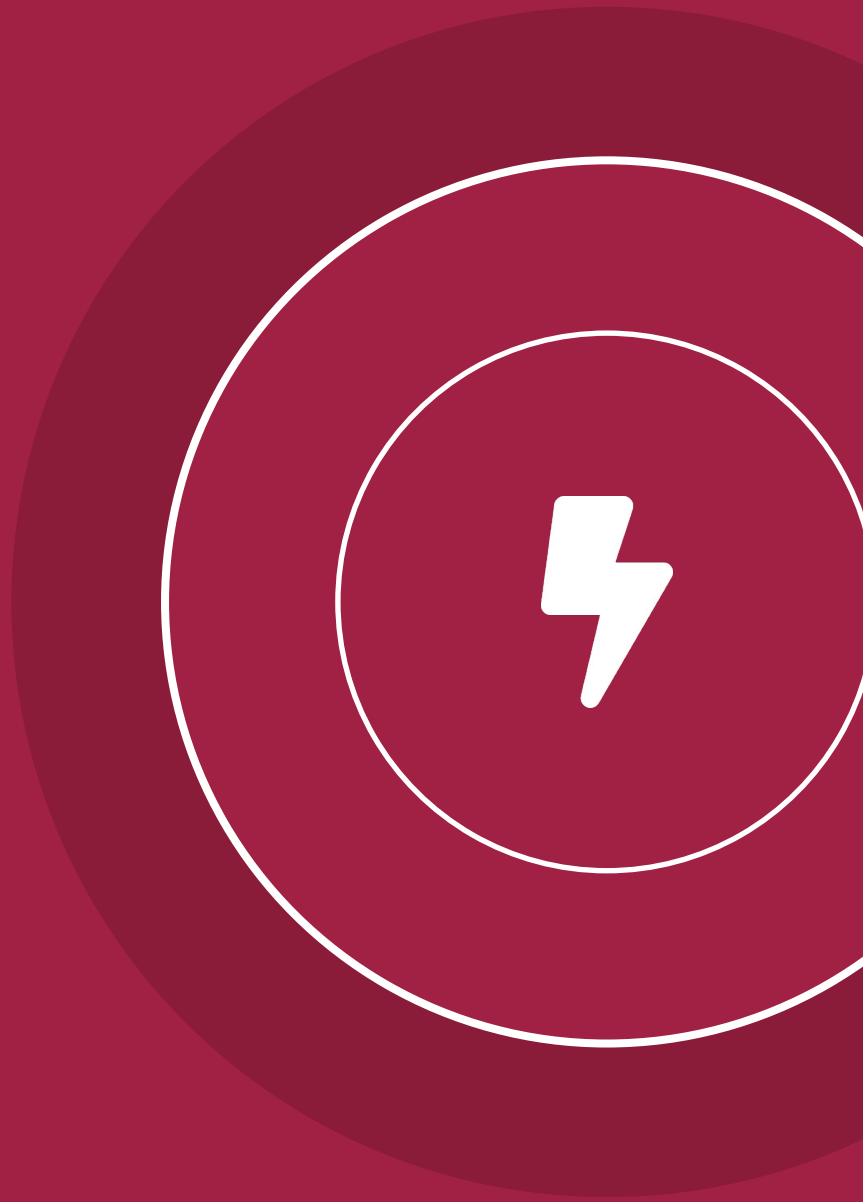
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Grid-aware voltage control

How OLTC regulators and enliteAI FLEX work together to unlock more capacity from the grid you already have



Less copper. More code.

The critical voltage is no longer at the busbar

PV feeders

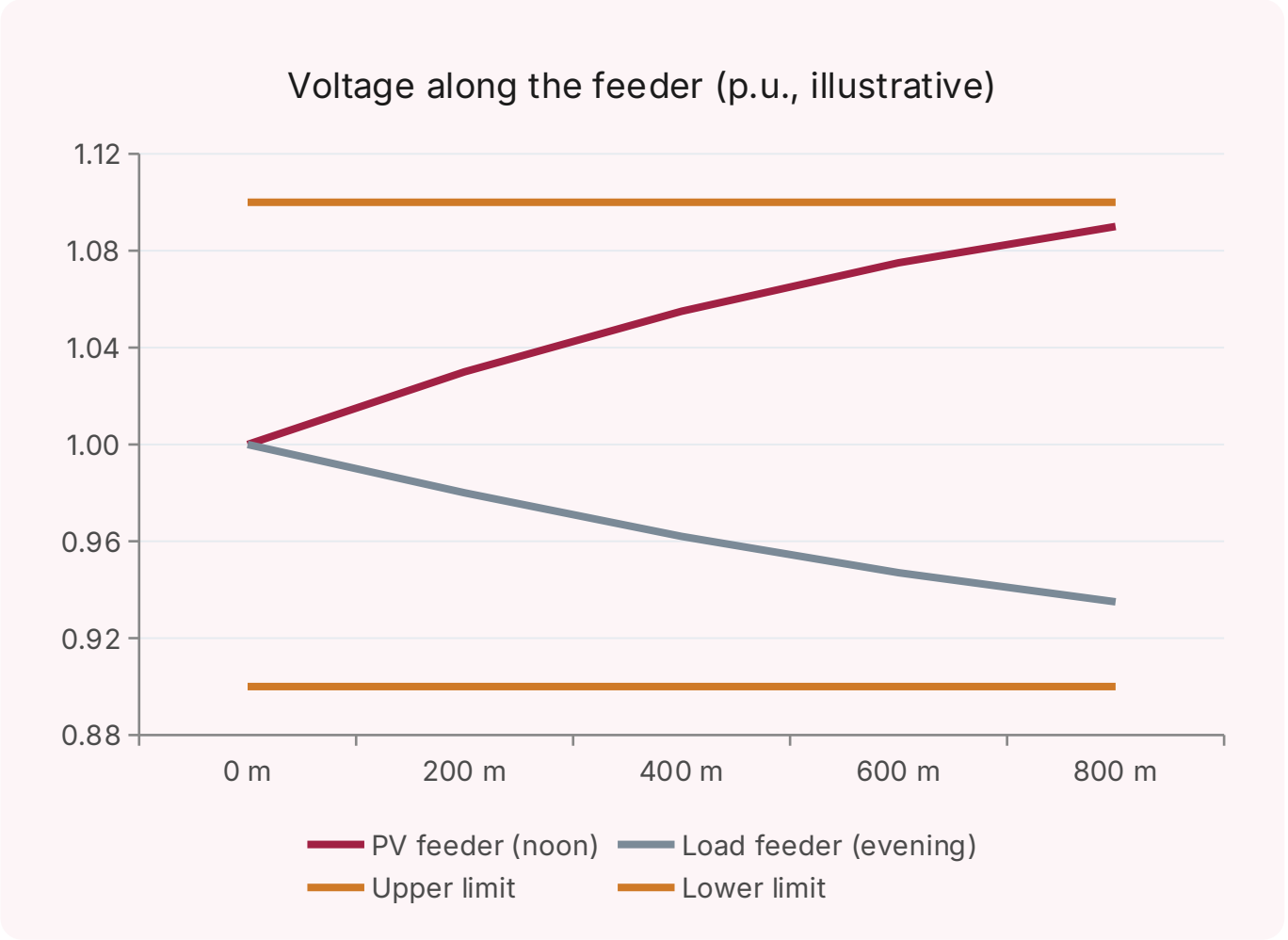
Overvoltage at the feeder end at noon

Heat pump and EV feeders

Undervoltage at the feeder end in the evening

Both on one transformer

One tap position cannot fix both at the same time



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How an OLTC voltage regulator works

A proven two-point controller with a deadband, running locally next to the transformer

1 Measure

U and I at its own busbar via local VTs and CTs

2 Compare

Against a setpoint, e.g. 1.00 p.u., with bandwidth ±1–2 %

3 Delay

Waits T1 (30–120 s) to ignore short fluctuations

4 Step

One tap ≈ 2.5 % (rONT) or 1–1.5 % (substation)

5 Supervise

Limits, tap position, counters, transformer health

Common extras: line drop compensation (R&X) · parallel control (master/follower, circulating reactive current) · remote setpoint via IEC 60870-5-104 / IEC 61850 · remote measured values (e.g. REG-DA via GOOSE or Sampled Values)

Who supplies the regulators

Substation regulators (HV/MV)

Maschinenfabrik Reinhausen
TAPCON® 230 / 260

Siemens
6GC65 (TAPCON-based)

A. Eberle
REG-DA, REGSys™

ABB / Hitachi Energy
SPAU 341 C, Relion® IEDs*

GE Vernova · SEL · Beckwith*
IED / tap changer control

Eaton / Cooper*
CL-7 for line regulators

Regulated distribution transformers (rONT)

Maschinenfabrik Reinhausen
ECOTAP® VPD

Schneider Electric
Minera SGrid (≤ 1 MVA, 36 kV)

Siemens Energy*
FITformer® REG

Hitachi Energy*
regulated DT

SGB-SMIT & other OEMs*
with ECOTAP VPD

J. Schneider Elektrotechnik
SmartActiveTransformer

LV string regulators

A. Eberle
LVRSys

- Keeps the existing transformer
- Series boosters in the LV feeder
- Balances asymmetries

** to be confirmed against current datasheets*

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Where local regulation hits its limits

Wrong measuring point

Keeps the busbar at 1.00 p.u. while the violation sits 800 m away

LDC fails with mixed feeders

One compensation setting cannot fit a PV feeder and a load feeder

Opposite violations

A tap shifts all feeders equally, fixing one can break another

No coordination

No link to Q(U), curtailment, storage or the upstream cascade

Regulator and FLEX: actuator and brain

	OLTC regulator	enliteAI FLEX
What it sees	Its own busbar: U, I, tap position	**Per-unit voltage across the whole grid**
Control target	Busbar inside a deadband	**Every relevant node inside the band**
Time scale	Seconds to minutes, deterministic	**Minutes, plus forecasts**
Opposite violations	Cannot detect them	**Detects the spread, calls flexibility**
Coordination	Parallel transformers only	**Cascade, Q(U), curtailment, storage, DOE**
Planning data	Local counters and logs	**Grid-wide history for NOVA and KPIs**

FLEX does not replace the certified regulator. It gives it grid-wide eyes and a target.

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What enliteAI FLEX adds

More hosting capacity

Use the voltage band where it is needed, defer reinforcement

Fewer violations

Control on real feeder-end voltages, not a busbar proxy

Fewer tap operations

Move the setpoint only when the grid needs it

Flex where taps can't help

Q(U), curtailment or DOE on the right feeder

Vendor-neutral

Works on top of MR, Siemens, A. Eberle, Hitachi, Schneider

Better planning

Shows where rONT, string regulators or cables pay off

Three ways to couple FLEX with the regulator

A

Advisory

FLEX computes the optimal setpoint. The control room decides.

No write access to OT. Ideal pilot start.

B RECOMMENDED

Setpoint control

FLEX writes a setpoint every few minutes via IEC 60870-5-104 / 61850.

Fast loop and protection stay local.

C

Virtual measurement

FLEX feeds U_max / U_min as the controlled variable.

Most effective, fully dependent on the data chain.

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Control logic: when to tap, when to flex

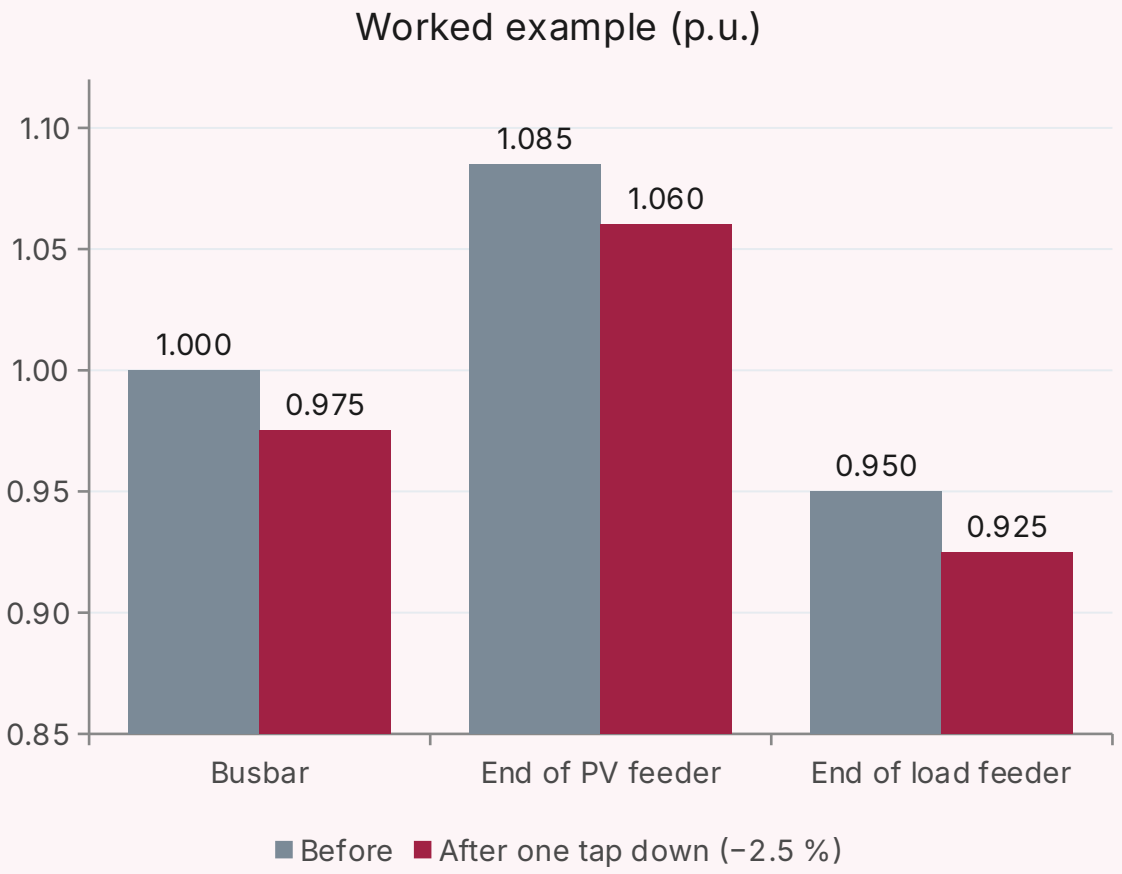
U_max > 1.08
lower the tap, if U_min stays above 0.92

U_min < 0.92
raise the tap, if U_max stays below 1.08

Both violated
keep the tap, activate Q(U), curtailment or DOE

All inside band
do nothing, save tap operations

Band 0.90–1.10 p.u. (EN 50160) with a 0.02 margin



Built for safe operation and compliance

Watchdog fallback
Stale FLEX data: regulator returns to its local setpoint

Tap limits
Max operations per hour and day, hard setpoint limits

Cascade time grading
HV/MV reacts faster, rONT slower, no hunting

NIS2
IEC 62443 zones, RBAC, IEC 62351, audit logs

AI Act
Every setpoint explainable, logged, human oversight

GDPR
Smart meter data aggregated, pseudonymised, purpose-bound

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From monitoring to closed loop

1 Pilot in advisory mode (A) on selected transformer areas

2 Prove the gain against a no-FLEX baseline

3 Switch to setpoint control (B) with watchdog and limits

Less copper. More code.

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