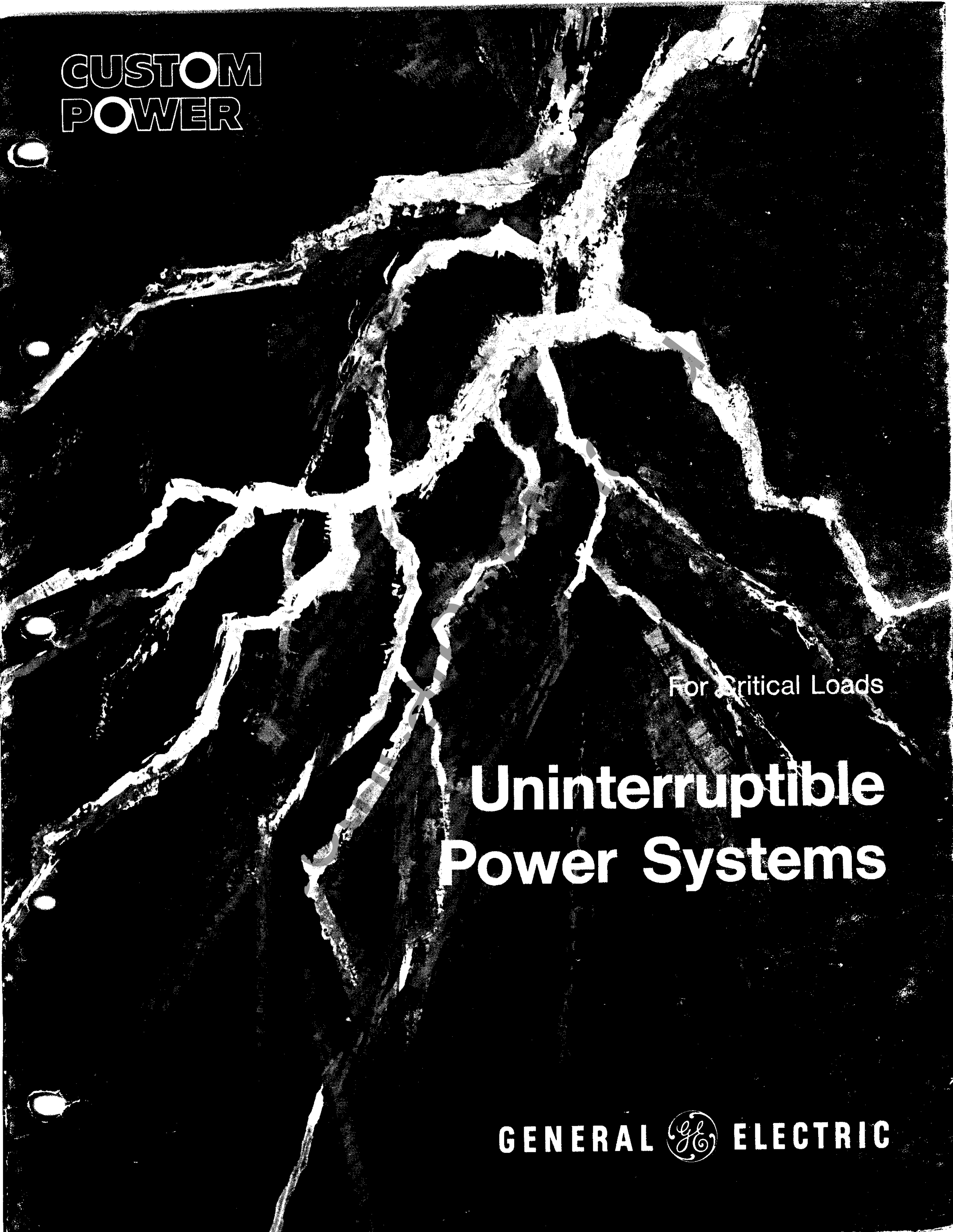
CUSTOM POWER



For Critical Loads

Uninterruptible Power Systems

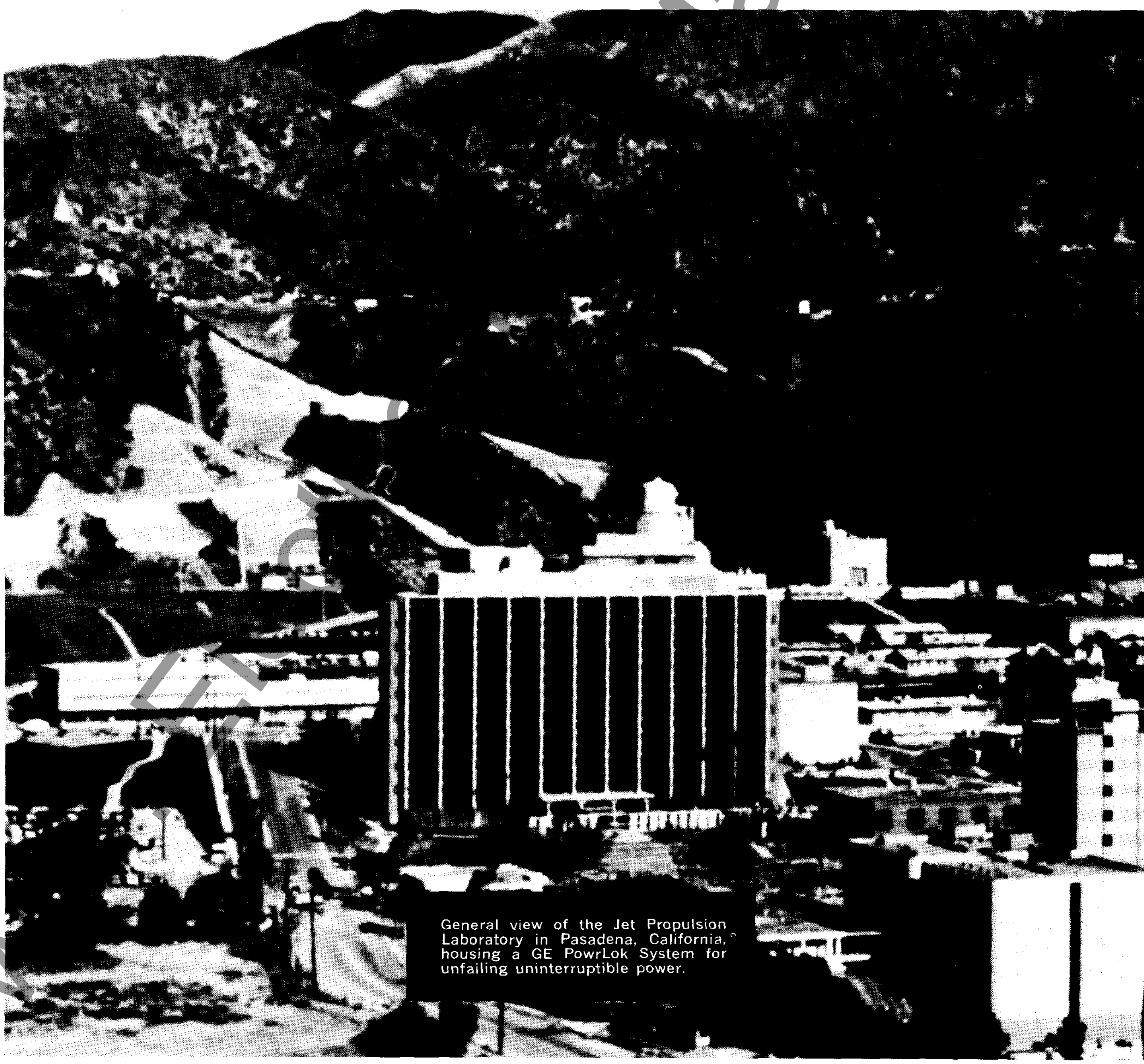
GENERAL ELECTRIC

General Electric PowrLok designed for critical applications

Custom Power is power designed to meet the specific demands of a wide variety of electrical loads. It is General Electric's capability of taking any power input, and providing any output rating needed—high or low frequency, single- or multi-phase a-c, or d-c, any voltage.

Static uninterruptible power is Custom Power designed to meet the requirements of electronic equipment users who consider the applications of their equipment "critical" and cannot tolerate the errors and lost time resulting from millisecond power disturbances or prolonged shutdowns. Some typical examples of critical loads are:

- Data processing computers
- Process control computers
- Critical process machinery
- Electronic process instrumentation
- Critical communications complexes
- Flame and boiler control
- Microwave and cryptographic equipment



General view of the Jet Propulsion Laboratory in Pasadena, California, housing a GE PowrLok System for unfailing uninterruptible power.

These loads can be adversely affected by incoming power line disturbances such as voltage dips and surges, frequency variation, and momentary or sustained loss of power. These disturbances are inherent in conventional distribution systems and generally result from exposure to a wide variety of natural phenomena, such as lightning, wind, tree contact and animals, as well as from transient conditions caused by fault clearing and other loads being operated on the same feeder.

General Electric is the recognized leader in the field of static Uninterruptible Power Systems, with more large solid-state systems installed than any other manufacturer. This leadership is the result of GE's capability of combining advanced semiconductor technology with unmatched experience in the control, protection and distribution of electric power.

SCR'S AND DIODES — THE HEART OF THE SYSTEM

General Electric high performance, power rated Silicon Controlled Rectifiers and diodes, today's most reliable and efficient means of power conversion, are the key components of PowrLok (Uninterruptible Power Systems). Because their function is so critical, special steps are taken to assure that all power semiconductors meet the highest production standards and pass a set of rigid tests to insure reliability.

GE SCR's and silicon diodes are manufactured under the most carefully controlled conditions. The devices are assembled in an inert nitrogen atmosphere, with the cell then being hermetically sealed to prevent contamination of the silicon wafer.

GE EXPERIENCE ASSURES DEPENDABLE SYSTEM COORDINATION

An uninterruptible power system is part of a power distribution system. General Electric, manufacturer of switchgear, relays, and power conversion equipment, offers the highest degree of technical power system competence. Having manufactured over 1,000,000 hp of SCR rectifiers, 250 megawatts of SCR switches, 1,500,000 kw of diode rectifiers and 75,000 kva of static inverters, GE is the acknowledged leader of static power conversion equipment. In addition, General Electric has manufactured over *900,000* SCR and diode devices for their equipment which at an average rating per device of 1200 VDC and 250 amp represents the staggering sum of 270,000 megawatts.

The GE static UPS — PowrLok — is unique in that the SCR's, the basic power element, are manufactured by the same department that designs and produces the entire system. There is no coordination problem, since the cells are designed specifically for UPS requirements. Only the highest grade SCR's are used and all cells that fail to meet individual tests are rejected. All GE SCR's have 100% testing, all carry a serial number, and permanently recorded test and manufacturing data for each device is maintained. As a result, the individual SCR's have a field proven MTBF of over 5,800,000 hours, which is documented by an independent source.

The GE power thyristor. GE non-aging thyristors help reduce maintenance costs, provide higher efficiency and assure precise power at all times.

Static inverters...

The solid-state inverter consists basically of an SCR power circuit, a-c output magnetics, switchgear, output filter, and control circuits all housed in a sand gray and blue floor-mounted enclosure designed for heavy-duty industrial service. All components are accessible from the front of the enclosure through lockable, hinged doors. This allows the inverters to be mounted against a wall or arranged in back-to-back configuration to utilize available floor space. Provisions are made for incoming and feeder cables to be brought in the top of the unit.

MODULAR CONSTRUCTION FOR EASY MAINTENANCE

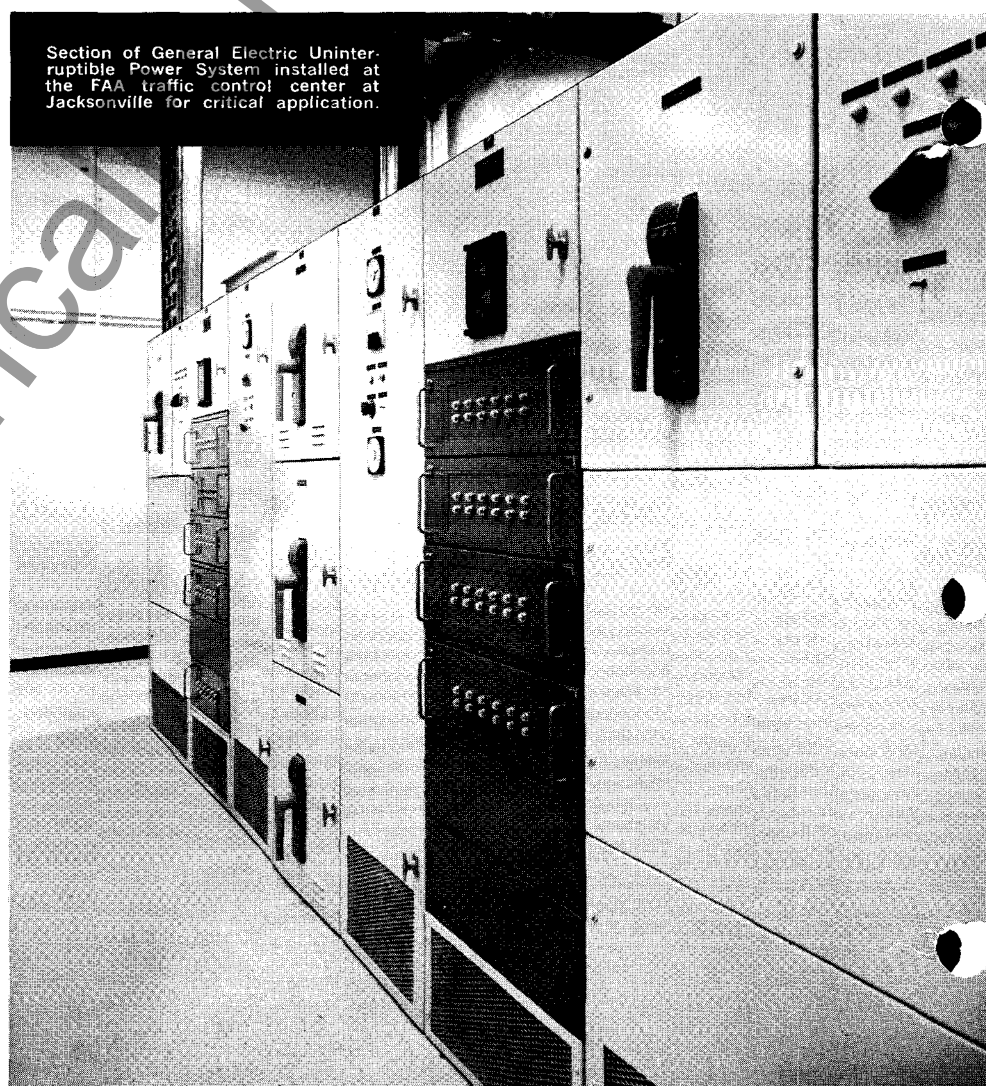
GE static inverter construction utilizes a modular concept to keep the functional circuits of the unit easily accessible and removable. Power semi-conductors and their associated commutating components are mounted on roll-out carts for maximum accessibility. A-c and d-c power connections to the carts are made with flexible cables bolted to the rear of the cart. Test jacks are located on the front of each power cart for easy inspection. Semi-conductors and fuses are removable from the front of the cart.

The top half of the inverter cabinet, above the power carts, houses the output transformer, the inverter starting circuit, draw-out control circuit trays, input and output disconnects, and appropriate metering. Additional cabinets are used to house peripheral components, when required.

A redundant forced-air system is used to cool inverter components. There is an air passage between each pair of compartments and each compartment blower is rated to cool both compartments should one blower fail. Intake air vents are located at least 10″ from the floor and are provided with easily removable, disposable filters.

Input d-c power is fed through an input d-c disconnect and filter choke to the SCR bridge circuit. Properly timed turn-on of the power circuit SCR's produces alternating current square waves in the output transformer primary. These square waves are combined in the output transformer zig-zag wye secondary to produce a smooth sine wave with less than 5% harmonic distortion.

Voltage Control is maintained by a closed loop regulation system. A feedback signal proportional to the average of the output phase voltages is compared to a reference voltage and the resultant error voltage is fed to the control circuit. Depending upon the magnitude of the error voltage, the control circuit will advance or delay the time at which



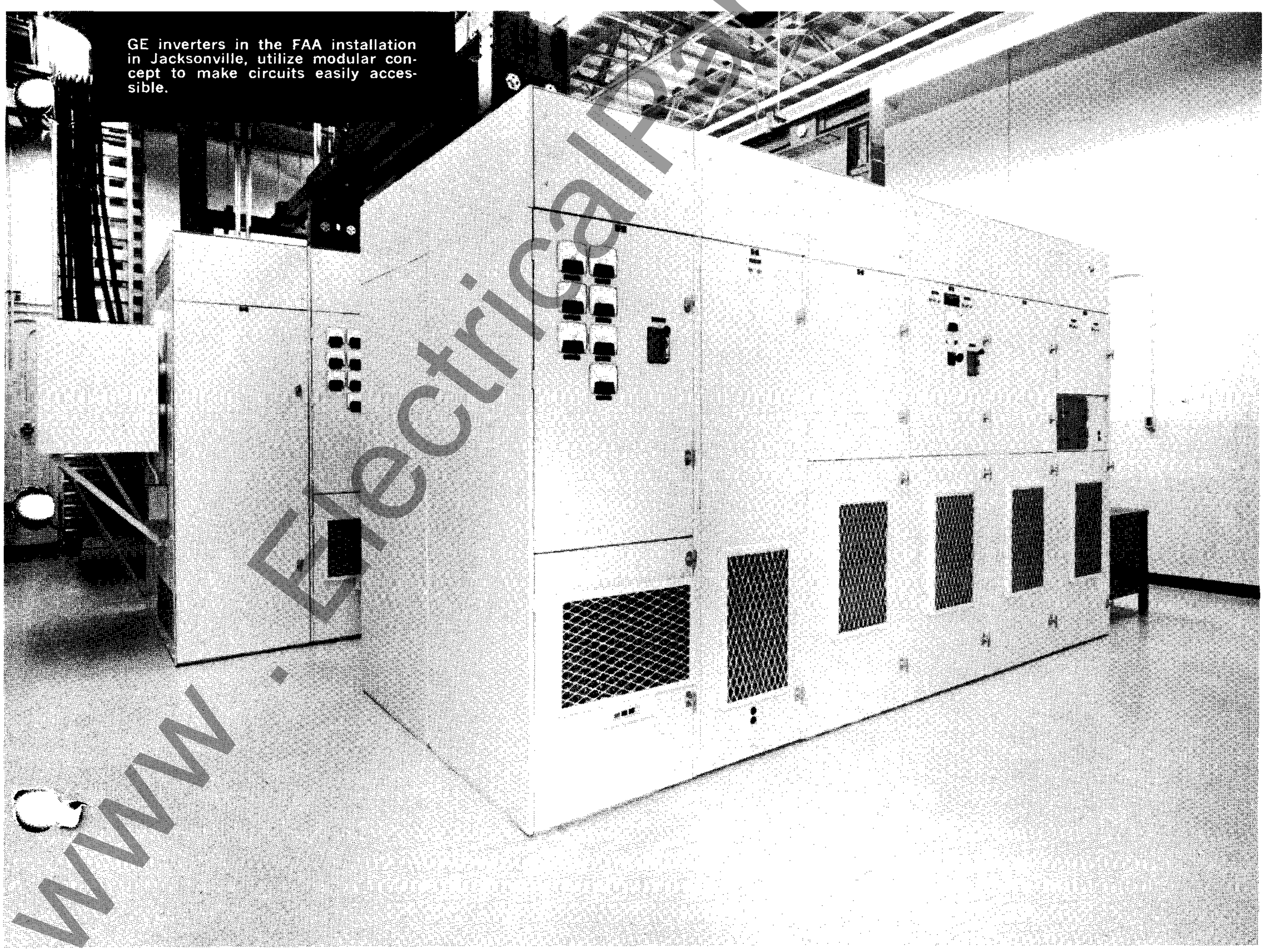
Section of General Electric Uninterruptible Power System installed at the FAA traffic control center at Jacksonville for critical application.

designed for maximum accessibility

the power circuit SCR's are turned on. This changes the relative width or average voltage of the a-c square wave pulses to the output transformer primary, and thus changes the voltage output. Output voltage level can be changed by adjusting the reference signal potentiometer.

Output Frequency depends on the frequency at which the SCR power cells are gated. Frequency control of the gating signal is maintained by a solid-state oscillator (adjustable ± 1 Hz. The oscillator generates a voltage pulse which is shaped, amplified, and used to gate the SCR's. The frequency control circuit is open loop (not controlled by output feedback) and is therefore unaffected by dynamic inverter loading.

Control Circuits are assembled on printed circuit cards which plug into the slide-out control tray. Standard metering on each inverter includes a d-c input ammeter, one a-c output voltmeter with selector switch and an a-c output ammeter, with selector switch. D-c input and a-c output disconnects are located on the front panels. The inverter can be isolated from the load by opening the output disconnect. In event of inverter overload or internal faults the inverter is self-protecting using fast-acting current limiting fuses.


GE inverters in the FAA installation in Jacksonville, utilize modular concept to make circuits easily accessible.

PowrLok ratings... non-redundant and redundant

NON-REDUNDANT CONFIGURATION

The major considerations in determining the proper size system are the total system load in kva and the power factor, the amount of time the battery must carry the load (battery discharge, t_d) and the time required for battery recharge (t_r). Another important consideration is the maximum inrush in kva that the UPS must support. It may be necessary to oversize the system to accommodate the inrush if it cannot be started on one of the various by-pass arrangements available. If the inrush occurs only at starting, one of the synchronized by-pass transfer schemes would be more practical than oversizing the inverter.

Various systems can be described using the one line rating:

3ϕ - UPS - NR - kva (p.f.) - t_d min. - t_r hrs. (Type of by-pass transfer)

This one line rating indicates the following:

3ϕ Output phases

UPS Uninterruptible Power System

NR Non-Redundant

kva Load kva

p.f. Load power factor

t_d Battery discharge time (support)

t_r Battery recharge time

By-pass Transfer

MT — Manually-initiated synchronized transfer

AT — Automatic synchronized transfer

ST — Automatic synchronized static transfer

(See page 12-13 for details)

Examples:

3ϕ — UPS - NR - 275 (0.8) kva -15 min. - 8 hrs. (MT)

3ϕ — UPS - NR - 80 (0.8) kva - 5 min. - 4 hrs. (ST)

POWRLOK NON-REDUNDANT OPTIONS

For non-redundant PowrLok various options are available to accommodate specific operating characteristics:

1. Manually-initiated synchronized transfer to and from a by-pass line. (MT)
2. Automatic synchronized transfer to and from by-pass line. (AT)
3. Automatic synchronized static transfer to and from by-pass line. (ST)
4. Initial provisions for future expansion.
5. Special ambient temperature range.
6. Altitude above 3,300 feet.
7. Three percent harmonic filters.
8. Special instrumentation as required.
9. Inverter test cabinet.
10. Spare parts.

Standard non-redundant PowrLok ratings are shown in Table 1, pg. 14.

SPECIAL APPLICATIONS

For critical load applications for which the standard system ratings do not apply, the following calculations may be used to determine various component ratings:

Inverter kva

Choose the rating from the single inverter column in Table 2, pg. 14 for loads up to 300 kva. For loads exceeding that amount, use the fewest number of inverters possible, using the ratings in the multiple inverter column. Note that when inverters are paralleled to serve the same load, the ratings cannot be mixed. No special control circuits are necessary for paralleling inverters.

BATTERY SELECTION

$$kw_{Battery} = \frac{kva_{Load} \times P.F._{Load}}{\text{Inverter Efficiency (85\%)}}$$

Note that the inverter efficiency remains essentially as shown from 50% to 100% load.

For most practical situations, the battery will be capable of 5, 15, 30, or 60 minute ride-through capability. For intermediate times, use the next larger time column. With the kw determined above, enter the appropriate column in Table 3, pg. 14, and select the battery. Since the ratings shown have no safety factors, always use the larger battery if the calculated kw falls between values shown in the table.

RECTIFIER SELECTION

The rectifier selection is a function of load kw required and the necessary kw to recharge the battery in the time specified. The following formula is used to determine the rectifier size:

$$kw_{Rectifier} = kw_{Battery} \times N$$

t_d	t_r Time to Recharge (Hrs.)			
Time of Discharge	4 N	8 N	16 N	24 N
5 min.	1.1289	1.1145	1.1072	1.1048
15 min.	1.1869	1.1434	1.1217	1.1145
30 min.	1.2739	1.1868	1.1434	1.1289
1 hr.	1.4475	1.2727	1.1867	1.1579
2 hr.	1.795	1.4475	1.2725	1.2158
3 hr.	2.1425	1.6212	1.3606	1.2737
4 hr.	2.490	1.795	1.4475	1.3317

Select the next largest rectifier to the value calculated above, from Table 4, Page 15.

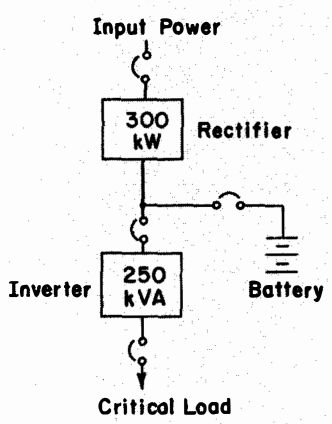


Fig. 2
250 kva non-redundant

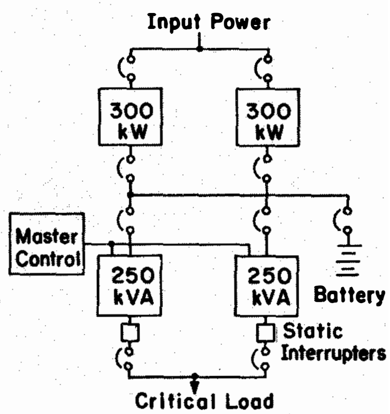


Fig. 3
250 kva redundant

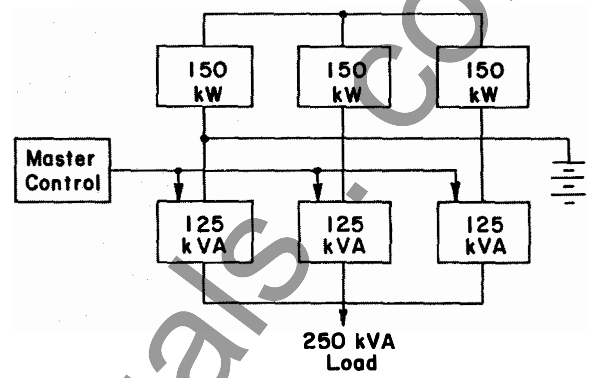


Fig. 4
Less reliable 250 kva redundant

REDUNDANT POWRLOK CONFIGURATION

As loads increase in magnitude, they generally become more critical. For such extremely critical loads, it is important to provide power system reliability of the highest order. It is possible to improve system reliability by duplication of various system components, but it is necessary to simultaneously minimize the total number of parts since the fewer parts, the higher the reliability. With properly designed and coordinated components, this system (redundant) can achieve reliabilities with MTBF's of nearly 10 years. The selection of the components to be duplicated is especially critical since duplication where unnecessary is costly and can reduce, rather than improve reliability. Instead of an arbitrary determination, the reliability of the various subsystems has been calculated, studied, and analyzed. As a result it has been determined that:

1. The basic power elements (Silcomatic rectifier and inverter) required duplication.

2. It was unnecessary and impractical to duplicate the battery since its inherent reliability is extremely high.

3. Certain control elements (such as the frequency oscillator) should be redundant.

4. A satisfactory method of isolating any failed component is required to prevent that component from causing "a chain reaction" which would cause additional modules to fail or which would cause the system to operate outside of its specified characteristics.

Basically, redundant PowrLok consists of one *more* rectifier and inverter than necessary to carry the load, so that should a rectifier or inverter in the system fail, it is automatically removed from service. The remaining module(s) assume its load, and the critical load bus tolerances are maintained. For any system a minimum number of inverters are used.

Consider a system to support a 250 kva load: A non-redundant system to support this load would consist of one inverter and one rectifier as shown in Fig. 2.

To make this system redundant an additional rectifier and inverter is required, with the addition of a master control to consolidate and centralize control elements and to provide system monitoring and annunciation. Fig. 3 depicts a redundant system to serve a 250 kva load.

Alternate approaches to serving this same load were considered and rejected. One such system would involve three rectifiers and three inverters appropriately rated as shown in Fig. 4.

It is immediately seen that this system:—

1. Has a higher probability of failure simply because more components are involved.

2. Can occupy more floor space.

3. Has a higher installation cost because more interconnections, mechanical and electrical, are required.

Assuming this system is supplying a 250 kva load and an inverter fails, assuming further that the failed inverter is properly isolated, two rectifiers and inverters continue to serve the load, versus the single rectifier and inverter discussed in the first system. The system with two rectifiers and inverters remaining has a higher probability of failure, again, because more components are involved. It might be thought that there is merit in having two rectifiers and inverters remaining because if one unit fails there is still one left. Because the system is carrying 250 kva, under the circumstances that two inverters have failed, leaving only one 125 kva inverter to carry the entire 250 kva load, the remaining inverter will go into an overload mode, reducing the critical bus voltage below its tolerances. As a result, the critical load is lost. If the current limit feature failed to operate for this situation, SCR's and fuses within the remaining inverter itself would be lost.

Thus far, it has been assumed that failed inverter isolation is relatively straight-forward, but it in fact, is not. Typical thyristor inverters fail in a short circuit mode across the d-c supply which is subsequently removed by fuse action. However, this also rapidly creates a short circuit across at least a portion of the output terminals. If the failing thyristor inverter remains connected to the a-c bus, fault currents will be drawn from that bus and produce significant voltage transients. At first fuses were considered, but were rejected since tests proved that fuse isolation times were too long and the critical bus voltage would be affected. Even the fastest available fuse was too slow to isolate a problem without serious effect on the critical load bus! For low magnitude fault currents, fuse isolation was even slower.

GE static interrupters protect the critical load

Conventional methods of inverter isolation such as fuses or circuit breakers depend upon considerable fault current for actuation and significant time periods for operation.

Therefore, conventional methods of inverter isolation cannot protect an electronic system a-c bus.

Because of the problems associated with conventional methods, General Electric developed its patented static interrupter. This device is placed in series with the output of each inverter in redundant PowrLok. In normal operation, the interrupter allows each inverter output to pass to the load bus. Should an inverter malfunction, the SCR's allowing current to pass are instantaneously forced "off" (commutated), completely isolating that inverter from the load bus.

The static interrupter is the only known way to properly isolate a failing redundant thyristor inverter in UPS service!

The static interrupter is an independent thyristor device that is capable of rapidly interrupting power flow whenever actuated. Impending thyristor inverter failure can be detected and circuit isolation can be achieved in less than one twenty-fifth of a cycle, on a 60 hertz basis. It literally isolates the failing inverter from the output a-c bus before an a-c fault develops. Since it is an independent thyristor device all modes of thyristor inverter failure are isolated. Specific inverter component failures isolated by the static interrupter include: thyristor, diode, commutating circuit, pulse amplifier and pulse power supply.

The static interrupter is provided with another mode of operation i.e.: current limit. This limits each thyristor inverter output current to a predetermined value in the event of a critical load bus fault. Fault current is supplied for several seconds to actuate feeder circuit protective devices. If the fault persists beyond the alloted time the bus is deenergized. Typical current pickup value is 125 percent and current limit is 100 percent.

MASTER CONTROL COMPARTMENT

As previously indicated, a master control compartment is incorporated in every redundant PowrLok. This centralizes total system controls and instrumentation. In addition to the instrumentation and annunciation provided on each rectifier and inverter the master control contains at least the following instruments and indications on the front.

(3) Phase ammeters—system output

(1) Neutral ammeter (for 4-wire systems)

(1) A-c voltmeter — system input and output

(1) Frequency meter — system input and output

Input power loss indication

Oscillator malfunction indication

D-c overvoltage indication

D-c undervoltage indication

D-c undervoltage trip

Inverter output disconnects open closed indication

Static interrupters on-off indication

Loss of cooling air indications

The master control also contains redundant frequency oscillators and redundant control power supplies, to enhance total system reliability.

Within the master control, the frequency oscillators are redundant such that a failure of either oscillator does not affect the critical load bus.

POWRLOK RATINGS – REDUNDANT

Redundant systems are rated similar to non-redundant systems, i.e. in terms of output kva required by the load. For the 250 kva system described, with a 15 minute battery ride-through capability and an 8 hour recharge the one-line rating would be

3ϕ - UPS - R - 250 (0.8 p.f.) kva - 15 min- 8 hr.

This indicates that this system has two inverters, each with a static interrupter, two regulated rectifiers and necessary controls. The same calculations are used for redundant as non-redundant (see pg. 15) but *one additional* inverter and rectifier of the same rating is included in the system. The multiple inverter ratings must be used for inverter selection.

For all redundant systems, various options are available to accommodate specific operating characteristics.

1. Manually - initiated synchronized transfer to and from a by-pass line.
2. Frequency lock to input power source.
3. Initial provisions for future expansion.
4. Special ambient temperature range.
5. Altitude above 3300 feet.
6. Three percent harmonic filters.
7. Special instrumentation as required.
8. Inverter test cabinet.
9. Spare parts.

Coordinated instrumentation and performance characteristics

Instrumentation and Annunciation

Each PowrLok contains at least the following instruments and indications on the front of the equipment.

Rectifier:

- (1) D-c ammeter.
- (1) D-c voltmeter.
- Thyristor fuse indicating lamps.
- (1) Input transformer over-temperature lamp.
- (1) Loss of cooling air indicating lamp.
- Input breaker open-closed.
- Battery breaker open-closed.

Inverter:

- (1) Phase and neutral ammeter with selector switch.
- (1) Phase voltmeter and selector switch.
- (1) D-c voltmeter.
- (1) Control power "on" indicating lamp.
- Thyristor fuse indicating lamps.
- Filter capacitor fuse indicating lamps.
- Input breaker—open-closed.
- Output breaker—open-closed.
- D-c under-voltage.
- Loss of cooling air alarm.

PowrLok Performance Characteristics

Input Power:	
Voltage	120/208 or 277/480
Voltage regulation	± 5% from nominal (other ranges optional)
Phases	3, 3 or 4 wire
Frequency	50 or 60 Hz
Frequency regulation	± 1 Hz
Current walk-in	40% to 100% in 15 secs.
Output Power:	
System ratings	35 to 300 kva (Ratings can be increased for special applications.)
Voltage	120/208
Voltage range adjustment	± 5%
Phases	3, 3 or 4 wire
Frequency	50 or 60 Hz
Frequency range adjustment	± 1 Hz
Steady-state voltage regulation at 100% load	± 2%
Steady-state frequency regulation (0-100% load)	± 0.5%
Harmonic content	5% max. total
Overload	150% for one (1) minute
Phase displacement	120° ± ½° (Balanced load)
Load unbalance	35% between line currents with neutral not exceeding 45% of rated line current.
Environment:	
Ambient temp.	10° to 40°C. (50°-104°F.)
Humidity	Up to 95%
Elevation	Sea level to 3,300 feet.
Transient Conditions:	
Up to 50% step load (depending on rating)	± 10% max.
Loss of a-c input power	± 10% max.
Return of a-c input power	None
Max. voltage recovery time	100 milliseconds
Efficiency:	
Rectifier	95% minimum at full load
Inverter	85% minimum 50% to 100% load
System	80% minimum at full load.

MANUALLY-INITIATED SYNCHRONIZED BY-PASS TRANSFER (MT)

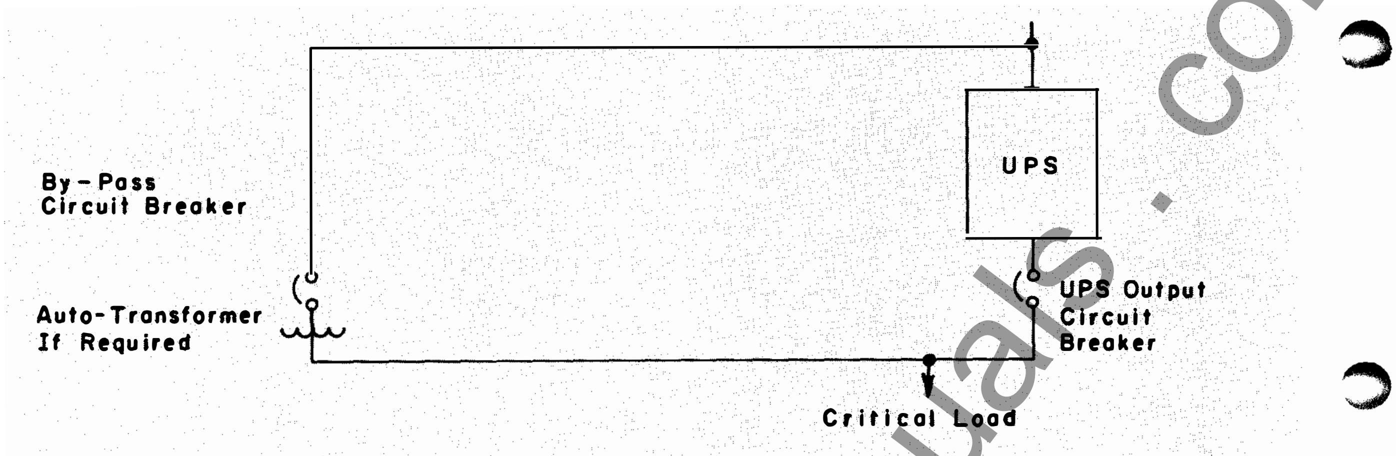


Fig. 5

When this option is specified, the load can be manually transferred from the UPS to the by-pass source, and vice-versa, without exceeding specified performance characteristics. The necessary controls and electrically-operated circuit breakers or contactors, depending on the UPS rating, in both the UPS output and by-pass lines are included. This would involve a synchroscope, frequency meter, UPS frequency and voltage adjustment potentiometers, by-pass line voltmeters and selector switch, transfer selector switch, and transfer initiation pushbutton. In the case where the system input and output voltages are not identical a by-pass auto-transformer with a protective circuit breaker can be incorporated in the by-pass line.

This scheme is available for both redundant and non-redundant UPS.

The output of all inverters is paralleled together to feed a common bus, which is connected to the load through the UPS output circuit breaker or contactor which is normally closed. This bus can be by-passed by the alternate source power lines through the UPS by-pass circuit breaker or contactor. The two breakers or contactors are electrically controlled such that if one is closed, the other will open automatically in one-half of a second or less.

To transfer the load from the UPS output bus to the by-pass power, or vice-versa, the two buses are manually synchronized under the following procedure:

1. The direction of transfer (utility or UPS) is selected with the transfer switch.

2. The voltage and frequency of each bus is checked to insure proper matching. Voltage and frequency adjustment potentiometers are provided to make changes if necessary.

3. The removable (to preclude inadvertent operation) synchronizing switch handle is inserted in its receptacle and closed. If the two sources are synchronized, the pointer on the synchroscope will be stationary at twelve o'clock. At this time the voltage vectors of the sources are in phase and of matched frequency. If necessary a re-adjustment is accomplished with the frequency potentiometer.

4. When the synchroscope indicates synchronism as described, the transfer control push-button is pushed, initiating the transfer. The selected breaker then closes. After a pre-determined interval (approximately ten cycles) the original running breaker or contactor opens automatically.

The operation cannot be performed unless the synchronizing switch is closed. After the transfer the synchronizing switch handle should be removed and the transfer control switch should be returned to the "OFF" position. Each breaker has a red (closed) and green (open) indicating lamp. The push-button can be used to disengage the running breaker or contactor at any time.

AUTOMATIC SYNCHRONIZED BY-PASS TRANSFER (AT)

This option is available on non-redundant UPS in ratings up to and including 300 kva. In this arrangement the load is transferred automatically to the by-pass power line in the event of an incipient inverter malfunction. Normally, the critical load is powered by the UPS which is synchronized and in phase-lock with the by-pass supply. The transfer to the by-pass will be a closed (make-before-break) transition such that performance characteristics are maintained, under the following circumstances:

a) A-c output undervoltage (sustained)
b) A-c output overvoltage (sustained)
c) A-c output overcurrent (sustained)
d) Rectifier or inverter transformer overtemperature
e) Rectifier or inverter fan failure
f) Manual selection of bypass

Annunciation of a transfer due to any of the above conditions except manual selection of by-pass is included. The load can also be manually returned to the UPS via a closed transition with no power interruption to the load. A provision to initiate automatic transfer should the inverter output disconnect be inadvertently opened, is also incorporated.

Should the inverter have a total internal failure such as an SCR — thyristor failure, an automatic open-transfer is initiated.

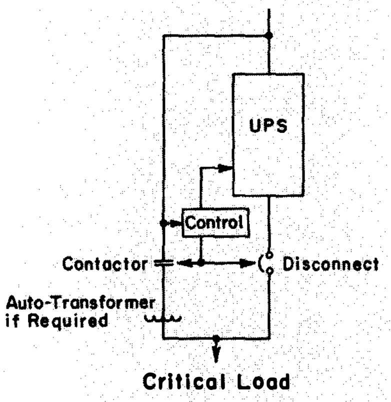


Fig. 6

The following equipment is included with this arrangement:

1. By-pass synchronizing and phase lock logic.
2. All malfunction detection circuits and relays.
3. Synchroscope and frequency meter with selector switch.
4. Necessary contactor and disconnects.
5. Annunciation as described (with indicating lamps).
6. Manual by-pass selector switch.
7. Status indicating lights
   Rectifier "ON"
   Inverter "ON"
   By-pass "READY"
   By-pass "ON"

In the case where the system input and output voltages are not identical, a by-pass autotransformer is incorporated in the by-pass line. The synchronizing signal is rejected if it is beyond pre-set tolerances and the system operates from its independent frequency oscillator and controls. When the by-pass returns to normal, the system automatically resynchronizes to it.

AUTOMATIC SYNCHRONIZED STATIC BY-PASS TRANSFER (ST)

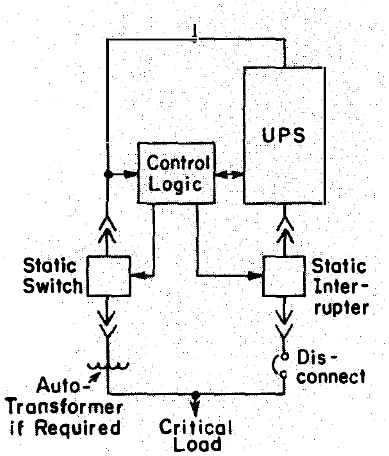


Fig. 7

This option is available for nonredundant PowrLok up to and including 250 kva.

In this scheme, the patented General Electric static interrupter is placed in series with the UPS output which in turn is placed in parallel with a static switch as shown above. The load is automatically transferred to the by-pass line under all inverter malfunctions in one millisecond or less for worst case conditions, i.e. SCR failure. For incipient inverter malfunctions, the automatic transfer to the by-pass will be a closed (make-before-break) transition such that performance characteristics are maintained. The incipient failure modes are as follows:

a) A-c output undervoltage (sustained)
b) A-c output overvoltage (sustained)
c) A-c output overcurrent (sustained)
d) Rectifier or inverter transformer overtemperature
e) Rectifier or inverter fan failure

Under normal conditions the UPS operates in synchronism and phase-lock with the by-pass power source. Should this source deteriorate beyond specified tolerances, the UPS continues to operate on its internal redundant frequency oscillators and controls.

The system is designed so that the synchronizing signal from the by-pass is disconnected when the UPS is being supported from an emergency diesel-generator set. This is done since in most cases the frequency variations inherent with an E-G set are undesirable on the critical load. A contact from the E-G set output breaker is used to disengage the synchronizing tie.

In the event of an inverter failure the static interrupter operates to isolate the inverter from the critical bus. Simultaneously a signal is given to the static switch located within the by-pass circuit to switch it from the "Off" to the "On" state. The operation will be similar to a closed transition transfer switch, transferring the critical load from the inverter to the utility source in less than one (1) millisecond.

A closed transition manual transfer can be made with the selector switch and pushbutton, to and from the by-pass line.

The equipment included with this scheme will be as follows:

1. By-pass synchronizing and phase-lock logic.
2. All malfunction detection circuits and necessary relays.
3. Synchroscope and frequency meter with selector switch.
4. Drawout type General Electric static interrupter.
5. Annunciation of the incipient failure modes.
6. Manual by-pass selector switch.
7. General Electric static switch.
8. UPS output disconnect.

In the case where the system input and output voltages are not identical, a by-pass auto-transformer can be incorporated in the by-pass line.

In addition to modularized controls and drawout static switch and static interrupter to simplify routine maintenance, specific safety features are incorporated in this system. The static interrupter on the output of the UPS prevents load faults from causing inverter fuse blowing or SCR failure. The interrupter includes a current limit feature which senses a load current which reaches 125% of the system rated value and automatically inserts an impedance into the output circuit. This limits current to the rated value for three seconds, usually sufficient time for downstream protective devices to isolate the fault. If the fault is not isolated, the UPS output disconnect is automatically opened. If the fault is isolated, the system returns to normal operation. Should the system output disconnect be opened inadvertently, the system automatically transfers to the by-pass line.

Specifications

Table 1 General Electric Non-Redundant PowrLok Specifications

Output kva Rating	Inverter kva Rating	Rectifier kw Rating	Battery Rating (Ampere-Hours)			
			t_d 5 min. t_r 2 hr.	15 min. 8 hr.	30 min. 12 hr.	80 min. 24 hr.
35	35	50	100	120	150	240
50	50	70	150	175	240	320
80	80	90	200	320	400	480
112.5	112.5	130	400	400	560	720
137.5	137.5	150	400	480	640	900
160	160	170	480	560	720	900
225	225	250	640	800	1050	1350
275	275	300	800	1050	1350	1650

Overload: 150% for one (1) minute

Environment: Ambient temperature: 10° — 40° C.

Humidity: 95%

Elevation: 0-3,300 feet

Efficiency: 80% minimum at full load.

t_d = Battery support time (based on 0.8 load power factor)

t_r = Battery recharge time

A-c Input: 120/208 or 277/480V., ± 10%, 3ϕ, 3 or 4 wire, 50 or 60 Hz

D-c Bus: 322-405 vdc

A-c Output: 120/208 V., 3ϕ, 3 or 4 wire, 50 or 60 Hz

Steady-state voltage regulation: ± 2%

Steady-state frequency regulation: ± 0.5%

Harmonic Content: 5% max. total

Table 3 General Electric PowrLok Battery Specifications (184 Lead Calcium Cells)

Ampere Hour Rating	Two-tier Rack Dimensions				Battery kw				Approx. Total Weight
	Quan.	Length	Width	Height	5 Min.	15 Min.	30 Min.	60 Min.	
25	3	6′	12″	43″	10	7	5	4	2,250
50	3	6′	12″	43″	19	15	11	8	2,600
75	3	9′	12″	43″	29	23	17	12	4,000
100	**3**	**9′**	**12″**	**43″**	**40**	**32**	**23**	**18**	**4,300**
120	3	11′	12″	43″	47	37	28	19	5,200
150	6	10′	12″	43″	59	47	35	24	8,500
175	6	10′	12″	43″	69	55	41	28	8,900
180	**3**	**8′**	**16″**	**58″**	**58**	**45**	**35**	**25**	**8,700**
200	6	10′	12″	43″	80	64	47	32	9,300
240	3	11′	16″	58″	83	67	52	38	15,000
320	**3**	**14′**	**16″**	**58″**	**102**	**87**	**68**	**49**	**18,000**
400	3	14′	16″	58″	140	113	88	64	20,000
480	3	16′	16″	58″	167	135	105	77	24,000
580	**8**	**10′**	**16″**	**58″**	**195**	**157**	**123**	**89**	**27,000**
640	6	12′	16″	58″	223	180	141	102	31,000
720	6	12′	16″	58″	251	202	158	115	33,000
800	**8**	**12′**	**16″**	**58″**	**280**	**228**	**178**	**128**	**35,000**
900	6	11′	20″	66″	284	237	192	144	44,000
1050	6	11′	20″	66″	330	276	224	168	46,000
1200	6	11′	20″	66″	379	317	256	192	49,000
1350	**8**	**11′**	**20″**	66″	**425**	**350**	**288**	**218**	**52,000**
1500	6	13′	20″	66″	474	395	320	240	60,000
1650	6	15′	20″	66″	520	435	352	264	66,000
1800	6	15′	20″	66″	567	475	384	288	70,000
1950	**8**	**15′**	**20″**	**68″**	**815**	**515**	**418**	**312**	**72,000**
2030	9	13′	20″	66″	637	533	434	325	74,000
2175	9	13′	20″	66″	683	570	464	348	77,000
2320	9	13′	20″	66″	728	609	495	372	80,000

Table 2 — General Electric Powr/Lok Inverter Specifications

Single kva Rating	Multiple kva Rating	Dimensions W	x D	x H
35	30	85″	36″	90″
50	45	85″	36″	90″
80	70	115″	36″	100″
112.5	100	160″	36″	100″
137.5	125	160″	36″	100″
160	150	175″	36″	100″
225	200	175″	36″	100″
275	250	175″	36″	100″

D-c Input: 322/405V.
A-c Output: 120/208V.
Voltage Regulation: ± 2%
Frequency Regulation: ± 0.5%
Power Factor Range: 0.6 lag to unity
Circuit Protection:
Input d-c breaker
Output a-c disconnect
Current limiting fuses

Instrumentation:
D-c Ammeter
A-c Voltmeter
A-c Ammeter
Overload Capability: 150% for one (1) minute
NEMA I Enclosure
Front access only req'd
Paint: Sand grey and blue

Weight is approximately 300 lbs. per square foot.

Table 4 — General Electric Powr/Lok Silcomatic Rectifier Specifications

Output kw Rating	Dimensions Width	Depth	Height	Approx. Weight
30	36″	36″	100″	2500
50	36″	36″	100″	2700
70	36″	36″	100″	3000
90	48″	36″	100″	3600
110	48″	36″	100″	4000
130	48″	36″	100″	4200
150	48″	36″	100″	4500
170	72″	36″	100″	5300
190	72″	36″	100″	5400
210	72″	36″	100″	5700
230	72″	36″	100″	6000
250	72″	36″	100″	6100
300	72″	36″	100″	6400
350	90″	63″	90″	8000
400	96″	63″	90″	8600
450	96″	63″	90″	9000
500	96″	63″	90″	9200
550	96″	63″	90″	9400
600	132″	63″	90″	11000
650	162″	63″	90″	12900
700	162″	63″	90″	13400
750	162″	63″	90″	13800
800	162″	63″	90″	14000
850	185″	63″	90″	14900
900	185″	63″	90″	15200
950	185″	63″	90″	15600
1000	185″	63″	90″	16000

A-c Input: 120/208 or 277/480V., ± 10%, 3φ, 3 or 4 wire, 50 or 60 Hz, ± 1Hz
D-c Output: 360-405V., current-limited
Current walk-in feature
Circuit Protection: Input circuit breaker
On redundant rectifiers, an output disconnect is provided which increases widths shown by 30″ above 250kw.
CLF Fuses and surge suppressors
NEMA I Front access only through 300 kw, front and rear access above 300 kw

Table 5 — General Electric Powr/Lok Control Compartments

Description	Dimensions Width	Depth	Height
Single Inverter 80 kva and above	30″	36″	100″
2 Parallel Inverters — all ratings	30″	36″	100″
3 or more Parallel Inverters	72″	36″	100″

Table 6 — General Electric Powr/Lok Transfer Scheme Dimensions

Type	Dimensions Width	Depth	Height
MT, AT, ST (all rated 275 kv and below)	30″	36″	100″

See Page 8 for calculations and application information for tables 1 thru 4.

Join the solid state revolution for power shaped to your needs

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GEA-8631B
11-71 5000

PRINTED IN U.S.A.