Energypac®
Engineering

COMPREHENSIVE SOLUTIONS FROM DESIGN TO DELIVERY

AUTOMATIC VOLTAGE REGULATOR

300 MVA
230/132/33kV
POWER TRANSFORMER

Client

Power Grid Company of Bangladesh

Sirajganj, Bangladesh

INDEX

Energypac® Engineering

1. INTRODUCTION

1.1 What is an Automatic Voltage Regulator?

Automatic Voltage Regulator (AVR) provides complete protection to sophisticated equipment against large input voltage variations.

1.2 Operation Process

Excessive voltage variations are highly dangerous for sophisticated electrical and electronic equipment such as electro-medical equipment, PLC machine, communication equipment, etc.

The equipment requires a specified constant stabilized source for their desired optimum operation. The small variation in the input voltage affects the performance of these equipment to a considerable extent, and the large variation in the input voltage is highly dangerous.

AVR monitors, corrects and maintains the desired output voltage by adding or subtracting the required amount of voltage to/from the input voltage.

Fig: Oil type Auto Voltage Regulator

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2. SPECIFICATION & FEATURES

SL	DETAILS	LT	HT
01	Capacity	10 kVA to 3000 kVA	500 kVA to 10000 kVA
02	Type of Supply	Balanced or unbalanced	Balanced or unbalanced
03	Input Voltage	320 ~ 460V or as per customer requirement	9 ~ 12kV or as per customer requirement
04	Output Voltage	400V ± 2% or as per customer requirement	11kV ± 1% or as per customer requirement
05	Frequency	50 Hz or as per customer requirement	50 Hz or as per customer requirement
06	Voltage Correction Rate	20 volt/sec	530 volt/sec
07	Response Time	Approx. 1 to 30 seconds (adjustable)	Approx. 1 to 30 seconds (adjustable)
08	Waveform Distortion	Nil	Nil
09	Temperature Range	0 - 110°C	0 - 110°C
10	Environment	Designed for indoor use Outdoor type unit available on request	Designed for indoor use Outdoor type unit available on request
11	Ambient Temperature	0 - 55°C	0 - 55°C
12	Cooling	AN/ONAN (as per capacity & requirement)	AN/ONAN (as per capacity & requirement)
13	Load PF Effect	Nil	Nil
14	Efficiency	Better than 95%	Better than 95%

* For dry type AVR, 10 to 60 kVA are available on request.

2.1 STANDARD FEATURES:

SL	DETAILS	DESCRIPTION
01	Controller	Analog electronics type
02	Protection	High & low voltage protection for LT AVR, phase failure protection for LT AVR, overload & short circuit protection by MCCB for LT AVR, built in time delay 5 – 6 secs with re-start for LT AVR
03	Metering	Analog type voltmeter to read input & output voltage and current with selector switch
04	Indications	Three lamps for input phase indicate, oil level indicate
05	Switches	Start/stop switch, bypass switch
06	Name Plate	Small size marks by screen print and big size marks by input phase plate, output phase plate, earth plate and main name plate

2.1 STANDARD FEATURES:

- Fully automatic & solid control
- Robust and extremely reliable in operation
- Auto/manual operation
- Very high regulation (±1% to ±2%)
- User–friendly
- Maximum protection provided
- Ensure smooth output with available power
- Wide range of choice of input voltage (as per customer requirement)
- Minimum maintenance
- Environmentally friendly

2.2 OPTIONAL FEATURES:

- Microprocessor type controller
- Digital voltmeters
- Digital ammeter
- Digital multifunction meter
- MCCB
- ACB
- Isolation transformer
- Earth fault protection
- Neutral fail protection
- Bypass switch

2.3 HOW DOES IT WORK?

The equipment comprises a voltage regulator alone or in combination with transformers and an automatic or motorized control circuit.

3. REGULATOR

The regulator is a continuously tapped autotransformer with core and coils similar to those of an orthodox transformer. The main frame supports the coils, which are fully insulated. A carrier with self-centering graphite roller contacts, which can be moved vertically by a chain drive, provides a variable tapping point for the output voltage. The complete assembly is oil cooled.

The contact carrier is driven by a servo motor, which is coupled to the chain. The power supply for the motor is derived from the regulator or external source unless otherwise specified.

3.1 TRANSFORMER

The transformers are of conventional design. The variable positive and/or negative voltage supplied to the primary winding from the regulator output controls the output voltages of the secondary windings over the desired range.

3.2 CONTROL CIRCUIT

The automatic control circuit comprises a control unit with a sensing circuit. When the regulator output deviates from a preset level, a relay is energized to switch on the motor and drive the contact carrier in the appropriate direction until the output has been restored to the preset level. The relay is then de-energized to switch off the motor. The control unit is normally installed with the sensing equipment in an auxiliary cubicle.

04. INSTALLATION AND OPERATION STEPS

a) Lock the AVR unit in its permanent position and fix it securely to the floor, packing where necessary to ensure that it is levelled. If possible use a crane to place the unit in position, otherwise move it on rollers or a trolley, do not drag them. Do not allow the unit to be tilted more than 15º from vertical.

b) Remove the transport seals from cooling louvers if any, and other openings.

c) The equipment must be properly located on a firm foundation or plinth so that the equipment does not tilt.

d) As stated elsewhere, handling, lifting, and positioning must be done by using a suitable crane to avoid damage to the expensive equipment.

e) The equipment must be switched on only after all pre-commissioning tests have shown healthiness of the equipment and all protections like fuse, circuit breaker, etc. have been checked. It is advisable to commission the equipment by manufacturer's trained personnel only.

f) The relay has been calibrated at the correct value at works. Do not distort the potentiometer of the relay. Check the tightness of all control connections.

g) Connect suitably rated input and output cables following the information on current ratings given on the rating or diagram plate or wiring diagram. If the unit is contained in more than one tank, connect interconnecting cables as per the current specified and of the applicable voltage grade.

h) Connect earthing cables to the terminal provided on the tank.

i) Connect auxiliary cables where required.

j) Before energizing, check that the input voltage is within the range as stated on the rating plate.

k) Use the hand wheel to set the automatic voltage regulator to the correct output voltage position. Energize the regulator on no-load and measure and correctly set output voltage.

05. OPERATION TEMPERATURE RANGE

The AVR is designed to work from + 5 °C to 45 °C ambient temperature

For higher ambient temperature, the output current must be dated as under:

For ambient of + 50 °C - Derate by 10%
For ambient of + 55 °C - Derate by 20%

06. MAINTENANCE

In common with other electrical equipment, the Energypac voltage regulators require regular maintenance. A simple procedure is outlined below. For the maintenance of relays and other control equipment, the manufacturer's instruction should be followed.

6.1 REGULATOR UNIT

Under normal operating conditions, only the rolling contact units and the contact bar brushes require inspection. The procedure is given below. No definite recommendations can be given regarding the time between inspections of the contacts or how often they should be replaced, as this depends upon the type of service and the number and duration of the movements the regulator mechanism performs each year. It is recommended, however, that the contacts in oil cooled units be inspected within a year of installation. The condition of the contacts will provide a guide as to future inspection periods assuming the duty cycle remains constant. Move the contacts up and down the coil by turning the hand wheel and check whether the rollers rotate. If the rollers do not rotate or are worn, remove and inspect them following the given procedure.

1. a) Remove the tank lid.

b) Drive the contact carrier to the top position.

2. Inspect each brush to see that it moves freely in its holder and that it is under pressure by pulling it away from the contact bar by the flexible copper tail. Replace brush if damaged or shorter than 16 mm.

3. Unscrew the retaining plate screws to release the plate.

4. Remove the plate, screws and brush assemblies completely.

5. Lift out the roller contact units and inspect. Replace the complete contact unit if:

a) The rollers do not rotate, the wear is uneven or the roller surface is damaged.

b) The width of the tracks on any roller exceeds 5/16 in (8mm) or reaches the edge of the roller.

6. Before replacing the contact units in the carrier, check that the rollers run freely on the spindle with a minimum of play and that all spindle screws are tightly locked.

CAUTION – Do not interchange worn rollers and spindles.

7. Refit the contact units, ensure that both rollers of each unit make even contact with the coil face by moving the carrier up and down to see whether the rollers rotate.

8. Replace the retaining plate, locking the screws securely and maintaining the brush lead positions.

9. Repeat this inspection procedure on each limb of the regulator on the other carrier.

6.2 REGULATOR COILS

Normally there is slight discoloration of the coil surface owing to oxidization (the surface turns a darker color similar to the unwiped section of a motor commutator). The film is harmless but should be removed from the commutator portion of the coil with a clean rag and white spirit or carbon tetrachloride. Where oil cooled units have been on continuous load, a thin film of sludge may be found. Wipe this off with a clean rag.

If the coil surface is marked or pitted, carefully smoothen it with a clean grade 0 emery cloth rubbed gently around the coil surface in the direction of winding. Ensure that no copper is lodged between turns of the coil and that all copper dust produced is removed from the coil surface and framework with a clean rag. Before replacing the contact units, apply normal voltage for 3–4 minutes to check whether any copper dust is short-circuiting the commutating tracks. Check the insulation of the regulator drive.

6.3 REGULATOR MECHANISM

Check the tightness of all nuts and the chain tensions. Normally there is very little stretch in the chains and they should not require adjustment. If however they are very slack, inspect the bearings for wear. If they are satisfactory, tighten the chains using the adjusters on the contact carriers.

The chain should not be taut but should have an approximately ±0.25 inches per foot of the maximum free chain length, measured at the center. Adjust the chains so that the tension is even on both sides of each carrier and between carriers. Ensure that the carrier is tilted and that the chain lengthens on both sides.

If the carriers are equal after adjusting the chains, check the operation of the limit switches.

In oil cooled equipment, the internal mechanism is self-lubricating and should run without attention for many years.

In twin assemblies, similar attention should be given to the lubrication and tension of the chain drive coupling the two regulators. Chain tension can be adjusted by moving the two jockey wheels equally in the same direction.

CAUTION – If regulators are coupled out of line, heavy circulating currents will severely damage the equipment.

6.4 TRANSFORMERS

It is not necessary to remove the transformers annually for inspection, but it is recommended after the first years' service. Ensure that they are checked and the tie bolts are tightened up as necessary. Clean insulators and examine them carefully for small fractures, replace them if necessary.

6.5 OIL

The oil is used for cooling and insulation. It should be clear and free from sludge and there should be no indication of acid action on steel work. The acrid smell associated with acidity and sludge formation should not be present.

Check the oil level regularly and make up for any deficiencies immediately. If there is a substantial drop in the level, inspect for leads on the tank welds and joints. It is essential that any leak be immediately sealed. There will be a slight discrepancy in oil level, if the temperature is higher or lower than that at which the unit was filled.

It is recommended that the electric strength of the oil be tested annually following standard practice. If no facilities for these tests are available locally, send the oil sample to Energypac Engineering Limited and we will advise you as to its condition and the action you should take. Alternatively, send the sample to your oil supplier who will carry out the tests at a nominal charge and advice you accordingly. The sample must be taken from the bottom of the tank and placed in contamination by moisture or dust which could affect the test result.

7. WHAT TO DO DURING TIMES OF TROUBLESHOOTING

7.1 PROCEDURE

SYMPTOM	CORRECTIVE ACTION
Servo motor contentious moving	✓ Check the servo motor sprocket ✓ If ok, check the main sprocket ✓ If ok, check the coupling
Servo controller not working	✓ Check the sensing transformer ✓ If ok, check the MCB & fuse ✓ If ok, check the all control connection ✓ If ok, check the servo controller
Abnormal output	✓ Check the input voltage ✓ If balanced, check the transformer secondary voltage ✓ If balanced, check the regulator input voltage ✓ If ok, check the carbon roller, contact post & contact bar ✓ If ok, check the balance CT

SYMPTOM	CORRECTIVE ACTION
Servo motor not moving	✓ Check the motor voltage & R-C network ✓ If ok, check the motorized mechanism ✓ If ok, check the regulator mechanism ✓ If ok, check the servo motor coil
No output	✓ Check the input voltage ✓ If ok, check the transformer and regulator voltage ✓ If ok, check the bypass switch
Temperature is high	✓ Check the load position ✓ If ok, check tightening of all bushing terminal and all joint ✓ If ok, check air flow and room temperature ✓ If ok, check the oil level and electric strength
Servo motor not stopping when regulator at maximum or minimum position	✓ Check the micro switch ✓ If ok, check the micro switch stopper

8. COMPREHENSIVE COMPONENT LIST

8.1 TRANSFORMER UNIT

a) Series (Buck-Boost & Auto) Transformer
b) Terminal Bushing (LT & HT)
c) Pressure Release Valve
d) Breather Box
e) Oil Level Indicator
f) Earthing Terminal

8.2 REGULATOR UNIT

a) Regulator/Dimmer
b) Servo Motor
c) R-C Network
d) Micro Switch
e) Gear Assembly
f) Sensing Transformer
g) Voltmeter & Selector Switch
h) Auto/Manual Switch
i) Push Switch (Increase/Decrease)
j) Servo Controller
k) MCB/Fuse
l) Terminal Bushing
m) Balancer CT

9. DIAGRAMS

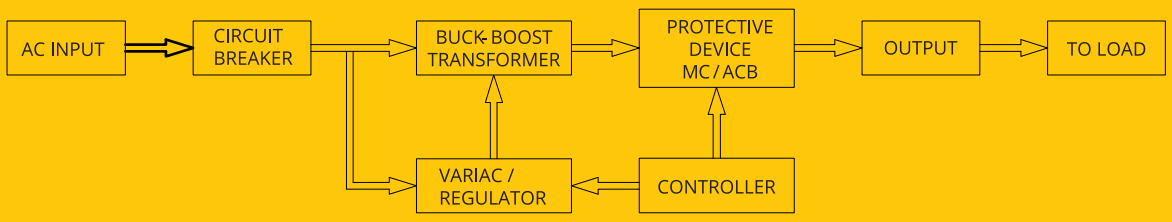

Fig: Block diagram of AVR

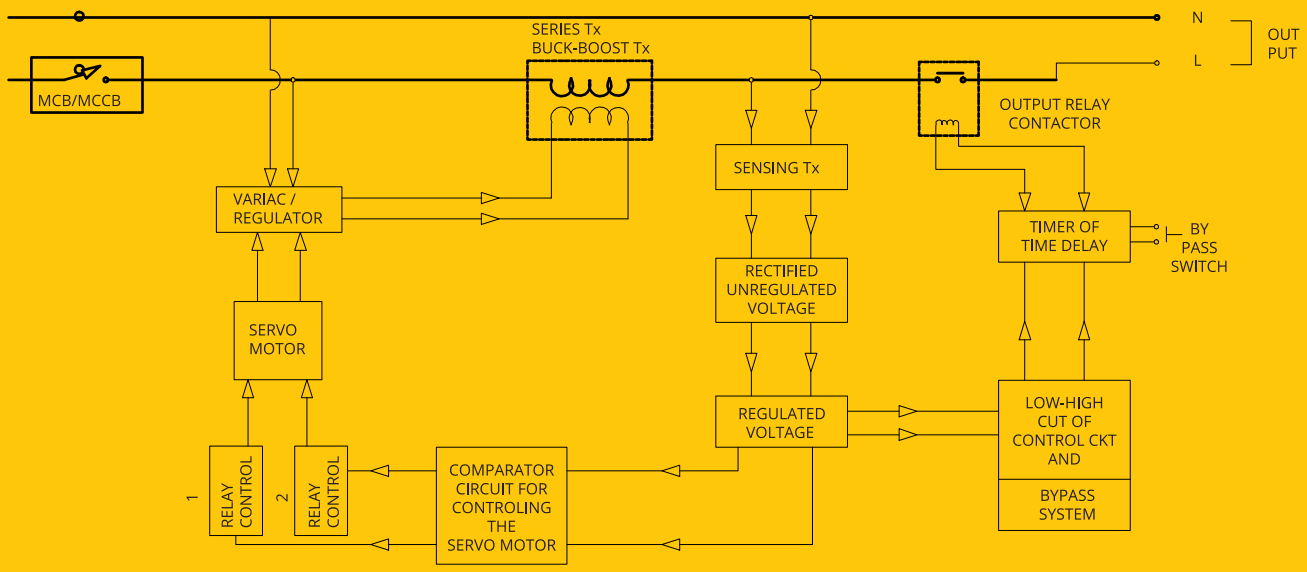

Fig: Block diagram of AVR control system

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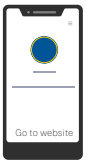
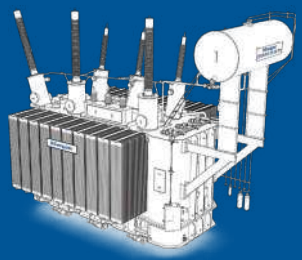




POWER TRANSFORMER

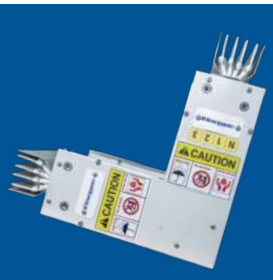
DISTRIBUTION TRANSFORMER
(OIL FILLED)

DISTRIBUTION TRANSFORMER
(DRY TYPE)

INSTRUMENT TRANSFORMER

VACUUM CIRCUIT BREAKER

SWITCHGEAR



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