Voltage-Dip Proofing Inverters

For DPI 52 Series Models
120V & 208 / 230V 50/60Hz
# Notice

**IMPORTANT SAFETY INSTRUCTIONS.**  
**SAVE THESE INSTRUCTIONS!**

This manual contains important instructions that should be followed during installation and adjustment of all DPI52 series Voltage Dip-Proofing Inverters.

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Introduction

The reliability of electrical power to industry is in general very high, nevertheless, voltage sags and short power interruptions or voltage dips occur. These instabilities are caused by short circuits, lightning strikes on overhead power lines and heavy load switching. The duration of such faults is generally shorter than one second.

Most plant can ride through such voltage dips by virtue of their mechanical and electrical inertia. However, this is not the case with electrically held-in contactors and relays that control the machinery. Contactors typically drop out from 5ms to 20ms after power is removed. Each short voltage dip now becomes a power failure and the plant must be restarted. This can be complicated, time-consuming and costly.

DIP-PROOFING TECHNOLOGIES’ VOLTAGE- DIP PROOFING INVERTERS are designed to maintain the switchgear control voltage during voltage dips, effectively keeping the plant connected. The stored electrical and magnetic energy is allowed to flow, supporting the mechanical inertia of the machinery. When the power is restored after a short voltage dip, the plant is still running at near synchronous speed, the inrush currents will be small and the stress to the system minimal.

Historically, this problem has been addressed by using DC contactors, latched contactors and intelligent controls such as PLC’s. These systems are complex and expensive and do not provide a solution for equipment already in existence. The current approach to this problem has been to employ intelligent control systems which provide a curative solution. In contrast, the Voltage-Dip Proofing Inverter, provides a preventative solution.

Theory of operation

The VOLTAGE-DIP PROOFING INVERTER is designed to be maintenance free and highly reliable. It consists of a static switch in series with, and an inverter parallel to, the load. Energy is stored in a capacitor bank: the inverter block diagram is shown in Fig 1.
The STATIC SWITCH is robust and can withstand large current surges. It is ideally suited for contactor operation where high peak currents of short duration occur during energizing.

The INVERTER is configured as a full bridge with overcurrent and short circuit protection. The output waveform is a square wave where the RMS and the peak voltage are the same as for a sine wave as shown in Fig 2.

![Inverter stepped square wave output waveform](image)

This is important for circuits where magnetic devices, such as transformers and contactors (RMS voltage) are in circuit with electronic relays that derive their DC voltage from capacitor input filters (peak voltage).

The computer grade CAPACITOR BANK operates under ideal conditions, being charged to working voltage but carrying no ripple current most of the time.

During stand-by operation, the static switch supplies power directly to the load, the inverter is switched off and the capacitors are charged to the full operating voltage. The supply voltage is constantly monitored for deviations; should there be a deviation from Vnom which is greater than the preset value, the static switch is switched off and the inverter is activated. The switch-over is accomplished in less than 700µs. A 3.1 second timer, adjustable in increments of 100ms, starts timing the inverter out. Should the input voltage recover within the set time, the inverter supply is synchronized to the mains and the load is switched back to the supply, the capacitors are recharged in less than one second and the inverter is ready to compensate for the next voltage dip. If the input voltage does not recover within the set time the load is switched back to the supply regardless of the voltage level.
Specifications
DPI 52 series 120V models

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<thead>
<tr>
<th>120V MODELS</th>
<th>DPI52S25-12</th>
<th>DPI52S50-12</th>
<th>DPI52S190J12</th>
<th>DPI52L1K5-12</th>
<th>DPI52L238J12</th>
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<th>DPI52L713J12</th>
<th>DPI52L3K12</th>
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<th>DPI52L1188J12</th>
<th>DPI52L1663J12</th>
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<td>&lt;3s</td>
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<td>red LED</td>
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<td>Height (mm) (Dim. L3 on p14):</td>
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<td>309</td>
<td>309</td>
<td>379</td>
<td>329</td>
<td>355</td>
<td>419</td>
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<td>507</td>
<td>507</td>
<td>644</td>
<td>1145</td>
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<td>15.53</td>
<td>9.3</td>
<td>9.3</td>
<td>14.4</td>
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<td>27.0</td>
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<td>1.76 Nm (15.6 lb-in)</td>
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<td>UL Listed, Control # 37WJ / File # E205817</td>
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**WARNING**
Risk of electric shock! Dangerously high voltages can be present up to 2 hours after the DPI has been disconnected.
NEVER attempt maintenance on the DPI during this period unless storage capacitors have been manually discharged.
WARNING
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NEVER attempt maintenance on the DPI during this period unless storage capacitors have been manually discharged.

Specifications
DPI 52 series 208 / 230V models

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<thead>
<tr>
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<td>DPI52S50-23</td>
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<td>DPI52S108J23</td>
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<td>DPI52S216J23</td>
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<td>DPI52L2K23</td>
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<td>DPI52L396J23</td>
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<td>DPI52L4K5-23</td>
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<td>DPI52L794J23</td>
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<td>DPI52L1587J23</td>
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<td>DPI52L2381J23</td>
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<td>DPI52L3174J23</td>
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<td>DPI52L3968J23</td>
</tr>
</tbody>
</table>

AC INPUT SUPPLY
- Single phase supply voltage: 208 / 230Vac 50/60Hz
- Maximum input voltage: +10%
- Full load current (A): 1.1A 2.2A 8.7A 20A

STATIC SWITCH
- Nominal off-state voltage: 250Vac RMS
- Peak off-state voltage: 800V
- Nominal current (A): 1.1A 2.2A 8.7A 20A
- Short time overload current (<100ms): 26A 60A
- Non-repetitive peak on-state current (10ms): 26A 180A

INVERTER
- Nominal output voltage: 208 / 230Vac RMS
- Voltage fluctuations over full operating range: ±15% to +10%
- Nominal load current (A): 1.1A 2.2A 8.7A 20A
- Power factor range: cos Φ from 1 to 0
- Wave shape: Stepped square
- Nominal inductive load (VA): 250 500 2000 4500
- Storage capacitors (F): .00204 .00408 .00828 .015 .03 .06 .09 .12 .15
- Usable stored energy factor (η): 0.39 0.43 0.42 0.46 0.47
- Minimum up-time as function of the load (t): t = (η°C_cap/V_supply) / (I_load*cos Φ)
- Transistor peak current limit: 26A 50A
- Output frequency: 50/60Hz ±1%
- HBC fuse rating: 16A 32A

TIMER
- Range: 0.1 to 3.1s
- Setting: 0.1s steps
- Maximum recovery time of capacitors to 1,4Vin: <1s <1.4s <2s <3s <3.6s

INDICATORS
- System OK: green LED
- Inverter running: red LED

TEMPERATURE
- Maximum ambient working temperature: 45°C (113°F)

CUBICLE
- Construction: Extruded Aluminum
- Height (mm) (Dim. L3 on p14): 259 309 309 379 329 419 419 595 785 974 1145
- Height (in) (Dim. L3 on p14): 10.20 12.17 12.17 14.92 12.35 12.95 12.95 16.50 16.50 23.43 30.91 38.35 45.08
- Width mm (in): 150 (5.80) 311 (12.24)
- Depth mm (in): 110 (4.33) 162 (6.38)
- Mass (kg): 3.0 3.6 3.3 4.3 7.9 7.88 11.0 11.0 17.25 23.64 30.12 36.2
- Mass (lbs): 6.6 7.93 7.31 9.46 17.42 17.37 24.25 24.25 38.03 52.12 66.40 79.81

CONNECTION
- Cable, Copper panel wire: 2mm² (14 AWG) 5mm² (10AWG)
- Screw terminal torque: 1.76Nm (15.6lb-in)

LISTINGS
- Underwriters Laboratories Inc: UL Listed, Control # 37WJ / File # E205817
Up-time considerations

The up-time that a DPI can achieve is dependent on the usable energy in the storage capacitors and on the characteristics of the supported load. Load characteristics are critical in determining the up-time. Resistive loads with a power factor near 1 consume real power and the up-time will be shortest. Resistive loads include lamps, switch mode power supplies and linear power supplies. Contactors use little real power as they are a reactive load with power factors around 0.15. Reactive loads such as contactors give the longest up-time.

The formulae below can be used to determine the minimum up-time that can be achieved for an application. It uses the load current, load voltage, load power factor, the value of the DPI storage capacitors and an efficiency factor to calculate the value.

Minimum up-time as function of the load: \( t = \frac{\eta \cdot C_{cap} \cdot V_{supply}}{I_{load} \cdot \cos \Phi} \)

Minimum up-time \( t \)
Value of storage capacitor(s) = \( C_{cap} \)
Stored energy factor = \( \eta \)
Load voltage = \( V_{supply} \)
Load current = \( I_{load} \)
Load power factor = \( \cos \Phi \)

From the formulae it can be seen that the power factor \( (\cos \Phi) \) has a significant influence on the up-time. Resistive loads with \( \cos \Phi = 1 \) will yield the shortest up-time while reactive loads with \( \cos \Phi = 0.15 \) will yield the longest up-time. For example:

A. Using DPI model DPI52S50-23 find the minimum up-time for a predominantly resistive load; say a PLC power supply and some small relays.

Value of storage capacitor(s) = 0.00408F
Stored energy factor = 0.46
Load voltage = 230V
Load current = 0.43A
Load power factor = 0.8

Minimum up-time \( t = \frac{0.46 \times 0.00408 \times 230}{0.43 \times 0.8} = 1.25 \text{ seconds}. \)

B. Using DPI model DPI52S50-23 find the minimum up-time for a predominantly reactive load; say some small contactors and relays.

Value of storage capacitor(s) = 0.00408F
Stored energy factor = 0.46
Load voltage = 230V
Load current = 0.43A
Load power factor = 0.15

Minimum up-time \( t = \frac{0.46 \times 0.00408 \times 230}{0.43 \times 0.15} = 6.69 \text{ seconds}. \)

The examples illustrate the importance of knowing the load power factor when calculating the minimum up-time for a DPI application. For best accuracy use the on line DPI Selector to find the correct size DPI for an application. Link:  www.dipproof.com/products/dpi_selector.asp
Installation Guide

1. Remove the unit from its packing
2. Place the unit horizontally on a bench and visually check for any mechanical damage. Ensure that all the casing screws are tight then shake the unit to check that there is nothing loose internally.

Note: Please inform your shipping agent if any damage has occurred during transit: the damaged unit(s) and all packing material should be kept in case the insurers wish to inspect the damage.

3. Check that the inverter voltage is the same as the system control voltage.
   Refer to the rating label on the unit end plate.

   **WARNING:** Never connect a 120V unit to a 230V supply!

4. Decide on the location where the unit is to be installed, this will probably be inside a switch gear panel.

5. Mount the unit vertically using M6 bolts.

6. Connect unit as shown in Fig 3 using 2mm² (14AWG), DPI52 S series & 5mm² (10AWG), DPI52 L series copper panel wire.

7. Apply terminal screw tightening torque of 0.6 - 0.8Nm (5.2 - 7 lb-in), DPI52 S series & 1.5 - 1.8Nm (13 - 16 lb-in) DPI52 L series.

8. This device does not have a disconnect switch. If such a switch is required it must be provided by others.

**Power Wiring**

- Connect Line In (Supply) to Terminal 1
- Connect Common Line in to Terminal 2
- Connect Common Line out to Terminal 3
- Connect Line Out (Load) to Terminal 4
- Connect the ground screw(s) on the unit to the panel ground point.

![Fig 3 Power Wiring Diagram](image-url)
9. Once the unit has been mounted and the external wiring completed, power can be applied. Turn on the power to the unit. After about two seconds the green LED indicator "System OK" should come on. The unit is now fully operational.

10. In applications which require no break maintenance, a bypass switch must be installed. Order Housed Bypass Switch model DPIBPSW which should be connected as shown in Fig 4.

**Functional Description Indicators**

- **System OK**: Green LED indicator
  
  When the green LED is ON the system is fully functional; the unit self test & initialization routine has run successfully.

- **Inverter Running**: Red LED indicator
  
  The red LED is on when the inverter is running during a voltage dip. A stepped square wave is present on the output terminals 3 & 4.
Test and Maintenance

There are no user serviceable parts inside the unit, if faulty return to factory or local agent for repairs.

WARNING: Risk of electric shock, capacitor(s) store hazardous energy.

NEVER attempt any maintenance on the DPI until storage capacitors are fully discharged. Dangerously high voltages can be present up to 2 hours after the DPI has been disconnected unless the storage capacitors have been manually discharged.

Adjustments

All adjustment points are marked on the control card and can be reached by removing the front cover of the DPI; see Mechanical Construction on page 14. Note that the Set Inverter Run Time switch (SW1) is dual function. It is used to set the inverter run time and to program the inverter output voltage.

INVERTER RUN TIME - SW1 (see Fig.5 page 11)

This switch sets the running time of the inverter and can be set in 100ms steps to a maximum of 3.1 seconds. To determine the inverter run time which is currently set, add the figures printed next to each switch which is in the ON position. For example, a running time setting of one second requires that the following switches be in the ON position: 200 + 800: these figures added give 1000ms or 1 second.

Factory Setting : 1000ms

INVERTER OUTPUT VOLTAGE - SW1 (see Fig.5 page 11)

The inverter output voltage can be reset to match a different supply voltage, for example a 230V unit used on a 208V supply. The Set Inverter Run Time switch (SW1) is dual function and is used to program the inverter output voltage.

With the unit energized switch all switches (SW1-1 to 6) OFF.
Set the switch (SW1-1 to 5) equal or closest to the supply voltage ON.
To program the inverter output voltage set “Test 2min” switch (SW1-6) to ON.
The System OK LED will begin to flash.
Return the switch (SW1 - 6) to the OFF position, the System OK LED will remain on continuously.
The inverter output voltage now equals the DPI supply voltage and programming is complete.
Reset the Inverter Run Time switches (SW1-1 to 5) to the required run time.
Factory Setting : Vnom @ full load - Refer to Specification Sheet on page 5 & 6

TRANSFER LEVEL - SW2 (see Fig.5 page 11)

Sets the supply voltage level at which the inverter switches to run mode. The level can be varied between 55% and 90% of the nominal supply voltage by setting the switches according to the table in Fig.5.

Factory setting : 75%

Fuses

The inverter fuse is mounted on the motherboard.

52 S series - Main Fuse Type SIBA70 125 40 : 16A 6x32mm Ultra Rapid.
52 L series - Main Fuse Type SIBA 50 138 06 : 32A 14x51mm UltraRapid.
Alternate - Buss FPW-32A14F : 32A 14x51mm UltraRapid.
Fig 5
Control Card Indicator & Adjustment Locations

Fault Diagnosis Chart

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Probable Cause</th>
<th>Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>System OK LED is off, no voltage on output terminals.</td>
<td>No supply voltage on input terminals (1 &amp; 2).</td>
<td>Check supply.</td>
</tr>
<tr>
<td></td>
<td>Short circuit on the output.</td>
<td>Disconnect the load from terminal 4. Switch off the supply voltage then switch it on again. If unit is not damaged the System OK indicator will come on. Check for short circuit on the load side.</td>
</tr>
<tr>
<td>System OK LED is off, voltage on terminals 3 &amp; 4 no voltage on 1 &amp; 2.</td>
<td>Supply and load wires are reversed. Terminals 1 &amp; 4.</td>
<td>Swap supply &amp; load wires. Connect supply to terminal 1 &amp; load to terminal 4. <strong>There is a possibility that the unit may be damaged by incorrect connection.</strong></td>
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<tr>
<td>System OK LED is off, voltage present on output terminals.</td>
<td>A 230v unit is being used with a 120v supply.</td>
<td>Change unit to 120v model.</td>
</tr>
<tr>
<td>Unit failure when supply switched on.</td>
<td>A 120v unit is being used with a 230v supply.</td>
<td>Change unit to 230v model. <strong>Note: The 120v unit will be damaged.</strong></td>
</tr>
</tbody>
</table>
Accessories
Housed Bypass Switch

Description
Where no-break maintenance is required a bypass switch must be installed. It connects the supply directly to the load, "Bypass" position, and disconnects the power terminals of the inverter without interrupting the supply. When in "DPI" position the load is connected to the supply via the inverter.

Specifications
MODEL
MODEL BPSW25A

ELECTRICAL
Maximum current: 25A
Maximum input voltage: 600Vac

TEMPERATURE
Maximum working temperature: 45°C (113°F)

HOUSING
Construction: Extruded Aluminum
Height: 202mm (7.95in)
Width: 150mm (5.9in)
Depth: 141mm (5.55in)
Mass: 1kg (2.2lbs)

Mechanical outline

Ordering
Stock No: 5003-006
Description: Housed By-Pass Switch 25Amp
Installation & Service Manual

Mechanical Construction

**52 S series** - The DPI case is made from extruded aluminium sections. The four parts that make up the case are interlocked and secured by screws. To remove the front cover unscrew four screws: the two top screws from the end plate where the terminal block is located and the two bottom screws from the other end plate. Slide the front cover away from the terminal block to access adjustment area.

**52 L series** - The DPI case is made from extruded aluminium sections. The six parts that make up the case are interlocked and secured by screws. To remove the front cover unscrew three screws: one from the front cover and one each from the top and bottom end plates.

### Dimension Table

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<th>DPI &amp; VDC Dimensions mm (in)</th>
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<th>L2</th>
<th>L3</th>
<th>L4</th>
<th>L5</th>
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* Indicates 6 mounting holes see dimension L1*
Mechanical Outline

"L" series case.

Model # example
DPI52L3K23
or
VDC L4T5K120

"S" series case.

Model # example
DPI52S50-23
or
VDC S4T1K230

Note 1:
Terminal cover shown dashed.

Note 2:
Terminal #1 - Line in (Supply)
Terminal #2 - Common line in
Terminal #3 - Common line out
Terminal #4 - Line out (Load)

Fig 7
Dimensions of the DPI 52 Series in mm & (in inches)
Voltage-Dip Proofing Inverters

For DPI 52 Series Models
120V & 208 / 230V 50/60Hz

A typical DPI connection diagram