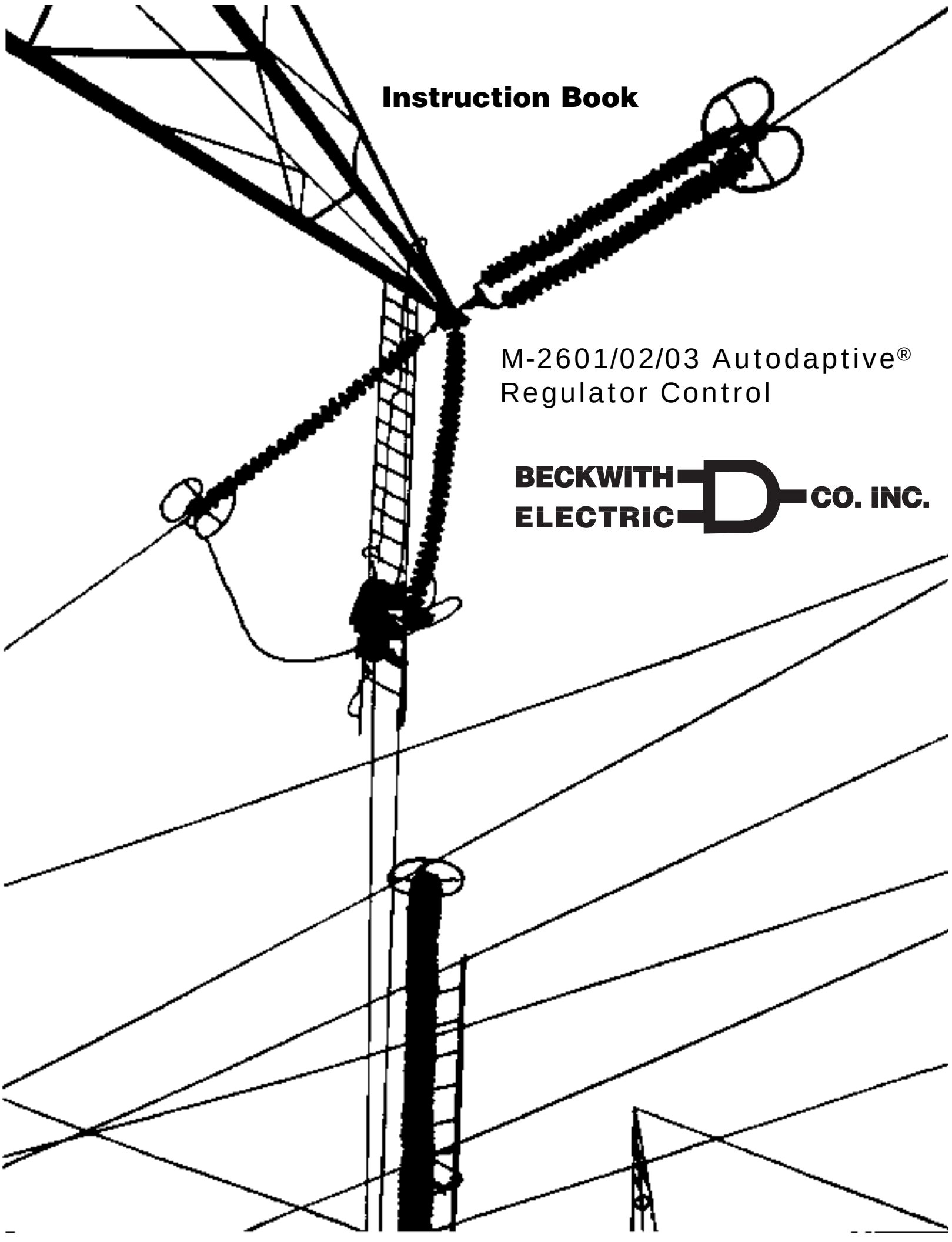
Instruction Book

M-2601/02/03 Autodaptive®
Regulator Control

BECKWITH ELECTRIC CO. INC.



Autodaptive® Regulator Control M-2601

Replaces Siemens Regulators MJ-1A, MJ-2A, MJ-3, MJ-3A, MJ-X; IJ-2, IJ-2A; SJ-4, SJ-5, SJ-6; UJ-2, UJ-4, UJ-5, UJ-5C and some UA Series Regulator Controls

- **Adaptive control feature significantly reduces number of tap changes for a given Voltage Regulation Quality Factor (VRQF)**
- **Uses proprietary sampling to measure fundamental voltage, Watts and VArs at a rate of 240 samples per half cycle**
- **Enhanced data output display with SLIMcom® software**

The M-2601 Autodaptive® Regulator Control is a unique microcontroller-based solution to regulator control requirements. Using conventional Siemens Regulator inputs, the control accomplishes regulator control, based on voltage. Communication and control features of the M-2601 are accomplished utilizing either M-2802 SLIMcom® for Windows™ from a PC platform, or M-2808 SLIMcom for Visor™ Communications Software.

Features

The M-2601 Autodaptive Regulator Control includes a user-defined Bandcenter and Voltage Regulation Quality Factor (VRQF) that permits optimization of the tapchanging process. Also included are: a **DRAG HANDS RESET** button, a **VOLTAGE SOURCE** selector switch and binding posts for Motor Power, Control Voltage and Voltage Test. Separate fuses for motor power, control, relays and the neutral circuit are located on the rear of the panel.

Configurable setpoints include:

Bandcenter: Adjustable from 90.0 V to 135.0 V in 0.1 V increments.

Bandwidth: 1 V, predetermined by regulator step size.

VRQF: Adjustable from 0.4 V to 2.0 V in 0.1 V increments.

CT to VT Phasing Correction: Adjustable from 0° to +330° in 30° increments.

VT User Correction Voltage: VT correction from –12 V to +12 V in 0.01 V increments.

CT User Correction Multiplier: Adjustable from 50% to 200%, in 1% increments.

Voltage Limiting: Upper Voltage Limit adjustable from 90 V to 136 V, Lower Voltage Limit adjustable from 89 V to 135 V.

Line Drop Compensation: R & X (forward and reverse) adjustable from –24 V to +24 V in 1 V increments.

Intertap Minimum Delay: Adjustable from 5 seconds to 15 seconds in 0.1 second increments.

Raise/Lower Maximum Output Hold Time: Adjustable from 1 second to 15 seconds in 0.1 second increments.

VAr Bias Setpoints:

Largest Cap Bank: Adjustable from 0 KVAr to 11057 KVAr.

Control Functions

Presettable Operations Counter: This software counter increments by one or two counts (user-selectable) per close/open cam switch operation, and may be preset by the user from 0 to 999,999.

Resettable Operations Counter: A second software counter, similar to the operations counter, which may be reset by the user.

Inputs

Control Voltage Input: Nominal 120 V ac, 60 Hz; operates properly from 80 V ac to 140 V ac. The burden imposed on the input is 6 VA or less.

Motor Power Input: Nominal 120 V ac or 240 V ac, 60 Hz, at up to 6 A.

Line Current Input: Line drop compensation is provided by a current transformer input with a 0.2 A full scale rating. The burden imposed on the current source is 0.03 VA or less, at 200 mA. The input will withstand 400 mA for two hours and 4 A for 1 second.

The unit will withstand twice the voltage input for one second, and four times the voltage input for one cycle. Fuse protected for voltage above these limits.

Front Panel Controls

AUTO/MANUAL switch**:** Selects operational mode of regulator.

RAISE/OFF/LOWER switch: Provides manual tap position control.

VOLTAGE SOURCE: Allows the selection of either an internal or external voltage source.

LED Indicators

The front panel LED indicators alert the user to the following conditions:

Out-of-Band **RAISE** and **LOWER** (3 position): GREEN (Initial Timing), AMBER (switch operation in 1 to 5 minutes), RED (switch operation in 1 minute or less).

CPU OK, flashing GREEN, indicates the control is working properly.

REV PWR, RED, indicates a reverse power condition exists.

NEUTRAL LIGHT, AMBER, indicates regulator is in the neutral position.

Output Contacts

Raise Output: Capable of switching 6 A at 120 V ac to 240 V ac motor power.

Lower Output: Capable of switching 6 A at 120 V ac or 240 V ac motor power.

Voltage Measurement Accuracy

Voltage accuracy of ±0.7% in accordance with ANSI/IEEE C57.15-1986 defining control accuracy of operation.

Communications

Serial communications is available via a front panel-mounted, optically-isolated RS-232 serial data port in a DE 9-pin configuration, with available data rate of 9600 baud.

Environmental

Temperature: Stated accuracies maintained from –40°C to +80°C.

Humidity: Stated accuracies are maintained up to 95% relative humidity (non-condensing).

Fungal Resistance: A conformal coating is used on the printed circuit board to inhibit fungal growth.

Transient Protection

High Voltage: All input and output terminals will withstand 1500 V ac to chassis or instrument ground for one minute, for all terminals to ground with a leakage current less than 25 mA. 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.

Electrostatic Discharge Sensitivity: Per IEC 1000–4.

Physical

Size: 15" high x 9-7/8" wide x 3-1/2" deep (38.1 cm x 25.08 cm x 8.9 cm)

Mounting: Mechanically interchangeable with existing Siemens equipment.

Approximate Weight: 4 lbs, 13 oz (2.18 kg)

Approximate Shipping Weight: 10 lbs (4.54 kg)

Accessories

M-2802 SLIMcom® for Windows™

M-2808 SLIMcom for Visor™

Metering

The following are examples of measured and calculated parameters that are available in real-time:

- PrimaryVoltage
- KWatts**
- Secondary Voltage
- CT Phasing
- Preset Counter
- Primary Current
- KVArs**
- Secondary Current
- Avg Taps/Day
- Alarm Status
- Power Factor
- KVA**
- VRQF†
- Tap Position
- Voltage Profile

Historical Data Plot

- Up to seven time-stamped analog calculated or measured values
- 1 digital parameter can be plotted

■ **NOTE**: All stored data available with time stamp. Five minute averaged samples are stored 111 days. Sampling rate adjustable from 5 to 60 minutes, with resultant change to storage period.

Voltage Outage Plot

- Voltage plots (previous 10 seconds of data) for the last 4 voltage outage events are displayed.

Tap Statistics Plot

- The Tap Statistics Plot presents a graphical representation of tap position usage history.

Other

- Prints detailed reports of all setpoints and data.
- Entry and Readout of setpoints.

***Value calculated in SLIMcom. All primary quantities are also calculated in SLIMcom.*

† VRQF is the RMS deviation in the fundamental component of an AC voltage from a desired AC voltage. It is computed as the square root of the sum of the squares of deviations in the fundamental component of the voltage from the desired value. The sum is computed as a running recursive average of frequently taken samples of the fundamental component, obtained in at least one full cycle of the wave. The time constant of the recursive computation is 6 hours. The recursive average takes at least six hours to settle to a proper sum, and is generally never stopped, once started.

M-2931 Handspring™ Visor™ Deluxe, with SLIMcom for Visor Communications Software

Patents

The M-2601 Autodaptive® Regulator Control is covered by U.S. Patents, 5,315,527, 5,554,064, 5,541,498 and 5,530,338 with other patents pending.

Warranty

The M-2601 Autodaptive Regulator Control is covered by a two year warranty from date of shipment.

Specification subject to change without notice.

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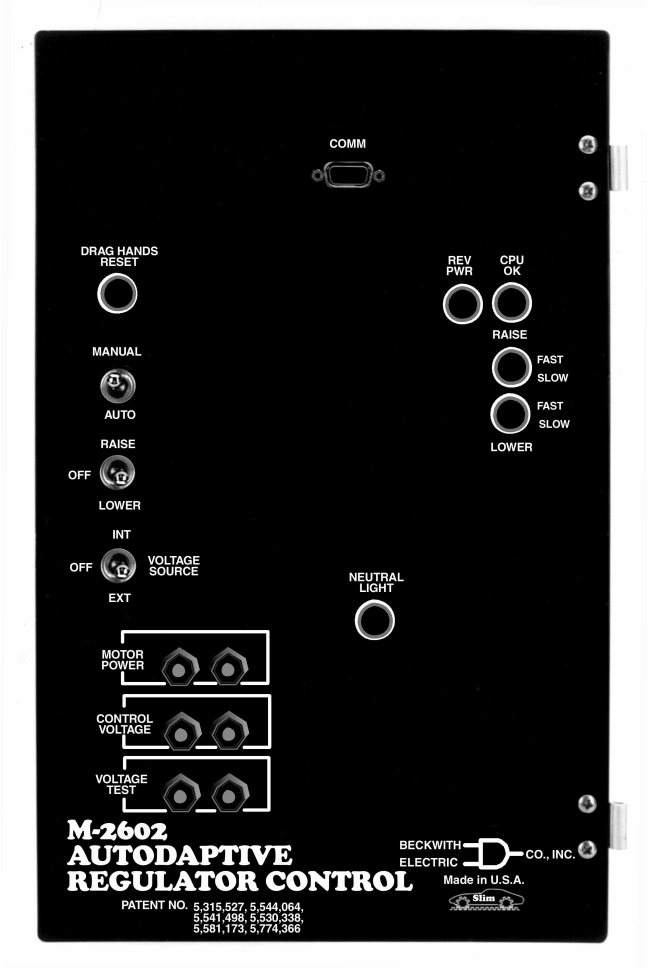
800-2601-SP-03 09/01

Autodaptive® Regulator Control M-2602

Replaces General Electric ML-32 and VR-1 Regulators, and SM-1, SM-2, and SM-2A Regulator Controls



- **Adaptive control feature significantly reduces number of tap changes for a given Voltage Regulation Quality Factor (VRQF)**
- **Uses proprietary sampling to measure fundamental voltage, Watts and VArs at a rate of 240 samples per half cycle**
- **Enhanced data output display with SLIMcom® software**

The M-2602 Autodaptive® Regulator Control is a unique microcontroller-based solution to regulator control requirements. Using conventional GE Regulator inputs, the control accomplishes regulator control, based on voltage. Communication and control features of the M-2602 are accomplished utilizing either M-2802 SLIMcom® for Windows™ from a PC platform, or M-2808 SLIMcom for Visor™ Communications Software.

Features

The M-2602 Autodaptive Regulator Control includes a user-defined Bandcenter and Voltage Regulation Quality Factor (VRQF) that permits optimization of the tapchanging process. Also included are: a **DRAG HANDS RESET** button, a **VOLTAGE SOURCE** selector switch and binding posts for Motor Power, Control Voltage and Voltage Test. Separate fuses for motor power, control, relays and the neutral circuit are located on the rear of the panel.

Configurable setpoints include:

Bandcenter: Adjustable from 90.0 V to 135.0 V in 0.1 V increments.

Bandwidth: 1 V, predetermined by regulator step size.

VRQF: Adjustable from 0.4 V to 2.0 V in 0.1 V increments.

CT to VT Phasing Correction: Adjustable from 0° to +330° in 30° increments.

VT User Correction Voltage: VT correction from –12 V to +12 V in 0.01 V increments.

CT User Correction Multiplier: Adjustable from 50% to 200%, in 1% increments.

Voltage Limiting: Upper Voltage Limit adjustable from 90 V to 136 V, Lower Voltage Limit adjustable from 89 V to 135 V.

Line Drop Compensation: R & X (forward and reverse) adjustable from –24 V to +24 V in 1 V increments.

Intertap Minimum Delay: Adjustable from 5 seconds to 15 seconds in 0.1 second increments.

Raise/Lower Maximum Output Hold Time: Adjustable from 1 second to 15 seconds in 0.1 second increments.

VAr Bias Setpoints:

Largest Cap Bank: Adjustable from 0 KVAr to 11057 KVAr.

Control Functions

Presettable Operations Counter: This software counter increments by one or two counts (user-selectable) per close/open cam switch operation, and may be preset by the user from 0 to 999,999.

Resettable Operations Counter: A second software counter, similar to the operations counter, which may be reset by the user.

Inputs

Control Voltage Input: Nominal 120 V ac, 60 Hz; operates properly from 80 V ac to 140 V ac. The burden imposed on the input is 6 VA or less.

Motor Power Input: Nominal 120 V ac or 240 V ac, 60 Hz, at up to 6 A.

Line Current Input: Line drop compensation is provided by a current transformer input with a 0.2 A full scale rating. The burden imposed on the current source is 0.03 VA or less, at 200 mA. The input will withstand 400 mA for two hours and 4 A for 1 second.

The unit will withstand twice the voltage input for one second, and four times the voltage input for one cycle. Fuse protected for voltage above these limits.

Front Panel Controls

AUTO/MANUAL switch**:** Selects operational mode of regulator.

RAISE/OFF/LOWER switch: Provides manual tap position control.

VOLTAGE SOURCE: Allows the selection of either an internal or external voltage source.

LED Indicators

The front panel LED indicators alert the user to the following conditions:

Out-of-Band **RAISE** and **LOWER** (3 position): GREEN (Initial Timing), AMBER (switch operation in 1 to 5 minutes), RED (switch operation in 1 minute or less).

CPU OK, flashing GREEN, indicates the control is working properly.

REV PWR, RED, indicates a reverse power condition exists.

NEUTRAL LIGHT, AMBER, indicates regulator is in the neutral position.

Output Contacts

Raise Output: Capable of switching 6 A at 120 V ac to 240 V ac motor power.

Lower Output: Capable of switching 6 A at 120 V ac or 240 V ac motor power.

Voltage Measurement Accuracy

Voltage accuracy of ±0.7% in accordance with ANSI/IEEE C57.15-1986 defining control accuracy of operation.

Communications

Serial communications is available via a front panel-mounted, optically-isolated RS-232 serial data port in a DE 9-pin configuration, with available data rate of 9600 baud.

Environmental

Temperature: Stated accuracies maintained from –40°C to +80°C.

Humidity: Stated accuracies are maintained up to 95% relative humidity (non-condensing).

Fungal Resistance: A conformal coating is used on the printed circuit board to inhibit fungal growth.

Transient Protection

High Voltage: All input and output terminals will withstand 1500 V dc to chassis or instrument ground for one minute, for all terminals to ground with a leakage current of less than 25 mA. 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.

Electrostatic Discharge Sensitivity: Per IEC 1000–4.

Physical

Size: 15" high x 9-1/4" wide x 2-3/8" deep (38.1 cm x 23.5 cm x 5.6 cm)

Mounting: Mechanically interchangeable with existing GE equipment.

Approximate Weight: 4 lbs, 4 oz (1.93 kg)

Approximate Shipping Weight: 10 lbs (4.54 kg)

Accessories

M-2802 SLIMcom® for Windows™

M-2808 SLIMcom for Visor™

Metering

The following measured and calculated parameters are available in real-time:

- PrimaryVoltage
- KWatts**
- Secondary Voltage
- CT Phasing
- Preset Counter
- Primary Current
- KVArs**
- Secondary Current
- Avg Taps/Day
- Alarm Status
- Power Factor
- KVA**
- VRQF†
- Tap Position
- Voltage Profile

Historical Data Plot

- Up to seven time-stamped analog calculated or measured values
- 1 digital parameter can be plotted

■ **NOTE**: All stored data available with time stamp. Five minute averaged samples are stored 111 days. Sampling rate adjustable from 5 to 60 minutes, with resultant change to storage period.

Voltage Outage Plot

- Voltage plots (previous 10 seconds of data) for the last 4 voltage outage events are displayed.

Tap Statistics Plot

- The Tap Statistics Plot presents a graphical representation of tap position usage history.

Other

- Prints detailed reports of all setpoints and data.
- Entry and Readout of setpoints.

***Value calculated in SLIMcom. All primary quantities are also calculated in SLIMcom.*
† VRQF is the RMS deviation in the fundamental component of an AC voltage from a desired AC voltage. It is computed as the square root of the sum of the squares of deviations in the fundamental component of the voltage from the desired value. The sum is computed as a running recursive average of frequently taken samples of the fundamental component, obtained in at least one full cycle of the wave. The time constant of the recursive computation is 6 hours. The recursive average takes at least six hours to settle to a proper sum, and is generally never stopped, once started.

M-2931 Handspring™ Visor™ Deluxe, with SLIMcom for Visor Communications Software

Patents

The M-2602 Autodaptive® Regulator Control is covered by U.S. Patents, 5,315,527, 5,554,064, 5,541,498 and 5,530,338 with other patents pending.

Warranty

The M-2602 Autodaptive Regulator Control is covered by a two year warranty from date of shipment.

Specification subject to change without notice.

ISO 9001:1994 Registered

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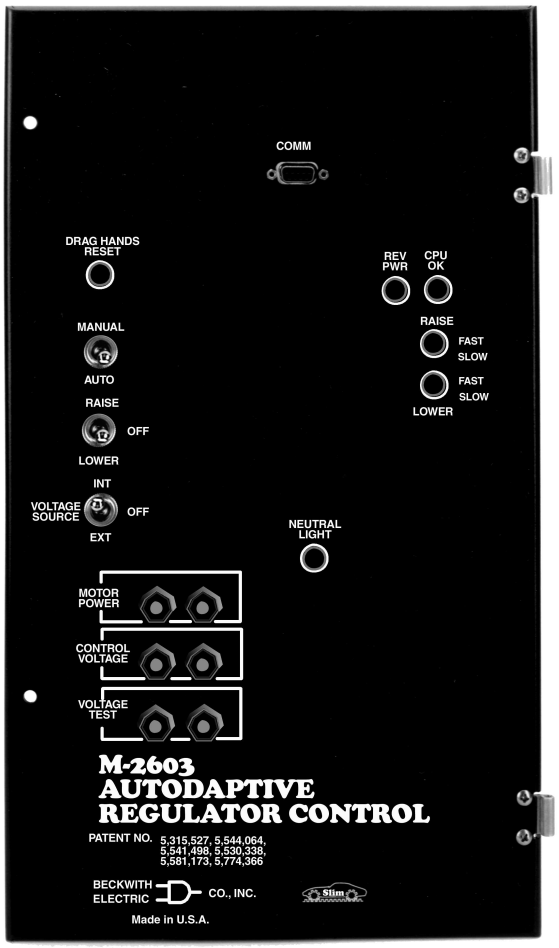
800-2602-SP-01 09/01

Autodaptive® Regulator Control M-2603

Replaces Cooper CL-2, CL-4A, CL-4B, and CL-4C Regulator Controls



- **Adaptive control feature significantly reduces number of tap changes for a given Voltage Regulation Quality Factor (VRQF)**
- **Uses proprietary sampling to measure fundamental voltage, Watts and VArs at a rate of 240 times per half cycle**
- **Enhanced data output display with SLIMcom® software**

The M-2603 Autodaptive® Regulator Control is a unique microcontroller-based solution to regulator control requirements. Using conventional Cooper Regulator inputs, the control accomplishes regulator control, based on voltage. Communication and control features of the M-2603 are accomplished utilizing either M-2802 SLIMcom® for Windows™ from a PC platform, or M-2808 SLIMcom for Visor™ Communications Software.

Features

The M-2603 Autodaptive Regulator Control includes a user-defined Bandcenter and Voltage Regulation Quality Factor (VRQF) that permits optimization of the tapchanging process. Also included are: a **DRAG HANDS RESET** button, a **VOLTAGE SOURCE** selector switch and binding posts for Motor Power, Control Voltage and Voltage Test. Separate fuses for motor power, control, relays and the neutral circuit are located on the rear of the panel.

Configurable setpoints include:

Bandcenter: Adjustable from 90.0 V to 135.0 V in 0.1 V increments.

Bandwidth: 1 V, predetermined by regulator step size.

VRQF: Adjustable from 0.4 V to 2.0 V in 0.1 V increments.

CT to VT Phasing Correction: Adjustable from 0° to +330° in 30° increments.

VT User Correction Voltage: VT correction from –12 V to +12 V in 0.01 V increments.

CT User Correction Multiplier: Adjustable from 50% to 200%, in 1% increments.

Voltage Limiting: Upper Voltage Limit adjustable from 90 V to 136 V, Lower Voltage Limit adjustable from 89 V to 135 V.

Line Drop Compensation: R & X (forward and reverse) adjustable from –24 V to +24 V in 1 V increments.

Intertap Minimum Delay: Adjustable from 5 seconds to 15 seconds in 0.1 second increments.

VAr Bias Setpoints:

Largest Cap Bank: Adjustable from 0 KVAr to 11057 KVAr.

Control Functions

Presettable Operations Counter: This software counter increments by one or two counts (user-selectable) per close/open cam switch operation, and may be preset by the user from 0 to 999,999.

Resettable Operations Counter: A second software counter, similar to the operations counter, which may be reset by the user.

Inputs

Control Voltage Input: Nominal 120 V ac, 60 Hz; operates properly from 80 V ac to 140 V ac. The burden imposed on the input is 6 VA or less.

Motor Power Input: Nominal 120 V ac or 240 V ac, 60 Hz, at up to 6 A.

Line Current Input: Line drop compensation is provided by a current transformer input with a 0.2 A full scale rating. The burden imposed on the current source is 0.03 VA or less, at 200 mA. The input will withstand 400 mA for two hours and 4 A for 1 second.

The unit will withstand twice the voltage input for one second, and four times the voltage input for one cycle. Fuse protected for voltage above these limits.

Front Panel Controls

AUTO/MANUAL switch**:** Selects operational mode of regulator.

RAISE/OFF/LOWER switch: Provides manual tap position control.

VOLTAGE SOURCE: Allows the selection of either an internal or external voltage source.

LED Indicators

The front panel LED indicators alert the user to the following conditions:

Out-of-Band **RAISE** and **LOWER** (3 position): GREEN (Initial Timing), AMBER (switch operation in 1 to 5 minutes), RED (switch operation in 1 minute or less).

CPU OK, flashing GREEN, indicates the control is working properly.

REV PWR, RED, indicates a reverse power condition exists.

NEUTRAL LIGHT, AMBER, indicates regulator is in the neutral position.

Output Contacts

Raise Output: Capable of switching 6 A at 120 V ac to 240 V ac motor power.

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Voltage Measurement Accuracy

Voltage accuracy of ±0.7% in accordance with ANSI/IEEE C57.15-1986 defining control accuracy of operation.

Communications

Serial communications is available via a front panel-mounted, optically-isolated RS-232 serial data port in a DE 9-pin configuration, with available data rate of 9600 baud.

Environmental

Temperature: Stated accuracies maintained from –40°C to +80°C.

Humidity: Stated accuracies are maintained up to 95% relative humidity (non-condensing).

Fungal Resistance: A conformal coating is used on the printed circuit board to inhibit fungal growth.

Transient Protection

High Voltage: All input and output terminals will withstand 1500 V ac to chassis or instrument ground for one minute, for all terminals to ground with a leakage current of less than 25 mA. 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.

Electrostatic Discharge Sensitivity: Per IEC 1000–4.

Physical

Size: 17-5/8" high x 10-1/8" wide x 2-3/8" deep (52.71 cm x 25.72 cm x 5.6 cm)

Mounting: Mechanically interchangeable with existing Cooper equipment.

Approximate Weight: 4 lbs, 13 oz (2.18 kg)

Approximate Shipping Weight: 10 lbs (4.54 kg)

Accessories

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M-2808 SLIMcom for Visor™

Metering

The following measured and calculated parameters are available in real-time:

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- Avg Taps/Day
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Historical Data Plot

- Up to seven time-stamped analog calculated or measured values
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Specification subject to change without notice.

ISO 9001:1994 Registered

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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 Co., Inc. 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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M-2601/02/03 Autodaptive® Regulator Control Instruction Book

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1 Introduction

1.0 Description

The Beckwith M-2601/02/03 Series of Autodaptive® Regulator Controls (ARC) are unique microcontroller-based solutions to regulator control requirements. Using conventional inputs, the control accomplishes regulator control, based on voltage. The unit has a user-defined Bandcenter and Voltage Regulation Quality Factor (VRQF) that permits optimization of the tapchanging process, as well as a variety of configuration setpoints to allow maximum flexibility.

The ARC senses voltage and current which permits the control of voltage through the regulator. The control utilizes nonlinear integrating algorithms which adapt to system operating conditions to reduce the number of tapchanger operations while maintaining the desired VRQF.

The ARC is protected from noise and transients likely to be found in typical regulator control applications. The control is designed to withstand the application of 1500 V ac for one minute between any terminal and ground connection, and meets or surpasses the requirements of ANSI/IEEE C.37.90.1-1989, which define surge withstand capability.

Interrogation of the control and setting changes are made through an optically-isolated RS-232 communications port mounted on the front of the unit. Using the M-2802 SLIMcom™ software, with a computer running Microsoft® Windows 95/98, the user can configure and monitor operation of the unit. Two passwords are available to the user and are accessed through the communications port. All setpoints are stored in nonvolatile memory which is unaffected by control voltage disturbances.

Two operation counters are provided. One counter may be reset; the other may be preset. The control has adjustable bandcenter, over and undervoltage, runback, and line drop compensation.

Nine LEDs are used to indicate Regulator **RAISE** and **LOWER** (Fast, Intermediate and Slow) command status, **CPU OK**, **REV PWR**, and **NEUTRAL LIGHT**.

The basic control settings allow regulation of the voltage at a remote location while assuring that the customer nearest the regulator is protected against overvoltage.

The control has a VT User Correction Voltage setting, and the capability to correct for current transformer and voltage transformer phasing connections without making wiring changes. This feature allows phase angle corrections in 30° increments from 0° to 330°.

The Autodaptive® Regulator Control uses a Motorola microcontroller which has a self-testing watchdog system, which is illustrated in Figure 1-1, below.

Use of LDC

The use of Line Drop Compensation (LDC) is outlined in Section 4.2, Voltage Regulation. This feature is recommended for use on regulators connected to distribution feeders which have switched capacitor banks that are controlled by Beckwith M-2501 Series Autodaptive Capacitor Controls, placed beyond the theoretical load center, or where other methods of cap bank control are used.

1.1 Accessories

M-2802 SLIMcom™ Communications Software

SLIMcom is a Windows™–based communications software package required for remote control and metering of the Autodaptive Regulator Control (ARC). It is designed to interface with the microcontroller of the ARC through an RS-232 port. The M-2802 SLIMcom communications software displays all pertinent operating information. These operations include:

- Changing setpoint values. (This includes those values for normal regulator control operation, as well as custom configuration to the site.)
- Observing values. (This includes measured and calculated values of real-time operating parameters.)
- Data retrieval and display in graphic form.
- Outage Data.

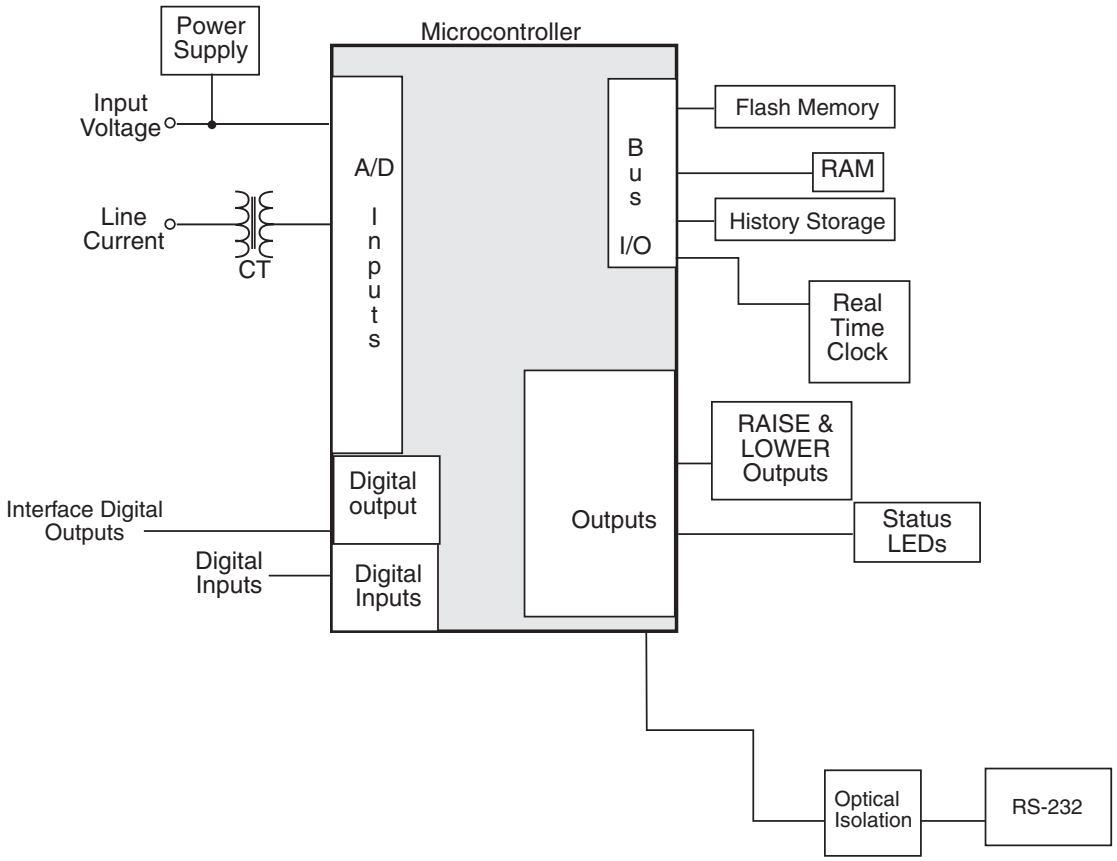


Figure 1-1 Functional Diagram

2 Front Panel Controls

2.0 Introduction

The front-panel user interface consists of an RS-232 serial communications port and five status indicators as shown in Figure 2-1, M-2601 Front Panel (M-2602 and M-2603 each possess identical user interface).

2.1 COMM Port

The RS-232 serial communications port is located at the top of the Autodaptive® Regulator Control front panel. Connections are made through a standard DE-9 type female connector. The pinout is of the computer type (DTE) configuration, and will typically require a null-modem type cable. See Appendix A, Null Modem Cable for pinout.

2.2 Status Indicators

RAISE LEDs – These LEDs indicate that the voltage is below the band and the timer has started timing for a tapchanger raise operation. The timer circuit first illuminates a GREEN LED, to indicate the initial timing phase, which is greater than 5 minutes to the anticipated switch operation. The middle timing period is indicated by an AMBER LED, which anticipates a switch operation in one to five minutes, and the final timing phase prior to switching is indicated by illuminating a RED LED, which anticipates a switch operation in less than 1 minute.

LOWER LEDs – These LEDs indicate that the voltage is above the band and the timer has started timing for a tapchanger lower operation. The timer circuit first illuminates a GREEN LED, to indicate the initial timing phase, which is greater than 5 minutes to the anticipated switch operation. The middle timing period is indicated by an AMBER LED, which anticipates a switch operation in one to five minutes, and the final timing phase prior to switching is indicated by illuminating a RED LED, which anticipates a switch operation in less than 1 minute.

CPU OK LED – The GREEN LED will flash at approximately 1 Hz whenever power is applied to the unit and the watchdog program (internal to the microcontroller), indicates the microcontroller is working properly.

Each time the control is powered up, it will briefly light all LED's to verify that LED indicators are functioning properly. After that brief period, the **CPU OK** LED will begin flashing.

REV PWR LED – The RED LED will light to indicate when the unit detects reverse power flow.

NEUTRAL LIGHT LED – This AMBER LED will light when the regulator is in the neutral tap position.

Figure 2-1 M-2601 Front Panel

3 Installation

3.0 Installation

Individual installation instructions for the M-2601 (Siemens), M-2602 (General Electric), and M-2603 (Cooper) are presented in Sections 3.1, 3.2 and 3.3 respectively. Mounting and outline dimensions are shown in Figures 3-1, 3-5 and 3-9.

● WARNING: In no case should the line current circuit be interrupted with the regulator energized.

● 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.

3.1 Installation of the M-2601

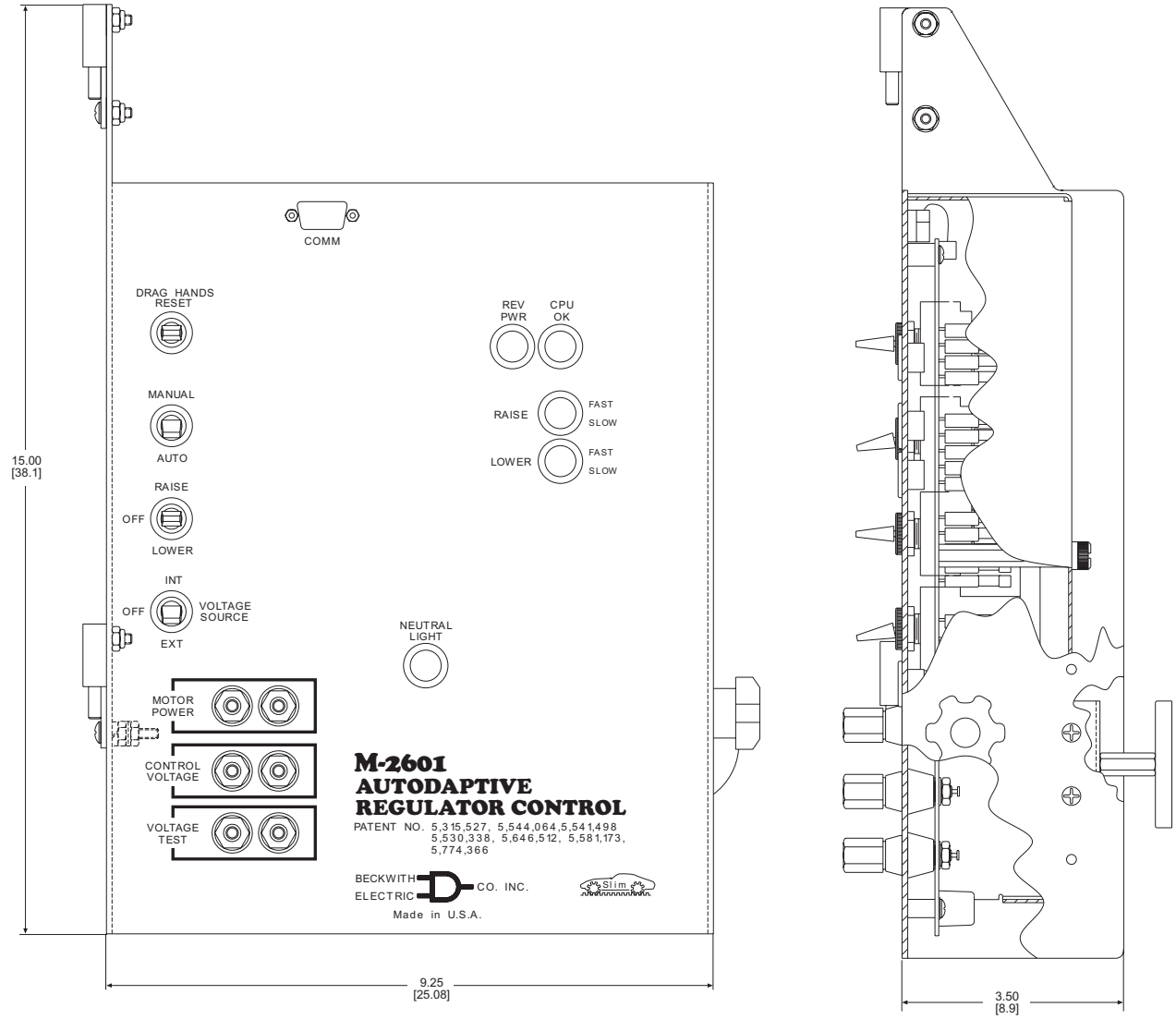
The M-2601 has hinges on the left side that allow easy mounting into the existing Siemens control cabinet. Refer to Figure 3-1 for outline dimensions.

Removal of the Siemens Control

Refer to Figure 3-2.

1. Open the cabinet door of the Siemens control.
2. Remove and save the wing nuts from the quick disconnect shorting plug located in the top right of the cabinet.
3. Pull down on the male connector portion of the plug to disconnect it from its female connector.
4. Swing the panel out. Lift panel off its hinges.
5. Remove the male connector portion of the plug by unscrewing its connections to the Siemens control's wiring harness.

■ **NOTE**: The quick disconnect shorting plug must be saved from the original control.



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

Figure 3-1 M-2601 Outline Dimensions

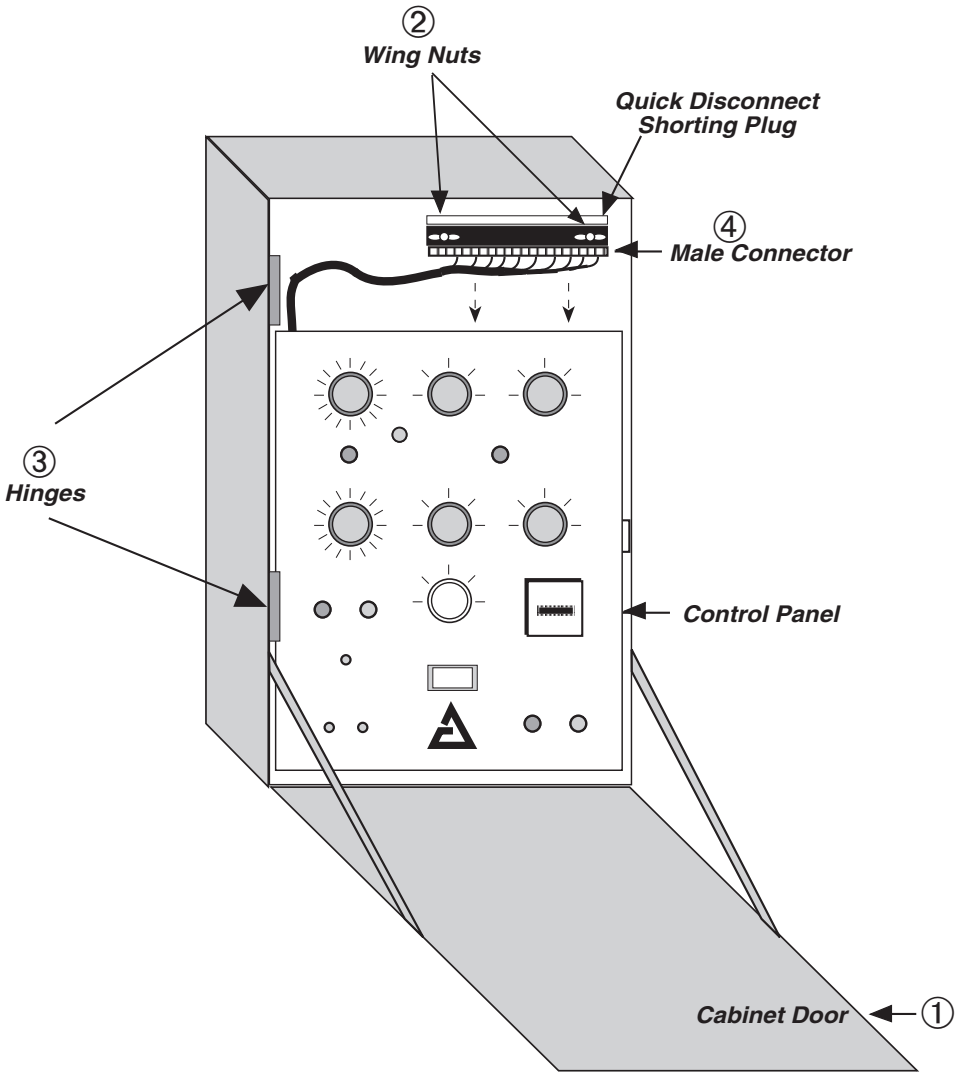


Figure 3-2 Siemens Control in Cabinet

Installation of the M-2601

Refer to Figure 3-3, below.

1. Mount the M-2601 Autodaptive® Regulator Control onto the hinges in the control cabinet. Leave the panel swung outward so that the back of the panel is accessible.
2. Connect the M-2601 wiring harness to the male connector, saved from the original control. Refer to Figure 3-4 for wiring connections.
3. Reinstall the male connector onto the quick disconnect plug and reinstall the wing nuts.
4. Swing the adapter panel closed; the magnet at the back of the panel will keep the panel affixed to the cabinet. Close cabinet door.

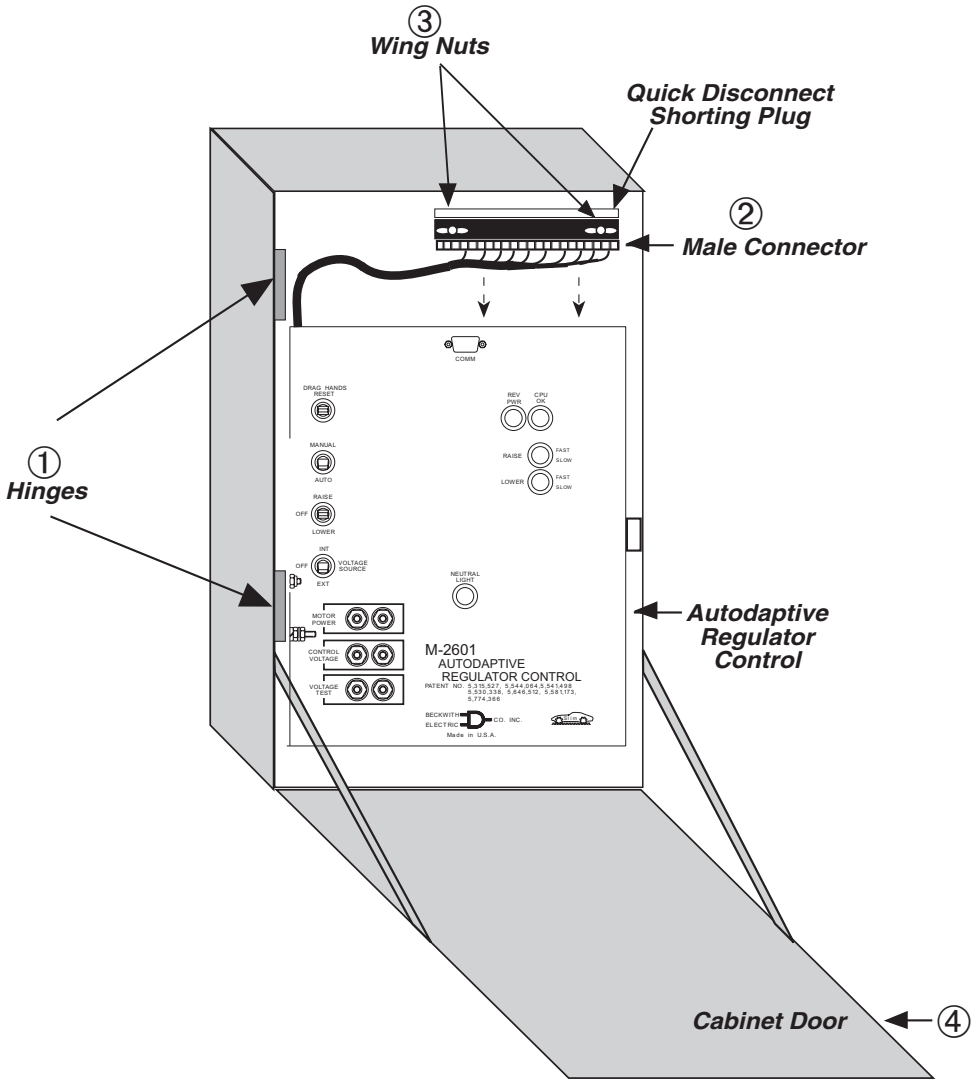


Figure 3-3 M-2601 Autodaptive Regulator Control in Cabinet

M-2601 SIEMENS Connection Diagram

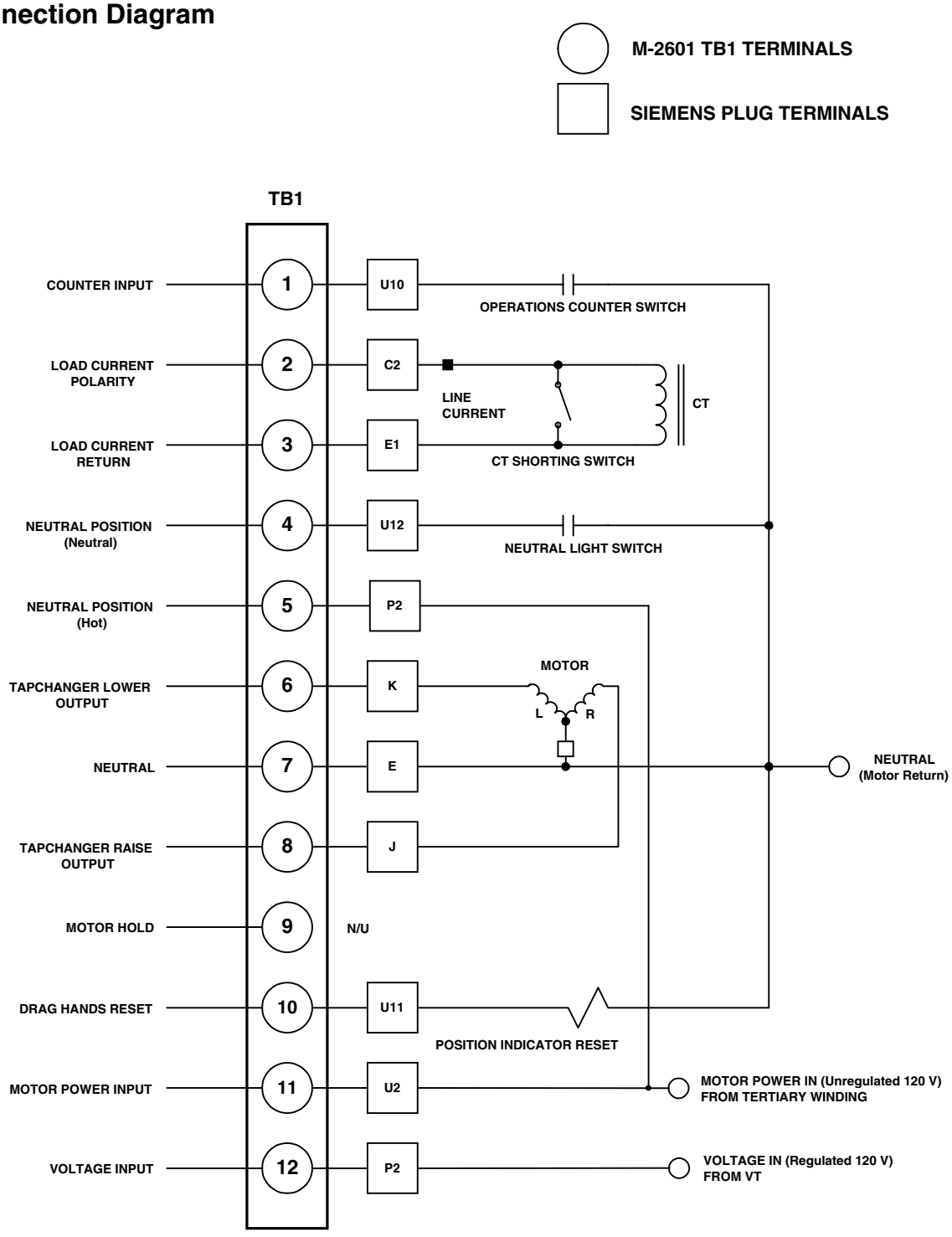
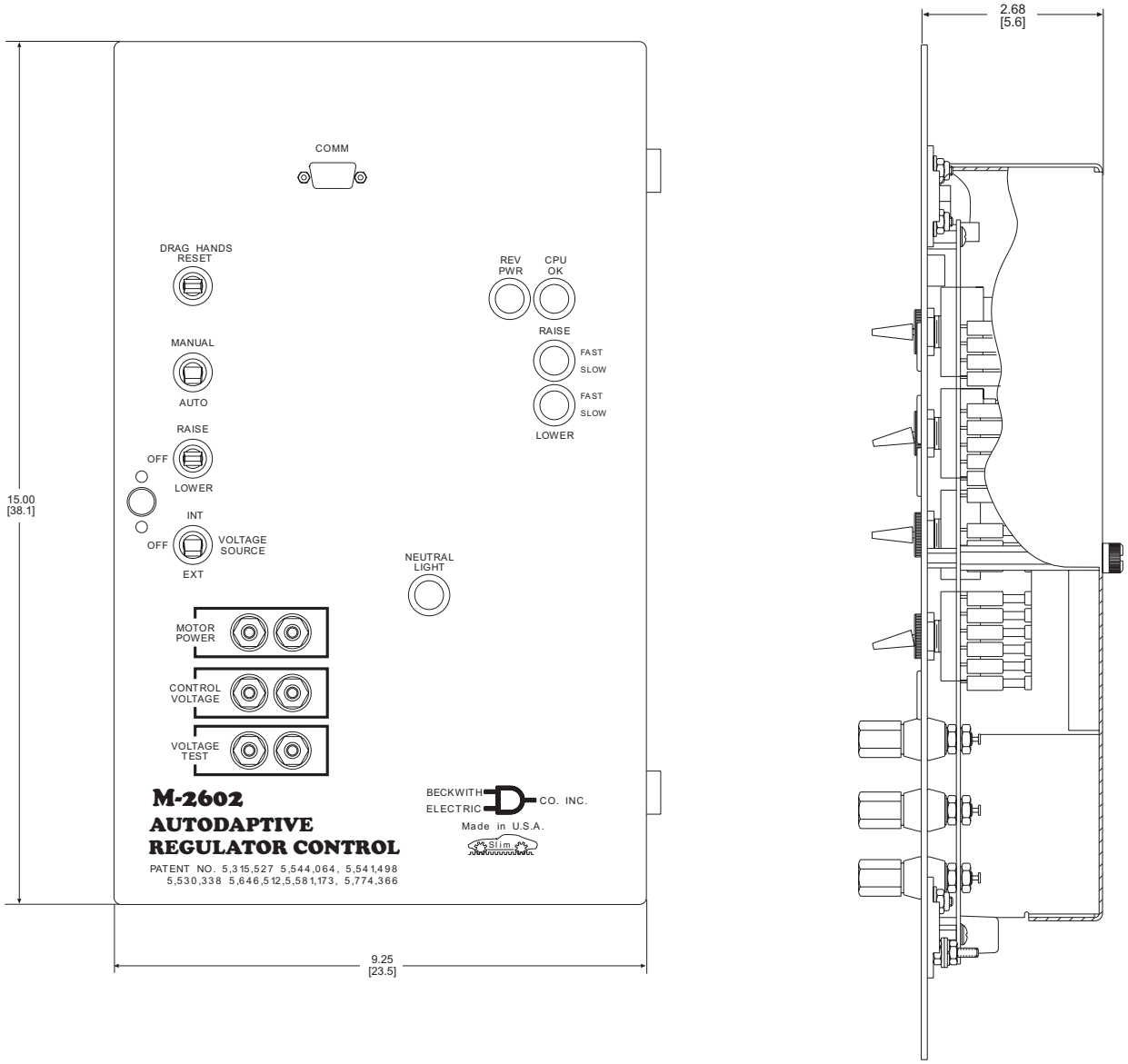


Figure 3-4 M-2601 External Connections

3.2 Installation of the M-2602

The M-2602 Autodaptive® Regulator Control has hinges on the right side that allow easy mounting into the existing General Electric control cabinet. Refer to Figure 3-5, below.



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

Figure 3-5 M-2602 Outline Dimensions

Removal of the General Electric Control

Refer to Figure 3-6, below.

1. Open the cabinet door of the General Electric control.
2. Loosen the two thumbscrews at the interface of the control cable plug and the tap position indicator on the regulator. Pull down on the plug to disconnect it.
3. Turn the knob on the control panel and swing the panel outward.
4. Disconnect the three plugs that connect the wiring harness of the front panel to the component board. Remove all connections from the component board to the NN terminal blocks. Using a screwdriver or other appropriate tool, remove the component board. Remove and save the two hinge pins and lift the panel off the hinges.

■ **NOTE**: The two hinge pins must be saved from the original control.

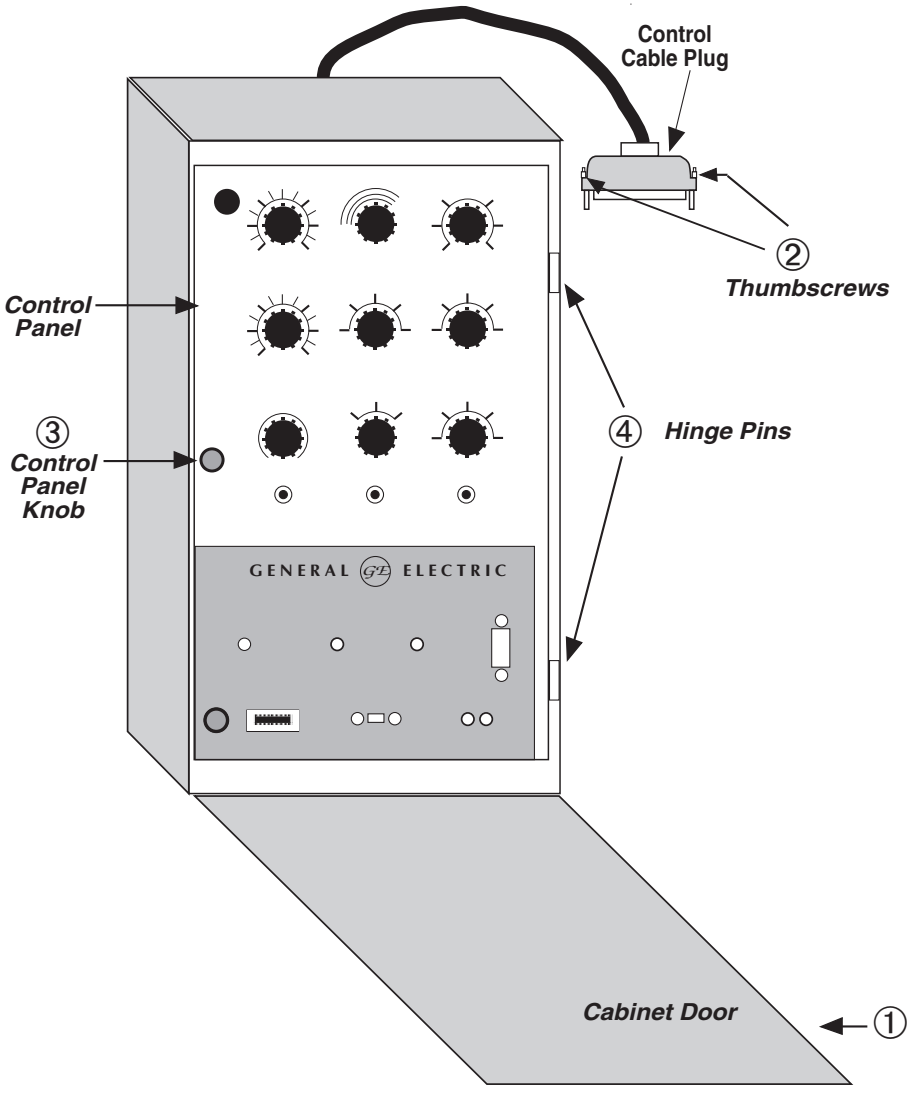


Figure 3-6 General Electric Control in Cabinet

Installation of the M-2602

Refer to Figure 3-7, below.

1. Mount the M-2602 Autodaptive® Regulator Control onto the hinges in the control cabinet, and install the two hinge pins saved from the original control. Leave the panel swung outward so that the back of the panel is accessible.
2. Connect the M-2602 wiring harness to the NN terminal blocks. Refer to Figure 3-8 for wiring connections. Swing the control panel closed and turn knobs to latch securely.
3. Reconnect control cable plug to tap position indicator and tighten the two thumbscrews.
4. Close cabinet door.

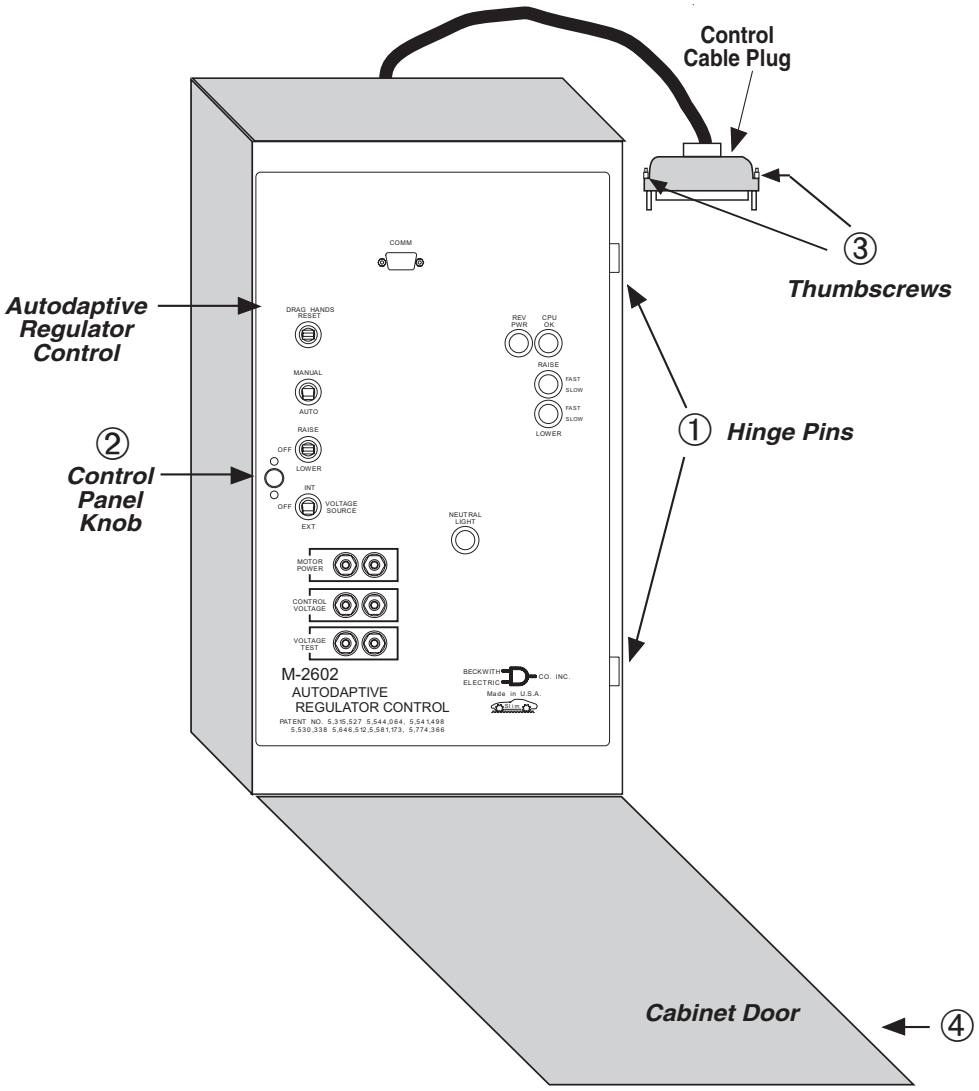


Figure 3-7 M-2602 Autodaptive Regulator Control in Cabinet

M-2602 GENERAL ELECTRIC Connection Diagram

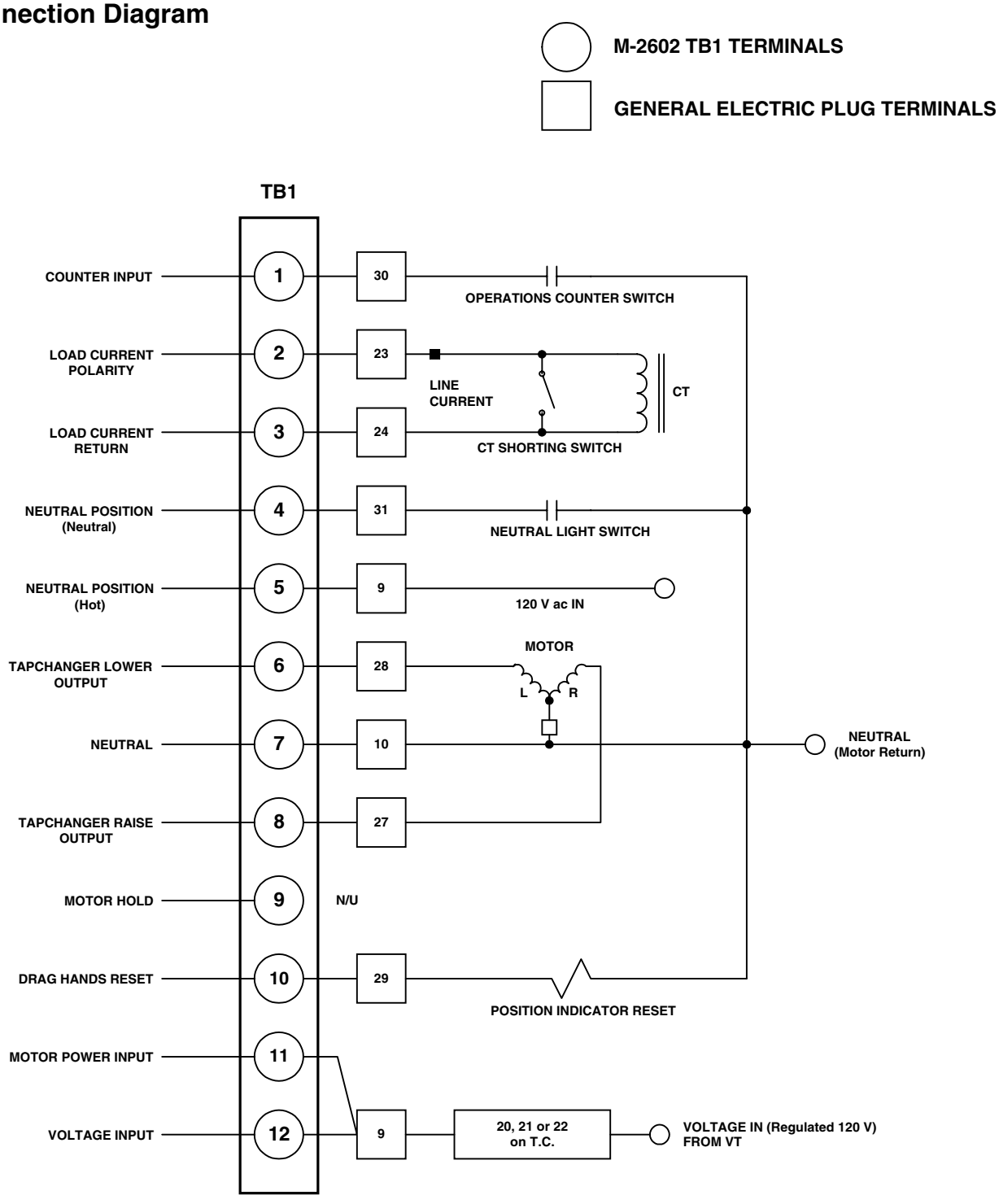
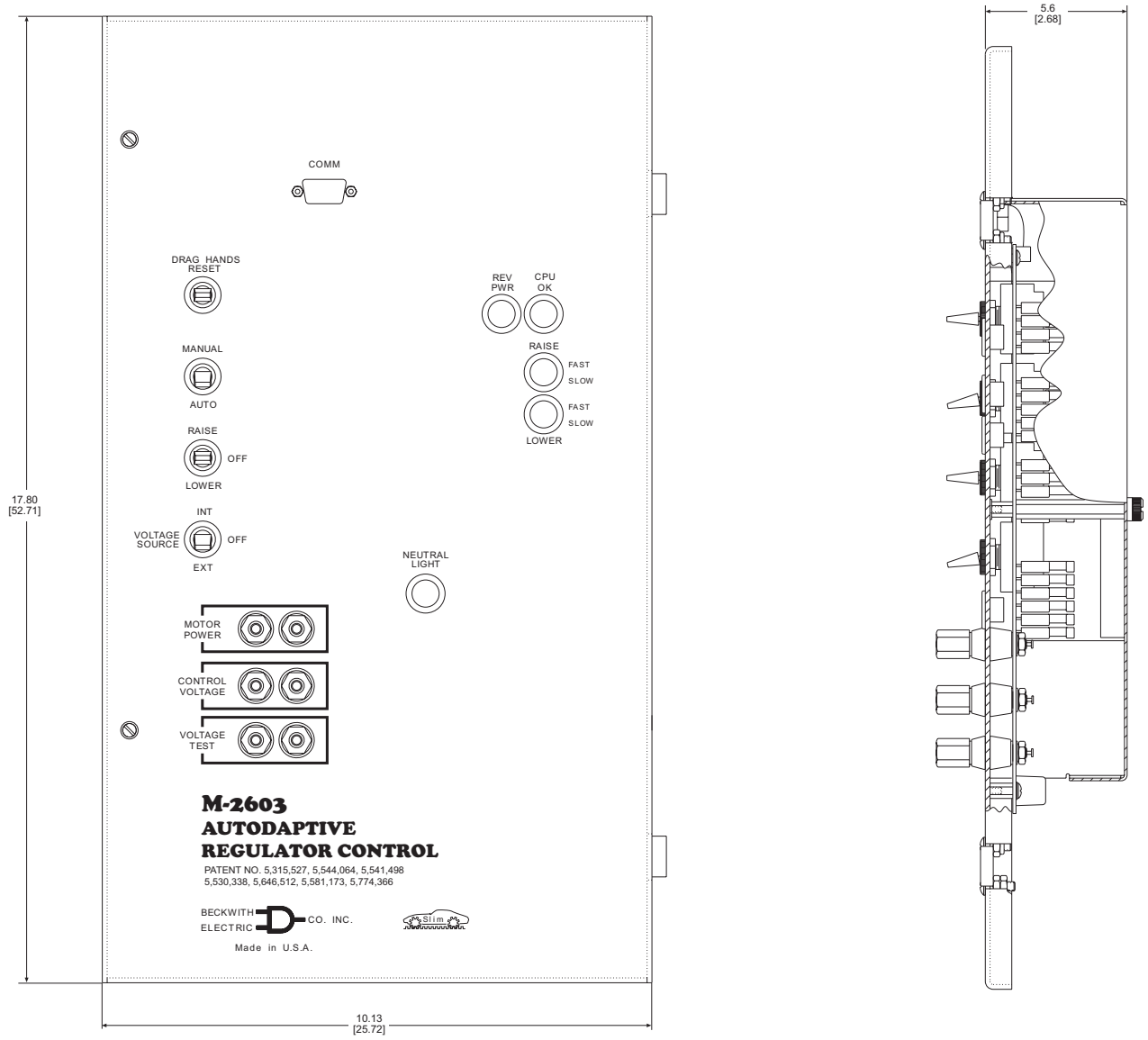


Figure 3-8 M-2602 External Connections

3.3 Installation of the M-2603

The M-2603 Autodaptive® Regulator Control has hinges on the right side that allow easy mounting into the existing Cooper control cabinet. Refer to Figure 3-9, below.



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

Figure 3-9 M-2603 Outline Dimensions

Removal of the Cooper Control

Refer to Figure 3-10, below.

1. Open the cabinet door of Cooper control.
2. Turn the doorknob on the control panel and swing the panel outward. To de-energize the control, open the VT disconnect switch and put the CT switch in the shorting position. Be sure that the CT in the regulator has been shorted.
3. Loosen the screws on the spreader bar terminal block at the bottom of the cabinet and pull down on the spreader bar to disconnect it.
4. Remove and save the two hinge pins and lift the panel off the hinges.

■ NOTE: The two hinge pins must be saved from the original control.

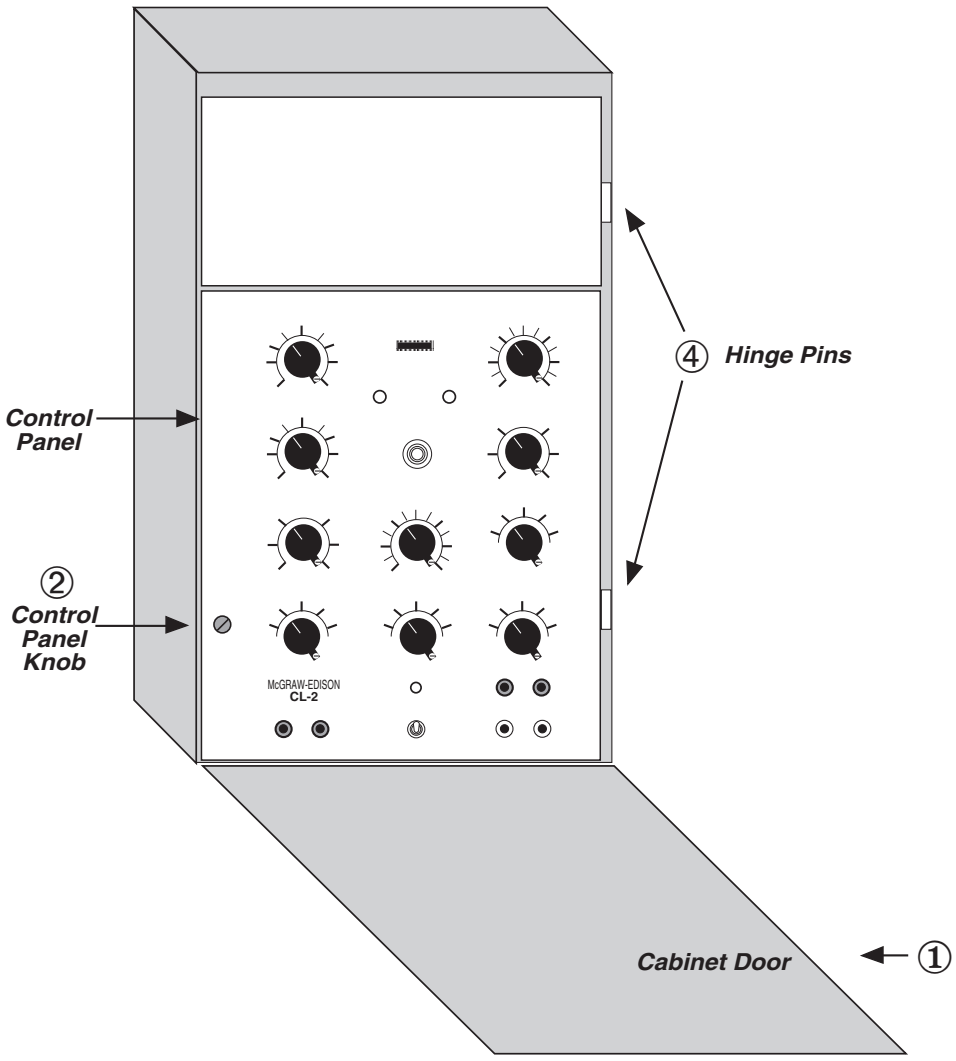


Figure 3-10 Cooper Control in Cabinet

Installation of the M-2603

Refer to Figure 3-11, below.

1. Mount the M-2603 Autodaptive® Regulator Control onto the hinges in the control cabinet and install the two hinge pins saved from the original control. Leave the panel swung outward so that the back of the panel is accessible.
2. Connect the M-2603 wiring harness to the terminal block at the bottom of the cabinet. Refer to Figure 3-12 for wiring connections.
3. To re-energize the control, open the CT switch, removing the CT short circuit, and close the VT disconnect switch. Swing the adapter panel closed and turn thumbscrews to latch securely.
4. Close cabinet door.

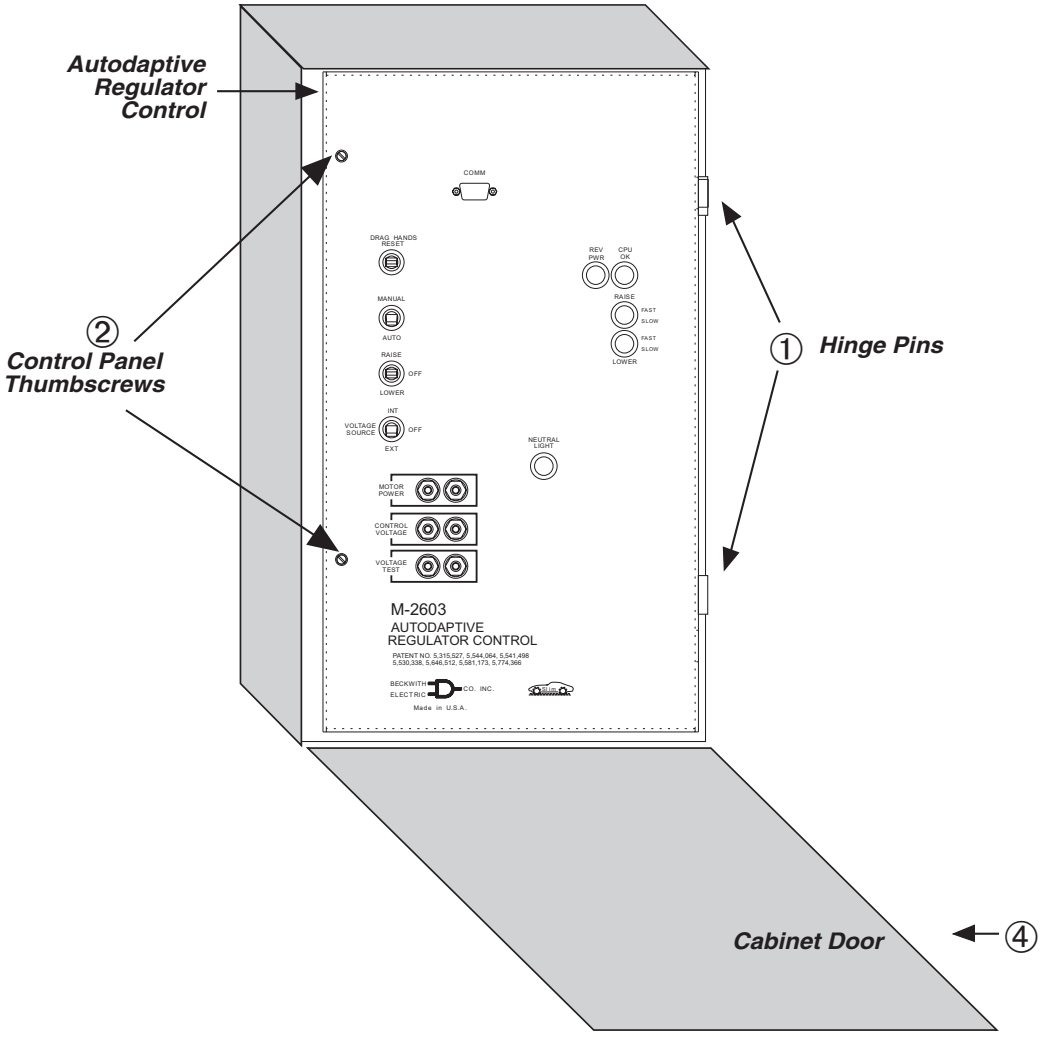


Figure 3-11 M-2603 Autodaptive Regulator Control in Cabinet

M-2603 COOPER Connection Diagram

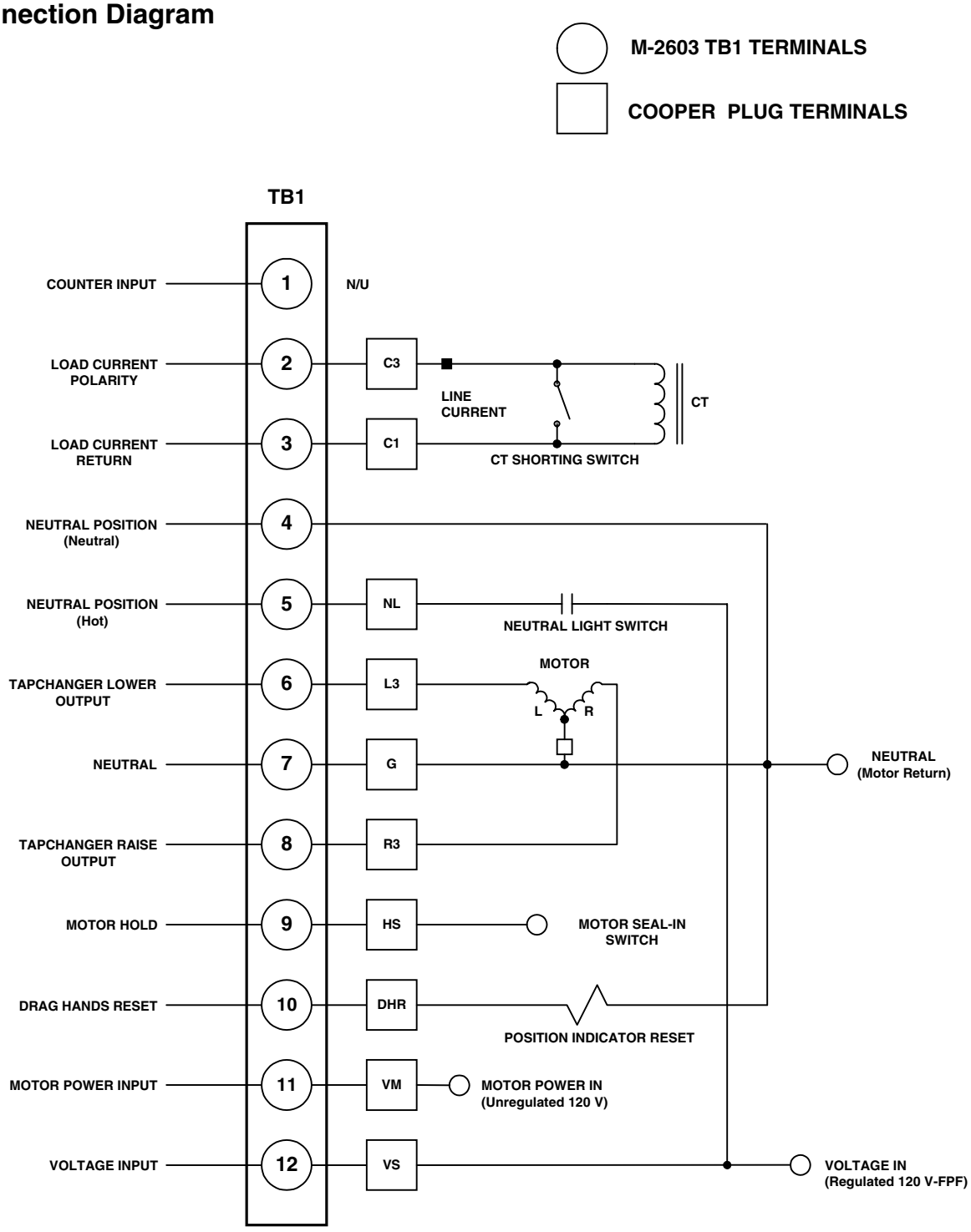


Figure 3-12 M-2603 External Connections

3.4 Transient Protection

In the Autodaptive® Regulator Control, transient voltages are suppressed by varistors.

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

3.5 External Connections

External connections are accomplished via a (12-connection) terminal strip located on the rear of the unit. See Figures 3-4, 3-8, and 3-12, External Connections, for connection points.

Terminal 1 – Counter Input

This digital input registers the counter contact closure. The operation count will increment when terminal 1 is connected to neutral (terminal 7) or disconnected from neutral through an external dry contact. The counter is configured through SLIMcom for X1 level sensing (G.E. regulators) or X2-edge sensing (Siemens regulators) operation. See Chapter 7 for details.

Terminal 2 – Load Current Polarity

The line current input range is 0–400 mA with 200 mA representing the nominal 1.0 per unit value. The measured current value is used for line drop compensation and metering calculations.

Terminal 3 – Load Current Return

This is the non-polarity input to the load current measuring transformer. The companion polarity input is terminal 2. The line current transformer input is isolated from other terminals.

Terminal 4 – Neutral Position (Neutral)

This is the input to the Neutral side of the Neutral Contact detection circuit. It is connected to the Neutral Contact output of the Regulator.

Terminal 5 – Neutral Position (Hot)

This is the input to the Hot side of the Neutral Contact detection circuit. It is connected to 120 V ac via the harness.

Terminal 6 – Tapchanger Lower Output

This switched output connects the tapchanger lower winding or an interposing relay to the source of motor power. It is capable of switching up to 6 A at 120/240 V ac.

Terminal 7 – Neutral

This is the return for the voltage input (terminal 9).

Terminal 8 – Tapchanger Raise Output

This switched output connects the tapchanger raise winding or an interposing relay to the source of motor power. It is capable of switching up to 6 A at 120/240 V ac.

Terminal 9 – Motor Hold

This output is used only with Cooper Regulators. It is left open for Siemens and GE Regulators.

Terminal 10 – Drag Hands Reset

This output is used to activate the Drag Hands Reset mechanism. It is protected by F4, a 2 A fuse.

Terminal 11 – Motor Power Input

The source for powering the tapchanger motor or interposing relay is connected here. It may have a nominal voltage of 120 or 240 V ac. This input is protected by F1, a 6 ampere fuse. Direct current may ***not*** be switched through these contacts.

Terminal 12 – Voltage Input

This input accepts nominal 120 V ac, 60 Hz to operate the control's power supply and voltage sensing input. The acceptable voltage range for proper control operation is from 80–140 V ac. Power consumption is 6 VA or less. The input voltage is referenced to line neutral (terminal 3). This input is protected by a 0.25 A fuse, F2. The unit will withstand 1000 V ac hi-pot from neutral to ground, since it is recommended that the VT neutral be grounded at only one point.

See Figure 3-4 for typical external connections.

● 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.

■ **NOTES**:

1. Motor voltage may be 120 or 240 V to neutral or 240 V phase-to-phase.
2. The customer is to provide earth ground connection to CT/VT's neutral connection, external to the control.

4 Applications

4.0 Introduction

The Autodaptive® Regulator Control (ARC) is a unique control that relies on Autodaptive-style algorithms to optimize voltage control while minimizing the number of tapchange operations required. This results in reduced tapchanger maintenance and optimized loading.

VRQF

VRQF (Voltage Regulation Quality Factor) is defined as the RMS deviation in voltage from a reference voltage, as averaged over a selected time period. The reference voltage for Autodaptive Regulator Controls is the voltage setpoint of the control. One purpose for the regulator control is to minimize the VRQF or variation of the supply voltage on a distribution system.

Use of the VRQF algorithm rather than conventional voltage setpoint/bandwidth/preset timer results in more precise distribution voltages with reduced tap operations. The autodaptive voltage controls operate with a voltage setpoint and a desired VRQF setting. The bandwidth is a function of the tapchanger voltage change per tap, and the timing is adapted from past voltage (VRQF) history, and the desired VRQF at the bus.

For example, with a condition of 5/8% taps (0.75 V) (therefore 1 V bandwidth setting), if the bus voltage varies more than 0.5 V (1/2 of bandwidth) from the voltage setting, the regulator control will begin timing towards an operation. The accumulating timer has an operational threshold which is adapted from the VRQF history and the VRQF setting. If the history illustrates a VRQF less than the setting (indicating a relatively stable bus voltage), the threshold will be increased. This allows the natural stability of the system to correct the voltage, and in many cases to avoid the need for a tapchange. If the history illustrates a VRQF higher than the setting (indicating a relatively variable bus voltage), the threshold will be decreased. This allows tapchanges to occur sooner, and system voltage variations to be minimized.

VAr Bias

Use of VAr Bias allows the Autodaptive® Regulator Control (ARC) to coordinate its operation with the M-2501A Autodaptive Capacitor Control (ACC) devices on the distribution system in order to minimize losses, subsequent voltage variations, and equipment capacity requirements of transmitting VArs.

The application of both the ARC and the ACCs on a circuit provides for an interaction between the devices that provides for faster response in times of rapidly changing conditions on the distribution system. This application combination adds a “substation requirements” aspect to the feeder requirements control of pole-top capacitor banks.

For example, with one transformer, six feeders, and 1200 KVAr pole-top feeder capacitor banks, if each feeder is correctly compensated to within 400 KVAr, all feeder bank controls would be operating correctly. However, the transformer would be transforming 2400 KVAr (six feeders times 400 KVAr) from the transmission system. The ARC on the transformer would detect this condition and affect additional line capacitor operation by making a temporary voltage level setting change. By effectively delaying a voltage tap change for a short time, a line capacitor bank control could be biased into operation by the tapchanger control, with reduced losses, better voltage profiles, and fewer tap changes.

4.1 Measurements & Calculations

Voltage Measurements

Normal

The ARC accomplishes waveform sampling by sampling a 60 Hz signal at a rate of four hundred and eighty samples per cycle, or two hundred and forty samples per half-cycle. This measurement is repeated twenty times per second. Two conditions terminate the sampling for one half-cycle. They are:

1. The voltage being sampled crosses the zero value line.
2. 240 voltage samples have been collected.

These samples are correlated with sine table entries and processed to produce a voltage value. This voltage is the fundamental component of the voltage wave.

Bandcenter

In the ARC, Bandcenter is the value of voltage selected by the customer as the desired value of voltage for regulation. This value is the center point for the selected bandwidth.

$V_{measured}$

$V_{measured}$ is the value of voltage which the control measures for regulation.

Current Measurements

Line Current

Current is measured by its two components with respect to the voltage signal, the in-phase or real component (P) and the 90° or quadrature component (Q). Values of P run from a positive maximum to a negative maximum. Values of Q run from a positive to a negative maximum, with the negative values indicating a lagging power factor on the load.

A vector sum of these current components is displayed as secondary current.

RAILS AND LIMITS

Lower Voltage Limit

If the value of the regulated voltage is below the Lower Voltage Limit, the control will not time towards a lower tapchange.

Upper Voltage Limit

If the value of the regulated voltage exceeds the Over Voltage Limit, the control will not time towards a raise tapchange. If the value of the regulated voltage exceeds the overvoltage limit plus a 2 volt Deadband, the control will issue a lower command in one second until the regulated voltage falls, at minimum, back into the deadband.

Tap Position Limits

The control is programmable to prevent automatic tapchanges that will allow excursions beyond the set values of minimum and maximum tap positions. This function does not have priority over any values of Voltage Limits programmed into the control.

4.2 Voltage Regulation

Standard Control Settings

With the Level 1 password implemented, the following setpoints are adjustable: BandCenter, Line Drop Compensation, Upper Voltage Limit, Lower Voltage Limit, and VRQF. The History sample period is also adjustable. Alarm Enables and Resets are settable, and VAr management can be enabled or disabled. See Table 4-1 for the ranges. All other setpoints and configuration choices require level 2 password clearance.

Password Applicability

Metering panel and list can be read under all circumstances.

No Password: Setpoint screen can be read, but not changed. Config screen cannot be read.

Level 1 Password: Setpoint screen can be read, but only bandcenter, limits, alarms, LDC, VRQF and history sampling can be changed. Ratio Corr, multipliers, CT phasing, counters, and clock cannot be changed. Config screen cannot be read.

Level 2 Password: All parameters in Setpoint screen can be changed. Config screen can be read and changed.

The control will send commands to the tapchanger to change taps as needed to hold the voltage within the bandwidth setting, as modified by the line drop compensation settings.

The control will only respond to an out-of-band voltage excursion after the timer has reached the Autodaptive® time delay which is set by the algorithms. The algorithm functions as an integrating timer dependent on the VRQF, which increments during time out-of-band and decrements during time in band, but not below zero. The further the voltage is away from the setpoint, the shorter the time delay between tapchanges and vice versa.

Bandcenter

The center of the voltage band is adjustable from 90 to 135 V ac in 0.1 volt increments.

Voltage Regulation Without LDC

When the control is only used to regulate the voltage on the transformer or regulator low-side bus, the only input required is voltage from a line-to-line or line-to-ground VT with a nominal 120 V ac secondary.

Voltage Regulation with LDC

When it is desirable to regulate the voltage at some distance from the transformer or voltage regulator, the Line Drop Compensation (LDC) feature is used.

The bandcenter function is set the same as if LDC were not used, and still represents the desired voltage at the remote location.

A classical approach can be used to determine the settings for the LDC, however this assumes a load center point and is usually not applicable to the typical distribution feeder. For more information, contact Beckwith Electric for Application Note #17.

A simpler method is recommended which will work for most applications. This involves analyzing the feeders leaving the station and estimating the reactance/resistance (X/R) ratio. The reactive and resistive line drop compensation setpoints should then be entered in this same X/R ratio.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING
Bandcenter	90.0 to 135.0 V	0.1 V	120.0 V
VRQF	0.4 to 2.0 V	0.1 V	0.6 V
LDC Resistance	-24 to +24 V	1 V	0 V
LDC Reactance	-24 to +24 V	1 V	0 V

Table 4-1 Level 1 Password Adjustable Parameters

If the CT and VT phasing corrections have been made, only positive values of R and X compensation need to be used.

Table 4-2, Approximate Ratio of Line Reactance to Resistance (X/R) of Typical Distribution Circuits, gives the X/R ratio for various wire sizes.

By knowing the ratio of the maximum expected load to the present load, the amount of voltage compensation needed is found as shown in the following example.

Example:

Desired: local voltage @ min load=120 volts

local voltage @ max load=124 volts

Using the following assumptions:

Desired Bandcenter = 120 volts

Desired Bandwidth = 1 volt

The device being controlled is 50% loaded

Setting

Start with R=0 and X=0, and increase both values using the ratio shown in the table for the feeder conductor. Keeping the X/R ratio, increase R_{set} and X_{set} until tapchanger raises the voltage by two volts (50% of the desired voltage rise at full load).

With this simplified method of LDC setting, the first customer's voltage will be limited by the upper voltage limit at the highest daily load, depending on the accuracy of the daily load projection. At the same time, the furthest customer will receive the highest voltage possible under the line and loading conditions. The first customer protection can be set on the control. Refer to Section 4.3, Regulation Limits.

ACSR		COPPER	
MCM	X/R	MCM	X/R
795	4.0	750	6.0
477	2.5	500	4.5
336	2.0	350	3.3
266	1.5	250	2.4
AWG	X/R	AWG	X/R
4/0	1.2	4/0	2.0
2/0	1.0	2/0	1.5
2	0.5	2	0.7
6	0.2	6	0.3

Table 4-2 Approximate Ratio of Line Reactance to Resistance (X/R) of Typical Distribution Circuits

Since the daily load projections will likely have a seasonal variation, the best balance of first customer to furthest customer voltage may require seasonal adjustment of the LDC settings. Note that the settings of R and X compensation are proportional to the peak load projection and that new settings can be scaled from the first setting obtained by the experimental process just described.

4.3 Regulation Limits

Upper Voltage Limit

A setpoint is available to establish a block raise limit. The overvoltage limit is adjustable from 90.0 V to 136.0 V. This limit is equivalent to a First Customer Protector to limit overvoltage from line drop compensation action during heavy loading.

If the voltage exceeds the upper voltage limit plus the 2 V deadband, the control will immediately call for an “automatic” lower without any time delay.

The upper voltage limit block can be effectively disabled by setting it to 136 V.

Lower Voltage Limit

This limit is adjustable from 89.0 V to 135.0 V in 1.0 V increments. This limit can be set to limit low customer voltage to safe limits and will block voltage reduction action that could cause motor stalling and other undesirable low voltage effects. Lower Voltage Limit can be effectively disabled by setting it to 89 volts. If the voltage is below the Lower Voltage Limit setpoint, the control will not issue further lower commands.

Tap Position Limits

This provides for the settings of upper and lower tap positions beyond which the control is blocked. Note that these settings can interact with the over and under voltage limits. Refer to Section 4.8, Tap Position.

4.4 Non-Sequential/Blocking

The control operates in non-sequential mode. The control will make one tapchange and then timeout once more before making another. This is accomplished by energizing an Output until a counter contact input is received.

The tap change output is initiated after the Autodaptive® integrating timer has timed out. The waiting time between the tap changes is adaptive, subject to a minimum value as set by the Intertap Minimum Delay.

4.5 Counters

Operations Counter

Two counters, resettable and presettable, are available on the Autodaptive Regulator Control. Both counters accommodate numbers up to 999,999, and will record from either an X1 or X2 operations counter output, settable in SLIMcom™.

The resettable counter is reset to zero by command, and does not retain the value prior to reset.

The presettable counter can be preset from zero to 999,999 by command, and does ***not*** retain the preset value after operations counts are received. Counters are not affected by a loss of power to the control.

4.6 CT/VT Phase Shift

With the CT and VT signals in-phase for unity power flow to the load, the control will properly calculate line drop compensation. In the majority of regulator operations, the CT and VT are in-phase. If an application arises where the CT and VT are not in phase, the phase shift can be corrected through software. The characteristics of three phase systems only allow multiples of 30° phase shifts. The control, therefore, has a range of 0° to 330° in 30° increments.

When two single-phase regulators are connected in open delta, the current signals will be out-of-phase with the voltage signals. For one regulator, the current will lead the voltage by 30° and is called the “leading” regulator. For the “lagging” regulator, the current will lag the voltage by 30°.

4.7 Ratio Multipliers

VT User Correction Voltage

This feature is included to permit **VOLTAGE TRANSFORMER** ratio correction. It permits the measured voltage to be adjusted over a ±12 V ac range to compensate for voltage transformer ratios that would yield an improper representation of customer voltage.

CT User Correction Multiplier

This feature is included to permit **CURRENT TRANSFORMER** ratio correction. It permits the measured voltage to be adjusted over a 50 to 200% range to compensate for current transformer ratios that would yield an improper representation of customer voltage.

Primary Voltage and Current Multipliers

Primary quantities are displayed when voltage and current multipliers are set into the control. The voltage multiplier is: $V_{mult} = V_{pri}/(V_{sec} + (V_{sec})(V_{corr}))$. For example: If the VT ratio is 7620/120 = 63.5 and the correction multiplier is +5.8%, the ratio of the voltage multiplier is 60.

The current multiplier is the value of the line CT primary rating divided by 0.2 A.

For a CT primary rating of 1000 A, the multiplier is:

$$CT_{mult} = 1000/0.2 = 5000$$

The current multiplier setting range is from 20 to 25,000 in increments of 1.

4.8 Tap Position

The Autodaptive® Regulator Control applies to tapchanger designs with a lowest tap position configuration of –16 to a highest tap position configuration of +16.

Tap Position by Keep Track

This feature allows the control to keep track of the presently operating tap.

It is recommended that the indicated tap position be compared to the mechanical tap position indicator at regular intervals, and that the indicated value be corrected, if necessary.

The user initializes the control at a given, known, tap position upon installation by performing the following steps:

1. Determine the actual tap position from the external tap position indicator on the regulator.
2. Using the SLIMcom™ communications program, calibrate the tap position by entering the current tap value under "tap position". The tap position is now calibrated to recognize all subsequent operations so as to “keep-track” of the present tap position.
3. The present tap position is indicated in the Tap Position screen.

The keep-track procedure recognizes tapchanges commanded via:

- The control software.
- The panel switches.
- External contacts.

The tap position stored in memory is not affected by a loss of supply power.

5 Communications

5.0 Introduction

Currently, there is only one available method of communication to the Autodaptive® Regulator Control, through the front panel RS-232 serial COMM port, using the Beckwith M-2802 SLIMcom™ Communications program. This proprietary protocol is compatible with Microsoft® Windows 95/98, and establishes a link using COMM ports available on-board with most popular computers.

The RS-232 COMM port is optically isolated to assure no compromise of the voltage isolation integrity of the device.

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6 Field Operation Verification

Disclaimer

The purpose of this procedure is to verify the basic functionality of the Autodaptive® Regulator Control (ARC). Considering the inherent Autodaptive characteristics of the regulator control, such as cumulative behavior of operating variables, the reproducibility of some variables may be limited. For additional information regarding testing of the ARC, please contact Beckwith Electric Company.

Refer to Chapter 7, M-2802 SLIMcom™ for SLIMcom operating instructions.

■ **NOTE**: This procedure is to be performed by qualified personnel who are familiar with the safe operation of test equipment in substation environments.

6.0 Bench Test

Equipment needed:

- Variable voltage and current source
  - 90-145 V ac, 60 Hz
  - 0-200 mA, 60 Hz phase locked to voltage source. Phase angle adjustable from 0 to +180°
- High impedance true RMS voltmeter with accuracy of ±0.2% or better
- AC current meter with accuracy of ±1% or better
- Two 120 V ac indicator lamps
- PC with SLIMcom software and RS-232 cable

Procedure:

1. Connect the equipment as shown in Figure 6-1.
2. Apply 120 V ac and verify that the green **OK** LED is blinking.
3. Using SLIMcom, check that the displayed secondary voltage is 120 V ac ±0.3% with the same voltage applied to the control.
4. Apply 100.0 mA$\angle$ 0° confirm that the displayed secondary current is 100.0 mA ±2.0%.
5. Remove the current applied in step 4.
6. Bandcenter check:
   a. Set the voltage bandcenter to 120 V.
   b. Slowly raise the input voltage until the green **LOWER** LED lights. Record the voltage at which the LED first lights.
   c. Slowly lower the input voltage until the green **RAISE** LED lights.
   d. Record the voltage at which the LED first lights.
   e. The bandcenter should be the midway point between these two voltages.
7. Return the input voltage to 120 V ac.

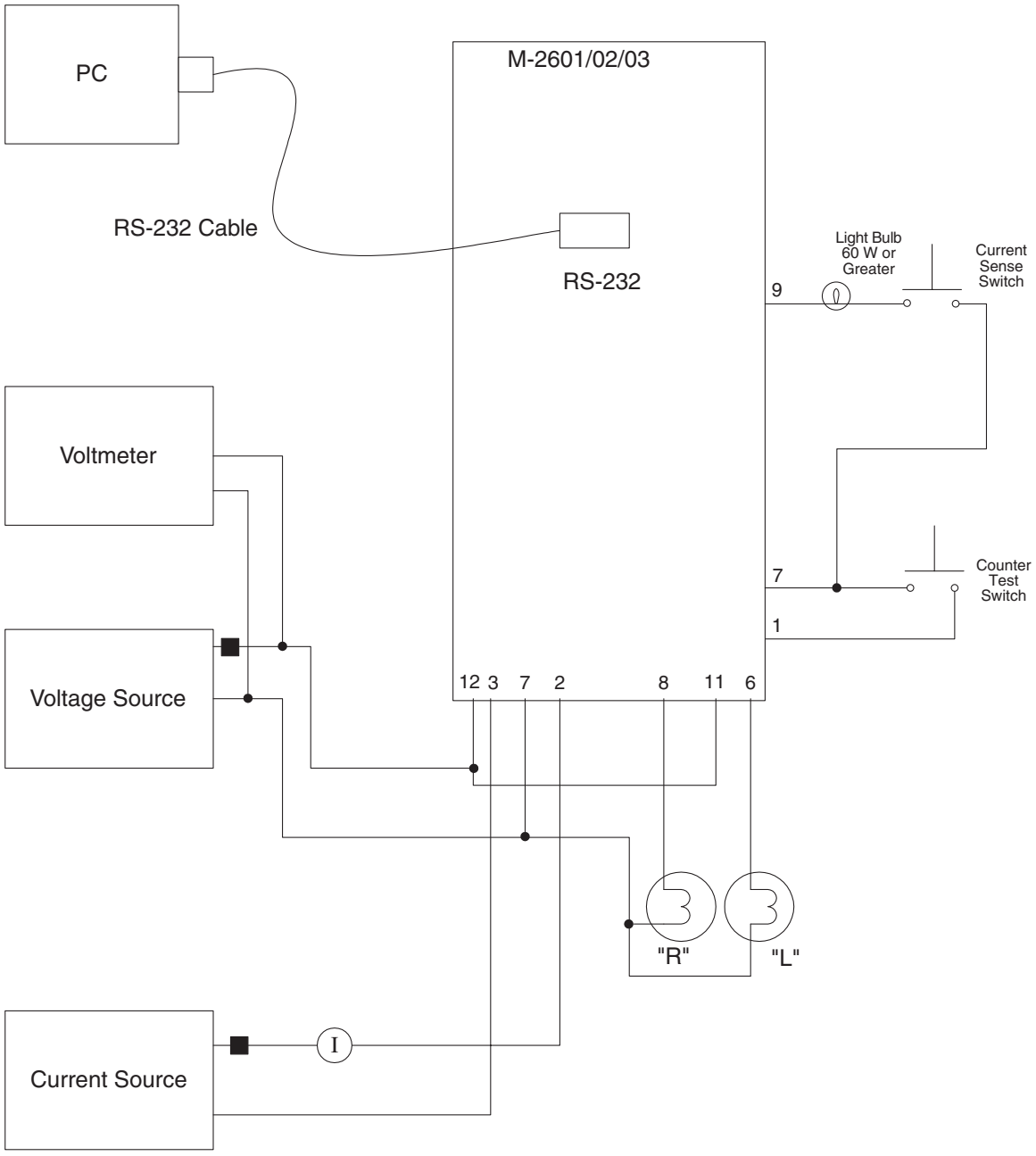


Figure 6-1 External Connections for Test Procedure

8. Raise the input voltage until the red LOWER LED lights. Observe that the lower relay picks up and lights the LOWER indicator lamp in one minute or less.
9. Lower the input voltage until the red RAISE LED lights. Observe that the raise relay picks up and lights the RAISE indicator lamp in one minute or less.
10. Resistive LDC check:
    a. Apply a current of 200 mA ∠ 0° to the Line Current Input.
    b. Set the Resistive LDC to +12 V.
    c. Verify that the raise relay closes, causing the RAISE indicator lamp to light.
    d. Raise the input to above 132 V ac, and verify that the RAISE indicator lamp extinguishes, and the control RAISE LEDs are extinguished.
    e. Set the resistive LDC to –12 V.
    f. Verify that the lower relay closes, causing the LOWER indicator lamp to light.
    g. Lower the input to below 108 V ac, and verify that the LOWER indicator lamp extinguishes, and that the control LOWER LEDs are extinguished.
    h. Set the Resistive LDC to 0 V.
11. Reactive LDC Check:
    a. Apply a current of 200 mA ∠ 90° to the LDC current input.
    b. Set the reactive LDC to +12 V.
    c. Verify that the raise relay closes, causing the RAISE indicator lamp to light.
    d. Raise the input to above 132 V ac, and verify that the RAISE indicator lamp extinguishes, and the control RAISE LEDs are extinguished.
    e. Set the reactive LDC to –12 V.
    f. Verify that the lower relay closes, causing the LOWER indicator lamp to light.
    g. Lower the input to below 108 V ac, and verify that the LOWER indicator lamp extinguishes, and that the control LOWER LEDs are extinguished.
12. Counter Check (2601, 2602):
    a. Adjust input voltage until the unit initiates a Raise or Lower.
    b. Press the button connected to the counter input.
    c. Using SLIMcom™, confirm that the presettable and resettable counter values increment when the button is pressed.
13. Current Sense Check (2603):
    a. Adjust input voltage until the unit initiates a Raise or Lower.
    b. Push the current sense switch.
    c. Raise or Lower relay should be dropped.
    d. Using SLIMcom™, confirm that the presettable and resettable counter values increment when the ∠ button is pressed.
14. Upper/Lower Blocking Check:
    a. Apply a current of 200mA 0° to the Line Current Input.
    b. Set the resistive LDC to +24 V.
    c. Set the Upper Voltage Limit to 132 V.
    d. Verify that the red RAISE LED is on.
    e. Slowly raise the input voltage until the RAISE LED extinguishes.
    f. Confirm that this occurs at 132.00 V ±0.3%.
    g. Apply a current of 200 mA 180° to the LDC current input.
    h. Set the resistive LDC to –24 V.
    i. Set the Lower Voltage Limit to 108 V.
    j. Verify that the red LOWER LED lights.
    k. Slowly lower the input voltage until the LOWER LED extinguishes.
    l. Confirm that this happens at 108 V ±0.3%.

6.1 Post-Installation Test

1. Install control as described in Section 3.0, Installation.
2. Place the **AUTO/MANUAL** switch in the **MANUAL** position.
3. Manually raise the tap until the RED **LOWER** LED on the control lights.
4. Place the **AUTO/MANUAL** switch of the test unit in the **AUTO** position.
5. Verify that the unit issues at least one lower command in one minute or less. Subsequent operations may require an extended time period.
6. Place the **AUTO/MANUAL** switch in the **MANUAL** position.
7. Manually lower the tap until the RED **RAISE** LED on the control lights.
8. Place the **AUTO/MANUAL** switch in the **AUTO** position.
9. Verify that the unit issues at least one Raise command in one minute or less. Subsequent operations may require an extended time period.

7 SLIMcom™

7.0 Introduction

The M-2802 SLIMcom Communication Software program is designed to provide communication for setting up, monitoring, and downloading history from the Autodaptive® Regulator Control (ARC).

7.1 Installation and Setup

SLIMcom runs under the Microsoft® Windows 95 or 98 operating system, and is available in the following IBM PC-compatible format:

- two 3.5" double-sided, high-density (DS/HD 1.44 Mb) disks

Hardware Requirements

SLIMcom will run on any IBM PC-compatible computer that provides at least the following:

- 8 Mb of RAM (Win 95) or 16 Mb (Win 98)
- Windows 95 or Windows 98
- One 3.5" double-sided, high-density (DS/HD 1.44 Mb) disk drive
- one serial (RS-232) communication port
- VGA monitor (800 x 600 or greater resolution recommended)
- Mouse or pointing device
- One null-modem 9-pin female to male modem cable.
- One Autodaptive Regulator Control.

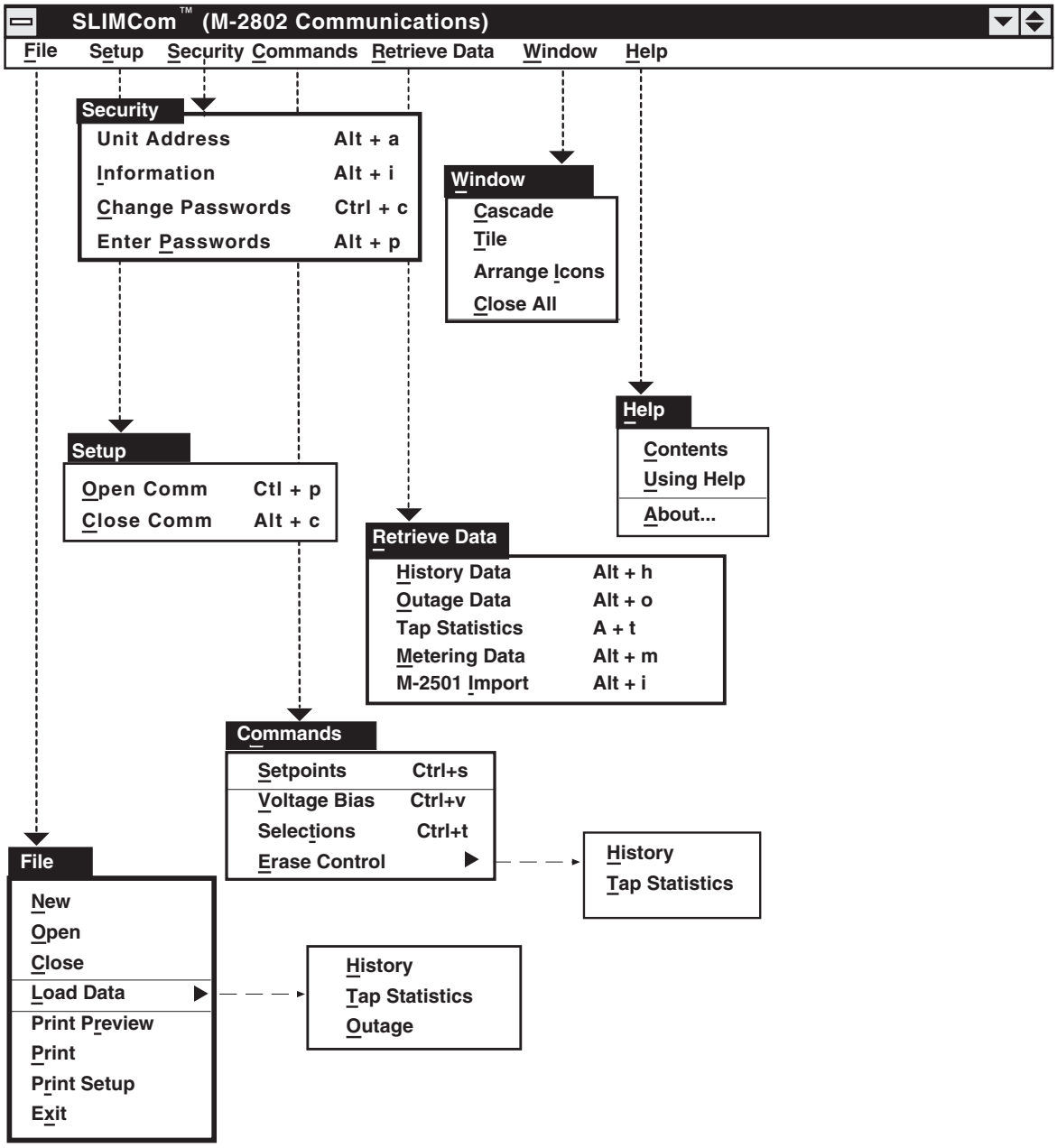


Figure 7-1 SLIMcom Main Menu Flow

■ **NOTE**: Greyed-out commands denote functions which are unavailable at this time.

Installation

An installation utility has been provided as a part of SLIMcom™. After installation, the program can be run from the hard drive by choosing the SLIMcom icon from the **Start** menu.

System Setup

Connect a null-modem cable from the COMM port of the control to the PC serial port.

7.2 Description

This section describes each SLIMcom menu selection and explains the commands in the same order as they are displayed in the software program.

When SLIMcom is run, a **Metering Status** screen is displayed (see Figure 7-2, below).

■ **NOTE**: If no control is attached to the PC, then zero values will appear on the **Metering Status** screen.

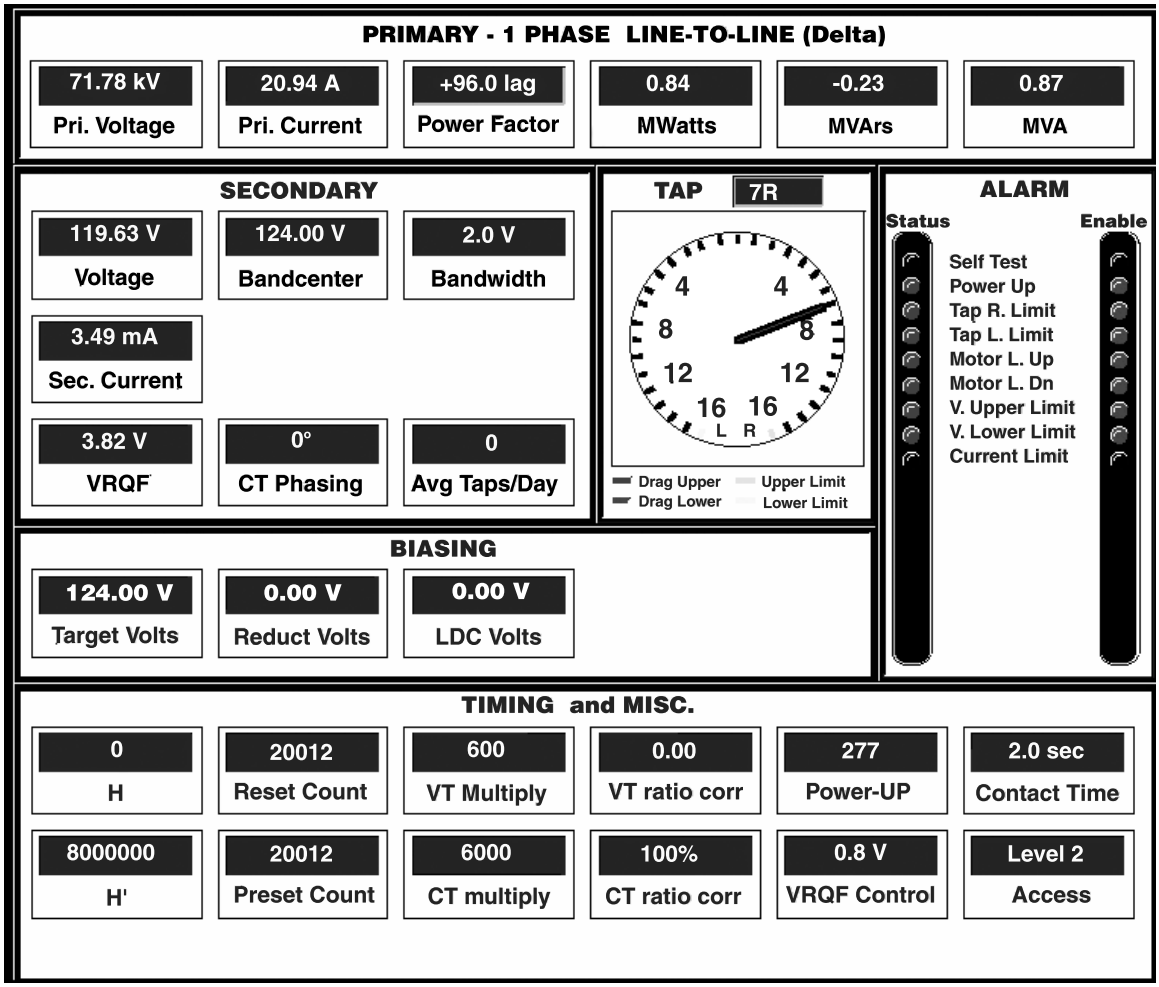
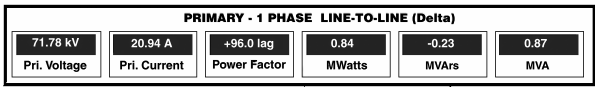


Figure 7-2 Metering Status Screen

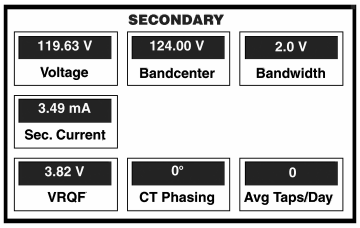
PRIMARY Status

The **Primary Status** display bar shows the primary quantities calculated, based on secondary values of the load tap changer, and appropriate multipliers.

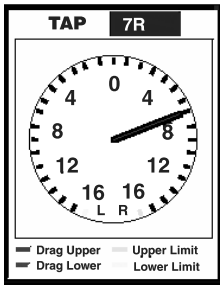


SECONDARY Status

The **Secondary Status** display box shows the quantities calculated at the end of the ARC connection point.



TAP Position Clock



TAP Indicators

The black pointer indicates actual tap position.

Drag Upper (red) dial hand: Records the highest tap position. The dial hand remains fixed at the highest tap position until reset.

Drag Lower (green) dial hand: Records the lowest tap position until reset.

Upper Limit (blue): Indicates the highest tap position indication permitted.

Lower Limit (yellow): Indicates the lowest tap position indication permitted.

ALARM LED Indicators

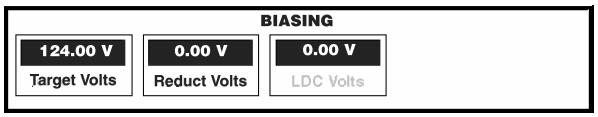
The **Metering Status** screen (see Figure 7-2), contains an array of **Alarm** LEDs that illuminate to indicate a specific Tap Changer Control condition.

Status LED column identifies and indicates (when lit) the condition of an alarm, if enabled.

Enable LED column indicates whether or not a particular alarm is tracked.

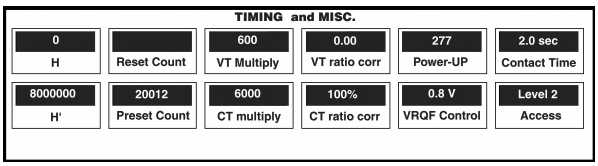
BIASING Display Bar

The **Biasing** display bar displays the amount of voltage that is added or subtracted from the voltage bandcenter.

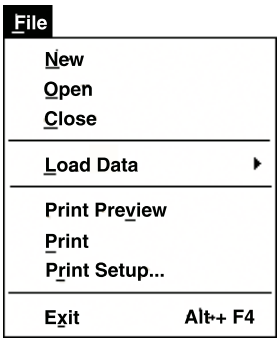


TIMING and MISC Display Bar

The **Timing** and **MISC** (miscellaneous) display bar includes timing parameters to perform “raise” and “lower” tap change positions. The display bar also includes miscellaneous counter reset and presets.



File Menu



The **File** menu enables the user to create a **New** Setpoint file, and **Open** a previously created Setpoint file.

New – A new file is established with the **Setpoints** dialog box (see Figure 7-4). This feature is currently unavailable, and will appear greyed-out in display.

■ **NOTE:** By choosing the **New** command, unit and setpoint configuration values are based on factory settings specified.

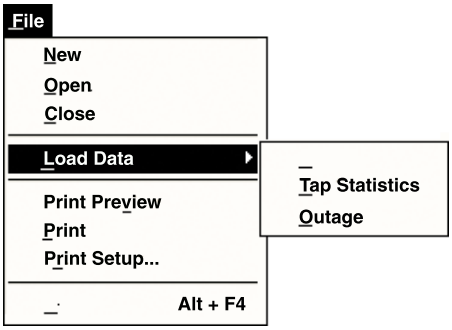
Print Preview – Allows previewing of the Status/Metering/Graphing screens before sending the data to the printer. Only available when downloaded data is viewed.

Print Setup – Allows the user to select printer options such as landscape or portrait orientation. Only available when downloaded data is viewed.

Print – Allows printing of the top-most window selected. Only available when downloaded data is viewed.

Exit – The **Exit** command quits the SLIMcom™ program, and automatically closes the communication port used.

Load Data submenu



The **Load Data** submenu presents three commands: **History, Tap Statistics,** and **Outage.** The first three commands will each display history graphs of the selected data. Each of these screens may be previewed and printed. The data screens that may be loaded are as shown in Figures 7-3, 7-4, and 7-5.

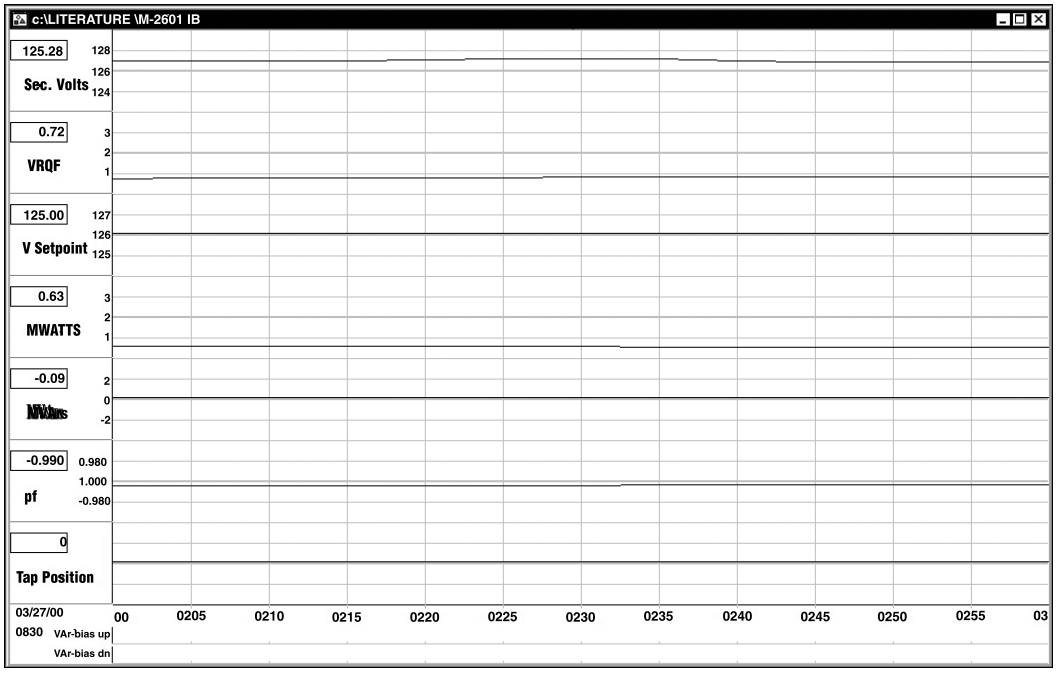


Figure 7-3 History Data Screen

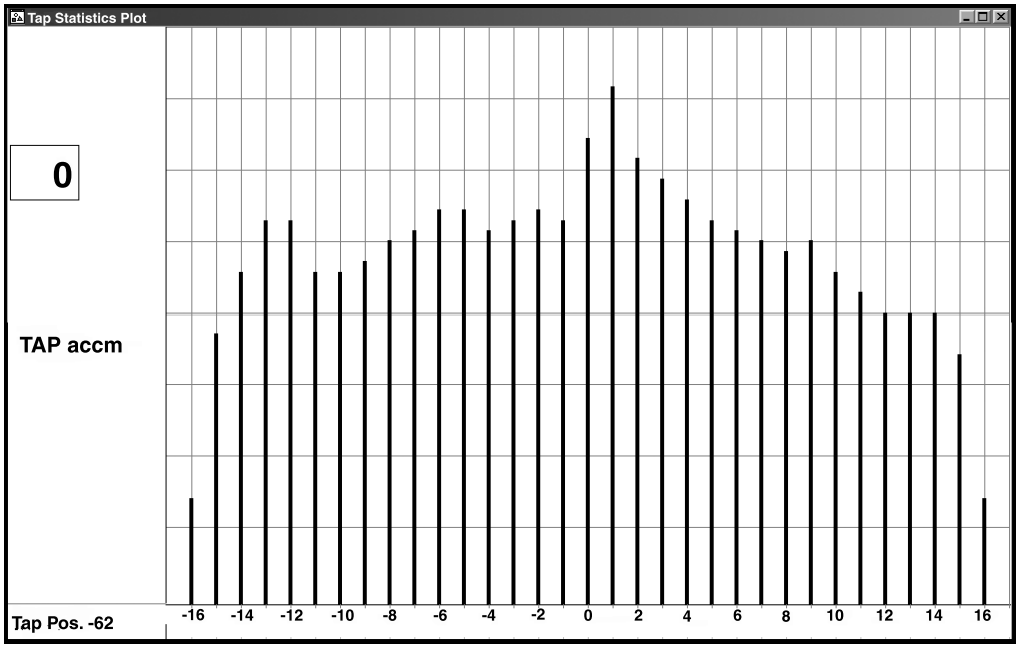


Figure 7-4 Tap Statistics Screen

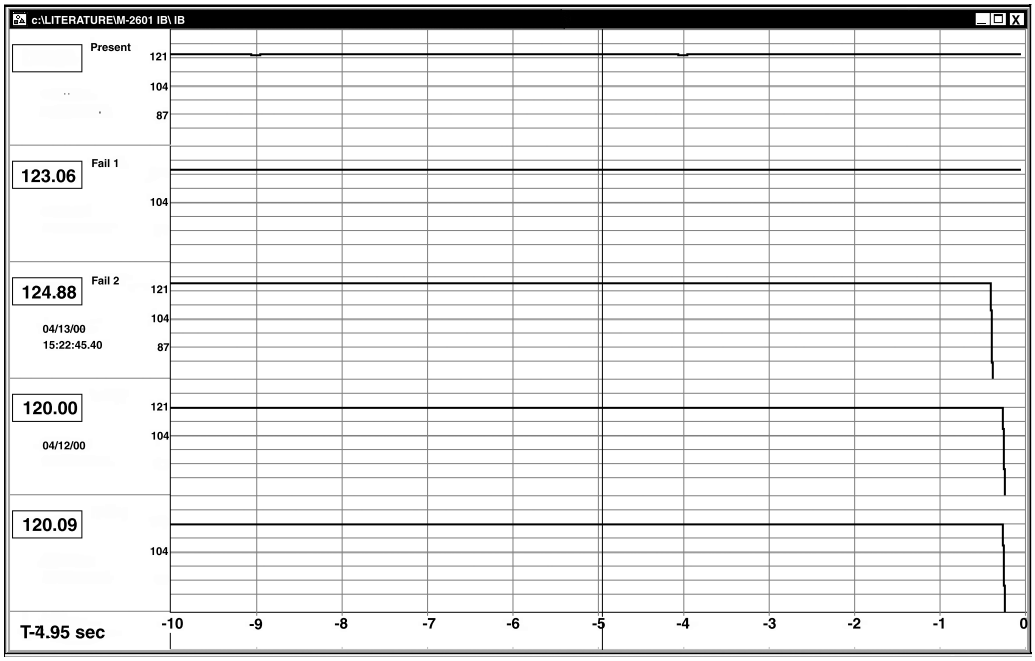
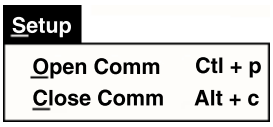


Figure 7-5 Outage Screen

Setup Menu



The **Setup** menu provides two commands: **Open COMM** and **Close COMM.**

The **Open COMM** displays a communications screen (see Figure 7-6) to select the appropriate information regarding the system on which the controller is operating.

Modem baud rate is fixed at 9600 baud. Other rates are greyed-out and currently unavailable.

The Pass-Thru and Router/MUX selections are also currently unavailable, and will appear greyed-out in display.

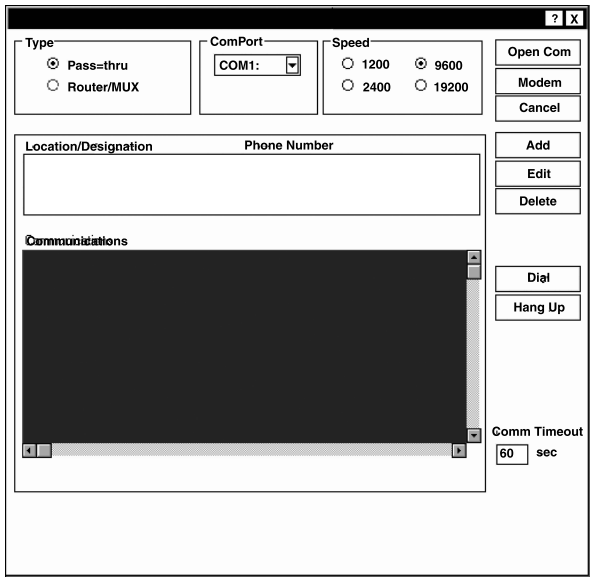
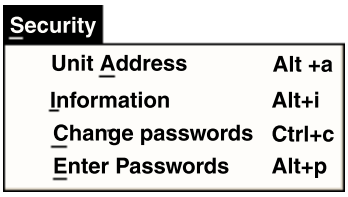


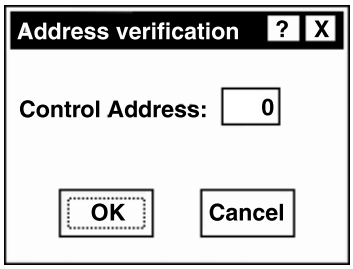
Figure 7-6 Setup Communications Screen

Security Menu



The **Security** menu provides four commands: **Unit Address**, **Information**, **Change Passwords** and **Enter Passwords**.

Selection of the **Unit Address** command



Selection of the **Information** command displays an **Identification** dialog screen (see Figure 7-7), which allows the user to enter specific CT and controller identification data.

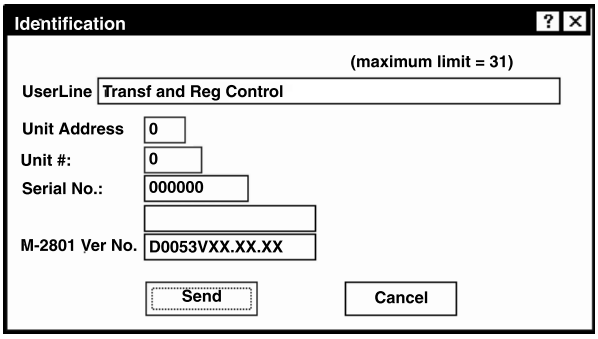


Figure 7-7 Identification Dialog

The **Identification** dialog box reflects the following:

User Line – A 31-character description which identifies the location of the Load TapChanger (LTC).

Unit Address – An integer from 0 to 127; 0 disables.

■ **NOTE**: In multiple control installations, set unit address prior to connecting to communication multiplexing equipment.

Transformer Number – Contains the description of the transformer (LTC) number (an integer from 0 to 65,535).

Serial Number – Contains Beckwith's assigned unit serial number.

M-2601/02/03 Ver. No. – Contains assigned Beckwith version number for Regulator Control.

M-2802 Ver. No. – Contains assigned Beckwith version number for SLIMcom™.

Send – Sends the currently displayed information to the control.

Cancel – Returns user to the SLIMcom main window. Any changes to the displayed information are lost.

Change Passwords Command

When the **Change Passwords** command is selected, a **Change Level Access Code** dialog box (see Figure 7-8*)* is displayed. The access codes in this menu are all four-digit decimal (0–9) combinations. If the correct password is entered, then the corresponding level is achieved. If the user is at level 2 or higher, then the "change password" will permit passwords to be changed. The **New Level Access Code** and the **Confirm Level Access Code** must be the same.

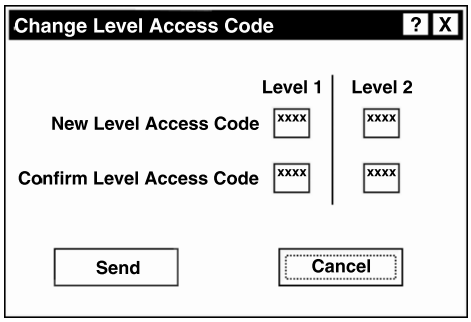


Figure 7-8 Change Level Access Code

Password Entry Command

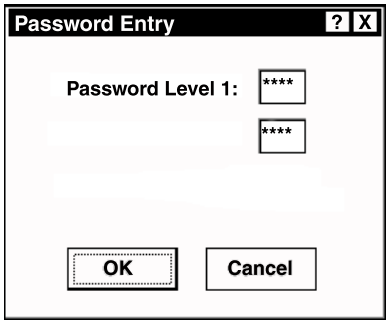


Figure 7-9 Password Entry Submenu

When the **Enter Passwords** command is selected, a **Password Entry** dialog (see Figure 7-9) is displayed. This menu contains three levels of passwords:

Level 1: Read and write, no password change allowed. Default is 1111.

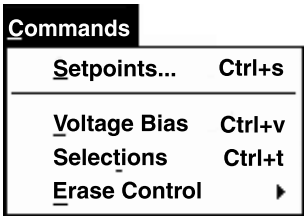
Level 2: Read and write, password changes allowed. Default is 2222.

Command Buttons

OK: Sends the appropriate password level to gain access to the controller.

Cancel: Returns user to the SLIMcom main window. Any changes to the displayed information are lost.

Commands Menu



The Commands menu provides three commands (**Setpoints, Voltage Bias, and Selections)** and one submenu (**Erase Control**) to allow the user select the necessary control functions. Please note that **Voltage Bias** is currently unavailable and will appear greyed-out in display.

Setpoints Command

Selection of the **Setpoints** command displays a **Setpoints** dialog box (see Figure 7-10) from which the individual control functions can be selected.

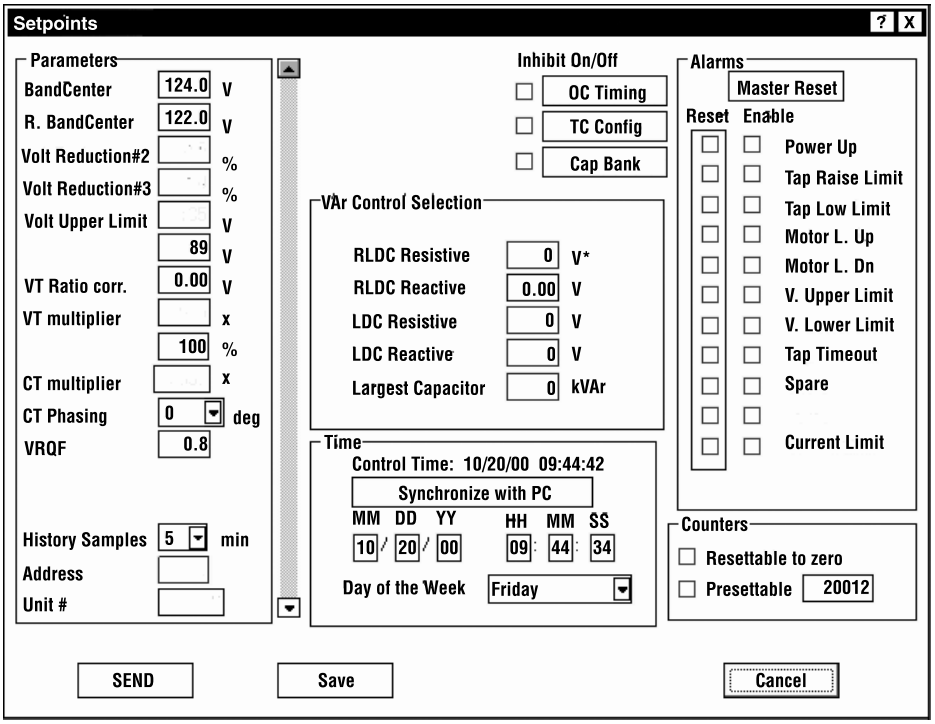
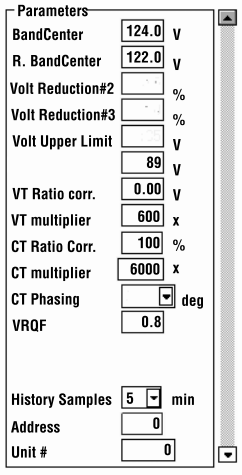


Figure 7-10 Setpoints Dialog Box

Parameters

The Parameters dialog allows the user to select desired voltage values for regulation during initialization of the tap changer control.



Forward power **Bandcenter** is adjustable from 90.0 V to 135.0 V in 0.1 increments with a factory setting of 120 V.

Volt Reduction is currently unavailable, and will appear greyed-out in display.

Two voltage limits, each adjustable from 89 V to 135 V in 1 V increments for the **Lower Voltage Limit**, and 90 to 136 V in 1 V increments for the **Upper Voltage Limit**. The **Volt Upper Limit** is factory set at 132 V. The **Volt Lower Limit** is factory set at 108 V.

VT User Corr voltage is adjustable from –12 V to +12 V in 0.01 increments, with a factory setting of 0.00 V.

VT Ratio Multiplier adjustable from 20 to 5000 in 1 increments, with a factory setting of 60.

CT User Corr multiplier is adjustable from 50% to 200% in 1% increments, with a factory setting of 100%.

CT Multiplier adjustable from 20 to 25,000 in 1 increments with a factory setting of 60.

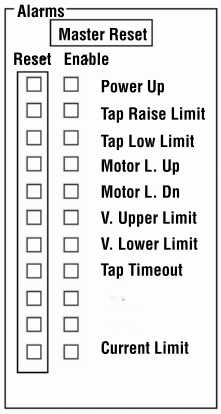
CT Phasing correction is adjustable from 0° to 330° in 30° increments with a factory setting of 0°.

VRQF is adjustable from 0.4 V to 2.0 V in 0.1 V increments.

History Samples: 5–60 minutes, at 1 minute increments, with a default setting of 5.0 minutes.

Alarms

Alarms are set when the relevant condition is encountered, and will cause the alarm contacts to close if enabled. All alarms, once set, remain thus until deliberately reset.



Master Reset – Reset or toggle all reset check boxes to enable clearance of all alarms.

Power Up – Alarm is set when power is reapplied to the unit.

Tap High Limit – Alarm is set when the tap position reaches the tap upper limit.

Tap Low Limit – Alarm is set when the tap position reaches the tap lower limit.

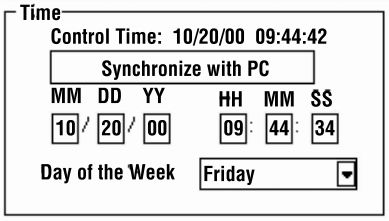
V. Upper Limit – Alarm is set when the measured voltage is greater than the voltage upper limit.

Tap Timeout and **Current Limit** are currently unavailable and will appear greyed-out in display.

Spaces labeled "**Spare**" are reserved for future releases.

V. Lower Limit – Alarm is set when the measured voltage is less than voltage lower limit.

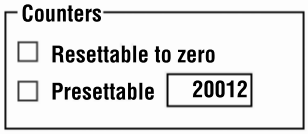
Time



The **Time** dialog screen enables the user to review the internal clocks, prior to entering a new time setting.

Synchronize with PC – Enables the user to set the control time to match the PC time.

Counters

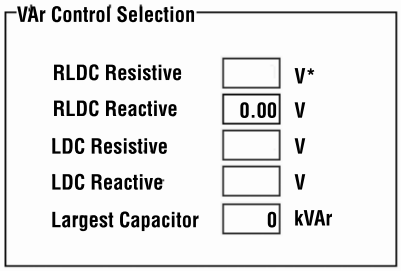


The **Counters** screen records the number of ARC raise and lower operations.

Resettable to zero – Allows the user to reset the counter to zero.

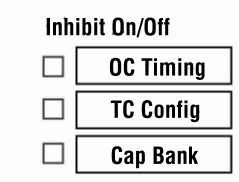
Presettable – Allows counter to be preset to the number entered.

VAr Control



VAr Control allows user to select the largest cap size for VAr control. This group also allows the user to select the amount of LDC and RLDC desired. If VAr bias is not required, then the amount for largest capacitor should be zero (0).

Inhibit On/Off



This provides three dialog buttons; please note that **OC Timing** and **Cap Bank** are currently unavailable and will appear greyed-out in display.

TC Config allows the user to calibrate the control keep-track for initial tap position.

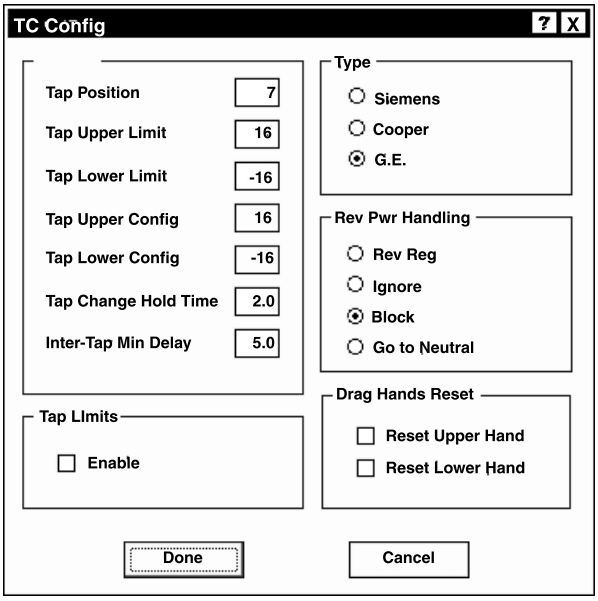


Figure 7-11 Tap Position Setpoints

Command Buttons

Send - Sends the currently displayed information to the control.

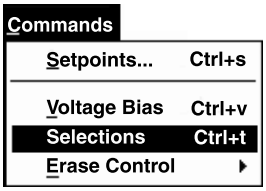
Save - The setpoint information is saved to a specified file name.

Cancel - Returns the user to the SLIMcom™ main window. Any changes to the displayed information is lost.

Voltage Bias Command

The Voltage Bias command is currently unavailable and will appear greyed-out in display.

Selections Command



The **Selections** command enables the user to select the information that he would require to view on the screen and printer. The submenu provides two choices, one for Graphs and the other for Metering of setpoints.

Graph Selections Table

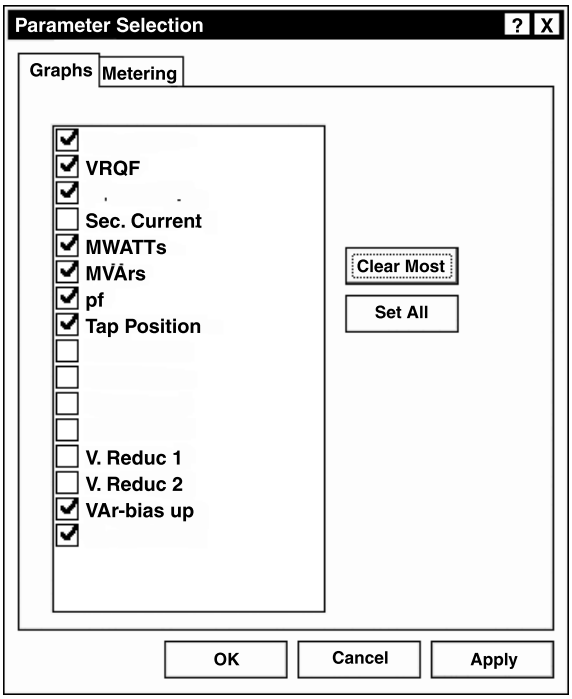


Figure 7-12 Graph Selections

Command Buttons

Clear Most – Will clear most available parameters for viewing.

Set All – Will check all available parameters for viewing.

OK – Updates SLIMcom™ with desired selections.

Cancel – Returns user to the SLIMcom main window.

Metering Setpoints Selection Table

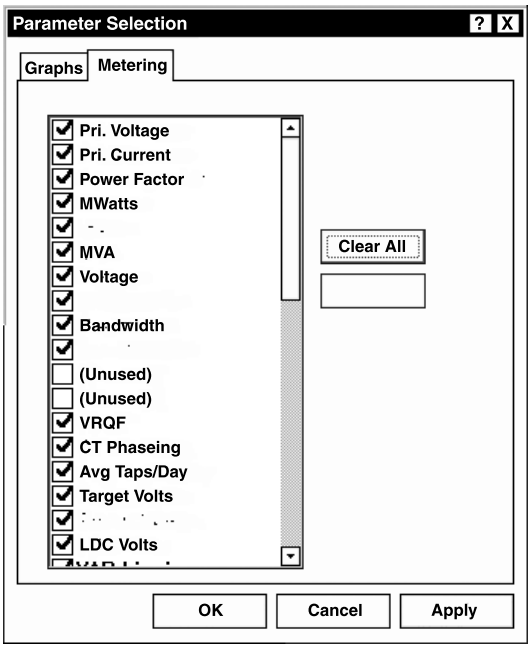


Figure 7-13 Metering Selections

Command Buttons:

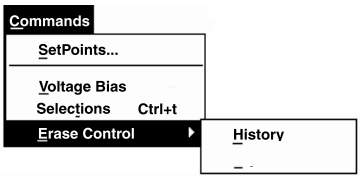
Clear Selections: Will uncheck all parameters except voltage because one value, as a minimum, should be displayed.

Set All Selections – Will check all available setpoint parameters for viewing.

OK – Sends the currently displayed information to the controller.

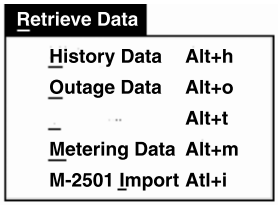
Cancel – Returns user to the SLIMcom main window. Any changes to the displayed information are lost.

Erase Control Submenu



The **Erase Control** submenu allows the user to erase all data for **History** or **Tap Statistics**. This function erases not only the on-board flash in the control, but all downloaded data files stored on your hard drive. To erase current History and Tap Statistics files from the computer only, use the **Erase Data** command from the **File** menu.

Retrieve Data Menu



The **Retrieve Data** menu provides four commands: **History Data**, **Outage Data**, **Tap Statistics, Metering Data, and M-2501 Import**.

■ **NOTE**: These are the only commands which provide print control.

History Data

If a control is connected to your PC, then any history data stored in the control is added to the main history database. If no control is connected, then the main history database is loaded for viewing. The database is capable of storing months to years of data at 0 to 60 minutes intervals. Selection of the **History Data** submenu displays a history plot of Voltage, VRQF and MWatts waveforms (see Figure 7-3*).*

Outage Data

The **Outage Data** command allows retrieval of five Autodaptive Regulator Control outages, for a period of 10 seconds each. The outages (see Figure 7-5), are similar to the waveforms shown in Figure 7-3.

Tap Statistics

Tap Statistics provides a continuously updated graph of the taps being made by the control. See Figure 7-4 for an example of the graphic format.

Metering Data

Metering Data provides a continuous update of user-selected data quantities (refer to **Metering Setpoints Selection Table**).

The Metering Data screen provides an easy-to-print accounting of all metering data sampled from the control.

M-2501 Import

This command is currently unavailable and will be greyed-out in display.

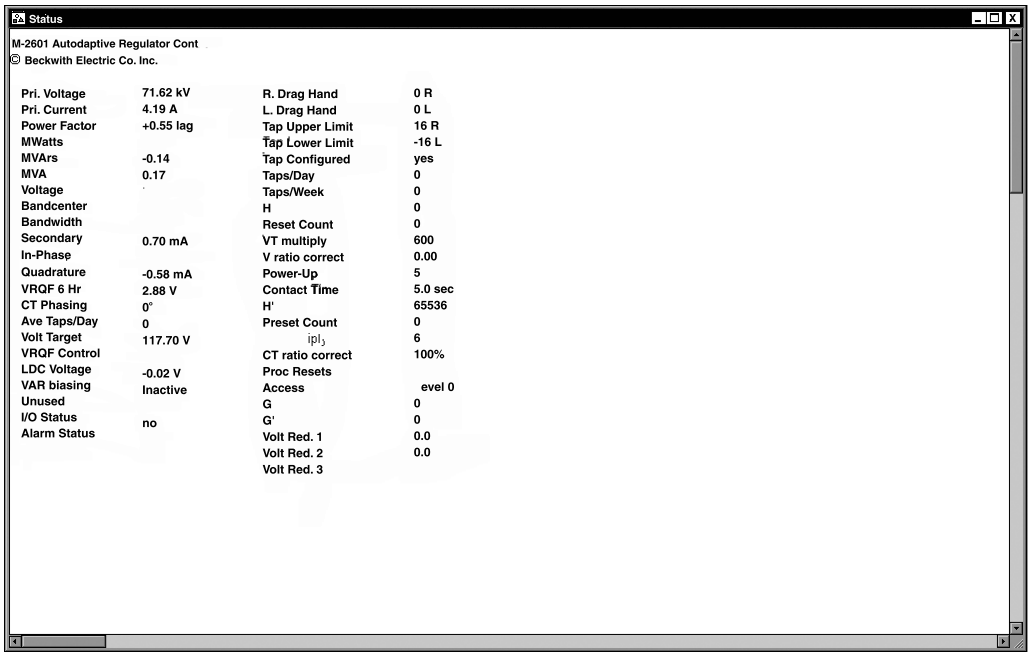
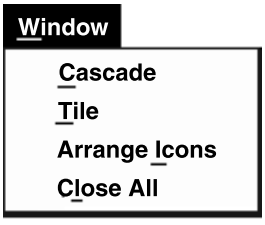


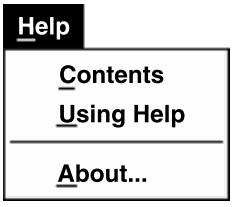
Figure 7-14 Metering Data

Window Menu



The Window menu contains a group of standard Windows commands to perform screen arrangements.

Help Menu



The Help menu provides documentation for windows only.

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A Appendix

A.0 Null Modem Cable

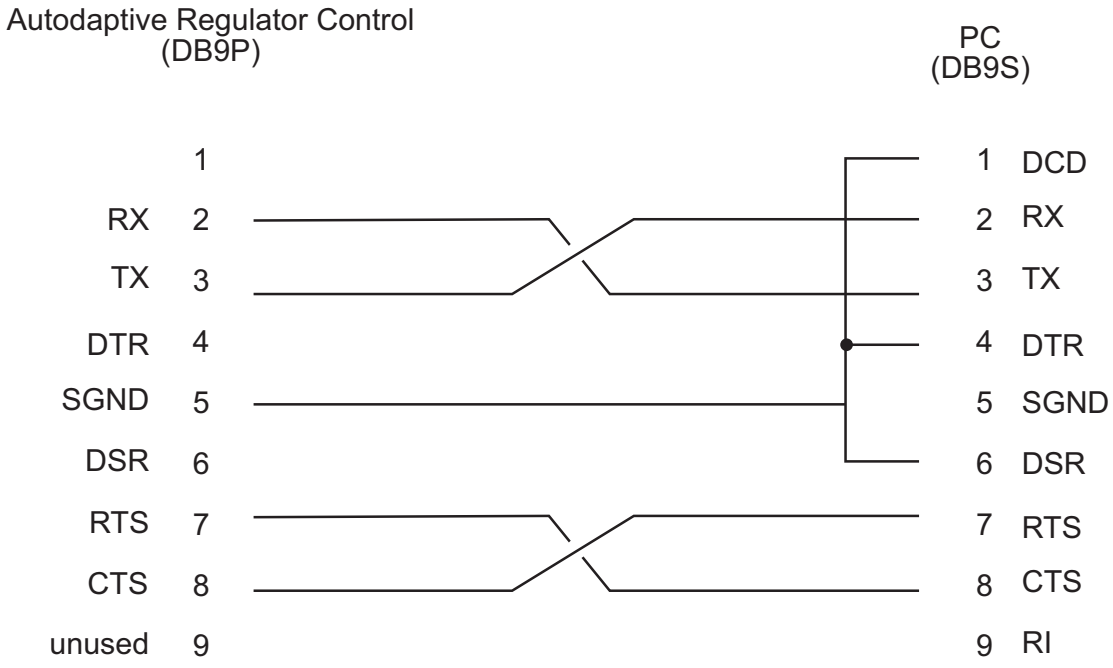

Figure A-1 Null-Modem Cable, 9 pin to 9 pin

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Legal Information

Patent

The units described in this manual are covered by U.S. Patents 5,315,527, 5,554,064, 5,541,498 and 5,530,338 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 infringementof United States Letters Patent or rights accruing thereform 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 two years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to peform 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.

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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.

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

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