Howard Industries, Inc.
Certified to ISO 9001:2015

Catalog Section
28-10

Single-Phase Step
Voltage Regulators

INTRODUCTION

Howard Industries' SVR-1 single-phase step voltage regulators are tap-changing autotransformers designed to automatically regulate distribution line voltages in a range of plus or minus 10% in thirty-two steps of approximately 5/8% each. The following ratings are available:

- Voltage: 2500 Volts (60 kV BIL) through 19920 Volts (150 kV BIL)
- Current: 50 through 1665 Amps
- KVA: 38.1 through 1000
- Frequency: 50 or 60 Hertz

Internal potential winding taps and/or an external ratio correction transformer are provided on all ratings so that each regulator may be applied within a range of system voltages.

A digital control system automatically operates the tap changer mechanism to maintain system voltage within desired limits. The control system is externally programmable to allow precise setting of control limits and provides sophisticated capabilities for special control requirements, communication, and data logging.

Overhead type voltage regulators are supplied with support brackets for pole mounting and have bolt-down provisions for pad-mounted applications. Substation type voltage regulators are provided with rectangular substation bases. Elevating platforms are available as an option.

SVR-1 voltage regulators are designed for reliable operation and ease of maintenance and are supplied with a full array of standard features for routine applications. Optional accessories are available to accommodate special applications.

Figure 1: **SVR-1 Step Voltage** Regulator

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The SVR-1 features sealed-tank construction and a 65 ° C rise insulation system, which allows 55 ° C rise rated designs to provide an additional 12% capacity above nameplate rating without loss of normal insulation life. The HI-AMP™ feature provides capability for additional load capacity, as long as the regulator's maximum current rating is not exceeded.

The regulator's complete internal assembly (including tap-changer switch, motor, core-and-coil assembly, and reactor coil-and-coil assembly) is mounted to the cover (Figure 2). This construction simplifies removal of the internal assembly for inspection, maintenance, and repair.

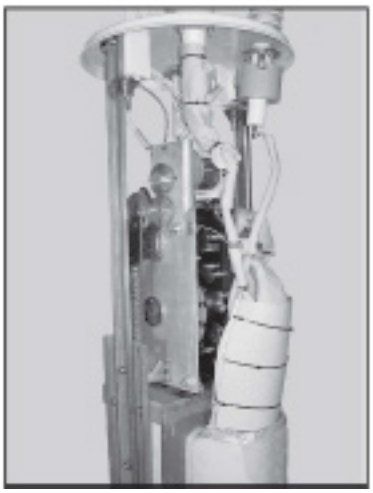

Figure 2: Internal Assembly

SVR-1 voltage regulators are designed, manufactured, and tested in accordance with the requirements of ANSI Standard C57.15.

STANDARD REGULATOR FEATURES

All SVR-1 voltage regulators are supplied with the following standard accessories and features:

- Gear-driven tap-changer switch with motor and power supply
- Motor capacitor mounted in control enclosure for ease of replacement
- Mechanical tap position indicator with externally adjustable HI-AMP™ limit switches
- Laser-etched nameplates (two)
- Lifting lugs
- Oil drain valve with sampling device
- Upper filter press connection
- Oil sight gauge
- High-creep porcelain bushings
- Bolt-down provisions (overhead type regulators)
- Pole mounting brackets (overhead type regulators)
- Rectangular substation base (substation type regulators)
- Externally mounted series arrester (MOV type)
- Mounting provisions for shunt arresters
- Automatic pressure relief device
- Powder coated mild steel tank, cover, clamp ring, and control enclosure
- Beckwith M-6200A digital regulator control (refer to description below)

OPTIONS

The following optional features and accessories are available for the SVR-1 voltage regulator:

- Externally mounted shunt arresters (MOV type)
- Wildlife protection for high-voltage bushing terminals and lightning arresters
- Extra-length control cable
- PTs and CTs for external metering
- Elevating platform
- Control enclosure heater
- 4-hole NEMA H-spade connectors
- Cooling fans
- Powder coated stainless steel tank, cover, clamp ring, and control enclosure
- Beckwith digital regulator control
- SEL digital regulator control

BECKWITH M-6200A DIGITAL VOLTAGE CONTROL SPECIFICATION

- Adjustable Bandcenter
- Adjustable Bandwidth
- Adjustable VAr Bias
- Line Drop Compensation, R, X and Z Compensation
- Time Delay, Definite and Inverse
- InterTap Time Delay
- Four Settings Profiles
- Compare Settings Tool
- Selectable Outputs, Continuous or Pulsed
- Reverse Power Operation for Single-Phase Regulator applications
- Real-Time Metering of measured and calculated parameters
- Demand Metering with selectable time interval
- Drag Hands Operation
- Adjustable Line Overcurrent Tapchange Inhibit
- Voltage Limits
- Tap Position Limits
- Auto Runback (due to overvoltage)
- Three Independent Voltage Reduction Steps
- Sequential and Non-Sequential Operation
- SCADA HeartBeat
- Manual HeartBeat Timer
- VT Ratio Correction

(Continued on page 4)

Figure 3: Beckwith M6200A Digital Voltage Control

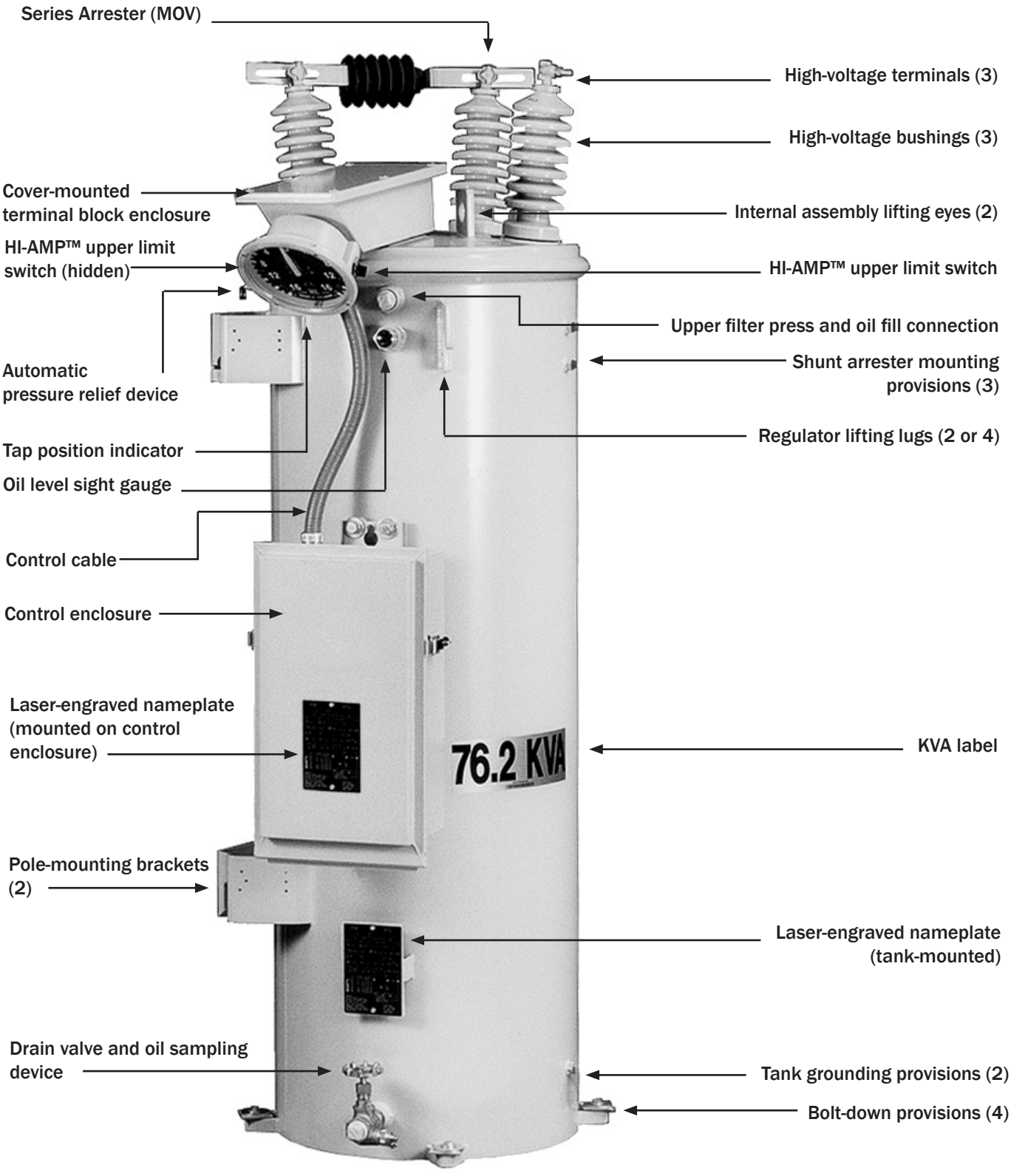

FIGURE 4: SVR-1 single-phase step voltage regulator standard features and access ories (overhead type as shown)

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- Tap Position Knowledge by Motor Direct Drive KeepTrack method
- Operations Counter
- Resettable Operations Counter
- Harmonic Analysis
- Tap Position Record
- Auto/Off/Manual Switch Status
- A or B Regulator Type Selection
- User Programmable Alarm/ Deadman Contact
- SCADA Cutout (Local/Remote) switch allows blocking of write commands from COM1, COM2 or Ethernet
- Control Voltage Input
- Source Side PT Input
- Motor Power Input
- Load Current Input
- Raise Output
- Lower Output
- 20 Character by 2 Row LED backlit LCD Display
- TapTalk S-6200 Communications Software
- USB (1.1) Communications Port
- Motor Current Profiling
- Up to 30 unique 15 character User Access Codes (Level 1 or Level 2)
- CBEMA monitoring to detect sags and swells within a range of 90 Vac to 180 Vac, and trigger data collection and alarming functions
- VAr Bias (Step and Linear Methods)
- Smart Flash SD Card Slot supporting SD and SDHC SD cards
- Smart Flash SD Card can be linked to one or multiple controls providing a physical security “Key” which provides User Access Level 2 Access to the control when the SD Card is inserted for settings manipulation
- Sequence of Events (SOE)
- Data Logging
- Oscillography
- External Inhibit of Auto Tapchange
- Front Panel LEDs for Out-of-Band Raise, Out-of-Band Lower, Reverse Power Flow Rev Pwr Detected, ALARM in effect, Voltage Reduction V/RED in Effect, CPU OK, Auto Operation Block MANUAL, SCADA Control blocked LOCAL and Com1 TX and RX
- Voltage Reduction 1 & 2 Inputs (Binary)
- Neutral Position Detect and Counter
- Counter Input (Binary)
- Motor Seal-In Input (Binary)
- Motor Seal-In Failure Alarm and Block
- Non-Sequential Input (Binary)
- COM1, RS-485 (two-wire), RS-232, or Serial Fiber (Specify)
- Communication Protocols include MODBUS, Secure DNP3.0 (Authentication) and Cooper 2179
- Control Power Back-Up Input – input (+12 Vdc) for backup of Fiber Optic loop-through communication
- One set (3) of spare fuses are included
- Supports Station and Feeder Level DNP addressing in addition to individual addressing for Smart Grid applications
- One pushbutton access to user configurable Wakeup screen for manual data recording with Smart Flash SD Card saving feature
- Run Through Neutral, Automatic Reversing Switch swiping
- Individual Tap Wear Alarm
- User selectable Tapchanger Type
- IEEE 1686 Standard Compliant Cyber Security
- IPsec (Internet Protocol Security)
- RADIUS Client Capability to manage local and remote access to the control

OPTIONAL FEATURES

- SCAMP (SCADA Controllable Auto/ Manual Pushbutton)
- COM1, Fiber Optic Port (ST or V-pin connectors available with 62.5 and 200 micro fiber supported)
- COM2, RS-232 Communications Port or Bluetooth*
- *Bluetooth option is not available in 50 Hz units shipped to locations subject to Radio Equipment Directive RE-D 2014/53/EU. Contact the factory for more information.
- Ethernet Port is available through a RJ-45 jack (10/100 Base-T) or Fiber Optic through ST connectors (100 Base-Fx). These ports support DNP over TCP/IP and MODBUS over TCP/IP

ACCESSORIES

- M-2026 AC-DC Control Power Backup Supply
- M-2027 Control Power Backup Supply–AC Only
- B-0920 Control Power Backup Harness
- USB Cable
- SD Card (1 GB) for Smart Flash functions

REGULATOR CONSTRUCTION

SVR-1 regulators are designed and built to provide reliable service, long life, and ease of maintenance. The entire internal assembly is mounted to the regulator cover and can be easily removed for inspection, repair, and maintenance.

Tank

SVR-1 regulators feature sealed-tank construction to prevent moisture and air from entering the internal environment. Tanks are constructed of mild steel
or stainless steel and electrostatically coated with a tough polyester powder finish.

Core and Coil Assembly

The use of a 65 ° C rise insulation system in 55 ° C rated designs provides an extra 12% capacity for the SVR-1 regulator without loss of insulation life. The series coil is wound with full-width aluminum strip conductor and compression-bonded thermosetadhesive insulation paper to provide exceptional protection from potentially damaging through-fault conditions.

Cores are manufactured from high quality grain-oriented silicon steel. Laminations are cut and assembled using a distributed-gap process to produce a low reluctance joint. A sturdy clamping assembly effectively secures the core and coils.

Tap Changer

All SVR-1 regulators feature rugged gear-driven tap changers (Figure 5). The tap-changing mechanism and current-carrying contacts are designed to provide exceptional reliability and long service life exceeding one million mechanical operations. The tap changer uses an electric motor, gear train, and spring drive to provide quick, reliable operation. The switch is mechanically coupled to the external tap position indicator (Figure 6) to provide visual indication of the switch position.

Figure 5: Tap changer Mechanism

Tap Position Indicator

The tap position indicator (Figure 6) is located on the cover-mounted terminal block enclosure and is directly connected to the tap changer by a flexible drive shaft. The indicator dial plate is marked in 32 steps, 16 each on the RAISE and LOWER segments of the dial. The “zero” mark designates the neutral position. Drag hands follow the pointer and indicate the pointer’s maximum and minimum positions since the last reset. Drag hands can be reset using the drag hand reset switch on the front panel of the control unit. HI-AMP™ limit switches are mounted on either side of the position indicator.

Figure 6: Tap position indicator

HI-AMP™ Feature

The HI-AMP’” Feature allows SVR-1 regulators to handle increased current capacity by reducing the regulation range. This is accomplished by setting the raise (boost) and lower (buck) limit switches (Figure 7) located on the tap position indicator to prevent the tap changer from traveling above or below the desired settings. Scales on the limit switches are graduated in percent regulation, including 5%, 6-1/4%m 7-1/2%, 8-3/4% and 10% regulation settings. Table 2 (Page 7) lists the load current and regulation ranges available with the HI-AMP ™ feature. At each setting, a detent stop provides positive adjustment. Upper and lower limits need not be the same.

Upper and lower limits can also be implemented with the digital control unit.

FIGURE 7: HI-AMP’” limit switches (one located on each side of tap position indicator)

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SURGE ARRESTERS

Series Arrester

Each SVR-1 regulator is equipped with an appropriately sized MOV-type surge arrester connected between the source and load bushings (Figure 4). This series arrester (also known as a bypass arrester) is provided to protect the series winding of the regulator from damage due to line surges, such as can result from lightning, switching surges, and line faults. The series arrester alone does not provide complete lightning protection. For more complete protection, option shunt arresters should be installed.
Shunt Arresters

MOV surge arresters are available as an option on the SVR-1 regulator to provide protection for the shunt winding. Shunt arresters are mounted on the regulator tank adjacent to the load bushing and the source bushing. Each arrester is connected between the bushing terminal and ground.

Table 1: Load Current and KVA Ratings, 60 Hz

Voltage (kV)	Load Current (Amperes)	kVA
2.5 kV 60 kV BIL	200 300 400 500 668 1000 1332 1665	50 75 100 125 167 250 333 416
5.0 kV 75 kV BIL	100 150 200 250 334 500 668 833	50 75 100 125 167 250 333 416
7.62 kV 95 kV BIL	50 75 100 150 219 328 438 546 656 875 1093	38 57 76 114 167 250 333 416 500 667 833
13.8 kV 95 kV BIL	50 100 150 200 300 400 483 604	69 138 207 276 414 552 667 833
14.4 kV 150 kV BIL	50 100 200 231 300 400 463 578	72 144 288 333 432 576 667 833
19.92 kV 150 kV BIL	50 100 167 200 335 418 502	100 200 333 400 667 833 1000

[1] 55/65 • C rating allows additional 12% increase In capacity, If the tap changer's maximum current rating has not been exceeded. For loading in excess of the values listed above, contact the Howard Industries Regulator Division.

Table 2: HI-AMP™ Capabilities, 60 Hz

Rated Volts	Rated kVA	Load Current (Amperes)[1]				
		Regulator Range				
		±10%	±8-3/4%	±7-1/2%	±6-1/4%	±5%
2.5 kV 60 kV BIL	50	200	220	240	270	320
	75	300	330	360	405	480
	100	400	440	480	540	640
	125	500	550	600	668	668
	167	668	668	668	668	668
	250	1000	1000	1000	1000	1000
	333	1332	1332	1332	1332	1332
	416	1665	1665	1665	1665	1665
5.0 kV 75 kV BIL	50	110	110	120	135	160
	75	150	165	180	203	240
	100	200	220	240	270	320
	125	250	275	300	336	400
	167	334	367	401	451	534
	250	500	550	600	668	668
	333	668	668	668	668	668
	416	833	833	833	833	833
7.62 kV 95 kV BIL	38.1[2]	50/53	55/58	60/63	68/72	80/85
	57.2[2]	75/79	83/88	90/95	101/95	120/127
	76.2[2]	100/106	110/116	120/127	135/143	160/169
	114.3[2]	150/159	165/175	180/190	203/215	240/254
	167[2]	219/232	241/255	263/278	296/313	350/370
	250[2]	328/347	361/382	394/417	443/469	525/556
	333[2]	438/464	482/510	526/557	591/625	668
	416[2]	548/580	603/638	658/668	668	668
	500[2]	656/668	668	668	668	668
	667[2]	875/926	875/926	875/926	875/926	875/926
	833[2]	1093/1157	1093/1157	1093/1157	1093/1157	1093/1157
13.8 kV 95 kV BIL	69	50	55	60	68	80
	138	100	110	120	135	160
	207	150	165	180	270	240
	276	200	220	240	312	320
	414	300	330	360	405	480
	552	400	440	480	540	640
	667	483	531	580	625	668
	833	604	664	668	668	668
14.4 kV 150 kV BIL	72	50	55	60	68	80
	144	100	110	120	135	160
	288	200	220	240	270	320
	333	231	254	277	312	370
	432	300	330	360	405	480
	576	400	440	480	540	640
	667	463	509	556	625	668
	833	578	636	668	668	668
19.92 kV 150 kV BIL	50	25	28	30	34	40
	100	50	55	60	68	80
	200	100	110	120	135	160
	333	167	184	200	225	267
	400	200	220	240	270	320
	667	335	369	402	452	536
	833	418	460	502	564	668

[2] SVR-1 regulators are capable of carrying current corresponding to the rated kVA when operated at 7200 Volts,

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