ESIG Spring Workshop 2021
Session 3: Grid Forming Inverter Research Landscape

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ENERCON
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GFM – new?

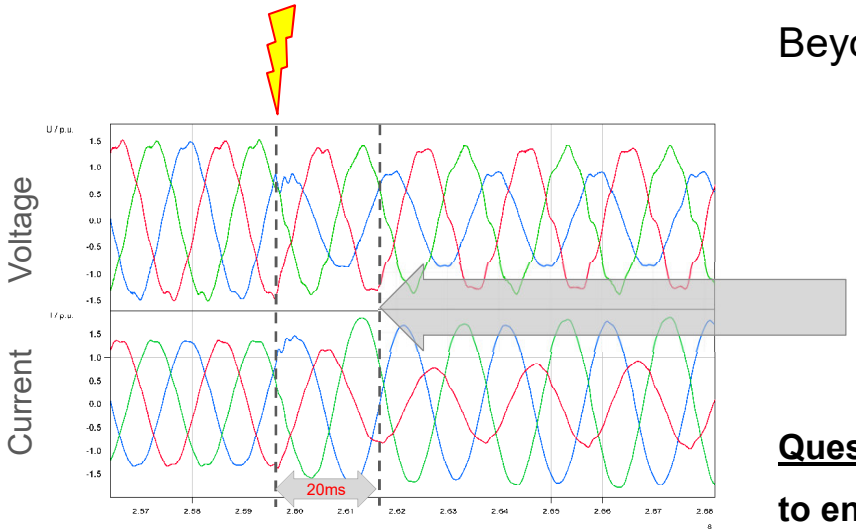
- Inverters with Grid-forming capabilities (GFM) are available on the market
- Technically possible, typically bound to BESS

But

- PV- and wind-turbines with GFM are not available on the market
- On purpose, reasons:
  - It is not required, nor is it paid for
  - It is incompatible to MPP tracking
  - It is incompatible with todays grid codes (anti islanding, FRT)
  - Implementing it costs significant money (R&D, CAPEX, OPEX)

GFM – GFL – what's the difference?

- In the very short term performance, prior to a Grid Following (GFL) inverter detecting the position of U-phasors from the external grid: state of the art: <1 cycle



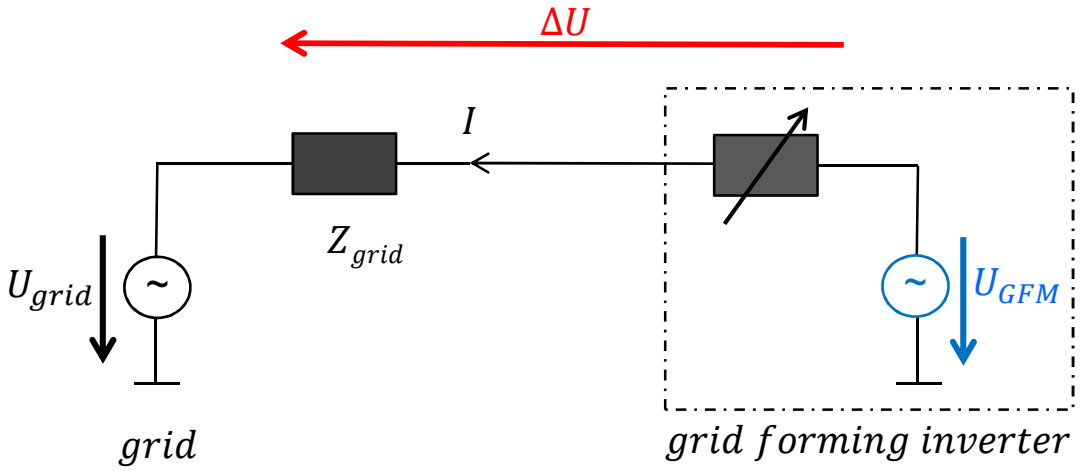
Grid Following inverter facing unsym. fault
Field measurement at LV terminals

Beyond that point in time GFM and GFL have

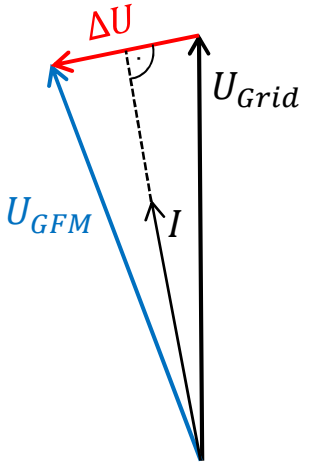
- same physical limitations (current and power/energy)
- same capabilities to implement a "power system supportive performance"

<u>Question:</u> Is this initial ~1st cycle the topic we need to fix to ensure power system stability at high IBR penetration?

Assume we have a GFM

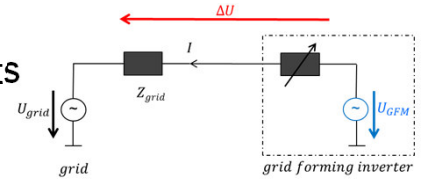


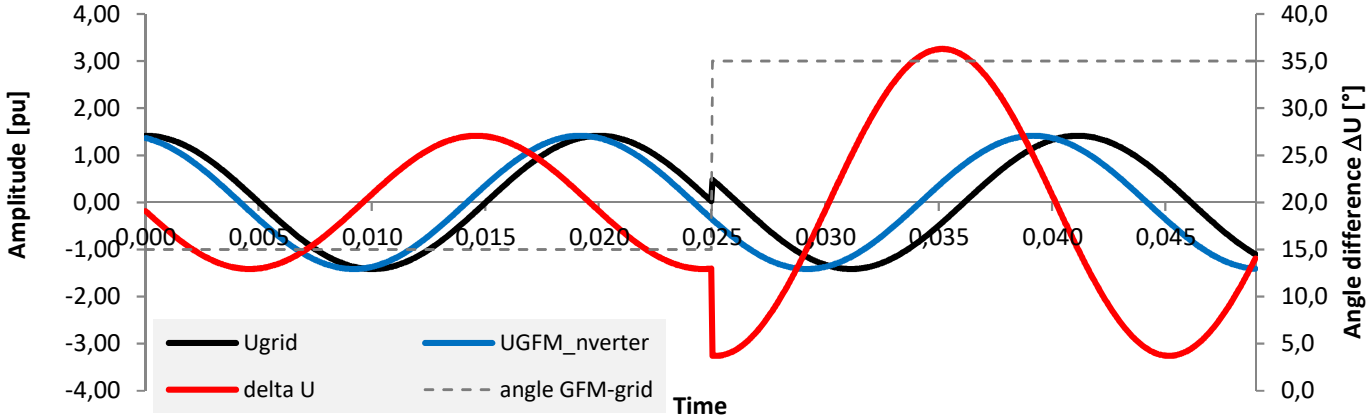
$$U_{GFM} = \Delta U + U_{Grid}$$



GFM and grid incidents

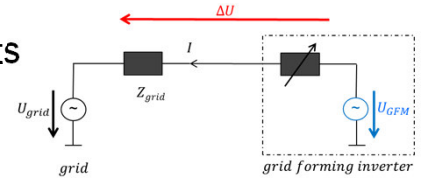
- A GFM Inverter connected to the grid. No matter what is feeding the GFM
- Initial situation: $f_{GFM} = f_{grid}$, $\Delta\varphi$ set to stable infeed, ΔU and resulting $\mathbf{I}$ within limits
- Incident on the grid => 20° phase jump
- Consequence:
  - ΔU step ↑ and $\mathbf{I}$ step ↑ potentially exceeding limits (depends on Z, I_{max} …)
  - Power buffer available to maintain that operation for Δt?
  - When & how to return to steady state?
- In a WEC: Requires BESS/Supercap and/or WEC has to withstand severe mechanical stress

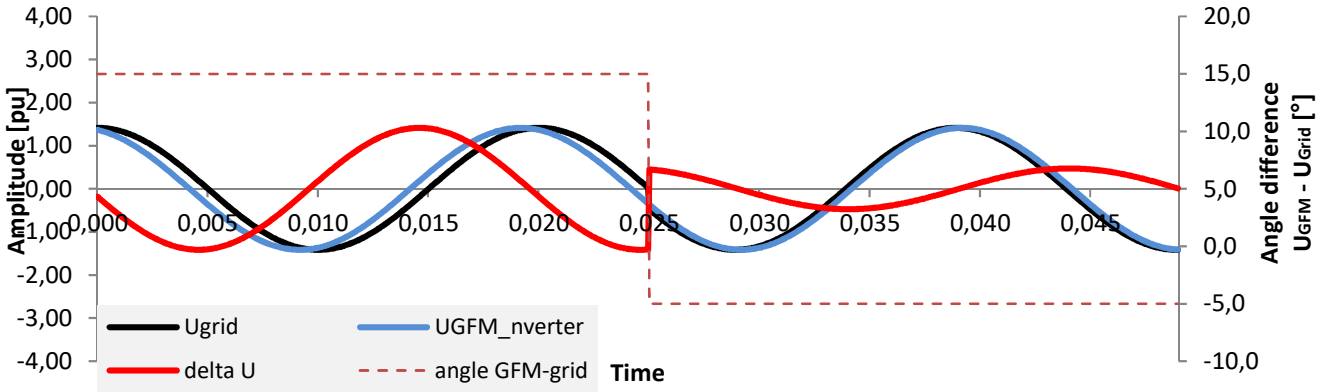




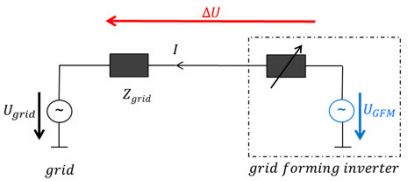
GFM and grid incidents

- A GFM Inverter connected to the grid. No matter what is feeding the GFM
- Initial situation: $f_{GFM} = f_{grid}$, $\Delta\varphi$ set to stable infeed, ΔU and resulting $\mathbf{I}$ within limits
- Incident on the grid => -20° phase jump
- Consequence:
  - ΔU step ↓
  - $\mathbf{I}$ step ↓
- In a WEC: Chopper could be used





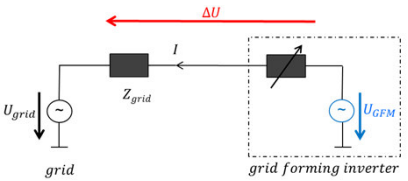
GFM and grid incidents



- The challenge is not to build an inverter with GFM as such.
  The challenge is rather: “If it is a GFM, how shall the power system supportive performance look like in detail?”

- i) How much overcurrent capability?
- ii) How much P_{buffer} resp. E_{buffer} ?
- iii) How to limit current? (keep sinus shape of current or accept trapezoid cutting?)
- iv) How to do best system-supportive transition from GFM to GFL (and back)
- v) How to avoid unintentional islanding, as an IBR with GFM is perfect to keep any island stable?

If we need it, who should do the GFM job?



- It is all about money:
  - i) How much GFMs do we need in a power system?
    And where?
  - ii) Which players are most predestinated for GFM?
  - iii) Which ones can do it at lowest overall cost?
  - Iv) How to organize this service lean and safe?

Most questions are “power system questions”.

Making **BESS** with GFM?

Possible, with much less effort than PV or WEC

Making **PV** with GFM?

Possible, but with significant effort

Making **WECs** with GFM?

Possible, but with highest effort of all power electronics-options, due to mechanical impact

Thank you