Voltage Sag Simulator

For use with all DPI's & VDC's 120/208/240V 50/60Hz

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Smart Engineering solutions…

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Contents

1. Introduction

The reliability of electrical power to industry is in general very high; nevertheless, brown outs 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.

SWITCHING SYSTEMS' 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.

2. 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.
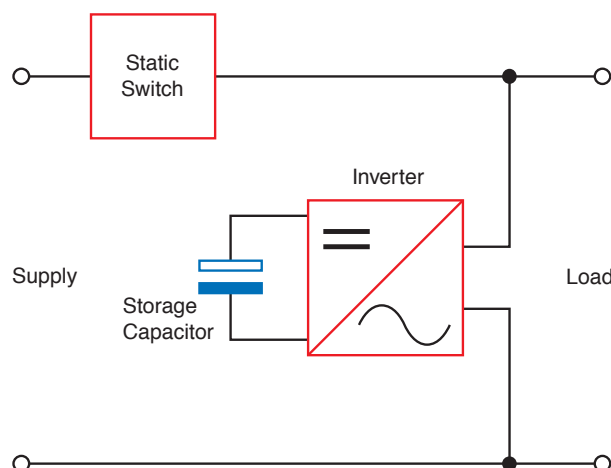

Fig 1
Inverter Block Diagram

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.
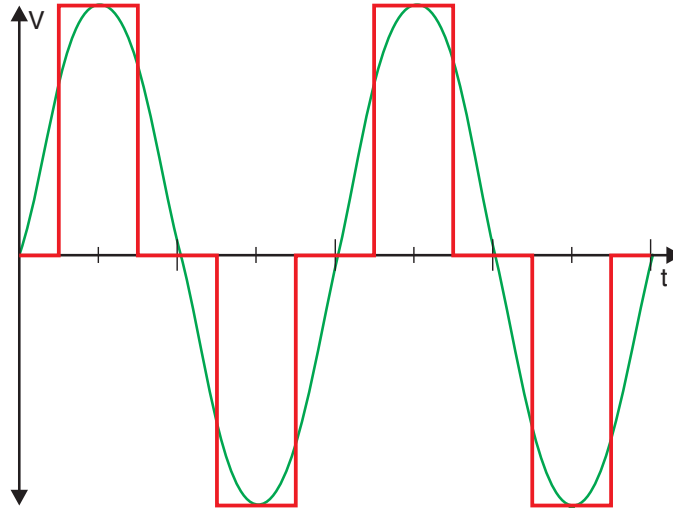
Fig 2
Inverter stepped square wave output waveform

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 $700\mu s$. 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.

Description - Voltage Sag Simulator

The Sag Simulator is intended to be used as a tool to evaluate the effects of momentary voltage sags and interruptions on industrial controls. When used in conjunction with a Voltage Dip-Proofing Inverter or a Voltage Dip Compensator and Bypass switch, it may be used to prove the effectiveness of the DPI or VDC as a solution for these power quality problems. The Simulator has two other useful functions that may be selected via the Function Select menu,

a Variac Output that enables direct output from the variac and a Soak Test function that may be used to perform repetitive testing.

The Sag Simulator is designed for 120/208/240Vac operation. The main controls and their functions are listed below, refer to Fig 7 page 14 for their locations :-
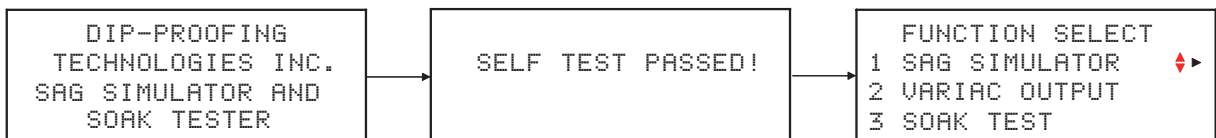
1. A variac that is used to set the depth of an under voltage (sag) condition.

2. The sag level set by the variac is indicated on the LCD display.

3. A variable interrupt timer that is used to set the duration of the voltage sag and the point in the cycle at which it begins. Both variables are set using the programming keys and are indicated on the LCD display. Refer to the menu flow chart and programming key function table in Fig 3 p7 for Sag Simulation, page 8 for Variac Output and Fig 4 p11 for Soak Test.

Operation

Sag Simulation

Follow the steps outlined below to set up and operate the Sag Simulator. Refer to Fig 3 on page 7 for information on menu layout and programming key functions.

1. Connect the supply, Voltage Dip-Proofing Inverter or Voltage Dip Compensator, Bypass Switch and load to the Sag Simulator as shown in Fig 8 page 15.

2. Set the variac to zero output and the Bypass Switch to *Inverter Bypassed*.

3. Switch on the power to the Sag Simulator; the display will show:

```
   DIP-PROOFING              FUNCTION SELECT
 TECHNOLOGIES INC.    SELF TEST PASSED!    1 SAG SIMULATOR    ▲▼▶
 SAG SIMULATOR AND                         2 VARIAC OUTPUT
    SOAK TESTER                            3 SOAK TEST
```

Note: If an error message is displayed and the Simulator shuts down please refer to *Error conditions* at the end of this section on page 10.

4. Press the ▶ key to reach the Sag Simulator menu; the display will show:
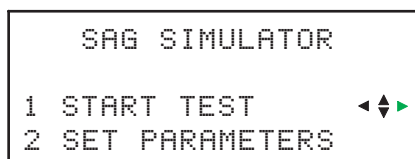
```
      SAG SIMULATOR

 1 START TEST          ◀▲▼▶
 2 SET PARAMETERS
```

5. Press the ▶ key to reach the *Start Test* display; the display will show:

```
      START TEST   ◀  ▶
 VOLTAGE:      000Vac
 DELAY:        05.0ms
 DURATION:     1.000s
```
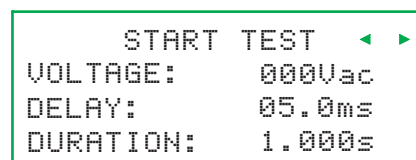
6. The Sag Depth may be adjusted using the Variac prior to performing the test. The value is shown on the Voltage readout. In this case preset values are used for Sag Delay (5ms) & Sag Duration (100ms). The simulator will store the values used for the last test and use them as the defaults for the next test.

7. Press the ▶ key to Start Test or press the ◀ key to return to the Sag Simulator menu.

8. To set the Sag Parameters to values different to the defaults navigate to the Sag Simulator menu, press the ▼ key to select Set Parameters then press the ▶ key to reach the adjustment menus. The *Sag Depth* is set using the variac and then the interrupt timer should be programmed to set the position and duration of the voltage sag to be generated. The three parameters are adjusted as follows :-

   8.1 Set *Sag Depth*: At the Set Sag Depth Menu press the ▶ key to reach the Adjust Variac menu. Adjust the variac until desired voltage is indicated on the display.

   8.2 Set *Sag Delay* position after a positive zero crossing: At the Adjust Variac menu press the ▼ key to select the *Set Sag Delay* menu. Press the ▶ key to program the Sag Delay value. Use the ▶ and ◀ keys to select the digit to adjust. The active digit will flash. Use the ▲ ▼ keys to increment or decrement the digit to the desired value.

   8.3 Set *Sag Duration*: From the Set Sag Delay menu press ▼ key to select the *Set Sag Duration* menu. Press the ▶ key to program the Sag Duration value. Use the ▶ and ◀ keys to select the digit to adjust. The active digit will flash. Use the ▲ ▼ keys to increment or decrement the digit to the desired value.

9. *Start Test*: When the *Sag Voltage*, *Delay* and *Duration* have been set navigate back to the Sag Simulator menu by pressing the ◀ key. Press the ▶ key to reach the Start Test menu. At this point the variac may be used to readjust the sag voltage. The voltage setting will be indicated on the display. The supply voltage can be interrupted by pressing the ▶ key. The effect of the programmed sag can be seen on the unprotected load; one or more contactors or relays will drop out. The sag profile can be observed using a power monitor or an oscilloscope if these are available. The simulation can be tried with various settings (sag depth, delay and duration) as often as desired to pinpoint sensitive components in the control system.

10. *Test with DPI or VDC in circuit*: The Bypass Switch should now be set to *Inverter in Circuit* and the sag simulations repeated to evaluate the effectiveness of using the Voltage Dip-Proofing Inverter or Voltage Dip Compensator to harden the controls against momentary sags and interruptions.

11. *Sync pulse output:* A synchronization pulse is available at terminals 4 & 5. This pulse may be used to trigger an oscilloscope in order to display the sag profile. The output remains at zero volts until a sag is initiated at which time the output rises to 5 volts and remains at this level until the end of the sag duration period. The output then returns to zero volts. The sync pulse output is electrically isolated.

START SAG TEST
VOLTAGE: 154Vac
DELAY: 05.0ms
DURATION: 1.000s

>>> TESTING >>>
VOLTAGE: 154Vac
DELAY: 05.0ms
DURATION: 1.000s

Displays for duration of sag.

Key	Menu navigation	Set value
▲	Next menu above	Increment digit
▼	Next menu below	Decrement digit
◀	Next menu left	Previous digit
▶	Next menu right	Next digit

DIP-PROOFING
TECHNOLOGIES INC.
SAG SIMULATOR AND
SOAK TESTER.

Power on - start.

SAG SIMULATOR

1 START TEST
2 SET PARAMETERS

SAG SIMULATOR

1 START TEST
2 SET PARAMETERS

SET VOLTAGE: 154Vac

SET THE SAG DEPTH BY
ADJUSTING THE VARIAC

SET SAG DEPTH
VOLTAGE: 154Vac
DELAY: 05.0ms
DURATION: 1.000s

DELAY: 05.0ms
SET POINT WHERE SAG
STARTS AFTER A ZERO
CROSSING

SET SAG DELAY
VOLTAGE: 154Vac
DELAY: 05.0ms
DURATION: 1.000s

DURATION: 1.000s

SET SAG DURATION

SET SAG DURATION
VOLTAGE: 154Vac
DELAY: 05.0ms
DURATION: 1.000s

Displays for 3 sec.

SELF TEST PASSED!

Displays for 3 sec.

FUNCTION SELECT
1 SAG SIMULATOR
2 VARIAC OUTPUT
3 SOAK TEST

Power on error messages.

SUPPLY FREQUENCY NOT
50 or 60Hz!
SWITCH OFF AND ON
TO RETRY.

CURRENT OVERLOAD
OR SHORT CIRCUIT!
SWITCH OFF AND
CHECK THE LOAD.

SYSTEM FAILURE!
PLEASE CONTACT
DIP-PROOFING
TECHNOLOGIES INC.

Fig 3

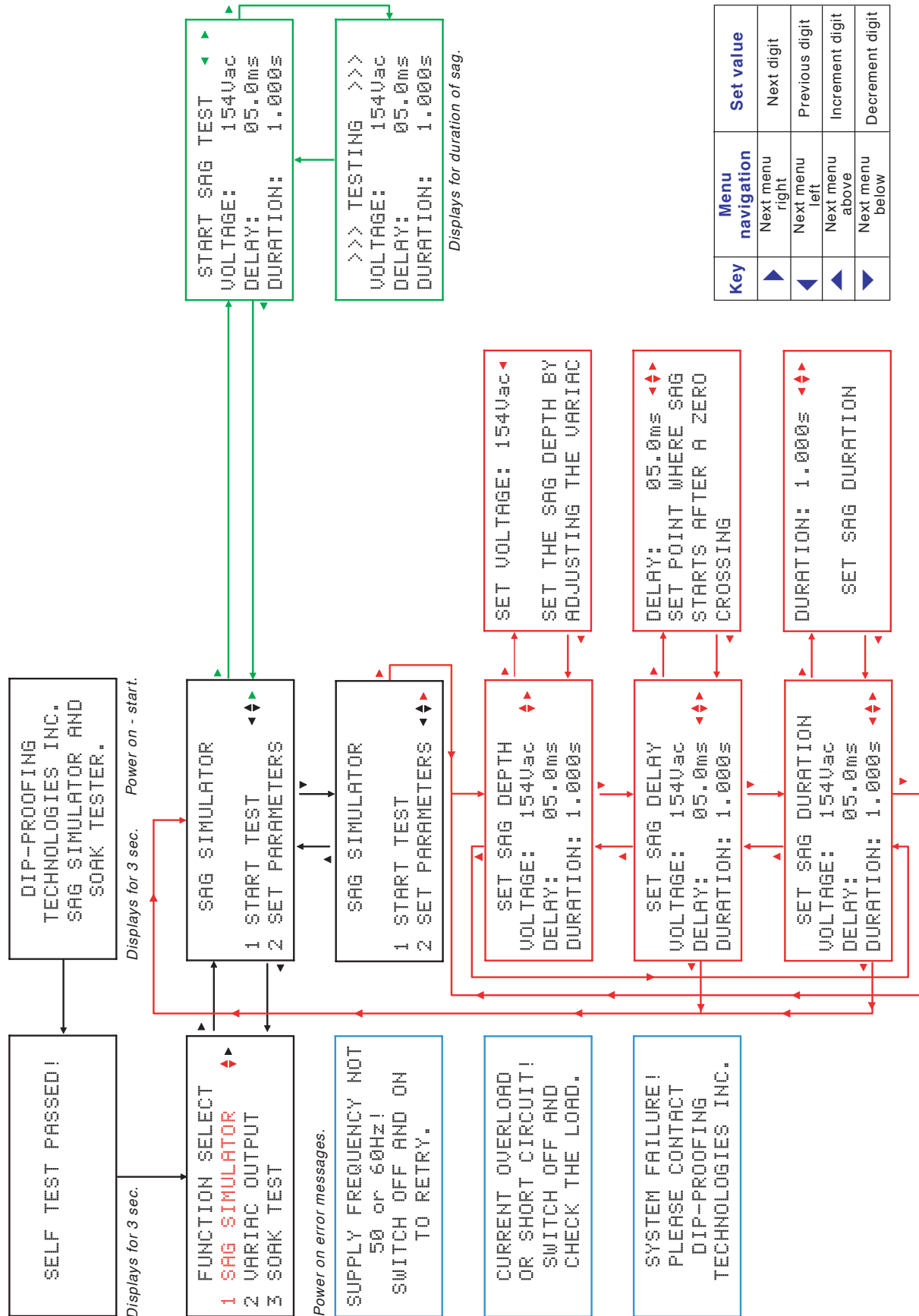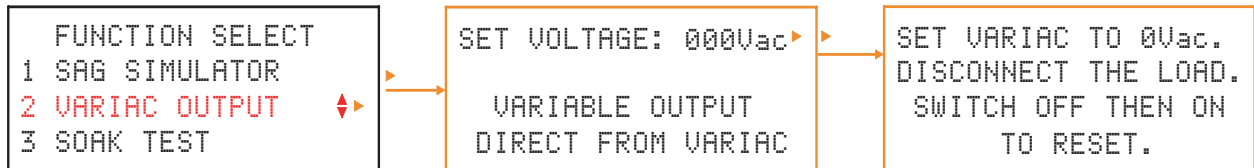*Programming key function table & Sag Simulator menu flowchart.*

Variac Output

1. *Output direct from variac:* At times it is convenient to have a variable AC supply available. The Sag Simulator can be programed to connect the variac output to terminal 3. In this mode the output voltage is set by the variac and is available continuously; the set value is indicated on the display. The output is overload and short circuit protected. To enable direct variac output navigate to the Function Select Menu. Select Variac Output and press the ▶ key. The display will show:

```
  FUNCTION SELECT          SET VOLTAGE: 000Vac▶  ▶     SET VARIAC TO 0Vac.
1 SAG SIMULATOR                                        DISCONNECT THE LOAD.
2 VARIAC OUTPUT    ▲▼▶        VARIABLE OUTPUT          SWITCH OFF THEN ON
3 SOAK TEST                  DIRECT FROM VARIAC              TO RESET.
```
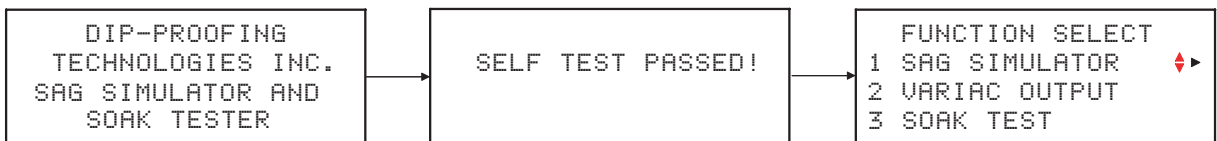
2. To exit Variac Output mode first set the variac output to zero and disconnect the load. Then switch the Sag Simulator off and then on to reset to normal operation.
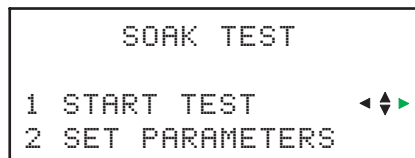
Soak Test

Follow the steps outlined below to set up and operate the Soak Tester. Refer to Fig 4 on page 11 for information on menu layout and programming key functions.

1. Connect the supply, Voltage Dip-Proofing Inverter or Voltage Dip Compensator, Bypass Switch and load to the Sag Simulator as shown in Fig 8 page 15.

2. Set the variac to zero output and the Bypass Switch to *Inverter in circuit* .

3. Switch on the power to the Sag Simulator; the display will show:

```
   DIP-PROOFING                                       FUNCTION SELECT
  TECHNOLOGIES INC.        SELF TEST PASSED!        1 SAG SIMULATOR    ▲▼▶
 SAG SIMULATOR AND                                  2 VARIAC OUTPUT
   SOAK TESTER                                       3 SOAK TEST
```
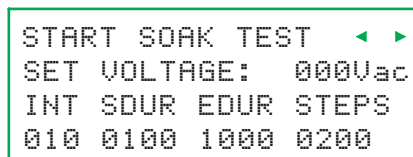
Note: If an error message is displayed and the Simulator shuts down please refer to *Error conditions* at the end of this section on page 10.

4. Press the ▼ key twice to select Soak Test then Press the ▶ key to reach the Soak Test menu; the display will show:

```
           SOAK  TEST

1 START TEST        ◀▲▼▶
2 SET PARAMETERS
```

5. Press the ▶ key to reach the *Start Test* display; the display will show:

```
START SOAK TEST   ◀  ▶
SET VOLTAGE:    000Vac
INT SDUR EDUR STEPS
010 0100 1000 0200
```

6.　　The Sag Depth may be adjusted using the Variac prior to performing the test. The value is shown on the Voltage readout. Stored values are used for :

　6.1　INT - Interval between consecutive dips - initial default = 10 seconds

　6.2　SDUR - Duration of the first test dip - initial default = 100ms

　6.3　EDUR - Duration of the last test dip - initial default = 1000ms

　6.4　STEPS - Number of steps between first dip & last dip - initial default = 200

　6.4.1　Each step consist of a series of 20 dips. The first dip starts at zero crossing, the next dip is delayed by the period of the supply frequency divided by 20. Subsequent dips sweep through a complete cycle with increasing delays after zero crossing.

　6.5　Note that the values shown above are factory settings for "first use". When parameters are set up for a test the new values are stored and will become the default values for the next test.

7.　　Press the ▶ key to Start Test or press the ◀ key to return to the Soak Test menu.

8.　　To set the Soak Test Parameters to values different to the defaults navigate to the Soak Test menu, press the ▼ key to select Set Parameters then press the ▶ key to reach the adjustment menus. Five parameters may be adjusted as follows :-

　8.1　Set *Dip Interval*: At the Set Dip Interval menu press the ▶ key to program the Dip Interval value. Use the ▶ and ◀ keys to select the digit to adjust. The active digit will flash. Use the ▲ ▼ keys to increment or decrement the digit to the desired value.

　8.2　Set *Start Dip Length (t Start)* : At the Set Dip Interval menu press the ▼ key to select the *Start Dip Length* menu. Press the ▶ key to program the Start Dip length value. Use the ▶ and ◀ keys to select the digit to adjust. The active digit will flash. Use the ▲ ▼ keys to increment or decrement the digit to the desired value.

　8.3　Set *End Dip Length (t End)*: From the Set Start Dip Length menu press ▼ key to select the *Set End Dip Length* menu. Press the ▶ key to program the End Dip Length value. Use the ▶ and ◀ keys to select the digit to adjust. The active digit will flash. Use the ▲ ▼ keys to increment or decrement the digit to the desired value.

　8.4　Set *Number of Steps*: From the Set End Dip Length menu press ▼ key to select the *Set Number of Steps* menu. Press the ▶ key to program the Number of Steps value. Use the ▶ and ◀ keys to select the digit to adjust. The active digit will flash. Use the ▲ ▼ keys to increment or decrement the digit to the desired value.

　8.5　Set *Sag Depth*: The Set Sag Depth is set from the Start Soak Test Menu. Set Voltage will flash and the current sag level voltage will be displayed. Adjust the variac to the desired Sag Depth value. The value may be adjusted at any time during testing.

9. *Start Test*: When the parameters have been set navigate back to the Soak Test menu by pressing the ◀ key. Press the ▶ key to reach the Start Soak Test menu. Set Voltage will flash; use the variac to adjust the Sag Depth voltage (see 8.5 above). Start the Soak Test by pressing the ▶ key. The display will show:

```
>>>SOAK TESTING >>>▶
VOLTAGE:       000Vac
TIME TO END: 000h00m
DIP 00000 OF 00000
```

10. Stop or interrupt the test by pressing the ▶ key. The display will show:

```
SOAK TEST STOPPED!  ▶
  SET UP NEW TEST?
OR TESTING WILL
RESUME IN 30 SECONDS.
```

Press the ▶ key to stop the test and return to the Soak Test Menu. If no action is taken testing will resume in 30 seconds.

11. When the test is complete the total number of dips are displayed.

```
SOAK TEST COMPLETE!▶

TOTAL NUMBER OF DIPS
       0000
```

Press the ▶ key to return to the Soak Test Menu.

Start up error conditions

1. *Error conditions:* The simulator will perform a power on test to check the supply frequency and the load current. If the supply frequency is not 50 or 60Hz or if there is an overload then one of the error messages below will be displayed:

```
SUPPLY FREQUENCY NOT
    50 or 60Hz!
 SWITCH OFF AND ON
    TO RETRY.
```
or
```
CURRENT OVERLOAD
OR SHORT CIRCUIT!
 SWITCH OFF AND
 CHECK THE LOAD.
```

When an error condition is detected the simulator will shut down automatically and the error message will remain on the display. Check the test setup for the source of the problem. To reset the simulator switch the power off and then back on again.
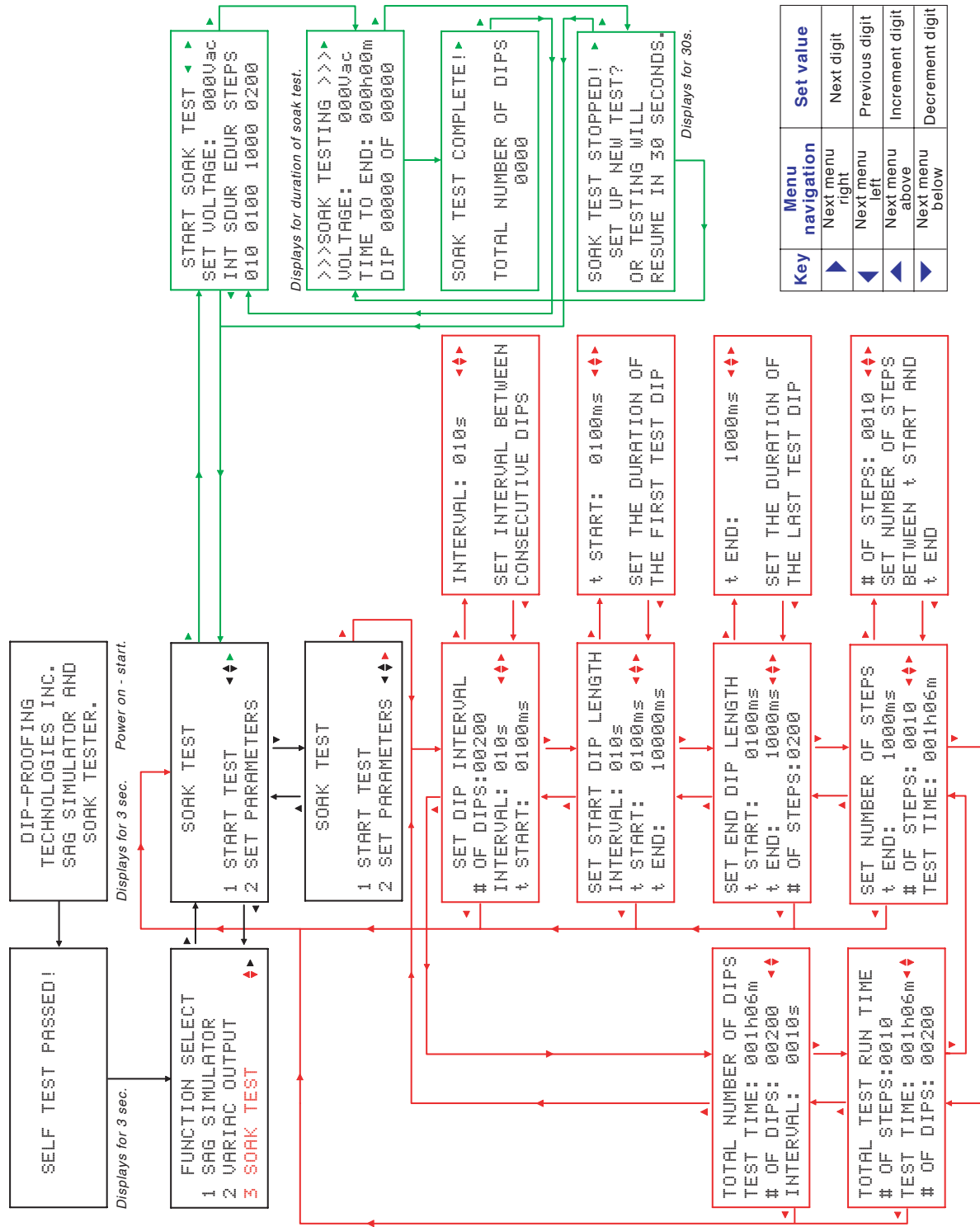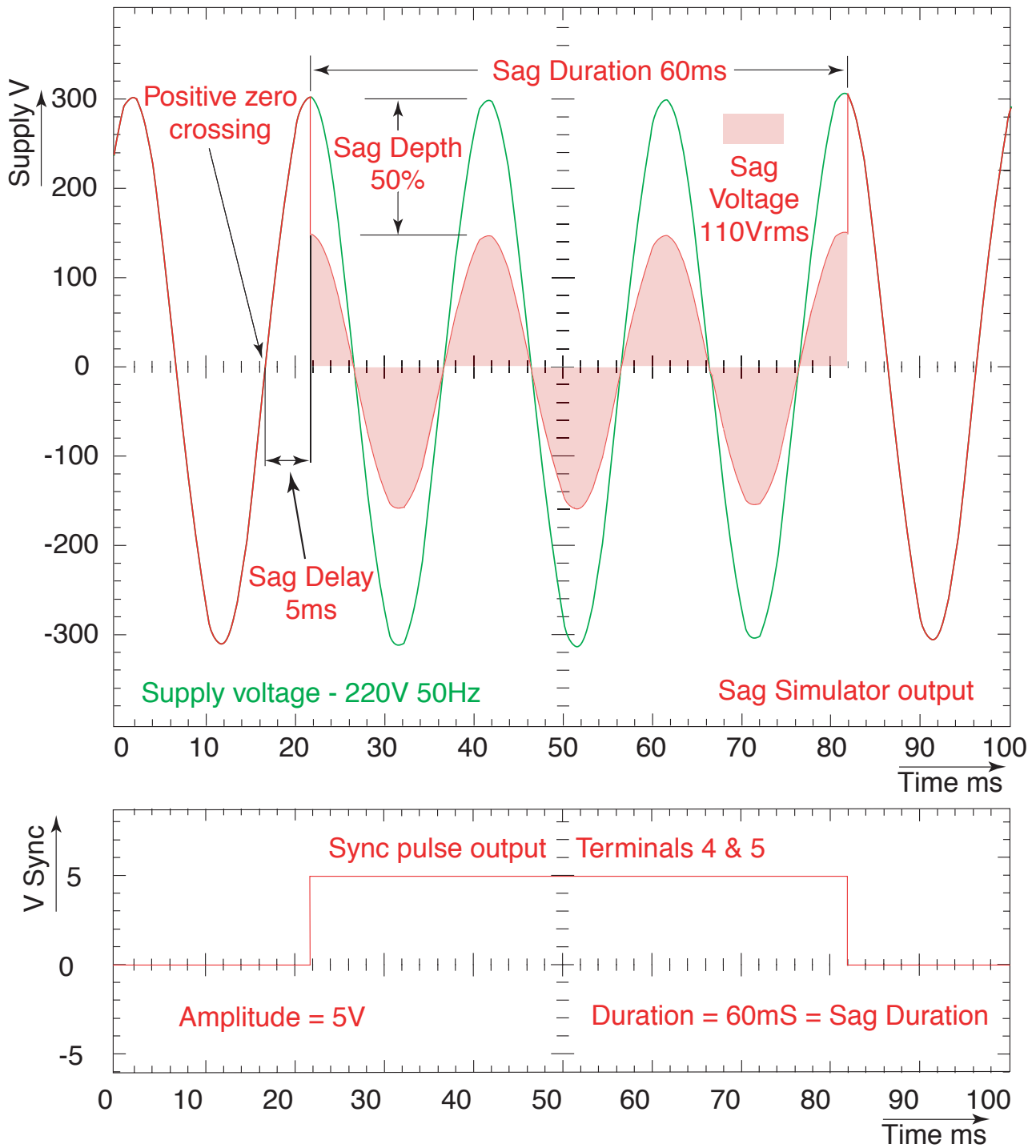
Fig 4

Programming key function table & Soak Tester flowchart.

Key	Menu navigation	Set value
▲	Next menu right	Next digit
▼	Next menu left	Previous digit
◀	Next menu above	Increment digit
▶	Next menu below	Decrement digit

DIP-PROOFING TECHNOLOGIES INC. SAG SIMULATOR AND SOAK TESTER.
Power on - start.

SELF TEST PASSED!
Displays for 3 sec.

FUNCTION SELECT
1 SAG SIMULATOR
2 VARIAC OUTPUT
3 SOAK TEST

SOAK TEST
1 START TEST
2 SET PARAMETERS
Displays for 3 sec.

SOAK TEST
1 START TEST
2 SET PARAMETERS

START SOAK TEST
SET VOLTAGE: 000Vac
INT SOUR EDUR STEPS
010 0100 1000 0200

>>>SOAK TESTING >>>
VOLTAGE: 000Vac
TIME TO END: 000h00m
DIP 00000 OF 00000
Displays for duration of soak test.

SOAK TEST COMPLETE!
TOTAL NUMBER OF DIPS
0000

SOAK TEST STOPPED!
SET UP NEW TEST?
OR TESTING WILL
RESUME IN 30 SECONDS.
Displays for 30s.

SET DIP INTERVAL
OF DIPS:00200
INTERVAL: 010s
↑ START: 0100ms

INTERVAL: 010s
SET INTERVAL BETWEEN
CONSECUTIVE DIPS

SET START DIP LENGTH
INTERVAL: 010s
↑ START: 0100ms
↑ END: 10000ms

↑ START: 0100ms
SET THE DURATION OF
THE FIRST TEST DIP

SET END DIP LENGTH
↑ START: 0100ms
↑ END: 1000ms
OF STEPS:0200

↑ END: 1000ms
SET THE DURATION OF
THE LAST TEST DIP

SET NUMBER OF STEPS
↑ END: 1000ms
OF STEPS: 0010
TEST TIME: 001h06m

OF STEPS: 0010
SET NUMBER OF STEPS
BETWEEN ↑ START AND
↑ END

TOTAL NUMBER OF DIPS
TEST TIME: 001h06m
OF DIPS: 00200
INTERVAL: 0010s

TOTAL TEST RUN TIME
OF STEPS:0010
TEST TIME: 001h06m
OF DIPS: 00200

Simulated Sag Profile

Positive zero crossing

Sag Duration 60ms

Sag Depth 50%

Sag Voltage 110Vrms

Sag Delay 5ms

Supply voltage - 220V 50Hz

Sag Simulator output

Supply V: 300, 200, 100, 0, -100, -200, -300

Time ms: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Sync pulse output   Terminals 4 & 5

V Sync: 5, 0, -5

Amplitude = 5V

Duration = 60mS = Sag Duration

Time ms: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Fig 5
Profile of simulated sag output & sync pulse from simulator.

Sag Simulator Specifications

AC INPUT SUPPLY

Supply voltage:	120/208/240Vac 50/60Hz
Maximum input voltage:	+10%
Full load current:	20A

VARIAC CONTROL

Variac range:	0-240Vac RMS
Maximum power:	1200VA @ 120V / 2400VA @ 240V
Maximum continuous current:	10A
Maximum short term current for 3 seconds:	20A
Overload & short circuit protection:	Yes

DIRECT VARIAC OUTPUT

Variac range:	0-240Vac RMS
Maximum power:	1200VA @ 120V / 2400VA @ 240V
Maximum continuous current:	10A
Overload & short circuit protection:	Yes

SAG DELAY TIMER

Range:	0.00 to 20.00 ms
Setting:	0.01 ms steps

SAG DURATION TIMER

Range:	0.010 to 9.999 seconds
Setting:	0.001 second steps

CONTROLS & INDICATORS

Programming:	Four push switches
Menu/parameter indication:	4 x 20 LCD display

SYNC PULSE OUTPUT

Amplitude:	5V
Polarity:	Positive
Electrically isolated output:	Yes
Duration:	Equal to sag duration

TEMPERATURE

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

HOUSING

Construction:	Extruded aluminium
Height:	390mm (15.35in)
Width:	311mm (12.24in)
Depth:	162mm (6.38in)
Mass:	
15kg (33lb)	

Sag Simulator block diagram
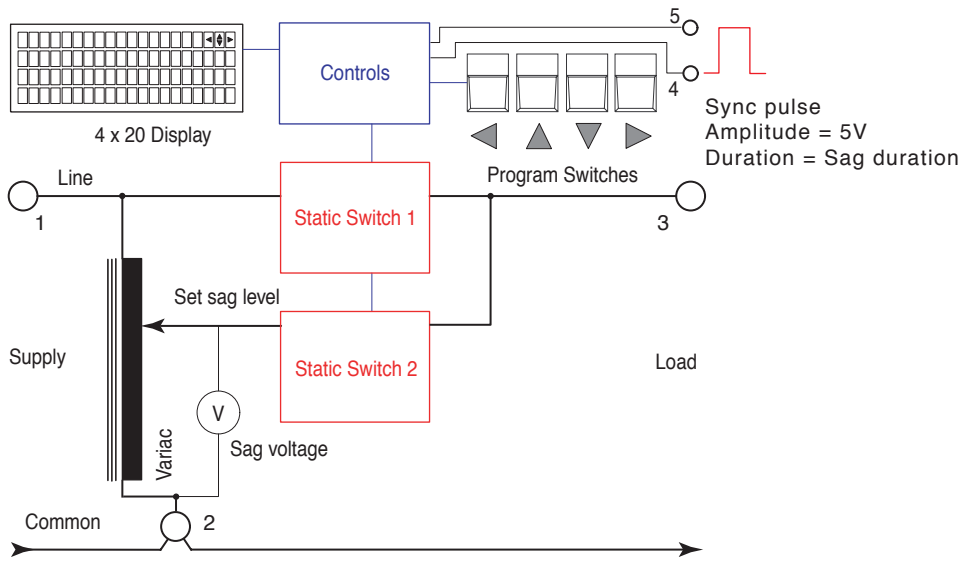
Fig 6
Sag Simulator block diagram

Controls & indicators
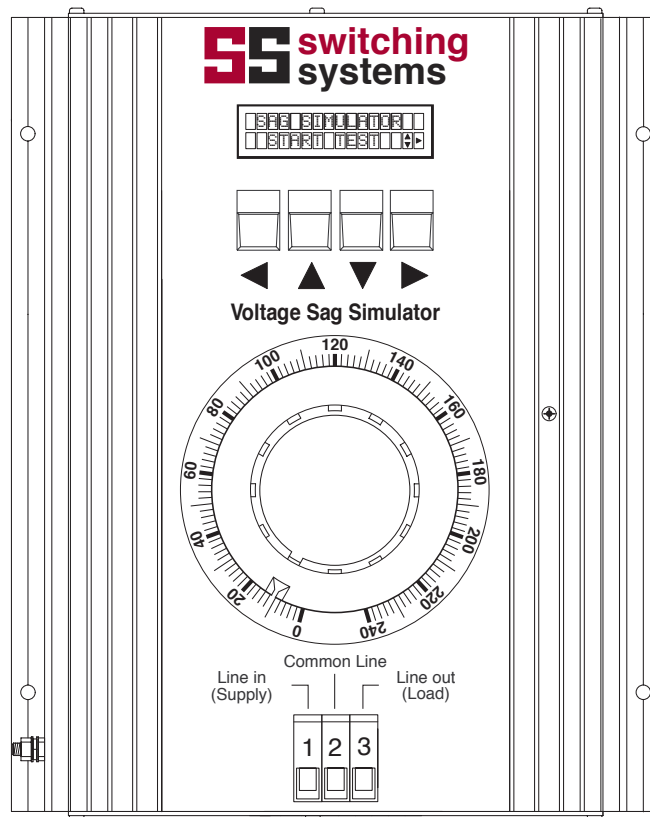
Fig 7
Controls & indicators
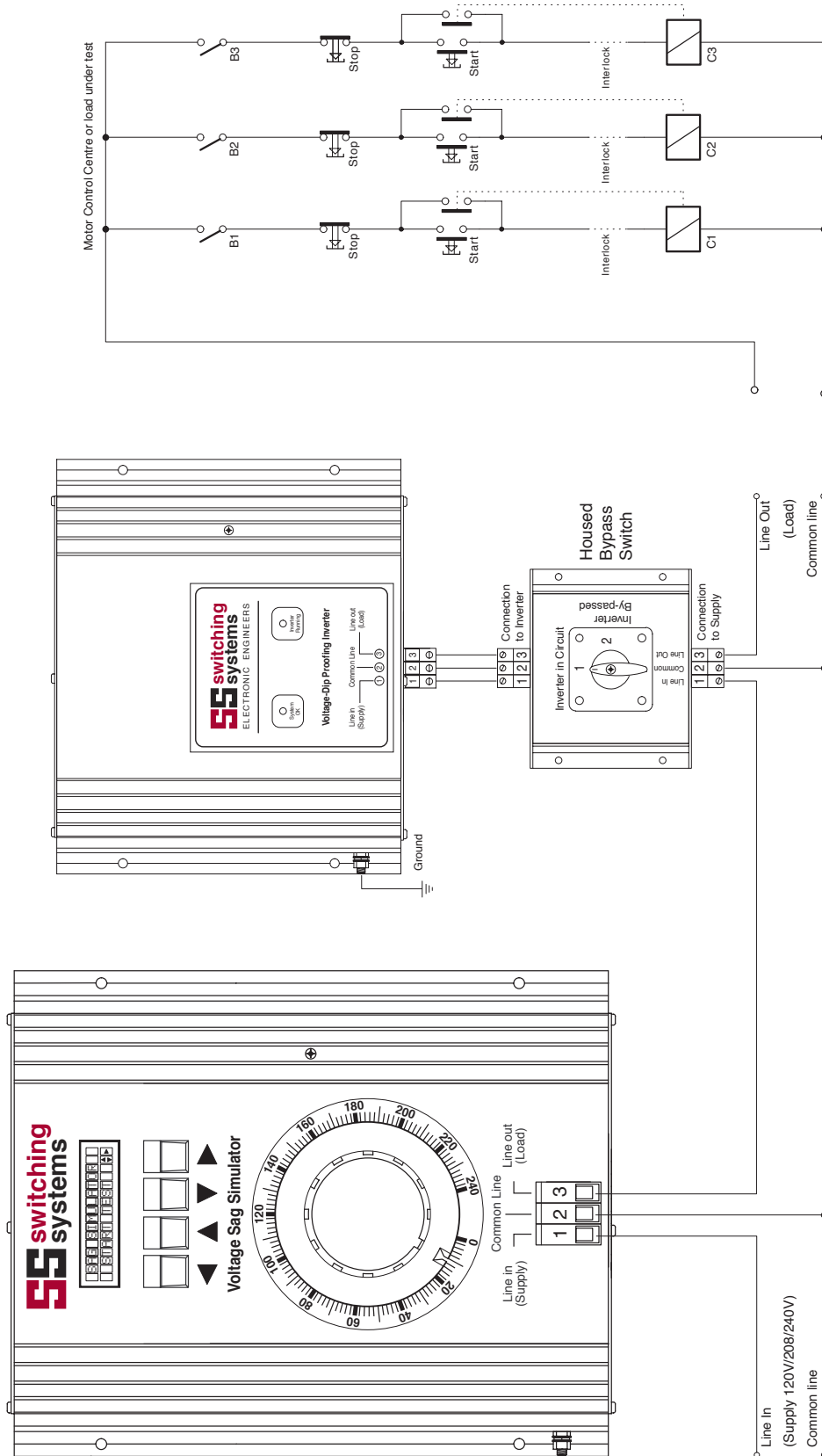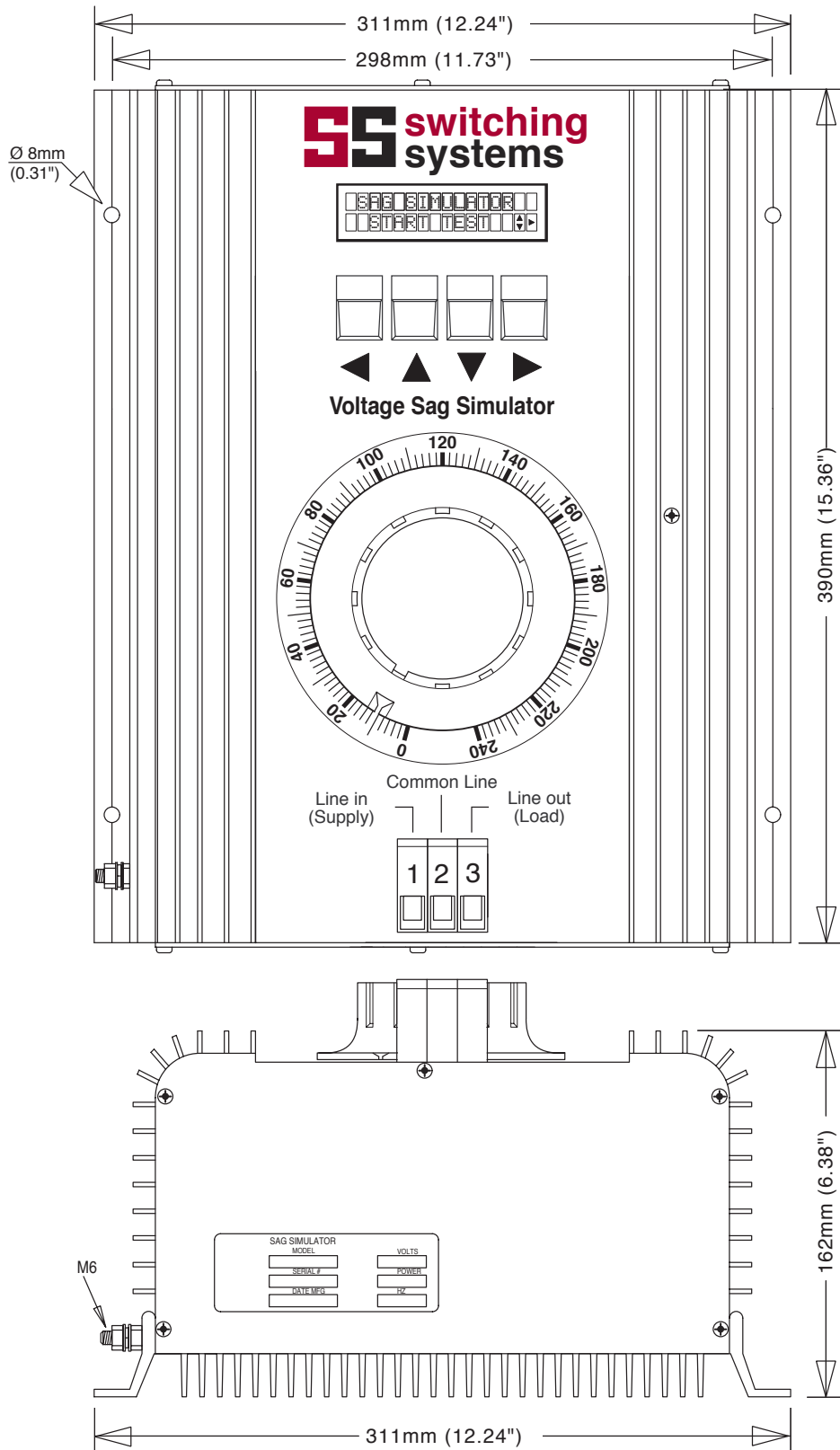
Typical test setup

Fig 8
Sag Simulator connection diagram.

Mechanical Outline

Fig 9
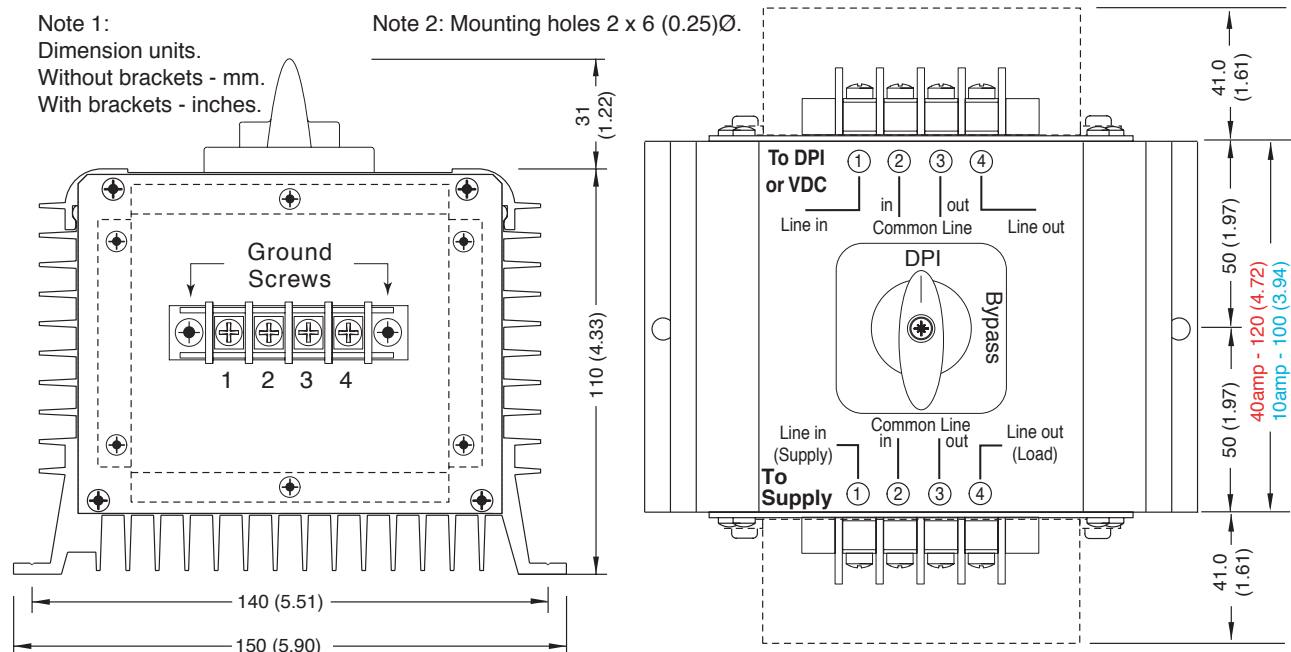*Dimensions of the Sag Simulator (in mm/inches)*

Housed Bypass Switches
Description

Where no-break maintenance is required a by pass 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

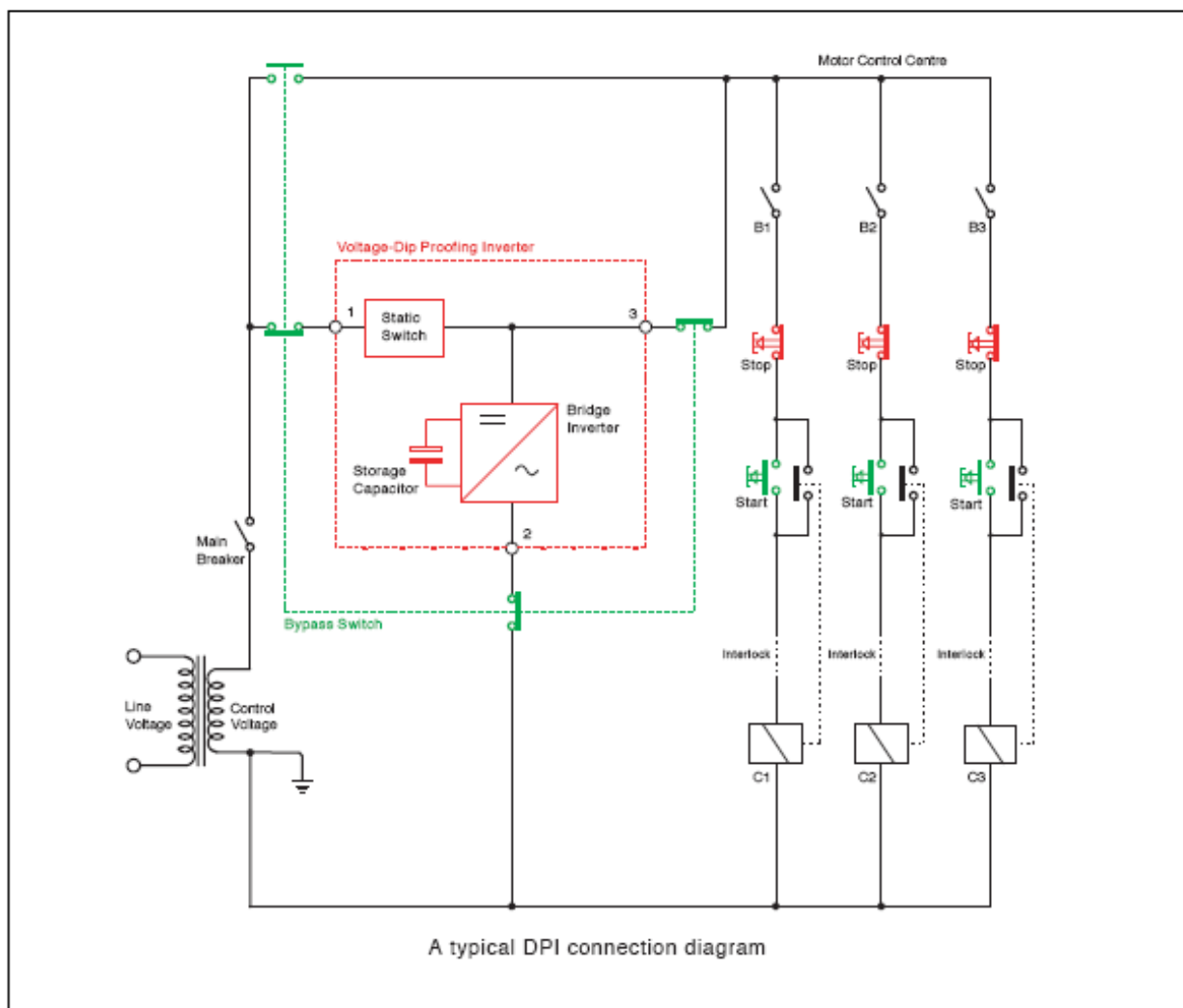| MODEL	BPSW10A	BPSW40A
ELECTRICAL		
Maximum current:	10A	40A
Maximum input voltage:	500Vac	500Vac
TEMPERATURE		
Maximum working temperature:	45°C (113°F)	45°C (113°F)
HOUSING		
Construction:	Extruded Aluminum	
Height:	182mm (7.17in)	202mm (7.95in)
Width:	150mm (5.9in)	150mm (5.9in)
Depth:	141mm (5.55in)	141mm (5.55in)
Mass:	0.72kg (1.58lbs)	1kg (2.2lbs)

Mechanical outline

Ordering

Stock No:	Description
5003-005	Housed By-Pass Switch 10Amp
5003-007	Housed By-Pass Switch 40Amp

User Manual

Voltage Sag Simulator

For use with all DPI's & VDC's
120/208/240V 50/60Hz

A typical DPI connection diagram

IGS Engineering Company

Smart Engineering solutions…

Email : info@igs.com.sa, gert@igs.com.sa,
O: 00966 346 2121, M: 00966 55 614 0055