GARD

*Unparalleled Protection*


# GEMINI

## HIGH RESISTANCE GROUNDING

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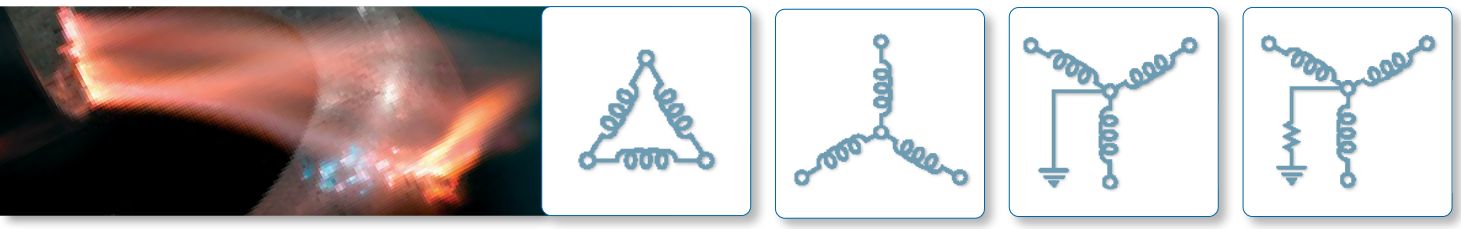

C-102EM Instruction Manual, January 2015

# ABOUT I-GARD

I-Gard's commitment to electrical safety provides both industrial and commercial customers with the products needed to protect their electrical equipment and the people that operate them.

As the only electrical-safety focused company whose product portfolio includes neutral grounding resistors, high-resistance grounding systems and optical arc mitigation, we take pride in our technologies that reduce the frequency and impact of electrical hazards, such as arc flash and ground faults.

For those customers who have purchased from us over the last 30 years, you know us for the quality and robustness of our products, our focus on customer service and technical leadership. We build on this foundation by investing in developing new products in electrical safety education - including EFC scholarship program - by actively participating in the IEEE community programs on technical and electrical safety standard, and working with local universities at discovering new technologies. We remain unrelenting in our goal of improving electrical safety in the workplace.

Our commitment to excellence is validated by long-standing relationships with industry leaders in fields as diverse as petroleum and gas, hospitals, automotive, data centers, food processing, aerospace, water and waste water plants, and telecommunications. We provide our customers with the product and application support required to ensure that their electrical distribution system is safe and reliable.

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# 1. GENERAL DESCRIPTION

Gemini is a unique, fail-safe, all-in-one neutral grounding system, combining ground fault protection with a redundant resistor system, in addition to a built-in resistor integrity monitoring relay.

Providing protection against any compromising of the resistor integrity, the patented twin resistance paths in combination with the integrity monitoring relay form the heart of the Gemini system. Limiting any ground fault to predetermined and safe levels, the parallel resistance circuit protects against the damaging effect of a ground fault and should the integrity of either resistor path be compromised, the second path continues to provide the necessary protection while an alarm is activated.

IMPORTANT

Each Gemini system is carefully inspected before being packed into a custom designed carton. The unit should be examined immediately upon receipt. If damage or indication of rough handling is apparent, a claim should be filed without delay with the transport company. I-Gard should be notified promptly if replacements for damaged goods are necessary. If units received are not to be installed immediately they should be stored in their original containers in an area free of dust and moisture.

To increase reliability in high-resistance grounded power systems, I-Gard has introduced the Gemini grounding resistor system, which you have purchased. The resistor provides a return path for hazardous capacitive currents, which can break down the system insulation under conditions of intermittent ground faults. The Gemini provides a dual resistor element to double the reliability of the resistor elements. Two separate elements are used to provide redundancy thus providing protection in the event of an open circuit failure of one of the elements.

A versatile ground fault relay I-Gard Type Sigma, in the Gemini system indicates the presence of ground faults that may occur on the power system by current measurement within the Gemini unit itself. In addition to providing a monitor that will operate a local and remote alarm if the value of the grounding resistor elements changes to a lower or higher limit set by the user.

When a single ground fault occurs: Gemini controls and limits the fault current. Gemini provides alarms that indicate the presence of an active fault, and if equipped with the optional pulsing relay, plant electrical personnel may follow a simple sequence to locate and isolate the fault without interrupting or opening circuit breakers. This allows for the uninterrupted operation of process equipment.

Faults are indicated by front panel lights. The TRIP lamp lights whenever a ground fault or a resistor fault is detected separate lights for GROUND FAULT and RESISTOR FAULT indicate which condition caused the TRIP lamp to turn on. Two form C contacts are available for the user's application- one for ground fault and the other for resistor fault. See Wiring Diagram Figure 1 for details.

A meter scaled from 0-100% is supplied on the front of the panel. This meter indicates the amount of ground fault current present relative to the let-through current.

A TEST button on the front panel allows a confidence check of the Gemini unit. When pressed, the Gemini will go into the alarm condition with SYSTEM HEALTHY lamp going out and both RESISTOR FAULT and GROUND FAULT and TRIP lamps lighting. The corresponding contacts will operate to energize the user devices if connected.

If supplied, the Gemini pulsing system, when activated, will cyclically limit the ground fault current to 100% and 50% of the available ground fault current. The user can modify the duration of this pulse to suit the requirements of his sensing device.

The cyclic pulsing combined with the hand held current sensor, and a single line diagram can be used to rapidly locate a ground fault even in a very complex power distribution system.

Figure 1: Close-up of Front Panel

## 2. INSTALLATION

| DANGER |
| --- |
| Hazard of Electrical Shock, Burn or Explosion |
| All installation, servicing and testing referred to in this manual must be performed by qualified personnel. All power should be disconnected prior to removing covers or enclosures and where live conductors may otherwise be exposed. |
| Failure to observe these precautions may result in death or severe personal injury and damage to equipment. Before placing an intentional ground fault on the power system, check that a fault does not already exist. Any test ground fault equipment must be rated for full system voltage and be fused for protection. |

Typical catalogue numbers for Gemini: GS-277 for 480V, GS-347 for 600V, 5A resistor units.
Gemini systems are also available for medium voltage systems. Contact I-Gard for details.

Please ensure before installation of the unit that the correct version has been supplied!

On receipt, carefully open the protective shipping carton, remove all packing material and visually inspect the unit. If the unit is damaged do not proceed with installation. Contact I-Gard at the numbers listed on the final page of this document. Loosen the two door bolts and open the front door to access the mounting holes. Gemini is housed in a NEMA 2 enclosure; see Figure 2 for installation details.

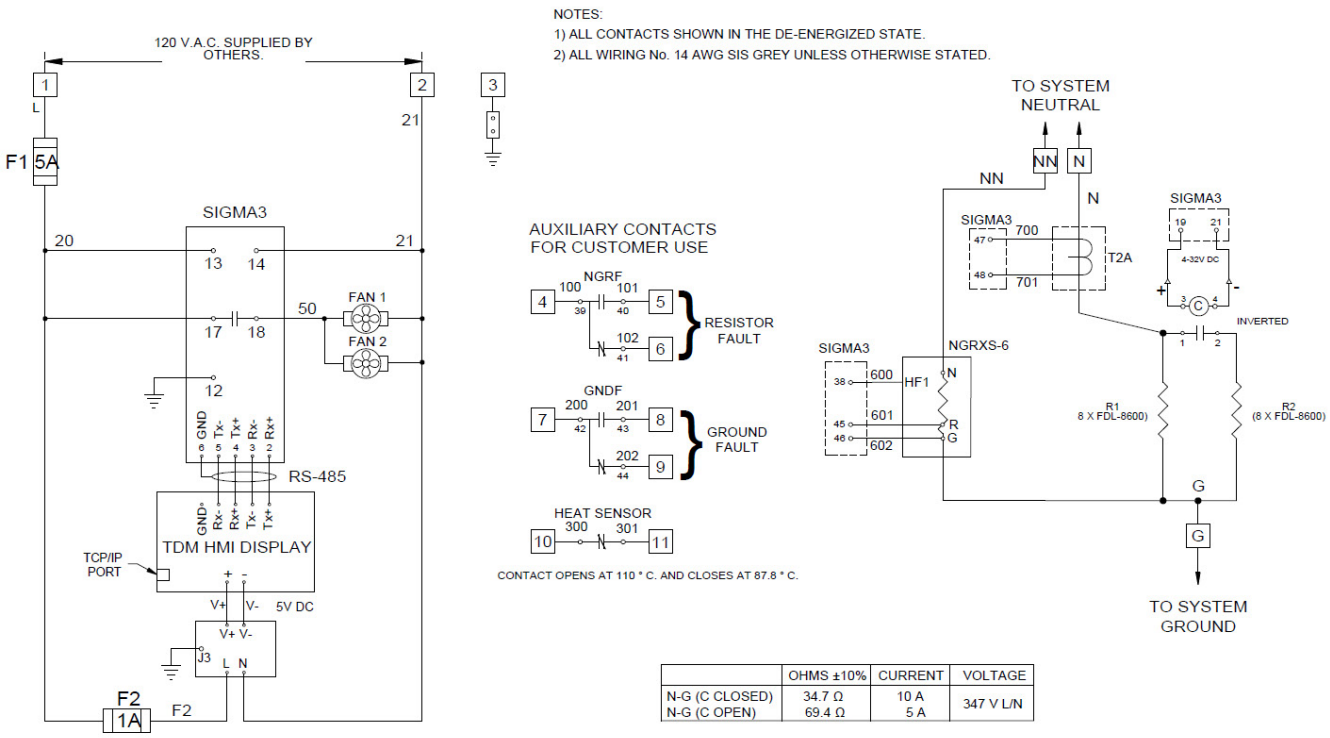



Figure 2: Wiring Diagram for Gemini

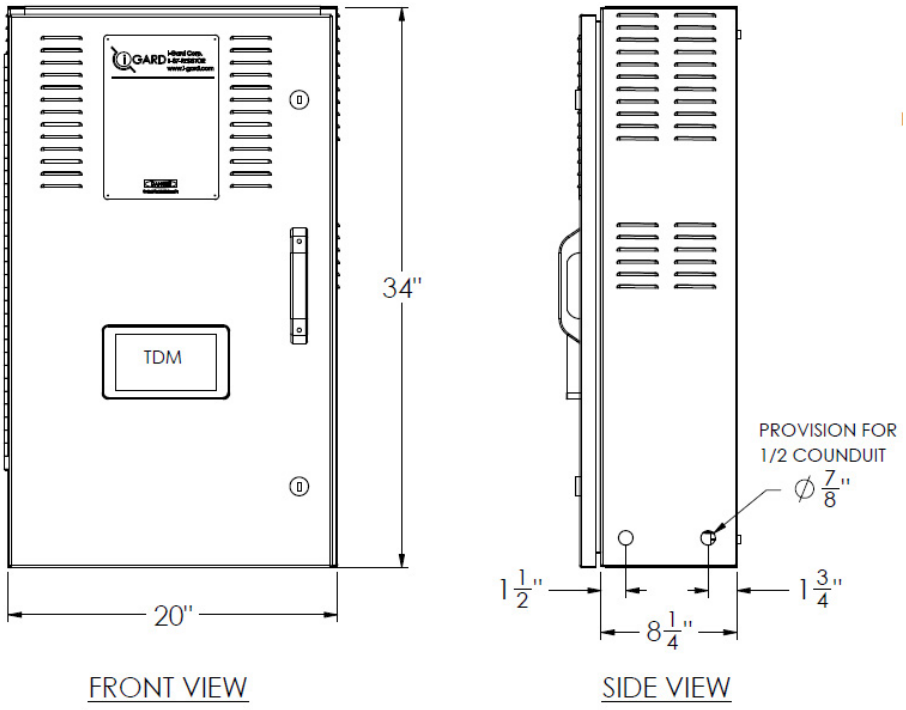



Figure 3: Outside Dimensions

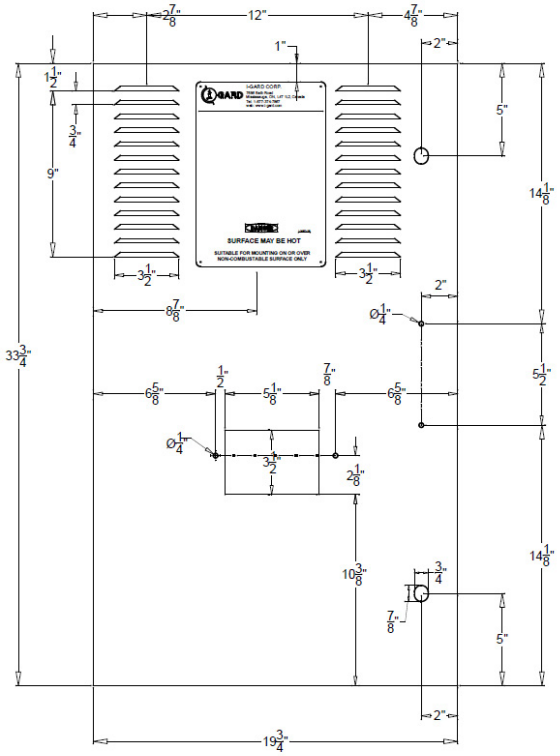



Figure 4: Mounting Dimensions

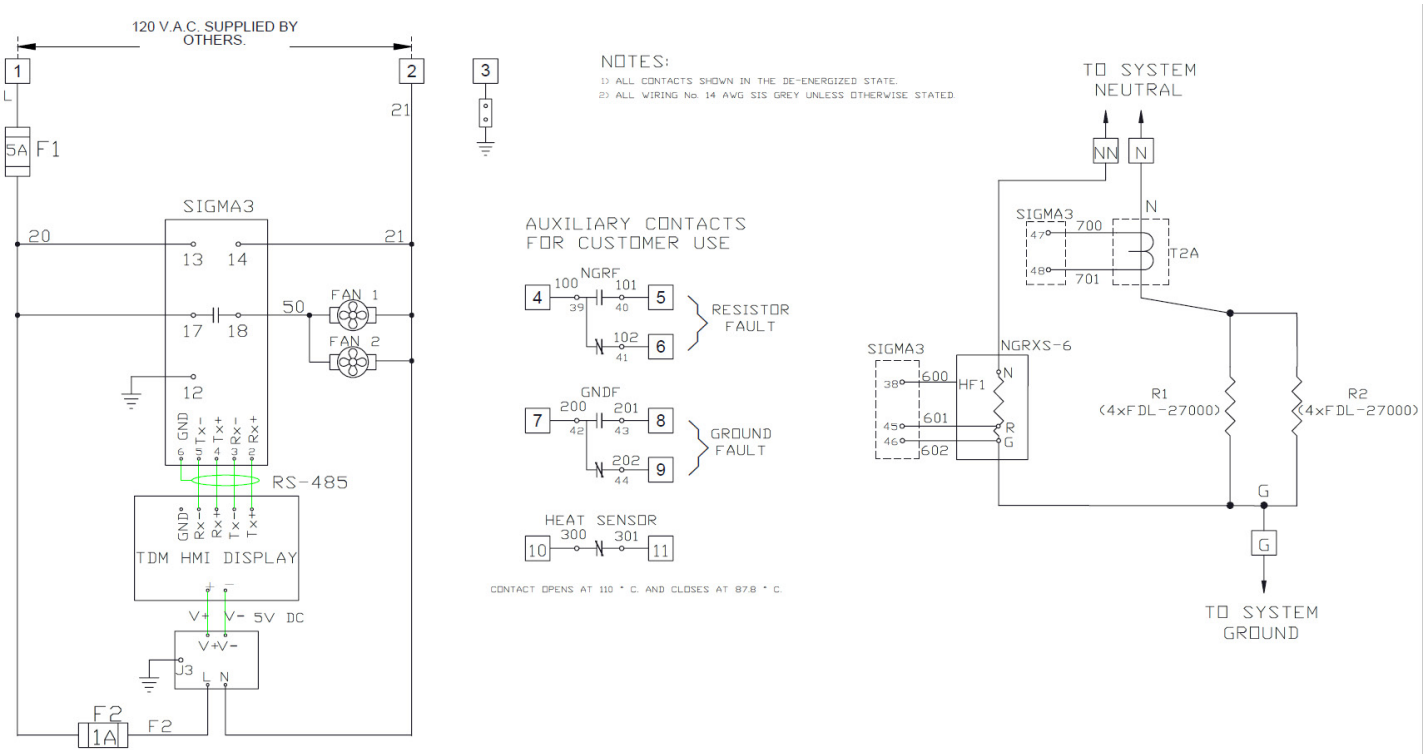



Figure 5: Wiring Diagram for Gemini Pulsing

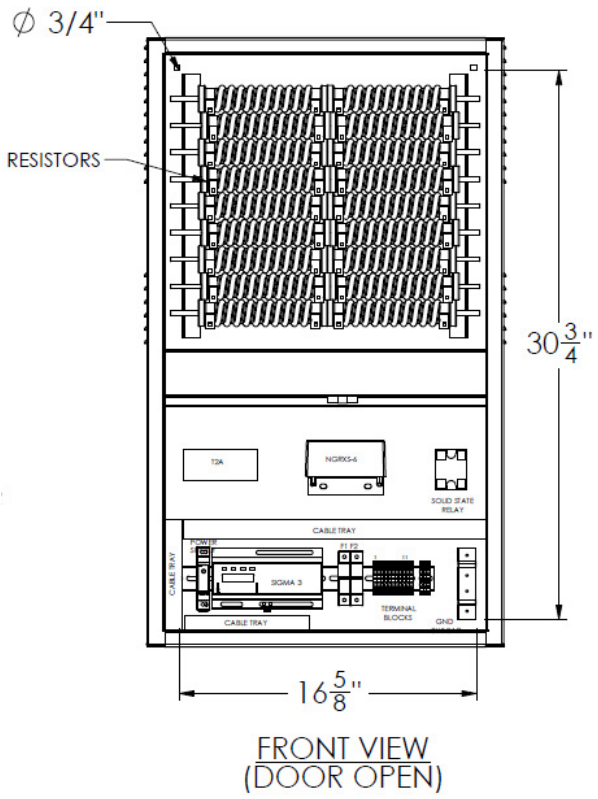



Figure 6: Mounting Pulsing

The wall mounting holes are located in the rear corners of the cabinet (Figure 4). The distance between mounting holes is 20 3/4″ or 527 mm in the vertical direction and 16 5/8″ or 422.3 mm in the horizontal direction. Mounting holes are 3/8″ or 9.5 mm wide allowing for the use of 5/16″ or 9 mm diameter fasteners.

Mounting holes for the pulsing option are shown in figure 6.

Mount the Gemini securely to the wall in accordance with local codes. Once the Gemini is securely mounted, proceed to the connections. Electrical access to the interior is provided by means of eight knock out openings (See Figure 3) suitable for ½″ conduit. Two are located near the bottom of each side and two are located in the bottom near each sidewall. Gemini requires a 120 VAC supply. Proper connection for the 120 VAC supply is a follows. Connect line to terminal 1, neutral to terminal 2 and ground to terminal 3. Recommended supply cable size is 14 or 12 AWG. Connect the system neutral (neutral bushing of the transformer) to the point identified as N (#10 on terminal block) and the system ground to the point identified as G (#11 on terminal block).

Both the Canadian Electrical Code and the National Electrical Code require a minimum size of 8 AWG if conduit is used and size 6 AWG if exposed wiring is used.

IMPORTANT
System neutral (N) must be connected to the X0 point of the main power transformer on wye systems or the X0 point of the zigzag transformer for delta systems. There should be no other connections to this point. All conductors must be insulated to the full system voltage.

Following installation, always perform a final inspection. All foreign objects must be removed. All conductors must be secured in the proper positions before closing the door and energizing the system.

DO NOT ENERGIZE the Gemini unless the door is closed and secured by the two bolts provided.

## 3. OPERATION


Figure 7: Gemini Control Panel

Upon energizing the control panel only the green SYSTEM HEALTHY, light will turn ON signifying that no ground faults are on the system and the Gemini is receiving control voltage. Verify the Gemini condition by pushing the TEST button and holding for the delay time set on the Sigma. This causes the Sigma to trip. The green light turns OFF, the red GROUND FAULT light turns ON and the fans activate. This confirms that control voltage is available, the Sigma is functioning and the fans are operational.

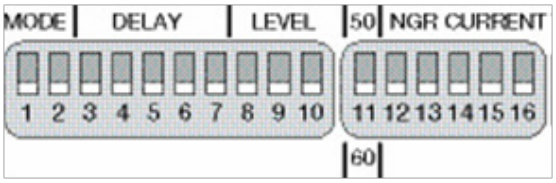
Push the RESET button to restore the system to normal operational status. The red GROUND FAULT, RESISTOR FAULT and TRIP lights will go OFF and the green SYSTEM HEALTHY light will turn ON, and the fans stop. (The meter may indicate a slight leakage). The Gemini is now ready to monitor the distribution system.

When a ground fault occurs the potential between the system neutral and ground will increase causing the meter to display the fault level which may be any value between 0% and 100% of the let-through ground fault current. This current is also being monitored by the FAULT CURRENT ammeter. If the fault current magnitude is greater than the pickup setting of the Sigma and the duration is greater than the time delay setting on the Sigma, the Sigma will trip, changing the state of the GROUND FAULT TRIP contacts. The green SYSTEM HEALTHY light turns OFF and the red GROUND FAULT and TRIP lights turn ON, and cooling fans activate.

By adjustment of the Sigma relay, the ground fault pickup level can be set from 5% to 50% of the let-through current. The time delay can be adjusted from 60 ms to 3.15 s this allows the Gemini settings to be adjusted for the unique requirements of each system in order to avoid nuisance tripping.

Both ground fault pickup level and time delay are adjusted using the bank of Dipswitches located on the front plate of the Sigma relay, which is located inside the Gemini enclosure. (Refer to I-Gard Manual C-453EM Sigma, for complete details of this relay).

Sigma Monitor Relay Configuration Switches




| TABLES FOR DIP SWITCH ARRAY | | |
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| Table 1.1 | Operating Mode Setting | DIP Switch 1 |
| Table 1.2 | Trip Memory Selection | DIP Switch 2 |
| Table 1.3 | Ground Fault Trip Time Delay Settings | DIP Switch 3, 4, 5, 6, 7 |
| Table 1.4 | Ground Fault Trip Current Level Settings | DIP Switch 8, 9, 10 |
| Table 1.5 | System Frequency Selection | DIP Switch 11 |
| Table 1.6 | NGR Let-through Current Settings | DIP Switch 12, 13, 14, 15, 16 |

Table 1.1: Trip Relay Operating Mode Setting
DIP Switch #1 (Left Hand Array) U= UP, D= DOWN

| MODE | DIP SWITCH SETTING |
|---|---|
| FailSafe (Under Voltage Trip) | UP |
| SIGMA relay is idle/not-tripped:<br>Trip relay is energized<br>Aux fault relays are not energized<br>SIGMA relay is tripped:<br>Trip relay is not energized<br>Aux fault relays are energized | |
| Non-FailSafe (Shunt Trip) | DOWN |
| SIGMA relay is idle/not-tripped:<br>Trip relay is not energized<br>Aux fault relays are not energized<br>SIGMA relay is tripped:<br>Trip relay is energized<br>Aux fault relays are energized | |

Table 1.2: Trip Memory Selection
DIP Switch #2 (Left Hand Array) U= UP, D= DOWN

| TRIP MEMORY | DIP SWITCH SETTING |
|---|---|
| Trip Memory ON | UP |
| Control voltage off after trip:<br>When control voltage restored Trip and Aux relays Idle* then immediately re-trip (within 2 seconds). | |
| Trip Memory OFF | DOWN |
| Control voltage off after trip:<br>When control voltage restoredTrip and Aux relays Idle* do not immediately re-trip.<br>Trip and Aux relays will re-trip if a fault is detected after monitoring starts. | |

*Idle state: See Table 1.1, Trip relay operating mode setting for description of relay states when the SIGMA relay is idle/not-tripped for FailSafe and Non-FailSafe operating modes.

Table 1.3: Ground Fault Trip Time Delay Settings

DIP Switches #3, 4, 5, 6, 7 (Left Hand Array) U= UP, D= DOWN

| G/F TRIP TIME DELAY | DIP SWITCH SETTINGS | | | | |
|---|---|---|---|---|---|
| (milliseconds) | 3 | 4 | 5 | 6 | 7 |
| 60 | D | D | D | D | D |
| 150 | D | D | D | D | U |
| 250 | D | D | D | U | D |
| 350 | D | D | D | U | U |
| 450 | D | D | U | D | D |
| 550 | D | D | U | D | U |
| 650 | D | D | U | U | D |
| 750 | D | D | U | U | U |
| 850 | D | U | D | D | D |
| 950 | D | U | D | D | U |
| 1050 | D | U | D | U | D |
| 1150 | D | U | D | U | U |
| 1250 | D | U | U | D | D |
| 1350 | D | U | U | D | U |
| 1450 | D | U | U | U | D |
| 1550 | D | U | U | U | U |
| 1650 | U | D | D | D | D |
| 1750 | U | D | D | D | U |
| 1850 | U | D | D | U | D |
| 1950 | U | D | D | U | U |
| 2050 | U | D | U | D | D |
| 2150 | U | D | U | D | U |
| 2250 | U | D | U | U | D |
| 2350 | U | D | U | U | U |
| 2450 | U | U | D | D | D |
| 2560 | U | U | D | D | U |
| 2650 | U | U | D | U | D |
| 2750 | U | U | D | U | U |
| 2850 | U | U | U | D | D |
| 2950 | U | U | U | D | U |
| 3050 | U | U | U | U | D |
| 3150 | U | U | U | U | U |

Table 1.4: Ground Fault Trip Current Level Settings
DIP Switches #8, 9, 10 (Left Hand Array) U= UP, D= DOWN

| G/F TRIP LEVEL (% of NGR let-through current) | DIP SWITCH SETTINGS 8 | 9 | 10 |
|---|---|---|---|
| 5 | D | D | D |
| 10 | D | D | U |
| 15 | D | U | D |
| 20 | D | U | U |
| 25 | U | D | D |
| 30 | U | D | U |
| 40 | U | U | D |
| 50 | U | U | U |

Table 1.5: System Frequency Selection
DIP Switches #11 (Right Hand Array) U= UP, D= DOWN

| SYSTEM FREQUENCY 60/50 HZ | DIP SWITCH SETTINGS |
|---|---|
| System Frequency 50 Hz | UP |
| System Frequency 60 Hz | DOWN |

Table 1.6: NGR Let-through Current Settings
DIP Switches #12, 13, 14, 15, 16 (Right Hand Array) U= UP, D= DOWN

| NGR LET-THROUGH CURRENT (amperes) | DIP SWITCH SETTINGS 12 | 13 | 14 | 15 | 16 | USE ZSCS |
|---|---|---|---|---|---|---|
| 1 | D | D | D | D | U | TxA or Rx-yA w/10 Turns Through Primary |
| 2 | D | D | D | U | U | TxA or Rx-yA w/10 Turns Through Primary |
| 3 | D | D | U | D | U | TxA or Rx-yA w/10 Turns Through Primary |
| 4 | D | D | U | U | U | TxA or Rx-yA w/10 Turns Through Primary |
| 5 | D | D | D | D | D | TxA or Rx-yA |
| 10 | D | D | D | D | U | TxA or Rx-yA |
| 15 | D | D | D | U | D | TxA or Rx-yA |
| 20 | D | D | D | U | U | TxA or Rx-yA |
| 25 | D | D | U | D | D | TxA or Rx-yA |
| 30 | D | D | U | D | U | TxA or Rx-yA |
| 35 | D | D | U | U | D | TxA or Rx-yA |
| 40 | D | D | U | U | U | TxA or Rx-yA |
| 45 | D | U | D | D | D | TxA or Rx-yA |
| 50 | D | U | D | D | U | TxA or Rx-yA |

| NGR LET-THROUGH CURRENT (amperes) | DIP SWITCH SETTINGS 12 | 13 | 14 | 15 | 16 | USE ZSCS |
|---|---|---|---|---|---|---|
| 55 | D | U | D | U | D | TxA or Rx-yA |
| 60 | D | U | D | U | U | TxA or Rx-yA |
| 65 | D | U | U | D | D | TxA or Rx-yA |
| 70 | D | U | U | D | U | TxA or Rx-yA |
| 75 | D | U | U | U | D | TxA or Rx-yA |
| 80 | D | U | U | U | U | TxA or Rx-yA |
| 90 | U | D | D | D | U | TxA or Rx-yA |
| 95 | U | D | D | U | D | TxA or Rx-yA |
| 100 | U | D | D | U | U | TxA or Rx-yA |
| 125 | U | D | U | D | D | TxA or Rx-yA |
| 150 | U | D | U | D | U | TxA or Rx-yA |
| 175 | U | D | U | U | D | TxA or Rx-yA |
| 200 | U | D | U | U | U | TxA or Rx-yA |
| 225 | U | U | D | D | D | TxA or Rx-yA |
| 250 | U | U | D | D | U | TxA or Rx-yA |
| 275 | U | U | D | U | D | TxA or Rx-yA |
| 300 | U | U | D | U | U | TxA or Rx-yA |
| 325 | U | U | U | D | D | TxA or Rx-yA |
| 350 | U | U | U | D | U | TxA or Rx-yA |
| 375 | U | U | U | U | D | TxA or Rx-yA |
| 400 | U | U | U | U | U | TxA or Rx-yA |
| 500 | D | U | D | D | U | 10;000:1 |
| 600 | D | U | D | U | U | 10;000:1 |
| 800 | D | U | U | U | U | 10;000:1 |
| 1000 | U | D | D | U | U | 10;000:1 |
| 1250 | U | D | U | D | D | 10;000:1 |
| 1500 | U | D | U | D | U | 10;000:1 |
| 2000 | U | D | U | U | U | 10;000:1 |
| 2250 | U | U | D | D | D | 10;000:1 |
| 2500 | U | U | D | D | U | 10;000:1 |

# 4. MAINTENANCE

Gemini is designed and constructed to operate properly with minimal maintenance, however it is recommended that it be tested on a regular basis at a minimum of once every six months. The self-test feature allows for a rapid and reliable test.

### SELF-TEST PROCEDURE

Push the TEST button located on the front of the panel. The following changes take place.

a) The red GROUND FAULT light turns ON
b) The green SYSTEM HEALTHY light turns OFF
c) The TRIP light turns ON
d) The internal fans turn on
e) Auxiliary contacts change state

This change confirms that your Gemini is functioning normally. Return the Gemini to normal operating mode by pushing the RESET button.

### TROUBLESHOOTING

If a lamp fails to function, check the bulb. If a bulb is blown, replace with (Cutler Hammer E22R2). If the fans fail to start, remove power and check the electrical connections.
If all power fails, check the internal fuse and replace it if necessary (Edison EDCC5 fuse (5A).
For complete testing it will be necessary to apply a short to the system.

| DANGER |
| --- |
| Hazard of Electrical Shock, Burn or Explosion |
| All installation, servicing and testing referred to in this manual must be performed by qualified personnel. All power should be disconnected prior to removing covers or enclosures and where live conductors may otherwise be exposed. All exposed metallic enclosures must be grounded. |
| Failure to observe these precautions will result in death or severe personal injury. |

This should be done at a convenient downstream location (and not at the main substation for example) using a suitable low impedance protected by a HRC fuse mounted in a grounded enclosure for safety. This test should only be performed when there is no other fault indicated on the system.

### CLEANING

To clean the Gemini, first disconnect the electrical power. Using compressed air, blow away any accumulated dust and foreign material. The exterior may be cleaned using a slightly damp cloth. Ensure that the Gemini is completely dry before energizing. Close the front door and reconnect electrical power. Test the unit again before returning to normal service.

# 5. APPENDIX

## 5.1 HIGH RESISTANCE GROUNDING

Both the Canadian Electrical Code, Part 1, C22.1-12 and the National Electrical Code, NFPA 70 2011, approve the use of high-impedance grounding neutral systems up to 1000 VAC where the ground fault current is limited to 10 amperes or less. These new changes to the electrical code allow users of the Gemini to maintain a ground fault current of 5 amperes or less on their electrical distribution system without shutting down because of a single ground fault, thereby avoiding unscheduled down times. Gemini users can locate, isolate and repair faulty equipment at convenient time.

The reason for limiting ground fault current by resistance grounding may be one or more of the following, as indicated in IEEE Std. 142-2007, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems. pp.10.

(1) To reduce burning and melting effects in faulted electric equipment, such as switchgear, transformers, cables, and rotating machines.

(2) To reduce mechanical stresses in circuits and apparatus carrying fault currents.

(3) To reduce electric-shock hazards to personnel caused by stray ground-fault currents in the ground return path.

(4) To reduce the arc blast or flash hazard to personnel who may have accidentally caused or who happen to be in close proximity to the ground fault.

(5) To reduce the momentary line-voltage dip occasioned by the occurrence and clearing of a ground fault.

(6) To secure control of transient overvoltage's while at the same time avoiding the shutdown of a faulted circuit on the occurrence of the first ground fault (high-resistance grounding).

To secure control of transient over voltages while at the same time avoiding the shutdown of a faulty circuit on the occurrence of the first ground fault.

## 5.2 DEFINITIONS AND APPLICABLE STANDARDS

Grounding means a permanent and continuous conductive path to the earth with sufficient ampacity to carry any fault current liable to be imposed on it, and of a sufficiently low impedance to limit the voltage rise above ground and to facilitate the operation of protective devices in the circuit. Bonding means a low impedance path obtained by permanently joining all non-current-carrying metal parts to assure electrical continuity and having the capacity to conduct safely any current likely to be imposed on it.

Excerpts from: National Electric Code (NEC) NFPA 70
250-36. High-Impedance Grounded Neutral Systems

High-impedance grounded neutral systems in which a grounding impedance, usually a resistor, limits the ground-fault current to a low value shall be permitted for 3-phase ac systems of 480V to 1000V where all of the following conditions are met.

1) The conditions of maintenance and supervision ensure that only qualified persons will service the installation
2) Ground detectors are installed on the system
3) Line-to neutral loads are not served

HIGH-IMPEDANCE GROUNDED NEUTRAL SYSTEMS SHALL COMPLY WITH PROVISIONS (A) THROUGH (F).

a) Grounding Impedance Location: The grounding impedance shall be installed between the grounding electrode conductor and the system neutral point. If a neutral point is not available, the grounding impedance shall be installed between the grounding electrode conductor and the neutral point derived from a grounding transformer.

b) Neutral Conductor: The grounded system conductor from the neutral point of the transformer or generator to its connection point to the grounding impedance shall be fully insulated. The grounded system conductor shall have an ampacity of not less than the maximum current rating of the grounding impedance but in no case shall the grounded system conductor be smaller than 8 AWG copper or 6 AWG aluminum or copper-clad aluminum.

c) System Neutral Connection: The system shall not be connected to ground except through the grounding impedance.

d) Neutral Conductor Routing: The conductor connecting the neutral point of the transformer or generator to the grounding impedance shall be permitted to be installed in a separate raceway from the ungrounded conductors. It shall not be required to run this conductor with the phase conductors to the first system disconnecting means or overcurrent device.

e) Equipment Bonding Jumper: The equipment bonding jumper (the connection between the equipment grounding conductors and the grounding impedance) shall be an unspliced conductor run from the first system disconnecting means or overcurrent device to the grounded side of the grounding impedance.

f) Grounding Electrode Conductor Location: The grounding electrode conductor shall be connected at any point from the grounded side of the grounding impedance to the equipment grounding connection at the service equipment or first system disconnecting means.

g) Equipment Bonding Jumper Size: The equipment bonding jumper shall be sized in accordance with (1) or (2) as follows:

(1) If the grounding electrode conductor connection is made at the grounding impedance, the equipment bonding jumper shall be sized in accordance with 250.66, based on the size of the service entrance conductors for a service or the derived phase conductors for a separately derived system.

(2) If the grounding electrode conductor is connected at the first system disconnecting means or overcurrent device, the equipment bonding jumper shall be sized the same as the neutral conductor in 250.36(B).

CSA Canadian Electrical Code Part 1, C22.1-12

10-1100 Scope (see Appendix B)

Rules 10-1102 to 10-1108 apply to the installation of neutral grounding devices used for the purpose of controlling the ground fault current or the voltage-to-ground of an alternating-current system.

10-1102 Use (see Appendix B)

(1) Neutral grounding devices shall be permitted to be used only on systems where all neutral conductors are insulated to the nominal system voltage.

(2) Where line-to-neutral loads are not served, provision shall be made to automatically de-energize the system on the detection of a ground fault unless the electrical system is operating at 5 kV or less, in which case it shall be permitted to remain energized on the detection of a ground fault provided that

(a) the ground fault current is controlled at 10 A or less; and

(b) a visual and/or audible alarm is provided to indicate clearly the presence of the ground fault.

(3) Where line-to-neutral loads are served, provision shall be made to automatically de-energize the system on the occurrence of

(a) a ground fault;

(b) a grounded neutral on the load side of the neutral grounding device; or

(c) a lack of continuity of the conductor connecting the neutral grounding device from the neutral point through the neutral grounding device to the system grounding electrode.

10-1104 Neutral grounding devices

(1) Neutral grounding devices shall be specifically approved for the application.

(2) Only neutral grounding devices with a continuous rating shall be permitted where provision is not made to de-energize the system on the detection of a ground fault.

(3) Neutral grounding devices not having a continuous rating shall be permitted where

(a) provision is made to automatically de-energize the system on the detection of a ground fault; and

(b) the time rating of the device is coordinated with the time/current rating of the protective devices of the system.

(4) Neutral grounding devices shall have an insulation voltage rating at least equal to the system line-to-neutral voltage.

10-1106 Location of neutral grounding devices and warning signs

(1) All live parts of neutral grounding devices shall be enclosed or guarded in compliance with Rule 2-202.

(2) Neutral grounding devices shall be placed in a location that is accessible only to qualified persons to perform inspection, testing, and maintenance of the neutral grounding device.

(3) Neutral grounding devices shall be placed in a location so that heat dissipation from the device under ground fault conditions will not damage or adversely affect the operation of the device or other equipment.

(4) Where neutral grounding devices are used, warning signs indicating that the system is impedance grounded and the maximum voltage at which the neutral may be operating relative to ground shall be placed at the,

(a) transformer or generator, or both;

(b) consumer's service switchgear or equivalent; and

(c) supply authority's metering equipment.

10-1108 Conductors used with neutral grounding devices

(1) The conductor connecting the neutral grounding device to the neutral point of the transformer, generator, or grounding transformer shall be

(a) insulated for the nominal system voltage;

(b) identified white or grey;

(c) sized to conduct the rated current of the neutral grounding device, and in no case less than No. 8 AWG; and

(d) installed in accordance with other appropriate Rules of this Code.

(2) The conductor connecting the neutral grounding device to the neutral point of a transformer, generator, or grounding transformer shall not be grounded.

(3) The conductor connecting the neutral grounding device to the system grounding electrode shall be

(a) a copper conductor which shall be permitted to be insulated or bare;

(b) identified green if insulated;

(c) sized to conduct the rated current of the neutral grounding device, and in no case less than No. 8 AWG in size; and

(d) installed in accordance with other appropriate Rules of this Code.

(4) Where line-to-neutral loads are served, the conductors connecting to the neutral grounding device shall be sized to conduct the rated current of the neutral grounding device, and they shall in no case be smaller than No. 12 AWG.

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4.6.2 Neutral-grounding Devices

A neutral-grounding device shall be

(a) continuously rated, except when ground-fault tripping is provided;

(b) monitored to de-energize the supply in less than 60 s if the neutral-grounding device opens; and

(c) connected as close as practicable to the supply neutral.

5.4.3.4.1 Resistance Grounding

Where on-board three-phase power transformers larger than 20 kV•A and operating at voltages exceeding 150 V to ground are used, the following requirements shall apply:

(a) Except as permitted by Item (g), either a direct or derived neutral shall be grounded through a resistor at the power source to limit the prospective ground-fault current to 25 A or less.

(b) A grounding circuit shall originate at the grounded side of the resistor and extend along with the power conductors to ground the frames of all electrical apparatus supplied from the circuit, except where the steel structure provides the ground-return path as permitted by Clause 5.4.5(b).

(c) The size of the grounding conductors may be reduced, provided that the ampacity exceeds the prospective ground-fault current.

(d) Neutral-grounding resistors shall be isolated by elevation or guarded in accordance with Clause 5.4.4.1.

(e) Neutral-grounding resistors shall be rated and protected in accordance with Clause 4.6.2.

(f) Ground-fault protection with a minimum tripping ratio of five shall be provided, except as permitted by items (g) and (h).

(g) Ungrounded systems with ground-fault detection may be used for specialized drive circuits.

(h) Ground-fault detection that alerts the operator to the ground fault may be used instead of ground-fault protection where de-energizing a circuit can create a machine operation hazard.

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