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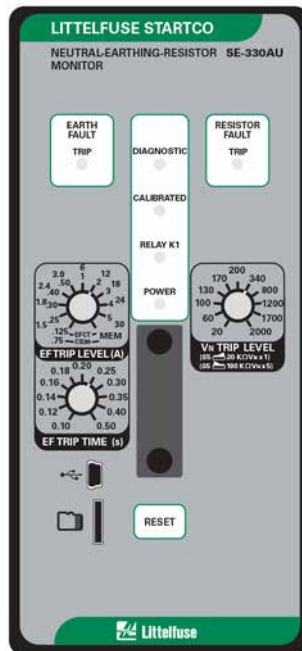
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SE-330AU MANUAL

NEUTRAL-EARTHING-RESISTOR MONITOR

Revision 4-H-120716



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1. GENERAL

1.1 MODERN RESISTANCE-EARTHED SYSTEMS

A high-resistance-earthed system uses a neutral-earthing resistor (NER) with a low let-through current to limit earth-fault current. This is an improvement over low-resistance or solidly-earthed systems because, in those systems, an earth-fault flash hazard exists and an earth fault can result in substantial point-of-fault damage. High-resistance earthing eliminates these problems and modern earth-fault protection operates reliably at low current levels. Furthermore, the probability of an arc-flash incident is significantly reduced in a high-resistance NER system.

NER selection depends on system charging current. System charging current is the capacitive current that flows to earth when a bolted earth fault occurs. This current can be calculated or measured. For small systems, the magnitude of charging current can be conservatively estimated as $\frac{1}{2}$ A per 1,000 kVA on low-voltage systems and 1 A per 1,000 kVA on medium-voltage systems.

Choose an NER with a let-through current larger than the system charging current. Set the pick-up current of earth-fault devices at or below 10% of the NER let-through current for systems up to 1.1 KV and 20% of the NER let through current for systems above 1.1 KV.

Use earth-fault devices with a definite-time characteristic to achieve time coordination. Use the same pick-up current for all earth-fault devices—this value must be larger than the charging current of the largest feeder. Select an NER with a let-through current between five and 10 times the pick-up current of the earth-fault devices.

Do not use an earthing transformer with a low-voltage resistor:

- The combined cost of a transformer and a low-voltage resistor is more than the cost of a resistor rated for line-to-neutral voltage.
- A transformer saturated by an earth fault through a rectifier can make earth-fault protection inoperative.
- Transformer inrush current up to 12 times rated current can cause an earth-fault voltage larger than expected.
- A parallel transformer winding makes it difficult to monitor NER continuity.
- A transformer can provide the inductance necessary to cause ferroresonance if the NER opens.

Following these guidelines will reduce the flash hazard, reduce point-of-fault damage, achieve reliable earth-fault protection, and ensure a stable system not subject to ferroresonance.

1.2 SE-330AU NER MONITORING

The SE-330AU is a microprocessor-based neutral-earthing-resistor monitor that detects NER failures and earth faults in resistance-earthed systems. The SE-330AU measures NER resistance, NER current, and transformer or generator neutral-to-earth voltage. The components required to monitor an NER are an SE-330AU, an ER-series sensing resistor, and a current transformer (CT).

Power-circuit elements, other than neutral-connected NER's, that purposefully connect the power system to earth may not be compatible with SE-330AU NER monitoring. These elements include single-phase earthing transformers, earthed-wye-primary potential transformers (PT's), and earthed-wye-primary power transformers.

The SE-330AU continuously measures NER resistance in an unfaulted system. It will trip on resistor fault if NER resistance varies from its calibrated value. When an earth fault occurs, voltage is present on the neutral and NER current will flow if the NER is healthy. The SE-330AU will trip on earth fault if fault current exceeds the EF TRIP LEVEL setting for an interval greater than the EF TRIP TIME setting. However, if the NER fails and creates an open circuit during an earth fault, it is possible for fault resistance to satisfy the NER resistance measurement. To detect this double-fault condition, the SE-330AU measures neutral voltage. If neutral voltage exceeds the V_N TRIP LEVEL setting, and if NER current is less than 5% of the current transformer (CT) rating, the SE-330AU will trip on resistor fault. If the resistor-fault circuit is tripped and the neutral voltage exceeds the V_N TRIP LEVEL setting for an interval greater than the EF TRIP TIME setting, the earth-fault circuit will also trip. Earth-fault current is sensed by a sensitive CT (EFCT-x or SE-CS30-x). The trip level of the earth-fault circuit is adjustable from 0.125 to 5 A for the EFCT-x and 0.75 to 30 A for the SE-CS30-x. Trip time is adjustable from 0.1 to 0.5 seconds. Open-CT detection is provided with a fixed 2-second time delay.

The SE-330AU has four output relays. Relay K1 is the trip relay. Relays K2 and K3 provide earth-fault and resistor-fault indication. K4 is a solid-state relay that provides UNIT HEALTHY indication. Relay K1 operates in the fail-safe mode for undervoltage applications.

Additional features include LED trip indication, trip memory, front-panel and remote reset, 4-20-mA analog output, trip event recorder, USB local communications, microSD™ data logging, and optional network communications.

The SE-330AU is compatible with lockout earth-fault protection devices—the on line phase-to-earth resistance added by coupling components must be above the SE-330AU NER-failure-detection resistance.

The SE-330AU provides additional features over the SE-330AU legacy model (revision 01 or less):

- When the trip level is set to MEM, the earth-fault trip setting is defined by an internal non-volatile memory variable. Range is 2 to 100% in 1% increments of the CT-primary rating.
- Indication relays can be set to fail-safe or non-fail-safe.
- The number of trip records has been increased to 100 and includes date and time stamping.
- A microSD™ card interface can be used for long-term data logging and firmware updates. A microSD™ card and a microSD-to-SD adapter is included. See Section 4.1.
- For ease of connection to new devices, the RS-232 interface has been replaced by a Mini B USB port.
- Dual Ethernet ports are available with support for fiber-optic and RJ45 interfaces.
- The IEC 61850 protocol has been added.

2. OPERATION

2.1 SETTINGS

2.1.1 EF TRIP TIME

EF TRIP TIME (definite time) is adjustable from 0.1 to 0.5 seconds. Time-coordinated earth-fault protection requires this setting to be longer than the trip times of downstream earth-fault devices.

A trip-time accumulator provides an earth-fault memory function for detection of intermittent faults. The accumulated time increases when an earth fault is detected and decreases when an earth fault is not detected. A trip will eventually occur when the time for fault current above the trip level is greater than the time for fault current below the trip level.

2.1.2 EF TRIP LEVEL

The SE-330AU uses a Discrete-Fourier Transform (DFT) Algorithm to measure the fundamental component of NER current.

Choose an NER let-through current and an earth-fault trip level according to the guidelines in Section 1.1.

Earth-fault current is sensed by a sensitive CT (EFCT-x or SE-CS30-x). The trip level of the earth-fault circuit is adjustable from 0.125 to 5 A for the EFCT-x and 0.75 to 30 A for the SE-CS30-x.

When EF TRIP LEVEL is set to MEM, the earth-fault setting stored in non-volatile memory is used. This parameter must be set using a PC running the SE-MON330 software connected to the USB interface. The setting range is 2 to 100% of CT-primary rating in 1% increments. For example, if the MEM parameter is set to 15% (default), the trip level will be 0.75 A or 4.5 A when using the EFCT-x or SE-CS30-x respectively. Typical values are shown in Table 1. For other systems, refer to the NER Monitor Set-Point Assistant at www.littelfuse.com/relayscontrols. The Set-Point Assistant is included with the SE-MON330 software.

2.1.3 V_N TRIP LEVEL

The SE-330AU uses a DFT algorithm to measure the fundamental component of neutral voltage (V_N).

If neutral voltage is greater than the V_N TRIP LEVEL setting for the duration of the resistor-fault trip time and earth-fault current is less than 5% of the CT rating, the SE-330AU will trip on resistor fault. If the resistor-fault circuit is tripped and the neutral voltage exceeds the V_N TRIP LEVEL setting for an interval greater than the EF TRIP TIME setting, the earth-fault circuit will also trip.

The V_N TRIP LEVEL range is 20 to 2,000 V with switch S5 in the 20-k Ω (V_{x1}) position, and the range is 100 to 10,000 V with switch S5 in the 100-k Ω (V_{x5}) position. Calculate the voltage across the NER when NER current is equal to the pick-up current of the earth-fault circuit. Set the V_N TRIP LEVEL at the next largest value. See Fig. 1 and Section 2.1.4.3.

Typical values are shown in Table 1. For an NER resistance greater than 2 k Ω , use a 100-k Ω sensing resistor. For other systems, refer to the NER Monitor Set-Point Assistant at www.littelfuse.com/relayscontrols.

NOTE: A resistor-fault trip is held off if the earth-fault current is above 5% of the CT rating.

2.1.4 CONFIGURATION SETTINGS

Eight configuration switches (S1 to S8) and a calibration button are located behind the access cover on the front panel. See Fig. 1.

2.1.4.1 EARTH-FAULT-TRIP LATCH (S3)

Set switch S3 to select latching or non-latching earth-fault-circuit operation. See Section 2.4.

2.1.4.2 RESISTOR-FAULT-TRIP LATCH (S4)

Set switch S4 to select latching or non-latching resistor-fault-circuit operation. See Section 2.4

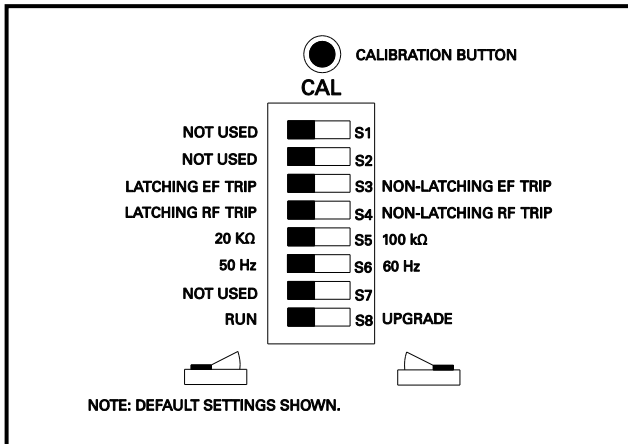


FIGURE 1. Configuration Switches.

2.1.4.3 SENSING-RESISTOR SELECTION (S5)

Set switch S5 to the resistance of the sensing resistor. For the ER-600VC, ER-5KV, and ER-5WP select 20 kΩ. For the ER-15KV, ER-25KV, and ER-35KV, select 100 kΩ. Switch S5 sets the V_N TRIP LEVEL range. See Section 2.1.3.

2.1.4.4 FREQUENCY (S6)

Set switch S6 to 50 or 60 Hz to tune the digital filter to the line frequency of the monitored system.

2.1.4.5 UPGRADE MODE (S8)

The microSD™ card is used for firmware upgrades. See Section 4.1.2 for upgrade instructions.

NOTE: An upgrade causes an SE-330AU restart and this may cycle the output relays.

2.1.5 RESISTOR-FAULT TRIP TIME

The resistor-fault trip time can be adjusted from 12 (default) to 60 seconds using the SE-MON330 software or via network communications.

2.1.6 RESISTOR-FAULT TRIP LEVEL

The resistor-fault trip level can be adjusted using the SE-MON330 software or via network communications. See Section 6.1.

2.1.7 GEO-MAGNETIC FILTER

A low-frequency earth current can be caused by the Earth's magnetic field and from charged clouds passing overhead during a thunderstorm. In some rare conditions, this can cause a false resistor-fault trip. Enabling the geo-magnetic filter and increasing the resistor-fault trip time can help counteract these effects.

A trip time of 30 seconds is recommended when the geo-magnetic filter is enabled.

The geo-magnetic filter is disabled by default, but can be enabled using the SE-MON330 software or via network communications.

2.2 CALIBRATION

The SE-330AU measures the resistance change of the NER relative to the NER-resistance value determined at the time of calibration. When the resistance change is greater than a threshold amount (500 Ω for 20-kΩ systems, 2,500 Ω for 100-kΩ systems), a resistor-fault trip occurs. Calibrate the SE-330AU on new installations, if the NER is changed, or if the sensing resistor is changed.

The CALIBRATION button is located behind the access cover on the front panel, and it is recessed to prevent inadvertent activation.

NOTE: Calibration must be performed with the SE-330AU connected to the sensing resistor and NER of the installed system.

NOTE: Where used, coupling components for lockout earth-fault protection devices must be disconnected from the supply during calibration.

To calibrate, press and hold the CALIBRATION button until the green CALIBRATED LED turns off and returns to on (if the LED is already off, press and hold until the LED turns on). Calibration takes approximately two seconds. If calibration is not successful, a resistor-fault trip occurs, the RESISTOR FAULT TRIP LED will be on, the CALIBRATED LED will be off, and the DIAGNOSTIC LED will flash the calibration-error code. See Section 2.8.

The SE-330AU may be calibrated remotely using the SE-MON330 software with the USB interface or the communications options.

If latching resistor fault (switch S4) is selected, the calibration-error code flashes until RESET is pressed even if the CALIBRATED LED is on.

The calibration value is stored in non-volatile memory.

2.3 CT DETECTION

The SE-330AU monitors the continuity of the CT circuit. When an open CT circuit is detected for two seconds, the SE-330AU will trip on earth fault and the diagnostic LED will flash the CT-Detection-Error code. See Section 2.8. The CT-Detection-Error code remains until CT-circuit continuity is detected and RESET is pressed. If supply voltage is cycled, earth-fault trip indication is not reset but the CT-Detection-Error indication is reset. CT-Detection-Error indication will resume after two seconds if CT-circuit continuity is not detected.

2.4 TRIP INDICATION AND RESET

Red LED's and indication relays indicate earth-fault and resistor-fault trips. The indication relays K2 (EF) and K3 (RF) operate in fail-safe or non-fail-safe mode. The default is non-fail-safe mode. In this mode, the relays are energized when a fault occurs. The relay mode setting is stored in non-volatile memory and can be set using the SE-MON330 software or network communications.

When a trip occurs with latching operation selected, the SE-330AU remains tripped until reset with the front panel button or the remote-reset input. See Sections 2.1.4.1 and 2.1.4.2. Terminals 15 and 16 are provided for remote reset as shown in Fig. 3. The reset circuit responds only to a momentary closure so that a jammed or shorted button does not prevent a trip. The front-panel RESET button is inoperative when terminal 15 is connected to terminal 16. If non-latching operation is selected, trips and corresponding indication automatically reset when the fault clears. Resistor-fault-trip reset can take up to one second.

The red DIAGNOSTIC LED annunciates latched calibration error and remote trips. See Section 2.8.

When supply voltage is applied, the SE-330AU returns to its state prior to loss of supply voltage. A resistor-fault trip-memory trip can take up to three seconds after SE-330AU power-up.

2.5 REMOTE OPERATION

Relays K2 and K3 can be used for remote indication, and terminals 15 and 16 are provided for remote reset. RK-332 Remote Indication and Reset components are shown in Fig. 19. Connect them as shown in Fig. 3. RK-332 components are not polarity sensitive.

Indication relays can be set to fail-safe or non-fail-safe operation using the SE-MON330 software or network communications. The default mode is non-fail-safe. In non-fail-safe mode, relays energize on fault.

Network-enabled SE-330AU's can be remotely tripped, reset, and calibrated by the network master. The red DIAGNOSTIC LED indicates a network-initiated trip. See Section 2.8. Refer to the appropriate SE-330AU communications manual.

2.6 RELAY K1 LED

The yellow RELAY K1 LED follows the state of relay K1 and is on when K1 is energized (contact closed).

2.7 UNIT HEALTHY OUTPUT

UNIT HEALTHY relay K4 is energized when the processor is operating. It can be ordered with N.O. or N.C. contacts. See Section 7.

NOTE: The K4 output changes state momentarily during a processor reset.

NOTE: K4-contact rating is 100 mA maximum.

2.8 DIAGNOSTIC LED

The DIAGNOSTIC LED is used to annunciate trips without individual LED indication. The number of short LED pulses between two long pulses indicates the cause of the trip. See Section 5.

2.9 ANALOG OUTPUT

An isolated 4–20-mA output indicates NER current with full-scale output corresponding to the CT rating. An internal 24-Vdc supply allows the analog output to be connected as a self-powered output. Power from an external supply is required for loop-powered operation. See Fig. 2. The PGA-0520 analog meter can be panel-mounted to display the NER current. See Fig. 20 and Section 7.

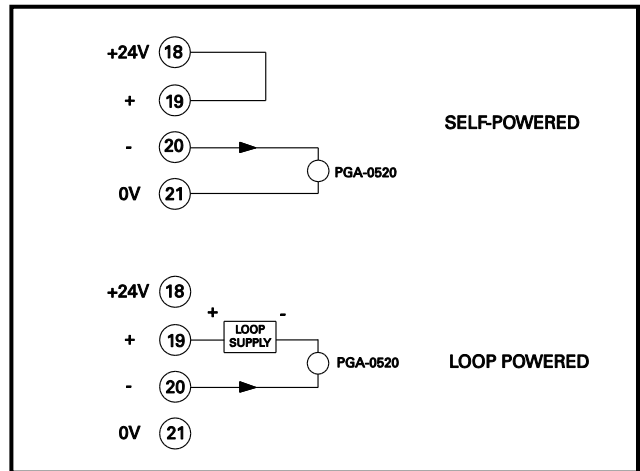


FIGURE 2. Analog-Output Connections.

TABLE 1. TYPICAL VALUES FOR TRIPPING SYSTEMS

SYSTEM VOLTAGE (VOLTS)		NEUTRAL-EARTHING RESISTOR		EARTH-FAULT TRIP LEVEL (AMPERES)		V _N TRIP LEVEL (VOLTS)	SENSING RESISTOR	S5
LINE TO LINE	LINE TO NEUTRAL	CURRENT (AMPERES)	RESISTANCE (OHMS)	EFCT-X (5-A RATING)	SE-CS30-X (30-A RATING)			
110 (3)	55	5	11	0.5	(1)	20	ER-600VC	20 kΩ
120 (3)	60	5	12	0.5	(1)	20	ER-600VC	20 kΩ
110	64	5	13	0.5	(1)	20	ER-600VC	20 kΩ
127	73	5	15	0.5	(1)	20	ER-600VC	20 kΩ
240 (3)	120	5	24	0.5	(1)	20	ER-600VC	20 kΩ
240	139	5	28	0.5	(1)	20	ER-600VC	20 kΩ
270	156	5	31	0.5	(1)	20	ER-600VC	20 kΩ
415	240	5	48	0.5	(1)	60	ER-600VC	20 kΩ
433	250	5	50	0.5	(1)	60	ER-600VC	20 kΩ
690	398	5	80	0.5	(1)	60	ER-600VC	20 kΩ
970	560	5	112	0.5	(1)	60	ER-5KV	20 kΩ
1,000	575	5	115	0.5	(1)	60	ER-5KV	20 kΩ
1,050	605	5	121	0.5	(1)	100	ER-5KV	20 kΩ
1,100	635	5	127	0.5	(1)	100	ER-5KV	20 kΩ
1,140	658	5	132	0.5	(1)	100	ER-5KV	20 kΩ
3,300	1,905	5	381	0.5	(1)	200	ER-5KV	20 kΩ
6,600	3,810	5	762	0.5	(1)	500	ER-15KV	100 kΩ
6,600	3,810	10	381	1.0	0.75	500	ER-15KV	100 kΩ
6,600	3,810	25	152	2.0	1.5	500	ER-15KV	100 kΩ
11,000	6,350	5	1,270	0.5	(1)	650	ER-15KV	100 kΩ
11,000	6,350	10	635	1.0	0.75	650	ER-15KV	100 kΩ
11,000	6,350	20	318	2.0	1.5	650	ER-15KV	100 kΩ
11,000	6,350	25	254	2.0	2.4	650	ER-15KV	100 kΩ
22,000	12,700	5	2,540	0.5	(1)	1,700	ER-25KV	100 kΩ
22,000	12,700	10	1,270	1.0	0.75	1,700	ER-25KV	100 kΩ
22,000	12,700	20	635	2.0	1.5	1,700	ER-25KV	100 kΩ
22,000	12,700	25	508	2.0	2.4	1,700	ER-25KV	100 kΩ
22,000	12,700	50	254	(2)	24	8,500	ER-25KV	100 kΩ
33,000	19,050	50	380	(2)	24	10,000	ER-35KV	100 kΩ

- (1) Minimum setting is 0.75 A. Use EFCT-x for AS/NZS 2081:2002 compliance.
- (2) Maximum setting is 5 A. AS/NZS 2081:2002 allows 25 A.
- (3) Single phase, centre tap.

3. INSTALLATION

3.1 SE-330AU

Outline and panel-cutout dimensions for the SE-330AU are shown in Fig. 4. To panel mount the SE-330AU, insert it through the panel cutout and secure it with the four included 8-32 locknuts and flat washers. If an optional SE-IP65CVR-G Hinged Cover is used, follow the included installation instructions. See Figs 6 and 7.

All connections to the SE-330AU are made with plug-in, wire-clamping terminal blocks. Each plug-in terminal block can be secured to the SE-330AU by two captive screws for reliable connections.

Outline dimensions and mounting details for surface mounting the SE-330AU are shown in Fig. 5. Fasten the optional SE-330-SMA Surface-Mount Adapter to the mounting surface and make connections to the adapter terminal blocks. Follow Fig. 5 instructions to mount or remove the SE-330AU.

Connect terminal 7 (G) to earth and connect terminal 6 (R) to the sensing-resistor R terminal.

Use terminal 1 (L1) as the line terminal on ac systems, or the positive terminal on dc systems. Use terminal 2 (L2/N) as the neutral terminal on ac systems or the negative terminal on dc systems. Connect terminal 3 (\oplus) to earth. Connect terminal 4 (SPG) to terminal 5 (SPGA).

NOTE: Disconnect terminal 1 (L1) and terminal 2 (L2/N) before performing dielectric strength testing of the control panel.

3.2 SENSING RESISTOR

Outline and mounting details for the ER-600VC, ER-5KV, ER-5WP, ER-15KV, ER-25KV, and ER-35KV sensing resistors are shown in Figs. 8, 11, 12, 13, 14 and 15. Install the NER and the sensing resistor near the transformer or generator. An optional SE-MRE-600 Moisture Resistant Enclosure is available for applications which may expose an ER-600VC to moisture. See Figs 9 and 10. The weather-protected ER-5WP shown in Fig. 12 is an ER-5KV with moisture-resistant terminal covers. Use an ER-5WP in applications in which it might be exposed to moisture. The ER-15KV, ER-25KV, and ER-35KV include moisture-resistant terminal covers. Use suitable water-tight fittings. Connect terminal G to earth. Pass the sensing-resistor-to-neutral conductor and the NER-to-neutral conductor through the earth-fault-CT window as shown in Fig. 3. Separately connect sensing-resistor terminal N and the NER to the neutral to include neutral connections in the monitored loop. Alternatively, if the NER connection to system neutral need not be monitored, connect terminal N to the NER neutral terminal.

If an earth fault in the sensing-resistor conductor is unlikely, a minimal loss of protection will result if it does not pass through the earth-fault-CT window. See Fig. 3.

NOTE: Voltage at terminal N rises to line-to-neutral voltage when an earth fault occurs. The same clearances are required for sensing resistors as for NER's.

NOTE: A parallel earth path created by moisture can result in a false resistor-fault trip. Moisture sources include wind-driven rain or snow, and condensation. Sensing-resistor terminal R and its connection to SE-330AU terminal R, including interposing terminal blocks, must remain dry.

NOTE: The neutral-to-sensing-resistor-terminal-N connection is not a neutral conductor. Since current through this conductor is always less than 250 mA, a 1.5 mm² conductor insulated to the system voltage is more than sufficient.

NOTE: For outdoor installations, sensing resistors must be in an IP14 enclosure.

3.3 EARTH-FAULT CT

Select and install an earth-fault CT that will provide the desired trip level. Typically, the CT-primary rating should be approximately equal to the NER let-through-current rating. This provides an appropriate EF TRIP LEVEL setting range and analog-output scaling. The primary rating of the EFCT-x is 5 A and the primary rating of the SE-CS30-x is 30 A. See Sections 2.1.2 and 2.9.

Outline and mounting details for the sensitive EFCT-x and SE-CS30-x current sensors are shown in Figs. 16, 17, and 18. Earth-fault-CT connections and the typical earth-fault-CT location are shown in Fig. 3. If an earth fault in the NER is unlikely, a minimal loss of protection will result if the earth-fault CT monitors the NER connection to earth rather than its connection to neutral.

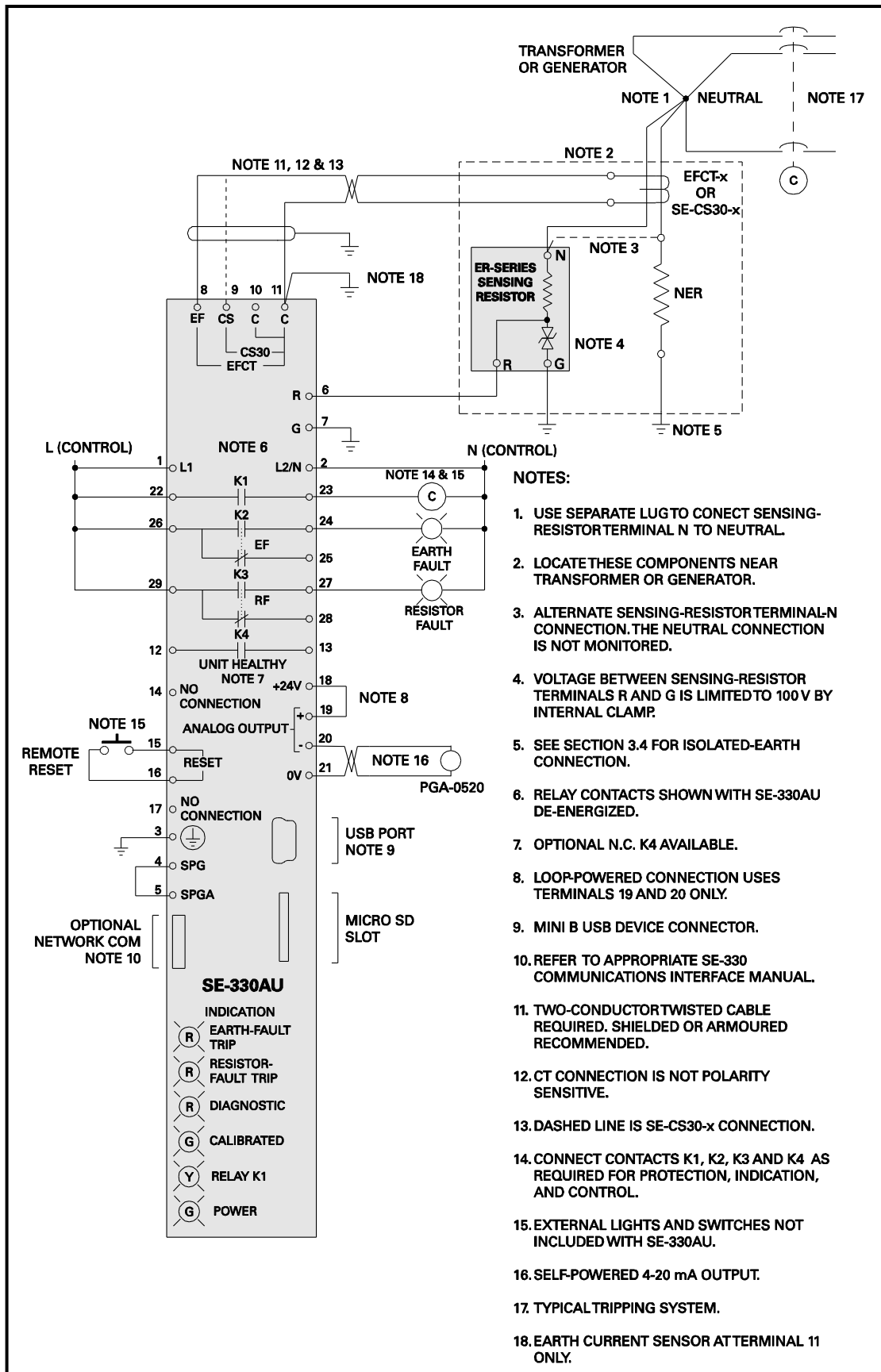


FIGURE 3. SE-330AU Connection Diagram.

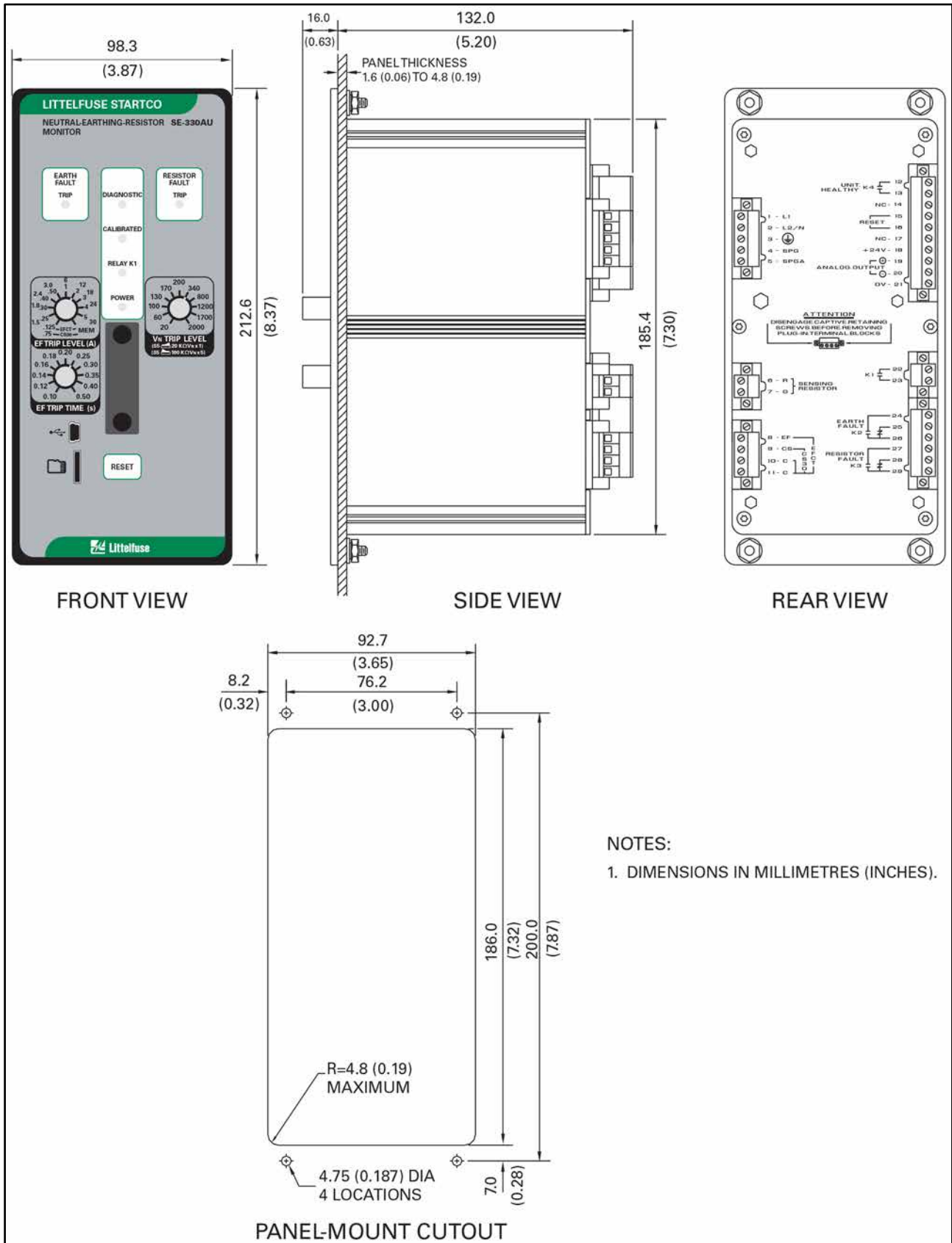


FIGURE 4. SE-330AU Outline and Panel-Mounting Details.

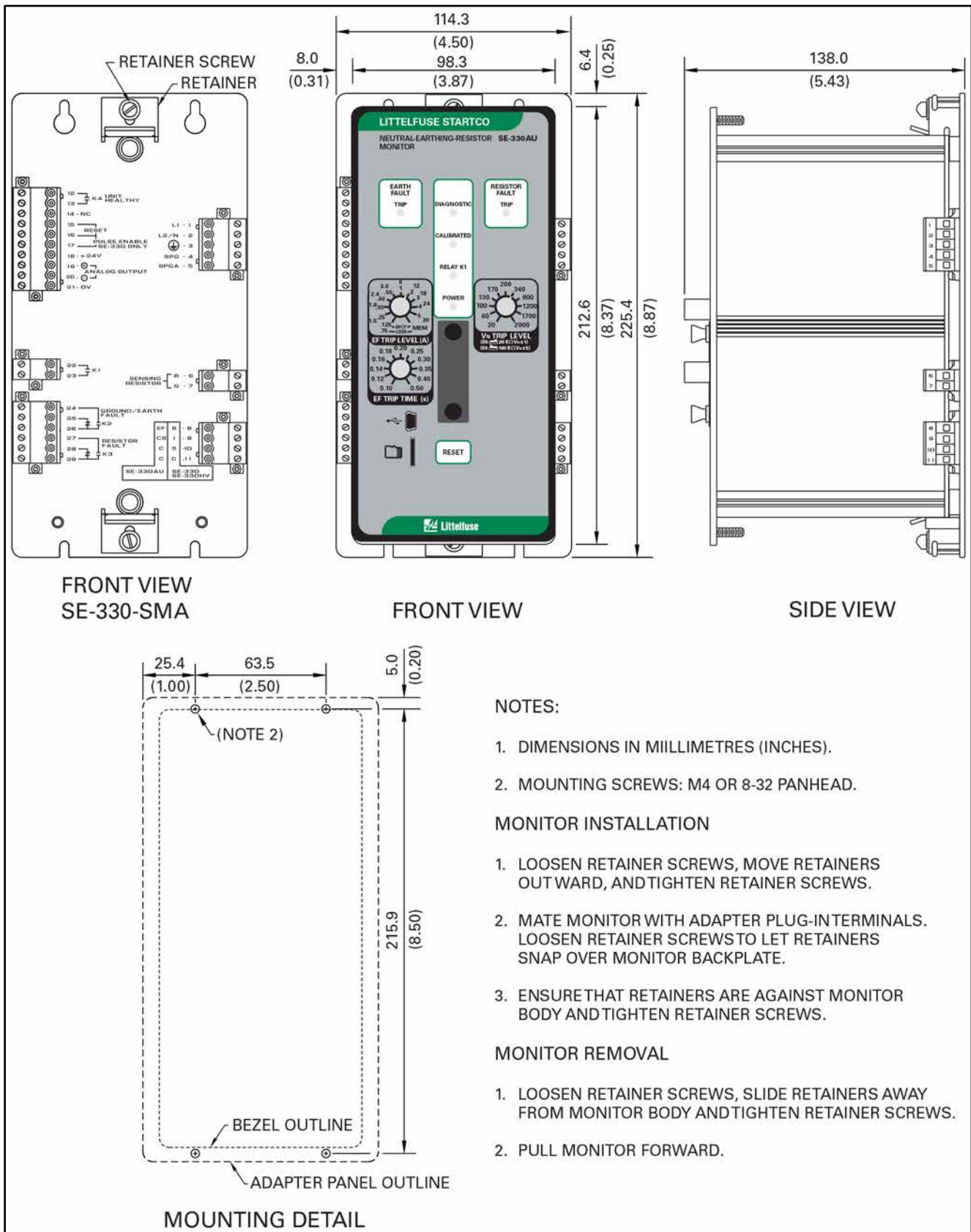


FIGURE 5. SE-330AU Outline and Surface-Mounting Details.

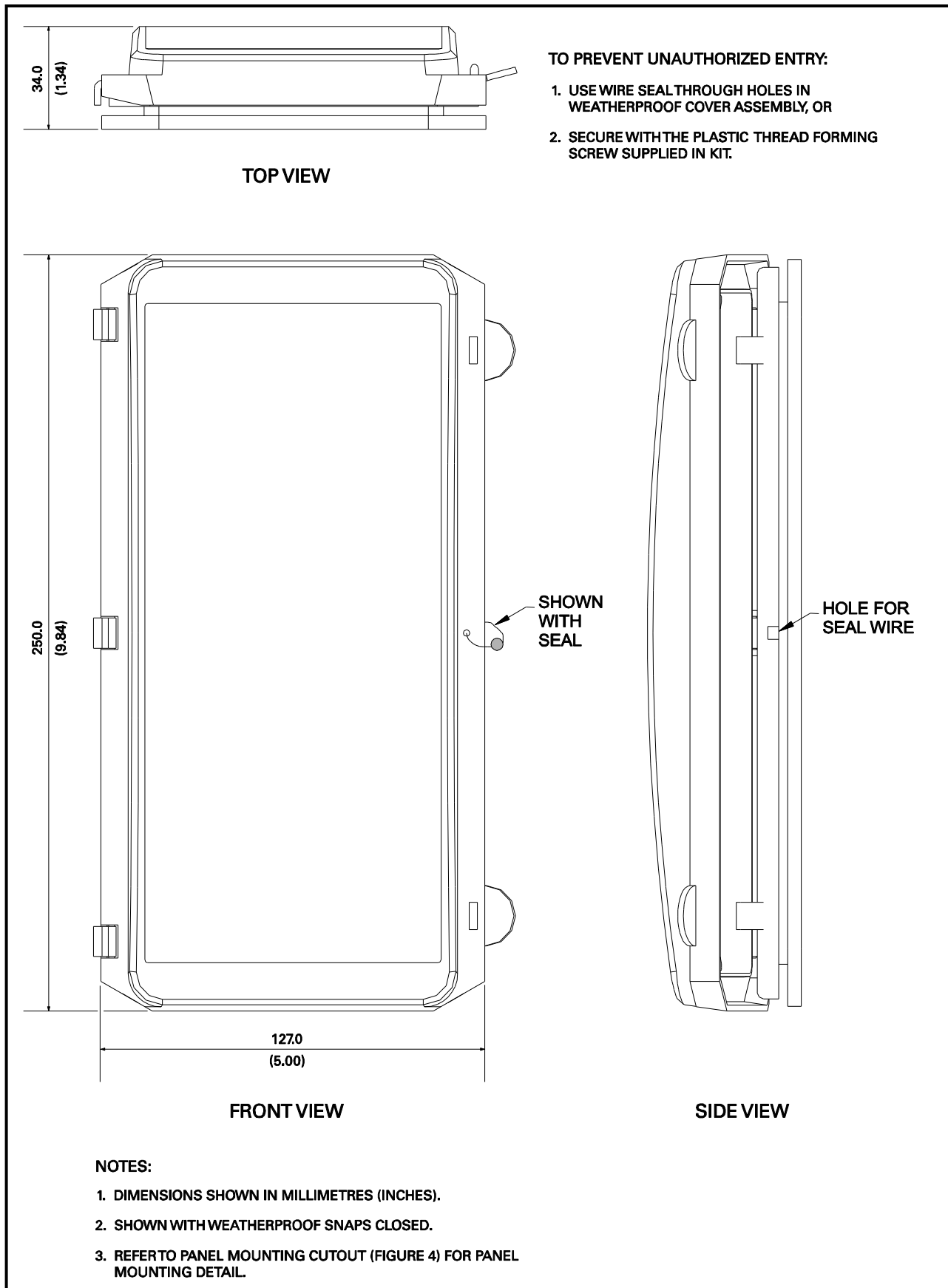


FIGURE 6. SE-IP65CVR-G Weatherproof Cover Outline.

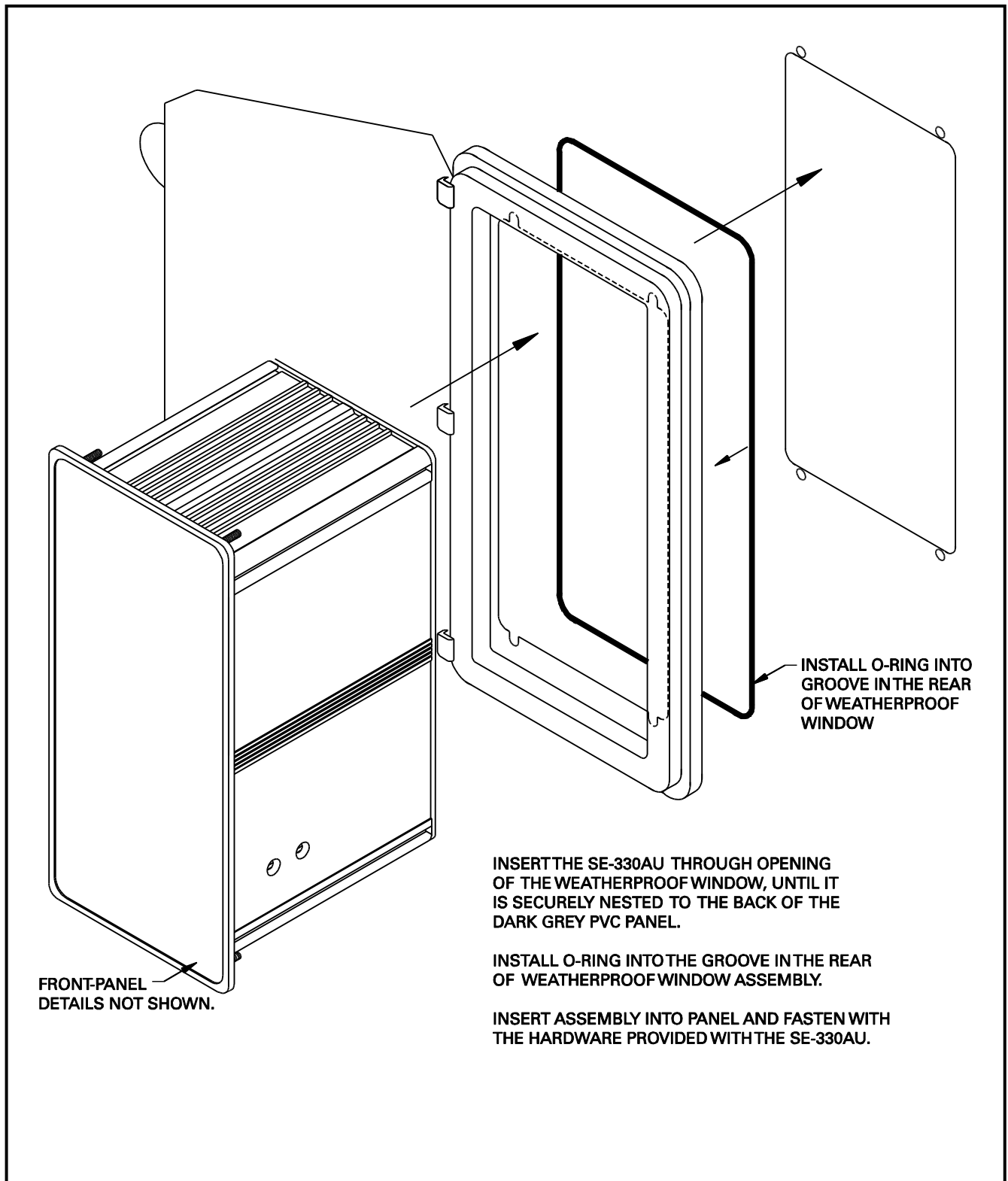


FIGURE 7. SE-IP65CVR-G Weatherproof Cover Installation.

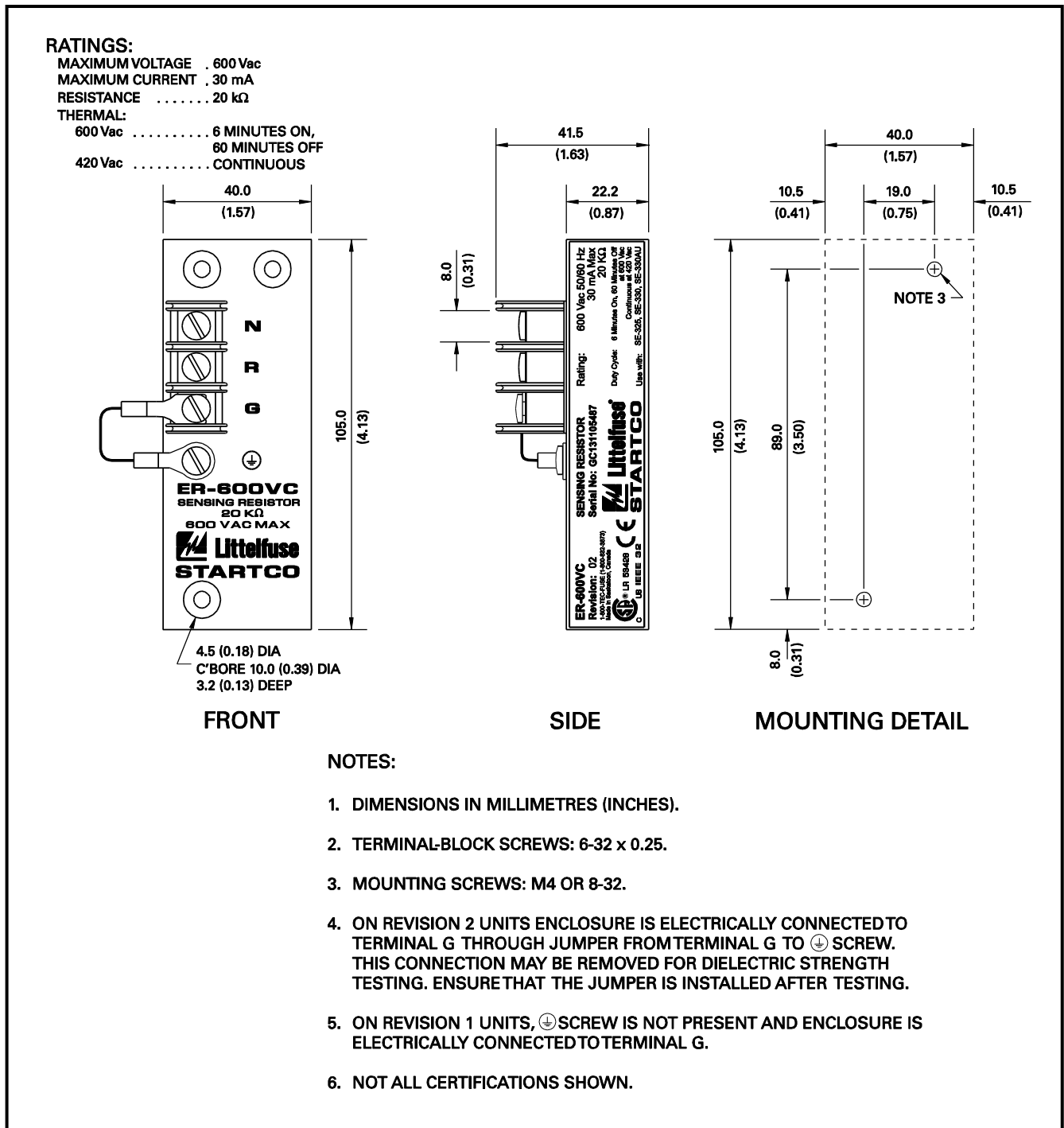


FIGURE 8. ER-600VC Sensing Resistor.

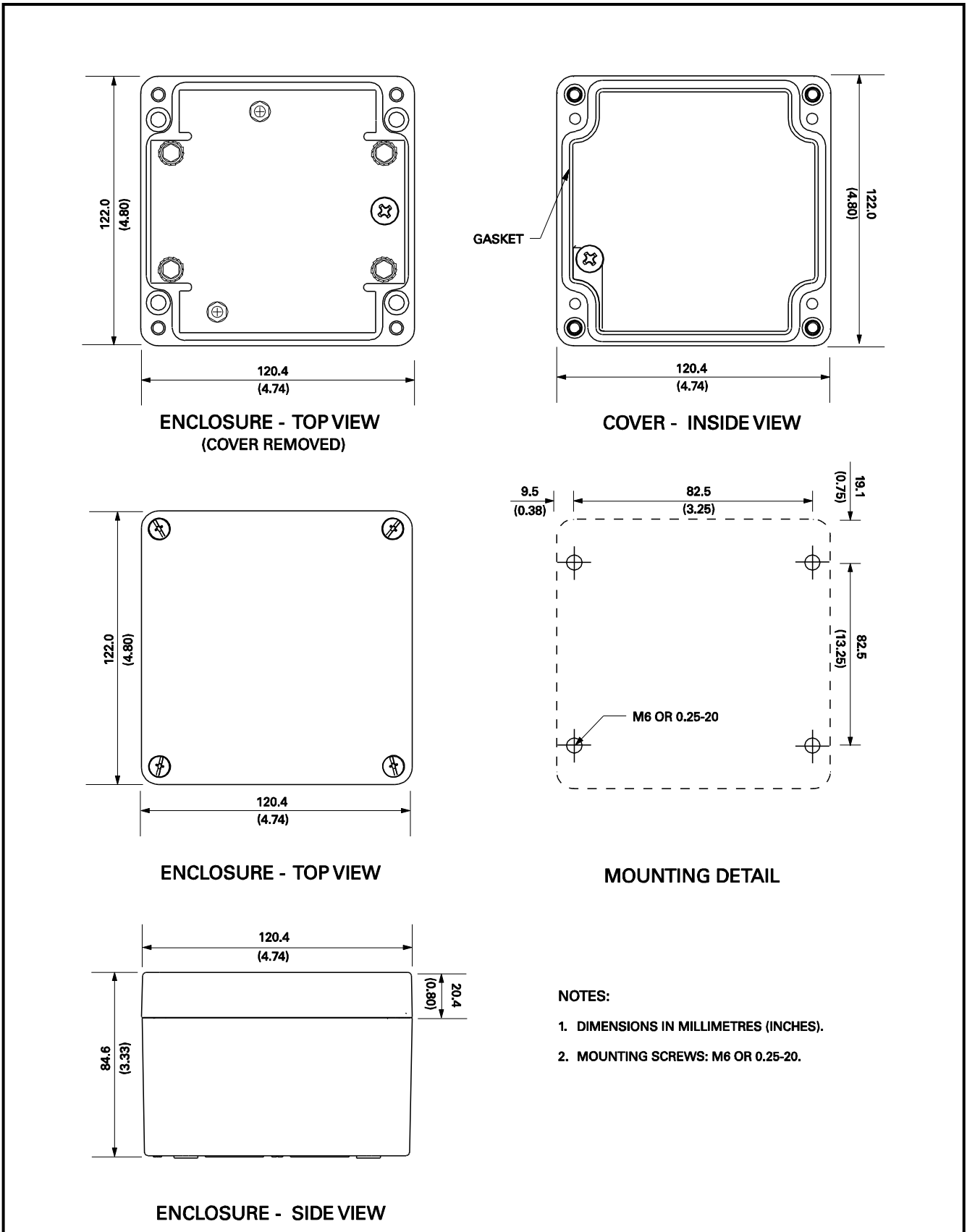


FIGURE 9. SE-MRE-600 Moisture Resistant Enclosure.

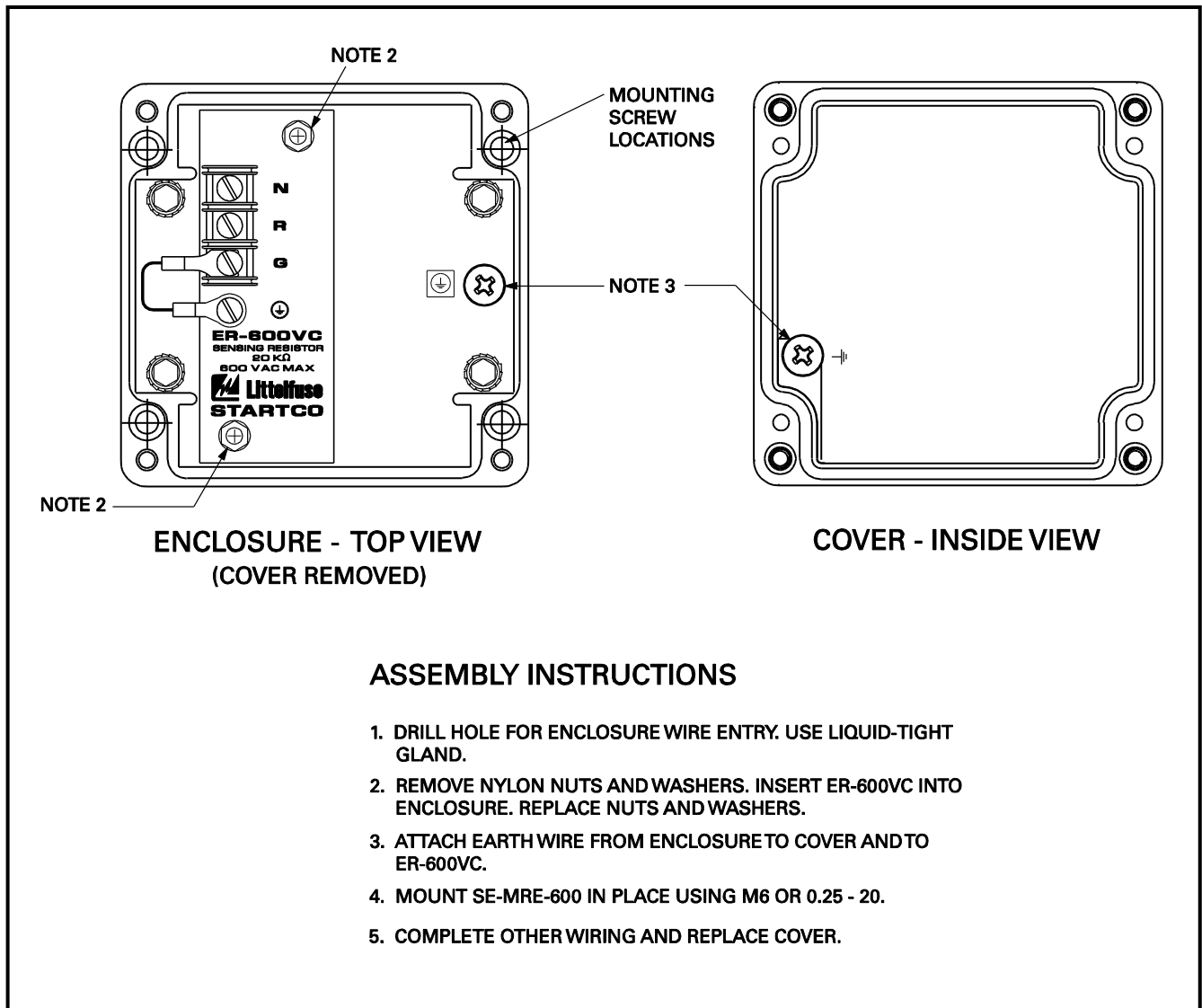


FIGURE 10. ER-600VC Installed in SE-MRE-600.

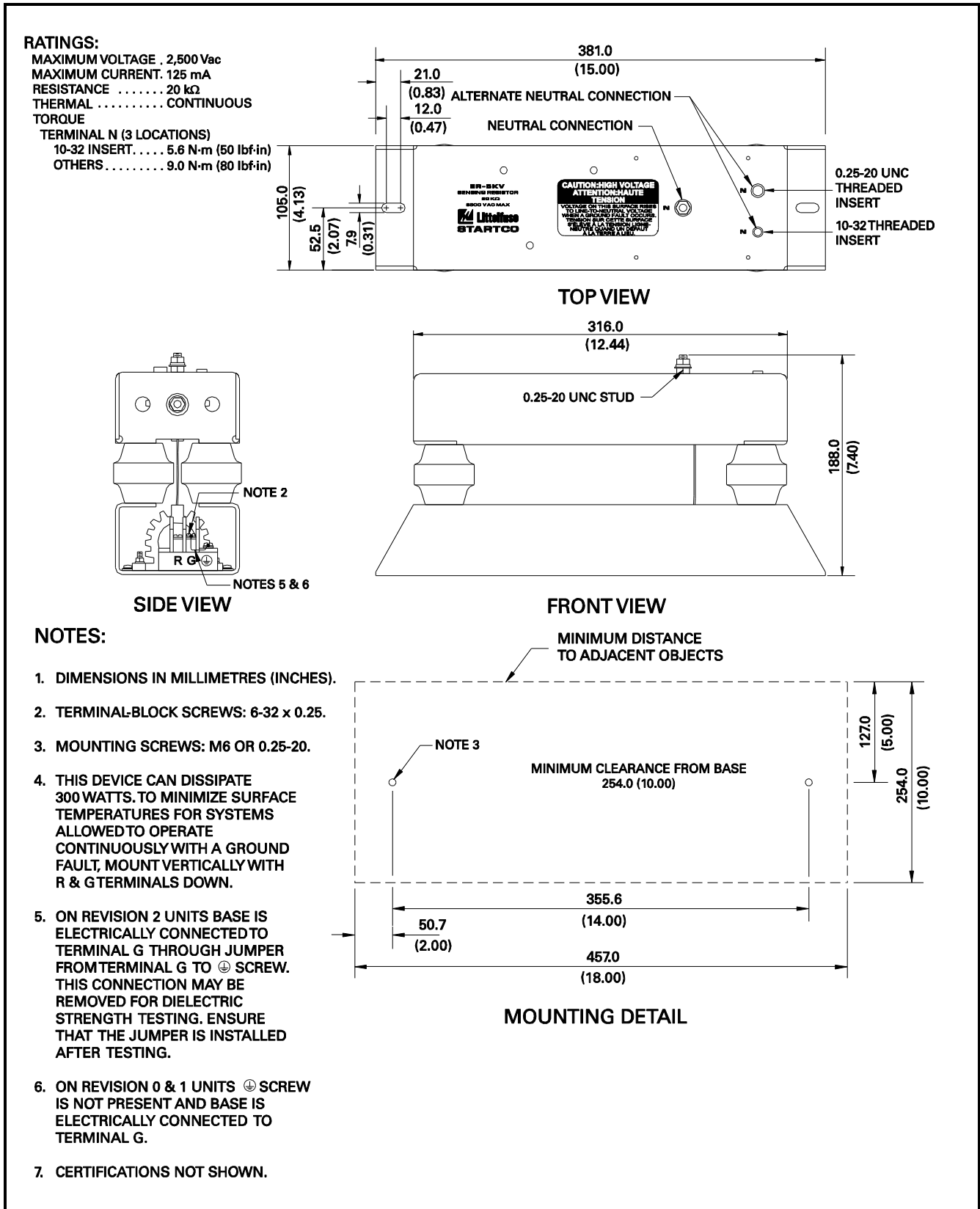


FIGURE 11. ER-5KV Sensing Resistor.

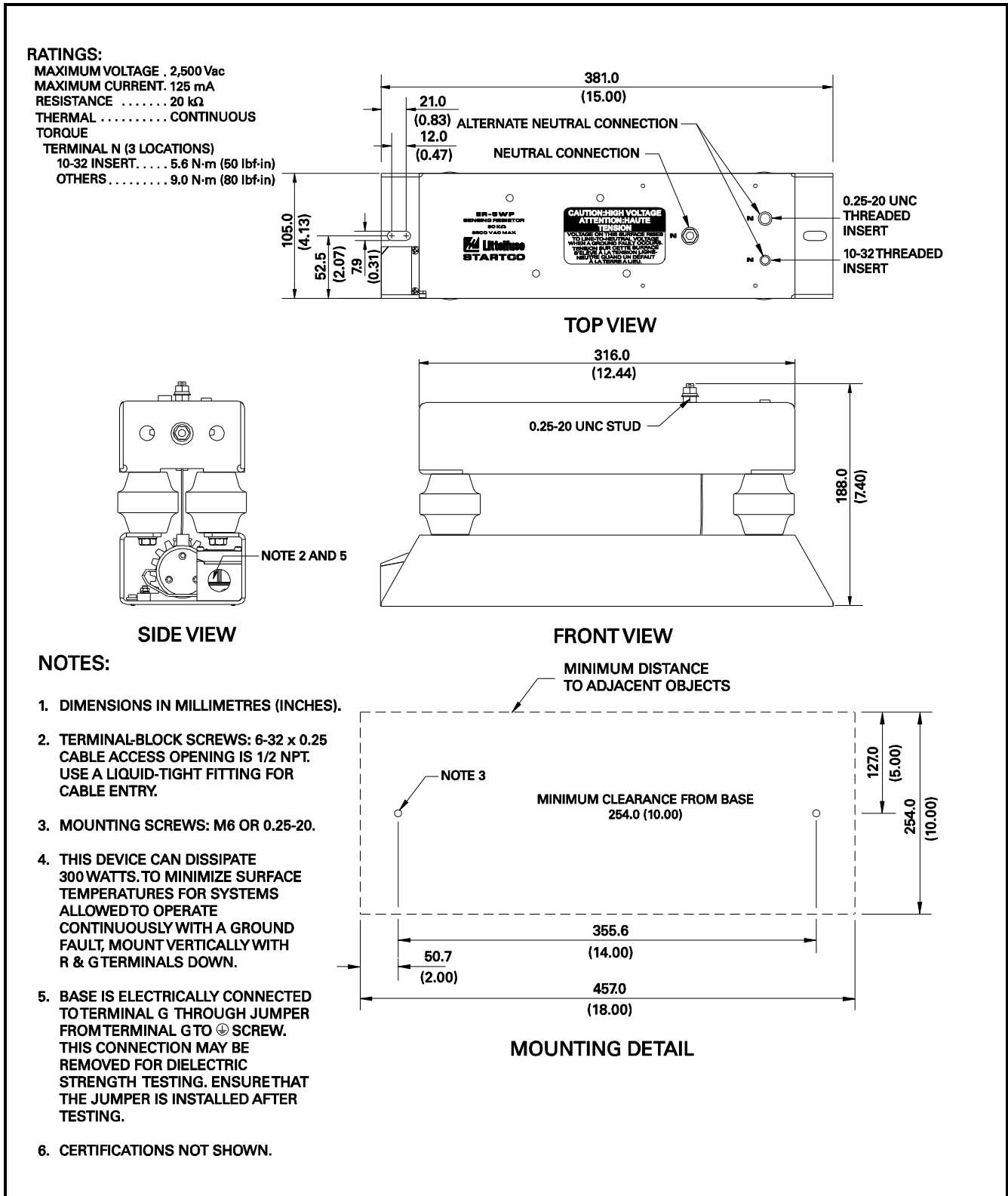


FIGURE 12. ER-5WP Sensing Resistor.

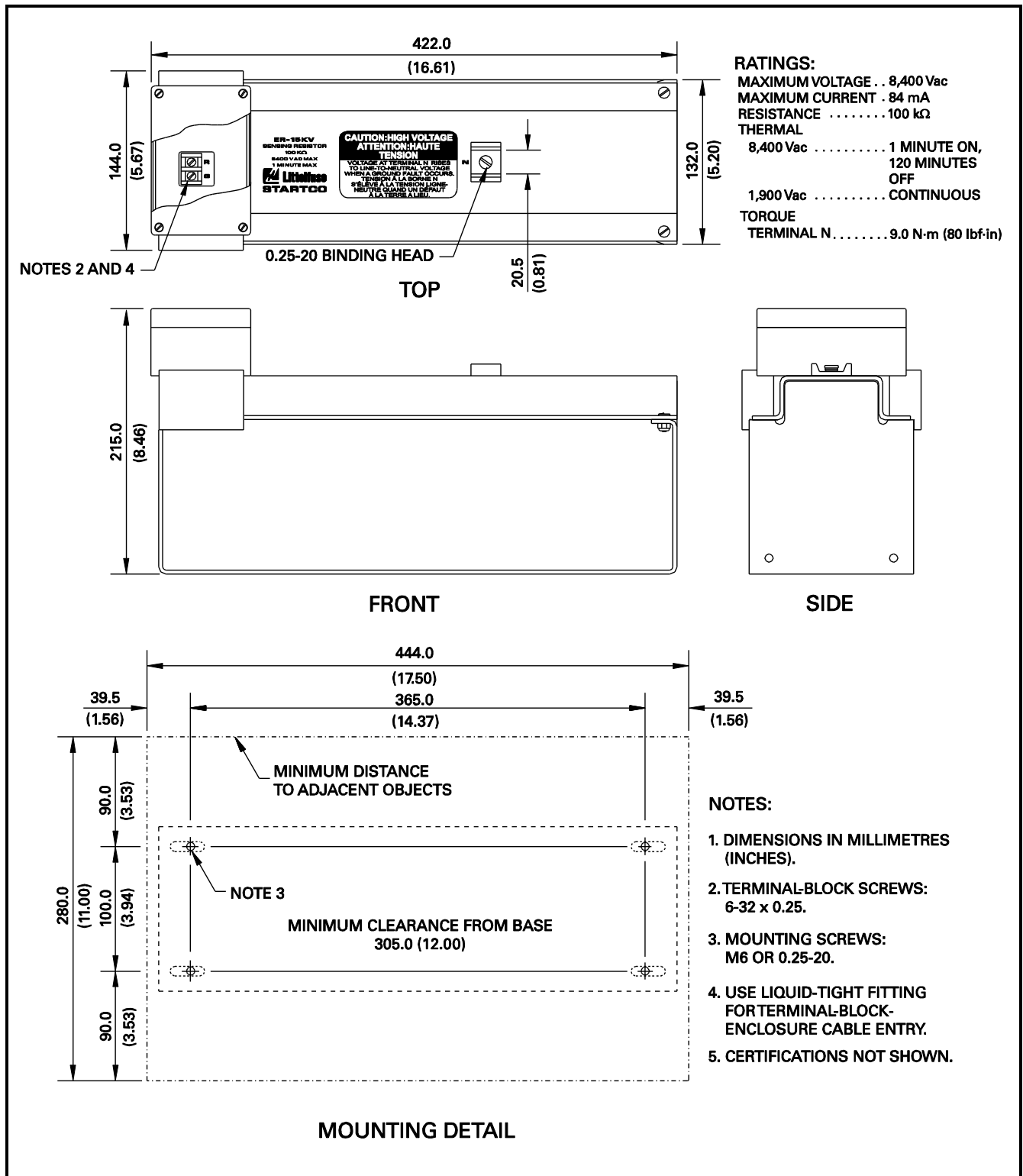


FIGURE 13. ER-15KV Sensing Resistor.

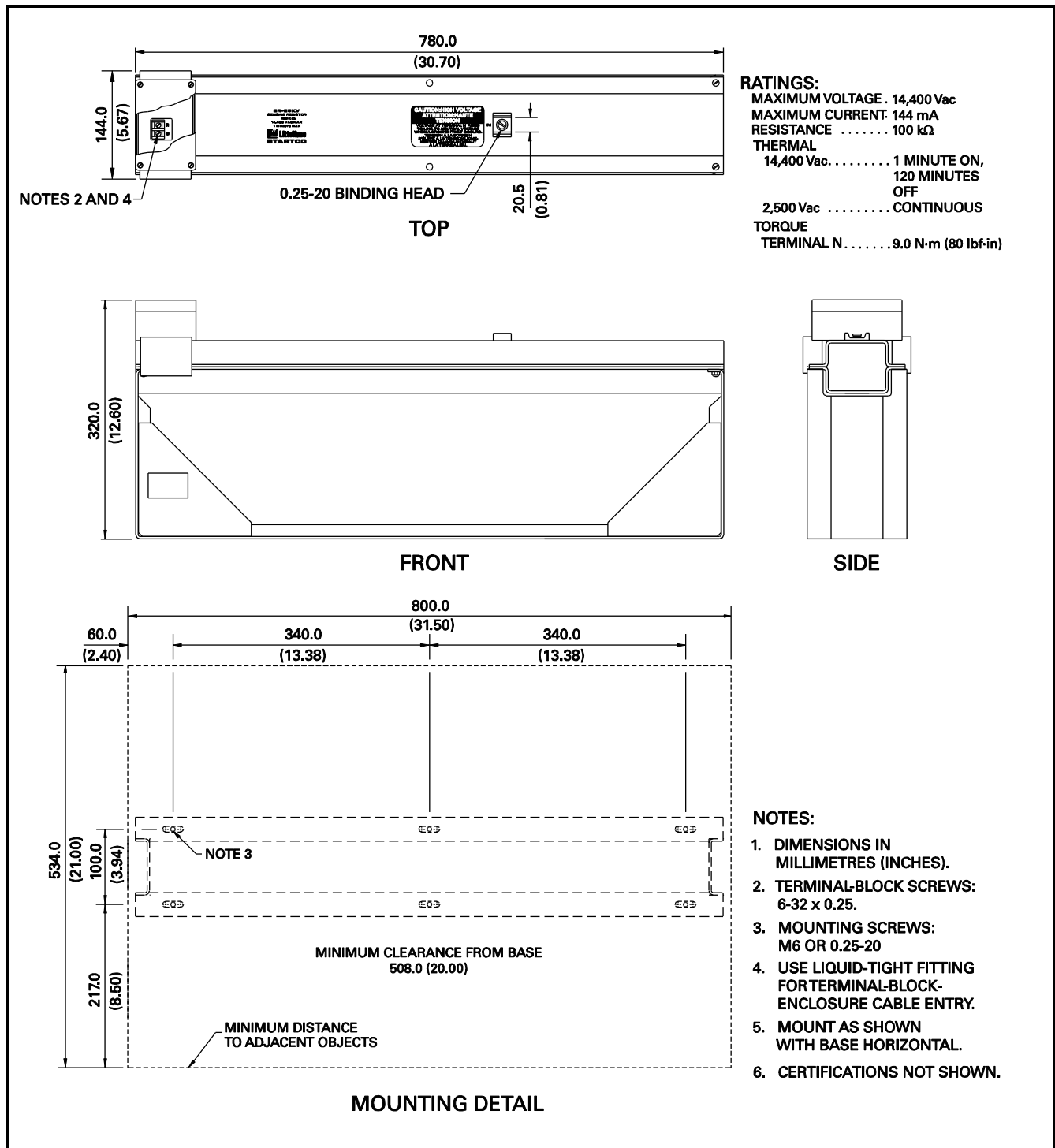


FIGURE 14. ER-25KV Sensing Resistor.

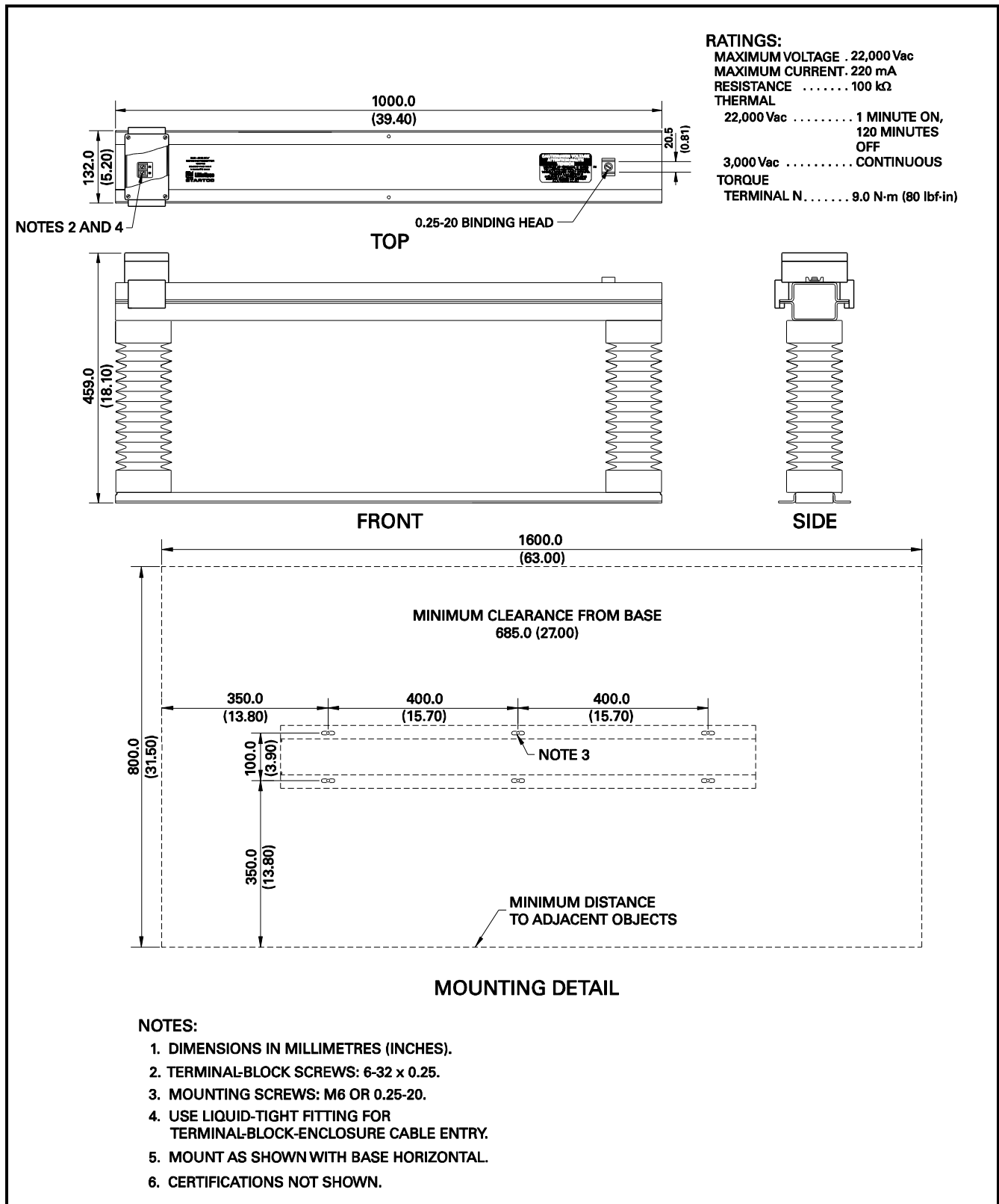


FIGURE 15. ER-35KV Sensing Resistor.

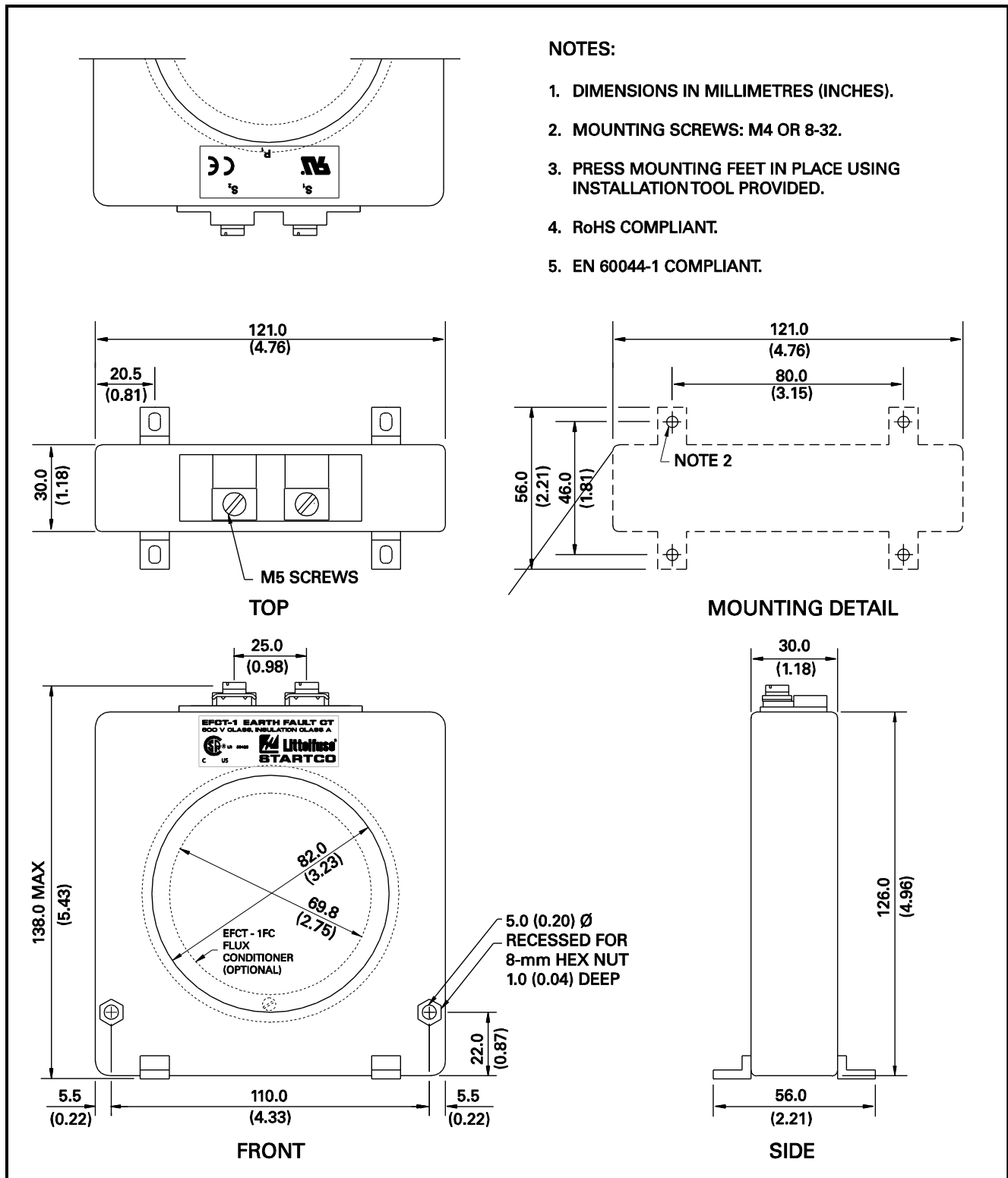


FIGURE 16. EFCT-1 Earth-Fault Current Sensor.

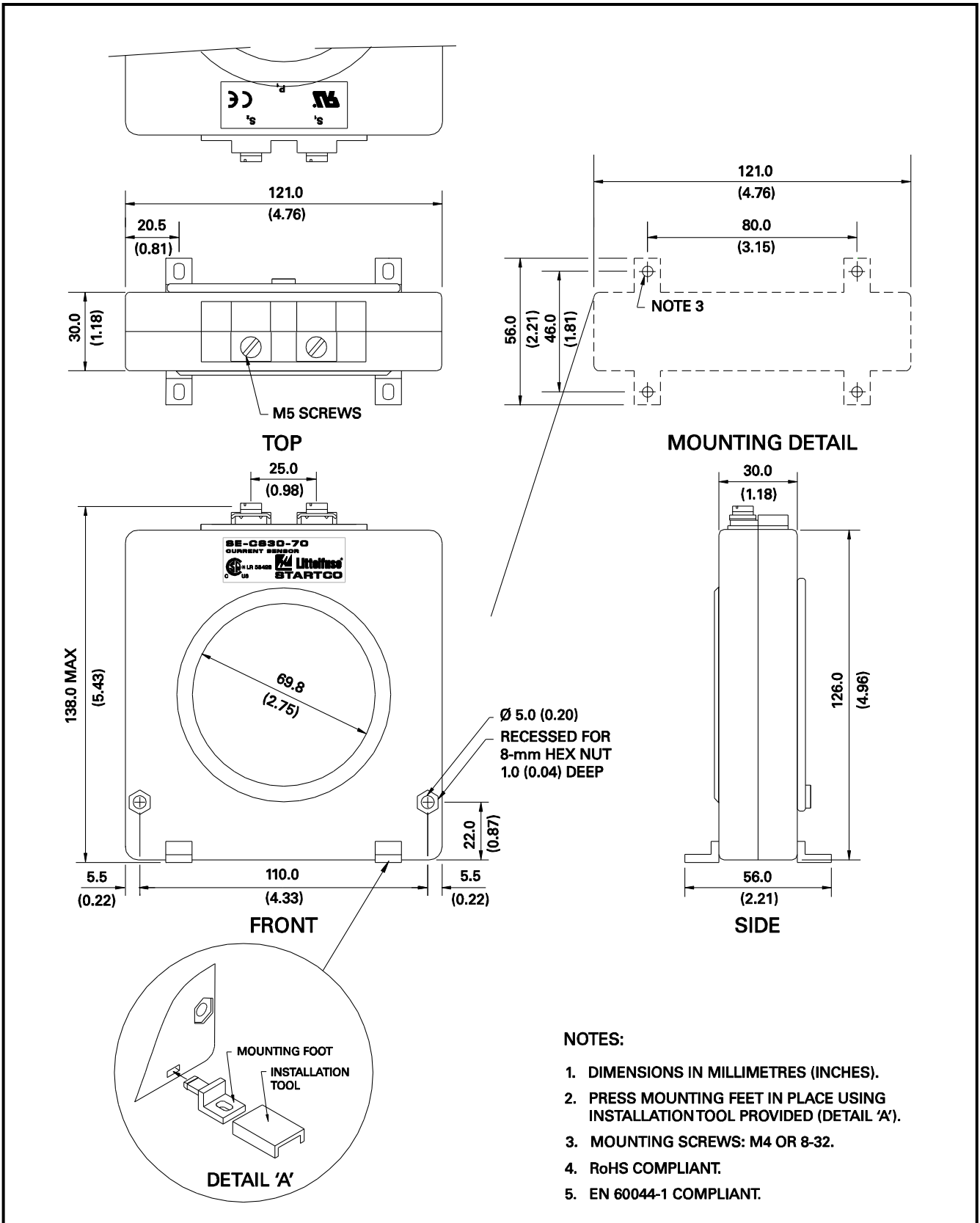


FIGURE 17. SE-CS30-70 Earth-Fault Current Sensor.