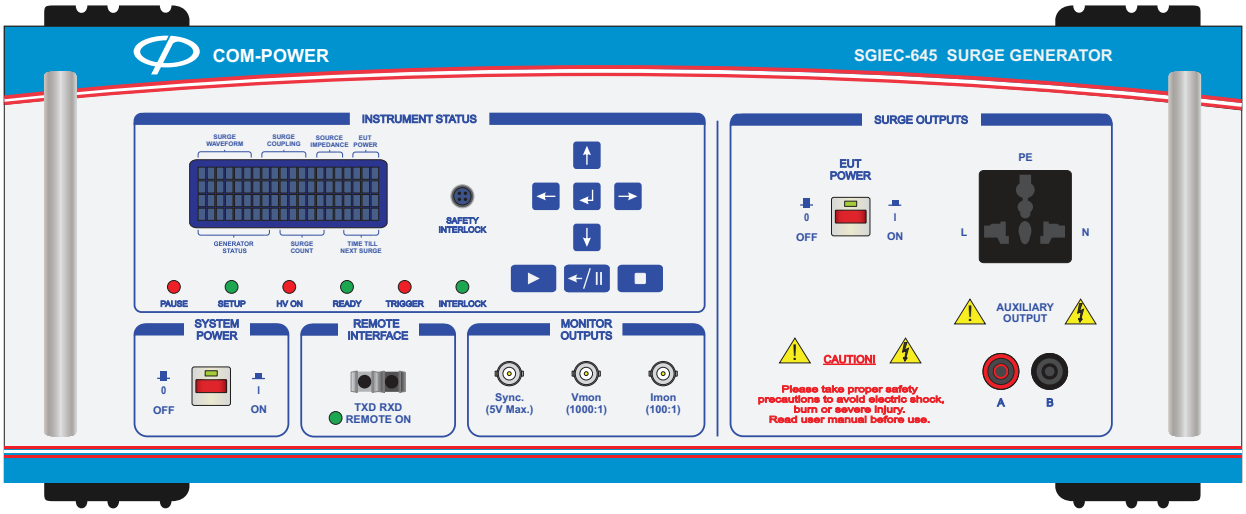
INSTRUCTION MANUAL
for

COMBINATION WAVE SURGE GENERATOR

Model: **SGIEC-645**



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1.0 Introduction

This manual includes descriptions of front and rear panel ports, controls and indicators; product specifications, safety precautions, operational instructions and warranty information and guidelines and instructions for its proper usage.

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2.0 Products Available from Com-Power

Antennas

Antenna Kits

Absorbing Clamps

Coupling/Decoupling Networks (CDN)

Comb Generators

Current Probes

Emissions Test Systems

Conducted Immunity Test Systems

Impedance Stabilization Networks (ISN)

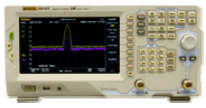
Line Impedance Stabilization Networks (LISN)

Antenna Masts

Near-Field Probe Sets

Preamplifiers

Power Amplifiers



Spectrum Analyzers

Product Safety Test Equipment

Transient Limiters

Turntables

Antenna Tripods

Telecom Test Systems

www.com-power.com

3.0 Product Information

3.1 Incoming Inspection

WARNING – To avoid possibility of electrical shock, do not apply power to the Com-Power SGIEC-645 if there is any evidence of shipping damage. If shipping damage to the product or any of the accessories is suspected, or if the package contents are not complete, contact Com-Power or your Com-Power distributor.

Please check the contents of the shipment against the package inventory in section 3.2 to ensure that you have received all applicable items.

3.2 Package Inventory

STANDARD ITEMS:

- ✓ **SGIEC-645 Combination Wave Surge Generator**
- ✓ **Safety Interlock Port Key** (4-pin, 7mm, Push-Pull plug)
- ✓ **4-pin, 7mm, Push-Pull Plug Connector**
  (for optional connection of remote switch for safety interlock)
- ✓ **IEC Power Cord (NEMA 5-15R-male to IEC C13-female)**
  (for SGIEC-645 system power input)
- ✓ **ABB 216C6 16A IP44 Connector**
  (for SGIEC-645 connection to supply for EUT power)
- ✓ **Calibration Certificate and Data**

OPTIONAL ITEMS:

- ✓ **OTA-232 Optical Transreceiver Adapter**
  - ✓ Fiber Optic Cable (Duplex Latching POF Connector at each end)
  - ✓ USB Cable (USB Type A to USB Type B)
- ✓ ***TransWare-645™* PC Software on CD**
  (for remote operation of generator via fiber optic interface)

3.3 Product Safety Information

3.3.1 Product Hazard Symbols Definitions

The hazard symbols appearing on the product exterior are defined below.

The yellow triangle with an exclamation mark indicates the presence of important operating and/or maintenance (servicing) instructions in the literature accompanying the product.

The yellow triangle with a lightning bolt indicates an alert to the user that uninsulated ***dangerous voltages*** are present within the product enclosure and on output connectors. These voltages may be of sufficient magnitude to constitute a risk of electric shock to persons.

3.3.2 Product Warning/Caution Statements

WARNING: TO PREVENT ELECTRIC SHOCK, DO NOT OPEN COVER. SERVICING ONLY BY QUALIFIED PERSONNEL. NO USER SERVICEABLE PARTS INSIDE

CAUTION: FOR CONTINUED PROTECTION AGAINST RISK OF FIRE, REPLACE ONLY WITH THE SAME TYPE AND RATING OF FUSE.

3.3.3 General Safety Instructions

The following safety instructions have been included in compliance with safety standard regulations. Please read them carefully.

- **READ AND RETAIN INSTRUCTIONS** - Read all safety and operating instructions before operating the instrument. Retain all instructions for future reference.
- **HEED WARNINGS** - Adhere to all warnings on the instrument and operating instructions.
- **FOLLOW INSTRUCTIONS** - Follow all operating and use instructions.
- **WATER AND MOISTURE** - Do not use the instrument near water.
- **WALL OR CEILING MOUNTING** - Do not mount the instrument on a wall or ceiling.
- **VENTILATION** - The instrument should be situated so that its location or position does not interfere with its proper ventilation. Do not install in a cabinet or in other situations that may impede the flow of air through the ventilation openings.
- **HEAT** - The instrument should be situated away from heat sources such as heat registers or other instruments which produce heat.
- **POWER SOURCES** - Connect the instrument only to the type of power source described in the operating instructions or as marked on the instrument.
- **GROUNDING AND POLARIZATION** - Take precautions to insure that the grounding of the instrument is not defeated. Operate only with a grounded power cord.
- **POWER CORD PROTECTION** - Place power supply cords so that they are not likely to be walked on or pinched by items placed on them or against them.
- **CLEANING** – Clean the instrument only as recommended by the manufacturer.
- **NON-USE PERIODS** - Unplug the power cords of the instrument when it will be left unused for a long period of time.
- **OBJECT AND LIQUID ENTRY** - Take care that objects do not fall and that liquids are not spilled into the enclosure through openings.
- **DEFECTS AND ABNORMAL STRESS** - Whenever it is likely that the normal operation has been impaired, make the equipment inoperable and secure it against further operation.
- **DAMAGE REQUIRING SERVICE** - Instrument should be serviced by qualified personnel when:
  - ✓ The power supply cord or the plug has been damaged.
  - ✓ Objects have fallen or liquid has been spilled into the instrument.
  - ✓ The instrument has been exposed to rain.
  - ✓ The instrument does not appear to operate normally.
  - ✓ The instrument has been dropped, or the enclosure has been damaged.
- **SITTING OR CLIMBING** - Do not sit or climb upon the instrument or use it as a step or ladder.

3.3.4 Safety Guidelines During Surge Testing

- Do not work alone.
- Do not use the equipment in conditions other than reasonable laboratory conditions. There should be no condensing humidity or water standing on the floor or work surfaces; there should not be significant dust or other contamination.
- Ensure that no one is touching the equipment under test (EUT) during the test or immediately after the test until AC power to the EUT has been turned off.
- Ensure that there is a barrier to act as protection in case the equipment under test explodes. The barrier should be interlocked to prevent surging and to disconnect all AC if the barrier is removed.
- The equipment under test must be surrounded by sufficient insulating material to withstand twice the surge voltage. Consider distance to the floor or table and walls if air is the insulating material.
- Ensure that the proper supply mains voltages are applied to both Com-Power equipment and to the equipment under test, and that the AC branch circuit is capable of supplying the current.
- The ground (protective earth), neutral and phase lines of the AC supply to the equipment under test (EUT) and Com-Power equipment must be connected properly. Do not defeat the protective earth connection.
- When surging a powered EUT, the mains supply to the equipment under test must be capable of handling the potential AC fault current (e.g. do not use a UPS to power the EUT).
- Never surge an AC mains line other than through the EUT output connector or compatible Com-Power single-phase or three-phase coupler.
- Use only equipment which is designed to be safe for the test being performed.
- Do not test in a potentially explosive atmosphere (e.g. where there are gas fumes).
- Never use equipment that is operating in a strange manner, or that shows clear indication of abuse.
- If probes are in use, be sure they are differential probes which have no ground connection to the surged ground or to the equipment under test.

3.3.5 Safety Concerns During Surge Testing

Surge testing is hazardous. The equipment under test (EUT) can ignite, possibly explosively. Noxious, toxic and sometimes fatal fumes can be generated by the burning equipment. Accumulated gases may ignite explosively (i.e., flashover).

In an environment where surge testing takes place, it is absolutely crucial that these minimum safety precautions be taken:

- Surge testing should be performed only by properly trained test personnel who are experienced in conducting such tests, or be observed and supervised by such experienced personnel. No person subject to heart or neurological conditions should be allowed to conduct surge tests. Persons with pacemakers should not be allowed in or near the area where testing is conducted.
- Never leave a procedure or a test setup unattended.
- All personnel working in the area must be shielded with appropriate eye protection, body protection and electrical protection. They should not be allowed to work in a direct line of a possible explosion of the equipment under test.
- The test area should be a clear and unobstructed environment dedicated to such tests.
- The test area should be equipped with ventilating hoods and blowers to remove gases hat may be caused by exploding or burning components.
- The test area should have nonflammable walls and floors plus shielding to contain exploding parts and flames.
- There must be fire extinguishers certified for use in electrical and chemical fires readily available at the test site. DO NOT USE WATER TO EXTINGUISH AN ELECTRICAL FIRE.
- All flammable materials and debris must be outside the test area, and the area must be well marked, preferably by physical barriers, to prevent accidental intervention by non-test personnel while a test is in progress.

3.4 Product Features

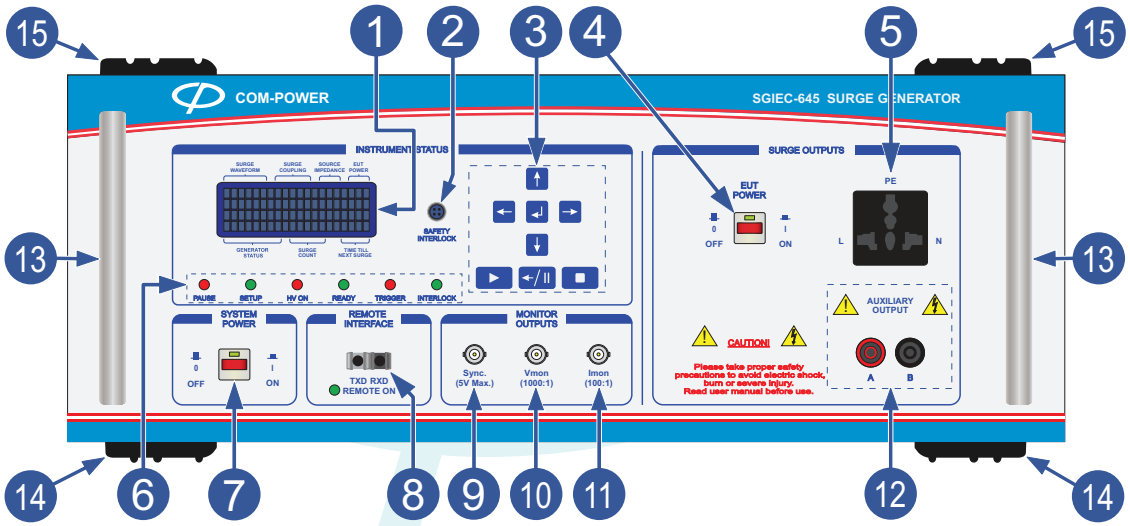


FIGURE 1 - *Product Features – Front Panel*

1. **LCD Display**
   Used in conjunction with control keypad to operate surge generator from the front panel.
2. **Safety Interlock Port**
   This is a safety interlock port. Refer to section 4.2.1 for details.
3. **Control Keypad**
   For locally controlling the generator. Refer to section 6.4.1 for details.
4. **EUT Power Switch**
   This switch, in conjunction with the *TransWare-645*™ EUT power enable function (when controlled remotely), is/are used to disable/enable EUT power at the front panel EUT power receptacle.
5. **Internal CDN Surge Output Port - EUT Power Receptacle**
   This is the EUT port of the internal coupling/decoupling network (CDN). Power line surges, as well as EUT input power are provided through this port.
6. **Instrument Status LED Indicators**
   These six LED indicators provide the present instrument status for the SGIEC-645.
7. **System Power Switch**
   This switch toggles ON/OFF the SGIEC-645 surge generator, when the system power input switch on the rear panel is in the ON position.
8. **Fiber Optic Connector for Remote Interface**
   The SGIEC-645 can be remotely controlled by a computer using Com-Power's *TransWare-645*™ software, via this port. Refer to section 4.2.2 for details.
9. **Sync Monitor Output Port**
   The sync output port connects to the external trigger input of an oscilloscope.
10. **Voltage Monitor Output Port**
    Connects to a high impedance oscilloscope input for verification of surge voltage level.

11 **Current Monitor Output Port**
Connects to a high impedance oscilloscope input for verification of surge current level.

12 **Auxiliary (A/B) Surge Generator Output Port Terminals**
These are the primary generator output terminals. Waveform calibration of the generator output is performed at these terminals (see section 5.4). These terminals are also used for connection to external Coupling/Decoupling Networks (CDNs) for telecommunication lines, data lines, single-phase power lines > 16A and three-phase power lines.

13 **Front Panel Handles**
These handles are typically used for rack-mount installation; for sliding the generator in and out of the rack.

14 **Bottom-side Rubber Feet**
For rack-mount installation, these feet may be removed by removing the two screws (per foot) which attach the feet to the chassis. The screws can then be removed from each foot and screwed back into their respective holes to re-secure the bottom cover.

15 **Top-side Rubber Feet**
For rack-mount installation, these feet may be removed by removing the two screws (per foot) which attach the feet to the chassis. The screws can then be removed from each foot and screwed back into their respective holes to re-secure the top cover.

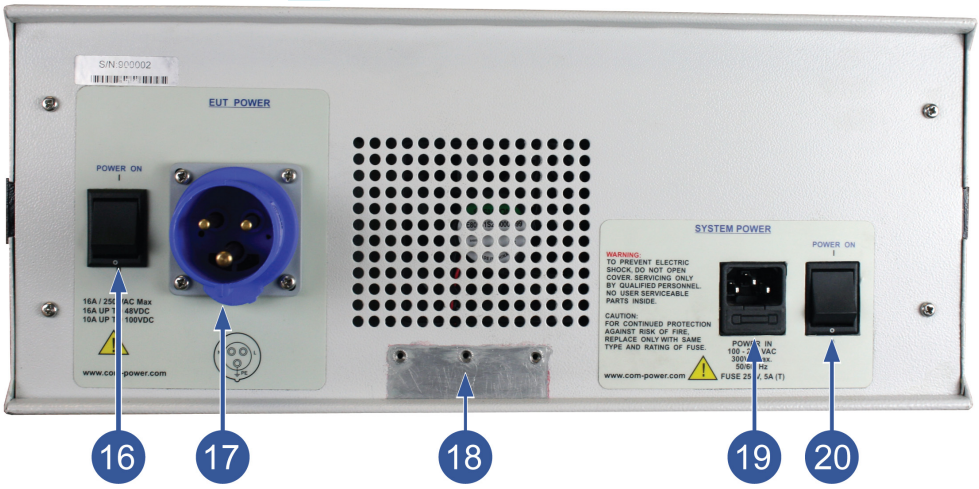


FIGURE 2 - *Product Features – Rear Panel*

16 **EUT Power Entry Switch**
Toggles ON/OFF EUT power at input port, where the EUT power source enters the generator.

17 **EUT Power Input Port**
This port connects to the EUT power source. See section 3.5 for input power specifications.

18 **Grounding Bracket Connection Point**
This is where the L-shaped grounding bracket connects to the chassis of the generator, using the supplied machine screws for attachment.

19 **SGIEC-645 System Power Input Port**
This port connects to the power source for the generator. See section 3.6 for input power specifications.

20 **SGIEC-645 System Power Switch**
This switch toggles ON/OFF the SGIEC-645 system input power. When this switch is in the ON position, the system may be turned on/off using the System Power Switch, located on the front panel 7.

3.5 Product Specifications

Surge Output Waveform Parameters

Surge Type (Source Impedance) @ Output Port	Open Circuit Voltage - V_{pk} (Volts)	Front Time - T_r (µs)	Duration - T_d (µs)	Short Circuit Current - I_{pk} (Amps)	Front Time - Tr (µs)	Duration - T_d (µs)
1.2/50 µs (2Ω) @ Generator Output	V_{set} ±10%	0.84-1.56	40-60	V_{set} / 2Ω ±10%	6.4-9.6	16-24
1.2/50 µs (2Ω) @ Internal CDN Output	V_{set} ±10%	0.84-1.56	40-60	V_{set} / 2Ω ±10%	6.4-9.6	16-24
1.2/50 µs (12Ω) @ Internal CDN Output	V_{set} ±10%	0.84-1.56	25-60	V_{set} / 12Ω ±10%	1.75-3.25	17.5-32.5
10/700 µs (40Ω) @ Generator Output	V_{set} ±10%	7-13	560-840	V_{set} / 40Ω ±10%	4-6	256-384

NOTE 1: Set Voltage (V_{set}) adjustable from 200-4000 Volts, in 1V increments

NOTE 2: Voltage Overshoot/Undershoot for 1.2/50 µs Waveform (2Ω) @ Generator Output <-30% of V_{set} (in Volts)
Current Overshoot/Undershoot for 1.2/50 µs Waveform (2Ω) @ Generator Output <-30% of V_{set} / 2 Ω (in Amps)

Surge Polarity	**Positive, Negative, Alternating**
Phase Synchronization (AC line)	**0-359°** ±10° (adjustable in 1° increments) *–or-* **Arbitrary (RND)**
Time Between Surges	**20-600 sec.** (1.2/50); **35-600 sec.** (10/700)

Monitor Ports

Voltage Monitoring Port (V_{mon})	**1000:1** ±10% *($V_{(actual)} = V_{(measured)} * 1000$)*
Current Monitoring Port (I_{mon})	**100:1** ±10% *($I = V_{(measured)} * 100$) [0.01 Volts/Amp]*
Sync Output Port	**0-5 V_{DC}**

Electrical

System Power Input	**100-250 $V_{AC\ (rms)}$, 50/60 Hz** *(300 VA Max.)*
Fuse Type	**5 Amps (T)**
EUT Power Input	**250 $V_{AC\ (rms)}$** *(maximum)*, **50/60 Hz** *(16A Max.)* **100 V_{DC}** *(maximum)* *16 Amps up to 48 V_{DC}, 10 Amps up to 100 V_{DC}*

Input/Output Connectors

EUT Power Input Port	**ABB 216B6 16A IP44 Socket Inlet** (mating connector provided)
SGIEC-645 System Power Input Port	**IEC C13 Receptacle**
EUT Power Output Port	**Universal Multi-Configuration AC Socket**
Safety Interlock Port	**4-pin, 7mm Receptacle** (mating push-pull plug provided)
Fiber Optic Port	**Avago Duplex Latching POF jack**
(A/B) Surge Output Ports	**(2) 4mm banana safety sockets**
Monitor Output Ports	**(3) BNC-type** (female)

Mechanical

Dimensions (H)x(W)x(D)	**(4U) 7.75" x 19" x 26.7"** *(19.7 x 48.3 x 67.7 cm)*
Weight	**53.5 lbs** *(24.3 kg)*

Environmental

Operating Temperature	**40°F to 104°F** *(5°C to 40°C)*
Cooling	**Forced Air** *(integral fan)*

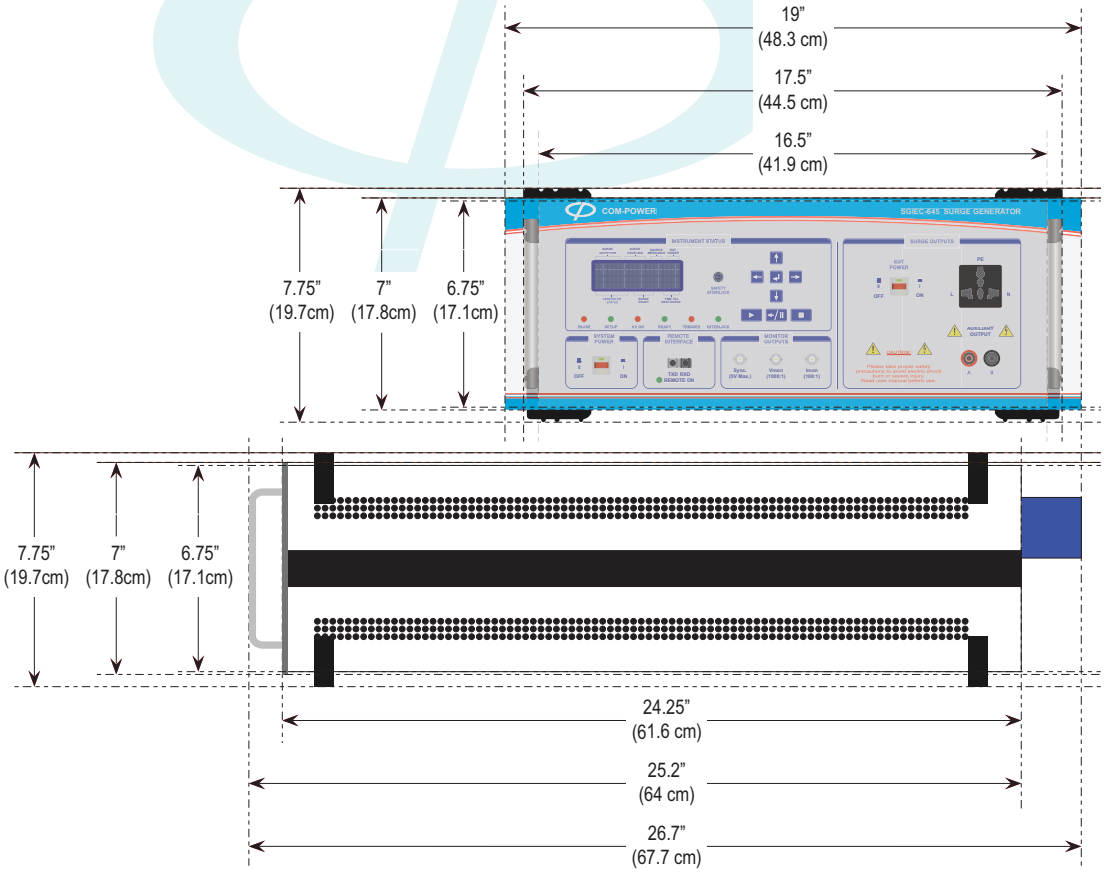


FIGURE 3 - *Product Dimensions*

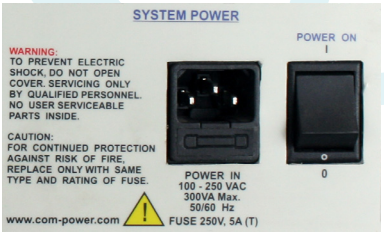
4.0 Setting up the SGIEC-645

In the following sections, guidance is provided pertaining to the external electrical connections/interconnections of the SGIEC-645 System and accessories. The guidance is given on a port-by-port basis.

4.1 Input Power Line Ports

WARNING - DO NOT EXCEED THE RELEVANT INPUT POWER SPECIFICATIONS DETAILED IN SECTION 3.5 AND ON THE REAR PANEL OF THE GENERATOR ITSELF.

4.1.1 SGIEC-645 System Power Input Port



The SGIEC-645 requires the following power source:

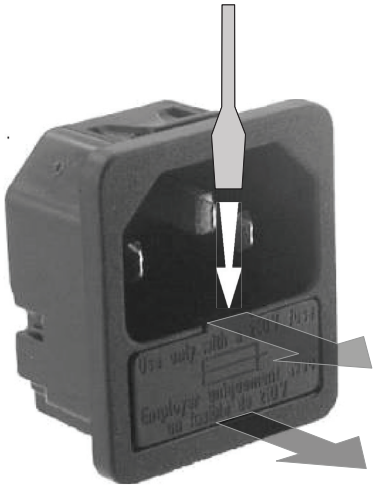
Voltage:	100-250 V_{AC}
Frequency:	50/60 Hz
Power:	300VA Maximum

In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate AC power outlet, this cable grounds the instrument frame.

WARNING: **For protection from electrical shock, the power cable ground must not be defeated.**

The power plug must be plugged into an outlet that provides a protective earth ground connection.

4.1.1.1 System Power Input Port Fuse



To access fuse, insert the end of a small flat-blade screwdriver into the slot as shown in Figure 4 to open the compartment.

Replace fuse only with same type and rating [250V, 5A (T)]. After replacing fuse, slide fuse holder firmly back into position within its cavity.

FIGURE 4 - ***Accessing the Input Power Fuse***

4.1.2 Equipment Under Test (EUT) Power Input Port

ONLY AFTER the SGIEC-645 is turned on, the power source which will power the Equipment Under Test (EUT) is to be connected to this input port through the provided, blue/gray/black AC power connector (wiring not included).

Illustrated in Figure 5 below are the instructions for the disassembly/assembly and wiring instructions for the connector.

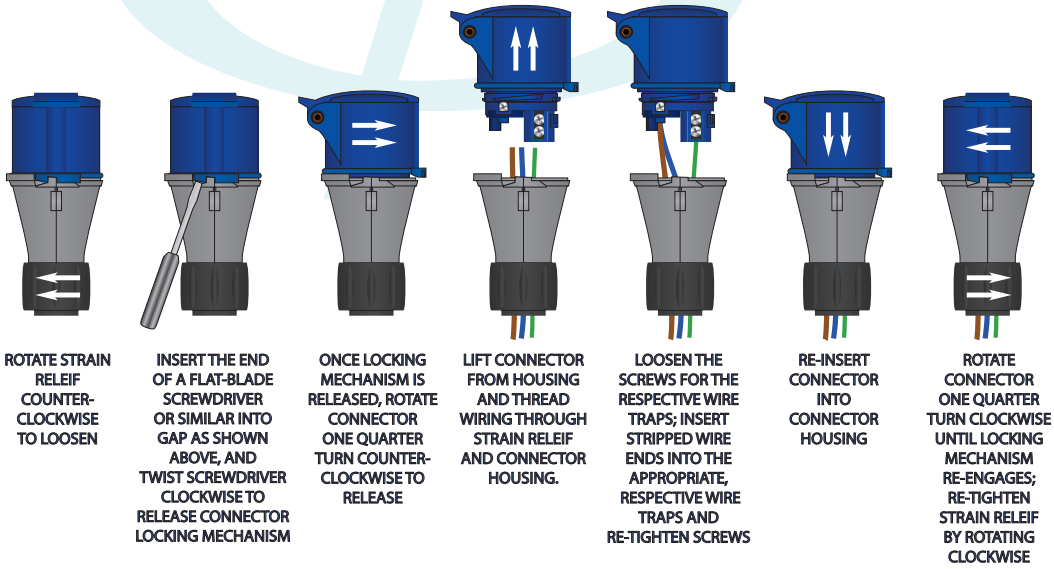


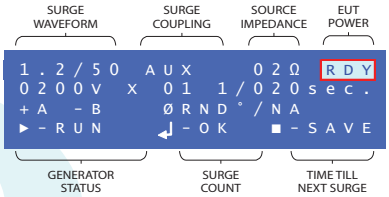
FIGURE 5 - *Wiring Procedure for EUT Power Input Plug*

The EUT power may be AC or DC. DO NOT EXCEED THE RATINGS FOR THIS PORT DETAILED IN SECTION 3.5 AND/OR THE RATINGS DISPLAYED ON THE SGIEC-645 GENERATOR.

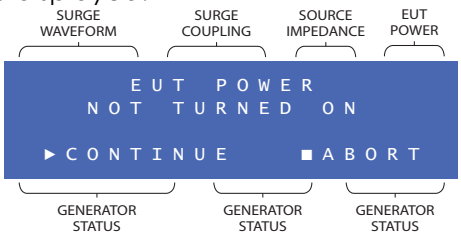
WARNING: **TO AVOID POSSIBLE DAMAGE TO YOUR SGIEC-645 SURGE GENERATOR, DISCONNECT POWER FROM EUT POWER INPUT PORT WHEN POWERING ON OR OFF THE GENERATOR.**

4.1.2.1 Turning ON/OFF EUT Power – LOCAL Control

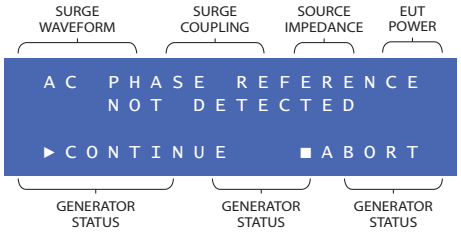
When the SGIEC-645 is NOT under software control, the EUT power state is controlled via the front and rear panel EUT POWER switches. If the EUT power input port is connected to an active source, power is available at the EUT POWER OUTPUT port when both the rear panel and front panel switches are turned on. The EUT power status is also displayed at the top right of the front panel display on the Surge Setup Menu.



For any test or test sequence which includes surges applied to the internal CDN output terminals, the SGIEC-645 surge generator will automatically check the front panel EUT power switch status prior to the start of the test. If the EUT power switch is not enabled on the SGIEC-645 front panel, the following message will be displayed:



For any test or test sequence which includes phase synchronization of the surge waveform with the AC sine wave, the generator will check for its AC phase reference. If no phase reference is detected, the following message will be displayed.

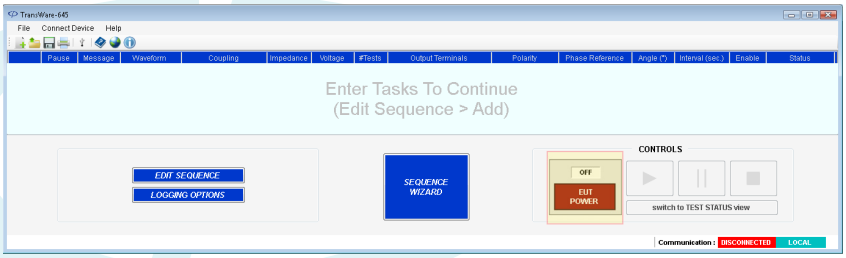


In either case, if it is your intention to run the test without EUT power enabled, as would typically be the case during waveform verification, for instance; choose the CONTINUE option by pressing the ▶ button, and the test will begin. Phase synchronization will be automatically disabled.

Otherwise, choose the ABORT option by pressing the ■ button to abort the test.

4.1.2.2 Turning ON/OFF EUT Power – REMOTE Control

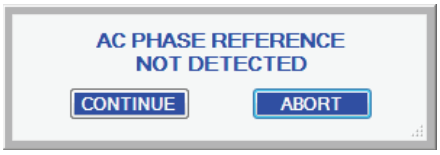
When the SGIEC-645 is under remote control using the *TransWare-645™* software, the EUT power state is controlled via the front and rear panel EUT POWER switches, in addition to the EUT POWER function located on the Control Panel within the TransWare-645™ software.



When the SGIEC-645 front panel EUT POWER switch is turned on, the EUT power status in the TransWare-645™ Control Panel will change from "**OFF**" to "**RDY**". At this point, the EUT power output can be turned on by pressing the *TransWare-645™* EUT POWER button.

The SGIEC-645 surge generator will automatically check the EUT power switch status at the start of any test or test sequence which includes surges applied to its internal CDN output terminals. If the EUT power switch is not enabled on the SGIEC-645 front panel, the following message will be displayed:

For any test or test sequence which includes phase synchronization of the surge waveform with the AC sine wave, the generator will check for its AC phase reference. If no phase reference is detected, the following message will be displayed:



In either case, if it is your intention to run the test without EUT power enabled, as would typically be the case during waveform verification, for instance; press the CONTINUE button, and the test will begin. Phase synchronization will be automatically disabled for the test/test sequence.

Otherwise, abort the test by pressing the ABORT button.

4.2 Input/Output Ports

4.2.1 Safety Interlock Port

SAFETY INTERLOCK

The safety interlock port *(left)* can *(optionally)* be used to disable the surge generator output for safety reasons or otherwise using an external SPST switch, such as the door contacts of the test chamber, for instance. **In cases where no interlock switch is used, simply connect the safety interlock key** *(right)* **to this port to enable the generator.**

For those cases where an external switch is to be used, wire your switch contacts to pins 2 and 3 of the supplied, spare 7mm push-pull connector as shown in Figure 6. Remove the interlock key from the SGIEC-645 interlock port, and plug in the wired switch assembly. The generator will now be enabled/disabled with the closing/opening of the switch contacts.

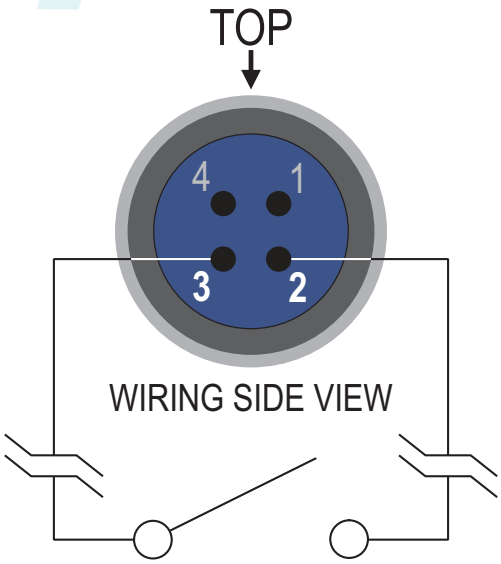
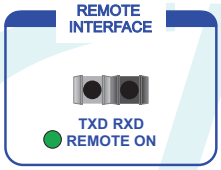


FIGURE 6 - *Safety Interlock Connector Pin-Out & Ext. Switch Connection*

4.2.2 Fiber Optic Port

The SGIEC-645 surge generator can be remotely controlled using a PC via the fiber optic remote interface, using Com-Power's *TransWare-645™* software.

4.2.2.1 Setting up the Remote Interface



As shown in Figure 7, connect the supplied fiber optic cable into the fiber optic remote interface port on the front of the SGIEC-645. Connect the opposite end of the fiber optic cable to the OTA-232 Optical Transreceiver Adapter. Finally, connect the OTA-232 Adapter to a PC with the Com-Power *TransWare-645™* software installed using the supplied USB Type A to USB Type B cable.

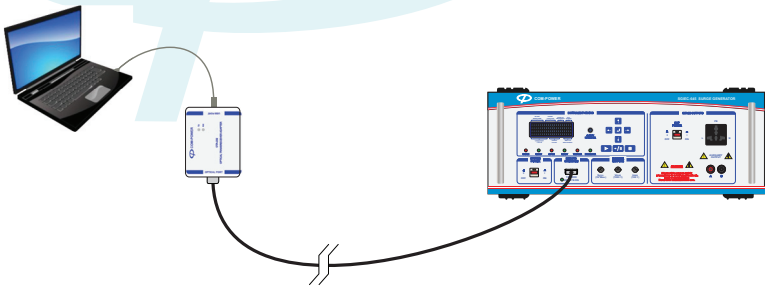
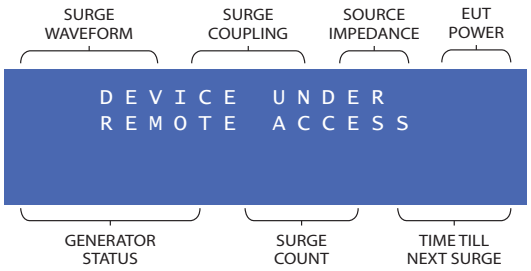
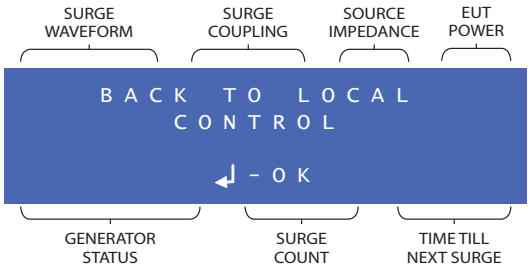


FIGURE 7 - *Remote Interface Setup Example*

Once connection has been made between the computer and the SGIEC-645, the message to the right will appear on the front panel display of the generator.

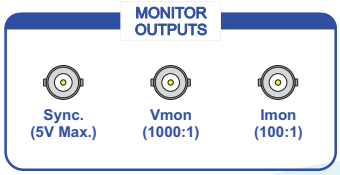


If the *TransWare-645™* software is closed, or the fiber optic or USB cable is disconnected, causing a break in the link, the message below will be will appear on the front panel display of the generator.



Refer to section 7 for detailed instructions on operation of the SGIEC-645 Surge Generator via the *TransWare-645™* software.

4.3 Monitor Ports



The Vmon & Imon monitor ports provide a convenient method for verification of the voltage/current levels of the applied surges.

The Sync. Output Port provides a convenient method for triggering the oscilloscope during the measurements made at the voltage or current monitor ports, as well as for measurements at the Auxiliary Surge Outputs, Internal CDN Surge Output Ports, and Surge Output Ports of any external CDN (for data lines, telecom lines or power lines).

4.3.1 Sync Output Port (Sync. O/P)

Sync. (5V Max.)

The SYNC OUTPUT port is provided as an alternative method of triggering the oscilloscope measurement, rather triggering on the rising or falling slope of the surge waveform. The SYNC OUTPUT port connects directly to the external trigger input of any oscilloscope. The output is 5 VDC steady state, until it drops to zero volts in synchronization with each surge discharge, for a period of 20 ms.

4.3.2 Voltage Monitor Port (V_{mon})

Vmon (1000:1)

The Voltage Monitor Port (Vmon) is intended to be connected to a high impedance (>10kΩ) input of an oscilloscope for verification of peak surge voltage for all waveforms. The output scaling is 1V / 1000V (1000:1 ratio).

The peak output voltage measured at this port is typically accurate to within ±10%.

The actual wave shape of the surge waveform may become distorted; and therefore this port should not be used for measurement of other parameters, such as rise time, decay time or over/undershoot. These parameters must be measured at the respective surge output terminals.

4.3.3 Current Monitor Port (I_{mon})

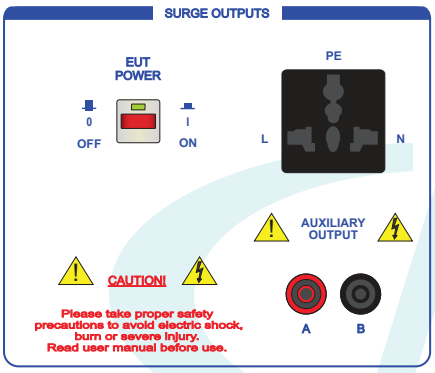
Imon (100:1)

The Current Monitor Port (Imon) is intended to be connected to a high impedance (>10kΩ) input of an oscilloscope for verification of peak surge current for all waveforms. The output scaling is 1V / 100V (100:1 ratio).

The peak output current measured at this port is typically accurate to within ±10%.

* **Open circuit** voltage measurements are performed with no external connections to the selected surge output terminals. **Short circuit** current measurements are performed with the surge output terminals short circuited. Measured values will vary with alternate output terminations (with the EUT connected, for instance).

4.4 Surge Generator Output Ports



The (A/B) output ports are fitted with 4 mm safety sockets.

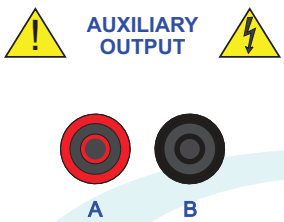
The internal power line CDN output port is fitted with a Universal Multi-Configuration AC Socket.

CAUTION: Due to the presence of ***DANGEROUS VOLTAGES***, the user should avoid all contact with these output ports, as well as any uninsulated cabling which connects to these ports while the SGIEC-645 is in operation. All connections should be made before applying power to the generator.

WARNING: Uninsulated, ***DANGEROUS VOLTAGES*** may be present on any and all surge output terminals. These voltages may be of sufficient magnitude to constitute a risk of electric shock to persons.

WARNING **NEVER CONNECT THE SURGE OUTPUT TERMINALS TO A POWER SOURCE DIRECTLY, AS THIS MAY RESULT IN INTERNAL DAMAGE TO YOUR SGIEC-645 SURGE GENERATOR. THESE ARE OUTPUT PORTS ONLY.**

4.4.1 Auxiliary (A/B) Surge Output Ports



The Auxiliary (A/B) output ports are typically used for verification/calibration of the surge waveform parameters at the generator output, and for connecting the surge generator to any external CDN. The latter is illustrated in Figure 8 below.

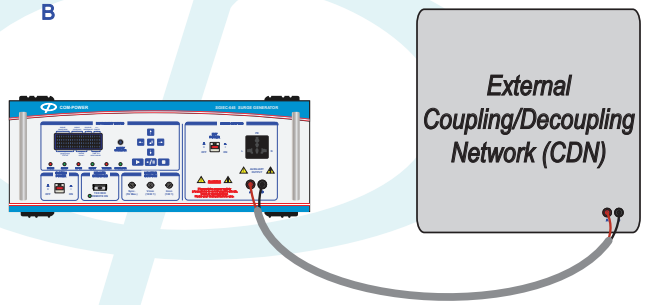
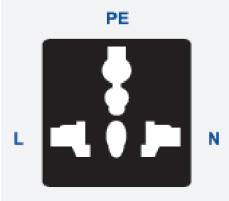


FIGURE 8 - *Connection to External CDN via Auxiliary (A/B) Ports*

4.4.2 Internal Powerline CDN Surge Output Port



Powerline surges will always be applied through a coupling/decoupling network (CDN). The SGIEC-645 surge generator includes an internal CDN accommodating both DC (16A up to 48V/10A up to 100V) and single-phase AC powered devices up to 16 amps.

For devices drawing greater than 16 amps of current and/or devices requiring a 3-phase power system, a compatible Com-Power external CDN is required, which connects to the (A/B) output terminals of the generator.

The powerline surges are typically applied between two current carrying conductors (**Line to Line** - *differential mode*) and between any current carrying conductor and ground (**Line to Ground** – *common mode*) A typical test setup is illustrated in Figure 9

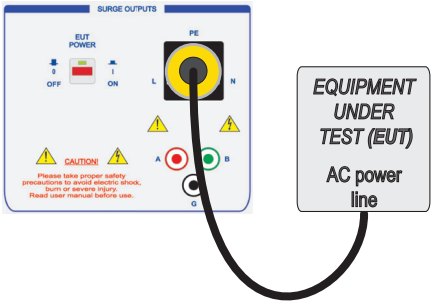


FIGURE 9 - ***EUT Connection to SGIEC-645 for Powerline Surge(s)***

5.0 Calibration of Surge Output Waveforms

This section provides guidance on the measurement (and associated calculations) of the SGIEC-645 Surge Generator output waveforms at the auxiliary(A/B) output terminals and at the EUT power output port terminals.

5.1 Recommended Test Equipment

Listed below are the three key components recommended for surge waveform measurements.

1) Digital Storage Oscilloscope (BW ≥ 100 MHz)
2) High Voltage (1000x1) Differential Oscilloscope Probe Set (BW ≥ 10 MHz)
3) Current Probe (BW ≥ 10 MHz, LF cutoff ≤ 0.5 Hz)
4) Coaxial cables, adapters and/or fixtures as necessary so that all required connections can be made properly.

5.2 Surge Waveform Measurements

As discussed in the following sections, open circuit voltage measurements are to be performed using high-voltage, ***differential-type*** oscilloscope probes, while the short circuit current measurements are made using an appropriate current probe.

5.2.1 Open Circuit Voltage Measurements

Open circuit voltage waveform measurements are made using high-voltage, differential–type oscilloscope probes connected directly to the appropriate SGIEC-645 output terminals.

5.2.2 Short Circuit Current Measurements

Short circuit current waveform measurements are made by shorting the appropriate output terminals using a short length of wire routed through an appropriate current probe, which is connected to the input of the oscilloscope.

5.3 Measurement Connections

Examples of typical measurement connection arrangements at the Auxiliary (A/B) surge output ports of the SGIEC-645 for both *open circuit voltage* (left) and *short circuit current* (right) are shown below in Figure 10.

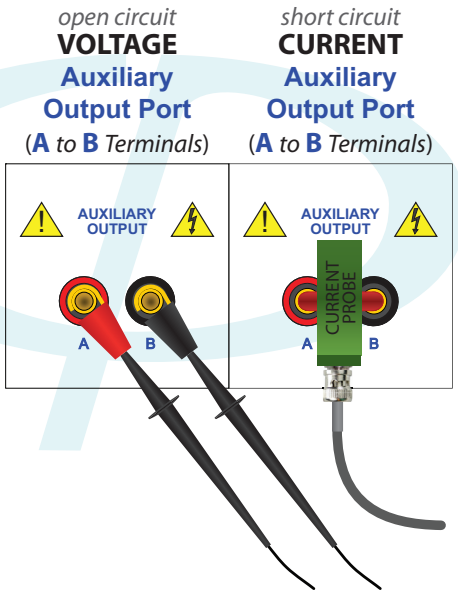


FIGURE 10 - *Example of Probe Connections at Auxiliary Output Port*

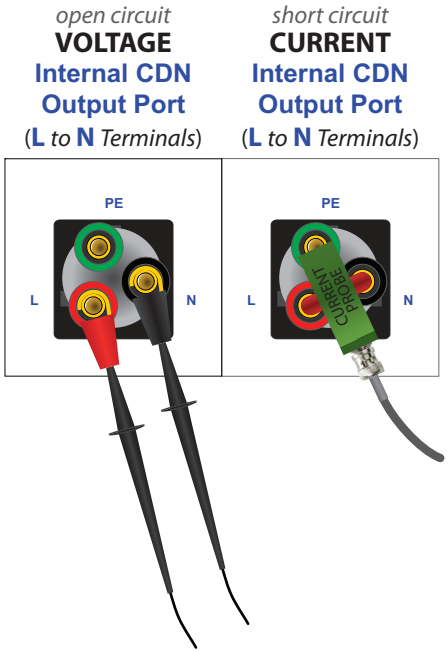


FIGURE 11 - *Example of Probe Connections at Internal CDN Output Port*

5.4 Surge Waveform Requirements (Generator Output)

IMPORTANT: The surge waveform requirements defined within this section apply only to surges measured at the [Auxiliary (A/B)] Generator Output terminals. Modified and/or relaxed waveform requirements have been defined for surges measured at the EUT port of coupling/decoupling networks. These requirements are detailed in Section 5.5 and 5.6 of this manual.

The waveform requirements for surges measured at the [Auxiliary (A/B] Generator Output Terminals are defined in terms of both open circuit voltage and short circuit current waveform requirements. For both voltage and current waveforms, the following parameters are defined:

TABLE I – Defined Waveform Parameters - Generator Output

OPEN CIRCUIT VOLTAGE WAVEFORM	SHORT CIRCUIT CURRENT WAVEFORM
Peak Voltage (V_{pk})	Peak Current (I_{pk})
Under/Overshoot ($V_{u/o}$)	Under/Overshoot ($I_{u/o}$)
Front Time (T_f)	Front Time (T_f)
Duration (T_d)	Duration (T_d)

Given in Table I (below) are the defined limits/limit ranges for the individual waveform parameters for each surge type, as measured at the [Auxiliary (A/B)] Generator Output Terminals.

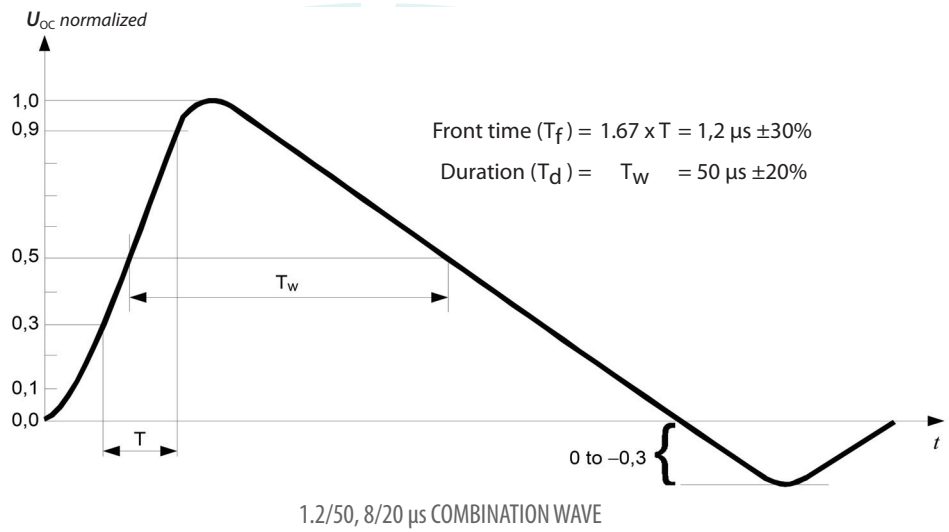
TABLE II – Waveform Requirements – Generator Output

	Waveform Parameter	1.2/50 µs (OC), 8/20 µs (SC) Combination Wave	10/700 µs (OC), 5/320 µs (SC) Combination Wave
Open Circuit	Peak Voltage (V_{pk})	Set Voltage ±10%	Set Voltage ±10%
	Under/Overshoot ($V_{u/o}$)	Set Voltage * -0.3	N/A
	Front Time (T_f)	0.84-1.56 µs	7-13 µs
	Duration (T_d)	40-60 µs	560-840 µs
Short Circuit	Peak Current (I_{pk})	(Set Voltage / 2Ω) ±10%	(Set Voltage / 40Ω) ±10%
	Under/Overshoot ($I_{u/o}$)	(Set Voltage / 2Ω) * -0.3	N/A
	Front Time (T_f)	6.4-9.6 µs	4-6 µs
	Duration (T_d)	16-24 µs	256-384 µs

These waveform requirements are discussed in more detail in the following sections. Measurement guidelines, as well as guidelines and examples of the associated calculations are also provided.

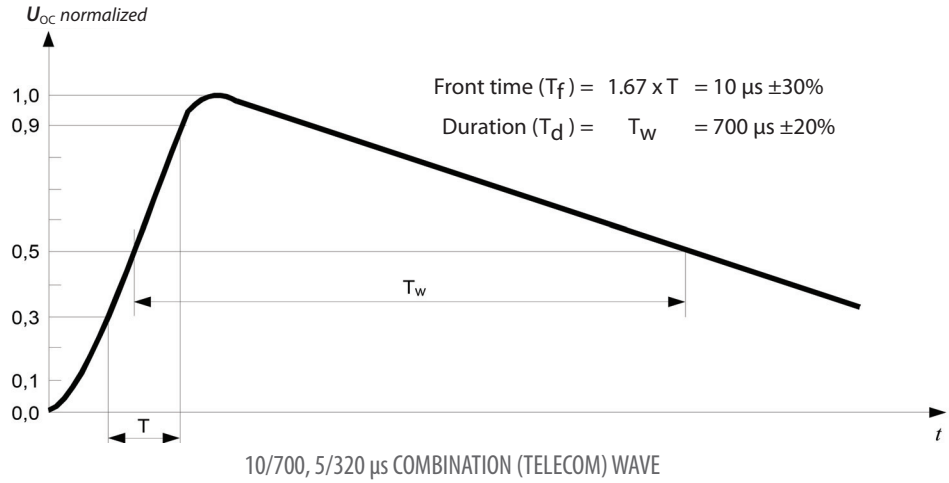
5.4.1 Open Circuit Surge Voltage Waveforms – Generator Output

The waveform in Figures 12 and 13 define the open circuit voltage wave shapes at the generator output for the two respective combination waveforms.



WAVEFORM OF OPEN-CIRCUIT VOLTAGE

FIGURE 12 - *1.2/50 µs, 8/20 µs - Open Circuit Voltage Wave Shape*



WAVEFORM OF OPEN-CIRCUIT VOLTAGE

FIGURE 13 - *10/700 µs, 5/320 µs - Open Circuit Voltage Wave Shape*

5.4.1.1 Measurement of Voltage Waveform Parameters

This section discusses the measurement process and calculations for proper determination of the individual waveform parameter values for surges measured at the [Auxiliary (A/B)] Generator Output Terminals.

PEAK VOLTAGE (V_{pk})

For positive surges, the Peak Voltage (V_{pk}) is the highest measured voltage value within the envelope of the surge waveform. For negative surges, the Peak Voltage (V_{pk}) is the lowest measured voltage value within the envelope of the surge waveform.

UNDER/OVERSHOOT VOLTAGE ($V_{u/o}$)

For positive surges, the Undershoot Voltage (V_u) is the lowest measured voltage value within the envelope of the surge waveform. For negative surges, the Overshoot Voltage (V_o) is the highest measured voltage value within the envelope of the surge waveform.

FRONT TIME (T_f)

The Front Time (T_f) is calculated based on the measurement of ***T**, which is defined below*:

T = Time difference between:

(A) the first point on the rising slope of the waveform at or above 30% of V_{pk}; **and,**

(B) the first point on the rising slope of the waveform at or above 90% of V_{pk}.

$$T_r = 1.67 \times T$$

DURATION (T_d)

The **Duration (T_d)** [*also known as **fall** or **decay time***] is calculated based on the measurement of T_w.

T_w = Time difference between:

(A) the first point on the rising slope of the waveform at or above **50%** of V_{pk}; **and,**

(B) the first point on the falling slope of the waveform at or below **50%** of V_{pk}.

$$T_d = T_w$$

5.4.1.2 Example calculations for Voltage Waveform Parameters

Considered in the following example calculations is a typical 1.2/50 µs, 8/20 µs Combination Wave Surge, with V_{pk} setting of 1 kV applied to the Auxiliary (A/B) surge output ports with a source impedance of 2 ohms.

NOTE: The final values determined for each waveform parameter are shown in blue (with the respective limit range in red)

The following values were measured:

MEASURED VALUES

V_{pk}:	1,004.64 Volts	(Limit Range: **900-1100V)**	
V_{us}:	0 Volts	(Limit [min.]: **-300V)**	
$V_{(30\%/pk)}$:	301.392 Volts	$T_{(30\%/pk)}$:	0.723 µs
$V_{(90\%/pk)}$:	904.176 Volts	$T_{(90\%/pk)}$:	1.423 µs
$V_{(50\%\text{-}Rise/pk)}$:	502.32 Volts	$T_{(50\%/pk)}$:	0.859 µs
$V_{(50\%\text{-}Fall/pk)}$:	502.32 Volts	$T_{(50\%/pk)}$:	55.95 µs

Based on these measured values, the following parameters are calculated:

FRONT TIME (T_f) = T x 1.67

$T = T_{(90\%/pk)} - T_{(30\%/pk)}$

$T = 1.423\ \mu s - 0.723\ \mu s$

$\mathbf{T = 0.7\ \mu s}$

$T_r = 0.7\ \mu s \times 1.67$

$\mathbf{T_r = 1.169\ \mu s}$ (Limit Range: **0.84-1.56 µs)**

DURATION (T_d) = $T_w = T_{(50\%\text{-}Fall/pk)} - T_{(50\%\text{-}Rise/pk)}$

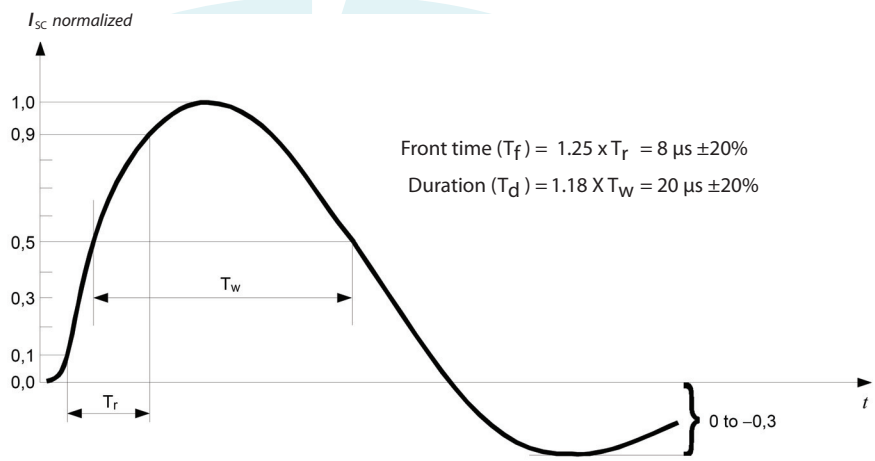
$T_w = 55.95\ \mu s - 0.859\ \mu s$

$T_w = 55.09\ \mu s$

$\mathbf{T_d = 55.09\ \mu s}$ (Limit Range: **40-60 µs)**

5.4.2 Short Circuit Surge Current Waveforms

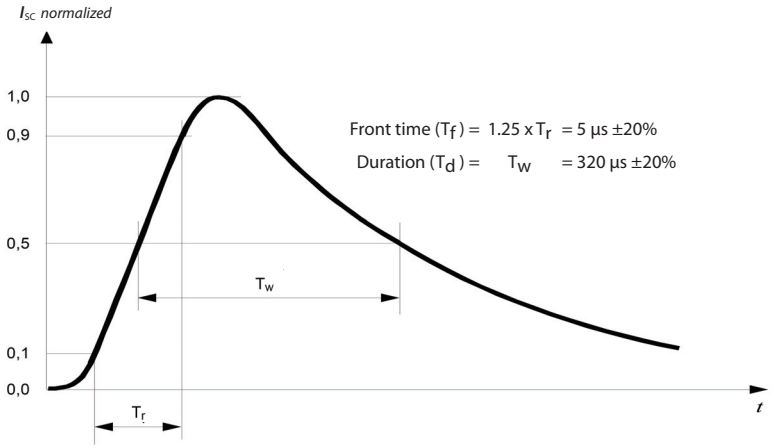
The waveforms in Figures 14 and 15 define the short circuit current wave shape requirements at the generator output for the two respective combination waveforms.



1.2/50, 8/20 µs COMBINATION WAVE

WAVEFORM OF SHORT-CIRCUIT CURRENT

FIGURE 14 - *1.2/50 µs, 8/20 µs - Short Circuit Current Wave Shape*



10/700, 5/320 µs COMBINATION (TELECOM) WAVE

WAVEFORM OF SHORT-CIRCUIT CURRENT

FIGURE 15 - *10/700 µs, 5/320 µs - Short Circuit Current Wave Shape*

5.4.2.1 Measurement of Current Waveform Parameters

This section discusses the measurement process and calculations for proper determination of the individual waveform parameter values.

PEAK CURRENT (I_{pk})

For positive surges, the Peak Current (I_{pk}) is the highest measured current value within the envelope of the surge waveform. For negative surges, the Peak Current (I_{pk}) is the lowest measured current value within the envelope of the surge waveform.

UNDER/OVERSHOOT CURRENT ($I_{u/o}$)

For positive surges, the Undershoot Current (I_u) is the lowest measured current value within the envelope of the surge waveform. For negative surges, the Overshoot Current (I_o) is the highest measured current value within the envelope of the surge waveform.

FRONT TIME (T_f)

The Front Time (T_f) is calculated based on the measurement of ***T**, which is defined below*:

T = Time difference between:

(A) the first point on the rising slope of the waveform at or above 10% of I_{pk}; **and,**

(B) the first point on the rising slope of the waveform at or above 90% of I_{pk}.

$$T_r = 1.25 \times T$$

DURATION (T_d)

The **Duration (T_d)** [*also known as **fall** or **decay time***] is calculated based on the measurement of ***T_w***.

T_w = Time difference between:

(A) the first point on the rising slope of the waveform at or above **50%** of V_{pk}; **and,**

(B) the first point on the falling slope of the waveform at or below **50%** of V_{pk}.

$$T_d = 1.18 \times T_w$$

5.4.2.2 Example calculations for Current Waveform Parameters

Considered in the following example calculations is a typical 1.2/50 µs, 8/20 µs Combination Wave Surge, with V_{pk} setting of 1 kV, applied at the Auxiliary (A/B) Surge Output Ports, with a 2 ohm source impedance.

NOTE: The final values determined for each waveform parameter are shown in blue (with the respective limit range in red)

The following values were measured:

MEASURED VALUES

I_{pk}:	**488 Amps**	(Limit Range: **450-550A)**	
I_u:	**-120 Amps**	(Limit [min.]: **-150A)**	
$I_{(10\%/pk)}$:	**48.8 Amps**	$T_{(10\%/pk)}$:	**-2.912 µs**
$I_{(90\%/pk)}$:	**439.2 Amps**	$T_{(90\%/pk)}$:	**2.916 µs**
$I_{(50\%\text{-Rise}/pk)}$:	**244 Amps**	$T_{(50\%/pk)}$:	**-0.78 µs**
$I_{(50\%\text{-Fall}/pk)}$:	**244 Amps**	$T_{(50\%/pk)}$:	**15.24 µs**

Based on these measured values, the following parameters are calculated:

FRONT TIME (T_f) = T x 1.25

$T = T_{(90\%/pk)} - T_{(30\%/pk)}$
T = 2.916 µs – -2.912 µs
T = 5.828 µs
T_r = 5.828 µs x 1.25
T_r = 7.285 µs (Limit Range: **6.4-9.6 µs)**

DURATION (T_d) = 1.18 x **T_w** = $T_{(50\%\text{-Fall}/pk)} - T_{(50\%\text{-Rise}/pk)}$

T_w = 15.24 µs – -0.78 µs
T_w = 16.02 µs
T_d = 16.02 µs x 1.18
T_d = 18.904 µs (Limit Range: **16-24 µs)**

5.5 Surge Waveform Requirements at CDN Outputs

IMPORTANT: The surge waveform requirements defined within this section apply only to surges measured at the EUT port of Coupling/Decoupling Networks (CDN). For waveform requirements for surges measured at the [Auxiliary (A/B)] Generator Output terminals, refer to Section 5.4.

5.5.1 CDN for Power Lines -1.2/50 µs, 8/20 µs Waveform

The waveform requirements for surges measured at the EUT port of power line coupling/decoupling networks (CDN) for the 1.2/50 µs, 8/20 µs Combination Wave Surge are given in Tables III through VI.

The waveforms are defined in terms of both:

open circuit voltage; and,
short circuit current

For both voltage and current waveforms, parameters are defined for generator source impedances of:

2 ohms (18 µF coupling capacitor [line to line surges]); and,
12 ohms (9 µF coupling capacitor [line to ground surges])

TABLE III – Defined Waveform Parameters – EUT Port of CDN

OPEN CIRCUIT VOLTAGE WAVEFORM	SHORT CIRCUIT CURRENT WAVEFORM
Peak Voltage (V_{pk})	Peak Current (I_{pk})
Front Time (T_f)	Front Time (T_f)
Duration (T_d)	Duration (T_d)
Phase Synchronization	N/A

TABLE IV – Voltage Waveform Limits – EUT Port of Power Line CDN

Surge voltage parameters under open-circuit conditions		Coupling Impedance	
		2Ω (18 μF) (line to line)	12Ω (9 μF) (line to ground)
Peak Voltage (V_{pk})	Current Rating ≤ 16A	Set Voltage +10% / -10%	Set Voltage +10% / -10%
	16A < Current Rating ≥ 32A	Set Voltage +10% / -10%	Set Voltage +10% / -10%
	32A < Current Rating ≥ 63A	Set Voltage +10% / -10%	Set Voltage +10% / -15%
	63A < Current Rating ≥ 125A	Set Voltage +10% / -10%	Set Voltage +10% / -20%
	125A < Current Rating ≥ 200A	Set Voltage +10% / -10%	Set Voltage +10% / -25%
Front Time (T_f)		1.2 μs ±30%	1.2 μs ±30%
Duration (T_d)	Current Rating ≤ 16A	50 μs +10 μs / -10 μs	50 μs +10 μs / -25 μs
	16A < Current Rating ≥ 32A	50 μs +10 μs / -15 μs	50 μs +10 μs / -30 μs
	32A < Current Rating ≥ 63A	50 μs +10 μs / -20 μs	50 μs +10 μs / -35 μs
	63A < Current Rating ≥ 125A	50 μs +10 μs / -25 μs	50 μs +10 μs / -40 μs
	125A < Current Rating ≥ 200A	50 μs +10 μs / -30 μs	50 μs +10 μs / -45 μs

TABLE V – Current Waveform Limits – EUT Port of Power Line CDN

Surge current parameters under short-circuit conditions	Coupling Impedance	
	2Ω (18 μF) (line to line)	12Ω (9 μF) (line to ground)
Front Time (T_f)	T_f = 1.25 x T_r = 8 μs ±20%	T_f = 1.25 x T_r = 2.5 μs ±30%
Duration (T_d)	T_d = 1.18 x T_w = 20 μs ±20%	T_d = 1.04 x T_w = 25 μs ±30%

TABLE VI – Peak Voltage/Current Relationship – Power Line CDN

Open-circuit peak voltage ±10% at EUT port of the CDN	Short-circuit peak current ±10% at EUT port of the CDN 2Ω (18 μF) (line to line)	Short-circuit peak current ±10% at EUT port of the CDN 12Ω (9 μF) (line to ground)
0.5 kV	0.25 kA	41.7 A
1.0 kV	0.5 kA	83.3 A
2.0 kV	1.0 kA	166.7 A
4.0 kV	2.0 kA	333.3 A

5.5.2 CDN for Data Lines - 1.2/50 µs, 8/20 µs Waveform

A summary of the calibration process and waveform requirements for surges measured at the EUT port of a CDN for unsymmetrical interconnection (data) lines for the 1.2/50 µs, 8/20 µs Combination Wave Surge are given in Tables VII and VIII, respectively.

The waveforms are defined in terms of both:

open circuit voltage; and,
short circuit current

For both voltage and current waveforms, parameters are defined for the following surge coupling devices:

0.5 µF Coupling Capacitor; and,
Gas Discharge Tube (GDT)

TABLE VII – Calibration Process Summary – Data Line CDN

	Coupling	Measuring	AE Side	EUT Side
Surge voltage at EUT side	Single line to PE	Single line, V_{pk}, T_f, T_d	All lines shorted to PE	Open-circuit
Surge current at EUT side	Single line to PE	Single line, V_{pk}, T_f, T_d	All lines shorted to PE	Short-circuit
Surge voltage at EUT side	Single line to line	Single line, V_{pk}, T_f, T_d	All lines shorted to PE	Open-circuit
Surge current at EUT side	Single line to line	Single line, V_{pk}, T_f, T_d	All lines shorted to PE	Short-circuit
Residual voltage on AE side (with protection elements)	Single line to PE	Line to PE at a time V_{pk}	Open-circuit	Open-circuit

TABLE VIII – Surge Waveform Specifications – Data Line CDN

Coupling Method	Output Voltage Setting	V_{OC} @ CDN EUT Port ±10%	Voltage Front Time (T_f) T_f=1.67 x T_r ±30%	Voltage Duration (T_d) $T_d = T_w$ ±30%	I_{SC} @ CDN EUT Port ±20%	Current Front Time (T_f) T_f=1.25 x T_r ±30%	Current Duration (T_d) T_d=1.18 x T_w ±30%
Line to PE R = 40Ω CD = 0.5 µF	4 kV	4 kV	1.2 µs	38 µs	87 A	1.3 µs	13 µs
Line to PE R = 40Ω CD = GDT	4 kV	4 kV	1.2 µs	42 µs	95 A	1.5 µs	48 µs
Line to Line R = 40Ω CD = 0.5 µF	4 kV	4 kV	1.2 µs	42 µs	87 A	1.3 µs	13 µs
Line to Line R = 40Ω CD = GDT	4 kV	4 kV	1.2 µs	47 µs	95 A	1.5 µs	48 µs

5.5.3 CDN for Telecom Lines - 1.2/50 µs, 8/20 µs Waveform

A summary of the calibration process and waveform requirements for surges measured at the EUT port of a CDN for symmetrical interconnection (telecom) lines for the 1.2/50 µs, 8/20 µs Combination Wave Surge are given in Tables IX and X, respectively.

The waveforms are defined in terms of both:

open circuit voltage; and,
short circuit current

TABLE IX – Calibration Process Summary – Telecom Line CDN (1.2/50)

	Coupling	Measuring	AE Side	EUT Side
Surge voltage at EUT side	Common mode – all lines to PE 40Ω path	All lines shorted together V_{pk}, T_f, T_d	All lines shorted to PE	Open-circuit all lines connected together
Surge current at EUT side	Common mode – all lines to PE 40Ω path	All lines shorted together V_{pk}, T_f, T_d	All lines shorted to PE	All lines shorted to PE
Residual voltage on AE side (with protection elements)	Common mode – all lines to PE 40Ω path	Each line to PE in turn V_{pk}	Open-circuit	Open-circuit

TABLE X – Surge Waveform Specifications – Telecom Line CDN (1.2/50)

Coupling Method	Output Voltage Setting	V_{OC} @ CDN EUT Port ±10%	Voltage Front Time (T_f) T_f=1.67 x T_r ±30%	Voltage Duration (T_d) $T_d = T_w$ ±30%	I_{SC} @ CDN EUT Port ±20%	Current Front Time (T_f) T_f=1.25 x T_r ±30%	Current Duration (T_d) T_d=1.18 x T_w ±30%
Common mode CD 40Ω path	2 kV	2 kV	1.2 µs	45 µs	48 A	1.5 µs	45 µs

5.5.4 CDN for Telecom Lines – 10/700 µs, 5/320 µs Waveform

A summary of the calibration process and waveform requirements for surges measured at the EUT port of a CDN for symmetrical interconnection (telecom) lines for the 10/700 µs, 5/320 µs Combination Wave Surge are given in Tables XI and XII, respectively.

The waveforms are defined in terms of both:

open circuit voltage; and,
short circuit current

TABLE XI – Calibration Process Summary – Telecom Line CDN (10/700)

	Coupling	Measuring	AE Side	EUT Side
Surge voltage at EUT side	Common mode – one pair to PE	Both lines from one pair shorted together V_{pk}, T_f, T_d	All used lines shorted to PE	Open-circuit, both lines from one pair shorted together
Surge current at EUT side	Common mode – one pair to PE	Both lines from one pair shorted together V_{pk}, T_f, T_d	All used lines shorted to PE	Both lines from one pair shorted to PE
Residual voltage on AE side (with protection elements)	Common mode – one pair to PE	Both lines from one pair shorted together V_{pk}	Open-circuit	Open-circuit

TABLE XII – Surge Waveform Specifications – Telecom Line CDN (10/700)

Coupling Method	Output Voltage Setting	V_{OC} @ CDN EUT Port ±10%	Voltage Front Time (T_f) T_f=1.67 x T_r ±30%	Voltage Duration (T_d) $T_d = T_w$ ±30%	I_{SC} @ CDN EUT Port ±20%	Current Front Time (T_f) T_f=1.25 x T_r ±30%	Current Duration (T_d) T_d=1.18 x T_w ±30%
Common mode CD 1 Pair 27.5Ω	4 kV	4 kV	8 µs	250 µs	145 A	3.2 µs	250 µs

5.6 Combined Reference Table of Waveform Limits

Combined in the following table are all of the surge output waveform requirements for both Combination Waves, at each of the respective surge generator/CDN outputs.

TABLE XIII – Combined Reference Table of IEC 61000-4-5 Waveform Limit Tables

	Surge Waveform:	**1.2/50 µs, 8/20 µs COMBINATION WAVE**						**10/700 µs, 5/320 µs COMBINATION WAVE**	
	Generator Source Impedance:	**2Ω** (18 µF coupling cap)		2Ω+10Ω = **12Ω** (9 µF coupling cap)		2Ω+40Ω = **42Ω**		**40Ω** @ Generator Output 15Ω+(25Ω‖25Ω)=**27.5Ω** @ CDN Output	
	SURGE GENERATOR OUTPUT TERMINALS	**OPEN (voltage)**	**SHORT (current)**	**OPEN (voltage)**	**SHORT (current)**	**OPEN (voltage)**	**SHORT (current)**	**OPEN (voltage)**	**SHORT (current)**
Peak Voltage/Current	Generator Output [Aux. (A/B)]	V_{set} ±10%	$V_{set(V)}/2\Omega=(A)$ ±10%					V_{set} ±10%	$V_{set}/40\Omega=(A)$ ±10%
Peak Voltage/Current	Power Line CDN ≤ 16A	V_{set} ±10%	$V_{set(V)}/2\Omega=(A)$ ±10%	V_{set} ±10%	$V_{set(V)}/12\Omega=(A)$ +10%/-10%				
Peak Voltage/Current	Power Line CDN > 16A ≤ 32A	V_{set} ±10%	$V_{set(V)}/2\Omega=(A)$ ±10%	V_{set} ±10%	$V_{set(V)}/12\Omega=(A)$ +10%/-10%				
Peak Voltage/Current	Power Line CDN > 32A ≤ 63A	V_{set} ±10%	$V_{set(V)}/2\Omega=(A)$ ±10%	V_{set} ±10%	$V_{set(V)}/12\Omega=(A)$ +10%/-15%				
Peak Voltage/Current	Power Line CDN > 63A ≤ 125A	V_{set} ±10%	$V_{set(V)}/2\Omega=(A)$ ±10%	V_{set} ±10%	$V_{set(V)}/12\Omega=(A)$ +10%/-20%				
Peak Voltage/Current	Power Line CDN > 125A ≤ 200A	V_{set} ±10%	$V_{set(V)}/2\Omega=(A)$ ±10%	V_{set} ±10%	$V_{set(V)}/12\Omega=(A)$ +10%/-25%				
Peak Voltage/Current	Telecom Line CDN					V_{set} ±10%	$V_{set(V)}/42\Omega=(A)$ ±20%	V_{set} ±10%	$V_{set(V)}/27.5\Omega=(A)$ ±20%
Peak Voltage/Current	Data Line CDN (0.5 µF CD)					V_{set} ±10%	$V_{set(V)}/46\Omega=(A)$ ±20%		
Peak Voltage/Current	Data Line CDN (GDT CD)					V_{set} ±10%	$V_{set(V)}/42\Omega=(A)$ ±20%		
	Under/Overshoot Voltage/Current Generator Output	−30%[V_{set}]	-30% [$V_{set(V)}/2\Omega=(A)$]						
Front Time (T_f)	Generator Output	$T_f = 1.67 \times T$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 8 µs ±20%					$T_f = 1.67 \times T_r$ = 10 µs ±30%	$T_f = 1.25 \times T_r$ = 5 µs ±20%
Front Time (T_f)	Power Line CDN < 200A	$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 8 µs ±20%	$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 2.5 µs ±30%				
Front Time (T_f)	Telecom Line CDN					$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 1.5 µs ±30%	$T_f = 1.67 \times T_r$ = 8 µs ±30%	$T_f = 1.25 \times T_r$ = 3.2 µs ±30%
Front Time (T_f)	Data Line CDN (0.5 µF CD, L-PE)					$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 1.3 µs ±30%		
Front Time (T_f)	Data Line CDN (GDT CD, L-PE)					$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 1.5 µs ±30%		
Front Time (T_f)	Data Line CDN (0.5 µF CD, L-L)					$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 1.3 µs ±30%		
Front Time (T_f)	Data Line CDN (GDT CD, L-L)					$T_f = 1.67 \times T_r$ = 1.2 µs ±30%	$T_f = 1.25 \times T_r$ = 1.5 µs ±30%		
Duration (T_d)	Generator Output	$T_d = T_w$ = 50 µs ±20%	$T_d = 1.18 \times T_w$ = 20 µs ±20%					$T_d = T_w$ = 700 µs ±20%	$T_d = T_w$ = 320 µs ±20%
Duration (T_d)	Power Line CDN ≤ 16A	$T_d = T_w$ = 50 µs +10 µs/-10 µs	$T_d = 1.18 \times T_w$ = 20 µs ±20%	$T_d = T_w$ = 50 µs +10 µs/-25 µs	$T_d = 1.04 \times T_w$ = 25 µs ±30%				
Duration (T_d)	Power Line CDN > 16A ≤ 32A	$T_d = T_w$ = 50 µs +10 µs/-15 µs	$T_d = 1.18 \times T_w$ = 20 µs ±20%	$T_d = T_w$ = 50 µs +10 µs/-30 µs	$T_d = 1.04 \times T_w$ = 25 µs ±30%				
Duration (T_d)	Power Line CDN > 32A ≤ 63A	$T_d = T_w$ = 50 µs +10 µs/-20 µs	$T_d = 1.18 \times T_w$ = 20 µs ±20%	$T_d = T_w$ = 50 µs +10 µs/-35 µs	$T_d = 1.04 \times T_w$ = 25 µs ±30%				
Duration (T_d)	Power Line CDN > 63A ≤ 125A	$T_d = T_w$ = 50 µs +10 µs/-25 µs	$T_d = 1.18 \times T_w$ = 20 µs ±20%	$T_d = T_w$ = 50 µs +10 µs/-40 µs	$T_d = 1.04 \times T_w$ = 25 µs ±30%				
Duration (T_d)	Power Line CDN > 125A ≤ 200A	$T_d = T_w$ = 50 µs +10 µs/-30 µs	$T_d = 1.18 \times T_w$ = 20 µs ±20%	$T_d = T_w$ = 50 µs +10 µs/-50 µs	$T_d = 1.04 \times T_w$ = 25 µs ±30%				
Duration (T_d)	Telecom Line CDN					$T_d = T_w$ = 45 µs ±30%	$T_d = 1.18 \times T_w$ = 45 µs ±30%	$T_d = T_w$ = 250 µs ±30%	$T_d = T_w$ = 250 µs ±30%
Duration (T_d)	Data Line CDN (0.5 µF CD, L-PE)					$T_d = T_w$ = 38 µs ±30%	$T_d = 1.18 \times T_w$ = 13 µs ±30%		
Duration (T_d)	Data Line CDN (GDT CD, L-PE)					$T_d = T_w$ = 42 µs ±30%	$T_d = 1.18 \times T_w$ = 48 µs ±30%		
Duration (T_d)	Data Line CDN (0.5 µF CD, L-L)					$T_d = T_w$ = 42 µs ±30%	$T_d = 1.18 \times T_w$ = 13 µs ±30%		
Duration (T_d)	Data Line CDN (GDT CD, L-L)					$T_d = T_w$ = 47 µs ±30%	$T_d = 1.18 \times T_w$ = 48 µs ±30%		

6.0 Controlling the SGIEC-645 via its Front Panel

The SGIEC-645 Surge Generator is able to perform all of its individual functions from the front panel interface, as described in the following sections. For either combination surge wave, the user can define the peak voltage level, surge output port, coupling mode, number of surges, delay time between surges, source impedance and AC sine wave synchronization angle (when applicable).

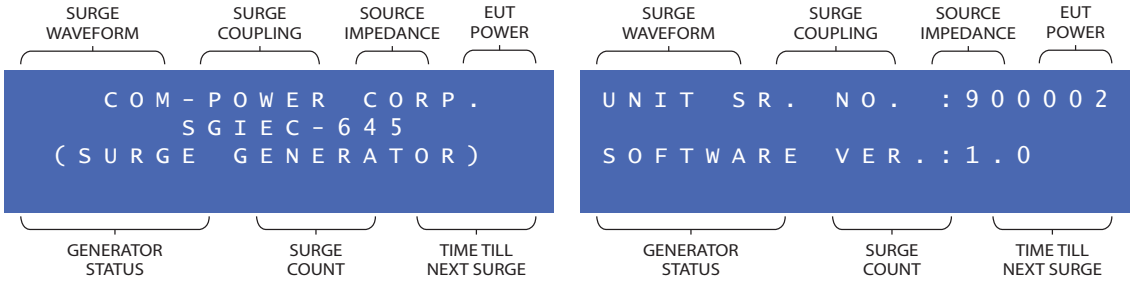
Further functionality, such as programming surge sequences and creating active test logs for recording results and observations during tests, is available using Com-Power's *TransWare-645*™ PC software, which controls the SGIEC-645 remotely via its fiber optic interface and fiber optic to USB adapter. Refer to section 7 for instructions on controlling the SGIEC-645 Surge Generator using *TransWare-645*™.

6.1 Initial Startup

To turn on the generator, locate the ***NEMA 5-15R-male to IEC C13-female*** *power* cord supplied with the generator. Plug the IEC C13 plug end of the cord into the system power input port on the back of the generator. Plug the other end of the power cord into an appropriate power outlet.

Turn on the system power switch located on the rear panel. Then, press the SYSTEM POWER button on the lower left corner of the front panel. The SGIEC-645 Surge Generator should then power up.

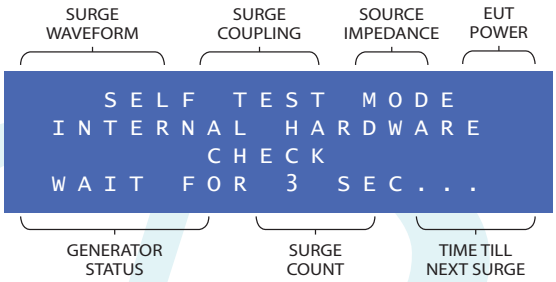
After power-up, the following splash screens will appear successively.



No user action is required at this point.

6.2 Self-Test

Each time the SGIEC-645 is turned on, it will automatically perform a three-stage self-test, and the following message will be displayed:



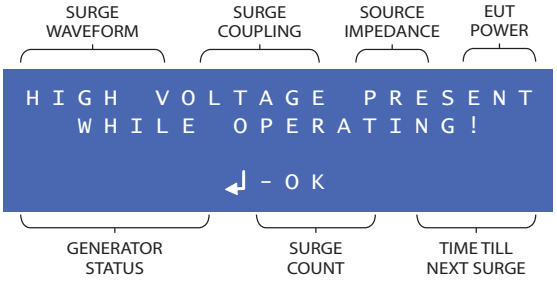
During the self-test, the following operations occur automatically:

1) SWITCHING RELAYS ON/OFF - During first stage of Self-Test, relays will toggle ON and OFF several times in order to remove moisture and demagnetize the coil.

2) STATUS CHECK OF HIGH VOLTAGE SUPPLY BOARD - During the second stage of the Self-Test, SGIEC-645 will check the operational status of the high voltage (HV) supply board. If a problem is sensed, system will halt and status message will be displayed. If no problem is found, self-test will continue with next step.

3) SAFETY INTERLOCK STATUS CHECK - The last stage of the Self-Test will check for a closed loop (short circuit) across the safety interlock port. If an open circuit is sensed, system will halt until safety interlock has been replaced. If short circuit is sensed, self-test will be completed.

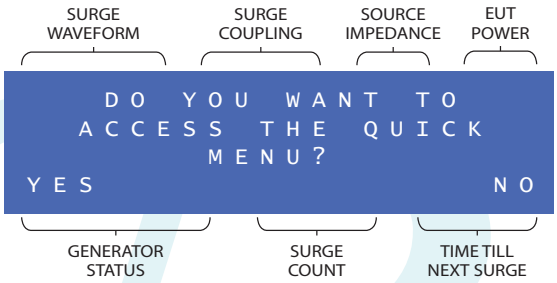
After successful completion of the self-test, the following high-voltage warning appears on the display.



Press the button, followed by the button to acknowledge this high-voltage warning.

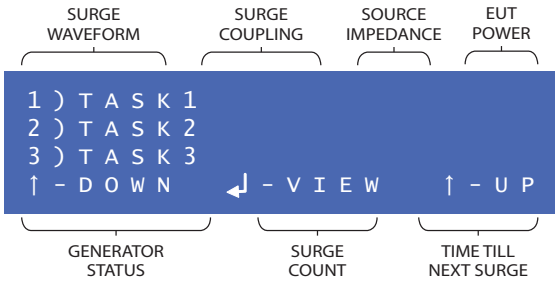
6.3 Quick Menu Access Option

After acknowledgement of the high-voltage warning, the following screen will appear on the display:



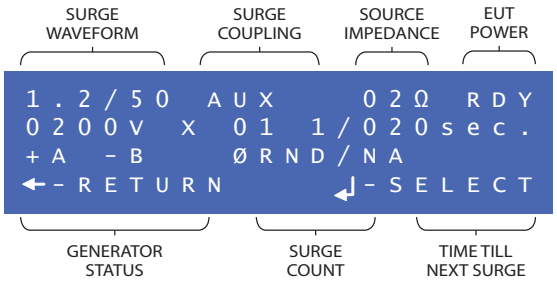
The default selection for this screen is NO. Pressing ↵ without changing the selected option will take you to the SURGE SETUP MENU SCREEN (Section 6.4).

The QUICK MENU contains any previously saved surge setups. To access this menu, from the above screen, press the ← button to change the selection from NO to YES, and press ↵. The QUICK MENU will be displayed:



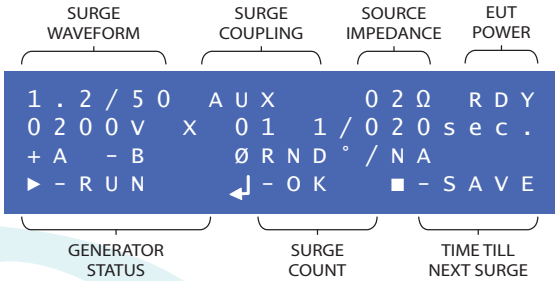
To access the QUICK MENU from the SURGE SETUP MENU screen, press the ↵/II button to reach the QUICK MENU ACCESS OPTION screen, press the ← button to change the selection from NO to YES, and press the ↵ button.

Up to ten (10) surge setups can be stored (see section 6.4), which can be accessed from this menu. Use the ↑ and ↓ buttons on the control pad to scroll through the stored surge setups (TASKS). Pressing the ↵ button will allow the user to view the selected surge setup:



Press the ↵ button to select this surge setup, and return to surge setup screen with these settings. Press the ↵/II button to return to the QUICK MENU.

6.4 Surge Setup Menu Screen



From this menu, the user is able to:

a) select the desired the ***SURGE WAVEFORM***;

b) select surge generator output port to which the surge will be coupled ***(SURGE COUPLING)***;

c) select the desired ***SOURCE IMPEDANCE*** value for the generator;

d) monitor the ***EUT POWER*** state;

e) set the ***SURGE OUTPUT VOLTAGE*** level for the surge event;

f) set the ***NUMBER OF SURGES*** to be applied;

g) set the ***TIME BETWEEN SURGES***;

h) set the desired ***COUPLING MODE*** and ***SURGE POLARITY;***

i) enable/disable ***PHASE SYNCHRONIZATION*** (applying the surge at a specific phase angle of the AC power line);

j) set the ***PHASE SYNCH ANGLE***;

k) ***RUN*** the surge test using the defined surge parameters; and,

l) ***SAVE*** the Surge Setup, so that it can be accessed later from the Quick Access Menu (see section 6.3)

Each of these functions are explained in detail in the following sections.

Illustrated in Figures 16 through 18 are the available menu options for surge output parameters for both the 1.2/50 µs and 10/700 µs Combination Wave Surges, respectively.

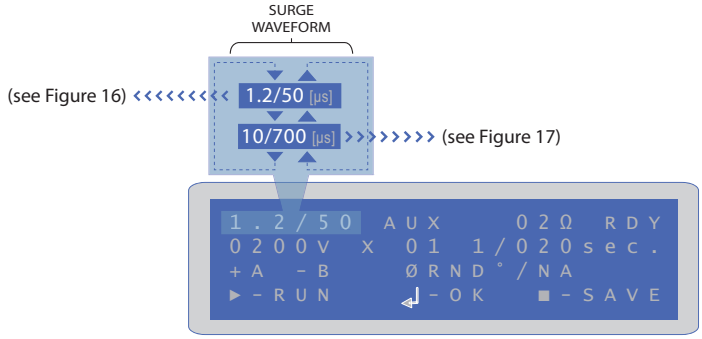


FIGURE 16 - ***Surge Waveform Selection on Surge Setup Menu***

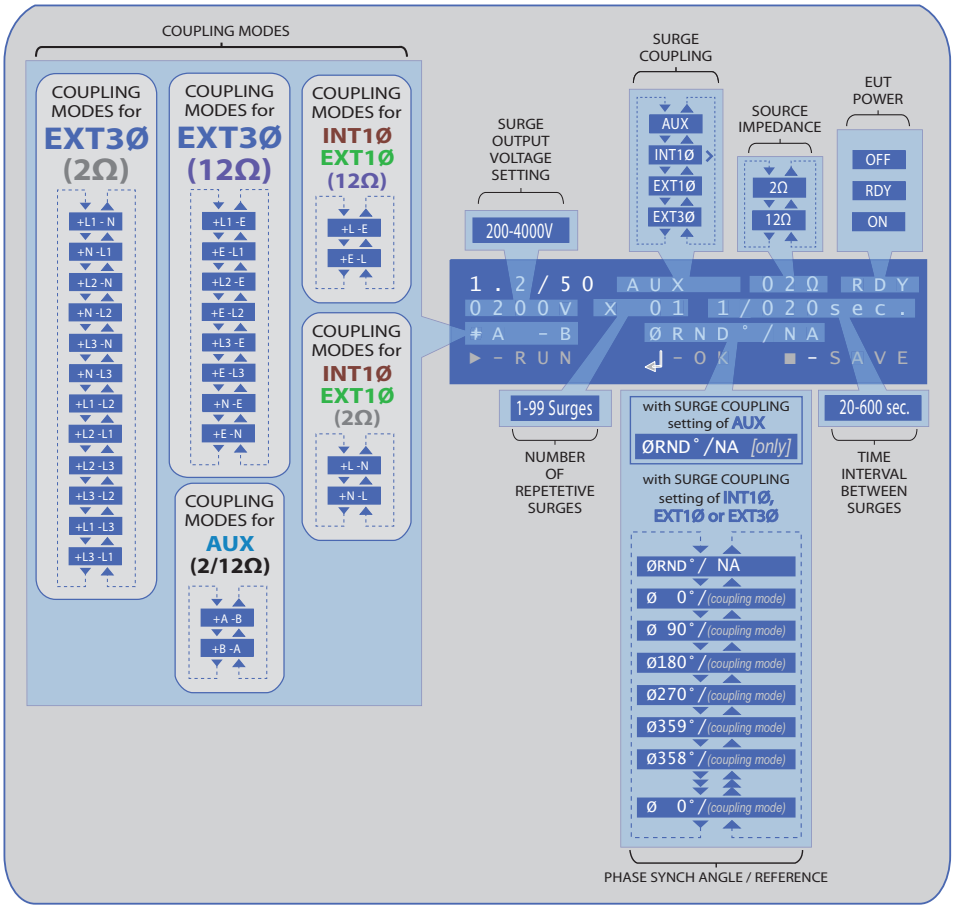


FIGURE 17 - ***Summary of Surge Parameters Options for 1.2/50 µs Wave***

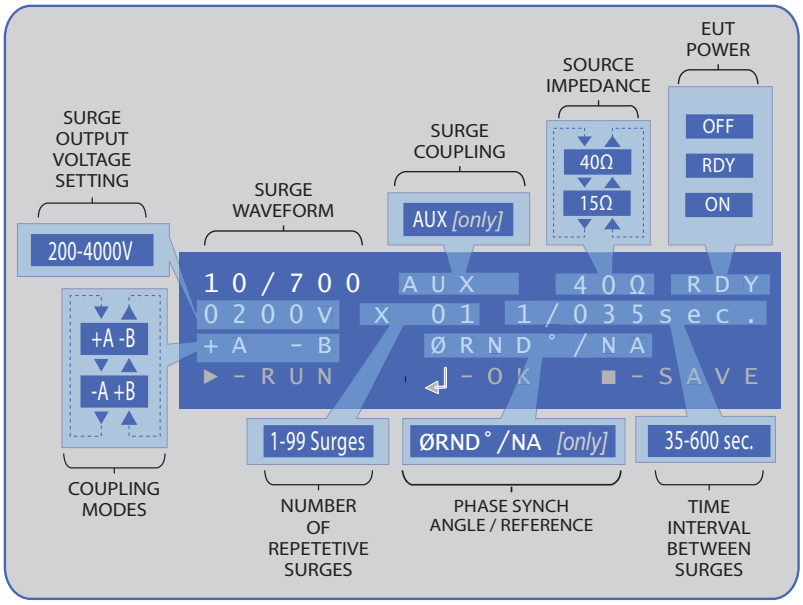
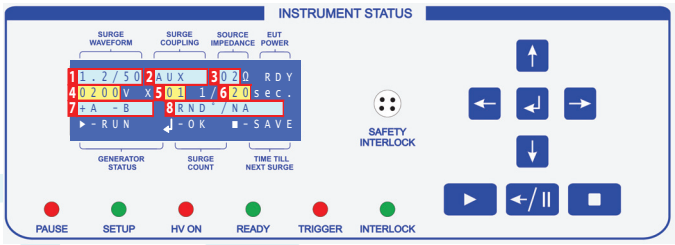


FIGURE 18 - ***Summary of Surge Parameter Options for 10/700 µs Wave***

6.4.1 Surge Setup Menu Navigation/Operation



On the surge setup menu screen, the user has the ability to modify any of the surge parameter fields which are highlighted / highlighted in the diagram to the right using the blue control panel arrow/function buttons located on the front panel, to the right of the display (shown above).

Pressing the ▶ button at any time will begin the test.

Pressing the ■ button at any time will save the current surge setup to memory, which can be accessed at any time by using the QUICK MENU.

6.4.1.1 Menu Navigation

By default, the SURGE WAVEFORM field is selected on this menu. On the above diagram, the fields are numbered in the order of selection. Whenever the ↵ button is depressed, the next field is selected. When the ←/II is depressed, the previous field is selected.

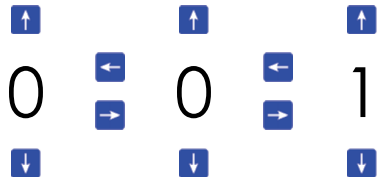
6.4.1.2 Modifying Non-Numeric Surge Parameter Fields

When any highlighted *(non-numeric)* field is selected is selected, the user can scroll through the available options for that field using the ↑ and ↓ buttons. Press the ↵ button once the desired option is selected. This will program your selection, and the next field on the menu will now be selected.

6.4.1.3 Modifying Numeric Surge Parameter Fields

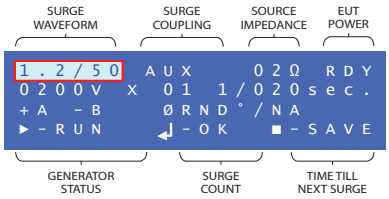
When any highlighted *(numeric)* field is selected, the user can modify the numeric value as shown below:

Use the ↑ ↓ keys to increment/decrement the value of the selected digit (0-9). Use the ← → keys to switch between selected digit as illustrated below.



Press the ↵ button once the desired value is entered. This will program your selection, and the next field on the menu will now be selected.

6.4.2 Surge Setup Menu Items



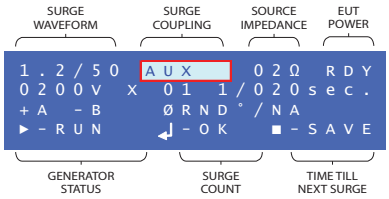
6.4.2.1 Surge Waveform

The SURGE WAVEFORM field contains two defined combination waveforms, as shown below. Use the ↑ ↓ buttons on the front panel to toggle through the available options:

Options	Description
1.2/50	1.2/50 µs, 8/20 µs Combination Wave Surge
10/700	10/700 µs, 5/320 µs Combination Wave

When the desired SURGE WAVEFORM is displayed, press the ↵ button to enter your selection.

6.4.2.2 Surge Coupling

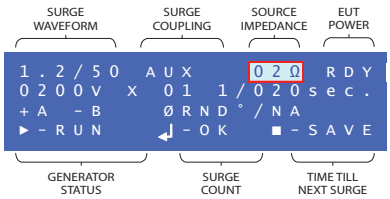


The SURGE COUPLING field allows the user to select the surge output port. Use the ↑ ↓ buttons on the front panel to toggle through the available options:

Options	Description	Availability
AUX	Auxiliary Output Port	1.2/50 & 10/700 Waveforms
INT1Ø	Int. CDN Output Port	1.2/50 Waveform only
EXT1Ø	Ext. 1Ø CDN	1.2/50 Waveform only
EXT3Ø	Ext. 3Ø CDN	1.2/50 Waveform only

When the desired SURGE COUPLING selection is displayed, press the ↵ button to enter your selection.

6.4.2.3 Source Impedance

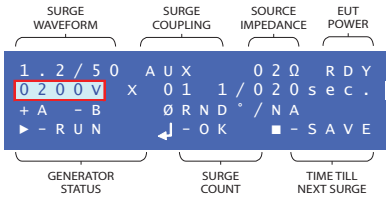


The SOURCE IMPEDANCE field allows the user to select the surge generator output impedance. Use the ↑ ↓ buttons on the front panel to toggle through the available options:

Options	Description	Availability
02Ω	2Ω Source Impedance	1.2/50 Waveform only
12Ω	2Ω+10Ω Source Impedance	1.2/50 Waveform only
40Ω	40Ω Source Impedance	10/700 Waveform only
15Ω	15Ω Source Impedance	10/700 Waveform only

When the desired SURGE COUPLING (output port) is displayed, press the ↵ button to enter your selection.

6.4.2.4 Surge Output Voltage



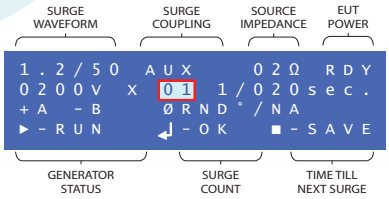
The SURGE OUTPUT VOLTAGE field allows the user to enter the peak voltage of the surge.

The output voltage can be set to any value between **200** and **4000** Volts.

Refer to section 6.4.1.3 for instructions to enter the voltage value.

When the desired SURGE OUTPUT VOLTAGE is displayed, press the ↵ button to enter your selection.

6.4.2.5 Number of Surges



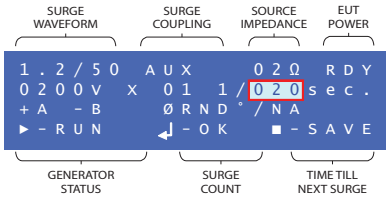
The NUMBER OF SURGES field allows the user to enter the number of times that the surge will be applied.

The number of surges can be set to any value from **1** and **99**.

Refer to section 6.4.1.3 for instructions to enter the number of surges.

When the desired NUMBER OF SURGES is displayed, press the ↵ button to enter your selection.

6.4.2.6 Time Between Surges



The TIME BETWEEN SURGES field allows the user to enter the time interval between consecutive surges.

The minimum time between surges depends on the SURGE WAVEFORM that is selected, due to varying charge times.

For the **1.2/50** waveform, the **minimum time** between surges is **20 seconds**.

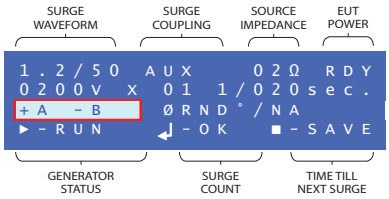
For the **10/700** waveform, the **minimum time** between surges is **35 seconds**.

The **maximum time** between surges for both the **1.2/50** and **10/700** waveforms is **600 seconds**.

Refer to section 6.4.1.3 for instructions to enter the time between surges.

When the desired TIME BETWEEN SURGES is displayed, press the ↵ button to enter your selection.

6.4.2.7 Coupling Mode



The COUPLING MODE field allows the user to select the output port terminals onto which the surge(s) will be applied, as well as the polarity of the surge.

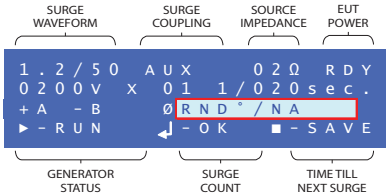
The available options for coupling mode will depend on the surge waveform, output port, and source impedance selections.

Please refer to Figures 17 and 18 for a list of available options in any given scenario.

Use the ↑ ↓ buttons on the front panel to toggle through the available options.

When the desired COUPLING MODE is displayed, press the ↵ button to enter your selection.

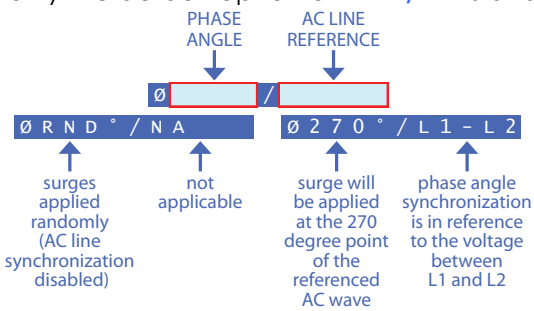
6.4.2.8 Phase Synchronization Angle/Reference



This field allows the user to enable/disable synchronization of the surge to a specific phase angle of the AC power for the lines being surged.

This phase synchronization feature is only available when the SURGE WAVEFORM selected is **1.2/50** and the SURGE COUPLING selection is either **INT1Ø**, **EXT1Ø** or **EXT3Ø**.

If the SURGE COUPLING selection is **AUX** (for either surge waveform), only the default option of **RND°/NA** is available.

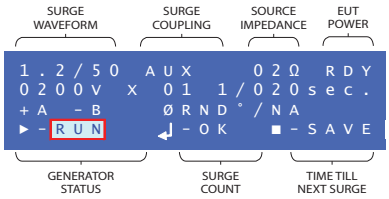


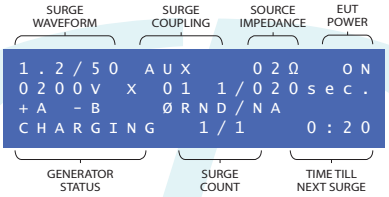
Please refer to Figure 17 for a list of the available options for this field. Use the ↑ ↓ buttons on the front panel to toggle through the available options.

When the desired **PHASE SYNCHRONIZATION ANGLE/REFERENCE** is displayed, press the ↵ button to enter your selection.

6.4.2.9 Run Test

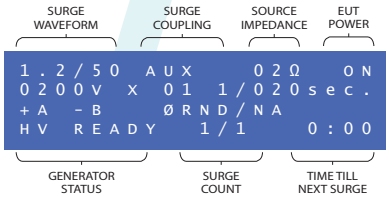
Pressing ▶ at any time on this menu screen will start the test with the presently defined parameters.

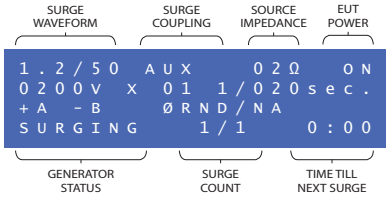




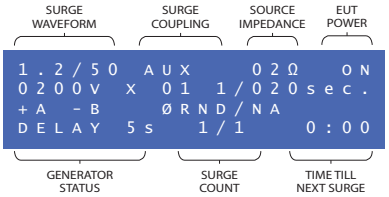
The screen to the left will be displayed while the generator charges. The counter at the bottom right corner will count down to 0:00.

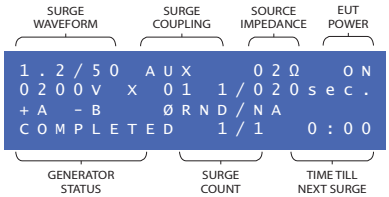
After charging, the following screens will be displayed; the first indicating that the high voltage is ready for discharging, and the second indicating that the surge is being applied.





After the surge has been applied (and assuming that there is only one surge to be applied), there will be a 5 second delay (shown on the screen below), followed by the next screen, indicating completion of the test.





After completion of the test, press the ↵/II button to return to the SURGE SETUP MENU screen.

6.4.2.9.1 Pausing the Test

At any point during the test, pressing the ↵/II key will immediately pause the current process and "PAUSED" will be displayed as the generator status.

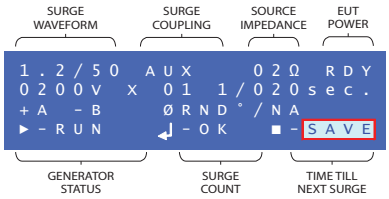
The test will remain paused until the test is resumed by pressing the ▶ key.

6.4.2.9.2 Aborting the Test

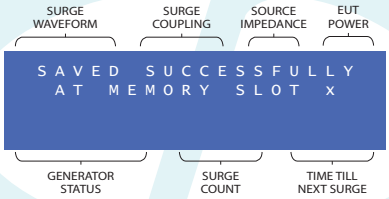
At any point during the test, pressing the ■ key will immediately abort the test process and "ABORTED" will be displayed as the generator status.

After aborting the test, press the ↵/II key to return to the Surge Menu.

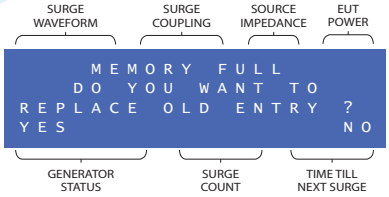
6.4.2.10 Save Test



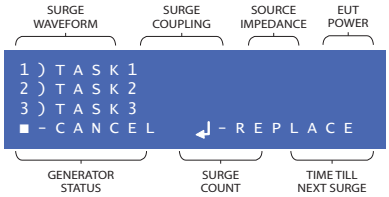
Pressing ■ at any time on the SURGE SETUP MENU screen will save the presently defined parameters into one of the ten available non-volatile memory locations.



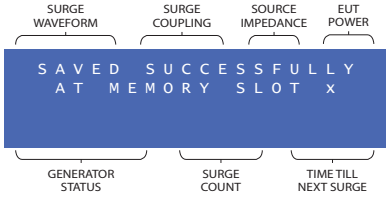
If there is at least one empty memory slot remaining, the screen to the left will be displayed, which will indicate the memory slot into which the surge setup is saved.



If there are no memory slots available, the screen to the right will be displayed. Selecting the NO option will return you to the setup screen without saving. If you select the YES option, the following screen will be displayed:



Use the ↑ ↓ buttons to navigate through the list of previously saved surge setups (TASKS). Press the ■ button to cancel the operation, and you will be returned to the setup screen. Press the ↵ button to select the memory slot to overwrite with the surge setup you are currently saving, and the following message will be displayed:



7.0 *TransWare-645™ Software*

7.1 Main Screen

The layout of the main screen is as shown in Figure 19.

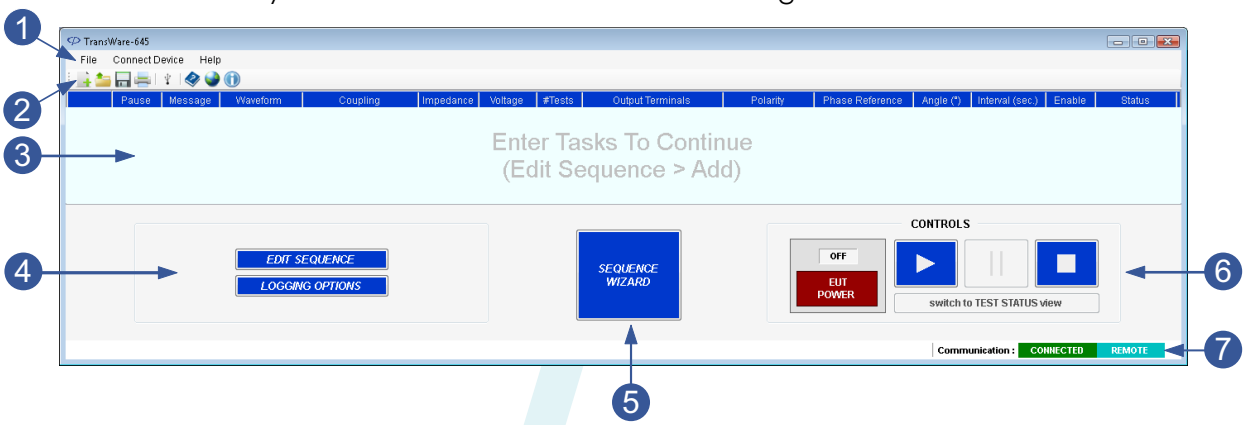


FIGURE 19 - *Main Screen – TransWare-645™ Software*

1. **Menu Bar**
   The menu bar options and respective functionality are discussed in section **7.1.1**.
2. **Tool Bar**
   The tool bar buttons and respective functionality are discussed in section **7.1.2**.
3. **Sequencing Panel**
   The sequencing panel is discussed in detail in section **7.1.3**.
4. **Task Options Panel**
   The task options panel is discussed in detail in section **7.1.4**.
5. **Sequence Wizard**
   It should be noted that this button does not appear on the initial main screen of the software. It appears only after pressing the EDIT SEQUENCE button. The sequence panel is discussed in detail in section **7.1.5**.
6. **Controls Panel**
   The controls panel is discussed in detail in section **7.1.6**.
7. **Remote Connection Status Bar**
   The remote connection status bar is discussed in detail in sections 4.2.2.1 and 7.2.1.2.

7.1.1 Menu Bar

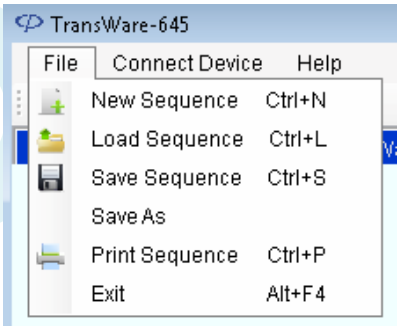
1

The menu bar is occupied by three menus:

1) ***FILE*** menu (refer to section 7.1.1.1)
2) ***CONNECT DEVICE*** menu (refer to section 7.1.1.2)
3) ***HELP*** menu (refer to section 7.1.1.3)

7.1.1.1 File Menu

The ***FILE*** pull-down menu contains the following options:



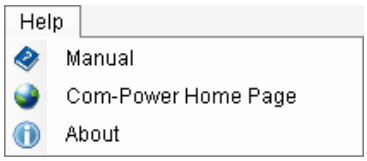
MENU ITEM	DESCRIPTION
New Sequence	Upon creation of a new sequence, *TransWare-645*™ will prompt you to save any active sequence before opening a blank template on which you can create your desired sequence.
Load Sequence	Opens dialog box from which the user can navigate directory system in order to open a previously saved test sequence (with .cpc extension).
Save Sequence	This function re-saves the sequence under the current file name and directory path.
Save As	Opens dialog window from which the user can navigate directory system, assign a file name and save the active test sequence (with .cpc extension).
Print Sequence	Opens the 'print' dialog window, from which the user can print the active test sequence. If the sequence has previously been saved, the file name under which the sequence was saved is used as the title of the sequence table. If the sequence has not been saved, the user is prompted to assign a title for the sequence table.
Exit	After prompting the user to save changes to any active sequence; exits the *TransWare-645*™ software.

7.1.1.2 Connect Device Menu

The ***Connect Device*** option is the only option for this menu.

MENU ITEM	DESCRIPTION
Connect Device	Initiates connection process between computer and SGIEC-645 Surge Generator. The *TransWare-645*™ software will scan the communication ports and engage connection upon recognition of a compatible generator. When the connection has been made, the Communication status at the bottom left corner of the *TransWare-645*™ window will change from: Communication : DISCONNECTED LOCAL to: Communication : CONNECTED REMOTE This indicates that the unit is in its remote operating mode. In this mode, all the front panel controls on the generator itself are disabled, with the exception of the EUT power switch.

7.1.1.3 Help Menu



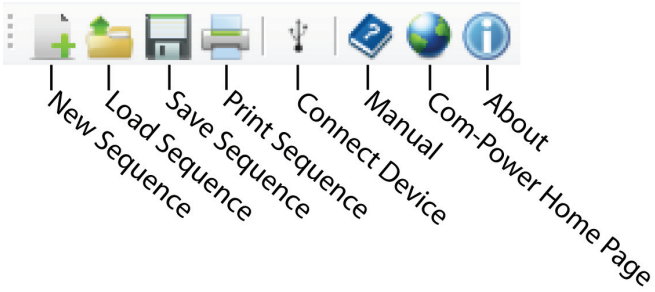
The ***Help*** menu contains the following options:

MENU ITEM	DESCRIPTION
Manual	Opens a pdf copy of the present manual.
Com-Power Home Page	Opens the computer's default internet brower to the following URL: http://www.com-power.com.
About	Opens a small window showing a short description of the *TransWare-645*™ software, including version and copyright information.

7.1.2 Tool Bar

2

The tool bar provides easy-access shortcuts to several commands from the menu bar.



7.1.3 Sequencing Panel

3

The sequencing panel contains all of the individual surge events in the test sequence. If a sequence has not yet been created, the sequencing panel is blank, as shown below.

	Pause	Message	Waveform	Coupling	Impedance	Voltage	#Tests	Output Terminals	Polarity	Phase Reference	Angle (°)	Interval (sec.)	Enable	Status

Enter Tasks To Continue
(Edit Sequence > Add)

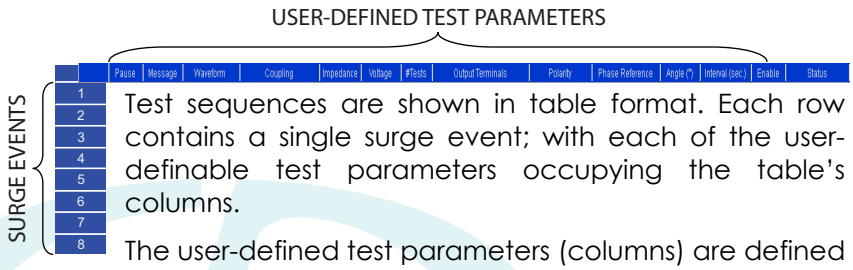
Adding, removing and editing surge events is done using the SEQUENCE EDITING FUNCTIONS, which is accessed by selecting the EDIT SEQUENCE option on the TASK OPTIONS panel (see section 7.1.4). Surge events are displayed in table format as shown below, with each surge event displayed on a single row.

	Pause	Message	Waveform	Coupling	Impedance	Voltage	#Tests	Output Terminals	Polarity	Phase Reference	Angle (°)	Interval (sec.)	Enable	Status
1	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Positive (+)	L-PE	0	60	☑	
2	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Positive (+)	L-PE	0	60	☑	
3	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Negative (-)	L-PE	90	60	☑	
4	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Negative (-)	L-PE	90	60	☑	
5	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Positive (+)	L-PE	180	60	☑	
6	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Positive (+)	L-PE	180	60	☑	
7	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Negative (-)	L-PE	270	60	☑	
▸ 8	☐		1.2 / 50us	Internal 1-Phase	12E	500	5	Internal (L - PE)	Negative (-)	L-PE	270	60	☑	

Each column in the table corresponds to a separate, user-definable test parameter for each surge event. These test parameters are defined in the following section (7.1.3.1).

	Pause	Message	Waveform	Coupling	Impedance	Voltage	#Tests	Output Terminals	Polarity	Phase Reference	Angle (°)	Interval (sec.)	Enable	Status

7.1.3.1 User-defined Surge Test Parameters



Test sequences are shown in table format. Each row contains a single surge event; with each of the user-definable test parameters occupying the table's columns.

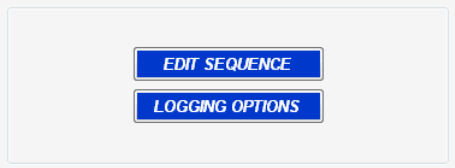
The user-defined test parameters (columns) are defined below:

TEST PARAMETER	DESCRIPTION
Pause	A check in this check box instructs the SGIEC-645 to pause the test prior to that surge event and display a message box with a pre-defined message to the user. Upon acknowledgement of message, the test sequence automatically continues.
Message	This is the message associated with the PAUSE check box. When the PAUSE check box is checked, the message editor automatically opens, enabling the user to either create a new message; or assign an existing message to appear in the message box when the sequence reaches the present surge event. No message can be assigned if the pause box is not checked.
Waveform	This (2) item pull-down menu is used to select the waveform for a given surge event.
Coupling	This (4) item pull-down menu is used to select the surge output port to which the surge will be coupled
Impedance	This (2) item pull-down menu is used to select the source impedance of the surge generator.
Voltage	This is a numeric entry field for setting the open circuit output voltage of the surge event. It may be set to any value between 200V and 4000V.
# Tests	This is a numeric entry field for setting the number of times this surge will be applied.
Output Terminals	This pull-down menu is used to select the specific output port terminals to which the surge(s) will be applied.
Polarity	This (2) item pull-down menu toggles the polarity of the surge between POSITIVE and NEGATIVE.
Phase Reference	This pull-down menu is used to select the phase reference terminals for phase synchronization, or to select RND (random), where no phase synchronization is to be used.

Angle (°)	This is a numeric entry field for setting the phase angle of the AC line at which the surge will be discharged. It may be set to any angle from 0 to 359 degrees; or RND (random/arbitrary) when no phase synchronization is to be used.
Interval (sec.)	This is a numeric entry field for setting the time between surges. It may be set to any value from 20 seconds (for the 1.2/50 waveform); or 35 seconds (for the 10/700 waveform) up to 600 seconds.
Enable	When checked, the present surge event is enabled. When unchecked, the surge event is disabled. Disabled events are skipped during the test.
Status	The status column displays the generator status while the test is running (discharging, charging, waiting, etc.)

7.1.4 Task Options Panel

4



The functions available on the within this panel change depending on which of the two main functions is selected. Initially the TASK OPTIONS panel contains two buttons:

Pressing the ***EDIT SEQUENCE*** button will reveal the SEQUENCE EDITING FUNCTION buttons, used for creating/editing test sequences in the sequencing panel (see section 7.1.4.1); as well as the SEQUENCE WIZARD button, which opens the sequence wizard in a separate window (please refer to section 7.1.5).

Pressing the ***LOGGING OPTIONS*** button will reveal the in-test observation logging (please refer to section 7.1.4.2).

7.1.4.1 Sequence Editing Functions

The sequence editing functions are displayed on the TASK OPTIONS panel after selecting ***EDIT SEQUENCE*** on the TASK OPTIONS menu.

Using these functions, the user can create and edit test sequences displayed in the sequencing panel.

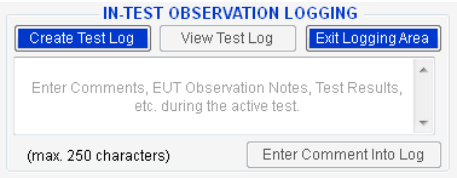
FUNCTION BUTTON	DESCRIPTION
Cut [1]	Cuts (removes) the selected surge events(s) from the sequence. The cut surge event(s) are then kept in the *QUEUE (aka: clipboard)*. [2]
Copy [1]	Copies the selected surge event(s) in the sequence. The copy of the surge event(s) are then kept in the *QUEUE*.
Paste [1]	Pastes the surge event(s) currently in the QUEUE directly above the selected task.
Add	Adds a surge event with default values at the end of the active sequence.
Insert [1]	Inserts a surge event immediately above, and with identical values to, the selected surge event.
Remove [1]	Removes the selected surge event(s) from the sequence.
Move Up [1]	Moves the selected surge event(s) upward by one row in the sequence.
Move Down [1]	Moves the selected surge event(s) downward by one row in the sequence.
Remove All	Removes ALL surge event(s) from the sequence.
Message Editor [3]	Opens the *MESSAGE EDITOR*, where you can edit, delete and assign messages associated with the pause function on the surge event(s).
Done	Exits the *SEQUENCE EDITOR* and returns to the to the *TASK OPTIONS MENU*.

[1] **In order for the CUT, COPY, INSERT, REMOVE, MOVE UP or MOVE DOWN functions to be active, surge event(s) must be selected by clicking the numbered column to the left of the sequence for the desired event(s).**

[2] **The QUEUE is used to temporarily store CUT or COPIED surge event(s) pending a PASTE action. The QUEUE will only store surge event(s) from a single CUT or COPY action. Any item(s) held in the queue prior to an additional CUT or COPY action are discarded.**

[3] **The MESSAGE EDITOR function is only active after selecting the MESSAGE column of any surge event.**

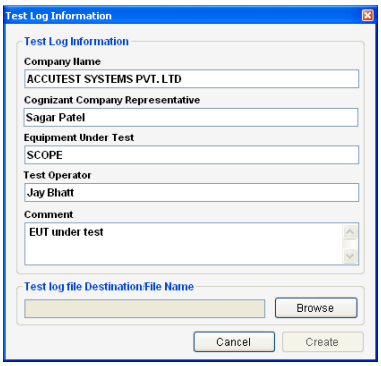
7.1.4.2 Logging Options



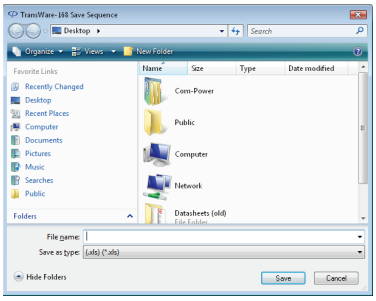
The IN-TEST OBSERVATION LOGGING functions are displayed on the task options panel after selecting ***LOGGING OPTIONS*** on the TASK OPTIONS menu.

Here, the user can create a test log; edit, view, and enter comments into, the test log.

FUNCTION BUTTON	DESCRIPTION
Create Test Log	Opens a form window with fields for Company Name, Cognizant Company Representative, Equipment Under Test, Test Operator, Comment and File Path.



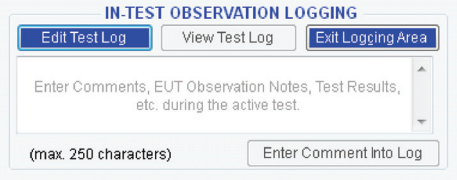
After filling out the form, click the BROWSE button, which will open another window.



In this window, navigate to the desired directory, assign a file name and click save.

Finally, click the CREATE button to finish the process.

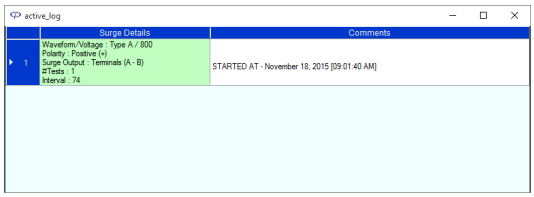
After creating the test log, the IN-TEST OBSERVATION LOGGING functions are as shown to the left and described below.



FUNCTION BUTTON	DESCRIPTION
Edit Test Log	Allows the user to modify the information entered in the test log form fields (Company Name, Cognizant Company Representative, Equipment Under Test, Test Operator, Comment and File Path)

During the test, the IN-TEST OBSERVATION LOGGING functions are as shown to the left and described below.

FUNCTION BUTTON	DESCRIPTION
View Active Test	Opens the active log form displaying entered comments and surge details.



Enter Comments Into Log	Allows the user to enter notes or comments (up to 250 characters) before and/or during the test. The intent of this feature is allow the test engineer to record EUT observations, such as signs of susceptibility, unintended operations, malfunctions, etc., as they occur during the course of the test. Comments are stamped with the exact time/date at which they were entered. The completed test log lists all entered comments chronologically with relation to the corresponding surge event at the time the comment was entered.
Exit Logging Area	Closes the logging functions and returns to the TASK OPTIONS MENU.

7.1.5 Sequence Wizard

5

The sequence wizard is used to quickly and intuitively create all types of surge test sequences; from the most basic sequence with only a few surges to long, complicated sequences with several hundred separate surge events.

The sequence wizard seamlessly incorporates the ability to create sequences based on the most recent changes to the IEC 61000-4-5, as well as sequences based on older versions of the standard.

Shown below is a screen shot of the sequence wizard window:

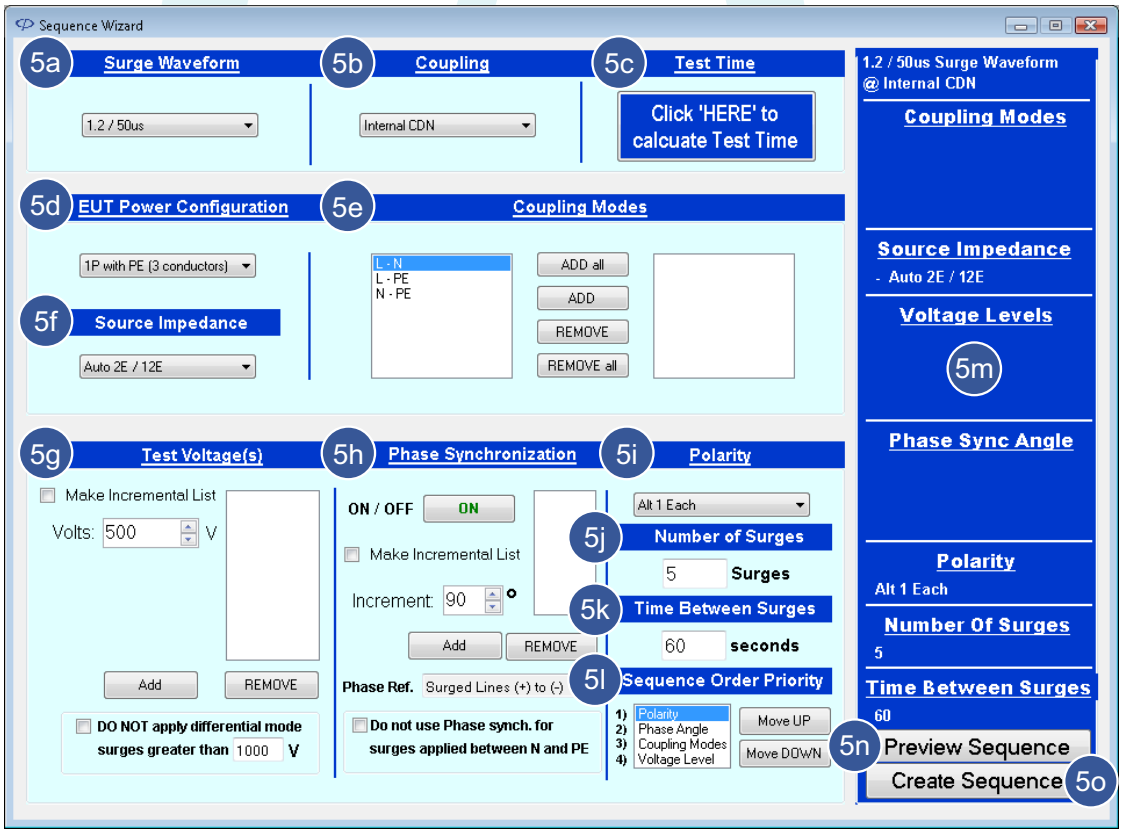
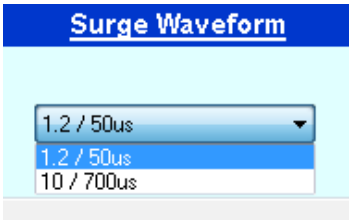


FIGURE 20 - *Sequence Wizard Screen*

Each of the individual functions ***(5a through 5o)***, are described in detail in the following sections, including instructions/guidance.

7.1.5.1 Surge Waveform

5a

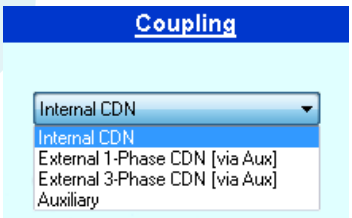


The SURGE WAVEFORM field contains two defined combination waveforms, as shown below. Use the pull-down menu to select the desired waveform from the following options:

Options	Description
1.2/50	1.2/50 µs, 8/20 µs Combination Wave Surge
10/700	10/700 µs, 5/320 µs Combination Wave

7.1.5.2 Coupling

5b

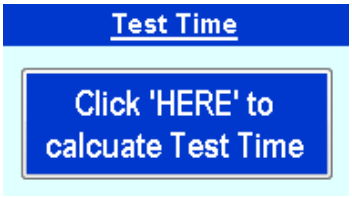


The COUPLING field allows the user to select the surge output port. Use the pull-down menu to select the surge output port (COUPLING) from the following options:

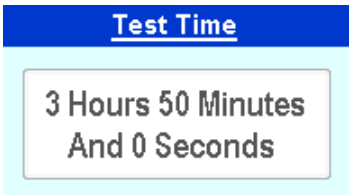
Description	Availability
Internal CDN	**1.2/50** Waveform only
External 1P CDN [via Aux]	**1.2/50** Waveform only
External 3P CDN [via Aux]	**1.2/50** Waveform only
Auxiliary	**1.2/50** or **10/700** Waveforms

7.1.5.3 Test Time

5c

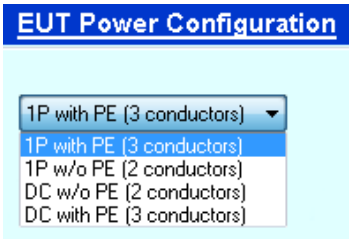


Pressing the "Click 'HERE'…" button at any time will calculate the test time based on the present selections/entries on the wizard screen. Any changes made to to the wizard selections/entries after the test time has been calculated will cause the previously calculated test time to be replaced by the original "Click 'HERE'…" button.



7.1.5.4 EUT Power Configuration

5d



The EUT Power Configuration menu is used to select the type of power system used by the EUT in order to determine the available coupling modes for the test.

The table below summarizes the available options and their availability based on the SURGE WAVEFORM and surge generator output port (COUPLING) selected.

Use the pull-down menu to select the applicable EUT power configuration.

Options	Description	Availability
1 Phase with PE (3 conductors)	Single phase AC power system **WITH** 3rd-wire GND	**1.2/50** Waveform only ***OUTPUT PORTS:*** **-Internal CDN** **-External 1-Phase CDN** [via Aux]
1 Phase w/o PE (2 conductors)	Single phase AC power system **W/O** 3rd-wire GND	
DC w/o PE (2 conductors)	DC power system **W/O** 3rd-wire GND	
DC with PE (3 conductors)	DC power system **WITH** 3rd-wire GND	
3-Phase WYE (5 conductors)	Three phase WYE AC power system (3 Lines, Neutral, GND)	**1.2/50** Waveform only ***OUTPUT PORT:*** **-External 3-Phase CDN** [via Aux]
3-Phase DELTA (4 conductors)	Three phase DELTA AC power system (3 Lines, GND)	
Aux [via A-B]	Auxiliary (A/B) Output Terminals	**1.2/50** *or* **10/700** Waveform ***OUTPUT PORT:*** **Auxiliary**

7.1.5.5 Coupling Modes

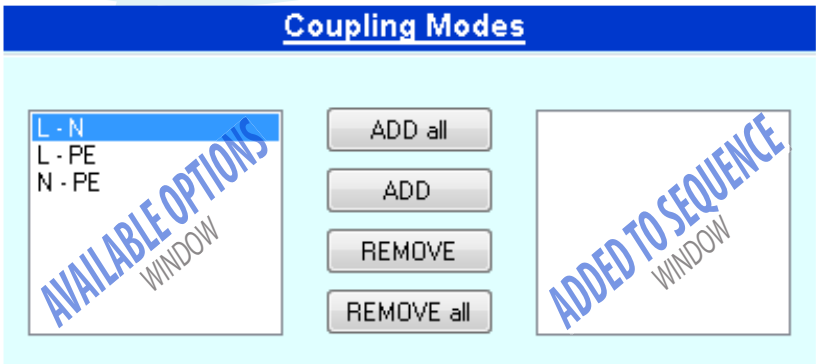
5e

The COUPLING MODES represent the surge generator output port terminals to which the surges will be applied.

The available coupling modes will vary depending on the SURGE WAVEFORM, selected output port (COUPLING) and EUT POWER CONFIGURATION.

Available options are always listed in the window to the left of the add/remove buttons. Please refer to Figures 18 and 19 for a complete list of available coupling modes for any given scenario.

The coupling modes added to the test sequence by the user are displayed in the window to the right of the add/remove buttons.



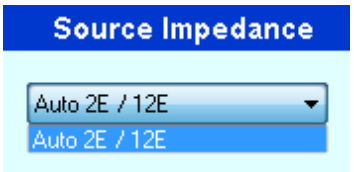
Pressing the **ADD all** button will add all the available coupling modes shown in the left window to the test sequence.

Pressing the **ADD** button will add the selected coupling mode(s) within the left window to the test sequence.

Pressing the **REMOVE** button will remove the selected coupling mode(s) in the right window from the test sequence.

Pressing the **REMOVE all** button will remove all coupling modes listed in the right window from the test sequence.

7.1.5.6 Impedance



5f

The IMPEDANCE pull-down menu allows the user to select the surge generator output impedance.

The table below summarizes the available options and their availability based on the surge generator output port (COUPLING) selected.

Use the pull-down menu to select the surge desired output impedance from the following options:

Options	Description	Availability
2E	2Ω Source Impedance	**1.2/50** Waveform only **Auxiliary** Output only
Auto 2/12E	2Ω Source Impedance *(for Line to Line Surges)* 2Ω+10Ω Source Impedance *(for Line to Ground Surges)*	**1.2/50** Waveform only **ALL** Output Ports *except* **Auxiliary**
40E	40Ω Source Impedance	**10/700** Waveform only **Auxiliary** Output only
15Ω	15Ω Source Impedance	**10/700** Waveform only **Auxiliary** Output only

7.1.5.7 Test Voltage(s)

5g

The test voltage(s) panel allows the user to define the surge test voltage(s) to be included in the sequence.

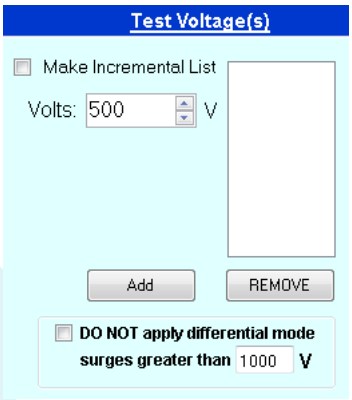
Test voltage(s) can be added one at a time as described in section 7.1.5.7.1.

By checking the "Make Incremental List" checkbox in the TEST VOLTAGE(s) panel, the user is able to define start, stop, step or delta values to define the test voltages for the test as described in section 7.1.5.7.2.

When applying surges to power lines, it is not uncommon to have higher test levels specified for line to ground (common-mode) surges than those specified for line to line (differential mode) surges.

Using the *TransWare-645™* software, this problem can be eliminated by simply checking a checkbox and typing a voltage value. Please refer to section 7.1.5.7.3 for further instructions.

7.1.5.7.1 Creating Test Voltage(s) List from Discrete Values

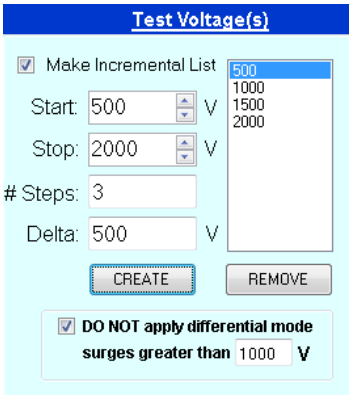


Individual, discrete voltage values can either be typed into the "Volts:" box, or the existing value may be increased/decreased in 50 Volt increments using the up/down arrow buttons on the right side of the box.

Press the **Add** button to add the value to the list box on the right.

Press the **REMOVE** button to remove the selected value from the list box on the right.

7.1.5.7.2 Creating Test Voltage(s) List using an Incremental List



By checking the "Make Incremental List" checkbox, the user may configure incremental lists of test voltages to be applied as part of the surge test sequence.

The start and stop voltages can either be typed into the respective boxes, or the existing value may be increased/decreased in 50 Volt increments using the up/down arrow buttons on the right side of each box.

After defining the start and stop voltages for the list, the user can specify either the number of steps, or the step voltage (delta). If the number of steps is changed, the delta will automatically be recalculated. If the delta is changed, the number of steps will automatically be recalculated.

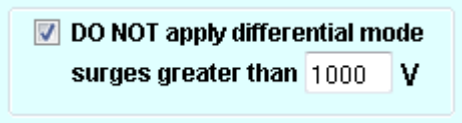
An example of an incremental test voltage list is given in the above illustration.

Press the **CREATE** button to add the incremental list values to the test voltage(s) list.

Press the **REMOVE** button to remove the selected value from the list box on the right.

7.1.5.7.3 Common Mode vs Differential Mode Surge Test Levels

Most product family standards, generic product environment standards, etc., specify higher surge voltage levels for Line to Ground (Common Mode) than those specified for Line to Line (Differential Mode) Surges



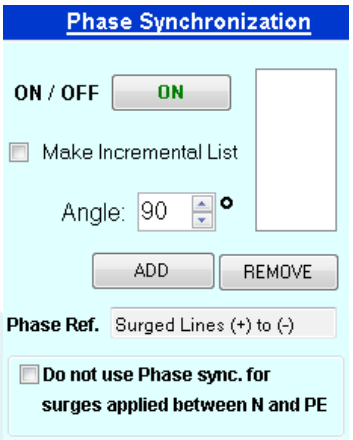
For convenience, rather than having two separate test voltage lists, there is checkbox/entry field at the bottom of the Test Voltages section of the wizard which allows the user to specify the highest surge voltage to be applied in differential mode.

For instance, if the test is to be performed at surge voltages of 0.5, 1 and 2 kV for common mode, but only 0.5 and 1 kV for differential mode; all three voltage values can be added to the list. In order to avoid having the 2 kV surges applied to the differential mode surges, the user can simply check the "***DO NOT apply differential mode surges greater than***", checkbox, and then enter "***1000***" (V) in the associated entry field.

In this scenario, the 0.5 kV and 1 kV surges will be applied for both common mode and differential mode coupling modes, while 2 kV surges will only be applied for common mode surges.

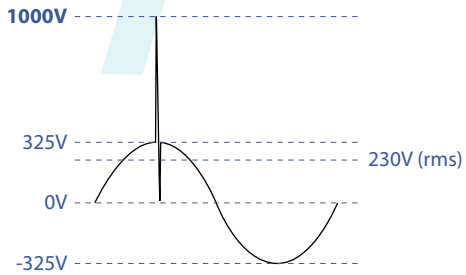
7.1.5.8 Phase Synchronization

5h



Phase synchronization applies only for tests performed using the **1.2/50** surge waveform applied to AC power lines via the internal or external power line CDN.

In these cases, when Phase Synchronization is turned ON, the application of the surges is initiated at the user-specified phase angle (0-359° ±10°) of the referenced lines of the AC power line. For example, a 1 kV surge applied at the 90 degree phase angle of the 230 VAC referenced lines would appear as shown below:



If phase synchronization is turned OFF, the surges are applied arbitrarily, or randomly (RND).

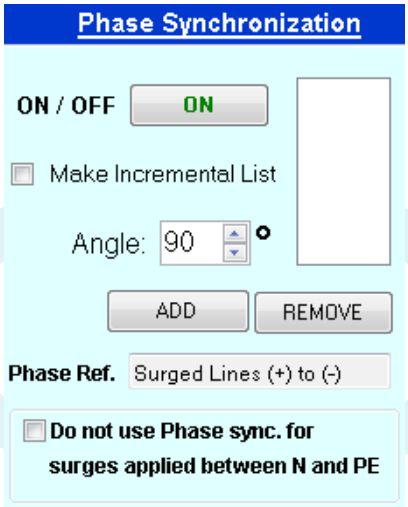
Phase synch angles can be added one angle at a time as described in section 7.1.5.8.1.

By checking the "Make Incremental List" checkbox in the PHASE SYNCHRONIZATION panel, the user is able to create the list of phase angles as described in 7.1.5.8.2.

It is stated in the IEC 61000-4-5, Edition 3.0 standard, that phase synchronization is to be applied for surges applied between Neutral and Earth conductors; which directly contradicts all previous versions of the same standard. Please refer to section 7.1.5.8.3 for instructions and guidance regarding this new policy.

With the exception of Neutral to Earth Surges with phase synch, the AC phase reference for phase synchronization is the voltage between the lines to which the surge is being coupled.

7.1.5.8.1 Creating Phase Angle List using Discrete Values

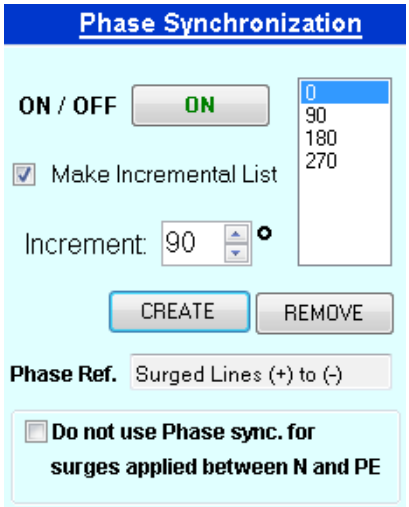


Individual, discrete phase angle values can either be typed into the "Angle:" box, or the existing value may be increased/decreased in 5 degree increments using the up/down arrow buttons on the right side of the box.

Press the **Add** button to add the phase angle value to the list box on the right.

Press the **REMOVE** button to remove the selected phase angle value from the list box on the right.

7.1.5.8.2 Creating Phase Angle List using Incremental List



By checking the "Make Incremental List" checkbox, the user may configure an incremental list of phase angles to be applied as part of the surge test sequence.

The phase angle increment can either be typed into the "Increment:" box, or the existing value may be increased/ decreased in 5 degree increments using the up/down arrow buttons on the right side of each box.

An example of an incremental phase angle list is given in the above illustration. With 90 degrees defined as the increment, the incremental list will include 0, 90, 180 and 270 degree phase angles.

After defining the phase angle increment, press the **CREATE** button to add the incremental list values to the phase angle list on the right.

Press the **REMOVE** button to remove any selected value from the list box on the right.

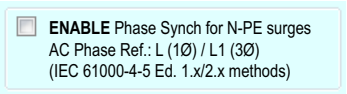
7.1.5.8.3 Phase Synch – N to PE Coupling Mode

In Edition 3.0 of the IEC 61000-4-5 standard, the following paragraph was added pertaining to the phase synchronization requirements when applying surges from Neutral to Protective Earth (N to PE):

"No synchronization is applied in case of absence of mains supply voltage between the coupled lines, e.g. between N and PE in TN-S power distribution systems. In this case, five positive impulses and five negative impulses shall be applied".

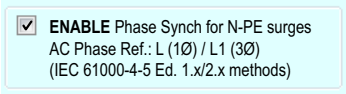
Based on the above, when performing tests according to IEC 61000-4-5, Edition 3.0, no phase synchronization is to be applied for N-PE surges.

Therefore, the checkbox at the bottom of the Phase Synchronization section should remain unchecked.



However, as many product family standards contain dated references to the IEC 61000-4-5 standard, it is sometimes necessary to perform the tests according to the Edition 2.x, or even 1.x of IEC 61000-4-5.

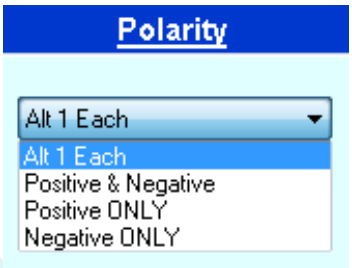
In order to accommodate the previous editions of IEC 61000-4-5, the user can check the checkbox at the bottom of the Phase Synchronization section, which will enable phase synchronization for N-PE surges, using the AC phase reference of the LINE conductor (for single-phase systems); or the LINE 1 conductor (for three-phase systems).



7.1.5.9 Polarity

5i

The POLARITY pull-down menu allows the user to specify the polarity(ies) of each type of surge in the sequence, and/or whether the polarities will alternate sequentially.



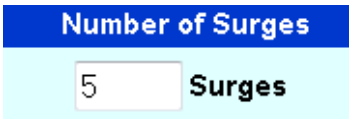
Use the pull-down menu to select the desired polarity option. Each option is defined in the following table:

Options	Description
Alt 1 Each	For any given surge, a single positively polarized surge is applied, subsequently followed by the same surge, negatively polarized
Positive & Negative	Applies both positively and negatively polarized surges of each type, which may or may not occur sequentially in the sequence, depending on the selected Sequence Order Priority (see section 7.1.5.12)
Positive ONLY	Only positively polarized surges will be applied
Negative ONLY	Only negatively polarized surges will be applied

7.1.5.10 Number of Surges

5j

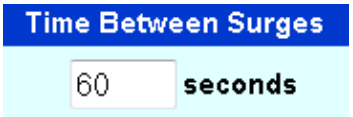
The NUMBER OF SURGES field defines the number of times each surge event will be applied.



If cases where the selected POLARITY option is **Alt 1 Each**; any given event will be applied in pairs; one with positive polarity, followed by one with negative polarity. If the entered Number of Surges is greater than one, this 'pair' of alternating polarity surges will then be repeated successively, until the number of surges has been completed, before proceeding to the next surge event.

The entered value can be any number between 1 and 99. The typical number of surges for tests according to any version of IEC 61000-4-5 is "5".

7.1.5.11 Time Between Surges



5k

The TIME BETWEEN SURGES field defines the time interval between successive surge applications.

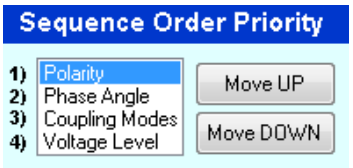
The minimum time between surges depends on the SURGE WAVEFORM that is selected, due to varying charge times.

For the **1.2/50** waveform, the **minimum time** between surges is **20 seconds**.

For the **10/700** waveform, the **minimum time** between surges is **35 seconds**.

The **maximum time** between surges for both the **1.2/50** and **10/700** waveforms is **600 seconds**.

7.1.5.12 Sequence Order Priority



5l

The SEQUENCE ORDER PRIORITY is a dynamic list of surge parameter categories which is used to determine the order of the final test sequence.

The order in which the surge parameter categories are listed may be modified by the user by selecting any one of the four in the list, and using the **MOVE UP** and/or **MOVE DOWN** buttons to move the selected event up or down in the list.

In the following example, the identical test sequence settings were used with four different Sequence Order Priority arrangements in order to illustrate its affects on the order of surge events in the sequence:

example
SURGE SEQUENCE (A)
Sequence Order Priority
1) Polarity
2) Voltage Level
3) Coupling Modes
4) Phase Angle

Coupling Mode	Pola-rity	Voltage Level	Phase Angle (°)
L - PE	(+)	500	0
L - PE	(-)	500	0
L - PE	(+)	1000	0
L - PE	(-)	1000	0
N - PE	(+)	500	0
N - PE	(-)	500	0
N - PE	(+)	1000	0
N - PE	(-)	1000	0
L - PE	(+)	500	90
L - PE	(-)	500	90
L - PE	(+)	1000	90
L - PE	(-)	1000	90
N - PE	(+)	500	90
N - PE	(-)	500	90
N - PE	(+)	1000	90
N - PE	(-)	1000	90

example
SURGE SEQUENCE (B)
Sequence Order Priority
1) Phase Angle
2) Polarity
3) Voltage Level
4) Coupling Mode

Coupling Mode	Pola-rity	Voltage Level	Phase Angle (°)
L - PE	(+)	500	0
L - PE	(+)	500	90
L - PE	(-)	500	0
L - PE	(-)	500	90
L - PE	(+)	1000	0
L - PE	(+)	1000	90
L - PE	(-)	1000	0
L - PE	(-)	1000	90
N - PE	(+)	500	0
N - PE	(+)	500	90
N - PE	(-)	500	0
N - PE	(-)	500	90
N - PE	(+)	1000	0
N - PE	(+)	1000	90
N - PE	(-)	1000	0
N - PE	(-)	1000	90

example
SURGE SEQUENCE (C)
Sequence Order Priority
1) Coupling Mode
2) Phase Angle
3) Polarity
4) Voltage Level

Coupling Mode	Pola-rity	Voltage Level	Phase Angle (°)
L - PE	(+)	500	0
N - PE	(+)	500	0
L - PE	(+)	500	90
N - PE	(+)	500	90
L - PE	(-)	500	0
N - PE	(-)	500	0
L - PE	(-)	500	90
N - PE	(-)	500	90
L - PE	(+)	1000	0
N - PE	(+)	1000	0
L - PE	(+)	1000	90
N - PE	(+)	1000	90
L - PE	(-)	1000	0
N - PE	(-)	1000	0
L - PE	(-)	1000	90
N - PE	(-)	1000	90

example
SURGE SEQUENCE (D)
Sequence Order Priority
1) Voltage Level
2) Coupling Mode
3) Phase Angle
4) Polarity

Coupling Mode	Pola-rity	Voltage Level	Phase Angle (°)
L - PE	(+)	500	0
L - PE	(+)	1000	0
N - PE	(+)	500	0
N - PE	(+)	1000	0
L - PE	(+)	500	90
L - PE	(+)	1000	90
N - PE	(+)	500	90
N - PE	(+)	1000	90
L - PE	(-)	500	0
L - PE	(-)	1000	0
N - PE	(-)	500	0
N - PE	(-)	1000	0
L - PE	(-)	500	90
L - PE	(-)	1000	90
N - PE	(-)	500	90
N - PE	(-)	1000	90

first priority
second priority
third priority
fourth priority

L-PE = **LINE (L)** - live [hot] conductor of EUT power input plug *to* **PROTECTIVE EARTH (PE)** - 3rd-wire ground conductor of EUT power input plug

N-PE = **NEUTRAL (N)** - return conductor of EUT power input plug *to* **PROTECTIVE EARTH (PE)** - 3rd-wire ground conductor of EUT power input plug

In Example SURGE SEQUENCE (A), for example, POLARITY is the first priority; therefore, the surge polarity will change after each surge event.

In the same example (A), VOLTAGE LEVEL is the second priority; therefore, the voltage level parameter will be the second item that will change. In this case, the voltage level changes after each (+)/(-) polarity. The coupling mode and/or phase angle will not change until each polarity and each voltage level has has been applied for the present coupling mode/phase angle.

The COUPLING MODE in the same example (A) is the third priority. Only after exhausting all possible polarities and voltage levels for the first coupling mode, the coupling mode will then change to the next coupling mode (assuming another exists).

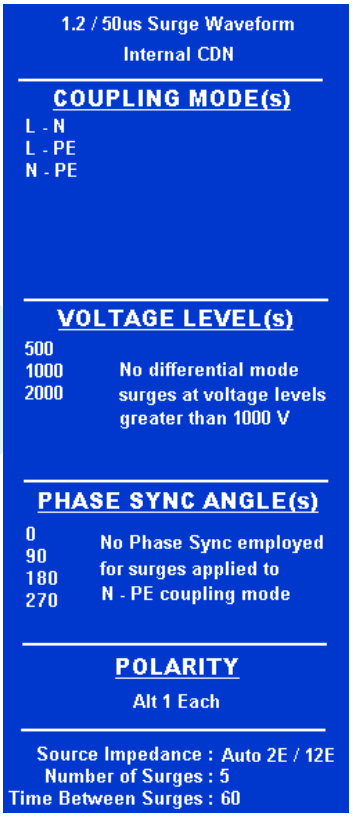
And finally, for the same example (A) the fourth priority is the Phase Angle. Only after exhausting all possible polarities, voltage levels and coupling modes, the phase angle will then change to the next available setting (assuming another exists).

In examples (B) through (D), the same test sequence is re-ordered using the respective SURGE ORDER PRIORITIES listed at the top of each example.

7.1.5.13 Sequence Wizard Surge Parameter Summary

5m

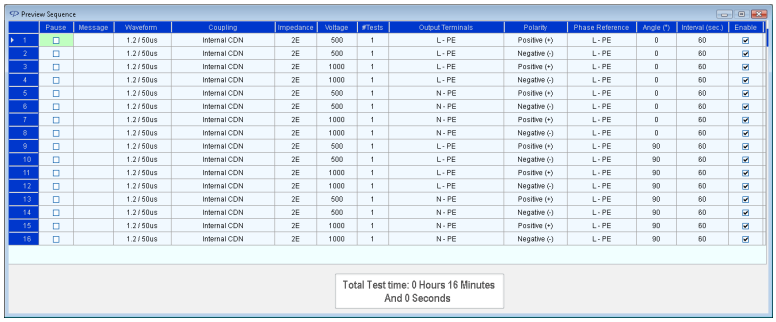
The sequence wizard surge parameter summary, shown with a blue background and white text on the right side of the sequence wizard, summarizes all of the present surge parameters settings for the present sequence.



7.1.5.14 Preview Sequence Button

5n

The PREVIEW SEQUENCE button creates a tabular preview of the present settings in the sequence wizard, similar to the sequencing panel (section 7.1.3). An example of the sequence preview is shown below:



Preview Sequence

	Pause	Message	Waveform	Coupling	Impedance	Voltage	#Tests	Output Terminals	Polarity	Phase Reference	Angle (°)	Interval (sec.)	Enable
1	☐		1.2 / 50us	Internal CDN	2E	500	1	L - PE	Positive (+)	L - PE	0	60	☑
2	☐		1.2 / 50us	Internal CDN	2E	500	1	L - PE	Negative (-)	L - PE	0	60	☑
3	☐		1.2 / 50us	Internal CDN	2E	1000	1	L - PE	Positive (+)	L - PE	0	60	☑
4	☐		1.2 / 50us	Internal CDN	2E	1000	1	L - PE	Negative (-)	L - PE	0	60	☑
5	☐		1.2 / 50us	Internal CDN	2E	500	1	N - PE	Positive (+)	L - PE	0	60	☑
6	☐		1.2 / 50us	Internal CDN	2E	500	1	N - PE	Negative (-)	L - PE	0	60	☑
7	☐		1.2 / 50us	Internal CDN	2E	1000	1	N - PE	Positive (+)	L - PE	0	60	☑
8	☐		1.2 / 50us	Internal CDN	2E	1000	1	N - PE	Negative (-)	L - PE	0	60	☑
9	☐		1.2 / 50us	Internal CDN	2E	500	1	L - PE	Positive (+)	L - PE	90	60	☑
10	☐		1.2 / 50us	Internal CDN	2E	500	1	L - PE	Negative (-)	L - PE	90	60	☑
11	☐		1.2 / 50us	Internal CDN	2E	1000	1	L - PE	Positive (+)	L - PE	90	60	☑
12	☐		1.2 / 50us	Internal CDN	2E	1000	1	L - PE	Negative (-)	L - PE	90	60	☑
13	☐		1.2 / 50us	Internal CDN	2E	500	1	N - PE	Positive (+)	L - PE	90	60	☑
14	☐		1.2 / 50us	Internal CDN	2E	500	1	N - PE	Negative (-)	L - PE	90	60	☑
15	☐		1.2 / 50us	Internal CDN	2E	1000	1	N - PE	Positive (+)	L - PE	90	60	☑
16	☐		1.2 / 50us	Internal CDN	2E	1000	1	N - PE	Negative (-)	L - PE	90	60	☑

Total Test time: 0 Hours 16 Minutes And 0 Seconds

7.1.5.15 Create Sequence Button

5o

The CREATE SEQUENCE button completes the sequence wizard operation and inserts the entire sequence into the sequencing panel (see section 7.1.3).

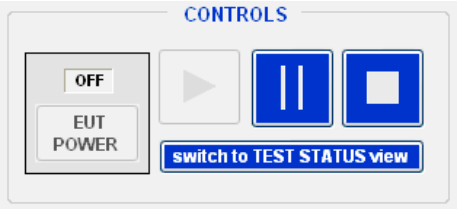
7.1.6 Controls Panel

6

The *CONTROLS* panel is used to toggle EUT power and to start, pause and/or abort the surge test. Prior to starting the test, the controls area appears as shown to the right, and as described below.

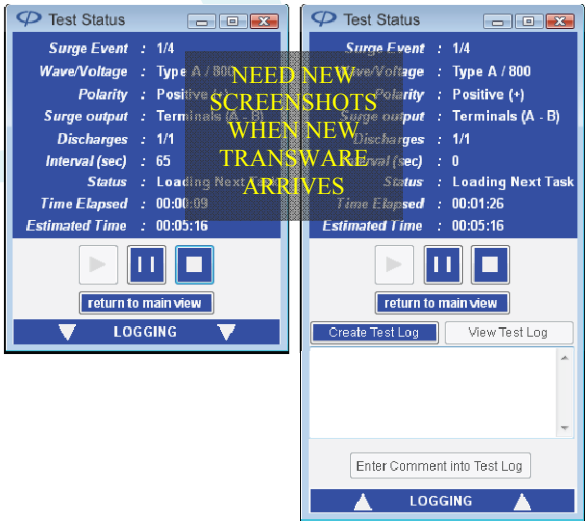
FUNCTION BUTTON	DESCRIPTION
	The EUT power button enables/disables the EUT power output on the internal CDN. The EUT power switches on the rear and front panels of the SGIEC-645 must also be in the 'ON' position in order to enable EUT power. Refer to section 4.1.2 for more information.
	The PLAY button begins the test by Initiating the active test sequence.

While the test is running, the CONTROLS panel appears as shown to the right, and as described below.



MENU ITEM	DESCRIPTION
	The PAUSE button pauses the active test. To resume the test from the point at which the test was paused, press the ▶ button again.
	The STOP button aborts the active test. Test cannot be resumed after aborting.

Changes the *TransWare-645*™ window to a smaller, compacted, repositionable window, while still providing access to all of the in-test features available with the larger window. This window will remain in front of all other open windows, enabling the user to work with other applications on the computer, while still monitoring the progression of the surge test. Logging functions are contained on a retractable logging subpanel of the TEST STATUS window, as shown below.



7.1.7 Remote Connection Status Bar

7

Please refer to sections 4.2.2.1 and 7.1.1.2.

8.0 Warranty

Com-Power warrants to its Customers that the products it manufactures will be free from defects in materials and workmanship for a period of three (3) years. This warranty shall not apply to:

- Transport damages during shipment from your plant.
- Damages due to poor packaging.
- Products operated outside their specifications.
- Products Improperly maintained or modified.
- Consumable items such as fuses, power cords, cables, etc.
- Normal wear
- Calibration
- Products shipped outside the United States without the prior knowlege of Com-Power.

In addition, Com-Power shall not be obliged to provide service under this warranty to repair damage resulting from attempts to install, repair, service or modify the instrument by personnel other than Com-Power service representatives.

Under no circumstances does Com-Power recognize or assume liability for any loss, damage or expense arising, either directly or indirectly, from the use or handling of this product, or any inability to use this product separately or in combination with any other equipment.

When requesting warranty services, it is recommended that the original packaging material be used for shipping. Damage due to improper packaging will void warranty.

If you feel that the product is not working as intended, or is malfunctioning, please contact Com-Power for assistance. If the product must be returned to Com-Power, a Return Merchandise Authorization (RMA) number will be supplied to you. The RMA number should be displayed in a prominent location on the packaging and on the product, along with a description of the problem, and your contact information.