BRUSHLESS SYNCHRONOUS
GENERATOR

INSTALLATION, SERVICE
MAINTENANCE MANUAL

Contents

SAFETY MEASURES

Before operating the generator set, read the generator set operation manual and this generator manual and become familiar with it and the equipment.

SAFE AND EFFICIENT OPERATION CAN ONLY BE ACHIEVED IF THE EQUIPMENT IS CORRECTLY OPERATED AND MAINTAINED.

Many accidents occur for failure to follow fundamental rules and precautions.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH.Observe all WARNING/CAUTION notices.

- Ensure installation meets all applicable safety and local electrical codes. Have all installations performed by a qualified electrician.
- Do not operate the generator with protective covers, access covers or terminal box covers removed.
- Disable engine starting circuits before carrying out maintenance.
- Disable closing circuits and/or place warning notices on any circuit breakers normally used for connection to the mains or other generators, to avoid accidental closure.

Observe all IMPORTANT, CAUTION, WARNING, and DANGER notices, defined as:

Important ! Important refers to hazard or unsafe method or practice which can result in product damage or related equipment damage.

Caution	Caution refers to hazard or unsafe method or practice which can result in product damage or personal injury.

Warning refers to a hazard or unsafe method or practice which CAN result in severe personal injury or possible death.

Warning !

Danger refers to immediate hazards which WILL result in severe personal injury or death.

Danger !

Due to our policy of continuous improvement, details in this manual which were correct at time of printing, may now be due for amendment. Information included must therefore not be regarded as binding.

FOREWORD

The function of this book is to provide the user of SG/LA generator with an understanding of the principles of operation, the criteria for which the generator has been designed, and the installation and maintenance procedures. Specific areas where the lack of care or use of incorrect procedures could lead to equipment damage and/or personal injury are highlighted, with WARNING and/or CAUTION notes, and it is important that the contents of this book are read and understood before proceeding to fit or use the generator.

Service, Sales and Technical staff of the factory are always ready to assist and reference to the company for advice is welcomed.

Warning ! Incorrect installation, operation, servicing or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.

CHAPTER 1
INTRODUCTION

1.1INTRODUCTION

The SG/LA range of generators is of brushless rotating field design, available up to 690V/50Hz (1500 rpm) or 60Hz (1800 rpm), and built to meet GB755 BS5000 and international standards.

1.2SERIAL NUMBER LOCATION AND IDENTITY NUMBER LOCATION

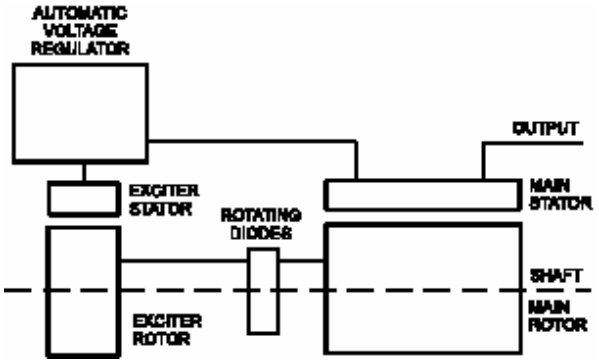
Each generator is metal stamped with it's own unique serial number

1.3 RATING PLATE

It is intended that this label will be stuck to the outside of the terminal box or other location.

CHAPTER 2
PRINCIPLE OF OPERATION

2.1SELF-EXCITED AVR CONTROLLED



The main stator provides power for 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 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.

The 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 softening the effect of load switching to relieve the burden on the engine.

The PMG system provides a constant source of excitation power irrespective of main stator loading and provides high motor starting capability as well as immunity to waveform distortion on the main stator output created by non linear loads, e.g. thyristor controlled dc motor.

CHAPTER3
APPLICATION OF THE GENERATOR

3.1 Running Environment

The generators have been designed for use in a maximum ambient temperature of 40°C and altitude less than 1000m above sea level in accordance with BS5000 and Gb755.

Ambients in excess of 40°C and altitudes above 1000m can be tolerated with reduced ratings - refer to the generator nameplate for rating and ambient. In the event that the generator is required to operate in an ambient in excess of the nameplate value or at altitudes in excess of 1000 metres above sea level, refer to the factory.

When the ambient temperature exceeds the range of -15℃~40℃, need to amend in generator prime power, pls check the following table:

Ambient Temperature	Ratio
45℃	0.97
50℃	0.94
55℃	0.91
60℃	0.88
Altitude	Ratio
1500m	0.97
2000m	0.94
2500m	0.91
3000m	0.85
3500m	0.82

The generators are of air-ventilated screen protected drip- proof design and are not suitable for mounting outdoors unless adequately protected by the use of canopies. Anti- condensation heaters are recommended during storage and for standby duty to ensure winding insulation is maintained in good condition.

When installed in a closed canopy it must be ensured that the ambient temperature of the cooling air to the generator does not exceed that for which the generator has been rated.

The canopy should be designed such that the engine air intake to the canopy is separated from the generator intake, particularly where the radiator cooling fan is required to draw air into the canopy. In addition the generator air intake to the canopy should be designed such that the ingress of moisture is prohibited, preferably by use of a 2 stage filter.

Important ! Reduction in cooling air flow or inadequate protection to the generator can result in damage and/or failure of windings.

3.2 VIBRATION

3.2 Dynamic balancing of the generator rotor assembly has been carried out during manufacture in accordance with BS 6861 Part 1 Grade 2.5 to ensure vibration limits of the generator are in accordance with GB10068
The main vibration frequencies produced by the component generator are as follows:- :

4pole 1500 rpm 25 Hz
1800 rpm 30 Hz

However, vibrations induced by the engine are complex and contain frequencies of 1.5, 3, 5 or more times the fundamental frequency of vibration. These induced vibrations can result in generator vibration levels higher than those derived from the generator itself. It is the responsibility of the generating set designer to ensure that the alignment and stiffness of the bedplate and mountings are such that the vibration limits of BS5000 Part 3 are not exceeded.

Definition of Bs5000–3

Alternators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25 mm between 5 Hz and 8 Hz, and velocities of 9.0 mm/s RMS between 8 Hz and 200 Hz, when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

Definition of ISO 8528-9

ISO 8528-9 refers to a broad band of frequencies; the broad band is taken to be between 10 Hertz and 1000 Hertz. The table below is an extract from ISO 8528-9 (Table C.1, value 1). This simplified table lists the vibration limits by kVA and speed for acceptable operation of standard generator set designs.

Linear Vibration Limits

Linear VibrationLevels As Measured On The Alternator				
Engine Speed RPM (min^{-1})	Power Output S (kVA)	Vibration Displacement RMS (mm)	Vibration Velocity RMS (mm/s)	Vibration Acceleration RMS (mm/s^2)
4 POLES	≤ 10KVA	—	—	—
4 POLES 1500RPM/M 50HZ 1800RPM/M 60HZ	>10KVA≤50KVA	0.64	40	25
	>50KVA≤125KVA	0.4	25	16
	>125KVA≤250KVA	0.4	25	16
	>250KVA	0.32	20	13
The broad band istaken as 2 Hz -300 Hz				

If the measured vibration of the generator set is not within the limits:
1.The generator set manufacturer should change the generator set design to reduce the vibration levels as much as possible.
2.Contact factory Generator Technologies to assess the impact on bearing and alternator life expectancy.

For generators open coupled require a substantial bedplate with engine/generator mounting pads to ensure a good base for accurate alignment.

Alignment of single bearing generators is critical and vibration can occur due to the flexing of the flanges between the engine and generator. A substanial bedplate with engine/generator mounting pads is required.

Close coupling of engine to generator can increase the overall rigidity of the set. A flexible coupling, designed to suit the specific engine/generator combination, is recommended to minimise torsional effects.

In standby applications where the running time is limited and reduced life expectancy is accepted, higher levels than specified in BS5000 can be tolerated, up to a maximum of 18mm/sec.

It is therefore necessary to consider the torsional vibration effect on the generator shaft and couplings. It is the responsibility of the generator set manufacturer to ensure compatibility, and for this purpose drawings showing the shaft dimensions and rotor inertias are available for customers to forward to the engine supplier. In the case of single bearing generators coupling details are included.

Important ! Torsional incompatibility and/or excessive vibration levels can cause damage or failure of generator and/or engine components.

The terminal box is constructed with removable panels for easy adaptation to suit specific glanding requirements. Within the terminal box there are insulated terminals for line and neutral connections and provision for earthing. Additional earthing points are provided on the generator feet.

The neutral is NOT connected to the frame.

The main stator winding has leads brought out to the terminals in the terminal box.


Warning !

No earth connections are made on the generator and reference to site regulations for earthing must be made. Incorrect earthing or protection arrangements can result in personal injury or death.

Fault current curves (decrement curves), together with generator reactance data, are available on request to assist the system designer to select circuit breakers, calculate fault currents and ensure discrimination within the load network.


Warning !

Incorrect installation, service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.

CHAPTER 4
INSTALLATION - SECTION 1

4.1LIFTING

Single bearing generators are supplied fitted with a rotor retaining bar at the non-drive end of the shaft.

Once the bar is removed, to couple the rotor to engine, the rotor is free to move in the frame, and care is needed during coupling and alignment to ensure the frame is kept in the horizontal plane.

4.2ASSEMBLY

During the assembly of the generator to the engine it will be necessary firstly to carefully align, then rotate, the combined generator rotor - engine crankshaft assembly, as part of the construction process, to allow location, insertion and tightening of the coupling bolts. This requirement to rotate the combined assemblies exists for both single and two bearing units.

During the assembly of single bearing units it is necessary to align the generator's coupling holes with the engine flywheel holes; it is suggested that two diametrically opposite location dowel pins are fitted to the engine flywheel, over which the generator coupling can slide into final location into the engine flywheel spigot recess. The dowels must be removed and replaced by coupling bolts before the final bolt tightening sequence.

While fitting and tightening the coupling bolts it will be necessary to rotate the engine crankshaft - generator rotor assembly. Care should be taken to ensure that rotation is carried out in an approved manner that ensures safe working practice when reaching inside the machine to insert or tighten coupling bolts, and that no component of the assembly is damaged by nonapproved methods of assembly rotation.

Engine manufacturers have available a proprietary tool or acility designed to enable manual rotation of the crankshaft assembly. This must always be used, having been engineered as an approved method of assembly rotation, engaging the manually driven pinion with the engine flywheel starter ring-gear.

Caution	Before working inside the generator, during the aligning and fitting of coupling bolts, care should be taken to lock the assembly to ensure there is no possibility of rotational movement.

4.2.1DOUBLE BEARING GENERATORS

A flexible coupling should be fitted and aligned in accordance with the coupling manufacturer's instruction. If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary. Ensure adaptor guards are fitted after generator/engine assembly is complete. Open coupled sets require a suitable guard, to be provided by the set builder. In the case of belt driven generators, ensure alignment of drive and driven pulleys to avoid axial load on the bearings. Screw type tensioning devices are recommended to allow accurate adjustment of belt tension whilst maintaining pully alignment. Side loads should not exceed values . Belt and pulley guards must be provided by the set builder.

Important ! Incorrect belt tensioning will result in excessive bearing wear.

Caution	Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.

4.2.2SINGLE BEARING GENERATORS

For transit and storage purposes the generator frame spigot and rotor coupling plates have been coated with a rust preventative.This must be removed before assembly to engine.

A practical method for removal of this coating is to clean the mating surface areas with a de-greasing agent based on a petroleum solvent.

Caution !	Care should be taken not to allow any cleaning agent to come into prolonged contact with skin.

The sequence of assembly to the engine should generally be as follows:

1. On the engine check the distance from the coupling mating face on the flywheel to the flywheel housing mating face. This should be within +/-0.5mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the a.c. generator bearing or engine bearing.

1. Check that the bolts securing the flexible plates to the coupling hub are tight and locked into position.

1. Remove covers from the drive end of the generator to gain access to coupling and adaptor bolts.

1. Check that coupling discs are concentric with adaptor spigot. This can be adjusted by the use of tapered wooden wedges between the fan and adaptor. Alternatively the rotor can be suspended by means of a rope sling through the adaptor opening.

1. Offer the a.c. generator to engine and engage both coupling discs and housing spigots at the same time, finally pulling home by using the housing and coupling bolts. Use heavy gauge washers between bolt head and discs on disc to flywheel bolts.

1. Tighten coupling disc to flywheel. Refer to engine manual for torque setting of disc to flywheel bolts.

1. Remove wooden wedges.

Caution !	guarding and/or generator Incorrect alignment can result in personal injury and/or equipment damage.

4.3EARTHING

The generator frame should be solidly bonded to the generating set bedplate. If antivibration mounts are fitted between the generator frame and its bedplate a suitably rated earth conductor (normally one half of the cross sectional area of the main line cables) should bridge across the antivibration mount.

Refer to local regulations to ensure that the correct earthing procedure has been followed.

Warning !

4.4PRE-RUNNING CHECKS

4.4.1INSULATION CHECK

Before starting the generator set, both after completing assembly and after installation of the set, test the insulation resistance of windings. (Refer to 7.1)

Important ! The windings have been H.V. tested during manufacture and further H.V. testing may degrade the insulation with consequent reduction in operating life. Should it be necessary to demonstrate H.V. testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage= 0.8 (2 X Rated Voltage + 1000)

4.4.2DIRECTION OF ROTATION

The generator is supplied to give a phase sequence of U V W with the generator running clockwise looking at the drive end (unless otherwise specified at the time of ordering). If the generator phase rotation has to be reversed after the generator has been despatched apply to factory for appropriate wiring diagrams.

4.4.3VOLTAGE AND FREQUENCY

Check that the voltage and frequency levels required for the generator set application are as indicated on the generator nameplate.

Three phase generators normally have a 12 ends out reconnectable winding. If it is necessary to reconnect the stator for the voltage required, refer to diagrams in the back of this manual.

4.4.4AVR SETTINGS

To make AVR selections and adjustments remove the AVR cover .Most of the AVR adjustments are factory set in positions which will give satisfactory performance during initial running tests. Subsequent adjustment may be required to achieve optimum performance of the set under operating conditions. Refer to 'Load Testing' section for details.

4.5 GENERATOR SET TESTING

Warning!

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments.

4.5.1 TEST METERING/CABLING

Connect any instrument wiring and cabling required for initial test purposes with permanent or spring-clip type connectors. Minimum instrumentation for testing should be line - line or line to neutral voltmeter, Hz meter, load current metering and kW meter. If reactive load is used a power factor meter is desirable.

Important ! When fitting power cables for load testing purposes, ensure cable voltage rating is at least equal to the genrator rated voltage. The load cable termination should be placed on top of the winding lead termination and clamped with the nut provided.

Caution !

Check that all wiring terminations for internal or external wiring are secure, and fit all terminal box covers and guards. Failure to secure wiring and/or covers may result in personal injury and/or equipment failure.

4.6INITIAL START-UP

Warning !

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

On completion of generator set assembly and before starting the generator set ensure that all engine manufacturer's prerunning procedures have been completed, and that adjustment of the engine governor is such that the generator will not be subjected to speeds in excess of 125% of the rated speed.

Important ! Overspeeding of the generator during initial setting of the speed governor can result in damage to the generator rotating components.

In addition remove the AVR access cover (on AVR controlled generators) and turn VOLTS control fully anti-clockwise. Start the generating set and run on no-load at nominal frequency. Slowly turn VOLTS control potentiometer clockwise until rated voltage is reached.

Important ! Do not increase the voltage above the rated generator voltage shown on the generator nameplate.

The STABILITY control potentiometer will have been pre-set and should normally not require adjustment, but should this be required, usually identified by oscillation of the voltmeter,

1.Run the generator set on no-load and check that speed is correct and stable

2.Turn the STABILITY control potentiometer clockwise, then turn slowly anti-clockwise until the generator voltage starts to become unstable.

4.7LOAD TESTING

Warning ! During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

4.7.1AVR ADJUSTMENT

Having adjusted VOLTS and STABILITY during the initial startup procedure, other AVR control functions should not normally need adjustment.

If however, poor voltage regulation on-load or voltage collapse is experienced, refer to the following paragraphs on each function to a) check that the symptoms observed do indicate adjustment is necessary, and b) to make the adjustment correctly.

4.7.2 AVR potentiometer locations and adjusting

Different AVR has different potentiometer location .

CHAPTER 5
INSTALLATION - SECTION 2

5.1GENERAL

The extent of site installation will depend upon the generating set build, e.g. if the generator is installed in a canopied set with integral switchboards and circuit breaker, on site installation will be limited to connecting up the site load to the generating set output terminals . In this case reference should be made to the generating set manufacturer's instruction book and any pertinent local regulations. If the generator has been installed on a set without switchboard or circuit breaker the following points relating to connecting up the generator should be noted.

5.2GLANDING

The terminal box is most conveniently glanded on either the right or left hand side. Both panels are removable for drilling/punching to suit glands/or glanding boxes. If single core cables are taken through the terminal box side panel an insulated or non-magnetic gland plate should be fitted.

Incoming cables should be supported from either below or above the box level and at a sufficient distance from the centre line of the generating set so as to avoid a tight radius at the point of entry into the terminal box panel, and allow movement of the generator set on its anti-vibration mountings without excessive stress on the cable.

Before making final connections, test the insulation resistance of the windings. The AVR should be disconnected during this test.

A 500V Megger or similar instrument should be used. Should the insulation resistance be less than 5MΩ the windings must be dried out as detailed in the Service and Maintenance section of this manual.

When making connections to the terminals the incoming cable termination should be placed on top of the winding lead termination(s) and clamped with the nut provided.

Important ! To avoid the possibility of swarf entering any electrical components in the terminal box, panels must be removed for drilling.

5.3EARTHING

The neutral of the generator is not bonded to the generator frame as supplied from the factory. An earth terminal is provided inside the terminal box adjacent to the main terminals. Should it be required to operate with the neutral earthed a substantial earth conductor (normally equivalent to one half of the section of the line conductors) must be connected between the neutral and the earth terminal inside the terminal box. Additional earth terminals are provided on the generator feet. These should be already bonded to the generating set bedplate by the generating set builder, but will normally be required to be connected to the site earth system.

Caution ! Reference to local electricity regulations or safety rules should be made to ensure correctearthing procedures have been followed.

5.4PROTECTION

It is the responsibility of the end user and his contractors/subcontractors to ensure that the overall system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site location.

To enable the system designer to achieve the necessary protection and/or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made.

Warning ! Incorrect installation and/or protective systems can result in personal injury and/or equipment damage. Installers must be qualified to perform electrical installation work.

5.5COMMISSIONING

Ensure that all external cabling is correct and that all the generating set manufacturer's pre-running checks have been carried out before starting the set.

The generator AVR controls will have been adjusted during the generating set manufacturer's tests and should normally not require further adjustment.

Should malfunction occur during commissioning refer to Service and Maintenance section 'Fault Finding' procedure

SECTION 6
ACCESSORIES

Generator control accessories may be fitted, as an option, in the generator terminal box. If fitted at the time of supply, the wiring diagram(s) in the back of this book shows the connections. When the options are supplied separately, fitting instructions are provided with the accessory.

The following matrix indicates availability of accessories with the differing AVRs.

6.1 REMOTE VOLTAGE ADJUST (ALL AVR TYPES)

A remote voltage adjust (hand trimmer) can be fitted.

6.2 PARALLEL OPERATION

Understanding of the following notes on parallel operation is useful before attempting the fitting or setting of the droop kit accessory. When operating in parallel with other generators or the mains, it is essential that the phase sequence of the incoming generator matches that of the busbar and also that all of the following conditions are met before the circuit breaker of the incoming generator is closed on to the busbar (or operational generator).

1. Frequency must match within close limits.

2. Voltages must match within close limits.

3. Phase angle of voltages must match within close limits.

A variety of techniques, varying from simple synchronising lamps to fully automatic synchronisers, can be used to ensure these conditions are met.

Important ! Failure to meet conditions 1, 2, and 3 when closing the cricuit breaker, will generate excessive mechanical and electrical stresses, resulting in equipment damage.

Once connected in parallel a minimum instrumentation level per generator of voltmeter, ammeter, wattmeter (measuring total power per generator), and frequency meter is required in order to adjust the engine and generator controls to share kW in relation to engine ratings and kVAr in relation to generator ratings.

It is important to recognise that :

1. True kW are derived from the engine, and speed governor characteristics determine the kW sharing between sets and

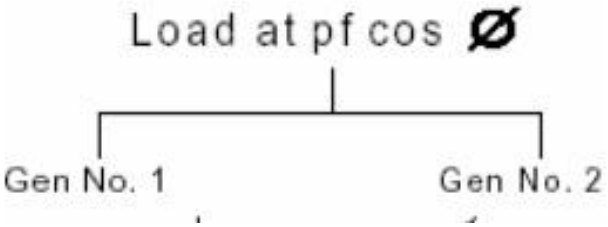
2. kVA are derived from the generator, and excitation control characteristics determine the kVAr sharing. Reference should be made to the generating set manufacturer's instructions for setting the governor controls.

6.2.1 DROOP

The most commonly used method of kVAr sharing is to create a generator voltage characteristic which falls with decreasing power factor (increasing kVAr). This is achieved with a current transformer (C.T.) which provides a signal dependent on current phase angle (i.e. power factor) to theAVR.

The current transformer has a burden resistor on the AVR board, and a percentage of the burden resistor voltage is summed into the AVR circuit. Increasing droop is obtained by turning the DROOP control potentiometer clockwise.

The diagrams below indicate the effect of droop in a simple two generator system : -



Generally 5% droop at full load current zero p.f. is sufficient to ensure kVAr sharing.

If the droop accessory has been supplied with the generator it will have been tested to ensure correct polarity and set to a nominal level of droop. The final level of droop will be set during generating set commissioning.

The following setting procedure will be found to be helpful.

6.2.1.1 SETTING PROCEDURE

Depending upon available load the following settings should be used - all are based on rated current level.

0.8 P.F. LOAD (at full load current) SET DROOP TO 3%
Zero P.F. LOAD (at full load current) SET DROOP TO 5%

Setting the droop with low power factor load is the most accurate. Run each generator as a single unit at rated frequency or rated frequency + 4% depending upon type of governor and nominal voltage. Apply available load to rated current of the generator. Adjust 'DROOP' control potentiometer to give droop in line with above table. Clockwise rotation increases amount of droop.

Note 1)

Reverse polarity of the C.T. will raise the generator voltage with load. The polarities S1-S2 shown on the wiring diagrams are correct for clockwise rotation of the generator looking at the drive end. Reversed rotation requires S1-S2 to be reversed.

Note 2)

The most important aspect is to set all generators equal. The precise level of droop is less critical.

Note 3)
A generator operated as a single unit with a droop circuit set at rated load 0.8 power factor is unable to maintain the usual +/-0.5% regulation. A shorting switch can be connected across S1-S2 to restore regulation for single running.

Important !LOSS OF FUEL to an engine can cause its generator to motor with consequent damage to the generator winding. Reverse power relays should be fitted to trip main circuit breaker.LOSS OF EXCITATION to the generator can result in large current oscillations with consequent damage to generator winding. Excitation loss detection equipment should be fitted on trip main circuit breaker.

6.2.2 ASTATIC CONTROL

The 'droop' current transformer can be used in a connection arrangement which enables the norma regulation of the generator to be maintained when operating in parallel.This feature is only supplied from the factory as a fitted droop kit,

Important ! When using this connection arrangement a shorting switch is required across each C.T. burden .The switch must be closed a) when the genset is not running and b) when a generating set is selected for single running.

Should the generator be required to be converted from standard droop to 'astatic' control, diagrams are available on request.

The setting procedure is exactly the same as for DROOP.

SECTION 7
SERVICE AND MAINTENANCE

As part of routine maintenance procedures, periodic attention to winding condition (particularly when generators have been idle for a long period) and bearings is recommended.

7.1 WINDING CONDITION

Warning !

Service and fault finding procedures present hazards which can result in severe personal injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures. Ensure engine starting circuits are disabled before commencing service or maintenance procedures. Isolate any anti-condensation heater supply.

Guidance of Typical Insulation Resistance [IR] Values

The following is offered as general information about IR values and is aimed at providing guidance about the typical IR values for generators from new through to the point of refurbishment.

New Machines

The generators Insulation Resistance, along with many other critical factors, will have been measured during the alternator manufacturing process. The generator will have been transported with an appropriate packaging suitable for the method of delivery to the Generating Set assemblers works. Where we expect it to be stored in a suitable location protected from adverse environmental conditions.

However, absolute assurance that the generator will arrive at the Gen-set production line with IR values still at the factory test levels of above 100 MΩ cannot be guaranteed.

At Generating Set Manufacturers Works

The generator should have been transported and stored such that it will be delivered to the assembly area in a clean dry condition. If held in appropriate storage conditions the generator IR value should typically be 25 MΩ.

If the unused/new generators IR values fall below 10 MΩthen a drying out procedure should be implemented by one of the processes outlined below before being despatched to the end customer's site.

Generators in Service

Whilst It is known that a generator will give reliable service with an IR value of just 1.0 MΩ. For a relatively new generator to be so low it must have been subjected to inappropriate operating or storage conditions.

Any temporarily reduction in IR values can be restored to expected values by following one of the drying out procedures.

7.1.1 WINDING CONDITION ASSESSMENT

Caution ! The AVR should be disconnected and the Resistance Temperature Detector (R.T.D.) leads grounded during this test.

The condition of the windings can be assessed by measurement of insulation resistance [IR] between phase to phase, and phase to earth.

Measurement of winding insulation should be carried out : -

1.As part of a periodic maintenance plan.

2.After prolonged periods of shutdown.

3.When low insulation is suspected, e.g. damp or wet windings.

Take care when dealing with windings that are suspected of being excessively damp or dirty. The initial measurement of the [IR] Insulation Resistance should be established using a low voltage (500V) megger type instrument. If manually powered the handle should initially be turned slowly so that the full test voltage will not be applied, and only applied for long enough to very quickly assess the situation if low values are suspected or immediately indicated.

Full megger tests or any other form of high voltage test should not be applied until the windings have been dried out and if necessary cleaned.

Procedure for Insulation Testing

Disconnect all electronic components, AVR, electronic protection equipment etc. Ground the [RTD's] Resistance Temperature Detection devices if fitted. Short out the diodes on the rotating diode assembly. Be aware of all components connected to the system under test that could cause false readings or be damaged by the test voltage.

Carry out the insulation test in accordance with the ‘operating instructions for the test equipment.

The measured value of insulation resistance for all windings to earth and phase to phase should be compared with the guidance given above for the various 'life stages' of a generator. The minimum acceptable value must be greater than 1.0 MΩ.

If low winding insulation is confirmed use one or more of the methods, given below, for drying the winding should be carried out.

1. METHODS OF DRYING OUT GENERATORS

Cold Run
Consider a good condition generator that has not been running for some time, and has been standing in damp, humid conditions.

It is possible that simply running the gen set unexcited – AVR terminals K1 K2 open circuit - for a period of say 10 minutes will sufficiently dry the surface of the windings and raise the IR sufficiently, to greater than 1.0 MΩ , and so allow the unit to be put into service.

Blown Air Drying

Remove the covers from all apertures to allow the escape of the water-laden air. During drying, air must be able to flow freely through the generator in order to carry off the moisture.

Direct hot air from two electrical fan heaters of around 1 – 3 kW into the generator air inlet apertures. Ensure the heat source is at least 300mm away from the windings to avoid over heating and damage to the insulation.

Apply the heat and plot the insulation value at half hourly intervals. The process complete when the parameters covered in the section entitled, ‘Typical Drying Out Curve’, are met.

Remove the heaters, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anticondensation heaters are energised, and retest prior to running.

Short Circuit Method

NOTE: This process should only be performed by a competent engineer familiar with safe operating practices within and around generator sets of the type in question.

Ensure the generator is safe to work on, initiate all mechanical and electrical safety procedures pertaining to the genset and the site.

Bolt a short circuit of adequate current carrying capacity, across the main terminals of the generator. The shorting link should be capable of taking full load current.

Disconnect the cables from terminals “F+” and “F-” of the AVR.

Connect a variable DCsupply to the “F+” (positive) and “F-” (negative) field cables. TheDCsupply must be able to provide a current up to 2.0 Amp at 0 - 24Volts

Position a suitable ac ammeter to measure the shorting link current.

Set the DC SUPPLY voltage to zero and start the generating set. Slowly increase the dc voltage to pass current through the exciter field winding. As the excitation current increases, so the stator current in the shorting link will increase. This stator output current level must be monitored, and not allowed to exceed 80% of the generators rated output current.

After every 30 minutes of this exercise:

Stop the generator and switch off the separate excitation supply, and measure and record the stator winding IR values, and plot the results. The resulting graph should be compared with the classic shaped graph. This drying out procedure is complete when the parameters covered in the section entitled 'Typical Drying Out Curve' are met.

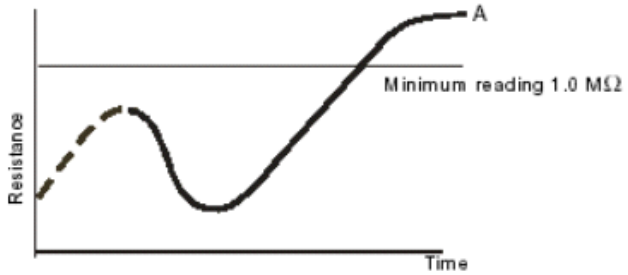
Once the Insulation Resistance is raised to an acceptable level - minimum value 1.0 MΩ the DC SUPPLY may be removed and the exciter field leads “F+” and “F-” re-connected to their terminals on the AVR.

If the set is not to be run immediately ensure that the anticondensation heaters are energised, and retest Insulation Resistance prior to running.

Important ! The short circuit must not be applied with the AVR connected in circuit. Current in excess of the rated generator current will cause damage to the windings.

TYPICAL DRYING OUT CURVE

Whichever method is used to dry out the generator the resistance should be measured every half-hour and a curve plotted as shown.



The illustration shows a typical curve for a machine that has absorbed a considerable amount of moisture. The curve indicates a temporary increase in resistance, a fall and then a gradual rise to a steady state. Point ‘A’, the steady state, must be greater than 1.0 MΩ. (If the windings are only slightly damp the dotted portion of the curve may not appear).

For general guidance expect that at least one hour to reach point 'A' will be :
Drying should be continued after point “A” has been reached for at least one hour.

It should be noted that as winding temperature increases, values of insulation resistance may significantly reduce. Therefore, the reference values for insulation resistance can only be established with windings at a temperature of approximately 20°C.

If the IR value remains below 1.0 MΩ, even after the above drying methods have been properly conducted, then a Polarisation Index test [PI] should be carried out.

If the minimum value of 1.0 MΩ for all components cannot beachieved rewinding or refurbishment ofthe generator will be necessary.

The generator must not be put into service until the minimum values can be achieved.After drying out, the insulation resistances should be rechecked to verify minimum resistances quoted above are achieved.
On re-testing it is recommended that the main stator insulation resistance is checked as follows :-

Separate the neutral leads

Ground V and W phase and megger U phase to ground
Ground U and W phase and megger V phase to ground
Ground U and V phase and megger W phase to ground

If the minimum value of 1.0MΩ is not obtained, drying out must be continued and the test repeated.

.7.2 BEARING

All bearings are supplied sealed for life and are, therefore, not regreasable.
Important ! The life of a bearing in service is subject to the working conditions and the environment.

Important ! Long stationary periods in an environment where there is vibration can cause false brinnelling which puts flats on the ball and grooves on the races.

Important ! High axial vibration from the engine or misalignment of the set will stress the bearing.
Important !Very humid atmospheres or wet conditions can emulsify the grease and cause corrosion.

We recommend that the health of the bearings be monitored, using ‘spike energy’ vibration monitoring equipment. This will allow the timely replacement of bearings, that exhibit a deteriorating trend, during a major engine overhaul.

7.3 TROUBLESHOOTING

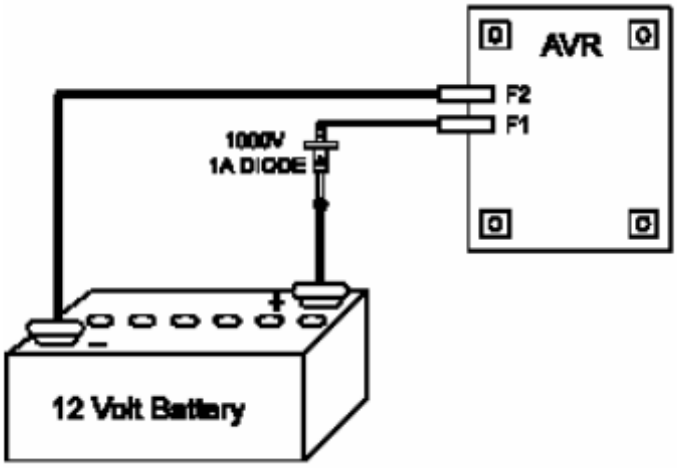
7.3.1 ALTERNATOR CHECK
7.3.2 RESIDUAL VOLTAGE CHECK

With the generator set stationary remove AVR access cover and leads F+ and F- from the AVR.

Start the set and measure voltage across AVR terminals
AVC63-2.5 or AVR63-4AV :3-4 on SX440 AVR or SX321 AVR :or P2-P3 If the measured voltage wasabove 5V the generator should operate normally.

If the measured voltage was under 5V follow the procedure below.
7.3.3 FIELD FLASHING THE GENERATOR
Using a 12 volt d. c. battery as a supply clip leads from battery negative to AVR terminal F-, and from battery positive through a diode to AVR terminal F+. See the photo below :.

Important ! A diode must be used as shown below to ensure the AVR is not damaged.



Important ! If the generating set battery is used for field flashing the generator main stator neutral must be disconnected from earth.

Restart the set and note output voltage from main stator, which should be approximately nominal voltage

Stop the set and unclip battery supply from terminals F+and F-. Restart the set. The generator should now operate normally. If no voltage build-up is obtained it can be assumed a fault exists in either the generator or the AVR circuits. Follow the SEPARATE EXCITATION TEST PROCEDURE to check generator windings, rotating diodes and AVR. Refer to subsection 7.5.

7.4 SEPARATE EXCITATION TEST PROCEDURE

The generator windings, diode assembly and AVR can be checked using the appropriate following section.

7.4.1 GENERATOR WINDINGS, ROTATING DIODES

Important ! The resistances quoted apply to a standard winding. For generators having windings or voltages other than those specified refer to factory for details. Ensure all disconnected leads are

Important ! Incorrect speed setting will give proportional error in voltage output.

CHECKING GENERATOR WINDINGS AND ROTATING DIODES

This procedure is carried out with leads F+ and F- disconnected at the AVR or transformer control rectifier bridge and using a 12 volt d.c. supply to leads F+ andF-.
Start the set and run at rated speed.
Measure the voltages at the main output terminals U, V and W. If voltages are balanced and within +/-10%of the generator nominal voltage

7.5.1.1BALANCED MAIN TERMINAL VOLTAGES

Iif all voltages are balanced within 1% at the main terminals, it can be assumed that all exciter windings,main windings and main rotating diodes are in good order, and the fault is in the AVR or transformer control.

If voltages are balanced but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to identify :-

Rectifier Diodes

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions.

On an electronic digital meter a healthy diode will give a low reading in one direction, and a high reading in the other.

Replacement of Faulty Diodes

The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be over tightened. The recommended torque tightening is 4.06 - 4.74Nm (36-42lb in).

Surge Suppressor

The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarised and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective this will be visible by inspection, since it will normally fail to short circuit and show signs of disintegration. Replace if faulty.

Main Excitation Windings

If after establishing and correcting any fault on the rectifier assembly the output is still low whenseparately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), as the fault must be in one of these

windings. The exciter stator resistance is measured across leads F+ and F-. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

Resistance values should be within +/-10% of the values

7.4.1.2 UNBALANCED MAIN TERMINAL VOLTAGES

If voltages are unbalanced, this indicates a fault on the main stator winding or main cables to the circuit breaker.
NOTE : Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied. Disconnect the main cables and separate the winding leads U1-U2, U5-U6, V1-V2, V5-V6, W1-W2, W5-W6 to isolate each winding section. (U1-L1, U2-L4 on single phase generators).
Each section resistance - values should be referred to the factory
Measure insulation resistance between sections and each section to earth.
Unbalanced or incorrect winding resistances and/or low insulation resistances to earth indicate rewinding of the stator will be necessary.

7.4.2 REMOVAL AND REPLACEMENT OF COMPONENT ASSEMBLIES
7.4.2.1REMOVAL OF BEARINGS

Important ! Position the main rotor so that a full pole face of the main rotor core is at the bottom of the stator bore.

NOTE: Removal of the bearings may be effected either after the rotor assembly has been removed

REMOVAL OF BEARINGS :

The bearing(s) are a press fit and can be removed from the shaft with 3 leg or 2 leg manual or hydraulic bearing pullers.

SINGLE BEARING ONLY : Before trying to pull off the bearing remove the small circlip retaining it.

When fitting new bearings use a bearing heater to expand the bearing before fitting to the shaft. Tap the bearing into place ensuring that it contacts the shoulder on the shaft.

Refit the retaining circlip on single bearing generators.

Environment :

Work procedures

Preparation of bearings for assembly

7.4.2.2 REMOVAL OF THE ROTOR ASSEMBLY

DOUBLE BEARING GENERATOR

1.Remove screws holding the sheet metal cover around the adaptor at the drive end and remove the cover.

2.Remove the bolts holding the adaptor to the endbracket at the drive end.

3.Tap off the adaptor. It may be preferred to sling the adaptor first depending on its size and weight.
4.Remove the screens and louvres (if fitted) at each side on the drive end.

5.Now ensure that the rotor is positioned with a full pole face at the bottom centre line. This is to avoid damage to the bearing exciter, or rotor winding, by limiting the possible rotor downward movement to the air gap length.

6.Remove 6 bolts holding drive endbracket onto adaptor ring DE. The boltheads face towards the non-drive end. The top bolt passes through the centre of the lifting lug.

7.Tap the drive endbracket away from the adaptor ring DE and withdraw the endbracket.

8.Ensure the rotor is supported at the drive end on a sling.

9.Tap the rotor from the non-drive end to push the bearing clear of the endbracket and its position within an 'O' ring.

10.Continue to push the rotor out of the stator bore, gradually working the sling along the rotor as it is withdrawn, to ensure that it is fully supported all the time.

SINGLE BEARING GENERATOR
1.Remove the screws, screens and louvres (if fitted) at each side on drive end adaptor.
2 Ensure the rotor is supported at drive end on a sling.
3Tap the rotor from the non-drive end to push the bearing clear of the endbracket and its position within an 'O' ring.
4.Continue to push the rotor out of the stator bore, gradually working the sling along the rotor as it is withdrawn, to ensure that it is fully supported at all times.
5Replacement of rotor assemblies is a reversal of the procedures above.

Caution ! When major components have been replaced, ensure that all covers and guards are securely fitted, before the generator is put into service.

7.5 RETURNING TO SERVICE

After rectification of any faults found, remove all test connections and reconnect all control system leads. Restart the set and adjust VOLTS control potentiometer on AVR controlled generators by slowly turning clockwise until rated voltage is obtained. Refit all terminal box covers/access covers and reconnect heater supply.

Caution ! Failure to refit all guards, access covers and terminal box covers can result in personal injury of death.

SECTION 8
SPARES AND AFTER-SALE SERVICE

8.1 Service parts are conveniently packaged for easy identification. Genuine parts may be recognized by the spare part name.

8.2 AFTER-SALE SERVICE

A full technical advice and on-site service facility is available from our Service Department at factory. A repair facility is also available at our factory.

A.C. GENERATOR WARRANTY PERIOD

A.C. Generators

In respect of a.c. generators the Warranty Period is eighteen months from the date when the goods have been notified as ready for despatch or twelve months from the date of first commissioning (whichever is the shorter period).

DEFECTS AFTER DELIVERY

We will make good by repair or, at our option, by the supply of a replacement, any fault which under proper use appears in the goods within the period , and is found on examination by us to be solely due to defective material and workmanship; provided that the defective part is promptly returned, carriage paid, with all identification numbers and marks intact, or our works or, if appropriate to the Dealer who supplied the goods.

We shall not be liable for any expenses which may be incurred in removing or replacing any part sent to us for inspection or in fitting any replacement supplied by us. We shall be under no liability for defects in any goods which have not been properly installed in accordance with factory recommended installation practices as detailed in the publications factory Installation , Service and Maintenance Manual' and f a c t o r y Application Guidelines', or which have been improperly stored or which have been repaired, adjusted or altered by any person except ourselves or our authorised agents, or in any second-hand goods, proprietary articles or goods not of our own manufacture although supplied by us, such articles and goods being covered by the warranty (if any) given by the separate manufacturers.

Any claim under this clause must contain fully particulars of the alleged defect, the description of the goods, the date of purchase, and the name and address of the Vendor, the Serial Number (as shown on the manufacturers identification plate) or for Spares the order reference under which the goods were supplied.

Our judgement in all cases of claims shall be final and conclusive and the claimant shall accept our decision on all questions as to defects and the exchange of a part or parts.

Our liability shall be fully discharged by either repair or replacement as above, and in any event shall not exceed the current list price of the defective goods.

Our liability under this clause shall be in lieu of any warranty or condition implied by law as to the quality or fitness for any particular purpose of the goods, and save as expressly provided in this clause we shall not be under any liability, whether in contract, tort or otherwise, in respect of defects in goods delivered or for any injury, damages or loss resulting from such defects or from any work undone in connection therewith.

MACHINE SERIAL NUMBER

SX460 AUTOMATIC VOLTAGE REGULATOR (AVR)

TECHNICAL SPECIFICATIONS

INPUT

Voltage	85-125 V or 170-250V , Jumper selectable
Frequency	50-60Hz nominal
Phase	1
Wire	2

OUTPUT

Voltage	Max.90Vdc @ 207Vac Input
Current	Continuous 4A
	Transient6A for10secs.
FieldResistance	Min.15ohms

REGULATION

±1.0% (with4% engine governing)

EXTERNAL VOLTAGE ADJUSTMENT

±5% with1Kohm 1 watt trimmer

BUILD UP VOLTAGE

3.5Vac @ AVR terminal

UNDER FREQUENCY PROTECTION

Set point 93% ratedfrequency

Slop 170% down to30Hz

THERMAL DRIFT

1% per 40℃ change inAVR ambient

ENVIRONMENT

Vibration	20-100Hz 50mm/sec
	100Hz-2kHz 3.3g
RelativeHumidity	0-60 ℃ 95％
Operating Temperature	-40℃ to+70 ℃
Storage Temperature	-55℃ to+80 ℃

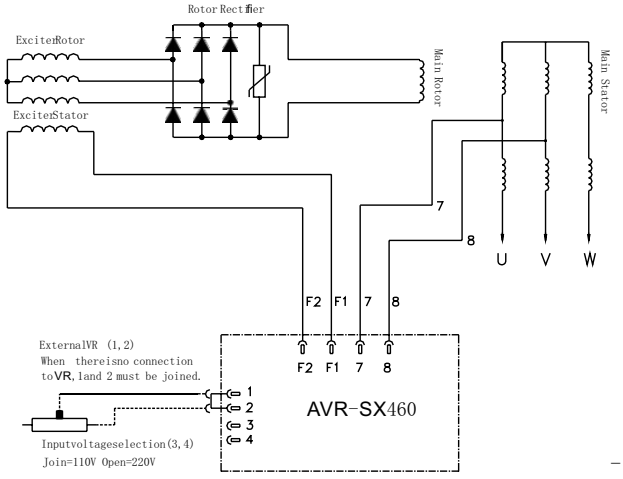
DIMENSIONS

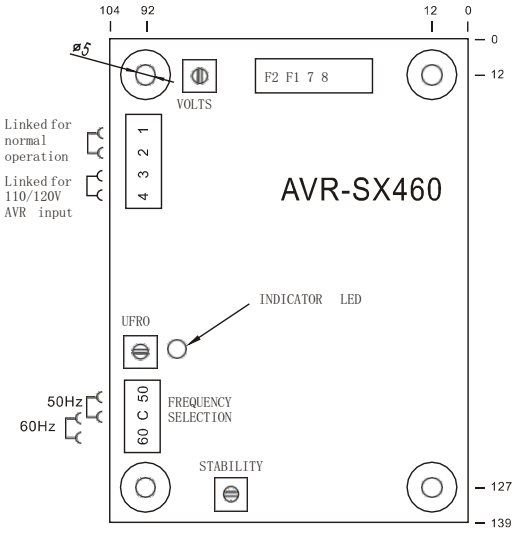
Outline Dimensions	104(W) ×139(H) ×39(D) (mm)
InstallationSize	80(W)×115(H) (mm) ×Φ5-4
Weight	300g
Color	Black

SUMMARY OF AVR CONTROLS

CONTROL	FUNCTION	DIRECTION
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASE STABILITYOR DAMPING EFFECT
UFRO	TO SET UNDER FREQUENCY ROLL OFF KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY

WIRING AND DIAGRAM





SX440 AUTOMATIC VOLTAGE REGULATOR (AVR)

TECHNICAL SPECIFICATIONS

SENSING INPUT

Voltage 170-250V (AC, Maximum)

Frequency 50-60 Hz nominal

Phase 2

Wire 2

OUTPUT

Voltage Max. 90Vdc @ 207Vac Input

Current Continuous 4A
Transient 6A for 10secs.

Field Resistance Min. 15 ohm

REGULATION

±1.0% (with 4% engine governing)

THERMAL DRIFT

1% for 40℃ change in AVR ambient

UNIT POWER DISSIPATION

12 watts maximum

TYPICAL SYSTEM RESPONSE

Field current to 90% 80ms

Machine Volts to 97% 300ms

EXTERNAL VOLTAGE ADJUSTMENT

±10% with 1K ohm 1 watt trimmer

UNDER FREQUENCY PROTECTION

Set point 95% rated frequency

Slop 170% down to 30Hz

BUILD UP VOLTAGE

3.5 Vac @ AVR terminal

ANALOGUE INPUT

Sensitivity ±1V for ±3% Generator Volts

QUADRATURE DROOP INPUT

10 ohms burden

Max. sensitivity 0.07A for 5% droop (PF=0)

ENVIRONMENT

Vibration 20-100Hz 50mm/sec
100Hz-2kHz 3.3g

Relative Humidity 0-60 ℃ 95％

Operating Temperature -40℃ to +70 ℃

Storage Temperature -55℃ to +80 ℃

DIMENSIONS

Outline Dimensions 140(W) ×155(H) ×39(D) (mm)

Installation Size 115(W) ×130(H) (mm) ×Φ5-4

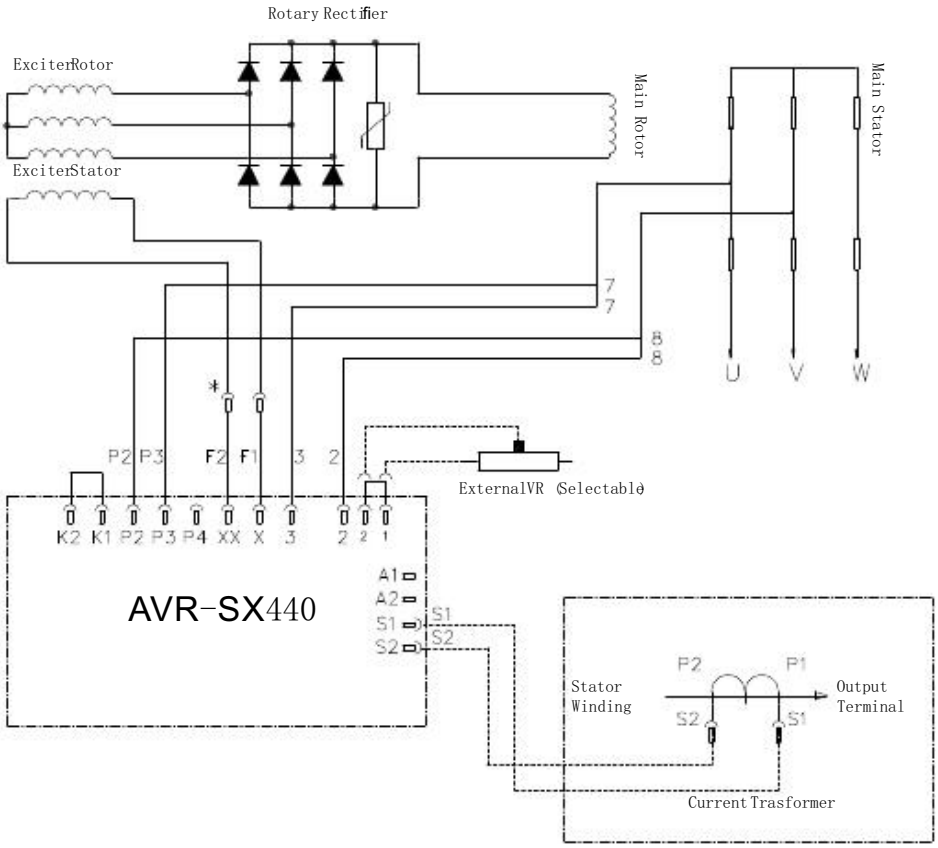
Weight 430g

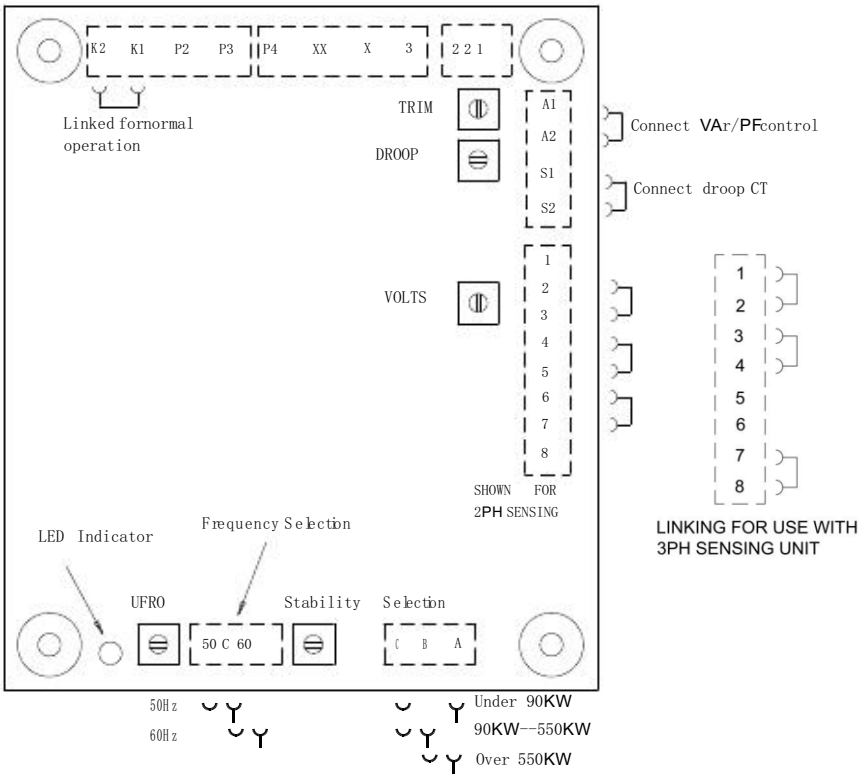
Color Black

SUMMARY OF AVR CONTROLS

CONTROL	FUNCTION	DIRECTION
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASES THE DAMPING EFFECT
UFRO	TO SET THE UFRO KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY
DROOP	TO SET THE GENERATOR DROOP TO 5% AT FULL LOAD	CLOCKWISE INCREASES THE DROOP
TRIM	TO MATCH AVR INPUT TO ACCESSORY OUTPUT	ALLOWS THE ACCESSORY MORE CONTROL OVER AVR

WIRING AND DIAGRAM





KR440 AUTOMATIC VOLTAGE REGULATOR (AVR)

TECHNICAL SPECIFICATIONS

SENSING INPUT

Voltage 170-250V (AC, Maximum)

Frequency 50-60 Hz nominal

Phase 2

Wire 2

OUTPUT

Voltage Max.90Vdc @ 207Vac Input

Current Continuous 4A
Transient6A for10secs.

Field Resistance Min. 15 ohm

REGULATION

±1.0% (with4% engine governing)

THERMAL DRIFT

1% for40℃ change in AVR ambient

UNIT POWER DISSIPATION

12 watts maximum

TYPICAL SYSTEM RESPONSE

Field current to 90% 80ms

Machine Volts to 97% 300ms

EXTERNAL VOLTAGE ADJUSTMENT

±10% with1K ohm 1 watt trimmer

UNDER FREQUENCY PROTECTION

Set point 95% rated frequency

Slop 170% down to 30Hz

BUILD UP VOLTAGE

3.5Vac @ AVR terminal

ANALOGUE INPUT

Sensitivity ±1V for±3% Generator Volts

QUADRATURE DROOP INPUT

10 ohms burden

Max. sensitivity 0.07A for5% droop (PF=0)

ENVIRONMENT

Vibration 20-100Hz 50mm/sec
100Hz-2kHz 3.3g

Relative Humidity 0-60 ℃ 95％

Operating Temperature -40℃ to+70 ℃

Storage Temperature -55℃ to+80 ℃

DIMENSIONS

Outline Dimensions 140(W) ×155(H) ×39(D) (mm)

Installation Size 115(W) ×130(H) (mm) ×Φ5-4

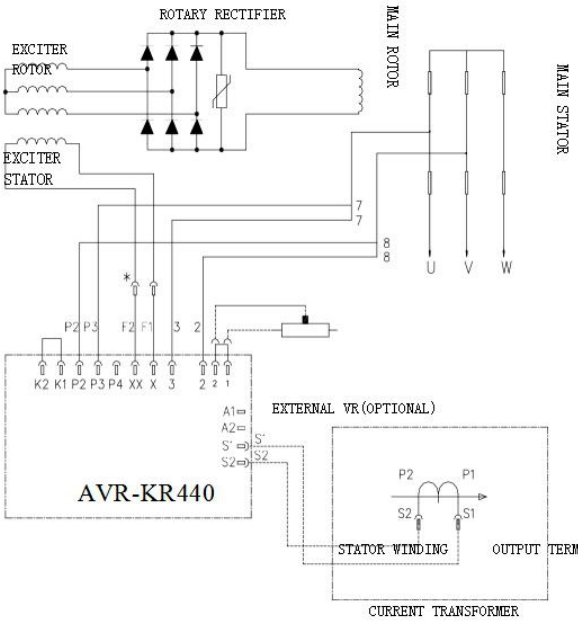
Weight 430g

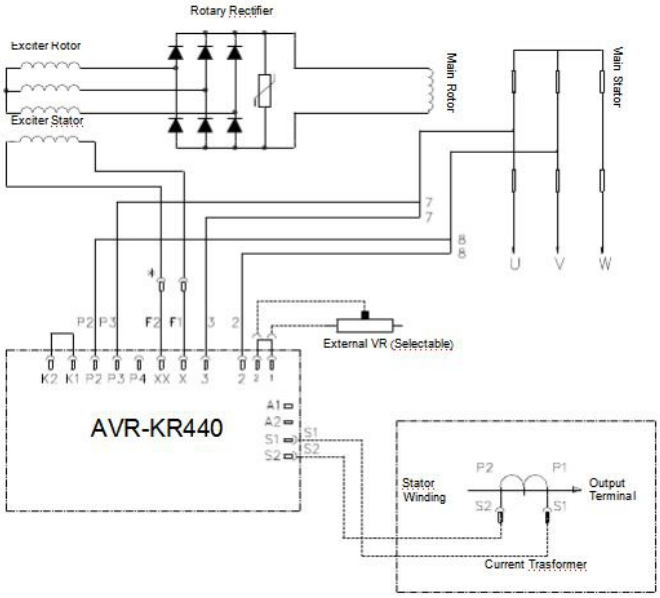
Color Black

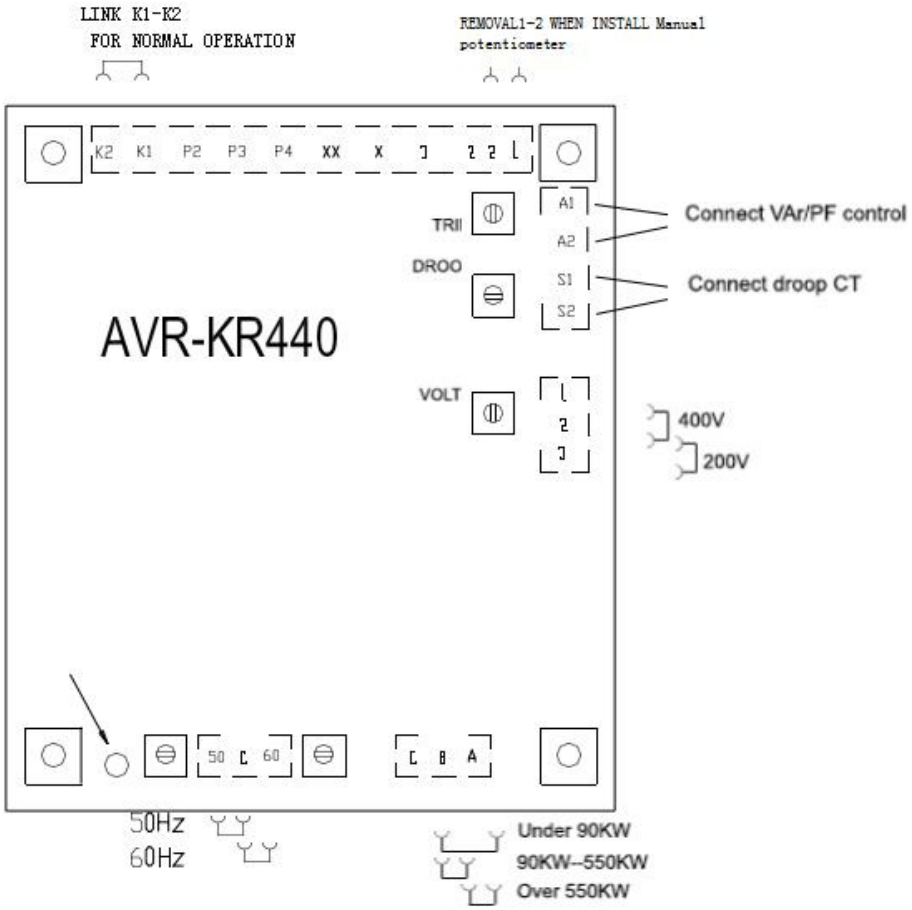
SUMMARY OF AVR CONTROLS

CONTROL	FUNCTION	DIRECTION
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASES THE DAMPING EFFECT
UFRO	TO SET THE UFRO KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY
DROOP	TO SET THE GENERATOR DROOP TO 5% AT FULL LOAD	CLOCKWISE INCREASES THE DROOP
TRIM	TO MATCH AVR INPUT TO ACCESSORY OUTPUT	ALLOWS THE ACCESSORY MORE CONTROL OVER AVR

WIRING AND DIAGRAM







AS440 AUTOMATIC VOLTAGE REGULATOR (AVR)

TECHNICAL SPECIFICATIONS

SENSING INPUT

Voltage 100-130Vac, 170-264Vac

Frequency 50-60Hz nominal

Phase 2

POWER INPUT

Voltage 100-264Vac 1 Phase

Frequency 50-60Hz

OUTPUT

Voltage Max.82Vdc @ 200Vac Input

Current Continuous 4A
Transient7.5A for10secs.

F ieldResistance Min.15 ohm (Min.10ohm when input voltageislessthan 175Vac)

REGULATION

±1.0% (with4% engine governing)

UNDER FREQUENCY PROTECTION

Set point 94-98%Hz

EXTERNAL VOLTAGE ADJUSTMENT

±10% with1K ohm 1 watttrimmer

Increasingresistancelowers voltage

BUILD UP VOLTAGE

4 Vac @ AVR terminal

QUADRATURE DROOP INPUT

10 ohms burden

Max. sensitivity 0.07A for5% droop (PF=0)

Max. Input 0.33A

ANALOGUE INPUT

Maximum input ±5Vdc

Sensitivity ±1V for5% Generator Volts

Inputresistance1k ohm

TYPICAL SYSTEM RESPONSE

AVR response 20 ms

Fieldcurrentto90% 80ms

Machine Voltsto97% 300ms

THERMAL DRIFT

0.02% per deg. C change inAVR ambient

OVER EXCITATION PROTECTION

Set point 65Vdc

Time delay 10-15 seconds (fixed)

ENVIRONMENT

Vibration 20-100Hz 50mm/sec
100Hz-2kHz 3.3g

RelativeHumidity 0-70 ℃ 95 %

Operating Temperature -40℃ to+70 ℃

Storage Temperature -55℃ to+80 ℃

DIMENSIONS

Outline Dimensions 104(W) ×139(H) ×39(D) (mm)

Installation Size 80(W)×115(H) (mm) ×Φ5-4

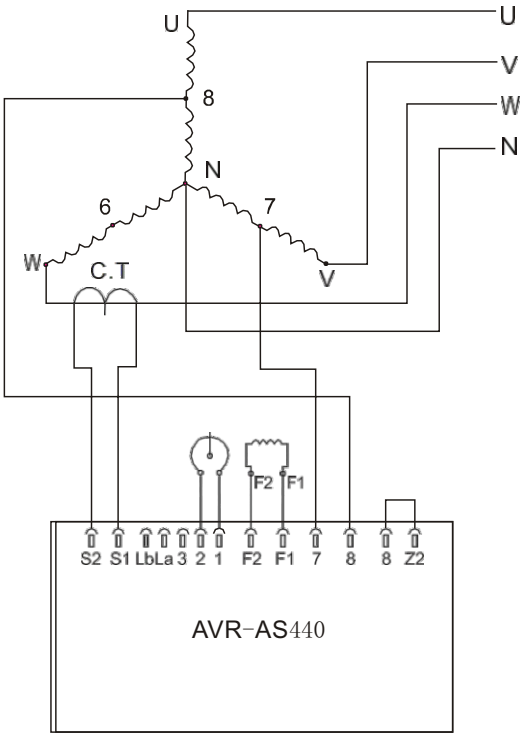
Weight 300g

Color Black

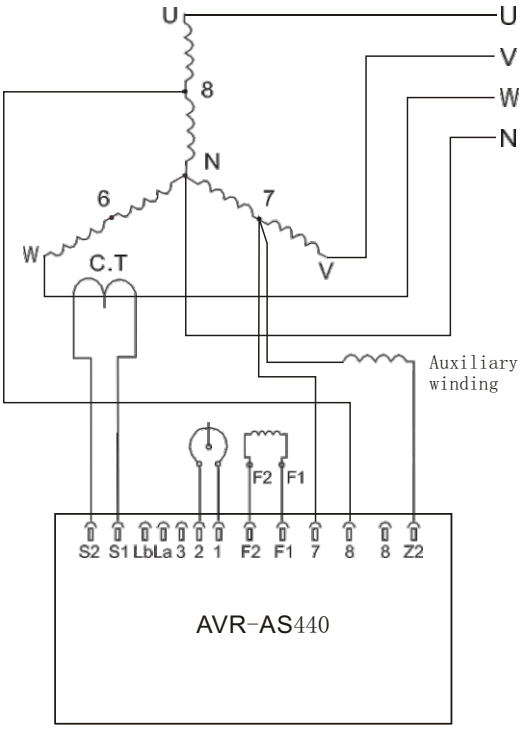
SUMMARY OF AVR CONTROLS

CONTROL	FUNCTION	DIRECTION
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASES THE DAMPING EFFECT
UFRO	TO SET THE UFRO KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY
DROOP	TO SET THE GENERATOR DROOP TO 5% AT FULL LOAD 0PF	CLOCKWISE INCREASES THE DROOP
TRIM	TO MATCH AVR INPUT TO ACCESSORY OUTPUT	ALLOWS THE ACCESSORY MORE CONTROL OVER AVR
EXC TRIP	TO SET OVER EXCITATIONTRIPCUT OFF LEVEL	CLOCKWISE INCREASES THE CUT OFF LEVEL

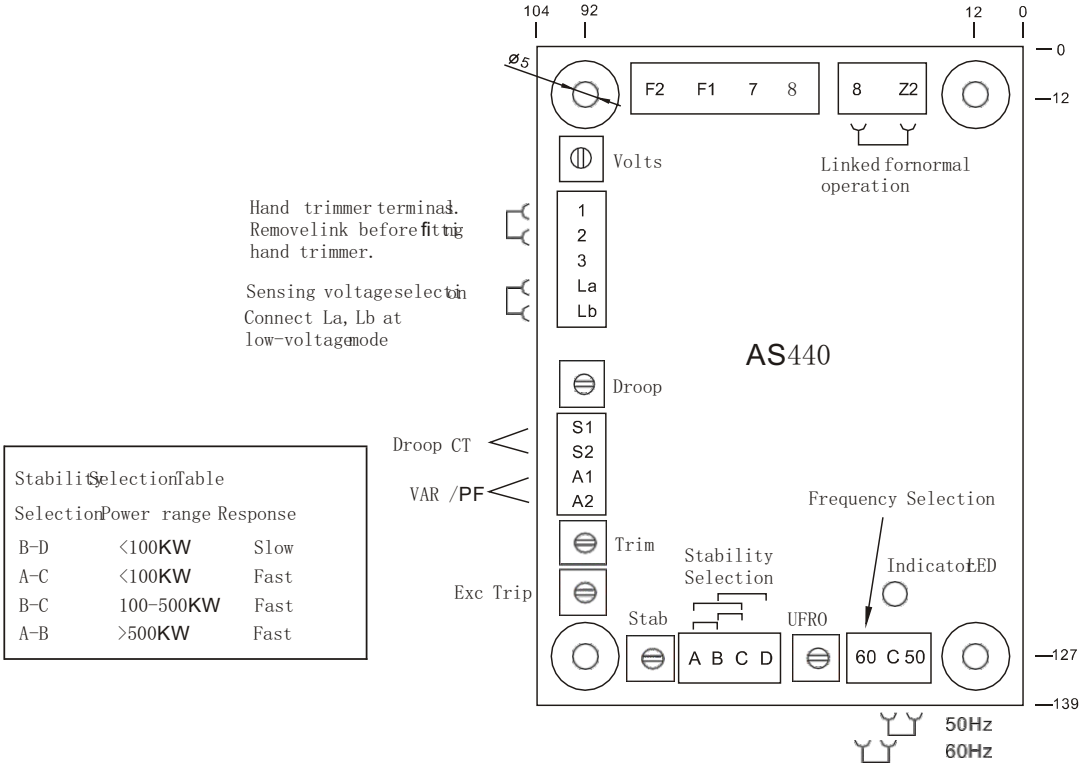
WIRING AND DIAGRAM



Wiring of generator with 12-line terminals, 240/415V Or 277/480V, 3 phases 4 wires



(Fundamental wave auxiliary winding)
Wiring of generator with 12-line terminals, 240/415V or 277/480V, 3 phases 4 wires



Stability Selection Table

Selection	Power range	Response
B-D	<100KW	Slow
A-C	<100KW	Fast
B-C	100-500KW	Fast
A-B	>500KW	Fast

MX341 AUTOMATIC VOLTAGE REGULATOR (AVR)

TECHNICAL SPECIFICATIONS

SENSING INPUT

Voltage	170-264V (AC, Maximum)
Frequency	50-60 Hz nominal
Phase	2
Wire	2

POWER INPUT (PMG)

Voltage	140-220Vac
Current	3A/Phase
Frequency	100-120 Hz
Phase	3
Wire	3

OUTPUT

Voltage	Max.120V dc
Current	Continuous 4A Transient 6A for 10secs.

Field Resistance Min.15 ohms

REGULATION

±1.0% (with 4% engine governing)

THERMAL DRIFT

1% for 40℃ change in AVR ambient

SOFT START RAMP TIME

3 sec.

TYPICAL SYSTEM RESPONSE

Field current to 90% 80ms

Machine Volts to 97% 300ms

EXTERNAL VOLTAGE ADJUSTMENT

±6% with 1K ohm 1 watt trimmer

UNDER FREQUENCY PROTECTION

Set point 95% rated frequency

U/f slop 30Hz down to 100-300%

ANALOGUE INPUT

Sensitivity ±1V for ±13% Generator Volts

QUADRATURE DROOP INPUT

10 ohms burden

Max. sensitivity 0.07A for 5% droop (PF=0)

OVER EXCITATION PROTECTION

Set point	75Vdc
Time delay	10 seconds (fixed)

ENVIRONMENT

Vibration	20-100Hz 50mm/sec 100Hz-2kHz 3.3g
Relative Humidity	0-60 ℃ 95%
Operating Temperature	-40℃ to +70℃
Storage Temperature	-55℃ to +80℃

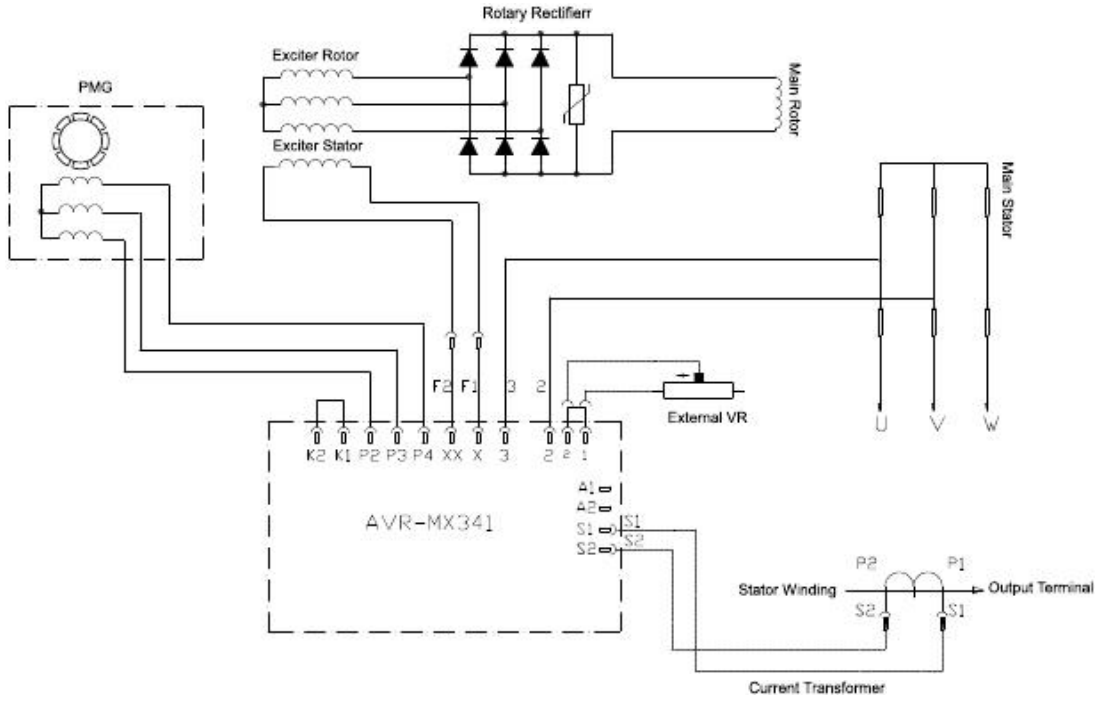
DIMENSIONS

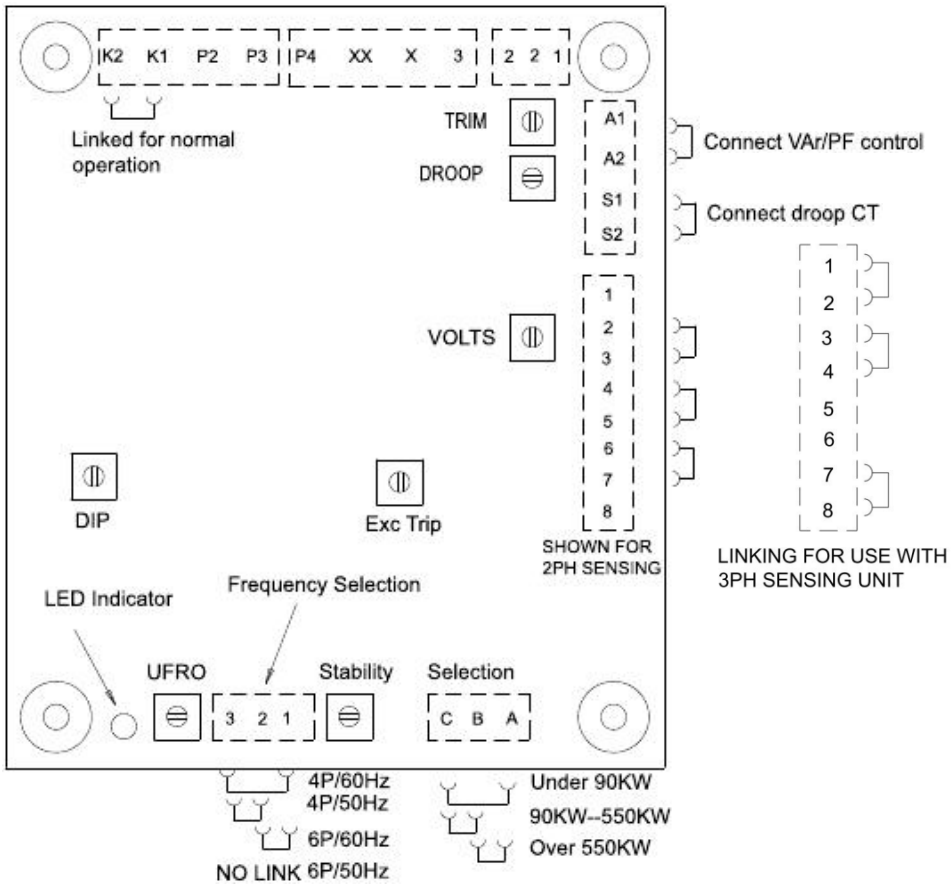
Outline Dimensions	140(W)×155(H)×39(D) (mm)
Installation Size	115(W)×130(H) (mm) ×Φ5-4
Weight	435g
Color	Black

SUMMARY OF AVR CONTROLS

CONTROL	FUNCTION	DIRECTION
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASES THE DAMPING EFFECT
UFRO	TO SET THE UFRO KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY
DROOP	TO SET THE GENERATOR DROOP TO 5% AT FULL LOAD0PF	CLOCKWISE INCREASES THE DROOP
TRIM	TO MATCH AVR INPUT TO ACCESSORY OUTPUT	ALLOWS THE ACCESSORY MORE CONTROL OVER AVR
EXC TRIP	TO SET OVER EXCITATION TRIP CUT OFF LEVEL	CLOCKWISE INCREASES THE CUT OFF LEVEL
DIP	TO SET U/f	CLOCKWISE INCREASES THE VALUE OF U/f

WIRING AND DIAGRAM





MX341B AUTOMATIC VOLTAGE REGULATOR (AVR)

TECHNICAL SPECIFICATIONS

SENSING INPUT

Voltage	170-264Vac, 340-528Vac Selectable
Frequency	50-60 Hz nominal
Phase	2
Wire	2

POWER INPUT (PMG)

Voltage	140-220Vac
Current	3A/Phase
Frequency	100-120 Hz
Phase	3
Wire	3

OUTPUT

Voltage	Max.120V dc
Current	Continuous 4A
	Transient 6A for 10secs.
Field Resistance	Min.15 ohms

REGULATION

±1.0% (with 4% engine governing)

THERMAL DRIFT

1% for 40℃ change in AVR ambient

SOFT START RAMP TIME

3 sec.

TYPICAL SYSTEM RESPONSE

Field current	to 90% 80ms
Machine Volts	to 97% 300ms

EXTERNAL VOLTAGE ADJUSTMENT

＞±6% with 1K ohm 1 watt trimmer

UNDER FREQUENCY PROTECTION

Set point	95% rated frequency
U/f slop	30Hz down to 100-300%

ANALOGUE INPUT

Sensitivity ±1V for ±13% Generator Volts

QUADRATURE DROOP INPUT

10 ohms burden

Max. sensitivity 0.07A for 5% droop (PF=0)

OVER EXCITATION PROTECTION

Set point	75Vdc
Time delay	10 seconds (fixed)

ENVIRONMENT

Vibration	20-100Hz 50mm/sec
	100Hz-2kHz 3.3g
Relative Humidity	0-60 ℃ 95%
Operating Temperature	-40℃ to +70℃
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Outline Dimensions	140(W)×155(H)×39(D) (mm)
Installation Size	115(W)×130(H) (mm) ×Φ5-4
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SUMMARY OF AVR CONTROLS

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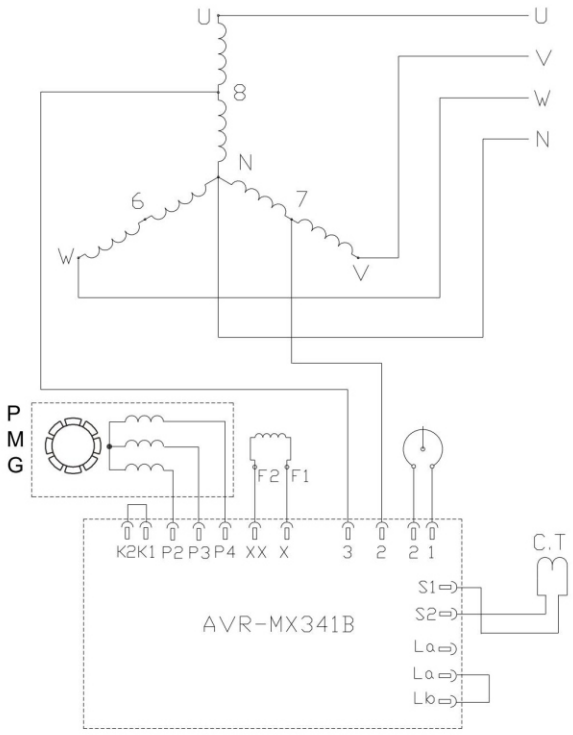
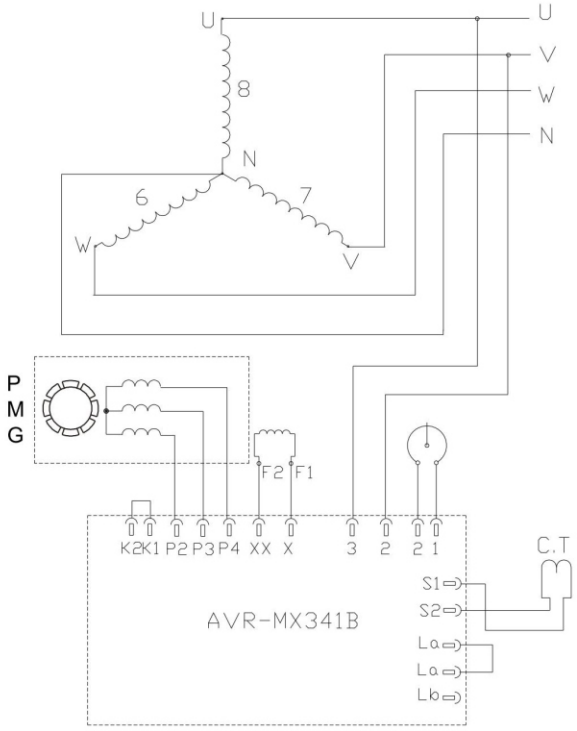
TRIM	TO MATCH AVR INPUT TO ACCESSORY OUTPUT	ALLOWS THE ACCESSORY MORE CONTROL OVER AVR
EXC TRIP	TO SET OVER EXCITATION TRIP CUT OFF LEVEL	CLOCKWISE INCREASES THE CUT OFF LEVEL
DIP	TO SET U/f	CLOCKWISE INCREASES THE VALUE OF U/f

WIRING AND DIAGRAM



Wiring of generator with 12-line terminals, 240/415V or 277/480V, 3 phases 4 wires



Wiring of generator with 6-line terminals, 240/415V, 3 phases 4 wires

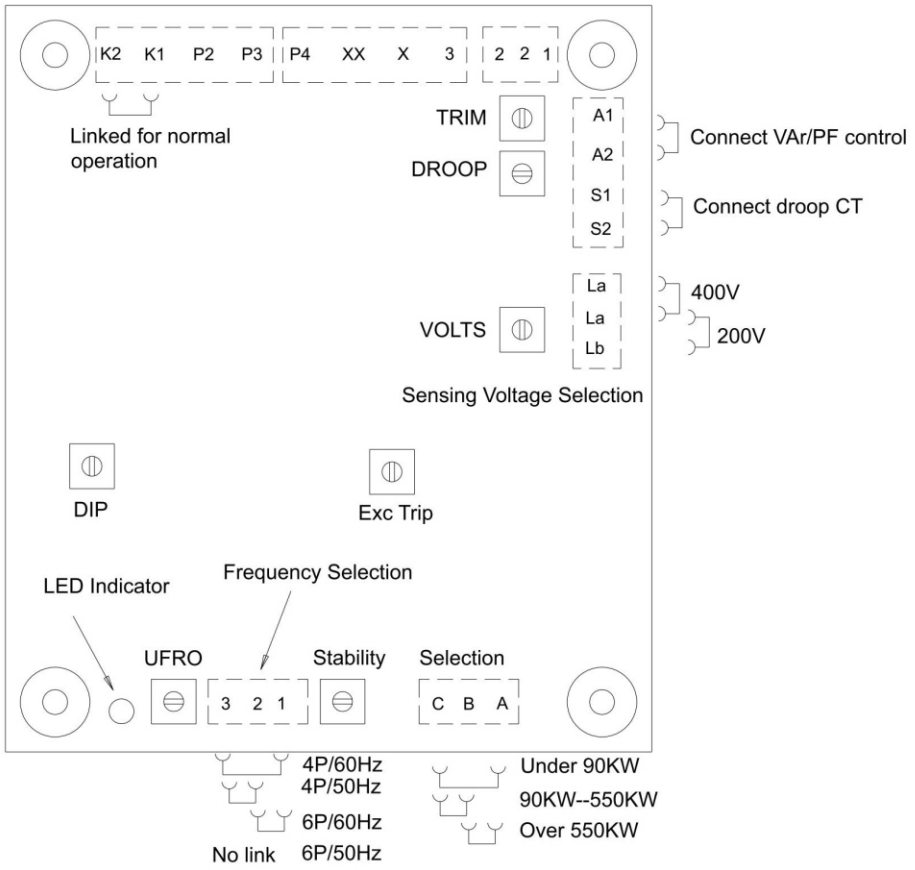
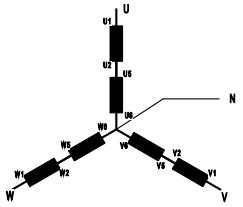
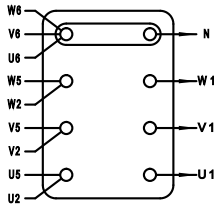
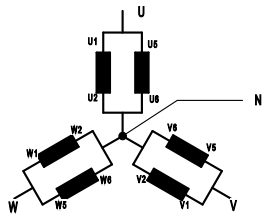
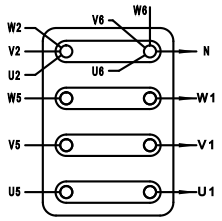
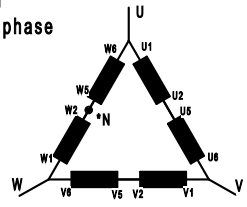
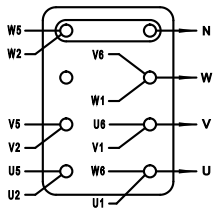
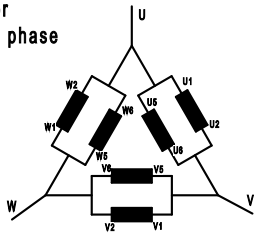
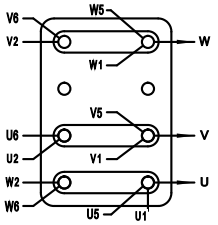
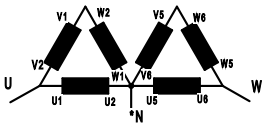
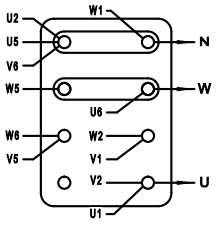


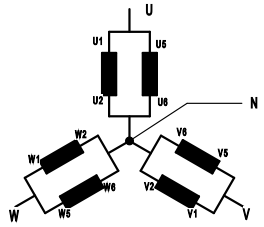
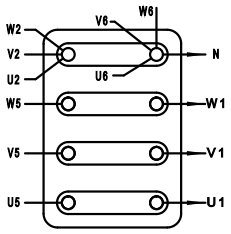
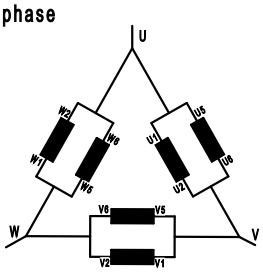
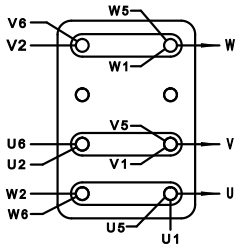
Diagram 1. 12 leads output connection diagram

Connection diagram	L.L Voltage		Factory connection
3 phase 	Winding	50Hz	60Hz
	6	380－415	380－480
	7	440－460	－
	8	－	380－416
	Star type series three phase four lines Terminals（U,V,W,N）		 NDE
3 phase 	Winding	50Hz	60Hz
	6	190－208	190－240
	7	220－230	－
	8	－	190－208
	Star type prarllel three phase four lines Terminals（U,V,W,N）		 NDE
1 phase or 3 phase  UN voltage = 1/2 UW voltage	Winding	50Hz	60Hz
	6	220－240	220－240
	7	250－260	－
	8	200	220－240
	Delta type series three phase four lines Terminals（U,V,W,N）		 NDE
1 phase or 3 phase 	Winding	50Hz	60Hz
	6	110－120	120
	7	120－130	－
	8	－	110－120
	Delta type parallel Terminals（U,V,W）		 NDE
1 phase  UN voltage = 1/2 UW voltage	Winding	50Hz	60Hz
	6	220－240	220－240
	7	250－260	－
	8	200	220－240
	Double Delta type single phase three lines Terminals（U,W,N）		 NDE

* U1(T1)-V1(T2)-W1(T3)-U2(T4)-V2(T5)-W2(T6)-U5(T7)-V5(T8)-W5(T9)-U6(T10)-V6(T11)-W6(T12)

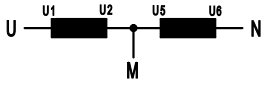
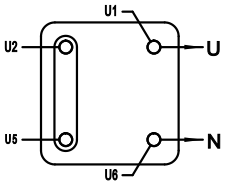
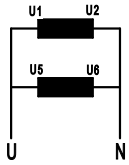
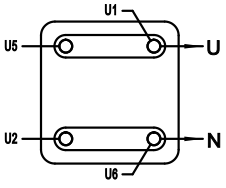
Warning:Misconnection can result in permanent machine damage,*N does not necessarily imply neutral.

Diagram 2. 6 leads output connection diagram

Connection diagram	L.L Voltage			Factory connection
3 phase 	Winding	50Hz	60Hz	
	6	380－415	380－480	
	7	440－460	－	
	8	－	380－416	
	Star type prarllel, three phase four lines, Terminals（U,V,W,N）			NDE
3 phase 	Winding	50Hz	60Hz	
	6	220－240	220－240	
	7	250－260	－	
	8	－	220－240	
	Delta type prarllel, three phase three lines, Terminals（U,V,W）			NDE

* U1(T1)-V1(T2)-W1(T3)-U2(T4)-V2(T5)-W2(T6)-U5(T7)-V5(T8)-W5(T9)-U6(T10)-V6(T11)-W6(T12)
Warning:Misconnection can result in permanent machine damage,*N does not necessarily imply neutral.

Diagram 3. Single phase generator output connection diagram

1 phase  UM voltage=1/2 UN voltage	50Hz or 60Hz 220 - 240 Series, Singal phase three lines, Terminals（U,N,M）	 NDE
1 phase 	50Hz or 60Hz 110 - 120 Prarllel, Singal phase two lines, Terminals（U,N）	 NDE

* U1(T1)-U2(T4)-U5(T7)-U6(T10)
Warning:Misconnection can result in permanent machine damage.