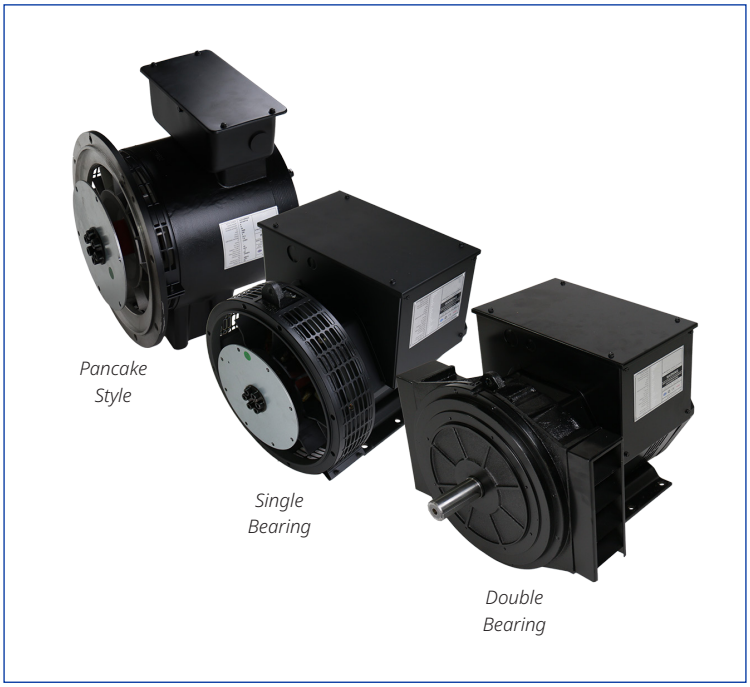
Generator User's Manual

This Manual Covers for the following WorldWide Electric Generators



AF Series

Installation, Operation, and Maintenance

Product Manual

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This manual includes procedures for the safe and proper transportation, storage, installation, connection, operation and maintenance of WorldWide Electric generators. For your protection, please read these instructions carefully before attempting to install, operate or service the generators. Please retain this manual in your files for future reference.

Safety Precautions

Safety precautions must be observed before installing, using, servicing and handling any WorldWide Electric generator. During the installation and operation of our generator in an industrial application, there is a danger of live electric parts and wires as well as hot surfaces and rotating parts. Therefore, please carefully read, fully understand, and heed all instructions, warnings, cautions and safety notices. Failure to do so could lead to personal injury, death and /or property damage.

Please review the following safety precautions:

- Be sure installation conforms to all applicable safety and local electrical codes. Licensed electricians should perform all installations.
- Never operate the generator with protective, access, or terminal box covers removed.
- Before conducting any maintenance, be sure to disable the engine start circuits.
- Avoid accidental closure by disabling closing circuits and any circuit breakers feeding into or from the generator – follow OSHA lockout/tagout procedures.
- Insure proper grounding (earthing) of the generator frame and distribution system in compliance with local and national electrical codes and specific site requirements.

Lifting or moving your generator is a hazardous set of operations, as noted in the installation and maintenance sections of this manual. Improper lifting or moving of the unit may well result in damage to the generator, and more importantly, injury to service personnel.

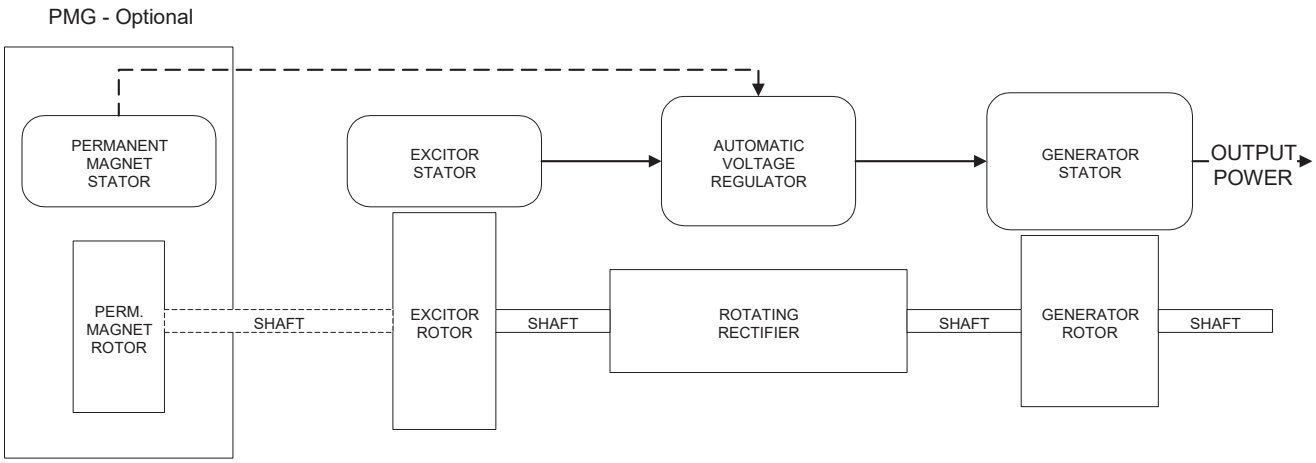
As an initial step in installation, insure that all generator leads are properly connected inside the saddle (connection) box. Residual voltage is always present at the generator terminals and at the automatic voltage regulator panel connections. Therefore, always assume that there will be voltage present at the generator terminals.

This manual is only a supplement to the proper training of installation and service personnel. Qualified, trained technicians MUST do installation and repairs. The cautions and warnings point out known conditions and situations that are considered potentially hazardous. Each installation WILL also have its own set of hazards that will only be identified by personnel that have been properly trained.

Principles of Operation

WorldWide Electric generators are brushless, self excited or permanent magnet generator (PMG) excited, synchronous AC generators. All units utilize sophisticated Automatic Voltage Regulators (AVR) to control the output voltages and frequencies.

The self excited generator is made up of six major components: main stator (armature), main rotor (field), exciter stator (field), exciter rotor (armature), rectifier assembly, and voltage regulator (AVR). The optional PMG adds the PMG excitation to the unit.



In the self excited units, the generator's exciter consists of a stationary field and a rotating armature. The stationary field (exciter stator) is designed to be the primary source of the generator's residual magnetism. This residual magnetism allows the exciter rotor (armature) to produce AC voltage even when the exciter stator (field) is not powered. This AC voltage is rectified to DC by the rotating rectifier assembly and fed directly to the main rotor (field). As the generator shaft continues to rotate, the main rotor (field) induces a voltage into the generator's main stator (armature). At rated speed, the main stator's voltage produced by the residual magnetism of the exciter allows the automatic voltage regulator to function. The regulator provides voltage to the exciter field resulting in a build-up of generator terminal voltage. This system of using residual magnetism eliminates the need for a special field flashing circuit in the regulator. After the generator has established the initial residual voltage, the regulator provides a controlled DC field voltage to the exciter stator resulting in a controlled generator terminal voltage.

Voltage Regulation

In the standard configuration (shunt excited), the automatic voltage regulator receives both its input power and voltage sensing from the generator's output terminals (See Figure 1). With the optional PMG configuration, the regulator receives input power from the PMG. The regulator automatically monitors the generator's output voltage against an internal reference set point and provides the necessary DC output voltage to the exciter field required to maintain constant generator terminal voltage. Adjusting the regulator's reference set point changes the generator's terminal voltage. Consult the regulator manual for specific adjustment and operating instructions.

Principles of Operation - continued

Motor Starting

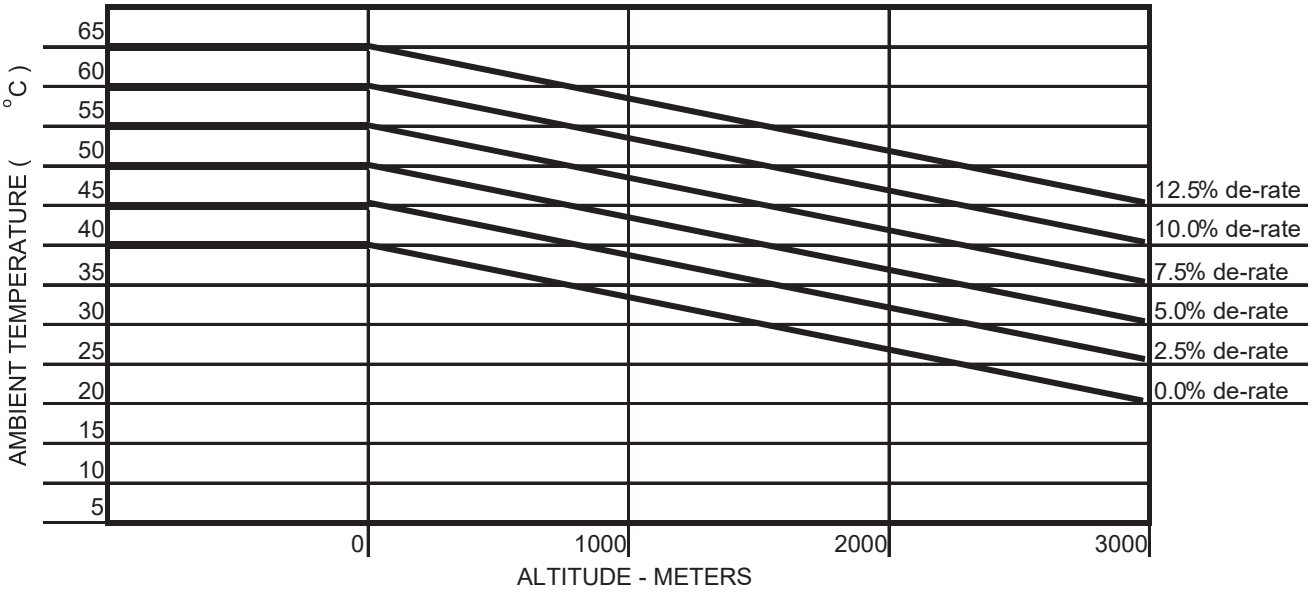
When a motor is started, the motor draws a large surge of current. This starting current is equivalent to the motor's locked rotor or stall current and is 5 to 10 times normal full load current. When the generator supplies this in-rush of starting current, the generator voltage dips temporarily. If the motor is too large for the generator, the generator's voltage dips greater than 30 percent. This may result in the motor starter de-energizing or the motor stalling.

Special Conditions

Outdoor Operations – Generators subjected to outside operation must be protected from the environments by fiberglass or metal housings with the proper forced air (fan) ventilation. Direct generator contact of rain, snow, or dust must be avoided. Space heaters are also recommended for certain environmental conditions.

Sand & Dust – Generator windings are protected against harsh environments. However, severe conditions may demand further protection. Special enclosures and filters may be necessary to protect the generator from contaminants carried into the generator by required airflow.

High Humidity & tropical Climates – Although the normal generator windings are humidity and moisture resistant, in service areas that are particularly moist or humid, such as tropical environments and all marine applications, additional protection is recommended. Special winding insulations are available, as well as space heaters, to compensate for these harsh environments.



Altitude & High Ambient Temperature Operations – For applications over 1000 meters (3300 feet) elevation or where the temperature of the ventilating air to the generator exceeds 40°C (104°F), de-rating of the generator is necessary.

Installation

Different generating set configurations will require different levels of site installation. For example, most enclosed sets that include switchboards and circuit breakers will require little or no connectors, passthroughs or wiring for grounding whereas open configurations will likely require both. Please read and follow each section as it applies to the specific generating set being installed.

Lifting

⚠ The Lifting Lugs on the generator are meant to support the generator only. Once assembled as a set, the lifting lugs on the generator cannot be used to lift the assembly. Severe personal injury or equipment damage may result.

Each generator is provided with two lifting lugs and should be used with a shackle and pin type safety lifting aid fitted to chains rated well above the minimum lifting force. The chains should then be attached to a beam, acting as a spreader, to provide even distribution of weight on the chains and help ensure the generator remains as level as possible when lifted. The use of rope is highly discouraged. The lugs are positioned to allow the generator to be lifted as close to its center of gravity as possible thereby allowing the generator to remain level with ground when lifted. However, design constraints limit the location of the lugs, so there is no guarantee that the generator will stay perfectly horizontal to the ground as it is lifted. Care must be exercised to prevent personal injury or equipment damage.

Each generator has been carefully inspected and tested before shipment from the factory. However, it is highly recommended that the generator be thoroughly inspected. Check all bolts to insure they are tight, and examine the insulation on lead wires for chafing. Remove all shipping tapes, bags, skids and rotor support blocking. For two bearing units, rotate the shaft by hand to ensure that it rotates smoothly without binding.

Engine – Generator Assembly

During assembly, the generator and engine shafts must be properly aligned and allowed to rotate so that the engine flywheel holes and the generator coupling holes can be lined up and coupling bolts installed and tightened. In order to help with alignment, it may be necessary to add shims to the generator's feet. This holds true for both single and dual bearing generators.

⚠ Disable and lockout any engine starting devices before installing or servicing the generator. Also note that improper alignment can result in equipment damage and/or personnel injury.

Single Bearing Generators

The generator frame housing and SAE coupling plates have been coated with a rust preventative to prevent corrosion during shipping and storage. This coating **MUST BE REMOVED** prior to assembly with the engine. Use a petroleum-based degreaser and clean all mating surfaces.

To make the alignment of the shafts and bolt holes of single bearing generators easier, place two dowels at diametrically opposite holes on the engine flywheel. The generator coupling plate can then be aligned with the engine flywheel as the generator is placed onto the base. Once the bolt patterns of the two plates are lined up, the dowels must be removed and coupling bolts and nuts installed in every bolt hole. Bolt sizes and required torque values are shown in Appendix D, SAE Data.

Installation - continued

The combined engine – generator shaft will need to be rotated as the coupling hardware is installed and should be done with care so as to ensure the safety of the installer(s) and protection of the assembly's components. Be sure to follow approved working practices, particularly when reaching inside the assembly to install and fastened coupling hardware.

Two Bearing Generators

Following the coupling manufacturer's guidelines for proper fit and alignment, a flexible coupling should be used to join the engine to the generator.

For belt-driven generators, avoid axial load on the bearings by verifying the alignment of the pulleys and belts. Using a screw-type tensioning mechanism is recommended to maintain pulley alignment while providing accurate belt tension adjustment.

Adapter guards must be installed after the coupling assembly is finished. The motor-generator set builder is responsible for providing a suitable guard for open coupled sets.

Grounding

The generator frame must be firmly mounted to the generator set base plate. Once the generator is mounted, be sure there is a solid electrical connection for ground by checking for continuity between the generator frame and the base plate. A properly rated ground conductor must be attached to the generator frame and base plate if anti-vibration mounts are used between the two. Normally this conductor can be half the cross-sectional area of one of the main power wires. Refer to all local electrical codes regarding grounding of the unit.

Preoperative Checkout

Insulation Resistance

The resistance of the insulation windings must be measured after both final assembly and installation of the generator set but before the unit is started for the first time. To measure the resistance of the windings, follow the steps below.

1. Disconnect the AVR.
2. Disconnect any conductors between ground and neutral.
3. Using a 500V Megger insulation tester or a similar device, test the resistance between one of the output lead terminals and ground. Resistance should be greater than 5MΩ.
4. If resistance is less than 5MΩ, follow the dry out procedure in this manual.
5. Repeat step 3 for the remaining two output leads.
6. NOTE: During manufacture, the windings are tested at high voltage. Further high voltage testing may degrade insulation and reduce operating life. If high voltage testing is required for customer acceptance, tests must be performed at lower voltages, i.e., Test Voltage = 0.8(2 X Rated Voltage + 1000).

Installation - continued

Direction Of Rotation

Viewing from the drive end, the direction of rotation is clockwise which follows the same direction of rotation used most often by diesel engine manufacturers.

The generator can be driven counter-clockwise with small efficiency reduction and a higher noise level. This will also change the phase rotation. To correct this, the output cables will need to be rewired. Contact the factory for details.

Voltage And Frequency

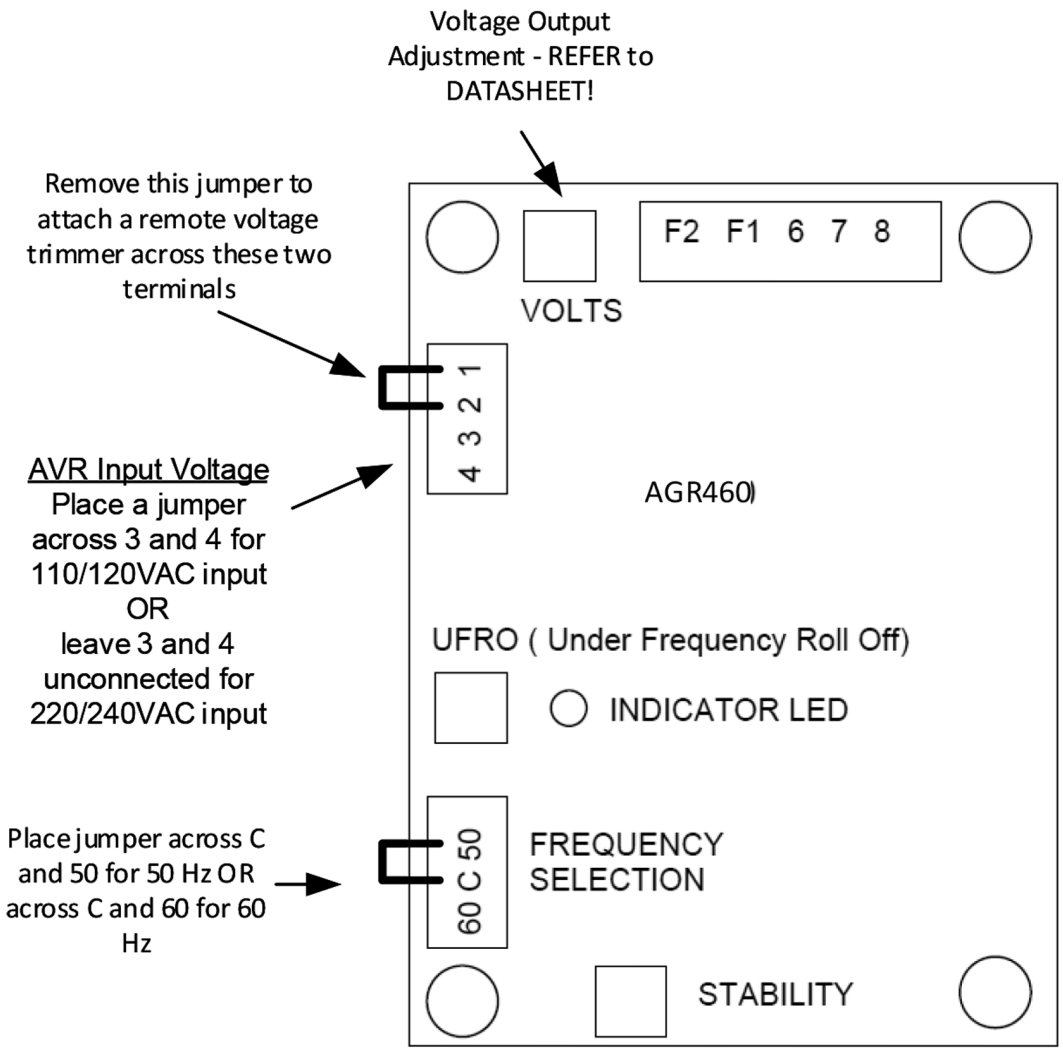
Verify that the voltage and frequency outputs listed on the generator nameplate match those required for the generator set application.

Avr Settings

The automatic voltage regulator (AVR) settings are pre-adjusted by the factory to give acceptable performance for initial testing. However, if adjustments need to be made, the AVR can be accessed by removing the saddle box cover. In some generators, the AVR will have a cover over it, which will need to be removed to gain access. The generator will have one of four AVR models: AS460, AS440, MX341, or MX321. A basic overview of adjustments is given below. The complete datasheet for each model is provided below in Appendix E. Please refer to the nameplate on the generator frame to determine which AVR model is installed in the generator.

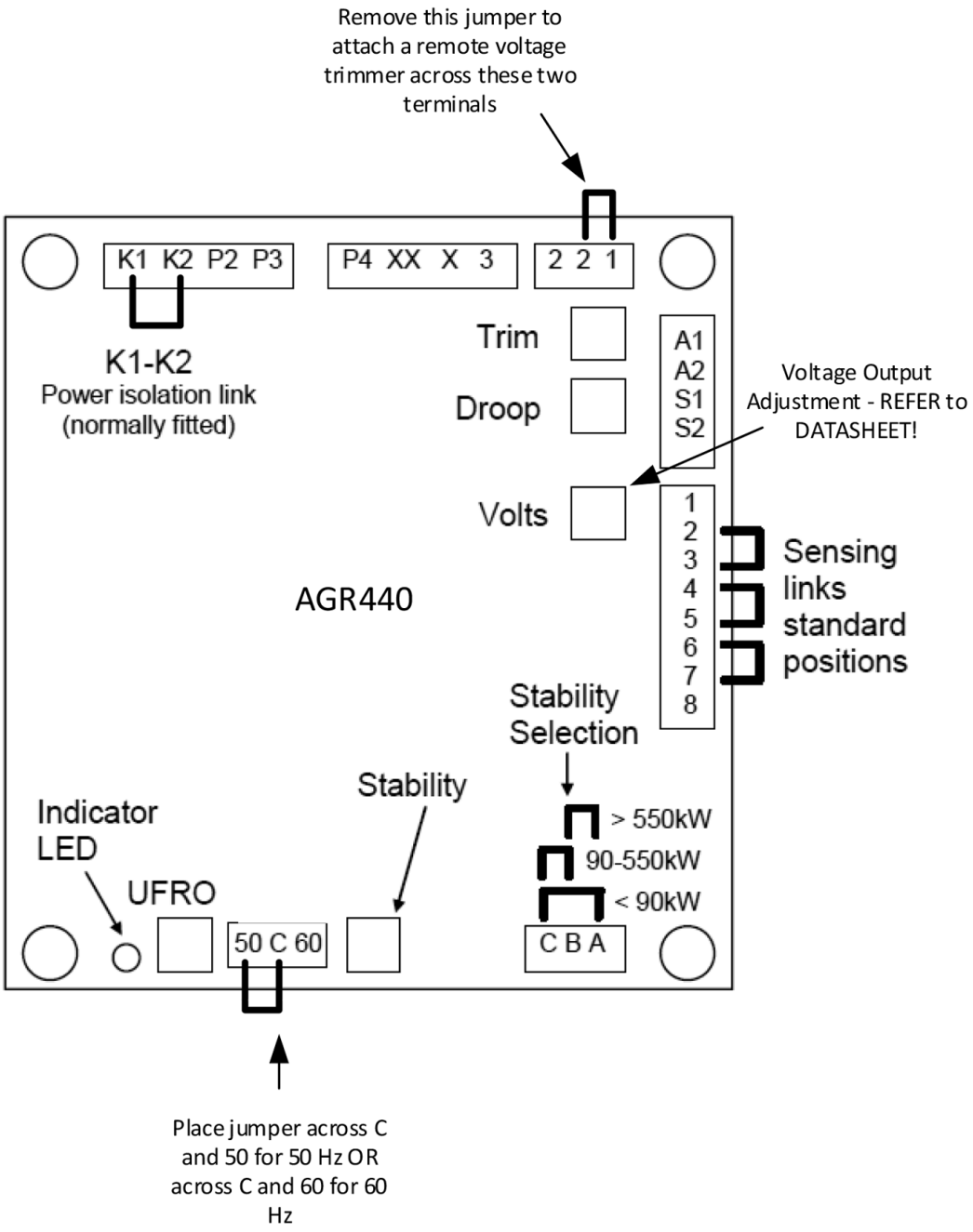
Installation - continued

AS460



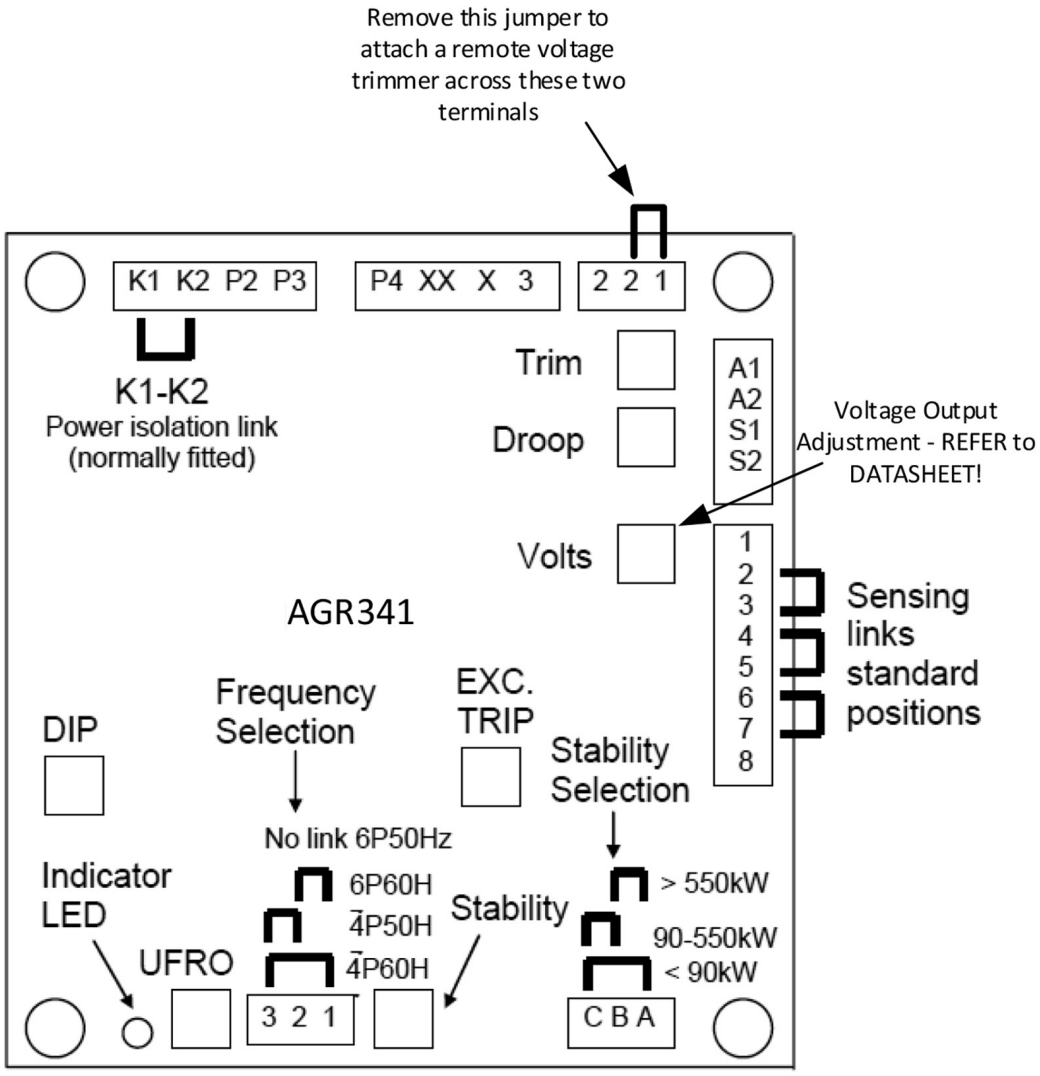
Installation - continued

AS440



Installation - continued

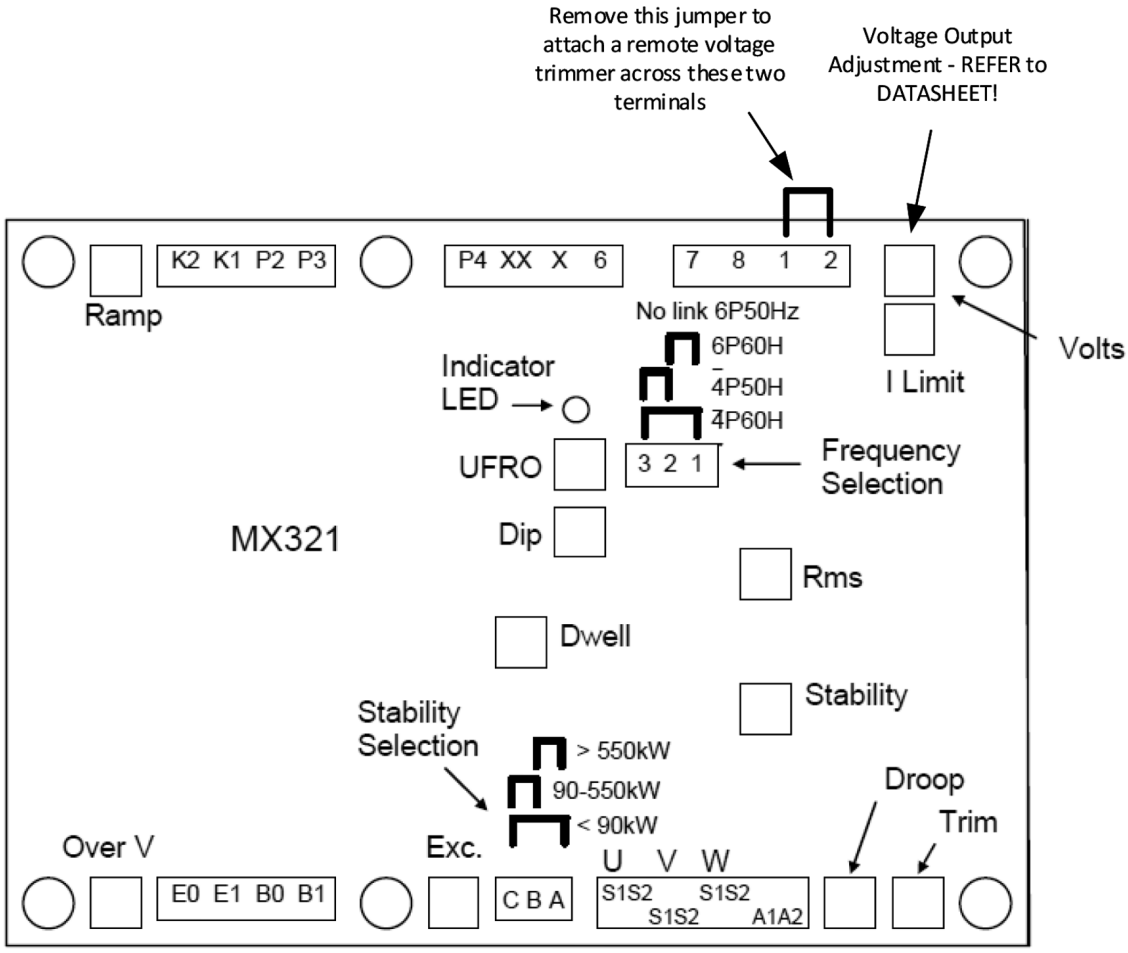
MX341



FOR	LINK
4 Pole, 50Hz	2 & 3
4 Pole, 60 Hz	1 & 3
6 Pole, 50 Hz	No Link
6 Pole, 60 Hz	1 & 2

Installation - continued

MX321



FOR	LINK
4 Pole, 50Hz	2 & 3
4 Pole, 60 Hz	1 & 3
6 Pole, 50 Hz	No Link
6 Pole, 60 Hz	1 & 2

Operation

Testing Of Generator Set

⚠ While testing, covers may need to be removed to make adjustments, which will expose live circuits and components. Only qualified personnel should make Testing and adjustments.

Test Equipment

Use a voltmeter, frequency meter and a current and/or power meter to perform basic checkout of the generating set. Measurements should be made either line-to-line or line-to-neutral. Using a power factor meter is recommended if applying a reactive load, i.e., inductive or capacitive. Be sure the AVR is exposed to make adjustments (see section 4).

Starting Up For The First Time

Once generator set assembly is complete, be sure all of the engine manufacturer's pre-start procedures or checkouts have been performed. Verify that the generator will not be run beyond 125% of its rated speed by checking the adjustment of the engine governor. Damage to the generator may result if the speed governor is set too high. Take special care during the initial setting of the speed governor. If in doubt, set low and slowly increase speed to proper level.

To adjust the voltage output:

1. Connect a voltmeter and frequency meter or a DMM capable of both functions to the output of the generator, either line-to-line or line-to-neutral. Be sure the expected voltage, which is different between the two types of connections, is known.
2. Refer to sections 2.4.4 to find the diagram of the specific AVR in the generator.
3. Find the potentiometer label 'volts'.
4. Using a small flathead screwdriver, turn the volt potentiometer counterclockwise until it stops.
5. Run the generating set with no load.
6. Verify the frequency output is correct.
7. Slowly turn the volt potentiometer clockwise until the desired voltage is reached.

   Again, please note the type of connection; line-to-line or line-to-neutral, the voltmeter is hooked up to when setting the voltage.

Operation - continued

The stability control of the AVR is preset at the factory and will not normally require further adjustment. However, if the voltage output oscillates (changes constantly) the stability can be adjusted following the instructions below.

1. Connect a voltmeter to the output of the generator, either line-to-line or line-to-neutral.
2. Run the generating set with no load and verify that the generator shaft speed is stable and spinning at the proper rpm.
3. Refer to sections 2.4.4 to find the diagram of the specific AVR in the generator.
4. Find the potentiometer label 'stability'.
5. Using a small flathead screwdriver, turn the stability potentiometer clockwise until it stops.
6. Slowly turn the stability potentiometer counterclockwise until the generator voltage begins to oscillate.
7. Turn the stability potentiometer clockwise slightly – just until the voltage stabilizes.
8. The stability should be set so that the voltage output is stable but close to the unstable range.

Load Testing

AVR ADJUSTMENTS

After adjusting the voltage and stability, the AVR will not typically require further adjustment.

However, if voltage collapse or poor voltage regulation result when a load is applied, additional adjustments may need to be made. Please see the subsections below on the other possible adjustments to determine if one or more of these will fix the problem being experienced. Be sure to read through each carefully to be sure the correct adjustment is being made and to be sure it is done correctly.

UNDER FREQUENCY ROLL OFF (UFRO)

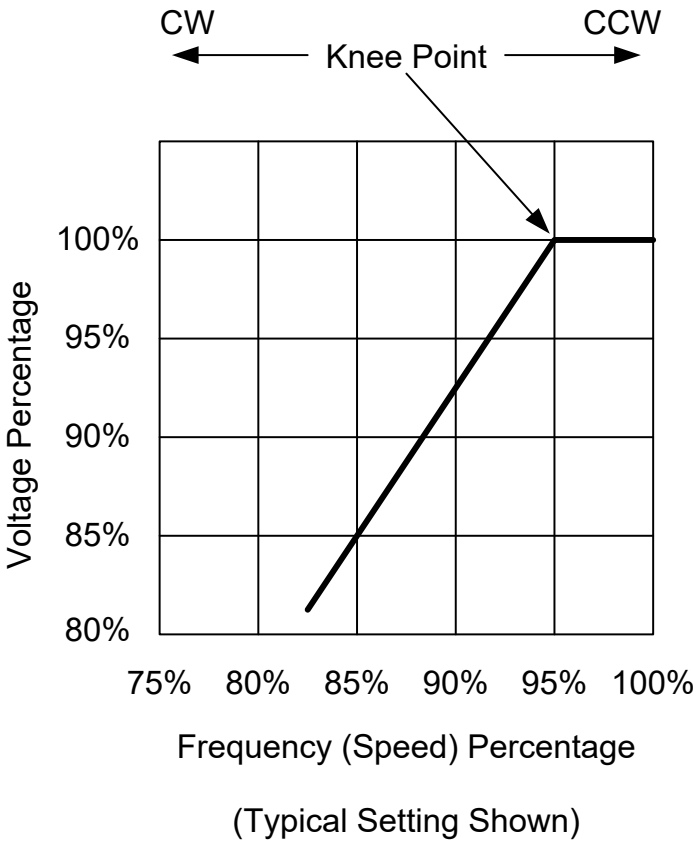
The UFRO is an under speed protection circuit that produces a volts/frequency (speed) characteristic whenever the speed of the generator shaft goes below a set threshold called the knee point. The UFRO needs adjustment if the generator is under load and a) the LED remains constantly lit or b) if voltage regulation is poor.

The knee point can be adjusted by using a small flathead screwdriver to turn the UFRO potentiometer. Please refer to the proper AVR diagram in section 2.4.4 to locate the UFRO potentiometer. Turning the UFRO potentiometer clockwise will lower the knee point frequency (speed) setting and turn off the LED. Ideally, the knee point should be set so that the LED lights whenever the frequency becomes less than the nominal frequency.

Operation - continued

For a 50 Hz generator, this would be about 47 Hz, while for a 60 Hz generator; it would be about 57 Hz.

The figure below shows the relationship between voltage and frequency within the UFRO. Note when the UFRO potentiometer is turned counterclockwise (CCW) the knee point is shifted to the right. If it is turned clockwise (CW) the knee point is shifted to the left.



(Typical Setting Shown)

Excitation Trip (Exc Trip)

Only for MX341 & MX321 AVRs

In the event of a short circuit from line-to-line or line-to-neutral or a large overload, PMG-excited AVRs such as the MX341 and MX321 provide maximum excitation power. Therefore, these AVRs utilize an over excitation circuit to protect the generator windings. This circuit detects high excitation and after a set amount of time, typically 8-10 seconds, it removes the excitation. If the excitation trip is not set properly, the output of the generator will fail when loaded or slightly overloaded and the LED will stay lit. The voltage across terminals X and XX should be within 5% of 70 volts. This is the correct setting of the excitation trip. Stop the generator to reset.

Operation - continued

Over Voltage (Over/V)
Only for the MX321 AVR

The over voltage function removes generator excitation (AVR output) if the AVR sensing input is lost. In addition, this AVR includes an output to trip an optional external circuit breaker.

Correct setting of the over voltage function can be verified by measuring the voltage across terminals E0 and E1 which should be within 5% of 300V. If incorrect, the voltage can be adjusted by using a small flathead screwdriver to turn the over voltage potentiometer – turning it clockwise will increase the voltage and vice versa.

If the over voltage setting is incorrect, the generator output voltage will drop either when load is removed or when no load is applied and the LED will come on and stay lit. Stop the generator to reset.

Other Adjustments/Options
Please refer to the proper AVR datasheet in Appendix F

Conduit Pass-Through
In order to run the output power wires from the generator terminal box, a hole will need to be cut into one of the two side panels on the saddle box. By default, the right panel – if facing the back of the generator – should be used. The left panel can be used if the generator was specially ordered for left side installation. Both panels are removable. Remove the proper panel before drilling or punching to avoid introducing metal debris inside the saddle box, which may cause a short or other damage.

Some type of conduit pass-through should be used to protect the wires from sharp edges and protect the saddle box from exposure to the elements or a harsh operating environment. The pass-through should minimize unsupported cable weight, apply no axial strain along the cables and support the cables outside the saddle box. Be sure the supports allow for vibration without introducing excessive force on the cables and allow a sufficient bending radius for all bends. An insulated or non-magnetic pass-through plate should be installed if single core cables are used.

Verify the winding resistance by following the steps in section 5.6.2 before final connections are made.

When making electrical connections to the terminal block, be sure the output cable connectors are placed on top of the existing generator winding connectors.

Operation - continued

Terminal Torque Settings

Before making any electrical terminal connections for the first time, clean plated surfaces with a degreasing agent then lightly abrade them to remove any tarnish. Do not score the surface.

All generator connections including links, CT's, accessories, cables, etc. should be torque to 45 Nm or 33 ft-lbs.

Generator output cables should be connected to terminals using 8.8 grade steel bolts in addition to anti-vibration hardware. The torque value on all electrical connections should be checked periodically.

Rounding

The generator neutral output does not come connected to the frame/ground. If the neutral is supposed to be earthed (connected to the ground), use a conductor no smaller than half the diameter of a main power wire to connect the neutral terminal to the earth terminal, both located inside the saddle box. If unsure, check the continuity between the neutral terminal inside the saddle box and any inner, unpainted panel in the saddle box.

The gen-set builder is responsible for verifying the generator frame; generating set bedplate and the main ground output terminal are electrically bonded. If unsure about the ground connection or simply to verify, remove the saddle box cover and perform a continuity check between the main ground output terminal and any inner, unpainted panel in the saddle box. Also check for continuity between the main ground output terminal and the generating set bedplate.

Protection

The installer and/or end user is responsible for making sure the all local electrical and safety codes & regulations pertaining to the installation site are followed.

Service

Performing routine service will help keep your generator running smoothly. The condition of the winding and bearings should be examined periodically, especially if the generator has been idle for a long time. Also, regular inspection and maintenance is required for generators fitted with air filters.

Air Filters

⚠ Removal of filters exposes live parts. Unit must be OFF. Air filters for the removal of airborne particulate matter (dust) are offered as an additional option. Filters need to be ordered concurrently with the generator. Air filters need to be charged with oil before the engine-generator is used. Filter maintenance periods will depend upon the severity of the site conditions. Regular inspection of the elements will determine when cleaning is necessary.

Cleaning Procedure

Remove the filter elements from their housings and wash the elements with a suitable degreaser material. Dry the elements completely before charging.

Charging Air Filters

The following must be done before using the unit for the first time, and after every filter cleaning. Soak the filter element in SAE 20W50 oil or Filterkote Type K. Allow elements to completely drain before reassembling the filters and putting the unit into service.

Winding Condition

Service and troubleshooting procedures performed improperly can result in severe personal injury or death. These procedures should only be performed by qualified personnel. Before carrying out any service or troubleshooting procedure, be sure engine-starting circuits are disabled and any anti-condensation heater supply is isolated.

Typical Insulation Resistance Values

The following information is provided to assist in determining the condition of the windings.

In operation, generators may be exposed to water. Units that have been in storage for may be exposed to temperature and humidity variations, which can cause significant condensation. Wet windings must be completely dried out before operating the generator. Otherwise, serious damage to the generator can occur.

A new or unused generator will have an insulation resistance (IR) value of around 25 MΩ, assuming it has been stored in a clean, dry area. If the value is below 10 MΩ, then the generator should undergo a drying out procedure and tested again.

Generators in service should have an IR value above 1 MΩ. If not, the generator should undergo a drying out procedure and tested again.

If the IR rating for all phase-to-phase and neutral to phase measurements are above 1 MΩ then the windings are in working order. If the IR value is still below 1 MΩ for any of the measurements, then the windings may need to be replaced.

Service - continued

Winding Condition Assessment

Be sure to disconnect the AVR and ground the leads of the Resistance Temperature Detector (RTD) before conducting this test. To determine the condition of the windings, the insulation resistance is measured from each phase-to-phase and from each phase to neutral. This measurement should be conducted as part of regular maintenance after extended shutdown periods, or if the insulation resistance value is suspected to be low, e.g., wet or dirty windings.

Caution is necessary when it is possible that alternator windings may be excessively damp or dirty. A low voltage, typically 500V, Mugger (mega-ohm meter) or similar instrument should be used to obtain the initial measurement of the insulation resistance. Test voltages should be applied gradually and only for a short period, only long enough to make a determination about the status.

In no event should high voltage tests be conducted until the alternator windings have been dried and cleaned as required.

Insulation Test Procedure

Disconnect all electronic components including Avers, electronic protection equipment, etc. If present, ground all resistance temperature detection devices. Short out all diodes on the rotating rectifier. Examine the system under test and look for any connected components that might cause false readings or that could be damaged by the test voltage.

Conduct the insulation test in accordance with the operating instructions for the test instrument.

Test the insulation resistance from each phase-to-phase and from earth to each phase. New or unused generators should have insulation values between 10 MΩ to 25 MΩ or greater. Used generators should be above 1 MΩ. If the winding resistance is low it must be dried (see below) or repaired.

Drying Methods

Dry Run

In some cases, a generator with a low IR value can simply be run without excitation. The natural flow of ambient air through the generator will tend to dry the windings. This may raise the IR above 1.0 MΩ and allow the unit to be put into service. To do so, run the generator for 10 minutes with AVR terminals K1 and K2 open, and inspect the windings to see if they look dry. Re-measure the insulation resistances. If all the IR values are above 1.0 MΩ, the windings are good. If not, use one of the other drying methods.

Forced Air Drying

Remove all covers from the generator to allow the moisture to escape. Be sure air can flow freely into one side of the generator and out another. At a minimum, there should be two openings.

Using two electric fan heaters rated 1 to 3 kW; direct hot air into one of the openings.

Service - continued

Make sure the heat source is at least 300 mm (12 inches) away from the windings to prevent overheating and insulation damage. Heat at the entry point should not exceed 80°C (180°F). A period of 3 hours is typical to restore the IR of a generator.

If the generator will not be run immediately, insure that anti-condensation heaters, if installed, are in operation, and retest windings before running.

Short Circuit Method

The short circuit method is a process that should only be performed by a technician qualified in the safe operating practices required around generator sets. Contact the factory for detailed instructions, should this method be chosen.

Bearings

All bearings are supplied from the factory pre-packed with WorldWide Electric Generator grease, conforming to the specifications of Kluber Asonic GHY 72 grease. Do not mix with any grease of different specifications. Mixing grease of differing specifications will reduce bearing life.

The specification for WorldWide Electric grease is available on request from the factory. Lifetime Lubricated bearings are fitted with integral seals and are not greasable.

The life expectancy of bearings in service is a direct function of the working conditions and the environment. High levels of vibration from the drive engine or misalignment of the set will stress the bearing and reduce its service life.

If the vibration limits set out in BS5000-3 and ISO 8528-9 are exceeded, bearing life will be reduced.

Long stationary periods in an environment where the generator is subject to vibration can also cause false brinelling (surface failure), which puts flats on the balls, and grooves on the races, leading to premature failure. Very humid atmospheric or wet conditions can emulsify the grease, causing corrosion and deterioration of the grease, leading to premature failure of the bearings.

For normal situations, users may expect to be able to obtain 30,000 hours service life from Lifetime Lubricated bearings, and 40,000 hours from greasable bearings.

Trouble Shooting Guide

WorldWide Electric generators are provided with excitation control systems. Four automatic voltage regulator (AVR) systems are available across the range of generator models and sizes. The following will assist the user in determining any faults. Follow the guide for the proper AVR in question.

AS460 AVR

SYMPTOMS	SOLUTIONS
Generator produces no voltage	• Check speed with tachometer • Check residual voltage and flash the field as necessary – see section 5.3 • Verify generator connections • Check diodes • Test and adjust or replace AVR
Generator produces unstable voltage	• Check speed with tachometer. • Verify generator connections • Replace defective or worn rheostat • Test and adjust or replace AVR
Generator produces high voltage	• Check speed with tachometer • Verify generator connections • Check load PF. Leading PF can cause voltage to climb. • Test and adjust or replace AVR
Generator produces low voltage at no load	• Check speed with tachometer • Verify generator connections • Check diodes • Test and adjust or replace AVR
Generator produces low voltage with load applied	• Check speed with tachometer • Check diodes • Test and adjust or replace AVR

Trouble Shooting Guide - continued

AS440 AVR

SYMPTOMS	SOLUTIONS
Generator produces no voltage	• Check speed with tachometer • Check residual voltage and flash the field as necessary • Verify generator connections • Check diodes • Test and adjust or replace AVR
Generator produces unstable voltage	• Check speed with tachometer. • Verify generator connections • Replace defective or worn rheostat • Test and adjust or replace AVR
Generator produces high voltage	• Check speed with tachometer • Verify generator connections • Check load PF. Leading PF can cause voltage to climb. • Test and adjust or replace AVR
Generator produces low voltage at no load	• Check speed with tachometer • Verify generator connections • Check diodes • Test and adjust or replace AVR
Generator produces low voltage with load applied	• Check speed with tachometer • Check diodes • Test and adjust or replace AVR

Trouble Shooting Guide - continued

Residual Voltage Check

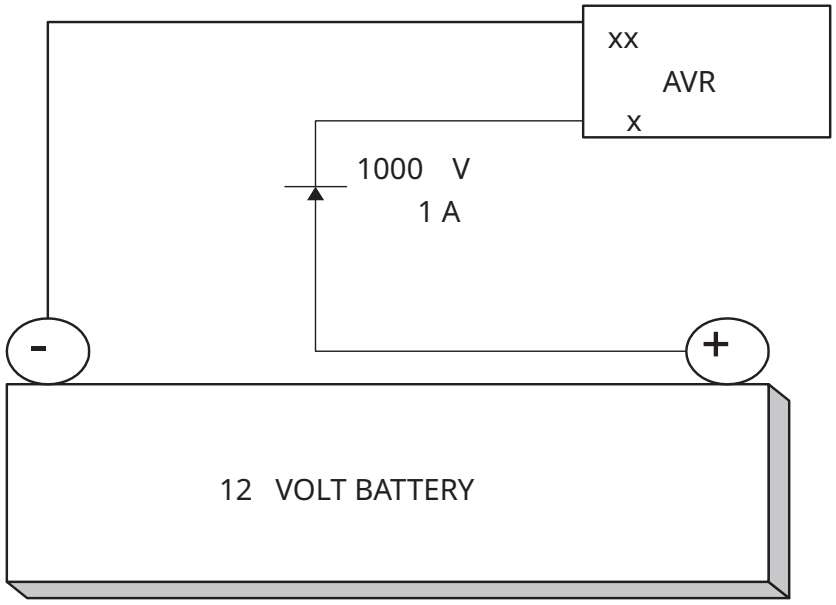
(This procedure is appropriate for use to with either AS460 or AS440 regulators.)

With the generator set stationary, remove the regulator access cover and leads X and XX from the AVR. Start the unit and measure voltage across the regulator terminals 7-8 on AS460 AVR or P2-P3 on AS440 AVR. Stop the set, and replace leads X and XX on the AVR terminals. If the measured voltage was above 5 volts, the generator should operate normally.

If the measured voltage was below 5 volts, follow the process described below.

Using a 12-volt DC battery as a power supply, clip leads from battery negative to AVR terminal XX, and from battery positive through a diode to AVR terminal X. See figure below.

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



NOTE: If the generator set battery is used for field flashing, the generator main stator neutral must be disconnected from ground.

Restart the unit and note output voltage from main stator, which should be approximately nominal voltage, or voltage at AVR terminals 7 and 8 on AS460, P2-P3 on AS440, which should be between 170 and 250 volts.

Stop the unit, unclip the battery supply from terminals X and XX, reinstall the regulator cover and restart the set. The generator should now operate normally. If no voltage rise is noted, then a fault exists in either the generator or the AVR.

Follow Section 5.6 to check generator windings and rotating diodes.

Trouble Shooting Guide - continued

MX341 AVR

SYMPTOMS	SOLUTIONS
Generator produces no voltage	• Check link K1-K2 on auxiliary terminals of AVR • Verify generator connections • Check diodes • Test and adjust or replace AVR
Generator produces low voltage with load applied	• Check speed with tachometer • Check diodes • Test and adjust or replace AVR
Generator produces high voltage	• Check speed with tachometer • Verify generator connections • Check load PF. Leading PF can cause voltage to climb. • Test and adjust or replace AVR
Generator produces unstable voltage	• Check speed with tachometer. • Verify generator connections • Replace defective or worn rheostat • Test and adjust or replace AVR

MX321 AVR

SYMPTOMS	SOLUTIONS
Generator produces no voltage	• Check link K1-K2 on auxiliary terminals of AVR • Verify generator connections • Check diodes • Test and adjust or replace AVR
Generator produces low voltage with load applied	• Check speed with tachometer • Check diodes • Test and adjust or replace AVR
Generator produces high voltage	• Check speed with tachometer • Verify generator connections • Check load PF. Leading PF can cause voltage to climb. • Test and adjust or replace AVR
Generator produces unstable voltage	• Check speed with tachometer. • Verify generator connections • Replace defective or worn rheostat • Test and adjust or replace AVR

Trouble Shooting Guide - continued

Excitation Tests

CHECKING PMG

(on units fitted w/PMG)

With the unit operating, measure voltages at the regulator terminals P2, P3 and P4. These should be balanced and within the following ranges:

- 50 Hz generators - 170-180 volts
- 60 Hz generators - 200-216 volts

Should the voltages be unbalanced, stop the set, remove the PMG sheet metal cover from the non-drive end bracket and disconnect the multi-pin plug in the PMG output leads. Check leads P2, P3, and P4 for continuity. Check the PMG stator resistances between output leads. These should be balanced and within +/-10% of 2.3 ohms. If resistances are unbalanced and/or incorrect the PMG stator must be replaced. If the voltages are balanced but low and the PMG stator winding resistances are correct, then the PMG rotor must be replaced.

CHECKING GENERATOR WINDINGS AND ROTATING DIODES

This procedure is carried out with leads X and XX disconnected at the AVR. Connect a 12-volt DC power supply to leads X and XX. 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, refer to 5.6.2.1. Check voltages at AVR terminals 6, 7 and 8. These should be balanced and between 170-250 volts.

If voltages at the main terminals are balanced but voltage at 6, 7 and 8 are unbalanced, check continuity of leads 6, 7 and 8. If voltages are unbalanced, refer to 5.6.2.2.

BALANCED MAIN TERMINAL VOLTAGES

Exciter windings, main windings and main rotating diodes are considered to be within acceptable limits if all voltages are balanced within 1% at the main terminals. Faults s in the AVR or transformer control are then assumed and described below.

If voltages are balanced but low, the probability is that there is a fault in the main excitation windings or rotating diode.

Rectifier Diodes

Diodes on the main rectifier assembly can be checked with a multimeter. The diode function must be checked, not simply the resistance measurement. The leads connected to each diode should be disconnected at the terminal end, thus isolating the AVR from the generator. Forward and reverse resistance should then be checked. A properly functioning diode will have a much greater resistance in one direction than the other. Typical reverse biased resistance will be 30K ohms or greater, while forward biased resistance will be less than 10 ohms. A open (bad) diode will give a infinite reading in both directions while a shorted (bad) diode will have a very low resistance in both directions.

Trouble Shooting Guide - continued

Replacement of Faulty Diodes

The following procedure can be used to replace faulty diodes as shown below. However, diode failures after a break-in period are usually traceable to an external fault, such as lightening strike. To avoid continuing problems, it is recommended that the entire rectifier assembly be replaced.

The rectifier assembly is split into positive and negative plates. 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. Insure that correct polarity diodes are fitted to each respective plate. The recommended torque for tightening diodes is 4.06 - 4.74 Nm (36-42 in lb).

Surge Suppressor

The surge suppressor is a metal-oxide varistor ("variable resistor" used to protect circuits against excessive voltage by acting as a spark gap) connected across the two rectifier plates to prevent transient reverse voltages in the field winding from damaging the diodes. The varistor should read virtual infinity in both directions with an ohmmeter. A defective unit will show visible signs of failure, and should be replaced.

Main Excitation Windings

If the output is still low when separately excited, the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), since the fault is in one of these windings. The exciter stator resistance is measured across leads X and XX. 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 given in the tables below.

Trouble Shooting Guide - continued

Winding Resistance

FRAME SIZE	MAIN ROTOR	EXCITER STATOR	EXCITER ROTOR	PM STATOR
AFD1	0.44	19	0.26	
AFD2	0.48	19	0.26	
AFD3	0.52	19	0.26	
AFD4	0.56	19	0.26	
AHD5	0.64	20	0.21	
AHD6	0.74	22	0.23	
AHD7	0.83	22	0.23	
AHD8	0.89	24	0.24	
AHD9	0.96	24	0.24	
BBD3	0.59	21	0.142	
BBD4	0.64	21	0.142	
BBD5	0.69	20	0.156	
BBD6	0.83	20	0.156	
BBD7	0.94	20	0.156	
BGD3	1.12	20	0.156	
BGD4	1.26	20	0.156	
BGD5	1.34	20	0.182	
BGD6	1.52	20	0.182	
BGD7	0.69	20	0.182	
BGD8	0.82	20	0.182	
BGD9	2.08	20	0.182	
BGD10	2.08	20	0.182	
D3	0.91	18	0.136	
D4	1.04	18	0.136	2.6
D5	1.17	18	0.136	2.6
D6	1.35	18	0.136	2.6
E3	1.55	17	0.184	2.6
E4	1.77	17	0.184	2.6
E5	1.96	17	0.184	2.6
E6	2.16	17	0.184	5.6
E7	1.75	17	0.158	5.6
F8	1.88	17	0.158	5.6
F9	2.09	17	0.158	5.6
F10	2.36	17	0.158	5.6

Trouble Shooting Guide - continued

UNBALANCED MAIN TERMINAL VOLTAGES

Unbalanced voltages indicate a fault on the main stator winding or main cables to the circuit breaker. These faults may also cause noticeable load increase on the engine.

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.

Avr Performance Testing

AVR CONTROLLED GENERATORS			
FRAME SIZE	SECTION RESISTANCE	FRAME SIZE	SECTION RESISTANCE
AFD1	0.81	D3	0.0083
AFD2	0.51	D4	0.0062
AFD3	0.36	D5	0.0045
AFD4	0.30	D6	0.0037
AHD5	0.20	E3	0.0033
AHD6	0.13	E4	0.0025
AHD7	0.11	E5	0.0022
AHD8	0.085	E6	0.0019
AHD9	0.074	E7	0.0017
BBD3	0.09	F8	0.0013
BBD4	0.065	F9	0.0011
BBD5	0.05	F10	0.0085
BBD6	0.033		
BBD7	0.028		
BGD3	0.03		
BGD4	0.019	AFB4	0.68
BGD5	0.016	AHB5	0.42
BGD6	0.012	AHB6	0.31
BGD7	0.01	AHB7	0.21
BGD8	0.008	AHB8	0.16
BGD9	0.006	AHB9	0.13
BGD10	0.006	AHB10	0.10

Trouble Shooting Guide - continued

All models of automatic voltage regulators can be tested as follows:

1. Remove exciter field leads X & XX (F1 & F2) from the AVR terminals X & XX (F1 & F2).
2. Connect a 60W 240V incandescent bulb to AVR terminals X & XX (F1 & F2).
3. Turn the AVR VOLTS control potentiometer fully clockwise.
4. Connect a 12V; 1.0A DC supply to the exciter field leads X & XX (F1 & F2) with X (F1) to the positive.
5. Start the generating set and run at rated speed.
6. Check that the generator output voltage is within +/- 10% of rated voltage.

The bulb should light for approximately 8 seconds and then turn off. Failure to turn off indicates a faulty protection circuit and the AVR should be replaced. Turning the “VOLTS” control potentiometer fully counter-clockwise should turn off the lamp with all AVR types. Should the bulb fail to light, the AVR has failed and should be replaced.

Appendix A - Generator Warranty

Return Policy

1. All WorldWide Electric products (electric motors, motor controls and gearing products) that are purchased as normal stock items may be returned, with freight to be paid, back to the closest WorldWide Electric warehouse by the customer.
2. Any returned products must be new, undamaged and in original cartons/packaging. Final credit will not be issued until WorldWide Electric has verified the products/shipping cartons as such.
3. All RGA requests must be made within 90 days of original purchase.
4. If the returned products were ordered incorrectly by the customer, 20% will be levied as a restocking charge which carries a minimum $75 charge.
5. If the customer places an order equal to or greater than the goods being returned, then the restocking charge will be 10% (minimum $75 charge).
6. If the product being returned was originally shipped to the customer prepaid and allowed, the original freight charge will be deducted from the return credit.
7. If the returned products are not in original condition (as well as the packaging), there will be additional fees applied to repair and/or replace those parts/products.

Warranty Length

Standby Duty Generators, whichever of the following comes first:

- 24 months from date of commissioning,
- 30 months from date of shipment,
- 1200 hours of run time

Continuous Duty Generators, whichever of the following comes first:

- 12 months from date of commissioning,
- 18 months from date of shipment,
- 5000 hours of run time

Appendix A - Generator Warranty - Continued

Warranty Procedure

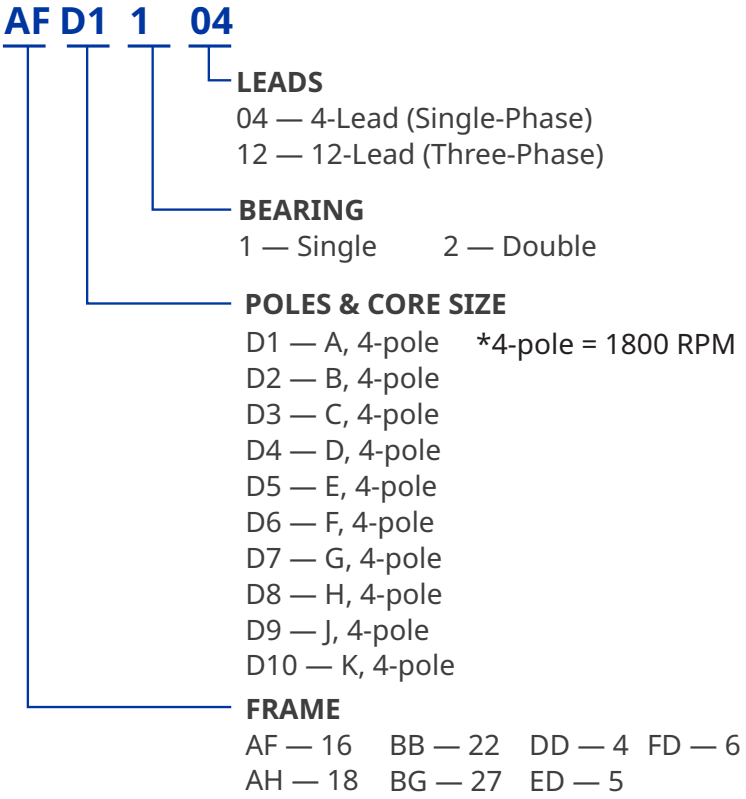
This warranty is extended only to customers who purchase directly from WorldWide Electric Corporation, LLC. The warranty policy does not extend to customers of the initial buyer.

THE FOREGOING WARRANTIES ARE IN LIEU OF ALL OTHER EXPRESS AND IMPLIED WARRANTIES (EXCEPT TITLE), INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. NO EMPLOYEE, REPRESENTATIVE, OR AGENT OF WORLDWIDE ELECTRIC CORPORATION, LLC OTHER THAN AN OFFICER OF THE CORPORATION IS AUTHORIZED TO ALTER OR MODIFY ANY PROVISION OF THIS WARRANTY OR TO MAKE ANY GUARANTEE, WARRANTY, OR REPRESENTATION, EXPRESS OR IMPLIED, ORALLY OR IN WRITING, WHICH IS CONTRARY TO THE FOREGOING.

Appendix B - Generator Data

Model Number

WorldWide Electric Generators use a model number system conforming to that used by many manufacturers of similar types and models of generators. For example, WorldWide Electric Generator Model BBD4 can be interpreted as shown below:



Serial Number Location

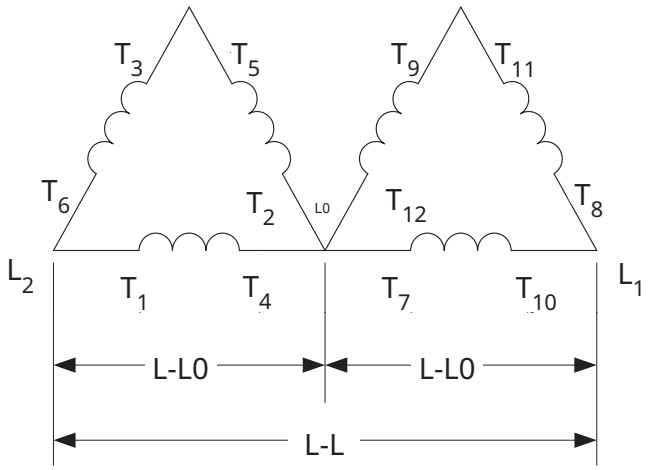
Each generator has a serial number stamped on the Nameplate supplied with each unit. It is important to record and preserve this serial number for use when ordering parts or requesting service.

Appendex B -Connection Diagrams

Terminal Ends

TERMINAL ENDS	
IEC	NEMA
U1	T1
U2	T4
U5	T7
U6	T10
V1	T2
V2	T5
V5	T8
V6	T11
W1	T3
W2	T6
W5	T9
W6	T12

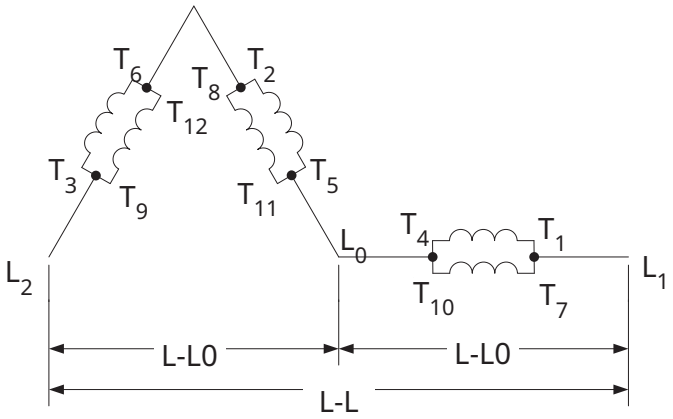
Double Delta 1PH 3W



DOUBLE DELTA		
1PH 3W		
HZ	L-L	L-L0
60	200	100
	220	110
	240	120
50	220	110

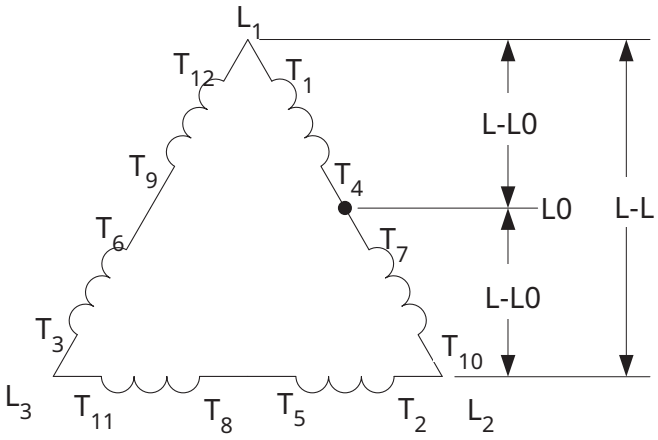
Appendix B - Connection Diagrams - continued

Parallel Low Zig Zag 1PH 3W



PARALLEL LOW ZIG ZIG		
1PH 3W		
HZ	L-L	L-L0
60	200	100
	220	110
	240	120
50	220	110

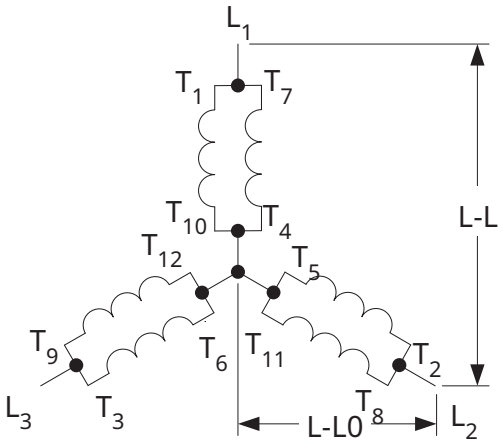
Series High Delta 3PH 4W



SERIES HIGH DELTA		
3PH 4W		
HZ	L-L	L-L0
60	240	120
	277	139
50	200	100
	220	110
	240	120

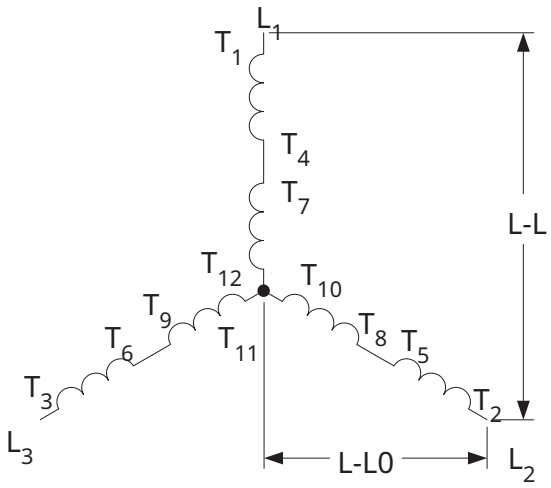
Appendix B - Connection Diagrams - continued

Parallel Low Wye (Star) 3PH 4W



PARALLEL LOW WYE (STAR)		
3PH 4W		
HZ	L-L	L-L0
60	208	120
	220	127
	230	133
	240	139
50	190	110
	400	115
	415	127

Series High Wye (Star) 3PH 4W



SERIES HIGH WYE (STAR)		
3PH 4W		
HZ	L-L	L-L0
60	416	240
	440	254
	460	266
	480	277
50	380	219
	400	231
	415	240

Appendix C - Parallel Operations

Paralleling Basics

The following points are basic criteria, which must be met before two units can be paralleled.

Additional paralleling circuitry

- Voltage regulator-paralleling provisions (Note: AVR Model AG460 is not suitable for parallel operation).
- Paralleling current transformer(s)
- Paralleling provisions on governor controls

Before operating generator sets in parallel, each set should be checked by starting, operating, and adjusting the sets as individual units before attempting paralleling. The driving engines should have the same speed regulation characteristics and the governors should be adjusted to give the same speed regulation. The generators must have the same phase rotation. The voltage and frequency must be the same for all sets with voltages in phase.

Voltage Regulator

The voltage regulator controls the generator output voltage and the reactive power supplied by the generator. When two or more AC generators operate in parallel, the voltage regulator must have paralleling provisions (either internally or external to the regulator) to allow the voltage regulator to control the reactive or VAR load while it is in parallel operation. Additional paralleling circuitry is absolutely necessary to control the reactive current flowing between the generator sets.

A droop kit accessory is required for parallel operation. When operating in parallel with other generators, it is important that:

- Frequency must match within close limits.
- Voltages must match within close limits.
- Phase angle of voltages must match within close limits.

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.

Reactive Load Control

When two identical generators are operating together in parallel and an unbalance occurs in field excitation, circulating currents begin to flow between the generators. This current will appear as a lagging power factor or inductive load to the highly excited generator, and as a leading power factor or

Appendix C - Parallel Operations - continued

capacitive load to the generator with the lower field current. This is known as the reactive circulating current, and there are two methods of controlling it in parallel operation:

- Reactive droop compensation: The bus voltage droops, or decreases, as the reactive lagging power factor load is increased.
- Reactive differential compensation: The re active differential compensation circuit allows parallel generators to share reactive loads with no decrease or droop in generator voltage.

Droop

WorldWide Electric Generators use the droop method. The 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 the AVR.

If parallel operation is envisioned for your generator, please contact the factory at time of ordering, so that the proper accessories can be provided.

Appendix D - SAE Data

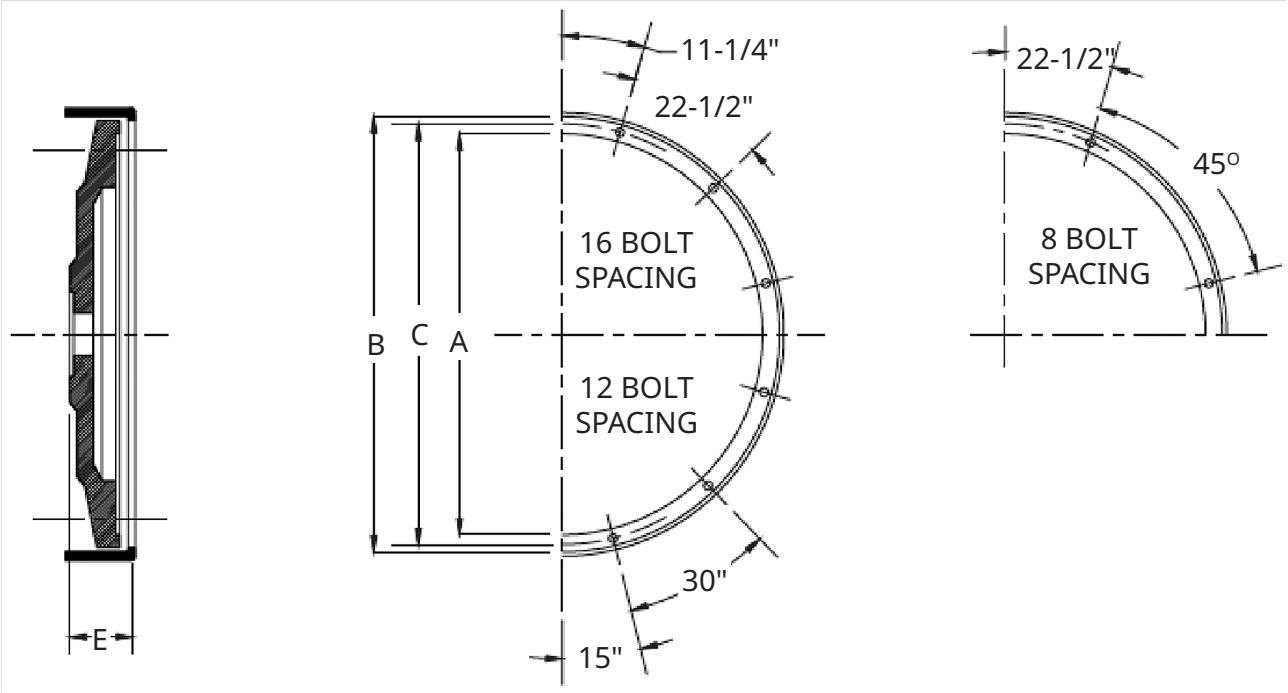
SAE ADAPTOR / COUPLING COMBINATIONS

Adaptor	Coupling	AF	AH	BB	BG	D	E	F
6	6.5	A						
	7.5	A						
5	6.5	O	A					
	7.5	A	A					
	ALHA	A	A					
4	6.5	A	A					
	7.5	O	A	X				
	8	O	O*	A				
	10	O	O*	A				
	11.5	A						
3	8		X	A				
	10	A	O*	O	O			
	11.5	A	O*	O	O			
2	10			A	A			
	11.5		X	O	O	A		
1	11.5			A	A	A		
	14			A	O	O	A	A
	17.75D				X	A	A	
1/2	14					A	A	A
	18						A	A
	17.75D					A	A	A
0	14						A	A
	18					O	A	O
	17.75D					A	O	A
0	18						A	A
	21						A	A
	24						A	A
A - Available O - Most Common X - Special Order								

AG184 H & J - Only Coupling & Adaptor Combinations Available

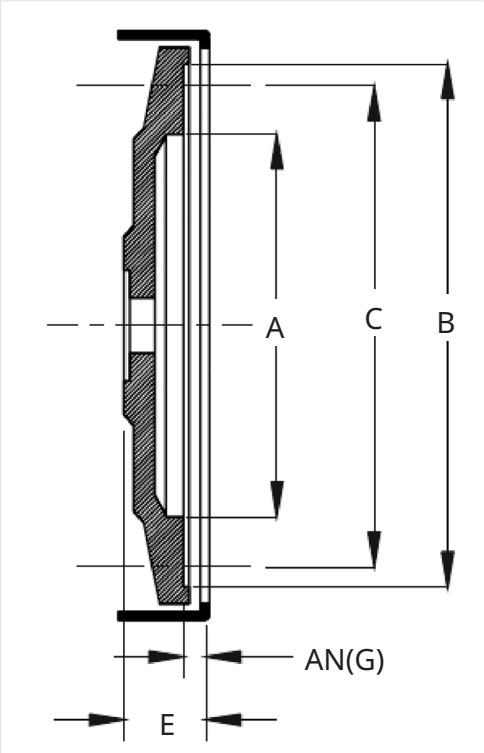
Appendix D - SAE Data - continued

STANDARD INDUSTRIAL FLYWHEEL HOUSING						
SAE No.	A	B	C	E	# Holes	Size
0	31	34-3/4	33-1/2	3-15/16	16	1/2-13
0	25-1/2	28	26-3/4	3-15/16	16	1/2-13
1/2	23	25-1/2	24-3/8	3-15/16	12	1/2-13
1	20-1/8	21-3/4	20-7/8	3-15/16	12	7/16-14
2	17-5/8	19-1/4	18-3/8	3-15/16	12	3/8-16
3	16-1/8	17-3/4	16-3/8	3-15/16	12	3/8-16
4	14-1/4	15-7/8	15	3-15/16	12	3/8-16
5	12-3/8	14	13-1/8	2-13/16	8	3/8-16
6	10-1/2	12-1/8	11-1/4	2-13/16	8	3/8-16



Appendix D - SAE Data - continued

STANDARD INDUSTRIAL FLYWHEELS							
Nom. Clutch Diameter	A	B	C	E	AN (G)	# Holes	Bolt Size
6-1/2	7-1/4	8-1/2	7-7/8	2-13/16	1-3/16	6	5/15-18
7-1/2	8-1/8	9-1/2	8-3/4	2-13/16	1-3/16	8	5/15-18
8	8-7/8	10-3/8	9-5/8	3-15/16	2-7/16	6	3/8-16
10	10-7/8	12-3/8	11-5/8	3-15/16	2-1/8	8	3/8-16
11-1/2	12-3/8	16-1/8	13-1/8	3-15/16	1-9/16	8	3/8-16
14	16-1/8	18-1/8	17-1/4	3-15/16	1	8	1/2-13
16	18-1/8	20-3/8	19-1/4	3-15/16	5/8	8	1/2-13
18	19-5/8	22-1/2	21-3/8	3-15/16	5/8	8	5/8-11
21	23	26-1/2	25-1/4	3-15/16	0	12	5/8-11
24	25-3/8	28-7/8	27-1/4	3-15/16	0	12	3/4-10
15.5D	---	15-1/2	13-7/8	---	23/32	8(4X2)	5/8-11
17.75D	---	17-3/4	15-1/2	---	23/32	8(4X2)	5/8-11



Appendix D - SAE Data - continued

SAE PLATE BOLT TORQUE VALUES

Model Number	Bolt Size	Torque (Nm)	Torque (Ft-lb)
AF	M10 X 30mm	75	55
AH	M10 X 30mm	75	55
BB	M16 X 35mm	320	236
BG	M16 X 35mm	320	236
D	M20 X 55mm	625	461
E	M16 X 65mm	625	461
F	M24 X 65mm	1072	791

Appendex E - AVR Data Sheets

MX321 AUTOMATIC VOLTAGE REGULATOR

SPECIFICATIONS		
Sensing Input	Voltage Frequency Phase	190-264V AC 50/60 Hz nominal Single or Three Phase
Power Input (PMG)	Voltage Frequency Current	140-220 VAC (max), 3 Phase 3 Wire 100-120 HZ nominal 3 Amps per Phase
Output	Voltage Current Resistance	Max 120 VDC Continuous 3.7 ADC; Intermittent 6A-10 sec [6] Minimum 15 Ohms
Regulation	+/- 0.5% [1]	
Thermal Drift	0.02% per degree C in AVR ambient [2]	
Soft Start Ramp Time	0.4 to 4 Seconds	
System Response	AVR response Field Current to 90% Machine Volts to 97%	10 ms 80 ms 300ms
External Voltage Adjustment	+/- 10% w/ 1k ohm —1 watt trimmer [3]	
Under Frequency Protection	Set Point Slope Max Dwell	95% Hz [4] 100-300% down to 30 Hz 20% Volts/S Recovery
Unit Power Dissipation	10 Watts Max	
Analog Input	Maximum Input +/- 5 VDC [5] Sensitivity 1V per 5% Generator Voltage (adjustable) Input Resistance 1 K Ohms	
Quadrature Droop Input	10 Ohms burden Max Sensitivity 0.22A for 5% droop 0PF Max Input 0.33A	
Current Limit Input	10 Ohms burden Sensitivity Range 0.5-1A	
Over Voltage detector Input	Set Point 200V, Time delay 1 second (fixed) CB Trip Coil Voltage 10-30 VDC CB Trip Coil Resistance 20-60 Ohms	
Over-Excitation Protection	Set Point 75 VDC Time Delay 8-15 seconds (fixed)	
Environment Specifications	Operating Tempera-ture Relative Humidity 0-70° C	-40° C to +70° C 0-95% non condensing -55° C + 80° 20-100 Hz–50 mm/sec; 100-2K Hz – 3.3g
NOTES	1 - With 4% Engine Governing 2 - After 10 minutes 3 - Some de-rating may occur at voltage extremes 4 - Factory set, semi sealed, select w/jumper 5 - Device connected must be galvanically isolated from ground, >500 VAC 6 - De-rating linear from 3.7 A at 50° C to 2.7 A at 70° C	

Appendix E - AVR Data Sheets- continued

MX341 AUTOMATIC VOLTAGE REGULATOR

SPECIFICATIONS		
Sensing Input	Voltage Frequency Phase	190-264V AC 50/60 Hz nominal Single
Power Input (PMG)	Voltage Frequency Current	140-220 VAC (max), 100-120 HZ nominal 3 Amps per Phase
Output	Voltage Current Resistance	Max 120 VDC Continuous 3.7 ADC; Intermittent 6A-10 sec Minimum 15 Ohms
Regulation	+/- 1.0% [1]	
Thermal Drift	0.03% per degree C in AVR ambient [2]	
Soft Start Ramp Time	3 Seconds	
System Response	AVR response Field Current to 90% Machine Volts to 97%	10 ms 80 ms 300ms
External Voltage Adjustment	+/- 10% w/ 1k ohm —1 watt trimmer [3]	
Under Frequency Protection	Set Point Slope	95% Hz [4] 170% down to 30 Hz
Unit Power Dissipation	12 Watts Max	
Analog Input	Maximum Input +/- 5 VDC [5] Sensitivity 1V per 5% Generator Voltage (adjustable) Input Resistance 1 K Ohms	
Quadrature Droop Input	10 Ohms burden Max Sensitivity 0.07A for 5% droop 0PF Max Input 0.33A	
Over-Excitation Protection	Set Point 75 VDC Time Delay 10 seconds (fixed)	
Environment Specifications	Operating Temperature Relative Humidity 0-70° C Storage Temperature Vibration	-40° C to +70° C 0-95% non condensing -55° C + 80° 20-100 Hz–50 mm/sec; 100-2K Hz – 3.3g
NOTES	1 - With 4% Engine Governing 2 - After 10 minutes 3 - Some de-rating may occur at voltage extremes 4 - Factory set, semi sealed, select w/jumper 5 - Device connected must be galvanically isolated from ground, >500 VAC	

Appendix E - AVR Data Sheets- continued

AS440 AUTOMATIC VOLTAGE REGULATOR

SPECIFICATIONS		
Input	Voltage Frequency Phase	95-132V or 190-264V AC (jumper) 50/60 Hz nominal Single Phase
Output	Voltage Current Resistance	Max 90V DC @ 207V AC input Continuous 4 DC; Intermittent 6A-10 sec Minimum 15 Ohms
Regulation	+/- 1.0% [1]	
Thermal Drift	0.04% per degree C in AVR ambient [2]	
System Response	AVR response Field Current to 90% Machine Volts to 97%	20 ms 80 ms 300ms
External Voltage Adjustment	+/- 10% w/ 1k ohm —1 watt trimmer [3]	
Under Frequency Protection	Set Point Slope	95% Hz [4] 170% down to 30 Hz
Unit Power Dissipation	12 Watts Max	
Build-up Voltage	4 Volts at AVR terminals	
Analog Input	Maximum Input +/- 5 VDC [5] Sensitivity 1V per 5% Generator Voltage (adjustable) Input Resistance 1 K Ohms	
Quadrature Droop Input	10 Ohms burden Max Sensitivity 0.07A for 5% droop 0PF Max Input 0.33A	
Environment Specifications	Operating Temperature Relative Humidity 0-70° C Storage Temperature Vibration	-40° C to +70° C 0-95% non condensing -55° C + 80° 20-100 Hz–50 mm/sec; 100-2K Hz – 3.3g
NOTES	1 - With 4% Engine Governing 2 - After 10 minutes 3 - Some de-rating may occur at voltage extremes 4 - Factory set, semi sealed, select w/jumper 5 - Device connected must be galvanically isolated from ground, >500 VAC	

Appendix E - AVR Data Sheets- continued

AS460 AUTOMATIC VOLTAGE REGULATOR

SPECIFICATIONS		
Input	Voltage Frequency Phase	95-132V or 190-264V AC (jumper) 50/60 Hz nominal Single Phase
Output	Voltage Current Resistance	Max 90V DC @ 207V AC input Continuous 4 DC; Intermittent 6A-10 sec Minimum 15 Ohms
Regulation	+/- 1.0% [1]	
Thermal Drift	0.05% per degree C in AVR ambient [2]	
System Response	AVR response Field Current to 90% Machine Volts to 97%	20 ms 80 ms 300ms
External Voltage Adjustment	+/- 10% w/ 1k ohm —1 watt trimmer [3]	
Under Frequency Protection	Set Point Slope	95% Hz [4] 170% down to 30 Hz
Unit Power Dissipation	10 Watts Max	
Build-up Voltage	4 Volts at AVR terminals	
Environment Specifications	Operating Temperature Relative Humidity 0-70° C Storage Temperature Vibration	-40° C to +70° C 0-95% non condensing -55° C + 80° 20-100 Hz–50 mm/sec; 100-2K Hz – 3.3g
NOTES	1 - With 4% Engine Governing 2 - After 10 minutes 3 - Some de-rating may occur at voltage extremes 4 - Factory set, semi sealed, select w/jumper	

Appendex F - Generator Certifications

WorldWide Electric Generator Certificatios

WorldWide Electric Generators are designed and manufactured for safe and reliable operation, in factories certified to ISO 9001:2000. WorldWide Electric Generators are rated for standby or continuous duty.

WorldWide Electric AC synchronous generators are brushless 4 pole, self-ventilated alternators, which create 60 Hz power at 1800 RPM or 50 Hz power at 1500 RPM. The generators can be provided in one or two bearing configurations. They are designed and built in accordance with IEC 6003 1-1 & -2 requirements, BS4990 & 5000, NEMA MG1 2006, CSA & C/UL, and CE.

WorldWide Electric Generators carry the following quality marks from internationally recognized agencies:

WORLDWIDE
ELECTRIC CORPORATION

RELIABLE GENERATORS

FOR INDUSTRIAL AND LIGHT TOWER APPLICATIONS

(OH, AND THEY'RE IN STOCK TOO.)

Call us today at **(800) 808-2131**
or browse our complete product lines at **worldwideelectric.com**.

WorldWide Electric Corporation
3540 Winton Place, Rochester, NY 14623
24/7 Phone: (800) 808 - 2131
24/7 Service: (844) WWE - SERV
Email: CustomerService@worldwideelectric.com
worldwideelectric.com

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