Technical Description

CATERPILLAR®
1000 kVA POWER MODULE
C32 ACERT® TECHNOLOGY
50 / 60 Hz CONVERTIBLE
SOUND ATTENUATED
ISO 20 ft. CSC CERTIFIED

400 V, 50 Hz, 1000 kVA (800 EKW)
480 V, 60 Hz, 910 EKW

(optional equipment shown)

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1. OVERVIEW

This specification describes the Caterpillar® Utility Power Module. This module is rated for 400 V at 50 Hz producing 1000 kVA (800 EkW) or 480 V at 60 Hz producing 910 ekW. Included are: the Caterpillar C32 engine, the Caterpillar® SR4B 693 frame generator, the Utility paralleling switchgear, a industry standard 20 foot (6 m) high-cube sound attenuated CSC certified container and a cooling system for 50°C ambient. The complete solution is fully tested at 60 and 50 Hz and delivered ready to operate. Its modes of operation are field configurable and include single or multiple island mode (up to 18 units) and single unit utility paralleling mode.

2. CATERPILLAR® C32 4-STROKE-DIESEL ENGINE

2.1. Specifications

V-12, 4-stroke-cycle Diesel
Bore – mm (in)……..……...145 (5.7)
Stroke – mm (in)…….……162 (6.4)
Displacement – L (cu in)……..……..32.1 (1958)
Aspiration…….Turbocharged – Air to air Aftercooled
Fuel system: Electronic Ignition System
Governor type: Electronic ADEM A4

Fig. 2.1. C32 genset

2.2. ADEM® A4 Engine Controller

2.2.1. Introduction

The ADEM® A4 is an integral part of the innovative ACERT® Technology that provides higher degree of control over a large number of combustion variables than ever before
The ADEM® A4 engine system is composed of the ADEM® A4 ECM, control software, sensors, actuators, fuel injectors and interface to the generator system.
The prime benefit of an ADEM® A4 engine system is to better control and maintain the particulate emissions, both steady state and transient, while improving engine performance.

Advanced Features

_ Isochronous or droop speed control
_ Enhanced performance from fuel injection timing and limiting
_ Adjustable monitoring of vital engine parameters
_ Idle / rated speed setting
_ Programmable speed acceleration ramp rate
_ Adjustable cool down duration

2.2.2. Features

1 - General features

RELIABLE, DURABLE - All ADEM® A4 controllers are designed to survive the harshest environments. Environmentally sealed, die-cast aluminum housing isolates and protects electronic components from moisture and dirt contamination. Rigorous vibration testing ensures product reliability and durability. Accuracy maintained from -40° C to +85° C. Electrical noise immunity to 100 volts/meter. Internal circuits are designed to withstand shorts to +battery and –battery.

SIMPLE SERVICING –

SIMPLE SERVICING - Each ADEM® IV system works in combination with the Caterpillar ET service tool software to keep the engine operating at peak performance.

_ Displays measured parameters
_ Retrieves active and logged event codes documenting abnormal system operation
- Performs calibrations and diagnostic tests.
- Supports flash programming of new software into the ADEM® A4 ECM.

SELF-DIAGNOSTICS

Each ADEM® A4 ECM has a full compliment of self-diagnostics. The ECM can detect faults in the electrical system and report those faults to the service technician for quick repair. Self-diagnostic capability pinpoints operational problems in need of attention.

2 - **Advanced features**

- Isochronous or droop speed control.
- Enhanced performance from fuel injection timing and limiting.
- J1939 Communications.
- Adjustable monitoring of vital engine parameters.
- Idle/rated speed setting.
- Programmable speed acceleration ramp rate.
- Adjustable cool down duration.
- Data link interfaces.

2.2.3. Description

The ECM is housed in an environmentally sealed casting. All wiring connections to the ECM are made at the two sealed seventy-pin connectors.

ENGINE SPEED GOVERNING - Desired engine speed is calculated by the ECM and held within ±0.2 Hz for isochronous and droop mode. The ECM accounts for droop that is requested. The proper amount of fuel is sent to the injectors due to these calculations.
The ECM also employs cool down/shutdown strategies, acceleration delays on startup, acceleration ramp times, speed reference and a low/high idle switch is also available via communications to the EMCP 3.3 generator mounted local control panel.

FUEL LIMITING - Warm and cold fuel-air ratio control limits are controlled by the ECM. Electronic monitoring system derates, torque limit, and cranking limit, programmable torque scaling, and cold cylinder cutout mode are standard features.

FUEL INJECTION TIMING - Master timing for injection is controlled by the ECM control. Temperature dependencies are accounted for in the fuel injection calculations.

ELECTRONIC MONITORING - Electronic monitoring of vital engine parameters can be programmed. Warning, derate and shutdown event conditions may be customized by the user.

INFORMATION MANAGEMENT -The ECM stores information to assist with electronic troubleshooting. Active and logged diagnostic codes, active events, logged events, fuel consumption, engine hours, and instantaneous totals aid service technicians when diagnosing electronic faults and scheduling preventive maintenance.

CALIBRATIONS - Engine performance is optimized through injection timing. Auto/manual sensor calibrations are standard features.

ON-BOARD SYSTEM TESTS - System tests are available to assist in electronic troubleshooting. These tests include: injector activation, injector cutout, and override of control outputs.

ELECTRONIC SENSORS - The following sensing is available on the ADEM® IV controller: oil pressure, fuel pressure, fuel temperature, atmospheric pressure, air inlet temperature, turbo outlet pressure, engine coolant temperature, engine speed, throttle speed, droop position, exhaust temperature, engine control switch position, oil filter pressure differential, fuel filter pressure differential, air filter pressure differential, crankcase pressure, and remote e-stop switch position.

ELECTRONIC ACTUATORS - Electronic Unit Injectors are driven by the ECM. Actuators to control ether are optional.

2.2.4. ADEM® A4 Specifications

- Humidity: 0 to 90% relative humidity.
- Impervious to: salt spray, fuel, oil and oil additives, coolant, spray cleaners, chlorinated solvents, hydrogen sulfide and methane gas and dust.
- Input and output protection: all inputs and outputs are protected against short circuits to +battery and -battery Input voltage range (24 VDC nominal) 18 to 32 VDC.
- Mounting: engine mounted.
- Reverse: polarity protected.
- Shock: withstands 20 g
- Temperature range:
    - Operating: -40° C to 85° C (-40° F to 185° F)
    - Storage: -50° C to 120° C (-58° F to 248° F)
- Vibration: withstands 2.0 g at 18 to 500 Hz.

Fig. 2.2. ADEM® A4 main board

3. CATERPILLAR® SR4B® 693 FRAME GENERATOR

3.1. Specifications

Type:	Revolving field, solid-state automatic voltage regulator.
Construction:	Two bearing close coupled – 693 frame 4 pole, three phase, wye connected.
Insulation:	Class H rated at class F.
Enclosure:	Drip proof IP 22, guarded.
Overspeed capability:	150%.
Waveform:	Less than 5% deviation.
Paralleling capability:	Standard with adjustable voltage droop.
Voltage regulator:	3-phase true RMS sensing with adjustable Volts-per-Hertz response.
Voltage regulation:	Less than ± 0.5%.
Voltage gain:	Adjustable to compensate for engine speed droop and line loss.
THD:	Less than 3%.
TIF:	Less than 50.
Number of leads:	6
Excitation:	Permanent magnet.

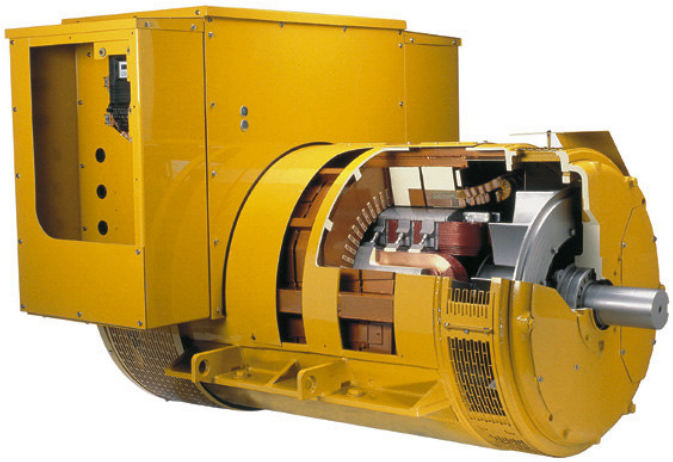


Fig. 3.1. SR4B Generator

3.2. Features

The Caterpillar® Series generators are the worldwide industry leaders. Features include:

- Superior harsh environment performance.
- Class H rotor and stator insulation.
- Suitable for continuing or prime power operation in harsh environments.
- Random wound/VPI stators provide superior handling of high switching loads & harmonics.
- Built-in paralleling capability with adjustable voltage droop.
- 4-Pole terminal strip for convenient customer load connection.
- Least total harmonic distortion 0.7222 winding pitch.
- Standard voltages: 480V, 60Hz, 380V to 415V at 50 Hz.
- Standards: meets or exceeds the requirements of IEC 34-1, NEMA MG 1-22, BS4999, BS5000, VDE0530, UTE5100, CSA22.2, ISO8528-3

Permanent Magnet Excited Generator:

The Caterpillar® SR4B® Permanent magnet exciter provides power isolation to voltage regulator, which eliminates the need for series boost. The permanent magnet provides circuit current sustaining for 300% rated current for 10 seconds. An additional feature is improved performance with non-linear loads.

Marine certified by ABS, LR, DNV, BV, and others.
Radio frequency noise suppression meets industry standards MIL-STD-461, 82/449/EEC, VDE875/10.84.

3.3. Random Wound Stator Winding before Impregnation

- Coils fit precisely into slots, without voids, giving better mechanical and electrical strength.
- Crimped and soldered lead connections.
- Large spaces between symmetrical coils:
  - Improves winding cooling
  - Reduces moisture retention
- Lacing, double surge ropes, and blocking of coil end turns minimizes coil movement during surges.
- Insulation – Each stator is vacuum pressure impregnated (VPI) with class H polyester insulation material. Each stator is then sealed with a class H epoxy material for excellent abrasion protection.

3.4. Rotor construction

The exciter rotor is machine wound and receives two dips and bakes of a fungus-resisting resin. The main rotor uses a precision “wet” layer wound process, with epoxy painted on the bare rotor and on each layer. This ensures bonding of all the wire layers together, bonding of the coils to the rotor laminations, and a sealed insulation system. The rotor epoxy is then oven-cured.

3.5. Caterpillar® Digital Voltage Regulator® (CDVR®)

3.5.1. CDVR® Description

The Caterpillar® Digital Voltage Regulator (CDVR) is a microprocessor-based control designed to provide precise voltage control, robust transient response, and generator protection with industry leading features and versatility.

3.5.2. CDVR® Features

- Microprocessor based control featuring choice of three control modes standard:
  - Automatic Voltage Regulation (AVR)
  - Power Factor Regulation (PF)
  - Reactive Power Regulation (Var)
- Programmable stability settings.
- Soft start control with an adjustable time setting in AVR control mode.
- Dual Slope Underfrequency (volts/hertz) regulation
- Three-phase or single-phase generator voltage (RMS) sensing/regulation in AVR mode
- Single-phase generator current sensing for regulation purposes
- Field current and field voltage sensing
- Five contact sensing inputs for system interface
- One common LED for visual indication of Alarm and Shutdown fault conditions
- Fault Shutdown Driver and Alarm Output Driver for indication of Alarm and Shutdown fault conditions
- Generator paralleling with reactive droop compensation and reactive differential compensation
- Line drop compensation
- UL 508A Recognized and CE certified
- Ten generator protective functions.
  - Generator Overvoltage
  - Generator Undervoltage
  - Loss of Excitation
  - Instantaneous Field Overcurrent
  - Over Excitation
  - Loss of Sensing
  - Diode Fault Monitor
  - Internal Watchdog Failure
  - Internal Memory Failure
  - Fault Reset Closed Too Long

3.5.3. CDVR® Specifications

General Specifications	
Voltage regulation Temp. Drift	±0.25% no load to full load
Response Time	±1.0% for a 40° C change
Variable Sensing Range	Maximum of 10 milliseconds
Control Power	90 to 600 Volts 24 Vdc Supply (18 to 30 Vdc, 5VA)
Regulator Filtering	THF 3% per IEC34-1 - TIF of 50 NEMA MG1-22.43
Harmonic Tolerance	0.5% Voltage regulation with 40% THD
Weight	1.47 kg (3.25 lb)
Environmental	
Operating Temperature	–40° C to 70° C (–40° F to 158° F)
Storage Temperature	–40° C to 85° C (–40° F to 185° F)
Relative Humidity	95% non-condensing 30° C to 60° C
Salt Spray	5% for 48 hrs at 38° C at 115% nominal operating voltage
Vibration	4.5G (peak) 18-2000 Hz in 3 perpendicular planes
Shock	20G
Certifications	CE Approved UL Recognized CSA Listed

Programmable Variables	Adjustment
Voltage vs. Frequency Characteristic	Two slope ranges adjustable from 1 to 10 PU in 0.1 increments
Fine Voltage Level	–10% to +10% in 0.1% increment
Droop Adjustment	0 to 10% in 0.1% increment
Overvoltage Setpoint	105 to 135% of rated voltage in 1.0% increment
Overvoltage Time Delay	2 to 30 seconds in 1 second increments
Undervoltage Setpoint	60 to 95% of rated voltage in 1.0% increment
Undervoltage Time Delay	10 to 120 seconds in 1 second increments
Gain	1 to 20% in 0.1% increments
Single Phase or Three Phase Sensing	
Under Frequency Point	20 to 40 Hz
Knee Frequency	45 to 65 Hz in 0.1 Hz increments
Minimum Voltage Setpoint	50 to 100% of rated voltage
Var Operating Mode	100% to –100% in 0.001 increments
PF Operating Mode	0.6 lead to 0.6 lag in 0.01 increments
Line Drop (IR) Compensation	0 to 10% in 0.1% increment
Loss of Excitation	0.1 to 1.0 PU leading vars
Loss of Excitation Time Delay	0.1 to 9.9 seconds in 0.1 second increments
Over Excitation	0 to 12 Adc in 0.1 Adc increments
Time Delay — Fixed Time Option	0 to 10 sec in 0.1 sec increments
Loss of Sensing Time Delay	0 to 25 sec in 1 sec increments
Diode Fault Monitor	1 to 10A rms field ripple current
Soft Start Function	1 to 120 sec

3.5.4. CDVR® Regulation Characteristic

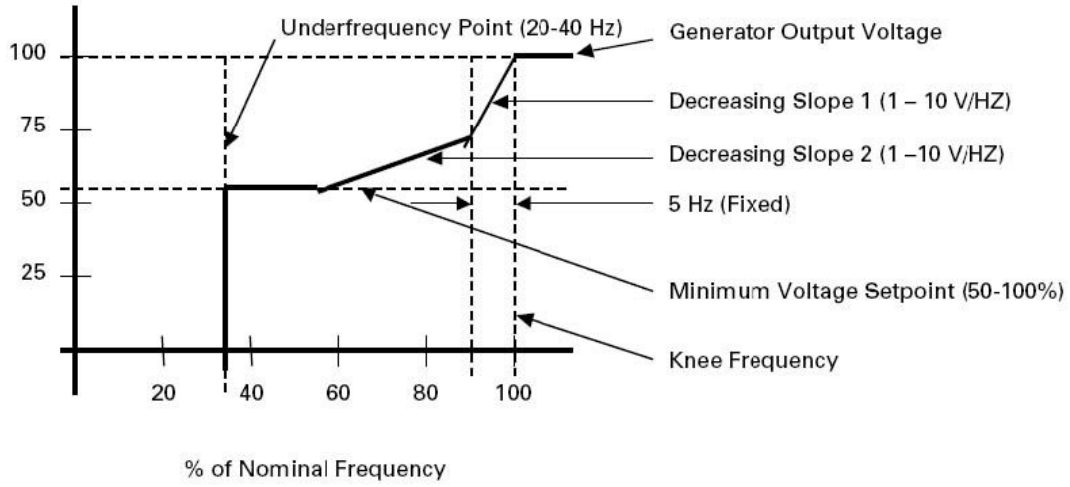


Fig. 3.2. Caterpillar Digital Voltage Regulator

3.6. Technical data

3.6.1. 50 Hz - Caterpillar® SR4B® Generator 2628094

kW Rating:	800	**Frequency**	50
Power Factor:	0.80	**Insulation**	H
kVA Rating:	1000	**Poles**	4
Duty (C):	105	**Excitation**	PM
Frame:	693	**Winding Type**	Random
RPM:	1500	**Leads**	6
Volts:	400	**Pitch**	0.7222
Bearings:	2	**Phases**	3
Conn.	STAR	**Amperage**	1443.4

I. Efficiency Data

Generator Efficiency		
Per Unit Load	kW	Efficiency %
0.25	200.0	92.8
0.5	400.0	95.0
0.75	600.0	95.3
1.0	800.0	95.0
1.1	880.0	94.9

II. II. Reactance Data

Reactances	Per Unit	Ohms
SUBTRANSIENT - DIRECT AXIS X''_d	0.1475	0.0236
SUBTRANSIENT - QUADRATURE AXIS X''_q	0.3188	0.0510
TRANSIENT - SATURATED X'_d	0.2188	0.0350
SYNCHRONOUS - DIRECT AXIS X_d	3.1100	0.4976
SYNCHRONOUS - QUADRATURE AXIS X_q	1.5388	0.2462
NEGATIVE SEQUENCE X_2	0.2331	0.0373
ZERO SEQUENCE X_0	0.0694	0.0111

III. Time Constants (s)

Time Constants	Seconds
OPEN CIRCUIT TRANSIENT - DIRECT AXIS T'_{d0}	3.8410
SHORT CIRCUIT TRANSIENT - DIRECT AXIS T'_{d}	0.2708
OPEN CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_{d0}	0.0054
SHORT CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_{d}	0.0045
OPEN CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_{q0}	0.0100
SHORT CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_{q}	0.0086
EXCITER TIME CONSTANT T_e	0.2225
ARMATURE SHORT CIRCUIT T_a	0.0451

Short Circuit Ratio: 0.37	Stator Resistance = 0.0056 Ohms	Field Resistance = 1.401 Ohms

IV. Mechanical Data

Center of Gravity

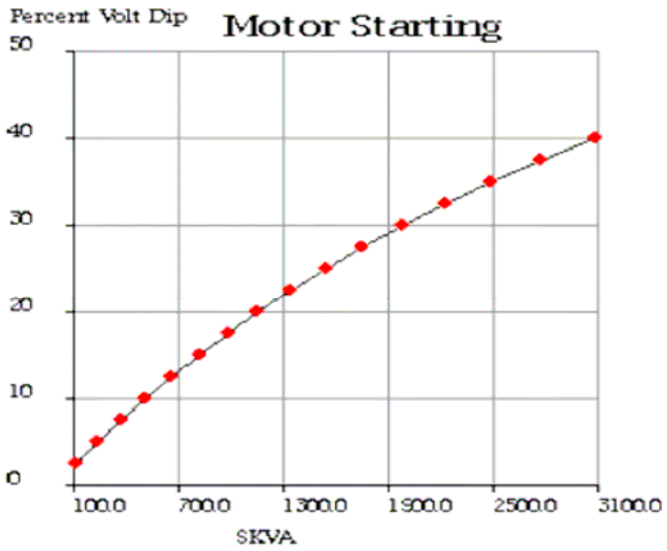
Dimension X	-960.1 mm	-37.8 IN.
Dimension Y	0.0 mm	0.0 IN.
Dimension Z	0.0 mm	0.0 IN.

- "X" is measured from driven end of generator and parallel to rotor. Towards engine fan is positive. See General Information for details
- "Y" is measured vertically from rotor center line. Up is positive.
- "Z" is measured to left and right of rotor center line. To the right is positive.

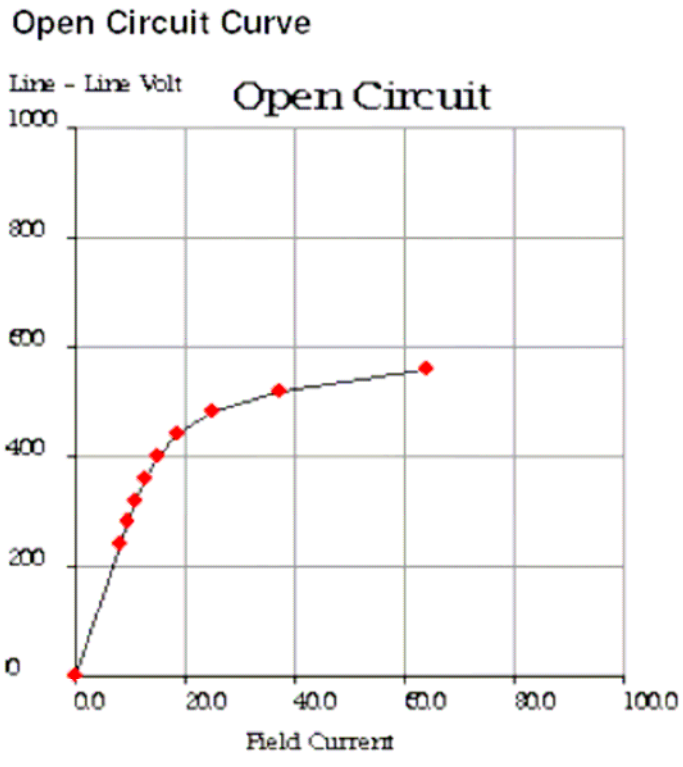
Generator WT = 3108 kg * Rotor WT = 1017 kg * Stator WT = 2091 kg
6,852 LB 2,242 LB 4,610 LB

Rotor Balance = 0.0508 mm deflection PTP
Overspeed Capacity = 180% of synchronous speed

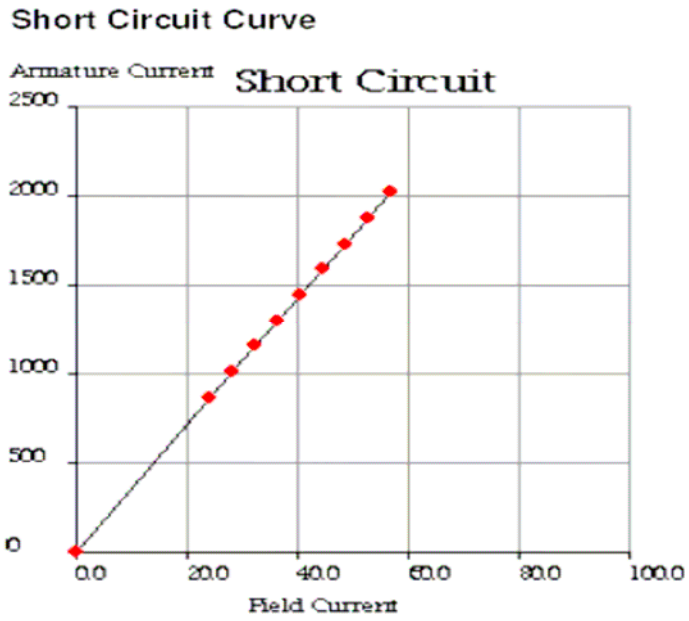
V. Motor Starting 50 Hz



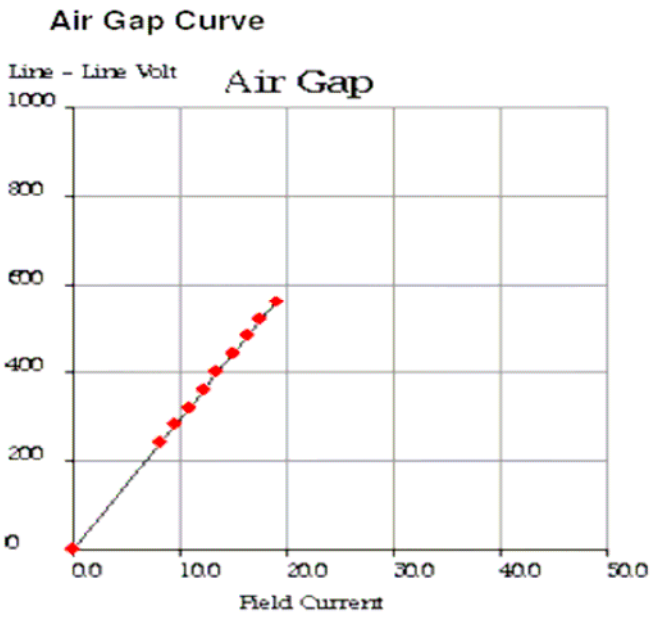
VIII. Open Circuit Curve 50 Hz



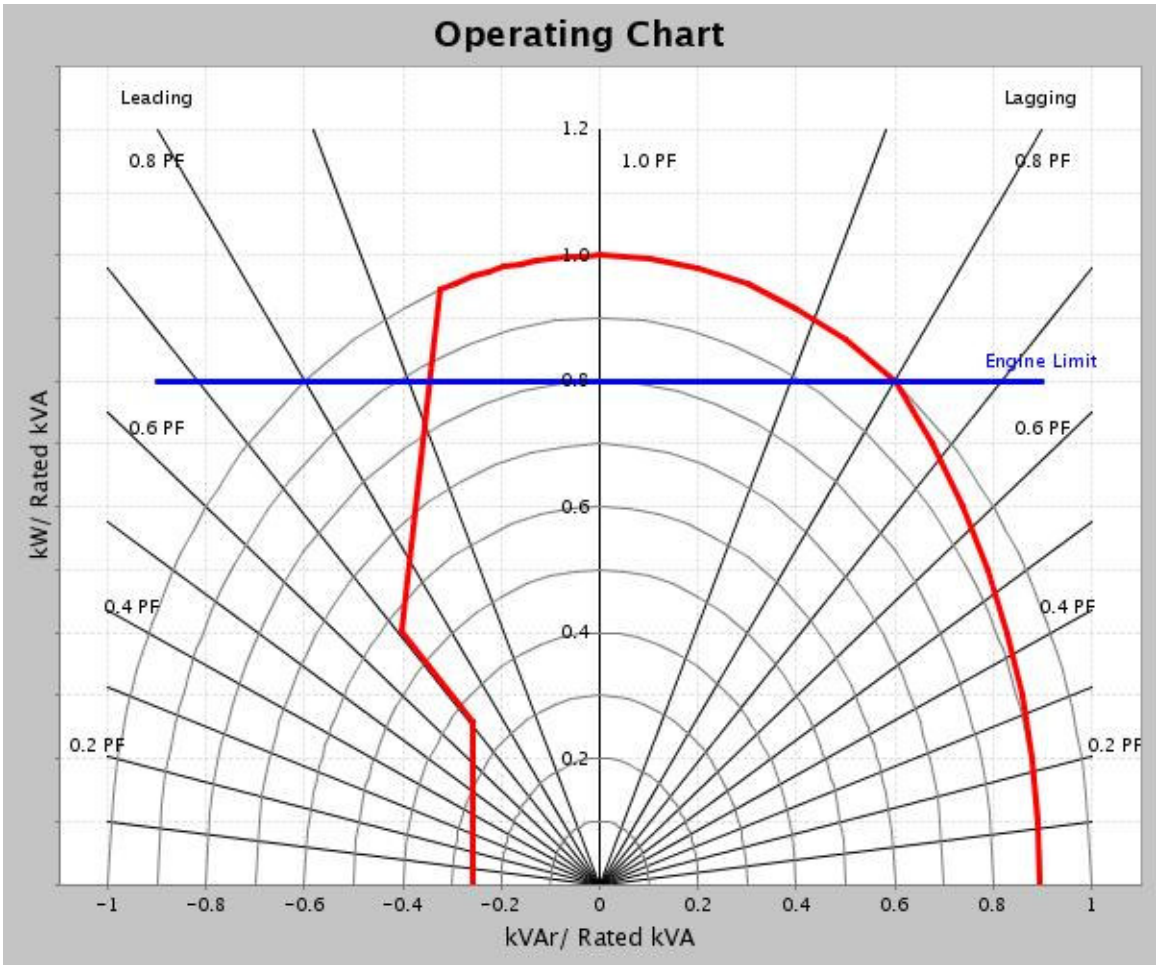
IX. Short Circuit Curve 50 Hz



X. Air Gap Curve 50 Hz



Reactive chart



3.6.2 60 Hz Technical Data - Caterpillar® SR4B® Generator 2628094

kW Rating:	910	**Frequency**	60
Power Factor:	0.80	**Insulation**	H
kVA Rating:	1140	**Poles**	4
Duty (C):	105	**Excitation**	PM
Frame:	693	**Winding Type**	Random
RPM:	1800	**Leads**	6
Volts:	480	**Pitch**	0.7222
Bearings:	2	**Phases**	3
Conn.	STAR	**Amperage**	1416

I. Efficiency Data

Generator Efficiency		
Per Unit Load	kW	Efficiency %
0.25	227.5	91.6
0.5	455.0	94.5
0.75	682.5	95.2
1.0	910.0	95.3
1.1	1001.0	95.2

II. Reactance Data

Reactances	Per Unit	Ohms
SUBTRANSIENT - DIRECT AXIS X''_d	0.1397	0.0283
SUBTRANSIENT - QUADRATURE AXIS X''_q	0.3021	0.0612
TRANSIENT - SATURATED X'_d	0.2074	0.0420
SYNCHRONOUS - DIRECT AXIS X_d	2.9479	0.5971
SYNCHRONOUS - QUADRATURE AXIS X_q	1.4589	0.2955
NEGATIVE SEQUENCE X_2	0.2212	0.0448
ZERO SEQUENCE X_0	0.0657	0.0133

III. Time Constants (s)

Time Constants	Seconds
OPEN CIRCUIT TRANSIENT - DIRECT AXIS T'_{d0}	3.8410
SHORT CIRCUIT TRANSIENT - DIRECT AXIS T'_d	0.2708
OPEN CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_{d0}	0.0054
SHORT CIRCUIT SUBSTRANSIENT - DIRECT AXIS T''_d	0.0045
OPEN CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_{q0}	0.0100
SHORT CIRCUIT SUBSTRANSIENT - QUADRATURE AXIS T''_q	0.0086
EXCITER TIME CONSTANT T_e	0.2225
ARMATURE SHORT CIRCUIT T_a	0.0451

Short Circuit Ratio: 0.39	Stator Resistance = 0.0056 Ohms	Field Resistance = 1.401 Ohms

IV. Mechanical Data

Center of Gravity

Dimension X	-960.1 mm	-37.8 IN.
Dimension Y	0.0 mm	0.0 IN.
Dimension Z	0.0 mm	0.0 IN.

- "X" is measured from driven end of generator and parallel to rotor. Towards engine fan is positive. See General Information for details
- "Y" is measured vertically from rotor center line. Up is positive.
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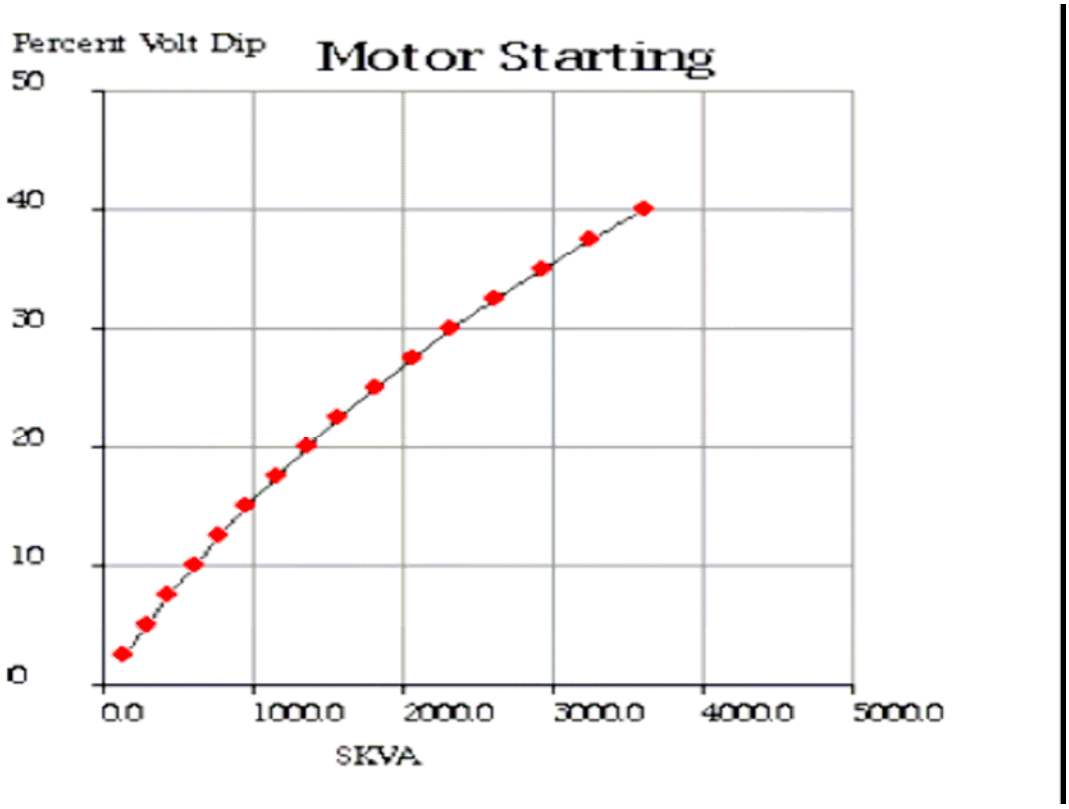
Generator WT = 3108 kg * Rotor WT = 1017 kg * Stator WT = 2091 kg
6,852 LB 2,242 LB 4,610 LB

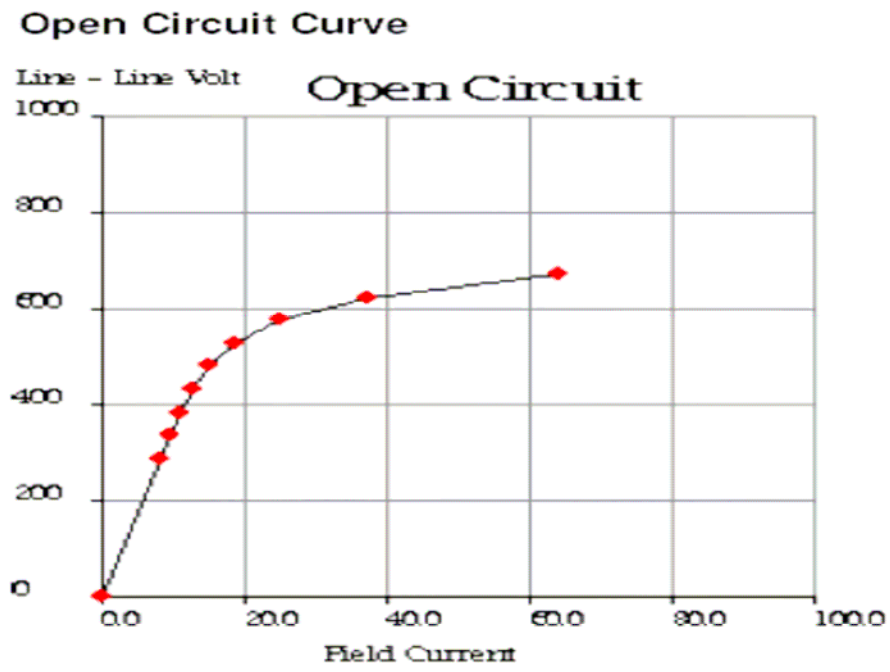
Rotor Balance = 0.0508 mm deflection PTP

Overspeed Capacity = 150% of synchronous speed

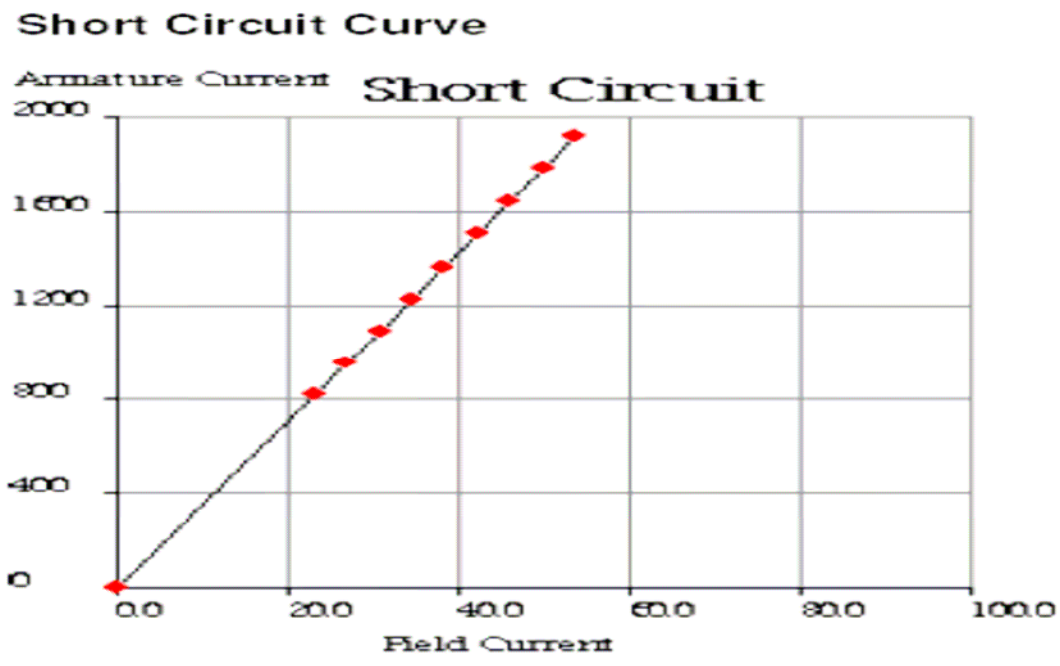
V. Motor Starting 60 Hz



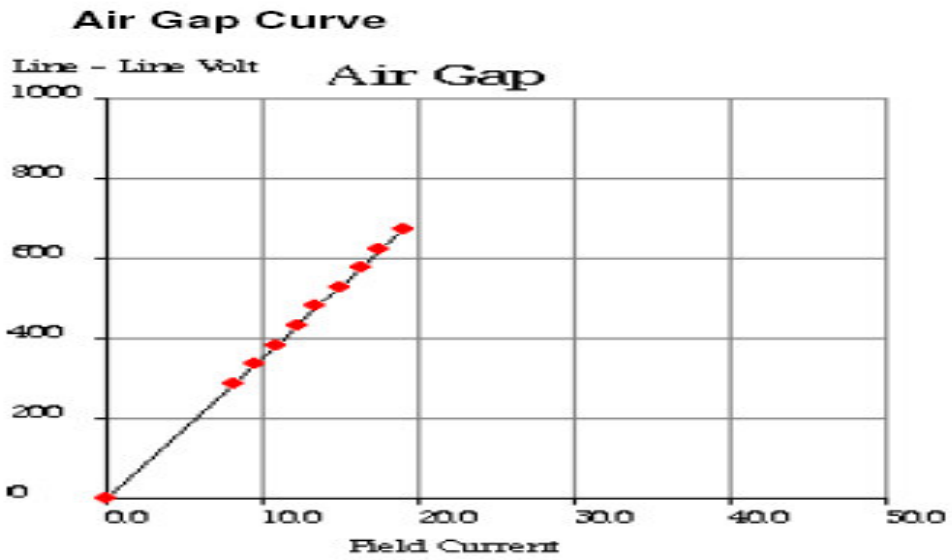
VI Open Circuit Curve 60 Hz



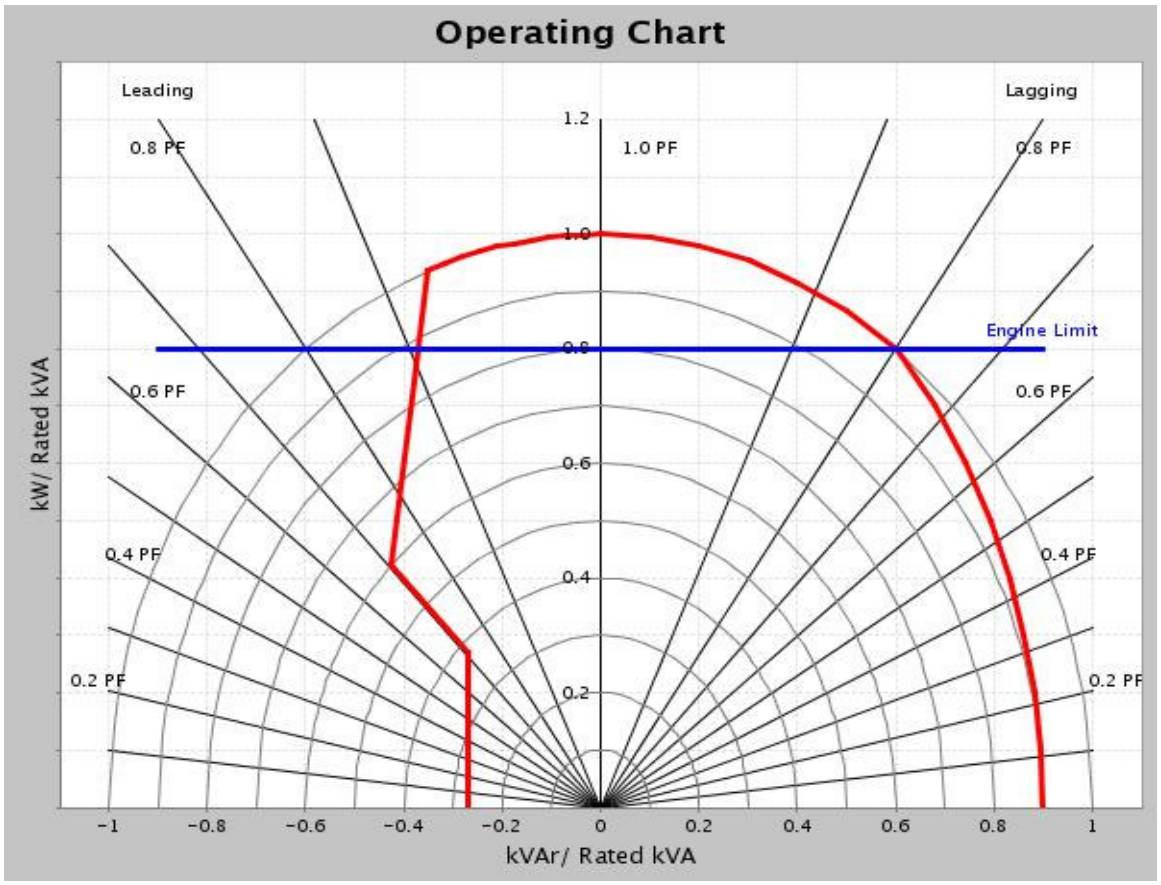
VII. Short Circuit Curve 60 Hz



VIII. Air Gap Curve



IX Reactive curve



4. EMCP 3.3 GENERATOR SET CONTROLLER

4.1. EMCP 3.3 General Description

The Caterpillar® EMCP 3.3 includes fully featured power metering, protective relaying and engine and generator control and monitoring. Engine and generator controls, diagnostics, and operating information are accessible via the control panel keypads; diagnostics from the J1939 Network modules can be viewed and reset through the EMCP 3.3. The EMCP 3.3 features a graphical display with a white backlight visible in all types of light as well as an advanced engine monitoring system.

4.2. EMCP 3.3 Operator Interface

- Graphical display with positive image, transflective LCD, adjustable white backlight/contrast.
- Two LED status indicators (1 red, 1 amber).
- Three Engine Control Keys and Status Indicators (Run/Auto/Stop).
- Lamp Test Key.
- Alarm Acknowledgement Key.
- Display Navigation Keys.
- Two Shortcut Keys: Engine Operating Parameters and Generator Operating Parameters.

4.3. EMCP 3.3 Features & Benefits

- A 64 x 240 pixel, 28 mm x 100 mm, white backlit graphical display denotes text alarm/event descriptions and is visible in all lighting conditions.
- Textual display with multiple language capability, including character languages such as Arabic, Chinese, and Japanese.
- Advanced engine monitoring is available on systems with an electronic engine control module.
- Integration with the CDVR provides enhanced system performance.
- Ability to view and reset diagnostics on J1939 Network modules via the control panel removes the need for a separate service tool for troubleshooting.
- Fully featured power metering, protective relaying, engine and generator parameter viewing, and expanded AC metering are all integrated into this controller.
- Real-time clock allows for date and time stamping of diagnostics and events in the control's logs as well as service maintenance reminders based on engine operating hours or calendar days.
- Customer programmable protective relaying, available as alarm and shutdown, protects against undervoltage, overvoltage, underfrequency, overfrequency, overcurrent, and reverse power.
- Digital, 32-bit microprocessor-based system eliminates the need for multiple switches, meters, transducers, relays, and sending units, which translates to less wiring and fewer opportunities for mechanical failures.
- Expanded remote customer communications are supported by MODBUS RTU (1/2

duplex) protocol using RS-485, which easily interfaces with existing plant systems and equipment.
- Simultaneous viewing of all AC L-L voltages, all AC L-N voltages, or all AC line currents.
- User-friendly, convenient, customer programmability directs the customer to logical parameter groups (Ex. AC metering, protective relaying, engine monitoring) for quick keypad access.
- Set points and software are stored in nonvolatile memory, preventing loss during a power outage.
- Compatibility with both mechanical and electronic engines makes it versatile.
- True RMS sensing ensures AC metering accuracy of ± 1% for AC voltage (L-L and L-N) and current.
- kW and kVA metering accuracy of 5%.
- Three levels of security allow for configurable operator privileges.
- Single, standard 70-pin connector
- Communication, assured by J1939 (Primary Data Link), J1939 #2 (Secondary Data Link) and MODBUS RTU (1/2 duplex) and RS-485 (Customer Communication).

4.4. EMCP 3.3 Environmental specifications

- Environmentally sealed front face rated for IP56. Resistant to chemical splash, including: diesel fuel, engine oil and machine oil.
- Protection level IP22 for rear of controller
- Resistant to salt spray
- Vibration: withstands 4.3G @ 24-1000 Hz
- Shock: withstands 15G
- Monitoring Functionality and Controls Operational from –40° C to 70° C (–40° F to 158° F)
- Display Operational from –20° C to 70° C (–4° F to 158° F)
- Storable from –40° C to 85° C (–40° F to 185° F)
- 0 to 95% Humidity, non-condensing from 30° C to 60° C (86° F to 140° F).

4.5. EMCP 3.3 Standards

- UL 508 Listed
- CSA C22.2 No.100,14, 94
- Complies with all necessary standards for CE Certification 98/37/EC Machinery Directive
    - BS EN 60204-1 Safety of Machinery (89/336/EEC EMC Directive)
    - BS EN 50081-1 Emissions Standard
    - BS EN 50082-2 Immunity Standard
- 73/23/EEC Low Voltage Directive
- EN 50178 LVD Standard
- ISO3046, ISO8528
- IEC529, IEC60034-5, IEC61131-3
- MIL STND 461

4.6. EMCP 3.3 Standard features

4.6.1. Controls

- Auto/Start/Stop
- Engine Cool-Down Timer
- Emergency Stop
- Engine Cycle Cranking
- Lamp Test
- Generator Voltage (w/CDVR)
- Engine Speed/Generator Frequency (Electronic Engines Only)

4.6.2. Digital (LCD) Indication

- Generator AC Voltage – 3 phase (L-L and L-N)
- Generator AC Current (per phase and average)
- Generator Power (kW) (total and per phase)
- Generator kVAR (total and per phase)
- Generator kVAR-hr (total)
- Generator % of rated (total)
- Generator kVA (total and per phase)
- Generator kW-hr (total)
- Generator Power Factor (PF) (average and per phase)
- Generator Frequency
- Engine RPM
- Battery Voltage
- Engine Hours
- Engine Successful Start Counter
- Engine Oil Temperature
- Engine Oil Pressure
- Engine Coolant Temperature
- Engine Crank Attempt Counter
- Service Maintenance Interval (EngDays)
- Real Time Clock
- Twenty (20) Event Fault Log
- Air Filter Differential Pressure
- Boost Pressure
- Engine Crankcase Pressure
- Engine Operating Hours or Calendar
- Engine Exhaust Temperature (L & R)
- Fuel Filter Differential Pressure
- Fuel Pressure
- Engine Intake Manifold Temperature
- Oil Filter Differential Pressure
- Oil Temperature
- Fuel Consumption (US/Imperial gal/hr or Liters/hr)
- Total Fuel Consumed

Notes:

1. *Temperature indications are viewable in either ℃ or ℉ (operator selectable).*
2. *Pressure indications are viewable in psi, kPa, or bar.*
3. *Fuel Consumption viewable in US/Imperial gal/hr or Liters/hr.*

4.6.3. Warning/Shutdown indication

- Overcrank
- Low Coolant Temperature Warning
- High Coolant Temperature Warning/Shutdown
- Loss of Coolant Warning/Shutdown
- Low Oil Pressure Warning/Shutdown
- Overspeed
- Control Switch Not In Auto
- High/Low Battery Voltage
- Emergency Stop Activated
- Low Fuel Pressure Warning/Shutdown
- High Fuel Pressure Warning/Shutdown
- Fuel Filter Restriction Warning/Shutdown
- High Intake Manifold Air Temperature Warning/Shutdown
- High Oil Temperature Warning/Shutdown

Notes:

- *Warning condition activates common alarm output signal and common flashing yellow indicating lamp.*
- *Shutdown condition activates common alarm output signal and common flashing red indicating lamp.*
- *Warning/Shutdown conditions result in text message on EMCP 3 display.*

4.6.4. Digital inputs (8 Total)

- Emergency Stop
- Remote Start
- 6 Programmable

Digital inputs can be programmed for various alarm, shutdown, and status conditions including: Low Fuel Level, High Fuel Level, Fuel Leak Detected, High Exhaust Temperature, Air Damper Closed, Circuit Breaker Open/Closed, Low Engine Oil Level, Low Coolant Level, Low Starting Air Pressure, Low/High Ambient Air Temperature, Spare Fault #1-6. Inputs can be programmed for either high or low activation using programmable Normally Open or Normally Closed contacts.

4.6.5. Protective relaying

- Generator Over/Under Voltage
- Generator Over/Under Frequency

- Generator Reverse Power Relay
- Generator Overcurrent

4.6.6. Relay outputs (8 Total)

- Starter Motor
- Fuel Control
- 6 Programmable

Relay outputs can be programmed for various operating conditions including:
Air Shut-off, or Pre-lube, Common Alarm, Common Shutdown, Common Warning, Engine Running, Crank Alert, and Idle/Rated.
Relays are rated for 2A at 30 VDC and consist of 6 Form A (Normally Open) contacts. Two of the programmable outputs are Form C (Normally Open and Normally Closed) contacts.

4.6.7. Discrete outputs (2 Total)

Discrete outputs can be programmed for various operating conditions including:
Air Shut-off, Pre-lube, Common Alarm, Common Shutdown, Common Warning, Engine Running, Crank Alert, and Idle/Rated.
Discrete outputs can sink up to 300mA and are suitable for driving relay coils or incandescent lamps.

4.6.8. Sensor inputs

- Engine Speed (Magnetic Pick-up)
- Engine Oil Pressure (0-2 k Ω resistive sender, 1 or 2-wire) – MUI Engines only
- Engine Coolant Temperature (0-2 k Ω resistive sender, 1 or 2-wire) – MUI Engines only
- Configurable Input (0-2 k Ω resistive sender) (for engine oil temperature, etc.)

4.7. EMCP 3.3 Available local display languages

- Arabic
- Chinese
- Danish
- Dutch
- Finnish
- French
- German
- Greek
- Hungarian
- Icelandic
- Italian
- Japanese
- Norwegian
- Portuguese
- Russian
- Swedish
- Spanish

Note: Displays contain 2 languages: English and local

Fig. 4.1. EMCP3.3 Local control panel

5. CONTAINER

5.1. General description

The module is contained in an industry standard 20 foot (6 m) high-cube container. The container is sound attenuated to meet 85 dB (A) at 7 m prime power. It's Lloyds CSC (Convention for Safe Containers) certified for convenient transport and stackable up to 3 high for transport and storage.

5.2. Features

- New container with checkered steel deck on floor. Interior walls and ceiling are insulated with 50 mm (2 in) of acoustic glass and covered with perforated galvanzed steel for a durable interior wall surface.
- Three personnel doors provided with sound attenuation and double sealed. One door located on each side of the engine and one in control room. Includes stainless steel hardware and hinges and panic release.
- External access door provided for bus bars and auxiliary connections (jacket water heaters, battery charger, space heater in generator and optional interior loads).
- Two 24 VDC interior lights with 60 min. timer in switchgear room and 3 in engine room.
- AC / DC Distribution and Motor Control Assembly includes the following distribution IEC rated breakers for Power Module accessories:
    - 1 # 10A, two (2) pole # Battery Charger input
    - 1 # 15A, single pole - AC Lighting Controls.
    - 3 # 15A, two pole # Generator Space Heater, Receptacles and Lighting.
    - 1 # 20A, single pole # Switchgear DC Control Power.
    - 2 # 30A, two pole # Jacket Water Heater #1 & #2.
- Duct Silencers for engine room and radiator room

5.3. Drawings, Dimensions & Weight

5.3.1. Container dimensions & weight

CONTAINER SHIPPING DIMMENSIONS

Length	6 058.0 mm	20.0 ft
Width	2 476.5 mm	97.5 in
Height	2 896.3 mm	114.1 in

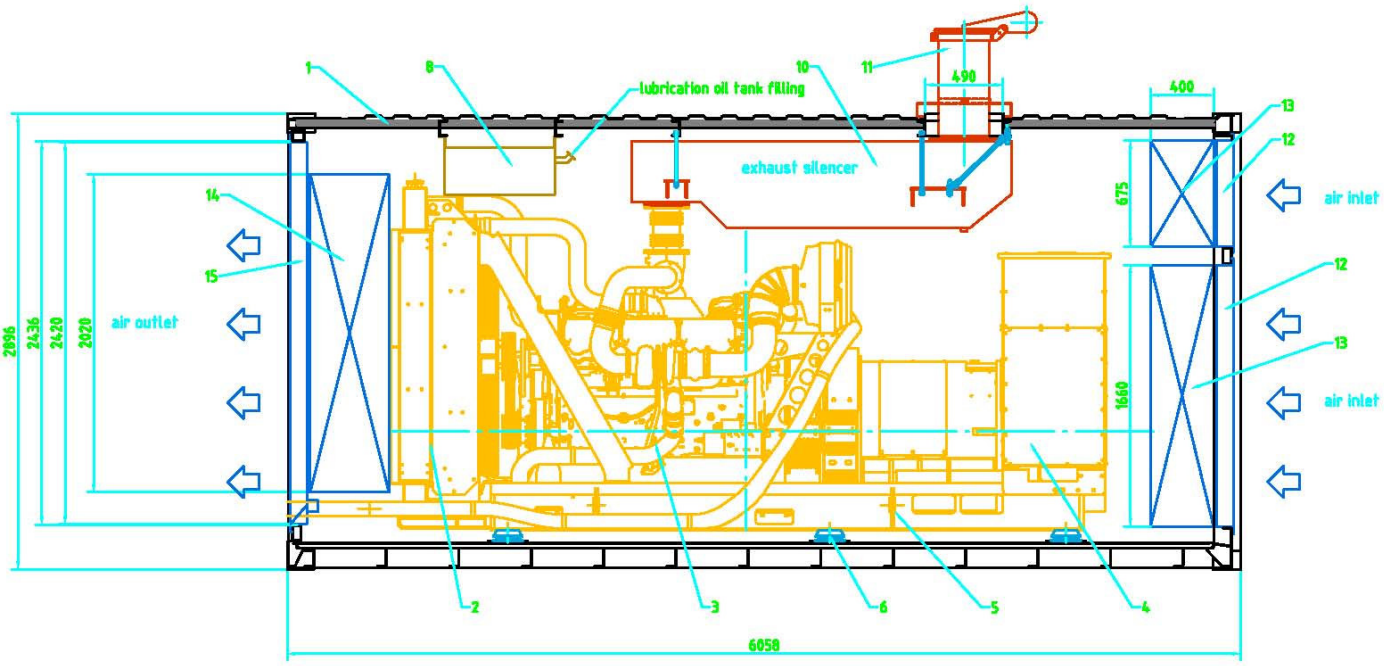
CONTAINER WEIGHT (WET):

15 240 Kg	33 640 lb

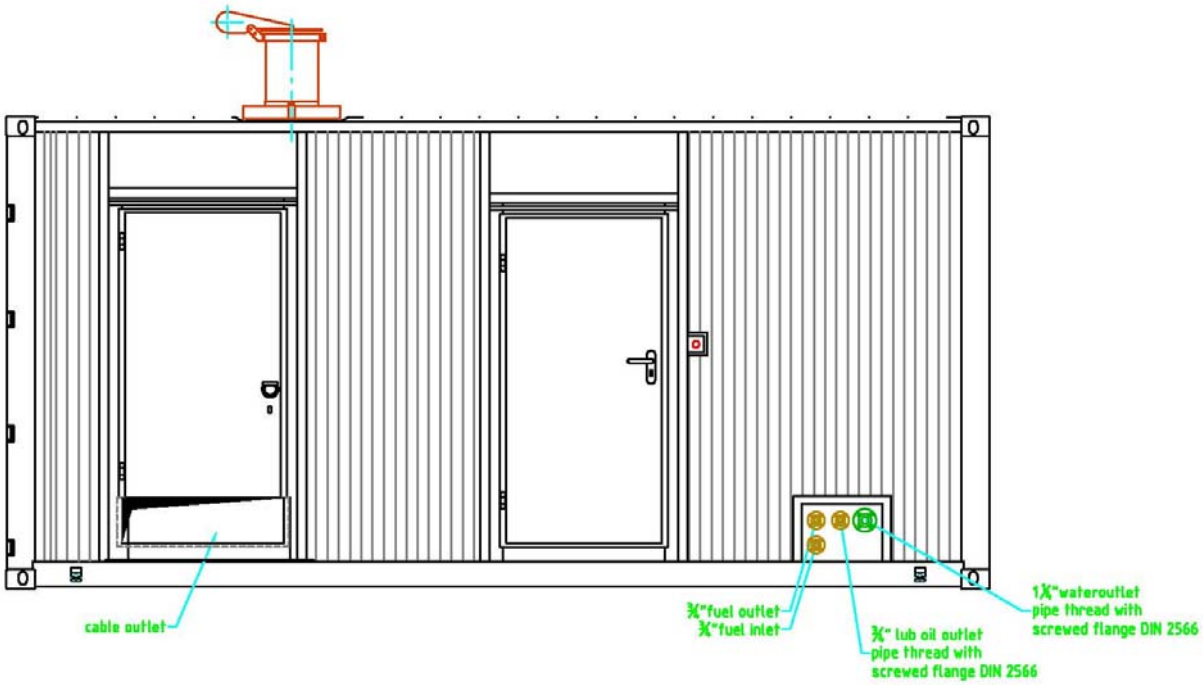
5.3.2. Container views:

CONTAINER VIEWS:

Left Side View
(Left side wall removed to show interior components)

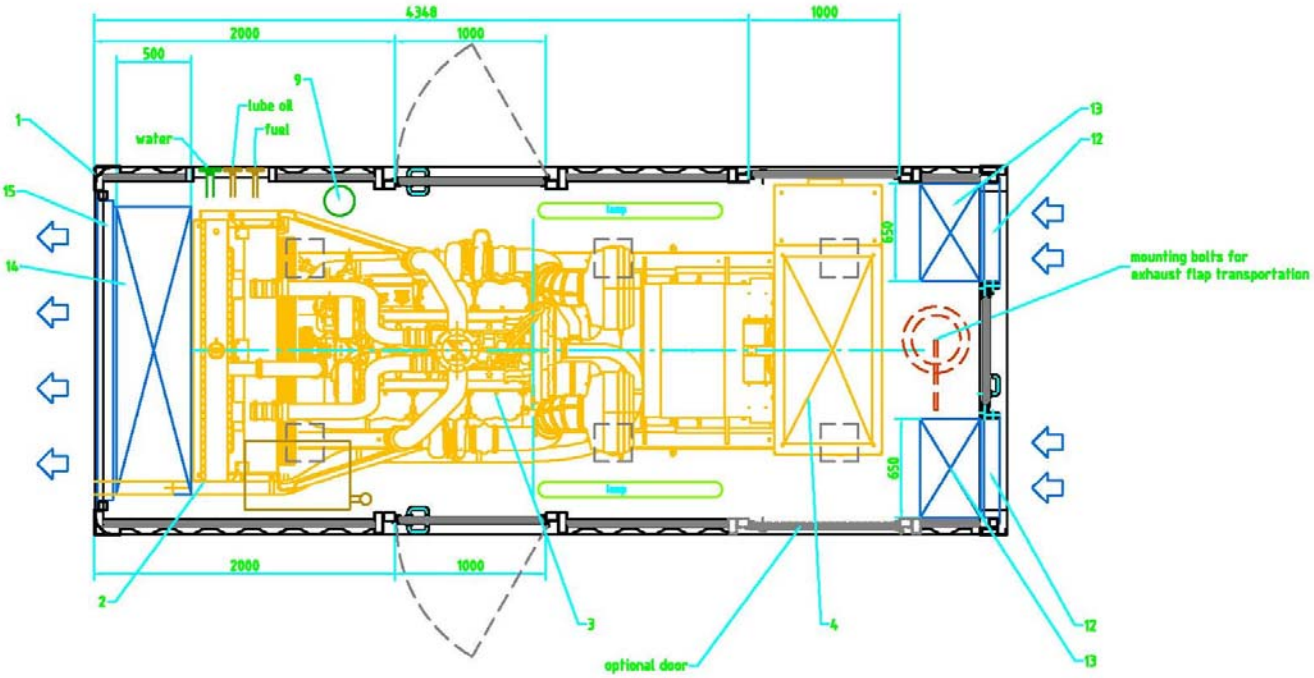


Right Side View

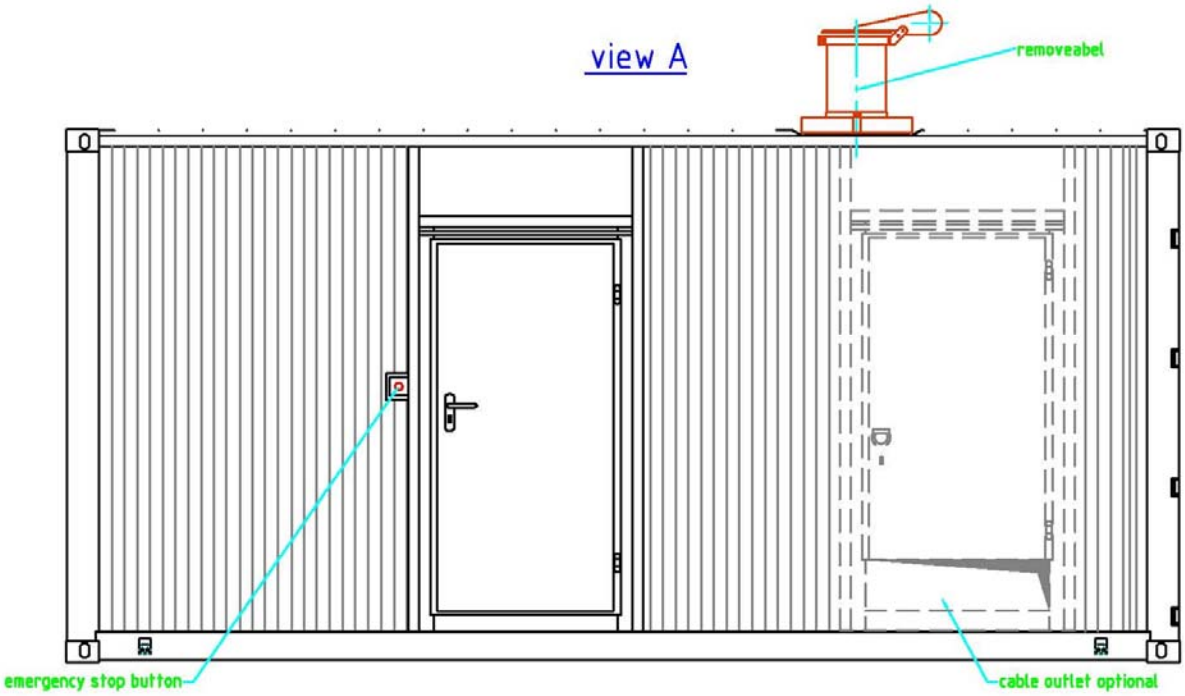


Top View

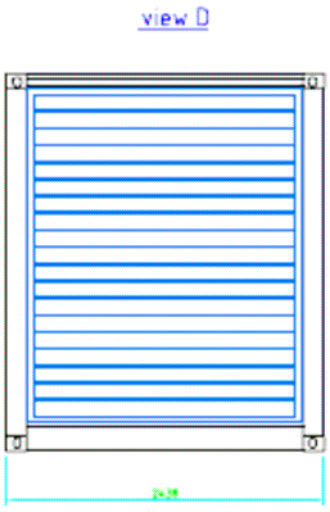
(Roof removed to show interior components, dimensions in inch)



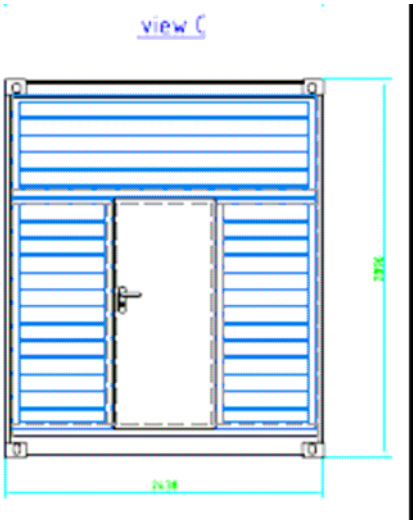
Left Side View



Front view



Rear view



Legend

COMPONENTS	
ITEM	DESCRIPTION
1	CONTAINER
2	RADIATOR
3	DIESEL ENGINE C32
4	ALTERNATOR SR4B-GD
5	BASE FRAME
6	VIBRATION ABSORBER
7	BATTERY
8	80 l LUBRICATION TANK
9	OIL PUMP
10	EXHAUST SILENCER
11	EXHAUST PIPE WITH FLAP
12	AIR INLET WEATHER PROTECTION SCREEN
13	AIR INLET ATTENUATOR
14	AIR OUTLET ATTENUATOR
15	AIR OUTLET WEATHER PROTECTION SCREEN

6. Switchgear & Controls

6.1 CONTROL SYSTEM DESCRIPTION

Utility paralleling switchgear is intended for automatic or manual synchronizing with a utility power source as a load management system, with provisions for standby operation feeding an isolated load network. Modes of operation are field configurable and include:

- Single Unit Island Mode.
- Multiple Unit Island Mode (up to 18 units).
    - Includes Load Sense / Load Demand control, ramp loading, bumpless transfer
    - Load sharing (kW and kVAR) capability is provided via network communication.
- Single Unit Utility Parallel Mode.
    - Automatic paralleling.
    - Selectable for Import / Export control. (Requires 4-20 mA customer input.)
    - This product is intended for unmanned operation Automatic paralleling.
    - .Convenient operator interface
- 4 lines text display
- Graphical one-line diagrams with LED status indicators.
    - Modules can operate in groups up to 18 with all communications synchronizing and load sharing between units by datalink for quick and convenient setup. (Max cumulative distance 450 m)
    - Protection includes 1600A motorized generator 3 poles circuit breaker with 55kA interrupt capability, extensive protective relays and internal power distribution.
    - Convenient customer connections for power
- Request to run / stop signal (customer input)
    - Can also be paralleled to Woodward compatible legacy modules in island operation.
    - Languages available: Dutch, German, French, Russian, Spanish.

FACTORY INSTALLED STANDARD EQUIPMENT

Features	Benefits
Switchgear Controls	**MODES of OPERATION** Utility paralleling switchgear is included for automatic paralleling with a utility power source as a load management system, with provisions for standby operation feeding in an isolated load network. Modes of operation are field configurable and include: - Single Unit Island Mode - Multiple Unit Island Mode (up to 18 modules per site) with ramp loading · Includes Load Sense / Load Demand control · Each module displays system summary power level and summary alarms. · Load sharing capability is provided via CAN network communication - Single Unit Utility Parallel Mode. · Automatic paralleling · Selectable for Import / Export control · If Import control is selected a 4-20mA or 0 - 10 V signal is required and will be provided by others that is scalable to the utility contribution. · Provision for Manual Paralleling 50 - 60 Hz selectable controls.
	AUTOMATIC LOAD DEMAND: Load demand operation includes sequencing of multiple units, with configurable start stops levels and timers. Although the modules are intended for prime power rental applications, they can also be configured for various stand-by scenarios as well. This includes strategies where the first module up to speed becomes the master and can close on a dead bus with the remaining packaging automatically paralleling to it.
	AUTOMATIC SYNCHRONIZING: The control system provides soft loading and unloading for bumpless transfer in parallel operation. The control system also works together with EMCP 3.3 to provide automatic cooldown feature. The control system provides data communication for 1 to 18 modules in a network. Communication is provided with a robust high speed CAN network. The CAN data link was selected for robust high speed deterministic data transfer. Modules are connected in series with a 15 m long high speed CAN cabes (provided with each module). Parallel operation includes both real kW and reactive KVAR load sharing and control.

FACTORY INSTALLED STANDARD EQUIPMENT (Continued)

Feature	Benefits
Switchgear Monitoring	The monitoring system includes a mimic one line that shows the generator with it's respective circuit breaker in a one-line representation of the system. The graphic COLOR LED indicators display the following information: - Generator circuit breaker open/closed/tripped - Engine running - System summary alarm The monitoring system also includes an additional display conveniently monted in the EMCP 3.3 panel. This display is a 4 line text display with pushbuttons for various controls. This display provides quick module set up with all parameters stored in non-volitile memory. In addition to individual module information, each module also provides overall plant information including: overall power production; and alarm / shutdown status of each MODULE. The control system monitors and manages various module functions. This includes the automatic lube oil make up system, alarms and emergency stop functions. The 693 frame generator is provided with winding temperature sensors as standard. The control system monitors and displays these values, providing alarm and shutdown. Various diagnostic features are provided including breaker synchrnonizing time out and reclose alarms, circuit breaker posistion feedback, phase rotation mismatch, network communication error alarms, sensor diagnostics, and multiple unit configuration checks.
Switchgear Protection	**MONITOR AND PROTECTION FUNCTIONS** - Generator over current — ANSI 50 / 51 - Neutral earth current — ANSI 50 / 51 (requires optional CT) - Generator current imbalance — ANSI 46G - Generator under voltage — ANSI 27G - Generator over voltage — ANSI 59 G - Generator voltage imbalance — ANSI 18 G - Generator leading power factor - Generator lagging power factor - Generator under frequency — ANSI 81 U/G - Generator over frequency — ANSI 81 O/G - Generator reverse power — ANSI 32 G - Generator overload — ANSI 32 O / G - Busbar under voltage — ANSI 27G - Busbar over voltage — ANSI 59 G - Busbar voltage imbalance — ANSI 18 - Busbar under frequency — ANSI 81 U - Busbar over frequency — ANSI 81 O

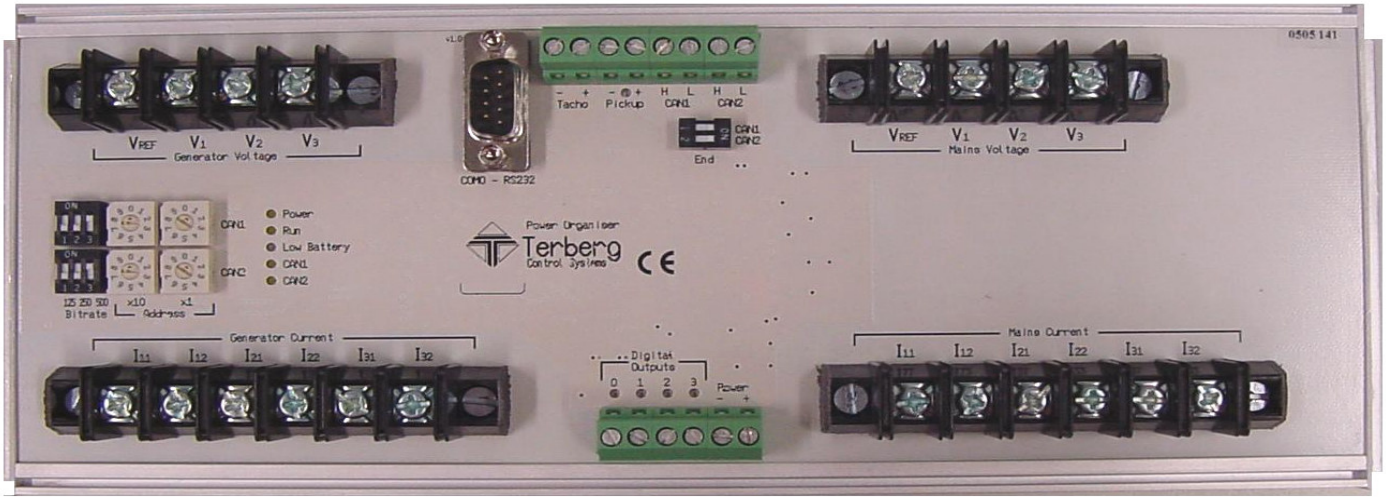
FACTORY INSTALLED STANDARD EQUIPMENT (Continued)

Feature	Benefits
Electrical Connections	**SHORE POWER CONNECTION** The module is provided with shore power connection for lighting, generator space heater, and battery charger. The control system provides a 20 Amp internal transfer switch that automatically transfers internal loads to the genset for autonomous operation.
	POWER OUTPUT CONNECTION The electrical power output connections are provided through a convenient door on the right hand side of the module. The paralleling circuit breaker is rated for 65 kA interrupt capability. The module features robust well braced busbars with easy customer access. These busbars are three phase plus full rated neutral. They include IEC standard hole pattern, fully rated for 0.8 power factor.

AVAILABLE OPTIONAL CONTROL EQUIPMENT

Feature	Benefits
Remote Software	Provides modem and software for off-site monitoring of installations C32 EAME power modules installations can be accessed via telephone connection. Operator can contact local installation from remote via telephone line, and monitor it as if in front of the local control panel. Depending on a password, operator has access to control functions. Local communications, via Internet Explorer located on customer PC, provided to interface with touchscreen. Server software and Windows compatible touchscreen provided.
Site Controller	Includes industrial PC and site software for EAME modules. Local communications, via internet Explorer located on PC, with touchscreen. Server software and Windows compatible This option is browser based with ability to view 1 to 18 individual units with Internet Explorer. From the customer PC you can launch a browser and look at each individual unit with same views displayed at each local unit. Plant controller includes overview screen.

6.2. Controls – Power organizer



Functional description
The power organiser is a measuring device that in cooperates 3 phase measuring, combined with complete automatic synchronising capabilities. The module is typical suitable for generator application, but it can also be used for power measuring applications like outgoing load feeders or mains incomer load control.

Electrical information can be used for diagnostics, control and protection. Variables required for control and protection can be retrieved at high sample rate, such that high performance can be achieved.

Current inputs are used both for measurements and for over current protections.
Different selectable inverse time characteristics over current protections are applicable:

IEC Normal inverse
IEC Very inverse
IEC Extremely inverse
IEC Short inverse
ANSI Normal inverse
ANSI Very inverse
ANSI Extremely inverse
ANSI Short inverse

Active synchronisation is integrated. Synchronisation is only activated if:

- Frequency from both generator and busbar side are above threshold.
- Phase sequence from both generator and busbar are equal
- All 3 line voltages are above threshold value
- Synchronisation is activated

Synchronisation pulse is given if

- Frequency is within given window
- Phase difference is corresponding the given circuit breaker time delay

Power organiser will send raise and lower pulses to the engine control panel in order to change generator frequency. Because both generator and mains voltage are available, engine control will be able to match generator voltage with busbar voltage

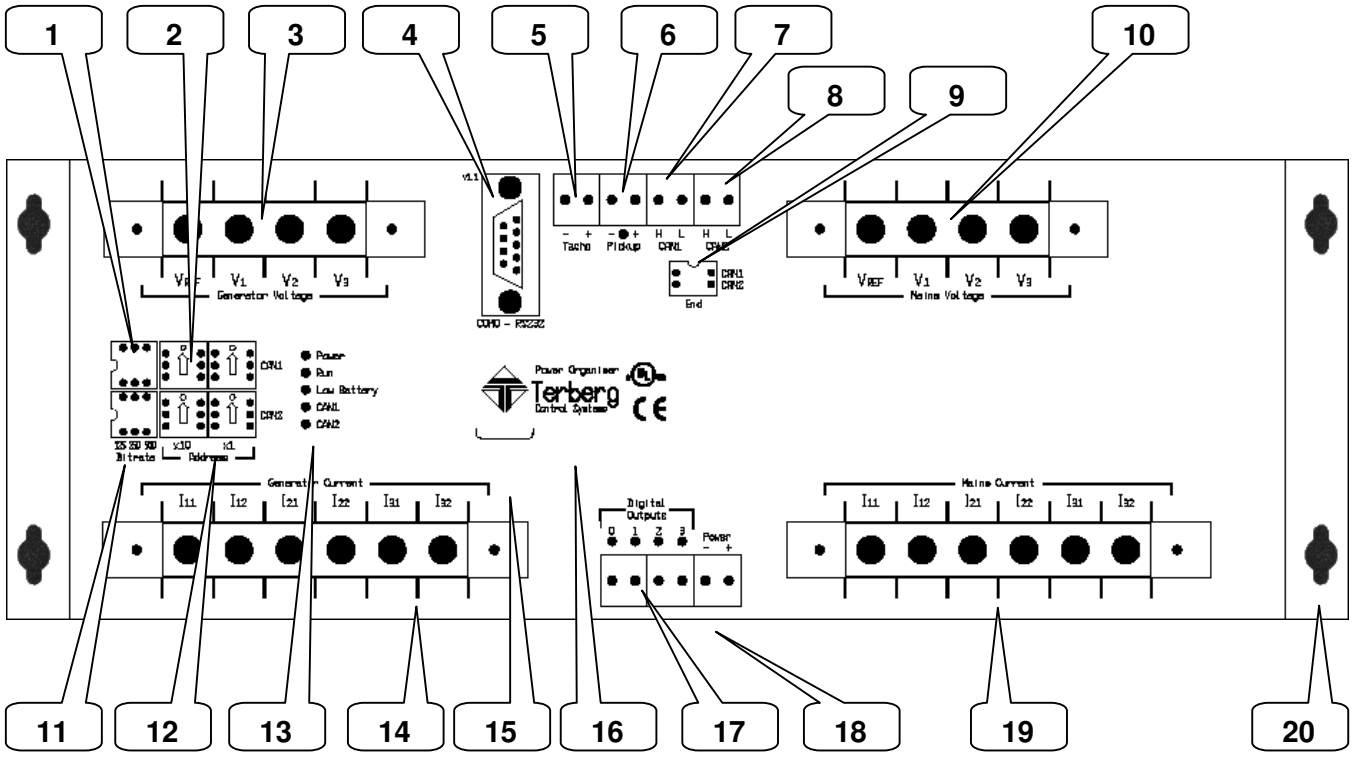
Available variables at 4 wire WYE:

Generator side	
Frequency Measured on any available line voltage	**Phase voltages** V L1-L2 V L2-L3 V L3-L1 V L-L average
Current I L1 I L2 I L3 I L average	**Active Power** kW L1 kW L2 kW L3 kW total
Reactive power kVAr L1 kVAr L2 kVAr L3 kVAr total	**Apparent Power** kVA L1 kVA L2 kVA L3 kVA total
Powerfactor Pf L1 Pf L2 Pf L3 Pf average	**Energy** kWh total
Mains side	
Frequency Measured on any available line voltage	**Phase Voltage** V L1-L2 V L2-L3 V L3-L1
Protections	
Overcurrent protection I L1 I L2 I L3	
Synchroniser	
Phase difference Between generator and	
Frequency difference	

Available variables at 3 wire open delta:

Generator side	
Frequency Measured on any available line voltage	**Phase voltages** V L1-L2 V L2-L3 V L3-L1 V L-L average
Current I L1 I L2 I L3 I L average	**Active Power** kW total
Reactive power kVAr total	**Apparent Power** kVA total
Powerfactor Pf average	**Energy** kWh total kVarh total
Mains side	
Frequency Measured on any available line voltage	**Phase Voltage** V L1-L2 V L2-L3 V L3-L1
Protections	
Overcurrent protection I L1 I L2 I L3	
Synchroniser	
Phase difference Between generator and	
Frequency difference	

Terminals and connections:



1. Dipswitch for CAN 1 Bitrate (125,250, 500 Kbit).
2. Dipswitches for card address CAN 1.
3. Barrier strip connector for generator voltages.
4. Serial communication (standalone or monitor).
5. Connector for Tacho (0..10V).
6. Connector for Pickup with LED indication.
7. Connector for CAN 1.
8. Connector for CAN 2.
9. End of bus dipswitch for CAN 1 and 2.
10. Barrier strip connector for mains voltages.
11. Dipswitch for CAN 2 Bitrate (125,250, 500 Kbit).
12. Dipswitches for card address CAN 2.
13. LED indication for Power, Run, Low Battery, CAN 1 and CAN 2.
14. Barrier strip connector for generator currents.
15. Drawing reference code.
16. Logo and description
17. 4 Digital outputs with LED indication.
18. Supply voltage.
19. Barrier strip connector for mains current.
20. Chassis ground connection (4 connection points; one in each corner).

Listing of available monitoring and protective functions

- Generator over current	ANSI 50/51
- Neutral earth current	ANSI 50/51 ** Subjected to optional CT*
- Generator current imbalance	ANSI 46G
- Generator under voltage	ANSI 27G
- Generator over voltage	ANSI 59 G
- Generator voltage imbalance	ANSI 18 G
- Generator leading power factor	
- Generator lagging power factor	
- Generator under frequency	ANSI 81 U/G
- Generator over frequency	ANSI 81 O/G
- Generator reverse power	ANSI 32 G
- Generator overload	ANSI 32 O/G
- Busbar under voltage	ANSI 27
- Busbar over voltage	ANSI 59
- Busbar voltage imbalance	ANSI 18
- Busbar under frequency	ANSI 81 U
- Busbar over frequency	ANSI 81 O

Technical description

CAN NETWORK

2 CAN connections can be used to retrieve data. CAN 1 is used to get data at high sample rate. CAN2 is used to get all other data. The bit rate at CAN1 needs to be the same as the bit rate from all I/O modules (default 500kBit) The bit rate at CAN2 needs to be the same as set-up for CAN-COM interface cards (by default 500kBit).
CAN1 address is 1 for the first Power organiser that is connected to the network. Address is 2 if a second Power organiser is added. This is similar as used when setting up addresses for I/O card. First digital input card will have address 1, second digital input card will have address 2 etc.
CAN2 address is by default 1, (please check drawing to confirm). It is important that all nodes connected at CAN2 network do have a unique node address.

All current measuring is implemented via internal CT's.

Current sensing		
Nominal measuring current	5	A
Maximal current (< 0,1 sec)	100	A
Input impedance	< 0,1	Ohm
Power consumption	5	VA

Voltage sensing (AC) Barrier strip connector rated to 600V Line to Line		
Nominal voltage	420	Volt
Maximal voltage continuous	500	Volt
Maximum voltage < 0,1sec	4000	Volt

Burst voltage test (20usec)	15000	Volt
Input impedance	1200	kOhm

Power supply (DC)		
Nominal voltage	24	Volt
Minimal voltage	18	Volt
Maximal voltage continuous	30	Volt
Input current	500	mA

Digital Outputs		
Maximum forward current	200	mA
Output voltage	24	Volt

LED indication		
Power	On if 24V powersupply is connected	
Run	Flashing if device is in operation. Starts automatically after powerup	
Low battery (internal battery)	Flashing if backup battery voltage is low	On if battery is low low
CAN	Flashing once per second if not connected to sbc	Flashing fast (more than twice per second) if communicating with sbc

Measurements (@ 50Hz or @60Hz at full range)

Parameter	**Accuracy +/-**	**Display**
Voltage	0,4%	0 V
Frequency	0,01%	0,00Hz
Current	0,4%	0 Amp
kVA	0,5%	0 kVa
kVAr	0,8%	0 kVar
kWatts(1)	0,5%	0 kWatts

(1) Update time faster than 150 mSec

6.3. Monitoring

Single line shows the Generator with its respective circuit breaker in a one-line representation of the system. The graphics shall utilize black and white indicators and bar graphs while actively displaying the following information:

6.4. Protection

6.4.1. Power assembly

Power Module switchgear lineup is 480V rated for indoor use with one C32 generator set.

6.4.2. Generator circuit breaker

IEC rated 1600A, 55KAIC, fixed mounted, three poles, motor operated, molded case circuit breaker.

The switch-disconnectors are derived from the corresponding circuit-breakers, of which they maintain the overall dimensions and the possibility of mounting accessories.
This version only differs from the circuit-breakers in the absence of overcurrent releases.
The circuit-breaker is available in both fixed and withdrawable, three-pole and four-pole versions. The switch-disconnectors, identified by the letters "/MS", can be used according to category of use AC-23A (switching motor loads or other highly inductive loads) in accordance with the IEC 60947-3 Standard. The electrical specifications of the switch-disconnectors are listed in the table below.

		E1B/MS	E1N/MS	E2B/MS	E2N/MS	E2S/MS	E3N/MS	E3S/MS	E3V/MS	E4S/MS	E4H/MS	E4H/MS	E4S/fMS	E6H/MS	E6H/fMS
Rated uninterrupted current (at 40 °C) Iu	[A]	800	800	1600	1000	1000	2500	1000	800	4000	3200	3200	4000	4000	4000
	[A]	1000	1000	2000	1250	1250	3200	1250	1250		4000	4000		5000	5000
	[A]	1250	1250		1600	1600		1600	1600					6300	6300
	[A]	1600	1600		2000	2000		2000	2000						
	[A]							2500	2500						
	[A]							3200	3200						
Rated service voltage Ue															
	[V ~]	690	690	690	690	690	690	690	690	690	690	690	690	690	690
	[V –]	250	250	250	250	250	250	250	250	250	250	250	250	250	250
Rated insulation voltage Ui	[V ~]	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Rated impulse withstand voltage Uimp	[kV]	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Rated short-time withstand current Icw (1s)	[kA]	42	50 (1)	42	55	65	65	75	85	75	85	100 (2)	75	100	100
(3s)	[kA]	36	36	42	42	42	65	65	65	75	75	75	75	85	85
Rated making capacity under short-circuit (peak value) Icm															
220/230/380/400/415/440 V ~	[kA]	88,2	105	88,2	143	187	143	165	286	165	220	220	165	220	220
500/660/690 V ~	[kA]	75.6	75.6	88.2	121	143	143	165	220	165	220	187	165	220	220

Note: the breaking capacity Icu, at the maximum rated use voltage, by means of external protection relay, with 500 ms maximum timing, is equal to the value of Icw (1s), except:

(1) Icu = 50kA @ 690V
(2) Icu = 85kA @ 690V

7. Testing

7.1. Prototype Testing

The Caterpillar® Utility Power Module has extensive prototype testing and validations. This includes an 8 hr. of the load test with the following parameters will be recorded:

- Fuel rate and specific fuel consumption
- Frequency and speed
- Real and reactive power
- Power factor
- Jacket water temperature
- Oil pressure
- Fuel pressure
- Phase voltages and currents
- Sound level measurements
- Alarms / shutdowns functional tests settings
- Multiple units paralleling

7.2. Standard Power Module Test

Testing for production power module switchgear containing generator set controller (GSC), GSC+, and microprocessor based inertia and generator protection relays. The purpose of this power module switchgear test procedure is to:

- Verify the programs contained in the controls.
- Verify that the GSC panel has been properly programmed.
- Verify the setting of the trip unit contained in the main circuit breaker (EMCP).
- Verify stand-by operation using both local and remote start/stop.
- Verify parallel operation using both local and remote start/stop.
- Verify both manual and automatic base-load control using both local and remote start/stop.
- Check the setting of the generator mounted voltage regulator.
- Set the isochronous governor and load share module.
- Check the mechanical and electrical integrity of the power module switchgear assembly.

Because generator set engines and the generators have been pre-tested, this test is not intended to provide a measurement of the generator set power capability.

Note: Power Module will be tested at 60hz first then tested at 50hz and will leave the factory at 50hz.

Prior to the testing described herein, the engine and the generator and the genset package shall be pre-tested by their respective manufacturer's normal production test standards. These tests will be recorded and available for review at the Power Module witness test.

The 3L-0284 generator set package test will be as follows:
Results at full load reported are: engine RPM, frequency, average voltage, line-to-line voltages for all three phases, average current, line-to-line current for all three phases, and observed power (all at 0.8 power factor). Engine RPM, average voltage and line-to-line voltages for all three phases are reported at no-load.
This will be followed by a transient response test where the following load steps (at 0.8 pf) will be applied: ISO load steps for 50hz operation: 0-41, 41-60, 60-92, 92-100.

7.3. Documentation

Caterpillar® Utility Power Module documentation includes:

- As built electrical schematics
- Container package drawings
- Caterpillar sheets
- Repair parts lists.

Reference: DCQ123-9