SX421 AUTOMATIC VOLTAGE REGULATOR (AVR)

SPECIFICATION, INSTALLATION AND ADJUSTMENTS

GENERAL DESCRIPTION

The SX421 is a three phase sensed 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 a number of protective features. Excitation power is derived directly from the generator terminals.

Positive voltage build-up from residual levels is ensured by the use of efficient semiconductors in the power circuitry of the AVR.

The AVR is linked with the main stator and exciter field windings to provide closed loop control of the output voltage with load regulation in the order of +/-0.5% RMS.

The AVR senses the output voltage from the main stator windings and in response to this controls the power fed to the exciter field and hence the main field to maintain output voltage within the specified limits, compensating for load, speed, temperature, and power factor of the generator.

Overvoltages caused by open circuit sensing terminals or short circuit power device are avoided by overvoltage detection circuitry which provides circuit breaker trip signals for circuit isolation. (see note 1).

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 V/Hz slope, to improve frequency recovery time on turbo-charged engines.

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

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

TECHNICAL SPECIFICATION

SENSING INPUT

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

OUTPUT

Voltage	max 90 V dc at 207 V ac input
Current	Continuous 4 A dc
	Transient 6 A for 10 seconds
Field Resistance	15 Ω minimum

REGULATION

(See Note 2) +/- 0.5% RMS

THERMAL DRIFT

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

TYPICAL SYSTEM RESPONSE

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

EXTERNAL VOLTAGE ADJUSTMENT

+/- 6% with 1 K Ω trimmer

UNDER FREQUENCY PROTECTION

Set Point (See Note 3)	95% Hz
Slope	100-300% down to 30 Hz

UNIT POWER DISSIPATION

20 watts maximum

BUILD UP VOLTAGE

3.5 V ac @ AVR terminals

ACCESSORY INPUT

+/- 1V = +/- 5% change in output volts @ 415 V

QUADRATURE DROOP

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

OVER VOLTAGE PROTECTION

Set Point	300 V dc
Time Delay (fixed)	1 second
Circuit Breaker Trip Coil Voltage	12-30 V dc
C/B Trip Coil Resistance	25-40 Ω

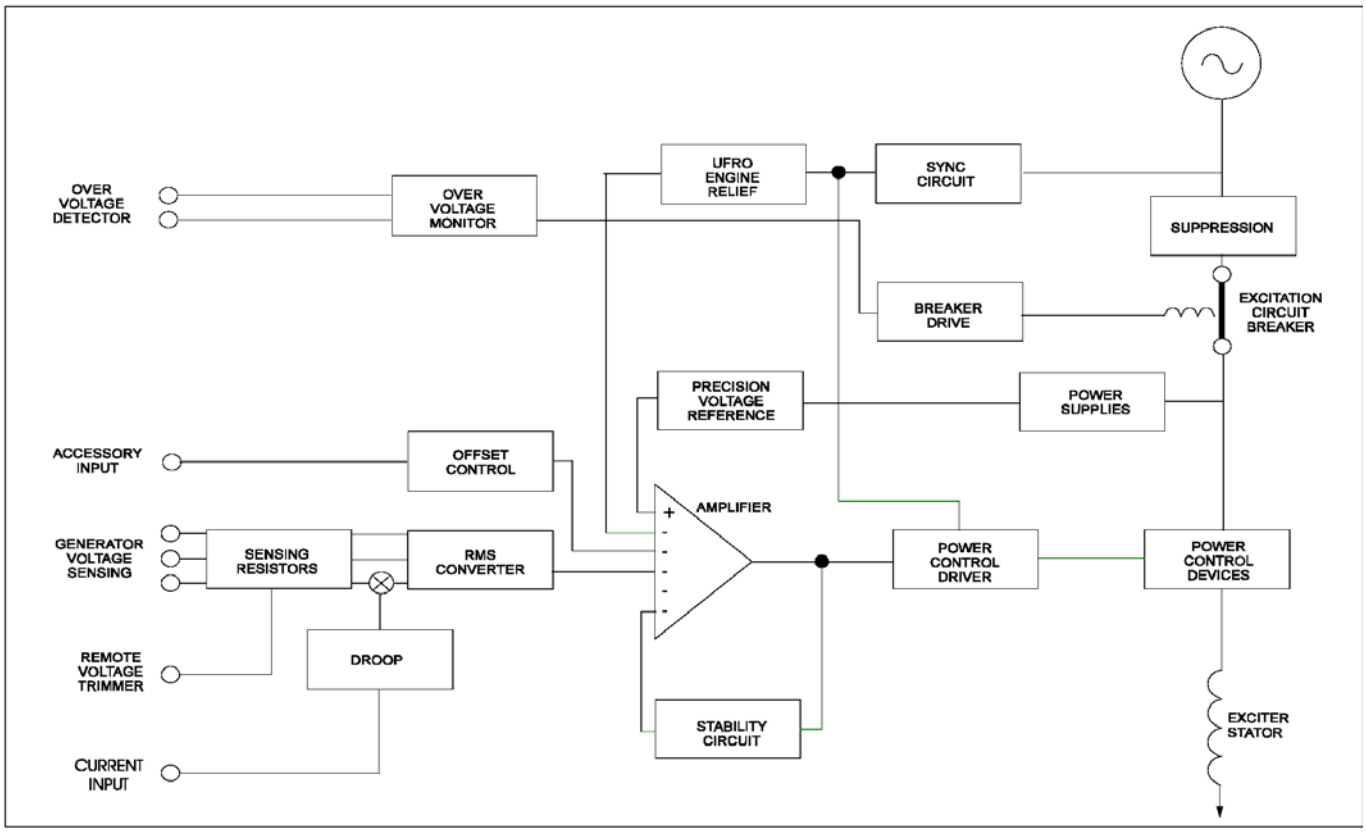
ENVIRONMENTAL

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

NOTES

1. A miniature circuit breaker must be fitted to use the Overvoltage Protection feature.
2. With 4% engine governing.
3. Factory set, semi-sealed, jumper selectable.

DESING DETAILS



The main functions of the AVR are:

Sensing Resistors take a proportion of the generator output voltage and attenuate it. This input chain of resistors includes the range potentiometer and hand trimmer which adjusts the generator voltage.

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.

A trimmer allows control over the amount of droop signal.

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.

Offset Control provides an interface between the AVR and accessories.

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 for comparison purposes.

Main Comparator/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 and Rectifier vary the amount of exciter field current in response to the error signals produced by the main comparator.

Synchronising Circuit provides a short pulse at the zero crossing of each cycle and is used to synchronise the Under Frequency Roll Off (UFRO) and power control circuits to the generator cycle period.

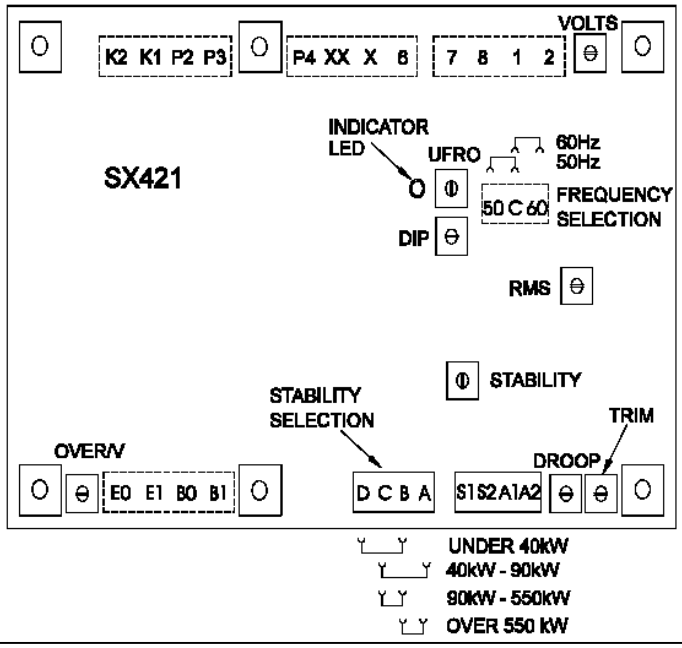
UFRO circuit measures the period of each electrical cycle and reduces the reference voltage linearly with speed below a presettable threshold. A light emitting diode (LED) gives indication of underspeed.

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

Overvoltage Monitor continuously monitors the voltage at the generator terminals and provides signals to trip a circuit breaker to isolate power from the exciter and AVR if sustained overvoltages occur. A one second timer is included in the circuit to prevent operation during transient overvoltages which are normal after load removal.

A miniature circuit breaker must be fitted to use the Overvoltage Protection feature.

FITTING AND OPERATING



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 FREQUENCY ROLL OFF KNEE POINT	CLOCKWISE REDUCES THE KNEE POINT FREQUENCY
FREQUENCY SELECTION	TO SELECT 'UFRO' CONTROL RANGE	LINK DEPENDING ON OPERATING FREQUENCY
DROOP	TO SET GENERATOR DROOP TO 5% AT FULL LOAD 0 PF	CLOCKWISE INCREASES THE DROOP
TRIM	TO MATCH AVR INPUT	CLOCKWISE ALLOWS THE ACCESSORY MORE CONTROL OVER AVR
DIP	TO SET THE INTIAL 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
RMS	SET AND SEALED AT FACTORY	

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 separately 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 inside the generator terminal box will be fitted with a shorting link if no hand trimmer is required.

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:-

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 for the frame size of the generator (See diagram above).

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).

FREQUENCY SELECTION

The "jumper" selection lead should be correctly linked for the nominal operating frequency of the generator (see diagram).

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 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 Voltage protection adjustment.

DIP ADJUSTMENT

The 'DIP' adjustment allows some control over the 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.
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.

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 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

An auxiliary input is provided to connect to the Power Factor controller. It is designed to accept dc signals up to +/- 5 volts.

The dc signal on this input (A1,A2) adds to or subtracts from the AVR sensing circuit, depending on polarity.

The Trim control allows the user to adjust the sensitivity of the AVR to the PF controller output.

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

OVER VOLTAGE (OVER V) ADJUSTMENT

A miniature circuit breaker is supplied for this feature. It may be fitted in the generator or supplied loose for fitting in the control panel.

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. (Typical E1, E0 voltage = 240 Vac).

Provision is made for the connection of the circuit breaker to break terminals K1, K2, interrupting the power supply to the exciter field. The addition of this circuit breaker (and leads B0 and B1) causes the AVR 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.

Caution !	**When the circuit breaker is supplied loose, the AVR is fitted with a link on terminals K1-K2 to enable operation of the AVR. When connecting the circuit breaker this link must be removed.**

In the event of operation of the circuit breaker, indicated by loss of generator output voltage, manual resetting is required. When in the "tripped" state the circuit breaker switch lever shows "OFF". To reset move the switch lever to the position showing "ON".

When fitted in the generator, access to the breaker is gained by removal of the AVR access cover.

 **Warning !**	**Terminals which are live with the generating set running are exposed when the AVR access cover is removed. Resetting of the circuit breaker must be carried out with the generating set stationary, and engine starting circuits disabled.**

The circuit breaker is mounted on the AVR mounting bracket either to the left or to the right of the AVR depending upon AVR position. After resetting the circuit breaker replace the AVR access cover before restarting the generating set. Should resetting of the circuit breaker not restore the generator to normal operation, refer to the Service section in the generator Instruction Manual.

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