Automatic Voltage Regulator Wiring PDF — Complete AVR Connection and Adjustment Guide

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Introduction

The Automatic Voltage Regulator (AVR) is one of the most critical components in a brushless synchronous alternator. It maintains the generator's output voltage at a constant level regardless of load variations, power factor changes, and engine speed fluctuations within the generator's operating range. The AVR achieves this by controlling the excitation current supplied to the alternator's exciter field, which in turn regulates the main rotor field current and hence the stator output voltage. Without a properly functioning AVR, generator output voltage will vary wildly with load changes, potentially causing damage to connected equipment or tripping the generator offline.

This comprehensive wiring guide covers the most common AVR models used in industrial and commercial generators: Stamford MX321, Newage SX440, Stamford/SEC SX460, Leroy-Somer R150/R230, Basler AVR-63-7, Mecc Alte ECP34-E1L, and Marathon SE350. We provide detailed pin assignments for each model, wiring diagrams for different excitation configurations, external connection options for remote voltage adjustment, and step-by-step adjustment procedures. The guide is designed for generator service engineers, alternator specialists, electrical technicians, and facility maintenance personnel who need to wire, adjust, or troubleshoot AVR systems.

The AVR receives its power input from the alternator's permanent magnet generator (PMG), auxiliary winding, or directly from the main stator terminals (self-excited / shunt configuration). The AVR senses the generator output voltage through sensing wires connected to the main stator terminals, compares it with an internal reference, and adjusts the exciter field current accordingly. The wiring between the AVR, the exciter field, and the sensing points must be correct for the regulator to function effectively. Incorrect wiring can result in voltage instability, over-excitation, under-voltage, or complete failure to build voltage.

AVR Wiring Connection Details

Stamford/Newage MX321 AVR Wiring

The MX321 is the most widely used AVR in larger alternators from Stamford (now part of Cummins Generator Technologies). It provides 3-phase RMS sensing with ±0.5% voltage regulation accuracy.

Terminal	Function	Connection	Wire Color	Notes
1	PMG Input (U)	From PMG winding	Red	185–220 VAC PMG supply
2	PMG Input (V)	From PMG winding	Yellow	185–220 VAC PMG supply
3	PMG Input (W)	From PMG winding	Blue	185–220 VAC PMG supply
4	Stab / Damping	Damping transformer	Grey	Optional stability circuit
5	Stab / Damping	Damping transformer	Grey	Optional stability circuit
6	Field Output +	Exciter field positive	Orange	To exciter F+ terminal
7	Field Output –	Exciter field negative	Black	To exciter F– terminal
8	Sense L1 (Phase A)	Generator output L1	Brown	Voltage sensing, via 2 A fuse
9	Sense L3 (Phase B)	Generator output L3	Grey	Voltage sensing, via 2 A fuse

10	Sense Neutral	Generator neutral	Blue	Sensing reference
11	Remote Voltage Trim	1 kΩ potentiometer wiper	White	±5% remote voltage adjust
12	Remote Voltage Trim	Potentiometer +	White	Connected to + reference
13	Remote Voltage Trim	Potentiometer –	White	Connected to – reference
14	Under-Freq Protect	Frequency sensing input	—	U/F threshold adjust
15-18	Auxiliary	Parallel droop CT	—	For parallel operation

Newage SX440 AVR Wiring

The SX440 is a self-excited AVR used in medium-sized Stamford alternators (UC, BC, and HC frame sizes). It senses single-phase voltage and requires no PMG.

Terminal	Function	Connection	Wire Color	Notes
1	Field Output +	Exciter field positive	Orange	To F+ terminal
2	Field Output –	Exciter field negative	Black	To F– terminal
3	AC Supply (L)	Generator output L1 or auxiliary winding	Brown	Via 5 A fuse
4	AC Supply (N)	Generator neutral	Blue	Supply return
5	Sense (Phase)	Generator output L1	Brown	Voltage sensing
6	Sense (Neutral)	Generator neutral	Blue	Sensing reference
P1	Voltage Adjust	Internal potentiometer	—	Factory set, ±10%
P2	Stability Adjust	Internal potentiometer	—	Anti-oscillation
P3	Under-Freq Roll-off	Internal potentiometer	—	V/Hz protection
K1-K2	Parallel Droop CT	External CT for paralleling	—	When used in parallel

Leroy-Somer R150/R230 AVR Wiring

The R150 (for ARE and DYN alternators) and R230 (for LSA series) are widely used across European generator sets.

Terminal	Function	Connection	Notes
X1	Auxiliary winding (phase)	Auxiliary winding output	100–220 VAC
X2	Auxiliary winding (neutral)	Auxiliary winding return	
F+	Field output positive	Exciter field positive	
F–	Field output negative	Exciter field negative	
1S1	Sense L1 (if 3-phase)	Generator L1 via 2 A fuse	Jumper set
1S2	Sense L3 (if 3-phase)	Generator L3 via 2 A fuse	Jumper set
SN	Sense Neutral	Generator neutral	
POT	Remote Voltage +	Potentiometer high end	1 kΩ, 2 W
POT	Remote Voltage wiper	Potentiometer wiper	±5% adjustment

POT	Remote Voltage –	Potentiometer low end	
DROOP	CT for parallel droop	External CT secondary	For isochronous load share
STAB	Stability circuit	External capacitor	For voltage oscillation dampening

AVR Pin Assignments Quick Reference

Common AVR Models Terminal Comparison

Function	MX321	SX460	SX440	R150	SE350	ECP34
PMG Supply	1,2,3 (3-phase)	—	—	—	—	1,2
AC Supply	—	1,2	3,4	X1,X2	5,6	5,6
Field (+)	6	F+	1	F+	F+	F+
Field (–)	7	F–	2	F–	F–	F–
Sense L1	8	3	5	1S1	1	3
Sense L2	—	—	—	—	2	—
Sense L3	9	—	—	1S2	3	—
Sense Neutral	10	4	6	SN	4	4
Voltage Trim	11-13	P1 (int.)	P1 (int.)	POT	—	P1
U/F Protection	14	P3 (int.)	P3 (int.)	—	—	P3
Parallel CT	15-18	5,6	K1,K2	DROOP	—	CT
Stability	4,5	P2 (int.)	P2 (int.)	STAB	—	P2

Compatible AVRs and Alternator Models

AVR Model	Compatible Alternators	Excitation Type	Regulation Accuracy	Power Supply
Stamford MX321	Stamford HC, HC4, HC5, HC6, HC7, LV6	PMG (3-phase)	±0.5%	185–220 VAC PMG
Newage SX460	Stamford BC, UC, UCI, UCDI	Self-excited (shunt)	±1.0%	180–260 VAC
Newage SX440	Stamford UC, BC, HC	Self-excited (shunt)	±1.0%	170–264 VAC
Leroy-Somer R150	ARE, DYN (8–45 kVA)	Self-excited (shunt)	±1.0%	100–220 VAC aux.
Leroy-Somer R230	LSA 37–49 series	Self-excited (shunt)	±1.0%	100–220 VAC aux.
Leroy-Somer R448	LSA 42–54 series	PMG (3-phase)	±0.5%	190–240 VAC PMG
Basler AVR-63-7	Various DC alternators	Shunt/PMG	±1.0%	120–240 VAC
Marathon SE350	Marathon MagnaPlus, MagnaMax	Self-excited	±1.5%	190–240 VAC
Mecc Alte ECP34-E1L	Mecc Alte SINCRO series	Self-excited	±1.0%	190–264 VAC
Mecc Alte ECP34-2	Mecc Alte ECO series	Self-excited	±1.0%	190–264 VAC
Stamford MX341	Stamford HC series (mid-size)	PMG (3-phase)	±0.5%	185–220 VAC PMG
Macurex AVR 24	Various DC alternators	Shunt	±1.5%	24–95 VDC

AVR Connection Specifications

Parameter	Specification	Notes
Regulation Accuracy	±0.5% to ±1.5%	PMG type typically more accurate
Response Time	15–50 ms	Step load change of 30%
Voltage Settling Time	0.3–1.5 seconds	To within 1% of setpoint
Voltage Adjustment Range	±10% (internal), ±5% (remote)	Typical
U/F Threshold	30–60 Hz (adjustable)	Roll-off slope programmable
Excitation Current (continuous)	2–15 A DC	Depends on alternator size
Excitation Voltage (max)	60–150 VDC	Depends on AVR model
PMG Input (if applicable)	185–220 VAC, 3-phase	Typical, check model spec
AC Supply (self-excited)	170–264 VAC	Single phase
Frequency Range	50–60 Hz (auto-sensing)	Some models require jumper
Operating Temperature	-40°C to +70°C	Derate above 60°C
Storage Temperature	-55°C to +85°C	—
Humidity	95% non-condensing	—
Vibration Resistance	1.5 g at 20–200 Hz	IEC 60068-2-6
Protective Coating	Conformal coating (standard)	Optional for harsh environments
Dimensions	170 × 110 × 55 mm (typical)	Varies by model
Weight	0.5–1.2 kg	—

AVR Adjustment Procedure

Voltage Adjustment

1. Ensure generator is running at rated speed (1500 RPM for 50 Hz, 1800 RPM for 60 Hz)
2. Connect a precision true-RMS voltmeter to generator output terminals
3. Locate the VOLTAGE pot (P1) on the AVR — typically a 15-turn or single-turn trimpot
4. Turn clockwise to increase voltage, counter-clockwise to decrease
5. Adjust to the desired output voltage (e.g., 400 VAC line-to-line)
6. Allow 30 seconds for voltage to stabilize between adjustments
7. Verify at no-load and at 50% load

Stability Adjustment

If voltage oscillates (hunts) when load is applied:

1. Locate the STABILITY pot (P2) on the AVR
2. Turn fully clockwise (maximum damping)
3. Apply 50% load and observe voltage stability
4. If oscillating, turn P2 counter-clockwise in small increments until oscillation stops

5. Leave 1/8 turn of additional margin for stability
6. Test at 25%, 50%, 75%, and 100% load

Under-Frequency Protection Adjustment

1. Determine the generator's nominal frequency (50 or 60 Hz)
2. Set U/F threshold to 2–3 Hz below nominal (e.g., 47 Hz for 50 Hz system)
3. Below this threshold, voltage rolls off linearly with frequency
4. This prevents over-excitation at low engine speeds (during start-up or overload)
5. Adjust P3 (U/F) to the desired knee frequency

Remote Voltage Trim Wiring

For remote panel-mounted voltage adjustment:

1. Install a 1 kΩ potentiometer (2 W minimum, linear taper)
2. Connect pot high side to AVR remote + terminal
3. Connect pot wiper to AVR remote wiper terminal
4. Connect pot low side to AVR remote – terminal
5. Adjust range typically ±5% of nominal voltage

Download PDF — Automatic Voltage Regulator Wiring Diagram

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Click the button above to download the complete AVR Wiring Diagram PDF. This downloadable reference includes:

• Detailed wiring diagrams for MX321, SX460, SX440, R150, R230, SE350, ECP34
• PMG-equipped alternator wiring with full PMG-to-AVR connections
• Self-excited (shunt) alternator wiring connections
• Remote voltage potentiometer wiring diagram
• Parallel operation droop CT wiring for multiple generators
• Three-phase sensing wiring (MX321, SX460 with jumper setting)
• Under-frequency protection circuit and adjustment chart
• AVR mounting and heat sink requirements
• Troubleshooting flow chart for "no voltage build" and "over-voltage" faults
• Alternator excitation winding resistance reference table
• Recommended spare AVR replacement guides

The PDF is 2.6 MB, fully vector graphics, A3 format printable. Contains both English and Chinese annotation options for field technicians.

15 Frequently Asked Questions About AVR Wiring

1. What is the difference between PMG excitation and self-excited (shunt) excitation?

PMG excitation uses a dedicated permanent magnet generator mounted on the alternator shaft to supply clean, stable power to the AVR regardless of load conditions or waveform distortion. Self-excited (shunt) AVRs draw their power from the main generator output terminals or auxiliary windings. PMG provides superior voltage regulation under non-linear loads (e.g., UPS, variable speed drives) and during motor starting. Self-excited AVRs are simpler and lower cost but more susceptible to voltage waveform distortion.

2. My generator builds no voltage. What should I check first?

With the generator at rated speed: (a) Check the AVR AC supply voltage at the input terminals — should match model specification, (b) Check the exciter field resistance — open or shorted field winding will prevent voltage building, (c) Measure residual magnetism in the main rotor — if lost, flash the field with a DC source (typically 12 V battery through a current-limiting resistor), (d) Check AVR sensing fuse continuity, (e) Verify all AVR connections are tight and correct per the wiring diagram.

3. How do I flash the alternator field to restore residual magnetism?

Connect a 12 V battery through a 10 Ω, 50 W resistor in series with the exciter field leads (F+ and F–). Energize for 2–3 seconds while the generator is at rest or at low speed. Do NOT exceed 5 seconds as the field resistance is low and current may damage the winding. After flashing, start the generator and check for voltage build-up. For larger alternators, a higher voltage (24–48 V) may be needed.

4. Can I replace an SX440 AVR with an MX321?

Direct replacement is not possible without modifications. The SX440 is self-excited while the MX321 requires a PMG supply. To upgrade, you would need: a PMG kit installed on the alternator, rewiring from the PMG to the MX321 AVR, and reconfiguration of the excitation system. The reverse (MX321 to SX440) is also not a drop-in replacement.

5. What causes an AVR to fail catastrophically?

Common failure causes: (a) Open-circuit or short-circuit on the exciter field while generator is running (causes high-voltage transients), (b) Lightning-induced surges on generator output cables, (c) Sustained over-excitation from a failed voltage sensing circuit, (d) Moisture ingress into the AVR enclosure, (e) Loose connections causing arcing and thermal damage, (f) Operation at voltage or frequency outside the AVR's design limits.

6. How do I wire the AVR for parallel generator operation?

For parallel operation, each generator's AVR needs a droop CT (current transformer) wired to the droop terminals (e.g., K1-K2 on SX440, or terminals 15-18 on MX321). The droop CT injects a signal proportional to the generator's reactive current, causing the AVR to reduce voltage slightly as reactive load increases — this ensures stable reactive load sharing between paralleled generators.

7. What is the correct setting for the under-frequency (U/F) protection?

Set the U/F knee frequency to 47 Hz for a 50 Hz system or 57 Hz for a 60 Hz system (3 Hz below nominal). Below this frequency, the AVR reduces voltage proportionally with frequency, preventing over-excitation of the generator when the engine speed drops due to overload or during startup. The voltage roll-off slope is typically 1:1 (voltage % = frequency %).

8. Why does generator voltage drop when I apply non-linear loads?

Non-linear loads (UPS, rectifiers, VFDs) draw harmonic currents that distort the generator output voltage waveform. Self-excited AVRs using average-sensing or peak-sensing circuits may incorrectly read the distorted waveform and reduce excitation. Solutions: (a) Upgrade to a PMG-equipped alternator with a true RMS-sensing

AVR (e.g., MX321), (b) Add harmonic filters, (c) Oversize the generator by 1.5–2× the non-linear load kVA.

9. How long does an AVR typically last?

Under normal operating conditions (clean environment, stable temperature, proper loading), an AVR can last 10–15 years. However, in harsh environments (high temperature, humidity, vibration, dust), AVR life may be reduced to 3–5 years. Regular inspection and cleaning of the AVR heat sink can extend service life. We recommend replacing the AVR every 8–10 years as part of a major generator overhaul.

10. Can I adjust the voltage while the generator is running?

Yes, you can adjust the AVR voltage setpoint while the generator is running and supplying power. Use a non-conductive adjustment tool (ceramic or plastic screwdriver) to adjust the VOLTAGE potentiometer. Monitor the voltmeter continuously during adjustment. Make small incremental changes (1/4 turn) and allow 10–15 seconds for the voltage to stabilize between adjustments.

11. What is the purpose of the stability potentiometer on the AVR?

The stability potentiometer adjusts the AVR's damping response to prevent voltage oscillation (hunting). If the stability is set too low, the voltage will oscillate — especially when load changes suddenly. If set too high (too much damping), the voltage response to load changes will be slow and may overshoot. Correct stability adjustment results in a critically damped response: quick settling to the setpoint without oscillation.

12. How do I determine if my alternator has a PMG or needs a self-excited AVR?

Inspect the alternator nameplate: PMG-equipped alternators will specify "PMG" or show an additional smaller alternator (the PMG) mounted on the back of the main alternator. The PMG typically has three output wires. Alternators without PMG have either auxiliary winding leads (often identified as Z1-Z2, X-X, etc.) or use the main stator output for AVR power. If uncertain, consult the alternator data sheet.

13. Can a failed AVR damage other generator components?

Yes. A shorted AVR output can cause uncontrolled excitation, resulting in severe over-voltage that can damage: (a) connected electrical equipment, (b) the exciter field winding, (c) the main rotor winding, (d) the main stator winding diodes (in the rotating rectifier assembly). Over-excitation can also cause the generator's circuit breaker to trip, leaving the facility without power. Always investigate the root cause of an AVR failure before installing a replacement.

14. What is the correct replacement procedure for a failed AVR?

Procedure: (1) Disconnect all leads from the failed AVR and label them, (2) Remove the mounting screws and remove AVR, (3) Clean the mounting surface and apply new thermal compound, (4) Mount the new AVR and apply thermal joint compound between the AVR and heat sink, (5) Reconnect all leads per the wiring diagram — double-check polarity of field and sense connections, (6) Verify all insulation and fuses are intact, (7) Start generator and perform voltage and stability adjustment, (8) Test at no-load and under 50% load, (9) Record new voltage settings for future reference.

15. Can I use the same AVR for 50 Hz and 60 Hz operation?

Most modern AVRs (MX321, SX460, SX440, R230) support both 50 Hz and 60 Hz operation without modification. The AVR automatically adapts to the system frequency. However, the under-frequency protection threshold must be adjusted to match the operating frequency — 47 Hz (50 Hz system) or 57 Hz (60 Hz system). If the U/F threshold is not adjusted, the AVR may incorrectly reduce voltage at rated frequency.

Advanced AVR Wiring Configurations

Parallel Operation AVR Wiring (Droop CT Method)

When two or more generators operate in parallel, the AVRs must share reactive load proportionally. This requires a wiring modification using droop current transformers (CTs).

Droop CT Wiring Steps:

1. Install a droop CT on one phase (typically L1) of each generator output, between the generator and the main circuit breaker

2. Connect the CT secondary to the AVR droop terminals:

• MX321: Terminals 15 (CT input) and 16 (CT return)

• SX440/SX460: Terminals K1 (CT input) and K2 (CT return)

• R150/R230: Terminal DROOP (CT input) and DROOP COM (CT return)

3. Set the droop percentage on the AVR — typically 3–5% droop at rated reactive current

4. Verify that all generators in the parallel system have identical droop settings

5. For isochronous load sharing (exact frequency regulation), a dedicated parallel controller (ComAp, DeepSea, Woodward) provides the load sharing signals rather than relying solely on AVR droop

Droop CT Specifications for Parallel Operation:

Generator Rating	CT Ratio	CT Class	Droop Setting
100–250 kVA	500/5 A	1.0	3%
251–500 kVA	1000/5 A	1.0	4%
501–1000 kVA	2000/5 A	0.5S	5%
1001–2000 kVA	4000/5 A	0.5S	5%

Remote Voltage Sensing for Long Cable Runs

When the generator is located far from the AVR (e.g., on a trailer or containerized system), voltage drop in the sensing wires can cause regulation errors. Remote voltage sensing compensates for this.

3-Wire Remote Sensing Wiring for SX460:

1. Run three wires from the generator output terminals back to the AVR sensing terminals: wire A (L1), wire B (N), wire C (shield)

2. Use 1.5 mm^2 or 2.5 mm^2 wire for runs over 50 meters to minimize voltage drop

3. Connect the shield at the AVR end only

4. The AVR reads generator terminal voltage directly, compensating for any voltage drop in the main power cables

5. Factory default sensing is internal (jumper between supply and sense terminals); remove jumper for remote sensing mode

For MX321 with 3-Phase Remote Sensing:

Use three sensing wires (L1, L2, N) from the generator load terminals to the MX321 sensing inputs (pins 8, 9, 10). Each sensing wire must be individually fused at 1 A at the generator end. The MX321 provides true RMS voltage regulation even with distorted waveforms from non-linear loads.

AVR Protection Circuit Add-Ons

For AVRs operating in harsh environments or critical applications, add the following protection circuits:

1. Over-Voltage Protection Module (OVP): Installs between the AVR output and the exciter field. If the AVR fails in the short-circuit mode (full excitation), the OVP module shunts the exciter field to prevent generator over-voltage exceeding 130% of nominal. Connect OVP module input to AVR field output and OVP module output to exciter field. Wire the OVP sense input to the generator output terminals.

2. Field Discharge Resistor: Connect a discharge resistor (100–200 Ω, 25–50 W) across the exciter field terminals (F+ and F–). This provides a path for the exciter field current when the AVR stops supplying excitation, preventing voltage spikes from damaging the AVR output transistors.

3. Surge Suppression RC Snubber: Install an RC snubber circuit (typically 0.1 μF capacitor + 100 Ω resistor in series) across the AVR AC supply input terminals. This dampens voltage transients from the generator when large loads are switched off.

4. Lightning and Surge Protection: For generators in lightning-prone areas, install surge protective devices (SPDs) on the generator output cables near the AVR sensing connection point. Use Type 2 SPDs rated appropriately for the system voltage.

AVR Maintenance and Testing Protocol

Quarterly Visual Inspection:

- Check for signs of overheating (discoloration on AVR heat sink or PCB)
- Inspect connections for corrosion or looseness
- Verify the AVR is securely mounted and heat sink is clean
- Check for moisture ingress or insect infestation in the AVR enclosure
- Examine the exciter field connection for signs of arcing or burning

Annual Performance Testing:

1. Measure and record no-load voltage at rated speed (should be within ±1% of nominal)
2. Measure voltage regulation at 25%, 50%, 75%, and 100% resistive load (should be within ±2%)
3. Measure voltage transient response: step apply 50% load — voltage dip should not exceed 15% and recovery should be within 1.5 seconds
4. Measure AVR exciter field output voltage at no-load and full load (compare with factory specifications)
5. Check AVR supply voltage (PMG or AC input) — should be within specified range
6. Verify under-frequency protection by reducing engine speed — voltage should roll off linearly below U/F setpoint
7. Test remote voltage trim (if fitted) by turning potentiometer full range — should adjust voltage ±5%

Replacement Indicators:

Replace the AVR if any of the following are observed:

- Voltage regulation exceeds ±5% from nominal
- Voltage oscillates (hunts) continuously despite stability adjustment
- Visible damage to PCB, capacitors bulging, or signs of burning
- Exciter field current at no-load is >20% above the factory specification

• The AVR fails to build voltage and field flashing does not resolve the issue

Related Downloads

• [Generator Control Panel Wiring Diagram]() — Complete generator control panel connections

• [Battery Charging System Wiring Diagram PDF]() — Battery and charger circuit connections

• [Synchronization Panel Wiring Diagram PDF]() — Multi-generator paralleling system guide

• [Fuel Pump Wiring Diagram PDF]() — Diesel generator fuel system wiring

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