PARLPV

Real-Time Compensation of Voltage Fluctuations in LV Networks

Online Workshop WG5: Data monitoring & analytics for better PV performance and grid integration"

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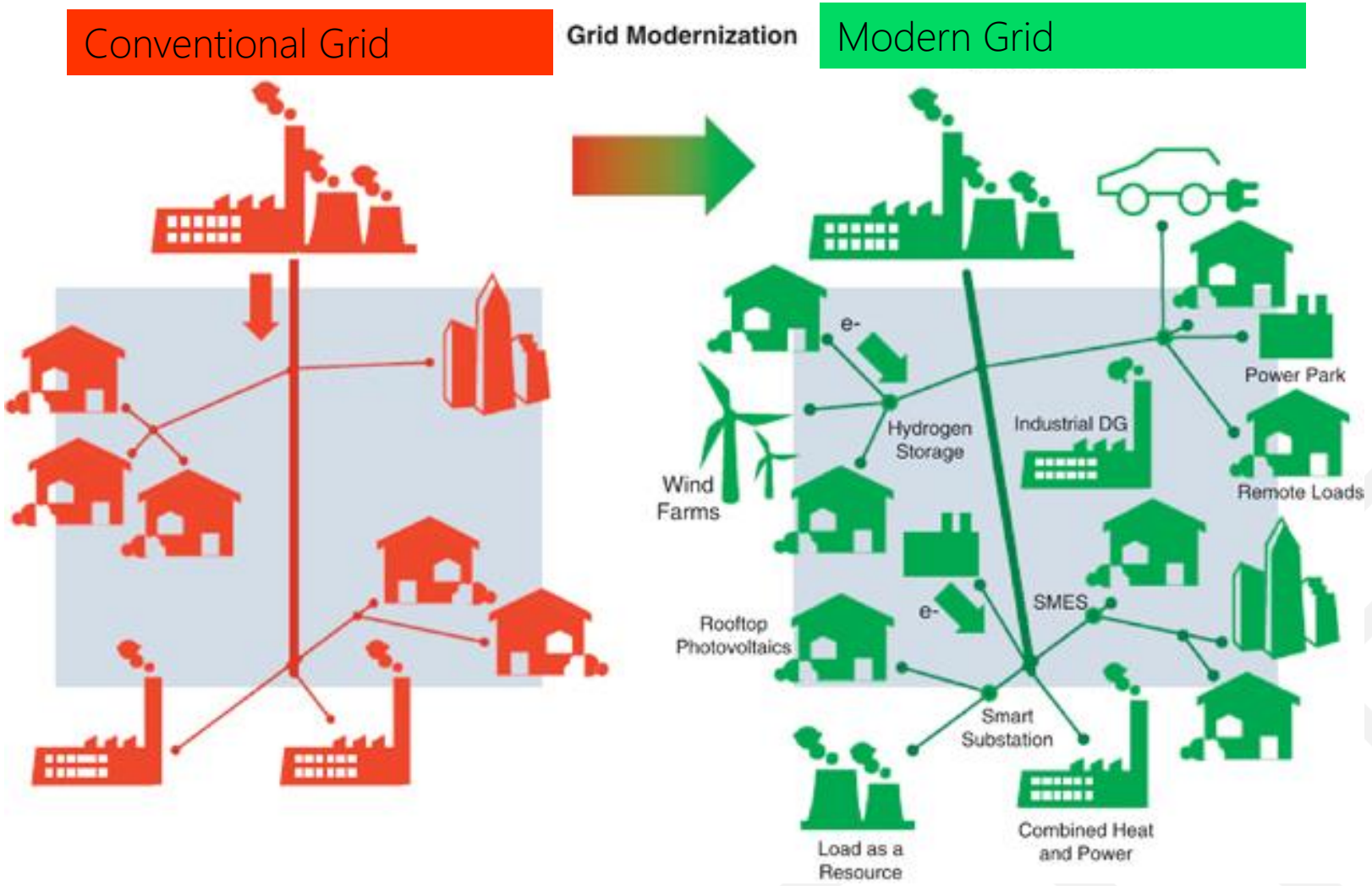
Overview

- Introduction
- Standard: EN50160
- Mitigation options
- Active voltage controller
- Simulation results
- Case study - Malta
- Conclusion

Introduction



Standards

EN50160:

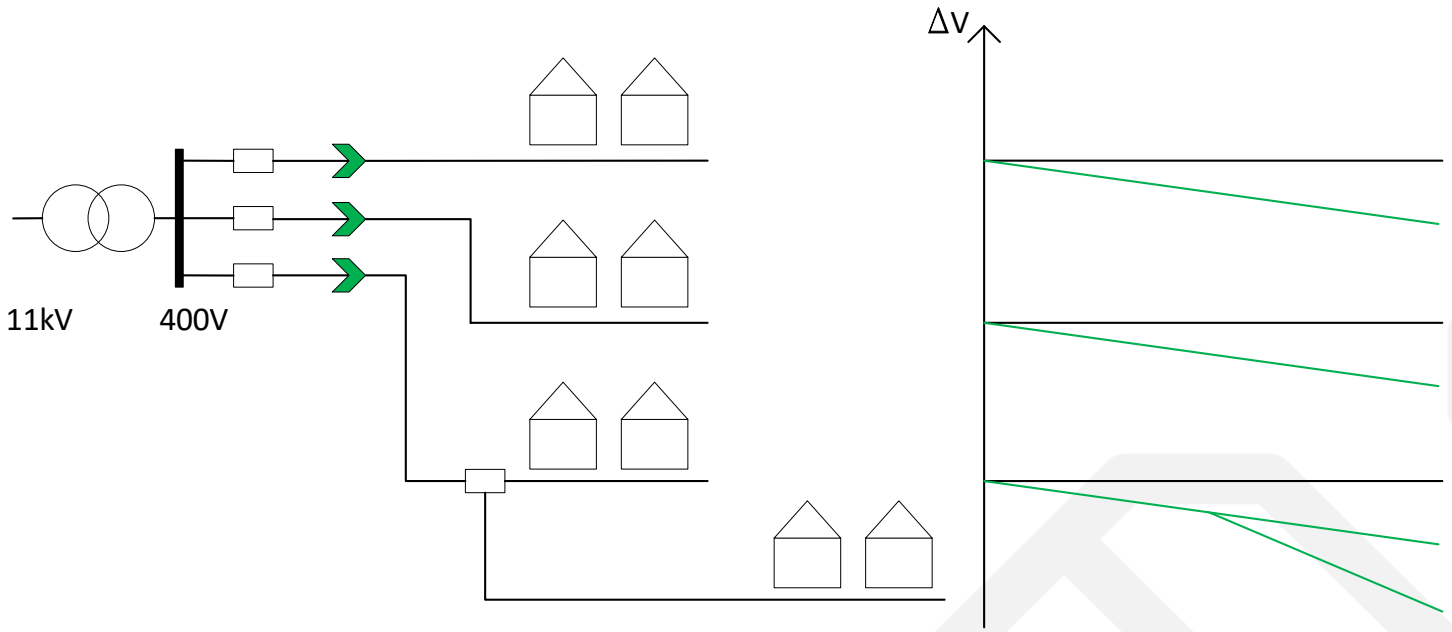
Voltage characteristics of electricity supplied by public electricity networks

- The EN 50160 is one of the standards that describes the voltage tolerance limits in electrical networks in Europe.
- The supply voltage variations[1] should not exceed ± 10% of the rated voltage U_n
- Equipment can be unnecessarily stressed or damaged if operated with a voltage outside the tolerance limits
- Inefficient operation of Machines, drives and lighting devices

[1] *during each period of one week 95 % of the 10 min mean r.m.s. values of the supply voltage shall be within the range of U_n ± 10 %;*

Conventional Grid Scenario

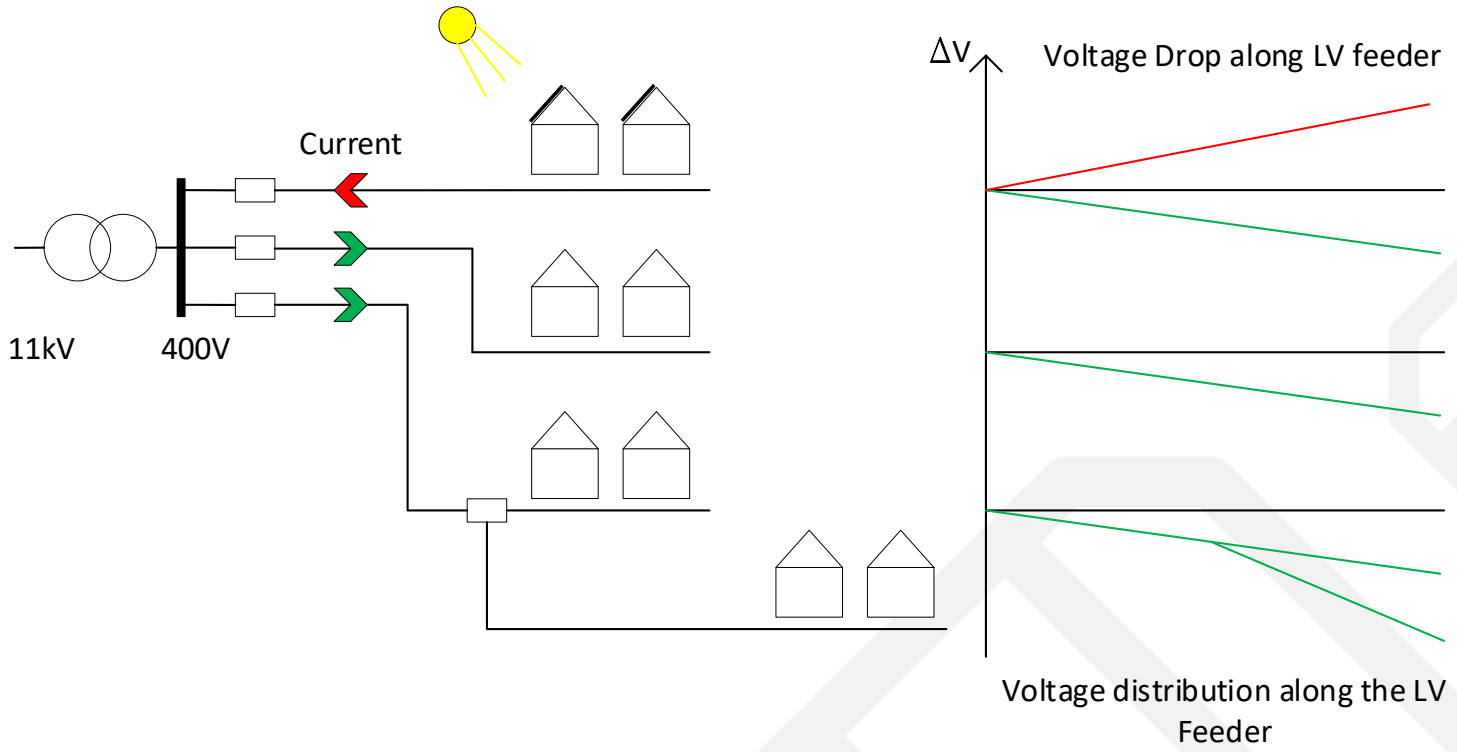
- Current flows from the grid to the loads
- Voltage reduces along the LV feeder & Over-head line



Voltage distribution along the LV Feeder

Modern Grid Scenario - Challenges to the Grid operator

- **High PV penetration scenario** – current flow from PV to the grid
- Voltage increases along the LV feeder / Over-head line



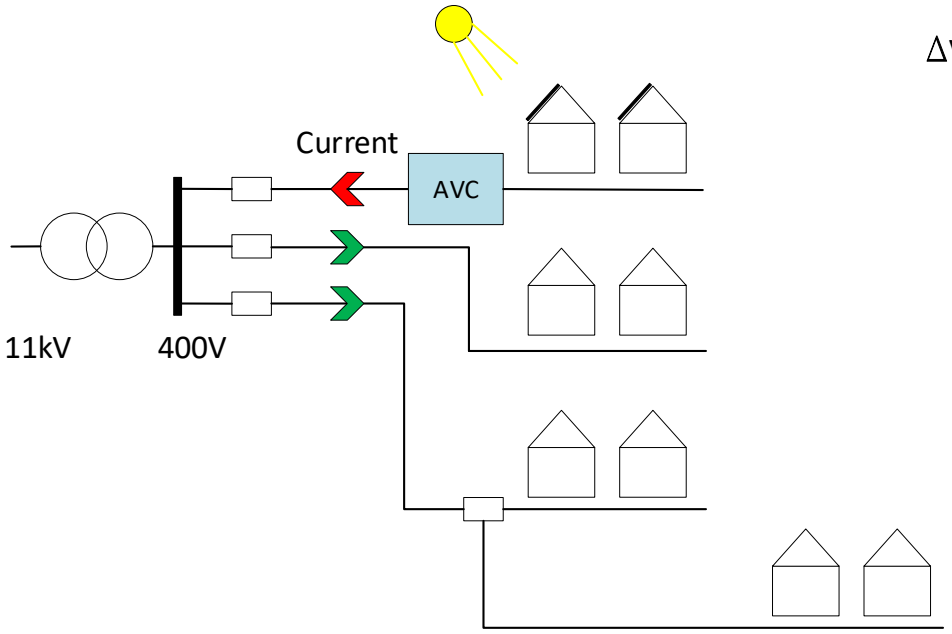
Mitigation Options (Consumer Side)

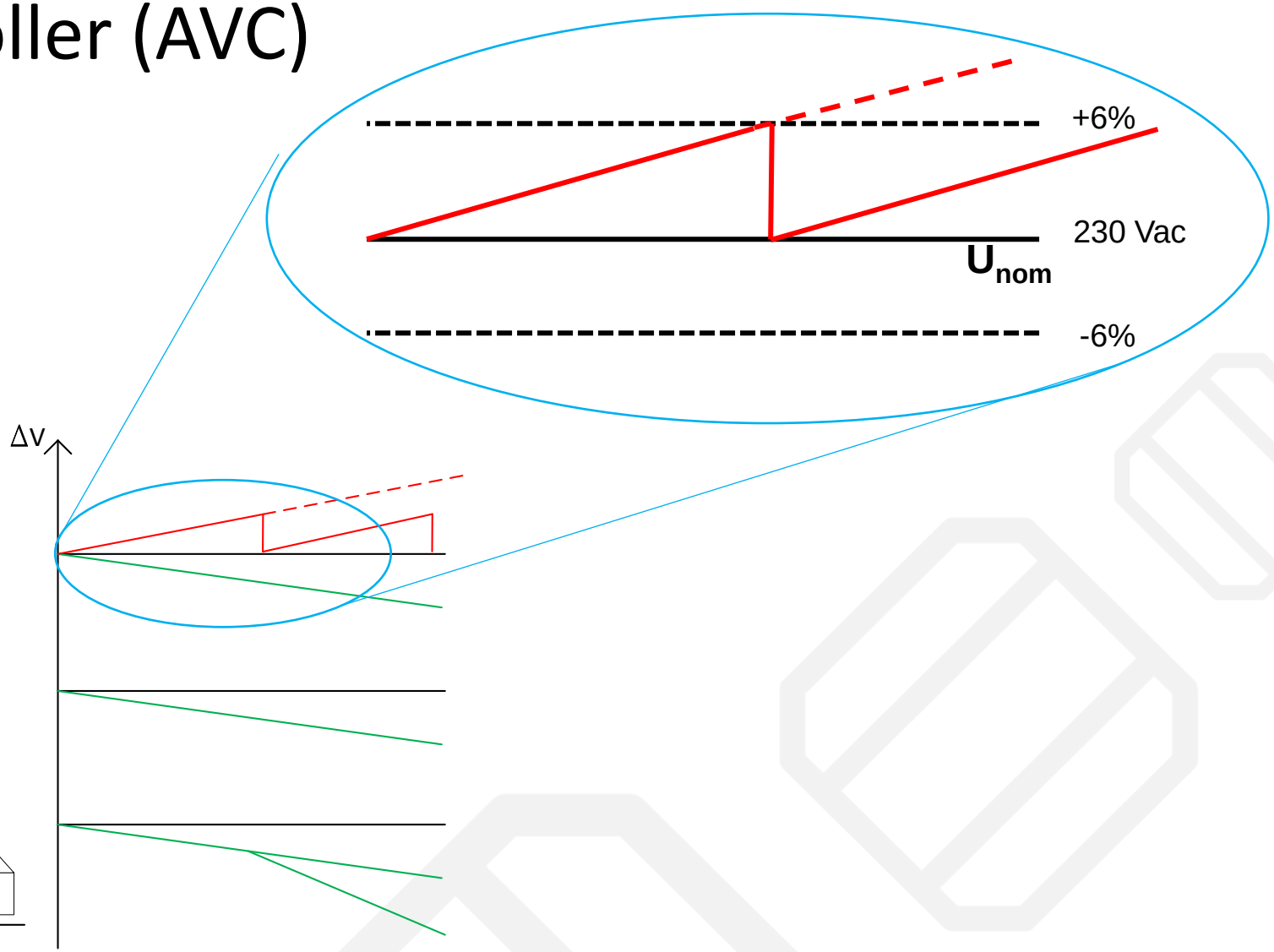
- PV Power Curtailment
  - PV system does not operate at its peak generation but at a reduced output - Not attractive due to loss of energy
- Reactive power compensation
  - Operating the PV Inverter at leading/lagging power factor - Not attractive due to loss of energy
- Optimise local consumption
  - Load management (PV power generated is used locally with reduced export to the grid)
- Electrical energy storage (Energy generated is stored and then used later when there is demand)
    - Battery Storage
    - Electrical Vehicle charging (an effective storage solution)

Mitigation Options (Network Operator)

- Distribution Transformer with On-load tap changer
  - Not good if different LV feeders need different adjustments
- Reactive power compensation
- Network Expansion – very expensive
- Energy Storage – still very expensive
  - Centralised storage system at sub-station level
- Other equipment such as **Voltage Regulators**

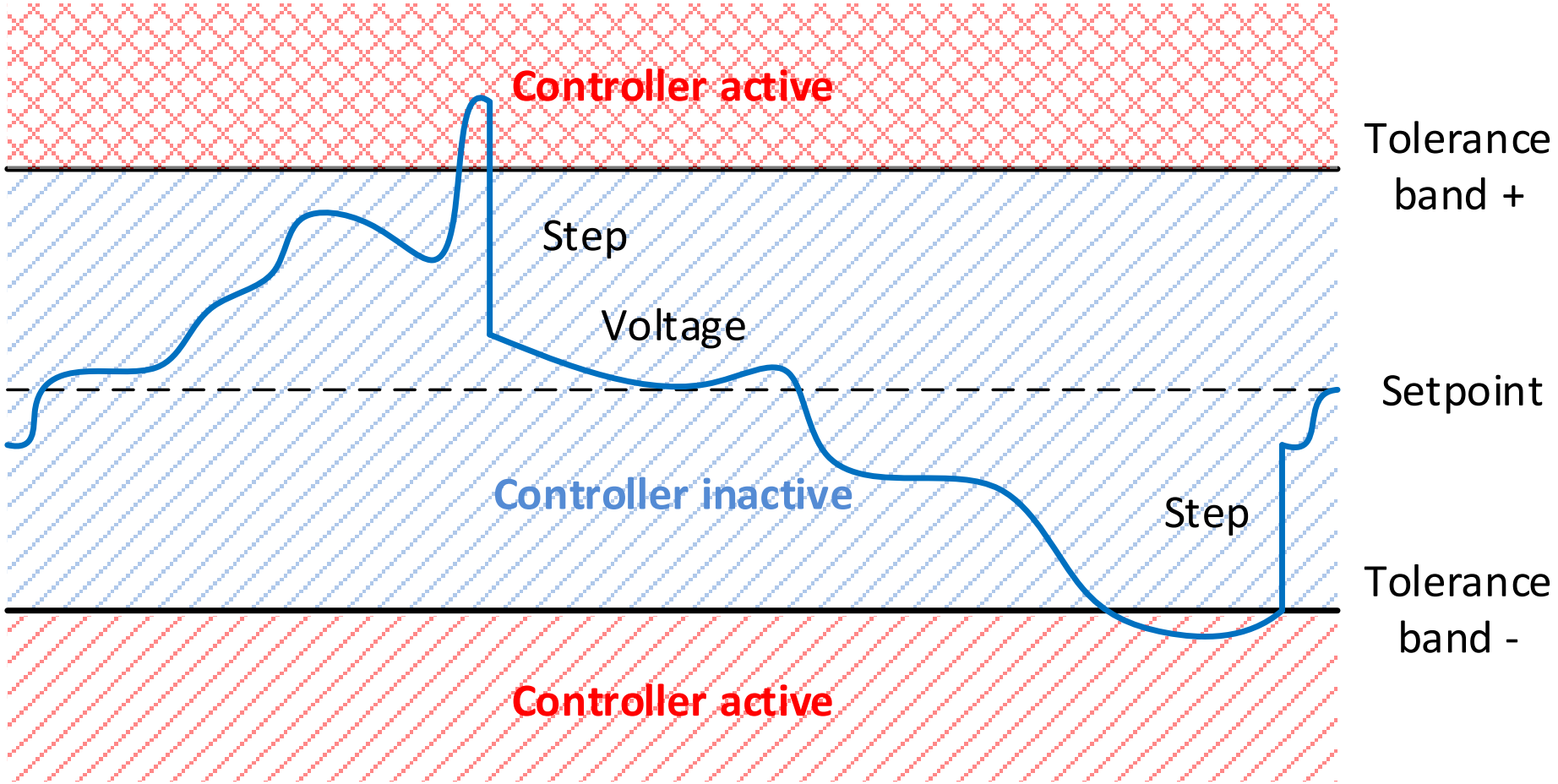
Active Voltage Controller (AVC)



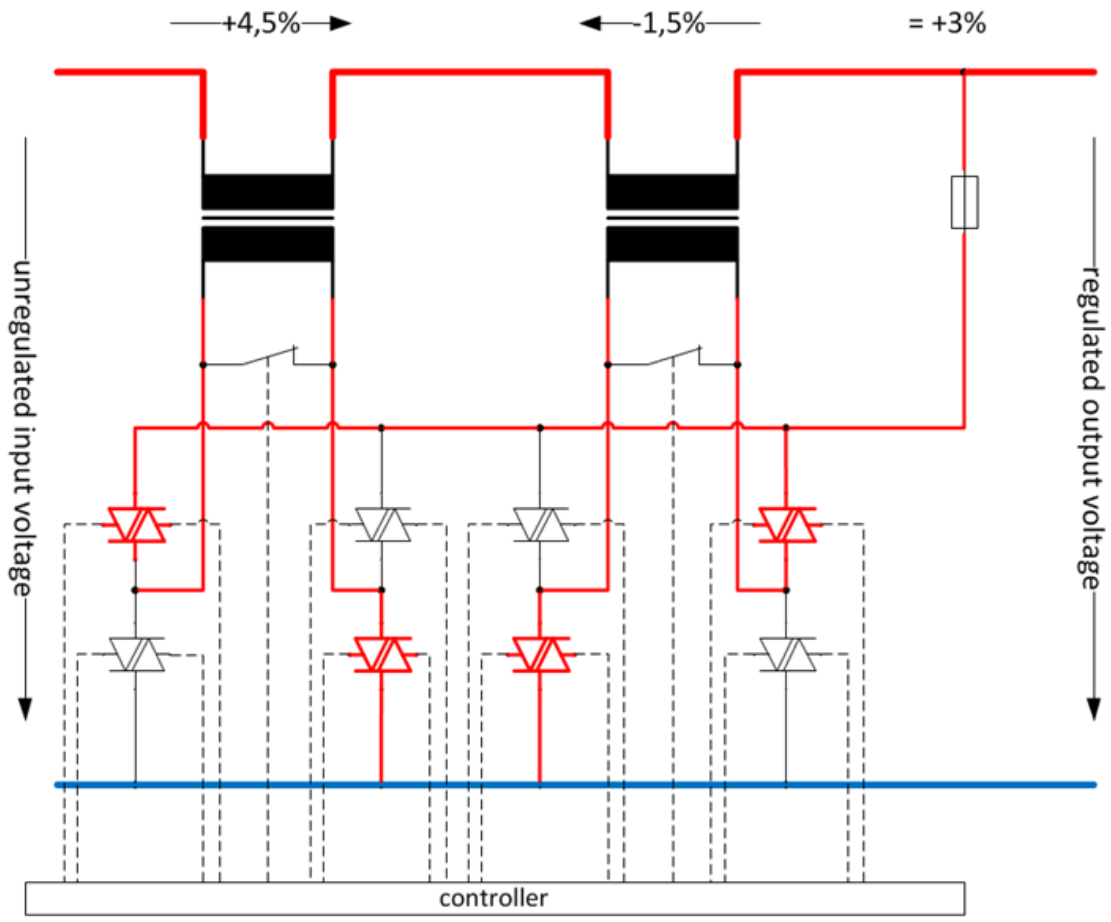


Voltage distribution along the LV Feeder

AVC – Operation Logic

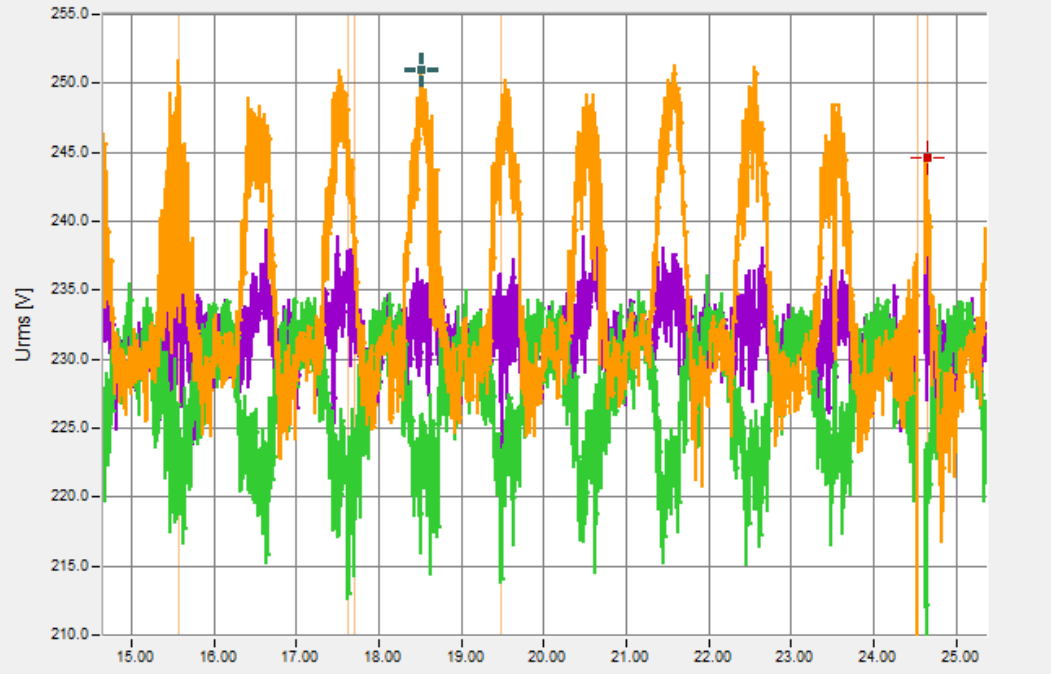


AVC - High Level Per Phase Topology



Step	Transformer 1.5%	Transformer 4.5%
-6%	-1.5%	-4.5%
-4.5%	0%	-4.5%
-3%	+1.5%	-4.5%
-1.5%	-1.5%	0%
0%	0%	0%
+1.5%	+1.5%	0%
+3%	-1.5%	+4.5%
+4.5%	0%	+4.5%
+6%	+1.5%	+4.5%

AVC – Simulated Operation



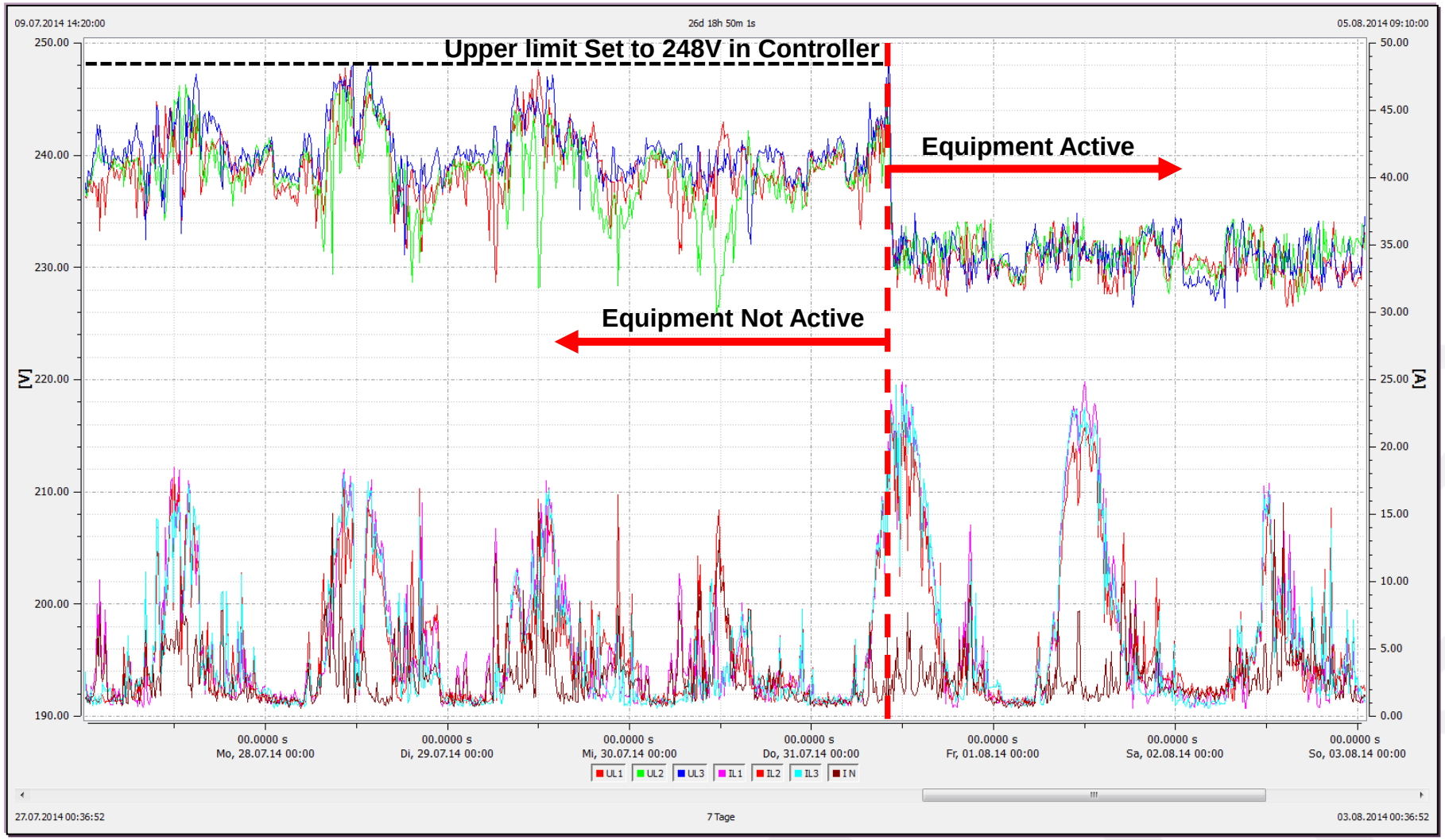
Without Controller

With Controller

Active Voltage Controller – A Case Study

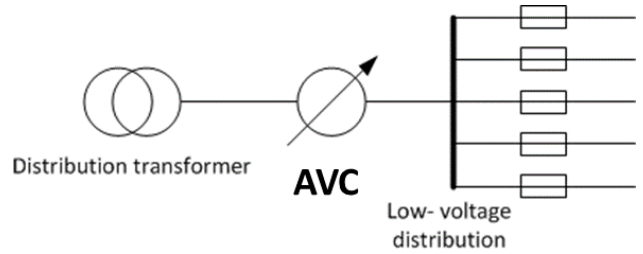
- A project of a 30kWp PV system was proposed
  - In a rural (remote location) in Malta with a long LV feeder
  - Other consumers were connected on the same feeder
  - Load flow analysis showed a clear problem of overvoltage on the network if the PV system is installed
- Together with the local Network operator a pilot project to test the performance of the **active voltage controller** was carried out.

AVC – Case Study

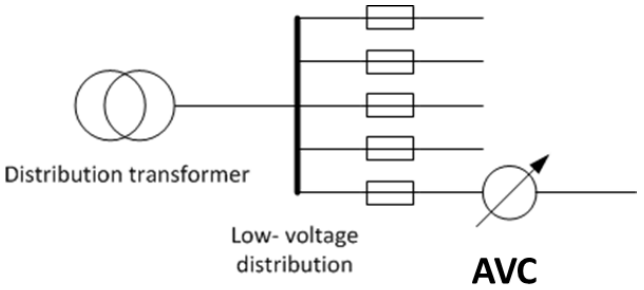


Active Voltage Controller – Installation Location

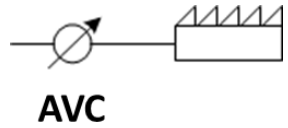
- At sub-station level



- At feeder level



- At unit level



Active Voltage Controller - Features

- Reaction time in ms (<25ms)
- Robust technology as it is based on Thyristors
- High efficiency (99%)
- Each phase can be compensated independently
- AVC can be moved to other parts of the network **easily** if the voltage variation is reduced through other means.
- No maintenance is needed as in the case of other equipment

Conclusion

- The case study was done in collaboration with the manufacturer of the equipment and the Network Operator.
- Its performance was analyzed both through simulations and through field testing
- The successful performance of the Active Voltage Controller has been confirmed

Thank you for your attention!

Questions?