Multi-phase pad-mountedstep voltage regulator

General

Eaton's Cooper Power™ series multi-phase pad-mounted step voltage regulators add a new dimension to underground system planning. The multi-phase units contain two or three single-phase voltage regulators in a single tank. They can be configured for wye or delta system applications.

Pad-mounted voltage regulators provide system planners freedom to improve the safety, reliability, and power quality of existing and new underground distribution systems. The pad-mounted voltage regulator provides all the functionality of traditional round-tank pole-mounted and substation voltage regulators, with the advantages of pad-mounting. Voltage regulators provide step-type voltage regulation in thirty-two (32) steps of approximately 5/8% each for a maximum of ± 10% regulation when used in wye-connected banks. Voltage ratings are available from 2500 volts (60 kV BIL) to 34,500 volts (150 kV BIL) for 60 Hz and 50 Hz systems.

The CL-7 multi-phase control is equipped as a standard on multi-phase pad-mounted voltage regulators. The CL-7 voltage regulator control is microprocessor-based, with a digital metering package of Class 1 accuracy. Instantaneous metering, time/date-stamped demand metering, and profile recording are provided. Features include voltage limiting capability, voltage reduction capability, reverse power flow operation, and tap position tracking.

The multi-phase pad-mounted voltage regulator provides state-of-the-art voltage regulation while both reducing installation costs and maintaining visual aesthetics.

Pad-mounted voltage regulators, in conjunction with pad-mounted transformers and switchgear, can be used to create a modular pad-mounted substation. This substation can be placed in areas that require a low profile installation. It will exist inconspicuously and quite possibly utilize shared rights-of-way.

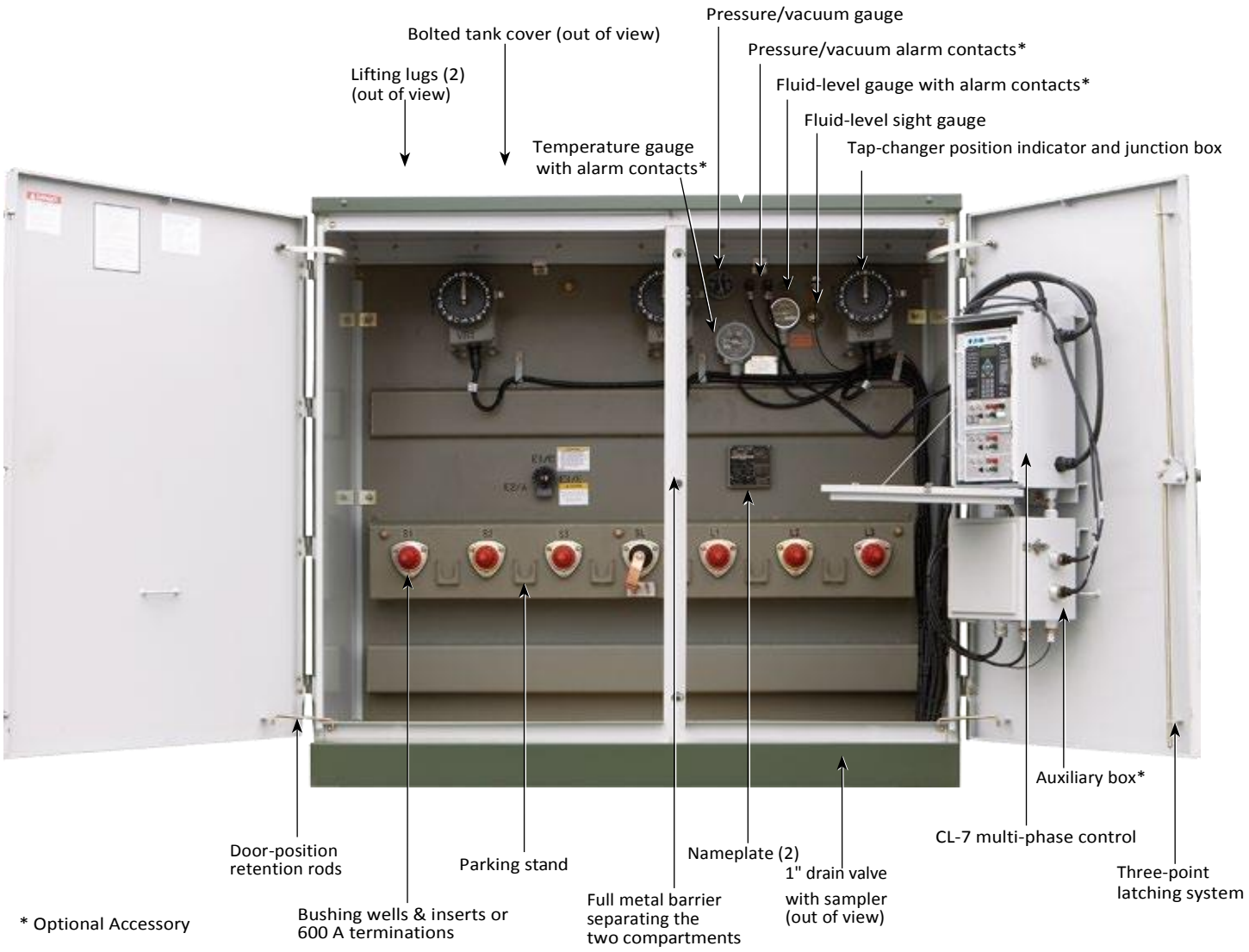

Figure 1. The multi-phase pad-mounted voltage regulator is delivered fully-equipped, ready for your application.

Standard features

A sealed tank construction combined with a 65°C average winding rise insulation system provides a proven design for long life installations. Additional capacity is available through the ADD-AMP™ feature.

Internal construction allows easy removal of the interior assembly. A bolted cover also provides a large area to perform maintenance while the voltage regulator assembly remains in the tank.

- Full metal barrier separating the two compartments
- A parking stand for each S and L bushing
- Bushing wells and inserts, 600 A or 900 A terminations
- Standard “pad-mounted green” paint (Munsell 7GY3.29/1.5)
- Ground pads
- Bolted tank cover
- Nameplates (2)
- Deep (31") removable cabinet
- Automatic pressure relief device
- Lifting lugs
- Under-oil series arrester (3 or 6 kV) for each phase
- Provisions for pressure/vacuum gauge & thermometer
- 1" filter press connection and fill plug
- Control box with CL-7 multi-phase control
- Oil level gauge
- Junction box and position indicator for each phase
- 1" drain valve with sampler
- Control cable disconnects at junction boxes and control box
- Line-side lift-off door secured with two captivated bolts
- Pad-lockable lift-off control-side door with three-point latching
- Door position-retention rods
- Internal differential PT
- Externally operated PT tap switch

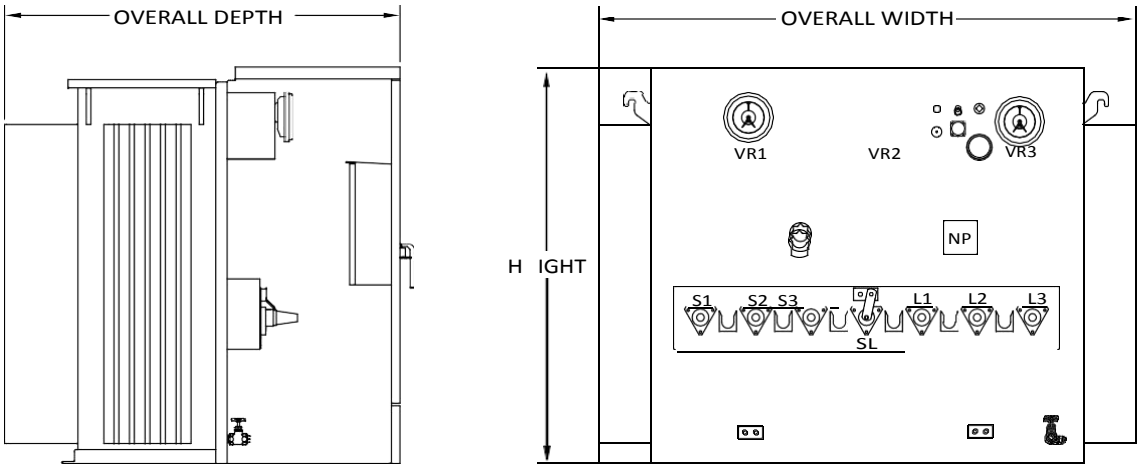

Figure 2. Multi-phase pad-mounted voltage regulator. Contact your Eaton representative for specific dimensional and weight information.

Optional accessories

- Envirotemp™ FR3™ dielectric fluid
- 41" deep cabinet
- Alternate top coat color
- Cabinet without barrier
- Pressure/vacuum gauge
- Pressure and vacuum contacts
- Dial-type thermometer (with or without alarm contacts)
- Under-oil shunt arresters
- Nameplates in alternate languages and/or metric units

Bypass switch options

Standard bypass switching options are not available for multi-phase pad-mounted voltage regulators. In order to bypass a multi-phase pad-mounted voltage regulator without de-energizing the line, separate pad-mounted switch gear is required.

Ease of operation

The control box is mounted on the door of the operational side of the cabinet for easy access.

The junction box has a removable side door which permits access to the terminal block for the connections from the tank to the control cable. The control is connected from the control box to the junction boxes with quick-disconnect control cables, which enables easy removal of the control box. The current transformer is automatically shorted by an electronic shorting device when the cable is disconnected.

Table 4. Regulator Voltage Ratings and Corresponding Terminations

Voltage (Volts)	Current (Amperes)	kVA	Bushing	BIL
60 Hz Ratings				
2500	200	50	200 A well & 15 kV class insert	60
2500	300, 400	75, 100	600 A integral bushing	60
2500	668, 875	167, 219	900 A integral bushing	60
7620	50, 75, 100, 150, 200	38, 57, 76, 114, 152	200 A well & 15 kV class insert	95
7620	328, 438, 548	250, 333, 416	600 A integral bushing	95
7620‡	656, 875	500, 667	900 A integral bushing	95
14400	50, 100, 200	72, 144, 288	200 A well & 25 kV class insert	125*
14400	300, 347, 400, 463	432, 500, 576, 667	600 A integral bushing	125*
14400	578	833	600 A integral bushing	125*
19920	50, 100, 167, 200	100, 200, 333, 400	600 A integral bushing	150
19920	250, 335	500, 667	600 A integral bushing	150
34500	50, 100, 150, 200	172.5, 345, 517.5, 690	600 A integral bushing	150
50 Hz Ratings				
11000	50, 100, 150, 200	55, 110, 165, 220	200 A well & 15 kV class insert	95
11000	300, 400	330, 440	600 A integral bushing	95
15000	50, 100, 150, 200	75, 150, 225, 300	200 A well & 25 kV class insert	125*
15000	300	450	600 A integral bushing	125*
22000	50, 100, 150, 200	110, 220, 330, 440	600 A integral bushing	150
22000	300	660	600 A integral bushing	150
33000	50, 100, 150	165, 330, 495	600 A integral bushing	150

Note: 600 A or 900 A bushing upgrades are available for each voltage rating.

* The 125 kV BIL rating is only limited by the bushing: all internal connections are designed and constructed to 150 kV BIL. A 600 A, 150 kV BIL integral bushing is available as an option.

‡ The 7620 V units rated 200 A or less are available with optional 25 kV class inserts.

Position indicator and ADD-AMP™ feature

Exclusive to Eaton, the uniquely designed position indicator offers corrosion resistant materials, an oversized viewing area and a reset solenoid that is replaceable using a single thumbscrew. It is mounted on a junction box on the frontplate of the regulator and is directly connected to the tap changer by a flexible drive shaft passing through the junction box and terminal board via a sealing gland.

The indicator face is graduated in steps, numbered 1 through 16 on each side of neutral. Drag hands indicate the maximum and minimum positions attained during raise and lower operations. The drag hands are reset around the position indicator hand by operating the drag hand reset switch on the control front panel.

The ADD-AMP feature of the pad-mounted voltage regulator allows increased current capacity by reducing the regulation range.

This is accomplished by either setting limit switches in the position indicator (Hard ADD-AMP feature) or enabling the Soft ADD-AMP feature through the control to prevent tap operations beyond the limits.

The CL-7 control also allows for an Adaptive ADD-AMP feature which will automatically change the Soft ADD-AMP setting based upon the current readings of the control.

The five possible load current ratings associated with the reduced regulation ranges are summarized in Tables 5 and 6. At each setting, a detent stop provides positive adjustment. Settings other than those with stops are not recommended. The raise and lower limits need not be the same value, except for locations where reverse power flow is possible.

Figure 3. Position Indicator.

Table 5. Regulator Voltage Ratings

Voltage Rating	Standard Internal Tap Settings							
60 Hz:								
2500 V	2500	2400*						
7620 V	8000	7970	7620‡	7200*	6930	4800	4160	2400
14400 V	14400*	13800	13200	12000	7970	7620	7200	6930
19920 V	19920*	17200	16000	15242	14400	7970	7620	7200
34500 V	34500*	19920						
50 Hz:								
11000 V	11600	11000*	10000	6930	6600	6350	6000	5500
15000 V	15000*	14400	13800	13200	12000	11000	10000	8660
22000 V	23000	22000*	20000	19100	15000	12700	11000	10000
33000 V	33000*	30000	22000	20000	11600	11000	10000	

Note: Other ratings may be available upon request. Contact your Eaton representative for more information.

* Standard voltage configuration setting.

‡ Alternate voltage configuration setting.

Table 6. ADD-AMP Capabilities of 60 Hz Ratings

		Load Current Rating (Amperes)				
		Regulation Range				
Rated Voltage	**Rated kVA**	**±10%**	**±8.75%**	**±7.50%**	**±6.25%**	**±5%**
2500	50	200	220	240	270	320
	75	300	330	360	405	480
	100	400	440	480	540	640
	167	668	668	668	668	668
	219	875	-	-	-	-
7620*	38	50	55	60	68	80
	57	75	83	90	101	120
	76	100	110	120	135	160
	114	150	165	180	203	240
	152	200	220	240	270	320
	250	328	361	394	443	525
	333	438	482	526	591	668
	416	548	603	658	668	668
	500	656	668	668	668	668
14400	72	50	55	60	68	80
	144	100	110	120	135	160
	288	200	220	240	270	320
	432	300	330	360	405	480
	500	347	382	416	468	555
	576	400	440	480	540	640
	667	463	509	556	625	668
19920	100	50	55	60	68	80
	200	100	110	120	135	160
	333	167	184	200	225	267
	400	200	220	240	270	320
	500	250	275	300	338	400
	667	335	369	402	452	536
34500	172.5	50	55	60	68	80
	345	100	110	120	135	160
	517.5	150	165	180	203	240
	690	200	222	240	270	320

* Regulators are capable of carrying current corresponding to rated kVA when operated at 7200 volts.

Note: Per IEEE Std C57.15-2009™ standard, single-phase regulators rated 668 A and below shall have the continuous current rating or 668 A, whichever is less, as shown in the table. To achieve 668 A, the bushings must be upgraded to 900 A.

Table 7. ADD-AMP Capabilities of 50 Hz Ratings

		Load Current Rating (Amperes)				
		Regulation Range				
Rated Voltage	Rated kVA	±10%	±8.75%	±7.50%	±6.25%	±5%
11000	55	50	55	60	68	80
	110	100	110	120	135	160
	165	150	165	180	203	240
	220	200	220	240	270	320
	330	300	330	360	405	480
	440	400	440	480	540	640
15000	75	50	55	60	68	80
	150	100	110	120	135	160
	225	150	165	180	203	240
	300	200	220	240	270	320
	450	300	330	360	405	480
33000	165	50	55	60	68	80
	330	100	110	120	135	160
	495	150	165	180	203	240

Note: Per IEEE Std C57.15-2009™ standard, single-phase regulators up to 19.9 kV rated 668 A and below shall have the continuous current rating or 668 A, whichever is less, as shown in the table. To achieve 668 A, the bushings must be upgraded to 900 A.

CL-7 series control

- Source-side voltage calculated from tap position
- Internal-external voltage source switch
- Automatic/manual control switch
- Manual raise/lower toggle switch
- Position indicator drag hand reset switch
- Supervisory OFF switch (for use with SCADA)
- Alpha numeric keypad
- 4x20 character LCD display
- Multilingual display
- Three date formats
- Six-digit operations counter
- Voltage test terminals
- External voltage source terminals
- Neutral indicating dual LEDS
- Panel-mounted motor fuse
- Metering-PLUS™ one-touch, grouped-data display feature
- Tap-position tracking
- Voltage limiter ("First House Protection")
- Line drop compensation settings
- Soft ADD-AMP feature with adaptive functionality
- Duty Cycle Monitor (DCM)
- TIME-ON-TAP™ tap position tracking feature
- Preventative Maintenance Tapping (PMT™) feature
- Tap-to-Neutral
- Security override
- Voltage reduction (3 modes)
- Digital metering package (including instantaneous, demand and time-tagged demand)
- Data profiler
- Configurable status alarms
- Configurable data alarms
- Event record
- USB PC port connection
- USB drive data port
- Resident communications protocol (DNP 3.0 and IEC 61850)
- CL-6 communications emulation
- Configurable logic
- Alternate configuration settings
- Five multi-phase modes of operation

CL-7 optional accessories

- Front panel overlays in alternate languages
- Serial communications interfaces:
  - RS232
  - Fiber Optic - ST
  - RS485
- Ethernet communications interfaces:
  - Fiber Optic - LC, MTRJ, ST, and SC
  - Copper - RJ45

Figure 4. CL-7 multi-phase regulator control.

- Communications protocols:
  - IEC 60870-5
  - 2179
  - MODBUS
- 8-input/8-output universal contact modules
- 13.5 Vdc radio power supply
- 13A-Hr control power battery backup
- 48/125 Vdc substation battery power provisions
- 240 V external power source capability

Construction

Core and coil assembly

The coil assembly features aluminum strip in the series winding that achieves the optimum in ampere turn balance for exceptional strength under through-fault conditions.

Grain-oriented steel is used in the core, with a low reluctance lap joint. The rugged core clamp assembly secures the coil effectively and positions the core for the optimum in quiet operation and low core losses.

Quik-Drive™ tap-changers

The load tap-changer product offering consists of three Quik-Drive™ tap-changer models, the most advanced tap-changers in the industry. Each device is sized for a specific range of current and voltage applications and shares many similarities in their construction.

The primary benefits of Quik-Drive tap-changers are:

- Direct motor drive for simplicity and reliability
- High-speed tapping operation
- Proven mechanical life tested to one million operations

Common Quik-Drive tap-changer features include:

- Neutral light switch
- Holding switch feedback circuit
- Position indicator drive
- Safety limit switches
- Logic (back-off) switches

Quik-Drive load tap-changers meet IEEE® and IEC standards for mechanical, electrical and thermal performance.

Figure 6. QD-3 Quik-Drive tap changer.

Figure 5. QD-8 Quik-Drive tap-changer.

Figure 7. QD-5 Quik-Drive tap changer.

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