

# Transformer Protection M-3310

Integrated Protection System® for Transformers of All Sizes



*Unit shown with optional M-3931 HMI Module and M-3910 Target Module*

- **Fully Digital Multifunction Relay with eight programmable outputs, six programmable inputs, and four multiple setpoint groups**
- **Suitable for two-winding transformers of any size, and some three-winding applications**
- **Windows-based software offers extensive graphics for easy in-service commissioning**
- **Optional three-phase Voltage Protection Package available**

## M-3310 Transformer Protection Relay

### Standard Protective Functions

- Negative-sequence inverse time overcurrent (46)
- Two winding, dual element instantaneous overcurrent (50W1 #1, 50W1 #2, 50W2 #1, 50W2 #2)
- Breaker Failure (50BF)
- Transformer neutral, instantaneous/inverse time overcurrent (50G/51G)
- Two winding inverse time phase overcurrent (51W1/51W2)
- Residual, inverse time overcurrent (51NW1/51NW2)
- Two winding, phase differential (87T) and High Set instantaneous (87H)
- Ground differential (87GD)
- Six External functions with individual timers

### Optional Three-Phase Voltage Protection Package

- Overexcitation (24) V/Hz
- Phase undervoltage (27) function for load shedding
- Neutral overvoltage (59G)
- Underfrequency (81U)

### Standard Features

- Multiple Setpoint Groups
- Eight programmable outputs and six programmable inputs
- Oscillographic recording
- 32-target storage
- Real time metering of measured parameters, with demand and maximum values
- Two RS-232 and one RS-485 communications ports
- Standard 19" rack-mount design
- Removable printed circuit board and power supply
- 50 and 60 Hz models available
- 1 and 5 A rated CT inputs available
- M-3820A IPScom® Communications Software
- IRIG-B time synchronization
- Includes MODBUS and BECO 2200 protocols

### Optional Features

- Redundant Power Supply
- M-3910 Target Module
- M-3931 Human-Machine Interface (HMI) Module
- M-3801D IPSplot® *PLUS* Oscillograph Analysis Software
- 4-Wire RS-485 Connection

## STANDARD PROTECTIVE FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
<b>Negative Sequence Overcurrent (Winding 2)</b>				
46	<b>Definite Time</b>			
	Pickup	0.10 to 20.00 A (0.02 to 4.00 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%
	<b>Inverse Time</b>			
	Pickup	0.50 to 5.00 A (0.10 to 1.00 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curves	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial Setting	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%
<b>Instantaneous Phase Overcurrent (Dual elements per winding)</b>				
50	<b>50W1/50W2</b>			
	Pickup #1, #2	1.0 to 100.0 A (0.2 to 20.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Trip Time Response	Fixed 2 Cycles	—	±2 Cycles
<b>Breaker Failure</b>				
50 BF	<sup>50</sup> <sub>BF-Ph</sub> Pickup (phase)	0.10 to 10.00 A (0.02 to 2.00 A)	0.01 A	±0.1 A or ±2% (±0.02 A or ±2%)
	<sup>50</sup> <sub>BF-N</sub> Pickup (residual)	0.10 to 10.00 A (0.02 to 2.00 A)	0.01 A	±0.1 A or ±2% (±0.02 A or ±2%)
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±2%
<b>Instantaneous Neutral Overcurrent</b>				
50G	Pickup	1.0 to 100.0 A (0.2 to 20.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Trip Response	Fixed 2 Cycles	—	±2 Cycles
<b>Inverse Time Phase Overcurrent</b>				
51	<b>51W1/51W2</b>			
	Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC curves		
	Time Dial Setting	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±3%
<b>Inverse Time Neutral Overcurrent</b>				
51G	Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial Setting	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±3%

†Select the greater of these accuracy values.

Values in parentheses apply to 1 A CT secondary rating.

**M-3310 Transformer Protection Relay**

STANDARD PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
<b>Inverse Time Residual Overcurrent</b>				
<b>51N</b>	<b>51NW1/51NW2</b>			
	Pickup	0.50 to 6.00 A (0.10 to 1.20 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC curves		
	Time Dial Setting	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%

<b>Phase Differential Current</b>				
<b>87</b>	<b>87H</b>			
	Pickup	5.0 to 20.0 PU	0.1 PU	±0.1 PU or ±3%
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%
	<b>87T</b>			
	Pickup	0.10 to 1.00 PU	0.01 PU	±0.02 PU or ±5%
	Percent Slope #1	5 to 100%	1%	±1%
	Percent Slope #2	5 to 200%	1%	±1%
	Slope Break Point	1.0 to 4.0 PU	0.1 PU	—
	Even Harmonics Restraint ( 2nd and 4th)	5 to 50%	1%	±1%or ±0.1 A
	5th Harmonic Restraint	5 to 50%	1%	±1% or ±0.1 A
Pickup at 5th Harmonic Restraint	0.10 to 2.00 PU	0.01 PU	±0.1 PU or ±5%	
CT Tap W1/W2	1.00 to 10.00 (0.20 to 2.00)	0.01	—	

*Trip response for 87T and 87H (if time delay set to 1 cycle) is less than 1.5 cycles. Each restraint element may be individually disabled, enabled, or set for cross phase averaging.*

<b>Ground Differential</b>				
<b>87 GD</b>	Pickup	0.2 to 10.00 A (0.04 to 2.00 A)	0.01 A	±0.1 A or ±5% (±0.02 A or ±5%)
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%
	CT Ratio Correction ( $R_c$ )	0.1 to 7.99	0.01	

*This function operates as a directional differential. If  $3I_0$  or  $I_n$  is extremely small, directional element is disabled.*

<b>External Functions</b>				
<b>EXT</b>	<b>EXT #1— #6</b>			
	Input Initiate	In #1–#6	—	—
	Output Initiate	Out #1–#8	—	—
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%

*Six functions are provided for externally connected devices to trip through the M-3310 to provide additional logic and target information. Any one or more of the input contacts (INPUT1 through INPUT6) or outputs (OUTPUT1 through OUTPUT8) can be programmed to activate designated output contacts after a selected time delay.*

†Select the greater of these accuracy values.

Values in parentheses apply to 1 A CT secondary rating.

**OPTIONAL THREE-PHASE VOLTAGE PROTECTION PACKAGE**

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
<b>Volts/Hz Overexcitation</b>				
	<b>Definite Time</b>			
	Pickup #1, #2	100 to 200%	1%	±1%
	Time Delay #1, #2	30 to 8160 Cycles	1 Cycle	+25 Cycles
<b>24</b>	<b>Inverse Time</b>			
	Pickup	100 to 150%	1%	±1%
	Characteristic Curves	Inverse Time #1–#4	—	—
	Time Dial: Curve #1	1 to 100	1	—
	Time Dial: Curves #2–#4	0.0 to 9.0	0.1	—
	Reset Rate	1 to 999 Sec. (from threshold of trip)	1 Sec.	±.06 Seconds or ±1%

Pickup based on nominal VT secondary voltage and nominal system frequency. Accuracy applicable from 10 to 80 Hz, 0 to 180 V, and 100 to 150% V/Hz.

<b>Phase Undervoltage</b>				
<b>27</b>	Pickup	5 to 140 V	1 V	±0.5 V
	Inhibit Setting	5 to 140 V	1 V	±0.5 V
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%

This function uses positive sequence voltage, inhibit setting may be enabled for load shedding.

<b>Neutral Overvoltage</b>				
<b>59G</b>	Pickup	5.0 to 140.0 V	0.1 V	±0.5 V
	Time Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%

May be configured to measure zero sequence voltage via externally wired broken delta connection.

<b>Underfrequency</b>				
<b>81U</b>	Pickup #1, #2, #3	48.00 to 59.99 Hz 38.00 to 49.99 Hz*	0.01 Hz	±0.02 Hz
	Time Delay #1, #2, #3	2 to 65,500 Cycles	1 Cycle	-1 to +3 Cycles or ±1%

Accuracy applies to 60 Hz models at a range of 57 to 60 Hz, and to 50 Hz models at a range of 47 to 50 Hz.

\* This range applies to 50 Hz nominal frequency models.

†Select the greater of these accuracy values.

Values in parentheses apply to 1 A CT secondary rating.

**OPTIONAL THREE-PHASE VOLTAGE PROTECTION PACKAGE (cont.)**

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
<b>Nominal Settings</b>				
	Nominal Voltage	60 to 140 V	1 V	—
	Nominal Current	0.5 to 6.00 A	0.01 A	
	VT Configuration	Line to Line/Line to Ground		
	Phase Rotation	ABC/ACB	—	—
	Transformer/CT Connection	14 Types		

**Functions that can be Implemented with Overcurrent/Input-Output Connections**

- Load Shedding  
**Can help prevent overloading of remaining transformers when a station transformer is out of service.**
- Bus Fault Protection  
**Provides high speed bus protection by combining digital feeder relay logic and transformer protection logic.**
- Feeder Digital Relay Backup  
**Provides backup tripping of feeder relays by combining the self test alarm output of the feeder relays with the transformer relay.**
- LTC fault blocking  
**Provides limited blocking of LTC during fault conditions.**

†Select the greater of these accuracy values.

Values in parentheses apply to 1 A CT secondary rating.

## Configuration Options

The M-3310 Transformer Protection Relay may be purchased as a fully configured two-winding Transformer Protection System. The M-3310 can also be purchased with the optional three-phase Voltage Protection Package, to expand the system to satisfy specific application needs.

## Multiple Setpoint Profiles (Groups)

The relay supports four setpoint profiles. This feature allows the user to define setpoint profiles for different power system configurations. Profiles can be switched either manually via the Human-Machine Interface (HMI), communication, or contact inputs.

## Metering

Real Time Demand (interval of 15, 30 or 60 minutes), and Maximum (with date and time stamp) metering of Voltage, Current, Power Factor, Load MW, MVA, MVAR.

Metering accuracies are:

Voltage:  $\pm 0.5$  V or  $\pm 0.5\%$ , whichever is greater

Current: 5 A rating,  $\pm 0.1$  A or  $\pm 3\%$ , whichever is greater  
1 A rating,  $\pm 0.02$  A or  $\pm 3\%$ , whichever is greater

Power:  $\pm 0.01$  PU or  $\pm 2\%$ , whichever is greater  
(real and reactive)

Frequency  $\pm 0.02$  Hz (from 57 to 63 Hz for 60 Hz models; from 47 to 53 Hz for 50 Hz models)

## Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms, storing up to 170 cycles of data. The total record length is user-configurable for 1, 2, 3 or 4 partitions. The sampling rate is 16 times the power system nominal frequency (50 or 60 Hz). The recorder is triggered by a designated status input, trip output, or using serial communications. When untriggered, the recorder continuously stores waveform data, thereby keeping the most recent data in memory. When triggered, the recorder stores pre-trigger data, then continues to store data in memory for a user-defined, post-trigger delay period.

The records may be analyzed or viewed using Beckwith Electric IPSplot® Oscillograph Analysis software, or M-3813 ComVert software, which converts Beckwith Electric oscillographic files to COMTRADE format.

## Target Storage

A total of 32 targets can be stored. This information includes the function(s) operated, the function(s) picked up, input/output contact status, time stamp, and phase and ground currents at the time of trip.

## Calculations

**Current and Voltage Values:** Uses discrete Fourier Transform (DFT) algorithm on sampled voltage and current signals to extract fundamental frequency phasors for M-3310 calculations.

## Power Input Options

Nominal 110/120/230/240 V ac, 50/60 Hz, or nominal 110/125/220/250 V dc. Operates properly from 85 V ac to 265 V ac and from 80 V dc to 288 V dc. Withstands 300 V ac or 300 V dc for 1 second. Burden 20 VA at 120 V ac/125 V dc.

Nominal 24/48 V dc, Operates properly from 18 V dc to 56 V dc. Withstands 65 V dc for 1 second. Burden 25 VA at 24 V dc and 30 VA at 48 V dc.

Optional redundant power supply.

## M-3310 Transformer Protection Relay

### Sensing Inputs

*Four Voltage Inputs:* Rated nominal voltage of 60 V ac to 140 V ac, 50/60 Hz. Withstands 240 V continuous voltage and 360 V for 10 seconds. Source voltages may be line-to-ground or line-to-line connected. Voltage transformer burden less than 0.2 VA at 120 V.

*Seven Current Inputs:* Rated current ( $I_R$ ) of 5.0 A or 1.0 A (optional), 50/60 Hz. Withstands  $2 I_R$  continuous current and  $100 I_R$  for 1 second. Current transformer burden is less than 0.5 VA at 5 A (5 A option), or 0.3 VA at 1 A (1 A option).

### Control/Status Inputs

The control/status inputs, INPUT1 through INPUT6, can be programmed to block any of the relay functions, trigger the oscillographic recorder, select setpoint profile, or to operate one or more outputs. The control/status inputs are dry contacts and are internally wetted to a 24 V dc power supply. To provide breaker status LED indication on the front panel, the INPUT1 control/status input must be connected to the 52b breaker status contact.

### Output Contacts

The eight programmable output contacts (six form 'a' and two form 'c'), the power supply alarm output contact (form 'b'), and the self-test alarm output contact (form 'c') are all rated as per ANSI/IEEE C37.90-1989 for tripping. Make 30 A for 0.2 seconds, carry 8 A, break 6 A @ 120 V ac, break 0.1 A @ 125 V dc, inductive break 0.1 A.

Any of the relay functions can be individually programmed to activate any one or more of the eight programmable output contacts.

### Target/Status Indicators and Controls

The **RELAY OK** LED reveals proper cycling of the microcomputer. The **BRKR CLOSED** LED turns on when the breaker is closed (when the 52b contact is open). The **OSC TRIG** LED indicates that oscillographic data has been recorded in the unit's memory. The corresponding **TARGET** LED will turn on when any of the relay functions operate. Pressing and releasing the **TARGET RESET** button resets the **TARGET** LED if the conditions causing the operation have been removed. Pressing and holding the **TARGET RESET** button displays the present pickup status of the protective functions. The **PS1** and **PS2** LEDs remain on as long as power is applied to the unit and the power supply is operating properly. **TIME SYNCH** LED turns on when valid IRIG-B signal is applied and time synchronization has been established.

### Communication

Communication ports include rear panel RS-232 and RS-485 ports, a front panel RS-232 port, and a rear panel IRIG-B port. The communications protocol implements serial, byte-oriented, asynchronous communication, providing the following functions when used with the Windows™-compatible M-3820A IPScom® Communications Software package. MODBUS and BECO 2200 protocols are supported, providing:

- Interrogation and modification of setpoints
- Time-stamped trip target information for the 32 most recent events
- Real-time metering of all quantities measured
- Downloading of recorded oscillographic data (Not available with MODBUS protocol)

### IRIG-B

The M-3310 accepts either modulated or demodulated IRIG-B time clock synchronization signals. The IRIG-B time synchronization information is used to correct the local calendar/clock and provide greater resolution for target and oscillograph time tagging.



### HMI Module (optional)

Local access to the M-3310 is provided through an optional M-3931 Human-Machine Interface (HMI) Module, allowing for easy-to-use, menu-driven access to all functions via a 6-button keyboard and a 2-line by 24 character alpha-numeric display. The M-3931 module connects quickly to the M-3310 and includes the following features:

- User-definable access codes providing three levels of security
- Interrogation and modification of setpoints
- Time-stamped trip target information for the 32 most recent events
- Real-time metering of all quantities measured

### Target Module (optional)

An optional M-3910 Target Module provides 24 target and 8 output LEDs. Appropriate target LEDs light when the corresponding M-3310 function operates. The targets can be reset with the M-3310 **TARGET RESET** button if the trip conditions have been removed. The **OUTPUT** LEDs indicate the status of the programmable output contacts.

### Type Tests and Standards

M-3310 Transformer Protection Relay complies with the following type tests and standards:

#### Voltage Withstand

##### **Dielectric Withstand**

IEC 255-5	3,500 V dc for 1 minute applied to each independent circuit to earth
	3,500 V dc for 1 minute applied between each independent circuit
	1,500 V dc for 1 minute applied to RS-485, IRIG-B circuit to earth
	1,500 V dc for 1 minute applied between RS-485, IRIG-B to independent circuit

##### **Impulse Voltage**

IEC 255-5	5,000 V pk, +/- polarity applied to each independent circuit to earth
	5,000 V pk, +/- polarity applied between each independent circuit
	1.2 by 50 $\mu$ s, 500 Ohms impedance, three surges at 5 second intervals

##### **Insulation Resistance**

IEC 255-5	> 40 MegaOhms
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#### Electrical Environment\*

##### **Electrostatic Discharge Test**

IEC 1000-4-2	Class 4 (8 kV) – point contact discharge
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##### **Fast Transient Disturbance Tests**

IEC 1000-4-4	Class IV (4kV, 2.5kHz)
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##### **Surge Withstand Capability**

ANSI/IEEE	2,500 V pk-pk Oscillatory applied to each independent circuit to earth
C37.90.1	2,500 V pk-pk applied between each independent circuit
1989	5,000 V pk Fast Transient applied to each independent circuit to earth
	5,000 V pk Fast Transient applied between each independent circuit

## M-3310 Transformer Protection Relay

### ***Radiated Susceptibility***

ANSI/IEEE 25–1000 MHz @ 35V/m  
C37.90.2  
1987

### ***Output Contacts***

ANSI/IEEE Make 30 A for 0.2 seconds off for 15 seconds for 2,000 operations  
C37.90.0

*\*Except where stated, digital data circuits IRIG-B, RS-232, and RS-485 communication ports are excluded.*

## Atmospheric Environment

### ***Temperature***

IEC 68-2-1 Cold, –20° C for 96 hours  
IEC 68-2-2 Dry Heat, +70° C for 96 hours  
IEC 68-2-3 Damp Heat, +40° C @ 93% RH, for 96 hours

## Mechanical Environment

### ***Vibration***

IEC 255-21-1 Vibration response Class 1, 0.5 g  
Vibration endurance Class 1, 1.0 g

## Compliance

UL Listed per 508 – Industrial Control Equipment  
CSA Certified per C22.2 No. 14-95–Industrial Control Equipment

## External Connections

M-3310 external connection points are illustrated in Figures 1, 2, and 3 on the following pages.

## Physical

**Size:** 19.00" wide x 5.21" high x 10.20" deep (48.3 cm x 13.2 cm x 25.9 cm)

**Mounting:** The unit is a standard 19", semiflush, 3-unit high, rack-mount panel design, conforming to ANSI/EIA RS–310C and DIN 41494, Part 5 specifications. Vertical mounting is also available.

Contact Beckwith Electric for optional GE L-2/Westinghouse FT-41 retrofit panel vertical mounting details.

**Approximate Weight:** 17 lbs (7.7 kg)

**Approximate Shipping Weight:** 25 lbs (11.3 kg)

## Patent & Warranty

The M-3310 Transformer Protection Relay has patents pending.

The M-3310 Transformer Protection Relay is covered by a five year warranty from date of shipment.

*Specification subject to change without notice.*

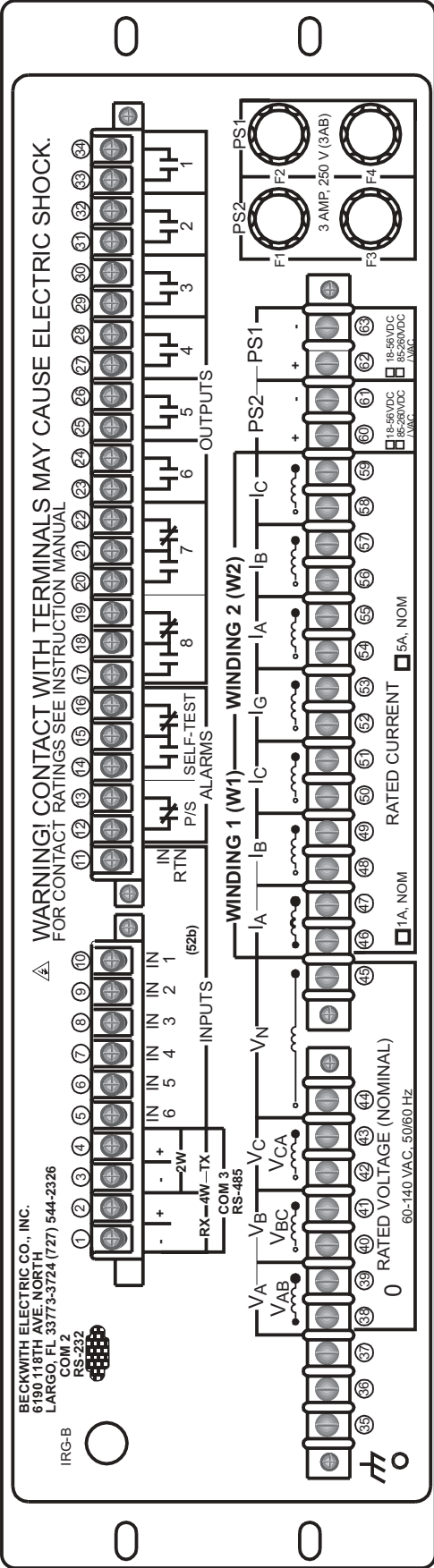




Figure 1 External Connections

■ NOTES:

1. Output contacts #1 through #4 contain special circuitry for high-speed operation and pick up 4ms faster than outputs 5 through 8. Outputs 1 through 6 are form "a" contacts (normally open) and outputs 7 and 8 are form "c" contacts (center tapped 'a' and 'b' contacts).
2. To comply with UL and CSA listing requirements, terminal block connections must be made with #12 AWG solid or stranded copper wire inserted in an AMP #324915 (or equivalent) connector. Wire insulation must be rated at 60°C minimum. Terminal block connections 1 through 34 must be tightened to 12 inch-pounds torque. Terminal block connections 35 through 63 must be tightened to 8 inch-pounds torque.
3. Only dry contacts must be connected to inputs (terminals 5 through 10 with 11 common) because these contact inputs are internally wetted. **Application of external voltage on these inputs may result in damage to the unit.**
4. All relays are shown in the de-energized state.
5. The power supply relay (P/S) is energized when the power supply is functioning properly.
6. The self-test relay is energized when the relay has performed all self-tests successfully.

**M-3310 Typical Connection Diagram**

-  This function is available as a standard protective function.
-  This function is available in the Optional Voltage Protection Package

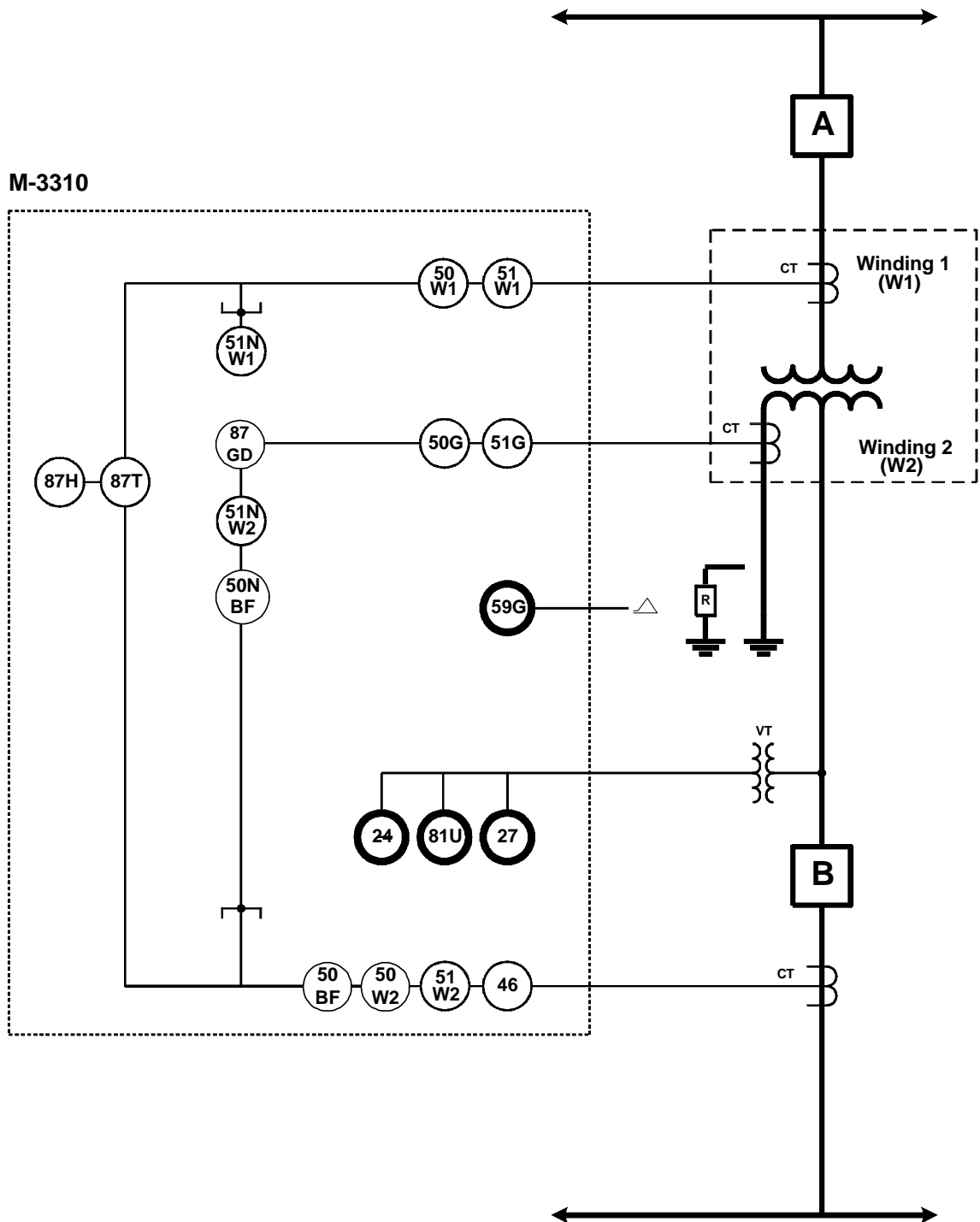


Figure 2 Typical One-Line Connection Diagram

# M-3310 Transformer Protection Relay

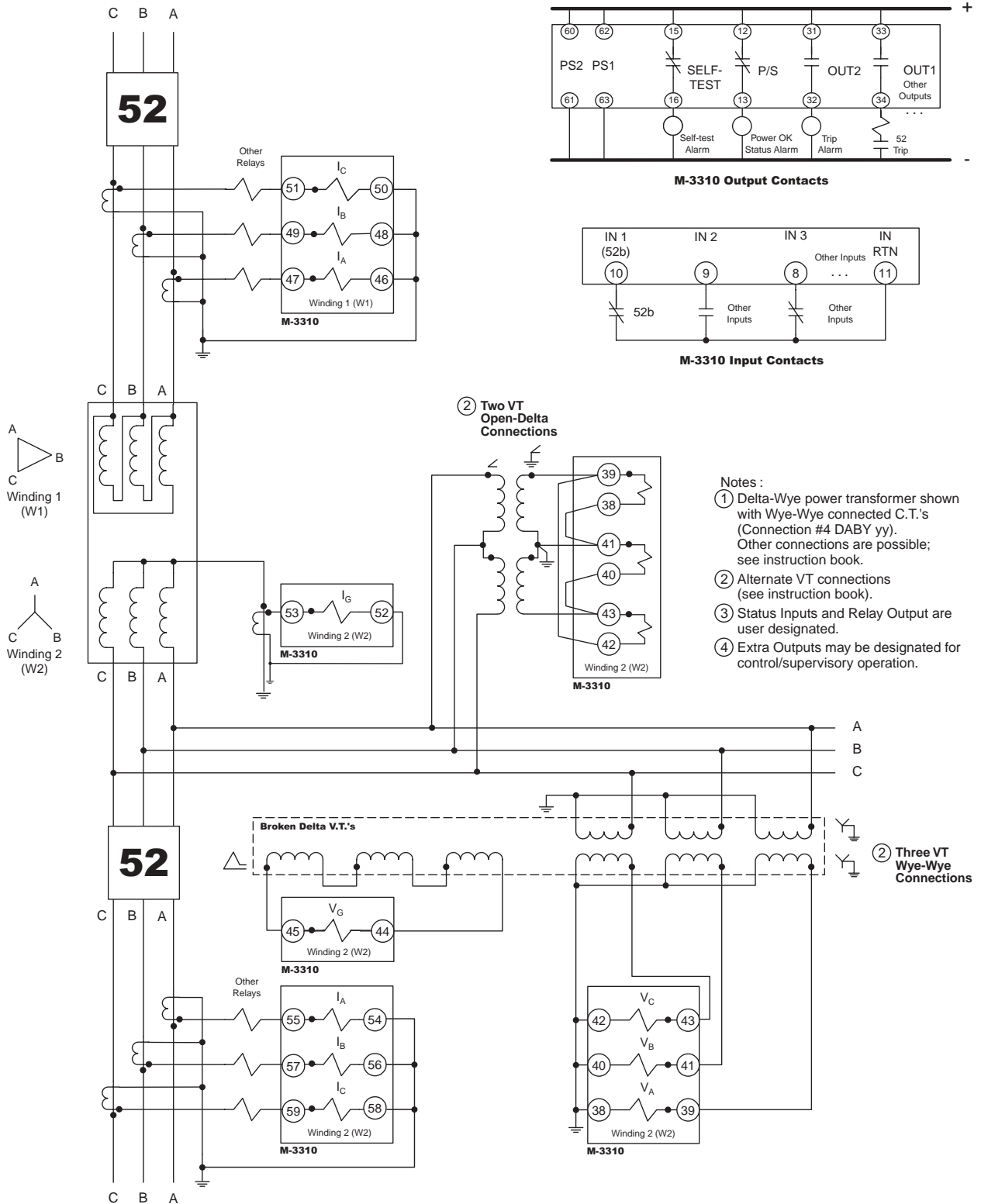
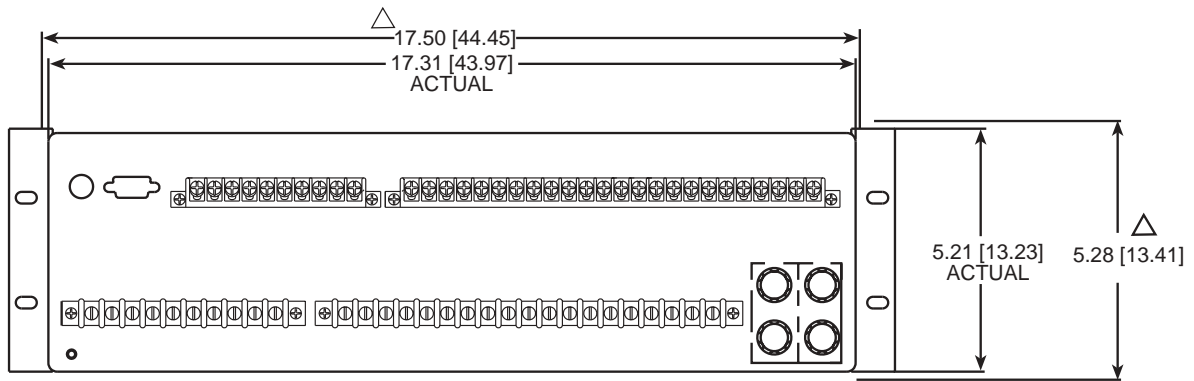


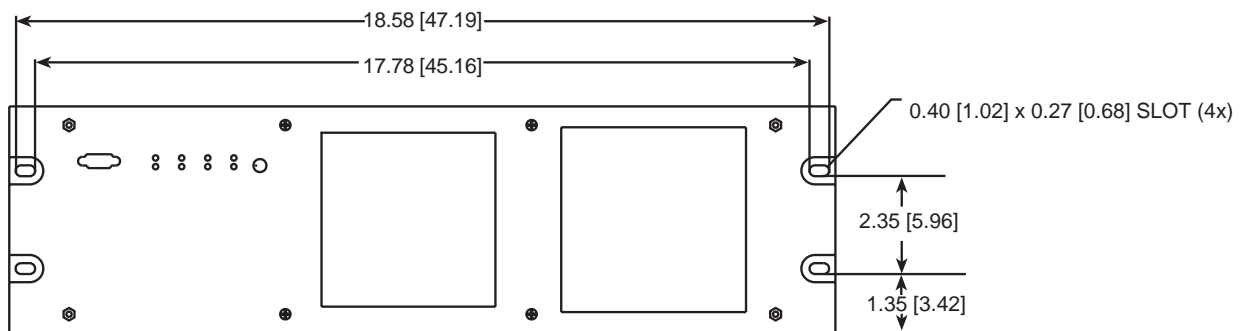
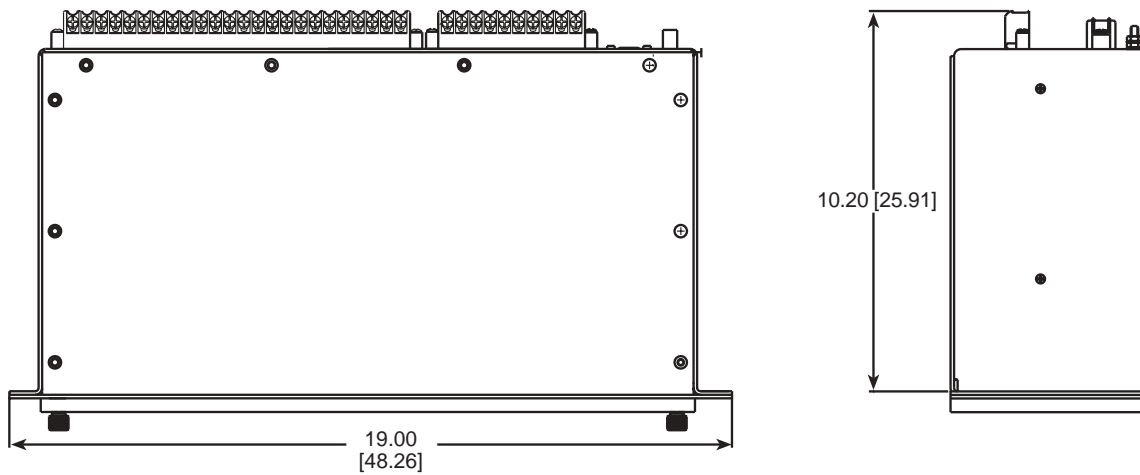
Figure 3 Typical Three-Line Connection Diagram

M-3310 Transformer Protection Relay



Rear View

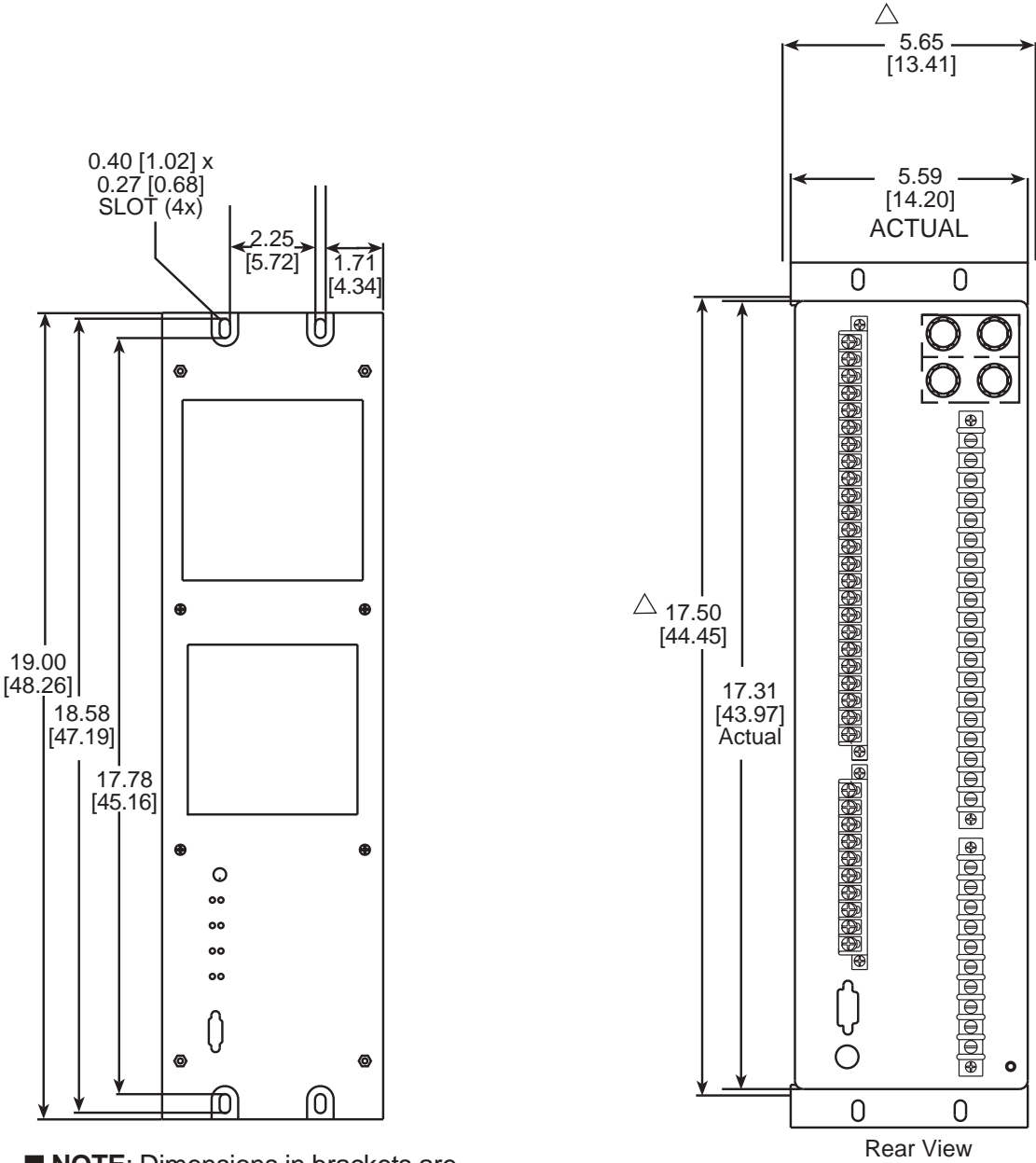
△ RECOMMENDED CUTOUT WHEN RELAY IS NOT USED AS STANDARD RACK MOUNT



Standard 19" Horizontal Mount Chassis

■ **NOTE:** Dimensions in brackets are in centimeters.

Figure 4 Horizontal Mounting Dimensions



■ **NOTE:** Dimensions in brackets are in centimeters.

△ RECOMMENDED CUTOUT WHEN RELAY IS NOT USED AS STANDARD RACK MOUNT

Optional Vertical Mount Chassis

Figure 5 Vertical Mounting Dimensions



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