Air Core Reactor Applications
Current Limiting Reactors

CONSEJO INTERNACIONAL DE GRANDES REDES ELÉCTRICAS

Current Limiting Reactors
Faults on Electrical System - Basic Concepts

Three major concerns arise from this scenario:

1- The mechanical stresses on the transformer windings are proportional to the square of the current ($F \sim I^2$)

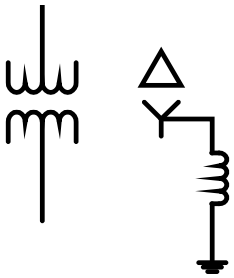
2 - The ability of the equipment to withstand the fault current without damage

3 - Equipment wear-out

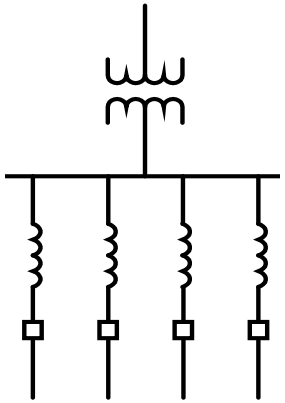
Current Limiting Reactors
Reactor as current limiting device

- Used to limit fault currents to values lower than would otherwise exist;
- Can be applied in a variety of different configurations at:

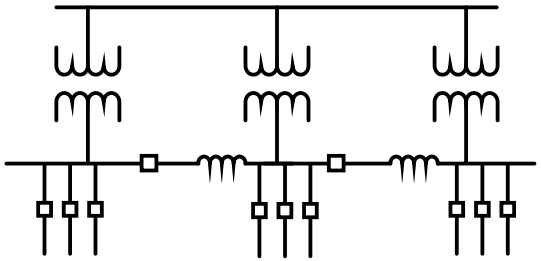
Distribution Voltages



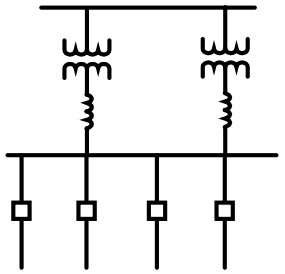
Neutral Grounding Reactors



Feeder Reactors



Bus Tie Reactors

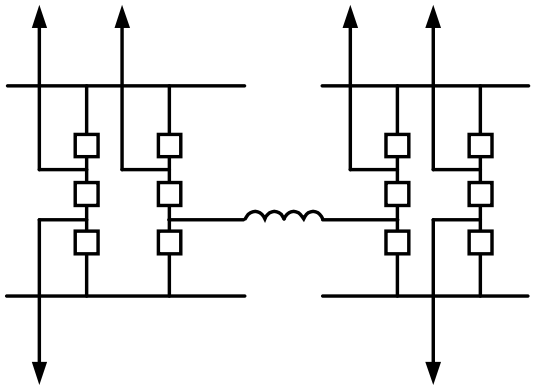


Transformer Secondary Reactors

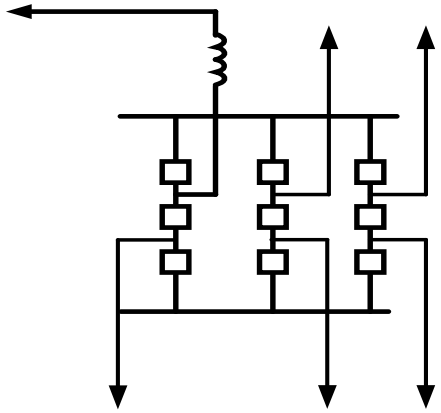
Current Limiting Reactors
Reactor as current limiting device

- Used to limit fault currents to values lower than would otherwise exist;
- Can be applied in a variety of different configurations at:

Transmission Voltages



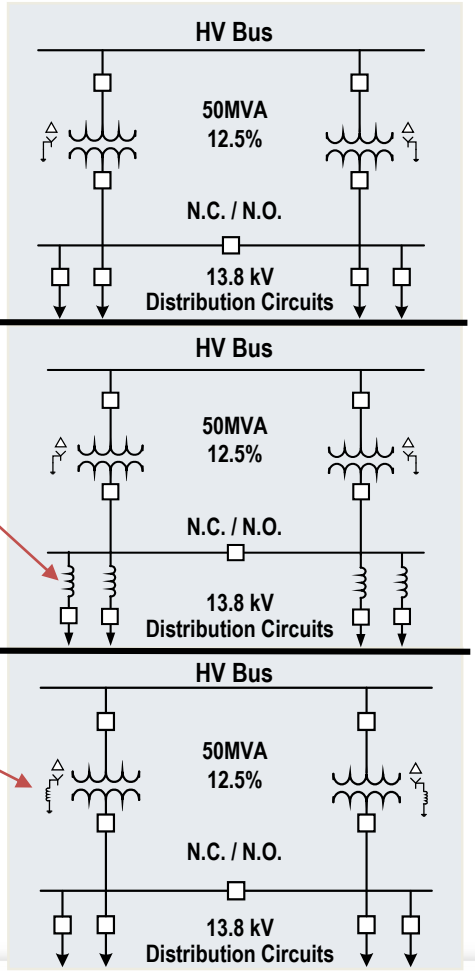
Bus Tie Reactors



Line Reactors

The Impact of Current Limiting Reactors

	N.O. Tie	N.C. Tie
1. With No Reactors		
3Φ [kA]	14.4	25.4
SLG[kA]	15.7	28.6
2. Add Series Reactors : 13.8 kV- 300 A, 2.9%, 0.77 ohms		
3Φ [kA]	6.1	7.4
SLG[kA]	6.2	7.6
3. Add NGR Reactors @ both Transformers: 13.8 kV-300 A, 0.77 ohms		
3Φ [kA]	14.4	25.4
SLG[kA]	6.2	12



Applying Current Limiting Reactors

Current Limiting Reactors Concerns

- Reactor losses — Negligible
- Voltage regulation — Negligible at a Normal Power Factor
- TRV — If Any Issue, Can be Resolved Very Easily
- $\frac{X}{R}$ — Can be resolved by further reduction of Short Circuit current with larger reactor

Current Limiting Reactors
Case Studies

Eletronorte (Brazil) : Tucurui Generating Station (500kV)

Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR

- A power plant with two power houses in one dam;
- Power House #1: Completed in 1995; 12 generators of 350 MVA each (4,200 MVA);
- Power House #2: Completed in 2006; 11 generators of 390 MVA each (4,290 MVA);
- Each power house has its own air insulated substation which, allowing for system flexibility, were to be operated in parallel;
- This would have caused the short circuit capability of the equipment associated with the original substation (40 kA), to be exceeded.

Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR

Options

1. Operate two stations independently

   1.Reduced Reliability

   2. Makes Operation difficult

2. Change all the equipment in the TUC #1

   Very Expensive

   Extensive down time (hence not practical)

3. Use a current limiting reactor

Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR

To achieve parallel operation of the two substations without exceeding any rating of existing equipment, Eletronorte selected to install bus tie reactors connecting the two substations. The following reactor characteristics requirements were specified:

- **Rated Voltage : 550/√3 kV**
- **Rated Current: 2,600 A**
- **Rated Short Circuit: 10 kA / 27 kA (1.0 Sec.)**
- **Rated Reactance: 20 Ohms**
- **Rated Power: 135 MVA / Phase**
- **Min. Q factor: 400**

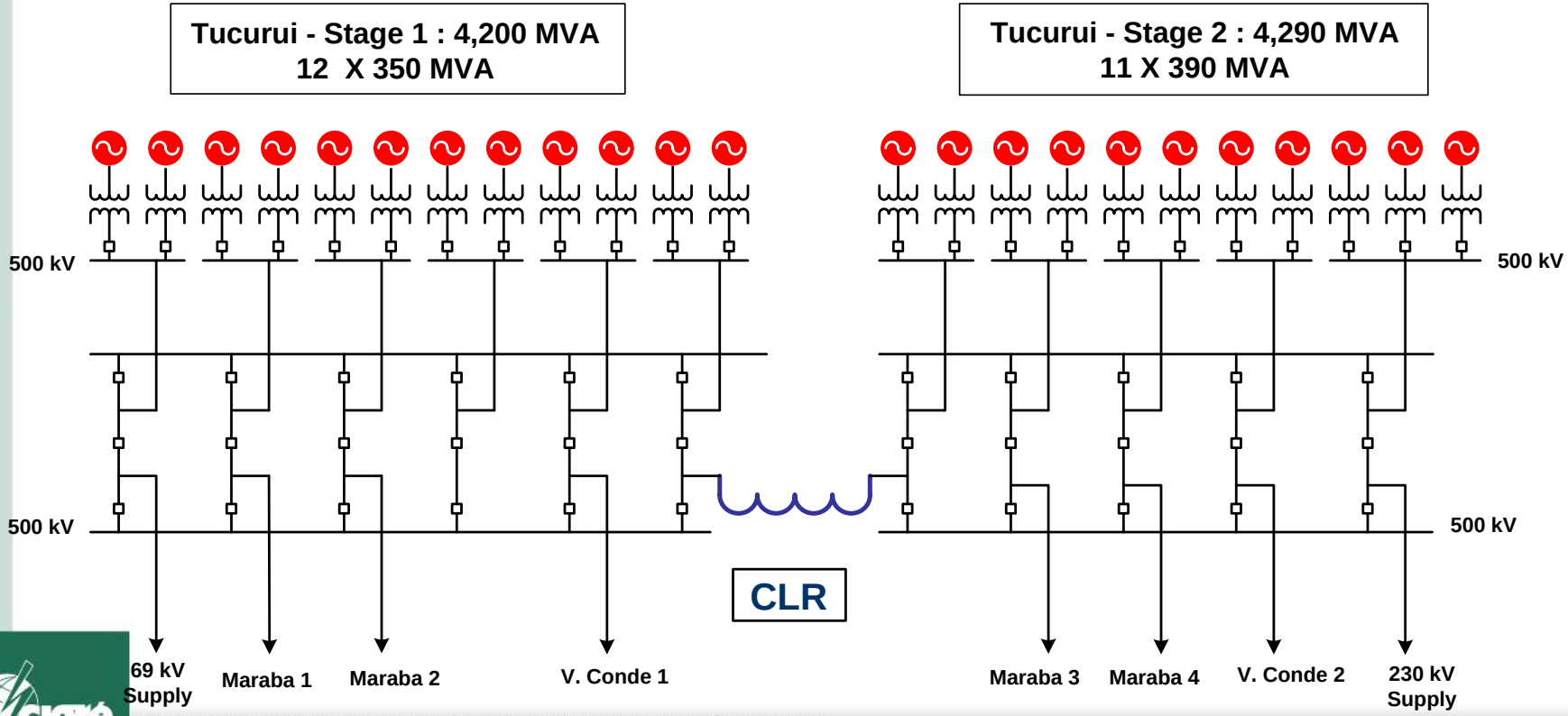
Due to the importance and high profile of the installation, Eletronorte also specified the following:

- **System Reliability: 100 %**
- **System availability: 100 %**
- **Max. RRTRV: 5.0 kV/μSec (on any breaker, for any fault)**
- **Turn Key installation in 240 days after signing of contract**

Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR

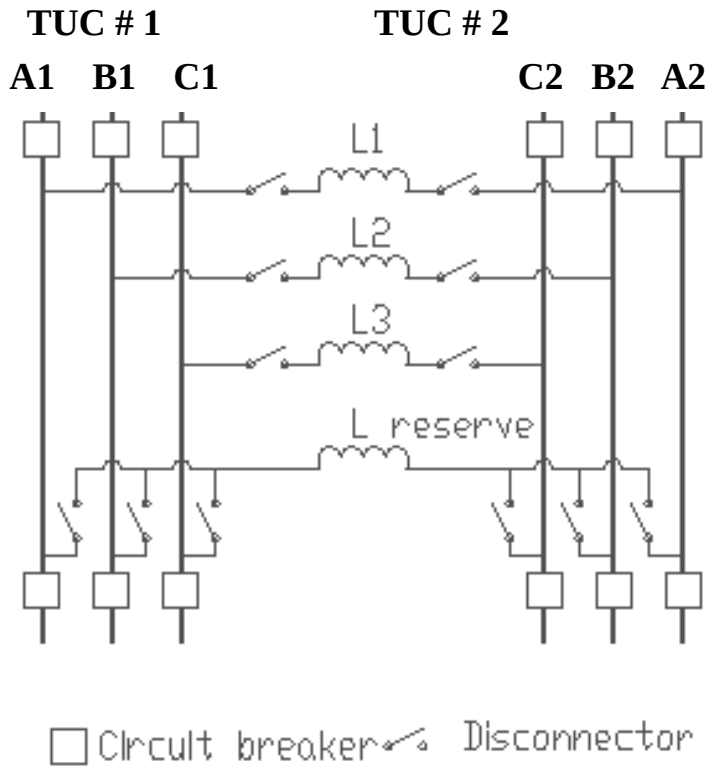
Simplified One Line Diagram



Current Limiting Reactors
Case Studies

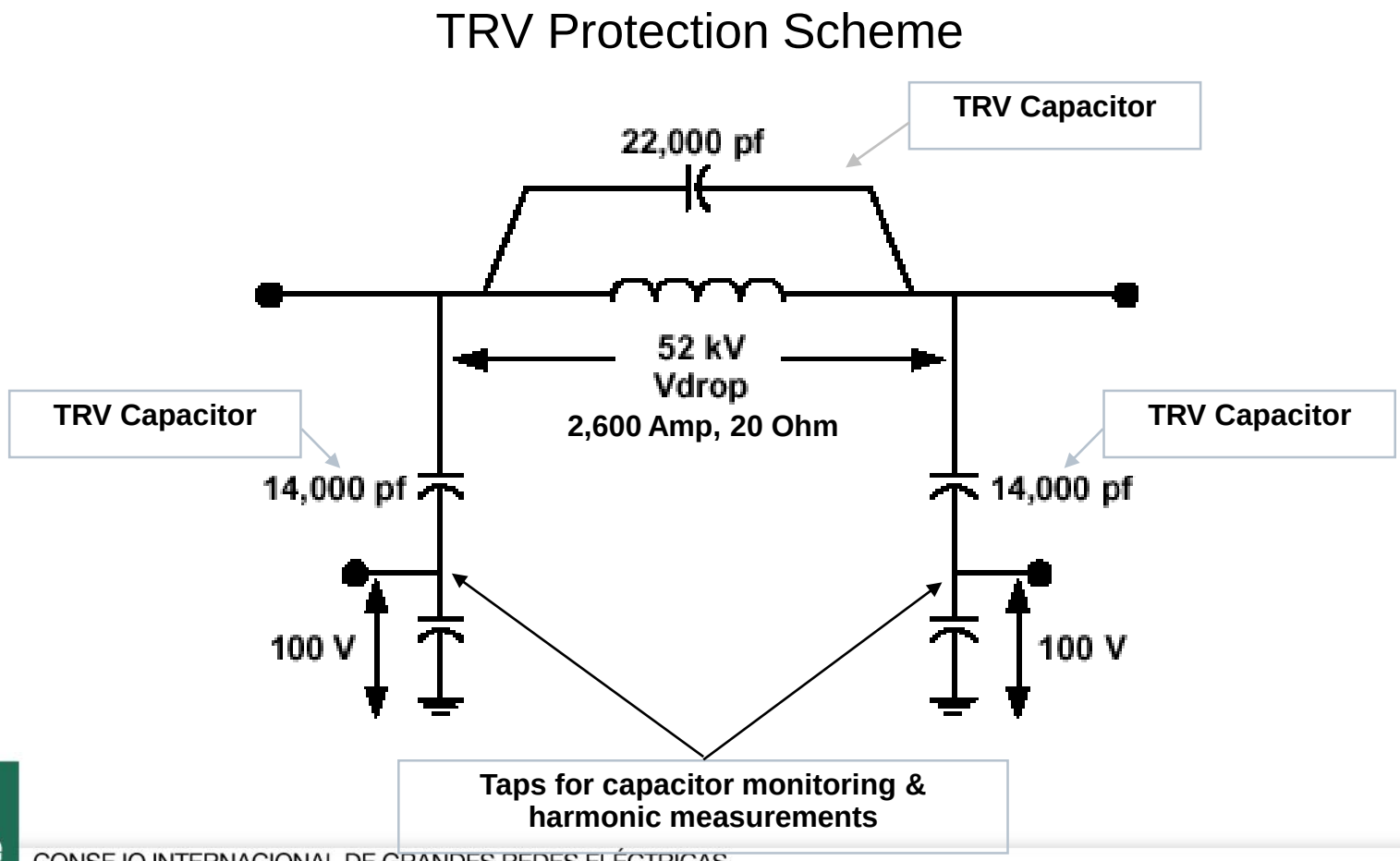
Eletronorte 500 kV CLR

- Reactor in any of the three phases can be be replaced by the reserve one.



Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR



Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR

Current Limiting Reactors
Case Studies

Eletronorte 500 kV CLR

System Voltage : 550 kV

Impedance : 20 Ω

Rated current : 2600 A

Rated Power: 135 MVA / Phase

Thermal Short Circuit: 10 KA / 1 Sec.

Mechanical Peak: 27 KA

BIL / SIL : 1550 / 1180 kV

Losses / Efficiency : 280 kW / 99.79 %

RRTRV control: < 5.0 kV/μsec

Weight : 32,000 kg (2 coils)

(insulator excluded)

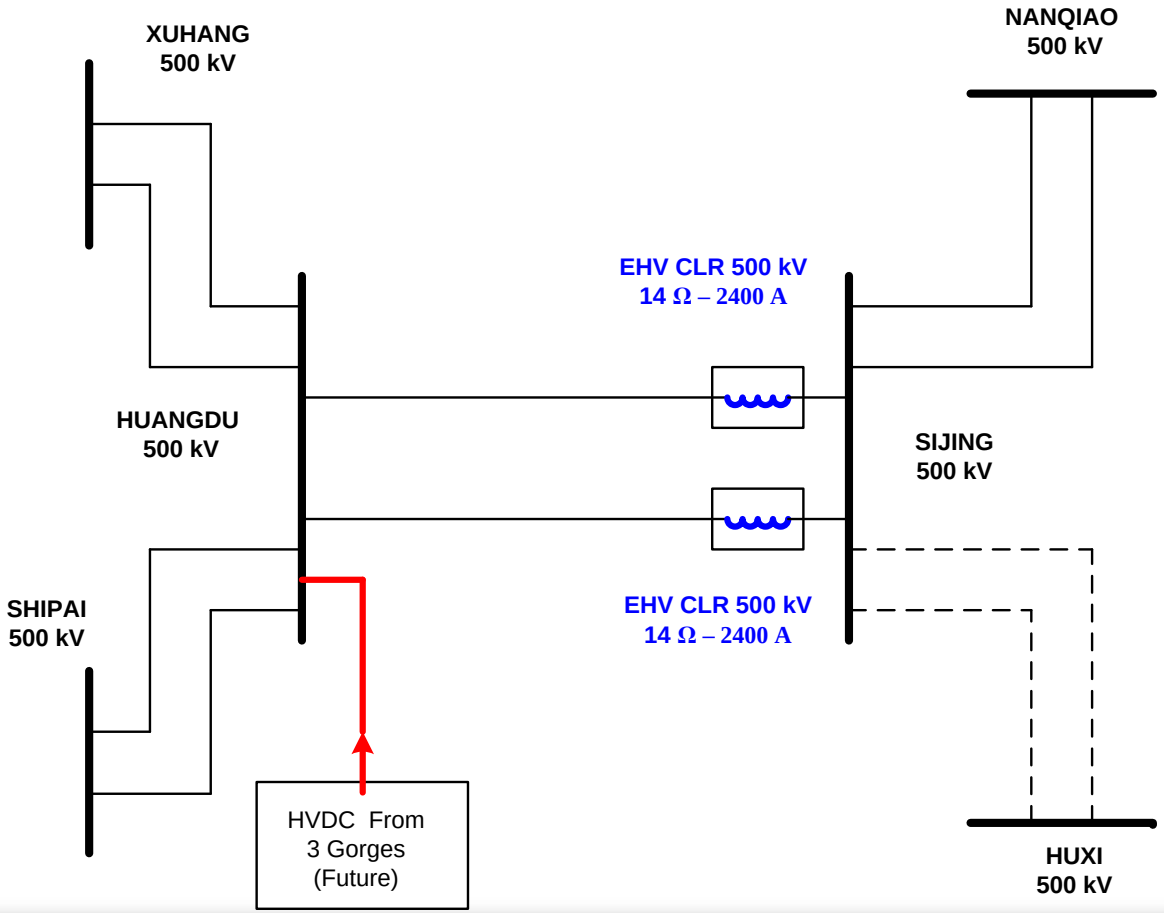
Estimated Savings: ≈ US$ 100 M

Current Limiting Reactors
Case Studies

East China Power Si Jing Station (500kV)

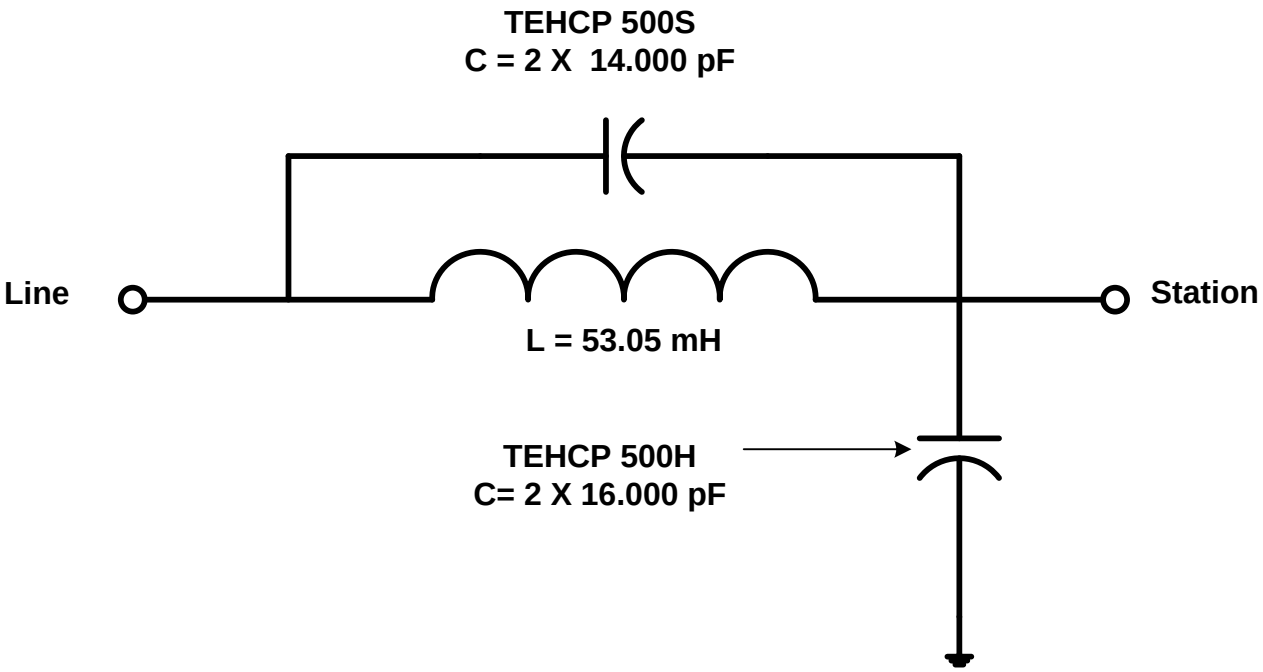
Current Limiting Reactors
Case Studies

Shanghai's 500 kV System - Basic Single Line Diagram



Current Limiting Reactors
Case Studies

Si Jing 500 kV CLR – TRV Protection Diagram



Current Limiting Reactors
Case Studies

Si Jing 500 kV CLR

Current Limiting Reactors
Case Studies

Si Jing 500 kV CLR

Rated System Voltage	500 kV
Rated Frequency	50 Hz
Rated Current	2400 A
Rated Inductance / Impedance	44.56 mH / 14 Ω
Rated Power	80.64 MVAr
Losses / Efficiency :	128 kW / 99.8 %
Rated Short Circuit current (3 Secs.)	16 KA
Peak Short Circuit Current	40 KA
BIL across Coil / Insulator	1550 kV
SIL across Coil / Insulator	1175 / 1300 kV

TRV Protection

Capacitance to ground (line side)	NA
Capacitance to ground (Station side)	2 * 16 nF
Capacitance across coil	2 * 14 nF

Current Limiting Reactors
Case Studies

- **Furnas 345kV - Brazil**

Current Limiting Reactors
Case Studies

Mogi das Cruzes SE
Furnas 345 kV CLR

Installation Characteristics

- **Rated Voltage : 345 kV**
- **Rated Current : 2,100 A**
- **Inductance: 24.05 mH**
- **Rated Power: 40 MVA / phase**
- **BIL / SIL: 1,300 / 850 kV**
- **Losses / Eff.: 133 kW / 99.7%**
- **TRV control: Not required**
- **Weight = 28,600 lbs. (13,000 kg)**
- **Operational Since Dec. 1998**

Estimated Savings:> US$ 10 M (only equipment)

Current Limiting Reactors
Case Studies

- **KEPCO 345 kV CLR – South Korea**

Current Limiting Reactors
Case Studies

Korea Electric Power
345 kV CLR Buk-Busan

Impedance = 5.9 Ω

System Voltage = 345 kV

Rated current = 2200 A

No TRV Protection Required