

7. ENGINE DESCRIPTION AND MAINTENANCE

7.1 Engine Description

7.1.1 General: The engine that powers the generator set is an industrial, heavy duty diesel engine that has been selected for its reliability and efficiency in operation. It is specifically designed and optimized to power generator sets. The engine is either a 4 stroke or 2 stroke compression ignition type with all the accessories necessary to provide a reliable power supply. Full details of the engine and associated equipment is provided in the Engine Manual. This section gives a brief discussion of the major systems and how they are integrated into the generator set.

If regular preventative maintenance is performed as per the Engine Manual, the diesel engine will continue to provide reliable power for many years.

7.1.2 Cooling System: The engine cooling system is comprised of a radiator, high capacity pusher fan, a mechanically driven water pump and a thermostat. The fan is a pusher type that pushes the air through the radiator. This system provides for cooling of the surface heat of the engine and alternator, and internal cooling of the engine by the water circulating in the radiator. The alternator also has an integral fan that circulates cool air inside the housing. The thermostat maintains coolant temperature at a level for efficient operation of the engine.

It is important to pay careful attention to air flow around the generator set to ensure proper cooling. Following the installation instructions in Section 4.7 should ensure satisfactory performance.

7.1.3 Engine Governing: The engine governor is either a mechanical or electronic device designed to maintain a constant engine speed in relation to load requirements. The engine speed is directly related to the frequency of the alternator output, so any variation in engine speed will effect the frequency of the power output.

The governor senses engine speed and controls the fuel rate. As load increases on the alternator the governor will increase fuel flow to the engine. As load is reduced the governor reduces fuel flow.

7.1.4 Fuel System: On most generator sets, the engine fuel system is connected directly to a fuel tank that is built into the baseframe. This tank is designed to provide sufficient fuel for approximately 8 hours operation at full load unless an extended capacity tank has been fitted. In this case approximately 24 hours operation is possible.

The base tank is provided with fittings to facilitate either manual or automatic filling from a larger bulk storage tank. See Section 4.9 for a discussion of the entire fuel system.

On larger sets, the baseframe does not include a fuel tank so the engine fuel system must be connected to a separate tank located next to the set.

7.1.5 Exhaust System: Exhaust systems are provided to reduce the noise level of the engine and to direct the exhaust gases to where they will not be a hazard.

On smaller sets the exhaust silencer and piping are mounted directly on the engine. On larger engines the exhaust system is supplied loose for installation on site.

7.1.6 Air Flap Valve: An air flap valve, if fitted, prevents overspeeds due to ingestion of gas or fumes by cutting off the air supply. Functional testing of these combustion air intake valves should not be performed on engines on load. A functional test should only be carried out when the engine is not running. If it is necessary to demonstrate air valves closing when the engine is running this should be done at no load. The engine should absolutely not be restarted immediately afterwards.

WARNING:

! The closing of the air flap valve while the engine is running can cause oil carry over into the exhaust system which is highly volatile. The engine should be left for a period of time to allow these gases to dissipate.

7.1.7 Starting Aids: Ethyl Ether starting aids are not recommended. They will reduce the efficient working life of the engine.

7.2 Engine Maintenance

The Engine Manual supplied with this manual contains detailed information on maintaining the engine. It also includes a comprehensive Trouble Shooting guide for engine faults.

7.3 Radiator Maintenance

7.3.1 General Notes: Corrosion in the radiator can be a prime cause of failure. This is prompted by air in the water. Always ensure pipe connections are free of leaks and bleed air from top of the radiator regularly to keep the system "air free".

Radiators should not be left standing in a partially filled condition. Radiators left partly filled with water will suffer much more rapidly from the effects of corrosion. For an inoperative generator set, either drain the radiator completely or ensure that it is maintained full. Wherever possible, radiators should be filled with distilled or naturally soft water, dosed with suitable corrosion inhibitors.

WARNING:

! Radiator coolant is normally very hot and under pressure. Do not work on the radiator or disconnect pipework until it has cooled. Do not work on the radiator or remove any guarding while the fan is in motion.

7.3.2 External Cleaning: In dusty or dirty conditions the radiator fins can become blocked with loose debris, insects, etc. and this fouling will have an effect on the performance of the radiator.

For regular removal of light deposits use a low pressure steam jet. More difficult deposits may need a detergent with a low pressure hot water hose. Spray steam jet or water from the front of the radiator towards the fan. Spraying in the opposite direction will force debris further into the core. Covering the engine/alternator during this process will keep them clean.

Stubborn deposits, which cannot be removed by the above methods may require removal of the radiator and immersion in a heated alkali degreasing solution for about 20 minutes and then washing off with a hot water hose.

7.3.3 Internal Cleaning: If, due to leaky joints for instance, indiscriminate topping-up with hard water has been carried out for some time, or if the generator set has been run without inhibitors the system may become fouled by scale.

To descale the radiator, use the following procedure:

1. Drain the water system and disconnect and blank off the pipe connections to the engine.
2. Prepare a 4% solution of inhibited acid solvent and fresh water. Add the acid to the water, never vice versa.
3. Allow several minutes for mixing, then heat the solution to 49°C (120°F) maximum.
4. Run the solution slowly into the radiator via the filler cap or a branch in the manifold. Effervescence will occur. When it ceases, fill the radiator completely with the heated solvent.
5. Allow to stand for several minutes; then drain the solvent back into the original container through the bottom manifold or drain plug.
6. Examine the interior of the headers. If scale remains repeat the process outlined above with the solvent strength increased to 8%.
7. After descaling the acid solution has to be neutralized as follows:-

Fill the mixing container with fresh water, heat to boiling point then add common washing soda crystals at the following strength: 0.5 kg of soda to 20 liters water (1 lb. soda to 4 gallons water). Fill the radiator with this solution, then drain it back into the container.
8. Flush the radiator in this manner several times, finally leaving the radiator full for at least an hour. Drain until empty and wash out the radiator with hot fresh water.
9. Before putting the radiator into service again, fill with water and apply a test pressure equal to twice that of the working pressure. Examine carefully for any leaks which may have been revealed by descaling.
10. Prior to recommissioning, the coolant must have any necessary corrosion inhibitors and/or the correct proportion of antifreeze added.

8. ALTERNATOR DESCRIPTION AND MAINTENANCE

8.1 Alternator Description

8.1.1 General: The alternator fitted on the generator set is of the brushless self-excitation type which eliminates the maintenance associated with slip rings and brushes. The control system consists of an automatic voltage regulator, protective circuits and the necessary instruments to allow monitoring of the output of the generator set.

8.1.2 Construction/Major Components: The alternator unit is completely self-contained and is designed and constructed to provide trouble free operation, ease of maintenance and long service life.

The stator core is produced from insulated low loss electrical grade sheet steel laminations. These are built and welded under a fixed pressure to give an extremely rigid core to withstand vibrations and load impulses. The complete wound stator is, after impregnation, pressed into the frame and pinned into position.

A high grade precision machined shaft carries the rotor assembly which comprises the alternator rotating field systems, the exciter rotor/rotating diode system and the cooling fan. The rotor is mechanically wedged and supported on the winding end to allow an overspeed of up to 2250 RPM. The complete rotor assembly is dynamically balanced to ensure vibration-free running.

At the drive end of the rotor assembly a cast-aluminum centrifugal fan draws cooling air through screened/louvered covers at the non drive end and discharges it through similar side mounted covers at the drive end.

8.1.3 Alternator Method of Operation: The electrical power produced by the generator set is derived from a closed loop system consisting principally of the exciter rotor, the main revolving field and the automatic voltage regulator (See Figure 8.1).

The process begins when the engine starts to rotate the internal components of the alternator. The residual magnetism in the main rotor (item 1) produces a small alternating voltage (AC) in the main stator (item 2). The automatic voltage regulator (item 3) rectifies this voltage (converts it to DC) and applies it to the exciter stator (item 4).

This DC current to the exciter stator creates a magnetic field which, in turn, induces an AC voltage in the exciter rotor (item 5). This AC voltage is converted back to DC by the rotating diodes (item 6).

When this DC voltage appears at the main rotor, a stronger magnetic field than the original residual field is

created which induces a higher voltage in the main stator.

This higher voltage circulates through the system inducing an even higher DC voltage back at the main rotor. This cycle continues to build up the voltage until it approaches the proper output level of the generator set. At this point the automatic voltage regulator begins to limit the voltage being passed to the exciter stator which, in turn, limits the overall power output (item 7) of the alternator.

This build-up process takes place in less than one second.

8.1.4 Automatic Voltage Regulator: The Automatic Voltage Regulator (AVR) maintains a no load to full load steady state voltage to tight tolerances. The AVR has a volts/hertz characteristic which proportionally reduces the regulated voltage at reduced speeds. This feature aids the engine during sudden large additions of load.

8.2 Alternator Maintenance

Although maintenance is rarely required, periodic inspection and cleaning is recommended.

Perform a winding insulation test according to procedures provided in the Alternator Manual before the initial start, after generator set storage, and every 3 to 6 months depending on humidity levels (more often in higher humidity). In high humidity areas, installing space heaters to operate when the generator set is not running will help keep the windings dry.

The alternator air filters, if fitted, should be inspected regularly depending on site conditions. If cleaning is necessary, remove the filter elements from the filter frames. Immerse or flush the element with a suitable detergent agent until the element is clean. Dry the elements thoroughly before refitting.

Additionally the alternator unit should be cleaned on a regular basis. The frequency of such cleanings depends on the environmental conditions of the operating site. The following procedure should be followed when cleaning is necessary: Disconnect all power. Wipe dust, dirt, oil, water and any other liquids from the external surfaces of the alternator unit and from the ventilation screens. These materials can work their way into the windings and may cause overheating or insulation breakdown. Dust and dirt is best removed using a vacuum cleaner. Do not use compressed air, steam or high pressure water!

The separate Alternator Manual provided with this manual contains more detailed information on alternator maintenance. It also includes a trouble shooting guide for alternator faults.

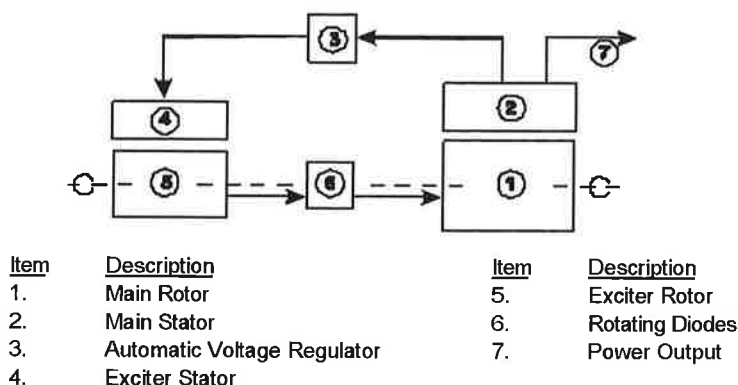


Figure 8.1: Block Diagram of Alternator Operation

9. CONTROL SYSTEM DESCRIPTION AND TROUBLE SHOOTING

9.1 Control System Description and Identification

9.1.1 Description: An advanced electronic control system has been designed and installed to control and monitor the generator set. Depending on the requirements of the set, one of several different standard control systems may be fitted. These include the 1001 Series Keystart System, 2001 Series Autostart System, 4001 Series Deluxe Autostart System and the 4001E Series Enhanced Deluxe Autostart System. Other more specialized systems may be installed for specific installations in which case separate documentation is provided.

These control systems consist of three major components working together - a control panel, an engine interface module (EIM), and an alternator output circuit breaker.

The control panel provides a means of starting and stopping the generator set, monitoring its operation and output, and automatically shutting down the set in the event of a critical condition arising such as low oil pressure or high engine coolant temperature. A 1001, 2001, 4001 or 4001E Series Panel is installed as appropriate for the requirements of the generator set installation.

The Engine Interface Module is a sealed, engine mounted module that provides switching relays for the Starter Motor Solenoid, Glow Plug and Fuel Solenoid. Each of these circuits is protected with individual fuses mounted in the module. Individual LED's illuminate when each circuit is energized. The Engine Interface Module is available in three models depending on the type of control panel being used - the 12 volt EIM SR, the 12 volt EIM Plus and the 24 volt EIM Plus. The table below indicates which EIM module is used on which generator sets:

Panel	Sets up to 150kVA	Sets above 150kVA
<u>Fitted</u>	<u>(12 volt systems)</u>	<u>(24 volt systems)</u>
1001	12 Volt EIM SR	24 Volt EIM Plus
2001	12 Volt EIM Plus	24 Volt EIM Plus
4001	12 Volt EIM Plus	24 Volt EIM Plus
4001E	12 Volt EIM Plus	24 Volt EIM Plus

The power output circuit breaker serves to protect the alternator by automatically disconnecting the load in the event of overload or short circuit. It also provides a means of switching the generator set output.

9.1.2 Identification: Figure 9.1 shows each of the control panels to aid in identifying the system fitted on the generator set. The 1001 Series Panel, being a "Key Start" panel has a removable key to control the system. Only two fault lamps are provided on this panel. The 2001 Series Panel has a Control Switch, instead of a Key Switch, located below 5 fault lamps. The 4001 Series Panel is similar to the 2001 except the Control Switch is located below the gauges and there are 7 fault lamps. The 4001E Series Panel also has the Control Switch located below the gauges but has up to 16 fault lamps.

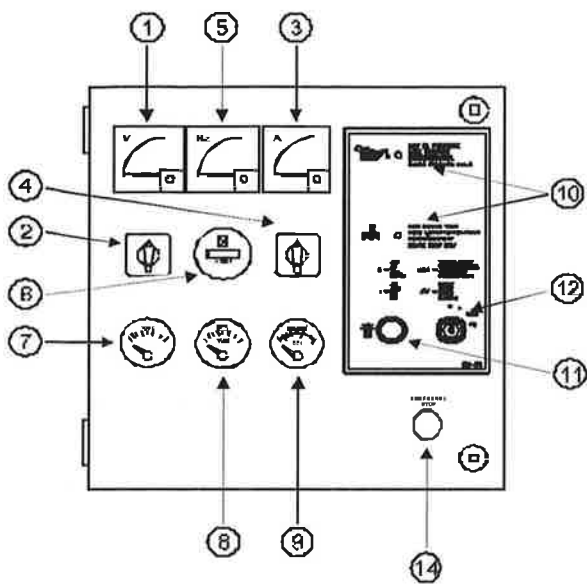
9.1.3 Panel Equipment: Before starting or running the generator set, the operator should become fully acquainted with the instruments and controls. The instruments should be observed from time to time while the generator set is running so that any abnormal readings can be detected before problems arise.

Figure 9.1 shows typical diagrams of each of the control panels. Addition of optional equipment will add items to

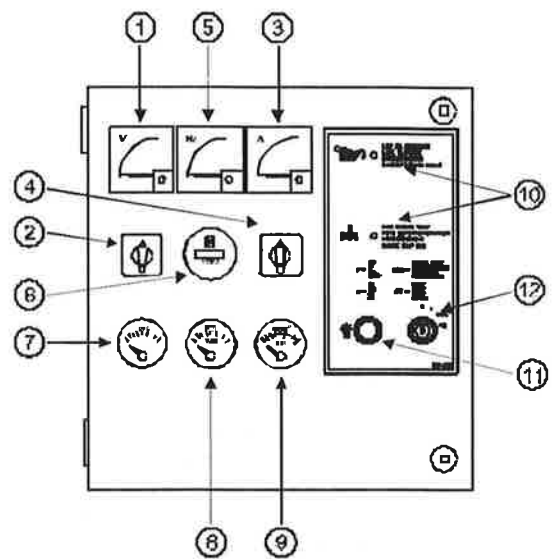
the panel so the panel fitted on the generator set may be slightly different from the typical ones shown. The following descriptions explain the function of each item on the panels:

Item Description

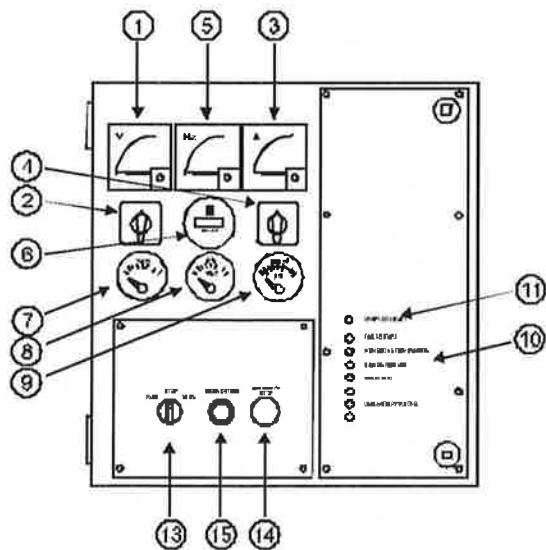
1. **AC VOLTMETER** - A voltmeter that indicates the AC voltage generated at the alternator output terminals. The reading indicated on the voltmeter will vary depending on the connections made inside the alternator terminal box, the setting of the voltage regulator and the position of the voltmeter selector switch (item 2). It should not, however, vary while the set is operating. In the event of alternator excitation failing, the output voltage will fall to approximately 20 to 40 volts. If the meter gives no reading while the generator set is running, ensure that the AC voltmeter selector switch is not in the OFF position.
2. **AC VOLTMETER SELECTOR SWITCH** - A selector switch allowing the operator to select voltage reading between phases or between a phase and neutral. The OFF position allows the voltmeter "zero" position to be checked while the generator set is running.
3. **AC AMMETER** - An ammeter that indicates the AC electrical current being delivered which is dependent on the connected load. A separate reading from each of the phases is possible using the ammeter selection switch (item 4). If the meter gives no reading while the generator set is running, ensure that the AC ammeter selector switch is not in the OFF position.
4. **AC AMMETER SELECTOR SWITCH** - A selector switch allowing the operator to select a current reading from each of the phases. The OFF position allows the ammeter "zero" position to be checked while the generator set is running.
5. **FREQUENCY METER** - A meter that indicates the output frequency of the generator set. The engine maintains a relatively constant speed under governor control so as to provide the proper operating frequency of 50 Hz or 60 Hz when the generator set is operating at full rated load. At partial load the frequency will be slightly higher than normal, depending on the droop of the governor. In practice, no load frequencies of approximately 52 and 62 Hz for 50 Hz and 60 Hz respectively, are considered normal. The frequencies will fall, as the set is loaded, to 50 Hz and 60 Hz at full load.
6. **HOURS RUN METER** - A meter that indicates the total number of hours of generator set operation to aid in maintenance.
7. **ENGINE WATER TEMPERATURE GAUGE** - A temperature gauge connected to a sensor in the engine to monitor engine coolant temperature. The normal operating temperature should be approximately 85°C (185°F).



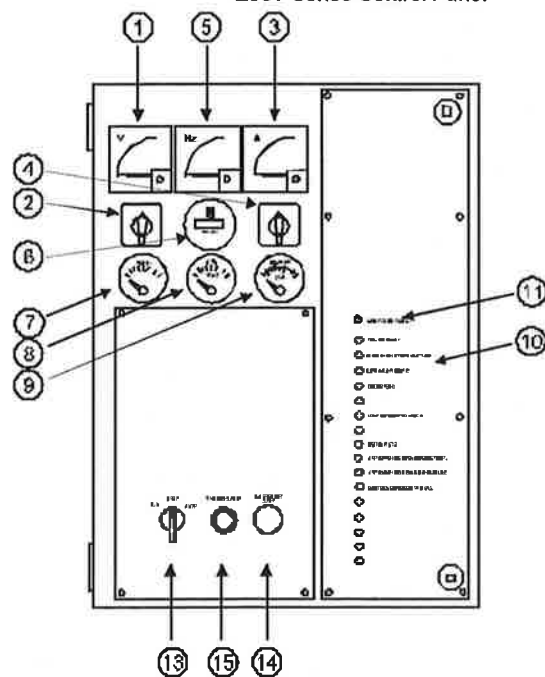
1001 Series Control Panel



2001 Series Control Panel



4001 Series Control Panel



4001E Series Control Panel

Figure 9.1 Design of Typical Control Panels

8. **DC BATTERY VOLTMETER** - A voltmeter that indicates the state of charge of the battery. When the engine is at standstill the normal battery voltage will be 12 to 14 volts on a 12 volt system and 24 to 28 volts on a 24 volt system. During starting, the needle will drop to about 70% of normal and oscillate as the engine cranks. Once the engine has started, the needle should return to its normal value. If the battery charging alternator is charging correctly, the voltage reading will always be higher with the generator set running than when it is stopped.
9. **ENGINE OIL PRESSURE GAUGE** - A gauge to monitor engine oil pressure from the moment the engine is cranked. The proper oil pressure rating should be approximately 35 to 60 p.s.i. for 50 Hz and 45 to 65 p.s.i. for 60 Hz. On cold engines the oil pressure will be significantly higher until the engine warms up.
10. **FAULT INDICATOR LAMPS** - Fault lamps that illuminate to indicate that the protective circuitry has sensed the indicated condition. The lamp should be red on conditions for which the system will initiate a shutdown of the set. For alarms, the lamp can be red or amber.
11. **LAMP TEST PUSHBUTTON** - A button to test the fault lamps and to reset an alarm warning lamp and circuitry after an alarm has been initiated.
12. **KEY SWITCH (1001 Series Only)** - A four position switch that provides a means of controlling or interrupting the battery supply to the control system, thermostart and starter motor.

Position "O" Off/Reset

Power is turned off and protection circuitry is reset in this position.

Position "I" On

DC power is supplied to the control system and the fault protection timer relay is initiated.

Position "000" Thermostart

DC power is supplied to the thermostart circuit, if fitted.

Position "Start" Start

DC power is supplied to the starter motor to crank the engine. The thermostart circuit is also powered, if fitted.

13. **CONTROL SWITCH (2001, 4001 and 4001E Series Only)** - A three position switch that provides a means of controlling the generator set functions.

Position 1 "RUN"

The auto start function is initiated to immediately start and run the generator set.

Position 2 "STOP"

The generator set is shut down if running, and automatic start is inhibited. The fault protection circuitry is reset in this position.

Position 3 "AUTO"

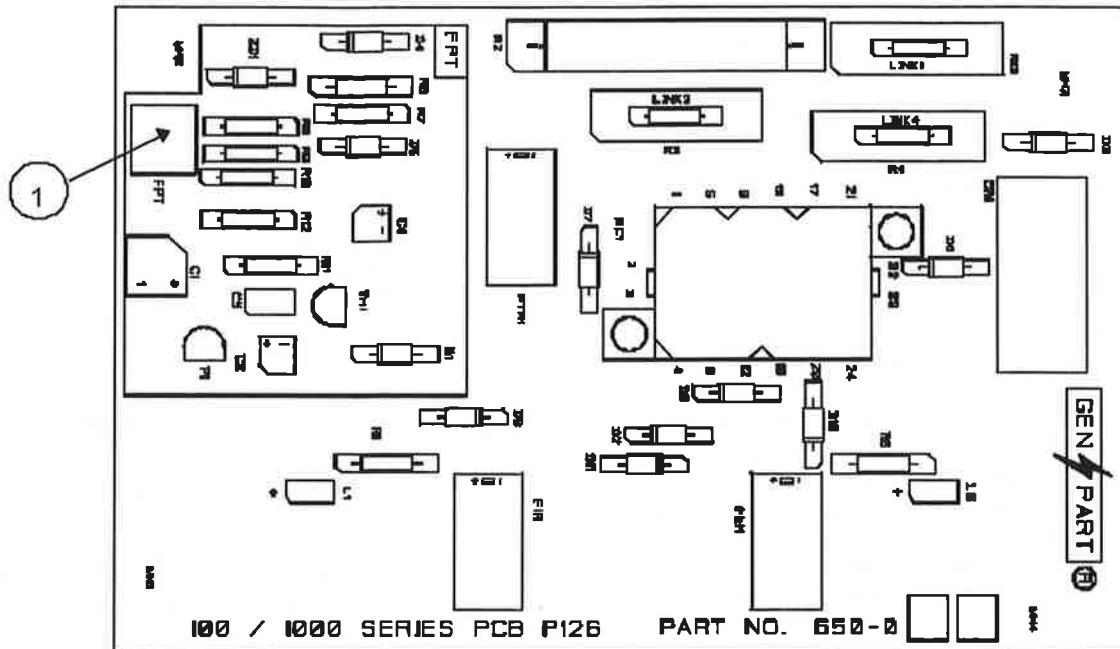
The control circuitry is ready to initiate an automatic start upon receiving a remote start signal.

14. **EMERGENCY STOP PUSHBUTTON (1001, 2001, 4001 and 4001E Series)** - A red lock-down pushbutton that immediately shuts down the generator set and will inhibit start until the pushbutton has been released by turning it clockwise. Prior to restarting the set, the fault lamp must be reset by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.
15. **THERMOSTART PREHEAT BUTTON (2001, 4001 and 4001E Series Only)** - A button to power the thermostart preheat circuit, if fitted.

9.2 Functional Description 1001 Series Control System

The 1001 Series Control System provides for manual starting and stopping of the generator set and provides protection for the engine against both high engine coolant temperature and low oil pressure.

The control system is of the relay timer type based on a Printed Circuit Board (P.C.B.). The P.C.B. is off board fuse protected and controls the starting, stopping and fault protection of the engine. Figure 9.2 shows the layout of the 1001 Series P.C.B.



- | Item | Description |
|------|---|
| 1. | FPT: Fault Protection Timer Adjust
Range: 1-70 seconds
Set: 15 ± 1 second |
- Figure 9.2: Layout of the 1001 Series P.C.B.

9.2.1 Function (1001 Series): Section 5 of this manual provides detailed guidance and checklists for the operation of the generator set. This section provides a more detailed description of the functions of the control system during operation.

During starting, turning the Key Switch from Position "O" (Off) to Position "I" (On) applies voltage to the P.C.B. and energizes Control Relay CR. With relay CR energized, contact CR/1 closes to energize the fuel control solenoid and the engine gauges.

WARNING:

! The Key Switch must not be turned to position "Thermo" or "Start" while the engine is running.

During start, turning the Key Switch through Position "I" (On) to Position "Thermo" activates the thermostart, if fitted. This preheats the induction air and should be held for 7 seconds. Turning the Key Switch further to Position "Start" provides power to the starter motor which cranks the engine. The starter motor will be disengaged when the Key Switch is released so it must be held in this position until the engine starts and then immediately released and allowed to return to Position "I" (On).

To prevent overheating of the starter motor the engine should not be cranked for more than 5 to 7 seconds. An interval of 10 seconds should be allowed between start attempts. If the engine has not started after 4 attempts, refer to the trouble shooting guide or Engine Manual to determine the cause of failure to start.

Turning the Key Switch past Position "I" (On) initiates the Fault Protection Timer (FPT) relay. This timer is set at 15 seconds but is adjustable on the P.C.B. Until the FPT times out the high engine coolant temperature and low oil pressure protective circuits are inhibited. This will keep the low oil pressure of a starting engine from causing the protection circuits to initiate a shutdown during start.

Should the oil pressure not have reached the proper specified operating point by the time FPT times out or, when running, should the pressure drop below this level, the protective circuitry will initiate a shutdown. The "LOW OIL PRESSURE" fault lamp will illuminate. Start up will be inhibited and no attempt should be made to start the set until the cause of the fault has been traced and remedied. High engine coolant temperature (and/or low coolant level on some larger models) will also shut down the generator set in the same way and will illuminate the "HIGH ENGINE TEMP" fault lamp.

WARNING:

! If at any time the generator set stops because of a fault, the fault should be rectified before trying to restart the generator.

These protective circuits will prevent start of the generator set until they are reset. Turning the Key Switch to Position "O" (Off) resets the protective circuits of the control system.

Once the generator set is running properly, the electrical load is applied to the set by switching the alternator output circuit breaker to "ON" (handle in the up position).

When shutting down the generator set, the load should be turned off by switching the alternator output circuit breaker to "OFF" (handle down). The engine should be

allowed to cool prior to stopping it. After a few minutes the Key Switch is turned to Position "O" (Off) which shuts the generator set down.

In case of emergency where immediate shutdown is necessary, the Emergency Stop button should be pressed immediately without first disconnecting the load.

9.2.2 Protective Circuits (1001 Series): Engine coolant temperature is monitored by the high temperature switch located on the engine. This is a normally open switch designed to close at 95°C (203°F). On closing, relay R1 energizes and self latches, illuminating the red colored fault lamp labeled "HIGH ENGINE TEMPERATURE". The second set of contacts on R1 (R1/2) opens to break the circuit that was energizing the control relay (CR). This closes the fuel solenoid valve, shutting down the engine. The fault lamp will remain illuminated and the engine locked out until the fault has been acknowledged and reset by turning the Key Switch to Position "O" (Off). On some larger models a low coolant level sensor will also cause the generator set to shut down and will also illuminate the "HIGH ENGINE TEMPERATURE" fault lamp even though the temperature may be in the normal range.

Engine lubricating oil pressure is also monitored to check for an excessively low pressure condition. This is monitored by an engine mounted, normally closed, switch that opens under normal running conditions. Should the oil pressure fall to or below about 22 p.s.i. (1.6 bar) the switch will close. This in turn energizes relay R5 which self latches, illuminating the "LOW OIL PRESSURE" fault lamp. The second set of contacts (R5/2) opens de-energizing the CR relay. This causes the fuel solenoid valve to close and the engine to shutdown. Reset is effected by turning the Key Switch to Position "O" (Off).

9.3 Functional Description 2001, 4001 and 4001E Series Control Systems

The 2001, 4001 and 4001E Series Control Systems provide for automatic starting and stopping of the generator set from a remote signal as well as manual starting and stopping. This makes it appropriate for standby generating systems. Protection is provided by the control system against high engine coolant temperature, low oil pressure, fail to start and overspeed. On the 4001 and 4001E Series Control Systems alarm protection is also provided for Low Battery Voltage. On 4001E Series Control Systems there are additional alarms for Approaching Low Oil Pressure, Approaching High Engine Temperature, Battery Charger Failure and Not in Auto Mode.

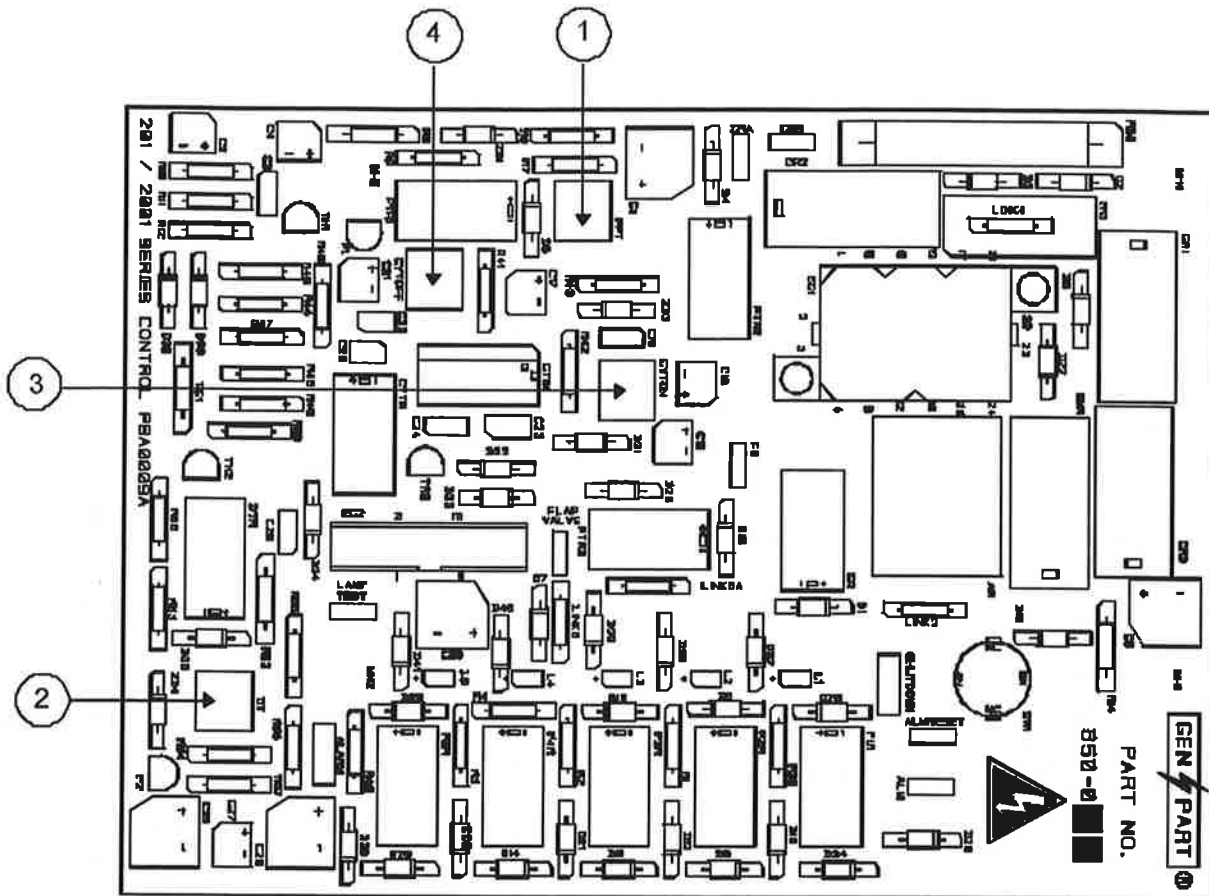
These control systems are of the relay timer type based on a double sided Printed Circuit Board (P.C.B.). The P.C.B. is off board fuse protected and controls the starting, stopping and fault protection of the engine. Figures 9.3, 9.4 and 9.5 show the layout of the 2001 Series P.C.B., the 4001 Series P.C.B. and the 4001E Series Expansion P.C.B. respectively.

Since these control systems are designed for automatic starting, they are fitted with connections for remote control. Included are terminals for Remote Emergency Stop and an interface to an Intelligent Load Transfer Panel. Additionally, the 4001 and 4001E Series Control Systems are fitted with an interface to Remote Annunciators which are described in Section 9.4.8.

9.3.1 Function (2001, 4001 and 4001E Series): Section 5 of this manual provides detailed guidance and checklists

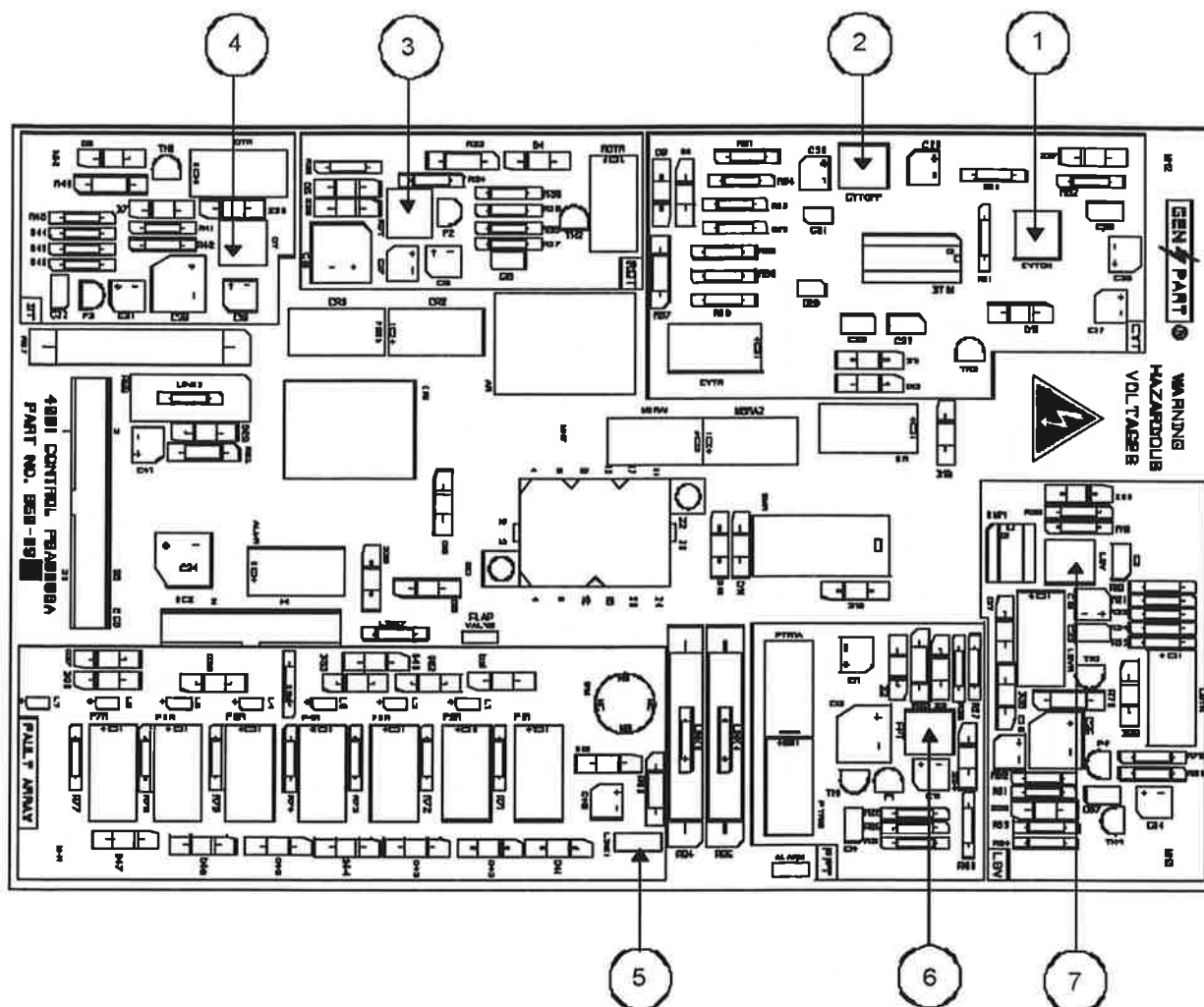
for the operation of the generator set. This section provides a more detailed description of the functions of the control system during operation.

When the Control Switch is turned to "RUN" or a remote start signal is received with the Control Switch in the "AUTO" position, the control system will initiate its automatic start sequence. The fuel control solenoid is turned on providing fuel to the engine. The starter motor is then energized via the auxiliary start solenoid (ASS) to crank the engine. If the engine does not start after a preset duration (CYTON) then a delay of a preset duration (CYTOFF) will elapse before cranking again.



Item	Description	Item	Description
1.	FPT: Fault Protection Timer Adjust Range: 1-70 seconds Set: 15 ± 1 second	3.	CYTON: Crank On Period Range: 0.25-20 seconds Set: 5 ± 1 second
2.	DT: Duration Timer (sets duration of cranking sequence) Range: 1-90 seconds Set: 27.5 ± 2.5 seconds	4.	CYTOFF: Crank Off Period Range: 0.25-20 seconds Set: 5 ± 1 second

Figure 9.3: Layout of the 2001 Series P.C.B.



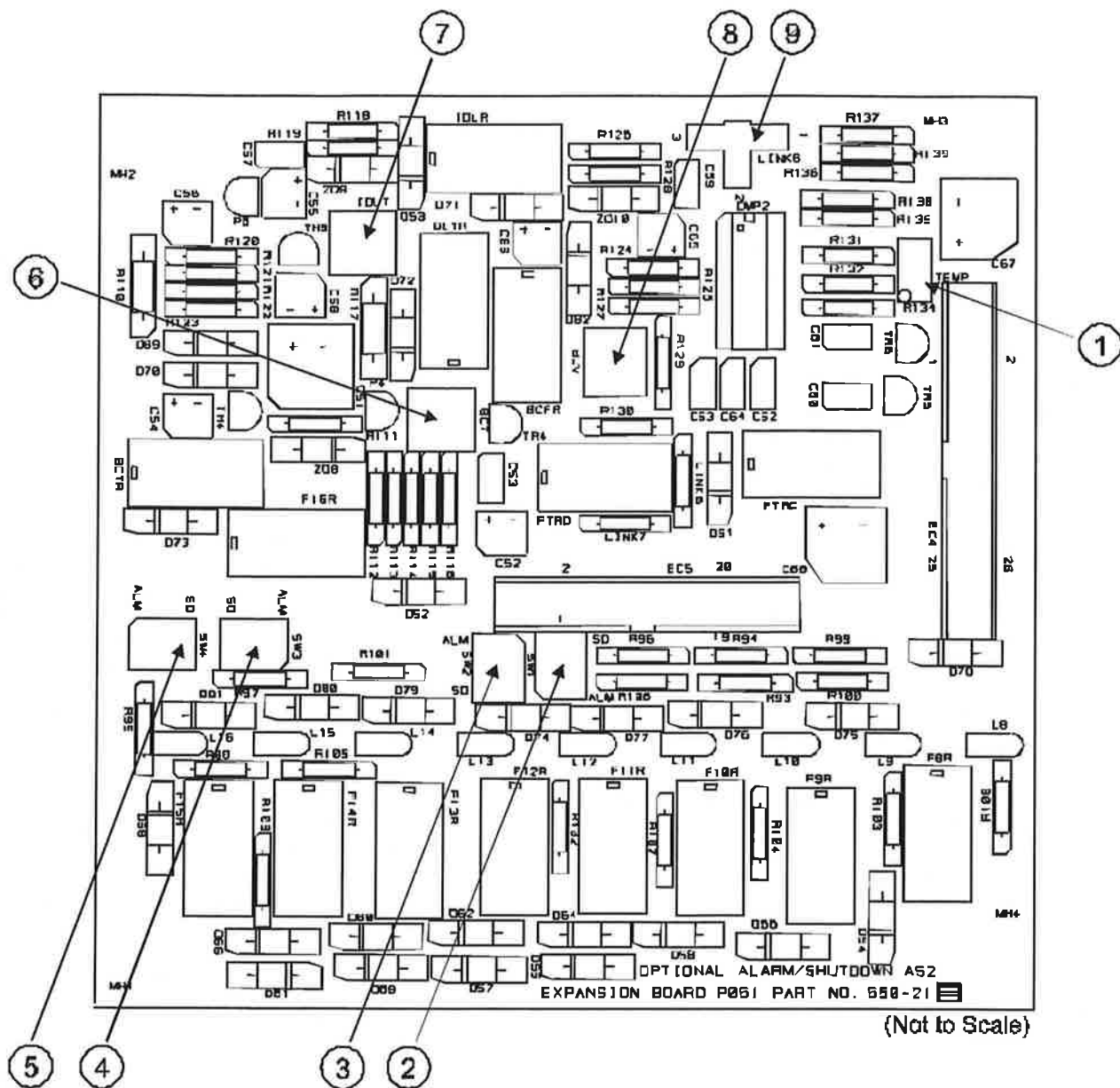
Item Description

1. CYTON: Crank On Period
Range: 1-65 seconds
Range: 1-20 seconds
Set: 5 ± 1 second
2. CYTOFF: Crank Off Period
Range: 1-20 seconds
Set: 5 ± 1 second
3. ROT: Run On Timer (sets cool down period)
Range: 3-330 seconds
Set: 240 ± 15 seconds

Item Description

4. DT: Duration Timer (sets duration of cranking sequence)
Set: 27.5 ± 2.5 seconds
5. LINK 1: Remove for 4001E system
where expansion board is used
6. FPT: Fault Protection Timer Adjust.
Range: 1-70 seconds
Set: 15 ± 1 second
7. LBV: Low Battery Voltage Monitor Adjust
Set: 10.75 volts for 12 volt systems 22.75 volts for 24 volt systems

Figure 9.4: Layout of the 4001 Series P.C.B.



Item Description

1. TEMP: Approaching High Engine Temperature Set Point
Set: 90°C ± 1°C
2. SW1: Shutdown/Alarm Selector for Fault L12
3. SW2: Shutdown/Alarm Selector for Fault L13
4. SW3: Shutdown/Alarm Selector for Fault L14
volts for
5. SW4: Shutdown/Alarm Selector for Fault L15
6. BCT: Battery Charger Timer Set
Range: 3-330 seconds
Set: 180 ± 15 seconds

Item Description

7. IDLT: Input Delay Timer Set
Range: 0.25-30 seconds
Set: 1 ± 0.5 seconds
8. BCF: Battery Charger Failure Detection Set Point
Set: 11.75 volts for 12 volt systems 22.25
24 volt systems
9. LINK 6: Battery Charger Failure Operating Mode

Figure 9.5: Layout of the 4001E Series Expansion P.C.B.

If the engine fails to fire after 3 start attempts then the "FAIL TO START" fault lamp will illuminate. The number of starts is dependent on the setting of CYTON, CYTOFF and the Duration Timer DT. With CYTON and CYTOFF set at 5 seconds and DT set at 27.5 seconds, this gives 3 crank attempts before FAIL TO START - 5 seconds on, 5 seconds off, 5 seconds on, 5 seconds off, 5 seconds on, 2½ seconds off, "FAIL TO START". Refer to the trouble shooting guide or Engine Manual to determine the cause of failure to start. Start will be inhibited until the protection circuits of the control system are reset by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button for the 4001 and 4001E panels. All time periods are approximate.

When the engine fires and is above cranking speed the starter motor is automatically disengaged. This condition is detected from the W/L terminal of the engine driven battery charging alternator. In addition, when the generator is providing voltage a back up signal is sent to cancel the start sequence. The voltage of the alternator is detected via relay AR.

Note:

- As soon as the generator starts, the power supply to the engine auxiliaries is disconnected via contactor HC, when fitted. Whenever the generator stops contactor HC re-energizes and reconnects the supply to the auxiliaries.

The beginning of the start sequence initiates the Fault Protection Timer (FPT) relay. Until the FPT times out (factory set at 15 seconds) the low oil pressure and high engine coolant temperature protective circuits are inhibited. This will keep the low oil pressure of a starting engine from causing the protection circuits to initiate a shutdown.

Should the oil pressure not have reached the proper specified operating point by the time FPT times out or, when running, should the pressure drop below this level, the protective circuitry will initiate a shutdown. The "LOW OIL PRESSURE" fault lamp will illuminate. Startup will be inhibited and no attempt should be made to start the set until the cause of the fault has been traced and remedied. High engine coolant temperature (and/or low coolant level on some larger models) will shut down the generator set and will illuminate the "HIGH ENGINE TEMPERATURE" fault lamp. An overspeed condition will, in the same way, shut down the set and illuminate the "OVERSPEED" fault lamp.

WARNING:

- ! If at any time the generator set stops because of a fault, the fault should be rectified before trying to restart the generator.

These protective circuits will prevent start of the generator set until they are reset. Turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button for the 4001 and 4001E panels resets the system.

Manually the generator set can be stopped at any time by pressing the Emergency Stop Pushbutton or by turning the Control Switch to "STOP". The set will also automatically shutdown when the remote start signal is removed. On 4001 and 4001E Control System the Run On Timer (ROT)

will allow a cool down period at low power prior to shutdown.

9.3.2 Protective Circuits (2001, 4001 and 4001E Series): Engine coolant temperature is monitored by the high temperature switch located on the engine. This is normally an open switch designed to close at 95°C (203°F). On closing, a relay energizes and self latches, which illuminates the "HIGH ENGINE TEMPERATURE" fault lamp. It also breaks the circuit energizing the control relay (CR). This closes the fuel solenoid valve, shutting down the engine. The fault lamp will remain illuminated and the engine locked out until the fault has been acknowledged and reset by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels. On some larger models a low coolant level sensor will also cause the generator set to shut down and will also illuminate the "HIGH ENGINE TEMPERATURE" fault lamp even though the temperature may be in the normal range.

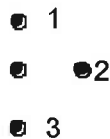
Engine lubricating oil pressure is also monitored to check for an excessively low pressure condition. This is monitored by an engine mounted, normally closed, switch that opens under normal running conditions. Should the oil pressure fall to or below about 22 p.s.i. (1.6 bar) the switch will close. This in turn energizes a relay which self latches, and illuminates the "LOW OIL PRESSURE" fault lamp. Again the relay CR is de-energized which causes the fuel solenoid valve to close and the engine to shutdown. Reset is effected by turning the Control Switch to "STOP" for the 2001 panel or by pressing the RESET button on the P.C.B for the 4001 and 4001E panels.

The OVERSPEED fault is monitored by the E.I.M via the speed signal from the magnetic pick-up. If the engine speed rises above a certain pre-settable value, the module sends a zero volt signal to the generator set control panel to activate the Overspeed Fault circuitry. Upon this signal a relay energizes and self latches, which illuminates the "OVERSPEED" fault lamp. Again the relay CR is de-energized which causes the fuel solenoid valve to close and the engine to shutdown. Reset is effected by turning the Control Switch to "STOP" for the 2001 panel or by pressing the RESET button on the P.C.B for the 4001 and 4001E panels.

The Low Battery Voltage alarm which is fitted as standard on the 4001 and 4001E Series Control Systems detects the battery voltage and compares it to an adjustable reference (LBV) which is factory set at 10.75 volts for 12 volt systems and 22.75 volts for 24 volt systems. This alarm has a built in time delay to prevent spurious tripping such as when the engine is cranking.

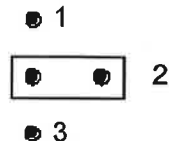
Four additional Alarm circuits are provided on the 4001E Series Control System. The Approaching Low Oil Pressure and Approaching High Engine Temperature alarms work off the sensors fitted for the gauges. The temperature alarm is factory set to go off at 90°C ± 1°C. The Not in Auto Mode Alarm senses the position of the Control Switch. The Battery Charger Failure Alarm detects low voltage from the charger. This level (BCV) is factory set at 11.75 volts for 12 volt systems and 22.25 volts for 24 volt systems. This alarm can be operated in one of 3 modes depending on the position of Link 6 on the 4001E Expansion P.C.B. (see diagrams below):

Mode 1: Link in Position 1



For generator sets with trickle charger and engine driven charging alternators. In this position the charger failure circuit only monitors when the engine is not running.

Mode 2: Link in Position 2



For generator sets fitted with AC powered chargers only (no engine driven charging alternator.)

Mode 3 Link in Position 3



For generator sets with no battery charger fitted. In this position the charger failure circuit is disabled.

The 2001 Series Control System has one additional channel beyond the standard that can be either a Shutdown circuit or an Alarm circuit depending on how it is programmed at the factory.

The 4001 Series Control System has one additional Shutdown circuit and one additional Alarm circuit beyond the standard. The use of these circuits is programmed at the factory.

The 4001E Series Control System has two additional Shutdown circuits, one additional Alarm circuit and four additional circuits that can be either Shutdown or Alarm circuit. Each of these is programmed at the factory.

The additional possible Shutdown circuits (not all available on all sets) include shutdown on:

- High Lube Oil Temperature
- Low Coolant Level
- Low Fuel Level
- Underspeed
- Overvoltage
- Undervoltage
- Earth Fault
- Earth Leakage
- Combined Over/Under Voltage

The additional possible Alarm circuits (not all available on all sets) include alarms for:

- Low Fuel Level
- Low Coolant Temperature

For the 2001 Series Control System, the Fault Indicating Lamps are grouped on the control panel as follows-

- L1 Fail To Start Shutdown
- L2 High Engine Temperature Shutdown

- L3 Low Oil Pressure Shutdown

- L4 Overspeed Shutdown

- L5 Additional Shutdown or Alarm (programmed at factory)

For the 4001 Series Control System, the Fault Indicating Lamps are grouped on the control panel as follows-

- L1 Fail To Start Shutdown

- L2 High Engine Temperature Shutdown

- L3 Low Oil Pressure Shutdown

- L4 Overspeed Shutdown

- L5 Additional Shutdown

- L6 Low Battery Alarm

- L7 Additional Alarm

For the 4001E Series Control Systems nine additional Fault Indicating Lamps are included on the separate 4001E expansion P.C.B. which are grouped on the control panel as follows-

- L8 Not In Auto Alarm

- L9 Approaching High Engine Temperature Alarm

- L10 Approaching Low Oil Pressure Alarm

- L11 Battery Charger Failure Alarm

- L12 Programmable Channel 1

- L13 Programmable Channel 2

- L14 Programmable Channel 3

- L15 Programmable Channel 4

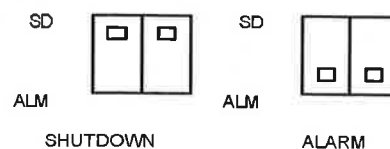
- L16 Additional Shutdown

Indicators L12-L14 are programmed for shutdown or alarm functions using the Dil switches on the P.C.B.

The DIL switches are assigned as follows:

Fault Channel	Dil Switch
L12	SW1
L13	SW2
L14	SW3
L15	SW4

The setting of these programmable Fault Indicator Lamps can be checked on the P.C.B. With both poles in "SD" position, the fault channel is configured as a shutdown. With both poles in "ALM" position, the fault channel is configured as an alarm.



9.4 Control System Options and Upgrades

A large variety of options may be fitted to customize the control system to a specific installation. The following sections cover the use and operation of some of these options.

9.4.1 Battery Trickle Chargers: These chargers are designed to ensure that the starter batteries maintain their charge even if the generator set is not operated for long periods.

The chargers are generally available with a 5 Amp nominal rating and are usually mounted within the control panel. A 10 Amp nominal rating battery charger may be fitted in some circumstances but would be located in a separate box placed adjacent to the control panel. These chargers require a continuous electrical power supply of either 220/240 volts AC or 120 volts AC depending on the charger.

Control switches for the chargers are not normally fitted to prevent inadvertent switching off of the charger. The control system will automatically disconnect the charger on startup of the generator set. While the engine is running the batteries are charged by the engine driven battery charging alternator.

As additional options, an "ON"/"OFF" switch and a battery charger boost control may be fitted. The boost control overrides the automatic control mechanism of the charger that would normally reduce charging level as the battery becomes charged. This can allow faster charging of the battery, however care must be taken to only use the boost control for a short time to avoid overcharging the battery and/or boiling the battery dry.

As an option, a battery charger ammeter may be fitted to the control panel in order for the operator to monitor the functioning of the battery charger.

9.4.2 Heaters: In addition to conventional space heaters that are useful in keeping the generator set warm and dry in cold or humid environments, four types of heater may be fitted on the generator set.

For water cooled engines, immersion type heaters (engine heaters) may be fitted in the engine coolant system to ensure that the engine is easy to start and able to take load more quickly. These heaters are provided with an integral non-adjustable thermostat set at approximately 40°C (104°F).

Alternator anti-condensation heaters (alternator heaters) may be fitted to the alternator stator winding to keep them dry in humid conditions. These are in the form of "heat-tracing" tape and operate at relatively low temperatures so they do not require a thermostat.

Lube oil sump heaters (sump heaters) may be fitted to the sump when the generator is to be sited in a low ambient temperature environment. The heater maintains the engine lubricating oil at a temperature which facilitates rapid starting and load acceptance.

AC Powered Battery heater (Battery Heater) may be fitted to the battery when the generator is sited in a low ambient temperature environment. The heater maintains the battery at an optimum operating temperature allowing full rated current to be drawn (providing that the battery is in a fully charged condition). The heater includes a thermostatic controller to regulate the output temperature to within safe limits.

All of these heater types require a continuous AC power source. The heaters are automatically disconnected on engine start-up.

9.4.3 Electric Fuel Transfer Pumps: Fuel transfer pumps are required when fuel must be transferred from a bulk storage tank to the generator set day tank. An AC pump requiring a 220/240 volt AC power supply may be fitted. These pumps are generally mounted on the baseframe and float switches are fitted in the day tank. Control relays, switches, lamps and overloads are fitted in the control panel.

The controls consist of two illuminated pushbuttons on the control panel door. The red button is a combined trip lamp and stop button. The green button is a run lamp and manual start pushbutton.

To operate the pump manually, ensure the red pushbutton is in the "ON" position (pulled out). Press and hold the

green pushbutton to manually run the pump. The pump will only run in the manual mode while the green button is held in.

To operate the pump in automatic mode, just ensure that the red pushbutton is in the "ON" position (pulled out). A DC relay inside the panel (PR) is energized by a low level float switch in the day tank. This will start the pump running and will illuminate the green run lamp. A high level float switch in the day tank de-energizes relay PR when the tank is full. This stops the pump and turns off the green run lamp.

An electrical overload is sensed if the pump draws significantly more current than normal. When this occurs the red lamp will illuminate.

Care must be taken to ensure that the pump is primed with fuel prior to operation to lubricate the seals. Also, the pump should never be run when the bulk tanks are empty or when valves on the fuel fill lines are closed.

9.4.4 Meters/Gauges: When more information is required than that which is provided by the standard panels, the following meters or gauges may be fitted to the control panel:

3 *Ammeters* mounted on the panel instead of one ammeter and a selector switch. This allows a continuous indication of the current flowing in each phase.

Kilowatt (kW) Meter to provide accurate readings of the load being supplied by the generator set. The meter is mounted on the control panel and the transducer is mounted inside the panel.

Combined Tachometer and Frequency Meter to replace the standard frequency meter. This meter allows both engine speed in revolutions per minute (RPM) and output frequency to be indicated on the front panel.

Lube Oil Temperature Gauge to monitor the lubricating oil temperature when the engine is operating. This is an electrical device powered by the generator set battery. The normal operating temperature should be approximately 90°-110°C (195°-230°F).

Ammeter for Battery Trickle Charger to monitor the current flow to the battery. It is used to observe the charging current being supplied by the battery trickle charger. When the batteries are fully charged this current will be small (less than 5 Amps) but with a partially discharged battery this current may be as high as 40 Amps.

9.4.5 Speed/Voltage Control: Three controls may be fitted to adjust the speed or voltage of the generator set.

The *speed adjust potentiometer* can only be used when the engine is controlled by an electronic governor. Clockwise adjustment increases the speed of the engine and anti-clockwise adjustment decreases it. The potentiometer is fitted with a dial mechanism which allows the potentiometer to be locked at the desired setting.

A *raise/lower switch* may be fitted on the control panel to control the speed of engines with mechanical or hydraulic governors. The governor must also be fitted with a motor operator. A "spring return to off" switch is then used to raise or lower the speed.

The *voltage adjust potentiometer* allows minor adjustments of voltage to be made from the control panel. About 3% adjustment is possible

9.4.6 Alarm Signaling: Three options may be fitted to the control panel to supplement the standard alarm indications of the alarm lamps:

A panel mounted alarm siren is DC operated and will sound when an alarm condition is indicated. An Alarm Mute pushbutton is fitted on the panel to silence the siren.

An audible alarm siren supplied loose is also DC powered and will sound when an alarm condition is indicated. It can be fitted at a convenient location. An Alarm Mute pushbutton is fitted on the panel to silence the siren.

A set of volt free contacts for common alarm change over in the event of an alarm condition. These are for connection to an existing alarm system. These contacts remain in the "alarm" state until the control system is reset.

9.4.7 Automatic Preheat Control: The thermostart induction air preheating operates automatically prior to and during engine cranking. The automatic cranking sequence will be delayed by the preheating period.

9.4.8 Remote Annunciator Panels: 8 or 16 channel remote annunciators may be fitted and connected to 4001 and 4001E Series Control Systems. These provide repeat indicators for the shutdown and alarm fault lamps on the control panel. They also include an audible alarm and alarm mute button. The connection is via a plug type terminal bar for easy installation.

Each channel is equipped with a LED that can display red, green or amber depending on the selection of the DIL switches. Each channel can also be selected to sound the audible alarm via a DIL switch.

Two further options may be fitted with the remote annunciators: A Normal/Run switch allows manual starting of the set from the remote location and an Emergency Stop Pushbutton allows manual stopping.

9.5 Control System Fault Finding/Trouble Shooting Guide

FAULT	SYMPTOM	REMEDY
Engine Fails to Start (1001 Series Only)	Engine Does Not Crank when Key Switch Turned to Position  (Start)	1. Check all Emergency Stop Pushbuttons are released (including any remote buttons). 2. Check operation of Key Switch. 3. Check no fault lamps illuminated. Reset, if required, after remedying indicated fault. 4. Check battery voltage on control panel. If voltage is not registering check fuses F4 and F5. If voltage is registering but is low then recharge the batteries with separate battery charger and reconnect to the set. (Ensure Key Switch is in Position 'O' (Off) when disconnecting and reconnecting the battery leads.) 5. Check supply to slave solenoid on starter motor - connect a DC voltmeter between this connection and the battery negative terminal. Try starting the engine using the Key Switch. If the meter registers a voltage then the starter motor or solenoid is faulty and must be replaced. If no voltage registers, check wiring from panel for loose connections or broken/shorted wires.
Engine Fails to Start (2001, 4001, or 4001E Series Only)	Engine Does Not Crank when Start Signal Given, Either Manually Via Control Switch or Automatic-ally Via a Remote Signal	1. Check all Emergency Stop Pushbuttons are released (including any remote buttons). If no remote stop is used, ensure "Remote Stop" terminals are linked. 2. Check that Control Switch is not off. 3. Check no fault lamps illuminated. Reset, if required, after remedying indicated fault. 4. Check battery voltage on control panel. If voltage is not registering check fuse F5. If voltage is registering but is low then recharge the batteries with separate battery charger and reconnect to the set. (Ensure the Control Switch is off when disconnecting and reconnecting the battery leads.) 5. Check supply to slave solenoid on starter motor - connect a DC voltmeter between this connection and the battery negative terminal. Try starting the engine manually by turning the Control Switch to RUN. If the meter registers a voltage then the starter motor or solenoid is faulty and must be replaced. If no voltage registers, check wiring from panel for loose connections or broken/shorted wires. 6. If wiring is not damaged then replace the P.C.B.
Engine Fails To Start (All control systems)	Engine Cranks But Does Not Fire or Engine Starts But Stops After 20 Seconds ("FAIL TO START" Fault Lamp Illuminates on 2001, 4001 or 4001E Panels.)	1. Check fuel level. 2. Check that Canopy External Emergency Stop Pushbuttons, if fitted, are not depressed (1001 Series). 3. Check wiring to the fuel control solenoid "FCS" and the voltage at the FCS. 4. Check fuses F1, F2, F3 on alternator side plate. 5. Check fuel lines and fuel filter for obstructions. 6. If white smoke comes from the exhaust then fuel is entering the engine but the engine is not firing. Refer to the Engine Manual for further checks. 7. If ambient temperature is low ensure thermostart aid is used, if fitted. 8. Check voltage output of P.C.B. to FCS. If signal not present, Replace the P.C.B. 9. Once the fault has been rectified, clear the fault lamp by turning the Control Switch to STOP for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.

FAULT	SYMPTOM	REMEDY
Engine Stops Due to High Engine Temp. (or on some larger models due to Low Coolant Level) (All control systems)	"HIGH ENGINE TEMP" Fault Lamp Illuminates	1. Check engine was not overloaded. 2. Check radiator obstructions. 3. Check fan belt tension. 4. Check ambient temperature is within the design limits of the generator set. 5. After engine has cooled, check coolant level. Do not add large amounts of cold water to a hot engine as serious damage could result. 6. Refer to Engine Manual. 7. Once fault has been rectified, clear the fault lamp by turning the Key Switch to position "O" (Off) for the 1001 panel, Turning the Control Switch to "STOP" for the 2001 panel or by Pressing the P.C.B RESET button on the 4001 and 4001E panels, as appropriate. 8. Cool the engine by starting and running it off-load for 10 minutes with the circuit breaker off (handle down).
Engine Stops Due to Low Oil Pressure (All control systems)	"LOW OIL PRESSURE" Fault Lamp Illuminates	1. Check oil level. 2. Refer to Engine Manual. 3. Check oil pressure switch with test gauge. Replace if faulty. 4. Once fault has been rectified, clear the fault lamp by turning the Key Switch to position "O" (Off) for the 1001 panel, Turning the Control Switch to "STOP" for the 2001 panel or by Pressing the P.C.B RESET button on the 4001 and 4001E panels as appropriate.
Engine Stops Due to Overspeed (2001, 4001 or 4001E Series Only)	"OVERSPEED" Fault Lamp Illuminates	Note: The "OVERSPEED" fault lamp will also illuminate after the Emergency Stop Pushbutton has been depressed even though there has been no overspeed condition. The Emergency Stop Pushbutton and any remote stop buttons must be released before the fault can be cleared. 1. Check if governor speed setting lever has moved. Re-adjust if required. 2. If electronic governor is fitted check linkage for free movement. Adjust if required. 3. Refer to Engine Manual. 4. Replace the P.C.B. 5. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.
Engine Stops Due to High Lube Oil Temp (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"HIGH LUBE OIL TEMP" Fault Lamp Illuminates	1. See trouble shooting guide on "Engine Stops Due To High Engine Temp" to see if cooling system is operating efficiently. 2. After radiator has cooled, check coolant level. 3. Check oil level. 4. Ensure proper maintenance procedures have been carried out. 5. Refer to Engine Manual. 6. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.
Engine Stops Due to Low Coolant Level (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"LOW COOLANT LEVEL" Fault Lamp Illuminates	1. Allow engine to cool. 2. Check coolant level. Fill as required with correct coolant mixture. Do not add large amounts of cold water to a hot engine as serious damage could result. 3. Check radiator, engine and pipework for leaks. Repair as necessary. 4. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.

FAULT	SYMPTOM	REMEDY
Engine Stops Due to Low Fuel Level (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"LOW FUEL LEVEL" Fault Lamp Illuminates	1. Check fuel level in day tank. Fill as necessary. 2. Check operation of the fuel transfer system, if fitted, as described in Section 9.4.3. 3. Once fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.
Engine Stops Due to Underspeed (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"UNDERSPEED" Fault Lamp Illuminates	1. Ensure engine has not been overloaded. 2. Ensure there is an adequate supply of fuel to the engine. 3. Check if governor speed setting lever has moved. Re-adjust if required. 4. If electronic governor is fitted check linkage for free movement. Adjust if required. 5. Clear the fault by turning the Control Switch to "STOP" and restart the engine. 6. Ensure alternator is running at the correct voltage by checking on the panel meters. 7. With engine running set correct speed on the engine governor control. 8. Refer to the Engine Manual.
Engine Stops Due to Overvoltage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"OVERVOLTAGE" Fault Lamp Illuminates	1. Disconnect the alternator from the load by turning off the circuit breaker (handle down), reset the fault by turning the Control Switch to "STOP" and restart engine. 2. Check voltage on panel meters. If voltage is normal, ensure that the load is non-capacitive (power factor correction equipment may inadvertently lead to a capacitive load). 3. If voltage remains high and can not be adjusted to the normal level using the voltage adjust potentiometer, if fitted, then refer to the Alternator Manual.
Engine Stops Due to Under-voltage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"UNDERVOLTAGE" Fault Lamp Illuminates	1. Disconnect the alternator from the load by turning off the circuit breaker (handle down), reset the fault by turning the Control Switch to "STOP" and restart engine. 2. Check voltage on panel meters. If voltage is normal check the load characteristics (i.e. ensure not overloaded). 3. If voltage remains low and can not be adjusted to the normal level using the voltage adjust potentiometer, if fitted, then check the voltage at the alternator terminals with an independent meter. If voltage is correct check wiring. 4 Check AVR. 5. Refer to Alternator Manual.
Engine Stops Due to Overvoltage /Under-voltage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"OVERVOLTAGE/UNDER-VOLTAGE" Fault Lamp Illuminates	1. Disconnect the alternator from the load by turning off the circuit breaker (handle down), reset the fault by turning the Control Switch to "STOP" and restart engine. 2. Check voltage on panel meters. If voltage is normal check the load characteristics (i.e. not capacitive and not overloaded). 3. If voltage remains high or low and can not be adjusted to the normal level using the voltage adjust potentiometer, if fitted, then check the voltage at the alternator terminals with an independent meter. If voltage is correct check wiring. 4 Check AVR. 5. Refer to Alternator Manual.
Engine Stops Due to Earth Fault (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"EARTH FAULT" Fault Lamp Illuminates	1. Check all cable and wiring for bad connections or shorts to earth. 2. Check alternator windings - refer to Alternator Manual. 3. Once the fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.
Engine Stops Due to Earth Leakage (Optional Shutdown - 2001, 4001 or 4001E Series Only)	"EARTH LEAKAGE" Fault Lamp Illuminates	1. Check outgoing cable and wiring for faults. 2. Do not restart the generator set until fault has been found. 3. Once the fault has been rectified, clear the fault lamp by turning the Control Switch to "STOP" for the 2001 panel or by pressing the P.C.B RESET button on the 4001 and 4001E panels.

FAULT	SYMPTOM	REMEDY
Alarm for Low Battery Voltage (4001 or 4001E Series Only)	"LOW BATTERY VOLTAGE" Alarm Lamp Illuminates	1. Check battery voltage at least 12 volts for a 12 volt system or at least 24 volts for a 24 volt system. 2. If voltage is low and generator set is not running then recharge the battery by connecting a separate battery charger to the disconnected battery or run the engine. 3. If voltage is low and generator set is running then the battery charging alternator is not charging. Stop the set and check the fan belt tension. 4. If fan belt tension is correct then check battery charging alternator - refer to Engine Manual. 5. If battery does not hold a charge then replace battery. 6. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Not in Automatic Mode (4001E Series Only)	"NOT IN AUTO MODE" Alarm Lamp Illuminates	1. Check Control Switch is in "AUTO". 2. Check Emergency Stop Pushbuttons are not pressed. 3. Check Circuit Breaker is on (handle up). 4. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Approaching High Engine Temp. (4001E Series Only)	"APPROACHING HIGH ENGINE TEMP" Alarm Lamp Illuminates	1. Check engine is not overloaded. 2. Check radiator and ventilation for obstructions. 3. Check ambient temperature is within the design limits of the generator set. 4. If the above are okay, reduce load and stop the set as soon as possible. Check the fan belt tension. 5. Refer to Engine Manual. 6. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Approaching Low Oil Pressure (4001E Series Only)	"APPROACHING LOW OIL PRESSURE" Alarm Lamp Illuminates	1. Check oil level with engine stopped as soon as possible. 2. Refer to Engine Manual. 3. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Battery Charger Failure (4001E Series Only)	"BATTERY CHARGER FAILURE" Alarm Lamp Illuminates	1. Check trickle charger is switched on and producing power. 2. Carry out checks as per low battery voltage alarm. 3. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button.
Alarm for Low Fuel Level (Optional Alarm - 2001, 4001 or 4001E Series Only)	"LOW FUEL LEVEL" Alarm Lamp Illuminates	1. Check fuel level in day tank. Fill as necessary. 2. Check operation of the fuel transfer system, if fitted, as described in Section 9.4.3. 3. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button for the 4001 and 4001E panels or by turning the control switch to "STOP" for the 2001 panel.
Alarm for Low Coolant Temp. (Optional Alarm - 2001, 4001 or 4001E Series Only)	"LOW COOLANT TEMP" Alarm Lamp Illuminates	1. Check that the immersion heaters are switched on and are operating. 2. Once the cause of the alarm has been rectified, clear the alarm lamp by pressing the "LAMP TEST" button for the 4001 and 4001E panels or by turning the control switch to "STOP" for the 2001 panel.
No Voltage Produced When Generator set is Running (All control systems)	No Voltage On AC Voltmeter	1. Check voltmeter selector switch is not in the "OFF" position. 2. Check fuses F1, F2, and F3, usually located on the alternator terminal box. 3. Check voltage at alternator terminals with an independent meter. If voltage is correct check wiring between alternator and panel. Check voltmeter. Replace if necessary. 4. Check AVR and rotating diodes. Refer to Alternator Manual for details. 5. Check engine speed is correct.
Generator set Does Not Go On Load (All control systems)	Generator set is Running but the Load is Not Being Powered	1. Check circuit breaker is "ON" (handle up). 2. Check generator set is producing AC voltage. If not, see fault above.

FAULT	SYMPTOM	REMEDY
Generator set Does Not Stop Manually (All control systems)	Generator set Continues Running After Being Switched Off	1. Check Key Switch or Control Switch position, as appropriate. 2. Check fuel control solenoid (FCS). Replace if necessary.
Generator set Does Not Stop When In Auto Mode (2001, 4001 or 4001E Series Only)	Generator set Does Not Stop After Remote Start Signal is Removed	Note: On 4001 and 4001E Series Control Systems the generator set does not stop immediately on removal of the remote start signal. Removal of this signal first initiates the cool down period. 1. Wait 5 minutes to ensure cool down period has elapsed (4001 and 4001E Series Control Systems Only). 2. Check that generator set stops when the Emergency Stop Pushbutton is depressed or the Control Switch is turned off. 3. If the set does not stop as in step 2 above then check the fuel control solenoid (FCS). Replace if necessary.

9.6 Load Transfer Panel

When the generator set is installed to automatically provide standby power in the event of mains failure, a load transfer panel is required. This transfer panel is designed to sense when the mains have failed, signal the generator set to start, switch the load from the failed mains to the generator set and then switch it back after the mains are re-established. See Figure 9.6.

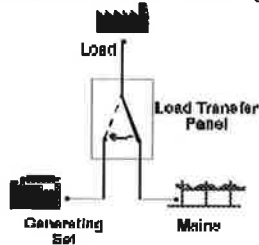


Figure 9.6: Function of a Load Transfer Panel

There is one standard range of Load Transfer Panel: The TI Series Intelligent Transfer Panel.

9.6.1 TI Intelligent Load Transfer Panel: The TI Intelligent Load Transfer Panel is designed to work with the Autostart Control Systems (2001, 4001, and 4001E Series) to form an automatic mains failure system. Only a two wire control interconnection is necessary between the generator set control panel and the TI panel making the installation very simple.

The control system consists of two Printed Circuit Boards (P.C.B.'s), control switches, a status panel and the contactors. The TI P.C.B. (see Figure 9.8) controls all the detection and monitoring circuits, the mode control switch and fuses. The P.C.B., switches and fuses are all mounted on the back of a hinged drop down door which is on the front of the transfer panel.

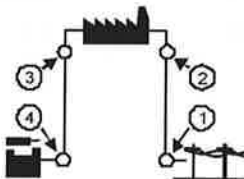
Status Panel: The front of the door has the status panel and main control switch. This status panel has four indicator lamps as shown in Figure 9.7. They are "Mains Available" (amber), "Mains on Load" (green), "Generator on Load" (red), and "Generator Available" (amber). Pressing the Lamp Test Button located below these indicator lamps will illuminate them for testing.

Controls: The main control switch on the front panel has three positions:-

AUTOMATIC MODE - The normal position for automatic operation.

TEST WITHOUT LOAD - For testing the generator set without connecting the load.

TEST WITH LOAD - For testing the generator set with the load connected.



Item	Description
1.	"Mains Available" Status Lamp
2.	"Mains on Load" Status Lamp
3.	"Generator on Load" Status Lamp
4.	"Generator Available" Status Lamp

Figure 9.7: TI Series Load Transfer Panel Status Display

In addition to the main control switch on the panel face, there is an internally mounted 3 position "Control Bypass" keyswitch for use by service personnel only. In the "normal" position the TI Panel operates normally. The other two positions allow the service personnel to manually connect the load to the operating generator set or to the mains supply. This switch would be used if the TI P.C.B. has been damaged.

WARNING:

! The internal maintenance switch should only be operated by trained personnel due to the high voltages present inside the enclosure.

Functional Description: The TI Series Load Transfer Panel operates as follows:

With the mains supplying electrical power to the load, the "Mains Available" and "Mains on Load" Status Lamps will be illuminated. These lamps indicate that the mains supply voltage level is above the Mains Voltage Set point (MVS) on the P.C.B. and that the load is connected to the mains supply. Potentiometer MVS is factory set at the voltage trip point for all three phases.

When the mains voltage on any of the 3 phases drops below the trip level MVS, both the "Mains Available" and "Mains on Load" status lamps extinguish. The Delay on Start timer (2MT) is energized. This timer avoids false engine starts due to momentary mains fluctuations. If the mains have not returned by the time 2MT has timed out then the mains contactor is opened and a start signal is sent to the generator set control panel.

Once the generator set has started and is producing voltage the "Generator Available" status lamp is illuminated and the Delay on Transfer Timer (AT) is enabled. This timer permits alternator output to stabilize before the standby contactor is closed. Once AT has timed out, and as long as the generator set voltage is above the Generator Voltage Set point (GVS), then the standby contactor is closed. This allows the generator set to power the load. The "Generator on Load" status lamp will be illuminated at this time.

On restoration of mains power above the trip point MVS, the "Mains Available" status lamp will illuminate and the Delay on Retransfer Timer (1MT) will be energized. This timer allows a period of time to ensure that the mains supply is reliable before transferring the load back. If the mains voltage drops below MVS at any time during this period then 1MT will be reset and not restarted until the mains voltage again goes above MVS.

9.8 Output Circuit Breaker Description

The alternator output circuit breaker is a molded case circuit breaker (MCB/MCCB) of sufficient rating for the generator set output. Electrical output is switchable through this device, with "ON" being indicated by the handle being up. The breaker will carry its rated current continuously but will trip to mid-position if the rating on any one phase is exceeded for a period depending on the percentage overload and the circuit breaker characteristics. The breaker must then be switched "OFF" (handle down) before reclosing.