PHOTOVOLTAIC INVERTER 3-PHASE CSI – CEA – TRAININGS

TECNALIA, SAN SEBASTIAN NOVEMBER 6TH 2019
CRICURSA, BARCELONA NOVEMBER 7TH 2019

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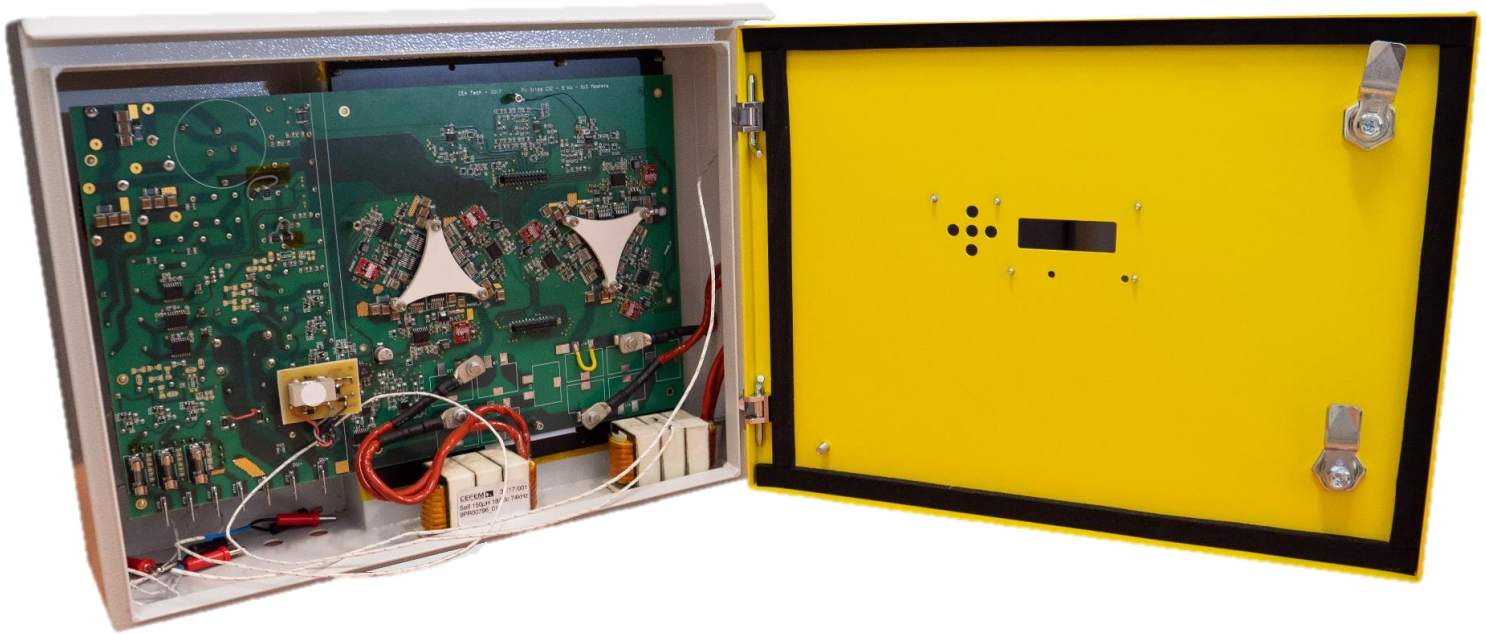
3-phase current-source inverter

Characteristics

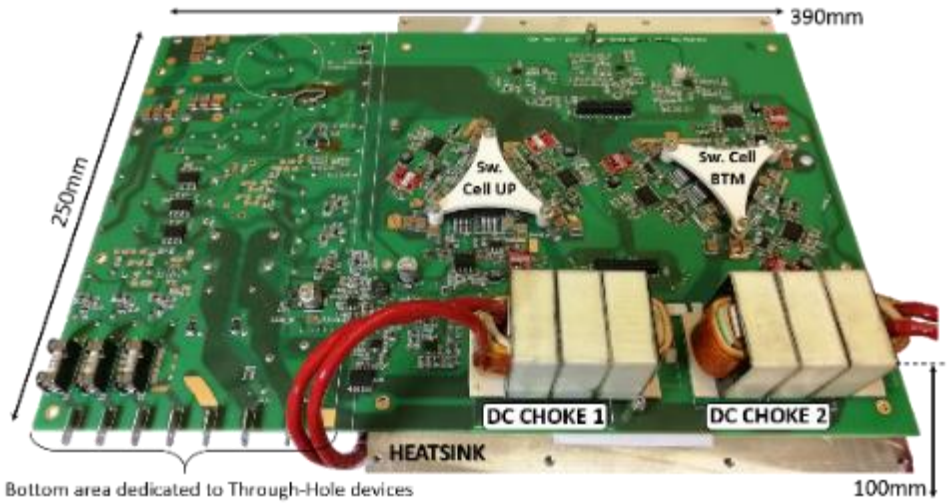


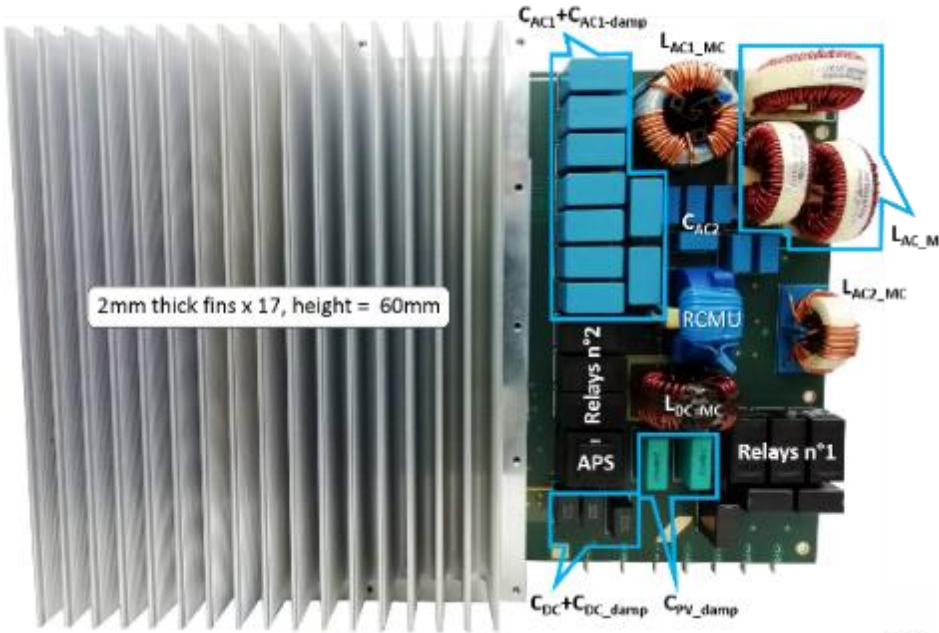
- Power : 5 kW
- Topology : Silicon carbide based 3-phase transformer-less current-source inverter
- Maximum PV voltage : 400 V_{DC}
- Assigned grid AC voltage : 400 V_{ACrms} / 50 Hz
- Switching frequency : 125 kHz
- Maximum efficiency : 98 %

Design

Printed circuit board

- Top-side:
  - Surface mounted component
    - Switching cells
    - Power supply
    - Switches drivers
    - Measuring channel
    - …
  - DC chokes
- Bottom-side:
  - Through-holes mounted component
    - Differential and common-mode filtering
    - Relays
    - RCMU
  - Heatsink

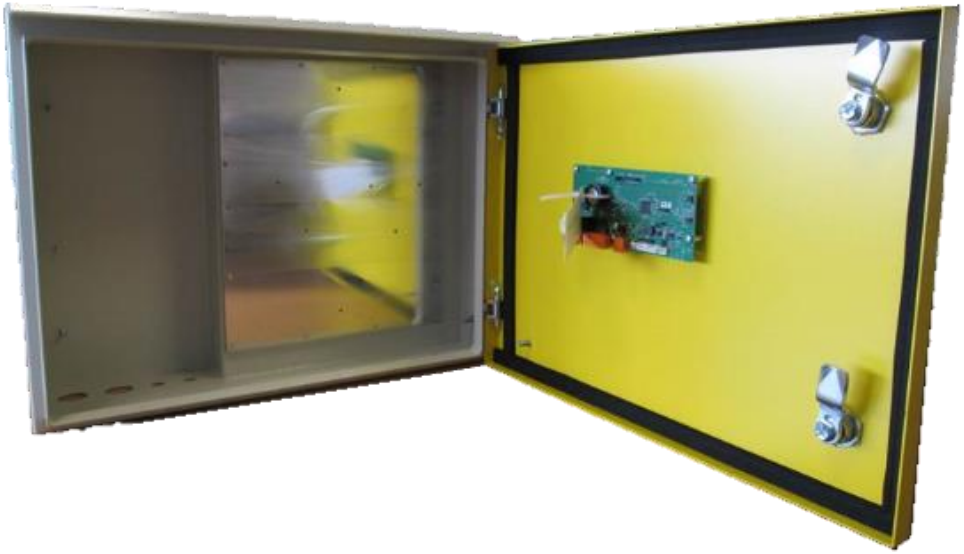




Design

Enclosure

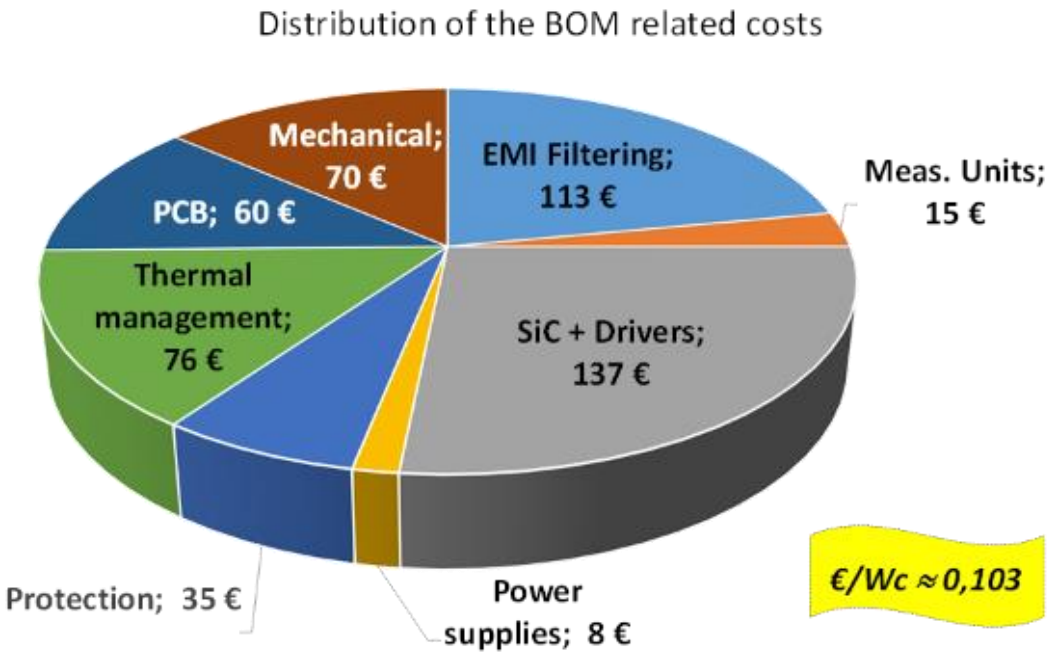
- Front-side
  - Metallic cabinet with key-locked door
  - Human-to-machine front interface
  - Holes for cable connections
- Back-side
  - Heatsink
  - Fixture system for wall mounting



Design

Bill of materials

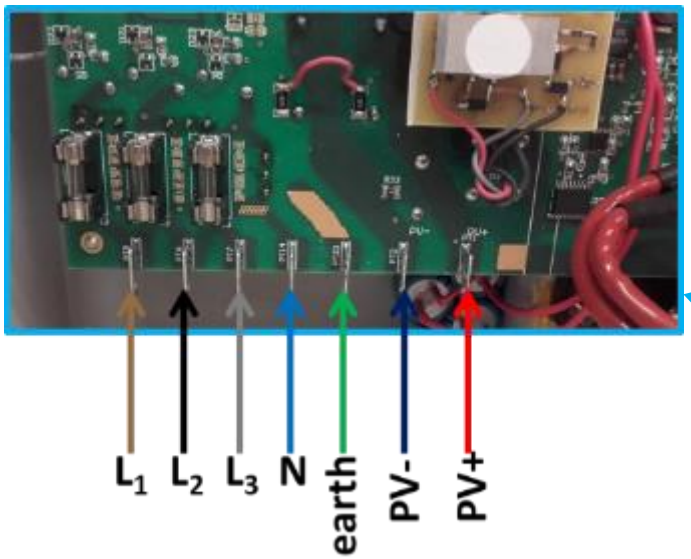
- Costs repartition of the inverter components



Connection

DC and AC cables

- Plug connectors for:
  - 3-phase AC cables
  - Neutral
  - Earth
  - DC plus and minus PV cables

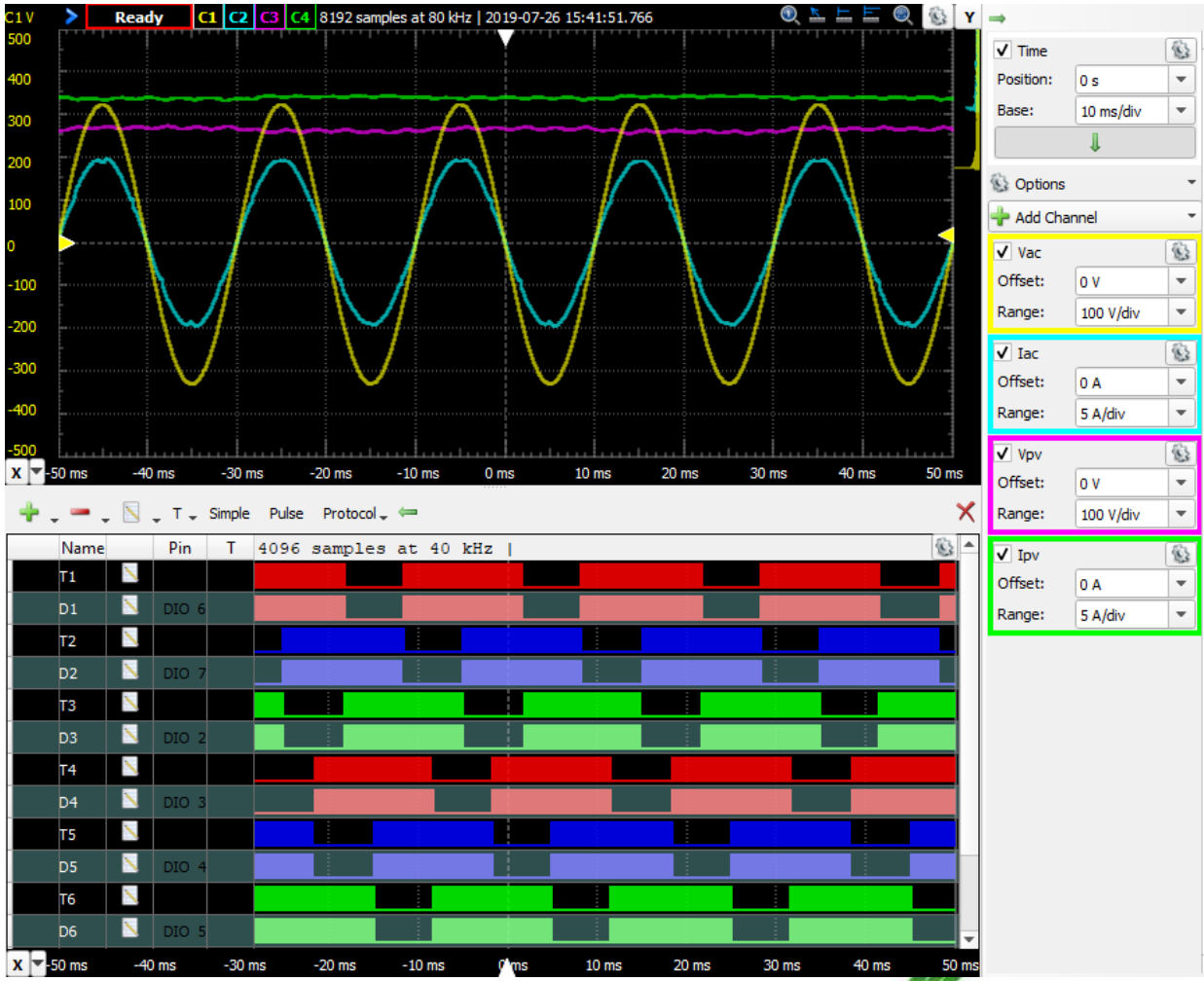


Test

Electrical normal-mode operation

- Electrical waveforms analysis for operation under normal conditions test:
  - **PV voltage V_{PV}**
  - **PV current I_{PV}**
  - **Grid voltage V_{AC}**
  - **Injected grid current I_{AC}**

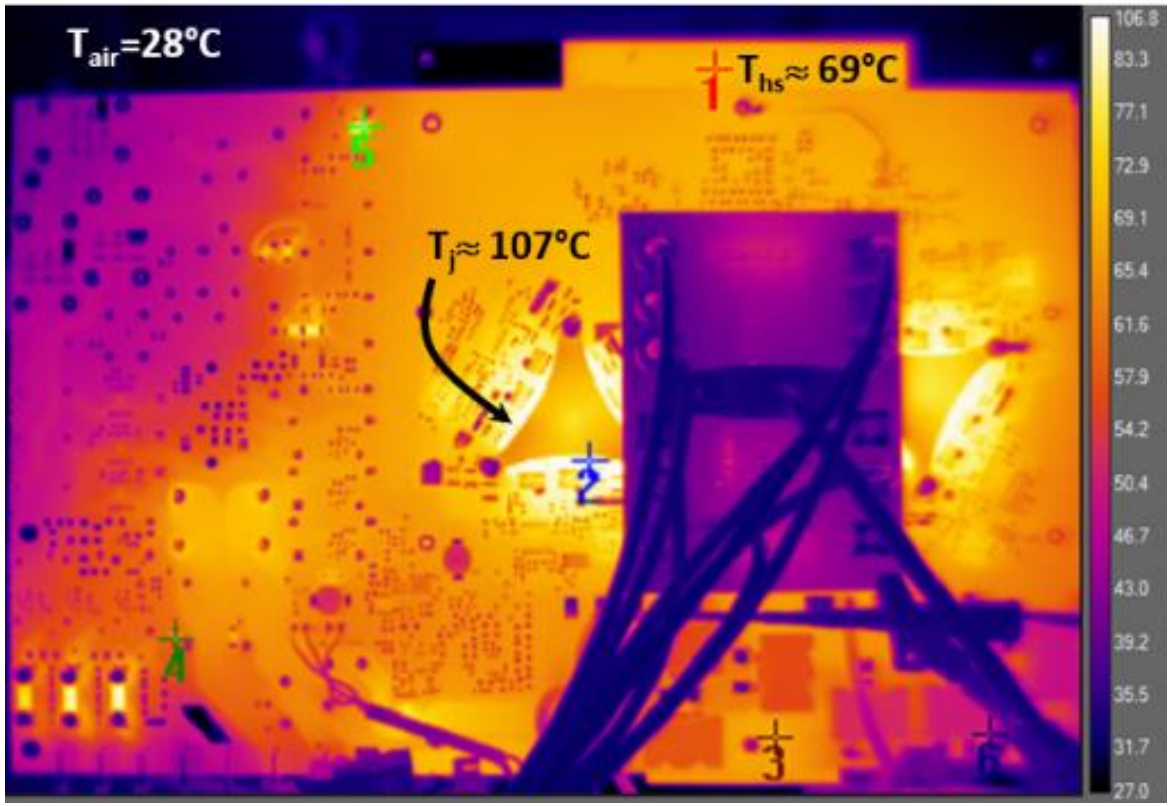
- Control signals for the 12 CSI switches



Test

Thermal management

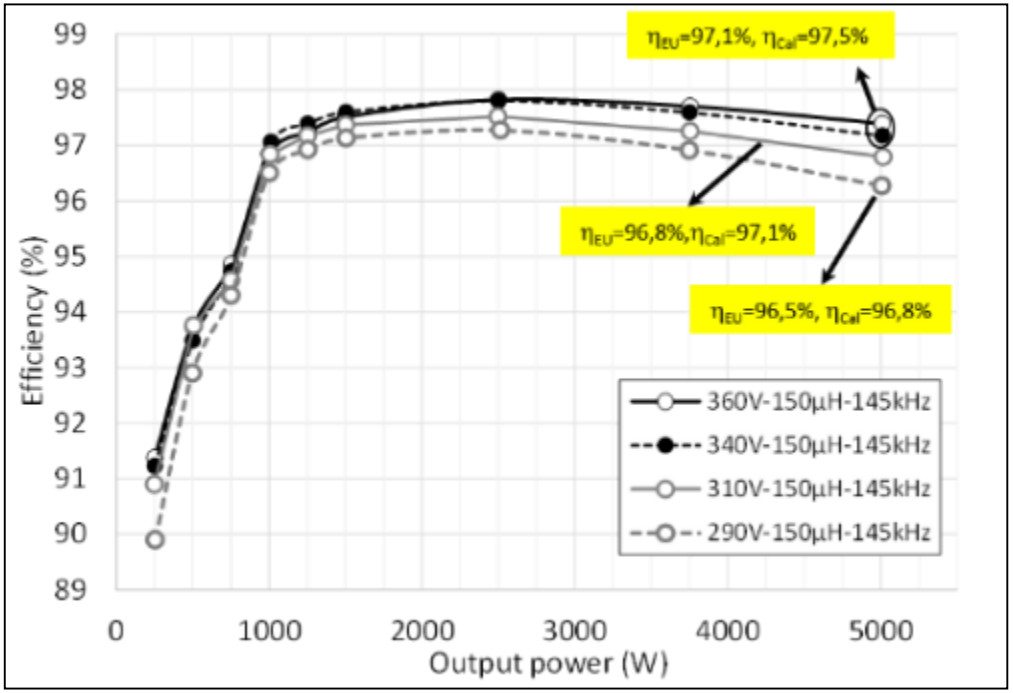
- Checking of several component temperatures along operation cycles for different powers at steady states
- At rated power (5 kW):
  - T_{air} = 28° C
  - $T_{heatsink}$ = 69° C
  - $T_{switches\_junction}$ = 107° C



Test

Efficiency

- Conversion efficiency measurement according to the EN50530 standard
- European weighted efficiencies:
  - 96,5% at 290 V_{PV}
  - 96,8% at 310 V_{PV}
  - 97,1% at 340 V_{PV}
  - 97,1% at 360 V_{PV}
- Californian weighted efficiencies:
  - 96,8% at 290 V_{PV}
  - 97,1% at 310 V_{PV}
  - 97,5% at 340 V_{PV}
  - 97,5% at 360 V_{PV}
- Maximum efficiency : 98%



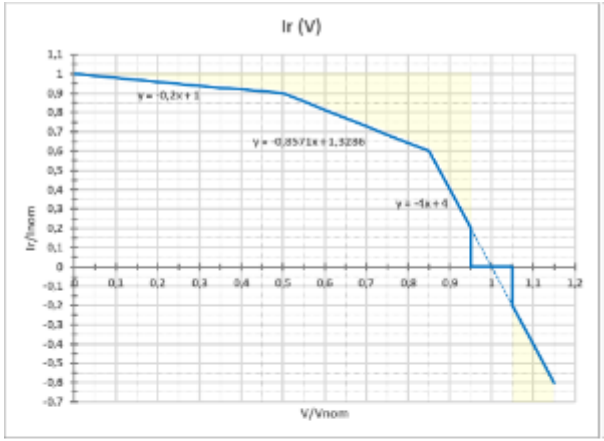
Test

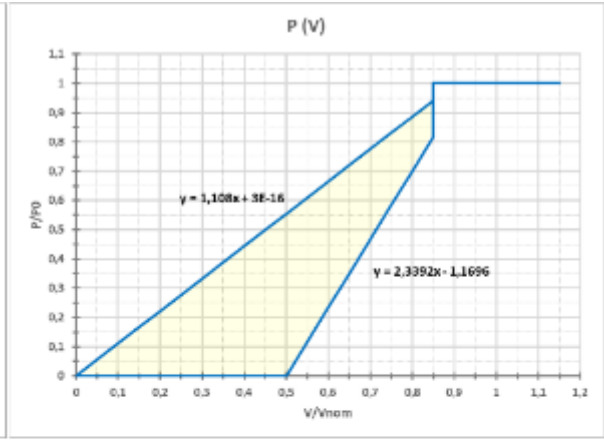
Safety and Grid requirements

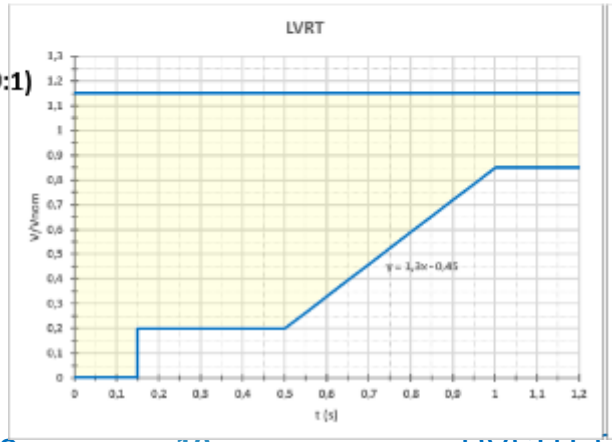
- Normal operation, grid requirement and safety standards to comply with:

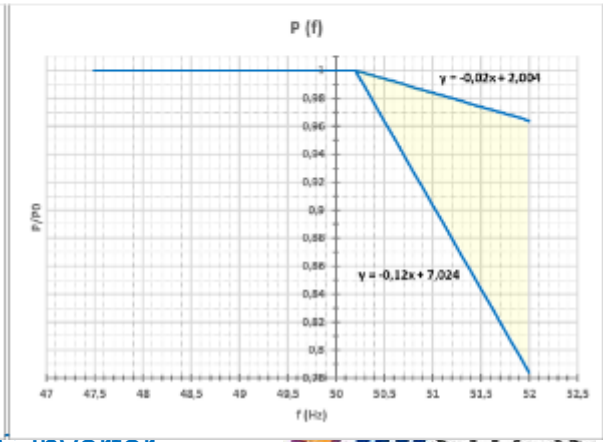
1- Normal Operating Range
   a. Voltage & Frequency Operating Range. (EN50438)
   b. Under-frequency response (EN50438)
   c. Over-Frequency response (EN50438)
2- Interface Protection
   a. Under / Over Voltage Test (EN50438)
   b. Under / Over Frequency Test (EN50438)
   c. Main Loss Detection (Islanding) (IEC 62116)
   d. Automatic Reconnection (EN50438
3- Safety Protections
   a. Residual current detection (IEC 62109:2)
   b. PV array insulation resistance detection (IEC 62109:1)
4- Power Quality
   a. Harmonic & Flicker (61000-3-2, 61000-3-3)
   b. DC Current Injection (EN50438)
5- Low Voltage Ride Through (IEC 62910)
6- Reactive Power Delivery (EN50438)
7- MPPT Tests (EN50530)
8- Power Conversion Efficiency (EN50530)

- Standard profiles as described in PO12.3
  - Reactive current vs AC voltage level
  - Active power vs AC voltage level
  - Grid low-voltage ride through capability
  - Active power vs grid voltage frequency









Thanks for the attention

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