# MA325 Automatic Voltage Regulator (AVR)

Specification, installation and adjustments.

## General description

The MA325 is a phase controlled thyristor type AVR and forms part of the excitation system for a brushless generator. The design employs Surface Mount Technology (SMT) to provide a host of features with minimum component count.

Excitation power is derived from a permanent magnet generator (PMG), to reduce Radio Frequency Interference (RFI) and isolate the AVR control circuits from the effects of thyristor controlled loads.

The AVR senses the voltage in the main generator winding and controls the power fed to the exciter stator and hence the main rotor to maintain the generator output voltage within the specified limits, compensating for load, speed, temperature and power factor of the generator. Three phase RMS sensing is employed for superior voltage regulation.

Soft start circuitry is included to provide a smooth controlled build up of generator output voltage.

A frequency measuring circuit continually monitors the shaft speed of the generator and provides underspeed protection of the excitation system by reducing the generator output voltage proportionally with speed below a presettable threshold. A further enhancement of this feature is an adjustable volts per Hertz slope to improve engine recovery time on turbo charged engines.

Protection circuitry is included which cuts off the excitation power in event of over voltage.

Current limiting may be included to allow control over the amount of short circuit current flowing during short circuits of the generator output.

Uncontrolled excitation is limited to a safe period by internal shutdown of the AVR output device. This condition remains latched until the generator has stopped.

For complete protection, a circuit breaker option is available providing circuit isolation in event of a short circuit power device.

Provision is made for the connection of a remote voltage trimmer allowing the user fine control of the generators output.

## Technical specification

**Sensing input**

| | |
|---|---|
| Voltage | 170-250 Vac max |
| Frequency | 50-60 Hz nominal |
| Phase | 1 or 3 |
| Wire | 2 or 3 |

**Power input (PMG)**

| | |
|---|---|
| Voltage | 170-220 Vac max |
| Current | 5A/phase |
| Frequency | 100-120 Hz nominal |
| Phase | 3 |
| Wire | 3 |

**Output**

| | |
|---|---|
| Voltage | max 120V dc |
| Current | continuous 4.5A<br>Intermittent 8A for 10 secs |
| Resistance | 15 ohms minimum |

**Regulation**

( 4% engine governing) +/- 0.5% RMS

**Thermal drift**

0.015%V per degree centigrade change in AVR ambient

**Soft start ramp time**

3 seconds

**Typical system response**

| | |
|---|---|
| Field current to 90% | 80ms |
| Generator volts to 97% | 500ms |

**External voltage adjustment**

+/-6% with 1k ohm 1 watt trimmer

**Under frequency protection**

| | |
|---|---|
| Set point | 97% Hz |
| Slope | 100-300% down to 30Hz |
| Dwell (recovery) | 0.5 to 2 seconds |

**Unit power dissipation**

25 watts max

**Accessory input**

+/-1 volt input = +/- 5% generator volts

**Quadrature droop sensitivity**

0.075 Amps for 5% droop @ pf

**Current limit**

| | |
|---|---|
| sensitivity | 0.45A to 1A (10 ohm burden) |

**Over excitation protection**

| | |
|---|---|
| Set point | 65 V dc |
| Time delay | 10 seconds (fixed) |

**Over-volts protection**

| | |
|---|---|
| Set point | 300 volts |
| Time delay | 1 second |

Circuit breaker trip coil voltage 10 to 60 V dc

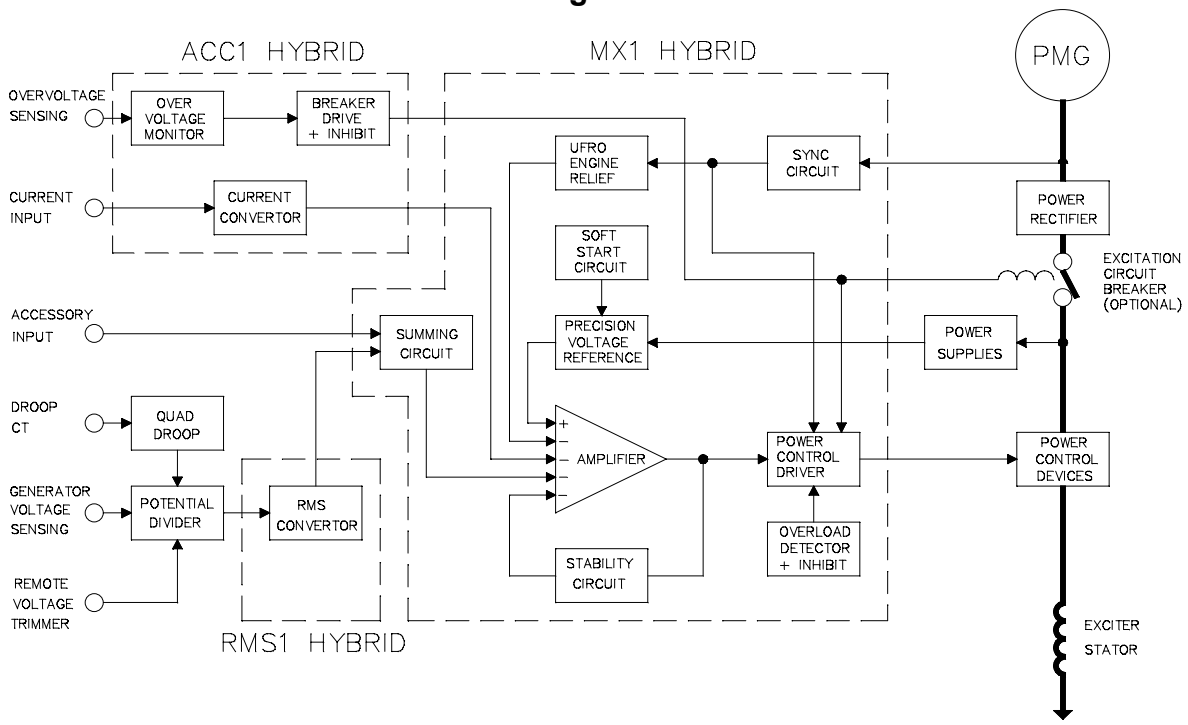
Circuit breaker trip coil resistance 50 to 100 ohms

**Environmental**

| | | |
|---|---|---|
| Vibration | 20-100Hz | 50mm/sec |
| | 100Hz-2kHz | 3.3g |
| Relative humidity 0-60c | | 95% RH |
| Operating temperature | | -40 to +60c |
| Storage temperature | | -55 to +80c |

Accessories are available for this AVR

# Design detail




The main functions of the AVR are as follows:-

**Potential divider** takes a proportion of the generator output voltage and attenuates it. This input chain of resistors includes the hand trimmer adjustment. Isolating transformers are included to allow connection to windings of different polarity and phase.

**Quadrature droop** circuit converts the current input from a CT into a voltage which is phase mixed with the sensing voltage. The result is a net increase in the output from the sensing network as the power factor lags, causing the reduction in excitation needed for reactive load sharing of paralleled generators.

**RMS converter** converts the AC signals from the potential divider into a DC signal representing the mean squared value of the wave form.

**Summing circuit** provides an interface between the AVR and accessories, allowing the accessory output voltage to be summed with the sensing voltage for control purposes.

**Power supply** components consist of dropper resistors, zener diodes and smoothing to provide the required voltages for the Hybrid.

**Precision voltage reference** is a highly stable temperature compensated zener diode used for dc voltage comparison purposes.

**Soft start circuit** overrides the precision voltage reference during run up to provide a linear rising voltage.

**Amplifier** compares the sensing voltage to the reference voltage and amplifies the difference (error) to provide a controlling signal for the power device.

**Stability circuit** provides adjustable negative ac feedback to ensure good steady state and transient performance of the control system.

**Power control driver** controls the conduction period of the output device. this is achieved by pedestal and ramp control followed by a level detector and driver stage.

**Power control devices** vary the amount of exciter field current in response to the error signals produced by the amplifier.

**Sync circuit** provides a short pulse at the beginning of each cycle of the PMG wave form and is used to synchronise the Under Frequency Roll Off (UFRO) and power control circuits to the generator cycle period.

**Current converter** converts the outputs from current transformers into a signal representing the average value of the current wave form.

**UFRO** circuit measures the period of each electrical cycle and reduces the reference voltage linearly with speed below a presettable threshold.
A light emitting diode (LED) gives indication of underspeed.

**Engine relief** or load acceptance circuit provides adjustment for increasing the voltage roll off

(steepness of V/Hz slope), to aid engine recovery after application of block load. A "Dwell" feature is included which delays the recovery of generator volts after application of load, providing further assistance.

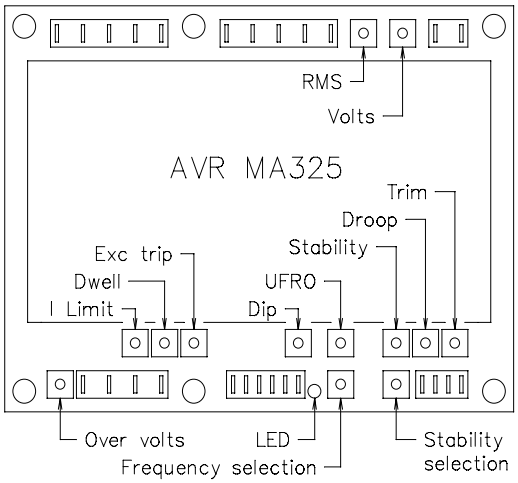
**Overload detector** continuously monitors the excitation voltage and provides signals to shutdown the output device if overloads last for more than ten seconds. An overload condition produces a latched fault requiring the generator to be stopped for reset.

**Over-voltage monitor** continuously monitors the voltage at the Generator terminals and provides signals to shut down the output device and trip an optional circuit breaker.

The circuit breaker isolates power from the exciter and AVR if sustained over-voltage occurs. A one second timer is included in the circuit to prevent operation during transient over-voltages, which are normal after load removal.

The generator must be stopped to reset an over voltage trip.

# POSITIONS OF AVR CONTROLS




| UFRO Table | Stability Table |
|---|---|
| | |
| 0 50 Hz 6 Pole | 0 Under 100 kW |
| 2 60 Hz 6 Pole | 1 100-500 kW |
| 4 50 Hz 4 Pole | 2 500-1000 kW |
| 5 60 HZ 4 Pole | 3 1000-1500 kW |
| | 4 1500-2000 kW |
| | 5 2000-2500 kW |
| | 6 Over 2500 kW |
| | 7 Special |
| | 8 Special |
| | 9 Special |

| Controls | Function | Direction |
|---|---|---|
| | | |
| Volts | To adjust generator output voltage | Clockwise increases output voltage |
| Stability | To prevent voltage hunting | Clockwise increases the damping effect |
| Stability selection | To optimise transient performance | See table |
| UFRO | To set under frequency knee point | Clockwise reduces knee point frequency |
| Frequency selection | To set UFRO control range | See table |
| Droop | To set voltage droop to 5% at 0 PF | Clockwise increases the droop |
| Trim | To match accessory output to AVR input | Clockwise increases AVR sensitivity |
| Dip | To adjust frequency related voltage dip | Clockwise increases the dip |
| Over volts | To set over voltage protection cut off level | Clockwise increases the overvoltage level |
| RMS | Set and sealed at the factory | |
| I limit | To set maximum short circuit current | Clockwise increases the current |
| Exc trip. | To adjust over excitation trip level | Clockwise increases the trip level |
| Dwell | To set voltage recovery time after block loading | Clockwise increases the recovery time |

# ADJUSTMENTS OF AVR CONTROLS

## Voltage adjustment

The generator output voltage is set at the factory, but can be altered by careful adjustment of the volts control on the AVR board, or by the external hand trimmer if fitted.

**WARNING!**

**DO NOT INCREASE THE VOLTAGE ABOVE THE RATED GENERATOR VOLTAGE. IF IN DOUBT, REFER TO THE RATING PLATE MOUNTED ON THE GENERATOR CASE.**

If a replacement AVR has been fitted or re-setting of the VOLTS adjustment is required, proceed as follows:-

Before running generator, turn volts control fully anti-clockwise

Turn remote volts trimmer (if fitted) to midway position

Turn stability control to midway position

Connect a suitable voltmeter across line to neutral of the generator

Start generator set, and run at a no-load condition at nominal frequency e.g. 50-53 Hz or 60-63 Hz

If the red light emitting diode is illuminated, refer to the under frequency roll off adjustment (UFRO)

Carefully turn the VOLTS control clockwise until rated voltage is reached

If instability is present at rated voltage, slowly turn the stability control clockwise until voltage is steady, then re-adjust voltage if necessary

Voltage adjustment is now complete

**Stability adjustment**

The AVR includes a STABILITY or damping circuit to provide good steady state and transient performance of the generator.
A switch is provided to change the response of the stability circuit to suit different frame size machines and applications, (see stability table on previous page).

The correct setting of the stability control can be found by running the generator at no load and slowly turning the stability control anti-clockwise until the generator voltage starts to become unstable.

The optimum or critically damped position is slightly clockwise from this point, ( i.e. where the machine volts are stable but close to the unstable region ).

**Under Frequency Roll Off adjustment (UFRO)**

The AVR incorporates an under speed protection circuit which gives a volts per Hertz characteristic when the generator speed falls below a presettable threshold known as the knee point.

The red light emitting diode (LED) gives indication that the UFRO circuit is operating. Turning the UFRO control clockwise lowers the frequency setting of the knee point and extinguishes the LED.

For optimum setting, the LED should illuminate as the frequency falls below just below nominal, i.e.47-48 Hz on a 50 Hz system and 57-58 Hz on a 60 Hz system.

The UFRO adjustment is preset and sealed at the works and normally only requires the selection of 50/60 Hz using the selector switch.

If the LED is illuminated and no output voltage is present, refer to Over Excitation and Over-Voltage protection adjustments.

**Dip adjustment**

The dip adjustment allows the user to have some control over the amount of generator voltage dip upon the application of load.

This feature is mostly used when the generator is coupled to turbo charged engines with limited block load acceptance, and operates only when the speed is below the UFRO knee point, (LED illuminated).

The circuit works by increasing the volts per Hertz slope to give greater voltage roll off in proportion to falling speed.

With the DIP control fully anti-clockwise the generator voltage characteristics will follow the normal volts per Hertz line as the frequency falls below nominal.

Turning the DIP control more clockwise provides greater voltage roll off allowing easier engine recovery.

**Dwell adjustment**

The Dwell operates only when the speed has fallen below the knee point set by the UFRO adjustment. With the Dwell control turned fully anti-clockwise, there is no Dwell and the voltage recovery will follow the engine speed recovery. Turning the Dwell control clockwise, introduces delay between engine speed recovery and generator voltage recovery.

**Droop adjustment**

Generators intended for parallel operation are fitted with a quadrature droop CT which provides a correction signal for the AVR.

The DROOP adjustment is normally preset in the works to give 5% voltage droop at zero power factor.

Clockwise increases the amount of CT signal injected into the AVR and increases the droop with lagging power factor. With the control fully anti-clockwise there is no droop.

**Trim adjustment**

An auxiliary input is provided to connect to accessories, (A1, A2) and is designed to accept DC signals up to +/- 5 volts.

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The DC signals presented to this input adds to or subtracts from the AVR sensing circuit, depending on polarity, and allows the accessory to have an influence on generator excitation.

The trim adjustment allows the user to determine or "trim" how much control the accessory has over the AVR.

With the trim control fully anti-clockwise the accessory has no control, clockwise maximum control.

**Over excitation adjustment**

The adjustment is set and sealed in the works and should not be altered.

An over excitation condition is indicated on the common red LED which also indicates underspeed running.

The generator must be stopped to reset an over excitation condition

**Over Voltage adjustment**

The AVR includes protection circuitry to remove generator excitation in event of an over-voltage on the generator terminals.

Separate terminals are provided for the over-voltage circuit (E0, E1), which connect to the generator windings independently of the AVR sensing terminals.

Provision is made for the connection of a small circuit breaker to break terminals K!, K2, interrupting the power supply to the exciter field, through simple manual switching. The addition to this circuit breaker of leads B0, B1, causes the power supply to be interrupted automatically in the event of an over-voltage.

The over-voltage adjustment is set and sealed at the factory but can be reset on retrofit AVRs. Clockwise rotation of the O/V adjustment increases the voltage trip level. The generator must be stopped to reset an over-voltage trip.

**Current Limit adjustment** (I Limit)

An optional extra current limit adjustment is provided to regulate the amount of short circuit current.

This is particularly useful during single phase short circuits, preventing over stressing of conductors and insulation.

To use this feature, three current transformers (CT's) are fitted on the generator to provide feedback signals to the AVR S!, S2 terminals

Under short circuit conditions, clockwise rotation of the I Limit adjustment increases short circuit current and anti-clockwise reduces it. Short circuit current is limited to a maximum duration of ten seconds by the over-excitation circuit.

Normally the I Limit adjustment would be set and sealed at the factory when the current limit feature is required

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