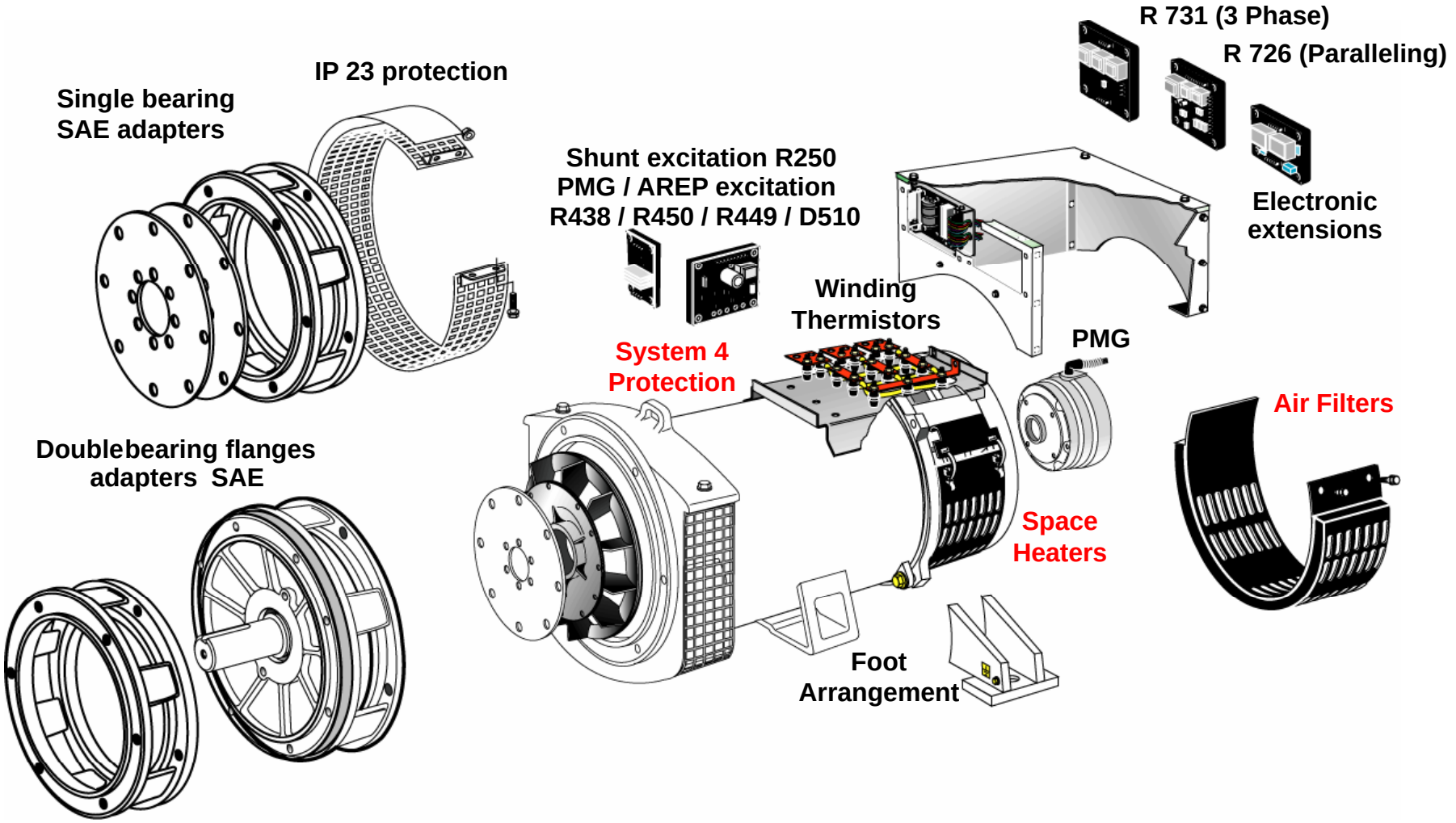
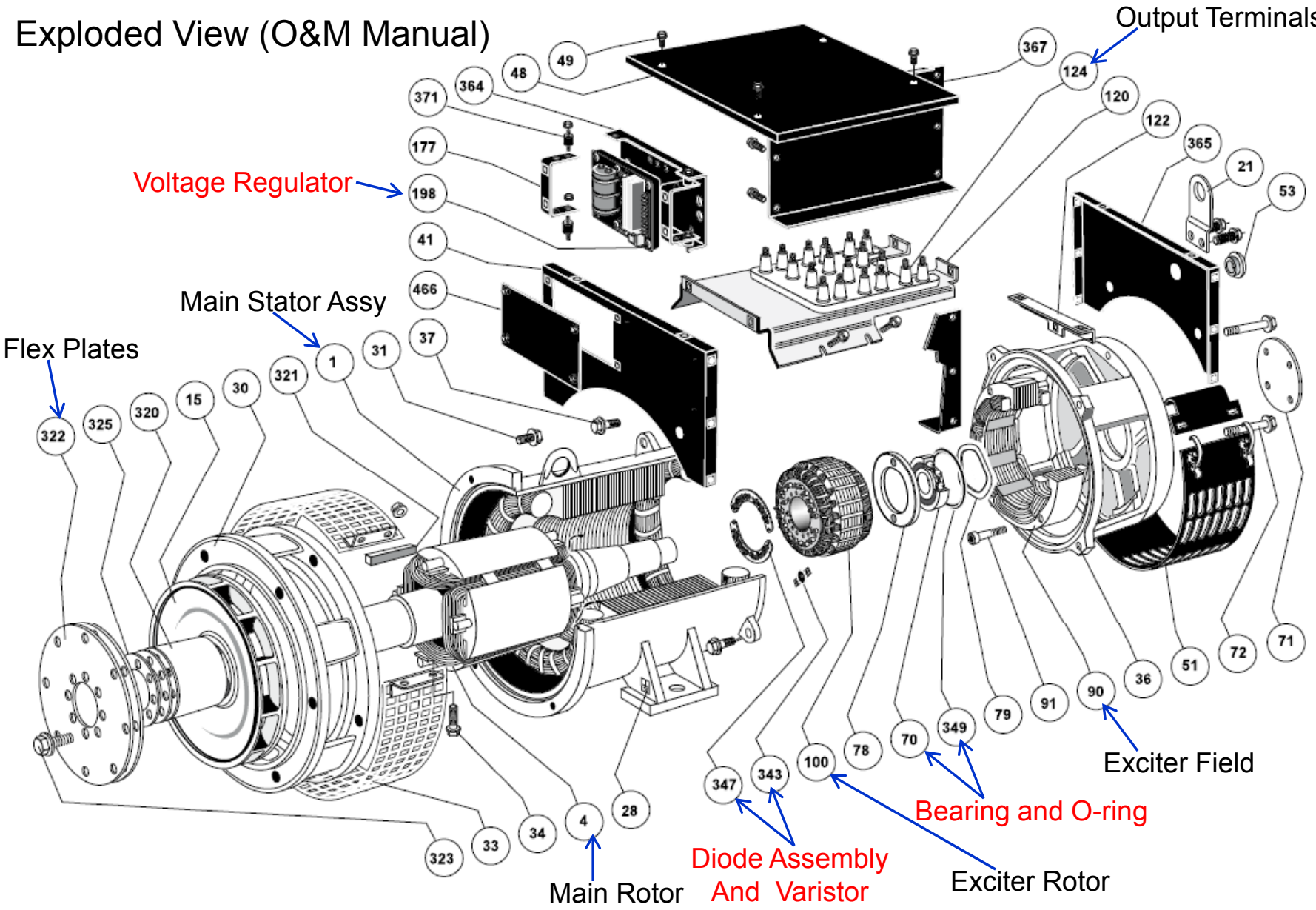
Typical Generator Options and Features



Leroy Somer Product Training

Exploded View (O&M Manual)



Excitation Systems: Shunt, AREP and PMG Principles

Shunt (Self Excited): The main stator output voltage is the voltage regulators input power supply. The voltage regulator and load are powered by the generator.

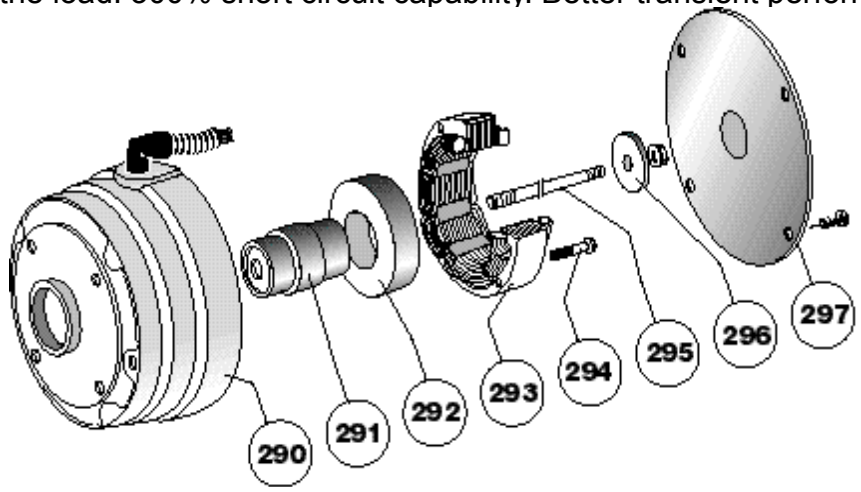
***AREP:** H1 (X1, X2): Internal winding that delivers a voltage proportional to the output voltage and is the voltage regulators steady state power supply
H3 (Z1, Z2): Internal winding delivering a voltage proportional to the output current and is the voltage regulators power supply during reduced voltage events

***PMG:** The permanent magnet generator supplies power to the voltage regulator and is its continuous power supply.

*The voltage regulator input power is isolated from the load. 300% short circuit capability. Better transient performance.

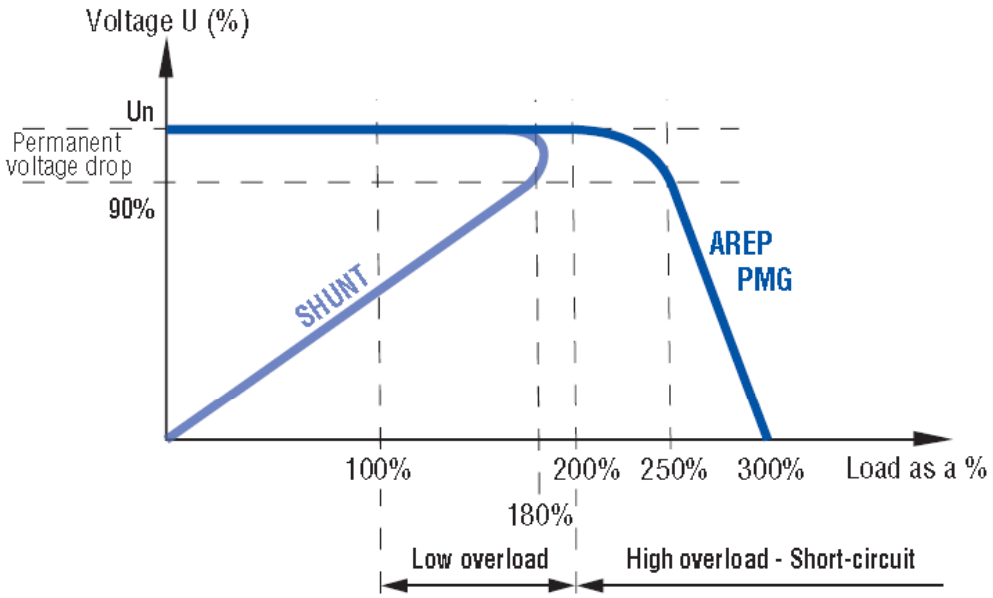
PMG Construction

290 Housing
291 Adaptation shaft
292 Rotor magnets
293 Stator
294 Fixing screw
295 Tie rod
296 Washer & nut
297 End plate

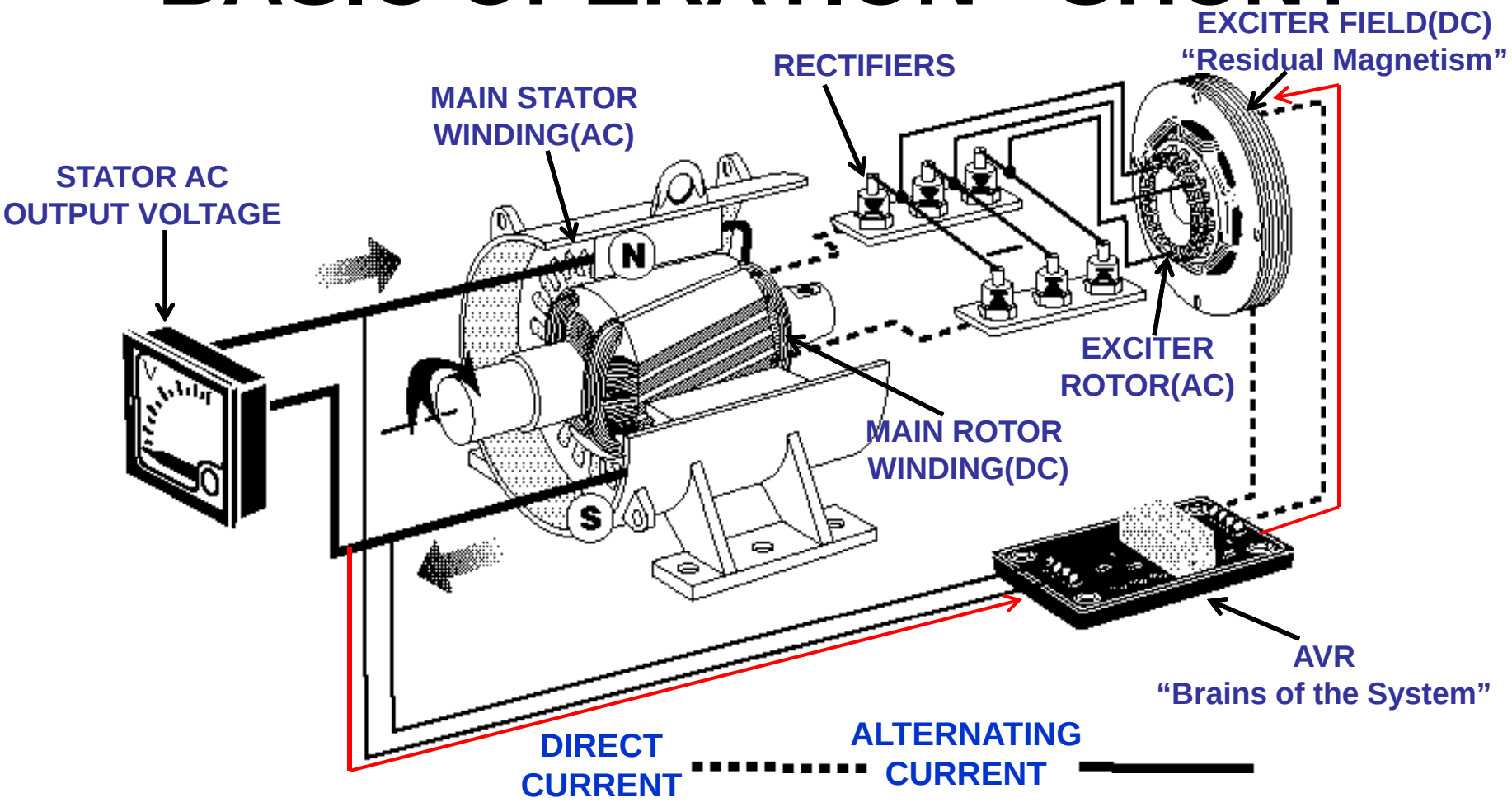


Excitation system selection chart

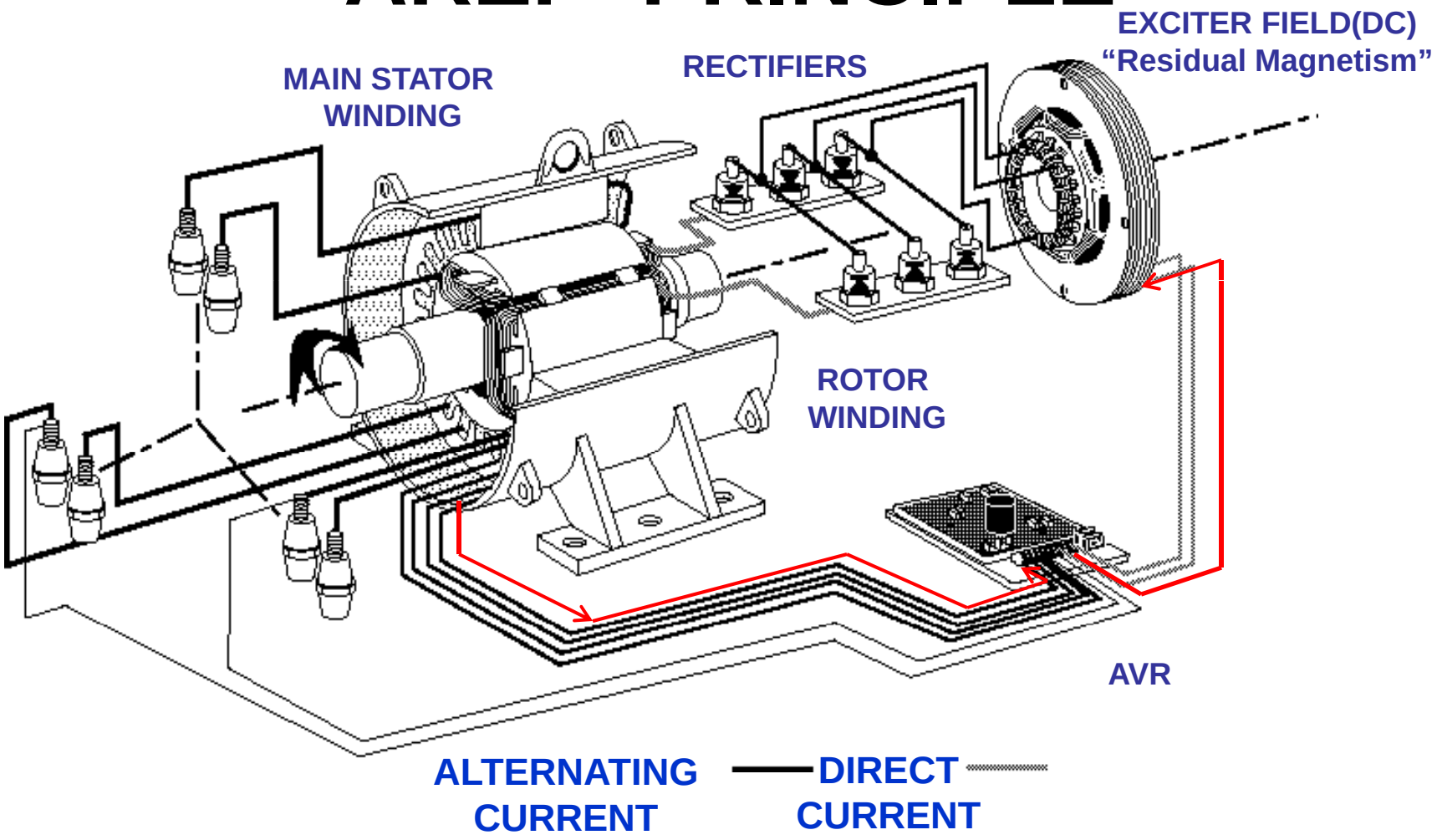
	SHUNT	AREP	SHUNT + PMG
Motor starting capacity	Basic	High	High
Short-circuit capability	No	300%/10 s	300%/10 s
Susceptibility to non-linear loads	Maximum	Minimum	Minimum
Number of components	Minimum	Minimum	Maximum
Possibility of conversion	Yes (PMG)	Yes (PMG or Shunt)	Yes (Shunt)
Alternator length	Minimum	Minimum	Maximum
Price	€	€€	€€€
		Special	Standard
		Residual magnetism (remanent)	Permanent magnets
		Marine, industry, construction, hospitals, banks, standard production	Marine, industry, construction, hospitals, banks, standard production
		Can't be repaired	Reduced: an additional turning part



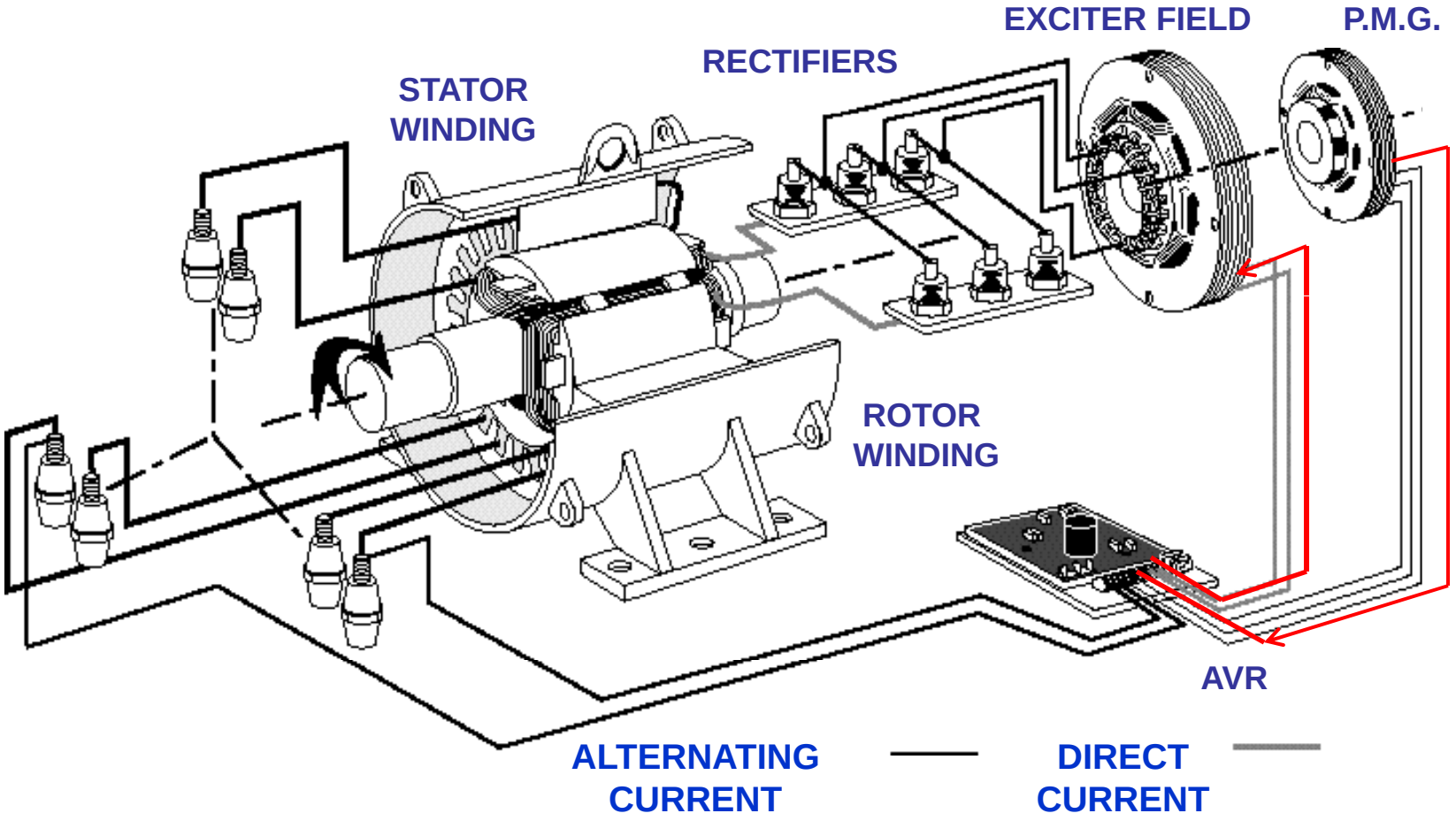
BASIC OPERATION - SHUNT



AREP PRINCIPLE

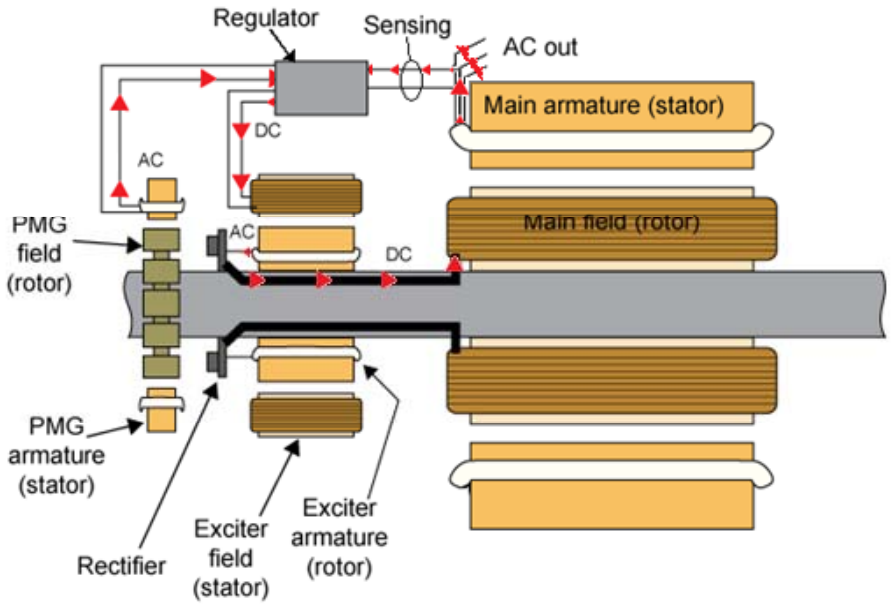


SHUNT + PMG PRINCIPLE



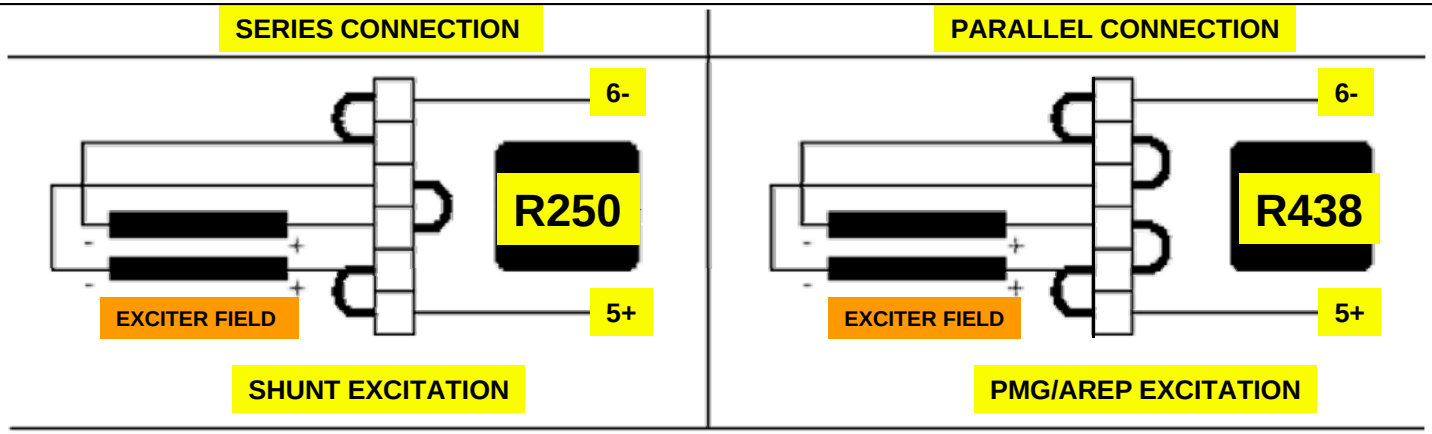
How Does it all Really Work Again?

- As the PM rotor rotates, it produces AC voltage in the PM stator. This voltage is applied to the voltage regulator (AVR).
- The AVR rectifies this AC voltage and applies the DC to the exciter stator.
- A three-phase AC voltage is induced in the exciter rotor, which is in turn rectified by the rotating rectifiers and applied to the main field winding.
- This DC voltage in the main field induces a higher AC voltage in the main stator winding.
- The output voltage is sensed by the AVR and compared to a reference level. The regulator then varies the DC output to the exciter stator to control the main stator AC output voltage.

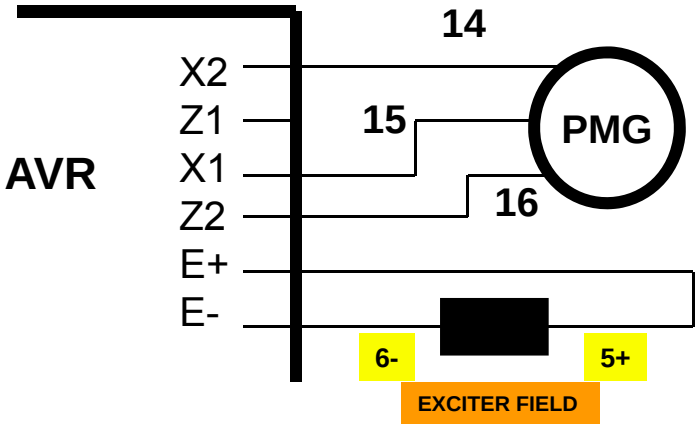


Automatic Voltage Regulators

Dual Winding Exciter Stator Connection



Only applicable to the 42.2 43.2 44.2 Series Alternators



AVR connection for PMG.

Leroy Somer Product Training

Voltage Regulator Overview

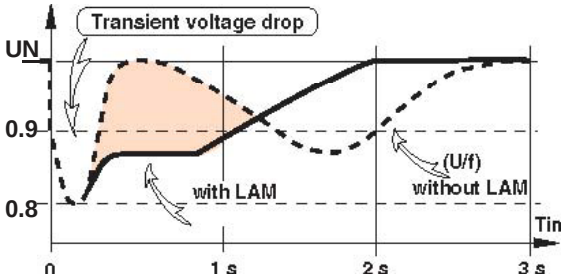
Leroy Somer AVRs have been designed to comply with market requirements regarding performance conformity to standards and reliability. Main Characteristics:

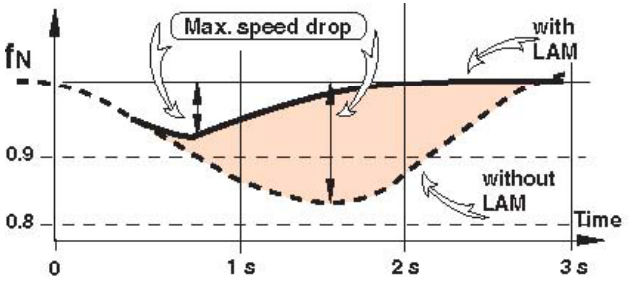
- •Simple and user friendly interface
- •Power switching transistor offers optimum response for nonlinear loads
- •Voltage regulation +/- .5% steady state with rapid time <500ms
- •Optimized design resistant to vibration and environmental condition(coated)
- •Conformance to IEC 60034-1 and UL 508

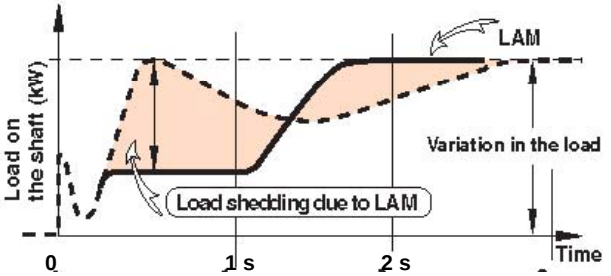
***Load Acceptance Module(LAM)**

The LAM helps a diesel engine when its speed drops after a load impact ; this function can be activated by a selector. Once activated, the LAM makes the voltage to drop of 13% or 25% (selection by selector) when frequency drops below the pre-adjusted frequency threshold (48hz or 57.5hz); the applied active load is reduced by 25% or 45% during the time the engine speed recovers to its nominal value (required power varies according to the square of voltage). The LAM then allows, either to decrease the engine speed variation and its duration for a given applied load, or to increase the possible applied load for a same speed variation (turbocharged engines).

The 25% LAM position must be used for very large load impacts (>60% SN) in order to avoid engine collapse when the load is applied (avoid the need for a larger engine). **The 25% voltage dip corresponding to this position <u>could</u> be incompatible with acceptable limits for protective devices or relays used on loads at the customers site.**





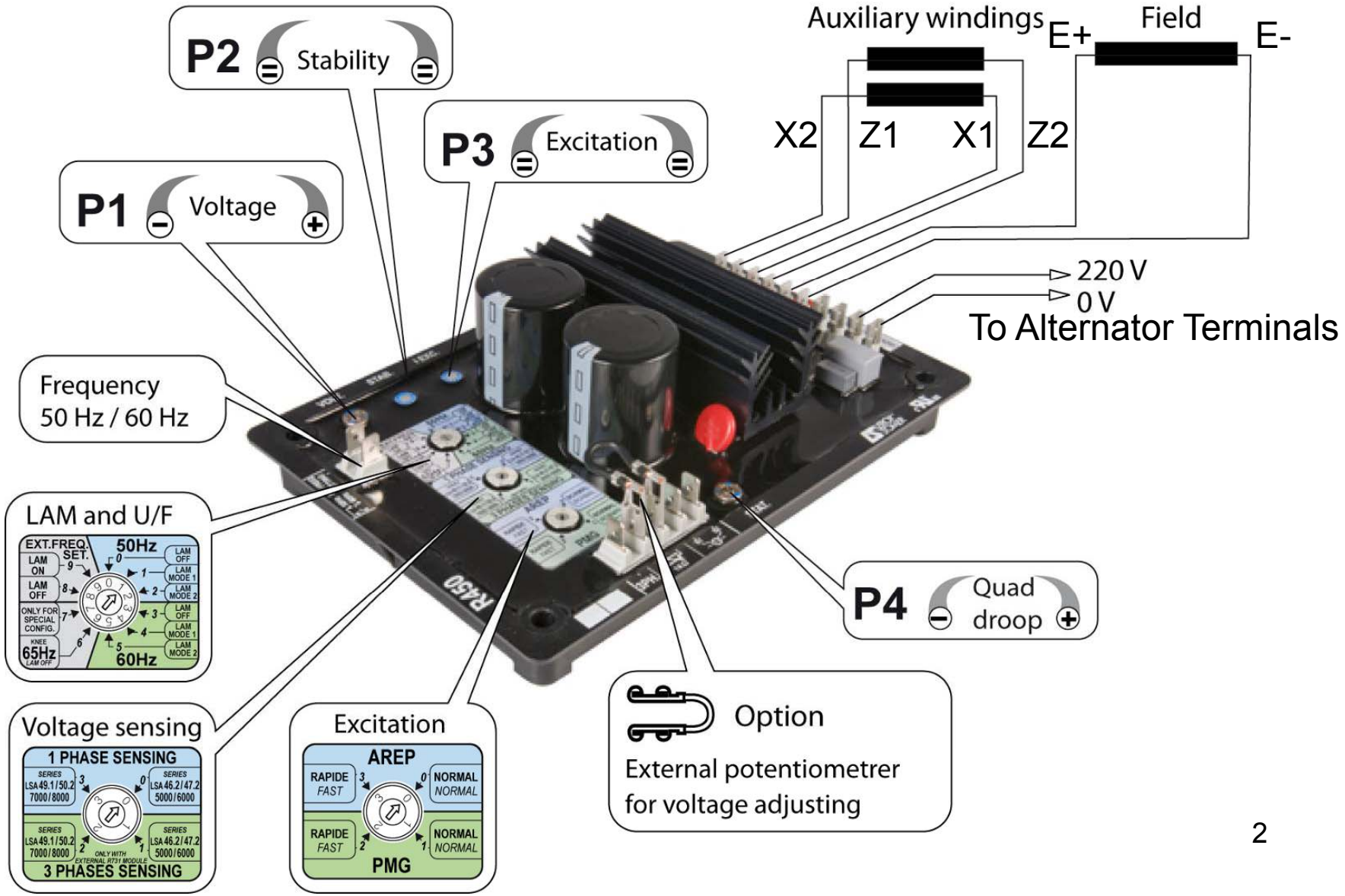


R250 is Shunt with single phase sensing only (110V), no overload protection, 6A Rated (42.2-46.2)

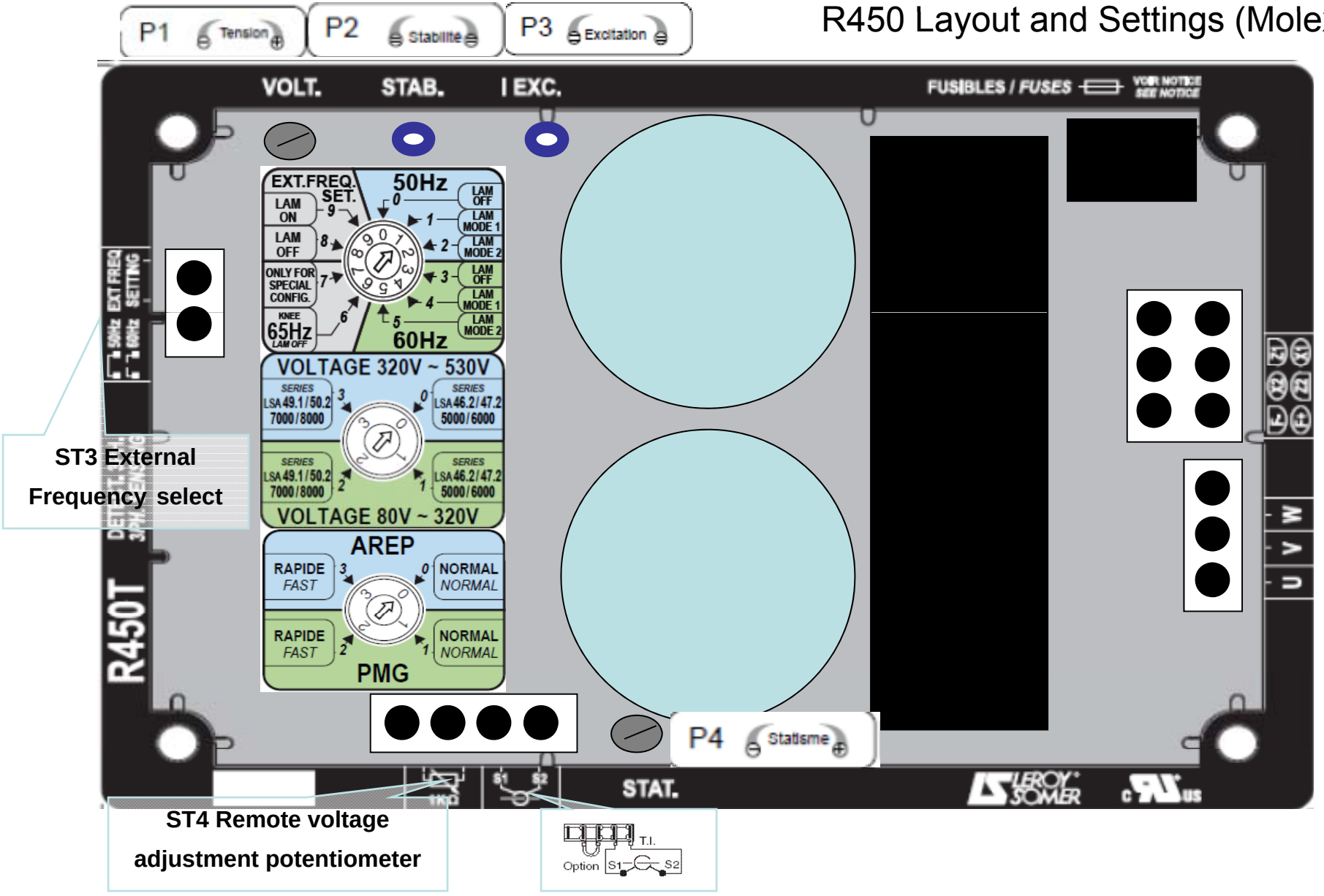
R438 is AREP or PMG, single or 3 phase sensing (110, 220, 380V), 8A Rated. (42.2-47.2)

R450 is Shunt, AREP or PMG, single or three phase sensing, 10A Rated (46.2-49.1)

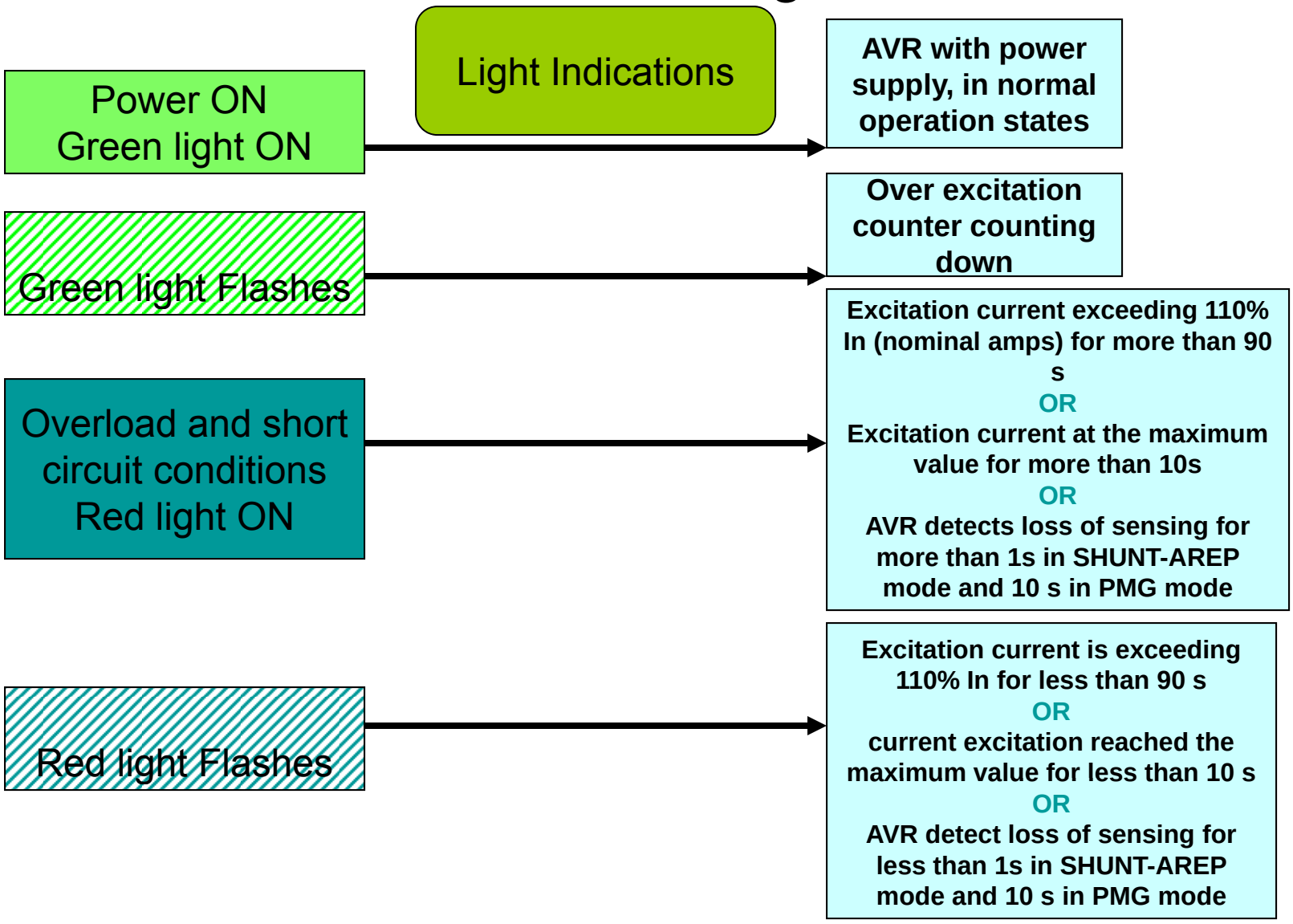
R450 Layout and Settings (Fast on)



R450 Layout and Settings (Molex)



R450 Red and Green Light Details



Generator Trouble-shooting

WARNING

UNIT SHOULD BE COMMISSIONED AND SERVICED BY QUALIFIED PERSONNEL ONLY.
LOCK OUT CIRCUIT BREAKER BEFORE PERFORMING ANY WORK.

WHEN THE ALTERNATOR IS STOPPED, MAINS VOLTAGE MAY STILL BE PRESENT AT THE MODULE VOLTAGE SENSING TERMINALS.

DO NOT USE HIGH-VOLTAGE MEASURING EQUIPMENT IN TESTING THE AVR. INCORRECT USE OF SUCH EQUIPMENT CAN CAUSE DAMAGE TO THE SEMICONDUCTORS CONTAINED IN THE AVR.

DO NOT PERFORM MEGGER OR HIGH POTENTIAL TEST TO THE WINDING WITHOUT DISCONNECTING THE AVR FIRST.

Before starting the machine for the first time, check:

1. the mounting bolts on the feet to the base rail are tight
2. the cooling air intake and exhaust are unobstructed
3. the protective screens and housing are correctly in place
4. the winding is clean and dry,
5. the alternator and regulator is wired and connected correctly*

* Reference the Installation and Maintenance manual for winding and regulator connections

Basic Tools List

- Multi-meter for measuring:
  Voltage, Ampere, Frequency, Resistance(>1 ohm)
- Insulation resistance meter: 500-1000VDC, capable of measuring up to 1000 Megohm
- Micro-ohm meter: Used to measure resistance down to .0001 ohm
- Variable DC supply for separate excitation tests (Connect resistor to 12V battery to supply 7-12Vdc to exciter field)
- General tool box: Basic Hand tools to include metric wrench and socket set 8-22MM

Insulation Resistance Test

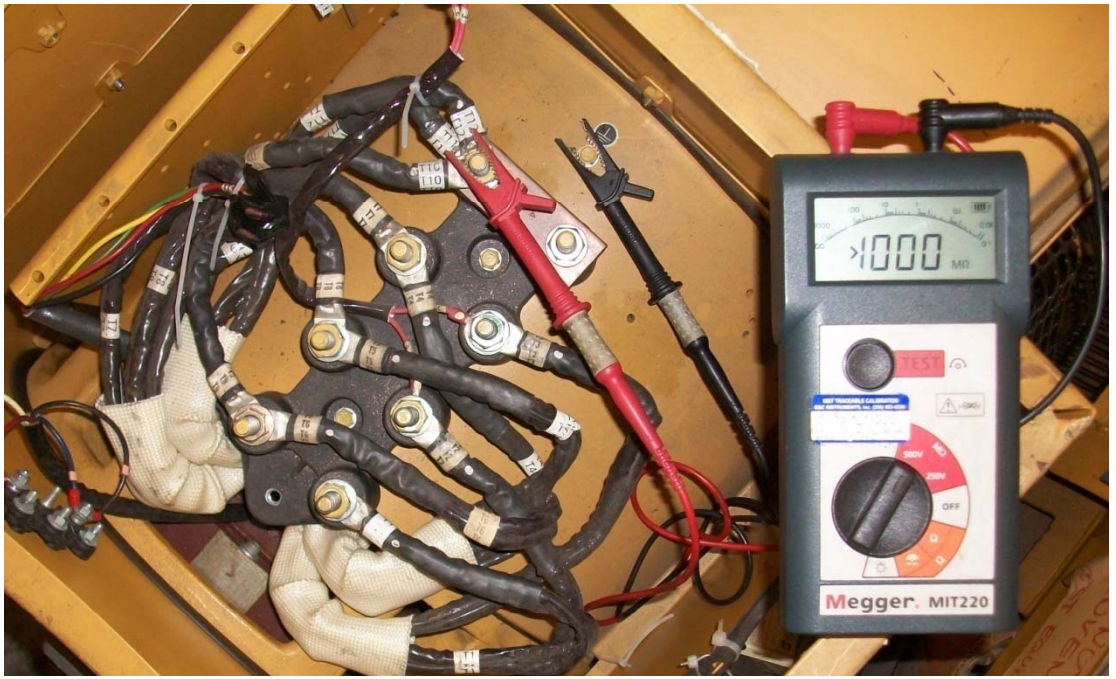
- **Causes of low insulation resistance**
  - Alternator has not been used for an extended period (transportation, storage, etc).
  - Alternator becomes wet and/or dirty (condensation, fog, dust accumulation, etc).
  - Lack of space heater usage or maintenance while unit not in use.

- **Equipment used for measuring insulation.** (AVR must be disconnected during test)
  - Megohm meter 1000Vdc for machine with nominal voltage – Un >5000
  - Megohm meter 500Vdc for machine with nominal voltage – Un <750

- **Results**
  - Insulation resistance between phases and each phase to earth must be over 10 Megohms for main stator windings and 1 Megohm DC windings
    - ❖ Do not run the alternator if the minimum insulation level is not reached, dry and clean the windings as necessary before proceeding. The Procedure for this will be discussed later in this presentation.
    - ❖ Insulation systems deteriorate over time due to thermal and environmental degradation, units nearing the end of their insulation life expectancy will not reach the minimum. This is a good time to plan downtime for alternator replacement or rewinding.

Insulation Resistance Test(Megger)

- When conducting Megohm test to earth, disconnect any electronic devices, such as voltage regulator, diodes, etc.
- The resistance of the insulation between the copper conductors and the metal frame of the machine is measured by means of an insulation tester or "Megger", which applies DC voltage across the insulation.
- The leakage current through the insulation gives a direct reading on the meter in megohms, and a normal value should be above 1 megohm for all component.
- Generators with an output voltage of between 120V to 600V should be tested as above. If the output winding (stator) is lower than 10 Megohm to earth, the windings must be dried, cleaned or taken to a workshop for refurbishing.



Method to Recover Good Insulation Resistance

- **After determining the insulation values are not to specification, Do the following based on insulation condition:**

  - Little to no surface contamination: use most suitable or practical drying method listed below.

  - Noticeable surface contamination: clean the windings with compressed air or steam cleaning (<30PSI). Use oven or short circuit drying method if water is used to clean unit.

- **Drying Methods**

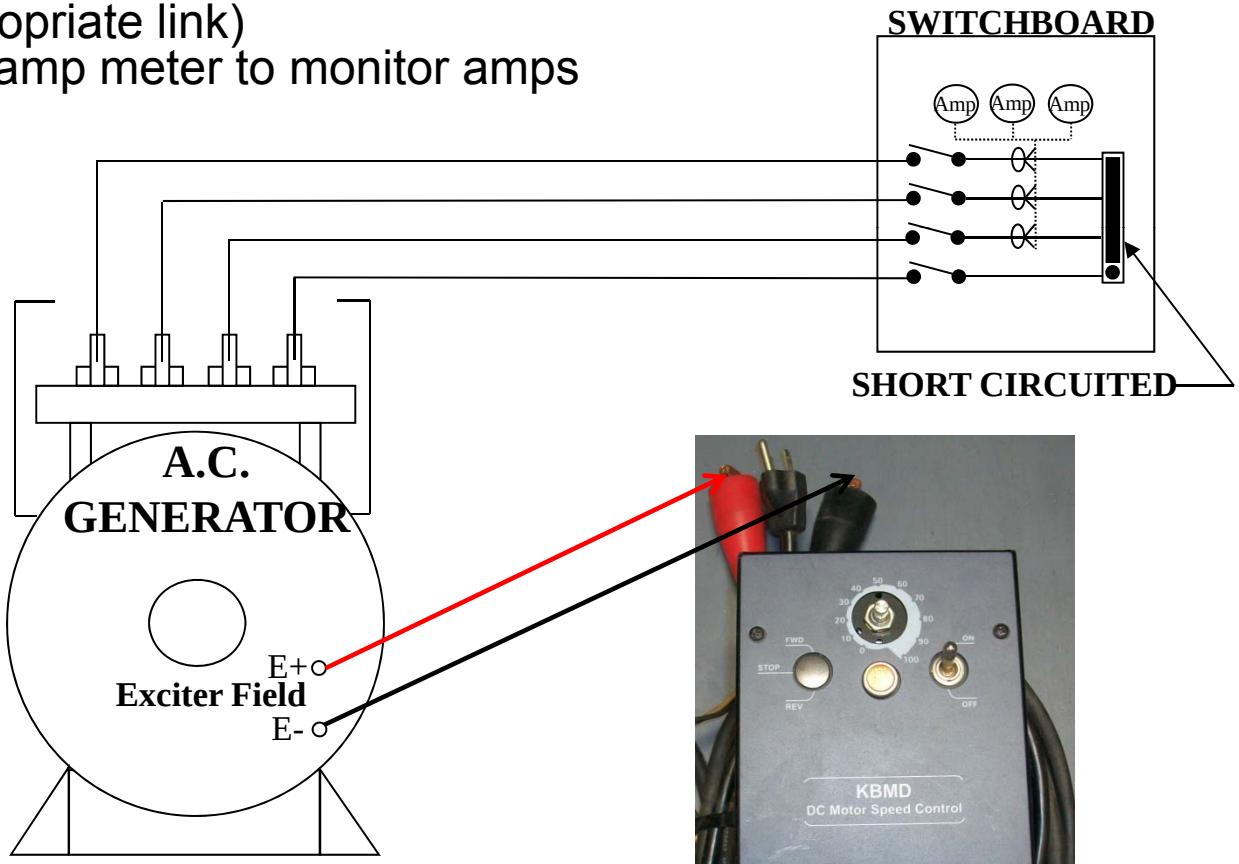
  - Put alternator into oven (100/110°C for 2-4 hrs).

  - Space heater energized and/or forced hot air for 24 hours(minimum)

  - Short circuit stator winding method. (See next page)

Recovering Insulation Resistance Using the Short Circuit Method

-Disconnect and isolate the AVR
-Short circuit output (used appropriate link)
-Use metering CT or clamp on amp meter to monitor amps
-Connect variable DC supply to E+ and E- as shown
-Open all ventilation
-Run alternator at rated speed
-Adjust rheostat to obtain rated current on the amp meter
-Operate unit for 2-4 hours then retest with megger
-Repeat until megger values are acceptable



Main Stator Windings Resistance Checks

- **When to do it**
  - Failures on the load side possibly damaging the generator
  - You have a suspected winding failure
  - Megger value is low

- **Procedures**
  - The checking of winding resistance is to be done with the circuit breaker open or leads disconnected. The test should also be conducted in cold/ambient condition using a micro-ohm meter.

  - Refer to alternator operating & maintenance manual to obtain winding resistance values.

  - If the main stator resistance values are unknown, compare the three phase readings. If all phases are equal(within 1%) the windings are likely still in good condition.

Trouble-shooting: Separate Excitation Test Method

-Stop the unit

-Disconnect & isolate the AVR

-Connect variable DC supply to E+ and E- as previously shown

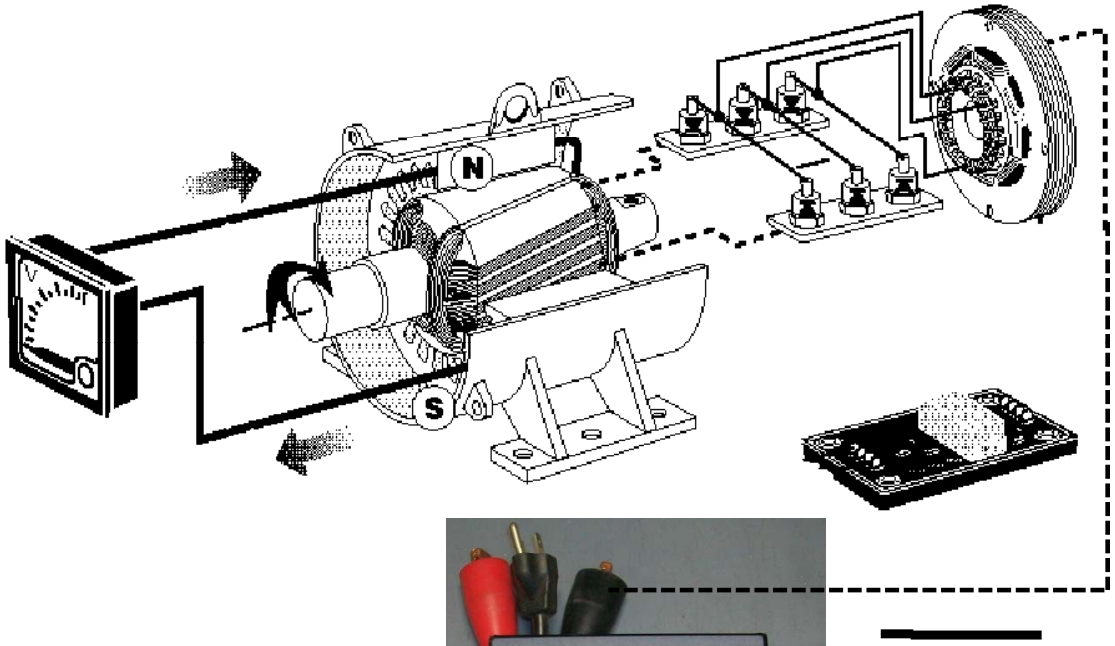
-Run the unit at rated speed.

-Gradually increase the exciter field current

-Check the output voltage across each phase

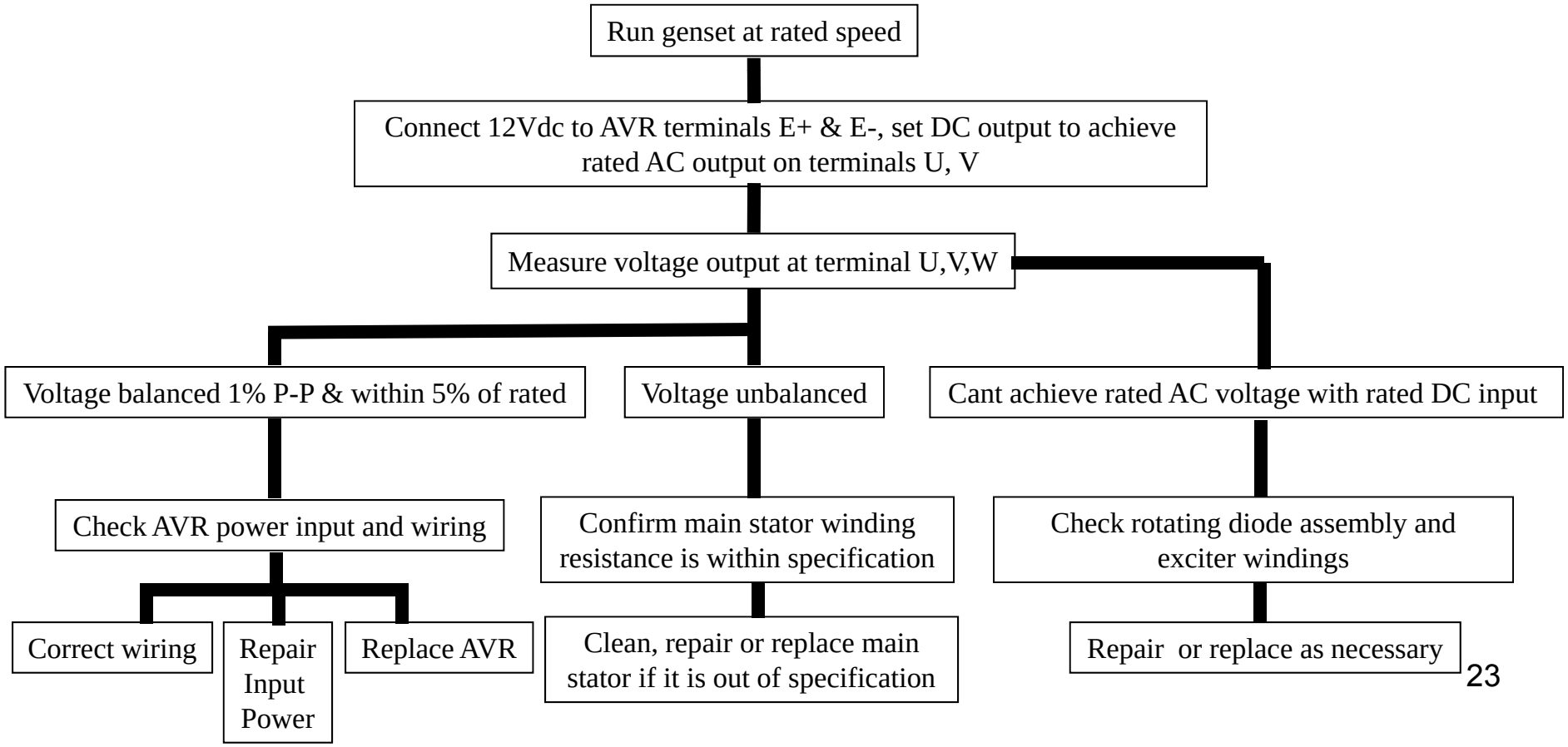
-Check the exciter field current

-The unit is good when the output voltage is balanced (<1%) at the rated value and the exciter current is within published data (O&M Manual)



Fault Finding Using The Separate Excitation Test

- Perform this test in case of no voltage output and/or to confirm generator is wired correctly
- Test should be performed with no load(breaker open), AVR disconnected, running at rated speed and cables free from earth ground.



Diode Test – A Diode must allow current to flow from the anode to the cathode only

A Diode has two resistance values, forward and reverse. These can be measured with a multimeter as shown above using the diode scale or the lowest resistance scale on the meter.

The forward resistance is being measured above with the positive meter lead connected to the forward side of the diode.

Note: For resistance values a 10 to 1 minimum front to back ratio is required. The diode test scale will give an audible forward indication and no reverse indication, as seen above.

Auxiliary Winding - AREP Damage

If the auxiliary windings are damaged you may still be able to use the alternator in SHUNT mode by using the AVR R450 for 46.2-49.1 alternators and the R250 for the 44.2 and smaller units. Verify main stator winding resistance, phase to phase and phase to ground insuation values before converting unit to shunt mode.

- You must disconnect and individually isolate the auxiliary winding X1/X2 and Z1/Z2 leads.

-Terminals X1 and X2 on the AVR must be connected to the T1 and T4 terminals of the main stator.

-The exciter field and AVR voltage sensing connections will remain the same.

- The adjustment of AVR will remain the same.

Mechanical Defects

Fault		Action
Bearing	Excessive overheating of one or both bearings (temperature > 80 °C on the bearing retainers with or without abnormal noise)	- If the bearing has turned blue or if the grease has turned black, change the bearing. - Bearing not properly seated. - End shields misaligned (flanges not properly fitted).
Temperature abnormal	Excessive overheating of alternator frame (more than 40 °C above the ambient temperature)	- Air flow (intake-outlet) partially clogged or hot air is being recycled from the alternator or engine - Alternator operating at too high a voltage (> 105% of Un on load) - Alternator overloaded
Vibration	Excessive vibration	- Misalignment (coupling) - Defective mounting or play in coupling - Rotor balancing fault
	Excessive vibration and humming noise coming from the machine	- Alternator operating in single-phase mode (single-phase load or faulty contactor or installation fault) - Stator short-circuit
Abnormal noise	Alternator damaged by a significant impact, followed by humming and vibration	- System short-circuit - Mis-paralleling Possible consequences - Broken or damaged coupling - Broken or bent shaft end - Shifting and short-circuit of main field - Fan fractured or coming loose on shaft - Irreparable damage to rotating diodes or AVR

Electrical Faults

Fault	Action	Effect	Check/Cause
No voltage at no load on start up	Connect between E- and E+ a new battery of 4 to 12 volts, respecting the AVR polarities, for 2 to 3 seconds	The alternator builds up and its voltage is still correct when the battery is removed.	- Lack of residual magnetism
		The alternator builds up but its voltage does not reach the rated value when the battery is removed. The alternator builds up but its voltage disappears when the battery is removed	- Check the connection of the voltage reference to the AVR - Faulty diodes - Armature short-circuit - Faulty AVR - Field windings disconnected - Main field winding open circuit. Check the resistance
Voltage too low	Check the drive speed	Correct speed	Check the AVR connections (AVR may be faulty) - Field windings short-circuited - Rotating diodes burnt out - Main field winding short-circuited - Check the resistance
		Speed too low	Increase the drive speed (Do not touch the AVR voltage pot. (P2) before running at the correct speed.)
Voltage too high	Adjust AVR voltage potentiometer	Adjustment ineffective	Faulty AVR
Voltage oscillations	Adjust AVR stability potentiometer	If no effect: try normal/rapid recovery modes (ST2)	- Check the speed: possibility of cyclic irregularity - Loose connections - Faulty AVR - Speed too low when on load (or LAM set too high)

Electrical Faults

Voltage correct at no load and too low when on load (*)	Run at no load and check the voltage between E+ and E- on the AVR	Voltage between E+ and E- SHUNT < 20 V - AREP/PMG < 10 V	- Check the speed (or LAM set too high)
		Voltage between E+ and E- SHUNT > 30 V - AREP/PMG > 15 V	- Faulty rotating diodes - Short-circuit in the main field. Check the resistance - Faulty exciter armature
(*) **Caution:** For single-phase operation, check that the sensing wires coming from the AVR are correctly connected to the operating terminals			
Voltage disappears during operation (**)	Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components	The voltage does not return to the rated value	- Exciter winding open circuit - Faulty exciter armature - Faulty AVR - Main field open circuit or short-circuited
(**) **Caution:** Internal protection may be activated (overload, open circuit, short-circuit)			

Open Question and Answer Session

For more information on LS Voltage Regulators and Generators visit:
http://www.leroy-somer.com/en/downloads/manuals/

There will be an open field to type your generator or voltage regulator number. Hit the “ok” button and the relevant literature will be displayed in PDF.