

# Open DC Grid Project

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# Agenda

- ❖ Current Issues
  - ❖ Safety in the standard
  - ❖ 48V max normal voltage
  - ❖ Physical isolation on bus
  - ❖ How to de-energize a bus?
  - ❖ Bus earthing (grounding)
  - ❖ Arcs
  - ❖ Power / energy routing
- ❖ P2030.10.1
- ❖ Reference Grid
- ❖ New Issues / Feedback

# Current Issues

<https://github.com/open-dc-grid/standard/issues>

open-dc-grid / standard

Unwatch 3 Star 0 Fork 1

Code Issues 8 Pull requests 0 Actions Projects 0 Wiki Security Insights Settings

Label issues and pull requests for new contributors

Dismiss

Now, GitHub will help potential first-time contributors [discover issues](#) labeled with [good first issue](#)

Filters is:issue is:open

Labels 9 Milestones 0

New issue

<input type="checkbox"/>	8 Open ✓ 0 Closed	Author	Label	Projects	Milestones	Assignee	Sort
<input type="checkbox"/>	<a href="#">Arc-fault detection on bus-type nanogrids</a> #9 opened 6 days ago by jlgula						
<input type="checkbox"/>	<a href="#">Over current protection on bus-type nanogrids</a> #8 opened 6 days ago by jlgula						
<input type="checkbox"/>	<a href="#">Physical isolation on 48V circuits</a> #7 opened 6 days ago by jlgula						2
<input type="checkbox"/>	<a href="#">How to de-energize a bus nanogrid</a> #6 opened 6 days ago by jlgula						2
<input type="checkbox"/>	<a href="#">Safety in the Standard</a> #5 opened 6 days ago by jlgula						
<input type="checkbox"/>	<a href="#">Energy Priorities</a> #4 opened 6 days ago by martinjaeger						
<input type="checkbox"/>	<a href="#">48V bus earthing (grounding)</a> #3 opened 9 days ago by jlgula						3
<input type="checkbox"/>	<a href="#">48V max normal voltage</a> #2 opened 20 days ago by jlgula						1

# Safety

## How should ODG address safety?

- \* Purposes of the standard:
  - \* Recipe book for vendor interoperability
  - \* Guide book for resellers and informed consumers
  - \* Minimize need for expensive references
  - \* Primary market focus – off grid and weak grid consumers
- \* Safety authorities – vendors should never sell unsafe products
  - \* What is safety?
  - \* Consider pharmaceuticals – are drugs safe?
- \* Safety has a cost – extreme safety has extreme cost
- \* Lack of electricity has profound impact on lives – including hazards
- \* No point to standard if conforming products unaffordable
- \* Need to find a balance between safety and cost

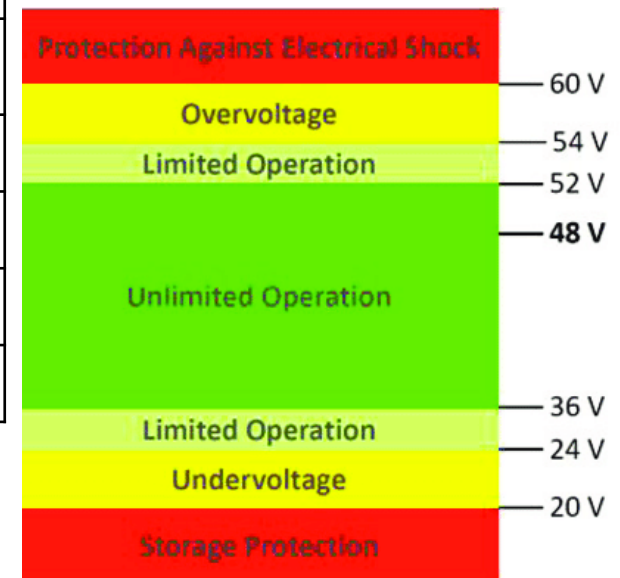
# 48V bus – upper maximum voltage

		12V Nominal				48V Nominal		
Battery Type	Cells	Bulk / Top	Equal	Tickle	Cells	Bulk / Top	Equal	Tickle
Flooded	6	14.4	15.0	14.1	24	57.6	60.0	56.4
Gel	6	15.0	n/a	13.8	24	60.0	n/a	55.2
AGM *	6	14.1	n/a	13.8	24	56.4	n/a	55.2
LiFePO4 *	4	13.8	n/a	n/a	16	55.2	n/a	n/a

Direct battery connection?

Is buck/boost required - expense?

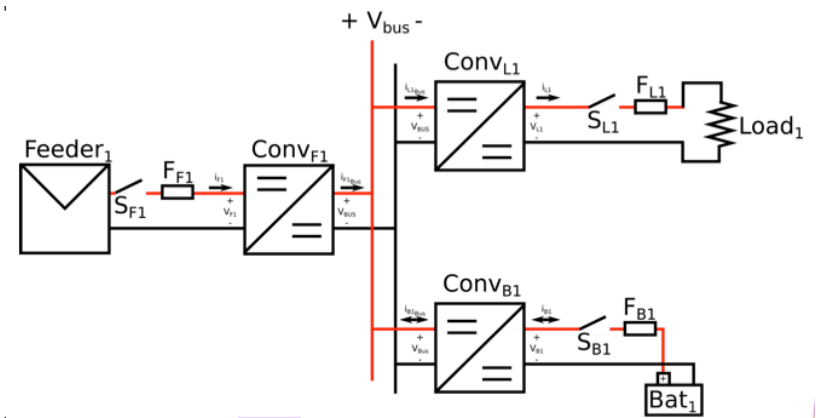
What about 2 battery banks?



# Physical Isolation on Bus

IEC 60364-5-53:2019: 536.2.2.3: Semiconductor devices shall not be used as isolating devices.

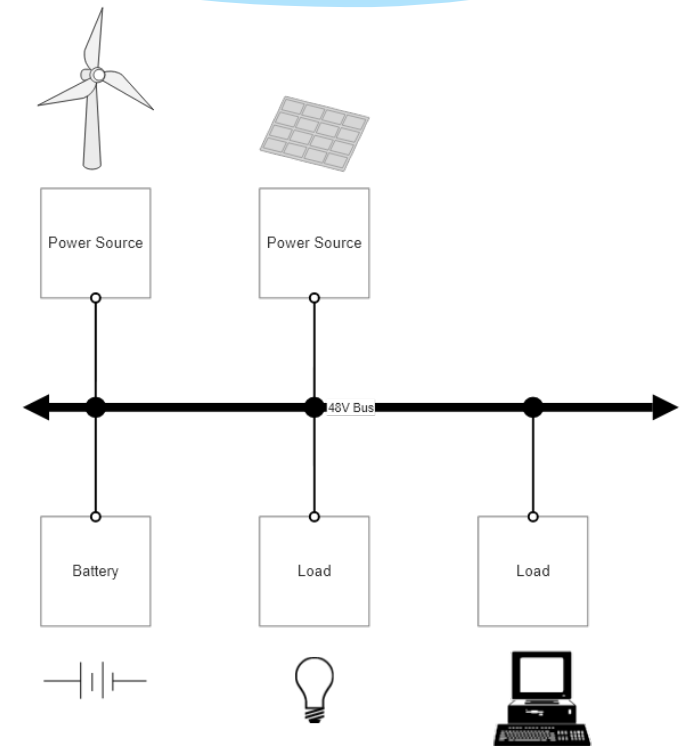
- \* MOSFET switches
  - \* Are they sufficient for bus maintenance?
  - \* Typically included in DC-DC converters
  - \* E-fuse == isolation?
- \* IEC/UL 60950 secondary circuits
  - \*  $< 42.4\text{V}$  or  $< 60\text{V}$  and  $< 240\text{VA}$
  - \* Every else is primary and hazardous
  - \* Hazardous needs isolation
  - \* IEC 62368 (hazard-based standard)?
- \* How best to provide physical isolation?
  - \* Switch – DC rated  $> 30\text{V}$  unusual
  - \* DC circuit breakers expensive
  - \* Galvanic isolation? When is it needed?



P2030.10.1 Diagram

# How to de-energize a bus?

- \* 48 bus potentially hazardous
  - \* 48V+ unsafe in wet conditions
  - \* large currents => arcs and fires
- \* Physical disconnect switches?
  - \* What if sources remote?
- \* Dedicated wire?
  - \* Nuisance for large grids
- \* Keep alive signal using PLC?
  - \* Sunspec Alliance Rapid Shutdown
  - \* Is PLC eg IEEE 1901 reliable enough?



# Bus Earthing (grounding)

- \* 48V is potentially hazardous in some conditions
  - \* SELV (unearthed) reduces risk but...
  - \* Only if no earth faults
  - \* How to detect earth faults?
- \* Complex topic
  - \* See Chris Moller's paper referenced in ODG issues
- \* Should ODG have 1 recommendation?
- \* How to manage interconnected nanogrids?
- \* Which approaches satisfy regulator authorities?

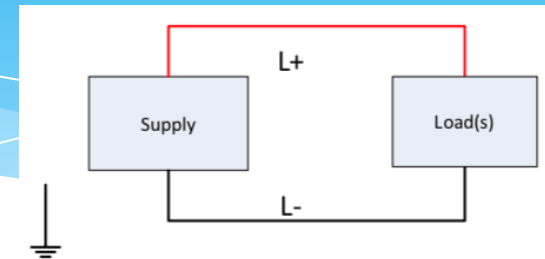


Figure 1 - Unearthed system

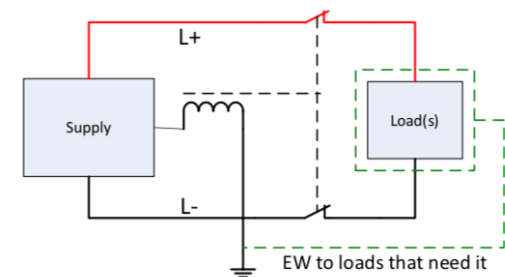


Figure 2 - Earthed system with single branch circuit

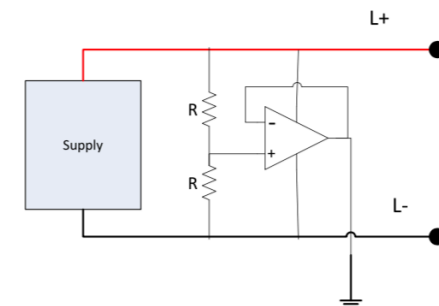


Figure 4 - Synthesised midpoint

Figures by Chris Moller:

# Arcs

- \* Arcs can occur at 48V
  - \* Risk increases sharply at higher voltages
- \* Arcs are rarely sustained at 48V
- \* Can detect arcs via voltage drop / noise
- \* May be difficult to detect reliably
- \* Is some protection better than none?
  - \* False confidence?
- \* Is a standard requirement worth while?
  - \* Minimum load capacitance to reduce risk?

Zhihao, et al, "Characterization of Series Arcs in LVdc Microgrids," ICDCM, 2017

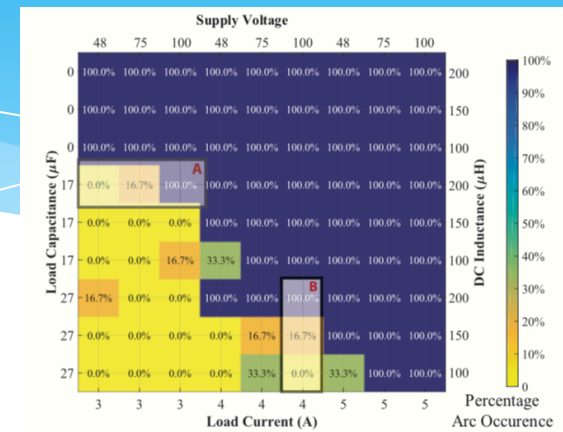


Fig. 4. Percentage times series arc occurs out of 6 tests per circuit condition.

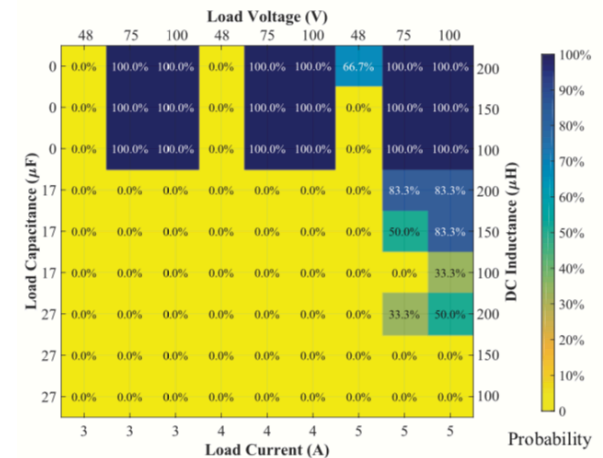
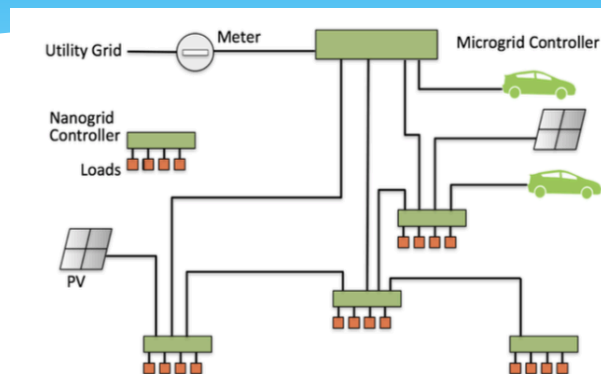
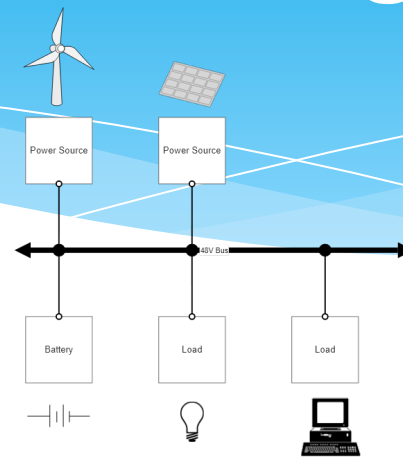


Fig. 5. Percentage times sustained series arcs were obtained.

# Power / energy routing



Microgrid: Nordman et al.



Nanogrid

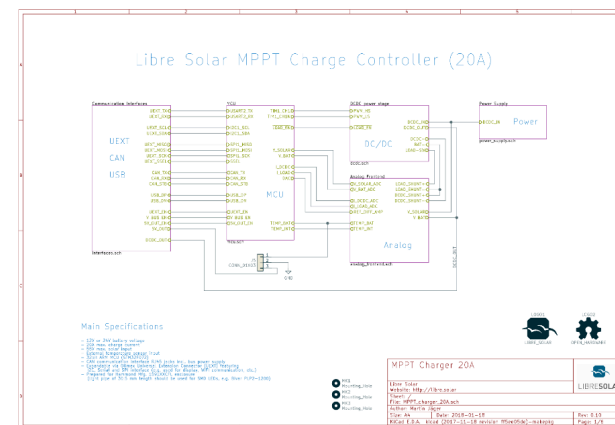
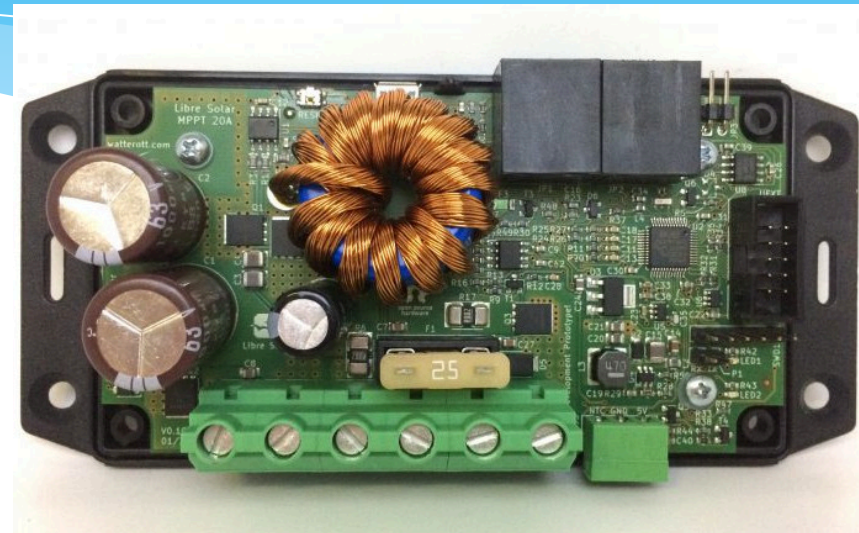
- \* Complex topic – need framework for discussion
- \* Terminology (for now)
  - \* Nanogrid: Network of wired devices observing approximately same voltage
  - \* Microgrid: Network of 1 or more nanogrids operating under a single administration
- \* Power routing and energy routing are distinct but related
- \* Power routing is primarily a nanogrid issue concerned with voltage stability
- \* Energy routing is primarily a microgrid issue concerned with economics
- \* ODG needs to address both
  - \* Open source protocol simulator in development

# ODG Reference – key building block

## Libre Solar MPPT-2420 Charge Controller

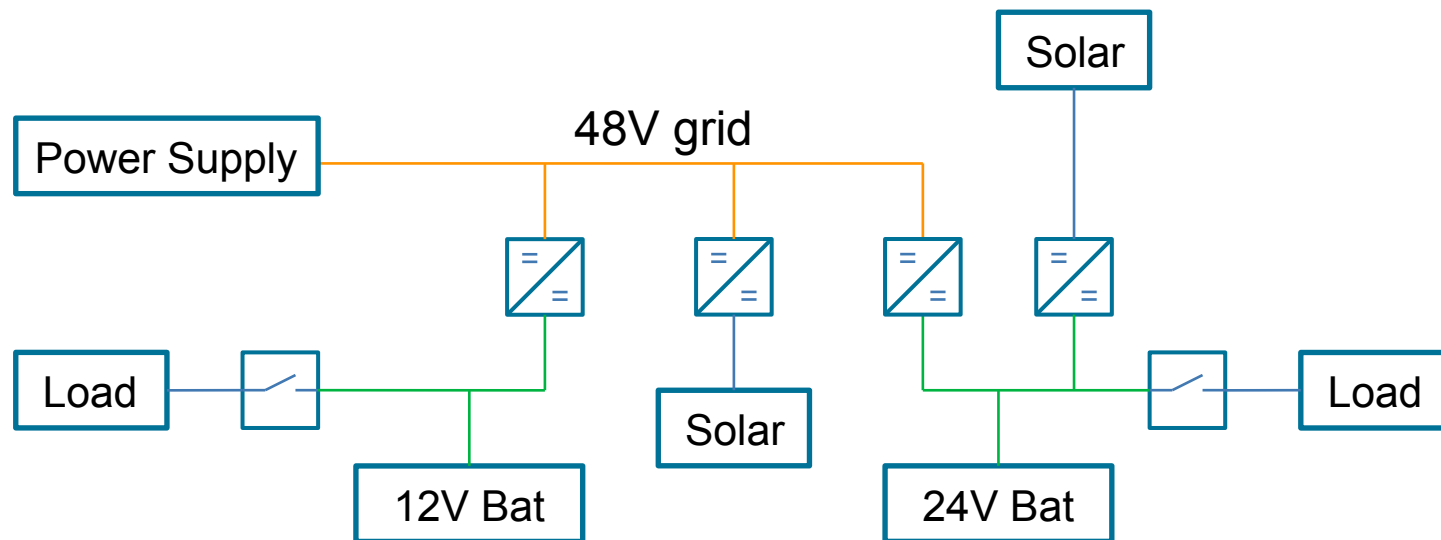
- \* MPPT Charge Controller (20A)
  - \* Synchronous DC/DC (bidirectional operation)
  - \* 55V max PV input
  - \* 12V or 24V battery
  - \* 32bit ARM MCU (STM32F072)
  - \* CAN communication interface
  - \* USB interface
  - \* Olimex Universal Extension

New HW revision under development



# ODG Reference Grid (Initial version)

- 48V grid with droop control
- 12V/24V bus with control via CAN



# Next Meeting

## ❖ Next Meeting:

- 14 April 2020 1400 UTC
- [FreeConferenceCall.com](https://www.freeconferencecall.com) meeting ID: jlgula

## ❖ Sharing Portals

- ❖ Web site: <https://open-dc-grid.org/>
- ❖ GitHub: <https://github.com/open-dc-grid>