Specification: Petbow 350 KVA Generator

Date of Manufacture	Dec-08
Prime Rating kVA	350
Make	Petbow
Model	CB280A
Serial No.	C990873409
Engine Make	Cummins
Engine model	NTA 855 G4
Engine serial	11939167
Engine CPL	1436
Cylinders	6
Engine Parts Supply	Cummins
Governor	Electronic
RPM	1500
Service Intervals	400
Air filter	AF4548
Fuel filter 1	2 x FS1000
Oil filter full flow	LF9039
Oil capacity	40 Litres
Coolant filter	WF 2074
Coolant capacity	60 Litres
Starter Motor 12/24v	OEX P/N DXS9150
DC Alternator 12/24v	Prestolite P/N 66021507
Fan belt	2 x 20A1055 + 6PK1105
DC Alternator belt	2 x 13A1040
Alternator model	Stamford HCI434F
Alternator serial	C990873409
Control panel	Gencon
Main Circuit Breaker	Motor Operated
Earth Leakage Type	NHP DSRM72C
Battery	2 x Delkor N120
Fuel Type	DIESEL
Fuel cons @ 75%	57 l/hr
Fuel capacity	1400 Litres
Avge noise @ 7m	74 db(a)
Length	5000 mm
Width	1650mm
Height	2460mm
Approx wet weight	8000kgs

■ GENERATOR LOAD TEST REPORT

WO / JOB NO: 25041 Location Load test
DATE: 2/4/26
ENGINE TYPE: Cummins NTA 855 G4
SERIAL NO: 11939167
ALTERNATOR TYPE: Stamford HCI434F
SERIAL NO: C990873409
SET SIZE / MODEL: 350kva Genset Gen set
SERIAL NO: C990873409
CLIENT: Total Generators Total Generators

Time	Load	Eng Hrs	Voltage			Amps			HZ	Eng Temp	Oil Pres	Oil Temp	Ambient Temp/ Smoke Level
	(KW)		U	V	W	U	V	W		°C	PSI/ KPA	°C	°C
08:50	194	.27	234	237	244	276	275	258	50.2	90	380	90.8	24
08:55	206	.30	235	239	242	304	306	306	50.1	94	350	96.6	24
09:00	256	.42	236	235	240	394	396	388	49.9	94	310	98.5	24
09:05	250	.44	238	238	240	390	391	388	49.9	98	300	99	24
09:10	280	.58	236	237	235	425	430	428	49.8	98	300	99	25
09:15	263	.53	239	234	236	411	408	403	49.9	99	300	102	25
09:20	263	.50	229	234	233	138	146	146	50.1	85	300	99.6	25
09:25	250	.02	233	235	236	390	391	388	49.9	98	300	99	25
09:30	280	.08	235	237	235	425	430	428	49.8	98	300	99	25
09:35	263	.11	233	235	233	411	408	403	49.9	99	300	102	25
09:40	263	.15	229	234	234	411	408	403	49.9	99	300	100	25
09:45	263	.21	232	235	235	411	408	403	49.9	98	300	99	25
09:50	98	.26	229	234	233	138	146	146	50.1	85	300	91.6	25

COMMENTS: 350kva/280kw = 389A @1.0pf max load.
Generator performed well under load taking 35A less at 100% load but we left it at 90% for the majority of the time during the load test.
Engine hours - 24,559.

TESTED BY: Brisbane Workshop Basic Pilot SIGNED JB

Diesel Powered Generating Sets C400 D5

Standard Genset Features

Cummins water cooled Diesel engine,
Oil and fuel filter fitted, water separator
Lube-oil drain valve fitted
Electric starter & Charge alternator 24 v D.C.
Electronic governor
Normal duty air filter
Single bearing alternator, class H/H
Standard voltage 400/230 volts 50 Hz
Exciter/Voltage reg - Torque Match as standard
PCC2100 with Bargraph as standard
Steel base frame with A/V mounting,
Engine, Alternator, Chassis & Control Box
Munsell Jade Green
Radiator
Packing under shrunk plastic film
Operation & Maintenance manual
Standard set of labels

Generator Set Performance

Voltage Regulation
Maintains voltage output to within ±1.0%.
At any power factor between 0.8 and 1.0
At any variations from No load to Full load
At any variations from Cold to Hot.
At speed droop variations up to 4.5%.
Frequency Regulation
Isochronous under varying loads from no load to 100% full load when electronic governor is fitted
Random Frequency Variation
Will not exceed ±0.25% of its mean value for constant loads – no load to full load.
Waveform
Total harmonic distortion open circuit voltage waveform in the order of 1.8%. Three-phase balanced load in the order of 5.0%.
Telephone Influence Factor (TIF)
TIF better than 50.
THF to BS 4999 Part 40 better than 2%.
Alternator Temperature Rise
Class H insulation.
Radio Interference
In compliance with BS 800 and VDE levels G and N.

Generator Set Options

Fuel options
Fuel Tank

Exhaust Options
Exhaust Silencer - Industrial In-Line
Exhaust Bellows
Exhaust Silencer - Residential , In-Line
Installation Kit - Industrial Silencer
Installation Kit - Residential Silencer

Voltage Connections
240/416V, 230/400V, 220/380V,
127/220V, 115/200V, 110/190V

Miscellaneous Options
3 pole or 4 pole Circuit Breaker
Optional Set mounted starting batteries
Coolant Heater 240V
Battery Charger 240V,5A
Automatic Transfer Switches
Packing - Export Box

Engine Specification

NTA855G4
In-line direct injection
6-cylinder diesel engine.
Type
Water cooled, four cycle, turbocharged
Construction
Two valves per cylinder, forged stee crankshaft and connecting rods, cast iron block.
Starting
24 volt negative earth. Battery charging alternator 35 amp on engine. Cranking current 640 amps at 0°C.
Fuel System
24 volt fail safe actuator. Spin-on paper element fuel filters with fuel pump injection system with integral electronic governor. Dual flexible fuel lines and connectors. Standard fuel water separator.
Filters
Air cleaner with dry element.
Spin-on full flow lube oil filter.
Cooling
40°C ambient temperature standard
Stone guard. Oil cooler. Drain Tap

Alternator Specification

Type
Brushless single bearing, revolving field, pole, drip proof, screen protected.
Class H Insulation, IP23 Protection
Fully interconnected damper winding.
AC exciter and rotating rectifier unit.
Epoxy coated stator winding.
Rotor and exciter impregnated with tropical grade insulating oil and acid resisting polyester resin. Dynamically balanced roto BS 5625 grade 2.5.
Sealed for life bearings.
Layer wound mechanically wedged rotor

Exciter
Triple dipped in moisture, oil and acid resisting polyester varnish and coated with anti-tracking varnish.

Output windings with 2/3 pitch for improved harmonics and paralleling ability.
Close coupled engine/alternator for perfec alignment.

Compliance Standards

To BS4999/5000 pt 99,
VDE 0530, UTE5100,
NEMA MG1-22, CEMA,
IEC 34, CSA A22.2,
AS1359, BSS 5514,
ISO 3046 and ISO 8528

Model name	kVA		kWe	
	Standby	Prime	Standby	Prime
C400 D5	390	350	312	280

Technical Data

Model	C400 D5	**Speed**	1500 rpm
Set output	380-440 V 50 Hz	**Alternator voltage regulation**	±1.0%
Prime Rating	280 kWe 350 kVA	**Alternator insulation class**	H
Standby Rating	312 kWe 390 kVA	**Fuel consumption (Prime)**	76 l/hr
Engine Make	Cummins	**Fuel consumption (Standby)**	84 l/hr
Engine Model	NTA855G4	**Lubrication system oil capacity**	38.6 Litres
Cylinders	Six	**Base fuel tank capacity – open set**	800 Litres
Engine build	In-line	**Coolant capacity**	65.8 Litres
Standard Governor/Class	Electronic	**Exhaust temp – prime**	524°C
Aspiration and cooling	Turbocharged and Aftercooled	**Exhaust gas flow – prime**	1128 l/s
Bore and stroke	140 mm x 152 mm	**Exhaust gas back pressure max**	76 mm Hg
Compression Ratio	14.0:1	**Air flow - radiator**	5.99 m³/s
Cubic capacity	14 Litres	**Air intake – engine (Prime)**	408 Litres/s
Starting/Min °C	10°C	**Minimum air opening to room**	2.10 m²
Battery capacity	100 A/hr	**Minimum discharge opening**	1.39 m²
Gross Engine output – Prime	317 kWm	**Pusher fan head (duct allowance)**	13 mm Wg
Gross Engine output – Standby	351 kWm	**Heat radiated by eng (Prime)**	46 kWm

PRIME POWER

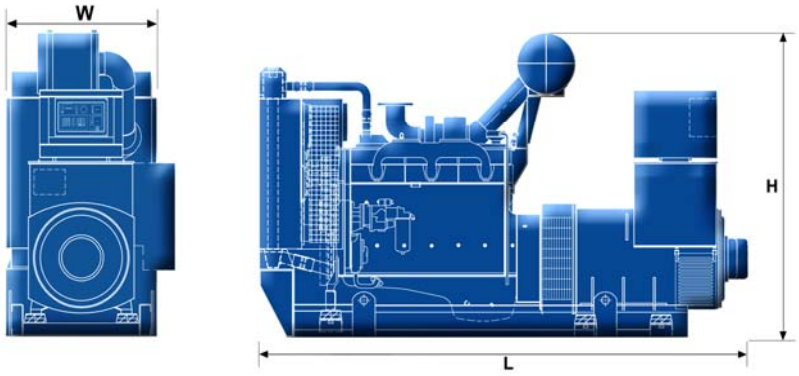
Prime Power is available continuously during the period of power outage in a variable load application. Variable load should not exceed a 70% average of the prime power rating during any 24 hour period. A 10% overload capability is available for a period of 1 hour within a 12 hour period of operation.

STANDBY POWER

The Standby Power is applicable for supplying emergency power for the duration of a utility power interruption. No overload, utility parallel or negotiated outage operation capability is available at this rating. In installations served by unreliable utility sources (where outages last longer or occur more frequently), where operation is likely to exceed 200 hours per year, the prime power rating should be applied. The Standby Power rating is only applicable for emergency and standby applications where the generator set serves as the back up to the normal utility source.

All ratings are based on the following reference conditions:

- Ambient temperature : 27°C
- Altitude above sea level : 150 metres
- Relative humidity : 60%



Dimensions and Weights

Open Version

Model	Engine	Length (mm)	Width (mm)	Height (mm)	Dry weight without tank (Kg)	Wet weight without tank (Kg)
C400 D5	NTA855G4	3156	1000	1914	3032	3143

Enclosed Version

Model	Engine	Length (mm)	Width (mm)	Height (mm)	Dry weight with tank (Kg)	Wet weight with tank (Kg)
C400 D5	NTA855G4	4500	1600	2250	5450	6230

See your distributor for more information.

Cummins Power Generation
Asia Pacific
10 Toh Guan Road #07-01
TT International Tradepark
Singapore 608838
Tel: (+65) 6417 2388
Fax: (+65) 6417 2399
Email: mktg.sing@cummins.com
www.cumminspower.com

WEXLER COMPUTER SYSTEMS DEVELOPMENT LTD.
P.O. Box 15108, Rishon Le-Zion 75050, ISRAEL
Tel: +972 3 965-5858, Fax: +972 3 965-5810

GENCON® II -- Standby V1.7h
High Performance Generator-Set Controller

Hardware **GENCON® II** is a computing platform that combines comprehensive, accurate and true RMS set of electrical measurements with control and monitoring functions.

Software: **GENCON® II** with the software **STANDBY V1.7h** is an extremely powerful generator-set control system for prime and for stand-by (emergency) power generation. The control system includes all the facilities necessary for paralleling a generator-set with the mains (the electric utility) as well as with other generator-sets.

Scope Technical manual, Edited 15 July '94.

Audience: People with genset know-how, interested in and appreciative of technical innovation

Comments Welcome! We are just a fax call away

Tolerance: Ground or earth, analog or analogue, emergency generator-set or standby generator-set, the utility or the mains... does it really matter?

Disclaimer: We believe that this document is a faithful description of the system. We may have erroneous information and we reserve the right to change the specification without notice. We do not assume any liability arising out of the application or use of the product or any circuit described herein.

Table of Contents

Features

GENCON® II, running the STANDBY V1.7h software, is a complete control system for measurement, monitoring and control of synchronous and asynchronous (induction) generators.
Its applications include:
1. ***Automatic mains failure standby (emergency),***
2. ***Paralleling with the mains,***
3. ***Paralleling multiple generator-sets.***

The **GENCON® II** control system, whilst so light and small,...

- Performs ***high accuracy*** (0.5%) and ***true RMS*** set of ***measurements***.
- Includes feedback control loops for ***automatic synchronization***, for ***sharing a common load*** active/kW & reactive/kVAr components proportionally ***among up-to eight paralleling generator-sets***, and for ***exporting power to the mains*** with programmable ***loading and unloading ramp***.
- Displays ***29 electrical parameters of 3Φ***, wye (star) connected, ***generators***: Volts (L-N, L-L), Amps, kVA's, kW's, kVAr's, kWH, Power-factors, Frequency (0.01 Hz resolution) and Harmonic Distortions. In-built galvanic isolation allows direct connection to the generator phases with high degree of transient protection (IEEE 587 class C). Currents are read by 5A current transformers.
- Displays ***3 parameters of the bus/mains***: Volts, Frequency and Harmonic distortion.
- Displays the ***Battery Volts***, the ***Engine Speed*** and the ***Elapsed Run Time***.
- Displays during synchronization the frequency slip, the phase shift and the voltage difference between the generator and the bus/mains -- ie ***no need for a synchroscope***.
- ***Continuously monitors the*** incoming stream of ***measurements to detect any irregularity***: Engine Over-Speed, Battery Over or Under Voltage, Generator Over or Under Voltage, Generator Over or Under Frequency, Generator Overcurrent (with inverse time constant), Generator Reverse Power, Generator Loss of Excitation, Excessive Harmonic Distortion, Mains Failure and more!
- Complies with the ***American stand-by generator-sets*** code NFPA 110 level 1.
- Provides for ***European stand-by generator-sets*** an integral Automatic Transfer Switch (ATS) logic, ie that controls the mains ⇔ genset changeover contactors.
- Up-to 8 generator-sets can run in ***parallel with random access to the bus***: The generator-set that builds its voltage first is connected without delay to the (dead) bus. The others join, one by one, after synchronization. The gensets can ***start and stop automatically according to the bus load*** -- the user can change their start/stop sequence from any controller panel!
- Provides on the LCD a clear genset activity report including ***display of timers countdown***.
- Logs ***warning and shutdown*** messages, with a time tag, in ***memory***.
- Facilitates adjustment of the ***numerous parameters*** (delays, set-points, options...) from the front panel key-pad or from a remote PC. The adjustment process is self-explanatory -- there is no need to carry the manual around! Passwords limit access to important user commands and to sensitive installation parameters.
- Operates in a ***wide battery voltage range***. Withstands even a high voltage LOAD DUMP[#1] !!!
- Operates in a ***wide temperature range***, from -20°C to +70°C.
- Has a ***sealed fascia panel*** (IP65) that protects it from dust and from splashing.
- Provides a "duplicate" control panel, up-to 1,200 meters away, on an IBM compatible PC console, through the ***RS485 communication LAN***. Eight control panels can be displayed simultaneously to monitor all the paralleling sets in the system. Easy user interface through mouse (🖱) clicking.
- Provides multilingual support -- all the LCD commands and messages are ***user translatable!***

- *Last but not least!* New software applications are in the pipeline... ✍
  GENCON® II is using the new non-volatile Flash memory technology. This means that ***software updates can be loaded, within seconds, without having to open the instrument cover.***

[#1] A phenomenon that occurs when the battery open circuits while the engine is running.

Abstract

The controller is made of three parts:

GENCON II This is the main unit that performs all computations, measurements, paralleling and communication. ***Standard models*** nominal line to neutral Vac: 120, 127, 220, 240 and 277.

IOB1 This is an auxiliary 16 input and 8 output relay board that is mounted on a DIN rail inside the control cubicle. It takes care of engine management (eg fuel-solenoid), handles external alarms (eg low oil pressure), etc. ***Standard models*** nominal battery Vdc: 12 and 24.

AVRx This is a small interface circuit between the main unit and the generator's (alternator) automatic voltage regulator (AVR). It is required for voltage-matching during synchronization and for reactive power (kVAr) control when in parallel.

Outlook

There are many situations that can be handled best by operating two or more generator sets in parallel on a common bus. Typical reasons are --

Reliability: In a standby system, when there is a mains failure, all generators in the system are started. The probability of having a generator start and achieve nominal voltage and frequency is increased according to the number of sets available.

Flexibility: Maintenance operations can be performed without having to shut down the whole system.

Economy: When the loads are expected to expand substantially, the initial investment is minimized by installing one smaller generator set, and then adding more sets in parallel as the loads increase. The number of generator sets running can change according to the load. In contrast, having one large genset run under light load conditions accelerates engine wear.

There are reasons to let a single generator set also have switch gear for paralleling with the mains --

Reliability: A standby generator set with a paralleling switch gear, when the mains supply is restored, can transfer the load back to the mains smoothly without the consumers having to undergo a (second) power cut.

Flexibility: Exercising standby generator sets under load does not interrupt the consumers supply.

Economy: Exporting to the mains lines can reduce the peak kilowatt demand of a facility at high tariff hours. Also, when an engine heat recovery system is installed (Combined Heat & Power), the generator set can export power through the mains lines to a local community and reach high overall efficiency.

With all these good reasons to use paralleling, for a given project kW requirements, the decision whether to opt for paralleling depends to a large extent on the following costs' ratio:

$$\frac{\textbf{Control Equipment + Design/Installation/Commissioning Man-Hours}}{\textbf{kW Generating Set}}$$

The **GENCON II** is designed to bring this ratio as low as possible with present day electronics.
Each numerator factor is carefully optimized:

Equipment: The generator set controller takes complete care of measurement, engine management, protection and paralleling. Virtually nothing but an electric governor and an AVR is additionally required.

Design: Numerous delays, set-points and options (parameters) adapt the controller's software to suit any application. Software programming skills are not necessary.

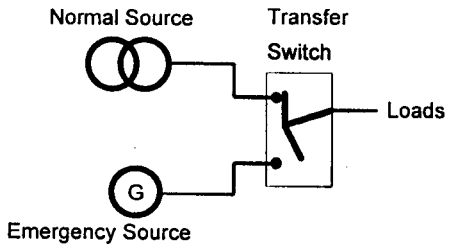
Installation: Compact design and unprecedented integration of functions, which are "interconnected" by software, makes wiring extremely simple (see the installation diagram).

Commissioning: With a built in measurement system, one can find wiring mistakes easily, eg incorrect phasing of a CT. As fault messages are logged in memory in plain language, marked with the time of their arrival, one does not confuse a "cause" with a "result". The large stock of parameters is edited using the controller's own LCD and keypad. Each parameter value is displayed with a short explanation -- no need to consult the manual each step.

The result ***Paralleling is no longer the realm of heavy kW genset projects.***

Applications

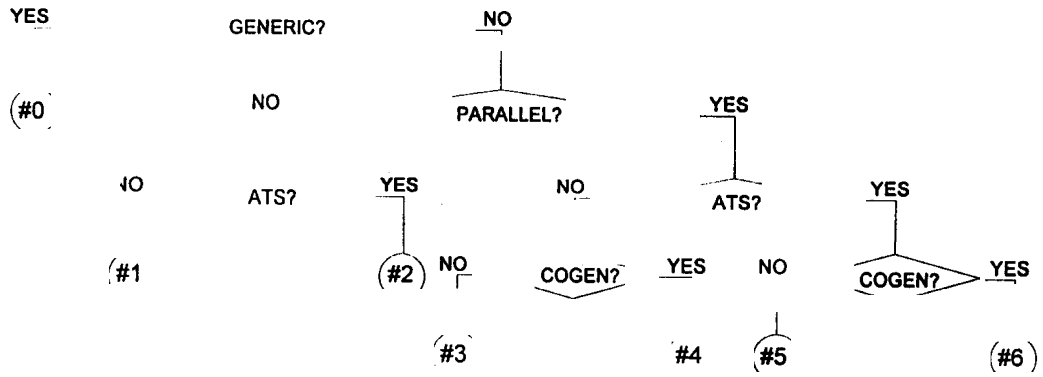
It is obvious that a switchboard design depends on the generator-set use: prime, standby, mains peak demand lopping (shaving), etc. However, the difference in the scope of the switchboard design between the continents is less known. Here is a block diagram of a classic standby set:



- In the USA, the transfer switch function is normally implemented by an independent device, the ***Automatic Transfer Switch*** (ATS): Detecting power failure, triggering the engine to start, transfer of load to the generator after build up of voltage and frequency, re transfer to normal source when power is restored and engine shutdown, are all handled by the ATS. The genset switchboard does not include these functions.
- However, particularly in Europe, all these functions are normally included in the genset switchboard. Typically the switchboard with two contactors directly implements the load transfer (called the changeover contactors).

The Americans claim that their approach is more reliable...
The Europeans claim that their approach is more economical...
GENCON II does not take sides -- It supports both traditions and its large number of parameters (delays, set points,...), all adjustable from the front panel, make it easy to adapt to any application.

Genset applications are built around the following seven configurations:



Abbreviation	SET-UP\OPTIONS	Description
GENERIC	Generic Configure?	Is contactors' switching under external control?
PARALLEL	Parallelin System?	Are the synchronizer and the load-sharing functions active?
ATS	Mains Standby ATS?	Does the relay K#8 control the mains contactor?
COGEN	Cogeneration Mode?	Will the genset parallel with the mains continuously?

The generic configuration, #0, is designed for the "special projects" department. Access is given to all the **GENCON II** functions, but the "glue logic", particularly control over the contactors (breakers), is handled by an external logic device, a PLC usually.

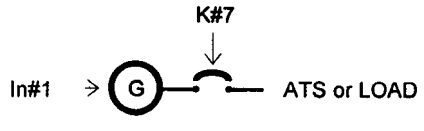
The configurations #1..#6, however, constitute complete solutions, including control of the contactors.

The following description of the applications assumes that the controller is in AUTO mode and that no shutdown fault is pending.

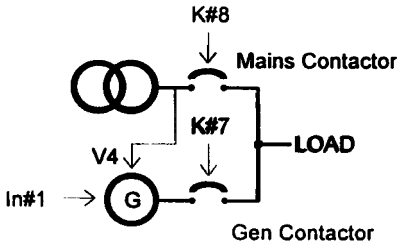
Single generator-set applications

#1 American standby

The controller starts the genset immediately when its In#1 input becomes active. When the genset is ready for load the relay K#7 is energized, the contactor is closed and the genset takes the load. When In#1 is deactivated, K#7 is de energized and the genset stops after a cooling off period. Momentary activation of In#2 starts the genset for a test without load session (ie K#7 is not energized).



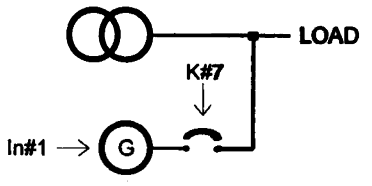
#2 Euro standby



The controller monitors the voltage and frequency of one phase of the mains by its V4 input (for 3 phase protection the external relay should disconnect V4 input on a mains failure). On a mains failure the controller energizes relay K#8 which, through a ***normally closed***[#1] contact, opens the mains contactor. After a predetermined time delay the genset is started. When the genset is ready for load, the relay K#7 is energized and its ***normally open*** contact closes the generator contactor. When the mains power is restored, after a predetermined time, the load is transferred back to the mains. To protect the load (eg synchronous motors), a time delay is introduced between the load power cut and load power re connection. In this configuration the two contactors are electrically interlocked (and sometimes mechanically interlocked) to prevent simultaneous engagement.

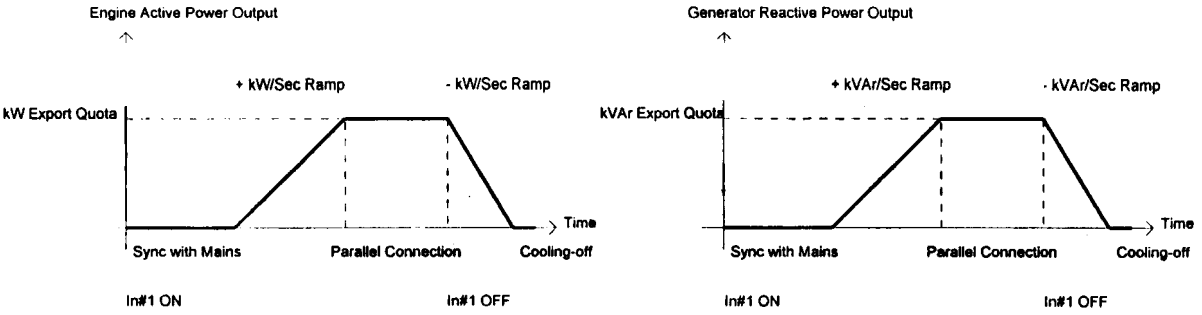
An active In#1 input starts the genset. When the genset is ready for load the relay K#8 is energized and the mains contactor opens, there is a time delay and then the relay K#7 is energized and the genset takes the load. Momentary activation of the In#2 input starts the genset for a test without load session.

#4 Paralleling with the mains



Note: This configuration also supports induction (asynchronous) generators. See in SET-UP\OPTIONS the parameter *Generator Syn|Asy.*

The genset starts immediately on an active In#1 input. The genset is synchronized with the mains. When the voltage and phase of V1 (generator) are sufficiently close to the voltage and phase of V4 (the mains), the relay K#7 is energized and parallel connection begins. The genset raises the amount of active (kW) and reactive (kVAr) power it exports to the mains at a predetermined rate, until the export quotas are met. When the In#1 input is deactivated, power export is reduced at a predetermined rate. When reaching zero the relay K#7 is de energized, the generator contactor opens and the genset stops after a cooling off period:



Momentary activation of the In#2 input starts the genset for a test without load session -- the genset is synchronized with the mains but the relay K#7 is not energized.

When detecting loss of mains during paralleling, the relay K#7 is de energized and the generator contactor opens. Loss of mains is detected within 100 ms, as follows:

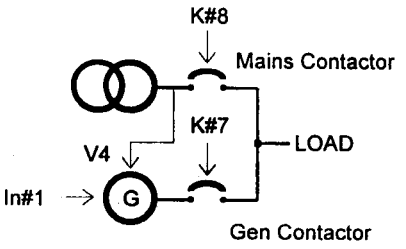
1. *PARALLEL LOAD SURGE:* Built-in protection mechanism: A sudden load change is measured, larger than the *Parll kW Surge* set-point. Response to load decrease is optional, see *kW Drop=LoadSurge?*.
2. *PARALLEL MAINS FAIL*: External protection: Low voltage is measured by V4 -- an external relay disconnects V4 input.

The user can select export quotas within the genset ratings, ie Export-kW ≤ Rating-kW and (Export-kW)² + (Export-kVAr)² ≤ (Rating-kVA)². See SET-UP\BASICS *Xre* and *Xap*.

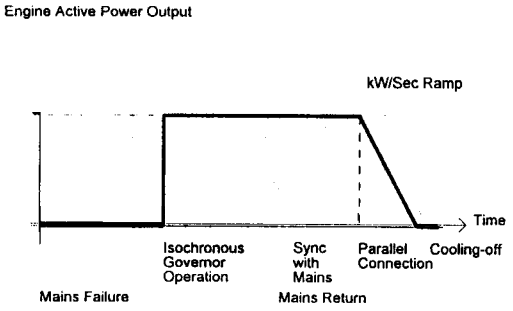
In this configuration the genset is used to parallel and export power to the mains in order to reduce the electricity supply tariff for peak loads. The electricity companies also surcharge consumers with low power factor (PF). The user should know that improper choice of the export quotas can worsen the mains supply PF: Suppose a plant load is 444 kVA at 0.9 PF, ie 400 kW & 193.7 kVAr. If the genset exports 200 kW only, ie the mains still carries the full 193.7 kVAr load, it turns that the mains is supplying power at an uneconomic 0.72 PF. However, if the genset export quotas are 200 kW and 150 kVAr (using a 250kVA genset at 0.8 PF) the mains is supplying power at an excellent 0.98 PF.

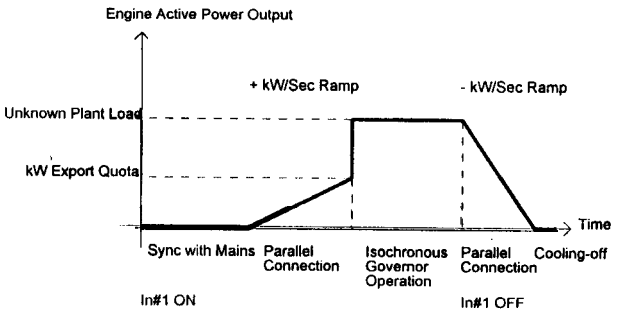
[#1] In this way the mains is connected to the load when **GENCON® II** is without DC supply

#5 Euro standby with soft load transfer



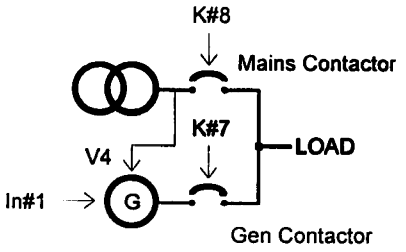
Unlike the configuration "#2 Euro Standby" here the changeover contactors must not be interlocked. On the mains return, the genset is synchronized and goes into paralleling with the mains. The genset power is reduced at a predetermined rate, gradually transferring the load back to the mains. When reaching zero genset power output, the relay K#7 is de-energized, the generator contactor opens and the genset stops after a cooling off period. The diagram on the left describes the mains failure and return cycle for the genset kW output (the kVAr case is similar).





When the mains is available, an active In#1 input starts the genset immediately. Before the genset takes the full plant load it reaches through paralleling a user selected export power quotas.
Momentary activation of the In#2 input starts the genset for a test without load session -- The genset is continuously synchronized with the mains but there is no load transfer.
In this configuration the genset stays in parallel with the mains only for the brief time it takes to perform a smooth power transfer (called "occasional paralleling"). Most electricity boards are more lenient in approving an installation of this sort than approving continuous paralleling with the mains.

#6 Euro standby with soft mains return & paralleling with the mains



This configuration provides an automatic mains failure standby operation with one power cut only as in configuration #5.
Active In#1 input starts the genset for continuous paralleling with the mains as in configuration #4.
When detecting loss of mains during paralleling, the relay K#8 is energized, the mains contactor opens and the genset remains with the load.
Loss of mains is detected within 100 ms, as follows:

1. *PARALLEL LOAD SURGE:* Built-in protection mechanism: A sudden load change is measured, larger than the *Parll kW Surge* set-point. Response to load decrease is optional, see *kW Drop=LoadSurge?*.
2. *PARALLEL MAINS FAIL*: External protection: Low voltage is measured by V4 -- an external relay disconnects V4 input.

Multiple generator-set applications

Up to 8 generator-sets can operate in parallel on a common bus. Their ratings need not be equal.
The controllers coordinate their operation by communicating through their RS485 local area network (LAN). The LAN maximal length, end to end, is 1,200 meters.
An IBM compatible PC can be connected to the LAN: The program, REMOTE.EXE, creates virtual duplicates to all the controllers' front panels, display and keys, simultaneously on the PC screen.

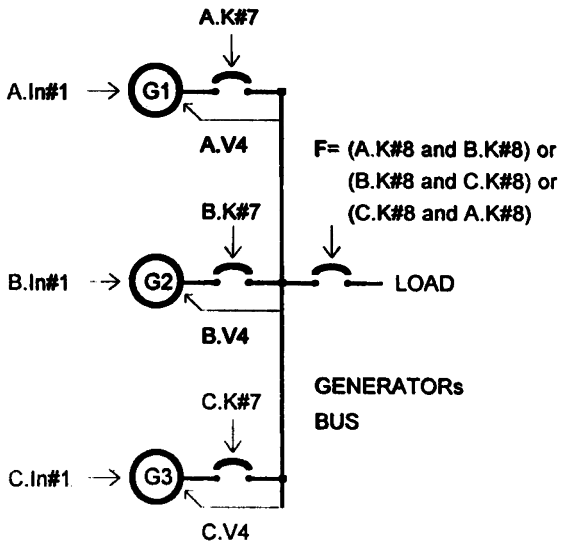
#3 Random access paralleling

All the controllers use configuration #3. The controllers synchronize the genset phase, measured by V1 input, with the bus phase, measured by V4 input.
The gensets start by activating their In#1 inputs. If the bus is dead, the first genset is connected without delay. Other gensets are synchronized with the bus before connecting them, one by one, to the bus. The K#7 relays control the generator to bus contactors. The K#8 relays follow K#7 with a time delay and can be used to ensure some time of paralleling on the bus without load.

The gensets share the load active (kW) and reactive (kVAr) components proportionally, ie each genset contributes an equal share of its kW and kVAr ratings. The genset connecting first to the (dead) bus is called

the "master" genset. Other gensets that are in parallel on the bus are called the "slave" gensets. If the "master" genset is disconnected from the bus, immediately one of the "slave" gensets becomes a "master" genset. The voltage and frequency of the bus are determined by the "master" genset governor and AVR independent characteristics. The "slave" gensets however by continuously varying the governor and AVR external controls make the "slave" gensets load share exactly match the load share of the "master".

The figure describes a three genset system with controllers A, B and C. The bus to load contactor is closed only if the bus is powered by at least two gensets.



#3 Load dependent start/stop sequencing

In power plants based on paralleling gensets it is often required to start and stop gensets automatically according to the plant load. If all the gensets have equal kW rating, the *Parall Auto Start* option in configuration #3 provides an all software solution. If there are only two gensets this option can still be used even if the ratings are different, see example 2. The power plant operator can define the gensets' starting/stopping sequence from ***any*** controller panel via the SEQUENCE command.

The following rules determine when the system starts and when it stops a genset. The word "system" means the collection of all the controllers that are connected to the RS485 network -- there is no dedicated "managing computer."

Denote the gensets' *Xre: Rated kW* as one unit of power (100%). Denote also by:

λ The power that each paralleling genset contributes. Thus, $(1-\lambda)$ is the spare genset power capacity.
N The number of gensets that run in parallel. Thus, $(1-\lambda)*N$ is the spare system power capacity.
α The set-point *+%kW/Xre→ Start*, usually the same value is defined in all the controllers.
β The set-point *+%kW/Xre→ Stop*, usually the same value is defined in all the controllers and $\alpha<\beta$.

1. One genset starts when the condition $(1-\lambda)*N \le \alpha$ exists for *Parll Start* time.
   The genset starts ***immediately*** when $(1-\lambda)*N \le 0$, eg when $\lambda \ge 1$ the system is near collapse.
2. One genset stops when the condition $(1-\lambda)*N \ge 1+\beta$ exists for *Parll Stop* time. Ie, giving up one unit of spare system power capacity still leaves the system with at least β spare units.
3. Another genset can start or stop only after *LS SettlingTime* delay following a previous genset change of state (time is required to re-distribute the load evenly).

Example 1:

A plant has 3 gensets, rated 80 kW each. Assume that all the gensets can in less than 20 seconds start and synchronize. Assume also that it is unlikely for the load to increase by more than 20 kW in 30 seconds.

Let $\alpha \equiv$ *+%kW/Xre→ Start* = 25%, *Parll Start* = 0'10"0, $\beta \equiv$ *+%kW/Xre→ Stop* = 50%, *Parll Stop* = 1'00"0. Suppose that all the conditions to start gensets automatically exist..., that the bus is dead and that the gensets operating sequence (the controllers ID numbers sequence) is →1→2→3:

Genset number 1 starts immediately because no genset is on load, ie N = 0. Suppose that the load is 64 kW, ie the system's λ is 80%. After 10 seconds genset number 2 starts and connects to the bus after synchronization. The system's λ becomes 40% (the load needs to fall below 40 kW for 1 minute to stop this genset). If one changes now the sequence to →3→2→1 (by an exchange 1,3 command) genset number 3 immediately starts and one minute after genset 3 connects to the bus genset 1 stops.
The load must be at least 140 kW for 10 seconds to start the third genset...

Example 2 (a special case):

A plant has 2 gensets: G1 rated X1 = 800 kW and G2 rated X2 = 500 kW. If only one genset is running, either G1 or G2 according to the defined SEQUENCE, when its spare capacity falls below A = 100 kW we need to start the second genset. When the two gensets run in parallel, we can stop one genset only if the remaining capacity would be B = 300 kW minimum. Solution:
G1: $\alpha = A/X2 = 20\%$, $\beta = (X1-X2+2*B) / (X1+X2) = 69\%$.
G2: $\alpha = A/X1 = 13\%$, $\beta = (X2-X1+2*B) / (X1+X2) = 23\%$.

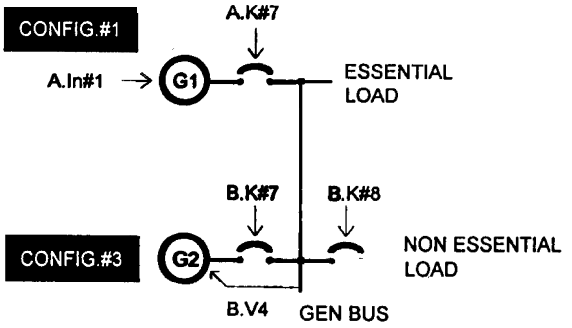
Hybrids

A hybrid paralleling system is made of one (***but only one***) controller in configuration #1, #2, #4, #5 or #6 and a number of controllers in configuration #3. The controllers in configuration #3 are said to be "permanent slaves" -- the different controller is said to be a "permanent master". The use of the hybrid system is similar to the use of the master controller. The slave gensets constitute an auxiliary power generation capacity that augments the capacity of the master genset. The following operating rules are common to all hybrids:

1. When the master genset starts, all the slave gensets start[#1],
2. When the master genset is taken off load, all the slave gensets are taken off load,
3. When the master genset stops, all the slave gensets stop,
4. The master genset is always first to be connected to the bus,
5. The slave gensets maintain the same load share of the master genset.

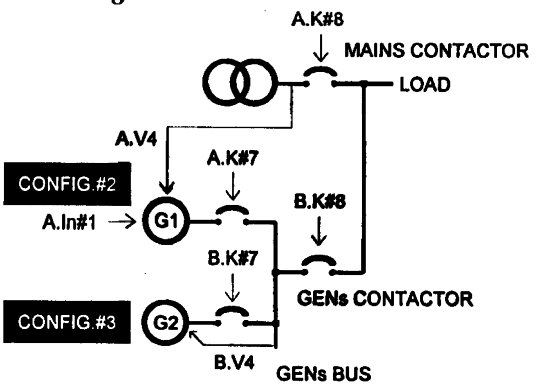
Hybrids will be demonstrated by a few practical examples:

Augmented American standby



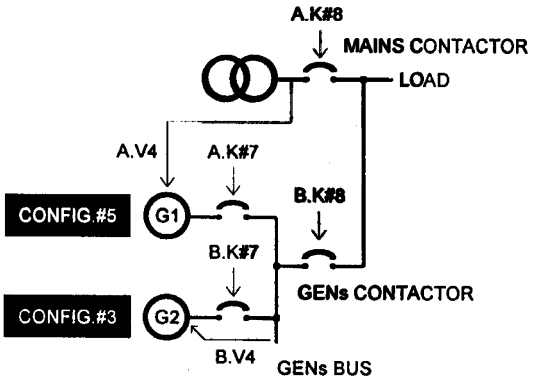
When A.In#1 starts genset G1, controller B automatically starts up genset G2. G1 takes the essential load first. Controller B, sensing the bus phase through V4, synchronizes G2 with the bus and the two gensets share the essential load. After a certain time, through B.K#8 the non essential load is also introduced and the two gensets share both loads proportionally. Since controller A does not use the auto synchronizer function,
G1 does not require an electric governor, nor an AVR with external voltage control.

Augmented Euro standby



In this example only the combined power of gensets G1 and G2 can supply the load:
Genset G1 is started either by a mains failure, detected by A.V4, or by an active A.In#1 input. Controller B automatically starts up the genset G2 too. When G1 is ready for load it is connected to the generators bus. Controller B then synchronizes the G2 phase it measures by V1 with the bus phase it measures by V4. After a certain time of running in parallel without load, the relay B.K#8 is energized and the plant load is taken and shared proportionally between the gensets. The Euro standby changeover delay between A.K#7 and A.K#8 driven contactors exists also between B.K#8 and A.K#8 since as soon as A.K#7 is de energized, according to the hybrids operating rules, B.K#7 and B.K#8 are also de energized. Since controller A does not use the auto synchronizer function,
G1 does not require an electric governor, nor an AVR with external voltage control.

Augmented Euro standby with soft mains return

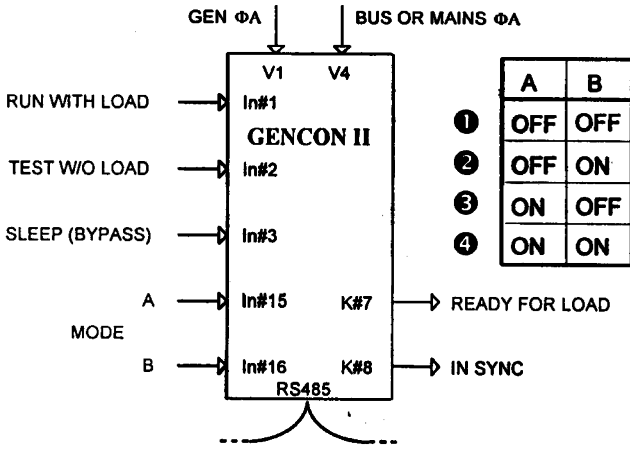


In this example only the combined power of gensets G1 and G2 can supply the load: Automatic mains failure standby is provided as in the previous example. When the mains returns, G1 synchronizes with the mains and in doing so "drags" G2 into synchronism with the mains. This works as follows: When G1 slightly increases its speed, it increases its load share. G2, being G1's slave, in trying to match his load share with his master, raises its governor speed setting and so forth. When synchronism is reached, controller A de energizes the relay K#8 and the "hybrid" enters into paralleling with the mains. As G1 gradually reduces its active and reactive export, smoothly transferring the load back to the mains, G2 does the same and at the same rate. When controller A de energizes the relay K#7, controller B does the same, the two gensets cool down and stop.

[#1] Unless it is not in AUTO mode or faulty

#0 The generic configuration

This configuration provides maximal flexibility in the design of parallel systems. The controller operates under the command of a PLC (Programmable Logic Controller) that also controls the system contactors.



	A	B	MODE
❶	OFF	OFF	SYNC W/O LOAD
❷	OFF	ON	EXPORT
❸	ON	OFF	LOAD-SHARE
❹	ON	ON	SYNC WITH LOAD

The controller starts the genset when activating its In#1 RUN or In#2 TEST command lines. An active In#3 SLEEP command overrides In#1 RUN and In#2 TEST and stops the genset.
When the controller starts the genset following an In#1 RUN command, after build up of the genset oil-pressure, frequency and voltage and waiting the *Set Stabil Min* time delay, it energizes the relay K#7 to indicate that it is ready to accept load.
Note: The controller does not energize the relay K#7 following an In#2 TEST command! When removing the In#2 TEST command the genset stops after a *Test Delay*.

The controller's operating mode is selected by In#15 and In#16 according to the above table. If the genset is not ready for load, ie the relay K#7 is not energized, mode ❶ must be selected by the PLC within a *Contactor Delay* time or the GENERIC CONFIG ERROR shutdown is declared.

In modes ❶ and ❹ the synchronizer is active. By adjusting the genset speed and voltage it tries to match the generator phase (V1) with the bus/mains phase (V4). The synchronizer energizes the relay K#8 any time it succeeds in holding V1 within a *Sync Window* ° and *Sync Window V* distance from V4 continuously for *Sync Dwell Time*.

In mode ❷ the controller runs the genset in parallel with the mains. If the command In#1 RUN is active, the genset power increases at *Ramp +kW/Sec* and *Ramp+kVAr/Sec* rates until reaching the Export Power Quotas where they are maintained as long as the command is active. When removing the In#1 RUN command, the genset power reduces at *Ramp -kW/Sec* and *Ramp-kVAr/Sec* rates until, when reaching zero, the relay K#7 is de energized, indicating to the PLC that it needs to take the genset off load.
Note: Detecting PARALLEL LOAD SURGE in mode ❷ de energizes the relay K#8 to warn the PLC against a possible mains failure.

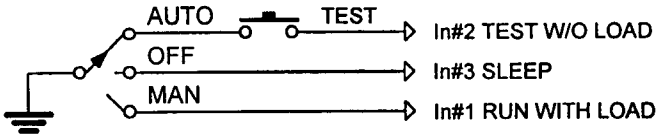
In mode ❸ the controller runs the genset in parallel with other sets. If one of the other genset controllers is in mode ❷ or ❹ that controller is "the master" and all the other controllers in mode ❸, "the slaves", try to match their active (kW) and reactive (kVAr) load share with that of the master (ie in proportion to each genset *Xre: Rated kW* and *Xap: Rated kVA*). If all the controllers are in mode ❸, one of them is nominated as the master and its genset determines the speed and the voltage of the bus.
Example: Given a group of standby gensets sharing a common load, ie the controllers run in mode ❸ under In#1 RUN commands. The PLC needs to transfer the load **softly** from the generators to the mains:

1. The PLC selects one of the paralleling controllers and switches its V4 channel to measure the mains (before V4 is connected to the bus). The PLC places the controller in mode ❹. This controller automatically becomes the bus master and drags the other gensets into synchronism with the mains.
2. When the selected controller relay K#8 energizes, the PLC connects the bus with the mains and places the controller in mode ❷.
3. The PLC places all the other controllers also in mode ❷.
4. The PLC removes all the In#1 RUN commands. The gensets power export gradually reduces. When each genset power reaches zero the controller's relay K#7 is de energized. The PLC then opens the genset contactor and places the controller in mode ❶.

Miscellaneous

Mechanical mode switches

Traditional rotary mode switches can be constructed using the **IOB1** In#1/2/3 lines. See this figure:
It is an alternative to the controller's OFF→AUTO, AUTO→OFF, OFF→MAN and MAN→OFF software commands. The rotary switch operates in AUTO mode only. It is also possible to reset the pending faults by activating In#3 SLEEP, see the *SleepClearsFaults?* option.



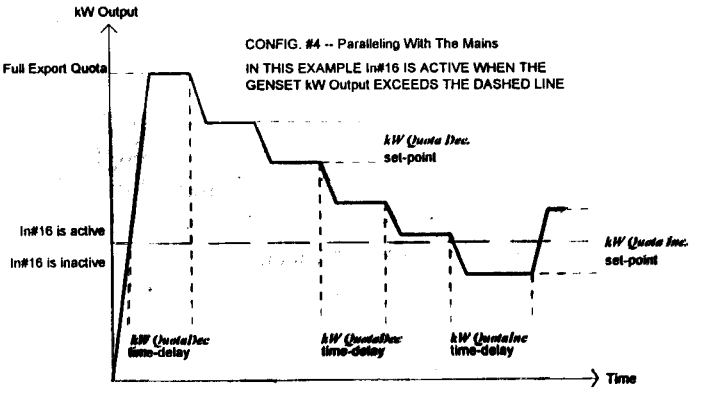
Dynamic export quota control

When paralleling a generator-set with the mains, with the controller in configuration #4, it is often required to prevent export of genset power to the grid. Indication of export to the grid can be obtained from a reverse power relay that is installed on the mains. When the reverse power relay trips, it is required to decrease temporarily the export quota.

IOB1 input terminal In#16, receives this kW QUOTA LIMIT indication:

An active In#16, after a *kW QuotaDec* time-delay, decreases the kW export quota by a *kW Quota Dec* set-point value. An inactive In#16, after a *kW QuotaInc* time-delay, increases the kW export quota by a *kW Quota Dec* set-point value.

The time-delays can be adjusted from 0 to 100 minutes. The set-points can be adjusted in 1 kW steps.



Basic load control

The controller monitors the system's load per rating ratio, ΣkW/ΣXre, in single and in parallel genset applications. ΣkW is the total active load. ΣXre is the **running sets** total kW rating. If the option *R#1 Shunt|kW Load:* is 1, RELAY#1 provides the following decisions based on the load ratio:

Non essential load release and re-entry

Case 1: The two set points satisfy: *%kW/Xre→R#1 On* < *%kW/Xre→R#1 Off*:
If the load ratio is ≤ *%kW/Xre→R#1 On* for *R#1 Off→On* time continuously, RELAY#1 is energized.
If the load ratio is ≥ *%kW/Xre→R#1 Off* for *R#1 On→Off* time continuously, RELAY#1 is de energized

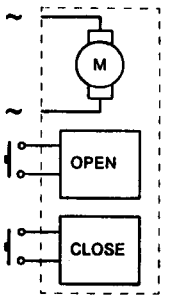
Dummy load control example:
It is required to introduce an artificial load to a lightly loaded genset and to remove this load once normal loading returns. The dummy load is 20% of the rated kW.
Solution: Drive the artificial load contactor by RELAY#1 AND K#7 (ie both relays must be energized).
Set points: *%kW/Xre→R#1 On* = 15, *%kW/Xre→R#1 Off* = 40,
Delays: *R#1 Off→On* = 5'00"0, *R#1 On→Off* = 5'00"0.
When the engine load is for 5 minutes less than 15% of its rating the dummy load contactor is closed. When the load is for 5 minutes more than 20% of the engine rating the dummy load contactor opens.

Parallel genset automatic start/stop

Case 2: The two set points satisfy: *%kW/Xre→R#1 Off* < *%kW/Xre→R#1 On*:
If the load ratio is ≥ *%kW/Xre→R#1 On* for *R#1 Off→On* time continuously RELAY#1 is energized.
If the load ratio is ≤ *%kW/Xre→R#1 Off* for *R#1 On→Off* time continuously RELAY#1 is de energized.

Example:
We are given two 100 kW gensets, G1 and G2, that can parallel on a common bus. Eg, the genset controllers are in configuration #3 (random access paralleling). It is required that G1 operates alone if the load is 60 kW or lower and that G2 is started automatically when the load is 80 kW or higher.
Solution: Activate In#1 RUN of the controller handling G2 by its RELAY#1 and set the set-points as follows: *%kW/Xre→R#1 On* = 80%, *kW Load→R#1Off* = 30%. Time delays are set according to need.

Handling motor driven contactors (breakers)



In high current installations the use of spring charged motor operated contactors is common. They are suited for auto-sync applications since they have a fast, ≈ 50 ms, closing action.
This type of contactor has two notable characteristics:

1. Charging the spring by the motor takes a few seconds, no more than 5 seconds usually.
2. Unless an undervoltage release mechanism is installed, the contactor stays closed when AC is removed from the motor.

This requires special handling because:

1. Before a contactor can be closed, time must be given to charging the spring.
2. In European standby applications, time must be given to opening the mains contactor before closing the generator contactor.

The solution is: Set the *K#6 Engine|Gen On* option to 1: The relay K#6 energizes when the generator builds normal phase voltages. Delay the generator contactor closing command (through the relay K#7) by an appropriate *Set Stabil Min* time delay. K#6 can then switch AC to the contactors' motors to charge the springs or, where applicable, to open the mains contactor, long enough before the closing command is given.
If you want to verify the contactors' action set the *Check Contactors* and *Motor Contactors* options to 1.

CAVEATS

GENCON II reliability had already been proven in many installations. Nevertheless, in a good switchboard design there should exist additional means, even duplicate, to prevent catastrophic consequences if there is a single component failure -- **GENCON II** is a single component in this respect.
Since the probability of simultaneous failure of two, same function, protection devices whose failure mechanism is statistically independent is the product of the failure probability of each, the effective overall system reliability is greatly enhanced.
For a generator-set operating in parallel with the mains we recommend to add as a minimum a short-circuit and a sync-check protection relays.

GENCON II -- The main unit

Attention!

The system supports three phase wye (star) connected generators (alternators). There are several controller models to choose from according to the phase (line to neutral) voltage and current to measure[#1]. **Be sure that you are using the correct model!**
The following models are standard[#2]:
Nominal AC phase voltage: 120, 127, 220, 240, 277.
Nominal AC phase current: 5 amps.
Note! The maximum voltage or current value that can be measured is approximately 120% times the nominal. For example, a 220 nominal phase volts model can measure 260.4 volts maximum.

Front panel

LED's

The green LED should always blink. Fast blinking rate indicates existence of one or more of the following conditions:

1. Normal engine oil pressure (ie In#5 OIL PRESS SHUT = OFF),
2. Engine speed greater than 60 RPM,
3. Gen frequency greater than 15 Hz.

Blinking red LED indicates detection of a shutdown fault.
Blinking yellow LED indicates detection of a warning fault.
Press RESET to clear fleeting faults.

STOP and RESET push buttons

- To stop the genset press the red STOP push-button. Shutdown fault is declared.
- To silence the audible alarm press the yellow RESET push-button once.
- To clear fleeting faults, if the audible alarm was silenced, press the RESET push-button again.

Pending faults cannot be cleared. If you press RESET, the faults will be re declared.

[#1] Model variations affect one low cost PCB (A50-3). Re-calibration must follow its replacement.
[#2] Contact factory for special requirements.

Liquid Crystal Display navigation primer

A user function can display on the LCD a set of measurements, it can execute a command or it can examine the system status. To select a particular function, the LCD presents a multilevel menu of options: Each option designates a function or it leads to a lower, more detailed, menu.

- A selected option is indicated by ▸ .
- Use the left← and right→ arrow push-buttons to select another option.
- Press the ENTER↵ push-button to call a selected option.
- Press ESC↱ to return to a higher menu level.
- Press any push-button to return from a measurement display function back to the menu mode.

The root menu

```
▸OVERVIEW  oREPORT
oCOMMAND   oMEASURE
oSET-UP    oHELP
Select←→ Enter↵ Esc↱
```

Short-cuts:

1. Enter any menu. The option that is selected by default is the one that was selected before leaving the menu by Esc↱ . Example: You are using a function from the MEASURE menu and need to call a function from COMMAND. Go up to the root (by Esc↱ s) and down to COMMAND... To return to the MEASURE function, go up to the root, select MEASURE and make a series of blind ENTER↵ s.
2. When a fault is detected, if no push-button is pressed for 20 seconds or if ESC↱ is pressed, REPORT is automatically called. Quit REPORT and you are back at the previous location.
3. The push-button 0 directly calls the system OVERVIEW function. Quit OVERVIEW and you are back at the previous location.

In this manual, references to functions are preceded with the path leading to them, beginning from the topmost menu level, the root. For example, MEASURE\GENERATOR\POWER+PF shows how to call the function that displays the genset power output and the power factors (cosϕ). Ie starting from the root call MEASURE, call GENERATOR and finally call POWER+PF.

Note!

The contrast of the LCD characters may change slightly with temperature (visibility is guaranteed from -20°C to +70°C). For adjustment use the trimmer on the rear panel.

Common menu options

OVERVIEW

OVERVIEW is a useful display function. It explains what the controller is doing at any moment. Hence, in addition to reaching OVERVIEW through the menu, you can call OVERVIEW by:

1. Pressing the 0 push-button at any menu level,
2. Pressing the ESC↱ push-button at the highest (root) menu level.

The following are a few OVERVIEW "snapshots" taken during the operation of a Euro standby generator-set installation with soft load transfer. See configuration #5 in **Applications**.

Snapshot 1

Line 1 `Mode=Auto  Tue 22:35`
Line 2 `GenSet Stationary`
Line 3 `Mains OK → Stand-by!`
Line 4 `Power Source: Mains`

Snapshot 2

`Mode=Auto  Tue 22:37`
`GenSet Stationary`
`Mains Fail→Run: 0'05`
`Power Source: None!`

Snapshot 3

Line 1 `Mode=Auto  Tue 22:40`
Line 2 `Set Runs with Load`
Line 3 `Mains Failure → Run!`
Line 4 `Power Source: GenSet`

Snapshot 4

`Mode=Auto  Tue 22:41`
`Set Runs with Load *`
`Mains OK→Stop:  0'24`
`Power Source: GenSet`

Snapshot 5

Line 1: `Mode=Auto  Tue 22:42`
Line 2: `kW Down Ramp: 0'04 *`
Line 3: `Mains OK → Stand-by!`
Line 4: `Parallel Connection!`

Snapshot 6

`Mode=Auto  Tue 22:43`
`Cooling-off:  2'45 *`
`Mains OK → Stand-by!`
`Power Source: Mains`

- Line 1 shows the controller operating mode and the clock. The clock appears only if the operator initialized the clock by the COMMAND\SET-CLOCK.
- Line 2 shows the genset current activity and the remaining time to its end. Asterisk (*) indicates that the genset is running in sync with the auxiliary phase V4, ie the mains phase A.
- Line 3 shows the genset command or countdown to the command start.
- Line 4 shows the automatic transfer switch status.

On the right is an OVERVIEW display of a generator-set test run triggered by In#2. Line 3 indicates that the genset will stop in 2 minutes and 38 seconds.

```
Mode=Auto  Sat 22:15
Set Runs w/o Load
Test w/o Load:  2'38
Press any key...
```

On the right is an OVERVIEW display of a #3 configured controller serving in multiple generator-set "random access paralleling" system. Line 3 shows that the controller **IOB1** input number 1 is active. Line 4 shows that other gensets are connected to the bus too.

```
Mode=Auto  Sat 22:11
Set Runs with Load
In#01→Run with Load!
Parallel on Gen Bus
```

This OVERVIEW displays a controller in multiple generator-set parallel system. Line 3 indicates that a system condition initiated the run command, eg response to increase in the system load.

```
Mode=Auto  Sat 22:26
Set Runs with Load
System→Run With Load
Parallel on Gen Bus
```

REPORT

```
HIGH WATER TEMP SHUT
Logged --▸  Sat 17:06
Clear message by ↵
Earlier← Later→ Esc
```

REPORT examines the log of messages. Each message includes the time it entered the log. If the clock was not running, "time ???" will appear. Most messages report some fault such as the example on the left.

- Press the ENTER↵ button to remove the displayed message from the log.
- Press the left arrow button (←) to examine earlier logged messages.
- Press the right arrow button (→) to examine later logged messages.
- Press ESC to leave the REPORT function.

Note!

1. Every new message automatically calls REPORT.
2. Clearing a fault message does not "accept" or "clear" the fault. Use the RESET button to accept faults.
3. REPORT opens the log of messages showing the most recent message first. The log keeps the last 8 messages.

COMMAND

OFF mode

When in OFF mode, the monitoring system is active except for the relays R#3 AUDIBLE ALARM and K#4 AIR DAMPER. If *Mains Standby ATS* = 1, the mains contactor, irrespective of the mains (V4) status is closed (ie K#8 MAINS CONTACTOR relay is off). It is possible to define the OFF mode as a warning fault.

OFF⇨AUTO

This function changes the operating mode to AUTO. User password may be required.

OFF⇨MAN

This function changes the operating mode to MAN. The genset immediately starts unless a shutdown fault exists.

MANual mode

When in MAN mode, the genset runs unless a shutdown fault exists. It is possible to define the MAN mode as a warning fault.

MAN⇨OFF

This function changes the operating mode to OFF. The genset stops after cooling down if necessary.

LOAD-GEN

This function instructs the genset to take the load. User password may be required.

OFF-LOAD

This function instructs the genset running in MAN mode to remove the load.

AUTOmatic mode

When in AUTO mode, unless a shutdown fault exists, the genset...

1. Starts immediately on active In#1 RUN WITH LOAD signal.
2. Starts immediately on active In#2 TEST W/O LOAD signal. Stops after a time delay following In#2 deactivation.
3. Starts after delay following a mains failure (ie abnormal V4 voltage). Stops after delay following the mains return. All this is provided that SET-UP\OPTIONS *Mains Standby ATS* = 1.
4. SLEEP is a special AUTO mode where genset start is disabled. It is selected by active In#3 SLEEP signal.

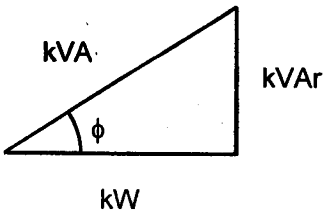
AUTO⇨OFF

This function changes the operating mode to OFF. User password may be required.

EXPORT

This function examines and changes the amount of active (kW) and reactive (kVAr) power that is exported to the mains in configurations #4, #5 and #6. The user may be required to enter a password to change the export quotas. In configurations #4 and #6, export to the mains is continuous. In configuration #5, export to the mains is maintained until ramp up brings the genset power output to the defined export quotas, the mains contactor opens, and the load is completely transferred to the genset. See **Applications** for further details.

genset p.f. = cos ϕ = kW / kVA



The export quotas must be within the genset kW and kVA ratings which are defined in SET-UP\BASICS. The user should be familiar with the **power right triangle** relationship and with the generator derating characteristics at low power factors (below 0.8 p.f.).

In configuration #4 it is possible to control dynamically the kW export quota through In#16. See **Applications** for further details.

SEQUENCE

This function examines and changes the order in which controllers start and stop their gensets in response to an increase or decrease in their common load. If any genset in the sequence cannot run, the next one is called. This function is applicable to controllers in configuration #3 (random access paralleling) that have the option *Parall Auto Start* set.

```
IDs →2→1→3
This Gen-Set ID No=1
Exchange Command 2,3
Initial Sequence 0,0
```

In this example three controllers are connected to the RS-485 network. The genset whose *Controller ID No* is 2 runs all the time. As the load increases genset 1 and later genset 3 join the bus. When the load decreases genset 3 is disconnected from the bus first.
The exchange command propagates to all the network controllers. It is called up by the ENTER↵ key (cancelled by ESC↶) followed by pressing 0. Entering the 2,3 exchange example results in the→3→1→2 sequence. Entering 0,0 followed by the user password, selects the→1→2→3→4→5→6→7→8 sequence.
The sequence is stored in the EEPROM memory, ie it is not lost when disconnecting the battery.

SET-CLOCK

The clock has no memory.Set it up after switching on the battery to have messages logged with time.

SET-COUNT

This function is for changing the **kW Hours** and **HoursRun** counts. User password may be required

MEASURE

ENGINE

```
Battery Volts:  13.8
MPU: 1513rpm 50.39Hz
kW Hours: 00,001,234
HoursRun: 000,150:10
```

Maximum reading is 40 volts
Pickup reading. See SET-UP\BASICS *Pick-up Teeth.*
Non-volatile count! See COMMAND\SET-kWH
Non-volatile count! See COMMAND\SET-HOURS

GENERATOR

OVERVIEW

Gen	Volts	Amps	Hz
ΦA	221	115	50.07
ΦB	222	117	ΣkW
ΦC	220	125	69.9

Phase-A RMS voltage, current and frequency
Phase-B...
Phase-C...+ total 3-phase TRUE power

POWER+PF

Total-Power		COSϕ(PF)	
ΣkVA:	78.9	ΦA:	0.91
ΣkW:	69.9	ΦB:	0.88
ΣkVAr:	36.4	ΦC:	0.87

Generator
Total apparent power, Phase-A power factor
Total true power, Phase-B power factor
Total reactive power, Phase-C power factor

GEN ΦA, GEN ΦB and GEN ΦC

Phase-A (L-N) display example. Phase-B and phase-C are similarly displayed.

Gen ΦA	Hz:	50.07
Volt: 221	%THD:	0.1
Amps: 115	kVAr:	10.5
kVA: 25.4	kW:	23.1

Phase-A frequency
RMS voltage, % Total Harmonic Distortion
RMS current, Reactive Power
Apparent Power, True power

Note!

1. %THD is a measure of how "pure" the generator sine wave is. Consider Total Harmonic Distortion (THD) above 2% as inappropriate for modern office equipment. Non-linear loads and ground faults at the generator stator windings are major sources of harmonics.
2. Positive kVAr means that the current is lagging after the voltage. Normal.
3. Negative kVAr means that the current is leading the voltage. Abnormal!

GEN ΦΦ

Gen	Volts	Hz:	50.07
ΦA:	221	ΦAB:	384
ΦB:	222	ΦBC:	383
ΦC:	220	ΦCA:	382

Generator phase-A frequency
L-N voltage, L-L voltage

MAINS or BUS

This function displays V4 phase measurements.

Mains ΦA	
Frequency Hz:	50.14
Voltage Vrms:	223
Distortion %THD:	0.1

The caption is MAINS or BUS according to SET-UP\OPTIONS *Mains Standby ATS*

SYNCscope

Synchroscope display example

Gen ΦA v Mains ΦA	
Freq Slip Hz:	-0.07
Phase Shift °:	11
Voltage Match:	-2

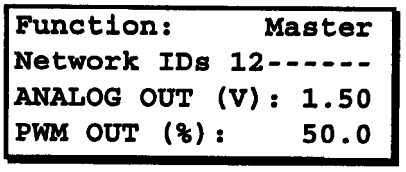
V1 gen phase-A vs V4 mains phase-A
V1 frequency - V4 frequency
V4 to V1 angles: -180°..180°
V1 volts - V4 volts

IN 1..16

This function shows which **IOB1** input channels are active. Use the left← and right→ push-buttons to move the LCD cursor to any input channel column to find its name. The input channel type, "normally open" or "normally closed", is defined by SET-UP\IN 1..16.

SYSTEM

This display function provides general system information.



A "Master" function indicates that the genset, when in parallel with other gensets, determines the bus voltage and frequency.
A "Slave" function indicates that the genset, when in parallel with other gensets, changes its governor speed and AVR voltage settings to make its active and reactive load-share match those of the "Master" set.

Up to eight controllers can be connected to the RS-485 network. Each has a unique ID number (See SET-UP\BASICS) in the range of 1..8. "Network IDs" identifies the controllers that are connected to the network.

ANALOG OUT and PWM OUT respectively control the governor speed/fuel and the AVR voltage/excitation.

SET-UP

This menu defines the systems parameters: set-points, delays, etc. The parameters are non-volatile (unaffected by battery disconnection). You need to know the installation engineer password to enter the menu. See **Set-up menu options** for further details.

HELP

This function displays useful information.

- Press ENTER to browse through the display pages.
- Press ESC to exit.

The first line of display, "Standby V1.7h Aug 94", identifies the controller's operating software.

The SET-UP menu

You can set-up the system parameters from the front panel key-pad or from the remote PC console (running the program REMOTE.EXE). The parameters are organized in several lists according to their type: Time-delays, set-points, yes/no options, N/O or N/C definitions of the **IOB1** inputs, basic definitions and factory calibration data. Each parameter is presented with a brief text prompt. The parameters are stored on a non-volatile memory. They are not affected by battery voltage disconnection.
Select a list and enter↵ :

- The ▸ marker points to the parameter last examined.
- Use the left← and the right→ arrow push-buttons to get to the parameter that you want to edit.
- Press ESC↱ to return to the SET-UP menu.
- Press ENTER↵ to begin the parameter value editing. A cursor starts blinking at the value field. If you come across the "Remove Write Protect" response, refer to the next paragraph ("Attention!").
- Press the left← and the right→ arrow push-buttons to move the LCD cursor across the value digits.
- Type any digit over a ± sign to invert it.
- Press ESC↱ to quit parameter editing (this leaves the parameter value unchanged).
- Press ENTER↵ to replace the parameter value with a new one. Choose different parameter value if you come across the *Value Outside Range!* message.

Important! Begin the first SET-UP session with a careful review of the SET-UP\ BASICS parameters.

Attention!

There are two methods the installation engineer can protect the system parameters:

LEVEL 1: SET-UP entry password is 1993. After typing the password you can leave and enter the SET-UP menu for 15 minutes without being asked for the password again.

LEVEL 2: Parameters can be made "read-only" by SET-UP\OPTIONS *Write Protect*. This protection is implemented in hardware -- ***IT IS RECOMMENDED TO USE THIS OPTION!*** To inhibit write protect temporarily (ie effective until the battery voltage is removed) press the push-button 0 while switching on **GENCON II** battery volts.

DELAYS

Time delay format is: xx'yy"z. xx denotes minutes, yy denotes seconds and z denotes tenths of a second

Set Overspeed

The time delay from detecting engine overspeed to the declaration of fault.

Gen OverVolts

The time delay from detecting over-voltage in any gen phase (V1,V2,V3) to the declaration of fault.

Gen UnderVolts

The time delay from detecting under-voltage in any gen phase (V1,V2,V3) to the declaration of fault.

Gen OverFreq

The time delay from detecting over-frequency in gen phase A (V1) to the declaration of fault.

Gen UnderFreq

The time delay from detecting under-frequency in gen phase A (V1) to the declaration of fault.

G 2x OvCurr

The time delay before declaring an over-current fault in each channel I1, I2 or I3 is inversely proportional to the phase current **I**:

$$\text{Time-Delay} = \frac{T \cdot Is}{I - Is}$$

Is is the current level that is defined in SET-UP\SET-POINTS.

T, this parameter, is the time-delay that corresponds to **I = 2Is** (substitute in the formula and check). However, note that this formula is correct only for currents within the controller measurable range, which is approximately 5.9 Amps * *CT RATIO* maximum.

This resulting time-delay vs. current relationship is called "very inverse" and is widely in use.

G Revrse kW

The time delay from detecting reverse active power in any gen phase (V1,V2,V3) to the declaration of fault.

G Rvrs kVAr

The time delay from detecting reverse reactive power in any gen phase (V1,V2,V3) to the declaration of fault, ie ***generator loss of excitation***.

G Over %THD

The time delay from detecting "percentage of harmonic distortion" higher than the set-point level in any gen phase (V1,V2,V3), to the declaration of fault.

SyncTimeout

Limit on the time it should take the genset to reach synchronization with the mains or the bus (ie match V1 with V4 in phase and in voltage). When this time delay expires, a warning fault is declared. Where load transfer is required (*Mains Standby ATS* = 1, etc.), after this time delay expires transfer through paralleling is discarded and "break→delay→make" transfer is made.

Sync Dwell Time

This is the minimum time that is required for the generator phase A (V1) and the bus or mains phase A (V4) to stay within the phase and voltage match windows to recognize synchronization.

At least 1/2 sec *Sync Dwell Time* is recommended.

The contactor parameters that are relevant to the synchronizer are its worst case closure time, Tc, and the maximal phase-shift it allows at the moment of closure, θc.

$$\theta w + \frac{2 \cdot \theta w}{Tw} \cdot Tc < \theta c$$

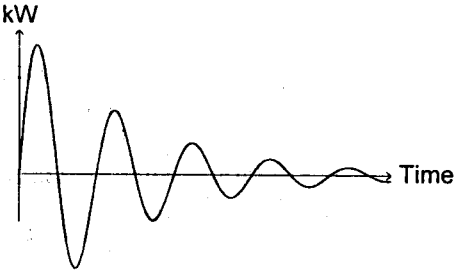
Denote *Sync Dwell Time* by Tw and *SYNC Window* ° by θw. You should make sure that Tw is large enough and θw is small enough to satisfy the above relation.

Example: Given a contactor with Tc=0.2 sec and θc=20°.

The default parameter values θw=10° and Tw=0.5 sec mean that the worst phase shift that the contactor will be subject to at the moment of closure is 18°, which is acceptable.

kW Surge Enable

When in parallel with the mains a sudden change in the active power of the set is a likely sign of mains failure. However, immediately when entering the parallel connection, fast kW oscillations are common. To demand very soft connection with the mains may call for an unacceptable synchronization time. To increase the *Parll kW Surge* above the oscillations' peak is also undesirable as we lose the effectiveness of the *PARALLEL LOAD SURGE* protection. This time delay provides a short term initial bypass.



Test Delay

The time delay from In#2 TEST W/O LOAD deactivation to genset stop.

V4 Volts Status

The time delay to reject transient abnormal status in the mains/bus phase A.

Standby On

The time delay between mains phase A (V4) failure to genset start in automatic mode. *Mains Standby ATS* = 1.

Standby Off

The time delay from mains phase A (V4) return to removing the genset load in automatic mode. *Mains Standby ATS* = 1.

Engine Preglow

The time delay for engine preglowing before cranking. See **IOB1** K#1 relay.

Engine Crank

The time limit on engine cranking.

CrankFail Rest

The time delay between cranking attempts.

Set Stabil Max

The time limit after detecting "firing speed" (SET-UP\SETPOINTS *CrankStop RPM*) to reach genset stabilization, ie reach normal voltage, frequency and oil pressure (In#5 OIL PRESS SHUT = OFF).

Set Stabil Min

The time delay between "firing speed" detection (SET-UP\SETPOINTS *CrankStop RPM*) to the connection of load by **IOB1** K#7 relay.

Coolin Down

The genset run time, without load, to cool off the engine.

Stoppin Max

The limit on the time from blocking fuel supply (through **IOB1** K#2 FUEL SOLENOID relay) to reaching genset standstill conditions.

AlarmOn Max

The time limit on R#3 AUDIBLE ALARM relay activity.

LubPump On

K#5 LUBRICATION PUMP cycle: On time.

LubPump Off

K#5 LUBRICATION PUMP cycle: Off time.

Load Break→Make

The minimal time delay before reconnecting the gen or mains power to the load. This delay is especially important if there are synchronous motor loads.

Contactor Delay

Limit on the time from applying a command to the gen or mains contactors by the K#7 or K#8 relays to sensing the expected response by In#15 or In#16 respectively. In#15 and In#16 are connected to auxiliary contacts on the contactors. Exceeding this time limit is a shutdown fault. This test is optional, see SET-UP\OPTIONS *Check Contactors*.

(ATS=0) K#7→K#8

When SET-UP\OPTIONS *Mains Standby ATS* = 0, ie K#8 is NOT driving the mains contactor it has an alternative use:

When the relay K#7 GEN CONTACTOR is energized, after a time delay, K#8 is also energized.

When K#7 is de energized, K#8 immediately is de energized too.

K#8 is used in multiple genset paralleling systems to delay loading the generators bus. See **Applications**.

kW QuotaInc

When the controller is in config. #4 (paralleling with the mains) and In#16 is not active, this is the time delay before the export kW quota is increased. See **Dynamic export quota control** in **Applications**.

kW QuotaDec

When the controller is in config. #4 (paralleling with the mains) and In#16 is active, this is the time delay before the export kW quota is decreased. See **Dynamic export quota control** in **Applications**.

R#1 Off→On

When *R#1: Trip|kW Load* option is 1, this is the time delay before RELAY#1 is energized.

See **Basic load control** in **Applications**.

R#1 On→Off

When *R#1: Trip|kW Load* option is 1, this is the time delay before RELAY#1 is de-energized. See **Basic load control** in **Applications.**

Parll Start

When the *Parall Auto Start* option is active, in parallel genset systems, as the system load increases this is the time delay before starting the next genset in the COMMAND\SEQUENCE. See **Applications.**

Parll Stop

When the *Parall Auto Start* option is active, in parallel genset systems, as the system load decreases this is the time delay before removing and stopping one genset. See **Applications.**

LS SettlingTime

When the *Parall Auto Start* option is active, in parallel genset systems, this is the minimal time between consecutive gensets start/stop in response to load changes. The load-sharing feedback loops should re-distribute the load evenly within this time. See **Applications.**

SET-POINTS

User Password

The user must enter this 4 digit password to change the operating mode, change the run-time count, etc. No password is required if this number is 0.

Cranking Attempts

This is the number of engine cranking attempts.

Overspeed RPM

This threshold applies to the speed read from the magnetic pickup. Make sure that a correct number of teeth is defined in SET-UP\BASICS.

CrankStop RPM

Engine "firing" speed. This threshold applies to the speed read from the magnetic pickup. Make sure that a correct number of teeth is defined in SET-UP\BASICS.

Bat OvVoltage

Battery over voltage threshold. Note, the battery equalize/recharge voltage, per cell is for lead-antimony 2.35, for lead-calcium 2.40 and for nickel-cadmium=1.65. Fault is declared after a 1 sec delay.

Bat UnVoltage

Battery under voltage threshold. The battery cell final voltage is dependent on the discharge rate. For a lead-acid type at high discharge rate it may even be 1.0V. Typical value is 1.75V. Battery undervoltage is ignored during engine cranking. Fault is declared after a 1 sec delay.

Gen OvVoltage

Over voltage threshold. Applies to each gen phase to neutral voltage.

Gen UnVoltage

Under voltage threshold. Applies to each gen phase to neutral voltage.

Gen OvFrequen

Generator phase A (V1) over frequency threshold.

Gen UnFrequen

Generator phase A (V1) under frequency threshold.

Gen OvCurrent

Overcurrent threshold, **Is**. It applies to each generator phase current separately. **Is** is usually selected as the 100% (nominal) generator phase current. The time delay before a fault is declared depends on the extent the current exceeds **Is**. If the phase current is just a few amps higher than **Is** it will take very long time before *GEN OVERCURRENT* is declared. See SET-UP\DELAYS *G 2x OvCurr* for more details. When in parallel with the mains/bus, if the phase current exceeds **Is**, the controller reduces the generator excitation level -- this provides an effective generator current limiting.

Gen Revrse kW

Reverse (negative) true power kW threshold. Applies to each gen phase (V1/I1, V2/I2 & V3/I3). Fault indicates a potential prime mover failure.

Gen Rvrs kVAr

Reverse (negative) reactive power kVAr threshold. Applies to each gen phase (V1/I1, V2/I2 & V3/I3). Fault is reported as *GEN EXCITATION LOSS* since it usually indicates, in parallel mode, AVR failure.

Gen Over %THD

IEC55 standard for clean AC power suggests 2% as the maximal harmonics percentage acceptable.

V4 Ov Voltage

Over voltage threshold for the mains/bus phase A (V4) input. If SET-UP\OPTIONS enables *Mains Standby ATS*, voltage above this threshold is a mains failure condition.

V4 Un Voltage

Under voltage threshold for the mains phase A (V4) input. If SET-UP\OPTIONS enables *Mains Standby ATS*, voltage below this threshold is a mains failure condition.

V4 Ov Frequen

Over frequency threshold for the mains phase A (V4) input. If SET-UP\OPTIONS enables *Mains Standby ATS*, frequency above this threshold is a mains failure condition.

V4 Un Frequen

Under frequency threshold for the mains phase A (V4) input. If SET-UP\OPTIONS enables *Mains Standby ATS*, frequency below this threshold is a mains failure condition.

Gov Volt Bias

ANALOG OUT voltage when the paralleling system is not active.

SYNC Window ÷

This ± value is the allowed phase shift between V1 and V4 during synchronization. Recommended 10° or less. See SET-UP\DELAYS *Sync Dwell Time.*

SYNC Window V

This ± value is the allowed voltage difference between V1 and V4 during synchronization.

SYgainV/180÷

Speed synchronizer gain "potentiometer". Adjusts ANALOG OUT reaction to the phase shift between the generator phase A (V1) and the mains/bus phase A (V4). ANALOG OUT controls the governor speed setting. It expresses the change in ANALOG OUT volts, as per 180° phase shift, in 0.1 second interval.

SYstbl V/Hz

Speed sync stability "potentiometer". Adjusts ANALOG OUT reaction to the frequency difference between the generator phase A (V1) and the mains/bus phase A (V4). ANALOG OUT controls the governor speed setting. The parameter expresses the change in ANALOG OUT volts, as per 1 Hz frequency difference, in 0.1 second interval. ***Important***: A + sign indicates that to raise the genset speed setting it is required to increase ANALOG OUT volts. A - sign indicates that to raise the genset speed it is required to decrease ANALOG OUT volts.

SYgain %P/V

Voltage sync gain "potentiometer". Adjusts PWM OUT reaction to the voltage difference between the generator phase A (V1) and the mains/bus phase A (V4). PWM OUT, through an appropriate interface module (see **AVRx**), controls the AVR voltage setting. The parameter expresses the change in PWM OUT duty-cycle as per 1 volt difference, in 0.1 second interval. ***Important***: A + sign indicates that to raise the generator voltage it is required to increase PWM OUT duty cycle. A - sign indicates that to raise the generator voltage it is required to decrease PWM OUT duty cycle.

Parll kW Surge

When in parallel with the mains, any change in the consumers load is normally absorbed by the "infinite" mains. If however a sudden change is measured, it is a likely sign of a mains failure. This parameter determines the amount of power change that triggers off the *PARALLEL LOAD SURGE* protection. Note that sensing a kW decrease is optional, see SET-UP\OPTIONS *kW Drop=LoadSurge?*.

In response to a *PARALLEL LOAD SURGE*, if a mains contactor is installed (ie *Mains Standby ATS?* 1) it immediately opens (by energizing **IOB1** K#8 relay) and the generator is left with the essential loads. If the mains contactor is not used, the generator contactor opens (by de-energizing **IOB1** K#7 relay). The response time of this protection is about 100 ms, which is acceptable by most electricity boards. An external loss of mains protection device can be installed, see *PARALLEL MAINS FAIL.*

LSgain V/Xre

Active load sharing gain "potentiometer". Adjusts ANALOG OUT reaction to the difference between the active power (kW) output of the genset and the desired output level (the "error"). ANALOG OUT controls the governor speed setting. The parameter expresses the change in ANALOG OUT volts, as per *Xre* error, in 0.1 second interval. *Xre* denotes the kW rating of the genset.

LSstbl V/Xre

Active load sharing stability "potentiometer". Adjusts ANALOG OUT reaction to the rate of change in the active power output of the genset (ie reacts to dKW/dt). ANALOG OUT controls the governor speed

setting. The parameter expresses the change in ANALOG OUT volts, as per *Xre* change in the genset power output in 0.1 second interval. *Xre* denotes the kW rating of the genset.

LSgain%P/Xap

Reactive load sharing gain "potentiometer". Adjusts PWM OUT reaction to the difference between the reactive power (kVAr) output of the genset and the desired output level (the "error"). PWM OUT, through an appropriate interface module (see **AVRx**), controls the AVR voltage setting. The parameter expresses PWM OUT duty-cycle change as per an *Xap* error in 0.1 second interval. *Xap* denotes the kVA rating of the genset.

LSstbl%P/Xap

Reactive load sharing stability "potentiometer". Adjusts PWM OUT reaction to the rate of change in reactive power output of the genset (ie reacts to d kVAr/dt). PWM OUT, through an appropriate interface module (see **AVRx**), controls the AVR voltage setting. The parameter expresses the change in PWM OUT duty-cycle as per an *Xap* change in the genset reactive power output in 0.1 second interval. *Xap* denotes the kVA rating of the genset.

Ramp +kW/Sec

Engine loading rate: After entering parallel connection with the mains the controller increases the active power output of the set, at the selected rate, until it reaches the export quota.

Ramp -kW/Sec

Engine unloading rate: Before leaving parallel connection with the mains the controller reduces the active power output of the set, at the selected rate, until it reaches zero.

Ramp+kVAr/Sec

Generator loading rate: After entering parallel connection with the mains the controller increases the reactive power output of the set, at the selected rate, until it reaches the export quota.

Ramp-kVAr/Sec

Generator unloading rate: Before leaving parallel connection with the mains the controller reduces the reactive power output of the set, at the selected rate, until it reaches zero.

kW Quota Inc.

When the controller is in configuration #4, paralleling with the mains, this is the increase step in the kW export quota when In#16 is not active. See **Dynamic export quota control** in **Applications**.

kW Quota Dec.

When the controller is in configuration #4, paralleling with the mains, this is the decrease step in the kW export quota when In#16 is active. See **Dynamic export quota control** in **Applications**.

%kW/Xre→R#1 On

When *R#1: Trip|kW Load* option is 1, this is the critical system load level (ΣkW/ΣXre) where RELAY#1 is, after delay, energized. See **Basic load control** in **Applications**.

%kW/Xre→R#1 Off

When *R#1: Trip|kW Load* option is 1, this is the critical system load level (ΣkW/ΣXre) where RELAY#1 is, after delay, de-energized. See **Basic load control** in **Applications**.

+%kW/Xre→ Start

When the *Parall Auto Start* option is active, in parallel genset systems, this value specifies when it is needed to start additional gensets. It is the least amount of extra power, specified as a percentage of the *Xre: Rated kW*, which the system must be capable of generating. See **Applications**.

+%kW/Xre→ Stop

When the *Parall Auto Start* option is active, in parallel genset systems, this value specifies when it is safe to stop one genset. It is the least amount of extra power, specified as a percentage of the *Xre: Rated kW*, which the system after stopping one genset must still be capable of generating. See **Applications**.

OPTIONS

```
ABBREVIATION SUMMARY
Question? 0→NO,1→YES
Select A|B: 0→A, 1→B
S|W=Shutdown|Warning
```

Note that if the parameter prompt line ends with...
'?' then 0 stands for no, 1 stands for yes.
':' then 0 stands for method A, 1 stands for method B.

WRITE PROTECT...!?

: makes all SET-UP parameters read only! ***IT IS RECOMMENDED TO USE THIS OPTION TO INCREASE THE SYSTEM RELIABILITY.*** See **Attention!**.

RMS use Harmonics?

Current and voltage RMS values can be calculated from the fundamental frequency only (0) or can include the harmonic content (1). Recommendation: use 0.

NOT IN AUTO Warn?

1 defines OFF and MAN modes to be illegal. Warning fault is declared.

Energize Run|Stop:

0 = fuel solenoid is "energize to run".

1 = fuel solenoid is "energize to stop".

Cool After NoLoad?

1 makes the engine cooling off delay mandatory. If 0 is defined, only if the genset contactor was closed (active **IOB1** K#7 relay) at the time genset stop command was issued, the genset enters cooling down before it stops.

Bat OverVolts S|W:

0 = battery over voltage condition is a shutdown fault.

1 = battery over voltage condition is a warning fault. Fault is declared after 1 second delay.

Recommendation: 0.

Gen UnderVolt S|W:

0 = gen undervoltage fault is shutdown.

1 = gen undervoltage fault is warning.

Gen UnderFreq S|W:

0 = gen phase A under frequency fault is shutdown.

1 = gen phase A under frequency fault is warning.

LowWaterLevel S|W:

In#10 LOW WATER LEVEL fault is: 0 = shutdown, 1 = warning.

Ext. Overload S|W:

In#14 can be connected to an external overload protection relay. When In#14 is active, the gen contactor immediately opens (ie **IOB1** K#7 relay de-energizes). If shutdown option is selected (0) the genset is shutdown after cooling off period.

GENCON LOW DC S|W:

Dangerously low DC voltage level can be defined as: 0 = shutdown, 1 = warning. Recommendation, enter 0. You may be tempted though to enter 1 to utilize 12V batteries to their end...

The following four parameters define the controller's configuration. They are described in greater detail in the ***Applications*** section.

Generic Configure?

1 selects the generic configuration #0. Having selected this option ***discards*** the following parameters: *Parallelin System*, *Mains Standby ATS*, *Cogeneration Mode* and *Check Contactors*. The controller's inputs In#15 and In#16 and output relays K#7 and K#8 get a special meaning, as follows:

In#15	In#16	OPERATION
OFF	OFF	**Synchronizing without load**
OFF	ON	**Paralleling with the mains (export quota ramp up/down)**
ON	OFF	**Paralleling with other gensets (load-sharing)**
ON	ON	**Synchronizing with load**

Energized K#7 indicates that the genset is ready for load,

Energized K#8 indicates that the genset runs in sync with the bus/mains,

De energized K#8 while in parallel with the mains indicates PARALLEL LOAD SURGE detection.

Parallelin System?

1 enables the synchronizer, load-sharing, etc.

Mains Standby ATS?

1 = The relay K#8 drives the mains contactor. The transfer of the load from the mains to the genset, and vice versa, is the controller's responsibility, as is the tradition in Europe: When abnormal AC level is detected at V4, the genset is started after a time delay, etc. See *Standby On* and *Standby Off*. If the paralleling system is enabled, a soft (synchronized zero-power) transfer is made whenever possible. If not possible (SYNCHRONIZER TIMEOUT etc.) a standard break → delay → make transfer is made.

0 = The relay K#8 follows K#7 GEN CONTACTOR with an adjustable delay. It can be used to ensure minimal time for multiple genset paralleling before taking the load. See the *(ATS=0) K#7→K#8* delay.

Cogeneration Mode?

If *Parallelin System = 1* and *Cogeneration Mode = 1* (configurations #4 and #6) the genset runs in parallel with the mains continuously, maintaining the user COMMAND\EXPORT quotas, as long as In#1 is active.

If the *Parallelin System = 1, Mains Standby ATS = 1* and *Cogeneration Mode = 0* (configuration #5) the genset runs in parallel with the mains briefly in response to active In#1, just as needed to transfer the load from the mains to the genset "softly". When In#1 is deactivated, after brief paralleling the load is "softly" transferred back to the mains.

If the *Parallelin System = 1, Mains Standby ATS = 0* and *Cogeneration Mode = 0* (configuration #3) the genset can be run in parallel with other generator-sets.

Parall Auto Start?

This option is relevant to controllers in configuration #3 that are used in multiple generator-set paralleling systems. 1 enables starting of the genset when the system load increases, etc.

See the **Applications** section.

Generator Syn|Asy:

0 for synchronous (self-excited) generators, 1 for asynchronous (induction) generators.

Induction generators can be used only in parallel with the mains (config. #4) since no exciter or voltage regulator is used. If left 1 in a different configuration it is automatically reset, **Generator Syn|Asy←0**.

An induction machine, when driven above the synchronous speed by the engine, converts mechanical power to electric power. When using this type of generator note the following differences:

- The V1, V2 and V3 input channels are connected directly to the mains. V4 is not used.
- The function of the synchronizer is ONLY to match the engine speed with the mains frequency. Hence, only the parameter *SYstbl V/Hz* matters (ie *SYgainV/180°* and *SYgain %P/V* are not used). Synchronization is achieved when the engine speed is held within a ± 0.5 Hz difference from the mains continuously for the selected *Sync Dwell Time*.
- The reactive power (kVAr) is not under **GENCON II** control. Hence, the related *LSgain%P/Xap* and *LSstab%P/Xap* parameters are not used.
- Negative kVAr is normal with asynchronous generators. Hence, set the *Gen Rvrs kVAr* large enough or otherwise **LOSS OF EXCITATION** shutdown is declared.

In#3 Sleep|Bypass:

0 = Active In#3 in automatic mode stops the genset: "Sleep Mode".

1 = Active In#3 is a request to override shutdown faults (fire extinguishing applications).

SleepClearsFaults?

1 means that switching the operating mode from AUTO to SLEEP by In#3 clears all the pending faults.

Check Contactors ?

1 introduces testing of the generator and the mains contactors. Test failure causes a **CONTACTOR(s) FAILURE** shutdown fault after a programmable *Contactor Delay*.

The test compares the auxiliary switches status, as read by the inputs In#15 and In#16, with the contactor commands issued by the relays K#7 and K#8, respectively. If the mains contactor is not used, ie the *Mains Standby ATS* option is 0, the test does not include In#16 and K#8. The testing method depends on the type of the contactor drive, an electromagnet or a motor.

1 also indicates to the *Parallelin System* that switching between the synchronizer and the load-sharing functions is determined by the contactors' auxiliary switches rather than by the contactors' commands.

Motor Contactors ?

0 indicates that the contactor(s) are driven by an electromagnet:

The gen contactor is powered by the gen ΦA, the phase that is monitored by V1.

The mains contactor, if enabled (ie the *Mains Standby ATS* option is 1), is powered by the mains ΦA, the phase that is monitored by V4. **Note:** This type of contactor opens when its power is removed.

1 indicates that the contactor(s) are driven by a motor or by a spring charged by a motor:

The gen contactor is powered by the gen ΦA, if the *Mains Standby ATS* option is 0.

If the mains contactor is enabled, the contactors are powered by a common power source that is either the gen ΦA or the mains ΦA -- whichever volts are high. This power source can be created by selecting the phase of the gen or the mains by the relay K#6, when the *K#6 Engine|Gen On* option is 1.

Note: This type of contactor stays closed when its power is removed (if no undervoltage release).

R#1 Shunt|kW Load:

0 prepares RELAY#1 to drive a circuit breaker (shunt) trip coil. RELAY#1 is energized when a shutdown fault is detected while the genset is running.

1 prepares RELAY#1 for basic load control applications. See **Applications**.

K#6 Engine|Gen On:

0 → K#6 is energized when the engine is running: RPM ≥ 60 or Hz ≥ 15.

1 → K#6 is energized when the generator voltage is high: V1, V2 and V3 ≥ *Gen Undervoltage* setpoint.

kW Drop=LoadSurge?

If selected, a sudden decrease in the kW load, while the genset is running in parallel with the mains, also triggers the PARALLEL LOAD SURGE protection. The same *Parll kW Surge* setpoint applies.

Smooth Mains→Gen ?

1 is effective with *Parallelin System* = 1 and *Mains Standby ATS* = 1 only (config's #5, #6). When the controller measures less than 50% of the nominal voltage by V4 during paralleling with the mains, it immediately opens the mains contactor and the genset remains with the plant load. The message PARALLEL MAINS FAIL is logged ***UNLESS*** this option is chosen. This message may be confusing if V4 is disconnected by some external relay to achieve a smooth power transfer, that is a mains to genset load transfer exactly when the genset power export during ramp up reaches the plant's demand.

Alter Sync Method?

1 introduces a slight modification to the synchronizer algorithm: Phase difference between the genset and the bus/mains is ignored when the frequency difference is larger than 0.2 Hz. The significance of this modification is debatable.

IN 1..16

Each **IOB1** board input can individually be defined as a N/O ("normally open") or N/C ("normally closed"). Select by the left← and right→ push-buttons the In#. Change definition by ENTER↵ .

BASICS

Always start system configuration with SET-UP\BASICS. They have side effects on several SET-UP\SET-POINTS.

Controller ID No

A value between 1 to 8. A unique number should be assigned to each controller that is connected to the RS485 communication line.

No of Alt Poles

The number of the rotor poles (always an even number). Determines the number of electrical cycles produced by each revolution of the shaft.

$$Frequency = \frac{RPM \times Number\_of\_Poles}{120}$$

Pick-up Teeth

Number of teeth on the gear. Determines the number of magnetic pickup pulses generated per each complete revolution of the shaft. On correct "teeth" assignment MEASURE\ENGINE Hz equals the MEASURE\GENERATOR\OVERVIEW Hz!

CT Ratio

Current transformers ratio. For example, ratio = 160 for 800A:5A transformers.

Xap: Rated kVA

The apparent power rating of the set, denoted Xap. The COMMAND\EXPORT quotas legitimacy will be tested against this value.

Xre: Rated kW

The true (active) power rating of the set (engine), denoted Xre. The COMMAND\EXPORT quotas legitimacy will be tested against this value.

Adj Sec/Week

Real time clock adjustment specified in seconds per week.

FACTORY

Calibration parameters. The password is: _ _ _ _ _ _. It is recommended to note down the calibration parameters in case they are accidentally damaged. See also SET-UP\OPTIONS *WRITE PROTECT...!*

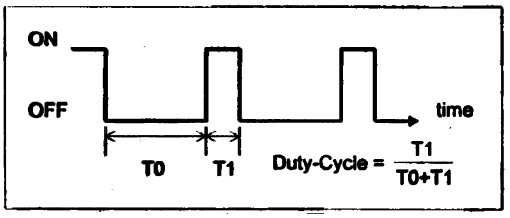
Tuning up the paralleling switch gear

GENCON II has four feedback controls built in:
1. SY: Phase synchronizer -- operates by regulating the engine speed,
2. SY: Voltage matching -- operates by regulating the generator voltage,
3. LS: Active load (kW) sharing -- operates by regulating the engine fuel supply,
4. LS: Reactive load (kVAr) sharing -- operates by regulating the generator excitation level.

The SY prepares the genset for a "soft" entry into parallel connection with the mains or the bus.
When in parallel with the mains, the LS maintains the genset power output at the level set by the user COMMAND\EXPORT. When in parallel with other gensets, the LS maintains an equal genset load share (ie equal genset-power/genset-ratings ratio).

GENCON II controls the engine speed and fuel supply by regulating its B2 ANALOG OUT DC voltage. ANALOG OUT is connected to the engine electric governor. Its 0 to 7.5 Vdc range is compatible with most electric governors. For example:
1. Woodward Governor Co., AUX INPUT 11+: *Gov Volt Bias* = 1.50 Vdc. Raising voltage increases speed.
2. Barber-Colman Company, ILS 8: *Gov Volt Bias* = 4.00 Vdc. Raising voltage increases speed.
3. Governors America Corp., AUX N: *Gov Volt Bias* = 1.50 Vdc. Raising voltage decreases speed.

GENCON II controls the generator voltage and excitation level by regulating the duty-cycle of its B3 PWM OUT signal (Pulse Width Modulated Output). A special interface module (see **AVRx**) converts this digital signal into a floating DC voltage source. The DC voltage changes the generator Automatic Voltage Regulator (AVR) reference voltage.



Each one of the four feedback controls monitors the error E between a value that it measures (eg, phase-shift) and the ideal one (eg, 0° phase-shift; or in other "λ" units -- volts, kW's or kVAr's -- according to the case) and the error rate of change, ΔE ("λ"/sec). In response, the ANALOG OUT (Vdc) or the PWM OUT duty-cycle (percentage) changes by: E * gain + ΔE * stability. The installation engineer can adjust the gain and the stability levels. For most installations, setting the ***gain as high as possible, while keeping the system stable with the stability adjustment***, results in a satisfactory control.
Though these (PID) control loops operate in discrete steps, 10 steps per second, they are quick enough for their behaviour to be identical to common analogue units.

Getting started

1. ***Check the measurement system thoroughly under load!*** Check SET-UP\BASICS *Xap* and *Xre*.
2. Run the generator-set with *Parallelin System* = 0. Make sure that by changing the *Gov Volt Bias* you change the engine speed. If the speed increases when raising the *Gov Volt Bias*, the *SYstbl V/Hz* sign should be positive (+). If the speed decreases, the sign should be negative (-). Set *Gov Volt Bias* to a value in the middle of its effective control range. Adjust the governor speed potentiometer to the nominal generator frequency (50Hz or 60Hz).
3. Adjust the AVR potentiometer to the nominal generator voltage. Disconnect B32. This is equivalent to a PWM OUT duty cycle fall from 50% to 0%. The generator voltage must change to its lowest or highest extreme. If the generator voltage also falls, *SYgain %P/V* sign should be positive (+), otherwise the sign should negative (-).

Tuning up the feedback controls

To tune up a feedback control loop we use the appropriate display, SYNCscope for the SY controls and POWER+PF for the LS controls, to examine how different gain and stability set points effect the error behaviour: Too much gain causes fast oscillations. Too much stability may cause slow oscillations. It can also be useful to look at the SYSTEM display to see how ANALOG OUT (V) and PWM OUT (%) change. The following general tuning up procedure is recommended:

- Start with the gain at its midpoint value if you haven't worked with this type of governor or AVR before. Otherwise, start with the values that you've found best last time. We don't expect that the new optimal values to be much different -- the engine and the alternator size plays a secondary effect.
- Try to reach an acceptable level of oscillations by different stability values -- prefer minimal stability level.

- Successful → Increase the gain and try to stabilize it...
- Failed → Reduce the gain and try to stabilize it...

Don't waste time, make significant set point changes. If a gain or stability value is 0.0123 you will not notice any change in the system's performance if you try 0.0124...
Moreover, ***the controller just approximates your keyboard entries*** to the nearest values that it can represent internally!

If you come to the conclusion that the governor "SY" and "LS" gain/stability parameters are very small, consult the section on ANALOG OUT to see if you can install a voltage divider between ANALOG OUT and the electric governor control input to reduce the Δspeed/Δvolts ratio. Check also if there is a trimmer on the governor that can do the same.

The same applies to the AVR "SY" and "LS" parameters. Note also that AVRx, the AVR interface module, has a built-in range trimmer -- use the minimal range that is acceptable.

Since new engines after a while change their characteristics, usually they respond faster to fuel injection, it is recommend after finding the optimal *LSgain V/Xre* value to reduce it, say, by 30%.

Synchronizer tune up tips

1. Check that *V4 Ov/Uv Voltage/Frequency* limits are reasonably set.
   Note: The synchronizer does not work when the voltage or the frequency measured by V4 are abnormal!
2. Run the set by **IOB1** In#2 Test W/O Load. The synchronizer works but the generator contactor stays open.
3. An asterisk (*) appears in the OVERVIEW display each time the *SYNC Window °*, *SYNC Window V* and *Sync Dwell Time* criteria are met:

Paralleling with the mains tune up tips

1. Tune up the LS gain/stability under config. #4 even if your application is #5 or #6, ie PARALLEL=1, ATS=0 and COGEN=1. This will prevent unnecessary mains tripping.
2. Search for the optimal gain and stability set-points with the COMMAND\EXPORT quotas to 0. This is when the genset is most unstable.
3. When tuning up the LS controls, dangerous kW and kVAr oscillations may develop. Hence, go through all the controller's protections and set them up for their shortest delay. Make also sure that appropriate SET-POINTS are selected for: *Gen OvCurrent*, *Gen Revrse kW*, *Gen Rvrs kVAr*, *Parll kW Surge*, etc.
4. Run the genset by In#1. If you come upon *PARALLEL LOAD SURGE* immediately when entering parallel connection you have two options:
   A. Delay introducing the *PARALLEL LOAD SURGE* protection by a suitable *kW Load Surge Enable* time.
   B. Increase the *Sync Dwell Time* (eg 0.5 sec → 1 sec) and narrow the *SYNC window* (eg 10° → 5°). This will make the synchronization time longer but the parallel connection will be become "softer" (extending *SyncTimeout* if necessary).

Example:
The following table lists the best parameters found for a 100 KVA, 80 KW, Perkins+Newage genset with Woodward isochronous 8290-040 governor and STAMFORD SX440 AVR (no droop kit!). Engine flywheel had 126 teeth. The current transformers were 5A:200A ie CT Ratio = 40.

Gov Volt Bias	1.50
SYgain V/180 deg	0.0020
SYstbl V/Hz	+0.0700
SYgain %P/V	+0.100
LSgain V/Xre	0.1013
LSstbl V/Xre	1.8995
LSgain %P/Xap	24.979
LSstbl %P/Xap	22.008

Multiple set paralleling tune up tips

1. Search for the optimal gain and stability set-points when the generator bus has no load. This is when the system is most unstable.

2. In a "#3 Random access paralleling" application it is convenient to let ***another*** controller be in configuration #1. This controller will always be the first to connect its genset to the bus and will run isochronously. Using this controller MEASURE\GENERATOR\POWER+PF display you can also tell the effect of the gain and stability parameters of your controller without leaving the SETPOINTS display.
3. The optimal (maximal) LS gain values when paralleling multiple sets are usually smaller than the optimal values found when paralleling a set with the mains using the same governor and AVR models.

Rear panel

V1,V2,V3,V4 - Voltage inputs

These inputs measure line to neutral AC voltages. ***All these four inputs are internally and mutually isolated*** and provide a very high degree of protection against electrical transients.
The software currently supports only wye (star) connected generators, as follows:
Connect A11 to gen phase A, A21 to gen phase B and A31 to gen phase C.
Connect A12, A22 and A32 to the generator neutral point.
The generator phase order should be "clockwise" or the *ILL GEN PHASE ORDER* warning fault is declared.
Connect A41 to the mains or bus phase A and A42 to the mains or bus neutral.

Note!

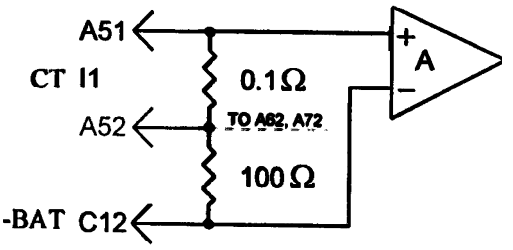
1. V4 can serve as a comprehensive single phase mains monitoring detector for automatic mains failure applications, see config's #2, #5 and #6. For three phase mains monitoring an external relay should be connected ***in series*** with V4, ie the relay disconnects the input of V4 on a mains failure.
2. If while paralleling with the mains the voltage measured by V4 is lower than 50% of its nominal level *PARALLEL MAINS FAIL* is declared -- this is caused by an external protection relay. Note that loss of mains during paralleling can also be detected by the in-built *PARALLEL LOAD SURGE.*
3. It is the installation engineer responsibility to make sure that the phase order of the bus/mains is identical to the phase order of the generator. ***DIFFERENT ORDER ENDANGERS LIFE AND PROPERTY!***
4. NEMA phase A, B and C designations are equivalent to IEC phase U, V and W designations.

I1,I2,I3 - Current transformer inputs

These inputs measure, through 5A current transformers, the generator phase currents. The CT ratio is defined in SET-UP\BASICS, eg *CT Ratio* = 160 for a 800A : 5A transformer. The CT's burden at 5A is 2.5VA.

The diagram shows one measurement circuit. *Note:*

1. It is recommended not to ground the CT's externally since any voltage difference between A52/62/72 and C12 will result in reading spurious currents.
   The voltage across the 0.1Ω resistor at 5A is only 0.5V!
2. Though A52/62/72 are connected internally, it is recommended to connect the CT's by 3 pairs of wires to reduce "crosstalk" between the channels (twisted pairs preferably).

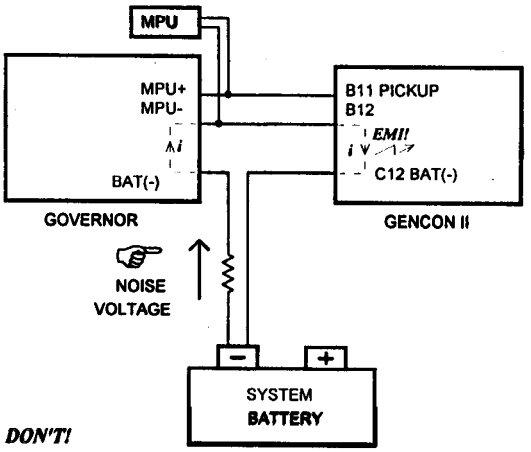


The phasing of the CT's should match the phasing of the corresponding voltage inputs. By MEASURE\ GENERATOR\GEN ΦA to ΦC it is easy to find the correct connection of the CT. Eg, inverse CT connection will result in reading negative kW's.

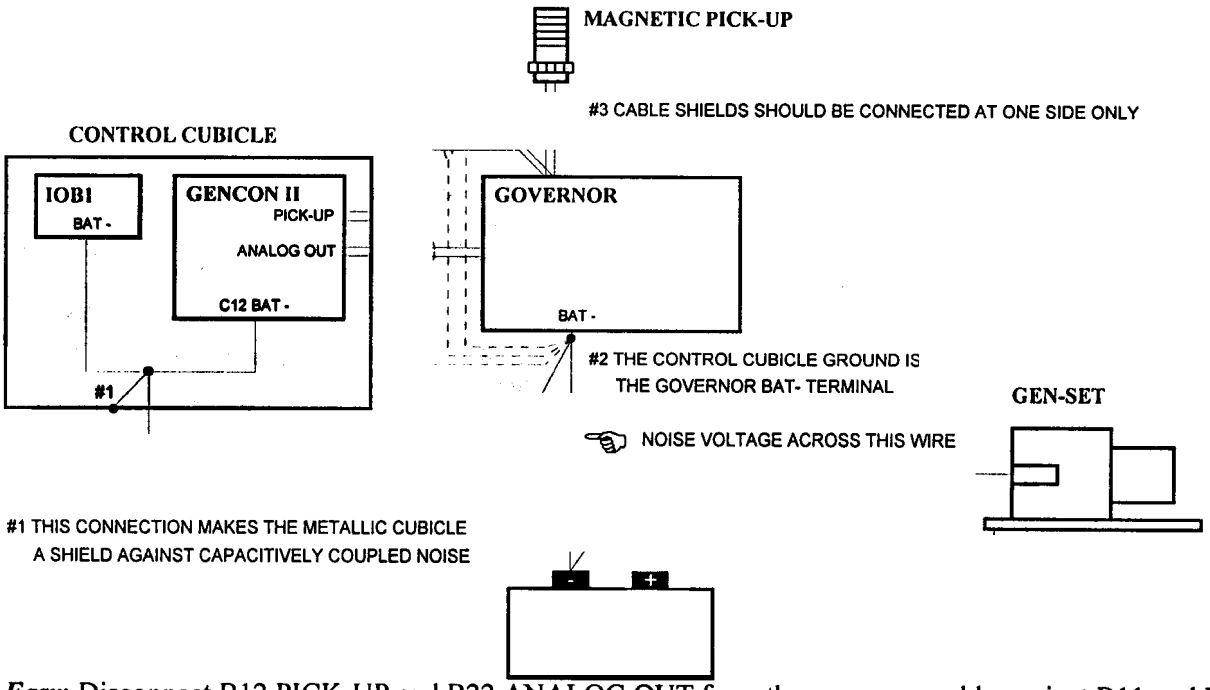
BATTERY & Ground Noise Hazards!

GENCON II is designed for continuous operation from 8 to 40 Vdc. In addition, it withstands short voltage dips during engine cranking and withstands the prolonged, even 100 Vdc high, transients during "LOAD-DUMP" (may happen if the battery open circuits while the engine is running).

Electric governors pass high current pulses from the battery positive pole to the battery negative pole. As a result, because of wiring impedance, considerable ground *noise voltage* develops at the governor battery(-) terminal. **GENCON II** is connected to the governor directly. Any voltage difference between the controller's battery(-) terminal (C12) and the governor's battery(-) terminal can lead to ground currents flowing through **GENCON II** (see illustration) . Ground currents degrade the system performance and can cause EMI (electromagnetic interference) errors!
This has two solutions:



Recommended: Make the governor battery(-) terminal the reference ground for the whole control system ie, connect **GENCON II** C12 and the **IOB1** BAT- directly to the governor battery(-) terminal and not to the system battery negative pole.



Easy: Disconnect B12 PICK-UP and B22 ANALOG OUT from the governor and leave just B11 and B21 connected.

Magnetic Pickup Input

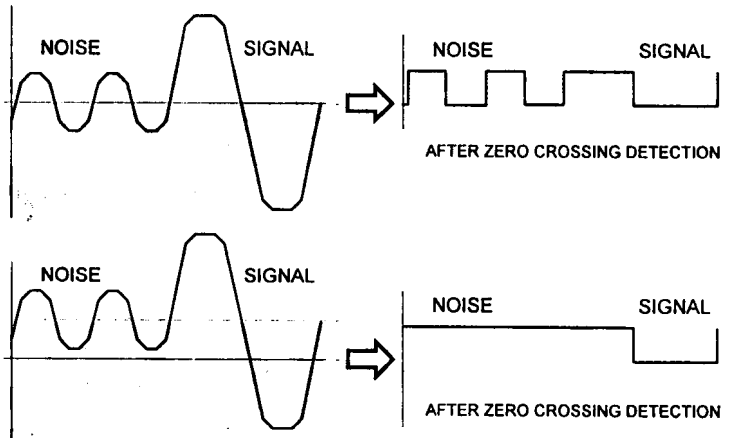
The magnetic pickup produces an AC voltage with every flywheel/gear tooth passing next to its coil. The magnetic pickup input, B11-B12 PICK-UP, detects AC signals starting from approximately 0.5 Vrms (± 0.7 volts peak to peak).

The system calculates the engine speed (RPM) and the generator frequency (Hz) from the MPU frequency, based on the number of flywheel teeth and the number of generator field poles defined in SET-UP/BASICS. The MPU measurements are displayed by MEASURE\ENGINE. The system also measures the generator frequency directly from the V1 phase input. It declares a warning fault if there is a difference between the two readings.

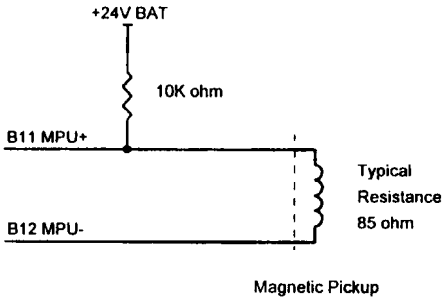
When the MPU is used only by **GENCON II**, use a twisted pair shielded cable as follows:
Connect B11 and B12 to the pick-up coil. Connect the shield to B13 only.

When the MPU is also used by the electric governor, if you did not make the governor battery(-) terminal the reference ground for the controller leave B12 not connected. See **Ground Noise Hazards**.

IMPORTANT NOTE:
Controllers that were manufactured before 20 Feb. 94 (last unit s/n A50 4 02 028) are very sensitive to the pickup AC signals (their circuit works by counting zero crossings). In some cases this lead to detection of spurious frequencies.



The simplest solution is to add a small DC offset to the magnetic pickup AC signal:



The example uses the magnetic pickup coil intrinsic 85Ω resistance to add a 0.2 Vdc bias to the pickup signal. AC signals smaller than ± 0.2 volts are ignored.

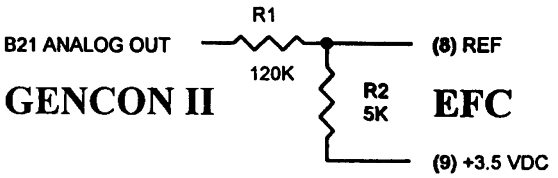
ANALOG OUT

This voltage source controls the engine speed and fuel through the electric governor external reference input:
Connect B21 to the positive reference input (there are sorts of names for it: "AUX", "ILS", etc.).
Connect B22 to the negative reference input (often simply the governor battery(-) terminal) ***ONLY*** if you've made the governor battery(-) terminal the reference ground of **GENCON II**. See **Ground Noise Hazards**.

ANALOG OUT voltage swing is from 0 to 7.5 Vdc. It is produced by a 12 bit D/A converter, hence the smallest voltage step that it is capable of is 1.8 mV. If this is too coarse, ie the governor ΔSpeed/ΔVolt is too large, you may find it convenient to introduce a voltage divider circuit between **GENCON II** and the governor.

For example, an 0.1 Vdc increase in Cummins's EFC governor reference leads to a 3 Hz frequency increase. This is still within the controller's resolution, however introducing the following voltage divider made it easier to find proper gain and stability parameters.

REF(ANALOG) = 3.5 + (ANALOG-3.5) * R2 / (R1+R2)



REF(ANALOG) = 3.5 + (ANALOG - 3.5) / 25

REF(0) = 3.5 - 0.14

REF(7.5) = 3.5 + 0.16

PWM OUT

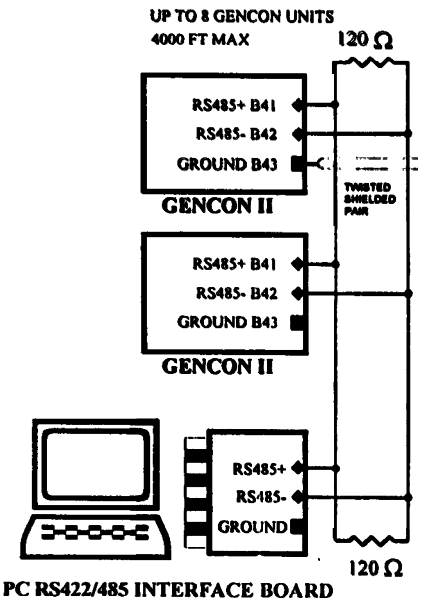
The PWM controls the generator AC voltage level during synchronization and controls the generator excitation level during paralleling. Read on the AVRx for further details.

RS-485 serial port

This is an industry standard serial communication port. ***When paralleling several generator-sets all the controllers' RS-485 ports MUST be connected.*** Each controller should have a unique *Controller ID No.* There can be up to eight controllers in the network. The controllers can be supervised from a PC that is running REMOTE.EXE. The RS-485 port is also used for software maintenance.

When connecting the RS-485 ports, check that all the ports maintain the same ± polarity. Connect the shield only to one controller B43.

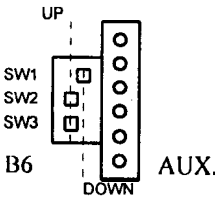
The communication line can stretch up-to 1,200 meters. Long lines should be made of a twisted pair shielded cable with 120Ω characteristic impedance (eg BELDEN 9841). It is important to place 120Ω termination resistors at each line end.
Inside the controller there is an optional 1K termination resistor for short-distance non-shielded cables. This resistor is switched on by SW1=DOWN (see **Dip-switches**).



AUXILIARY I/O

Connect B6 through the supplied cable to **IOB1**. The cable has 5 wires. If it has 6 wires (manufactured before 21 Mar '94) it is recommended to cut the green wire (signal ground, pin 3).
Route this cable as far away as possible from high AC voltage or current lines!

Dip-switches



Locate the three dip-switches inside the controller, next to the AUXILIARY I/O B6 connector opening. Denote the highest switch by SW1, the middle by SW2 and the lowest by SW3. UP position is when pointing to the "B6" inscription, DOWN position when pointing to the "AUXILIARY I/O" inscription.

SW1, Internal RS-485 1 KΩ termination resistor: DOWN→Connected, UP→Not connected.
SW2, Software mode: DOWN→Maintenance (see LOAD.EXE, READ.EXE & WRITE.EXE), UP→Normal
SW3, Flash memory voltage: DOWN→High for loading software (see LOAD.EXE), UP→Normal.

RELAYS #1, #2 and #3

There are 3 relays in the main unit (plus 8 additional ones in **IOB1**). Each relay has a Single Pole Double Throw (SPDT) contact configuration. The rating of each contact is 380 Vac / 10 Amps.

R#1 RELAY -- Circuit breaker trip coil or ***Load controller***

The use of this relay depends on the SET-UP\OPTIONS *R#1: Trip|kW Load* parameter.
0→ R#1 N/O contact is closed if during genset operation a shutdown fault is detected. It activates the generator circuit breaker (shunt) trip coil that avoids slow collapse of the voltage at the load side.
1→ It can be used for basic load control, non-essential load release and re-entry etc. See **Applications.**

R#2 RELAY -- Visual alarm

R#2, through a N/O contact, activates an external visual alarm when a warning or a shutdown fault is detected. When the fault is acknowledged by the RESET button, R#2 RELAY is deactivated.

R#3 RELAY -- Audible alarm

R#3, through a N/O contact, activates an external audible alarm when a warning or a shutdown fault is detected. R#3 is deactivated automatically after a time delay or by pressing the RESET button. See SET-UP\DELAYS.

Error messages

The following section lists all the system error messages in alphabetic order. Use the REPORT function to examine all the messages logged in memory.

AIR DAMPER CLOSED

The result of active In#13 AIR DAMPER SHUT. The air damper (flap) is activated by the relay K#4. Normally the air damper lever needs reset too.

AUX I/O BOARD ERROR -- Check:

1. Is DC voltage available to the **IOB1**?
2. Is the **GENCON II ⇔ IOB1** cable fitted?
3. Is the **GENCON II ⇔ IOB1** cable routed far off high AC voltage and current lines?

BATTERY CHARGR FAULT

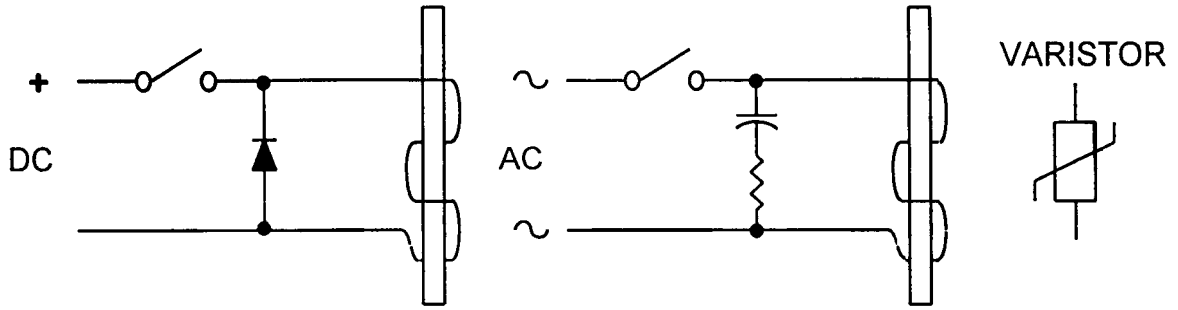
The result of active In#12 CHARGER FAULT.

CONTACTOR(s) FAILURE

Conflict detected between the status of the auxiliary contacts on the gen/mains contactors (see In#15/16) and the status of K#7/8 relays.

EMI (NOISE) DETECTED

This error message indicates the presence of an Electro Magnetic Interference source.
EMI can be caused by an electric spark across a switch contacts when it interrupts the current flow through an inductive load (the fuel solenoid for instance). ***Sparks can AND SHOULD be prevented*** by using diodes in DC circuits and by using capacitors (or varistors) in AC circuits, as follows:



EMI can also be caused by closing a noisy ground path through the controller, as explained in the section on **Battery & Ground Noise Hazards**.

Note! Each EMI causes a software restart with, in most cases, no apparent system disruption. In extreme cases, where the EMI's come in streams, you may see the controller locked in trying to restart the software but with no success. **Prevention is the best defense in fighting electrical noise!**

ENGINE OVERCRANK

All the engine cranking attempts have failed. See SET-UP\SET-POINTS.

ENGINE SHUTDOWN FAIL

Engine fuel supply was blocked yet, after delay (see SET-UP\DELAYS), "signs of life" are still detected. Hint: Check In#5 OIL PRESS SHUT.

ENGINE SLOW CRANK

The speed, read by the magnetic pickup, 2 seconds after starting to crank the engine, was found to be lower than 60 RPM.

EXTERNAL OVERLOAD

The result of active In#14 EXTERNAL OVERLOAD. This can be a shutdown or a warning fault. See SET-UP\OPTIONS. Immediately on detecting active In#14 status the generator contactor opens (K#7 is de-energized).

FREQUENCY NOT BUILT

Following detection of engine firing speed, after delay, normal gen frequency was not reached (see SET-UP\SET-POINTS & DELAYS).

GEN EXCITATION LOSS

Negative kVAr (reactive power) was detected. The generator is expected to supply kVAr! Is it an AVR fault? See also SET-UP\SET-POINTS & DELAYS.

GEN HIGH HARMONICS

Heavy non-linear loads? Improper generator type or size? Stator short-circuit can also cause high harmonics. See also SET-UP\SET-POINTS & DELAYS.

GEN OVER FREQUENCY

Generator frequency higher than SET-UP\SET-POINT existed for SET-UP\DELAY.

GEN OVERCURRENT

Note! The larger the overcurrent level is...the shorter gets fault declaration time delay. See SET-UP\SET-POINTS & DELAYS.

GEN OVERVOLTAGE

Generator voltage higher than SET-UP\SET-POINT existed for SET-UP\DELAY.

GEN REVERSE POWER

Negative Watts (true power) detected. Engine failure? See also SET-UP\SET-POINTS & DELAYS.

GEN UNDER FREQUENCY

Generator frequency lower than SET-UP\SET-POINT existed for SET-UP\DELAY.

GEN UNDERVOLTAGE

Generator voltage lower than SET-UP\SET-POINT existed for SET-UP\DELAY.

GENCON LOW DC DANGER

Dangerously low DC voltage level was detected. A little bit lower and the controller would have ceased functioning. This can be a shutdown or a warning fault, see SET-UP\OPTIONS.

GENCON MEMORY ERROR

Built-in test message. EEPROM data error (parameters memory). Contact nearest service facility.

GENCON PROGRAM ERROR

Built-in test message. FLASH data error (software memory). Try loading the the controller software again under ***safe*** DC conditions. If the problem continues contact the nearest service facility.

GENCON UP: SET CLOCK

Reminds the operator to set the clock after switching on the controller.

Generator Syn|Asy:←0

The parameter *Generator Syn|Asy* can be set to 1, to select asynchronous (induction) generators, only in configuration #4, paralleling with the mains.

GENERIC CONFIG ERROR

Applies to configuration #0 only (under a PLC command): The controller indicated that it cannot take any load (K#7 was de energized), nevertheless either In#15 or In#16 was left active for more than *Contactor Delay* time. Ie, the operating mode chosen by the PLC corresponds to "running with load".

HIGH BATTERY VOLTAGE

Battery voltage higher than SET-UP\SET-POINTS existed at least for 1 second.

HIGH WATER TEMP SHUT

The result of active In#7 HIGH TEMP SHUT.

HIGH WATER TEMP WARN

The result of active In#8 HIGH TEMP WARN.

ILL GEN PHASE ORDER

This warning indicates that the AC voltage connected to V1 is lagging after the voltage connected to V2. Normally V1 is 120° ahead of V2.

LOW BATTERY VOLTAGE

Battery voltage lower than SET-UP\SET-POINTS existed for 1 second while the set was stationary or running (ie not during start-up).

LOW FUEL LEVEL WARN

The result of active In#11 LOW FUEL WARN.

LOW OIL PRESS SHUTDN

The result of active In#5 OIL PRESS SHUT when the set is running.

LOW OIL PRESS WARNIN

The result of active In#6 OIL PRESS WARN when the set is running.

LOW WATER LEVEL

The result of active In#10 LOW WATER LEVEL. Can be shutdown or warning according to SET-UP\OPTIONS.

LOW WATER TEMP WARN

The result of active In#9 LOW TEMP WARN.

NETWORK RS-485 ERROR

Report only. Indicates an error in transmitting or receiving data through B4 RS-485. Cause → Solution:

- Short circuit in the network cable or wrong polarity connection of some network member → ...
- EMI noise → Use a twisted pair cable. Connect the cable shield, if used, to ground at one end only!
- Large difference in the ground potential between the network members → Use an isolated PC RS-485 port. Reduce members ground to ground resistance.
- Data reflections (long distance) → Use a cable designed for RS-422/485 applications. The typical characteristic impedance of such a cable is 120Ω -- use two 120Ω end of cable termination resistors. Verify that the PC RS-485 port can drive this load, ie maintain at least 2V while driving a 60Ω load.

NETWORK SET-UP ERROR

Report only. Another controller in the network is using the same ID no. Each controller should have a unique ID no. See SET-UP\BASICS. Ignore this message if *NETWORK RS-485 ERROR* is also reported.

NOT IN AUTO MODE

The controller was taken out of AUTO mode. Not generated by "Sleep mode" (see In#3 SLEEP).

OIL PRESS NOT BUILT

Following detection of engine "firing" speed, after delay, normal oil pressure was not reached. Check In#5 OIL PRESSURE SHUT status. See also SET-UP\DELAYS.

PARALLEL LOAD SURGE

When in parallel with the mains, a sudden kW load change was detected. It can be a kW increase or, optionally, a kW decrease (see *kW Drop=LoadSurge?*). This is a likely indication of a mains failure. In response, the genset is isolated from the mains (by energizing K#8 if the ATS logic is enabled or by de-energizing K#7 if not). See SET-UP\SET-POINTS *Parll kW Surge* parameter.

This error can also occur if the genset does not make a "soft" parallel connection with the mains.

You can make the parallel connection "softer" by increasing the *Sync Dwell Time* and narrowing the *SYNC Window* or you may delay the introduction of this protection by a suitable *kW Surge Enable* delay.

PARALLEL MAINS FAIL

When in parallel with the mains, the voltage measured by V4 is less than 50% of the nominal. An external protection relay disconnected the input of V4. The controller's immediate response is to isolate the generator from the mains. It is done by energizing K#8 or by de energizing K#7 according to the *Mains Standby ATS?* option. The *Smooth Mains→Gen ?* = 1option suppresses logging of this message.

REMOT EMERGENCY STOP

The result of active In#4 EMERGENCY STOP.

REVISE SETPOINTS

Following a change in SET-UP\BASICS or FACTORY parameters, the installation engineer is reminded to revise the SET-UP\SET-POINTS.

RPM OVERSPEED SHUTDN

Engine speed higher than SET-UP\SET-POINT existed for SET-UP\DELAY.

RPM v FREQUENCY ERRO

Conflict between measured engine speed (pickup) and gen frequency (V1). Display MEASURE\ENGINE. Hint: Check SET-UP\BASICS teeth & poles number.

SHUTDOWNS BYPASS ON!

The result of active In#3 BYPASS. Most shutdown faults become warning only!

STOP BUTTON PRESSED

GENCON II red STOP button was pressed. Shutdown fault was declared.

SYNCHRONIZER TIMEOUT

Failed to synchronize the genset with the mains within the allotted time. Check SET-UP\SETPOINTS & DELAYS.

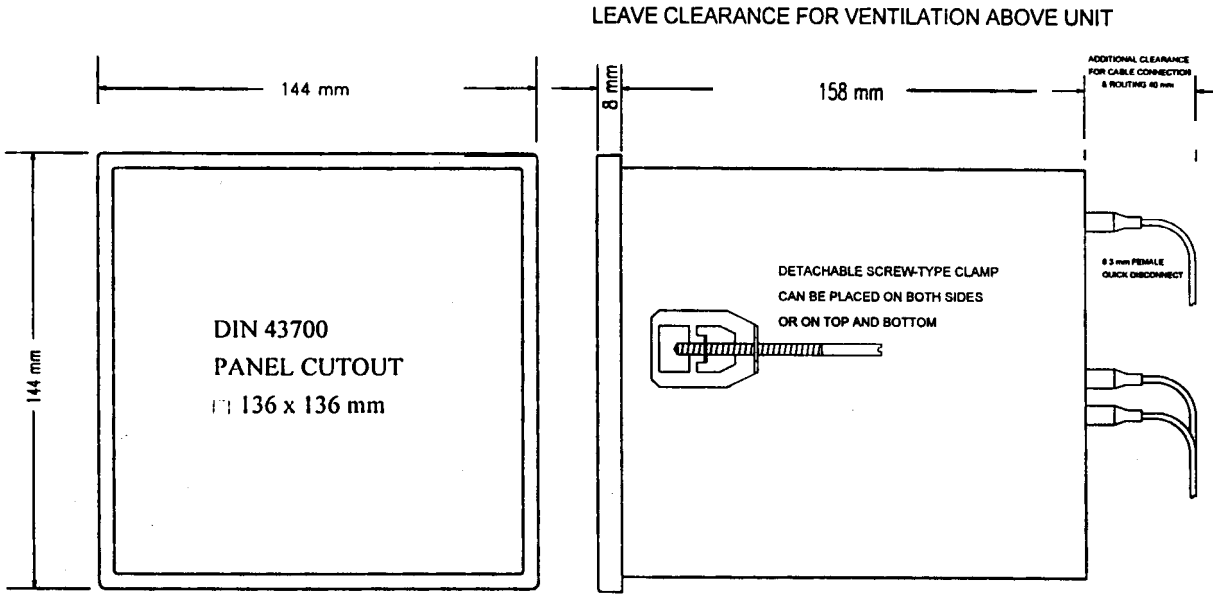
UNEXPECTED BUS VOLTS

Frequency is detected at V4 when logically it should have been dead.

VOLTAGE NOT BUILT

Following detection of engine firing speed, after delay, normal gen voltage level was not reached (see SET-UP\SET-POINTS & DELAYS).

GENCON II dimensions



IOB1 -- Auxiliary I/O board

Attention!

There are 2 **IOB1** models: One for 12 Vdc batteries and one for 24 Vdc batteries.
Be sure that you are using the correct model!

General

IOB1 is an auxiliary input and output interface board. It adds to **GENCON II** 16 input and 8 output channels. The input channels implement the set of alarms and pre-alarms that is specified in NFPA 110 level 1 (USA code), control the diesel engine and control the generator and mains (when applicable) contactors.
IOB1 is mounted on a DIN rail inside the control cubicle. It is connected to **GENCON II** by a special 120 cm symmetrical cable. Proper operation of the **IOB1** is continuously monitored and shutdown fault is declared on any malfunction. If the cable is removed all **IOB1** relays are off.

Input channels

The 16 input channel terminals are connected through "normally open" (N/O) or "normally closed" (N/C) contacts to the battery(-) potential. The type of contact to use with each input, N/O or N/C, is defined by SET-UP\IN 1..16. The input channels activity is displayed by MEASURE\ IN 1..16.

In#1 RUN WITH LOAD
Active In#1 starts the genset in AUTO mode unless a shutdown fault exists. When the genset is ready it takes the load or enters paralleling.

In#2 TEST W/O LOAD
Active In#2 starts the genset in AUTO mode unless a shutdown fault exists. When In#2 is deactivated, following the *Test Delay* time, the genset stops.

In#3 SLEEP or BYPASS
In#3 can be used in two ways according to the *In#3 Sleep|Bypass* option:
SLEEP: Active In#3 inhibits genset startup in AUTO mode. When it is active OVERVIEW displays "Mode=Sleep." It can be activated by a clock to disable standby operation after working-hours.
BYPASS: Active In#3 converts most shutdown faults to warnings (except In#4 EMERGENCY STOP). Active In#3 is also a warning fault. It is typically used when powering fire extinguishing pumps.

In#4 EMERGENCY STOP
Active In#4 is a shutdown fault. It also activates the K#4 AIR DAMPER relay.

In#5 OIL PRESS SHUT
Active In#5 indicates low lubricating oil pressure (see In#6). In#5 passes 0.5 sec delay to filter out transient contact statuses. When the engine is running it causes a shutdown fault. When the engine stops, after *Stoppin Max* time delay, it causes an ENGINE SHUTDOWN FAIL warning.

In#6 OIL PRESS WARN
Active In#6 indicates low lubricating oil pressure. When the genset is running it causes a warning fault.

In#7 HIGH TEMP SHUT
Active In#7 that is detected when the genset is running is a shutdown fault. It is ignored if detected when the engine stops since temperature in that case tends to rise.

In#8 HIGH TEMP WARN
Active In#8 that is detected when the genset is running is a warning fault. It is ignored if detected when the engine stops since temperature in that case tends to rise.

In#9 LOW TEMP WARN
Active In#9 is a warning fault.

In#10 LOW WATER LEVEL
Active In#10 is a warning or a shutdown fault. See SET-UP\OPTIONS.

In#11 LOW FUEL WARN
Active In#11 is a warning fault.

In#12 CHARGER FAULT
Active In#12 is a warning fault.

In#13 AIR DAMPER SHUT
Active In#13 is a shutdown fault. K#4 AIR-DAMPER does not operate if In#13 is already active.

In#14 EXTERNAL OVERLOAD

Active In#14 causes a warning or shutdown fault according to the *Ext. Overload S|W* option. The genset is taken off load immediately.

In#15 GEN CONTACTOR

Active In#15 indicates that the generator contactor is closed. In#15 status is expected to follow that of the K#7 GEN CONTACTOR relay within a *Contactor Delay* time. This time limit, if exceeded, is a shutdown fault condition. Under the *Generic Configure?* option this input has a special function.

In#16 MAINS CONTACTOR or ***kW QUOTA LIMIT***

When SET-UP\OPTIONS *Mains Standby ATS* is 1,
an active In#16 indicates that the mains contactor is closed. In#16 status is expected to follow the K#8 MAINS CONTACTOR relay command within a time limit (see SET-UP\DELAYS). This time limit, if exceeded, is a shutdown fault condition.
Under the *Generic Configure?* option this input has a special function.
When SET-UP\OPTIONS select configuration #4, and the genset is in parallel with the mains,
an active In#16 indicates that the export kW quota has to be decreased. An inactive In#16 input indicated that the export kW quota has to be increased. See **Dynamic export quota control** in **Applications**.

Output channels

There are 8 output relays, K#1 to K#8, driving 24 output terminals. The relays have Single Pole Double Throw (SPDT) contact configuration. 3 terminals belong to each relay: Pole, N/C Throw, N/O Throw. Follow the PC-board marking. Each contact rating is 380 Vac / 10 Amps.

K#1 PRE-GLOW

K#1, through a N/O contact, energizes an electric heater before cranking the engine. Use SET-UP\DELAYS to define the pre-glow time.

K#2 FUEL SOLENOID

K#2, through a N/O contact, operates the fuel solenoid. The fuel solenoid can be defined as either "energize to run" or "energize to stop", see SET-UP\OPTIONS. The genset should stop within a predetermined time after blocking its fuel supply (see SET-UP\DELAYS) or otherwise a fault is declared. If it just the oil pressure not falling fast enough (In#5 OIL PRESS SHUT), it is a warning fault only. However, if speed and voltage are measured, shutdown fault is declared and the K#4 AIR DAMPER relay is also activated.

K#3 CRANK

K#3, through a N/O contact, energizes the starter motor solenoid. Use SET-UP\DELAYS to define the maximal cranking time and the delay between the cranking attempts. Use SET-UP\SET-POINTS to define the number of cranking attempts and the minimal speed to stop cranking (ie engine "firing" RPM).

K#4 AIR DAMPER

K#4 is active for 2 seconds following an engine overspeed or following failure to stop the genset by K#2 FUEL SOLENOID. K#4 is inhibited if In#13 AIR DAMPER is already active.

K#5 LUBRICATION PUMP

K#5, when the genset is stationary, activates an auxiliary lubrication pump repetitively, with a predetermined on and off duration. See SET-UP\DELAYS.

K#6 SET RUNNING

If the *K#6 Engine|Gen On* option is:
0 → K#6 is active when the engine is running: RPM ≥ 60 or Hz ≥ 15.
1 → K#6 is active when the generator voltage is high: V1, V2 and V3 ≥ *Gen Undervoltage* setpoint.

K#7 GEN CONTACTOR

K#7, through a N/O contact, operates the generator to load contactor. In conjunction with K#8, complete automatic transfer switch (ATS) logic is provided. If the genset parallel operation with the mains is enabled, the ATS contactors should not use a mechanical or electrical interlock mechanism. It is recommended, especially when paralleling is used, to bring to In#15 GEN CONTACTOR an auxiliary contact from the gen contactor, to compare K#7 command with the contactor status.
Under the *Generic Configure?* option this relay indicates that the genset is ready for load.

K#8 MAINS CONTACTOR

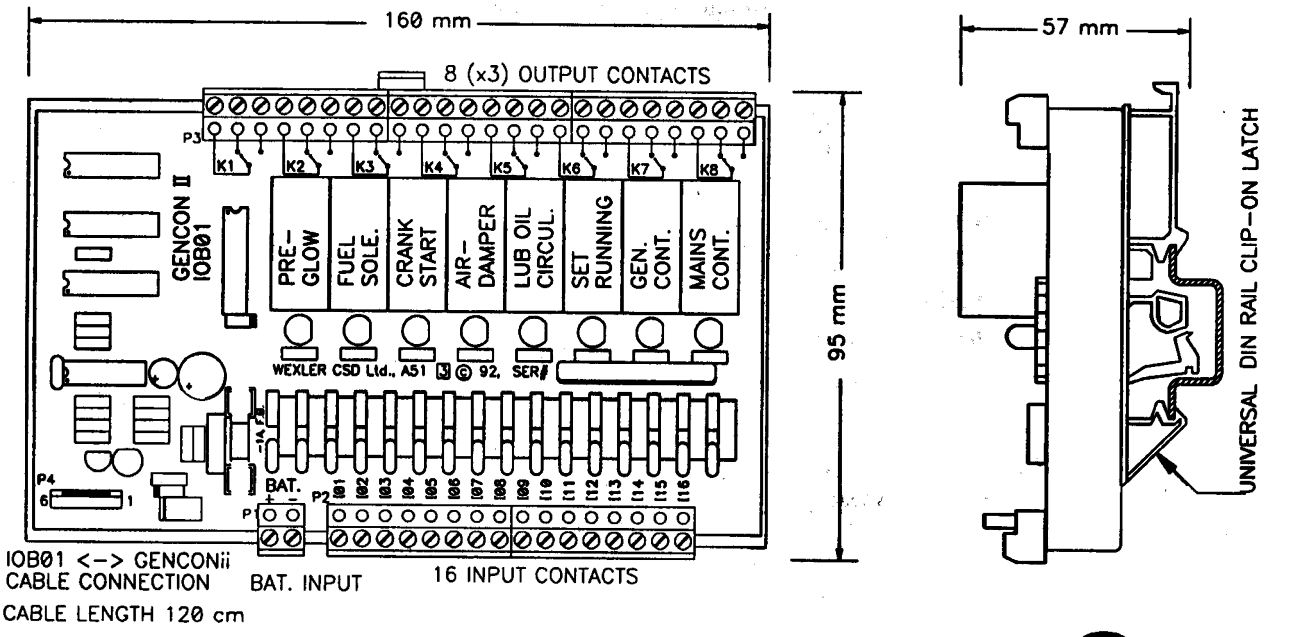
If *Mains Standby ATS* = 1, K#8, through a N/C contact, operates the mains to load contactor. In conjunction with K#7, complete automatic transfer switch (ATS) logic is provided. If the genset parallel operation with the mains is enabled, the ATS contactors should not use a mechanical or electrical

interlock mechanism. It is recommended, especially when paralleling is used, to bring to In#16 MAINS CONTACTOR an auxiliary contact from the mains contactor, to compare K#8 command with the contactor status.

If *Mains Standby ATS* = 0, K#8 follows K#7 with a programmable delay. See *(ATS=0) K#7→K#8.*

Under the *Generic Configure?* option this relay indicates that the genset runs in sync with the bus or mains.

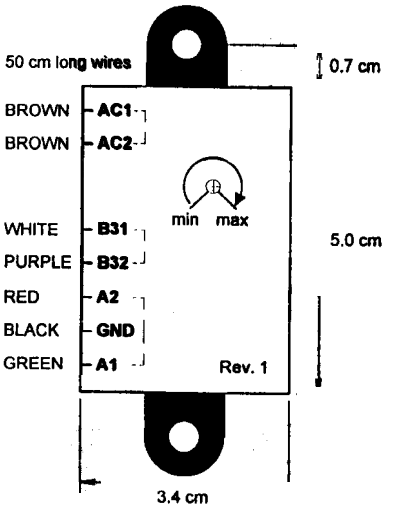
IOB1 dimensions



AVRx -- A universal voltage regulator interface

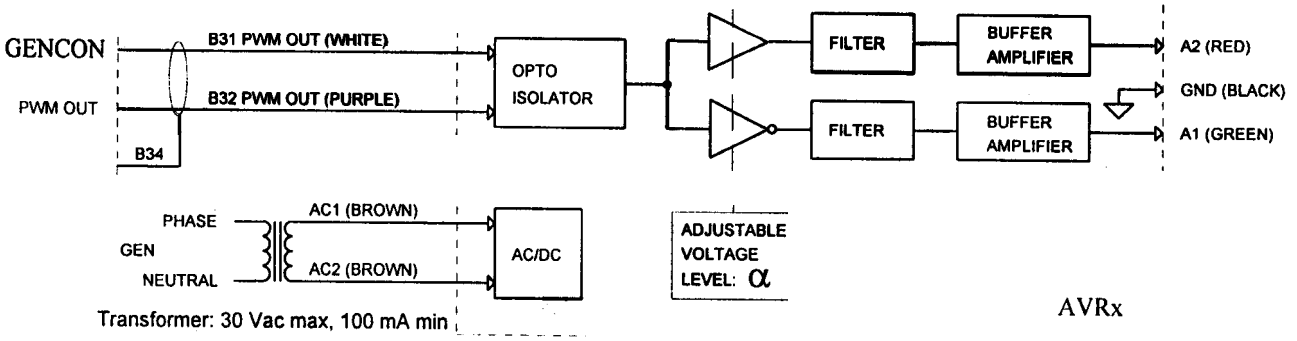
It is required to adjust dynamically the reference point of the Automatic Voltage Regulator (AVR) to achieve voltage matching when synchronizing the generator and to regulate the reactive power (VAR) output when running the generator in parallel.

In many AVRs it is possible to adjust the reference point by applying a DC voltage bias signal. The **AVRx** is an interface module that provides the genset controller with an isolated analogue output voltage channel for AVR control.



AVRx dimensions

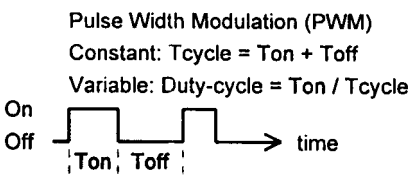
Block diagram



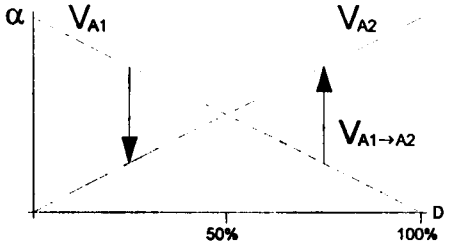
AVRx

Operation

The **AVRx** is a simple digital to analogue converter. The digital input, PWM OUT, has a variable duty cycle D. D is under software control ($0 \le D \le 1$).



The analogue output is related to D as follows:



The voltage between A1 to GND is: $V_{A1}=\alpha*(1-D)$.
The voltage between A2 to GND is: $V_{A2}=\alpha*D$.
The voltage between A1 to A2 is: $V_{A1\rightarrow A2}=V_{A2}-V_{A1}=\alpha*(2*D-1)$, ie $\pm\alpha$ volts **BIPOLAR OPERATION**.
α can be adjusted by the **AVRx** potentiometer from 3 to 9 volts approximately.
The A1, A2 terminals maximal current load is 20 mA.

Examples:

1. When the paralleling functions are not active, PWM OUT produces a "square" wave, ie D = 50%: $V_{A1}=\alpha/2$, $V_{A2}=\alpha/2$ and $V_{A1\rightarrow A2}=0$. Note that under this condition the AVR reference point should be set to the nominal AC volts of the system.
2. When the PWM OUT duty-cycle D is 0, $V_{A1}=\alpha$ volts, $V_{A2}=0$. Hence, $V_{A1\rightarrow A2}=-\alpha$ volts. This **AVRx** input can be simulated by disconnecting the B31 or B32 wires.

Notes:

1. For NEWAGE AVRs (eg SX440, MX341), set α to 3 volts (min position). Connect A1 & A2 to the AVR A1 & A2 terminals respectively. GND is not used. The transformer can be 16 Vac.
2. Contact WEXLER for further information on interfacing the **AVRx** module with AVRs of other manufacturers.

Remote control and monitoring

The RS-485 network connects up-to eight **GENCON II** controllers with an IBM compatible PC. The program REMOTE.EXE simultaneously builds eight control panels on the PC screen, "LCDs + Keypad."
NEW: The program VIEW.EXE builds one large control panel on screen (requires a graphic screen).

Prerequisites: PC DOS operating system. RS-485 serial communication port.
The RS-485 port transmitter (TX) enable signal should be DTR, RTS or OUT1. The RS-485 port should have preferably in built voltage isolation. It is useful to have a mouse and a printer (with PC 8-bit symbol-set).

Run the program by REMOTE SET. The program will ask the following:

RS485 port COM number: 1..4 (↵ = 3) ?	COM device codes: 1/3F8, 2/3E8, 3/2F8, 4/2E8
RS485 port IRQ number: 0=None, 2..7 (↵ = 5) ?	IRQ use#1: 2/HDD-LAN, 3/COM2,4/COM1,5/LPT2
Number of gensets: 1..8 (↵ = 2) ?	In the example the controllers ID numbers are 1 & 2
Screen: 1=Color, 0=Monochrome (↵ = 1) ?	Any IBM display adapter
Printer: 0=None, 1=LPT1, etc. (↵ = 0) ?	
Software character: 1=Spanish, 0=Swedish (↵ = 1) ?	Either ¿ or □

If you omit the argument SET, your last set of answers is used.
Each one of the display windows mimics one controller LCD. The *Controller ID No* determines the screen position of the LCD mimic. If there is no communication with a controller, the display window is blank.
The mouse keypad on the screen and the PC keyboard are linked to the controller shown with a double borderline window. Pressing a function key, F1 ... F8, links the keys with the corresponding controller. Alternatively, by clicking the mouse anywhere within a display window, automatically links the keys with the controller. Operating a controller through the PC console is identical to operating the controller through its own front panel. Operating the program through a mouse has the following additional advantages:

- Clicking a menu function by the mouse automatically activates the function. Clicking the lowest display line selects a higher menu level.
- When a function is active, clicking the mouse left button is equivalent to ESC and clinking the right button is equivalent to ENTER↵ .

Press the PC ⇩ arrow key to print a parameter value. The ⇧ key prints a carriage-return/line-feed.

#1 Without an IRQ, REMOTE is slower. Your computer may not be fast enough to handle the RS485 IRQ's.

Text editing

You may wish to change the name of an input alarm channel, or you may wish to translate all the commands and messages from English into another language. You can do this ***by yourself*** using the PC program ED.EXE. After editing the texts by ED.EXE, load the revised software into **GENCON II** using the procedure described in the following section.
Run the program by ED SET to define the program input and output files. If you omit the argument SET, ED.EXE will use the file names that it used in its previous execution. You can edit an existing software file by specifying the same input and output file names.
The layout of your PC keyboard may be different from the USA English standard. ED.EXE allows you to re-define the keyboard "stroke to font" linkage. You can link a font with a single key, with a function key or with a common key combination (ie Ctrl-key, Shift-key, Alt-key).
To link a key with a font, use the arrow keys first to point to the desired font and then strike the ENTER key, the blue font background turns to red. Strike the desired key to establish linkage. The PC beeps if you strike an unlinked key. If you strike a linked key, the blue "highlight" moves to the corresponding font. Strike Esc to end the keyboard definition phase.
The text editing process is straightforward: Type over the existing text (the PC left, right, insert and delete keys are at your disposal). Skip text line editing by striking the down arrow key.
Backtrack by striking the up arrow key. To introduce your text changes strike the ENTER key. End ED.EXE by striking the Esc key. ***Be careful not to place text where measured values are displayed!***

Software down loading

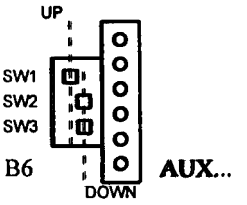
It may be required to load **GENCON II** with a new software version to enhance its capabilities, or it may be required to load **GENCON II** with software having modified texts (see **Text Editing**). The software is stored in a non-volatile Flash memory. The Flash memory is programmed (written to) by **GENCON II** itself. Flash memories can undergo 10,000 re-programming cycles. You can identify the version of the software resident in **GENCON II** using the COMMAND\HELP.

Prerequisites:

1. The PC should have an RS-485 serial communication port, preferably isolated from the PC ground. The RS-485 transmitter (TX) enable signal should either be DTR, RTS or OUT1. No IRQ line is required.
2. Minimum 15 volt DC power supply for **GENCON II**. The DC supply should be well regulated or loading the software may fail. It is advised to avoid electrical transients while loading software!
3. New software disk.

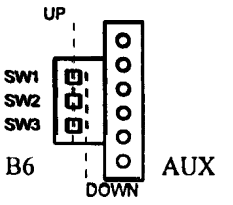
Procedure:

1. Using a long and thin screw-driver prepare the dip switches for Flash programming by: SW2=SW3=DOWN. ***You don't have to open the instrument cover!***
   See also **Dip-switches**.
2. Connect **GENCON II** to the PC RS-485 serial port. Only one controller can now be connected to the PC!
3. Run LOAD.EXE by LOAD SET. Change RS-485 communication port as necessary. If you type LOAD only, the program uses the set of arguments it used last.
4. Turn on **GENCON II** power supply.
5. Press ENTER to begin the software transfer. '>'s appear on the PC screen to indicate transfer progress. PROG message appears on the **GENCON II** LCD. Wait for successful programming completion message
6. Turn off **GENCON II** power supply.
7. Prepare **GENCON II** dip-switches back for normal operation by: SW2=SW3=UP.
8. Turn on **GENCON II** power supply. Press 0 if you are asked to do so.



Automatic text translation

TRAN.EXE is a utility program which picks up translations made for an earlier **GENCON II** software version and automatically introduces them to a newly released English software version. Run the program for further details.



Reading the EEPROM

All **GENCON II** parameters (time-delays, set-points, calibration values, etc.) are kept on a non volatile EEPROM memory. READ.EXE is a utility program for copying the EEPROM data to a disk file.

Procedure:

1. Set the dip-switch SW2 DOWN. The position of SW1 and SW3 is irrelevant.
2. Connect **GENCON II** to the PC RS-485 serial port. Only one controller can be connected.
3. Run READ.EXE by *READ SET* to define the program arguments as follows:
   RS485 port COM number: 1..4 (↵ = 3) ?
   EEPROM file name (↵ = EEPROM) ?
   Software ID (↵ = s17h) ? 's' stands for 'standby'. You can read EEPROMs of earlier software versions, as early as 's14a', and have them subsequently converted to 's17h' automatically by WRITE.EXE.
4. Turn on **GENCON II** power supply. The minimal power supply voltage is 8 volts.
5. Press ENTER.
6. Turn off **GENCON II** power supply.
7. Prepare **GENCON II** dip-switches for normal operation by: SW2=SW3=UP.

Writing the EEPROM -- The Fast Way!

WRITE.EXE is a utility program for copying a file created by READ.EXE to the EEPROM memory. If the EEPROM file was read from an earlier software release, as early as 's14a', its data is automatically converted to the latest 's17h' format.

Procedure:

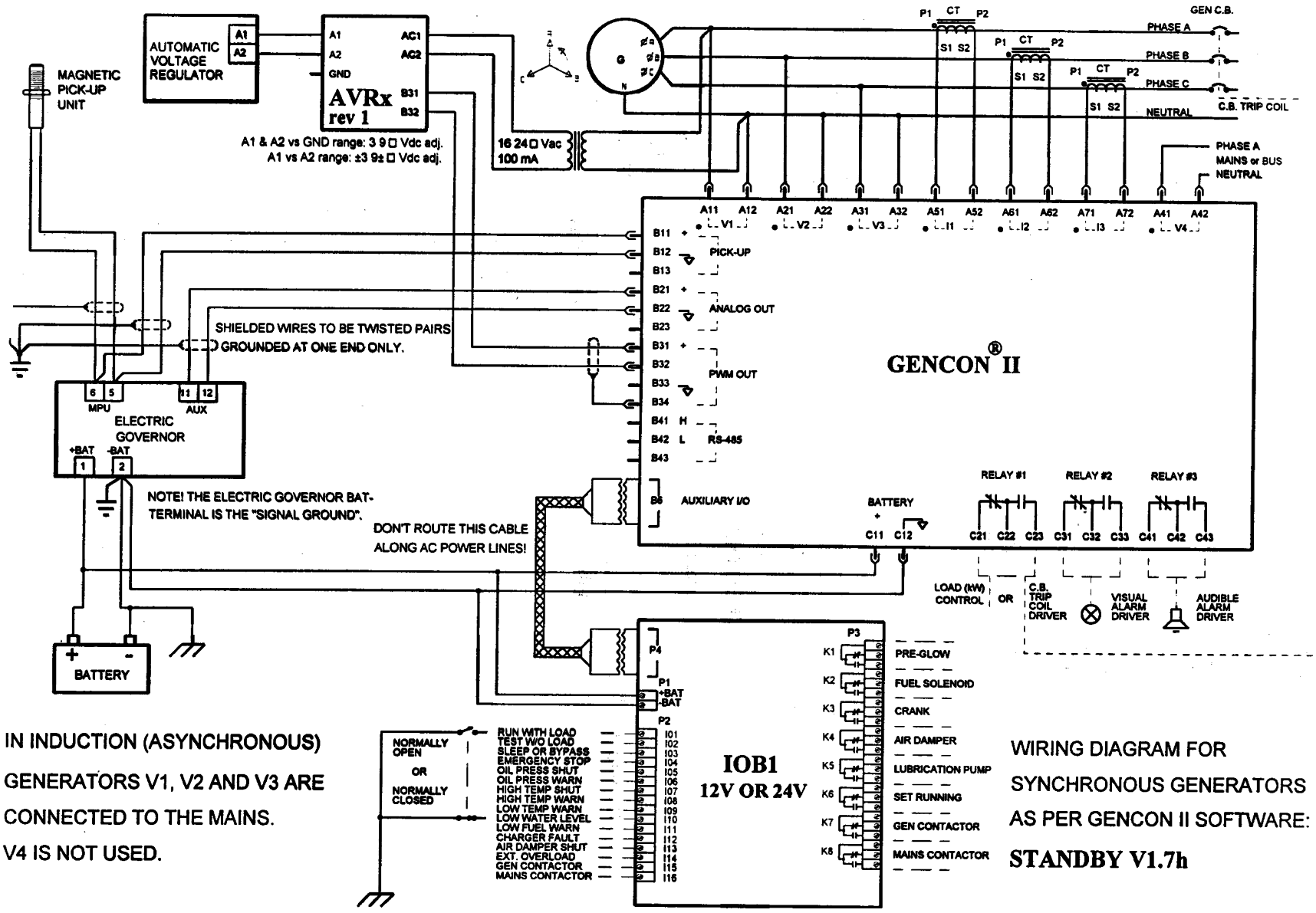
1. Set the dip-switch SW2 DOWN. The position of SW1 and SW3 is irrelevant.
2. Connect **GENCON II** to the PC RS-485 serial port. Only one controller can be connected
3. Run WRITE.EXE by *WRITE SET* to define the program arguments as follows:
   RS485 port COM number: 1..4 (↵ = 3) ?
   EEPROM file name (↵ = EEPROM) ?
4. Turn on **GENCON II** power supply. The minimal power supply voltage is 8 volts.
5. Press ENTER.
6. Turn off **GENCON II** power supply.
7. Prepare **GENCON II** dip-switches for normal operation by: SW2=SW3=UP.

EMC questions for the control panel builder

Electromagnetic interference (EMI) poses serious threats to the correct functioning of modern microprocessor based systems. **GENCON II** was tested under extreme EMI conditions to reduce the risk of erratic control behavior. Nevertheless, the panel designer should make his system electromagnetically compatible (EMC) to reduce the risk that **GENCON II**, even for a brief moment, gets out of control. No effort should be spared if the error message EMI (NOISE) DETECTED is registered even once. Here are the questions that should be asked:

1. Were all the switched inductive loads transients properly suppressed by placing diodes across the DC coils and capacitor-resistors (or varistors) across the AC coils... ?
2. Is **GENCON II** ground "riding" above the governor ground (the recommended method)? If not, choosing the easy method, one should not close noisy ground current paths through B12 and B22.
3. Are the **GENCON II** and **IOB1** ground terminals (bat-) connected by a short wire to the cubicle for electrostatic shielding?
4. Is the **GENCON II** ↔ **IOB1** cable separately routed, ie not loomed with high AC voltage & current wires? and in general...
5. Were all the cables in the system segregated? Cables carrying high frequency interfering currents should be kept away from other cables, even within shielded enclosures. AC power and return, DC power and return, analog controls, digital controls...

Installation Diagram



IN INDUCTION (ASYNCHRONOUS) GENERATORS V1, V2 AND V3 ARE CONNECTED TO THE MAINS. V4 IS NOT USED.

WIRING DIAGRAM FOR SYNCHRONOUS GENERATORS AS PER GENCON II SOFTWARE:

STANDBY V1.7h

Warranty limitation

Wexler warrants each unit it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1 year from date of purchase. This warranty shall not apply to damages caused by lightning or any product or parts which have been subject to misuse, neglect, accident or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, Wexler will repair the instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by a lightning, misuse, neglect, accident or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

ANY IMPLIED WARRANTIES OF MERCHANDISING OR FITNESS FOR A PARTICULAR PURPOSE OR USE SHALL BE LIMITED TO A PERIOD OF TWELVE MONTHS FROM THE DATE OF PURCHASE. THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER EXPRESS WARRANTIES. WEXLER SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify Wexler or the nearest Service Facility, giving full details of the difficulty, and include the serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.
2. On receipt of the shipping instructions, forward the instrument (in a suitable container that is rigid and of adequate size), transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing list unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact Wexler). Final claim and negotiations with the carrier must be completed by the customer.

Publication No: 2H-056
22nd Edition
02/01

STAMFORD

AC GENERATORS FROM
NEWAGE INTERNATIONAL

Installation, Service & Maintenance Manual

for AC generators with the following prefixes:

HCI; HCM; HCK 4,5,6,7.

SAFETY PRECAUTIONS

Before operating the generating set, read the generating set operation manual and this generator manual and become familiar with it and the equipment.

SAFE AND EFFICIENT OPERATION CAN ONLY BE ACHIEVED IF THE EQUIPMENT IS CORRECTLY OPERATED AND MAINTAINED.

Many accidents occur because of failure to follow fundamental rules and precautions.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH.

Observe all **WARNING**/**CAUTION** notices.

- Ensure installation meets all applicable safety and local electrical codes. Have all installations performed by a qualified electrician.
- Do not operate the generator with protective covers, access covers or terminal box covers removed.
- Disable engine starting circuits before carrying out maintenance.
- Disable closing circuits and/or place warning notices on any circuit breakers normally used for connection to the mains or other generators, to avoid accidental closure.

Observe all **IMPORTANT, CAUTION, WARNING, and DANGER** notices, defined as:

Important ! **Important refers to hazard or unsafe method or practice which can result in product damage or related equipment damage.**

Caution ! **Caution refers to hazard or unsafe method or practice which can result in product damage or personal injury.**

Warning !

Warning refers to a hazard or unsafe method or practice which CAN result in severe personal injury or possible death.

Danger !

Danger refers to immediate hazards which WILL result in severe personal injury or death.

Due to our policy of continuous improvement, details in this manual which were correct at time of printing, may now be due for amendment. Information included must therefore not be regarded as binding.

Front Cover Photograph

This photograph is representative only. Several variations are available within the range of generators covered by this manual.

FOREWORD

The function of this book is to provide the user of the Stamford generator with an understanding of the principles of operation, the criteria for which the generator has been designed, and the installation and maintenance procedures. Specific areas where the lack of care or use of incorrect procedures could lead to equipment damage and/or personal injury are highlighted, with **WARNING** and/or **CAUTION** notes, and it is important that the contents of this book are read and understood before proceeding to fit or use the generator.

The Service, Sales and technical staff of Newage International are always ready to assist and reference to the company for advice is welcomed.

Warning !

Incorrect installation, operation, servicing or replacement of parts can result in severe personal injury or death, and/or equipment damage.
Service personnel must be qualified to perform electrical and mechanical service.

EC DECLARATION OF INCORPORATION

All Stamford generators are supplied with a declaration of incorporation for the relevant EC legislation, typically in the form of a label as below.

EC DECLARATION OF INCORPORATION

IN ACCORDANCE WITH THE SUPPLY OF MACHINERY (SAFETY) REGULATIONS 1992 AND THE SUPPLY OF MACHINERY (SAFETY) (AMENDMENT) REGULATIONS 1994 IMPLEMENTING THE EC MACHINERY DIRECTIVE 89/392/EEC AS AMENDED BY 91/368/EEC.

THIS **STAMFORD A.C. GENERATOR** WAS MANUFACTURED BY OR ON BEHALF OF
NEWAGE INTERNATIONAL LTD
BARNACK ROAD STAMFORD LINCOLNSHIRE ENGLAND.

THIS COMPONENT MACHINERY MUST NOT BE PUT INTO SERVICE UNTIL THE MACHINERY INTO WHICH IT IS TO BE INCORPORATED HAS BEEN DECLARED IN CONFORMITY WITH THE PROVISIONS OF THE SUPPLY OF MACHINERY (SAFETY) REGULATIONS 1995/MACHINERY DIRECTIVE.

FOR AND ON BEHALF OF NEWAGE INTERNATIONAL LIMITED

NAME: LAWRENCE HAYDOCK
POSITION: TECHNICAL DIRECTOR
SIGNATURE:

THIS COMPONENT MACHINERY CARRIES THE CE MARK FOR COMPLIANCE WITH THE STATUTORY REQUIREMENTS FOR THE IMPLEMENTATION OF THE FOLLOWING DIRECTIVES

WARNING! The EMC Directive 89/336/EEC
This Component Machinery shall not be used in the Residential, Commercial and Light Industrial environment unless it also conforms to the relevant standard (EN 50081 - 1) REFER TO FACTORY FOR DETAILS

ii) The Low Voltage Directive 73/23/EEC as amended by 93/68/EEC

CE

ELECTROMAGNETIC COMPATIBILITY

Additional Information

European Union
Council Directive 89/336/EEC

For installations within the European Union, electrical products must meet the requirements of the above directive, and Newage ac generators are supplied on the basis that:

- They are to be used for power-generation or related function.
- They are to be applied in one of the following environments:

  Portable (open construction - temporary site supply)
  Portable (enclosed - temporary site supply)
  Containerised (temporary or permanent site supply)
  Ship-borne below decks (marine auxiliary power)
  Commercial vehicle (road transport / refrigeration etc)
  Rail transport (auxiliary power)
  Industrial vehicle (earthmoving, cranes etc)
  Fixed installation (industrial - factory / process plant)
  Fixed installation (residential, commercial and light industrial - home / office / health)
  Energy management (Combined heat and power and/or peak lopping)
  Alternative energy schemes

- The standard generators are designed to meet the 'industrial' emissions and immunity standards. Where the generator is required to meet the residential, commercial and light industrial emissions and immunity standards reference should be made to Newage document reference N4/X/011, as additional equipment may be required.
- The installation earthing scheme involves connection of the generator frame to the site protective earth conductor using a minimum practical lead length.
- Maintenance and servicing with anything other than factory supplied or authorised parts will invalidate any Newage liability for EMC compliance.
- Installation, maintenance and servicing is carried out by adequately trained personnel fully aware of the requirements of the relevant EC directives

CONTENTS

CONTENTS

SECTION 1

INTRODUCTION

1.1 INTRODUCTION

The HC range of generators is of brushless rotating field design, available up to 660V at 50 Hz or 60 Hz and built to meet BS5000 Part 3 and international standards.

1500 rpm (50Hz) or 1800 rpm (60Hz) 4 pole generators are available from 200kW to 2000kW in four frame sizes - HC4, HC5, HC6 and HC7.

1000 rpm (50Hz) or 1200 rpm (60Hz) 6 pole generators are available from 224kW to 1300kW in two frame sizes - HC6 and HC7.

Frame sizes HC4 and HC5 may be provided with a stator fed excitation system using SX440 or SX421 AVR, or with the permanent magnet generator (PMG) powered excitation system, using the MX341 or MX321 AVR.

Frames HC6 and HC7 are fitted with the PMG system using the MX321 AVR.

1.2 DESIGNATION

H	C	·	I	4	4	4	C	1
H	C	·	M	5	3	4	C	2
H	C	·	I	6	3	4	G	1
H	C	·	I	6	3	6	G	2
H	C	·	M	7	3	4	G	2

GENERATOR TYPE HC

SPECIFIC TYPE K = VOLUTED ADAPTOR AND UNI-DIRECTIONAL FAN

INDUSTRIAL = (I) OR MARINE = (M)

FRAME SIZE AND CONTROL TYPE ON HC/MV

NUMBER OF POLES 4, OR 6

CORE LENGTH

NUMBER OF BEARINGS 1 OR 2

1.3 SERIAL NUMBER LOCATION

Each generator has its unique serial number stamped in to the upper section of the drive end frame end-ring.

Inside the terminal box two adhesive rectangular labels have been fixed, each carrying the generators unique identity number. One label has been fixed to the inside of the terminal box sheet metal work, and the second label fixed to the main frame of the generator.

1.4 RATING PLATE AND CE MARK

The generator has been supplied with a self adhesive rating plate label to enable fitting after final assembly and painting. It is intended that this label will be stuck to the outside of the non drive end of the terminal box.

A CE Mark label is also supplied loose for fitment after final assembly and painting. This should be attached to an external surface of the Generator at a suitable location where it will not be obscured by the customer's wiring or other fittings. Before fitting the CE Mark label the genset builder must address the requirements of the relevant EC legislation to ensure the compliance of the genset as a whole. CE compliance will also need to be addressed when installed on site.

The surface in the area where a label is to be stuck must be flat, clean, and any paint finish be fully dry before attempting to attach label. Recommended method for attaching label is peel and fold back sufficient of the backing paper to expose some 20 mm of label adhesive along the edge which is to be located against the sheet metal protrusions. Once this first section of label has been carefully located and stuck into position the backing paper can be progressively removed, as the label is pressed down into position. The adhesive will achieve a permanent bond in 24 hours.

SECTION 2

PRINCIPLE OF OPERATION

2.1 SELF-EXCITED AVR CONTROLLED GENERATORS

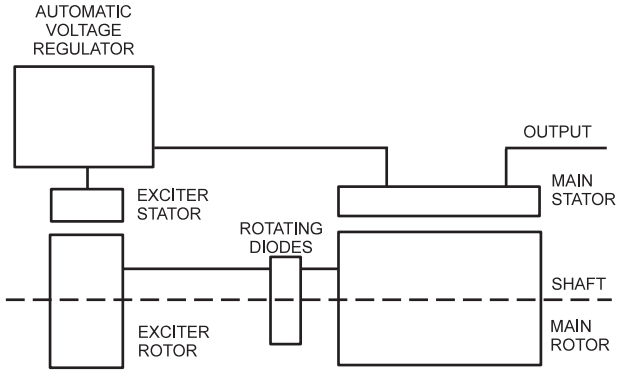


Fig. 1

The main stator provides power for excitation of the exciter field via the SX440 (or SX421) AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The SX440 AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.

The SX421 AVR in addition to the SX440 features has three phase rms sensing and also provides for over voltage protection when used in conjunction with an external circuit breaker (switchboard mounted).

2.2 PERMANENT MAGNET GENERATOR (PMG) EXCITED - AVR CONTROLLED GENERATORS

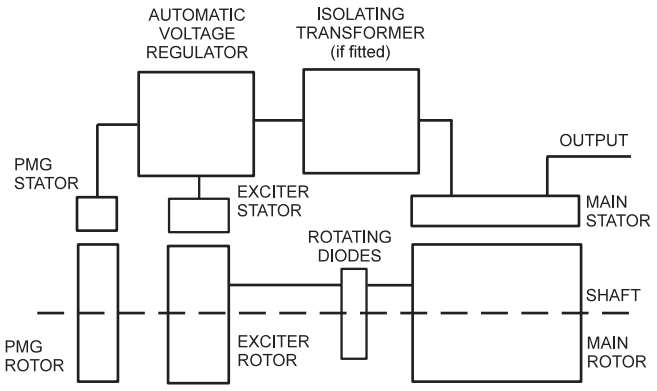


Fig. 2

The permanent magnet generator (PMG) provides power for excitation of the exciter field via the AVR MX341 (or MX321) which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived, via an isolating transformer in the case of MX321 AVR, from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The PMG system provides a constant source of excitation power irrespective of main stator loading and provides high motor starting capability as well as immunity to waveform distortion on the main stator output created by non linear loads, e.g. thyristor controlled dc motor.

The MX341 AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides an adjustable voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine. It also provides over-excitation protection which acts following a time delay, to de-excite the generator in the event of excessive exciter field voltage.

The MX321 provides the protection and engine relief features of the MX341 and additionally incorporates 3 phase rms sensing and over-voltage protection.

The detailed function of all the AVR circuits is covered in the load testing section (subsection 4.7).

2.3 AVR ACCESSORIES

The SX440, SX421, MX341 and MX321 AVRs incorporate circuits which, when used in conjunction with accessories, can provide for parallel operation either with 'droop' or 'astatic' control, VAR/PF control and in the case of the MX321 AVR, short circuit current limiting.

Function and adjustment of the accessories which can be fitted inside the generator terminal box are covered in the accessories section of this book.

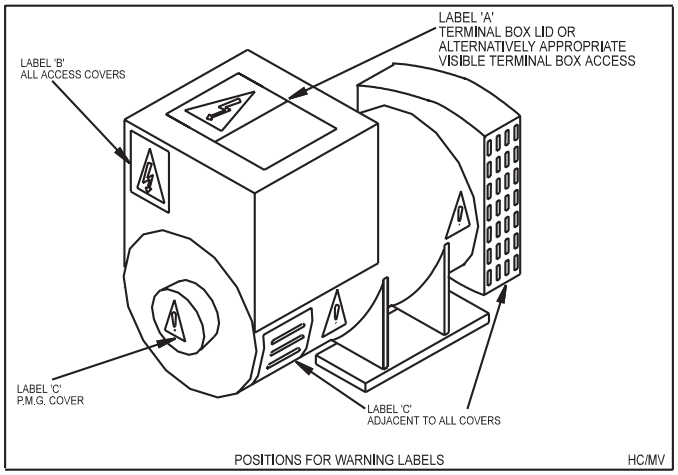
Separate instructions are provided with other accessories available for control panel mounting.

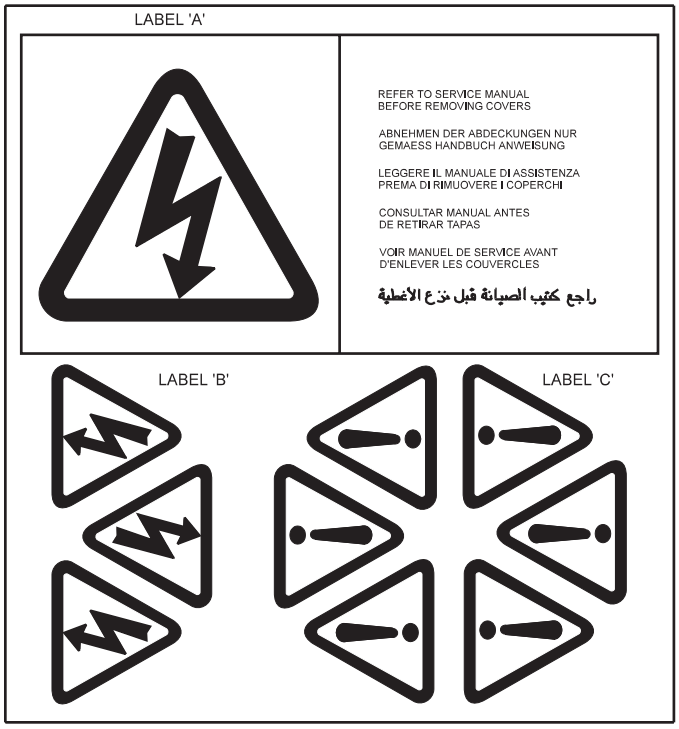
SECTION 3

APPLICATION OF THE GENERATOR

The generator is supplied as a component part for installation in a generating set. It is not, therefore, practicable to fit all the necessary warning/hazard labels during generator manufacture. The additional labels required are packaged with this Manual, together with a drawing identifying their locations. (see below).

It is the responsibility of the generating set manufacturer to ensure that the correct labels are fitted, and are clearly visible.





The generators have been designed for use in a maximum ambient temperature of 40°C, and altitude less than 1000 metres above sea level in accordance with BS5000.

Ambients in excess of 40°C, and altitudes above 1000 metres can be tolerated with reduced ratings - refer to the generator nameplate for rating and ambient.

In the event that the generator is required to operate in an ambient in excess of the nameplate value or at altitudes in excess of 1000 metres above sea level, refer to the factory.

The generators are of air-ventilated screen protected drip-proof design and are not suitable for mounting outdoors unless adequately protected by the use of canopies. Anti-condensation heaters are recommended during storage and for standby duty to ensure winding insulation is maintained in good condition.

When installed in a closed canopy it must be ensured that the ambient temperature of the cooling air to the generator does not exceed that for which the generator has been rated.

The canopy should be designed such that the engine air intake to the canopy is separated from the generator intake, particularly where the radiator cooling fan is required to draw air into the canopy. In addition the generator air intake to the canopy should be designed such that the ingress of moisture is prohibited, preferably by use of a two stage filter.

The air intake/outlet must be suitable for the air flow given in the following table with additional pressure drops less than or equal to those given below:

Frame	Air Flow		Additional (intake/outlet) Pressure Drop
	50Hz 1500 Rev/Min	60Hz 1800 Rev/Min	
HC4	0.48m³/sec	0.58m³/sec	6mm water gauge
	1030cfm	1240cfm	(0.25")
HCK4	0.68m³/sec	0.83m³/sec	6mm water gauge
	1450cfm	1760cfm	(0.25")
HC5	1.04m³/sec	1.31m³/sec	6mm water gauge
	2202cfm	2708cfm	(0.25")
HCK5	1.23m³/sec	1.59m³/sec	6mm water gauge
	2615cfm	3366cfm	(0.25")
HC6	1.62m³/sec	1.96m/sec	6mm water gauge
	3420cfm	4156cfm	(0.25")
HC7	2.64m³/sec	3.17m³/sec	6mm water gauge
	5600cfm	6720cfm	(0.25")
HCK7	3.0m³/sec	3.70m³/sec	6mm water gauge
	6550cfm	7860cfm	(0.25")

Table 1

If specified at the time of ordering, HC6 and HC7 generators may be fitted with air filters. Air filters can be supplied factory fitted or as parts for up-fit for the HC4 and HC5 generators. These are oil charged gauze filters and require charging during installation.

Important ! **Reduction in cooling air flow or inadequate protection to the generator can result in damage and/or failure of windings.**

Dynamic balancing of the generator rotor assembly has been carried out during manufacture in accordance with BS 6861 Part 1 Grade 2.5 to ensure vibration limits of the generator are in accordance with BS 4999 Part 142.

The main vibration frequencies produced by the component generator are as follows:-:

4 pole	1500 rpm	25 Hz
	1800 rpm	30 Hz
6 pole	1000 rpm	16.7 Hz
	1200 rpm	20 Hz

3.1 VIBRATION

Vibrations generated by the engine are complex and contain harmonics of 1.5, 3, 5 or more times the fundamental frequency of vibration. The generator will be subjected to this vibration, which will result in the generator being subjected to vibration levels higher than those derived from the generator itself.

Newage generators are designed to withstand the vibration levels encountered on generating sets built to meet the requirements of ISO 8528-9 and BS5000-3. (Where ISO 8528 is taken to be broad band measurements and BS5000 refers to the predominant frequency of any vibrations on the generating set.)

DEFINITION OF BS5000 - 3

Generators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25mm between 5Hz and 8Hz and velocities of 9.0mm/s rms between 8 Hz and 200 Hz when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

DEFINITION OF ISO 8528 - 9

ISO 8528-9 refers to a broad band of frequencies, the broad band is taken to be between 2 Hertz and 300 Hertz. The table below is an example from ISO 8528 - 9 (value 1). This simplified table lists the vibration limits by kVA range and speed for acceptable genset operation.

VIBRATION LEVELS AS MEASURED ON THE GENERATOR				
Engine Speed Min -^{1}	**SET OUTPUT kVA**	**VIBRATION DISPLACEMENT mm (rms)**	**VIBRATION VELOCITY mm/s (rms)**	**VIBRATION ACCELERATION m/s^{2} (rms)**
4 POLE 1500 rpm 50 Hz 1800 rpm 60 HZ	≤ 10 kVA	-	-	-
	> 10 but ≤ 50 Kva	0.64	40	25
	> 50 but ≤ 125 kVA	0.4	25	16
	> 125 but ≤ 250 kVA	0.4	25	16
	> 250 kVA	0.32	20	13
6 POLE 1000 rpm 50 Hz 1200 rpm 60 Hz	≥ 250 but ≤ 1250	0.32	20	13
	> 1250	0.29	18	11
The 'Broad band' is taken as 2 Hz - 300 Hz.				

Table 2

It is the responsibility of the generating set designer to ensure the alignment of the genset, stiffness of the bedframe and mountings are such that the vibration limits as defined above are met.

If the vibration levels of the generating set are not within the parameters quoted above :-

1. Consult the genset builder. The genset builder should address the genset design to reduce the vibration levels as much as possible.

2. Discuss, with Newage, the impact of not meeting the above levels on both bearing and generator life expectancy.

Important ! **Exceeding either of the above specifications will have a detrimental effect on the generating set and in particular on the life of the bearings. (See section on bearings). This will invalidate the generator warranty. If you are in any doubt, contact Newage International Limited.**

In standby applications where the running time is limited and reduced life expectancy is accepted, higher levels than specified in BS5000 can be tolerated, up to a maximum of 18mm/sec.

Two bearing generators require a substantial bedplate with engine/generator mounting pads to ensure a good base for accurate alignment. Close coupling of engine to generator can increase the overall rigidity of the set. A flexible coupling, designed to suit the specific engine/generator combination, is recommended to minimise torsional effects.

Alignment of single bearing generators is critical and vibration can occur due to the flexing of the flanges between the engine and generator. A substantial bedplate with engine/generator mounting pads is required.

For the purposes of establishing set design the bending moment at the engine flywheel housing to generator adaptor interface should not exceed that given in the table below:-

FRAME	BENDING MOMENT
4/5	140 kgm. (1000ft.lbs.)
6/7	275 kgm. (2000ft.lbs.)

The maximum bending moment of the engine flange must be checked with the engine manufacturer.

Torsional vibrations occur in all engine-driven shaft systems and may be of a magnitude to cause damage at certain critical speeds. It is therefore necessary to consider the torsional vibration effect on the generator shaft and couplings.

It is the responsibility of the generator set manufacturer to ensure compatibility, and for this purpose drawings showing the shaft dimensions and rotor inertias are available for customers to forward to the engine supplier. In the case of single bearing generators coupling details are included.

Important ! **Torsional incompatibility and/or excessive vibration levels can cause damage or failure of generator and/or engine components.**

The standard terminal box is arranged for cable entry on the right hand side looking from the non drive end of the generator. If specified at the time of order cable entry may be arranged on the opposite side.

The terminal box is constructed with removable panels for easy adaptation to suit specific glanding requirements. Within the terminal box there are insulated terminals for line and neutral connections and provision for earthing. Additional earthing points are provided on the generator feet.

Warning ! **No earth connections are made on the generator and reference to site regulations for earthing must be made. Incorrect earthing or protection arrangements can result in personal injury or death.**

The neutral is NOT connected to the frame.

Fault current curves (decrement curves), together with generator reactance data, are available on request to assist the system designer to select circuit breakers, calculate fault currents and ensure discrimination within the load network.

Warning ! **Incorrect installation, service or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service.**

SECTION 4

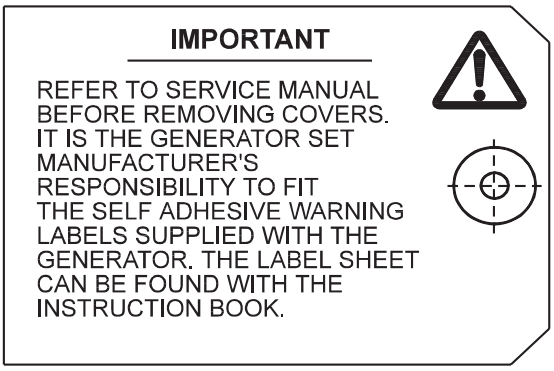
INSTALLATION - PART 1

4.1 LIFTING

Warning !

Incorrect lifting or inadequate lifting capacity can result in severe personal injury or equipment damage. MINIMUM LIFTING CAPACITY REQUIRED IS AS INDICATED ON THE LIFTING LABEL. Generator lifting lugs should not be used for lifting the complete generating set.

Two lifting lugs are provided for use with a shackle and pin type lifting aid. A spreader with chains to ensure that the lift is vertical of suitable length and lifting capacity must be used. Lifting points are designed to position the craneage point as close to the centre of gravity of the generator as possible, but due to design restrictions it is not possible to guarantee that the generator frame will remain horizontal while lifting. Care is therefore needed to avoid personal injury or equipment damage. The correct lifting arrangement is shown on the label attached to the lifting lug. (See sample below).



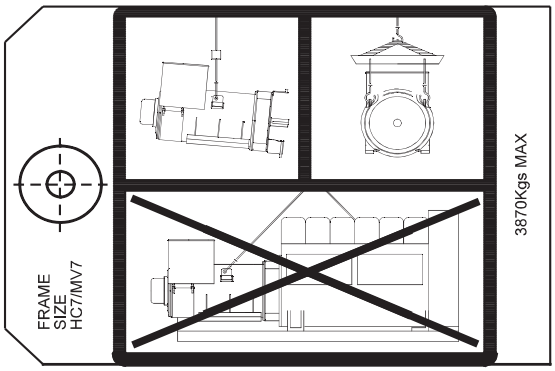


Fig. 3

Single bearing generators are supplied fitted with a rotor retaining bar at the drive end of the shaft. Single bearing generators are also fitted with wooden wedges supporting the fan for transit purposes.

Once the bar is removed to couple the rotor to engine, the rotor is free to move in the frame, and care is needed during coupling and alignment to ensure the frame is kept in the horizontal plane.

4.2 ENGINE TO GENERATOR COUPLING ASSEMBLY

During the assembly of the Generator to the Engine it will be necessary to firstly carefully align, then rotate, the combined Generator rotor - Engine crankshaft assembly, as part of the construction process, to allow location, insertion and tightening of the coupling bolts. This requirement to rotate the combined assemblies exists for both single and two bearing units.

During the construction of single bearing units it is necessary to align the generator's coupling holes with the engine flywheel holes: it is suggested that two diametrically opposite location dowel pins are fitted to the engine flywheel, over which the generator coupling can slide into final location into the engine flywheel spigot recess. The dowels must be removed and replaced by coupling bolts before the final bolt tightening sequence.

While fitting and tightening the coupling bolts it will be necessary to rotate the Engine crankshaft - Generator rotor assembly. Care should be taken to ensure that rotation is carried out in an approved manner that ensures safe working practice when reaching inside the machine to insert or tighten coupling bolts, and that no component of the assembly is damaged by non-approved methods of assembly rotation.

Engine Manufacturers have available a proprietary tool designed to enable manual rotation of the crankshaft assembly. This tool must always be used, having been engineered as an approved method of assembly rotation, by engaging the manually driven pinion with the engine flywheel starter ring-gear.

Danger !

Before working inside the generator, during the aligning and fitting of coupling bolts, care should be taken to lock the assembly to ensure there is no possibility of assembly rotational movement.

4.2.1 TWO BEARING GENERATORS

A flexible coupling should be fitted and aligned in accordance with the coupling manufacturer's instruction.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary. Ensure adaptor guards are fitted after generator/engine assembly is complete. Open coupled sets require a suitable guard, to be provided by the set builder.

Axial loading of the generator bearings should be avoided. Should it be unavoidable contact the factory for advice.

Caution ! **Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.**

4.2.2 SINGLE BEARING GENERATORS TYPES HC & HCK

For transit and storage purposes the generator frame spigot and rotor coupling plates have been coated with a rust preventative. This MUST BE removed before assembly to engine.

A practical method for removal of this coating is to clean the mating surface areas with a de-greasing agent based on a petroleum solvent.

Caution ! **Care should be taken not to allow any cleaning agent to come into prolonged contact with skin.**

Alignment of single bearing generators is critical. If necessary shim the generator feet to ensure alignment of the machined surfaces.

The sequence of assembly to the engine should generally be as follows:

1. On the engine check the distance from the coupling mating face on the flywheel to the flywheel housing mating face. This should be within 0.5mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the ac generator bearing or engine bearing.

2. Check that the bolts securing the flexible plates to the coupling hub are tight and locked into position. Refer to Section 7, subsection 7.5.3.4 for tightening torques.

3. Remove covers from the drive end of the generator to gain access to coupling and adaptor bolts. Check coupling joint interfaces are clean and lubricant free.

4. **TYPE HC GENERATORS**

   Check that coupling discs are concentric with adaptor spigot. This can be adjusted by the use of tapered wooden wedges between the fan and adaptor. Alternatively the rotor can be suspended by means of a rope sling through the adaptor opening.

   Offer the generator to engine and engage both coupling discs and housing spigots at same time, pushing generator towards engine until coupling discs are against flywheel face, and housing spigots located.

   TYPE HCK GENERATORS

   Screw the two supplied location studs into diametrically opposite engine flywheel tapped holes, about the horizontal centre line. Offer the generator to engine, locating rotor coupling discs over the location studs, pushing generator towards engine until housing spigots locate and coupling discs are against flywheel face.

5. Fit housing and coupling bolts taking care to use heavy gauge washers between coupling bolt head and coupling disc. Tighten bolts evenly around assembly sufficiently to ensure correct alignment.

   TYPE HCK GENERATORS

   Remove location studs and replace with coupling-flywheel bolts.

6. Tighten housing bolts.

7. Tighten coupling disc to flywheel bolts. Refer to engine manufacturers manual for correct tightening torque.

8. **TYPE HC GENERATORS**

   Remove rotor aligning aids, either wooden wedges, or the two M10 set screws and sheet metal wear plates.

Caution ! **Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.**

4.3 EARTHING

The generator frame should be solidly bonded to the generating set bedplate. If antivibration mounts are fitted between the generator frame and its bedplate a suitably rated earth conductor (normally one half of the cross sectional area of the main line cables) should bridge across the antivibration mount.

Warning ! **Refer to local regulations to ensure that the correct earthing procedure has been followed.**

4.4 PRE-RUNNING CHECKS

4.4.1 INSULATION CHECK

Insulation tests should be carried out before running the generating set, both after assembly and after installation on site. (see Section 7.1).

Important ! **The windings have been H.V. tested during manufacture and further H.V. testing may degrade the insulation with consequent reduction in operating life. Should it be necessary to demonstrate H.V. testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage= 0.8 (2 X Rated Voltage + 1000)**

4.4.2 DIRECTION OF ROTATION

4.4.2.1 FAN TYPES.

TYPE HC 4 & 5 GENERATORS.

These machines are fitted with a radial bladed bi-directional fan, operating within a conventional full height air outlet grills.

TYPE HC 6 & 7 GENERATORS.

These machines are fitted with an inclined bladed fan , operating within a conventional full height air outlet grills.

TYPE HCK 4, 5, & 7 GENERATORS.

These machines are fitted with a inclined bladed fan, operating within a voluted drive end adaptor with outlet grills half thee machine height . Designed to optimise the fans performance.

4.4.2.2 DIRECTION OF ROTATION

TYPE HCK GENERATORS.

These machines have been designed with an improved cooling fan system, incorporating the voluted fan housing. Therefore these machines are suitable only for clockwise rotation, as viewed from the drive end.

TYPE HC GENERATORS.

These machines can be operated in either direction of rotation.

Phase Rotation

HC generators can rotate efficiently in either direction. However phase rotation is fixed for clockwise rotation as viewed from the drive end. If the generator is to be rotated in a counter-clockwise direction it will be necessary for the customers to adjust their cabling to the output terminals accordingly. Refer to the factory for a reverse wiring diagram.

4.4.3 VOLTAGE AND FREQUENCY

Check that the voltage and frequency levels required for the generating set application are as indicated on the generator nameplate.

HC4/5 generators normally have a 12 ends out reconnectable winding. If it is necessary to reconnect the stator for the voltage required, refer to diagrams in the back of this manual.

4.4.4 AVR SETTINGS

To make AVR selections and adjustments remove the AVR cover and refer to 4.4.4.1, 4.4.4.2, 4.4.4.3 or 4.4.4.4 depending upon type of AVR fitted. Reference to the generator nameplate will indicate AVR type (SX440, SX421, MX341 or MX321).

Most of the AVR adjustments are factory set in positions which will give satisfactory performance during initial running tests. Subsequent adjustment may be required to achieve optimum performance of the set under operating conditions. Refer to 'Load Testing' section for details.

4.4.4.1 TYPE SX440 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 4a for location of selection links.

1. Frequency selection terminals

50Hz operation	LINK C-50
60Hz operation	LINK C-60

2. Stability selection terminals

Frame HC4/5	LINK B-C
Frame HC6/7	LINK A-B

3. Sensing selection terminals

LINK 2-3
LINK 4-5
LINK 6-7

4. Excitation Interruption Link

LINK K1-K2

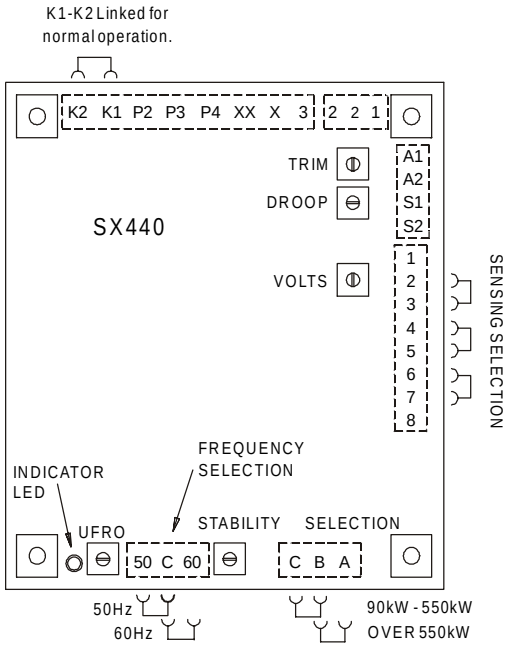


Fig. 4a

4.4.4.2 TYPE SX421 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 4b for location of selection links.

1.Frequency selection terminals

50Hz operation	LINK C-50
60Hz operation	LINK C-60

2.Stability selection terminals

Frame HC4/5	LINK B-C
Frame HC6/7	LINK A-B

3. Excitation Interruption Link

Linked at auxiliary terminal block. K1-K2

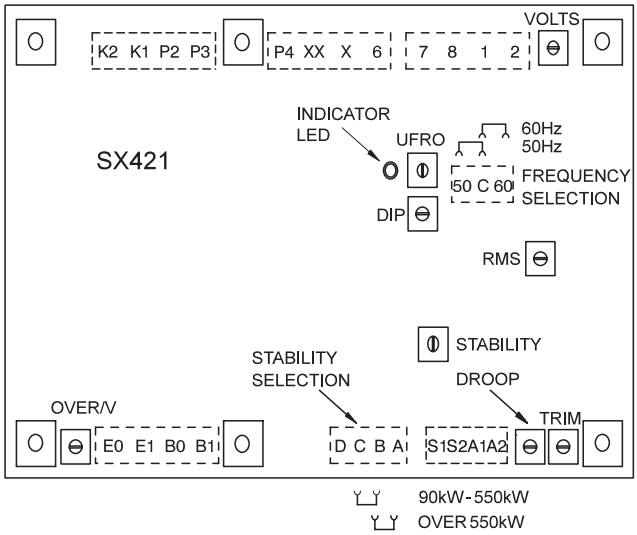


Fig. 4b

4.4.4.3 TYPE MX341 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 4c for location of selection links.

4 pole	50Hz operation	LINK 2-3
4 pole	60Hz operation	LINK 1-3
6 pole	50Hz operation	NO LINK
6 pole	60Hz operation	LINK 1-2

2. Stability selection terminals

Frame HC4/5	LINK B-C
Frame HC6/7	LINK A-B

3. Sensing selection terminals

LINK 2-3
LINK 4-5
LINK 6-7

4. Excitation Interruption Link

LINK K1-K2

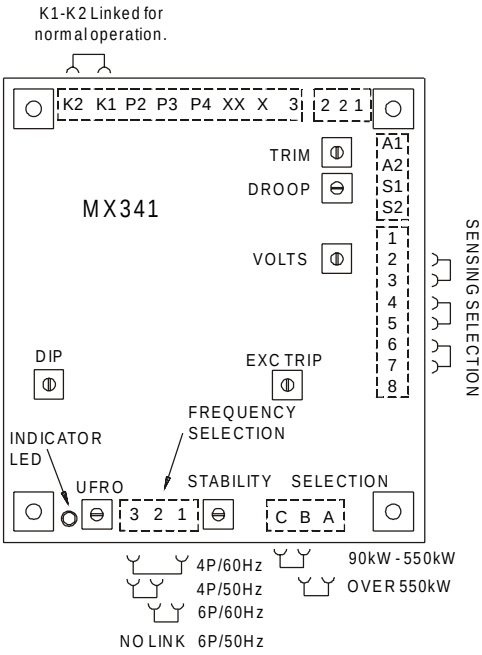


Fig. 4c

4.4.4.4 TYPE MX321 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

Refer to Fig. 4d for location of selection links.

1. Frequency selection terminals

4 pole	50Hz operation	LINK 2-3
4 pole	60Hz operation	LINK 1-3
6 pole	50Hz operation	NO LINK
6 pole	60Hz operation	LINK 1-2

2. Stability selection terminals

Frame HC4/5	LINK B-C
Frame HC6/7	LINK A-B

3. Excitation Interruption Link

Linked at auxiliary terminal block. K1-K2

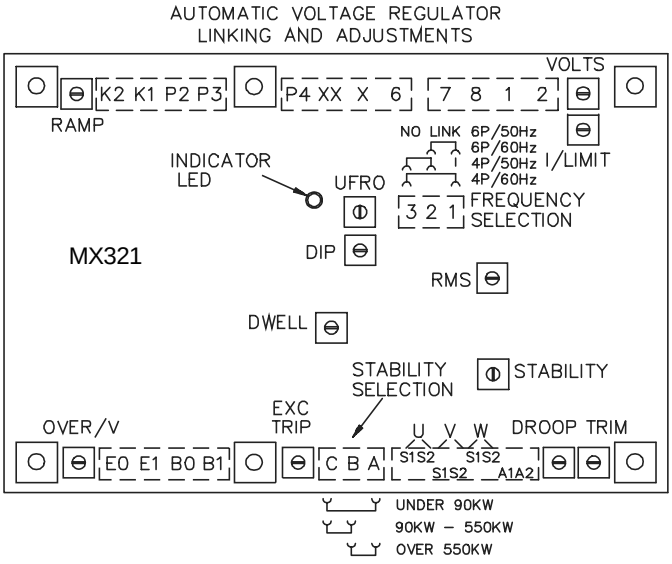


Fig. 4d

4.5 GENERATOR SET TESTING

Warning !

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments.

4.5.1 TEST METERING/CABLING

Connect any instrument wiring and cabling required for initial test purposes with permanent or spring-clip type connectors.

Minimum instrumentation for testing should be line - line or line to neutral voltmeter, Hz meter, load current metering and kW meter. If reactive load is used a power factor meter is desirable.

Important ! **When fitting power cables for load testing purposes, ensure cable voltage rating is at least equal to the generator rated voltage. The load cable termination should be placed on top of the winding lead termination and clamped between the two nuts provided, on HC4/5 generators.**

Caution ! **Check that all wiring terminations for internal or external wiring are secure, and fit all terminal box covers and guards. Failure to secure wiring and/or covers may result in personal injury and/or equipment failure.**

4.6 INITIAL START-UP

Warning !

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

On completion of generating set assembly and before starting the generating set ensure that all engine manufacturer's pre-running procedures have been completed, and that adjustment of the engine governor is such that the generator will not be subjected to speeds in excess of 125% of the rated speed.

Important ! **Overspeeding of the generator during initial setting of the speed governor can result in damage to the generator rotating components.**

In addition remove the AVR access cover and turn VOLTS control fully anti-clockwise. Start the generating set and run on no-load at nominal frequency. Slowly turn VOLTS control potentiometer clockwise until rated voltage is reached. Refer to Fig. 4a - 4d for control potentiometer location.

Important ! **Do not increase the voltage above the rated generator voltage shown on the generator nameplate.**

The STABILITY control potentiometer will have been pre-set and should normally not require adjustment, but should this be required, usually identified by oscillation of the voltmeter, refer to Fig. 4a - 4d for control potentiometer location and proceed as follows:-

1. Run the generating set on no-load and check that speed is correct and stable.

2. Turn the STABILITY control potentiometer clockwise, then turn slowly anti-clockwise until the generator voltage starts to become unstable.

The correct setting is slightly clockwise from this position (i.e. where the machine volts are stable but close to the unstable region).

4.7 LOAD TESTING

Warning !

During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.

4.7.1 AVR ADJUSTMENTS

Refer to Fig. 4a - 4d for control potentiometer locations.

Having adjusted VOLTS and STABILITY during the initial start-up procedure, other AVR control functions should not normally need adjustment. If instability on load is experienced recheck stability setting. Refer to subsection 4.6.

If however, poor voltage regulation on-load or voltage collapse is experienced, refer to the following paragraphs on each function to a) check that the symptoms observed do indicate adjustment is necessary, and b) to make the adjustment correctly.

4.7.1.1 UFRO (Under Frequency Roll Off) (AVR Types SX440, SX421, MX341 and MX321)

The AVR incorporates an underspeed protection circuit which gives a voltage/speed (Hz) characteristic as shown:

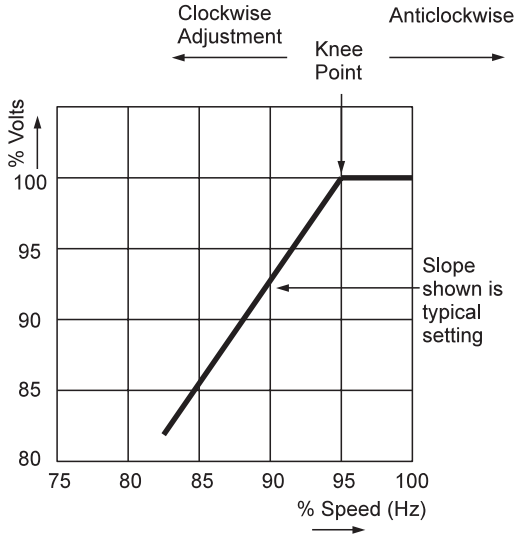


Fig. 5

The UFRO control potentiometer sets the "knee point".

Symptoms of incorrect setting are a) the light emitting diode (LED) indicator, just above the UFRO Control potentiometer, being permanently lit when the generator is on load, and b) poor voltage regulation on load, i.e. operation on the sloping part of the characteristic.

Clockwise adjustment lowers the frequency (speed) setting of the "knee point" and extinguishes the LED. For Optimum setting the LED should illuminate as the frequency falls just below nominal frequency, i.e. 47Hz on a 50Hz generator or 57Hz on a 60Hz generator.

Important ! **With AVR Types MX341 and MX321. If the LED is illuminated and no output voltage is present, refer to EXC TRIP and/or OVER/V sections below.**

4.7.1.2 EXC TRIP (Excitation Trip) AVR Types MX341 and MX321

An AVR supplied from a permanent magnet generator inherently delivers maximum excitation power on a line to line or line to neutral short circuit. In order to protect the generator windings the AVR incorporates an over excitation circuit which detects high excitation and removes it after a pre-determined time, i.e. 8-10 seconds.

Symptoms of incorrect setting are the generator output collapses on load or small overload, and the LED is permanently illuminated.

The correct setting is 70 volts +/- 5% between terminals X and XX.

4.7.1.3 OVER/V (Over Voltage) AVR Types SX421 and MX321

Over voltage protection circuitry is included in the AVR to remove generator excitation in the event of loss of AVR sensing input.

The MX321 has both internal electronic de-excitation and provision of a signal to operate an external circuit breaker.
The SX421 only provides a signal to operate an external breaker, which MUST be fitted if over voltage protection is required.
Incorrect setting would cause the generator output voltage to collapse at no-load or on removal of load, and the LED to be illuminated.

The correct setting is 300 volts +/-5% across terminals E1, E0.

Clockwise adjustment of the OVER/V control potentiometer will increase the voltage at which the circuit operates.

4.7.1.4 TRANSIENT LOAD SWITCHING ADJUSTMENTS AVR Types SX421, MX341 and MX321

The additional function controls of DIP and DWELL are provided to enable the load acceptance capability of the generating set to be optimised. The overall generating set performance depends upon the engine capability and governor response, in conjunction with the generator characteristics.

It is not possible to adjust the level of voltage dip or recovery independently from the engine performance, and there will always be a 'trade off' between frequency dip and voltage dip.

DIP-AVR Types SX421, MX341 and MX321

The dip function control potentiometer adjusts the slope of the voltage/speed (Hz) characteristic below the knee point as shown below:

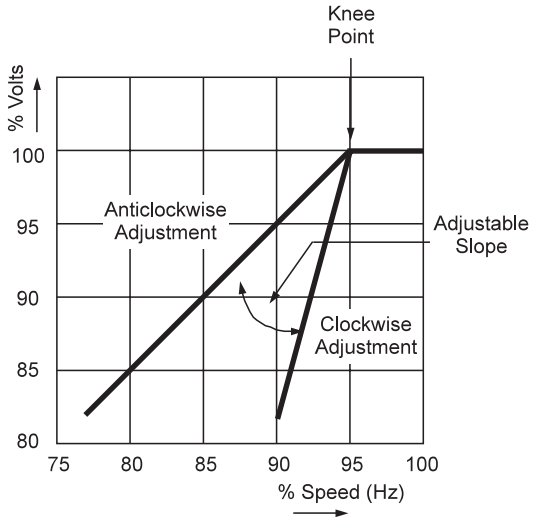


Fig. 6

DWELL-AVR Type MX321

The dwell function introduces a time delay between the recovery of voltage and recovery of speed.

The purpose of the time delay is to reduce the generator kW below the available engine kW during the recovery period, thus allowing an improved speed recovery.

Again this control is only functional below the "knee point", i.e. if the speed stays above the knee point during load switching there is no effect from the DWELL function setting.

Clockwise adjustment gives increased recovery time.

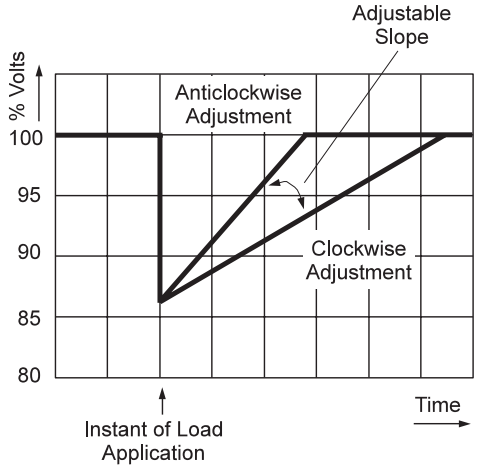


Fig. 7

The graphs shown above are representations only, since it is impossible to show the combined effects of voltage regulator and engine governor performance.

Warning !

Failure to refit covers can result in operator personal injury or death.

4.7.1.5 RAMP
AVR Type MX321

The RAMP potentiometer enables adjustment of the time taken for the generator's initial build up to normal rated voltage during each start and run up to speed. The potentiometer is factory set to give a ramp time of three seconds, which is considered to be suitable for most applications. This time can be reduced to one second by turning the pot. fully counter clockwise, and increased to eight seconds by turning the pot. fully clockwise.

4.8 ACCESSORIES

Refer to the "ACCESSORIES" Section of this Manual for setting up procedures related to generator mounted accessories.

If there are accessories for control panel mounting supplied with the generator refer to the specific accessory fitting procedures inserted inside the back cover of this book.

Replace AVR access cover after all adjustments are completed.

SECTION 5

INSTALLATION - PART 2

5.1 GENERAL

The extent of site installation will depend upon the generating set build, e.g. if the generator is installed in a canopied set with integral switchboards and circuit breaker, on site installation will be limited to connecting up the site load to the generating set output terminals. In this case reference should be made to the generating set manufacturer's instruction book and any pertinent local regulations.

If the generator has been installed on a set without switchboard or circuit breaker the following points relating to connecting up the generator should be noted.

5.2 GLANDING

The terminal box is arranged for glanding on the right hand side (or if specifically ordered on the left hand side) viewed from the non drive end. Both panels are removable for drilling/ punching to suit glands/or glanding boxes. If single core cables are taken through the terminal box side panel an insulated or non-magnetic gland plate should be fitted.

At entry to the terminal box incoming cables should be supported by a recognised glanding method such that minimum unsupported weight, and no axial force is transferred to the terminal assembly.

Incoming cables external to the terminal box should be supported at a sufficient distance from the centre line of the generating set so as to avoid a tight radius at the point of entry into the terminal box panel, and allow movement of the generator set on its anti-vibration mountings without excessive stress on the cable.

Before making final connections, test the insulation resistance of the windings. The AVR should be disconnected during this test and RTD leads grounded.

A 500V Megger or similar instrument should be used. Should the insulation resistance be less than 5MΩ the windings must be dried out as detailed in the Service and Maintenance section of this manual.

When making connections to the terminals of Frame 4 generators, the incoming cable termination lug should be placed on top of the winding lead termination lug(s) and then clamped with the nut provided.

Important ! **To avoid the possibility of swarf entering any electrical components in the terminal box, panels must be removed for drilling.**

5.3 TORQUE SETTINGS FOR TERMINAL CONNECTIONS

Pre treatment: Clean plated surfaces with a degreasing agent, then lightly abrade them to remove any tarnish. Don't score the surface.

The **generator torque settings** for all connections, links, CT's, accessories, cables, etc. is 45 Nm.

The **customer output cables** should be connected to the terminals using 8.8 grade steel bolts and associated anti-vibration hardware.

The following table is for your guidance.

FRAME	HOLE SIZE	BOLT SIZE	TORQUE Nm
4	-	12	45
5	13	12	50
6	17	14	70
7	17	16	90

Table 3

Carry out **periodic checks** to ensure the correct torque settings.

5.4 EARTHING

The neutral of the generator is not bonded to the generator frame as supplied from the factory. An earth terminal is provided inside the terminal box adjacent to the main terminals. Should it be required to operate with the neutral earthed a substantial earth conductor (normally equivalent to one half of the section of the line conductors) must be connected between the neutral and the earth terminal inside the terminal box. It is the responsibility of the generating set builder to ensure the generating set bedplate and generator frame are all bonded to the main earth terminal in the terminal box.

Caution ! **Reference to local electricity regulations or safety rules should be made to ensure correct earthing procedures have been followed.**

5.5 PROTECTION

It is the responsibility of the end user and his contractors/sub-contractors to ensure that the overall system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site location.

To enable the system designer to achieve the necessary protection and/or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made.

Warning ! **Incorrect installation and/or protective systems can result in personal injury and/or equipment damage. Installers must be qualified to perform electrical installation work.**

5.6 COMMISSIONING

Ensure that all external cabling is correct and that all the generating set manufacturer's pre-running checks have been carried out before starting the set.

Generators fitted with air filters should have the filters charged with oil prior to commissioning. Refer to Service Section for charging procedure (subsection 7.3.2).

The generator AVR controls will have been adjusted during the generating set manufacturer's tests and should normally not require further adjustment.

Should malfunction occur during commissioning refer to Service and Maintenance section 'Fault Finding' procedure (subsection 7.4).

SECTION 6

ACCESSORIES

Generator control accessories may be fitted, as an option, in the generator terminal box. If fitted at the time of supply, the wiring diagram(s) in the back of this book shows the connections. When the options are supplied separately, fitting instructions are provided with the accessory.

The following table indicates availability of accessories with the differing AVRs.

AVR Model	Paralleling Droop or Astatic	Manual Voltage Regulator	VAr/PF Control	Current Limit
SX440	✔	✖	✔	✖
SX421	✔	✖	✔	✖
MX341	✔	✔	✔	✖
MX321	✔	✔	✔	✔

Table 4

6.1 REMOTE VOLTAGE ADJUST (ALL AVR TYPES)

A remote voltage adjust (hand trimmer) can be fitted.

The remote voltage adjustment potentiometer is connected across AVR terminals 1-2.

These terminals are normally linked.

When the remote voltage adjust potentiometer is used the link across terminals 1-2 must be removed.

On AVR types SX440 and MX341 the link 1-2 is on an adjacent terminal block.

On AVR types SX421 and MX321 the link 1-2 is on the AVR terminals.

6.2 PARALLEL OPERATION

Understanding of the following notes on parallel operation is useful before attempting the fitting or setting of the droop kit accessory. When operating in parallel with other generators or the mains, it is essential that the phase sequence of the incoming generator matches that of the busbar and also that all of the following conditions are met before the circuit breaker of the incoming generator is closed on to the busbar (or operational generator).

1. Frequency must match within close limits.
2. Voltages must match within close limits.
3. Phase angle of voltages must match within close limits.

A variety of techniques, varying from simple synchronising lamps to fully automatic synchronisers, can be used to ensure these conditions are met.

Once connected in parallel a minimum instrumentation level per generator of voltmeter, ammeter, wattmeter (measuring total power per generator), and frequency meter is required in order to adjust the engine and generator controls to share kW in relation to engine ratings and kVAr in relation to generator ratings.

Important ! **Failure to meet conditions 1, 2, and 3 when closing the circuit breaker, will generate excessive mechanical and electrical stresses, resulting in equipment damage.**

It is important to recognise that

1. kW are derived from the engine, and speed governor characteristics determine the kW sharing between sets

and

2. kVAr are derived from the generator, and excitation control characteristics determine the kVAr sharing.

Reference should be made to the generating set manufacturer's instructions for setting the governor controls.

6.2.1 DROOP

The most commonly used method of kVAr sharing is to create a generator voltage characteristic which falls with decreasing power factor (increasing kVAr). This is achieved with a current transformer (C.T.) which provides a signal dependent on current phase angle (i.e. power factor) to the AVR.

The current transformer has a burden resistor on the AVR board, and a percentage of the burden resistor voltage is summed into the AVR circuit. Increasing droop is obtained by turning the DROOP control potentiometer clockwise.

The diagrams below indicate the effect of droop in a simple two generator system:-

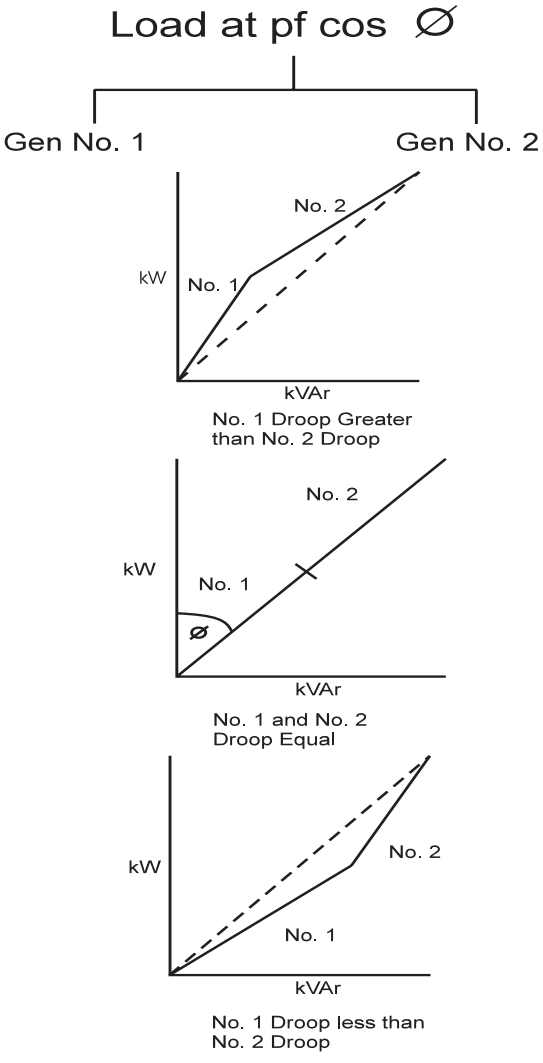


Fig. 8

Generally 5% droop at full load current zero p.f. is sufficient to ensure kVAr sharing.

If the droop accessory has been supplied with the generator it will have been tested to ensure correct polarity and set to a nominal level of droop. The final level of droop will be set during generating set commissioning.

Although nominal droop setting may be factory set it is advisable to go through the setting procedure below.

6.2.1.1 SETTING PROCEDURE

Depending upon available load the following settings should be used - all are based on rated current level.

0.8 P.F. LOAD	(at full load current)	SET DROOP TO 3%
Zero P.F. LOAD	(at full load current)	SET DROOP TO 5%

Setting the droop with low power factor load is the most accurate.

Run each generator as a single unit at rated frequency or rated frequency + 4% depending upon type of governor and nominal voltage. Apply available load to rated current of the generator. Adjust 'DROOP' control potentiometer to give droop in line with above table. Clockwise rotation increases amount of droop. Refer to Fig. 4a - 4d for potentiometer locations.

Note 1)
Reverse polarity of the C.T. will raise the generator voltage with load. The polarities S1-S2 shown on the wiring diagrams are correct for clockwise rotation of the generator looking at the drive end. Reversed rotation requires S1-S2 to be reversed.

Note 2)
The most important aspect is to set all generators equal. The precise level of droop is less critical.

Note 3)
A generator operated as a single unit with a droop circuit set at rated load 0.8 power factor is unable to maintain the usual 0.5% regulation. A shorting switch can be connected across S1-S2 to restore regulation for single running.

Important ! **LOSS OF FUEL to an engine can cause its generator to motor with consequent damage to the generator windings. Reverse power relays should be fitted to trip main circuit breaker.**
LOSS OF EXCITATION to the generator can result in large current oscillations with consequent damage to generator windings. Excitation loss detection equipment should be fitted to trip main circuit breaker.

6.2.2 ASTATIC CONTROL

The 'droop' current transformer can be used in a connection arrangement which enables the normal regulation of the generator to be maintained when operating in parallel.

This feature is only supplied from the factory as a fitted droop kit, however, if requested at the time of order, the diagrams inside the back cover of this book will give the necessary site connections. The end user is required to provide a shorting switch for the droop current transformer secondary.

Important ! **When using this connection arrangement a shorting switch is required across each C.T. burden (terminals S1 and S2.)**
The switch must be closed a) when a generating set is not running and b) when a generating set is selected for single running.

Should the generator be required to be converted from standard droop to 'astatic' control, diagrams are available on request.

The setting procedure is exactly the same as for DROOP. (Subsection 6.2.1.1)

6.3 MANUAL VOLTAGE REGULATOR (MVR) - MX341 and MX321 AVR

This accessory is provided as an 'emergency' excitation system, in the event of an AVR failure.

Powered from a PMG output the unit is manually set, but automatically controls the excitation current, independent of generator voltage or frequency.

The unit is provided with 'MANUAL', 'OFF', 'AUTO' switching facility.

'MANUAL'
- position connects the exciter field to the MVR output. Generator output is then controlled by the operator adjusting the excitation current.

'OFF'
- disconnects the exciter field from both MVR and the normal AVR.

'AUTO'
- connects the exciter field to the normal AVR and the generator output is controlled at the pre-set voltage under AVR control.

6.4 OVERVOLTAGE DE-EXCITATION BREAKER SX421 and MX321 AVR

This accessory provides positive interruption of the excitation power in the event of overvoltage due to loss of sensing or internal AVR faults including the output power device.

With the MX321 AVR this accessory is supplied loose for fitting in the control panel.

In the case of the SX421 the circuit breaker is always supplied and will normally be fitted in the generator.

Important ! **When the CB is supplied loose, terminals K1-K2 at the auxiliary terminal block are fitted with a link to enable operation of the AVR. When connecting the circuit breaker this link must be removed.**

6.4.1 RESETTING THE EXCITATION BREAKER

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".

Danger !

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.

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

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 subsection 7.5.

6.5 CURRENT LIMIT - MX321 AVR

These accessories work in conjunction with the AVR circuits to provide an adjustment to the level of current delivered into a fault. One current transformer (CT) per phase is fitted to provide current limiting on any line to line or line to neutral fault.

Note: The W phase CT can also provide "DROOP". Refer to 6.2.1.1. for setting droop independent of current limit.

Adjustment means is provided with the "I/LIMIT" control potentiometer on the AVR. Refer to Fig. 4d for location. If current limit transformers are supplied with the generator the limit will be set in accordance with the level specified at the time of order, and no further adjustment will be necessary. However, should the level need to be adjusted, refer to the setting procedure given in 6.5.1.

6.5.1 SETTING PROCEDURE

Run the generating set on no-load and check that engine governor is set to control nominal speed.

Stop the generating set. Remove the link between terminals K1-K2 at the auxiliary terminal block and connect a 5A switch across the terminals K1-K2.

Turn the "I/LIMIT" control potentiometer fully anticlockwise. Short circuit the stator winding with a bolted 3 phase short at the main terminals. An AC current clip-on ammeter is required to measure the winding lead current.

With the switch across K1-K2 open start the generating set.

Close the switch across K1-K2 and turn the "I/LIMIT" control potentiometer clockwise until required current level is observed on the clip-on ammeter. As soon as correct setting is achieved open the K1-K2 switch.

Should the current collapse during the setting procedure, the internal protective circuits of the AVR will have operated. In this event shut down the set and open the K1-K2 switch. Restart the set and run for 10 minutes with K1-K2 switch open, to cool the generator windings, before attempting to resume the setting procedure.

Important ! **Failure to carry out the correct COOLING procedure may cause overheating and consequent damage to the generator windings.**

6.6 POWER FACTOR CONTROLLER (PFC3)

This accessory is primarily designed for those generator applications where operation in parallel with the mains supply is required.

Protection against loss of mains voltage or generator excitation is not included in the unit and the system designer must incorporate suitable protection.

The electronic control unit requires both droop and kVAr current transformers. When supplied with the generator, wiring diagrams inside the back cover of this manual show the connections and the additional instruction leaflet provided gives details of setting procedures for the power factor controller (PFC3).

The unit monitors the power factor of the generator current and adjusts excitation to maintain the power factor constant.

This mode can also be used to control the power factor of the mains if the point of current monitoring is moved to the mains cables. Refer to the factory for appropriate details.

It is also possible to operate the unit to control kVAr of the generator if required. Refer to the factory for appropriate details.

SECTION 7

SERVICE AND MAINTENANCE

As part of routine maintenance procedures, periodic attention to winding condition (particularly when generators have been idle for a long period) and bearings is recommended. (Refer to subsections 7.1 and 7.2 respectively).

When generators are fitted with air filters regular inspection and filter maintenance is required. (Refer to subsection 7.3).

7.1 WINDING CONDITION

Warning !

Service and fault finding procedures present hazards which can result in severe personal injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures.
Ensure engine starting circuits are disabled before commencing service or maintenance procedures. Isolate any anti-condensation heater supply.

Guidance of Typical Insulation Resistance [IR] Values

The following is offered as general information about IR values and is aimed at providing guidance about the typical IR values for generators from new through to the point of refurbishment.

New Machines

The generators Insulation Resistance, along with many other critical factors, will have been measured during the alternator manufacturing process. The generator will have been transported with an appropriate packaging suitable for the method of delivery to the Generating Set assemblers works. Where we expect it to be stored in a suitable location protected from adverse environmental conditions.

However, absolute assurance that the generator will arrive at the Gen-set production line with IR values still at the factory test levels of above 100 MΩ cannot be guaranteed.

At Generating Set Manufacturers Works

The generator should have been transported and stored such that it will be delivered to the assembly area in a clean dry condition. If held in appropriate storage conditions the generator IR value should typically be 25 MΩ.

If the unused/new generators IR values fall below 10 MΩ then a drying out procedure should be implemented by one of the processes outlined below before being despatched to the end customer's site. Some investigation should be undertaken into the storage conditions of the generator while on site.

Generators in Service

Whilst It is known that a generator will give reliable service with an IR value of just 1.0 MΩ. For a relatively new generator to be so low it must have been subjected to inappropriate operating or storage conditions.

Any temporarily reduction in IR values can be restored to expected values by following one of the drying out procedures.

7.1.1 WINDING CONDITION ASSESSMENT

Caution ! **The AVR should be disconnected and the Resistance Temperature Detector (R.T.D.) leads grounded during this test.**

The condition of the windings can be assessed by measurement of insulation resistance [IR] between phase to phase, and phase to earth.

Measurement of winding insulation should be carried out: -

1. As part of a periodic maintenance plan.
2. After prolonged periods of shutdown.
3. When low insulation is suspected, e.g. damp or wet windings.

Care should be taken when dealing with windings that are suspected of being excessively damp or dirty. The initial measurement of the [IR] Insulation Resistance should be established using a low voltage (500V) megger type instrument. If manually powered the handle should initially be turned slowly so that the full test voltage will not be applied, and only applied for long enough to very quickly assess the situation if low values are suspected or immediately indicated.

Full megger tests or any other form of high voltage test should not be applied until the windings have been dried out and if necessary cleaned.

Procedure for Insulation Testing

Disconnect all electronic components, AVR, electronic protection equipment etc. Ground the [RTD's] Resistance Temperature Detection devices if fitted. Short out the diodes on the rotating diode assembly. Be aware of all components connected to the system under test that could cause false readings or be damaged by the test voltage.

Carry out the insulation test in accordance with the 'operating instructions for the test equipment.

The measured value of insulation resistance for all windings to earth and phase to phase should be compared with the guidance given above for the various 'life stages' of a generator. The minimum acceptable value must be greater than 1.0 MΩ.

If low winding insulation is confirmed use one or more of the methods, given below, for drying the winding should be carried out.

7.1.2 METHODS OF DRYING OUT GENERATORS

Cold Run

Consider a good condition generator that has not been run for some time, and has been standing in damp, humid conditions. It is possible that simply running the gen set unexcited - AVR terminals K1 K2 open circuit - for a period of say 10 minutes will sufficiently dry the surface of the windings and raise the IR sufficiently, to greater than 1.0 MΩ , and so allow the unit to be put into service.

Blown Air Drying

Remove the covers from all apertures to allow the escape of the water-laden air. During drying, air must be able to flow freely through the generator in order to carry off the moisture.

Direct hot air from two electrical fan heaters of around 1 – 3 kW into the generator air inlet apertures. Ensure the heat source is at least 300mm away from the windings to avoid over heating and damage to the insulation.

Apply the heat and plot the insulation value at half hourly intervals. The process is complete when the parameters covered in the section entitled, 'Typical Drying Out Curve', are met.

Remove the heaters, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest prior to running.

Short Circuit Method

NOTE: This process should only be performed by a competent engineer familiar with safe operating practices within and around generator sets of the type in question.

Ensure the generator is safe to work on, initiate all mechanical and electrical safety procedures pertaining to the genset and the site.

Bolt a short circuit of adequate current carrying capacity, across the main terminals of the generator. The shorting link should be capable of taking full load current.

Disconnect the cables from terminals “X” and “XX” of the AVR.

Connect a variable dc supply to the “X” (positive) and “XX” (negative) field cables. The dc supply must be able to provide a current up to 2.0 Amp at 0 - 24 Volts.

Position a suitable ac ammeter to measure the shorting link current.

Set the dc supply voltage to zero and start the generating set. Slowly increase the dc voltage to pass current through the exciter field winding. As the excitation current increases, so the stator current in the shorting link will increase. This stator output current level must be monitored, and not allowed to exceed 80% of the generators rated output current.

After every 30 minutes of this exercise:
Stop the generator and switch off the separate excitation supply, and measure and record the stator winding IR values, and plot the results. The resulting graph should be compared with the classic shaped graph. This drying out procedure is complete when the parameters covered in the section entitled 'Typical Drying Out Curve' are met.

Once the Insulation Resistance is raised to an acceptable level - minimum value 1.0 MΩ – the dc supply may be removed and the exciter field leads “X” and “XX” re-connected to their terminals on the AVR.

Rebuild the genset, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest the generator prior to running.

TYPICAL DRYING OUT CURVE

Whichever method is used to dry out the generator the resistance should be measured every half-hour and a curve plotted as shown. (fig 6.)

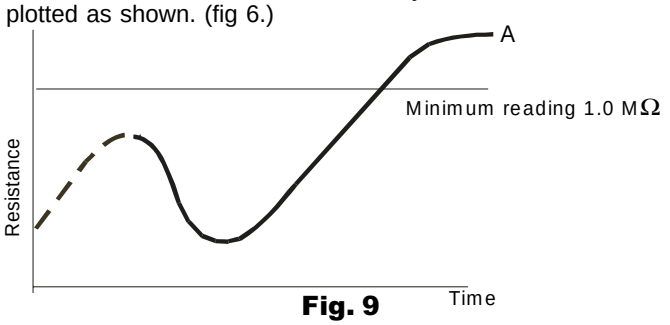


Fig. 9

The illustration shows a typical curve for a machine that has absorbed a considerable amount of moisture. The curve indicates a temporary increase in resistance, a fall and then a gradual rise to a steady state. Point ‘A’, the steady state, must be greater than 1.0 MΩ. (If the windings are only slightly damp the dotted portion of the curve may not appear).

For general guidance expect that the typical time to reach point 'A' will be:

1 hour for a BC16/18,
2 hours for a UC22/27
3 hours for an HC4,5,6&7

Drying should be continued after point “A” has been reached for at least one hour.

It should be noted that as winding temperature increases, values of insulation resistance may significantly reduce. Therefore, the reference values for insulation resistance can only be established with windings at a temperature of approximately 20°C.

If the IR value remains below 1.0 MΩ, even after the above drying methods have been properly conducted, then a Polarisation Index test [PI] should be carried out.

If the minimum value of 1.0 MΩ for all components cannot be achieved rewinding or refurbishment of the generator will be necessary.

The generator must not be put into service until the minimum values can be achieved.

Important ! The short circuit must not be applied with the AVR connected in circuit. Current in excess of the rated generator current will cause damage to the windings.

After drying out, the insulation resistances should be rechecked to verify minimum resistances quoted above are achieved.
On re-testing it is recommended that the main stator insulation resistance is checked as follows:-
Separate the neutral leads

Ground	V and W	phase and megger	U phase to ground
Ground	U and W	phase and megger	V phase to ground
Ground	U and V	phase and megger	W phase to ground

If the minimum value of 1.0MΩ is not obtained, drying out must be continued and the test repeated.

7.2 BEARINGS

One of two bearing options will be fitted to generators covered by this manual.

Bearing Options		
HC/HCK/HCM	**Regreasable***	**Sealed for life*†**
4	Not available	Standard
5	Optional	Standard
6	Optional	Standard
7	Standard	Not available

Table 5

***All bearings are supplied pre-packed with Kluber Asonic GHY 72 grease.
†Sealed for life bearings are fitted with integral seals and are not regreasable.

BEARING LIFE

Important ! The life of a bearing in service is subject to the working conditions and the environment.

Important ! High levels of vibration from the engine or misalignment of the set will stress the bearing and reduce its service life. If the vibration limits set out in BS 5000-3 and ISO 8528-9 are exceeded bearing life will be reduced. Refer to ‘Vibration’ below.

Important ! Long stationary periods in an environment where the generator is subject to vibration can cause false brinnelling, which puts flats on the ball and grooves on the races, leading to premature failure.

Important ! **Very humid atmospheric or wet conditions can emulsify the grease causing corrosion and deterioration of the grease, leading to premature failure of the bearings.**

HEALTH MONITORING OF THE BEARINGS

Newage recommends that the user checks the bearing condition, using monitoring equipment, to determine the state of the bearings. The 'best practice' is to take initial readings as a base line and periodically monitor the bearings to detect a deteriorating trend. It will then be possible to plan a bearing change at an appropriate generating set or engine service interval.

VIBRATION

Newage generators are designed to withstand the vibration levels encountered on generating sets built to meet the requirements of ISO 8528-9 and BS5000-3. (Where ISO 8528 is taken to be broad band measurements and BS5000 refers to the predominant frequency of any vibrations on the generating set.)

DEFINITION of BS5000 - 3

Generators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25mm between 5Hz and 8Hz and velocities of 9.0mm/s rms between 8 Hz and 200 Hz when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

DEFINITION of ISO 8528 - 9

ISO 8528-9 refers to a broad band of frequencies, the broad band is taken to be between 2 Hertz and 300 Hertz. The table below is an example from ISO 8528 - 9 (value 1). This simplified table lists the vibration limits by kVA range and speed for acceptable genset operation.

VIBRATION LEVELS AS MEASURED ON THE GENERATOR				
Engine Speed Min -^{1}	**SET OUTPUT kVA**	**VIBRATION DISPLACEMENT mm (rms)**	**VIBRATION VELOCITY mm/s (rms)**	**VIBRATION ACCELERATION m/s^{2} (rms)**
4 POLE 1500 rpm 50 Hz 1800 rpm 60 HZ	≤ 10 kVA	-	-	-
	> 10 but ≤ 50 Kva	0.64	40	25
	> 50 but ≤ 125 kVA	0.4	25	16
	> 125 but ≤ 250 kVA	0.4	25	16
	> 250 kVA	0.32	20	13
6 POLE 1000 rpm 50 Hz 1200 rpm 60 Hz	≥ 250 but ≤ 1250	0.32	20	13
	> 1250	0.29	18	11
The 'Broad band' is taken as 2 Hz - 300 Hz.				

Table 6

Important ! **Exceeding either of the above specifications will have a detrimental effect on the life of the bearing. This will invalidate the generator warranty. If you are in any doubt, contact Newage International Limited.**

If the vibration levels of the generating set are not within the parameters quoted above :-

1. Consult the genset builder. The genset builder should address the genset design to reduce the vibration levels as much as possible.

2. Discuss, with Newage, the impact of not meeting the above levels on both bearing and generator life expectancy.

Where requested, or deemed necessary, Newage will work with the genset builder in an attempt to find a satisfactory solution.

BEARING 'SERVICE LIFE' EXPECTANCY

Bearing manufacturers recognise that the "service life" of their bearings is dependent upon many factors that are not in their control, they cannot therefore quote a "service life".

Although "service life" cannot be guaranteed, it can be maximised by attention to the generating set design. An understanding of the genset application will also help the user to maximise the service life expectancy of the bearings. Particular attention should be paid to the alignment, reduction of vibration levels, environmental protection, maintenance and monitoring procedures.

Newage does not quote life expectancy figures for bearings, but suggests practicable replacement intervals based on the L10 life of the bearing, the grease and the recommendations of the bearing and grease manufacturers.

For general-purpose applications, providing the vibration levels do not exceed the levels stated in ISO 8528-9* and BS5000-3* and the ambient temperature does not exceed 50°C the following approximations can be applied when planning bearing replacements.
*(see section on vibration)

Sealed for Life Bearings. - Approximately 30,000 hours.

Re-greaseable bearings. - Approximately 40,000 hours.

(Provided the correct maintenance is carried out, and only Kluber Asonic GHY 72 grease is used in all bearings.)

It is important to note that bearings in service, under good operating conditions, can continue to run beyond the recommended replacement period. It should also be remembered that the risk of bearing failure increases with time.

If in doubt about any aspect of the 'bearing life' on generators supplied by Newage International, contact your nearest Newage subsidiary or contact the Stamford factory direct.

See the back cover for addresses.

7.3 AIR FILTERS

Air filters for the removal of airbourne particulate matter (dust) are offered as an addition to the standard build option. Filters on Frame 6 and 7 need to be ordered with the generator but Frame 4 and 5 can have air filters fitted after the generator is built.

Air filters need to be changed with oil before the gen set is put to work (see 7.3.1).

The frequency of filter maintenance will depend upon the severity of the site conditions. Regular inspection of the elements will be required to establish when cleaning is necessary.

Danger !

Removal of filter elements enables access to LIVE parts.
Only remove elements with the generator out of service.

7.3.1 CLEANING PROCEDURE

Remove the filter elements from the filter frames. Immerse or flush the element with a suitable degreasing agent until the element is clean.

As an alternative procedure a high pressure water hose with a flat nozzle can be used. Sweep the water spray back and forth across the element from the clean side (fine mesh side of element) holding the nozzle firmly against the element surface. Cold water may be adequate depending upon type of contamination although hot water is preferable.

The element can be inspected for cleanliness by looking through the filter towards the light.

When thoroughly clean, no cloudy areas will be seen. Dry elements thoroughly before attempting to carry out the recharging procedure.

7.3.2 RECHARGING (CHARGING)

Charging is best done by totally immersing the dry element into a dip tank containing "Filterkote Type K" or commercial lubricating oil SAE 20/50. Oils of higher or lower viscosity are not recommended.

Allow elements to completely drain before refitting the elements into the frames and putting into service.

7.4 FAULT FINDING

Important ! Before commencing any fault finding procedures examine all wiring for broken or loose connections.

Four types of excitation control system, involving four types of AVR, can be fitted to the range of generators covered by this manual. The systems can be identified by a combination of AVR type, where applicable, and the last digit of the generator frame size designation. Refer to the generator nameplate then proceed to the appropriate subsection as indicated below:-

DIGIT	EXCITATION CONTROL	SUBSECTION
4	SX440 AVR	7.4.1
4	SX421 AVR	7.4.2
3	MX341 AVR	7.4.3
3	MX321 AVR	7.4.4

7.4.1 SX440 AVR - FAULT FINDING

No voltage build-up when starting set	1. Check link K1-K2. 2. Check speed. 3. Check residual voltage. Refer to subsection 7.4.5. 4. Follow separate excitation test procedure to check generator and AVR. Refer to subsection 7.5.
Unstable voltage either on no-load or with load	1. Check speed stability. 2. Check stability setting. Refer to subsection 4.6.
High voltage either on no-load or with load	1. Check speed. 2. Check that generator load is not capacitive (leading power factor).
Low voltage no-load	1. Check speed. 2. Check link 1-2 or external hand trimmer leads for continuity.
Low voltage on-load	1. Check speed. 2. Check UFRO setting. Refer to subsection 4.7.1.1. 3. Follow separate excitation procedure to check generator and AVR. Refer to subsection 7.5.

Table 7

7.4.2 SX421 AVR - FAULT FINDING

No voltage build-up when starting set	1. Check circuit breaker ON. Refer to subsection 6.4.1. 2. Check speed. 3. Check residual voltage. Refer to subsection 7.4.5. 4. Follow separate excitation test procedure to check generator and AVR. Refer to subsection 7.5.
Unstable voltage either on no-load or with load	1. Check speed stability. 2. Check stability setting. Refer to subsection 4.6.
High voltage either on no-load or with load	1. Check speed. 2. Check link 1-2 or external hand trimmer leads for continuity. Check continuity of leads 7-8 and P3-P2 for continuity. 3. Check that generator load is not capacitive (leading power factor).
Low voltage no-load	1. Check speed. 2. Check link 1-2 or external hand trimmer leads for continuity.
Low voltage on-load	1. Check speed. 2. Check UFRO setting. Refer to subsection 4.7.1.1. 3. Follow separate excitation procedure to check generator and AVR. Refer to subsection 7.5.
Excessive voltage/speed dip on load switching	1. Check governor response. 2. Refer to generating set manual. Check 'DIP' setting. Refer to subsection 4.7.1.4.

Table 8

7.4.3 MX341 AVR - FAULT FINDING

No voltage build-up when starting set	1. Check link K1-K2 on auxiliary terminals. 2. Follow Separate Excitation Test Procedure to check machine and AVR. Refer to subsection 7.5.
Loss of voltage when set running	1. First stop and re-start set. If no voltage or voltage collapses after short time, follow Separate Excitation Test Procedure. Refer to subsection 7.5.
Generator voltage high followed by collapse	1. Check sensing leads to AVR. 2. Refer to Separate Excitation Test Procedure. Refer to subsection 7.5.
Voltage unstable, either on no-load or with load	1. Check speed stability. 2. Check "STAB" setting. Refer to Load Testing section for procedure. Refer to subsection 4.6.
Low voltage on-load	1. Check speed. 2. If correct check "UFRO" setting. Refer to subsection 4.7.1.1.
Excessive voltage/speed dip on load switching	1. Check governor response. Refer to generating set manual. Check "DIP" setting. Refer to subsection 4.7.1.4.
Sluggish recovery on load switching	1. Check governor response. Refer to generating set manual.

Table 9

7.4.4 MX321 AVR - FAULT FINDING

No voltage build-up when starting set	1. Check link K1-K2 on auxiliary terminals. Follow Separate Excitation Test Procedure to check machine and AVR. Refer to subsection 7.5.
Voltage very slow to build up	1. Check setting of ramp potentiometer. Refer to 4.7.1.5
Loss of voltage when set running	1. First stop and re-start set. If no voltage or voltage collapses after short time, follow Separate Excitation Test Procedure. Refer to subsection 7.5.
Generator voltage high followed by collapse	1. Check sensing leads to AVR. 2. Refer to Separate Excitation Test Procedure. Refer to subsection 7.5.
Voltage unstable, either on no-load or with load	1. Check speed stability. 2. Check "STAB" setting. Refer to Load Testing section for procedure. Refer to subsection 4.6.
Low voltage on-load	1. Check speed. 2. If correct check "UFRO" setting. Refer to subsection 4.7.1.1.
Excessive voltage/speed dip on load switching	1. Check governor response. Refer to generating set manual. Check "DIP" setting. Refer to subsection 4.7.1.4.
Sluggish recovery on load switching	1. Check governor response. Refer to generating set manual. Check "DWELL" setting. Refer to Load Testing section 4.7.1.4.

Table 10

7.4.5 RESIDUAL VOLTAGE CHECK

This procedure is applicable to generators with either SX460 or SX440 or SX421 AVR.

With the generator set stationary remove AVR access cover and disconnect leads X and XX from the AVR.

Start the set and measure voltage across AVR terminals P2-P3 on SX440 or SX421 AVR.

Stop the set, and replace leads X and XX on the AVR terminals.If the measured voltage was above 5V the generator should operate normally.

If the measured voltage was under 5V follow the procedure below.

7.4.6 'REFLASHING' TO RESTORE RESIDUAL

Using a 12 volt dc battery as a supply clip leads from battery negative to AVR terminal XX, and from battery positive through a diode to AVR terminal X. See Fig. 7.

Important ! A diode must be used as shown below to ensure the AVR is not damaged.

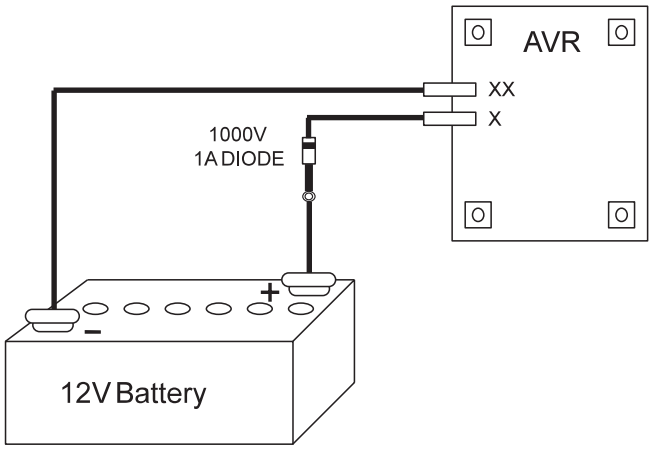


Fig. 7

Important ! If the generating set battery is used for field flashing, the generator main stator neutral must be disconnected from earth.

Restart the set and note output voltage from main stator, which should be approximately nominal voltage, or voltage at AVR terminals P2-P3 on SX440 or SX421 which should be between 170 and 250 volts.

Stop the set and unclip battery supply from terminals X and XX. Restart the set. The generator should now operate normally. If no voltage build-up is obtained it can be assumed a fault exists in either the generator or the AVR circuits. Follow the SEPARATE EXCITATION TEST PROCEDURE to check generator windings, rotating diodes and AVR. Refer to subsection 7.5.

7.5 SEPARATE EXCITATION TEST PROCEDURE

The generator windings, diode assembly and AVR can be checked using the appropriate following section.

7.5.1 GENERATOR WINDINGS, ROTATING DIODES and PERMANENT MAGNET GENERATOR (PMG)

7.5.2 EXCITATION CONTROL TEST.

7.5.1 GENERATOR WINDINGS, ROTATING DIODES and PERMANENT MAGNET GENERATOR (PMG)

Important ! **The resistances quoted apply to a standard winding. For generators having windings or voltages other than those specified refer to factory for details. Ensure all disconnected leads are isolated and free from earth.**

Important ! **Incorrect speed setting will give proportional error in voltage output.**

CHECKING PMG

Start the set and run at rated speed.

Measure the voltages at the AVR terminals P2, P3 and P4. These should be balanced and within the following ranges:-

50Hz generators - 170-180 volts
60Hz generators - 200-216 volts

Should the voltages be unbalanced stop the set, remove the PMG sheet metal cover from the non drive endbracket and disconnect the multipin plug in the PMG output leads. Check leads P2, P3, P4 for continuity. Check the PMG stator resistances between output leads. These should be balanced and within
+/-10% of 2.3 ohms. If resistances are unbalanced and/or incorrect the PMG stator must be replaced. If the voltages are balanced but low and the PMG stator winding resistances are correct - the PMG rotor must be replaced.

CHECKING GENERATOR WINDINGS AND ROTATING DIODES

This procedure is carried out with leads X and XX disconnected at the AVR or transformer control rectifier bridge and using a 12 volt d.c. supply to leads X and XX.

Start the set and run at rated speed.

Measure the voltages at the main output terminals U, V and W. If voltages are balanced and within +/-10% of the generator nominal voltage, refer to 7.5.1.1.

Check voltages at AVR terminals 6, 7 and 8. These should be balanced and between 170-250 volts.

If voltages at main terminals are balanced but voltage at 6, 7 and 8 are unbalanced, check continuity of leads 6, 7 and 8. Where an isolating transformer is fitted (MX321 AVR) check transformer windings. If faulty the transformer unit must be replaced.

If voltages are unbalanced, refer to 7.5.1.2.

7.5.1.1 BALANCED MAIN TERMINAL VOLTAGES

If all voltages are balanced within 1% at the main terminals, it can be assumed that all exciter windings, main windings and main rotating diodes are in good order, and the fault is in the AVR or transformer control. Refer to subsection 7.5.2 for test procedure.
If voltages are balanced but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to identify:-

Rectifier Diodes

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions.
On an electronic digital meter a healthy diode will give a low reading in one direction, and a high reading in the other.

Replacement of Faulty Diodes

The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be overtightened. The recommended torque tightening is 4.06 - 4.74Nm (36-42lb in).

Surge Suppressor

The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarised and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective this will be visible by inspection, since it will normally fail to short circuit and show signs of disintegration. Replace if faulty.

Main Excitation Windings

If after establishing and correcting any fault on the rectifier assembly the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), as the fault must be in one of these windings. The exciter stator resistance is measured across leads X and XX. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

Resistance values should be within +/-10% of the values given in the tables below:-

4 POLE GENERATORS			
FRAME SIZE	MAIN ROTOR	EXCITER STATOR	EXCITER ROTOR
4 - 4C	0.91	18	0.136
4 - 4D	1.04	18	0.136
4 - 4E	1.17	18	0.136
4 - 4F	1.35	18	0.136
5 - 4C	1.55	17	0.184
5 - 4D	1.77	17	0.184
5 - 4E	1.96	17	0.184
5 - 4F	2.16	17	0.184
6 - 4G	1.75	17	0.158
6 - 4H	1.88	17	0.158
6 - 4J	2.09	17	0.158
6 - 4K	2.36	17	0.158
7 - 4E	1.27	17	0.096
7 - 4F	1.41	17	0.096
7 - 4G	1.65	17	0.096
7 - 4H	1.77	17	0.096

Table 11

6 POLE GENERATORS			
FRAME SIZE	MAIN ROTOR	EXCITER STATOR	EXCITER ROTOR
6 - 6G	1.12	17	0.2
6 - 6H	1.33	17	0.2
6 - 6J	1.5	17	0.2
6 - 6K	1.75	17	0.2
7 - 6E	2.33	17	0.2
7 - 6F	2.83	17	0.2
7 - 6G	3.25	20	0.28

Table 12

7.5.1.2 UNBALANCED MAIN TERMINAL VOLTAGES

If voltages are unbalanced, this indicates a fault on the main stator winding or main cables to the circuit breaker. NOTE: Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied. Disconnect the main cables and separate the winding leads U1-U2, (U5-U6), V1-V2, (V5-V6), W1-W2, (W5-W6) to isolate each winding section.

Note:- leads suffixed 5 and 6 apply to 12 wire windings only.

Measure each section resistance - values should be balanced and within +/-10% of the value given below:-

MAIN STATOR SECTION RESISTANCES				
4 POLE GENERATORS				
SECTION RESISTANCES				
FRAME SIZE	WINDING 311 1-2 OR 5-6	WINDING 12 1-2	WINDING 17 1-2 OR 5-6	WINDING 07 1-2
4 - 4C	0.0085	N/A	0.0115	N/A
4 - 4D	0.006	N/A	0.01	N/A
4 - 4E	0.0045	N/A	0.0075	N/A
4 - 4F	0.0037	N\A	0.0055	N/A
5 - 4C	0.0032	N/A	0.0053	N/A
5 - 4D	0.0024	N/A	0.004	N/A
5 - 4E	0.0022	N/A	0.0034	N/A
5 - 4F	0.0019	N/A	0.0025	N/A
6 - 4G	0.0017	0.0034	N/A	0.0055
6 - 4H	0.0013	0.0025	N/A	0.0036
6 - 4J	0.0011	0.0022	N/A	0.003
6 - 4K	0.0085	0.0017	N/A	0.0026
7 - 4E	N/A	0.0016	N/A	0.0026
7 - 4F	N/A	0.0013	N/A	0.002
7 - 4G	N/A	0.0009	N/A	0.0015
7 - 4H	N/A	0.0008	N/A	0.0011

Table 13

6 POLE GENERATORS				
SECTION RESISTANCES				
FRAME SIZE	WINDING 311 1-2 OR 5-6	WINDING 12 1-2	WINDING 17	WINDING 07 1-2
6 - 6G	0.0045	0.009	N/A	0.015
6 - 6H	0.0032	0.0063	N/A	0.01
6 - 6J	N/A	0.0049	N/A	0.007
6 - 6K	0.002	0.0039	N/A	0.006
7 - 6E	N/A	0.0027	N/A	0.0042
7 - 6F	N/A	0.0018	N/A	0.0032
7 - 6G	N/A	0.0014	N/A	0.002

Table 14

Measure insulation resistance between sections and each section to earth.

Unbalanced or incorrect winding resistances and/or low insulation resistances to earth indicate rewinding of the stator will be necessary. Refer to removal and replacement of component assemblies subsection 7.5.3.

7.5.2 EXCITATION CONTROL TEST

7.5.2.1 AVR FUNCTION TEST

All types of AVR's can be tested with this procedure:

1. Remove exciter field leads X & XX (F1 & F2) from the AVR terminals X & XX (F1 & F2).
2. Connect a 60W 240V household lamp to AVR terminals X & XX (F1 & F2).
3. Set the AVR VOLTS control potentiometer fully clockwise.
4. Connect a 12V, 1.0A DC supply to the exciter field leads X & XX (F1 & F2) with X (F1) to the positive.
5. Start the generating set and run at rated speed.
6. Check that the generator output voltage is within +/- 10% of rated voltage.

Voltages at AVR terminals 7-8 on SX460 AVR or P2-P3 on SX440 or SX421 AVR should be between 170 and 250 volts. If the generator output voltage is correct but the voltage on 7-8 (or P2-P3) is low, check auxiliary leads and connections to main terminals.

Voltages at P2, P3, P4 terminals on MX341 and MX321 should be as given in 7.5.1.

The lamp connected across X-XX should glow. In the case of the SX460, SX440 and SX421 AVRs the lamp should glow continuously. In the case of the MX341 and MX321 AVRs the lamp should glow for approximately 8 secs. and then turn off. Failure to turn off indicates faulty protection circuit and the AVR should be replaced. Turning the "VOLTS" control potentiometer fully anti-clockwise should turn off the lamp with all AVR types.

Should the lamp fail to light the AVR is faulty and should be replaced.

Important ! **After this test turn VOLTS control potentiometer fully anti-clockwise.**

7.5.3 REMOVAL AND REPLACEMENT OF COMPONENT ASSEMBLIES

METRIC THREADS ARE USED THROUGHOUT

Caution ! **When lifting single bearing generators, care is needed to ensure the generator frame is kept in the horizontal plane. The rotor is free to move in the frame and can slide out if not correctly lifted. Incorrect lifting can cause serious injury to personnel.**

7.5.3.1 ANTI-CONDENSATION HEATERS

Danger !

The external mains electricity supply used to power the anti-condensation heater must be switched off and safely isolated before attempting any work adjacent to the heater, or removal of the non drive end endbracket on which the anti-con heater is mounted. Ensure that the engine is inhibited prior to work in generator.

7.5.3.2 REMOVAL OF PERMANENT MAGNET GENERATOR (PMG)

1. Remove access cover.
2. Disconnect P2, P3, P4 at the multiway connector inside the access cover.
3. Remove the 4 screws and clamps retaining the stator housing (Frames 4, 5 and 6) or the stator pack (Frame 7).
4. Tap the stator pack or housing out of its spigot.

NOTE:
As the highly magnetic rotor will attract the stator core, care must be taken to avoid a contact which may damage the winding.

5. Remove the exciter rotor securing bolt and stow safely and firmly pull the complete rotor assembly from its location.

N.B. Keep the rotor clean and avoid contact with metal dust or particles - preferably place in plastic bag.

Important ! **The rotor assembly must not be dismantled.**

Re-assembly is a reversal of the above procedure having due regard for the notes below:-

1. Ensure rotor magnet assembly is free of metal pieces or particles.
2. Care is needed to avoid winding damage when re-assembling the stator pack, due to strong magnetic attraction.

7.5.3.3 REMOVAL OF BEARINGS

Important ! **Position the main rotor so that a full pole face of the main rotor core is at the bottom Remove PMG of the stator bore if fitted.**

The generators in this manual will be fitted with one of three different bearing arrangements. There may be two different arrangements on a two-bearing generator. (See table 14 & 15)

BEARING OPTIONS FOR DRIVE-END BEARINGS				
	HC4	**HC5**	**HC6**	**HC7**
Reagreasable bearings	N/A	OPT	OPT	STD
Sealed for life with a cartridge	STD	STD	STD	N/A
Sealed for life without cartridge	N/A	N/A	N/A	N/A

Table 15

BEARING OPTIONS FOR NON DRIVE-END BEARINGS				
	HC4	**HC5**	**HC6**	**HC7**
Reagreasable bearings	N/A	OPT	OPT	STD
Sealed for life with a cartridge	NA	NA	STD	N/A
Sealed for life without cartridge	STD	STD	N/A	N/A

Table 16

Removal of the bearings may be effected either after the rotor assembly has been removed or more simply by removal of endbracket(s).

Be sure to note the location of all components during removal to assist during the assembly process.

BEARING REPLACEMENT

Environment

Every effort must be made to establish a clean area around the generator when removing and replacing bearings. Contamination is a major cause of bearing failures.

Equipment

Suitable cleaning solvent
Bearing puller, two or three leg
Thin protective gloves
Lint free cleaning cloth
Induction heater.

Preparation

Remove PMG if fitted
Remove the lubrication pipework if fitted
Position the rotor so that the full pole face of the main rotor is at the bottom of the stator bore.
Remove the end bracket, see 7.5.3.4 for procedure.

NOTES:

- It is not necessary to remove the rotor.
- Ensure that the bearing contact surfaces shows no sign of wear or corrosion prior to fitting the bearing.
- Never refit used bearings, wave washers or 'O'rings.
- Never refit used bearings, grease flingers, wave washer or 'O' rings.
- Only the outer race should be used to transmit load during assembly (NEVER use the inner race).

REMOVAL OF REGREASABLE BEARINGS

The bearings are a press fit on the shaft and can be removed with standard tooling, i.e. 2 or 3 legged manual or hydraulic bearing pullers.

To remove bearings proceed as follows:

1. Remove 4 screws holding bearing cap.
2. Remove cap.
3. Non drive end - remove wave washer and circlip (single bearing only).
4. Remove bearing cartridge housing complete with bearing (and grease flinger if fitted).
5. Remove bearing from cartridge.
6. Discard the old bearing 'O' rings and wave washer where fitted.

The bearing cap(s) and cartridge(s) must be thoroughly flushed out with clean solvent and checked for wear or damage, before re-assembly. Damaged components should be replaced before refitting the bearing.

ASSEMBLY OF REGREASABLE BEARINGS

NOTE: Gloves must be worn at all times when handling the bearings, grease and solvent.

1. Wipe clean the assembly surface, using cleaning solvent on lint free cloth.
2. Wipe clean: Bearing Cartridge, Wave Washer, Bearing Cap, grease flinger, all re-lubrication pipes and fittings (internal and external). Visually inspect all components after cleaning, for contamination.
3. Place all components on the clean assembly surface. Do not use an air line to blow off excess fluid.
4. Thoroughly clean the external surface of the grease gun nozzle using lint free cloth.

Bearing preparation

1. Remove the bearing from its packaging.
2. Wipe off the preservative oil from the surface of the inner and outer rings - using lint free cloth only.
3. Place the bearing on the clean assembly surface, with the bearing designation marking facing down.

Bearing Assembly (Lubrication, see TABLE 17)

Cartridge:

1. Apply the specified cartridge grease fill quantity to the back face of the bearing housing.
2. Apply a small amount of grease to the grooved sealing surface in the cartridge.
3. Apply anti-fretting lubricant (MP14002 - Klüber Altemp Q NB 50) to the bearing housing circumference. Apply paste in a thin coherent layer by use of a lint free cloth (DO NOT rub in) (use clean protective gloves).
4. Non-drive end - fit new 'O' Rings into the 'O' Ring grooves in the bearing housing circumference.

Bearing:

1. Apply half the specified bearing grease fill quantity (see table 16) to the upper face of the bearing (opposite side to the bearing designation markings).
2. Thumb the applied grease into the bearing, ensuring good penetration into the raceways/balls (use clean protective gloves).

Assemble Bearing into Cartridge

1. Heat the bearing cartridge to 25° C above ambient with an induction heater (Do not exceed 100°C).
2. With greased face of the bearing facing the cartridge bore, assemble the bearing into the bearing housing. Ensure the bearing outer race contacts the location shoulder.

Assemble Bearing onto Shaft

Bearing Cartridge

1. Heat the Bearing and Cartridge assembly to 80ºC above ambient with an induction heater. (use induction heater, no other heat source is suitable)

2. Slide the Bearing and Cartridge assembly over the shaft, pushing it firmly against the bearing seating shoulder.

3. Rotate the assembly (including inner race) 45º in either direction, to provide correct alignment. The bearing must be held firmly in place until it is cool enough to positively self locate.

NOTE: Ensure cartridge is at ambient temp. before assembling bracket.

Cap/Flinger:

Apply the specified cap grease fill quantity to the inside face of the cap (see table 16).

1. Fill the grease exhaust slot with grease.

2. Apply a small amount of grease to the grooved sealing surface in the cap.

3. Fit circlip. (single bearing only).

4. Heat flinger to 120°C and place on shaft up to the bearing inner race. Hold firmly until positively located.

5. Place wave washer in cap, fit cap to bearing cartridge.

Re-lubrication pipe:

1. Fill pipe and grease nipple with grease.

2. Fit pipe work to machine.

INITIAL LUBRICATION DETAILS, REGREASEABLE BEARINGS							
FRAME	BEARING POSITION	GREASE QUANTITY					
		BEARINGS		CARTRIDGE		CAP	
		CM^3	GRAMS	CM^3	GRAMS	CM^3	GRAMS
5	Non-Drive End	65	58	33	29	33	29
5	Drive End	92	82	46	41	46	41
6	Non-Drive End	121	111	63	56	63	56
6	Drive End	156	139	78	69	78	69
7	Non-Drive End	174	154	87	77	87	77
7	Drive End	208	185	104	92	104	92

Lubricant: Kluber Asonic GHY 72

Table 17

REMOVAL OF GREASED FOR LIFE BEARINGS WITH BEARING CARTRIDGE

The bearings are a press fit on the shaft and can be removed with standard tooling, i.e. 2 or 3 legged manual or hydraulic bearing pullers.

To remove bearings proceed as follows:

1. Remove 4 screws holding bearing cap.

2. Remove cap.

3. Non drive end - remove wave washer and circlip (single bearing only).

4. Remove bearing cartridge housing complete with bearing.

5. Remove bearing from cartridge.

6. Discard the old bearing, ‘o’ rings and wave washer where fitted.

The bearing cap(s) and cartridge(s) must be thoroughly flushed out with clean solvent and checked for wear or damage, before re-assembly. Damaged components should be replaced before refitting the bearing.

ASSEMBLY OF SEALED FOR LIFE BEARINGS WITH CARTRIDGE

Pre-assembly cleaning.

NOTE: Gloves must be worn at all times when handling the bearings, grease and solvent**.**

1. Wipe clean the assembly surface, using cleaning solvent on lint free cloth.

2. Wipe clean: Bearing Cartridge and Bearing Cap (internal and external). Visually inspect all components after cleaning, for contamination.

3. Place all components on a clean assembly surface. Do not use an air line to blow off excess fluid.

4. Thoroughly clean the external surface of the grease gun nozzle using lint free cloth.

Bearing preparation:

1. Remove the bearing from its packaging.

2. Wipe off the preservative oil from the surface of the inner and outer rings - using lint free cloth only.

3. Place the bearing on the clean assembly surface, with the bearing designation marking facing down.

Bearing Assembly

Cartridge:

1. Apply anti-fretting lubricant (**MP14002 - Klüber Altemp Q NB 50**) to the bearing housing circumference. Apply paste in a thin coherent layer by use of a lint free cloth (**DO NOT rub in**) (use clean protective gloves).

2. Fit 'O' Rings into the 'O' Ring grooves in the bearing housing circumference.

Assemble Bearing into Cartridge

1. Heat the bearing cartridge to 25° C above the ambient temperature (with an induction heater, do not exceed 100°C) and assemble the new bearing into the cartridge. Ensure that the bearing designation is visible after assembly.

2. With greased face of the bearing facing the cartridge bore, assemble the bearing into the bearing housing. Ensure the bearing outer race contacts the location shoulder.

NOTE: Only the outer race should be used to transmit load during assembly (NEVER use the inner race).

Assemble Bearing and Cartridge onto the Shaft

1. Heat the Bearing and Cartridge assembly to 80ºC above ambient.
   (use induction heater, no other heat source is suitable)

2. Slide the Bearing and Cartridge assembly over the shaft, pushing it firmly against the bearing seating shoulder.

3. Rotate the assembly (including inner race) 45º in either direction, to provide correct alignment. The bearing must be held firmly in place until it is cool enough to positively self locate.

4. Non drive end only - fit circlip (single bearing only) and wave washer.

5. Fit the bearing cap.

6. Rotate the bearing assembly on the shaft to check for free movement.

Note: Ensure cartridge is at ambient temp. before assembling bracket.

7. Refit the end bracket and PMG where fitted.

SEALED FOR LIFE BEARINGS (WITHOUT CARTRIDGE)

NOTE: Prior to commencement of removal of end bracket ensure rotor is positioned with full pole face at the bottom of the stator bore.

Preparation

1. Remove terminal box lid.

2. Cut cable ties and disconnect exciter leads.

3. Remove bolts from NDE terminal panel and place panel over terminal board with AVR still connected.

4. Remove Permanent Magnet Generator (if fitted) see 7.5.3.2.

5. Remove the rotor retaining circlip (Non drive end - single bearing only) and slack off remaining NDE bracket bolts.

6. Fit 2 off M10x60mm bolts into jacking locations on centre line and replace 2 bolts into end bracket for support as end bracket is removed (be aware of exciter lead and PMG lead, if fitted).

7. If alternator not connected to engine be aware of rotor pulling through stator, to avoid this, place wooden spacer between fan and frame each side at drive end.

8. Use available lifting equipment to remove the bracket.

9. Remove bearing circlip (Non drive end - single bearing only).

BEARING REMOVAL

1. Fit pulley drawers and draw off bearing, ensuring to protect the threaded hole in the end of the main shaft.

2. Heat the Bearing to 80ºC above ambient with an induction heater and fit to shaft. (use induction heater, no other heat source is suitable do not exceed 100°C) (ensure shaft and bearing are clean prior to assembly)

3. Replace the bearing circlip (single bearing only).

Replace the Endbracket

1. Remove jacking bolts from end bracket and lift end bracket into position and fit bracket onto bearing (heat bracket if required). Ensure exciter and PMG leads are pulled through and positioned.

2. Lift rotor to align exciter (use piece of wood as lever under shaft through NDE aperture) fit bolts and secure evenly around end bracket to ensure it is correctly aligned.

3. Replace rotor retaining circlip and permanent magnet assembly if fitted, and replace cover.

4. Connect exciter and re-tie all cables into position and re-assemble terminal box.

NOTE: Prior to re-fitting end bracket check exciter electrically and physically to ensure no damaged caused when dismantling.

7.5.3.4 MAIN ROTOR ASSEMBLY

SINGLE BEARING MACHINE

NOTE: On single bearing machines, before removal from, or re-assembly to the prime mover, position the rotor, if possible, such that a full pole face is at bottom dead centre.

1. Remove all access covers and terminal box lid.

2. Disconnect exciter leads X and XX and PMG leads P2-P3-P4 at the auxiliary terminals inside the terminal box.

3. Ensure that these leads are free to come away with the non drive endbracket when removed.

4. Remove the 8 bolts holding the drive end adaptor to the frame.

5. With a rope sling around drive end adaptor, tap adaptor out of its spigot location; guide over fan and remove.

6. If the generator is fitted with a cartridge. Remove the 4 bolts retaining the non drive end bearing cartridge in the non drive end endbracket (outer 4 bolts). (This includes all regreasable options).

7. Remove the 8 bolts securing the non drive end bracket to the frame.

8. Supporting the non drive end bracket with a hoist, insert two M10 bolts in the two holes provided for 'jacking' purposes (on the end bracket horizontal centre line). Screw in the bolts until the end bracket spigot is clear of the locating recess, lower the whole assembly until the main rotor is resting in the stator bore. Still supporting the non drive end bracket, tap the bracket off the non drive end bearing cartridge (taking care that the exciter stator does not foul exciter rotor windings) and remove.

9. To withdraw the rotor from the stator the rotor must be supported by a rope at the drive end and eased out of the stator core until half the main rotor is protruding out of the stator. At this point it is safe to release the weight from the rope sling.

10. Tightly bind a rope sling around the rotor core, and supporting the non drive end of the rotor, guide it clear of the stator.

The rope sling may not be at the centre of gravity of the rotor and guidance at the ends of the rotor is essential. THE FULL WEIGHT OF THE ROTOR GIVEN IN THE TABLE BELOW MUST BE SUPPORTED BY THE CRANE AND SLING. If the rotor core is allowed to drop more than a few millimetres at this point, it will make contact with the stator windings and may damage them.

MINIMUM ROTOR ASSEMBLY WEIGHTS

FRAME	WEIGHT
4 - 4 pole	473 kgs
5 - 4 pole	685 kgs
6 - 4 pole	1093 kgs
6 - 6 pole	1050 kgs
7 - 4 pole	1592 kgs
7 - 6 pole	1790 kgs

Re-assembly is a reversal of the above procedure.

Before assembly of a single bearing rotor into stator housing check that the drive discs are not damaged or cracked or showing any other signs of fatigue. Also check that holes in the discs for drive fixing screws are not elongated.

Damaged components must be replaced.

When refitting discs ensure that the number and thickness of discs, and the tightening torque of hub bolts is in accordance with the table below.

Refer to engine manual for torque setting of disc to flywheel bolts.

FRAME	NO. OF DISCS	SINGLE DISC THICKNESS	TOTAL THICKNESS	TIGHTENING TORQUE
4	4	1.2	4.8	48kgm
				479Nm
5	4	1.2	4.8	48kgm
				479Nm
6	6	1.2	7.2	84kgm
				822Nm
7	6	1.2	7.2	84kgm
				822Nm

Table 18

TWO BEARING MACHINES

NOTE:

Position rotor, if possible, such that a full pole face is at bottom dead centre.

The procedure for removal of a two bearing rotor is similar to that outlined for single bearing machines with the exception of Steps 4 and 5 relating to the drive end adaptor.

For removal of this item proceed as follows:-

1. Remove the 8 bolts holding drive end adaptor to frame and 4 bolts retaining bearing cartridge in drive end bracket (outer 4 bolts), if fitted.

2. With rope sling around the shaft extension, supporting the rotor weight tap the drive end bracket spigot out of its locating recess and lower rotor assembly to rest in the stator bore.

3. Take the weight of the drive end bracket on the sling and tap the bracket off the drive end bearing cartridge, guide over the fan and remove.

Re-assembly is a reversal of the above procedure.

7.6 RETURNING TO SERVICE

After rectification of any faults found, remove all test connections and reconnect all control system leads.

Restart the set and adjust VOLTS control potentiometer on AVR by slowly turning clockwise until rated voltage is obtained.

Refit all terminal box covers/access covers and reconnect heater supply.

Caution !	**Failure to refit all guards, access covers and terminal box covers can result in personal injury or death.**

7.7 MAINTENANCE

Re-lubrication

1. Ensure grease gun nozzle and re-lubrication nipple are free from contaminants or abrasive material.

2. Apply the specified re-lubrication grease fill quantity (see table below) via the grease nipple.

3. Run the machine for 10 minutes to allow excess grease to exhaust.

Check inside the non-drive end PMG cover for expelled grease. Clean out as necessary.

RELUBRICATION DETAILS FOR REGREASABLE BEARINGS				
HC/HCK	BEARING POSITION	GREASE QUANTITY		RELUBRICATION PERIOD
		CM3	GRAMS	
5	Non-Drive End	33	29	4,500 Hrs
5	Drive End	46	41	4,500 Hrs
6	Non-Drive End	60	53	4,500 Hrs
6	Drive End	75	66	4,500 Hrs
7	Non-Drive End	85	75	4,500 Hrs
7	Drive End	100	89	4,500 Hrs

Table 19

SECTION 8

SPARES AND AFTER SALES SERVICE

8.1 RECOMMENDED SPARES

Service parts are conveniently packaged for easy identification. Genuine parts may be recognised by the Nupart name.

We recommend the following for Service and Maintenance. In critical applications a set of these service spares should be held with the generator.

1. Diode Set (6 diodes with Surge Suppressors)

HC4/5	**RSK5001**
HC6/7	**RSK6001**

2.

SX440 AVR	**E000-24030**
SX421 AVR	**E000-24210**
MX321 AVR	**E000-23212**
MX341 AVR	**E000-23412**

3. Bearings

PART NUMBERS NON DRIVE-END BEARINGS				
	HC4	**HC5**	**HC6**	**HC7**
Reagreasable bearings	N/A	OPT 051-01068	OPT 051-01065	STD 051-01063
Sealed for life with a cartridge	N/A	OPT 051-01068	STD 051-01070	N/A
Sealed for life without cartridge	STD 051-01072	STD 051-01072	N/A	N/A

Table 20

PART NUMBERS FOR DRIVE-END BEARINGS				
	HC4	**HC5**	**HC6**	**HC7**
Reagreasable bearings	N/A	OPT 051-01067	OPT 051-01064	STD 051-01062
Sealed for life with a cartridge	STD 051-01070	STD 051-01071	STD 051-01069	N/A
Sealed for life without cartridge	N/A	N/A	N/A	N/A

Table 21

When ordering parts the machine serial number or machine identity number and type should be quoted, together with the part description. For location of these numbers see paragraph 1.3.

Orders and enquiries for parts should be addressed to:

Newage International Ltd.,
Nupart Department,
P O Box 17, Barnack Road,
Stamford,
Lincolnshire
PE9 2NB
England.

Telephone: 44 (0) 1780 484000
Fax: 44 (0) 1780 766074

Website: www.newagestamford.com

or any of our subsidiary companies listed on the back cover.

8.2 AFTER SALES SERVICE

A full technical advice and on-site service facility is available from our Service Department at Stamford or through our subsidiary companies. A repair facility is also available at our Stamford Works.

This manual is available in the following languages on request:
English, French, German, Italian and Spanish.

Denne manual er til rådighed på følgende sprog: engelsk, fransk, tysk, italiensk og spansk.

Denne håndboken er tilgjengelig på de følgende språkene: engelsk, fransk, tysk, italiensk og spansk.

Sur simple demande, ce manuel vous sera fourni dans l'une des langues suivantes: anglais, français, allemand, italien, espagnol.

Dieses Handbuch ist auf Anfrage in den folgenden Sprachen erhältlich: Englisch, Französisch, Deutsch, Italienisch, Spanisch.

Deze handleiding is op verzoek leverbaar in de volgende talen: Engels, Frans, Duits, Italiaans, Spaans.

Este manual pode também ser obtido nas seguintes línguas: inglês, francês, alemão, italiano e espanhol.

Tämä käsikirja on saatavissa pyynnöstä seuraavilla kielillä: Englanti, ranska, saksa, italia, espanja.

Il presente manuale è disponibile, su richiesta, nelle seguenti lingue: inglese, francese, tedesco, italiano e spagnolo.

Este manual también puede solicitarse en los siguientes idiomas: inglés, francés, alemán, italiano e español.

Αυτό το εγχειρίδιο οδηγιών χρήσεως διατίθεται στις ακόλουθες γλώσσες κατόπιν αιτήσεν: Αγγλικά, Γαλλικά Γερμανικά, Ιταλικά, Ισπανικά.

A.C. GENERATOR WARRANTY

WARRANTY PERIOD

A.C. Generators

In respect of a.c. generators the Warranty Period is eighteen months from the date when the goods have been notified as ready for despatch by N.I. or twelve months from the date of first commissioning (whichever is the shorter period).

DEFECTS AFTER DELIVERY

We will make good by repair or, at our option, by the supply of a replacement, any fault which under proper use appears in the goods within the period specified above, and is found on examination by us to be solely due to defective material and workmanship; provided that the defective part is promptly returned, carriage paid, with all identification numbers and marks intact, to our works or, if appropriate to the Dealer who supplied the goods.

Any part repaired or replaced, under warranty, will be returned by N.I. free of charge (via sea freight if outside the UK).

We shall not be liable for any expenses which may be incurred in removing or replacing any part sent to us for inspection or in fitting any replacement supplied by us. We shall be under no liability for defects in any goods which have not been properly installed in accordance with N.I. recommended installation practices as detailed in the publications 'N.I. Installation, Service and Maintenance Manual' and 'N.I. Application Guidelines', or which have been improperly stored or which have been repaired, adjusted or altered by any person except ourselves or our authorised agents, or in any second-hand goods, proprietary articles or goods not of our own manufacture although supplied by us, such articles and goods being covered by the warranty (if any) given by the separate manufacturers.

Any claim under this clause must contain fully particulars of the alleged defect, the description of the goods, the date of purchase, and the name and address of the Vendor, the Serial Number (as shown on the manufacturers identification plate) or for Spares the order reference under which the goods were supplied.

Our judgement in all cases of claims shall be final and conclusive and the claimant shall accept our decision on all questions as to defects and the exchange of a part or parts.

Our liability shall be fully discharged by either repair or replacement as above, and in any event shall not exceed the current list price of the defective goods.

Our liability under this clause shall be in lieu of any warranty or condition implied by law as to the quality or fitness for any particular purpose of the goods, and save as expressly provided in this clause we shall not be under any liability, whether in contract, tort or otherwise, in respect of defects in goods delivered or for any injury, damages or loss resulting from such defects or from any work undone in connection therewith.

MACHINE SERIAL NUMBER

NEWAGE INTERNATIONAL LIMITED

REGISTERED OFFICE AND ADDRESS:
PO BOX 17
BARNACK ROAD
STAMFORD
LINCOLNSHIRE
PE9 2NB ENGLAND

Telephone: 44 (0) 1780 484000
Fax: 44 (0) 1780 484100
Web site: www.newagestamford.com

SUBSIDIARY COMPANIES

1 AUSTRALIA: NEWAGE ENGINEERS PTY. LIMITED
PO Box 6027, Baulkham Hills Business Centre,
Baulkham Hills NSW 2153.
Telephone: Sydney (61) 2 9680 2299
Fax: (61) 2 9680 1545

2 CHINA: WUXI NEWAGE ALTERNATORS LIMITED
Plot 49-A, Xiang Jiang Road
Wuxi High - Technical Industrial Dev. Zone
Wuxi, Jiangsu 214028
PR of China
Tel: (86) 510 5216212
Fax: (86) 510 5217673

3 GERMANY: NEWAGE ENGINEERS G.m.b.H.
Rotenbrückenweg 14, D-22113 Hamburg.
Telephone: Hamburg (49) 40 714 8750
Fax: (49) 40 714 87520

4 INDIA: C.G. NEWAGE ELECTRICAL LIMITED
C33 Midc, Ahmednagar 414111, Maharashtra.
Telephone: (91) 241 778224
Fax: (91) 241 777494

5 ITALY: NEWAGE ITALIA S.r.l.
Via Triboniano, 20156 Milan.
Telephone: Milan (39) 02 380 00714
Fax: (39) 02 380 03664

6 JAPAN: NEWAGE INTERNATIONAL JAPAN
8 - 5 - 302 Kashima
Hachioji-shi
Tokyo, 192-03
Telephone: (81) 426 77 2881
Fax: (81) 426 77 2884

7 NORWAY: NEWAGE NORGE A/S
Økern Naeringspark, Kabeigt. 5
Postboks 28, Økern, 0508 Oslo
Telephone: Oslo (47) 22 97 44 44
Fax: (47) 22 97 44 45

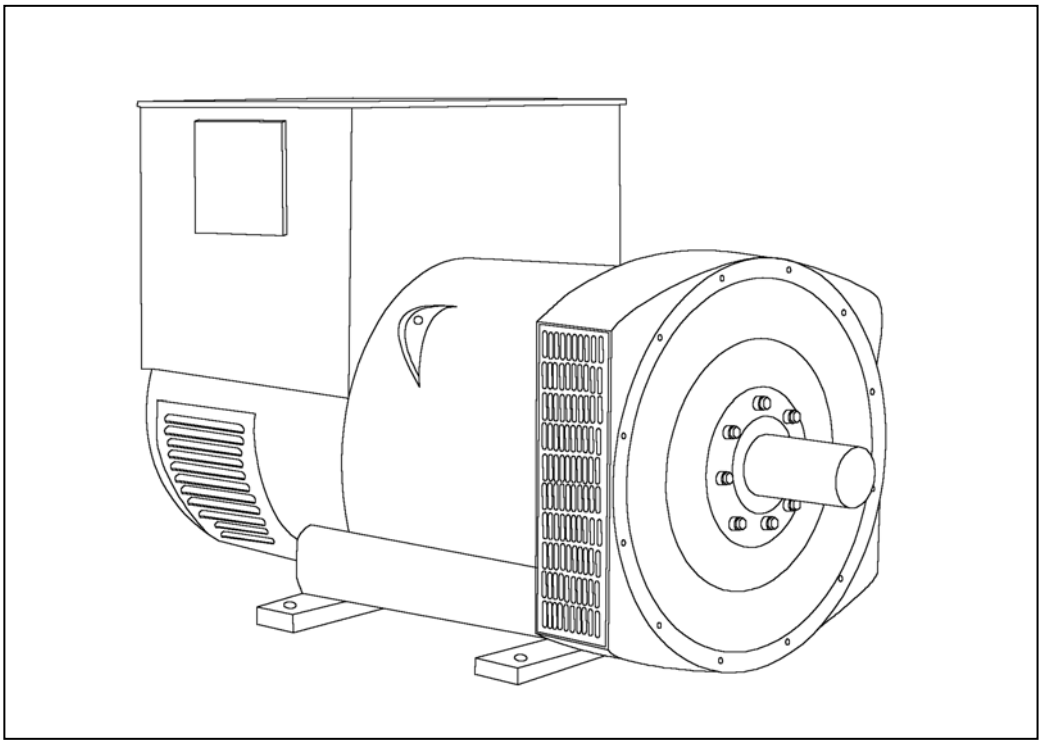
8 SINGAPORE: NEWAGE ASIA PACIFIC PTE LIMITED
10 Toh Guan Road #05-03
TT International Tradepark
Singapore 608838
Telephone: Singapore (65) 794 3730
Fax: (65) 898 9065
Telex: RS 33404 NEWAGE

9 SPAIN: STAMFORD IBERICA S.A.
Ctra. Fuenlabrada-Humanes, km.2
Poligono Industrial "Los Linares"
C/Pico de Almanzor, 2
E-28970 HUMANES DE MADRID (Madrid)
Telephone: Madrid (34) 91 604 8987/8928
Fax: (34) 91 604 81 66

10 U.S.A.: NEWAGE LIMITED
4700 Main St, N.E.
Fridley
Minnesota 55421
Telephone: (1) 800 367 2764
Fax: (1) 800 863 9243

STAMFORD
power generation

HCI 434F/444F - Technical Data Sheet



STANDARDS
Newage Stamford industrial generators meet the requirements of BS EN 60034 and the relevant section of other international standards such as BS5000, VDE 0530, NEMA MG1-32, IEC34, CSA C22.2-100, AS1359. Other standards and certifications can be considered on request.

VOLTAGE REGULATORS

SX440 AVR - STANDARD
With this self-excited system the main stator provides power via the Automatic Voltage Regulator (AVR) to the exciter stator. The high efficiency semi-conductors of the AVR ensure positive build-up from initial low levels of residual voltage.
The exciter rotor output is fed to the main rotor through a three-phase full-wave bridge rectifier. The rectifier is protected by a surge suppressor against surges caused, for example, by short circuit or out-of-phase paralleling.
The SX440 will support a range of electronic accessories, including a 'droop' Current Transformer (CT) to permit parallel operation with other ac generators.
If 3-phase sensing is required with the self-excited system, the SX421 AVR must be used.

SX421 AVR
This AVR also operates in a self-excited system. It combines all the features of the SX440 with, additionally, three-phase rms sensing for improved regulation and performance. Over voltage protection is provided via a separate circuit breaker. An engine relief load acceptance feature is built in as standard.

MX341 AVR
This sophisticated AVR is incorporated into the Stamford Permanent Magnet Generator (PMG) control system.
The PMG provides power via the AVR to the main exciter, giving a source of constant excitation power independent of generator output. The main exciter output is then fed to the main rotor, through a full wave bridge, protected by a surge suppressor. The AVR has in-built protection against sustained over-excitation, caused by internal or external faults. This de-excites the machine after a minimum of 5 seconds.
An engine relief load acceptance feature can enable full load to be applied to the generator in a single step.
If three-phase sensing is required with the PMG system the MX321 AVR must be used.
We recommend three-phase sensing for applications with greatly unbalanced or highly non-linear loads.

MX321 AVR
The most sophisticated of all our AVRs combines all the features of the MX341 with, additionally, three-phase rms sensing, for improved regulation and performance.
Over voltage protection is built-in and short circuit current level adjustments is an optional facility.

WINDINGS & ELECTRICAL PERFORMANCE
All generator stators are wound to 2/3 pitch. This eliminates triplen (3rd, 9th, 15th …) harmonics on the voltage waveform and is found to be the optimum design for trouble-free supply of non-linear loads. The 2/3 pitch design avoids excessive neutral currents sometimes seen with higher winding pitches, when in parallel with the mains. A fully connected damper winding reduces oscillations during paralleling. This winding, with the 2/3 pitch and carefully selected pole and tooth designs, ensures very low waveform distortion.

TERMINALS & TERMINAL BOX
Standard generators are 3-phase reconnectable with 12 ends brought out to the terminals, which are mounted on a cover at the non-drive end of the generator. A sheet steel terminal box contains the AVR and provides ample space for the customers' wiring and gland arrangements. It has removable panels for easy access.

SHAFT & KEYS
All generator rotors are dynamically balanced to better than BS6861:Part 1 Grade 2.5 for minimum vibration in operation. Two bearing generators are balanced with a half key.

INSULATION/IMPREGNATION
The insulation system is class 'H'.
All wound components are impregnated with materials and processes designed specifically to provide the high build required for static windings and the high mechanical strength required for rotating components.

QUALITY ASSURANCE
Generators are manufactured using production procedures having a quality assurance level to BS EN ISO 9001.

The stated voltage regulation may not be maintained in the presence of certain radio transmitted signals. Any change in performance will fall within the limits of Criteria 'B' of EN 61000-6-2:2001. At no time will the steady-state voltage regulation exceed 2%.

NB Continuous development of our products entitles us to change specification details without notice, therefore they must not be regarded as binding.

Front cover drawing typical of product range.

STAMFORD
power generation

HCI434F/444F

WINDING 311

CONTROL SYSTEM	SEPARATELY EXCITED BY P.M.G.							
A.V.R.	MX321	MX341						
VOLTAGE REGULATION	± 0.5 %	± 1.0 %	With 4% ENGINE GOVERNING					
SUSTAINED SHORT CIRCUIT	REFER TO SHORT CIRCUIT DECREMENT CURVES (page 7)							
CONTROL SYSTEM	SELF EXCITED							
A.V.R.	SX440	SX421						
VOLTAGE REGULATION	± 1.0 %	± 0.5 %	With 4% ENGINE GOVERNING					
SUSTAINED SHORT CIRCUIT	WILL NOT SUSTAIN A SHORT CIRCUIT							
INSULATION SYSTEM	CLASS H							
PROTECTION	IP23							
RATED POWER FACTOR	0.8							
STATOR WINDING	DOUBLE LAYER LAP							
WINDING PITCH	TWO THIRDS							
WINDING LEADS	12							
STATOR WDG. RESISTANCE	0.0073 Ohms PER PHASE AT 22°C SERIES STAR CONNECTED							
ROTOR WDG. RESISTANCE	1.37 Ohms at 22°C							
R.F.I. SUPPRESSION	BS EN 61000-6-2 & BS EN 61000-6-4,VDE 0875G, VDE 0875N. refer to factory for others							
WAVEFORM DISTORTION	NO LOAD < 1.5% NON-DISTORTING BALANCED LINEAR LOAD < 5.0%							
MAXIMUM OVERSPEED	2250 Rev/Min							
BEARING DRIVE END	BALL. 6317 (ISO)							
BEARING NON-DRIVE END	BALL. 6314 (ISO)							
	1 BEARING				2 BEARING			
WEIGHT COMP. GENERATOR	1160 kg				1160 kg			
WEIGHT WOUND STATOR	535 kg				535 kg			
WEIGHT WOUND ROTOR	463 kg				440 kg			
WR² INERTIA	5.4292 kgm^2				5.2304 kgm^2			
SHIPPING WEIGHTS in a crate	1775 kg				1780 kg			
PACKING CRATE SIZE	155 x 87 x 107(cm)				156 x 87 x 107(cm)			
	50 Hz				60 Hz			
TELEPHONE INTERFERENCE	THF<2%				TIF<50			
COOLING AIR	0.486 m³/sec 1030 cfm				0.580 m³/sec 1240 cfm			
VOLTAGE SERIES STAR	380/220	400/231	415/240	440/254	416/240	440/254	460/266	480/277
VOLTAGE PARALLEL STAR	190/110	200/115	208/120	220/127	208/120	220/127	230/133	240/138
VOLTAGE SERIES DELTA	220/110	230/115	240/120	254/127	240/120	254/127	266/133	277/138
kVA BASE RATING FOR REACTANCE VALUES	380	380	380	380	444	456	463	475
Xd DIR. AXIS SYNCHRONOUS	2.59	2.34	2.17	1.93	3.21	2.95	2.74	2.58
X'd DIR. AXIS TRANSIENT	0.17	0.15	0.14	0.12	0.18	0.17	0.15	0.14
X"d DIR. AXIS SUBTRANSIENT	0.12	0.11	0.10	0.09	0.13	0.12	0.11	0.10
Xq QUAD. AXIS REACTANCE	2.23	2.01	1.87	1.66	2.84	2.61	2.42	2.28
X"q QUAD. AXIS SUBTRANSIENT	0.30	0.27	0.25	0.22	0.42	0.39	0.36	0.34
X_L LEAKAGE REACTANCE	0.06	0.05	0.05	0.04	0.07	0.06	0.06	0.06
X_2 NEGATIVE SEQUENCE	0.21	0.19	0.18	0.16	0.28	0.26	0.24	0.22
X_0 ZERO SEQUENCE	0.08	0.08	0.07	0.06	0.10	0.09	0.09	0.08
REACTANCES ARE SATURATED	VALUES ARE PER UNIT AT RATING AND VOLTAGE INDICATED							
T'd TRANSIENT TIME CONST.	0.08s							
T"d SUB-TRANSTIME CONST.	0.019s							
T'do O.C. FIELD TIME CONST.	1.7s							
Ta ARMATURE TIME CONST.	0.018s							
SHORT CIRCUIT RATIO	1/Xd							

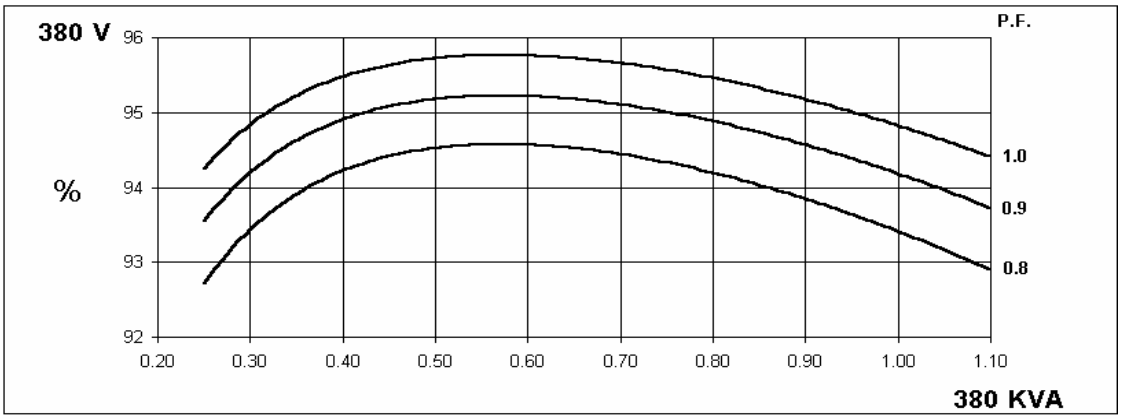
50 Hz

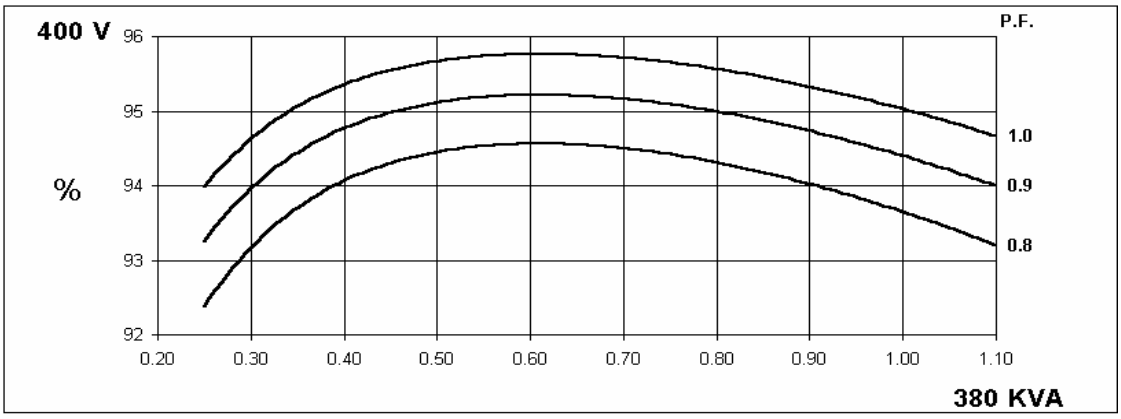
HCI434F/444F

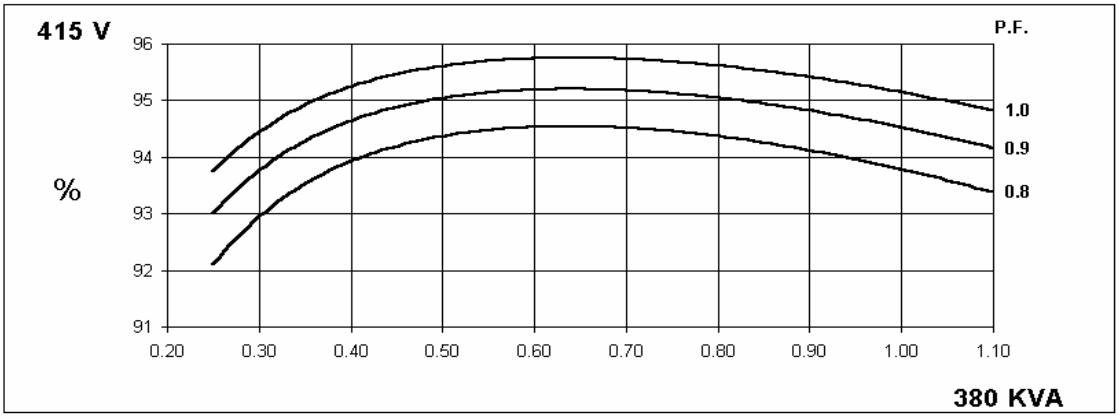
Winding 311

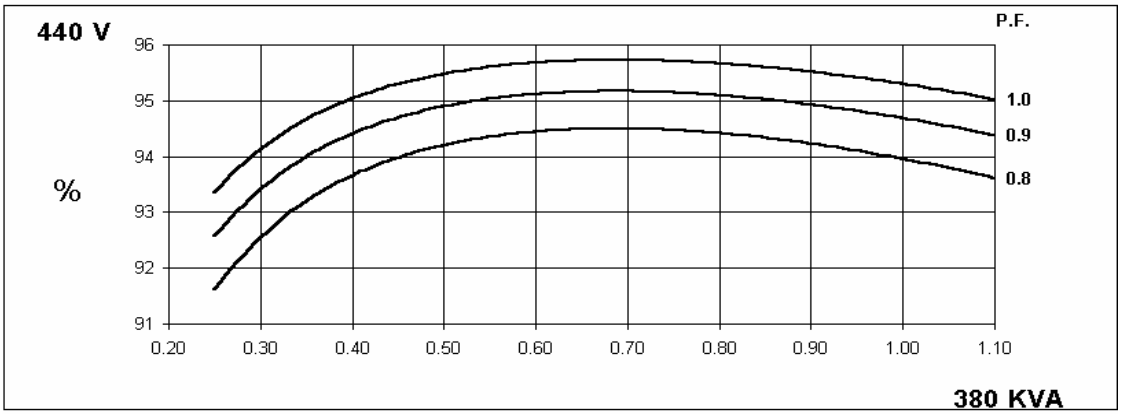
STAMFORD power generation

THREE PHASE EFFICIENCY CURVES









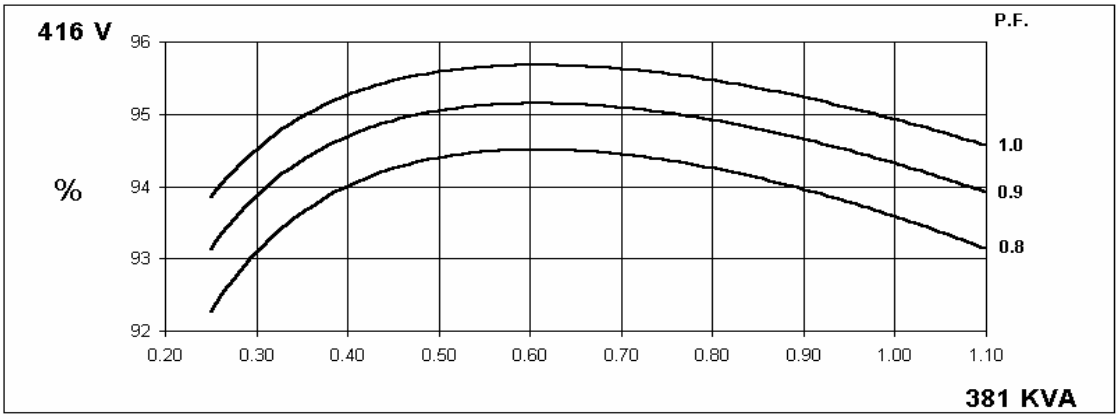
STAMFORD
power generation

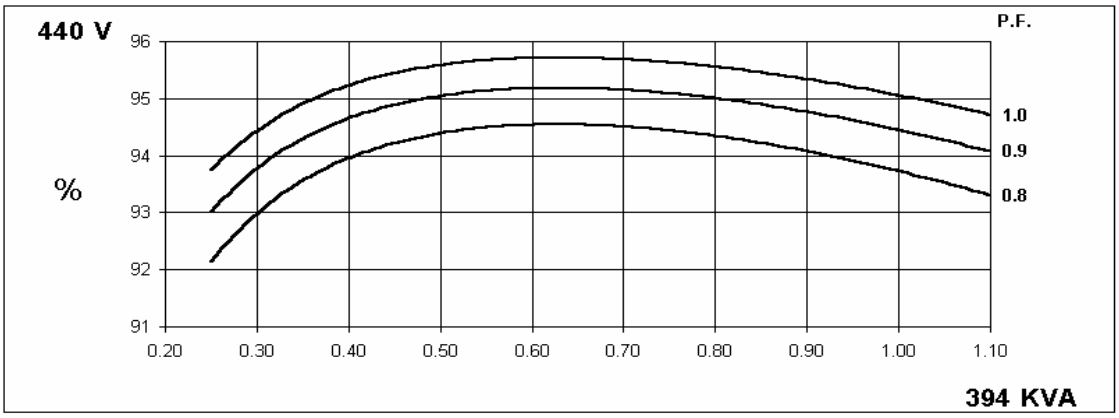
HCI434F/444F

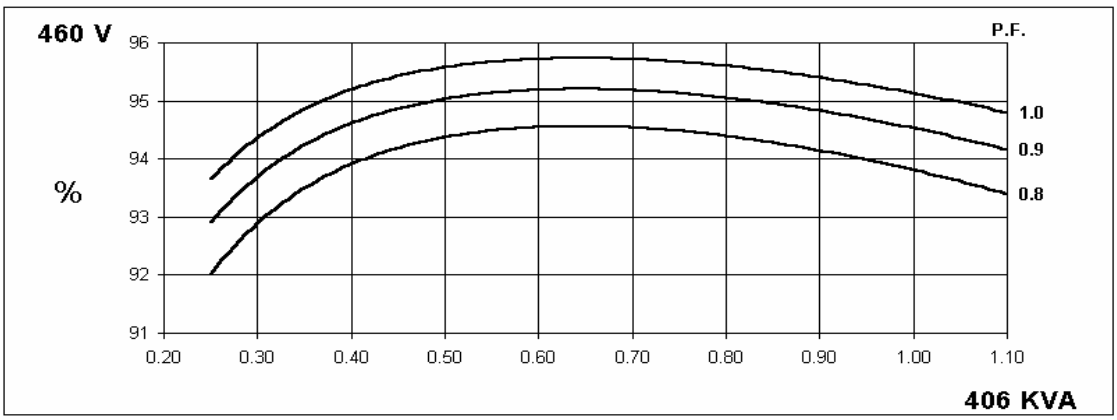
Winding 311

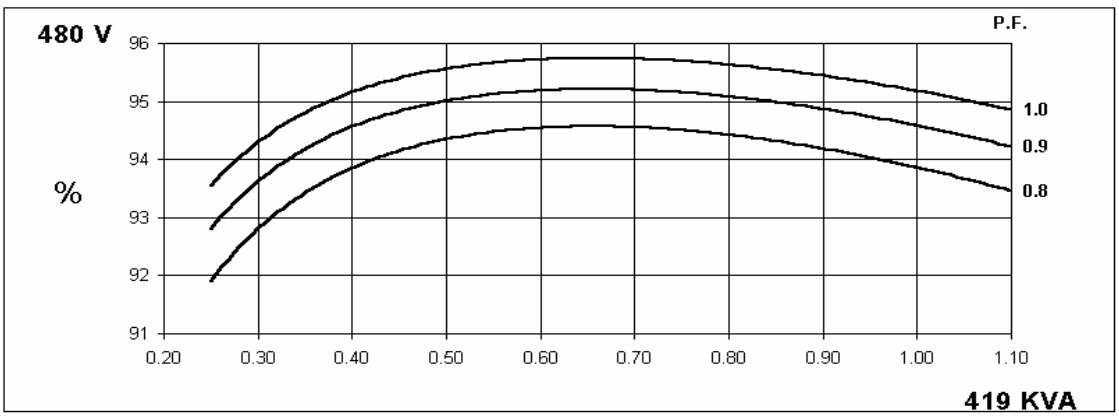
60 Hz

THREE PHASE EFFICIENCY CURVES









HCI434F/444F

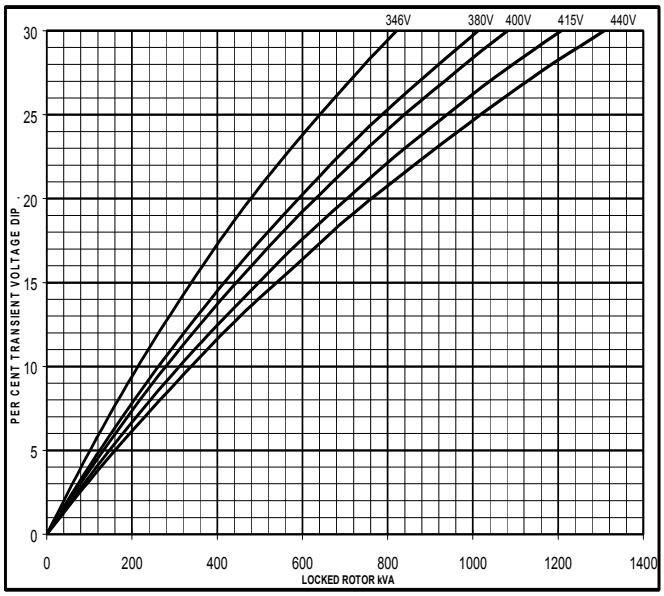
Winding 311

STAMFORD power generation

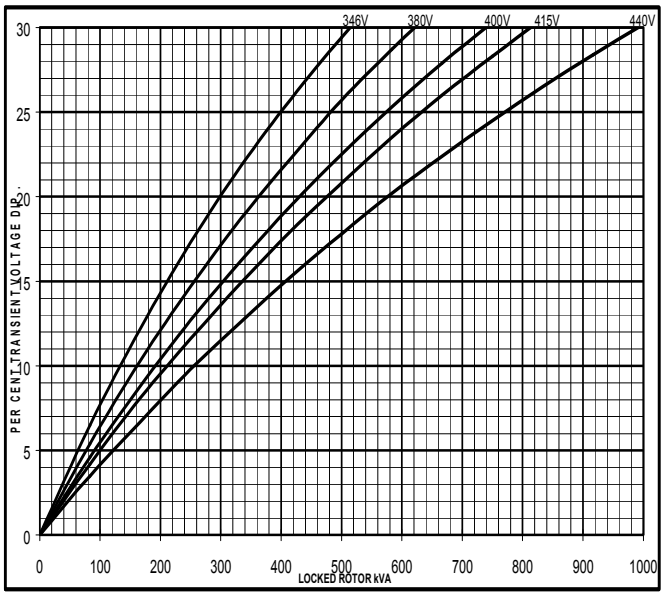
Locked Rotor Motor Starting Curve

50 Hz

MX

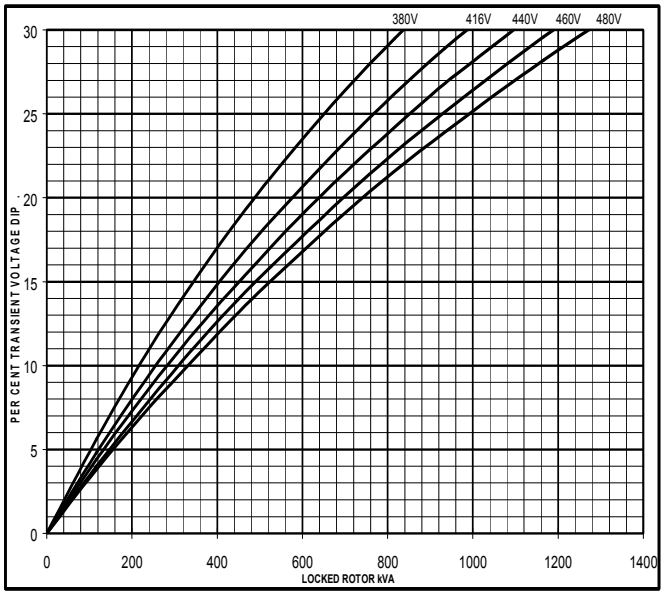


SX

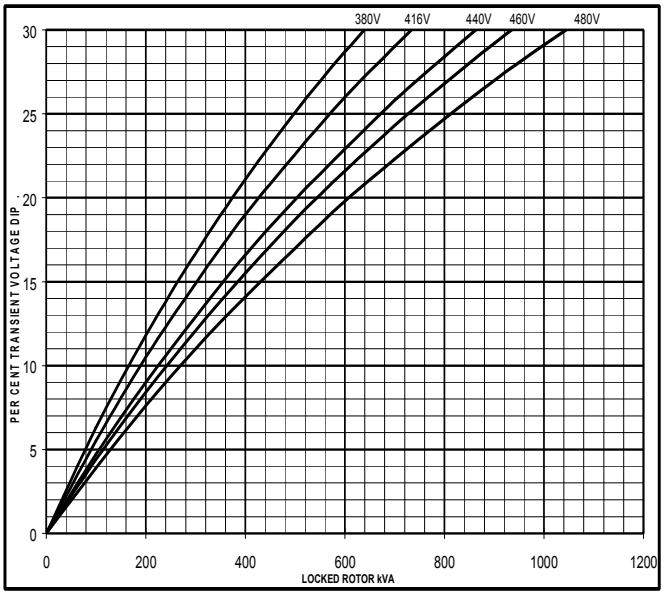


60 Hz

MX

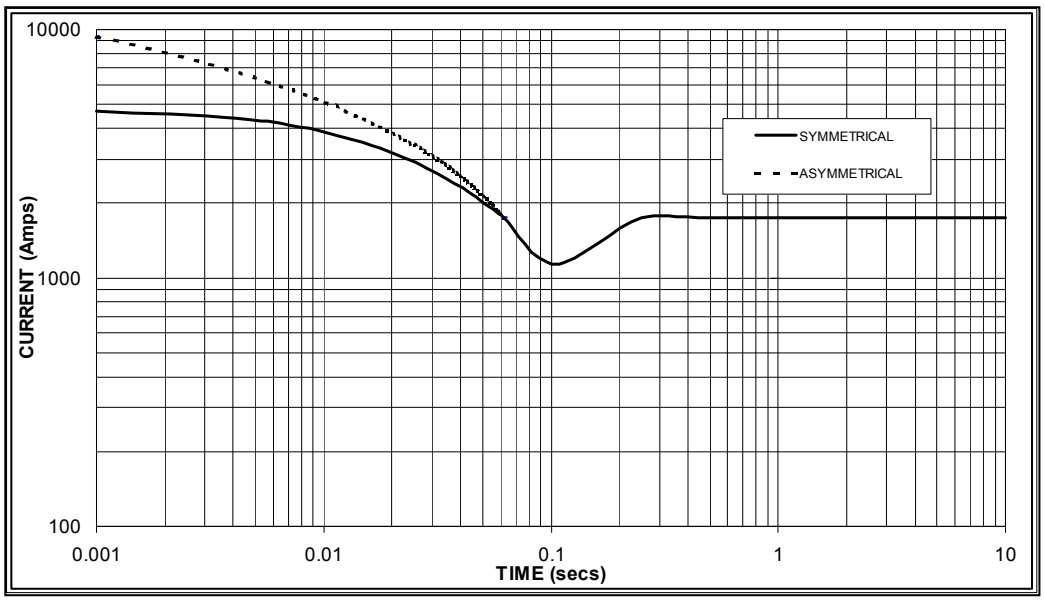


SX



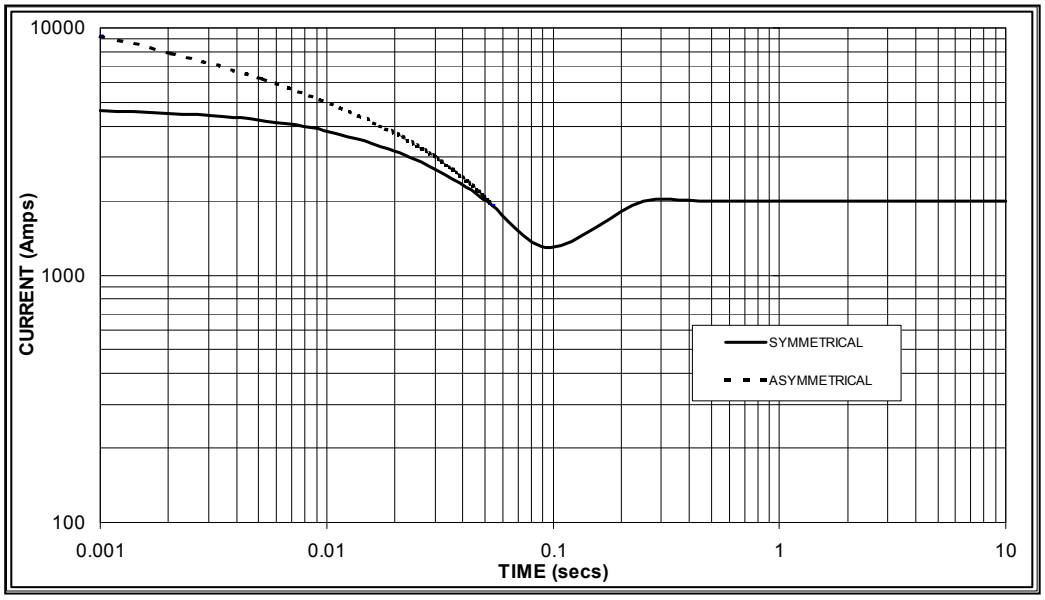
Three-phase Short Circuit Decrement Curve. No-load Excitation at Rated Speed Based on star (wye) connection.

50 Hz



Sustained Short Circuit = 1,750 Amps

60 Hz



Sustained Short Circuit = 2,000 Amps

Note 1

The following multiplication factors should be used to adjust the values from curve between time 0.001 seconds and the minimum current point in respect of nominal operating voltage :

50Hz		60Hz	
Voltage	Factor	Voltage	Factor
380v	X 1.00	416v	X 1.00
400v	X 1.05	440v	X 1.06
415v	X 1.09	460v	X 1.10
440v	X 1.16	480v	X 1.15

The sustained current value is constant irrespective of voltage level

Note 2

The following multiplication factor should be used to convert the values calculated in accordance with NOTE 1 to those applicable to the various types of short circuit :

	3-phase	2-phase L-L	1-phase L-N
Instantaneous	x 1.00	x 0.87	x 1.30
Minimum	x 1.00	x 1.80	x 3.20
Sustained	x 1.00	x 1.50	x 2.50
Max. sustained duration	10 sec.	5 sec.	2 sec.

All other times are unchanged

Note 3

Curves are drawn for Star (Wye) connected machines. For other connection the following multipliers should be applied to current values as shown :

Parallel Star = Curve current value X 2

Series Delta = Curve current value X 1.732

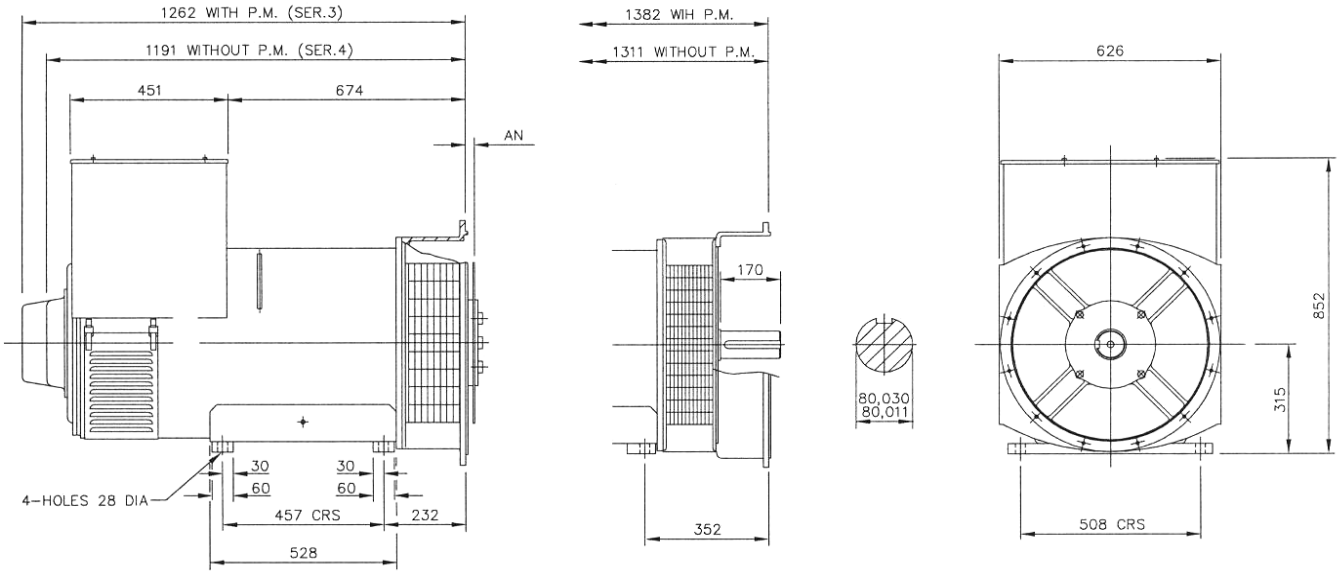
HCI434F/444F

Winding 311 / 0.8 Power Factor

RATINGS

	Class - Temp Rise	Cont. F - 105/40°C				Cont. H - 125/40°C				Standby - 150/40°C				Standby - 163/27°C			
50 Hz	Series Star (V)	380	400	415	440	380	400	415	440	380	400	415	440	380	400	415	440
	Parallel Star (V)	190	200	208	220	190	200	208	220	190	200	208	220	190	200	208	220
	Series Delta (V)	220	230	240	254	220	230	240	254	220	230	240	254	220	230	240	254
	kVA	350	350	350	350	380	380	380	380	390	390	390	390	404	404	404	404
	kW	280	280	280	280	304	304	304	304	312	312	312	312	323	323	323	323
	Efficiency (%)	93.8	94.0	94.1	94.2	93.4	93.7	93.8	94.0	93.3	93.5	93.7	93.9	93.1	93.4	93.5	93.7
	kW Input	299	298	298	297	325	324	324	323	334	334	333	332	347	346	346	345
60 Hz	Series Star (V)	416	440	460	480	416	440	460	480	416	440	460	480	416	440	460	480
	Parallel Star (V)	208	220	230	240	208	220	230	240	208	220	230	240	208	220	230	240
	Delta (V)	240	254	266	277	240	254	266	277	240	254	266	277	240	254	266	277
	kVA	405	420	425	438	444	456	463	475	475	483	488	500	488	500	506	519
	kW	324	336	340	350	355	365	370	380	380	386	390	400	390	400	405	415
	Efficiency (%)	93.9	94.0	94.1	94.1	93.5	93.7	93.8	93.9	93.2	93.4	93.6	93.7	93.0	93.2	93.4	93.5
	kW Input	345	357	361	372	380	389	395	405	408	414	417	427	420	429	433	444

DIMENSIONS



COUPLING DISC	AN
SAE 11,5	39,68
SAE 14	25,4
SAE 18	15,87

PO Box 17 • Barnack Road • Stamford • Lincolnshire • PE9 2NB
Tel: 00 44 (0)1780 484000 • Fax: 00 44 (0)1780 484100
Website: www.newage-avkseg.com