M5

Universal Surge Generator™

OPERATOR'S MANUAL

Compliance Design Inc.
593 Massachusetts Avenue
Boxborough, MA 01719
~~(508)~~ 264-4668
978-

© Compliance Design Inc. 1996

LIMITED WARRANTY

Compliance Design Incorporated warrants that its products, at the time of delivery, are free from defects of workmanship and material under normal use and service. CDI reserves a right, at its exclusive option, to replace or repair, in its own factory, any articles which are disclosed to CDI's satisfaction to be defective within one year of delivery. Transportation charges to CDI's factory shall be prepaid by the buyer.

THIS WARRANTY IS EXPRESSED IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY AND/OR ANY AND ALL OBLIGATIONS OR LIABILITIES. CDI NEITHER ASSUMES NOR AUTHORIZES ANY OTHER PERSON TO ACT AS AGENT FOR CDI OR TO ASSUME ANY OTHER LIABILITIES IN CONNECTION WITH DELIVERY OF THIS PRODUCT.

This warranty is limited to 90 days on out-of-warranty repairs and shall not apply to any products which have been repaired or altered by the buyer, or which have been misused or subjected to neglect or accident.

Table of Contents

CAUTION

In its operation, this equipment unavoidably produces hazardous voltages and currents at its outputs. Hazardous voltages are conventionally defined as any voltages greater than 42.5 volts at 5 milliamps. Hazardous currents are conventionally defined as those associated with outputs greater than 200VA or 20 joules at more than two volts. This equipment can be a source of 115 volts or 220 volts at up to 10 amps. Further, it is a source of a variety of surge waveforms at energies of hundreds of joules. These include pulses of up to 10 kV and up to 5000 amps.

Because of these hazards, certain cautions should be observed. Among these are those listed below.

- This device uses a grounded three wire plug. It must be attached to a grounded three wire electrical outlet. Furthermore, use only extension cords which are rated 15 amps or greater, three wire, and are NRTL listed or CSA certified.
- Do not expose this equipment to excessively moist environments or to sources of dripping water.
- Should sparking, erratic operation or fumes be observed in association with the equipment, the equipment should be disconnected from the AC power source and Compliance Design should be notified.
- There are no user serviceable parts in this equipment. Refer all servicing to Compliance Design Incorporated.
- This equipment should never be used by other than trained personnel. It should not be used if the personnel are subject to heart or neurological conditions.
- Surge testing should be done only in areas dedicated solely to that purpose. The boundaries of these areas should be clearly marked and care should be taken to ensure that the equipment under test and all equipment involved are within the assigned areas. Any equipment or materials which are not involved in the testing should be removed from the area and thought should be given to the possibility that a surge may arc over to circuits or exposed metals that were not intended to be surged. Enclosing the EUT in a barrier with separation from the floor will provide additional protection in a test area. The barrier must be safe for test voltages in excess of twice the applied surge voltage.
- Use of rubber floor mats provides additional protection and is recommended.
- In organizing the test area, one should consider the possibility of fire or explosion of the EUT under surge. Take precautions such as having fire extinguishers ready and removing combustible material from the site. Personnel should never remain in line of sight of open circuit boards under test as these components will often fail explosively scattering fragments throughout the test area. Use of goggles is mandatory.

- Only qualified personnel who are aware of the hazards involved should perform surge tests. These hazards include accidental discharge of the surge generator, the repercussions of flashover to an unfavorable circuit and the possibility of charge being trapped in the EUT as well as the consequence of violent component failure.

- For continued protection from fire or shock, replace fuses only with the same type and rating of fuse.

- The Simultaneous Transient Couplers (STCs) have associated plugins which must be used only in the STC for which they were designed and they must also be used only with their corresponding M5 plugin type, i.e. STC-5 10x1000 plugin with the M5 10x1000 plugin. Use with another plugin other than a matching one could result in catastrophic equipment failure.

I. Introduction

The M5 Universal Surge Generator™ is designed to be adaptable, yet precise. Front panel plug-ins allow the device to be used for a variety of surge testing applications including standards such as FCC Part 68, Canadian IC CS-03, Bellcore Standard GR-CORE-1089, IEEE/ANSI C62.41, and IEC1000-4-5(801-5). The surge creation is controlled via front panel switches using a softkey menu structure on the front panel LCD display.

Some standards, such as those that simulate transients on telephone lines are applied directly to the load. Others such as those that simulate transients on AC power lines require coupling the surge across a power source. Powered testing of the latter type is considerably more complex, and because of that considerable detail has been supplied in this manual on power line transient testing.

The sections that follow describe the test set up to be used, the use and design of the M5 Universal Surge Generator, the use and design of the 3CN single/three phase coupling network, monitoring of the resultant waveform using the TWM5, and remote computer control of the entire system with CDI's Surge Command™ Windows[1] based software.

II. Safety Considerations and Setting Up a Test Lab

Several considerations must be attended to prior to testing equipment. These include ensuring the safety of personnel, monitoring equipment under test, and the planning of the surge testing itself.

Safety First!

The currents and voltages associated with surge testing can be hazardous. Surge testing should only be done in areas dedicated solely to that purpose. The boundaries of these areas should be clearly marked, and care should be taken to ensure that the EUT and all equipment involved in the testing are within the assigned area. Any equipment or materials which are not involved in the testing should be removed from the area, and thought should be given to the possibility that a surge may arc over to circuits or exposed metals that were not intended to be surged. Enclosing the EUT in a barrier with separation from the floor will provide additional protection in the test area. The barrier must be safe for test voltages in excess of twice the applied surge voltage.

Further safeguards include standing on rubber floor mats and powering the surge equipment through ground fault interrupters. In organizing a test area one should also consider the possibility of fire or explosion of the EUT under surge. Taking such precautions as having fire extinguishers nearby and removing combustible materials

[1] Windows is a trademark of Microsoft Corporation.

is advisable. Personnel should never remain in line of sight of open circuit boards under test as components on these boards will often fail explosively, scattering fragments throughout the test area.

Only qualified personnel, who are aware of the hazards involved should perform the surge tests. Hazards include accidental discharge of the surge generator, the repercussions of a flashover to an unfavorable circuit, the possibility of a charge being trapped in the EUT, or the consequences of a violent component failure.

Choosing The Right Test For Your Product

Another consideration before implementation of surge testing involves selecting the proper test for the EUT under examination. All surge testing is performed with the goal of determining the surge withstand capability of a system or piece of equipment. The American National Standards Institute and IEEE have developed a guide outlining the important considerations for surge testing.

One first must decide what the purpose of the testing will be. What information do you wish to obtain by surging the EUT? Do you wish to learn its limits, whether or not it is compliant with relevant specifications, or do you wish to reproduce conditions that caused a unit to fail in the field? Each of these represent a valid reason for testing, and each requires a different approach.

A manufacturer might need to test for operating limits, for compliance with specifications, and for consistency of results, whereas a certifier would not need to conduct a production test. The manufacturer and the user should both be concerned with testing of an EUT should it fail while in service. The objective in this case would be to recreate the event that caused the failure and redesign or retrofit the equipment to give it sufficient protection in the future. In any case, the purpose of the test, the expected outcome, and the acceptance criteria should be clearly defined prior to conducting the tests.

AC Line Transient Testing -- Powered And Unpowered Testing

Surge tests may be applied directly to the load, or in the case of AC line transients, across the AC line. Note that a unit may be surged powered or unpowered. Unpowered testing is usually done when the susceptibility of the EUT is not in question and "power follow" is not a problem. This type of test is often performed as a preliminary test to powered testing for design and diagnostic purposes. An outcome of an unpowered test might be a clearance flashover of a device in a circuit. Powered testing of an EUT should be performed when one desires to determine the changes in logic or software performance due to the surge or when one is interested in the vulnerability related to a power follow.

AC Line Transient Testing -- Phase Angle And Power Follow

Power-follow is defined by ANSI as the current from the connected power source that flows following the passage of discharge current. It occurs as follows: An arc is triggered somewhere during the AC cycle. This arc then causes a conductive path. The AC current continues to flow in this path, maintaining the arc until the AC cycle ends. It is this AC power follow that continues to supply energy after the surge, causing arcing faults, insulation tracking, and printed circuit board trace destruction. Consequently, some surge-related failures of equipment depend on the phase of the AC voltage cycle at which the surge is applied. This explains the need for varying the phase during surge application, as the length of time to the next AC zero crossing determines the amount of energy delivered due to power follow. Varying phase angle can be done in several ways. Usually, the surge is applied several times randomly with respect to phase. This would simulate the incidence of "real world" events. The M5 Universal Surge Generator is equipped to test in that mode. For scientific analysis, the phase angle can be precisely controlled using the menu options.

Power follow may occur for any period of time less than one half cycle unless damage to the system results in a continuing short. This is not enough time for a fuse or circuit breaker to trip and so the amount of current is limited by the impedance of the backfilter. This impedance is caused by the inductance of the backfilter and the resistance of the wire. In the field, power follow fault currents are a function of the inductance and resistance of the building's wiring and may exhibit currents of hundreds of amps. The backfilters supplied by Compliance Design have been carefully tailored to minimize backfilter resistance and inductance, while still performing their filtering functions in order to permit high fault currents to flow during power follow. The backfilters are discussed in more detail elsewhere in this manual.

AC Transient Testing -- Coupling Modes

Another consideration involves the choice of coupling modes. These are selected in the M5 menu software and automatically executed by the coupler/backfilter. On single phase systems, this will usually involve surges between line and neutral (differential or "normal" mode), neutral and ground, line and ground, or line and neutral to ground (common modes). There will be cases when a grounding conductor is not present, and a surge may be applied only between line and neutral.

ANSI/IEEE C62.45-1987 describes these coupling requirements. The ANSI standard states that for a given number of power supply lines, there are a specific number of ways that a test surge should be applied. Recommended coupling modes for three phase lines are shown in Table 1.

Coupling Modes to be Explored						
				Low		
High		Line 1	Line 2	Line 3	Neutral	Protective Earth
Line 1			X	X	X	X
Line 2				X	X	X
Line 3					X	X
Neutral						X
Protective Earth						

TABLE 1

III. System Setup

A. Equipment List

The following is a list of accessories which are supplied with main catalogue items you may have purchased to complete your system. To use this list find the main catalogue item on the numbered line and confirm that you have received the accessories for that item. Any shortages should be reported promptly to Compliance Design Inc.

1. M5 Universal Surge Generator
   - IEC power cord
   - 18" backfilter/TWM coupling cable
   - 36" flying leads with separate alligator clip ends
   - 1 Surge Command 3.5" diskette

2. 3CN Single/Three Phase Backfilter (optional)
   - IEC power cord
   - 1 male amphenol connector
   - 1 female amphenol connector
   - 1 25pin-25pin 6' cable

3. TWM5 Transient Waveform Monitor (optional)

B. Installation

1. Unpack all components of your system and check for damage. Save all shipping packaging in a safe place as you may need it to return the equipment for calibration or repair.

2. Inventory your system components to insure that you received everything that you ordered. Report shortages to CDI.

3. Choose a location for the installation carefully. Read the cautions in this manual and ANSI c62.45.

4. Set up the equipment in a manner convenient for the style of testing you wish to conduct. Typical basic configurations consist of the 3CN on the bottom, the M5 in the middle and the TWM5 on top. If your system has one or more Simultaneous Transient Couplers (STC), it is recommended that these be swapped in on top as required.

5. If the system contains a 3CN coupler, connect the ground stud on the rear panel to a known good ground through a 12 gage or larger wire.

6. Connect the system cables. Plug the AC powered units into mains outlets insuring that the voltage is set correctly on the AC mains inlet. If the system has a 3CN, attach it to the M5 with the 25pin cable provided in the back and the amphenol terminated high voltage cable in the front.

7. Wire the backfilter amphenol connectors for the type of AC power you will be supplying to your EUT. The AC power should be wired so that it comes in through the front panel EUT power inlet on the left side of the 3CN and out the right side front panel EUT Power Outlet connector. Note that the EUT Power Outlet connector on the Backfilter has two interlock pins which must be connected together by the user supplied interlock loop in order for surge testing to be performed. See the more detailed backfilter section for the pin out of the backfilter connectors.

8. If a PC is to be added to the system for computer control, follow the detailed instructions in the hardware and software installation instructions later in this manual.

IV. The M5 Universal Surge Generator and Components

A. Using the M5 Universal Surge Generator System

The M5 Universal Surge Generator has been designed to supply a wide variety of surge transients. Prior to operating the equipment, one should familiarize oneself with the features of the M5 Universal Surge Generator. Refer to Figure 1.

In Manual mode the main screen of the M5 contains all the information about the currently programmed surge including surge type, peak open circuit voltage, polarity, phase, and coupling mode. From this menu the user can choose to execute that surge by pressing F1. Provided the interlocks are satisfied, the M5 will then charge to the programmed voltage and execute the surge without further user intervention. If the interlocks become violated during the charge cycle the M5 will automatically reset to the wait state. If the user desires to perform a surge other than that programmed in, the user can press F2 to access a menu structure which allows all parameters but plugin type to be changed. In order to change plugin type the user must physically remove the front panel waveshape plugin and replace it with the desired plugin.

A large red EMERGENCY STOP button on the front panel shuts the M5 down when pressed. In order to reactivate the M5 it is necessary to twist this button so that it returns to the out position.

The surge energy exits the M5 on pins A&B of the HV output connector. An interlock is provided on Pins D&E. In order for the M5 to process a surge, pins D&E must be connected together. The purpose of this interlock is to facilitate the development by the user of a user protected test area. An enclosure should be built to house the EUT. The enclosure should only be accessible to people through a door which is wired to the interlock circuitry in such a way as to disable the M5 surge capability whenever it is possible for people to come into contact with surge carrying wires or the EUT itself. Usually parts of the enclosure are transparent to allow for observation of the EUT. A Normally Open magnetic switch wired in series with the interlock circuitry and affixed to the enclosure door and frame such that the switch is activated when the door is closed and deactivated when the door is open is usually sufficient for enclosures small enough that people cannot remain inside when the door is closed. For larger enclosures a policy of locking and tagging out the interlock similar to the OSHA procedure for working on primary circuits should be adopted. The interlock should never be completed while it is possible for a person to come into contact with the surge outputs or the EUT itself. If you have any questions as to how this may be accomplished for your particular situation, please contact CDI.

The 3CN is considered to be an appropriate termination for the M5 and the interlock is satisfied as long as the M5 and 3CN are connected through the high voltage cable provided and the AC mains inlet of the 3CN is loaded with a cable which has the interlock loop configured as described in the backfilter section of this manual.

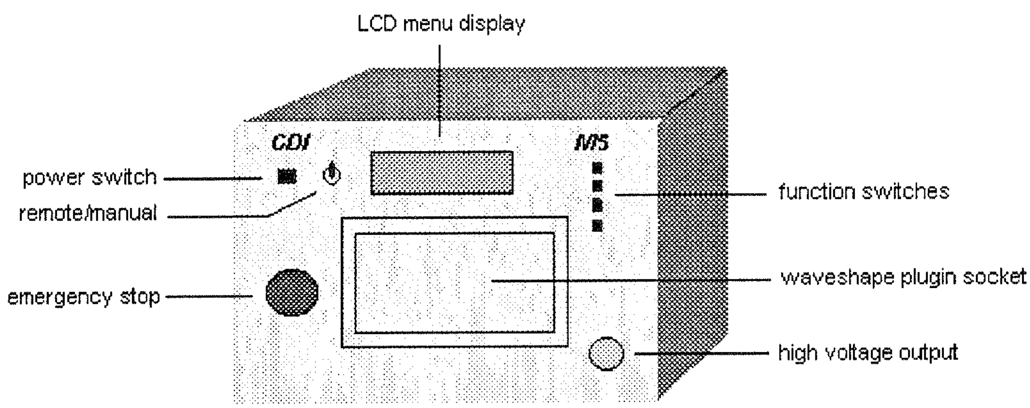


FIGURE 1: The M5 Universal Surge Generator™

WARNING: Do not operate unattended.

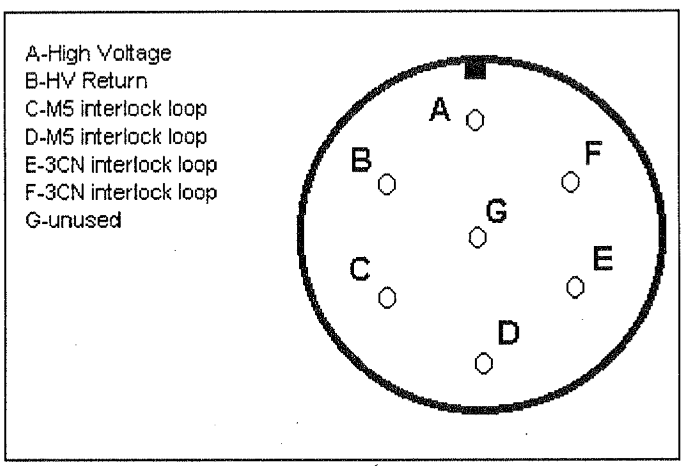


FIGURE 24: Pin out of the M5 High Voltage Output Connector

Surge Generator Specifications

Instrument Supply: 115V or 230 Vac, +15%/-20% 50/60 Hz, 750 Watts approx.

Type Of Pulses: Most single event lightning or switching pulses

Polarity: Positive & Negative

Pulse Outputs: Floating

Controls: Full manual front panel controls. All functions controlled via PC with the Surge Command™ expert software.

Automation System Requirements: 386 IBM compatible PC with windows operating system

Interface: Serial, RS 232C(Com 1)

Program Menu/Profile: Report
Test
File handling
Technical help

EUT Failure: Stop or continue mode

Test Reports: Automatic recording of test setup and test results with user-definable header and boilerplate.

Safety Interlock: Hardware and software safety interlocks included

Mechanical: Width: 17.7"
Height: 12.2"
Depth: 15.5"
Weight: Approx: 25kg

Ordering Information:

M5: Modular surge generator mainframe which allows testing to IEC, Bellcore, ANSI, UL, and virtually any other single event, lightning surge produced with appropriate plugin modules

Optional Accessories:

TWM-5: Transient Waveform Monitor

3CN: Single/Three phase Backfilter (270V/20A)

STC-5: Simultaneous transient coupler for bellcore multiple output surges

MLCDN-5: Multiline coupling device for data cables.

Specifications for Plug-ins

Each plug-in you receive from Compliance Design will have its own accompanying specifications sheet. Careful attention must be given to this information in order to avoid damage to the equipment or possible destruction of the plug-in. In particular, these specifications are the maximum charge voltage, the maximum D.C. current sink, and the maximum line voltage with which a plug-in should be used. This last value will be 240VAC in most cases.

C. *Understanding The M5 Universal Surge Generator*

The core of the surge generator consists of a High Voltage power supply, an energy storage capacitor, a high voltage discharge relay, and waveshaping components contained in the waveshape plugins. To create a surge the microprocessor controller causes the high voltage power supply to charge the energy storage capacitor to a predetermined value. Once the required energy is present in the capacitor the microcontroller activates the high voltage relay and the energy contained in the capacitor is released into the waveshaping network and a controlled surge is metered to the High Voltage Output connector. The microcontroller automatically senses the type of plugin waveshaping network inserted into the M5 and adjusts the charging parameters accordingly. Once the surge is generated, the remaining issue is to examine how it is applied to the EUT. For AC/DC powered EUTs where the surge is to be applied to the power port or terminals, the surge is coupled through the 3CN to the EUT. The 3CN performs three functions: 1) It prevents the surge energy from traveling back up the AC/DC mains toward potentially vulnerable parallel connected equipment, 2) It allows AC/DC power to flow through to the EUT, 3) It protects the waveshaping components of the M5 from the heating effects of the steady-state AC/DC mains voltage.

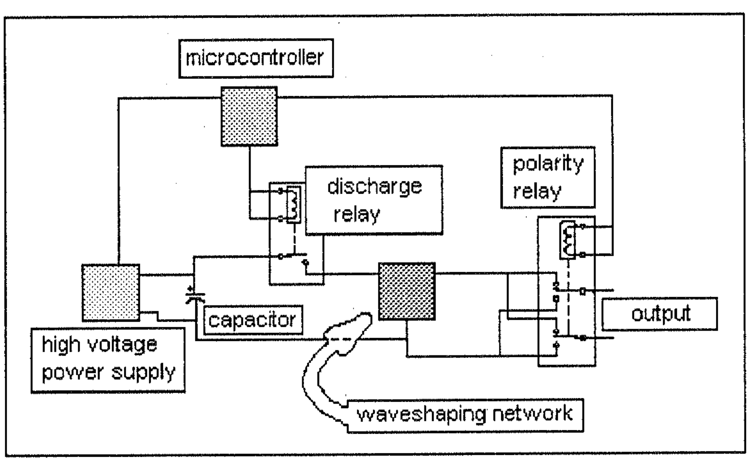


FIGURE 3: Block diagram of the M5 Universal Surge Generator™

D. *Using the 3CN Single/Three Phase Couping Network/Backfilter*

In some applications, the output of a surge generator has to be coupled to an AC load. This means bridging the waveform across the AC source supplying power to the load. A coupling means has to be utilized which allows the pulse to be transmitted to the load in an uninhibited fashion while still permitting the equipment under test to operate. Further, the pulse should neither be transmitted back to the supply mains nor should hooking a surge generator across the supply mains create a safety hazard. All these considerations make the design of the coupling mode a more complex endeavor than it would at first seem.

The coupling unit should be set up to simulate at least 4 types of surges on single phase lines and up to 10 types of surges on three phase lines. This would be the differential (or normal mode) surge between phase and neutral plus three common mode surges; phase to earthground, neutral to earthground and phase plus neutral to earthground. The circuitry of Figure 4 & 5 schematically accomplishes this.

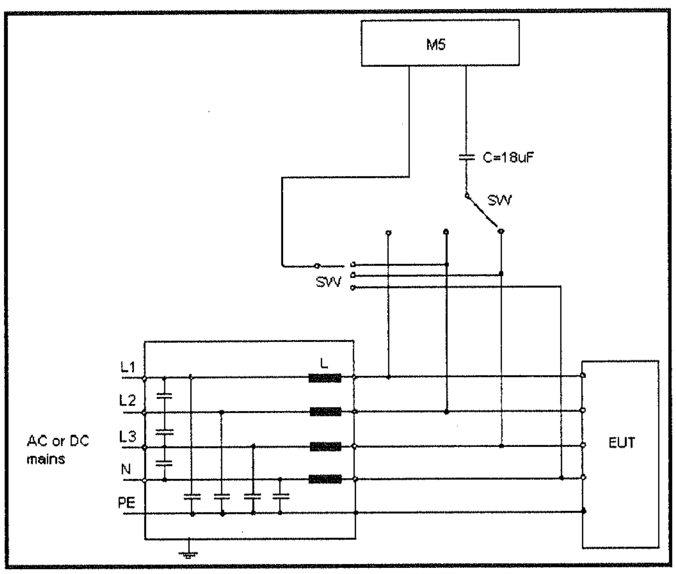


FIGURE 4: Schematic diagram of differential mode coupling.

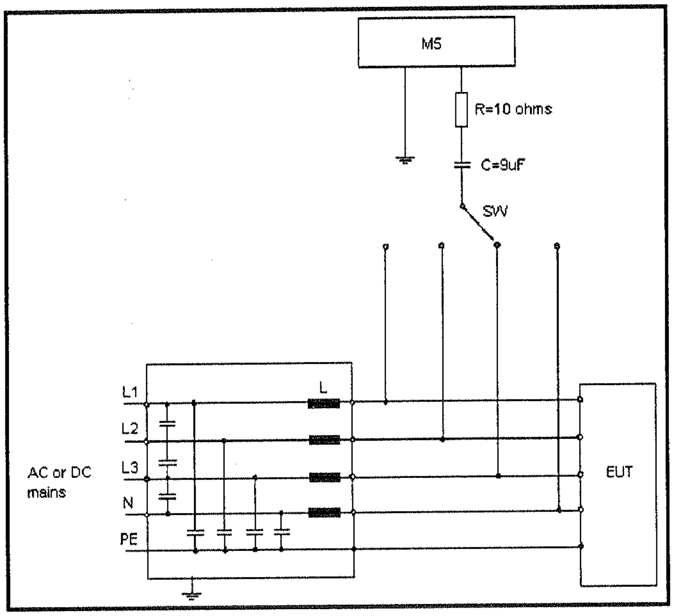


FIGURE 5: Schematic diagram of common mode coupling.

The first consideration which faces the designer is the size of the coupling capacitors. In selecting these, the dominant consideration is the impedance of the capacitor during short circuit waveforms. A 15-20uF capacitor has become standard in the industry.

There are other considerations which affect the design of the backfilter. The surge itself could cause components in the EUT to arc over, causing a momentary short of the AC line. The amount of current that flows immediately upon such an event is limited only by the impedance of the AC line itself. The circuit breaker in the service panel or EUT will not fire initially and, therefore, there is no current limiting other than the resistance of the wires themselves. The amount of "power follow" current which flows can be on the order of hundreds of amps. The design of the backfilter therefore, must not add significantly to the impedance of these wires. This constrains the design of the two inductors and limits their value.

The following describes the functions of the 3CN Single/Three Phase Coupling Network/Backfilter with reference to Figure 6.

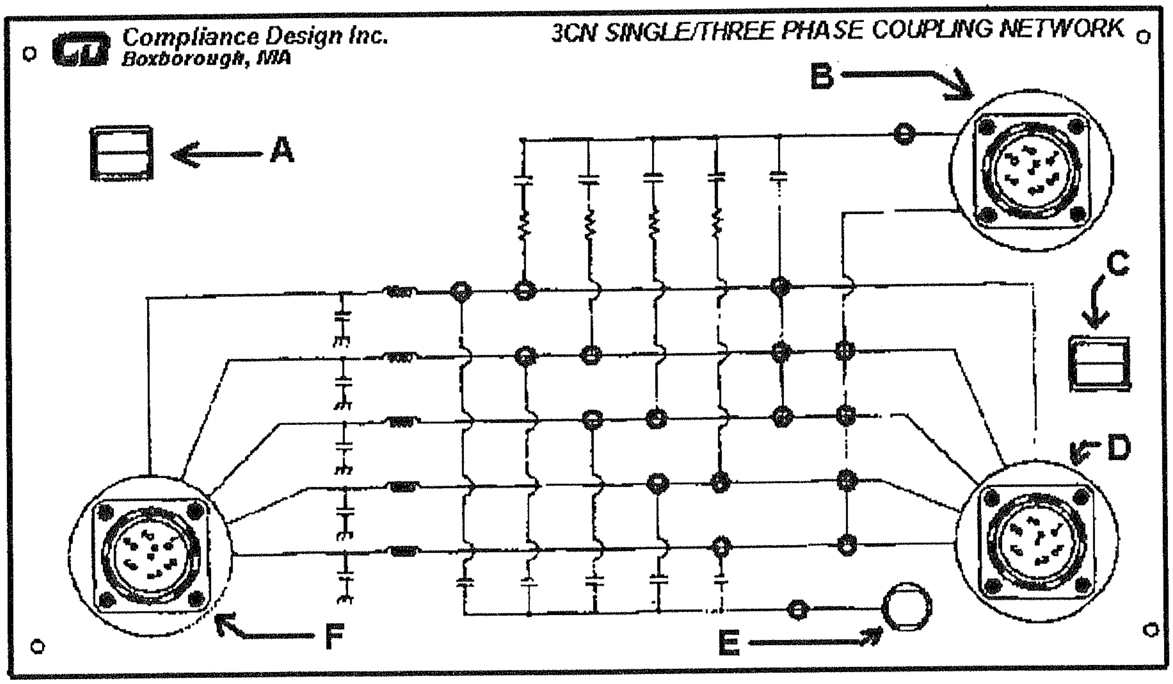


Figure 6: 3CN Coupling Network/Backfilter Front Panel

A) **Power Switch:** this switch controls the power to the unit's internal circuitry. In order for power and/or surges to be applied to the EUT, this switch must be on.

B) **Surge Input Connector:** This connector is the conduit for surges produced by the M5 surge generator. Using the cable provided the user should connect this to the M5 surge output connector.

C) **EUT Power Switch:** This switch controls the AC/DC power to the EUT.

D) **EUT Power Outlet:** The EUT is powered from this outlet and receives its mains surges/EFT bursts from this port.

E) **EFT/B Input Connector:** This connector is the conduit for the EFT bursts produced by the EFT generator. When appropriate the user should connect this port to the **COAX** output of the EFT generator.

F) **EUT Power Inlet Connector:** The external EUT power source (typically the AC mains) are connected to this port. (270V/20A)

Theory Of Operation

The 3CN allows for easy flexible coupling of power to a variety of EUTs. Mains power for the EUT enters through the EUT power inlet and is passed through a filter network to the EUT power outlet. An EUT power switch on the front panel allows the user to interrupt lines 1-3 and Neutral at will. See table 2 for a recommended connection configuration for single and three phase systems. Connections can be altered by the user to a certain degree, but the PE or protective earth line should not be used for anything other than Earth Ground.

3CN Recommended Connection Diagram for AC/DC mains						
Single Phase Systems						
Line	Pin A					
Neutral	Pin D					
Earth	Pin E					
Three Phase Systems						
Line 1	Pin A					
Line 2	Pin B					
Line 3	Pin C					
Neutral	Pin D					
Earth	Pin E					

Table 2: Recommended connections for mains circuits.

The surge or EFT disturbance is injected onto the mains circuitry between the inlet and the outlet. The internal filter components confine the transient energy to the EUT outlet and prevent it from propagating out through the power inlet to the rest of the parallel connected AC/DC mains circuitry in the world at large. With the appropriate computer control the 3CN may be used as a backfilter for the EFT as well. Computer control applied through the M5 is required in this case in order to configure the 3CN for the proper application of the EFT pulses. Computer control is not required for operation with the M5 as the M5's on-board microprocessor is equipped to control the 3CN standalone.

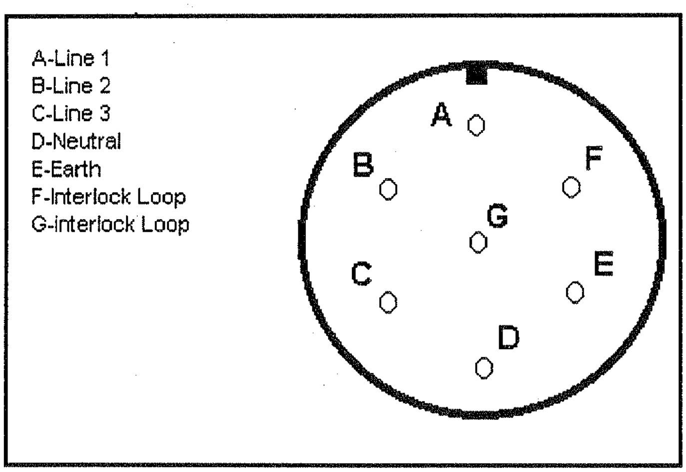


FIGURE 7: Pin out of the 3CN EUT Mains Outlet

E. Monitoring The Waveform

As part of your analysis, you may want to monitor the voltage and current waveforms produced during testing. At which point you choose to monitor these waveforms will depend on the data you wish to gather, however, any waveform monitoring requires the use of the optional Transient Waveform Monitor. Compliance Design has developed a monitor which is quite useful as a diagnostic tool when monitoring the voltages and currents resulting from an incident transient. It can be used to measure the effectiveness of surge protection devices, to monitor transients at various points in an EUT, or simply to confirm or calibrate the waveforms being generated by the M5 and the associated plug-ins. See section VII for more information on the transient waveform monitor.

F. Testing Procedure

Here is a checklist to be used to perform a typical test:

1. ☐ Connect both Surge Generator and, if utilized, the Backfilter to the AC power socket.

2. ☐ Connect High Voltage interconnect cord to the load, or between Surge Generator output and Backfilter surge input.

3. ☐ If the Backfilter is used, plug EUT into Backfilter front panel EUT power outlet connector.

4. ☐ If the Backfilter is used, select testing mode for either powered or unpowered test with the EUT power switch.

5. ☐ Seal the EUT containment enclosure to prevent personnel access and insure that the interlock mechanism is engaged.

6. ☐ Select the plug-in depending on your test requirements. NOTE: All plug-ins must be in place or the interlocks will not permit operation.

7. ☐ Select the polarity for positive or negative testing depending on your test requirements.

8. ☐ Select CONTROL for either manual or external modes depending on your test requirements. For external mode, the SURGE COMMAND™ software must be installed on your computer and the M5 attached to the computer's serial port.

9. ☐ If the Backfilter is used, select the coupling mode with the M5 menu or in Surge Command software for either the desired coupling mode depending on your test requirements.

10. ☐ Check to see that test area is free from additional equipment not related to the testing.

11. ☐ Turn on the power for the Surge Generator and, if utilized, the Backfilter.

12. ☐ Push the "perform surge" button. In the top level menu on the M5 this will be the F1 key. Once the desired peak open circuit voltage is reached release the M5 will automatically apply the surge to the Equipment Under Test. Typically charging will take less than 30 seconds, but certain specially high energy plugins may take up to several minutes to achieve full charge.

13. ☐ Observe the effect on the EUT.

14. ☐ Repeat applicable steps for the number of repetitions required for your application.

15. ☐ Turn off the Backfilter. Disconnect the EUT from the Surge Generator or the Backfilter.

V. Additional Options

Compliance Design provides a host of options which can be utilized with the M5 Universal Surge Generator. These include additional waveform plug-ins, additional backfilters, a Transient Waveform Monitor, and a computer based control system.

Additional waveforms are available through Compliance Design. The following list is comprised of a number of commonly requested plug-ins, and CDI has the ability to design plug-ins for many individual needs. Simply fax your requirements in to us, and we will quote your specific waveform.

Most commonly requested Plugins							
Open Circuit Voltage			*Short Circuit Current*			Type	
peak	front	fall	peak	front	fall		
V	uS	uS	A	uS	uS		
1500	10	160	200	10	160	Pt 68	
800	10	560	100	10	560	Pt 68	
2500	2	10	1000	2	10	Pt 68	
5000	2	10	1000	2	10	Bellcore	
2500	2	10	500	2	10	Bellcore	
5000	2	10	500	2	10	Bellcore	
1000	10	360	100	10	360	Bellcore	
600	10	1000	100	10	1000	Bellcore	
1000	10	1000	100	10	1000	Bellcore	
6000	1.2	50	3000	8	20	1000-4-5	
5000	10	700	125	10	370	1000-4-5	
6000	100kHz ring wave		200			ANSI c62.41	
6000	100kHz ring wave		500			ANSI c62.41	

In addition, the Surge Generator is compatible with a variety of backfilters. Available are backfilters for higher power applications.

When designing for transient immunity, our Transient Waveform Monitor may be found useful. This device allows the user to safely monitor transient voltages and currents at virtually any location in the surge testing environment. The monitor has proven to be particularly useful in situations where the transient passing through a surge suppressing device is of interest. Contact Compliance Design for details on any of these products.

VI. Phase Control

Some devices are sensitive to the placement of the surge in time with respect to the AC mains phase angle. For example, a device could be quite immune to surges which occur during the AC line zero crossing and also be subject to severe damage if the surge occurs as the AC line is approaching 90 degrees. The M5 has two discrete modes of operation. In the random mode, the surge is supplied irrespective of the phase of the AC line. It is reasonable to expect that a large number of surges will give good confidence in an EUTs performance as they would be randomly scattered across the cycle of the AC line. A more reasoned approach is allowed in the M5's phase controlled mode. In this mode the user selects the phase angle during which the surge is applied. If the EUT response is known, then a single worst case phase angle could be selected for all the testing. Otherwise the user should select some reasonable phase increment such as 45 degrees and test over the entire AC cycle. As this can be tedious, the user is directed to the use of a computer to automate the incremental application of the surges.

AC Line Transient Testing - Phase Angle and Power Follow

Power follow is defined by ANSI as the current from the connected power source that flows following the passage of discharge current. It occurs as follows: An arc is triggered somewhere during the AC cycle. This arc then causes a conductive path. The AC current continues to flow in this path, maintaining the arc until the AC cycle ends. It is this AC power follow that continues to supply energy after the surge, causing arcing faults, insulation tracking, and printed circuit board trace destruction. Consequently, some surge-related failures of equipment depend on the phase of the AC voltage cycle at which the surge is applied. This explains the need for varying the phase during surge application, as the length of time to the next AC zero crossing determines the amount of energy delivered due to power follow. Varying phase angle can be done in several ways. Usually, the surge is applied several times randomly with respect to phase. This would stimulate the incidence of "real world" events. For scientific analysis, the phase angle can be precisely controlled by the M5. Synching to the AC line is accomplished in either an external or internal mode. In Internal mode (selected with the M5 rear panel switch) the M5 uses it's own mains power line as the source for the phase information. In External mode, phase information is sensed from the power connector located next to the switch. Any power up to 270VAC may be connected to this AC sense port. Power follow may occur for any period of time less than one half cycle unless damage to the system results in a continuing short. This is not enough time for a fuse or circuit breaker to trip and so the amount of current is limited by the impedance of the backfilter. This impedance is caused by the inductance of the backfilter and the resistance of the wire. In the field, power follow fault currents are a function of the inductance and resistance of the building's wiring and may exhibit currents of hundreds of amps. The backfilters supplied by Compliance Design have been carefully tailored to minimize backfilter resistance and inductance, while still performing its filtering function in order to permit high fault currents to flow during power follow.

VII. The Transient Waveform Monitor

A. Introduction

The Transient Waveform Monitor is designed to allow precise monitoring of voltage and current transients wherever they might occur. While many owners will utilize the Transient Waveform Monitor simply to verify the open circuit and short circuit waveforms produced by their M5 Universal Surge Generator, others will find the Transient Waveform Monitor to be an invaluable diagnostic aid in developing an effective surge suppression program. The Transient Waveform Monitor's unique design allows it to be inserted into any part of the system making up the EUT allowing for easy monitoring of surge impressed currents and voltages.

In order to facilitate voltage monitoring, differential mode outputs are made available while measurements of current are converted to a voltage for easy observation. This permits the utilization of a standard oscilloscope (preferably digital storage) with standard probes to monitor the voltage and current waveshapes.

B. Operation of the Transient Waveform Monitor

As part of your analysis performed during testing you will want to monitor the voltage and current waveforms produced to verify their accuracy. The Transient Waveform Monitor (TWM5) allows you to easily complete this task.

Two cables are used to facilitate this monitoring. The high voltage cable previously described for connecting the backfilter to the M5 is used to connect the TWM5 to the M5 for verification of the surge waveshapes. For diagnostic testing another cable with alligator clip terminations is supplied.

Voltage Monitoring

In order to facilitate voltage monitoring differential mode measurements are made. Connect the two voltage test points to be measured to the voltage input port of the Transient Waveform Monitor.

!WARNING!

Before making any connections be sure the M5, backfilter, and entire test system is powered down. Surge testing obviously produces hazardous voltages and the constant voltages present in the EUT such as the AC power voltage may also be hazardous.

!WARNING!

Do not connect the Transient Waveform Monitor voltage inputs across steady-state voltage potentials in excess of 240VAC or 240VDC either differentially or to ground.

The Transient Waveform Monitor will measure the voltage differential between the two voltage monitoring points to which it is attached in the EUT subsystem. It will divide this voltage by a factor of 1000 and present the information as a differential voltage between the BNC output ports. In order to measure this voltage connect these BNC output ports to channel 1 and channel 2 respectively of your wideband scope. Utilize the scope in the mode which permits channel 2 to be subtracted from channel 1.

Current Waveform Monitoring

Transient Waveform Monitor provides the user with a single ended voltage which represents the current which is passed through the Transient Waveform Monitor. This signal must be measured across 50 ohms. One volt measured across 50 ohms indicates that 100 amps have flowed through the Transient Waveform Monitor.

In order to measure the current flowing through a conductor you must break that conductor and redirect its flow through the current input port of the Transient Waveform Monitor.

!WARNING!

Before making any connections be sure the M5, backfilter, and entire test system is powered down. Surge testing obviously produces hazardous voltages and the constant voltages present in the EUT such as the AC power voltage may also be hazardous.

!WARNING!

The Transient Waveform Monitor current inputs provide a short between the two points they are attached to. Do not draw more than 10A steady state through the Transient Waveform Monitor current section.

In order to measure the current using the Transient Waveform Monitor it is necessary to connect an oscilloscope to the current output port of the Transient Waveform Monitor. If the oscilloscope has a 50 ohm termination use it, otherwise you will need to provide an external 50 ohm termination in order to perform accurate measurements. Note that without this 50 ohm termination, readings will be unpredictable and inaccurate by an order of magnitude. The conversion factor used by the Transient Waveform Monitor equates 100 amps to 1 volt at the output. This conversion is linear such that two volts equal 200 amps, 3 volts equals 300 amps, etc., etc. In other words, the current monitor output provides a transconductance of 100 amps per volt.

VIII. Surge Command™ Expert Software

INTRODUCTION

The SURGE COMMAND™ software and I/O controller make it possible to control the M5 from an IBM compatible personal computer running Windows 3.1 or Windows 95. The software has been designed for ease of use. Computer control of the M5 offers all of the features of manual operation plus many new ones, including:

Complex test sequences can be programmed
- Unattended operation (Not Recommended)
- Automatic report generation of tests delivered
- User defined interrupts

The following sections discuss hardware and software installation and introduce the major features of the software. SURGE COMMAND™ also includes an extensive on-line help file.

HARDWARE INSTALLATION

The M5 must be attached to com1 on your host computer. If you wish to use a different com port, please contact compliance design for assistance. Use a standard RS232 cable to attach the M5.

The next step is installation of the SURGE COMMAND™ software.

SOFTWARE INSTALLATION

SURGE COMMAND will autoinstall under MS Windows 3.1 and Windows 95. To install SURGE COMMAND, enter windows and run the file "Setup.exe" on this disk. The installation program will load its setup files and install the software into the directory that you indicate.

In both versions of Windows, the installation program will establish a window and a program icon. You can move the icon to other program windows and groups as desired.

In Windows 95, the installation program also adds a topic to the Start Programs menu.

SOFTWARE OVERVIEW

Features:

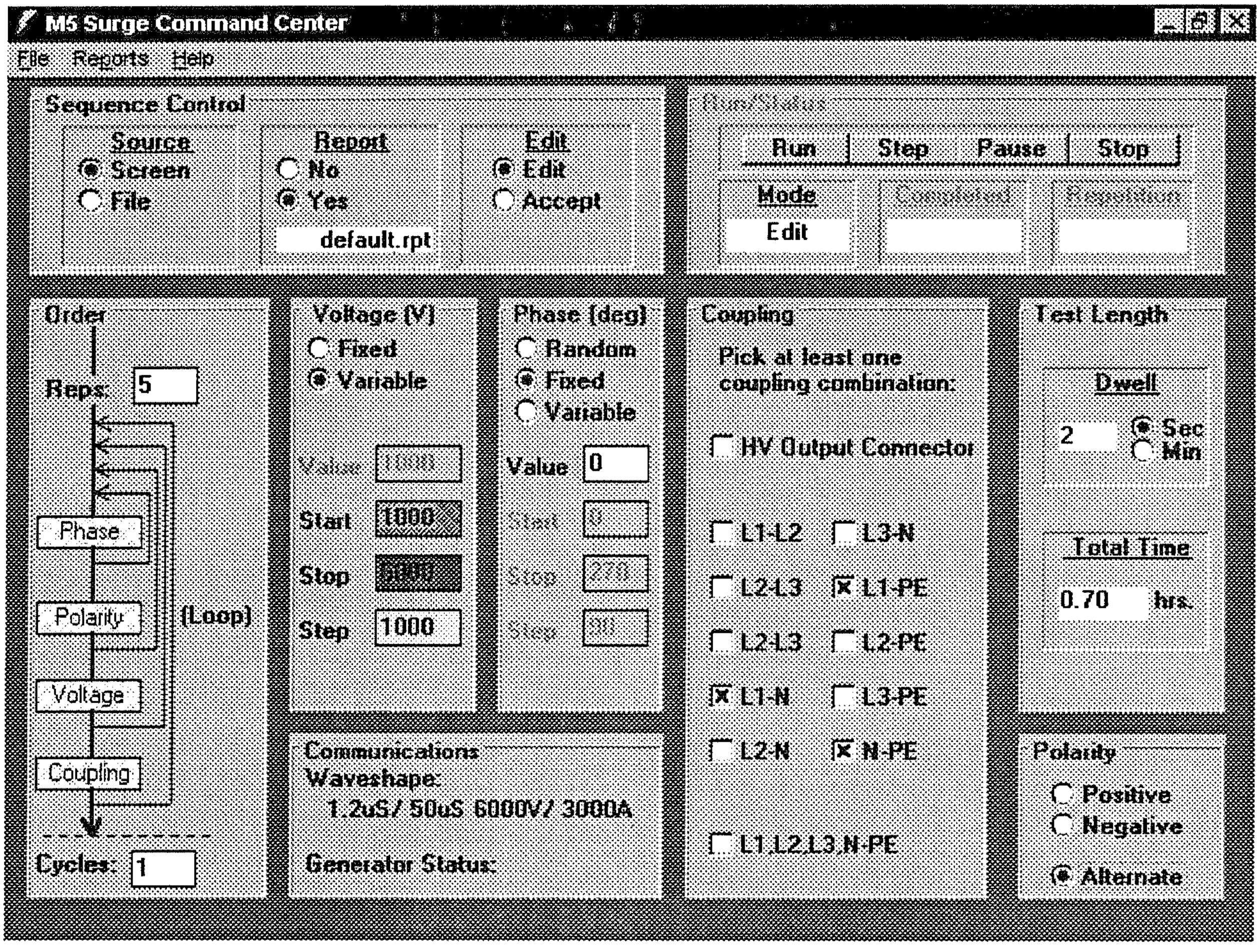
The SURGE COMMAND™ software makes automated Surge testing possible. A large number of tests can be set up for automatic, sequential operation. All tests are easily set up from a single main screen, and can be saved for reuse.

The software has been designed for flexibility. During testing, the test sequence can be halted, paused, single-stepped, resumed, or exited at any time. SURGE COMMAND™ includes a report generating facility which allows the user to generate automatic test reports.

We have also included a hardware interrupt facility, which enables the automated monitoring and logging of errors in the equipment under test. Four interrupt lines are available for user use. Activation of any user interrupt line, or any combination, will halt testing and generate a run-time error message. Testing can be resumed or aborted, and comments added to the automated report, as desired.

Introducing the Main Screen:

SURGE COMMAND's™ user interface is intuitive. There are only two basic modes of operation **Edit Mode** and **Test Mode**. When you operate the M5 manually using the front panel controls, you select the parameters of an individual test, such as voltage, polarity, coupling, and phase angle, and then you press the F1 button to perform a surge. With SURGE COMMAND™, **Edit Mode** is used to set all test parameters, and **Run Mode** is used to control the delivery of the surge sequence selected.



The Main Screen, which is displayed when SURGE COMMAND™ starts up, is shown above. In **Edit Mode**, every panel is available for user input *except* the **Run/Status Panel** and the **Total Time** field of the **Test Length Panel** (which is a calculated field). All of these panels are for user entry of test parameters. In contrast, in **Test Mode**, only the control buttons of the **Run/Status Panel** ("Run", "Step", "Pause", "Stop") will respond to user input.

Each of the available functions is described in detail in the sections that follow.

An Introduction to Reports:

SURGE COMMAND™ will generate ASCII test reports if requested. The user can fill in the basic report header information manually or use a stored report format (*.rpf) file. Optionally, the report generator can include "boilerplate" text, such as a description of the test facility and equipment, and the user can specify whether or not to enter comments.

A First Look at the Run-Time Error and Interrupt Facility:

During the course of the test, the user can decide to manually interrupt the test in response to equipment conditions. However, some things are not readily observable, and best monitored automatically. SURGE COMMAND™ will sense several error conditions in the M5 which would prevent a proper test, including loss of power, improper cabling, and improper positioning of the **REMOTE/MANUAL** switch.

In addition, the program constantly monitors the state of four interrupt leads that are available for the user's use. These leads are active low, so with appropriate logic they can be used to inform SURGE COMMAND™ of up to 15 external conditions. When any of these leads (or any combination) is pulled low, an interrupt vector is generated and the test is halted. The user is informed of the condition. You can choose to correct it and resume testing at the point in the test sequence where the interrupt occurred, or you can abort the test and return to **Edit Mode**. If the program is generating a report, the error condition is noted, and the user is given the option of adding an additional comment.

EDIT MODE

There are two major modes in the SURGE control program--**Edit Mode**, where test profiles are set up, and **Test Mode**, where they are run. Within each major mode, there are several possible states, or "sub-modes." The purpose of the Edit Mode is to set the parameters for the automated test. Specification of a test requires the entry of information (or acceptance of default values) for the following panels on the Main Screen:

- **Sequence Control Panel**
- **Order Panel**
- **Voltage Panel**
- **Phase Panel**
- **Coupling Panel**
- **Test Length Panel**
- **Polarity Panel**

Sequence Control Panel

The **Sequence Control Panel** contains three subpanels, labeled **Source, Report**, and **Edit**.

Source Subpanel

This panel allows the user to choose the source of the SURGE parameters. This panel is only enabled during **Edit Mode**, when the user sets the SURGE test parameters. If the Screen option is selected, the source file label is grayed, and user entry of parameters into the remaining active panels is enabled.

If the user selects **File**, a common dialog box prompts the user for a stored test profile. The default profile is "last.srg," which records the parameters last used. "Last.srg" is the default name used when the menu command **Alt-File-Save** is executed. When a file is selected, it is loaded and the Edit/Accept options in the **Edit Subpanel** are set to **Accept**, automatically placing the unit in the **Test Mode**. The file name is indicated on the label in the panel. An exception to the automatic transition to **Test Mode** upon the loading of a test profile occurs when the program is started. At start-up, the program automatically loads "last.srg," but sets the **Edit/Accept** option to **Edit**. This allows the user to pick up where he left off. If he wishes to continue editing, he may do so. If he wishes to run the SURGE with the same parameters that were entered the last time the program was used, he need merely hit Accept.

Report SubPanel

This panel allows the user to choose if a report will be generated during the test run. This panel is only enabled during **Edit Mode**, when the user sets the SURGE test parameters. If the **Yes** option is selected, the report file label is enabled and the output file name for the report is displayed. Any existing information in the destination file will be erased and overwritten by the new report. If a report is requested by selecting the **Yes** option, the user will be prompted by the **Report Format Screen** at the start of a test run (after **Test Mode** has been entered), allowing the user to make changes at that time to the report format (extension *.rpf) and to change the destination file for the report output (extension *.rpt).

By default, the last filename used is shown. This can be changed during **Edit Mode** by using the menu command **Alt-Reports-New**. It can also be changed during the dialog at the beginning of a test. See the dialog form, Figure 3, and the additional discussion below under the heading "Reports."

Edit Subpanel

The Edit Panel consists of two option buttons and their indicators, labeled **Edit** and **Accept**. When the program is started, it automatically loads the state it was in when last operated from the test profile file "last.srg" and enters the Edit state, as indicated by the indicator button light. If it cannot find that file, it loads default values. If the user wishes to alter the machine state prior to testing, he may do so directly, by entering new values in the various panels, or by choosing to load a different test profile from the **Source Subpanel**. Hitting **Edit** has no effect the **Edit** button is used as an indicator and is set on entry to **Edit Mode**. When the user hits **Accept**, the unit enters the **Test Mode**.

When the user exits the **Test Mode**--either through the Stop key and dialog, or because the tests have run to completion, he is placed back in the **Edit Mode** with the Edit option checked. From here, he can simply re-run the current test profile by hitting "Accept," edit it, or load a new test profile.

If the user selects and loads a stored test profile with the **Alt-File-Open Profile** command while in the **Edit Mode**, it is assumed he wishes to run the selected file. Therefore, once the file is loaded, the unit is placed in Test Mode, in the ready state. The unit does not start running until the **Run** button is pressed, so if the user wishes to edit the file further, he may do so after hitting the **Stop** button and re-entering the **Edit Mode**.

Order Panel

The order panel controls the order in which the SURGE parameters are incremented when stepping through the individual tests in a test profile, and the number of times the entire sequence is repeated.

To adjust the order in which parameters are incremented, drag and drop the four boxes above the dashed blue line. These boxes implement a four-level "DO Loop." As indicated by the arrows in the panel, the parameter occupying the box just above the dashed line is in the outermost repeat loop, while the parameter in the top box is in the innermost loop. For example, if "Polarity" is placed in the innermost loop, and the polarity (in the **Polarity Panel**) has been set for "Alternate," then the M5 will deliver a number of surges equal to the **Reps** of positive polarity, followed by **Reps** surges of negative polarity. It would then increment whatever parameter was in the next innermost loop (as indicated in the box below the Polarity box), and continue. The looping continues until all tests specified in the profile are performed.

It is also possible to repeat an entire test profile multiple times. The number of repetitions is set in the **Cycles** text box, and can range between 1 (the default) and 9.

Voltage Panel

The **Voltage Panel** serves two functions, depending on the operating mode.

In **Entry Mode,** the voltage panel is used to set the voltage level(s) that will be used in the test profile. If the **Fixed** option is selected, the fixed voltage value is entered in the "Value" text box. The other text boxes will be grayed out. If the **Variable** option is selected, three entries must be made for the starting voltage, the stopping voltage, and the voltage step size. The software will not allow erroneous entries such as voltages that are too large, or stop voltages that are lower than the start voltage.

In **Test Mode**, the "Value" test box is used to display the actual voltage that is being delivered at that point in the test. It is highlighted in red during testing.

Phase Panel

The **Phase Panel** serves two functions, depending on the operating mode.

In **Entry Mode,** the phase panel is used to set the phase angle(s) that will be used in the test profile. If the **Random** option is selected then the surges are applied with random phasing. If the **Fixed** option is selected, the fixed phase value is entered in the "Value" text box. The other text boxes will be grayed out. If the **Variable** option is selected, three entries must be made for the starting phase, the stopping phase, and the phase step size. The software will not allow erroneous entries such as phases that are too large, or stop phases that are lower than the start phase.

In **Test Mode**, the "Value" test box is used to display the actual phase angle that is being delivered at that point in the test. It is highlighted in red during testing.

Coupling Panel

The **Coupling Panel** determines which leads the surges are applied to. There are two sections to this panel--the **coupling check boxes** and the **Back Filter** selection.

In **Test Mode**, the active coupling configuration is highlighted in red.

Test Length Panel

The **Test Length Panel** has two subpanels. The first, labeled **Dwell**, is where the user enters the length of dwell time between each surge charge/discharge cycle. The units of time may be either seconds or minutes. The display adjusts when the units are changed.

The second subpanel, labeled **Total Time** is a calculated field which displays the total time in hours required to complete the test profile.

Polarity Panel

Use this panel to set the polarity of the transients delivered. If **Both** is selected, tests will be run in both positive and negative polarity. If **Both** is selected and **Polarity** is placed in the inner loop of the **Order Panel**, successive tests will alternate in polarity. If **Both** is selected and **Polarity** is placed in the outer loop of the **Order Panel**, the M5 will cycle through all selected **Voltage**, **Frequency**, and **Coupling** values first in positive polarity, and will repeat the cycle in negative polarity.

TEST MODE

Run/Status Panel

When a test profile is accepted, the **Run/Status Panel** is activated. It contains a control bar of four buttons--**RUN**, **STEP**, **PAUSE**, and **STOP**, and three status labels: **Mode**, **Completed**, and **Remaining**.

When the **Run/Status Panel** is first activated, the **Mode status label** indicates "Ready." The four control buttons are enabled. If the user hits **RUN** and a report has been requested, the **Report Format Form** will appear. After the report has been set up, the unit will start to deliver the test profile. If report generation is not enabled, the unit will begin testing.

At any time during testing, the user may depress the other three buttons. If **STEP** is hit, the unit will finish the current test within the profile and pause. If **PAUSE** is hit, the unit will pause immediately. Once paused, it can be restarted with **RUN** or **STEP** (for a single test delivery).

STOP is used to end delivery of the test profile. Because this can abort a long test, a dialog asks whether the user wishes to merely pause, or really wishes to stop and enter the **Edit Mode**. If the user decides to merely pause, the unit pauses, and can be restarted as noted above with the **RUN** or **STEP** controls. If the user chooses to stop, the test is aborted. Any open report files are closed.

The test can also be halted by two classes of interrupts. The first class is governed by the M5. If it senses one or more error conditions--such as an interruption of power, or user manipulation of the front panel Manual/Remote switch, it will interrupt the test and notify the user of the problem. The user is given the option of correcting the problem and annotating, if applicable, the automated test report, or of stopping.

The second class of interrupts are the user interrupts. Four leads are available for user interrupts. These leads are level sensitive (active low) with a latency of approximately 0.5 seconds. With multiplexing, these leads can be used to indicate up to 15 types of error condition. Again, the user is given the option of correcting the problem and continuing, or of aborting the test. The number of the user interrupt is indicated in the message and posted to the report file, if one is active.

The **Completed Status Label** indicates how many tests are contained in the test profile and how many have been completed (e. g., "5 of 12").

Reports

The **Report Format Screen** form is used to select the information that will be written to a report during a test run. The **Report Output Destination File** text box identifies the file to which the report output will be directed (extension *.rpt).

The **Report Contents** portion of the form allows the user to select the information which will be contained in the report. The Header information will be printed at the start of the report. A detailed description of the test method can optionally be included in the report as a "Boilerplate" section. A sample Boilerplate file has been included with the software in the file default.bpt. It can be customized using a text editor, saved to a file, and then selected by inserting the file name in the **From File:** text box. The Data Recorded section allows the user to select the data which will be recorded in the report output file.

When the test is executed, the information requested is written to the designated file on a test by test basis. The user can request the unit to pause after each test in the profile so he can annotate the results of each test.

Report formats can also be saved, with the extension *.rpf.

IX. Simultaneous Transient Couplers

A Simultaneous Transient Coupler(STC)allows the M5 surge system to deliver a simultaneous surge on more than one line at the same time. The energy from the storage source within the M5 mainframe is gated to the load by a single discharge switch and the STC distributes the surge to each separate output. The surge waveshape seen by each separate output is thus mostly independent of events occurring on other outputs. This capability is required by the Bellcore standards TR-NWT-001089 and its replacement GR-CORE-1089. Previous telecommunications standards allowed longitudinal surges to be applied to multiple lines simultaneously simply by connecting the pairs to be tested together. But this led to overtesting in the case where one lead broke over to ground drawing the total energy in the surge to that one lead. CDI's STC solves the problem of overtesting by supplying a calibrated fraction of the total surge to each output.

Lightning Transients and Telecommunications Equipment

Lightning disturbances are cause for serious concern to operators of telephone equipment and facilities. These disturbances can be caused by a direct lightning strike to the telephone line or to induction or ground currents. In some cases, telecommunications equipment can be exposed to transients that will deliver hundreds of joules of energy.

In order to describe the environment, and to provide a standard for telecommunications terminal equipment, a number of documents have been created. These include TR-EOP-00001 describing the environment and TR-NWT-001089/GR-CORE-1089 describing the tests to be applied to terminal equipment. In order to understand the proper use and function of a simulator designed to replicate lightning hazards, an understanding of these key documents is required.

Most telephone service is provided to the customer through two or four wire connections. In a two wire connection, the two lines that are provided are known as "tip" and "ring." Communications in both directions passes along this pair. In a four wire connection, four lines are provided, designated "tip," "ring," "tip 1," and "ring 1." This provides two separate pairs for transmitting and receiving.

In either of these combinations, station protectors or lightning arresters are provided by the local operating companies. They are placed on the operating side of the "network interface" which serves as a demarcation point between operating company owned lines and lines that are owned by the customer. These lightning arresters serve to limit the damage caused to customer premise equipment by lightning strikes. However, the residual energy contained in a lightning transient can still damage equipment and for that reason, terminal equipment must be evaluated for its immunity to these transients. Nonetheless, the characteristics of these station protectors are important in defining the kind of transients to which terminal equipment will be exposed.

Two types of station protectors are in common usage, 3-mil carbon blocks and gas discharge tubes. both operate through a crowbar effect. When the voltage across the arrester exceeds a breakdown potential, and arc forms effectively shorting the voltage across the arrester. On the average, station protectors such as 3-mil carbon blocks arc over at approximately 700 volts + 300 volts. Station protectors are usually connected from each telephone line to earth ground.

By and large, lightning events induce common mode voltages and currents on telephone lines. Several studies have attempted to identify the magnitude of these common mode (or "longitudinal")potentials and currents. By earthgrounding the telephone line at the customer premise, common mode current was measured.

These studies identified a worst case current waveform consisting of a double exponential pulse whose front time was 10 uS and whose fall time was 160 uS. Short circuit current peaks were measured as high as 100 amps per line.

The magnitude of the voltage associated with these currents by the station protector(neglecting the inductance of the grounding wire.) Ninety-five percent of station protectors will breakdown at voltages less than 1000 volts.

By disconnecting one of the telephone lines from ground, a measurement of the differential(or "metallic") voltage can be made. Metallic voltage transients will appear when one station protector breaks down while the other protector does not. The studies' main purpose was to identify the rise and fall times for metallic voltages.

The studies identified a nominal front time for the metallic pulse to be 10 uS. The longest fall time observed was associated with distant lightning events whose energy has been spread over time by the propagation dispersion. ninety-eight percent of the decay times were less than 560 microseconds.

The data from these studies served as the basis for the threshold limits in TR-NWT-001089/GR-CORE-1089. To simulate lightning events several waveshapes are specified. The 10x1000 waveform has a peak voltage of 1000 volts and with the STC, dual outputs which can each source 100 amps. The 2 x 10 waveform has a peak voltage of either 2500 volts or 5000 volts with STC outputs of 500 amps per lead in either case. There also exists a system level test which checks the common mode response of a full 24 line interface by applying a 10 x 360 waveform at 1000 volts/25 amps to each line simultaneously with respect to ground.

A. DUAL OUTPUT STC

Installation and Use of Your Dual Output STC

Remove the equipment for the packaging and verify that you have received two plugins for each dual output waveshape you requested. The plugins should be in matched pairs with one for insertion in the M5 mainframe and a companion plugin for the STC-5. In addition you should also have received two cables. The first with amphenol connectors on each end connects the M5 mainframe to the STC-5. The second cable is a 24" long three conductor cable which connects the output of the STC-5 to the interface to be surged. For your convenience alligator clips are affixed to the end of this cable. If your system contains more that four dual output surges or two four output surges then you will have more than one STC-5. Check the notation just below the product designation in the upper fight of the front panel to differentiate the units from each other. Only use plugins with the correct STC-5.

If any of the above equipment is missing contact Compliance Design, Inc.

Once the equipment location has been chosen(see cautions at front of manual)stack the equipment in that location. The STC-5 is placed on top of the CDI-5 to facilitate connections. If your system contains more than one STC-5 it will be necessary to swap this top piece of equipment during testing. Because of the high currents and fast rise times associated with these surges, connecting wires must be kept extremely short and it is not practical to allow connections between the M5 and equipment which is not located directly above it.

In order to use your STC-5 it is necessary to connect it to the M5 using the short cable labeled STC provided. Then connect the STC-5 output to the interface to be surged. Insert the desired plugin into the STC-5 and then insert the companion matching plugin into the M5. Verify that all information on the two plugins matches exactly (voltage and current specifications) before proceeding. to apply the surge simply charge and discharge the M5 as you would for single output surging using either manual or computer controlled techniques as described earlier in this manual.

To use the STC-5 output in a single output application such as a metallic surge, connect the unused output to ground in order to produce the most accurate surge on the remaining output.

CAUTION!: THE M5 PLUGINS MUST BE USED WITH AN STC-5. THEY CANNOT BE USED TO PRODUCE A CALIBRATED WAVESHAPE WITHOUT AN STC-5. TO PRODUCE A SINGLE OUTPUT WAVESHAPE, ONE OUTPUT OF THE STC-5 SHOULD BE USED.

The STC-5 waveshapes are designed for connection only. As such, their current handling capacities are limited. Do not connect them to AC lines or to equipment capable of sourcing current higher than the limits listed on the specification sheet for individual dual output surges. Ideally all testing performed with the STC-5 will take place on unpowered equipment.

B. 24 OUTPUT STC

Installation and Use of Your Dual Output STC

Remove the equipment for the packaging and verify that you have received a 10 x 360 24 output M5 plugin. In addition you should also have received a cable with amphenol connectors on each end to connect the M5 mainframe to the STC-5 24 output unit. Be careful not to confuse this with the Backfilter/M5 cable. Also included are 25 banana plug connectors because of the number of potential telecommunications connectors we have supplied you with a generic banana jack style interface in order to facilitate your connection of your specific type of interface jack. Check the notation just below the product designation in the upper right of the front panel to differentiate the STC-5 units from each other. Only use plugins with the STC-5 the correct STC-5.

If any of the above equipment is missing contact Compliance Design, Inc.

Once the equipment location has been chosen(See cautions at front of the manual)stack the equipment in that location. The Remote Automatic Controller is generally situated on the bottom followed by the M5 mainframe. The STC-5 is placed on top of the M5 to facilitate connections. If your system contains more than one STC-5 or a backfilter it will be necessary to swap this top piece of equipment during testing. Because of the high currents and fast rise times associated with these surges connecting wires must be kept extremely short and it is not practical to allow connections between the M5 and equipment which is not located directly above it.

In order to use your STC-5 it is necessary to connect it to the M5 using the short cable labeled STC provided. Then connect the STC-5 output to the interface to be surged. Because of the number of potential interface connectors, we have supplied the STC-5 24 output with a generic banana jack interface. To connect your equipment to the STC-5 simply wire the outputs of a connector of the opposite sex from you equipment's connector to 24 of the banana jacks provided. Insert the banana plugs into the BLACK banana jacks located on the front panel inside the protective bezel. The RED banana jack in the lower right corner is the low common point for the 24 high outputs and as such it should be connected to EUT ground. To apply the surge simply charge and discharge the M5 as you would for single output surging using either manual or computer controlled techniques as described earlier in this manual.

CAUTION!: THE M5 PLUGINS MUST BE USED WITH AN STC-5. THEY CANNOT BE USED TO PRODUCE A CALIBRATED WAVESHAPE WITHOUT AN STC-5. TO PRODUCE A SINGLE OUTPUT WAVESHAPE, ONE OUTPUT OF THE STC-5 SHOULD BE USED.

The STC-5 waveshapes are designed for direct connection only. As such, their current handling capacities are limited. do not connect them to AC lines or to equipment capable of sourcing current higher than the limits listed on the specification sheet for individual dual output surges. Ideally all testing performed with the STC-5 will take place on unpowered equipment.

X. Plug-in Specifications

Attached are the specifications for the plug-in modules originally purchased with the M5 surge system.