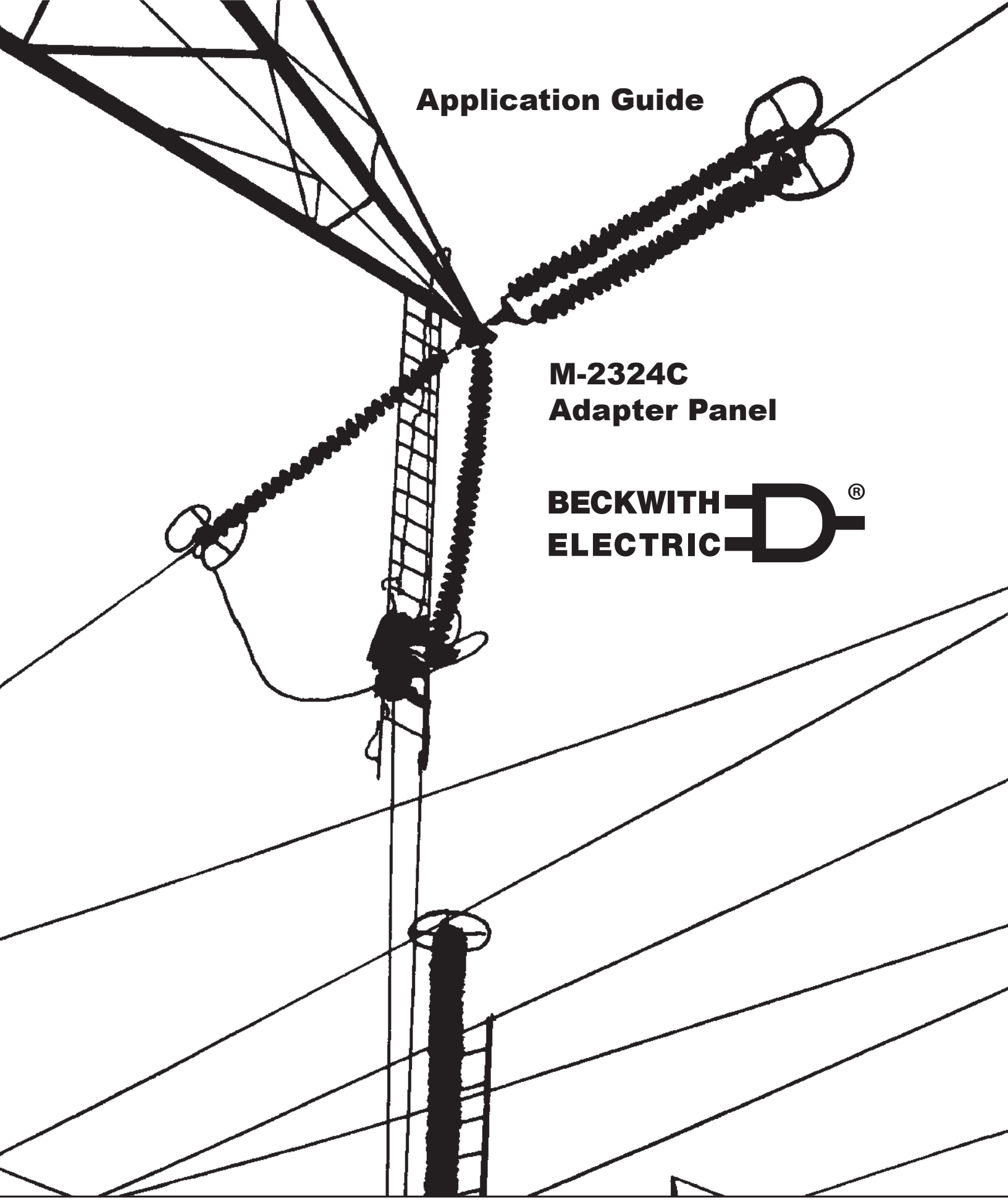
Application Guide



M-2324C
Adapter Panel

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Adapter Panel M-2324C

Adapts M-2001 Series Digital Tapchanger Control to Replace Pennsylvania Transformer (McGraw-Edison) Pole Star Regulator Controls

- Fits directly into existing regulator control cabinet using the existing two hinges and knurled knob
- Provides built-in CT shorting protection when the M-2001 Series Digital Tapchanger Control is removed
- Optional SCADA Cutout (Local/Remote) switch (for use with SCADA enabled M-2001C controls) allows Local Blocking of SCADA commands
- Optional SCAMP™ (SCADA Controllable Auto/Manual Pushbutton) switch replaces AUTO/OFF/MANUAL toggle switch
- Optional 2 Level Local Voltage Reduction switch

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The M-2324C is an adapter panel which, when combined with the M-2001 Series Digital Tapchanger Control, provides convenient direct replacement for Pennsylvania Transformer (McGraw-Edison) Pole Star regulator controls hinged on the right side. The M-2324C consists of a front door panel with hinge leaves on the right side and mounts into the control cabinet using the existing two hinges, and knurled knob which *must be saved* from the original control.

Interface

External connections are made via a wiring harness that connects to the terminal block in the existing control cabinet. Most connections come from a fifteen-position terminal block on the printed circuit board. An additional terminal block (TB2) provides access to auxiliary functions, including self-test alarm, user-programmable alarm, auto disable and manual raise/lower.

Features

Separate fuses for test terminal, voltage sensing and motor power are on the front panel. Spare fuses for each are in the fuse holder.

Binding posts on the front panel allow easy connections for test procedures.

RAISE/OFF/LOWER, **AUTO/OFF/MANUAL** and **VOLTAGE SOURCE** switches, **DRAG HANDS RESET** button, and **NEUTRAL LIGHT** are standard.

NEUTRAL LIGHT will light to indicate that the regulator or transformer is in the neutral position, for those products equipped with a circuit for this purpose.

Contains circuitry necessary for motor current seal-in.

Options

SCADA CUTOUT switch allows Local blocking of SCADA commands (for use with SCADA enabled M-2001C controls).

SCAMP™ (SCADA Controllable Auto/Manual Pushbutton) switch allows the Auto/Manual state on the adapter panel to be changed by a SCADA command.

Voltage Reduction switch allows 2 levels of Voltage Reduction to be selected.

Testing Specifications

High Voltage: All input and output terminals will withstand 1500 Vac rms to chassis or instrument ground for one minute with a leakage current not to exceed 25 mA, for all terminals to ground. Input and output circuits are electrically isolated from each other, from other circuits and from ground.

Surge Withstand Capability: All input and output circuits are protected against system transients. Units pass all requirements of ANSI/IEEE C.37.90.1-1989 defining surge withstand capability.

Radiated Electromagnetic Withstand Capability: All units are protected against electromagnetic radiated interference from portable communications transceivers.

Environmental

Temperature Range: Functionality is maintained from -40° to +85° C.

Humidity: Functionality is maintained under 95% relative humidity (non-condensing).

Fungus Resistance: A conformal printed circuit board coating inhibits fungus growth.

Physical

Size with M-2001 Series Digital Tapchanger Control: 16" high x 12" wide x 4-1/8" deep (40.64 cm x 30.48 cm x 10.48 cm)

Approximate Weight: 9 lbs, 8 oz (4.31 kg)

Approximate Shipping Weight: 12 lbs (5.44 kg)

Approximate Weight with M-2001 Series Digital Tapchanger Control: 13 lbs, 13 oz (6.27 kg)

Approximate Shipping Weight with M-2001 Series Digital Tapchanger Control: 18 lbs (8.16 kg)

Warranty

The M-2324C Adapter Panel is covered by a five year warranty from date of shipment.

Specification subject to change without notice.

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800-2324C-SP-02 11/23

WARNING

DANGEROUS VOLTAGES, capable of causing death or serious injury, are present on the external terminals and inside the equipment. Use extreme caution and follow all safety rules when handling, testing or adjusting the equipment. However, these internal voltage levels are no greater than the voltages applied to the external terminals.

DANGER! HIGH VOLTAGE

– This sign warns that the area is connected to a dangerous high voltage, and you must never touch it.

PERSONNEL SAFETY PRECAUTIONS

The following general rules and other specific warnings throughout the manual must be followed during application, test or repair of this equipment. Failure to do so will violate standards for safety in the design, manufacture, and intended use of the product. Qualified personnel should be the only ones who operate and maintain this equipment. Beckwith Electric assumes no liability for the customer's failure to comply with these requirements.

– This sign means that you should refer to the corresponding section of the operation manual for important information before proceeding.

Always Ground the Equipment

To avoid possible shock hazard, the chassis must be connected to an electrical ground. When servicing equipment in a test area, the Protective Earth Terminal must be attached to a separate ground securely by use of a tool, since it is not grounded by external connectors.

Do NOT operate in an explosive environment

Do not operate this equipment in the presence of flammable or explosive gases or fumes. To do so would risk a possible fire or explosion.

Keep away from live circuits

Operating personnel must not remove the cover or expose the printed circuit board while power is applied. In no case may components be replaced with power applied. In some instances, dangerous voltages may exist even when power is disconnected. To avoid electrical shock, always disconnect power and discharge circuits before working on the unit.

Exercise care during installation, operation, & maintenance procedures

The equipment described in this manual contains voltages high enough to cause serious injury or death. Only qualified personnel should install, operate, test, and maintain this equipment. Be sure that all personnel safety procedures are carefully followed. Exercise due care when operating or servicing alone.

Do not modify equipment

Do not perform any unauthorized modifications on this instrument. Return of the unit to a Beckwith Electric repair facility is preferred. If authorized modifications are to be attempted, be sure to follow replacement procedures carefully to assure that safety features are maintained.

PRODUCT CAUTIONS

Before attempting any test, calibration, or maintenance procedure, personnel must be completely familiar with the particular circuitry of this unit, and have an adequate understanding of field effect devices. If a component is found to be defective, always follow replacement procedures carefully to that assure safety features are maintained. Always replace components with those of equal or better quality as shown in the Parts List of the Instruction Book.

Avoid static charge

This unit contains MOS circuitry, which can be damaged by improper test or rework procedures. Care should be taken to avoid static charge on work surfaces and service personnel.

Use caution when measuring resistances

Any attempt to measure resistances between points on the printed circuit board, unless otherwise noted in the Instruction Book, is likely to cause damage to the unit.

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1.0 Introduction

The Beckwith Electric M-2324C Adapter Panel, used in conjunction with the M-2001 Series Tapchanger Control, uses modern digital design and digital processing circuitry to achieve enhanced application flexibility plus an overall stability and resolution unattainable with electromechanical and analog design tapchanger controls. CMOS semiconductors are used throughout the design.

This application guide should be used in conjunction with the M-2001C Instruction Book for M-2001 Series applications information.

1.1 Description

Standard Features

The M-2324C Adapter Panel with the M-2001 Series Tapchanger Control provides a solid-state voltage control relay designed to directly replace the Pennsylvania/McGraw-Edison Pole Star regulator controls with hinge pins on the right side of the cabinet. The combination of tapchanger control and adapter panel includes the following features:

- Voltage waveform sampling and digital processing circuitry to ensure accurate voltage sensing.
- Control accuracy is ±0.3 % when tested in accordance with the ANSI/IEEE C57.15.9-1999 standard over a temperature range of -30° C to +65° C. The control accuracy is ±0.5 % when tested over the full operational temperature range of -40° C to +85° C.
- Input and output circuits are protected against system transients. Units pass all requirements of ANSI/IEEE C37.90.1-1989, which defines surge withstand capability. All input and output terminals will withstand 1500 Vac RMS to chassis or instrument ground for one minute with a leakage current not to exceed 25 mA, for all terminals to ground. Input and output circuits are electrically isolated from each other, from other circuits and from ground.

Control Switches

RAISE/LOWER/OFF switch allows local manual raise and lower commands to be initiated

AUTO/OFF/MANUAL switch allows manual operation of the control.

VOLTAGE SOURCE switch disconnects the voltage transformer input and connects the **EXTERNAL POWER** binding posts to the voltage input and motor circuit.

▲ **CAUTION:** Do not reverse the ground and hot wires when connecting an external source. A 3 AG fuse (F2) is installed to protect the control from damage if these connections are accidentally reversed.

With the **VOLTAGE SOURCE** switch in the **EXT** position, the sensing and motor power circuits are connected to the External Power binding post on the front panel. The unit can be tested using an external 120 V RMS source of proper polarity applied to these terminals. Testing can be accomplished by adjusting the amplitude of the external source.

The **VOLTAGE SOURCE** switch will disconnect all power from the unit when selected to the **EXT** position with no source connected to the front panel voltage inputs.

DRAG HANDS RESET pushbutton resets the tapchanger position indicator drag hands.

Binding Posts

VOLTAGE IN binding posts allow application of a 120 V RMS nominal voltage to the unit for test procedures.

METER OUT binding posts allow reading of the input voltage when used in conjunction with the **BIAS TEST VOLTAGE** screen of the M-2001 Tapchanger Control.

MOTOR POWER IN binding posts allow application of 120 or 240 V RMS nominal voltage to the unit for test procedures.

■ **NOTE:** If the Motor Power Input configuration has a different return from the 120 V regulated Voltage Input, then Jumper J12 on the printed circuit board must be removed and TB1-16 should be used for the separate motor power source and return connections (See Figure 4 or 5 for J12 location).

Status Indicators

NEUTRAL light illuminates when the regulator is in the neutral tap position.

The Adapter Panel includes three replaceable fuses: Test Terminal (3 A), Voltage Sense (1 A), and Motor Power (6 A).

Optional Control Switches

VOLTAGE REDUCTION (VR1/OFF/VR2) switch allows local voltage reduction 1 or 2 to be initiated.

SCADA CUTOUT (LOCAL/REMOTE) switch allows the local blocking of SCADA commands.

SCAMP (AUTO/MANUAL) pushbutton allows the Auto/Manual state on the adapter panel to be changed by a SCADA command.

2.0 Application

Typical Connections

In general, the tapchanger motor must be operated from a different transformer than the VT used to measure regulated voltage. If this is not done, hunting at the upper band edge may result. As soon as the motor starts, and before it is sealed in, the motor current can drop the voltage within the band and reset the control. Some motor seal-in schemes are fast enough to prevent this, but others are not.

Pulsed output can be used on the M-2001 (see M-2001C Instruction Book Section 3.5, Pulsed Output).

Typical connections for the M-2324C are shown in Figures 3, 4 and 5. Connections are simplified and may not show all functions required in a typical load tapchanging transformer control scheme – for example, limit switches, etc.

External Connections

Power and voltage sensing are obtained either from a common source or from independent sources having a nominal 120 Vac output. Normally, this is line-to-neutral voltage, although line-to-line voltage can also be used if recognition is made of any phase shift between the voltage and current signals when using line drop compensation.

Load current must be reduced by an appropriate auxiliary current transformer to 0.2 A "full scale" before connecting to the M-2324C current inputs. The Beckwith Electric M-0121 (5.0 A to 0.2 A) or M-0169A (5.0 A or 8.66 A to 0.2 A) Auxiliary Current Transformer can be used for this purpose.

The M-0121 can be used with Beckwith Electric Tapchanger Controls when the only burden present is the Line Drop Compensator circuit of the voltage regulating relay.

The M-0169A is used in high burden circuits, such as are found in paralleling schemes. Outputs of the auxiliary CTs are protected against overvoltage.

For further information, obtain Beckwith Electric Application Note #17, *"Basic Considerations for the Application of LTC Transformers and Associated Controls"* (available for download from www.beckwithelectric.com).

The external connections for the M-2324C are made to terminal blocks TB1 and TB2 on the printed circuit board at the base of the adapter panel. For example, if SCADA is being used to control the Voltage Reduction Step #1 function in the M-2324C, connections for the external dry contacts may be made between TB1-7 and TB2-28 as shown in Figure 3. The dry contact inputs for non-sequential input and voltage reduction must be "wetted" by connecting to terminal TB2-28. The wiring harness and external connections for the M-2324C are shown in Figures 3, 4 and 5.

Lightning Protection

▲ **CAUTION:** For proper protection against system surges, chassis ground must be connected to earth ground.

It has been determined that transient voltages in excess of 1500 Vac RMS can exist on the "ground" lead normally tied to TB1-8. In the tapchanger controls, these voltages are suppressed by varistors which still permit the unit to pass a 1500 Vac hi-pot test for one minute, with a leakage of approximately 15 mA, all terminals to ground.

Multiple VT grounds far apart must be avoided, since a varying difference in ground voltage could add or subtract from the effective voltage, and cause variation in the tapchanger control's bandcenter voltage setpoint.

Neutral Light Circuit

The M-2324C is prepared for use with regulators which use a neutral light. Cooper products typically require that the Neutral Light terminal TB1-11, be powered inside the regulator when the light is to be illuminated. A switch on the printed circuit board is used to select the desired configuration (Up - Neutral, Down - Hot).

To configure the Neutral Light to be illuminated when TB1-11 is powered inside the regulator, place the **S1** toggle switch (located on the upper right hand corner of the adapter panel printed circuit board, see Figures 4 and 5) in the "Down" (Hot) position.

Non-Sequential Operation (N/A for BASE-R and BASE-RS Version)

▲ **CAUTION:** Voltage applied through dry contacts to actuate non-sequential input *must* be +12 Vdc obtained from pin TB2-28. If the M-0324 analog version tapchanger control had previously been installed, the wiring harness must be reconfigured to remove 120 Vac "wetting" voltage from TB1-9. Carefully examine the contacts of these functions to remove 120 Vac wetting voltages.

The operation of the control can be interrupted during tapchanger operation by applying the "wetting" voltage of terminal TB2-28 to TB1-1 (timer reset for non-sequential operation input) on the printed circuit board through an external contact. This causes the output to de-energize and re-initialize the time delay circuit when the reset signal is removed. This function can be used to cause the LTC transformer, if so equipped, to wait for the unit to time out between tapchanges.

Automatic Disable Input

To disable automatic operation of the M-2324C, remove Jumper #15 (See Figures 4 and 5, for location) on the printed circuit board.

If SCADA is used to enable and disable this function, a contact rated at 6 A minimum can be connected between the terminals.

Auto disable may also be accomplished by closing a contact between TB1-1 and TB2-28.

Operations Counter Input

▲ **CAUTION:** Do not apply any voltage to this terminal.

M-2324C TB1-13 is provided for operations counter input. No connection is necessary because alternate circuitry for activating the operations counter is typically used by Pennsylvania/McGraw regulator controls.

Local/Remote Input

Removing Jumper #14 (See Figures 4 and 5, for location) prohibits M-2001 operation by disabling the automatic raise and lower outputs and also by disabling the M-2324C Adapter Panel's manual **RAISE/OFF/LOWER** toggle switch. Removing this jumper does *not* disable the SCADA-supplied motor voltage input to the manual raise/manual lower contacts on the adapter panel.

Multi-Step Voltage Reduction

▲ **CAUTION:** Voltage applied through dry contacts to actuate Voltage Reduction Steps 1, 2, and 3 must be +12 Vdc obtained from pin TB2-28 of the M-2324C adapter panel. If the M-0324 analog version tapchanger control had previously been installed, the wiring harness must be reconfigured to remove 120 Vac "wetting" voltage from TB1-9. Carefully examine the contacts of these functions to remove 120 Vac wetting voltages.

On the M-2324C, TB1-2 and TB1-7 on the printed circuit board are used together to provide up to three levels of voltage reduction. The external connections to achieve these steps are shown in Table 1 and Figure 3, External Connections. Voltage reduction amounts are set within the M-2001 Series Tapchanger Control software.

Voltage Reduction Set-point: Multiplier Range	Apply "Wetting Voltage" from TB2-27 to Terminal #
Voltage Reduction Setpoint #1: 0 to 10%	TB1-7
Voltage Reduction Setpoint #2: 0 to 10%	TB1-2
Voltage Reduction Setpoint #3: 0 to 10%	TB1-7 and TB1-2

Table 1 M-2324C Multi-Step Voltage Reduction External Connections

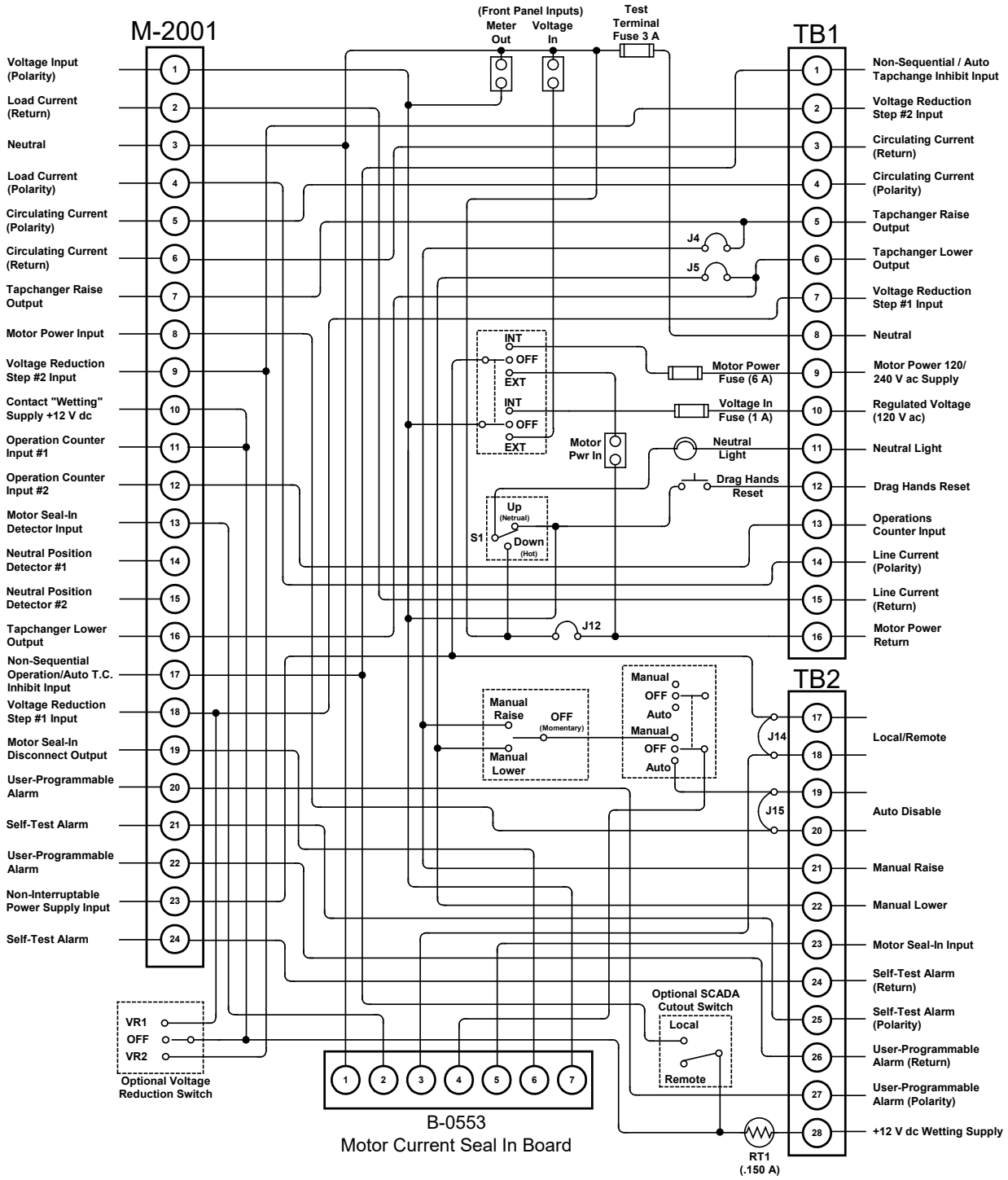
Paralleling

See M-2001 Instruction Book, Section 4.9, Parallel Operation.

Disabling Auto/Off/Manual Toggle Switch Status Detection

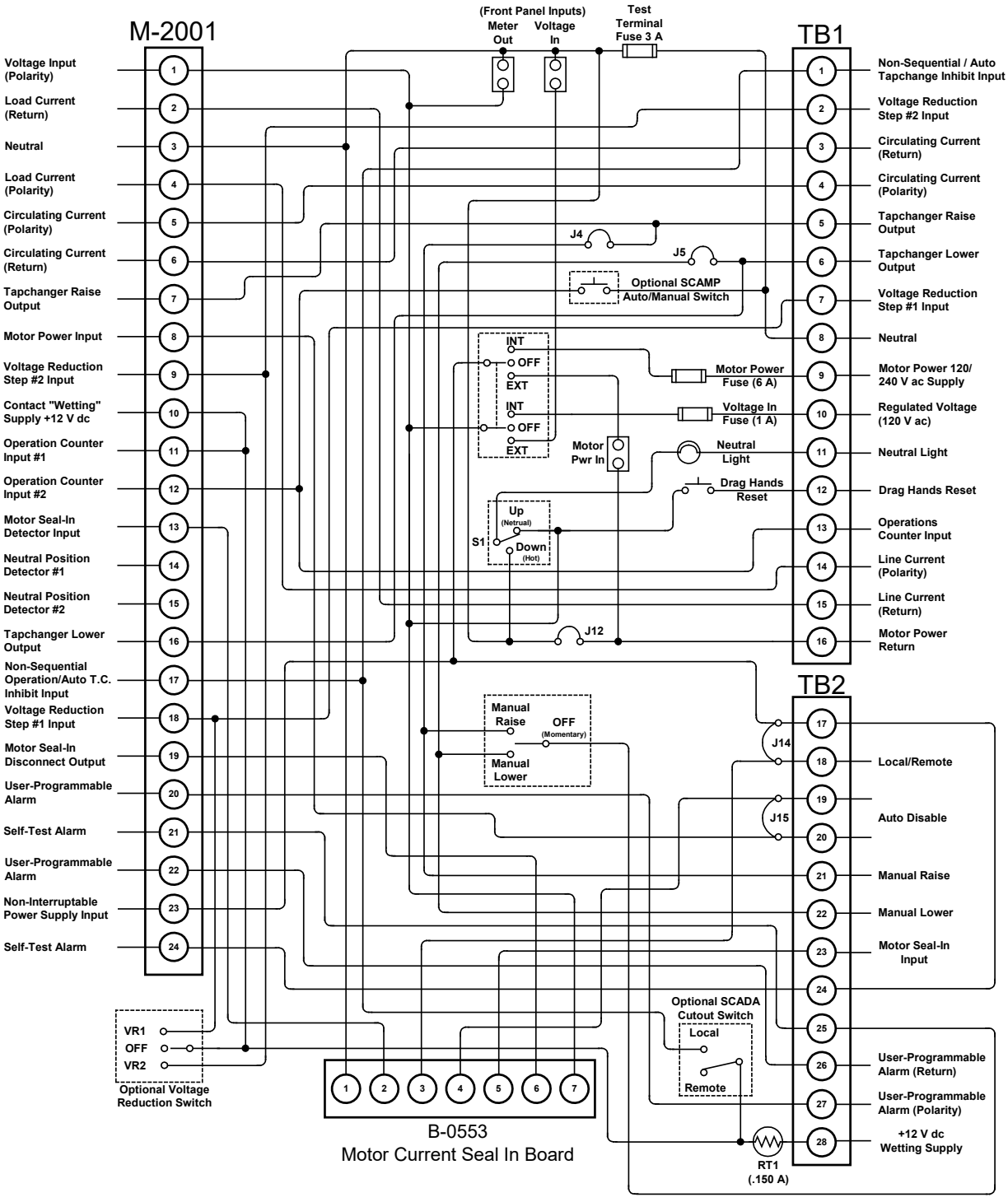
The Auto/Off/Manual Toggle Switch status detection feature is available on M-2001 Series Digital Tapchanger Controls that have Firmware Version D-0067V07.08.15 or later installed. To disable the Auto/Off/Manual Toggle Switch status detection feature for earlier firmware versions, perform the following:

1. Ensure that all power is removed from the M-2324C Adapter Panel and M-2001 control.
2. From the rear of the M-2324C Adapter Panel locate (Figure 4) and remove the wire connected to Terminal S3-4 on the rear of the **AUTO/OFF/MANUAL** switch.
3. Connect the wire removed in Step 2 to Terminal S2-4 on the rear of the **RAISE/OFF/LOWER** switch.
4. See M-2001 Instruction Book Section 6.1, External Connections, for information regarding M-2001 settings to disable this function.



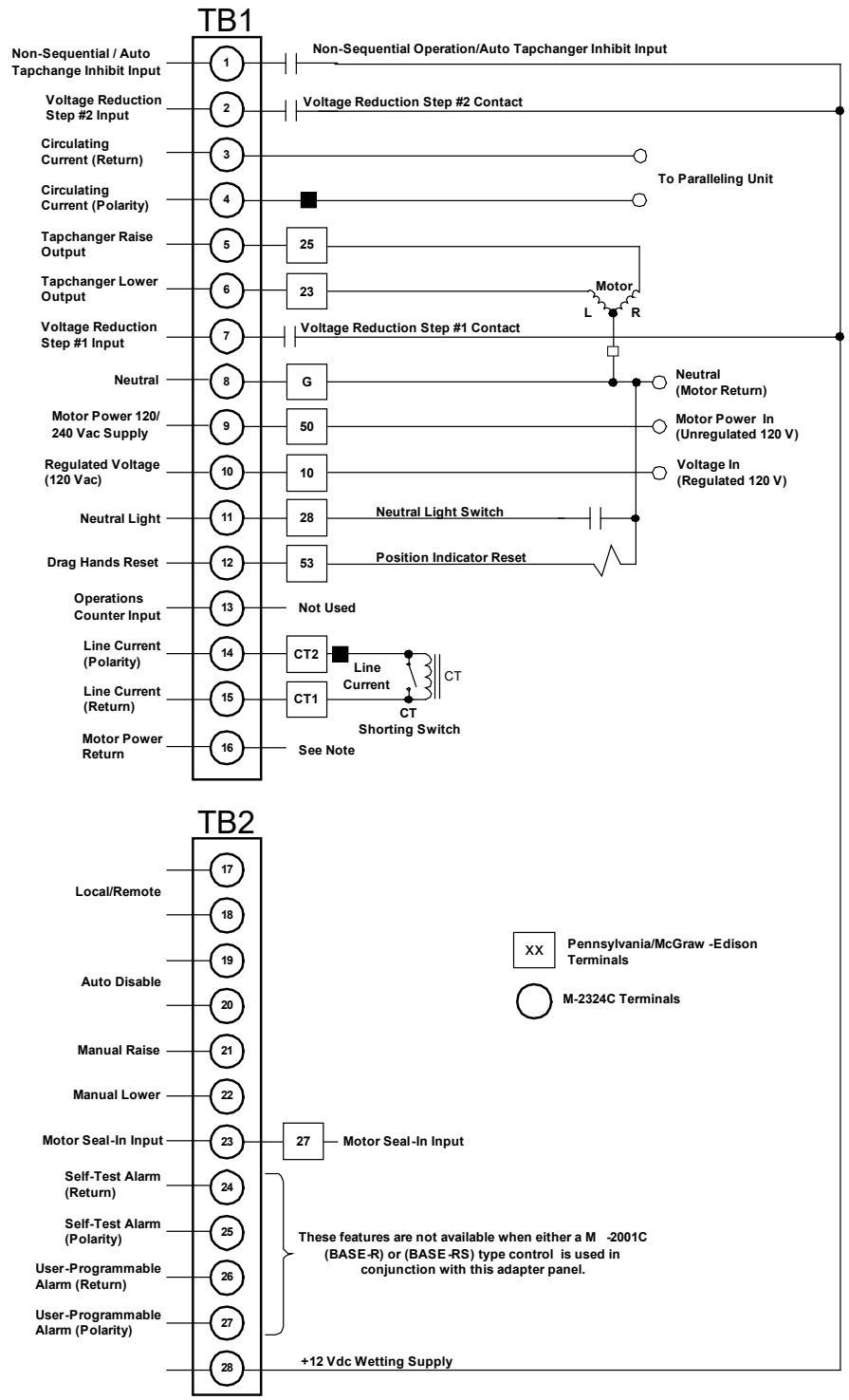
WARNING: In no case should the line current circuit be interrupted with the regulator or transformer energized. Do not remove auxiliary current transformers without shorting the current inputs. Death or severe electrical shock can occur.

Figure 1 M-2001 and M-2324C Panel With Standard AUTO/OFF/MANUAL Toggle Switch and Optional Voltage Reduction and SCADA Output Switches



WARNING: In no case should the line current circuit be interrupted with the regulator or transformer energized. Do not remove auxiliary current transformers without shorting the current inputs. Death or severe electrical shock can occur.

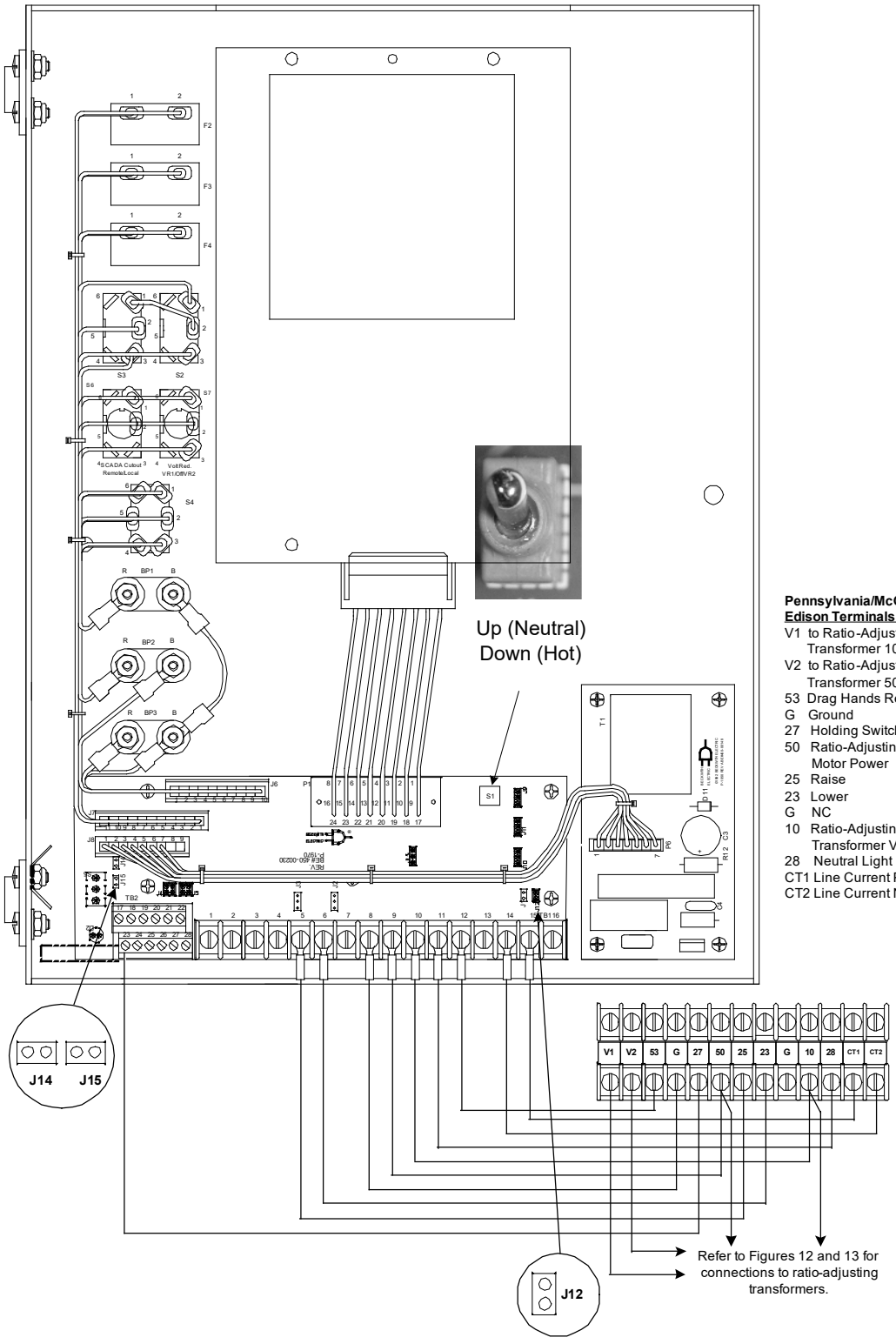
Figure 2 M-2001C and M-2324C Panel With Optional SCAMP (Auto/Manual), Voltage Reduction and SCADA Cutout Switches



WARNING: Open CT secondary will result in high voltage at CT terminals. Death, severe injury or damage to equipment can occur. Do not operate with CT secondary open. Short circuit or apply burden at CT secondary during operation.

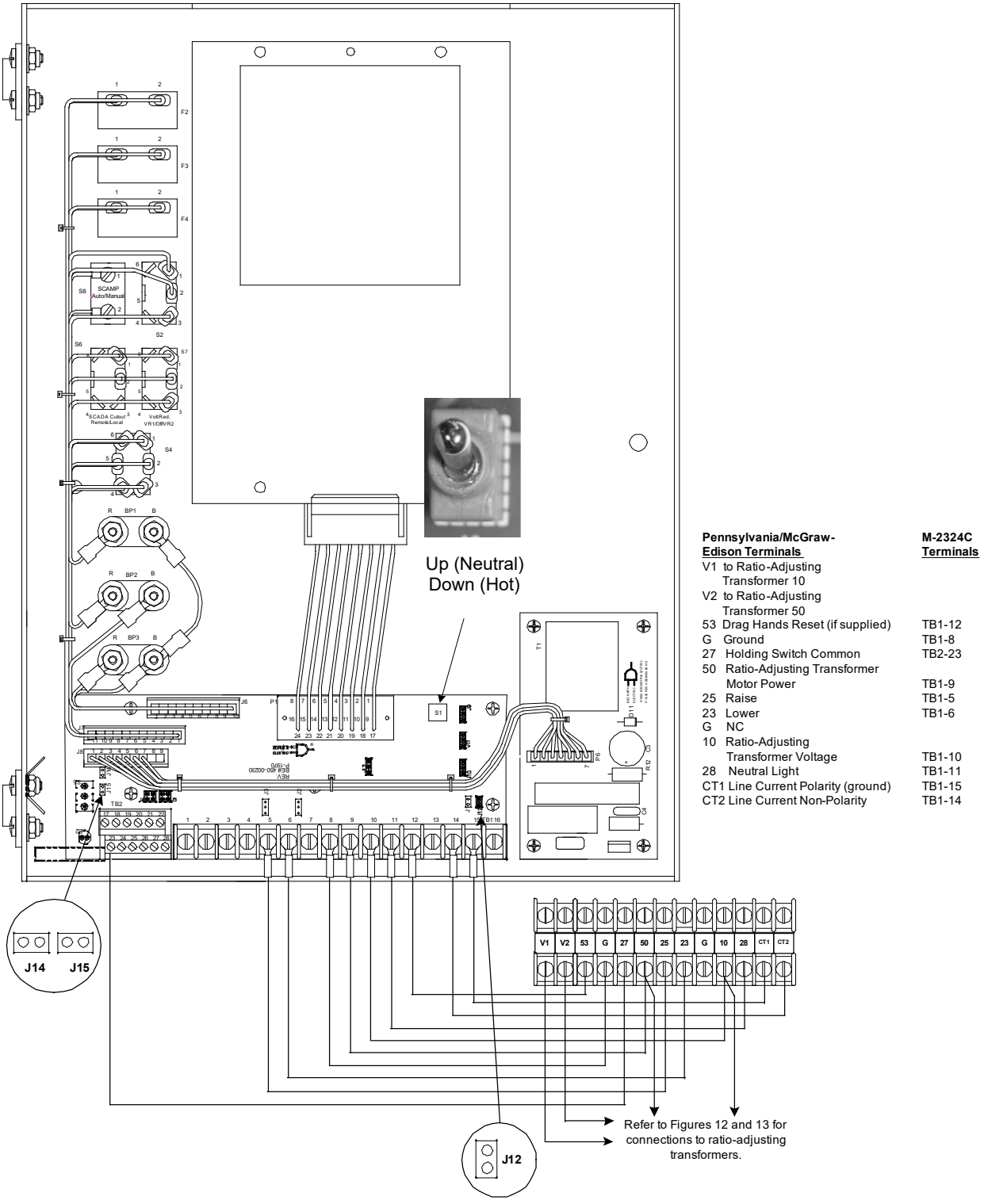
NOTE: If the Motor Power Input configuration has a different return from the 120 V regulated Voltage Input, then Jumper J12 on the printed circuit board must be removed and TB1-16 should be used for the separate motor power source and return connections (See Figure 4 or 5 for J12 location).

Figure 3 External Connections



Pennsylvania/McGraw-Edison Terminals	M-2324C Terminals
V1 to Ratio-Adjusting Transformer 10	
V2 to Ratio-Adjusting Transformer 50	
53 Drag Hands Reset (if supplied)	TB1-12
G Ground	TB1-8
27 Holding Switch Common	TB2-23
50 Ratio-Adjusting Transformer Motor Power	TB1-9
25 Raise	TB1-5
23 Lower	TB1-6
G NC	
10 Ratio-Adjusting Transformer Voltage	TB1-10
28 Neutral Light	TB1-11
CT1 Line Current Polarity (ground)	TB1-15
CT2 Line Current Non-Polarity	TB1-14

Figure 4 M-2324C Wiring Harness and External Connections with SCADA Cutout and Voltage Reduction Switches



Pennsylvania/McGraw-Edison Terminals	M-2324C Terminals
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53 Drag Hands Reset (if supplied)	TB1-12
G Ground	TB1-8
27 Holding Switch Common	TB2-23
50 Ratio-Adjusting Transformer Motor Power	TB1-9
25 Raise	TB1-5
23 Lower	TB1-6
G NC	
10 Ratio-Adjusting Transformer Voltage	TB1-10
28 Neutral Light	TB1-11
CT1 Line Current Polarity (ground)	TB1-15
CT2 Line Current Non-Polarity	TB1-14

Figure 5 M-2324C Wiring Harness and External Connections with SCAMP, SCADA Cutout and Voltage Reduction Switches

Use of the M-0329B LTC Backup Control With the Tapchanger Control

The M-0329B is a single-phase, solid-state backup control that prevents a defective tapchanger control from running the voltage outside the upper and lower voltage limits. The Block Raise and Block Lower voltage levels are set by accurately calibrated dials.

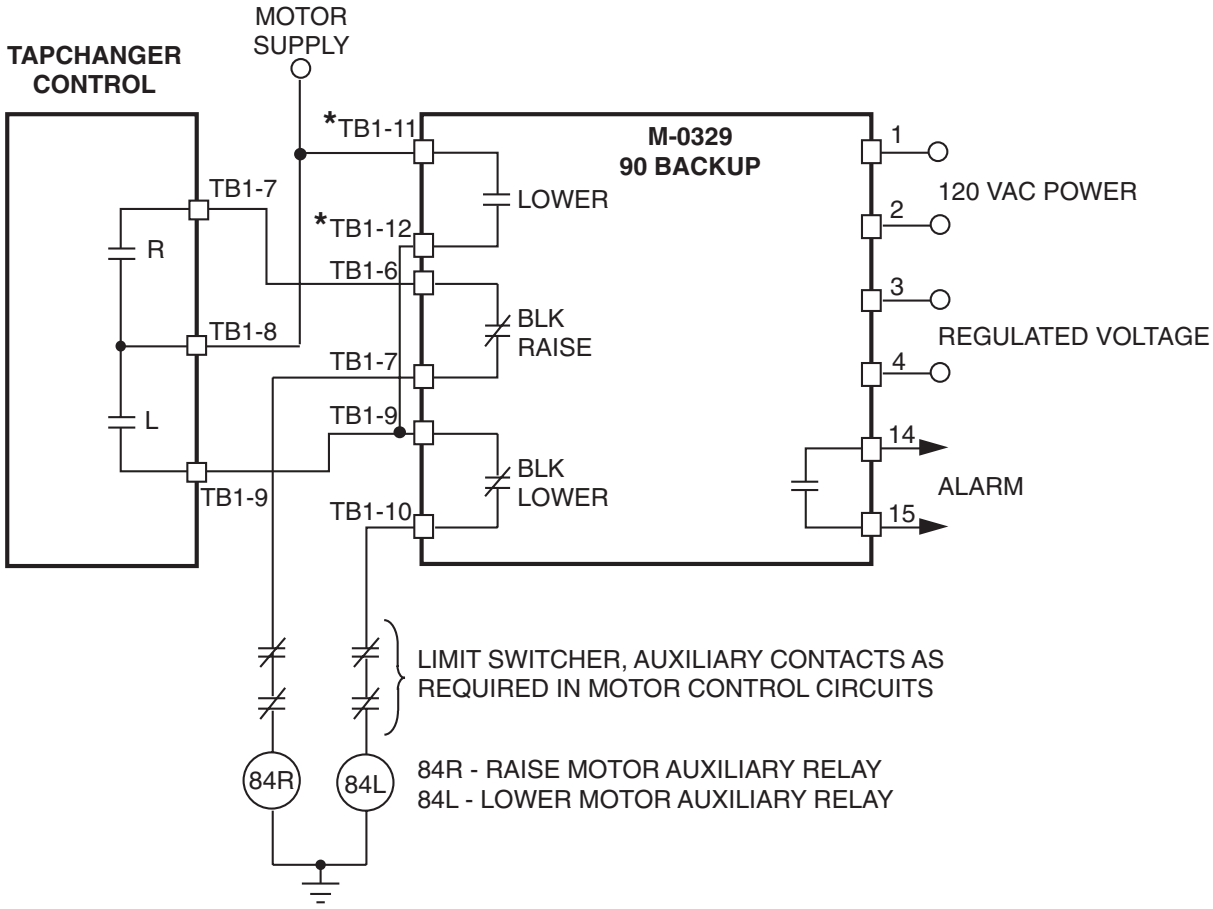
The M-0329B LTC Backup Control is connected as a two terminal device to the voltage transformer. Figure 6, below, illustrates a typical interconnection of the two devices with motor auxiliary relays.

M-0329 LTC BACKUP CONTROL SETTINGS

The **BANDCENTER** and **BANDWIDTH** dials on the M-0329 LTC Backup Control should be set so that the Block Lower limit is a small amount (approximately 2 V) below the lower band limit of the Tapchanger Control, and the Block Raise limit is a similar amount above the upper limit if line drop compensation is *not* used.

If line drop compensation is used, the M-0329 Block Raise limit should be set at the maximum voltage desired at the transformer secondary under full load.

The M-0329 LTC Backup Control also includes a deadband or runback function that regulates the maximum voltage from the transformer. This "Lower" function operates slightly above the Block Raise limit and is connected to force the tapchanger to lower the voltage if the upper limit is exceeded.



***■NOTE:** If first customer protection is not required, delete these connections.

The M-0329B Instruction Book is available on request and gives added details. Please refer to the M-0329B Instruction Book for complete ordering information.

Figure 6 Tapchanger Control and LTC Backup Control Interconnections

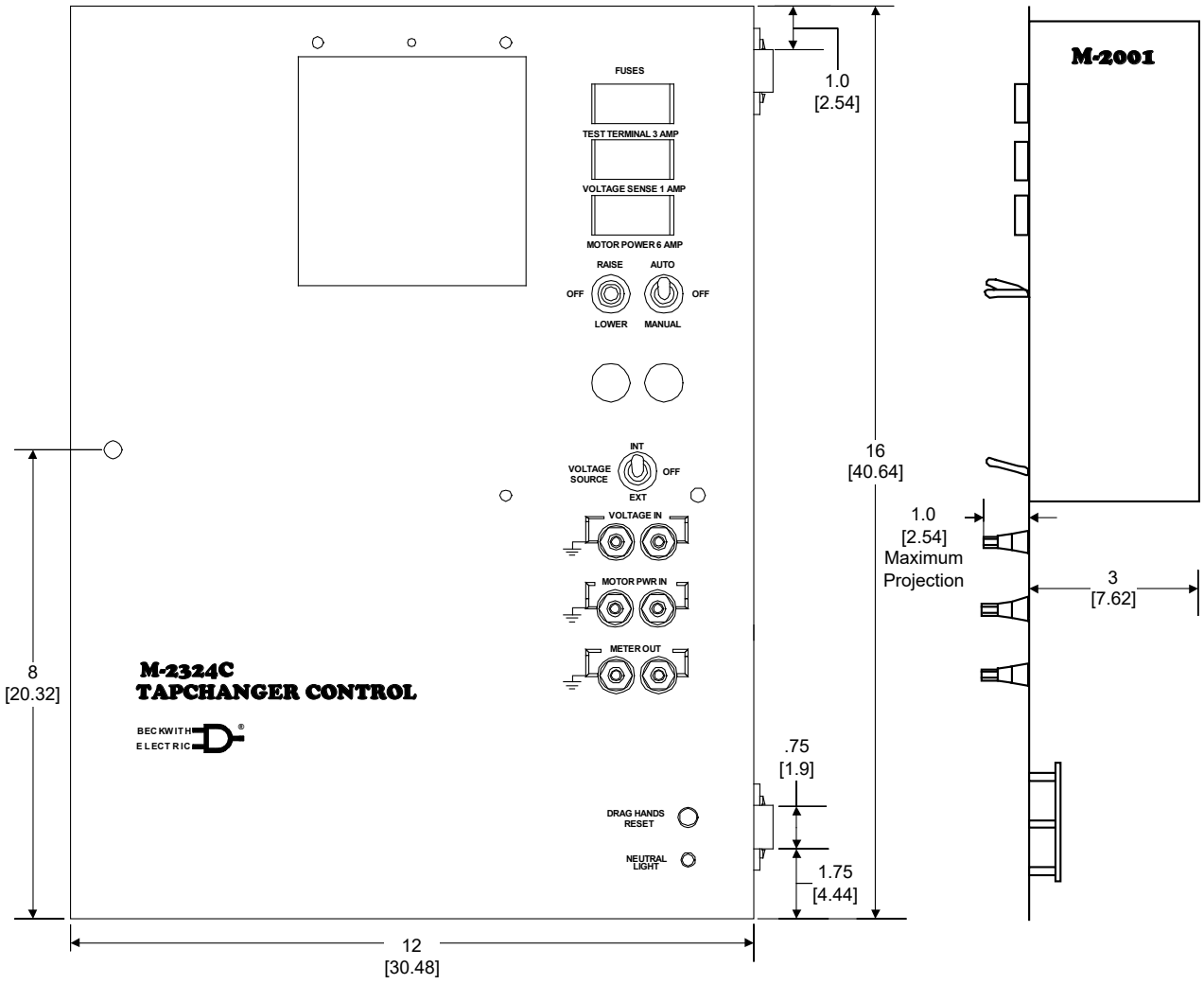


Figure 7 Outline Dimensions

3.0 Installation

The M-2324C is equipped with hinge leaves located on the right side of the adapter panel. The hinge leaves are oriented to match the existing hinge leaves of the Pennsylvania McGraw-Edison Pole Star control cabinet. Refer to Figure 7 for dimensions.

Removal of the Pennsylvania McGraw-Edison Pole Star Control

■**NOTE:** A CT Shorting Blade (CT shorting "tee") is required for this procedure.

1. Open the cabinet door of the Pennsylvania McGraw-Edison Pole Star control.
2. Turn the knob on the control panel, then swing the panel outward.
3. Install the CT shorting "tee" (Item #1, Figure 8).

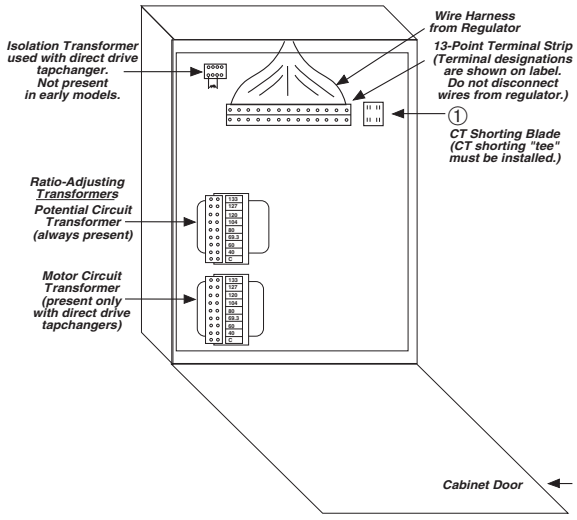


Figure 8 Pennsylvania/McGraw-Edison Control

4. Bypass the regulator and de-energize it. This removes power from the control.
5. Verify that no voltage is present at V1 or V2.

● WARNING: Open CT Secondary will result in high voltage at CT terminals.

6. Label CT1 and CT2 from the regulator (do not disconnect them at any time).
7. Remove all connections except those items on the rear panel that are shown in Figure 8.
8. While supporting the panel, remove and save the two hinges pins, then lift the panel off the hinges.
9. Remove the knob and save knob for future use.

Installing the M-2324C/M-2001

1. Mount the M-2001 to the M-2324C Adapter panel by using the hardware provided in the cloth bag. Use the lock washers supplied between the screws and the top of the front panel.

■**NOTE:** The blue connector is keyed by a "V" notch in the middle to prevent incorrect mating (Figure 9). Check location of the key before plugging connector into the M-2001.

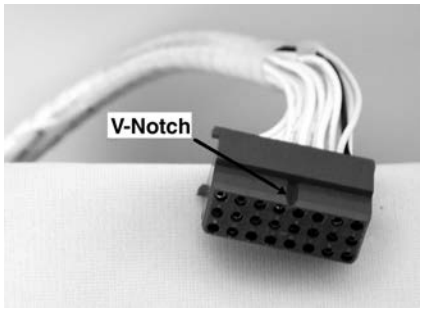


Figure 9 M-2001 Harness Connector

2. Plug the blue connector of the M-2324C harness into the bottom of the M-2001 (Figure 10).

If desired, bench testing may be performed as described in Section 4.0, Bench Test.

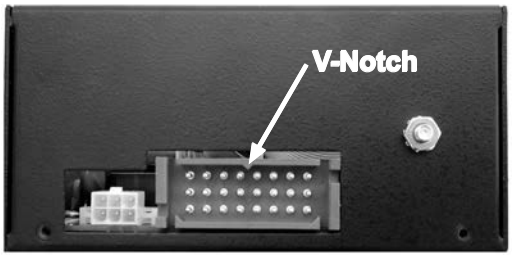


Figure 10 M-2001 V-Notch Orientation

3. Place the M-2324C panel onto the enclosure hinges, then insert hinge pins.
4. Attach the knurled knob saved from the original control to the M-2324C Adapter Panel.

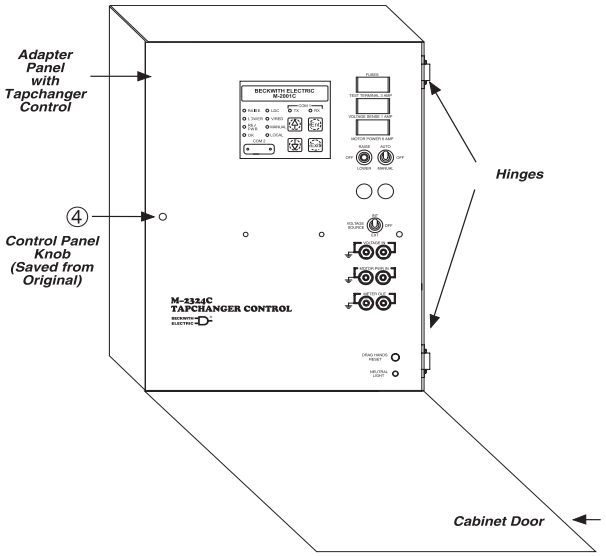


Figure 11 M-2324C Adapter Panel and M-2001 Tapchanger Control in Cabinet

5. Connect the M-2324C wiring harness to the terminal blocks at the top of the cabinet panel (refer to Figures 4 and 5).
6. Determine if the regulator is equipped with "Direct Drive" or "Spring Driven" tapchangers and proceed as follows:
   a. If the regulator is equipped with a "Spring Driven" tapchanger, then refer to Table 2 and Figure 12 for connections.
   b. If the regulator is equipped with a "Direct Driven" tapchanger, then refer to Table 2 and Figure 13 for connections.
7. Secure the M-2324C control panel thumb screw latch.
8. Set the toggle switch to the **Manual** position.
9. Set up the desired configuration and settings on the M-2001. See M-2001 Instruction Book Chapter 4, **Configuration**.
10. Verify manual operation of the unit.
11. Set the toggle switch to the **Auto** position and verify automatic operation.

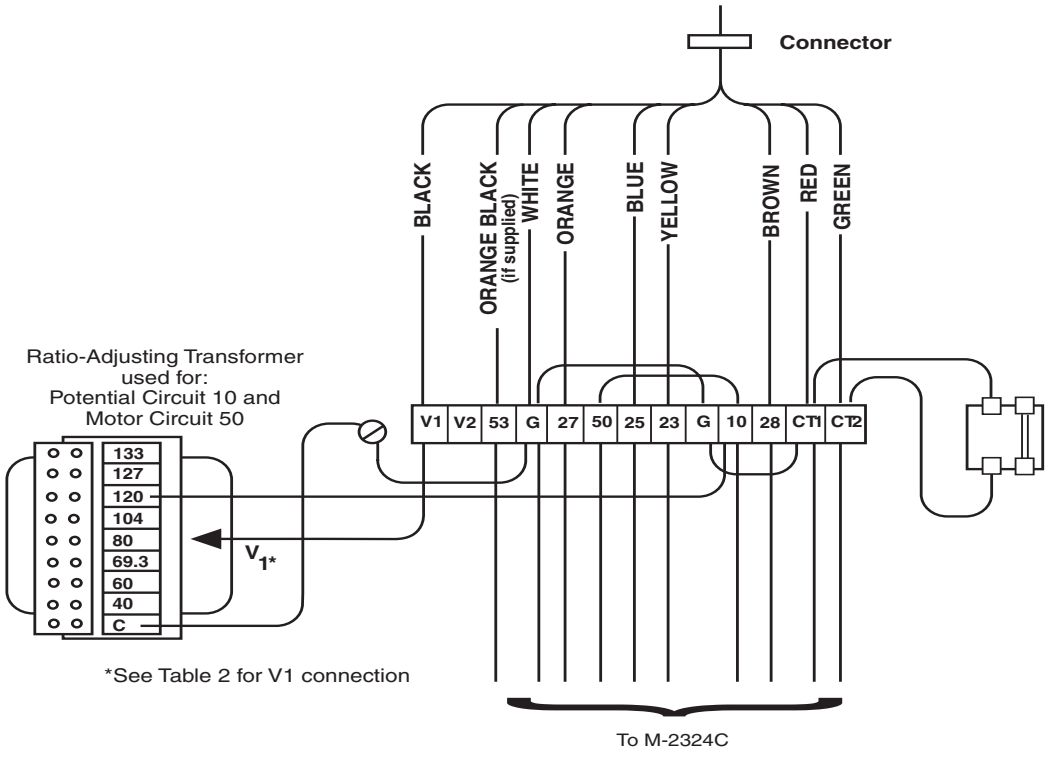


Figure 12 Wiring for Regulators Equipped with Spring-Driven Tapchangers

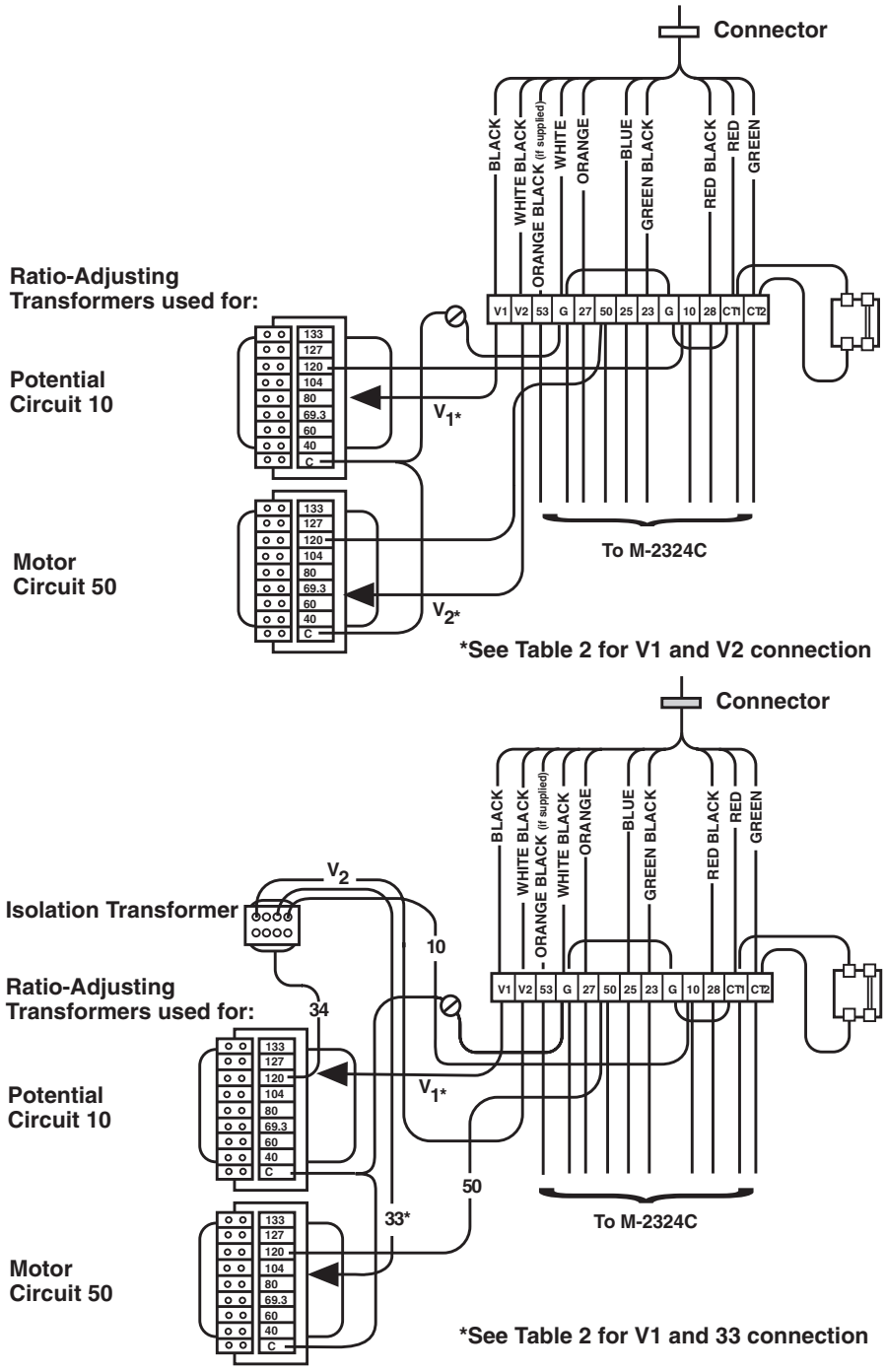


Figure 13 Wiring for Regulators Equipped with Direct Drive Tapchangers

Regulator Voltage Rating	Nominal Circuit Voltage	Ratio-Adjusting Transformers Tap Data		Overall Potential Ratio	Nominal Control Voltage	For M-2324C / M-2001 Application	
		Input Voltage	Tap Connection for V1, V2 or 33			Precise Control Voltage	VT Correcton for 120 V (volts)
2500	2500	No Ratio-Adjusting Transformer		20:1	125	125.0	-5.0
	2400			20:1	120	120.0	0.0
5000	5000	125.0	120	40:1	125	125.0	-5.0
	4800	120.0	120	40:1	120	120.0	0.0
	4330	108.3	104	34.7:1	125	124.8	-4.8
	4160	104.0	104	34.7:1	120	119.9	0.1
	2500	62.5	60	20:1	125	125.0	-5.0
	2400	60.0	60	20:1	120	120.0	0.0
7620	8000	133.3	133	66.5:1	120	120.3	-0.3
	7960	132.7	133	66.5:1	120	119.8	0.2
	7620	127.0	127	63.5:1	120	120.0	0.0
	7200	120.0	120	60:1	120	120.0	0.0
	6900	115.0	120	60:1	115	115.0	5.0
	5000	83.3	80	40:1	125	125.0	-5.0
	4800	80.0	80	40:1	120	120.0	0.0
	4300	72.2	69.3	34.6:1	125	124.3	-4.3
	4160	69.3	69.3	34.6:1	120	120.2	-0.2
	2500	41.7	40	20:1	125	125.0	-5.0
	2400	40.0	40	20:1	120	120.0	0.0
13800	13800	120.0	120	115:1	120	120.0	0.0
	13200	114.8	120	115:1	115	114.8	5.2
	12000	104.3	104	99.7:1	120	120.4	-0.4
	8000	69.6	69.3	66.4:1	120	120.5	-0.5
	7960	69.2	69.3	66.4:1	120	120.0	0.0
	7620	66.3	69.3	66.4:1	115	114.8	5.2
	7200	62.6	60	57.5:1	125	125.2	-5.2
	6900	60.0	60	57.5:1	120	120.0	0.0
14400	14400	120.0	120	120:1	120	120.0	0.0
	13800	115.0	120	120:1	115	115.0	5.0
	13200	110.0	104	104:1	127	126.9	-6.9
	12000	100.0	104	104:1	115	115.4	4.6
	8000	66.7	69.3	69.3:1	115	115.4	4.6
	7960	66.3	69.3	69.3:1	115	114.9	5.1
	7620	63.5	60	60:1	127	127.0	-7.0
	7200	60.0	60	60:1	120	120.0	0.0
	6900	57.5	60	60:1	115	115.0	5.0

Table 2 Ratio Adjusting Transformer Tap Connection and VT Ratio Connection for M-2324C/M-2001

The circuit designation and functions are as follows:

- V1-VT1 voltage from regulator. Jumper to Ratio Correcting Transformer per Table 2.
- V2-VT2 (when used) voltage from regulator. Jumper to Ratio Correcting Transformer per Table 2.
- 53–Drag Hands Reset (if supplied)
- G–Neutral
- 27–Holding Switch Common
- 50–Motor Voltage (ratio-corrected)
- 25–Tapchange Raise
- G Neutral–Jumper to CT1
- 10–Control Sensing Voltage (ratio-corrected)
- 28–Neutral Light Circuit
- CT1–Current Transformer, marked polarity, used for return
- CT2–Current Transformer, marked for non-polarity

4.0 Bench Test (M-2001 Connected to M-2324C)

■**NOTE:** This test assumes that the M-2001 Tapchanger Control is connected to the M-2324C Adapter Panel.

Test Equipment

- 0–200 MA current supply with phase angle settings of 0° to +90°.

▲**CAUTION:** The current input to the M-2001 is rated at 0.2 A continuous, 0.4 A for two hours, and 4.0 A for 1 second.

- 90–145 Vac voltage source at 60 Hz
- High impedance true RMS voltmeter with accuracy on ac of at least ±0.2% of reading
- Accurate stop watch

Setup

1. Make electrical setup connections as described in Figure 14, M-2324C Test Procedure External Connections.

■**NOTE:** Refer to the M-2001 Instruction Book Appendix A, Figures A-1 through A-13, for the locations of screens within the software.

■**NOTE:** There is a one-second delay between the out-of-band condition and panel LED indication.

2. Enter initial M-2001 settings as indicated in Table 3, Initial Settings.

FUNCTION	INITIAL SETTING
Bandcenter	120.0 V
Bandwidth	2.0 V
LDC Resistance	0.0 V
LDC Reactance	0.0 V
Paralleling	N/A For BASE-R Version Circulating Current Method
Block Raise	135.0 V
Block Lower	105.0 V
Deadband	2.0 V
Time Delay	5.0 Seconds

Table 3 Initial Settings

Procedure

▲**CAUTION:** Do not reverse the ground and hot wires when connecting an external source.

1. Apply 120 Vac from the power source.
2. The display of the M-2001 will automatically advance to the Local Voltage screen.
3. Increase voltage to 121.2. The **LOWER** LED should illuminate.
4. Decrease voltage to 118.8. The **RAISE** LED should illuminate.
5. Set the input voltage to 120.0 Vac, then wait for the **RAISE** and **LOWER** LEDs to extinguish.
6. Increase voltage to 122.0 Vac, then start timing when the voltage passes 121.0 Vac.
7. Stop timing when the lamp connected to the Lower output illuminates (should be approximately 5 seconds).

Resistance

1. Apply 100.0 mA in-phase current to TB1-14 (load current-polarity) and TB1-15 (load current-return) of the Adapter Panel.
2. Set S_1 to LDC and S_2 to $\mathbf{I}_R$ (Figure 14).
3. Set LDC Resistance to 24.0 V. The **RAISE** LED should illuminate.
4. Increase input voltage to 132.0 Vac. The **RAISE** and **LOWER** LEDs should be extinguished.
5. Set LDC Resistance to –24.0 V. The **LOWER** LED should illuminate.
6. Decrease input voltage to 108.0 Vac. The **RAISE** and **LOWER** LEDs should be extinguished.
7. Set LDC Resistance to 0.0 V.

Reactance

1. Apply 100.0 mA 90° leading current to TB1-14 (load current-polarity) and TB1-15 (load current-return) of the adapter panel.
2. Set S_1 to LDC and S_2 to IL (Figure 14).
3. Set LDC Reactance to 24.0 V. The **LOWER** LED should illuminate.

4. Decrease input voltage to 108.0 Vac. The **RAISE** and **LOWER** LEDs should be extinguished.
5. Set LDC Reactance to –24.0 V. The **RAISE** LED should illuminate.
6. Increase input voltage to 132.0 Vac. The **RAISE** and **LOWER** LEDs should be extinguished.
7. Set LDC Reactance to 0.0 V.

Paralleling (N/A For BASE-R Version)

1. Apply 100.0 mA 90° leading current to TB1-4 (circulating current-polarity) and TB1-3 (circulating current-return) of the adapter panel. The **LOWER** LED should illuminate.
2. Decrease voltage to 108.0 Vac. The **RAISE** and **LOWER** LEDs should be extinguished.
3. Turn off the current input.

Voltage Source Switch

1. Set the **AUTO/OFF/MANUAL** switch to **OFF**.
2. Set the **Voltage Source** switch to **EXT**.
3. Verify no manual **RAISE** or **LOWER** output.
4. Attach the voltmeter to the **Meter Out** terminals.
5. Verify no voltage is present.
6. Apply 120 Vac to the **External Power** jacks (Red-Hot, Black-Neutral).
7. Set the **AUTO/OFF/MANUAL** switch to **AUTO**.
8. Verify normal raise and lower operation.
9. Return the **Voltage Source** switch to **INT**.

Drag Hands Reset

1. Connect a lamp or ac relay from TB1-12 (drag hands reset) to TB1-8 (neutral) of the adapter panel.
2. Press the **DRAG HAND RESET** switch, the connected lamp or ac relay should illuminate/activate.

Counter/Neutral Light/Tap Position

1. Set the M-2001 Series Digital Tapchanger Control to display the Operations Count screen.
2. Verify counter operation by connecting a switch between TB1-13 (operations counter input) and TB1-8 (neutral) of the adapter panel.
3. Lower the input voltage until the **RAISE** LED illuminates.
4. Allow the delay timer to time out, then activate the switch between TB1-13 (operations counter input) and TB1-8 (neutral). The tap position should change.
5. Place a jumper between TB1-11 (neutral light) and TB1-8 (neutral).
6. Set the neutral light switch S1, located on the adapter panel printed-circuit board (see Figures 4 and 5), to the toggle "Up" position. The neutral light on the adapter panel should illuminate, and the tap position should return to "0 Neutral".
7. Remove the jumper placed between TB1-11 and TB1-8.

Block Raise/Block Lower/Dead Band

1. Set Block Raise to 126.0 V.
2. Set Block Lower to 114.0 V.
3. Set the M-2001 Series Digital Tapchanger Control to display the Bias Voltage screen.
4. Press **ENT**.
5. Increase voltage to 126.5 V. **BR** should be displayed on the screen.
6. Increase voltage to 128.5 V. **FL** should be displayed on the screen.
7. Decrease voltage to 113.5 V. **BL** should be displayed on the screen.

Motor Seal-In

1. Set the input voltage to 122.0 Vac.
2. Allow the lamp connected to the lower output to illuminate.
3. Press and hold (for approximately 2 seconds) the switch connected to TB2-23. The lamp connected to the LOWER output should extinguish.
4. Release the switch connected to TB2-23. After a one-to-two second time delay, the lamp connected to the LOWER output should illuminate.

–Bench Test Complete–

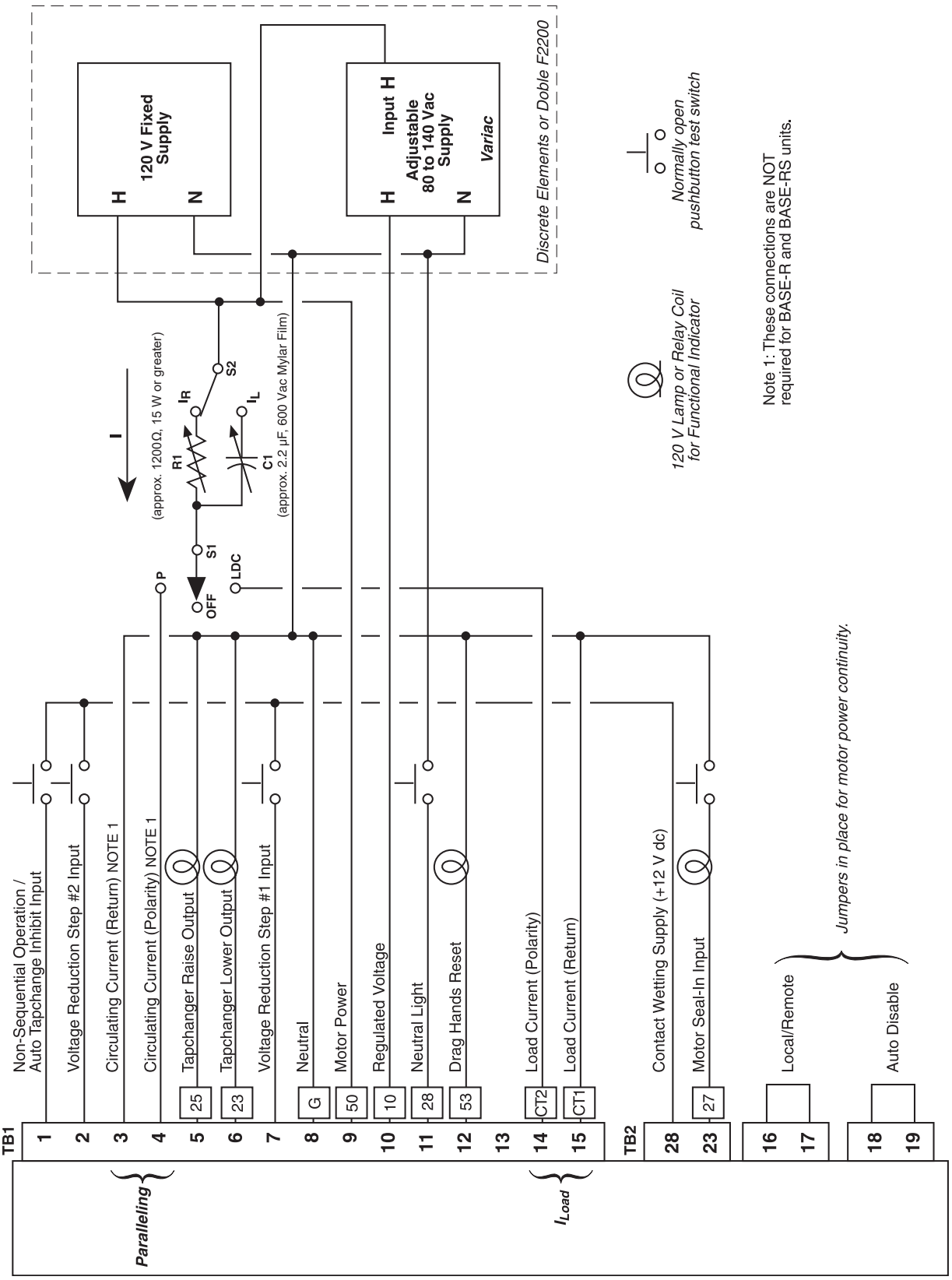


Figure 14 M-2324C Test Procedure External Connection

Basic Operational Test

1. Apply 120.0 Vac to TB1-9 (motor power) and TB1-10 regulated voltage) of the adapter panel.
2. Connect neutral to TB1-8 (neutral).
3. Verify local voltage equals input voltage ±0.3 V.
4. Apply 100.0 mA in-phase current to TB1-14 (load current-polarity) and TB1-15 (load current-return) of the adapter panel. Verify Control Load I equals 100 mA and Power Factor equals 1.0 ±0.02.
5. Apply 100.0 mA 90° leading current to TB1-4 (circulating current-polarity) and TB1-3 (circulating current-return) of the adapter panel.
6. Verify Control Circ I equals 100.0 mA ±2 mA.
7. Verify the ⬆ or ⬇ and **ENT** pushbuttons function properly.

—Checkout Procedure Complete—

In-Service Test

1. Set the M-2001 Tapchanger Control to display Bias Voltage screen.
2. Press **ENT**.
3. Use the ⬆ or ⬇ pushbuttons to cause **RAISE** and **LOWER** outputs.

—In-Service Test Complete—

RETURN UNIT TO DESIRED SETTINGS

5.0 Checkout Procedure

All M-2001 series units are fully calibrated at the factory. There is no need to recalibrate the units before initial installation.

■**NOTE:** This test assumes that the M-2001 Tapchanger Control is connected to the M-2324C Adapter Panel.

Pre-Test Conditions

1. Place the **AUTO/OFF/MANUAL** switch in the **OFF position.**
2. Verify that the **MOTOR POWER** and **VOLTAGE** fuses are correctly sized and have not blown.

Power

1. Remove any external connections between TB1-9 (Motor Power) and TB1-10 (Regulated Voltage), which are located on the adapter panel printed circuit board.
2. Remove any voltage applied to TB1-9 externally.
3. Apply a nominal 120 Vac test voltage source between TB1-10 (hot) and TB1-8 (neutral).
4. Using a voltmeter, verify that the voltage applied to TB1-10 is nominal 120.0 V ac with respect to TB1-8.

⬢ WARNING: Death or electrical shock can occur if a voltage source is connected at the METER OUT test terminal. Applying a voltage source may energize the regulator or transformer to a high voltage through the voltage transformer.

▲**CAUTION:** Do not reverse the ground and hot wires when connecting an external source.

5. Apply motor power to TB1-9 (hot) and TB1-8 (neutral).
6. Place the **AUTO/OFF/MANUAL** switch in the **MANUAL** position.
7. Using the **RAISE/OFF/LOWER** switch, verify that the motor runs in the proper direction when the switch is placed in the **RAISE** and **LOWER** positions.
8. Set the **AUTO/OFF/MANUAL** switch to the **AUTO** position.
9. Refer to M-2001 Instruction Book Chapter 3, **Setting the Control** for setup information.

Load Current CT

WARNING: In no case should the load current circuit be interrupted with the regulator or transformer energized.

WARNING: Do not remove auxiliary current transformers without shorting the current inputs. Death or severe electrical shock can occur.

1. Short the line drop compensator circuit by placing a shorting device of adequate capacity, across the LDC-CT secondary (See Figure 15).
2. Determine if the M-2001C being tested is a BASE-R or BASE-RS version and proceed as follows:
   a. If the M-2001C being tested is a BASE-R or BASE-RS version, then go to Step 3.
   b. If the M-2001C being tested is *not* a BASE-R or BASE-RS version, then short the circulating current paralleling input for the load current check by placing a shorting device of adequate capacity across TB1-3 and TB1-4.
3. Connect an ammeter (set to the 200 mA range) between the polarity input and TB1-14.
4. Open the load current shorting device.
5. With a known load on the transformer or regulator, measure the current in the load current circuit.
6. Verify that the current measured in Step 5 is correct for 0.2A full load.

LDC

1. Replace the shorting device across the load current input and remove the ammeter.
2. Reconnect polarity to the unit, then remove the installed shorting devices. The **LINE DROP COMPENSATION** will be activated.

   Verify correct CT polarity by incorporating sufficient +R compensation. The regulator should time out and run to raise the output voltage.

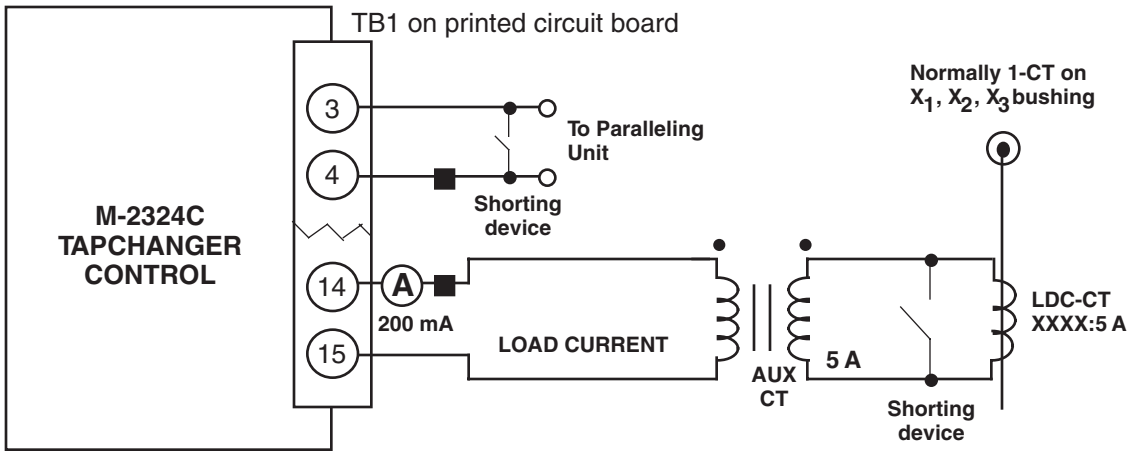


Figure 15 M-2324C Setup for Current Checkout Procedure

Legal Information

Patent

The units described in this manual are covered by U.S. Patents, with other patents pending.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringement of United States Letters Patent or rights accruing therefrom or trademarks, whether federal, state, or common law, arising from the Seller's compliance with Buyer's designs, specifications, or instructions.

Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of five years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to perform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided, however, that Buyers shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to replacement value of the equipment furnished under this contract.

Seller makes no warranties expressed or implied other than those set out above. Seller specifically excludes the implied warranties of merchantability and fitness for a particular purpose. There are no warranties which extend beyond the description contained herein. In no event shall Seller be liable for consequential, exemplary, or punitive damages of whatever nature.

Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the Buyer. The aforementioned warranties are void if the value of the unit is invoiced to the Seller at the time of return.

Indemnification

The Seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services covered by or furnished under this contract.

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Under no circumstances shall the Seller be liable for any personal injury whatsoever.

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