Distribution voltage regulators

Type JFR™ single-phase 2.5 to 19.9 kV
Type SFR™ three-phase 13.2 to 34.5 kV

Answers for energy.

SIEMENS

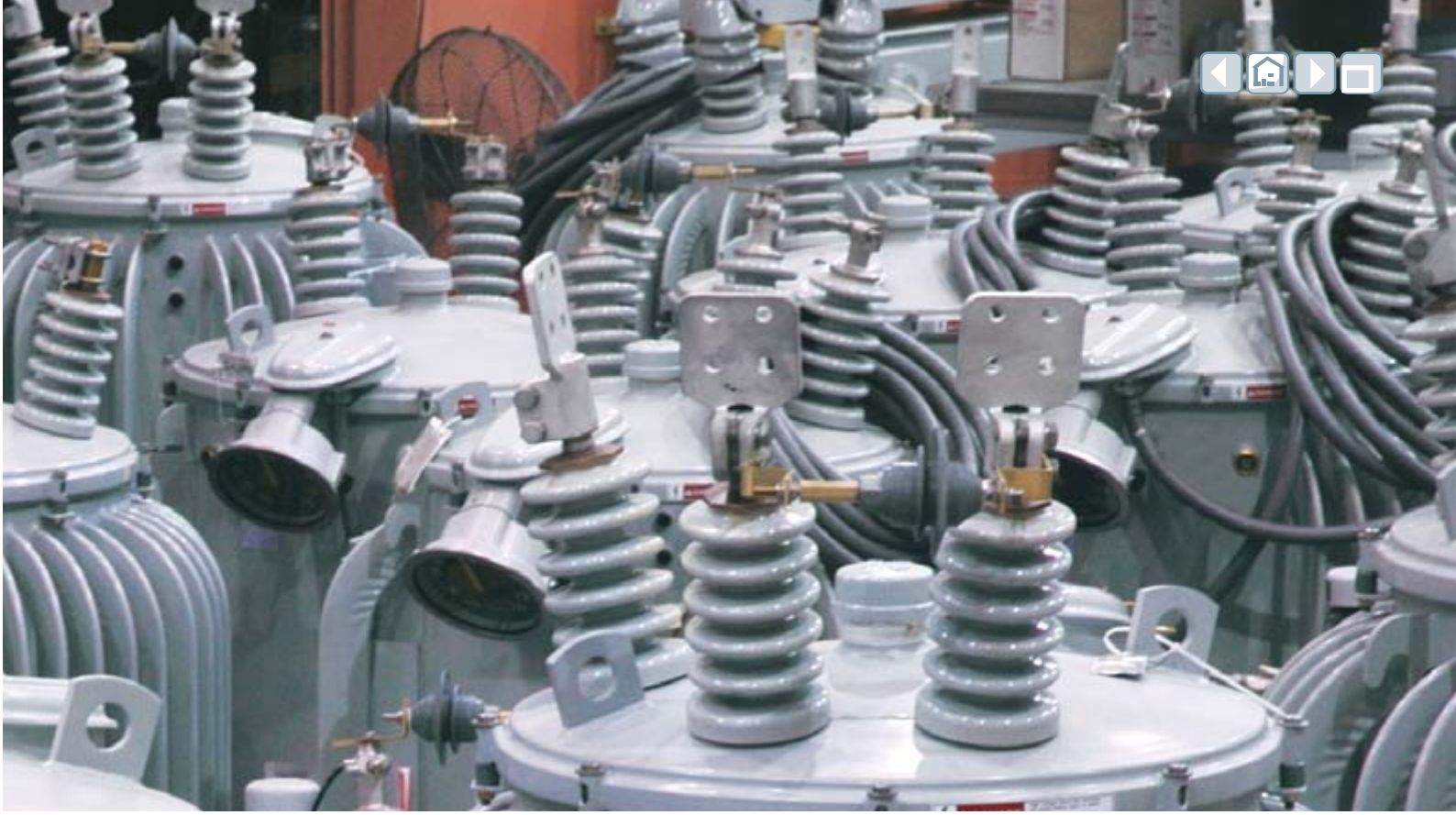
Siemens JFR and SFR voltage regulators

Improving quality of service and increasing utility revenues

Utility companies invest enormous amounts of resources in plant and equipment to assure enough capacity to meet their peak demand, which occurs for a limited time. During the non-peak times, that investment remains under-utilized.

Step voltage regulators can improve the return on utility investment by increasing demand at off peak periods and, with certain accessories, even reduce the demand peak load. This translates into improved revenue for the utility company while also improving the quality of service to the end user—the customer.

The step-type voltage regulator takes an incoming voltage that will vary with load conditions and maintains a constant output voltage. As the loading increases along the distribution feeder, the voltage will drop. This reduction in voltage reduces the amount of power used by the lighting portion of the load. By increasing the voltage to this load, additional power is consumed. This increased power translates into increased revenue for the utility company. The same principle can work for the utility company when it needs to reduce the voltage by a predetermined amount, thus reducing the overall power demand and delaying capital investments to meet peak demand.



Combining cutting-edge technology with decades of experience

For over a half century Siemens has led voltage regulator technology, continuously refining and improving its reliable, sturdy and innovative regulator product line. Pioneered in 1933, the 5/8% step voltage is now considered to be an industry-wide standard. Siemens led the way to innovations such as static controls and the evolution of state-of-the-art microprocessor-based control panels.

Siemens gives you a full range of ratings for most system voltages and current applications. Siemens supplies everything from the smallest single-phase pole mount units to large substation regulators. When it comes to voltage regulation, Siemens provides technology that serves the customer. Our manufacturing experience for voltage regulators and controls is unsurpassed in the industry. Today Siemens has the largest population of installed regulators worldwide.

Voltage regulation

Generator

As the generator is loaded, the load current flows through the impedance of the armature winding causing a voltage drop that vectorially subtracts from generated voltage.

Transformers

Under load, the terminal voltage of a generator differs from the generated voltage, depending upon the impedance of winding and power factor of load. Since most loads are lagging, the output of a generator usually drops as load is added.

Feeders

A line has series impedance as well. A line has resistance and reactance, both capacitive and inductive, distributed all along its length. On shorter lines capacitive effect is negligible, so as the load increases, the impedance drop increases and the receiving end voltage is smaller.

When a line is sufficiently long, the capacitive effect becomes appreciable and is subject to both high- and low-voltage conditions.

Since every component on the system is subject to regulation, the variation at the input terminals of the individual consumer is a vectorial summation of all of the variations that occur from generator to consumer.

Voltage regulation

Why the interest in voltage?

We see that most utility and industrial electrical distribution systems present problems with the voltage supplied to their loads. Progressive expansion, load growth and economic considerations eventually impose voltage conditions on these systems that are less than ideal. This can cause electric equipment to operate at reduced efficiency and overall power costs to rise. Increased industrial use of electronic equipment with demand for voltage within critical limits compounds the problem. As a feeder is loaded, the load current causes an impedance drop that subtracts from the voltage impressed on the feeder, resulting in a low-voltage condition. This is the voltage at the customers' terminals and is the voltage at which he is buying power.

It is advantageous to minimize this voltage drop in the line so that the voltage at the load is at the rated value or as near to the rated value as possible.

Hence, voltage correction methods described herein are required.

Voltage correction methods

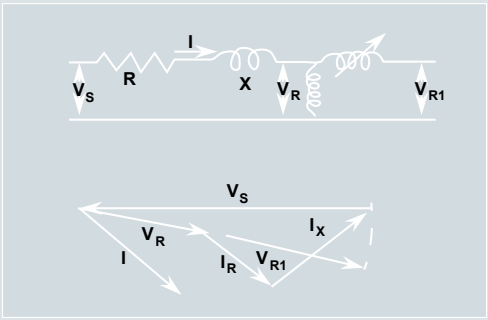
There are four possible methods for voltage correction:

- Reduce the series resistance and reactance
- Reduce the load current
- Use power factor correction
- Use voltage regulation.

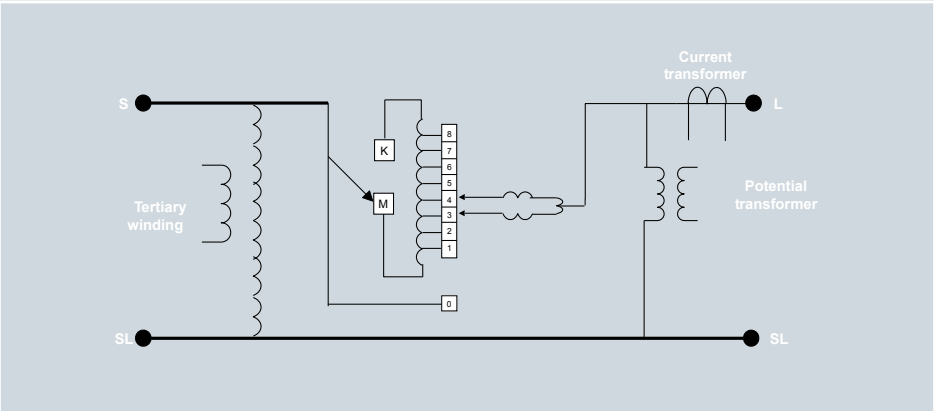
The first two options require high capital investment, high installation costs and long lead times.

The third option uses shunt capacitors along the feeders to correct power factor, but the voltage improvement is between 2-3%, usually not sufficient to correct most voltage problems.

In order to continuously regulate voltage in real-time by increasing or decreasing the source voltage, installation of voltage regulators provides the optimum solution. The application of the unit to the feeder is shown in the schematic, and its operation is pictorially shown in the vector diagram.



Introduction to voltage regulators



An auto-transformer is a transformer in which primary and secondary windings are coupled both magnetically and electrically as seen above. An input of 100 V will be stepped up to 110 V if the secondary winding is connected in to the high side of the primary winding in series. This is a step-up auto-transformer. When the other end of the secondary winding is connected to the primary winding in reverse polarity, the output will read 90 V for an input of 100 V. This is a step-down auto-transformer.

Using a raise/lower switch, it is possible to obtain both of these functionalities with a regulation range of 20%.

As discussed above, the voltage can be either raised or lowered in one 10% step. Finer regulation can be obtained by switching the series winding in smaller increments. If the series winding of this unit is connected in the raise direction and is tapped in eight equal increments, the voltage can be raised in small steps of 1-1/4%. However, a discontinuity results during each change from one tap to the next.

To eliminate the discontinuity during tap change, two moving fingers are mechanically ganged together to operate as a unit. The two moving fingers are connected together through a preventive auto-transformer so as not to place a short on the windings between the two tap positions.

Hence, voltage regulators are modified step-type auto-transformers with a preventive transformer and raise/lower switch.

Load tap change (LTC) versus voltage regulator

- Time-intensive installation and higher cost compared to voltage regulator
- Entire transformer has to come offline instead of remaining energized while only voltage regulators are taken offline
- Change out completed in hours with voltage regulators rather than days

Benefits

Stable supply voltages are critical for:

- Distribution grids
- Chemical and material processing plants
- Food and beverage plants
- Pharmaceutical plants
- Highly automated processes
- Hospitals
- Hotels
- Data centers
- Shopping malls.

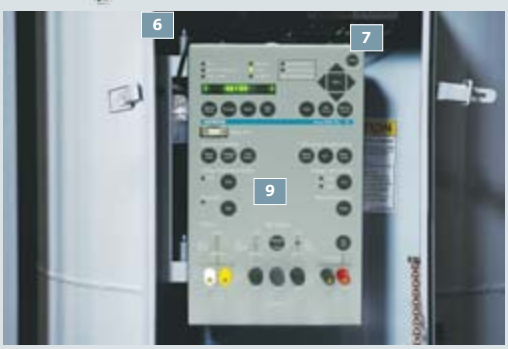
Installation of voltage regulators results in:

- Energy savings from higher efficiency and reduced system losses
- Extends life of equipment
- Centralized medium-voltage correction for an entire site
- Prevents damage to motors and automated equipment
- Reduced operation of diesel generators for stable voltage supply (lower operating cost)
- Prevents interruption of critical processes due to out-of-tolerance voltage supply.

Technical benefits of voltage regulators include:

- Flexibility with custom designs (including ±10%, ±15% and ±20%)
- Fine control with 32-step tap changer
- More robust and economical solution than capacitors and low-voltage stabilizers
- Up to 25 MVA load can be regulated by three single-phase regulators
- Installation of a voltage regulator is even simpler than a distribution transformer
- Long service life (typically 25+ yrs)
- Robust Siemens spring-drive mechanical tap changer
- All maintenance can be performed on site without load interruptions (with use of bypass switch).

JFR™ single-phase voltage regulator



1	Electrostatically-applied polyester paint gives greater resistance to corrosion in harsh environments.
2	Type 316 stainless steel external hardware is standard on all JFR models to eliminate rust and galling.
3	Sealed tank has pressure relief device to vent gases produced during tap changes. With the 65 °C insulation system, Siemens 55 °C rise regulators can be loaded up to 12 percent above nameplate rating.
4	External metal oxide varistor (MOV) bypass arrester gives superior protection to the regulator series winding from surge and system transients.
5	Oil sight gauge allows oil levels and oil conditions to be checked without de-energizing the regulator.
6	Motor capacitor installed in the control cabinet allows replacement without bypassing and taking the regulator out of service.
7	Polarized disconnect switch (PDS) facilitates easy control installation or change out without taking the regulator out of service.
8	Cover-mounted terminal block provides easier access to wiring by eliminating the need to go under oil to change tap connections.
9	Monitor and automatically control output voltage through the use of state-of-the-art microprocessor control panels MJ-4A™.
10	High creep bushings provide a minimum creep distance of 17 inches.
11	Oil drain valve that includes an oil sampling valve for easy access.
12	Platform base is equipped with provisions to securely attach regulator to sub-base assembly.

JFR modifications capabilities

External modifications

Line terminals

- Special ground pads/connectors
- Lowered control enclosure

Special ultra-creep bushings

- Thermometers or fans (if possible)
- Special drain valves
- Nameplate changes/modifications

Internal modifications

- Source-side potential transformer (not required with MJ-4A Control)
- Special current transformers

Accessories

- Remote mounting cables (15'-50')
- Substation bases
- Lightning arrester
- Bird guards
- Auxiliary potential transformer
- Auxiliary current transformer
- Bypass switches
- Paralleling balancers

Siemens type JFR™ single-phase distribution voltage regulators

Technical information **50 Hz applications**

Voltage class (kV) BIL (kV)	Load current (Amps)	KVA	Catalog no.
6.6 kV 95 kV BIL	75	50	10-06.6-050.0
	100	66	10-06.6-066.0
	150	99	10-06.6-099.0
	219	144	10-06.6-144.0
	328	216	10-06.6-216.0
	438	289	10-06.6-289.0
	546	360	10-06.6-360.0
	656	433	10-06.6-433.0
	875	578	10-06.6-578.0
	1,167	770	11-06.6-770.0
11 kV 95 kV BIL	50	55	10-11.0-055.0
	100	110	10-11.0-110.0
	150	165	10-11.0-165.0
	200	220	10-11.0-220.0
11 kV 150 kV BIL	50	55	10-11.0-055.0A
	100	110	10-11.0-110.0A
	200	220	10-11.0-220.0A
	300	330	10-11.0-330.0A
	400	440	10-11.0-440.0A
	463	509	10-11.0-509.0A
	500	550	11-11.0-550.0A
	578	636	10-11.0-636.0A
15 kV 150 kV BIL	50	75	10-15.0-075.0
	100	150	10-15.0-150.0
	167	251	10-15.0-251.0
	200	300	10-15.0-300.0
	335	503	10-15.0-503.0
	418	627	10-15.0-627.0
22kV 150 kV BIL	100	220	10-22.0-220.0
	150	330	10-22.0-330.0
	200	440	10-22.0-440.0

Notes:

1. Above units are single-phase units manufactured and tested per ANSI C57.15

2. Units with catalog number starting with:

10 = self-cooled

11 = forced air-cooled

Voltage class (kV) BIL (kV)	Load current (Amps)	KVA	Catalog no.
2.5 kV 60 kV BIL	400	100	10-02.5-100.0
	668	167	10-02.5-167.0
	1,000	250	10-02.5-250.0
	1,332	333	10-02.5-333.0
	1,665	416.3	11-02.5-416.3
7.6 kV 95 kV BIL	50	38.1	10-07.6-038.1
	75	57.2	10-07.6-057.2
	100	76.2	10-07.6-076.2
	150	114.3	10-07.6-114.3
	219	167	10-07.6-167.0
	328	250	10-07.6-250.0
	438	333	10-07.6-333.0
	548	416.3	10-07.6-416.3
	656	500	10-07.6-500.0
	875	667	10-07.6-667.0
	1,167	889	11-07.6-889.0
13.8 kV 95 kV BIL	50	69	10-13.8-069.0
	100	138	10-13.8-138.0
	150	207	10-13.8-207.0
	200	276	10-13.8-276.0
14.4 kV 150 kV BIL	50	72	10-14.4-072.0
	100	144	10-14.4-144.0
	200	288	10-14.4-288.0
	231	333	10-14.4-333.0
	300	432	10-14.4-432.0
	400	576	10-14.4-576.0
	500	720	11-14.4-720.0
	578	833	10-14.4-833.0
19.9 kV 150 kV BIL	50	100	10-19.9-100.0
	100	200	10-19.9-200.0
	167	333	10-19.9-333.0
	200	400	10-19.9-400.0
	335	667	10-19.9-667.0
	418	833	11-19.9-833.0

Notes:

1. Above units are single-phase units manufactured and tested per ANSI C57.15

2. Units with catalog number starting with:

10 = self-cooled

11 = forced air-cooled

SFR™ and SFR-X™

As a vertically integrated manufacturer of three-phase regulators, Siemens offers distinct advantages.

All of our three-phase regulators are engineered and manufactured in-house.

Our expertise in both technology and service gives us an additional advantage in the custom engineering necessary for most three-phase regulator applications. The SFR voltage regulator has proven its reliability and durability in the toughest environments. Unit construction, tough paint and side inspection door are just a few of the time-tested features of today's SFR™.

In addition, Siemens offers the popular SFR-X, which features a separate tap-changing mechanism compartment, allowing for easy inspection and maintenance. Separating the regulator tap changer significantly increases the life of the regulator by eliminating arcing in the main tank containing the coil and core.

SFR modifications include:

- Pressure relief device
- Lightning arrester brackets
- Magnetic type liquid level indicator
- Magnetic temperature indicator
- Special bushings
- MR tap changer
- Separate tap changer compartment (available with SFR-X™ and SFR-MR)
- Customized controls
- Special CT/PT
- Station class arresters.

Siemens type SFR™ three-phase distribution voltage regulators

Technical information **50 Hz applications**

Voltage class (kV)	Load current (Amps)	KVA	Catalog no.
11 kV	219	417	40-11.0-0417
	328	625	40-11.0-0625
	437	833	40-11.0-0833
	656	1,250	40-11.0-1250
	874	1,667	40-11.0-1667
	1,093	2,083	40-11.0-2083
	1,200	2,477	40-11.0-2477
11 kV	274	521	41-11.0-0521
	410	781	41-11.0-0781
	546	1,042	41-11.0-1042
	874	1,667	41-11.0-1667
	1,166	2,222	41-11.0-2222
	1,458	2,777	41-11.0-2777
	1,750	3,333	41-11.0-3333
22 kV	84	319	40-22.0-0319
	167	638	40-22.0-0638
	251	957	40-22.0-0957
	335	1,275	40-22.0-1275
22 kV	105	398	41-22.0-0398
	209	797	41-22.0-0797
	335	1,275	41-22.0-1275
	446	1,701	41-22.0-1701

Technical information **60 Hz applications**

Voltage class (kV)	Load current (Amps)	KVA	Catalog no.
13.2 kV	219	500	40-13.2-0500
	328	750	40-13.2-0750
	437	1,000	40-13.2-1000
	656	1,500	40-13.2-1500
	874	2,000	40-13.2-2000
	1,093	2,500	40-13.2-2500
	1,200	2,972	40-13.2-2972
13.2 kV	274	625	41-13.2-0625
	410	937	41-13.2-0937
	546	1,250	41-13.2-1250
	874	2,000	41-13.2-2000
	1,166	2,667	41-13.2-2667
	1,458	3,333	41-13.2-3333
	1,750	4,000	41-13.2-4000
34.5 kV	84	500	40-34.5-0500
	167	1,000	40-34.5-1000
	251	1,500	40-34.5-1500
	335	2,000	40-34.5-2000
34.5 kV	105	625	41-34.5-0625
	209	1,250	41-34.5-1250
	335	2,000	41-34.5-2000
	446	2,667	41-34.5-2667

MJ-4A™ voltage regulator control panel

The MJ-4A voltage regulator control panels are the ultimate feature-rich monitoring and data communications tool, designed to save you time and money. The user-friendly MJ-4A provides substantial cost savings to utilities by providing quick, flexible voltage reduction to lower actual demand during peak periods.

Features include the following:

- Predictive maintenance
- Tap changer contact wear status
- Duty cycle monitor
- Fast-path keys for immediate accessibility to the most commonly used functions
- Easy-to-use menu structure for panel configuration in three easy steps
- Convenient communications capabilities including data port, communication module and remote access via laptop computer or SCADA
- Customizable quick key allows the creation of a quick list to the users' most frequently accessed screens.

The powerful 32-bit microprocessor MJ-4A™ control panels can be retrofitted to all manufacturers' regulators eliminating costly and time-consuming replacements. The control panels mount into existing control cabinets and include all retrofit interface circuits. They're backed by Siemens' superior technical and field support, extensive on-site customer training and on-going assistance.

1	Highly visible LED display
2	Local data port
3	Dedicated fast-path function keys
4	Voltage reduction and voltage limit
5	Neutralite test button
6	Quick key
7	Voltage select key
8	Counters and electronic tap position fast-path key
9	Dedicated fast-path alert key
10	Easy-to-use keypad menu
11	Carry handle
12	Remote/local key
13	Maintenance fast-path key

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