

An aerial photograph of a lush green mountain range. Several high-voltage power line towers are visible, with power lines stretching across the landscape. The background shows more mountains under a hazy sky. In the top left corner, there is a white rectangular box containing the Siemens logo.

**SIEMENS**

# Line surge arresters for increased system reliability

[www.siemens.com/energy/arrester](http://www.siemens.com/energy/arrester)

Answers for energy.



# System reliability and better performance

## Improve the performance of your transmission system

### Reliability is increasingly important

Around the world, the growing demand for power has resulted in the need for existing networks to handle ever-greater capacities, sometimes even reaching their upper limits. Due to these factors, it is becoming increasingly difficult to responsibly and reliably operate a network.

In many markets, there is already a risk of liability for network operators, who are liable for compensation in the case of power failures. And natural events like lightning can cripple entire networks. That's why many network operators are seeking solutions that can help them increase the reliability of their networks. Expansion, retrofitting, and protection – for greater reliability.

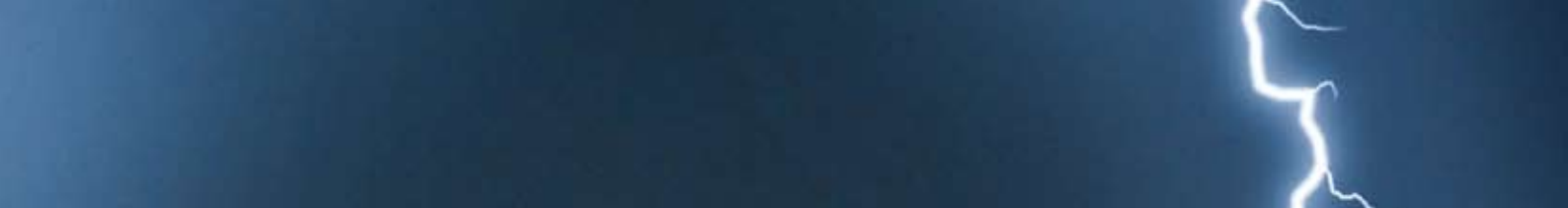
There are basically three options for improving network protection:

- Expansion of network capacities
- Installation of additional ground wires
- Use of surge arresters on hazardous stretches of line

Attempts to expand network capacities often fail during the approval process as frequently as they are rejected for cost reasons, particularly in densely populated or undeveloped areas.

Even the use of compact lines is not very helpful, because their reduced conductor spacing leads to serious problems in the case of lightning strikes. One alternative is to equip hazardous sections with additional ground wires wherever ground resistance is especially high. This usually results in significant problems and costs in high lightning areas such as mountains and plateaus.





A more affordable solution is the use of surge arresters, which can be used to respond in a graduated fashion to the potential hazard. The graphic on page 5 shows how the frequency of faults associated with lightning strikes decreases, depending on the ground resistance, when adding more surge arresters to protect the transmission line and therefore the connected systems.

Surge arresters are easy to transport and install even in difficult terrain. Along with a special installation kit, surge arresters help create a perfect system. And Siemens offers more. By working closely with an experienced power-line installer, Siemens provides the best possible results for all your applications – from system design to the final installation.





# Simulation

## Take advantage of the benefits for applications up to 800 kV

An optimal selection of line surge arresters, especially in terms of their quantity and installation locations, can have a significant impact on a system's long-term success.

The installation of line surge arresters on every tower along the entire line as well as on every single phase ensures complete lightning protection.

Siemens optionally offers software analysis (simulation) based on Cigré studies to examine and conduct preliminary tests of customer-specific applications as a way of determining the optimal, cost-effective solution. With this approach, the customer only needs to equip particular phases or individual line segments with line surge arresters, and can still ensure sufficient lightning protection of the overhead line and reduce network failures.

One particular benefit of this approach is that outstanding results can be achieved while investing only a fraction of the amount that would otherwise be required to install the maximum amount of equipment.

In the first phase of an analysis, all important parameters of the transmission line under study are entered into the simulation software, and the installations to be examined are selected. This approach takes the following factors into consideration:

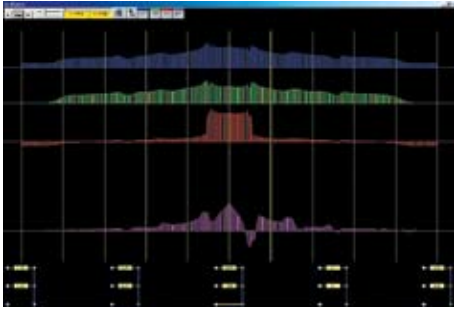
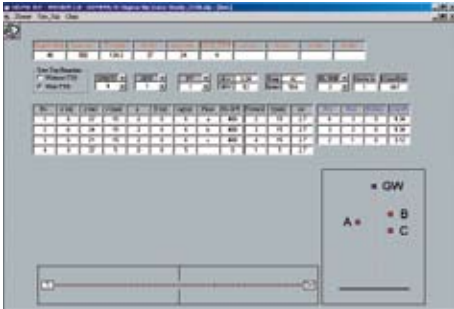
- Line parameters: operating voltage, number of three-phase circuits, ground wire data, length, span length and sag of the line, conductor type, diameter, and clearances

- Tower data: tower surge impedances and footing resistance, tower geometry (position and distances of the individual phases and any existing ground wires), as well as soil impedance
- Insulator data: arcing distance, connection length, rated lightning impulse withstand voltage
- Lightning activity: ground flash density (lightning strokes per year and km<sup>2</sup>) or keraunic level (thunderstorm days per year)
- Customer priorities: fewer short interruptions, prevention of phase and multisystem short circuits, elimination of ground wires

The software individually simulates up to eight different installation cases regarding positions of the line surge arresters in the phases to be protected in order to determine the most effective configuration. In addition, the software divides the line into segments (depending on the line topology or distribution of the tower footing resistances along the line) and varies the installation of the line surge arresters depending on the number of towers to be equipped.

After the simulation runs, a second phase of the analysis evaluates all the data. In a third phase, proposals are developed for an optimal solution.

These proposals are offered in consultation with the customer in order to jointly arrive at the best equipment strategy.



### The easy path to a customer solution:

#### Analyze the specific line characteristics

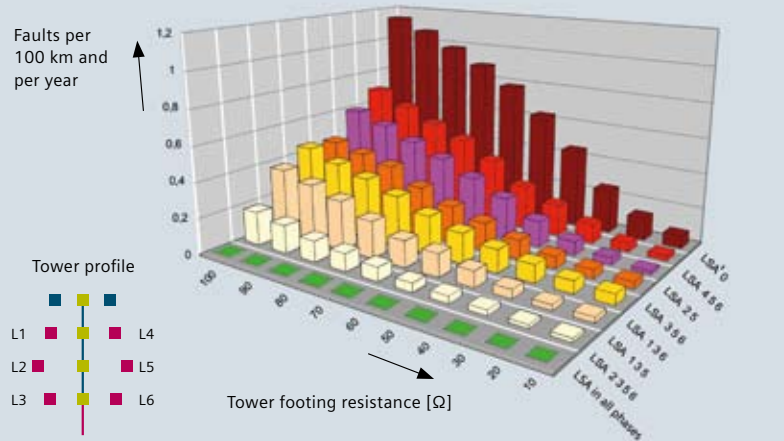
- Electric line parameters
- Geometric line parameters
- Ground flash density or keraunic level (strokes/km<sup>2</sup>/year or thunder days/year)
- Tower footing resistance
- Amount of real network faults caused by lightning

#### Proposals from Siemens

- Arrester type
- Advice regarding optimum protection strategy (including number of towers to be protected, selection of phases)

#### Installation

#### Analysis example of a double three-phase system



<sup>1</sup>LSA: Line Surge Arrester





# Security for your transport network

## Superior technology for optimal protection

**The best technology for your security**  
Arresters are designed to divert harmful overvoltages in order to keep them away from the components of a transmission network. These overvoltages can be caused either by lightning strokes terminating directly to or nearby the overhead power line, or they may be generated by switching operations.

The operation of surge arresters is based on the property of certain metal-oxide blocks which reduce their own resistance within nanoseconds in case of overvoltage, making it possible to safely clamp down the overvoltage. In normal operating line conditions, when there is no overvoltage, the higher resistance of the metal-oxide blocks (MO blocks) in the arresters causes them to act as insulators.

There is a basic distinction between arresters with porcelain housings and those with silicone housings. Compared to the considerably heavier and more brittle porcelain housings, silicone housings offer significant benefits when it comes to installation and operation. Silicone is not only flexible and weather-resistant, it also retains its hydrophobic ability to repel dirt and water throughout its entire lifetime. Thanks to these properties, leakage currents do not pose any problem – and the arresters are better protected against physical damage and vandalism.

When it comes to investing in the reliability and security of your transmission lines, you are absolutely right to demand

the highest level of performance. That is why we offer our arresters for voltages up to 550 kV in a Cage Design™ and in a Siemens tube design for higher voltages up to 800 kV. What these two designs have in common is the vulcanized silicone rubber housing, which effectively protects against air pockets, moisture penetration, and leakage currents.

### **The Siemens Cage Design**

The Cage Design from Siemens offers numerous advantages in terms of arrester technology, resulting in a big payoff for customers. For example, the benefits include the Cage Design's high mechanical stability coupled with low weight. This is achieved by integrating eight fiberglass-reinforced plastic rods that prevent interior parts from being ejected during an overvoltage. The design eliminates an enclosed interior space, which not only saves material, it also precludes the need for an overpressure relief device.

The fact that the silicone housing is vulcanized directly onto the active component is another significant advantage. Thanks to their high level of security, easy installation, mechanical ruggedness, and low weight, Cage Design arresters are recommended for any areas where installation is more complex due to particular factors; for example, in areas with difficult terrain.

In these situations, customers can rely on the performance of Cage Design arresters because they are one of the first



arrester series in the world to pass pressure-release testing in compliance with the new IEC 60099-4 Ed. 2.2 standard.

### Ideal for line surge arresters

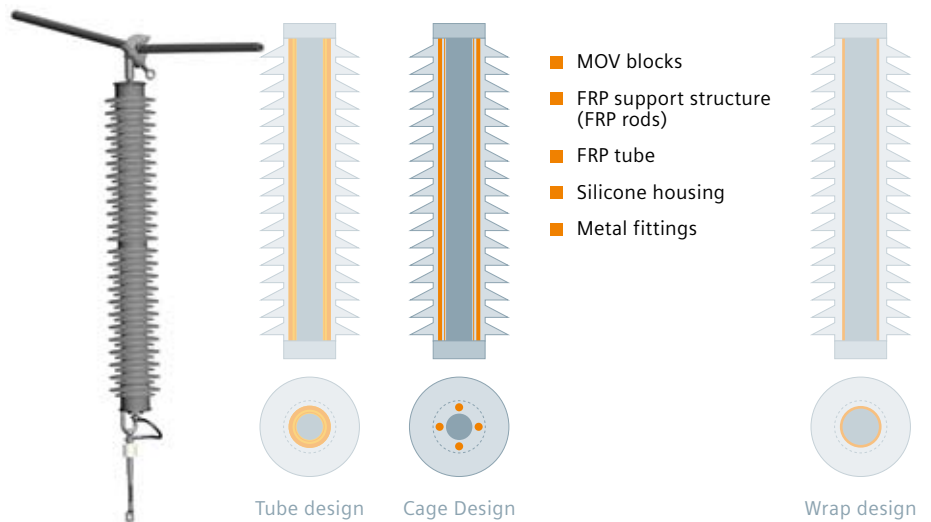
With their highly efficient combination of weight, strength, and security features, Siemens Cage Design arresters are ideal for use as line surge arresters. The table on this page provides an overview of the standard series from Siemens and their most important electrical properties.

Arresters with the competing wrap design have an EPDM or silicone rubber housing that can create air pockets and cause dangerous partial discharges. In addition, EPDM loses its ability to repel water and dirt after being exposed to UV radiation for a short period of time.

In competing wrap design arresters, the metal-oxide blocks are wrapped with fiberglass mats impregnated with epoxy, which results in inferior mechanical strength. The flammability of epoxy resin during an overvoltage is yet another concern against wrap design arresters: the silicone rubber used in Siemens arresters is self-extinguishing.

The tube design from Siemens can be used for special requirements. For example, in applications with very high requirements for energy absorption capability (to limit switching overvoltages) and for special mechanical duties.

## Design comparison and electrical properties of the line surge arrester series from Siemens



Maximum values		3EL5	3EL1	3EL2	3EL2	3EL2	3EL2
Highest voltage for equipment $U_m$	kV	145	362	362	420	420	550
Maximum rated voltage $U_r$	kV	144	288	288	360	360	468
Nominal discharge current	kA	10	10	10	10	10	20
Lightning impulse classifying current	kA	–	10	–	10	–	15
Maximum line-discharge class		2	2	2	3	3	4
Maximum energy absorption capability	$\text{kJ/kV}_r$	4.4	5	5	8	8	10
Maximum thermal energy absorption	$\text{kJ/kV}_{\text{MCOV}}$	–	6.3	–	10	–	12.5
Maximum long duration current impulse	A	550	750	1,100	1,100	1,200	1,200
Rated short circuit current	kA	20	65	65	65	65	65
Maximum specified short-term load SSL <sup>1</sup>	kNm	0.5	1.2	4	4	4	4
Maximum design cantilever load-static MDCL <sup>2</sup>	lb, x inch	3,098	7,435	24,782	24,782	24,782	24,782

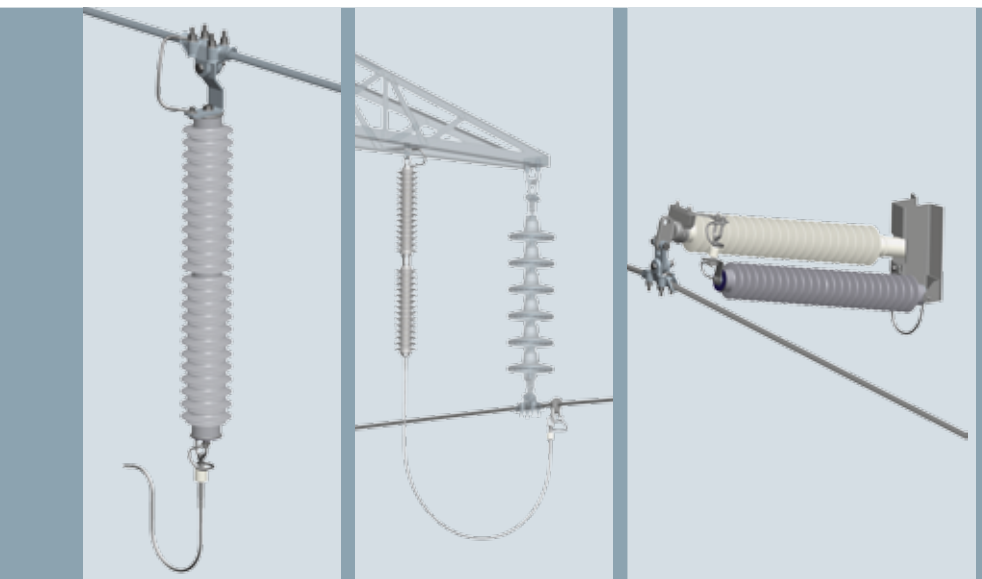
<sup>1</sup>According to IEC 60099-4, Ed. 2.0, 02/2009

<sup>2</sup>According to IEEE Std. C62.11, 2005





## Non-gapped line arresters (NGLA)



Mounting on a line wire

Mounting on an overhead line tower

Mounting on an insulator

Non-gapped line surge arresters (NGLA) offer a high degree of mounting flexibility and operational reliability. Depending on the tower design and the arrangement of insulators and lines, these arresters can either be installed directly on the insulators or on the tower.

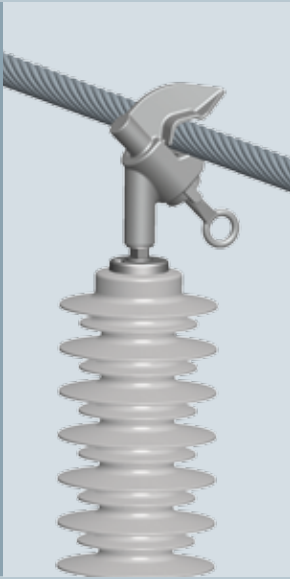
Thanks to their high energy absorption capacity, non-gapped line arresters offer a very high level of protection against overvoltages caused by lightning and network-generated switching impulse current overvoltages.

To galvanically isolate the line surge arrester from the line voltage in the unlikely event of a fault or thermal overload, a disconnecter is installed in series. It automatically and immediately disconnects the line surge arrester from the line voltage. This allows the affected overhead line to continue to be used until replacement can be scheduled.

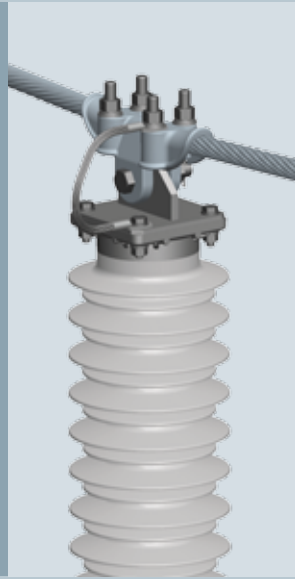
In addition to the line surge arresters, the new ACM advanced monitoring system can be installed to provide arrester condition monitoring. This system monitors wirelessly and provides detailed information about leakage currents and converted energy.



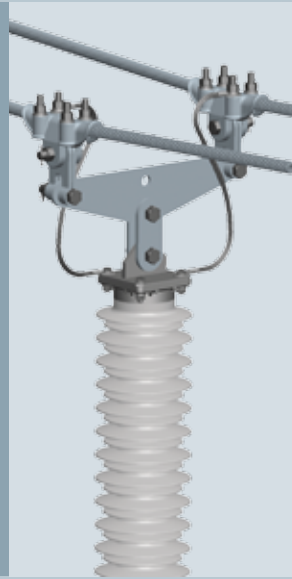
## Attachment options for mounting on a phase conductor



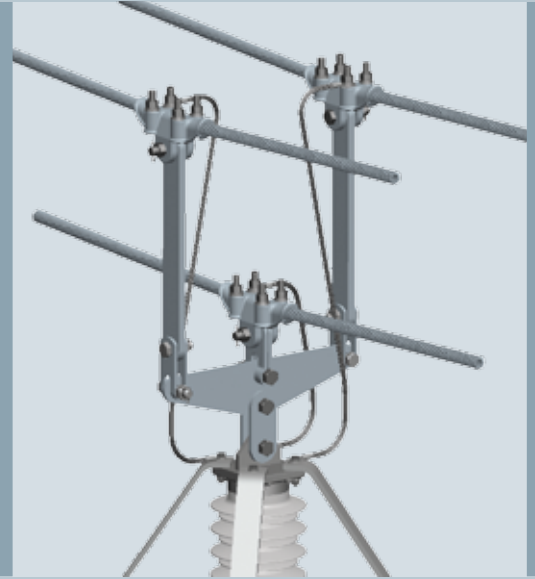
Simple hot-line clamp



Suspension clamp

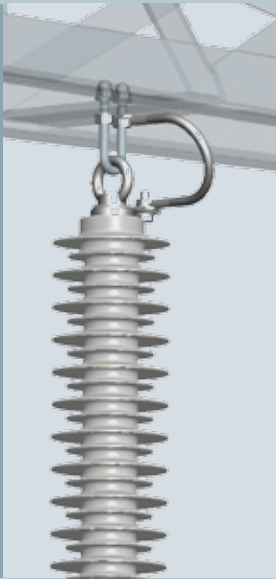


Suspension clamp 2-bundle

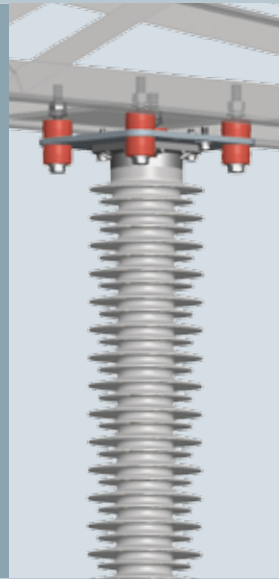


Suspension clamp 3-bundle

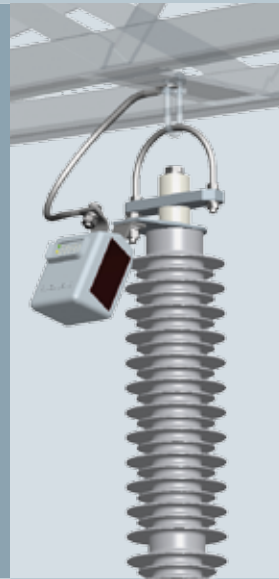
## Attachment options for mounting on an overhead line tower



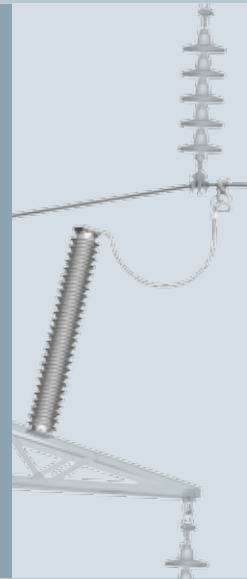
Flexible tower mount



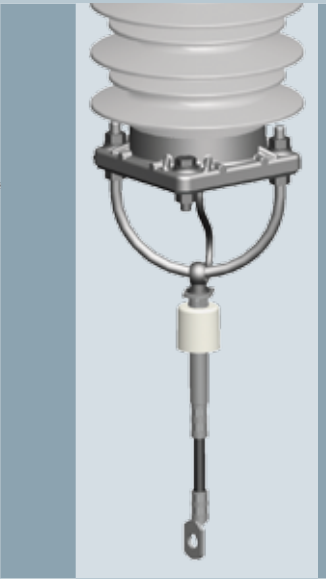
Fixed tower mount



Flexible tower mount with monitoring system (ACM)



Standing on a tower arm



Disconnecter with patented tension-relief device

## Disconnecter



## Externally gapped line arresters (EGLA)

Siemens EGLA line surge arresters have an external spark gap placed in series that galvanically isolates the active part of the line surge arrester from the line voltage under normal conditions. In case of lightning, the spark gap is ignited and the dangerous overvoltage is safely discharged through the resulting arc. The active component limits the subsequent current to ensure that the arc is extinguished within the first half-cycle of the operating power-frequency voltage. After this, the line surge arrester immediately returns to standby condition. In this manner, the EGLA line surge arrester prevents all insulator flashovers that would otherwise lead to short interruptions and failures in the power network. EGLA increases network stability as well as the availability of the overhead line.

An additional benefit of EGLA line surge arresters is that there is no leakage current, because the series gap disconnects the MO blocks, which are the active part

of the EGLA, from the system voltage in normal operating conditions.

Depending on the topology of the overhead line – for example, the arrangement of towers and insulators, the attachment options, and the line voltage – an EGLA line surge arrester can either be attached directly in parallel on the suspension/tension insulators, on the insulator string, or on the tower cross-arm. The active component can have either one or two bodies depending on the system voltage level required.

The compact design of the EGLA allows installation and lightning protection even on existing towers with very small clearances.

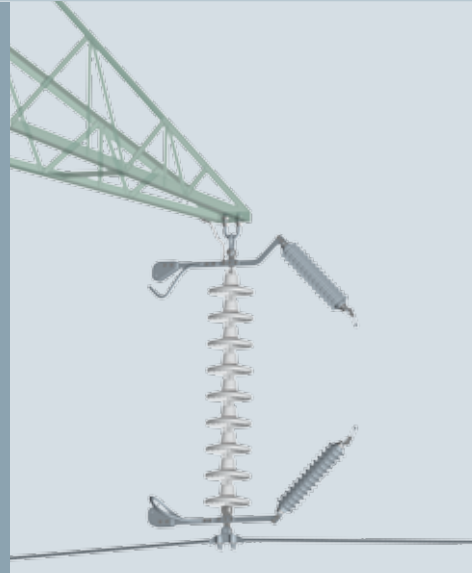
Siemens EGLA line surge arresters are available to protect overhead lines with system voltages of up to 550 kV.

All Siemens EGLAs are designed and tested to comply with the latest IEC 60099-8 standard, which became effective in January 2011.

## Mounting options



Mounted directly on a silicone long-rod insulator (Siemens type 3FL)



Mounted directly on a porcelain string insulator



Mounted on a tower cross-arm

## Testing



Type test on a 144-kV EGLA line surge arrester



Type test on a 400-kV EGLA line surge arrester

# Selected project references

## 1 115-kV transmission lines, North East Utilities, CT, U.S., 2007, 2009, 2010

- Main problem: lightning frequency, network stability
- Location and climate: continental to subtropical, hurricane season, frequently thunderstorms in summer
- Lightning frequency: very high, < 30 lightning strikes/km<sup>2</sup>/year

## 2 115-kV transmission lines, Rio Grande Electric Coop, TX, U.S., 2010

- Main problem: lightning frequency, network stability
- Location and climate: subtropical to tropical, six-month hurricane season every year
- Lightning frequency: very high, < 30 lightning strikes/km<sup>2</sup>/year

## 3 245-kV, 420-kV CFE transmission lines, Mexico

- Main problem: lightning frequency, network stability
- Location and climate: high mountains, up to 3,000 meters above sea level, alpine climate
- Lightning frequency: high, < 10 lightning strikes/km<sup>2</sup>/year

## 4 550-kV ISA transmission line, Colombia

- Main problem: lightning frequency, network stability
- Location and climate: high mountains, 2,000 meters above sea level, cold tropical climate
- Lightning frequency: high, < 10 lightning strikes/km<sup>2</sup>/year

## 5 245-kV REP transmission line, Peru, 2009

- Main problem: high mountains, lightning frequency
- Location and climate: high mountains, tropical
- Lightning frequency: high, < 10 lightning strikes/km<sup>2</sup>/year

## 6 123-kV, 245-kV CEMIG transmission lines, Brazil, 2007, 2008, 2010

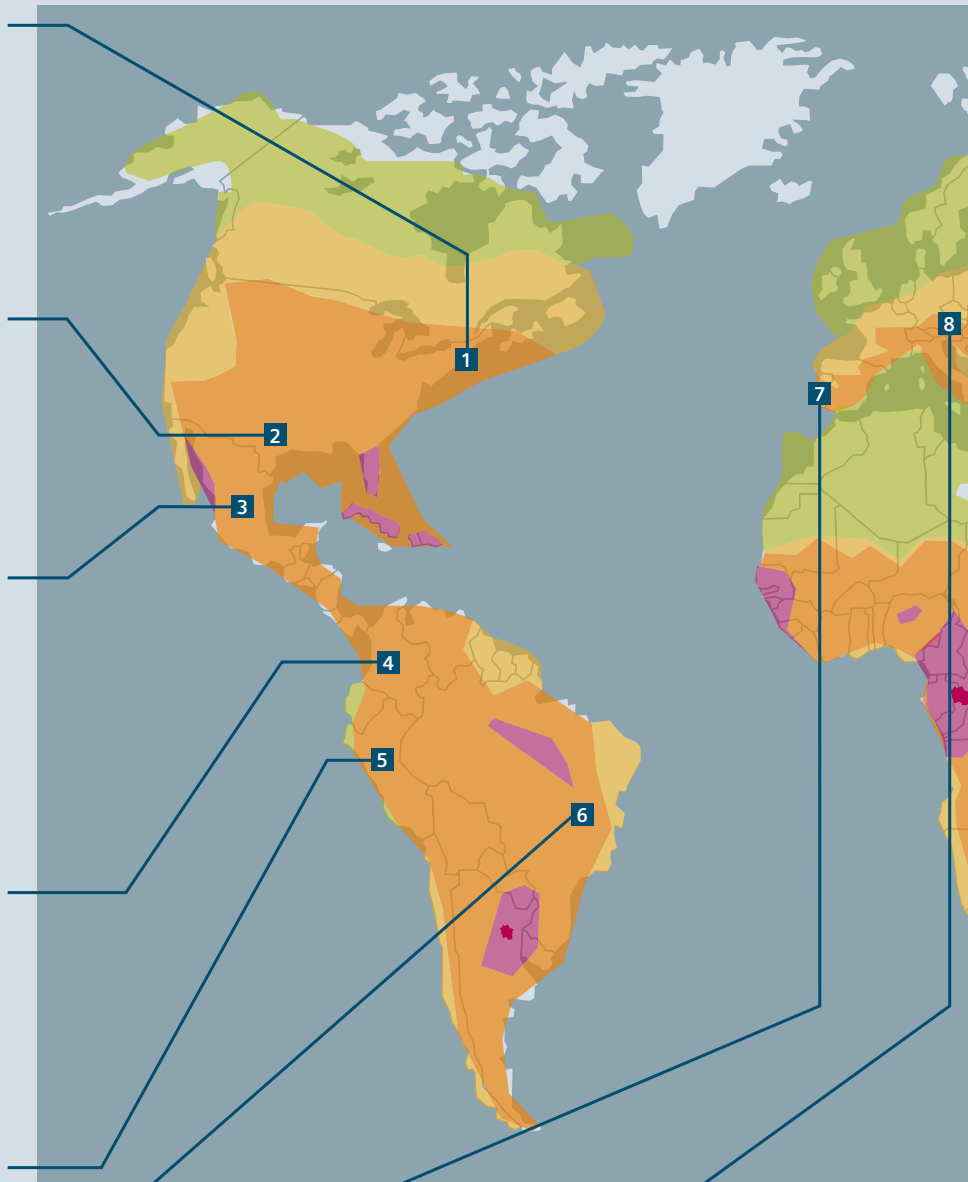
- Main problem: lightning frequency, network stability
- Location and climate: tropical
- Lightning frequency: high to very high, < 30 lightning strikes/km<sup>2</sup>/year

## 7 245-kV REN transmission line, Portugal, 2005

- Main problem: electromagnetic compatibility
- Operating conditions: normal
- Lightning frequency: low, < 3 lightning strikes/km<sup>2</sup>/year

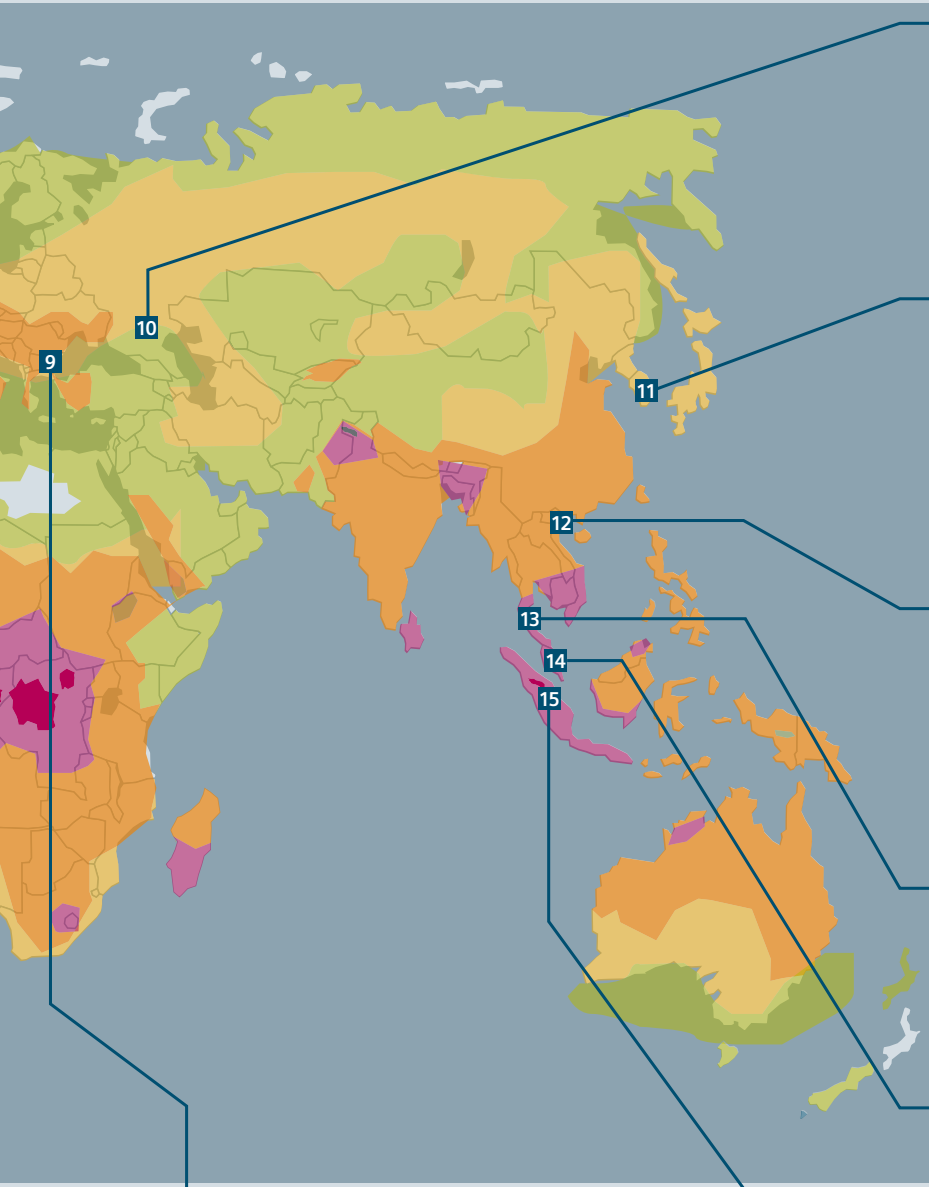
## 8 123-kV KELAG transmission line in the high Alps, Austria, 2007

- Location: high mountains, up to 2,300 meters above sea level
- Operating conditions: snow nine months/year
- Lightning frequency: average, < 5 lightning strikes/km<sup>2</sup>/year
- Ground resistance: up to 1,200 Ω



Average number of lightning strikes per km<sup>2</sup> per year

	Up to 70
	Up to 30
	Up to 10
	Up to 4
	-0.1 to 1



- 9 420-kV NEK transmission line in the high mountains, Bulgaria, 2004**

  - Location: high mountains, up to 1,800 meters above sea level
  - Operating conditions: snow and strong winds, frequent seasonal local thunderstorms
  - Lightning frequency: average, < 5 lightning strikes/km<sup>2</sup>/year
  - Ground resistance: up to 1,000 Ω
  
- 10 550-kV Sochi transmission line, RAO UES, Russia, 2007**

  - Main problem: high mountains, ground wire covered in ice
  - Location: high Caucasian mountains, up to 3,000 meters above sea level, long periods of rain and snow
  - Lightning frequency: high, < 10 lightning strikes/km<sup>2</sup>/year
  
- 11 170-kV KEPCo transmission line, South Korea, 2008, 2009, 2011**

First externally gapped line arrester (EGLA) from Siemens, 2008

  - Main problem: network stability
  - Location and climate: summer monsoon season, 120 days of rain per year
  - Lightning frequency: average, < 5 lightning strikes/km<sup>2</sup>/year
  
- 12 123-kV and 245-kV transmission lines, Vietnam, 2004, 2006, 2007, 2008, 2009, 2010, 2011**

  - Main problem: network stability
  - Location and climate: changeable tropical climate, typhoons during the rainy season
  - Lightning frequency: high, < 10 lightning strikes/km<sup>2</sup>/year
  
- 13 123-kV EGLA project EGAT, Thailand, 2010**

  - Main problem: lightning frequency, network stability
  - Location and climate: tropical-monsoonal, up to 11 humid months per year
  - Lightning frequency: very high, < 30 lightning strikes/km<sup>2</sup>/year
  
- 14 36-kV NGLA SESB, Malaysia, 2009**  
**145-kV EGLA SESB, Malaysia, 2010**  
**275-kV NGLA TNB, Malaysia, 2010**

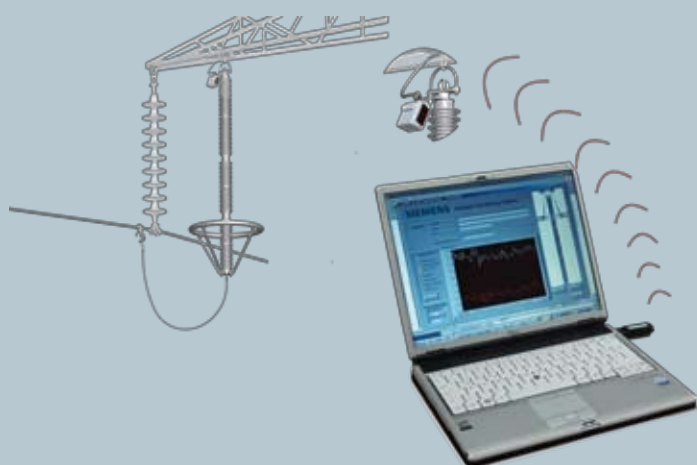
  - Main problem: lightning frequency, network stability
  - Location and climate: changeable tropical climate, typhoons during the rainy season
  - Lightning frequency: very high, < 30 lightning strikes/km<sup>2</sup>/year
  
- 15 72.5-kV and 170-kV projects, Sumatra, Indonesia, 2007, 2009, 2010, 2011**

  - Main problem: lightning frequency, network stability
  - Location and climate: tropical, frequent very heavy rainfall
  - Lightning frequency: very high, < 30 lightning strikes/km<sup>2</sup>/year

# Monitors for line surge arresters

These monitors can be connected to all arresters presented in this catalog.

ACM Advanced



## Condition monitor

### Arrester Condition Monitor (ACM) Advanced

Order number: 3EX5080-1 (ACM device)

Order number: 3EX5085 (wireless USB module)

Software CD: included in package



Sensor



Display

Up to 200 meters

## Sensor

Order number: 3EX5060

## Display

Order number: 3EX5062

## Connecting cable\*

Order number: 3EX5963-xx

\*Required for operation  
Available in different lengths

Order number (example)	3	E	L	2	120	-	2	L	M	3	2	-	4	Z	Z	9
<b>Non-gapped line arrester (NGLA)</b>	3	E	L													
Surge arrester type																
3EL1				1												
3EL2				2												
3EL5				5												
<b>Rated voltage in kV</b>					120											
-						-										
<b>Long-duration current, maximum values</b>																
550 A (3EL5)										0						
750 A (3EL1)										1						
1,100 A (3EL2)										2						
1,200 A (3EL2)										6						
<b>Application</b>																
Line surge arrester																L
<b>Housing size</b>																
																M
<b>Line discharge class</b>																
LD 2 (3EL5, 3EL1)																2
LD 3 (3EL2)																3
LD 4 (3EL2)																4
<b>Number of units</b>																
One unit																1
Two units																2
Three units																3
-																-
<b>Form of sheds</b>																
Alternating sheds																4
<b>Upper connection</b>																
Various (for example: suspension clamp for two-bundle lines, conductor diameter 28 mm)																Z
<b>Name plate</b>																
Special form for line surge arrester																Z
<b>Lower connection</b>																
Various (for example: disconnecter)																9

Order number (example)	3	E	V	1	144	-	0	L	K	1	6
<b>Externally gapped line arrester (EGLA)</b>	3	E	V								
Surge arrester type											
3EL1				1							
3EL2				2							
3EL5				5							
<b>Rated voltage of the complete EGLA in kV</b>					144						
-						-					
<b>Resistance type (according to long-duration current, maximum values)</b>											
550 A (3EL5)											0
750 A (3EL1)											1
1,100 A (3EL2)											2
1,200 A (3EL2)											6
<b>Application</b>											
Line surge arrester											L
<b>Housing size</b>											
											K
<b>Thermal energy absorption capability (in terms of line discharge class)</b>											
LD 1 (3EV5)											1
LD 2 (3EV5, 3EV1)											2
LD 3 (3EV2)											3
LD 4 (3EV2)											4
<b>Number of active part units</b>											
One unit, spark gap on end of active part											1
Two units, spark gap on end of active part											2
Three units, spark gap on end of active part											3
Four units, spark gap on end of active part											4
<b>Two units, spark gap between the two active part units</b>											6
Four units, spark gap between the active parts											8
Special design											9

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The required technical options should therefore  
be specified in the contract.