TEMPORARY OVERVOLTAGE STUDIES

Pterra CONSULTING

Innovation
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Overview

Temporary Overvoltage (TOV) is an oscillatory phase-to-ground or phase-to-phase overvoltage of long duration and that is weakly damped. Unlike lightning or switching surges, TOVs may last from several cycles to minutes - often going unnoticed until failures occur.

A Temporary Overvoltage Study **identifies**, **quantifies,** and **mitigates** these risks before they impact your electrical assets.

What Causes Temporary Overvoltage?

Ground Faults
Especially single line-to-ground (SLG) faults shift the system neutral potential, inducing power-frequency overvoltages on healthy phases that are typically limited to 1.3 p.u. in effectively grounded networks but can reach 1.73 p.u. in ungrounded systems.

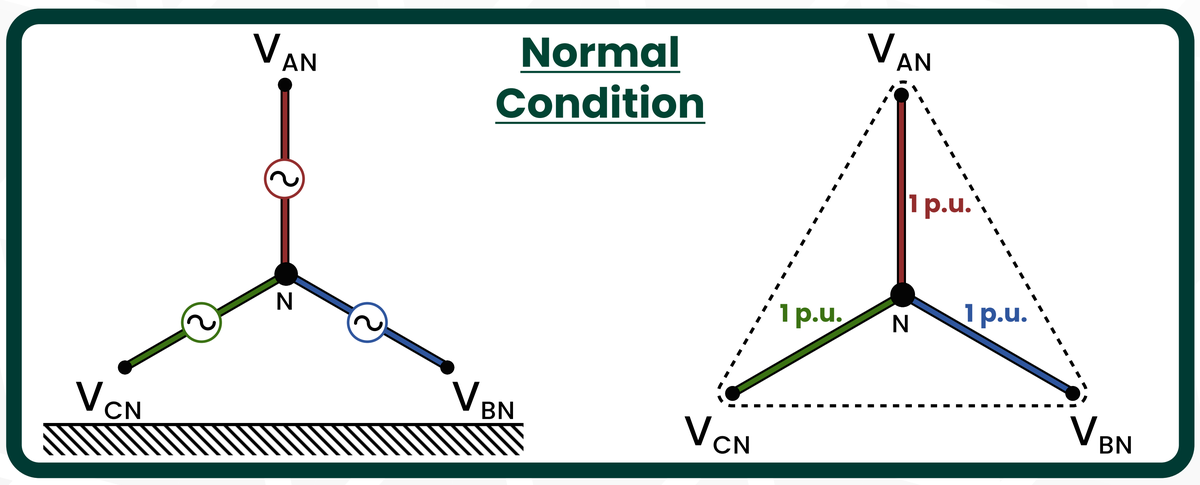
Load Rejection
The sudden loss of significant inductive load triggers voltage rises due to reduced impedance drops and generator regulator response, which can be intensified by the Ferranti effect.

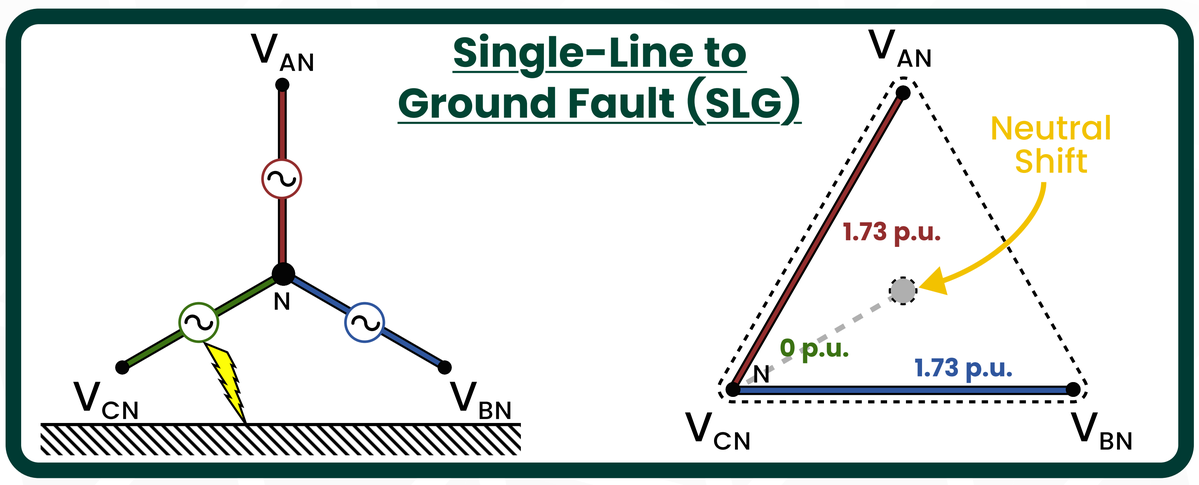
Resonance & Ferroresonance
Oscillations arise from the interaction between inductive (e.g., transformer) and capacitive elements, where nonlinear ferroresonance involving saturated cores can produce catastrophic magnitudes.

Transformer Energization
Harmonic-rich inrush currents generated when energizing unloaded transformers can excite system resonant frequencies, resulting in long-duration resonant overvoltages.

Islanding
Leave islanded regions ungrounded or poorly regulated, while synchronization across significant phase angle differences can creates longitudinal overvoltages reaching up to twice the nominal phase-to-ground voltage.

When TOV is detected, it may expose equipment to voltages exceeding insulation ratings for extended durations.

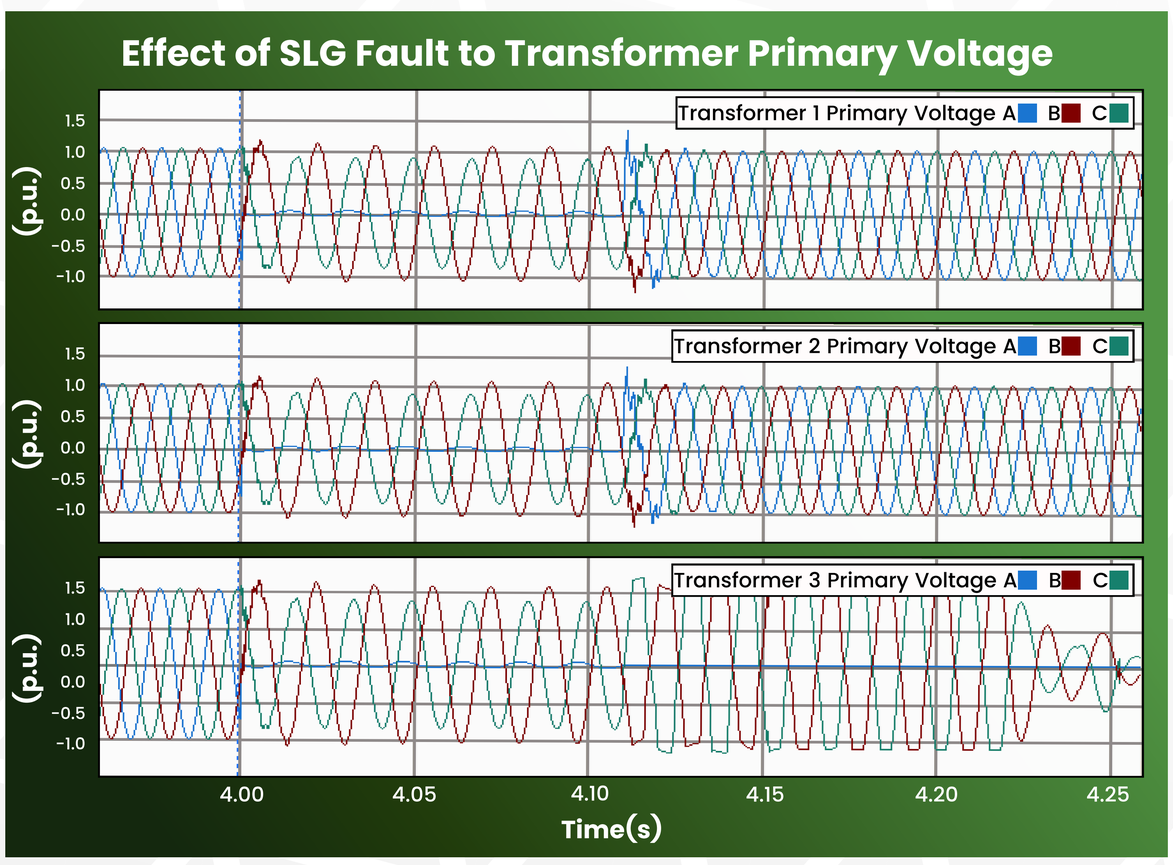




Who Needs a TOV Study ?

Surge protection is an important aspect of substation or line design. Selection of surge arresters often follows industry guidelines and confirmed with a detailed TOV study. Depending on the study objectives, a TOV study is often needed by:

- Project Developers (solar, wind, BESS)
- Transmission and Distribution Utilities
- Industrial and commercial power system
- EPCs and system designers
- Data centers and mission-critical facilities



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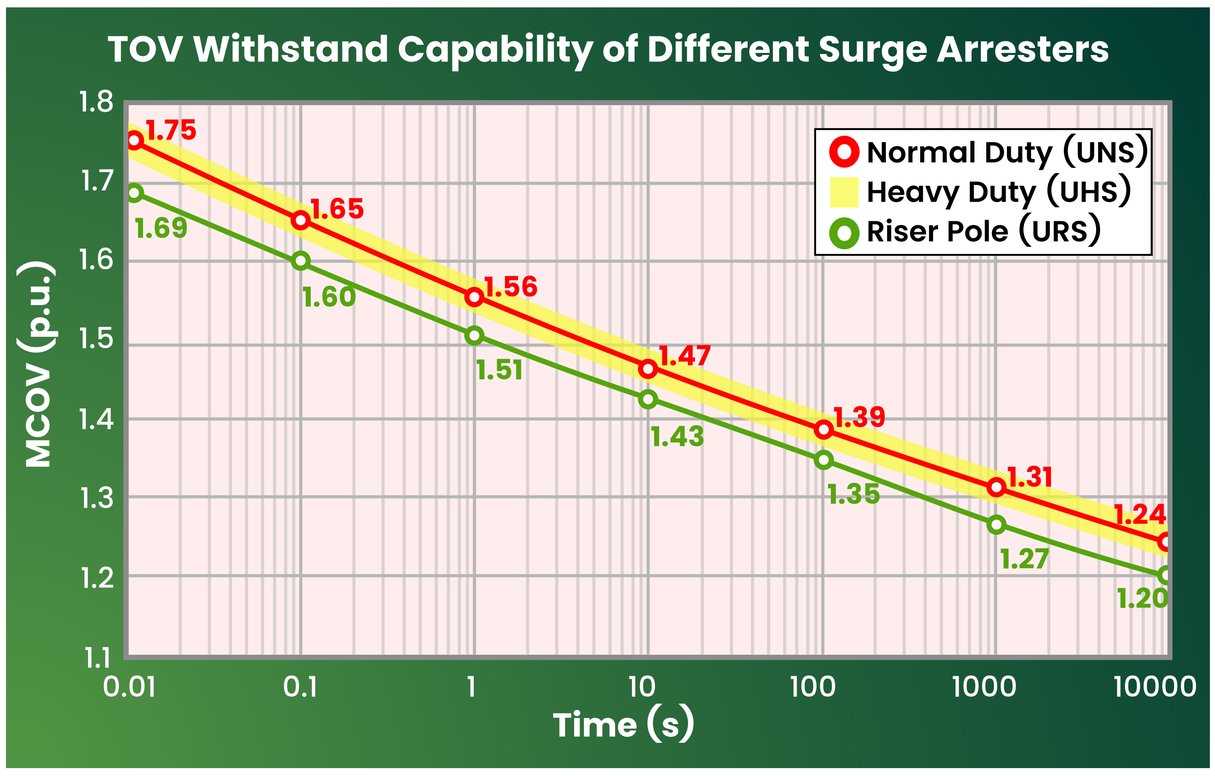
Standards & Guidelines

Equipped with real world understanding and practical experience in high-voltage equipment, Pterra brings unique expertise in analyzing TOV. Our study is also guided by industry standard and recommendations from:

IEEE Std. C62.2-1987
Application of Gapped Silicon-Carbide Surge Arresters for Alternating Current Systems

IEC TR 60071-2:2023
Insulation Coordination Part 4: Application Guidelines

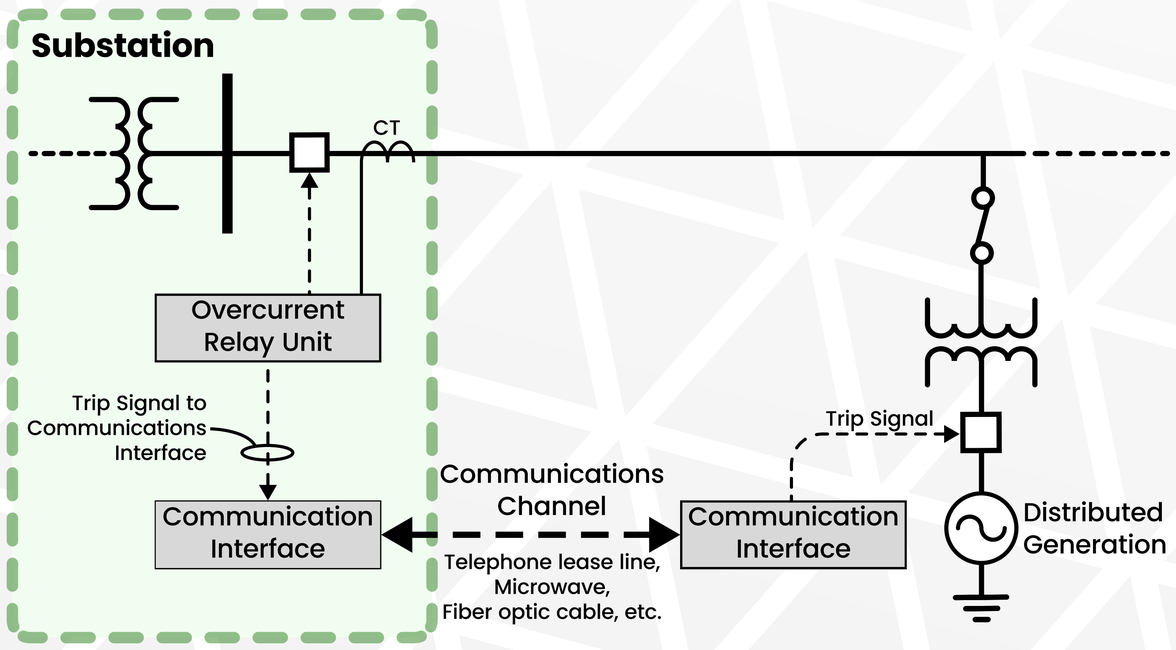
IEC TR 60071-4:2004
Insulation Co-ordination - Part 2: Computational Guide to Insulation Coordination and Modelling of Electrical Networks



Modeling Consideration for TOV Studies

To capture the phenomenon under study, power system components should be modeled properly. The typical modeling details include:

- **Power system components** such as source/utility representation, transformers, lines and underground cables, capacitors, and station buses
- **Component parameters** such as transformer core characteristics, tower geometry or cable layout, frequency dependent line models, and grounding resistance
- **Surge arrester manufacturer's data** and plotted V-I characteristics
- **Manufacturer's data of circuit breaker** and disconnect switches
- **Substation grounding**
- **Protection schemes** and clearing times

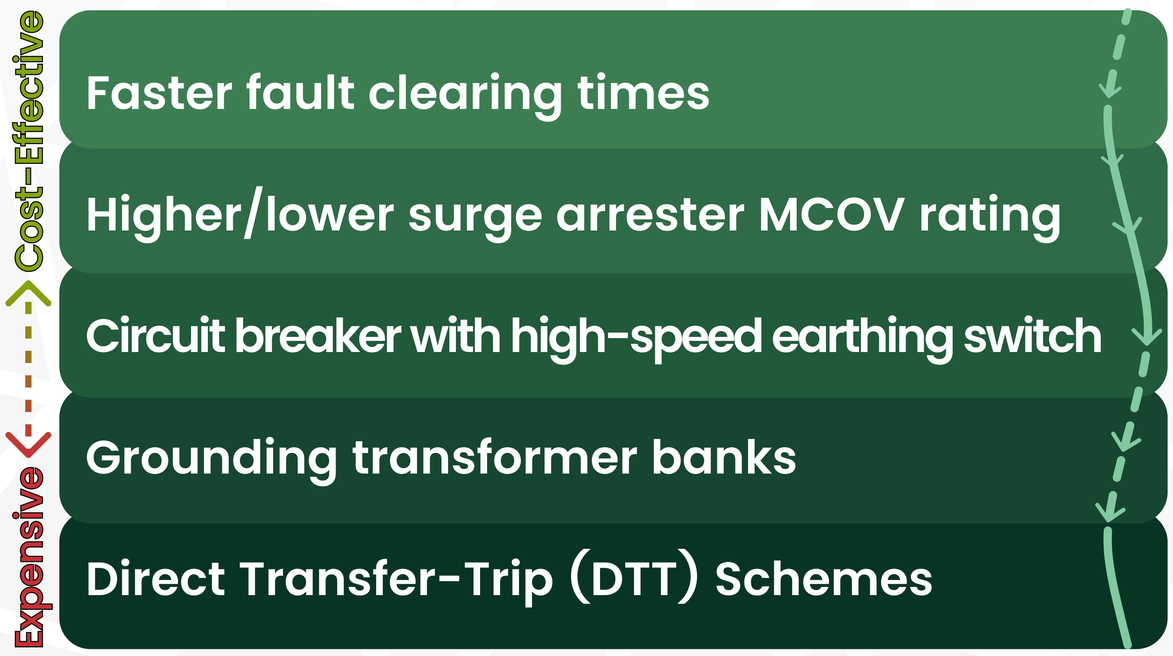


Key Deliverables

Equipment insulations are typically rated at line-to-ground basis. Therefore, it makes sense to monitor the peak line-to-ground overvoltage voltage and peak inrush current values when studying electrical transients. Instantaneous and root-mean square (RMS) values are plotted.

Surge arrester absorbed energy is compared against the manufacturer's data. Stress is also compared against switching devices' duties. The monitored parameters are analyzed both in qualitative and quantitative terms to give actionable action items and meaningful conclusions.

When simulations indicate potential violations, **mitigation** measures are explored starting from the least cost to the most expensive one.



Protect Your Assets Before Overvoltage Becomes a Failure

With a right study, temporary overvoltage is predictable and mitigations can be put in place.

Contact us to learn how a Temporary Overvoltage Study can **prevent failures** in your power system.

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