

High voltage three-phase synchronous generators



OPERATION & MAINTENANCE MANUAL

translation of original instructions

SAFETY WARNING

The generators which are the subject of these "instructions" are components designed for use in industrial areas (machines/plants) and therefore cannot be treated as retail goods.

This documentation consequently contains information that is only suitable for use by qualified personnel. It must be used in compliance with the regulations, laws and technical Standards in force and cannot under any circumstances take the place of plant standards or additional prescriptions, including any which are not legally enforceable, which have been issued for the purpose of ensuring safety.

Machines built to customer specifications or with constructional differences may differ in detail from the generators described herein. If you encounter any difficulties please do not hesitate to contact Evotec Power, specifying:

- The type of machine
- The full code number of the generator
- The serial number of the generator



Electric rotating machines have dangerous parts: when operating, they have live and rotating components. Therefore:

- *improper use*
- *the removal of protective covers and the disconnection of protection devices*
- *inadequate inspection and maintenance*

can result in severe personal injury or property damage.

The person responsible for safety must therefore ensure that the machine is transported, installed, operated, maintained and repaired by qualified personnel only, that must have:

- specific training and experience
- knowledge of applicable standards and laws
- knowledge of the general safety regulations, national and local codes and plant requirements
- the skill to recognize and avoid possible danger.

All maintenance and inspection operations must be carried out only with the authorization of the person responsible for safety, with the machine at a standstill, disconnected from the supply (including auxiliary circuits such as the anti-condensation heaters).

As the electric machine is a product to be installed in industrial areas, additional protection measures must be taken and assured by the person responsible for the installation, if stricter protection conditions are required.

As the electric generator is a component to be coupled to another machine, it is the responsibility of the installing engineer to ensure, during operation, proper protection against the risk of contact with bare rotating parts and to prevent people or things from approaching the machine.

If the machine shows deviations from the normal performance (excessive or too low voltage, increase in temperature, noise and vibrations) promptly advise the personnel responsible for maintenance.



Here enclosed with the "instructions manual" there are self-adhesive leaflets which are reporting symbols for security: the self-adhesive leaflets are to be applied to the generator surface, at the customer's charge, according the instruction presented on the sheet of the self-adhesive.

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1 **INTRODUCTION**

The instructions refer to three-phase synchronous generators series TH. Technical data and constructive details are given in the catalogue. In order to obtain the proper working of the generator it is necessary to read carefully all included instructions.

The generators TH are synchronous generators, brushless type, self excited and self regulated, manufactured according to the standards and in compliance to IEC34-1; EN60034-1; GB755; VDE 0530; BS5000 and NEMA MG21.

EvoTec is well recognized in Europe, Middle East, Africa and Asian continents as the leading supplier to the industrial, petrochemical, marine, on-shore and off-shore and any places where dependable electrical power is highly needed.

Degree of protection – characteristics

The protection degree of the generators and the rated data are shown on the name-plate.

Frequency

The generators are suitable for operation at 50Hz and 60Hz, according to the data reported on the name-plate: for correct operation for 50Hz and 60Hz, it is necessary to verify that the settings of the voltage regulator are proper for the required operation and that the use of the generator is in accordance with the value of the name-plate.

Accessories

According to the customer's order the generators can be equipped with accessories, such as anti-condensation heaters, thermistors, etc.

Generator Designation:

Example: TH568 A-6

T- series generator **H** - High voltage series **S**- special standard machines

568- core height **A**- power section mark (A, B, C, D, E, F etc.)

6- 6 pole , 4 pole omit don't write

NOTE: *S TYPES ARE USED FOR MARINE APPLICATION OR SPECIAL SURROUNDINGS WORKING*

Products Serial-number Position

Each generator has an only serial-number on the end ring of non-drive end.

Rating Plate

Rating-plates are of special sticker type and shall be stick onto the right hand side of the generator drive end position.

1.1 GENERATOR APPLICATION

Operating Environment

TH series generator rated output shall be operated according to the following altitude and temperature.

- Altitude height shall not over 1000m.a.s.l;
- Environment temperature shall be between -15°C and 40°C respectively
- Cool air relative humidity: ≤90% (25°C)
- Generator shall be operated in a protected area and shall not be used outdoor.
- It is strongly recommended that use anti-consideration heater to protect generator winding insulation.

NOTE: *INSUFFICIENT OF COOLING AIR FLOW OR PROTECTION WILL RESULT IN FAILURE, DAMAGE OR DECREASING THE LIFE EXPANTANCY OF THE MACHINES*

De-rating table

Following de-rating table must be considered if generator needs to be operated under conditions below :

Altitude (m.a.s.l.)	Revise coefficient	Temperature (°C)	Revise coefficient
1500	0.97	45	0.97
2000	0.94	50	0.94
2500	0.91	55	0.91
3000	0.88	60	0.88
3500	0.85		

Operating attitude and temperature above the standard, revise coefficient should be calculated together.

WARNING

All the generator ratings are specified in the rating-plate. The manufacturer hold no responsibility if any damage occurred to the machine caused by misuse.

1.3 GENERATOR PRINCIPLES

Self-excited generator with AVR control

Power for the excitation system is provided from the main stator output to the AVR to the exciter field. The AVR is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage-sensing signal derived from main stator winding. By controlling the low power of the excited field, control the high power requirement of the main field is achieved through the rectified output of exciter armature.

The AVC125-10A (DECS-150) AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and soften the effect of load switching to relieve the burden on the engine. The detailed function of the AVR circuits and their adjustment are covered in the load testing section.

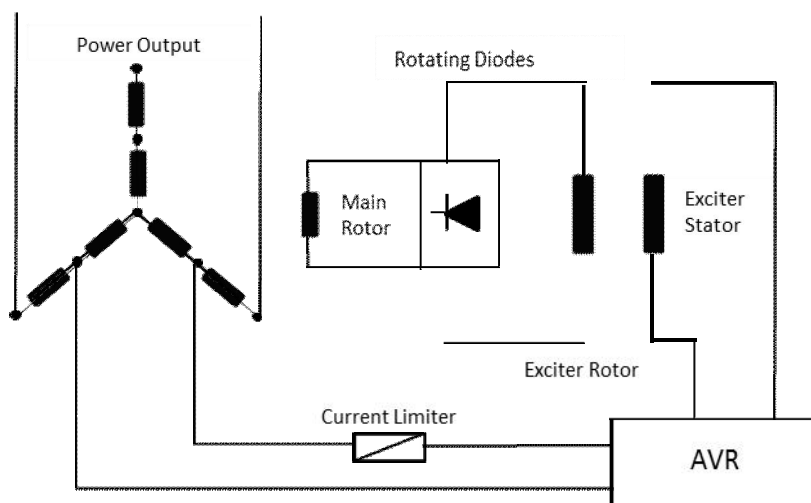


Figure 1 - Operation Principle

PMG excited generator with AVR control

The Permanent Magnet Generator (PMG) provides power for the excitation of the exciter field via the AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage-sensing signal derived, via an isolating transformer, from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

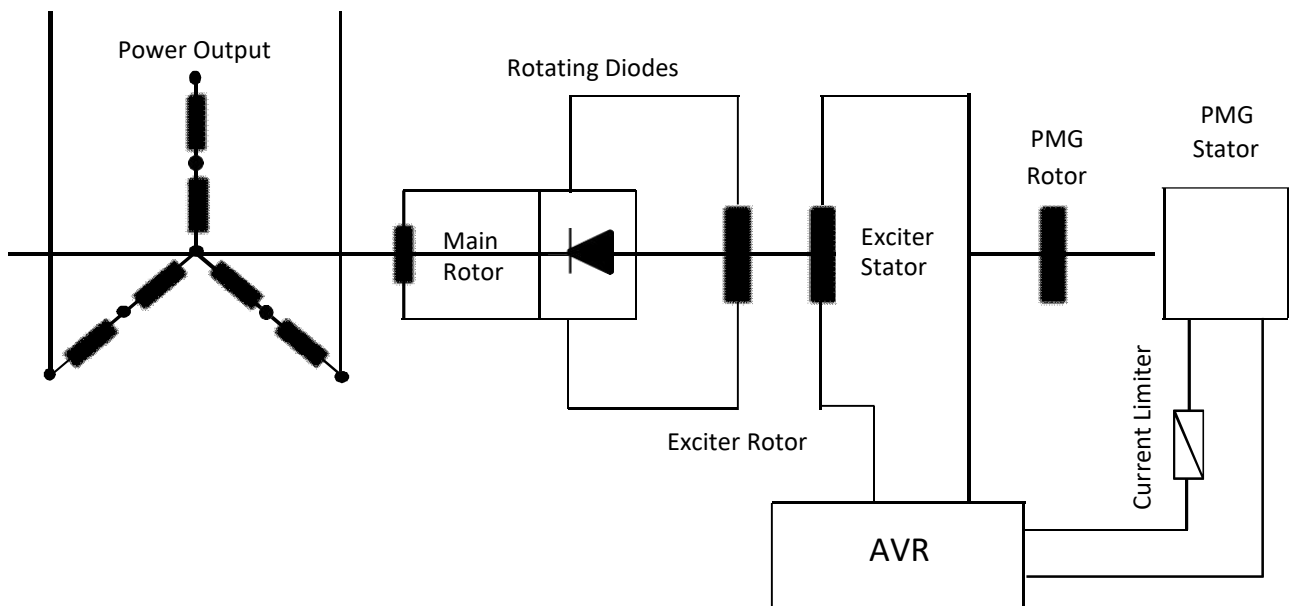


Figure 2 - PMG Operation Principle

Other description of the AVR

ETC-2 and ETC-3 AVR provides the function of paralleling. ETC-1, ETC-2 and ETC-3 AVR provides the function of short-circuit current limit control. ETC-3 AVR is used for PMG excitation system.

2 THE ESSENTIAL COMPONENT OF GENERATOR

MAIN STATOR

The main stator frames are most ruggedly constructed with high strength and solid support. The frame is welded with heavy rings and steel bars and reinforced with welding places between bars. The main stator windings are the configuration of triple-layer winding insulation type to ensure maximum insulation properties. All laminations of the stator core are externally welded under pressure.

MAIN ROTOR

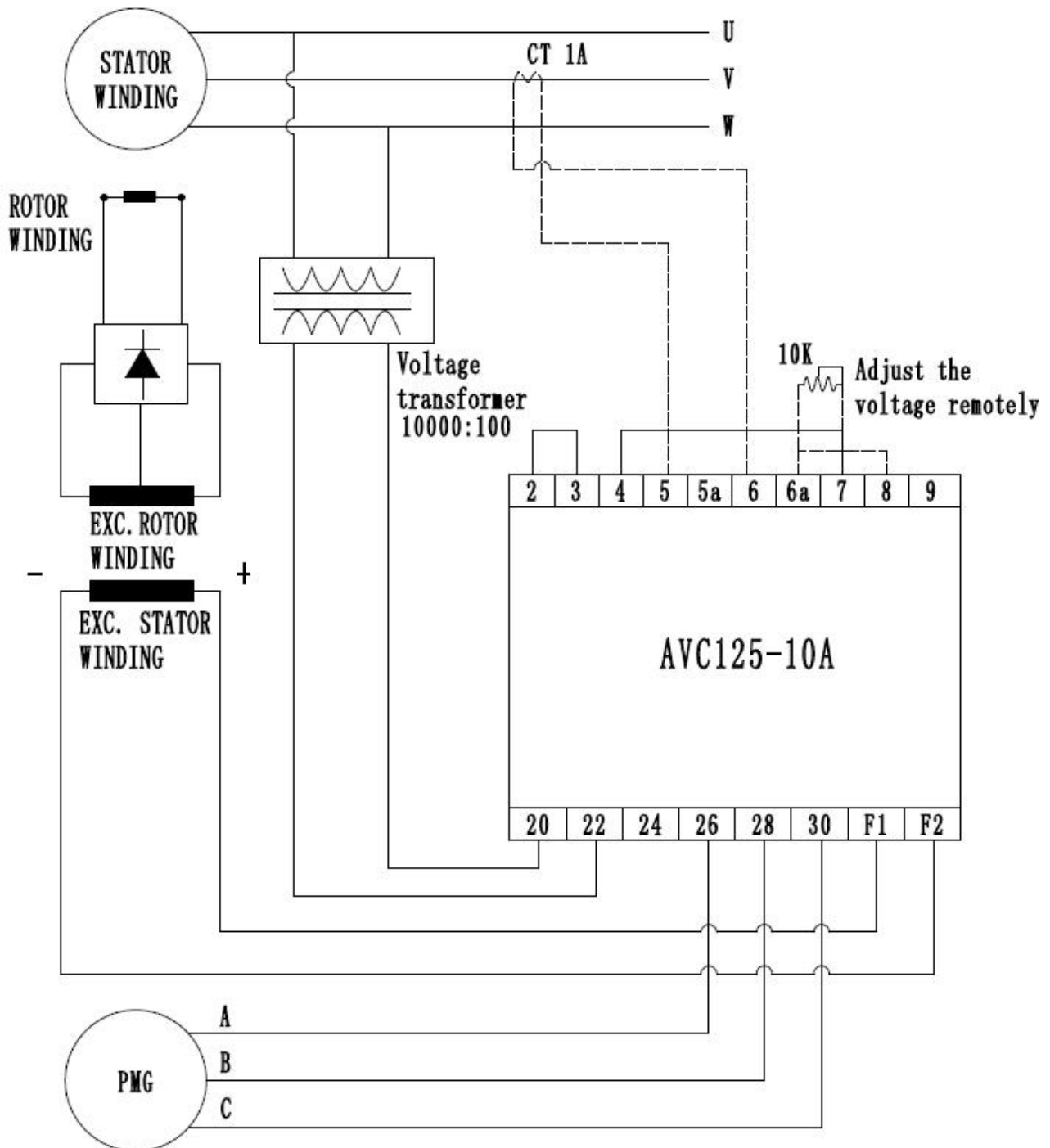
The main rotor is also the configuration of triple-layer winding protection type and the copper wires are of special made rectangular type. The magnetic core of the main field is directly mounted on the shaft. The laminated rotor core reduces the effect of superficial losses on the rotor. The rotor core at both end additional copper laminations and are used as "end rings" for the copper squirrel cage.

Excitation system

Excitation system is composed of A.C exciter, rotating diodes and AVR. A.C exciter contains exciter stator and exciter rotor.

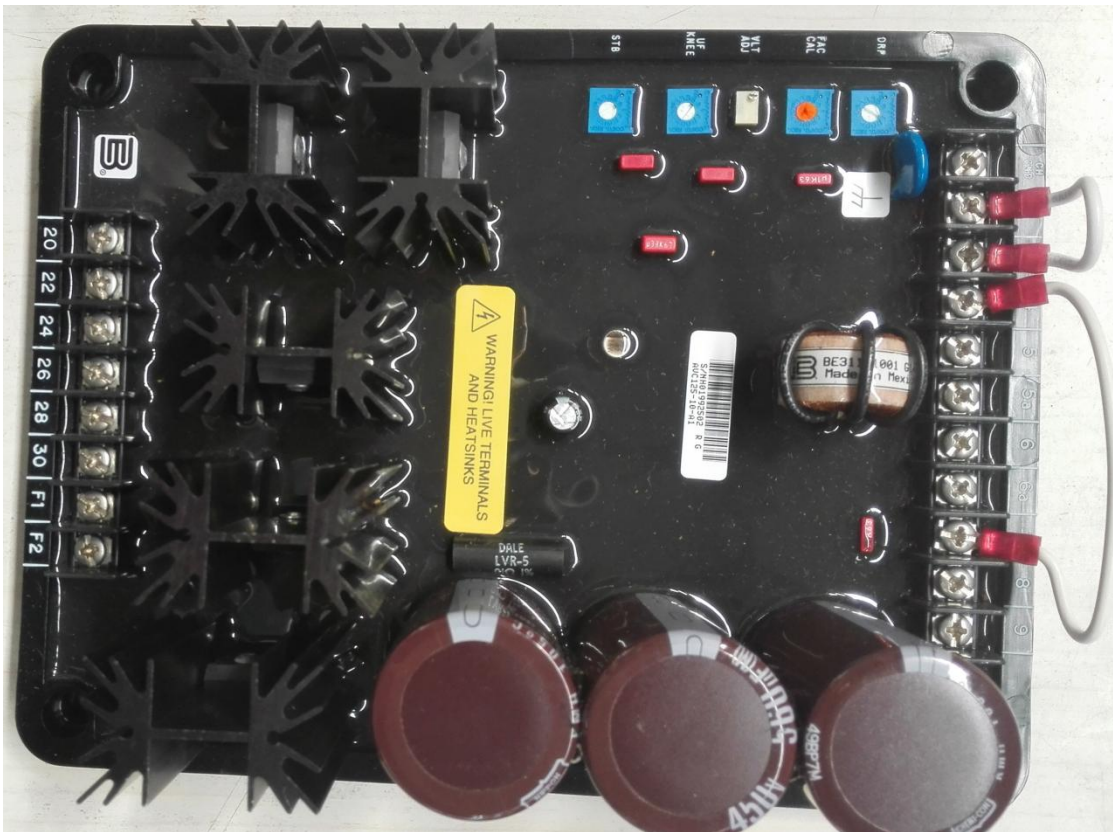
4.4.1 AVR description drawing

The wiring diagram of AVR ETC-1 in 400Vac system (fig.4)



Note: when using voltage parallel signal, connect 2 and 3 indirectly to the power supply of 3Vdc, and short connect 2 and 3 when not in use; If the current parallel machine signal is adopted, the difference adjustment of CT is connected, according to the dotted line in the drawing when connected to 5, the CT is 1A, and when connected to 5a, the CT is 5A.

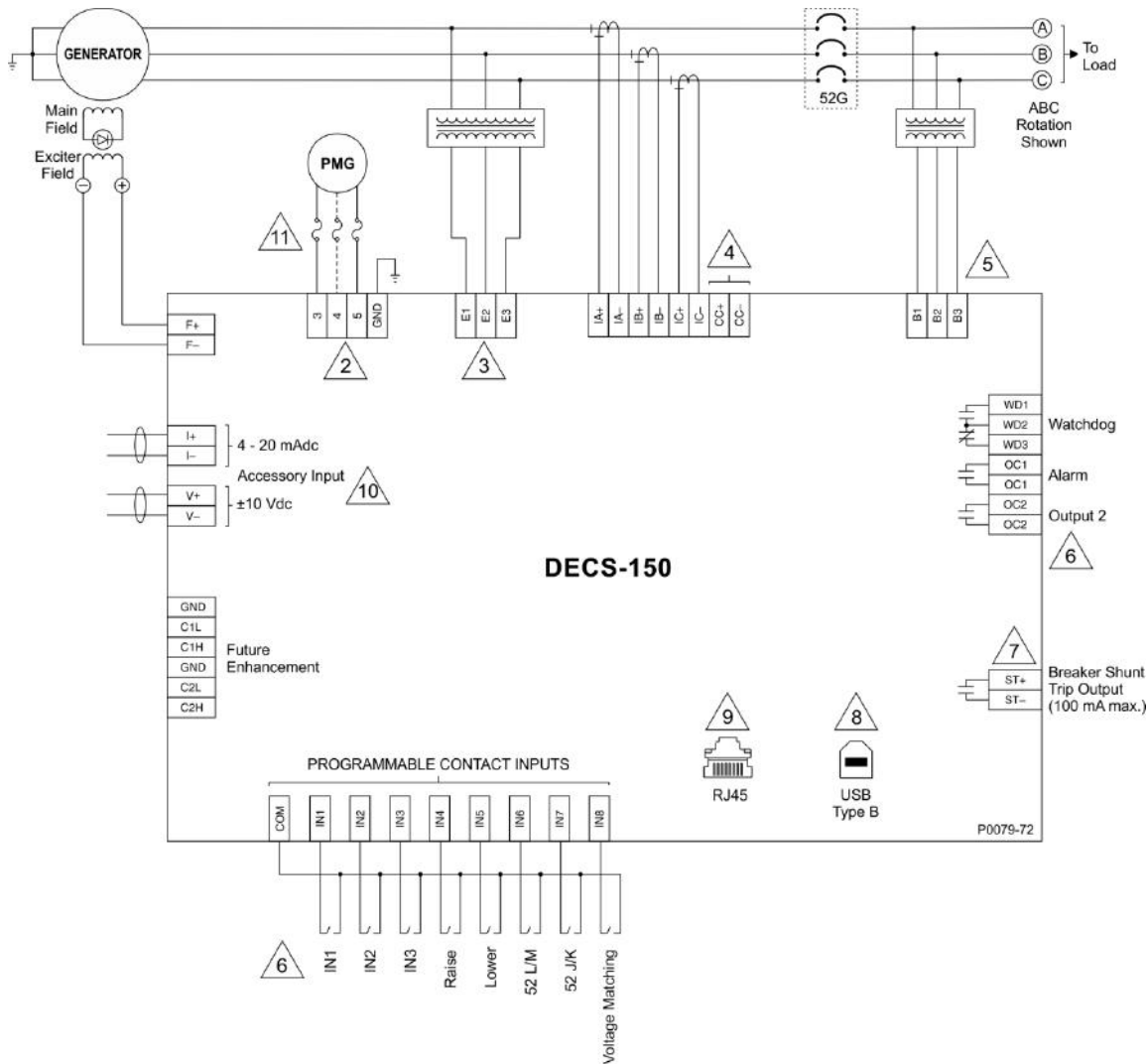
Fig 4 The wiring diagram of AVR AVC125-10A



AVR AVC125-10A

The wiring diagram of AVR DECS-150 (fig 5)





Under Frequency Roll-Off (UFRO)

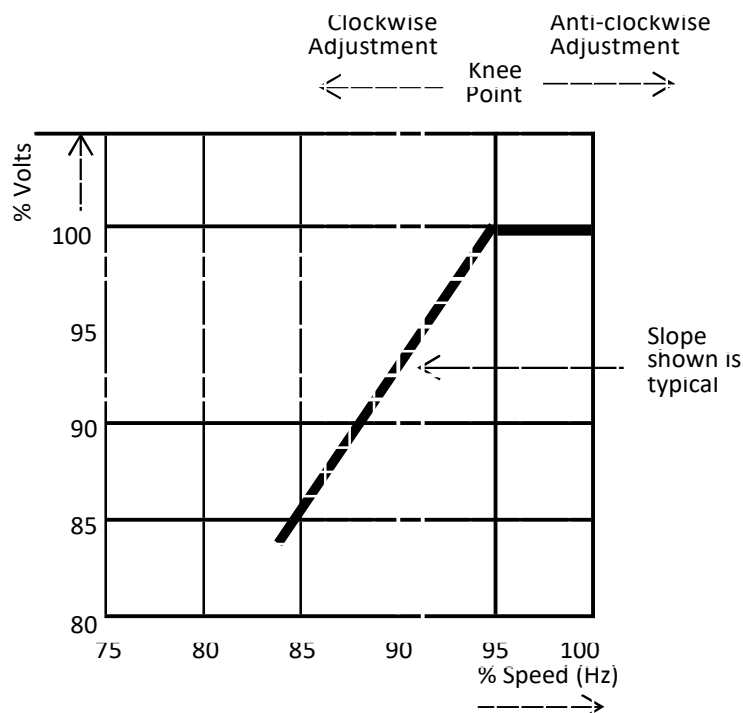


Figure 7

The AVR incorporates an under-speed protection circuit which gives a voltage/speed (Hz) characteristic as shown (figure 7): The UFRO control potentiometer sets the "knee point"

[1] Symptoms of incorrect setting are :-

- a) The LED indicator permanently lit when the generator is on load
- b) Poor voltage regulation on load, example: operation on the sloping part of the characteristic

[2] Adjustment Method: Clockwise adjustment lowers the frequency setting of the "knee point" and extinguishes the LED. For Optimum setting the LED should illuminate as the frequency falls just below nominal frequency, i.e. 47Hz on a 50Hz generator or 57Hz on a 60Hz generator.

Droop

The device is included in the voltage, to allow parallel operation between similar generators: the device permits to share correctly the total reactive required by the load among all generators operating in parallel. The device is composed by an external CT (which is sensing the current in phase U) and by a "droop" circuit internal in the regulator. The voltage regulator is provided with input terminals (terminals 5 and 5) for easy connection to CT. Such terminals are normally short circuit by a connection, when the generator is used in single operation. If the voltage is increase as load increases, It is necessary to reverse the leads of current transformer at terminals 5-6.

Excitation Trip

An AVR supplied from a permanent magnet generator inherently delivers maximum excitation power on a line to line or line to neutral short circuit. In order to protect the generator windings the AVR incorporates an over excitation circuit which detects high excitation and removes it after a pre-determined time, (8-10 seconds.) symptoms of incorrect setting are the generator output collapses on load or small overload, and the LED is permanently illuminated.

5 **INSTALLATION**

Before installation

Before installing the generator,

- make sure that name-plate data corresponds to the power supply and operating conditions and that the installation complies with the manufacturer's recommendation
- clean any protecting varnish from all connecting surfaces (such as surface of couplings and flanges and shaft extension for two-bearing generators).

Lifting

When moving the generator, always keep it in the horizontal position. The generator lifting points are designed to lift the generator only. Do not lift the complete generating set by the generator lifting points.



Operating condition

The operating conditions of the generator shall be identified before installation. The generator shall be operated and installed in a clean environment, with good air flow and with ample space for inspection, maintenance and routine checking. The surrounding of the generator shall be free of atmospheric contamination such as gasses and various chemicals, salt water spray, dust and rainfall. It is also important to have a good airflow position, away from any hot or exhaust system. It is also recommended that if the generator were to install in an area with high condensation, a space heater shall be added as an extra protection. If installed in an area of heavy laden of fine dust or sand, an inlet air filter shall be added on but due to these, a certain output deration is required.

Installation

During assembling of the generator and the engine, it is important to have a solid and rigid base-frame to ensure no frame deformation or frame twisting arises. We recommended to use Grade 8.8 bolt and nuts to assemble the generator set and to also make sure the base-frame

is sitting firmly to the ground surface. During installation, it is also important not to harm the bearing and shall always keep the rotor assembly in alignment. During the lifting of the generator, it is important to ensure the lifting slings or wires rope are in good condition and also ensure the lifting block are able to sustain the generator weight. We recommended the lifting method shall be as Figure 7.

Single bearing generator installation

Assembling procedure as follow:

- initial checking of the engine housing and flywheel measurement is correct as per generator flange and coupling SEA dimension supplied.
- dismantle the flange cover, position the generator in-line with the engine and then aligned the generator flange to the engine housing. After that, align the generator coupling to the engine flywheel. This is to make sure all the surface is vertically in-line with each other. Should it is not aligned, it can be adjusted by adding several shim to the base-frame.
- bolt the coupling disc to the flywheel housing using recommended number of bolts and size. We recommended to use Grade 8.8 or above bolt type.
- it is recommended to turn the rotor to check there is no touching between the rotor and the stator assembly.
- after assembling the generator footing to the base-frame, install back the flange cover.

Double bearing generator installation

Assembling procedure as follow:

- standard generators supplied are without special housing for connection between the generator to the engine housing and can be available upon request.
- before installation, it is required to have a pre-balancing coupling/adaptor fit to the generator shaft end.
- position the generator in-line with the engine and then aligned the generator to the engine side. After that, align the generator pre-balanced coupling to the engine flywheel. This is to make sure all surface is vertically in-line with each other.
- should it is not aligned, it can be adjusted by adding several shim to the base-frame.
- it is recommended to turn the rotor to check there is no touching between the rotor and the stator assembly.
- after that, assemble the generator footing to the base-frame.

Rotation

Please ensure the generator rotating direction shall be the same as the label indicated direction. Generators are normally supplied to operate correctly when rotating clockwise.

Electrical connection

Before the cable connection, please ensure to have the right connection. This can be referred to the Connection Diagram base on the specific voltage requested. The output cables have to be fixed to the terminal board as indicated in Figure 9.

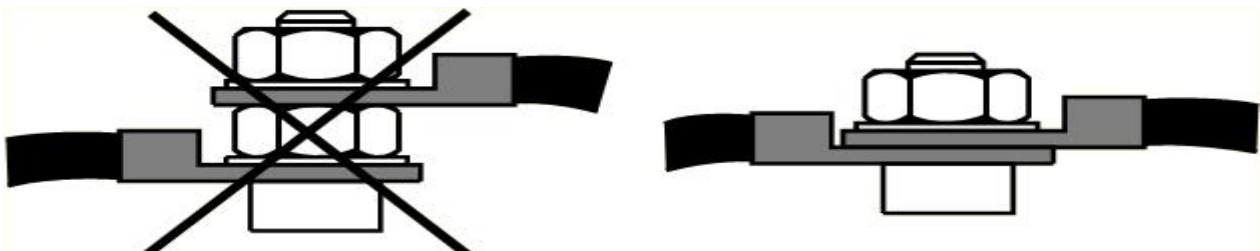


Figure 9 - Correct connection

Protection

The generator supplied neutral cable is not connected to the frame. Should it is required, it can be connected. Inside the terminal box, there is a earth terminal provided. There is a possibility during the complete generator set in operation, over-speed, over-voltage, short-circuit and other possibilities can be occurred. Reliable protections are required. If running on parallel operation, reverse power protection is also required.



During operation, it is required to followed strictly to the local regulations, laws and technical standard in force

6 **STARTING UP**

Pre-running checking

After transportation, storage, installation and assembling of the complete machine, it is necessary to do a final check on all the mechanical and electrical components before operation to ensure it is totally safe and properly protected.

Check the rotating rectified set

It is required to test the diodes of the rotating rectifying set with a multi-meter. Prior to the testing, it is required to disconnect all the connection cable of the diodes. A good condition diode enables the current to flow only on direction, from the anode to the cathode.

Surge suppressor is a metal oxidation voltage-dependent resistance type and connected between both incoming and outgoing cable of the main rotor. This surge suppressor is to protect the rotating diodes from damage caused by high load changes or misuse.

Check the insulation

The generator has a very good insulation protection construction, unless it is being store for a long time or used in severe climatic or atmospheric conditions, otherwise no other protection, for example heating is required. It is a good practice to test stator windings for ground insulation before starting the machine. If the ground resistance is below 2mohm, then it is necessary todry the generator.

Check the earth connection

All the earth bolts in the generator support should be connected. Grounding has to be carried out using a copper wire of suitable size, in compliance with applicable standards.

Check the connection

Standard generators are supplied with either 12leads or 6 leads. The entry terminals cables in the terminal box are on the right hand side. Terminals arrangement permits star series and star parallel connection. It is necessary when changing the connection from tar series and star parallel, to check and modify the connection to the AVR, according to the diagram provided.

Checking the final assembly

- check the engine and generator are properly alignment.
- check the inlet and outlet air passage is smooth and not being block by any big or large object or machinery. Also make sure there is no back pressure or hot air back circulation.
- check all the bolts are securely fastened and tighten and all protection are in proper.
- check if there is any dirty particles or waste inside the generator and check by turning the rotor to ensure again that there is no touching in between.

WARNING

Check the machine based on above recommendation before start to operate.

Commissioning

All generators are fully tested at the factory prior to delivery. All generators are factory set at star series connection, 400V at 1500rpm.

No load adjustment

When the prime mover reaches the rated speed, the generator should have also reaches the rated voltage. If there is a different in the voltage level, it can be corrected by adjusting the AVR. All three phase voltage should also be stable and balance.

Load adjustment

To ensure the generator is in good condition, applied the load by increasing and decreasing the load to check the voltage stability level, check all the control panel metering is functioning in proper condition and also check on the generator of any abnormal condition. After the above steps, the generator is safe to operate. Please note that it is required to unplug the AVR when the prime mover is running at low speed for a long time, otherwise, it will damaged the AVR and the excitation windings.

7 MAINTENANCE

WARNING

Improper setting of speed governor will result in rotating parts damage by over speed.

The generator will function in good condition if there is a routine maintenance and checking program. It is important to ensure safe and trouble free conditions throughout the operation period. It is recommended to follow every maintenance measures highlighted in this manual.

General maintenance

- Generator should always be kept dry. In order to keep out of the humidity, please cover with cloth if not used .
- Generator must be free from metal leftovers, drops, dust, acid-base steam or other harmful gases.
- During operation, the ventilation must be sufficient. Please ensure all openings are free and not be block by any machinery or panel. Do not put anything non top of the alternator for it is bad for ventilation and heat elimination. Please don't remove the top terminal box cover.
- Please check the generator load from time to time. The load current should not over the rated current of generator. When the load power factor is low, the excitation current should not over the rated value mentioned on the nameplate. When the three phase load is not balance, the biggest phase current of that phase should not over the rated current.
- Please note the temperature of the alternator bearing. The bearing temperature rise should not over 55K in general.
- During operation, the generator shall not over the rated speed, voltage and ampere. Once abnormal smells, strange sound audible and excessive vibration detected, please stop the machine immediately and a thorough check-up is required before restart the machine.

Inspection and maintenance

- If the generator is not in use for some time, check the windings insulation. If it is lower than 5Mohm, then it is necessary to dry the generator and then repeat the test. If the grounding insulation still remains the same, then the insulation has already aged and you should change the wire and insulation.
- Check the bearing and housing position to ensure there is no loose or wear and tear.
- check the airflow and internal condition. If inside the terminal box is too dusty, its required to be cleaned.
- Check the alignment of the generator to the engine to make it is not out of alignment and also check the fan assembly to ensure it is not deform.
- Check all cable connections especially the AVR side to make sure it is not loose.

Bearing checking

There are two types of bearing in generator:

- Pre-lubricated sealed for life bearing which do not need to lubricate again.
- Lubricable bearing which need to lubricate periodically during the operation procedure.

Generator Range	Bearing position	Lubrication weight (g)	Lubrication cycle (hour)
TH468	Drive end	47	1500
	Non-drive end	30	1500
TH528	Drive end	58	1500
	Non-drive end	47	1500
TH568	Drive end	65	1500
	Non-drive end	58	1500

The lubrication cycle above is in the condition of operation temperature below 70°C. Each 15°C temperature rise will decrease half lubrication cycle.

Assembling and Disassembling

Disassembling steps: (assembling steps reverse)

- disassemble generator lead wires, air outlet screen protection, coupler, coupling flange.
- disassemble end protection cover, terminal box, connection wire between exciter stator and main generator, disassemble the bolts of the back shield, then take off the back shield with the exciter stator.
- for single bearing generator, disassemble the coupling disc, lifting out the rotor from the stator with professional lifting device.
- for double bearing generator, take off the outer bearing cover of the front bearing, take out the bolt of the front shield, then lifting out the rotor from the stator with professional lifting device.
- for the large capacity generator with very heavy rotor, using professional lifting device as Fig.12



Figure 12 - professional lifting device

Trouble-shooting

Trouble	Possible cause	Measures
No power supply	<ul style="list-style-type: none"> - Wrong connection - Rotating diodes damage - AVR connection loose - Short circuit on main cables - Insufficient of residual voltage 	<ul style="list-style-type: none"> - Refer to the connection manual - Check in case of short circuit and repair or change diodes - Disconnect and reconnect all wire again - Apply 12V battery to recharge
No load voltage above rated voltage	<ul style="list-style-type: none"> - Fuse blown - Wrong connections of exciter 	<ul style="list-style-type: none"> - Replace the fuse. - If fuse blown again, check if the exciter stator is short circuit. otherwise, change the AVR - Check connection again
No load voltage below rated voltage	<ul style="list-style-type: none"> - AVR setting problem 	<ul style="list-style-type: none"> - Adjust the AVR potentiometer.
No load or load voltage unstable	<ul style="list-style-type: none"> - Check the speed stability 	<ul style="list-style-type: none"> - Readjust the stability selection
Excitation current too high	<ul style="list-style-type: none"> - Excitation current too high 	<ul style="list-style-type: none"> - Check, repair, or replace diode assembly
Vibration	<ul style="list-style-type: none"> - Generator to engine not in-line - Rotor balancing problem after repair - Bearing damage - Engine problem 	<ul style="list-style-type: none"> - Check the alignment and rectify the problem - Rebalancing required - Check and change bearing immediately - Check and service the engine
Bearing heating	<ul style="list-style-type: none"> - Operation exceed bearing recommended running hours - Insufficient of grease - Generator to engine not in-line 	<ul style="list-style-type: none"> - Change bearing - Change bearing or lubricate grease - Check the alignment and rectify the problem
Generator heating	<ul style="list-style-type: none"> - Overload - Power factor too low - Airflow problem 	<ul style="list-style-type: none"> - Adjust to the nominal rate - Adjust the load and the ampere to nominal level - Ensure the fan assembly not obstruct
Voltage unstable	<ul style="list-style-type: none"> - AVR problem 	<ul style="list-style-type: none"> - Check, adjust or change a new AVR

AVR trouble shooting

Trouble	Possible cause	Measures
No power supply	<ul style="list-style-type: none"> - Insufficient of residual voltage - Sensing cable not connected - Generator set under-speed - AVR damage 	<ul style="list-style-type: none"> - Apply 12V battery to recharge - Reconnect again - Adjust to rated speed - Change new AVR
Voltage too low	<ul style="list-style-type: none"> - Generator set under-speed - Wrong FREQ setting 	<ul style="list-style-type: none"> - Adjust to rated speed - Adjust the setting
Voltage too high	<ul style="list-style-type: none"> - AVR setting too high - AVR damage 	<ul style="list-style-type: none"> - Adjust AVR setting - Checking and replace new AVR
Voltage unstable	<ul style="list-style-type: none"> - Wrong AVR setting 	<ul style="list-style-type: none"> - Adjust AVR setting
Voltage fluctuation between 300V~400V	<ul style="list-style-type: none"> - generator set speed too low - Wrong FREQ setting 	<ul style="list-style-type: none"> - Adjust generator set speed - Adjust the setting

8 Checking and storage

After the generator set is arrival, customer should check if it is accordance with the order by the rating-plate. Meanwhile, check if there is any damage or loss of the files and documents about the goods.

Documents with the goods include Maintenance Manual, Certificate of Quality, Structural Drawing, Products List, Contract and etc.



For lifting and handling the purpose made eyebolts must be used. The lifting eyes are designed to support only the weight of the generator and they are not to be used for lifting the complete gen-set that incorporates the generator. Check that the lifting means available are suitable for the movement of all parts which have to be handled. Check also that the working conditions are suitable to operate without danger for safety of personnel.

If the generator is not used immediately, customer should pack it again. And put it in a dry and clean surrounding free of contaminations such as gases and various chemicals, salt water spray, dust and rainfall. Keep the generator alignment in delivery and upright in storage. It is not in the warranty range for damage of improper storage.

9 SERVICE

Service engineers of the company are available to give technical support and advice

After sales service:

Any fault that under proper use appears in the goods within the warranty period, an on-sit service will be provided in 48 hours until the effective operation of the generator.

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