MX321 AUTOMATIC VOLTAGE REGULATOR (AVR)

SPECIFICATION, INSTALLATION AND ADJUSTMENTS

GENERAL DESCRIPTION

The MX321 is a three phase, thyristor type Automatic Voltage Regulator (AVR) and forms part of the excitation system for a brushless generator.

In addition to regulating the generator voltage, the AVR circuitry includes protective features to ensure safe reliable control of the generator. Excitation power is derived from a permanent magnet generator (PMG) to guarantee low Radio Frequency Interference (RFI) and immunity from thyristor type loads.

The AVR is linked with the main stator windings and controls the power fed to the exciter stator and hence the main rotor to maintain the machine output voltage within the specified limits, compensating for load, speed, temperature and power factor of the generator.

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

Sustained overvoltage caused by open circuit sensing terminals is avoided by overvoltage detection circuitry which provides internal shutdown of the AVR output device.

A frequency measuring circuit continually monitors the generator output 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/Hz slope to improve frequency recovery time on turbo charged engines.

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

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

Accessories are available for this AVR. Please refer to factory for further details.

*The stated voltage regulation may not be maintained in the presence of certain transmitted radio signals. Any change in regulation will fall within the limits in Criteria B of EN50082-2.

TECHNICAL SPECIFICATION

SENSING INPUT

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

POWER INPUT (PMG)

Voltage	170-220 V ac
Current	3 A/phase
Frequency	100-120 Hz nominal
Phase	3
Wire	3

OUTPUT

Voltage	max 120 V dc
Current	continuous 3.7 A (See note 3) Transient 6 A for 10 seconds
Field Resistance	15 W minimum

REGULATION (See Note 1) +/- 0.5% RMS*

THERMAL DRIFT
(after 10 min)
0.5% for 40°C change in AVR ambient

SOFT START RAMP TIME
0.4 - 4 seconds

TYPICAL SYSTEM RESPONSE

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

EXTERNAL VOLTAGE ADJUSTMENT
+/- 6% with 4.7 K W trimmer

UNDER FREQUENCY PROTECTION

Set Point (see note 2)	95% Hz
Slope	100-300% down to 30 Hz
Dwell (Recovery)	0.5-2.0 seconds

UNIT POWER DISSIPATION
18 watts maximum

ACCESSORY INPUT
+/- 1 V = +/- 5% change in output volts

QUADRATURE DROOP
Maximum sensitivity (10 W Burden)
0.22 A for 5% droop @ 0p.f.

CURRENT LIMIT
sensitivity range (10 W Burden) 0.45 A - 1 A

OVER VOLTAGE PROTECTION

Set Point	300 V	
Time Delay (fixed)	8-15 seconds	
Circuit breaker	trip coil voltage	40-60 v dc
Circuit breaker	trip coil resistance	50-100 ohms

OVER EXCITATION PROTECTION

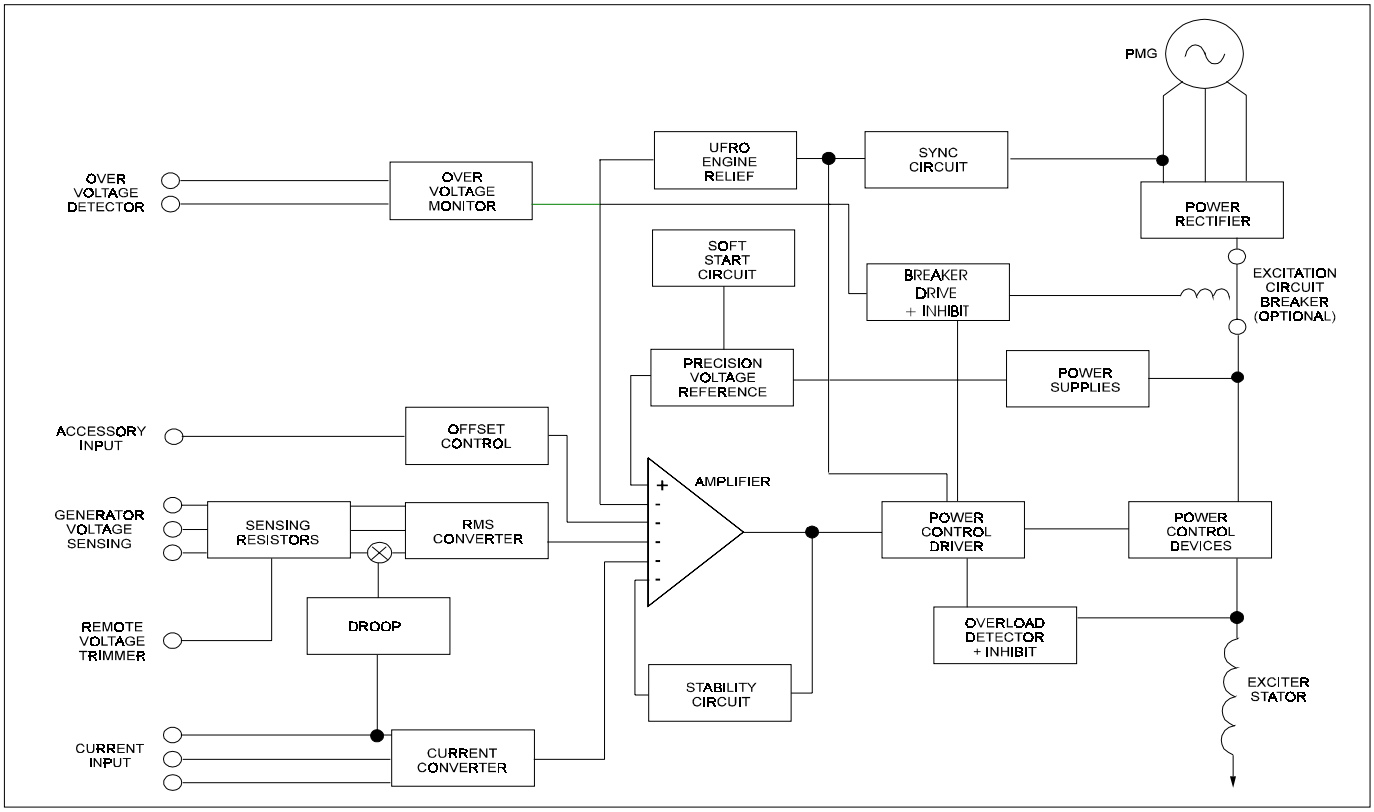
Set Point	75 V dc
Time Delay (fixed)	8-15 seconds

ENVIRONMENTAL

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

NOTES
1. With 4% engine governing.
2. Factory set, semi-sealed, jumper selectable.
3. Derate linearly from 3.7A at 50°C to 2.7A at 70°C operating temperature.

DESIGN DETAILS



The main functions of the AVR are:

Sensing Resistors take a portion of the generator output voltage and attenuate it. This input chain of resistors includes the hand trimmer adjustment.

Quadrature droop circuit converts the current input 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 is a square law precision rectifier circuit that converts the ac signals from the sensing networks into a composite dc signal representing the mean squared value of the waveform.

The output of the RMS converter includes a variable potential divider which is the voltage range control for the AVR.

Current converter is a three phase precision rectifier and amplifier that converts the inputs from current transformers into a dc signal representing the mean value of the current waveform.

Offset control provides an interface between the AVR and accessories and allows the generator's excitation to be controlled by adding or subtracting the accessory dc output voltage to the AVR rectified sensing voltage.

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

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

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

Main Comparator/Amplifier compares the sensing voltages with the reference voltage and amplifies the difference (error) to provide a controlling signal for the power device to supply the exciter with the required amount of power to maintain the generator voltage within the specified limits.

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

Power control driver provides the means to infinitely control 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 and rectifier vary the amount of exciter field current in response to the error signals produced by the main comparator.

Syncronising circuit provides a short pulse near the zero point of one of the phases on the PMG and is used to synchronise the Under Frequency Roll Off (UFRO) and power control circuits to the generator cycle period.

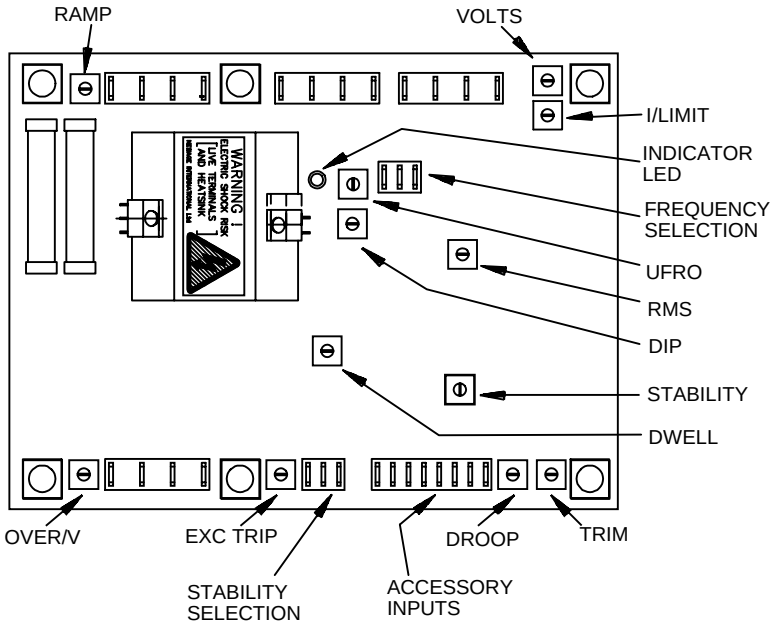
UFRO circuit measures the period of each electrical cycle and causes the reference voltage to be reduced linearly with speed below a presettable threshold. A light emitting diode (LED) gives indication of underspeed running.

Engine relief (load acceptance) circuit causes greater voltage roll off (makes the V/Hz slope steeper) to aid engine speed recovery after application of a "block" load.

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, to isolate power from the exciter and AVR if sustained overvoltage occurs. A one second timer is included in the circuit to prevent operation during transient overvoltages, which are normal after load removal.

Overload detector continuously monitors the level of excitation and provides signals to shut down the output device if overloads last more than ten seconds. Both the overload and overvoltage conditions are latched faults requiring the generator to be stopped for reset.

FITTING AND OPERATING



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SUMMARY OF AVR CONTROLS		
CONTROL	**FUNCTION**	**DIRECTION**
VOLTS	TO ADJUST GENERATOR OUTPUT VOLTAGE	CLOCKWISE INCREASES OUTPUT VOLTAGE
STABILITY	TO PREVENT VOLTAGE HUNTING	CLOCKWISE INCREASES STABILITY OR DAMPING EFFECT
STABILITY SELECTION	TO OPTIMISE TRANSIENT PERFORMANCE	LINK DEPENDING UPON KW OUTPUT
UFRO	TO SET UNDER FRQUENCY ROLL OFF KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY
FREQUENCY SELECTION	TO SELECT "UFRO" CONTROL RANGE	LINK DEPENDING ON OPERATING FREQUENCEY AND NUMBER OF MACHINE POLES
DROOP	TO SET GENERATOR DROOP TO 5% AT FULL LOAD O PF	CLOCKWISE INCREASES THE DROOP
TRIM	TO MATCH AVR INPUT TO ACCESSORY OUTPUT	CLOCKWISE ALLOWS THE ACCESSORY MORE CONTROL OVER AVR
EXC TRIP	TO SET THE OVER EXCITATION CUT OFF LEVEL	CLOCKWISE INCREASES THE CUT OFF LEVEL
DIP	TO SET THE INITIAL FREQUENCY RELATED VOLTAGE DIP	CLOCKWISE INCREASES THE VOLTAGE DIP
OVER/V	TO SET THE OVERVOLTAGE PROTECTION CUT OFF LEVEL	CLOCKWISE INCREASES THE OVERVOLTAGE CUT OFF LEVEL
I/LIMIT	TO SET THE MAXIMUM SHORT CIRCUIT CURRENT	CLOCKWISE INCREASES THE SHORT CIRCUIT CURRENT
DWELL	TO SET THE VOLTAGE RECOVERY TIME AFTER BLOCK LOADING	CLOCKWISE INCREASES THE RECOVERY TIME
RMS	SET AND SEALED AT FACTORY	
RAMP	SET AND SEALED AT FACTORY	CLOCKWISE INCREASE THE SOFT START RAMP TIME

The AVR is fully encapsulated to ensure long-trouble-free operation. It is usually fitted on a panel of the terminal box. It can also be seperately fitted in a switchboard.

ADJUSTMENT 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. Terminals 1 & 2 on the auxiliary terminal block in the generator terminal box will be fitted with a shorting link if no hand trimmer is required.

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:-

1) Before running generator, turn VOLTS control fully anti-clockwise.

2) Turn remote volts trimmer (if fitted) to midway position.

3) Turn STABILITY control to midway position.

4) Connect a suitable voltmeter (0-300V ac) across line to neutral of the generator.

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

6) If the red Light Emitting Diode (LED) is illuminated, refer to the Under Frequency Roll Off (UFRO) adjustment.

7) Carefully turn VOLTS control clockwise until rated voltage is reached.

8) If instability is present at rated voltage, refer to stability adjustment, then re-adjust voltage if necessary.

9) Voltage adjustment is now completed.

STABILITY SELECTION

The "jumper" selector lead should be correctly linked (A,B,C at the bottom of the board) for the frame size of the generator (See diagram).

STABILITY ADJUSTMENT

The AVR includes a stability or damping circuit to provide good steady state and transient performance of the generator.

The correct setting 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 (UFRO) ADJUSTMENT

The AVR incorporates an underspeed protection circuit which gives a volts/Hz characteristic when the generator speed falls below a presettable threshold known as the "knee" point.

The correct linking must first be set with the "jumper" lead for 4 Pole or 6 Pole, 50Hz or 60Hz. (See Diagram markings 1,2,3 near centre of board).

The red Light Emitting Diode (LED) gives indication that the UFRO circuit is operating, and 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 just below nominal, i.e. 47Hz on a 50Hz system or 57Hz on a 60Hz system.

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

DIP ADJUSTMENT

The 'DIP' adjustment allows some control over the generator voltage dip upon the application 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/Hz slope to give greater voltage roll off in proportion to speed.

With the 'DIP' control fully anti-clockwise the generator voltage characteristics will follow the normal V/Hz line as the frequency falls below nominal.

Turning the 'DIP' control more clockwise provides greater voltage dip allowing easier engine recovery.

DWELL ADJUSTMENT

The 'DWELL' operates only when the speed has fallen below the knee point set by the UFRO adjustment. The "dwell" or recovery time can be adjusted to time the voltage recovery period. Steep 'dip' gradients can be set without causing governor instability.

Clockwise adjustment increases dwell time. With the potentiometer fully counter clockwise there is no dwell and the recovery follows exactly the engine speed recovery.

DROOP ADJUSTMENT

Generators intended for parallel operation are fitted with a quadrature droop C.T. which provides a power factor correction signal for the AVR. The C.T. is connected to S1, S2 (W phase) on the AVR.

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

Clockwise increases the amount of C.T. signal injected into the AVR and increases the droop with lagging power factor (cos Ø).

With the control fully anti-clockwise there is no droop.

TRIM ADJUSTMENT (V/TRIM)

An auxiliary input is provided to connect to the VPF controller, (A1,A2). It is designed to accept dc signals up to +/- 5 volts.

The dc signal on this input adds to or subtracts from the AVR sensing circuit, depending on polarity.

The V/Trim control allows the user to adjust the sensitivity of the VPF controller.

With V/Trim fully anti-clockwise the VPF controller has no effect. Clockwise it has maximum effect. Normal setting is fully clockwise.

OVER EXCITATION (EXC) 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 trip.

OVER VOLTAGE (OVER V) ADJUSTMENT

The AVR includes over voltage protection circuitry to remove generator excitation in the event of a short circuit power device or loss of sensing input.

Separate terminals are provided for the over voltage circuit E1, E0 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 K1, K2, interrupting the power supply to the exciter field, through simple manual switching. The addition to this circuit breaker of leads B0 and B1, causes the power supply to be interrupted automatically in the event of an over voltage.

The OVER V adjustment is normally set and sealed at the factory but can be reset on retrofit AVRs. Clockwise increases the tripping voltage.

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

The generator must be stopped to reset an overvoltage trip.

CURRENT LIMIT (I/LIMIT) ADJUSTMENT

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 overstressing of conductors and insulation.

To use this feature, three current transformers (C.T.s) are fitted on the generator to provide feedback signals to the AVR S1 S2 terminals.

Under short circuit conditions, clockwise rotation of the I / LIMIT adjustment increases the short circuit current and anti-clockwise reduces it.

Short circuit current is limited to a maximum duration of ten seconds by the overload circuit.

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

RAMP ADJUSTMENT

The adjustment is normally set and sealed in the works to give a 3 second soft start or ramp time. The setting can be altered if desired to vary the ramp time over the range of 0.4 to 4 seconds. Clockwise increases the ramp time.

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