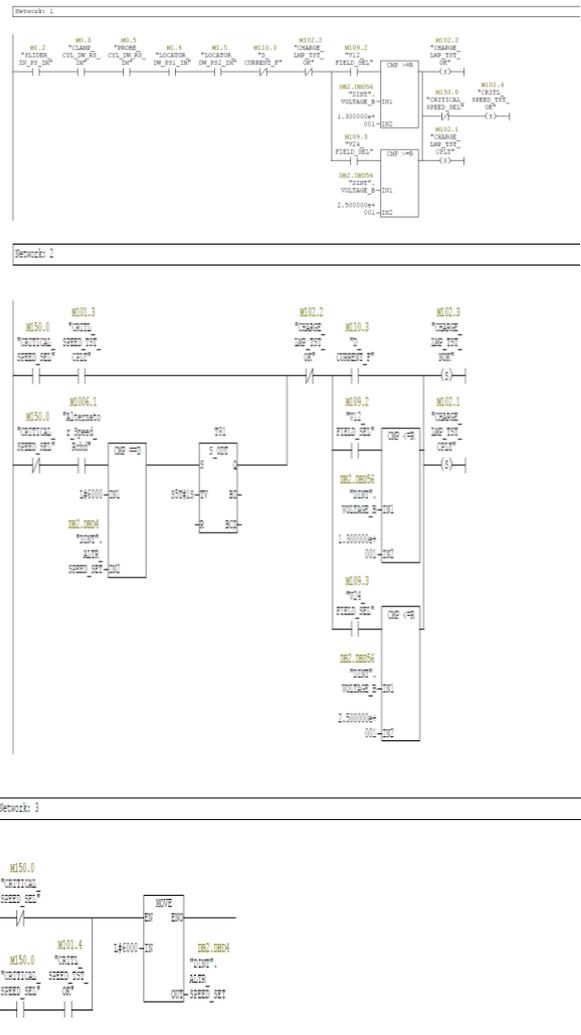
Data Monitoring is performed by Supervisory Control and Data Acquisition System (SCADA). SIEMENS WINCC SCADA is used for overall data monitoring of this system. The SCADA installed in a Personal Computer is used as HMI. SCADA for this system is developed from WinCC. WinCC is Application software belongs to Siemens. The PLC, Servo drive and SCADA are connected by Profibus network. The PC has a PCI adopter for the Profibus communication. The SCADA is configured for a data exchange of 128 tags. SCADA monitors the performance parameters of the alternator. The measured parameters were recorded for further analysis which induces the manufacturing of highly efficient alternators during production.

#### IV. PLC PROGRAM

##### CRITICAL SPEED TEST



##### CHARGE LAMP TEST



V. RESULTS

The start up screen will be similar to fig: 11.1. The navigation to the different screens is possible by a double click of the respective icons. Irrespective of the screens, the toolbar in the left margin will be available in all the screens. But entry to the screens like ‘SET’ (3) and ‘CALIBN’ (9) may need authorization. To login as a meticulous user and get the approval, select ‘LOGIN’ (1) icon and give the user name and password. The current mode selected will be displayed in the status tab (15). To exit from the runtime, select ‘EXIT’ (10)

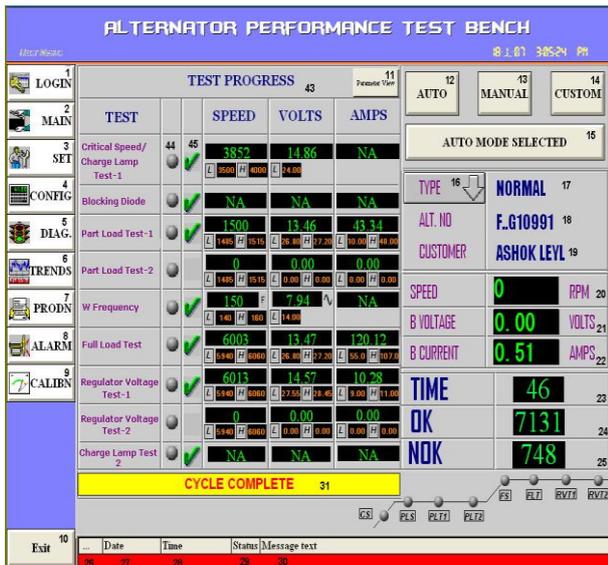


Figure 5: Start up Screen

Calibrated values are displayed in the Test process screen (43). The values in green are actual values. During test process, indication lamp (44) will blink until the process complete. If any one of the test fails, then CYCLE INCOMPLETE error message will be displayed in the in the status bar (31). The last occurred error message always displayed at the bottom of the main screen along with date (27), time (28), status (29) and Message text (30) as shown in Figure 5.

The three available modes of operation are

- Auto Mode (12)
- Manual Mode (13)
- Custom Mode (14)

A. AUTO MODE

During the Auto cycle run, the status display is given in the status bar (31).The time taken for the last auto cycle is given in the ‘TIME’ column of the main screen (23). The serial No of the tested Alternator is given in the ‘OK’ column of the main screen (24). The count of failed alternators is given in the ‘NOK’ column of the main screen (25). The currently selected model, Alternator No. and customer will be displayed in ‘TYPE’ (17), ‘ALT. NO’ (18) and ‘CUSTOMER’ (19) respectively. In the Auto mode, the passed test will be indicated by tick mark (45) in green color. Otherwise it will be indicated by wrong mark

B. PARAMETER VIEW

The result of various tests can be seen by clicking on parameter view (11), screen as shown in Figure 6 appears. The test result of each alternator will be stored in the database.

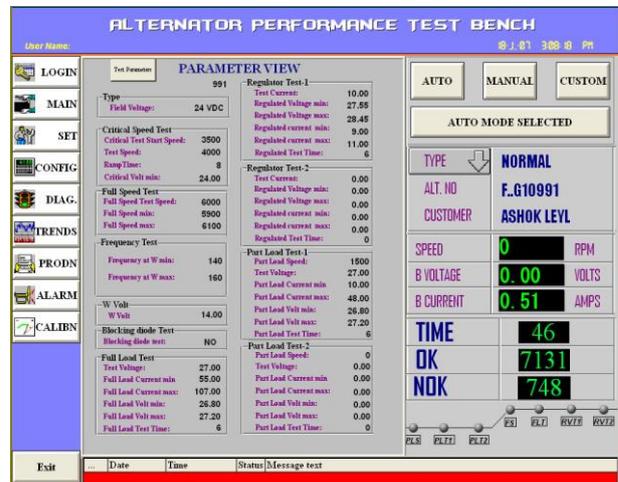


Figure 6: Parameter View Screen

VI. CONCLUSION

In this paper, the performance of alternator was analyzed by conducting charge lamp test and critical speed test. Alternators of different types can be tested using the same machine which requires changes in the induction table. The performance parameters are stored in database for future reference. This system provides supplying alternators satisfying customer requirements by verifying its linearity, repeatability and reliability.

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