



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: 50 through 833
- 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 single-phase step voltage regulator

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 core-and-coil assembly) is mounted to the cover (Figure 2). This construction simplifies removal of the internal assembly for inspection, maintenance, and repair.

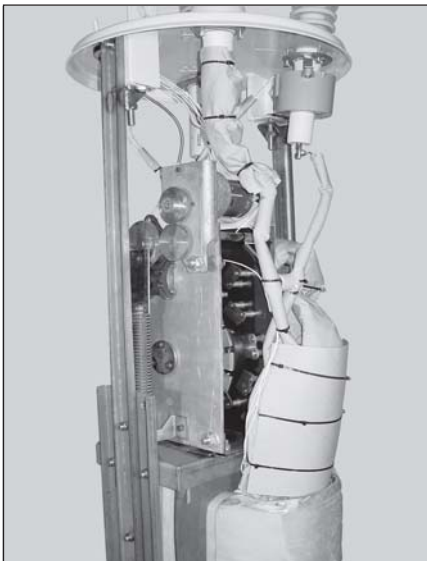


FIGURE 2: Internal assembly

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
- HI/ICMI UVR-1 digital regulator control (refer to description below)
- Digital processing and nonvolatile flash technology data storage with Motorola 32-bit processor
- Mil-spec modular design with Mil-std I-46085 conformal coated circuit boards
- Solid-state tap-changer relays
- 304 stainless-steel panel/shield
- Bright white/blue LCD high-visibility display
- Super-bright LED indicators, including High Band, In Band, Low Band, High Limit, Low Limit, Voltage Reduction, Reverse Power, Neutral Position, and Alert
- DNP 3.0 Level 2, report-by-exception communications protocol with ACS worldwide certification
- Multiple, inter-operable communications ports, including RS-232, IEEE-485 two- and four-wire, front panel serial program port, fiber optic interface, ethernet capable TCP/IP (optional), Blue Tooth wireless (optional), and eight-port input/output board (optional)
- Certifications: radio frequency interference withstand capability per ANSI/IEEE C37.90.2 (1987),

### 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
- PT's and CT's for external metering
- Elevating platform
- Control enclosure heater
- 4-hole NEMA H-spade connectors
- Cooling fans
- 240-Volt external source
- Powder coated stainless steel tank, cover, clamp ring, and control enclosure
- HI/ICMI USC-1 simplified regulator control
- Beckwith M-2001C digital regulator control

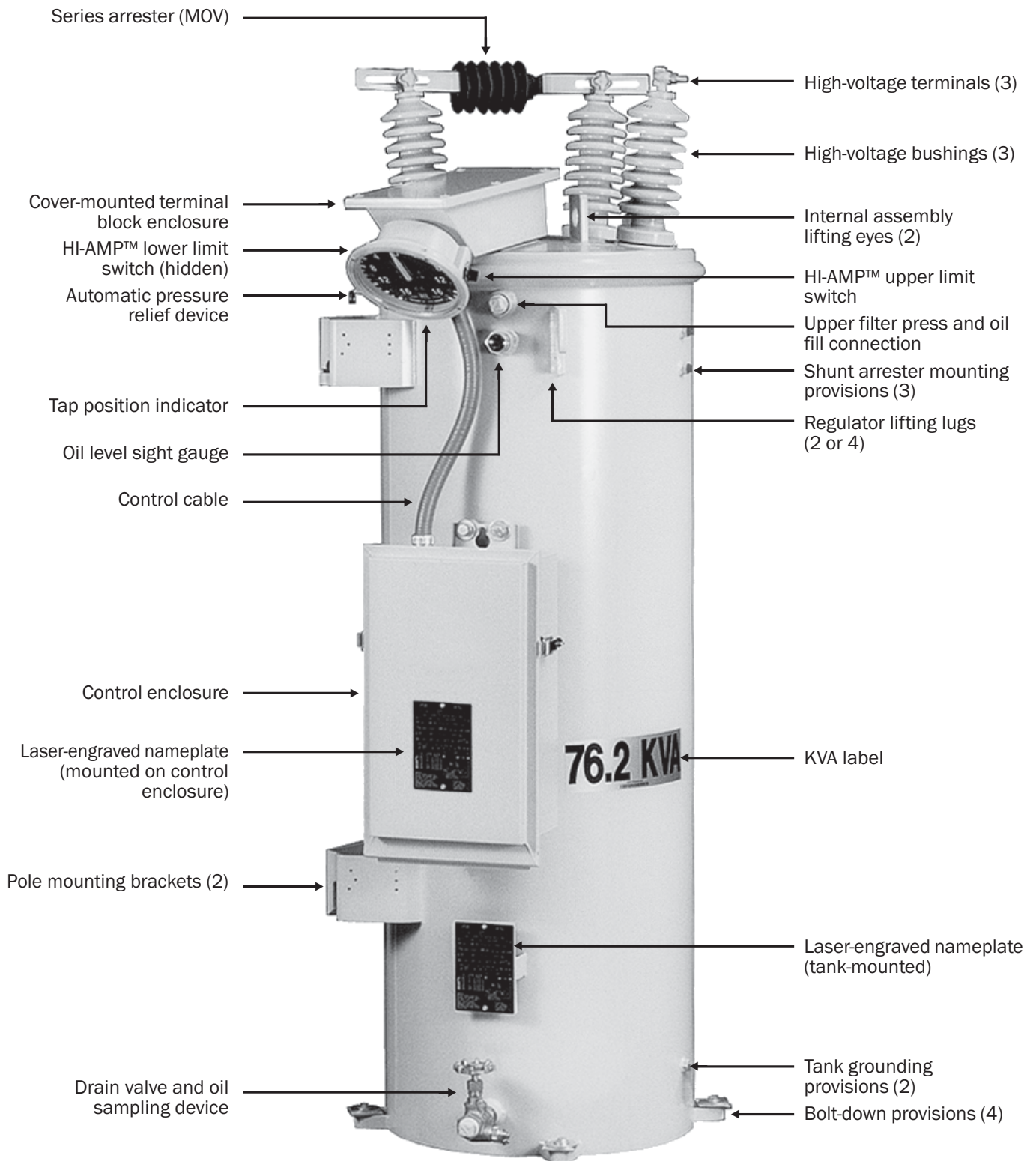
### HI/ICMI UVR-1 CONTROL

The HI/ICMI UVR-1 digital regulator control (Figure 3) has the following standard features and options:

(Continued on Page 4)



FIGURE 3: HI/ICMI UVR-1 Control



**FIGURE 4:** SVR-1 single-phase step voltage regulator standard features and accessories (overhead type shown)



electrostatic discharge withstand capability per IEC 61000-4-2 (1995-2001), oscillatory surge and fast transient surge withstand capabilities per ANSI C37.90.1 (2002), metering accuracy per IEEE C57.15 (1999) of 0.3% from  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  (excluding VT/CT errors)

- User-friendly scrolling control navigation with complete menu chart (minimizes obsolescence)
- Comprehensive controller programs on CD-ROM including Quick Start, Control Configure, DNP Point Configure, Data Log, Tap Contact Log, and Program Loader, with customer upgradeable expansion capability
- Front panel serial port
- Comprehensive control self-test capability and protection safeguards
- Front panel controls including automatic/manual motor control switch, manual raise/lower switch, drag-hand reset switch, local/remote control switch, and internal/external voltage source switch
- Panel-mounted fuses
- External voltage source terminals
- Voltage test terminals
- Line drop compensation R, X
- Temperature controller with settable levels for high and low temperature,  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$
- Sequential and time-integrating regulation algorithms
- Reverse power capability without need for internal potential transformer
- Multiple modes of operation including Locked Forward, Locked Reverse, Idle Reverse, Bidirectional, Neutral Reverse, and Cogeneration
- Adjustable high- and low-voltage limits with automatic runback (first house protection)

## 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  $65^{\circ}\text{C}$  rise insulation system in  $55^{\circ}\text{C}$  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 thermoset-adhesive 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.

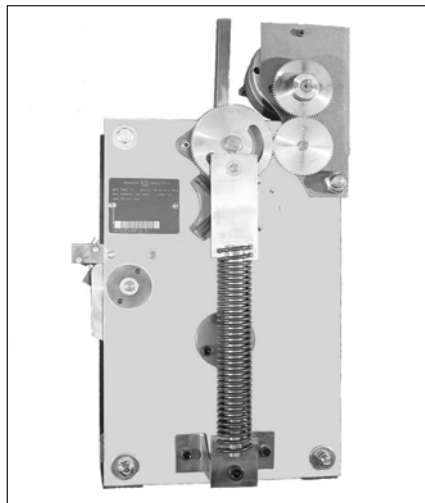


FIGURE 5: Tap changer mechanism



FIGURE 6: Tap position indicator

### 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.

### 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.

### 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%, 7-1/2%, 8-3/4% and 10% regulation settings. Table 2 (Page 6) 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)

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

**TABLE 2:**  
HI-AMP™ Capabilities, 60 Hz.

Rated Volts	Rated kVA	Load Current (Amperes) <sup>1</sup>				
		Regulator Range				
		±10%	±8-3/4%	±7-1/2%	±6-1/4%	±5%
2.5 kV	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	50	100	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	38.1 <sup>2</sup>	50/53	55/58	60/63	68/72	80/85
	57.2 <sup>2</sup>	75/79	83/88	90/95	101/95	120/127
	76.2 <sup>2</sup>	100/106	110/116	120/127	135/143	160/169
	114.3 <sup>2</sup>	150/159	165/175	180/190	203/215	240/254
	167 <sup>2</sup>	219/232	241/255	263/278	296/313	350/370
	250 <sup>2</sup>	328/347	361/382	394/417	443/469	525/556
	333 <sup>2</sup>	438/464	482/510	526/557	591/625	668
	416 <sup>2</sup>	548/580	603/638	658/668	668	668
	500 <sup>2</sup>	656/668	668	668	668	668
	667 <sup>2</sup>	875/926	875/926	875/926	875/926	875/926
	833 <sup>2</sup>	1093/1157	1093/1157	1093/1157	1093/1157	1093/1157
13.8 kV	69	50	55	60	68	80
	138	100	110	120	135	160
	207	150	165	180	203	240
	276	200	220	240	270	320
	414	300	330	360	405	480
	552	400	440	480	540	640
	667	483	531	580	652	668
	833	604	664	668	668	668
14.4 kV	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	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
34.5 kV	50	50	55	60	68	80
	100	100	110	120	135	160
	150	150	165	180	203	240
	200	200	220	240	270	320

<sup>1</sup> 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.

<sup>2</sup> SVR-1 regulators are capable of carrying current corresponding to the rated kVA when operated at 7200 Volts.



## **SVR-1 Single-Phase Step Voltage Regulators**

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