Commonwealth

VOLTAGE-BASED METHOD FOR LOW-COST, RELIABLE FAULT ISOLATION IN INVERTER-BASED MICROGRIDS (IBR)

Presenter Sebastien Billaut, P.E.

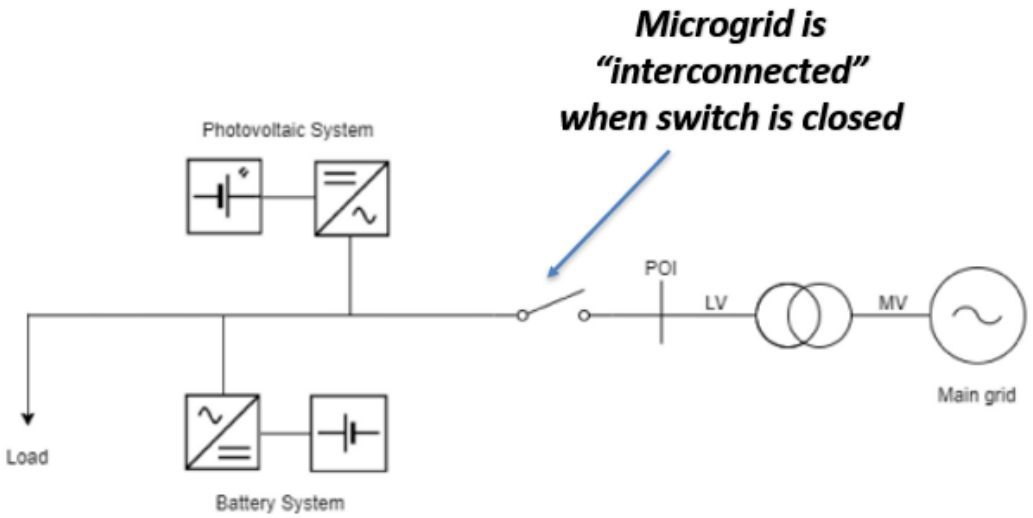
TOPICS

- Define IBR Microgrid
- Microgrid Protection
- Fault Characteristics
- The Microrupter Solution
- Microrupter Innovations

MICROGRIDS

- What are they?
- The Basics

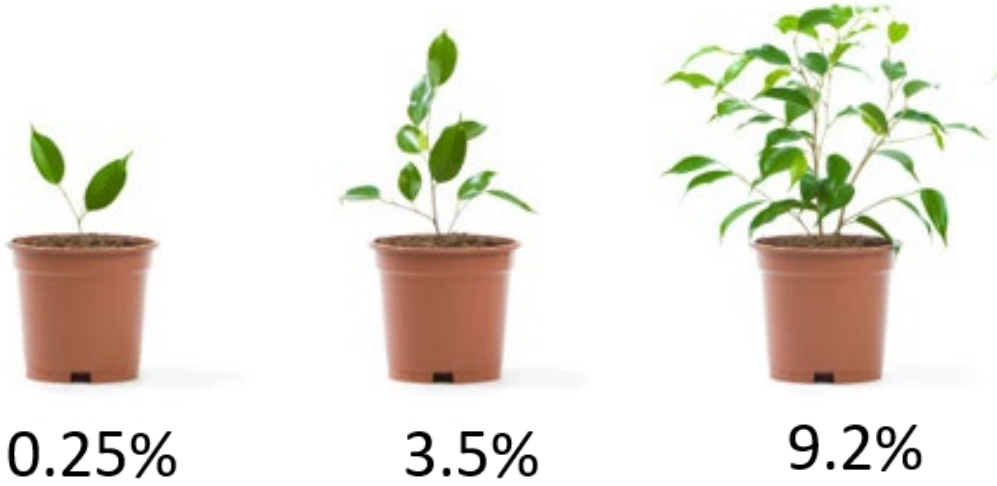
- What are they?
- The Basics
- Grid-connected or islanded
- Used when load/gen separated
- IBR = inverter-based



Microgrid schematic image courtesy of https://www.sit.fraunhofer.de/fileadmin/dokumente/artikel/Microgrid-Systems_Towards_a_Technical_Performance_Assessment_Frame.pdf?_=1623152605

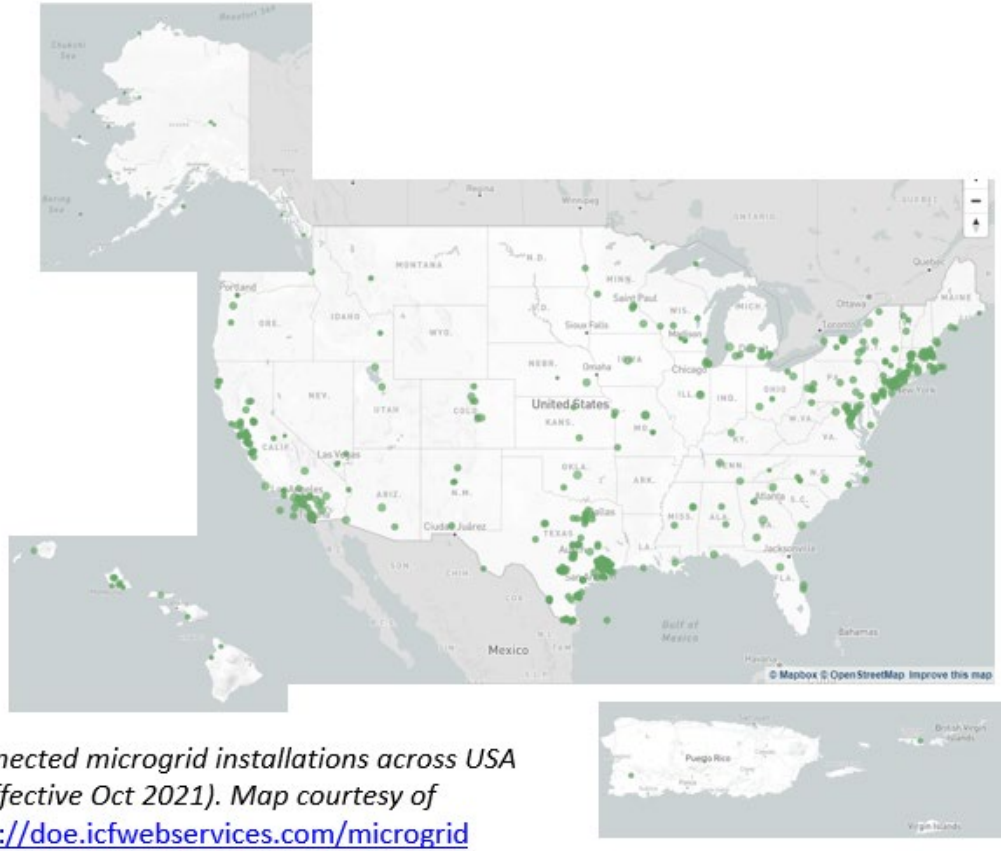
MICROGRIDS

- Where are they?
- Poll Question: What percentage of total US generation is provided by microgrids?



MICROGRIDS

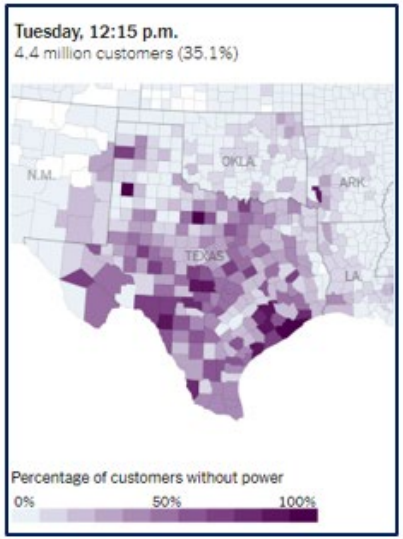
- Where are they?
- US microgrids: 3,100 MW
  - Total US net generation
    1,200,000 MW
  - = 0.25% of total generation



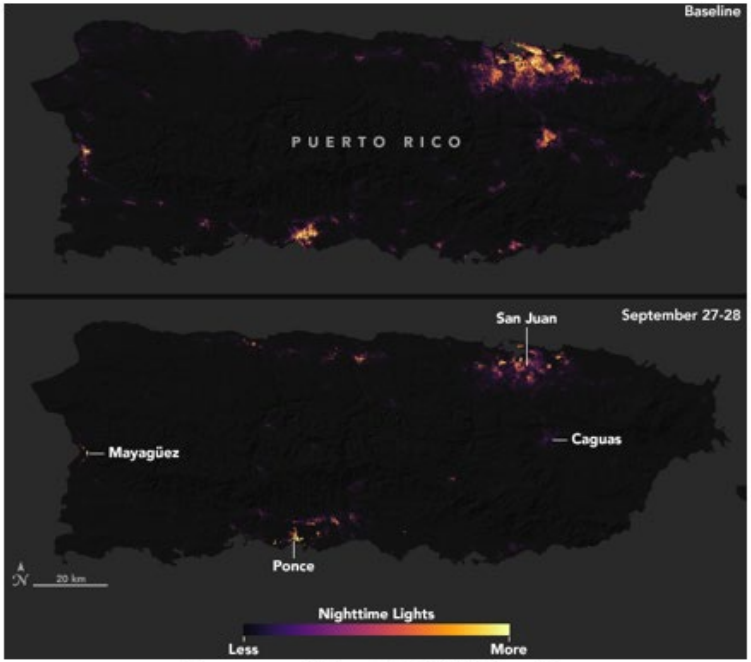
Grid-connected microgrid installations across USA (effective Oct 2021). Map courtesy of https://doe.icfwebservices.com/microgrid

MICROGRIDS

- Why do they matter?
- Mitigation for natural disasters



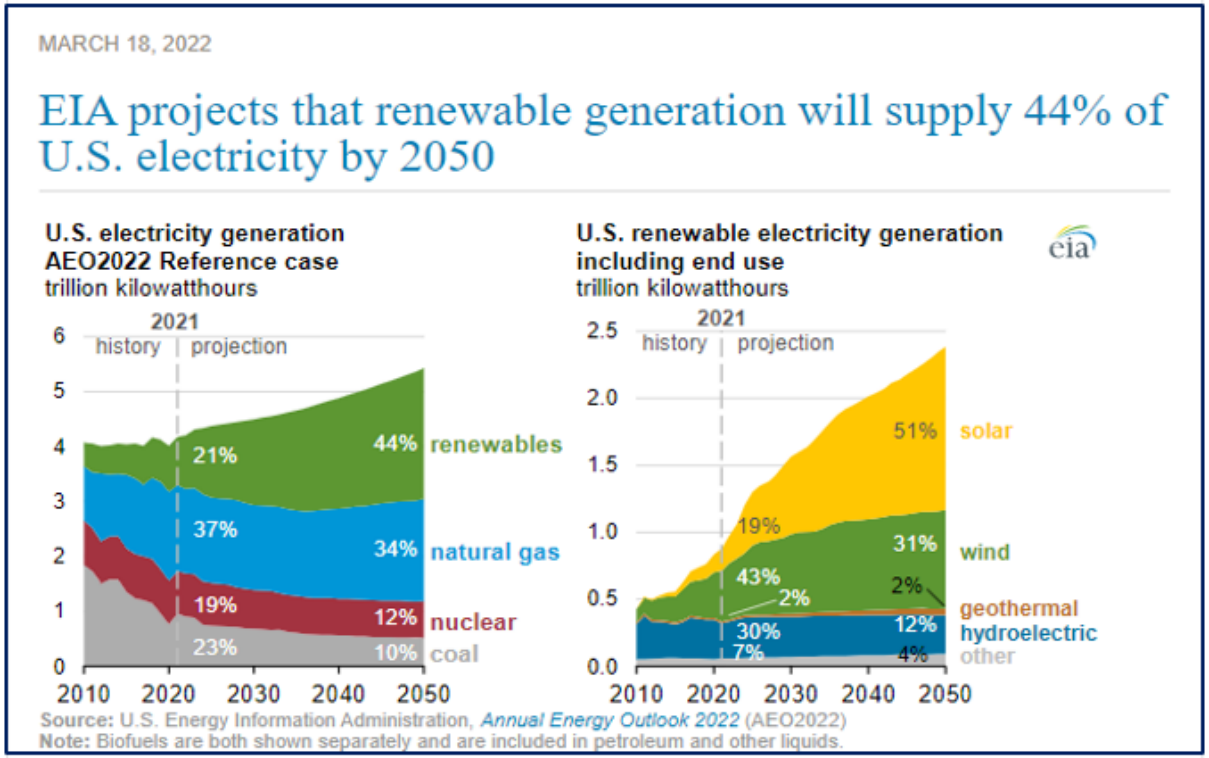
Texas 2021 Winter Blackout



Puerto Rico 2017 Blackout (Hurricane Maria)

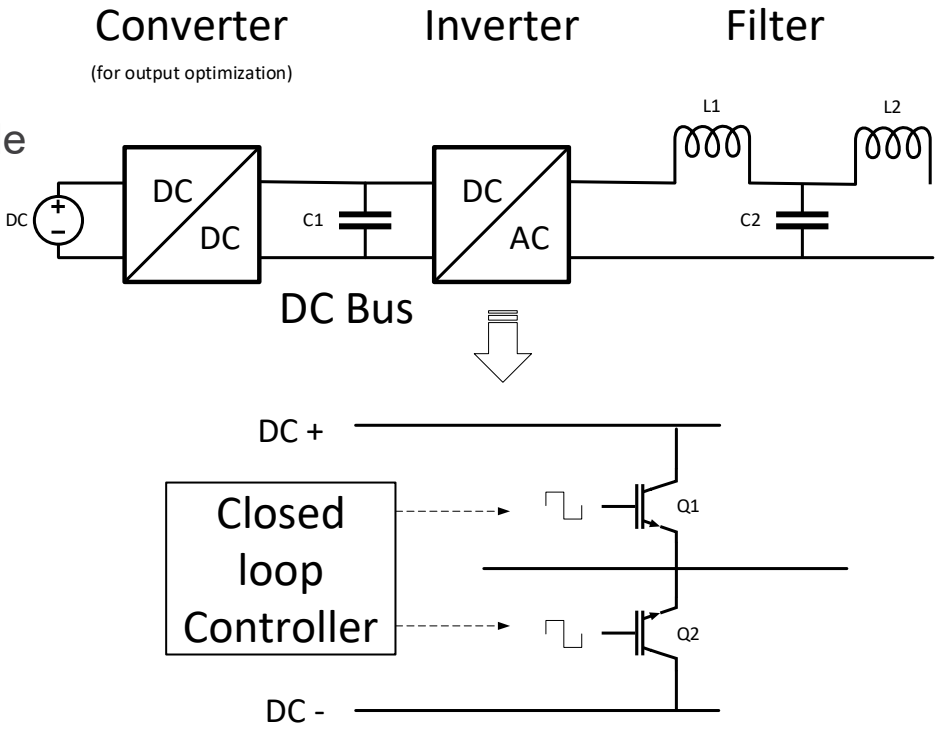
IBR MICROGRIDS

- Why do they matter?
- Proving ground for renewables integration technology



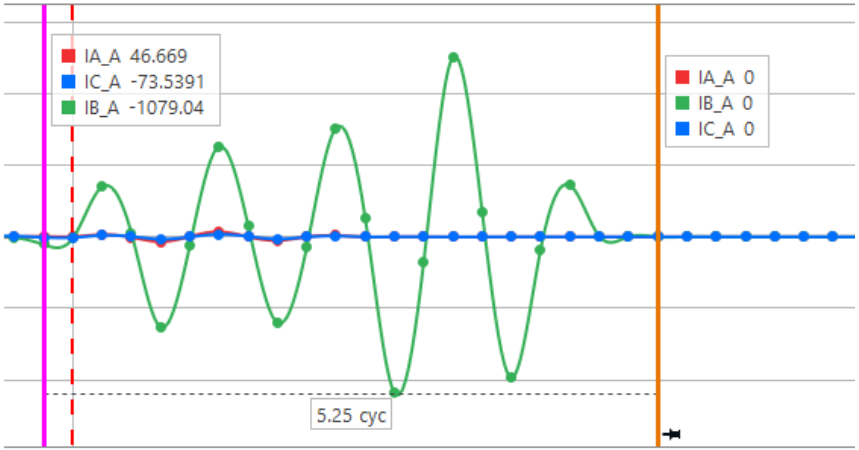
THE CHALLENGE: FAULT ISOLATION

- Inverter-Based Resources in Islanded Mode
- How are IBRs different than synch gen?
- No rotating mass component
- Can lack inductive characteristics
- Control varies by inverter manufacturer
- Control limits current below thermal rating

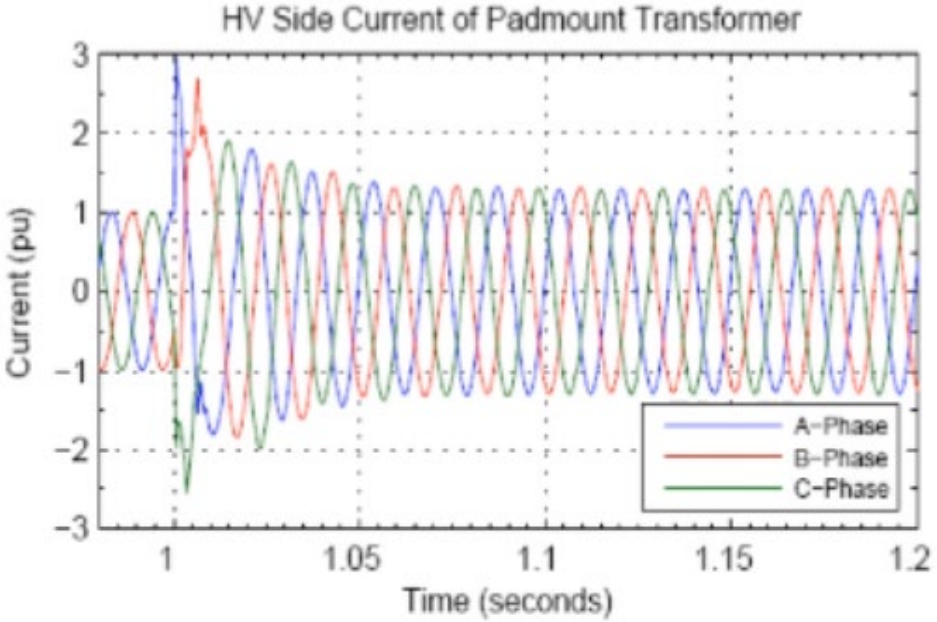


FAULT CHARACTERISTICS EXAMPLE

- Fault currents are Low, negative sequence unpredictable



Current for LG fault, utility-scale (green is faulted phase)

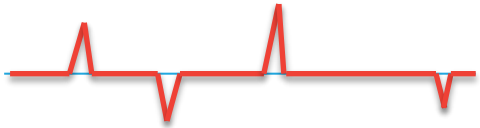


Current for LG fault, IBR system

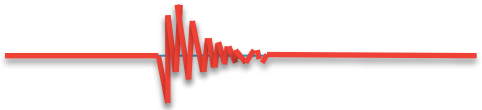
Note: scales differ between graphs

WAIT!

- … what about adaptive/machine learning? ($$$)
- … traveling wave?



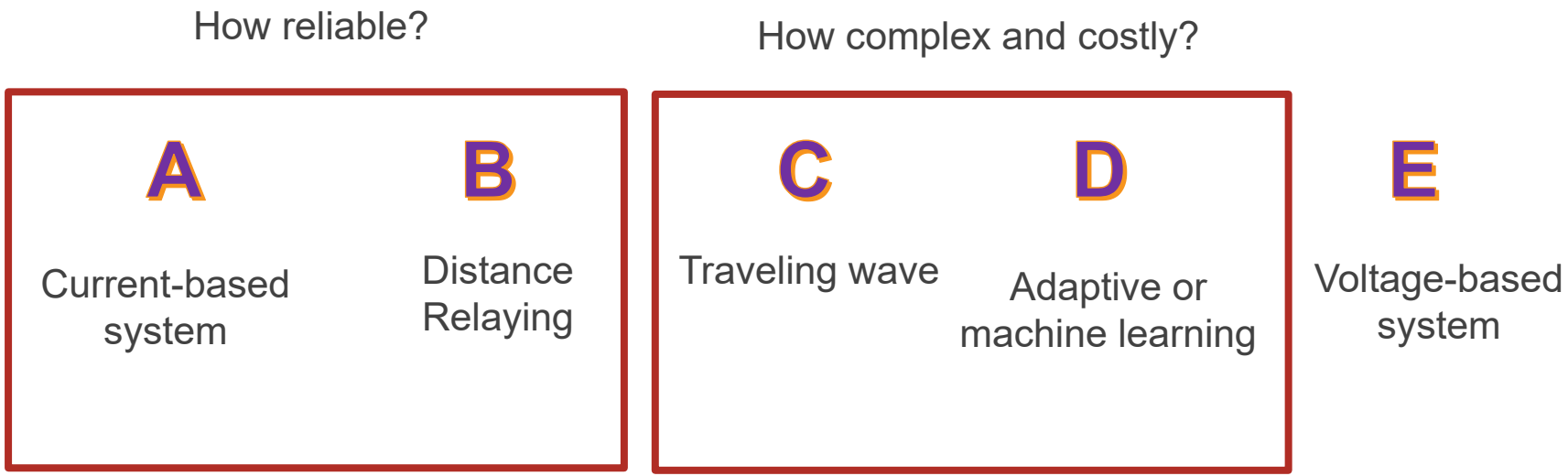
Faults on long transmission lines produce unique echos



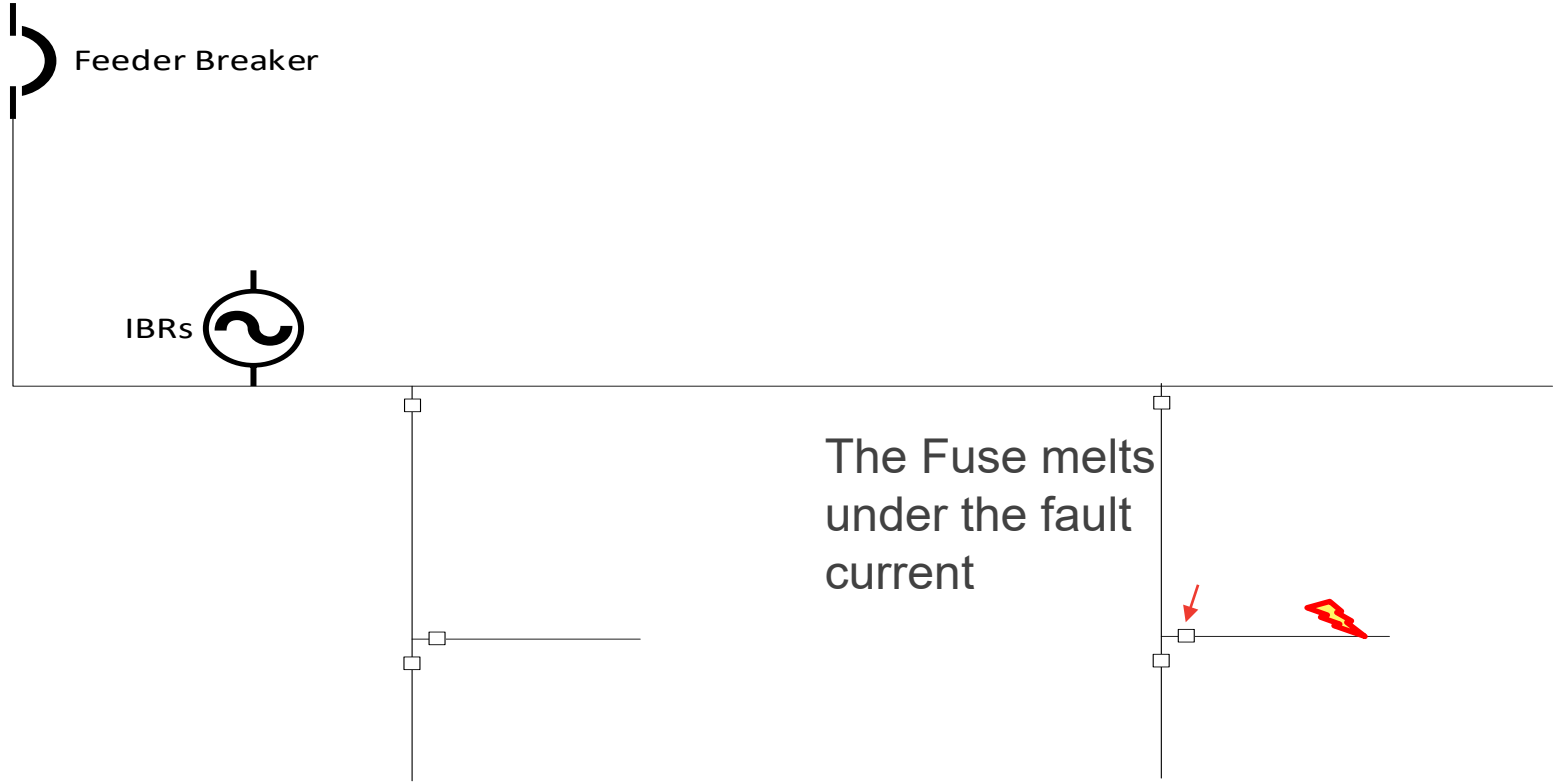
….but what about short lines?

THE CHALLENGE: FAULT ISOLATION

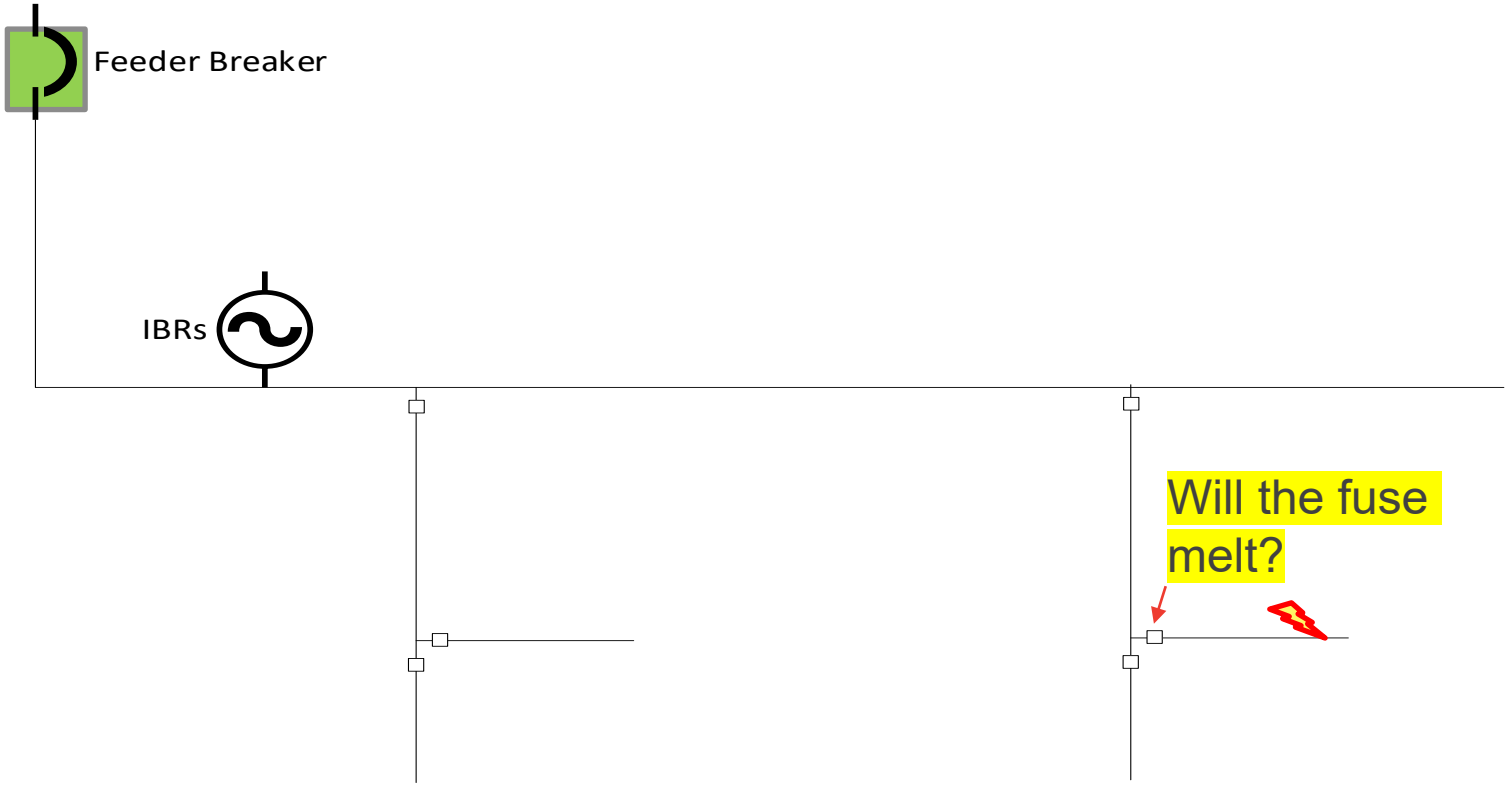
- Which of the following protection techniques could we apply to an islanded DER microgrid to isolate a fault?



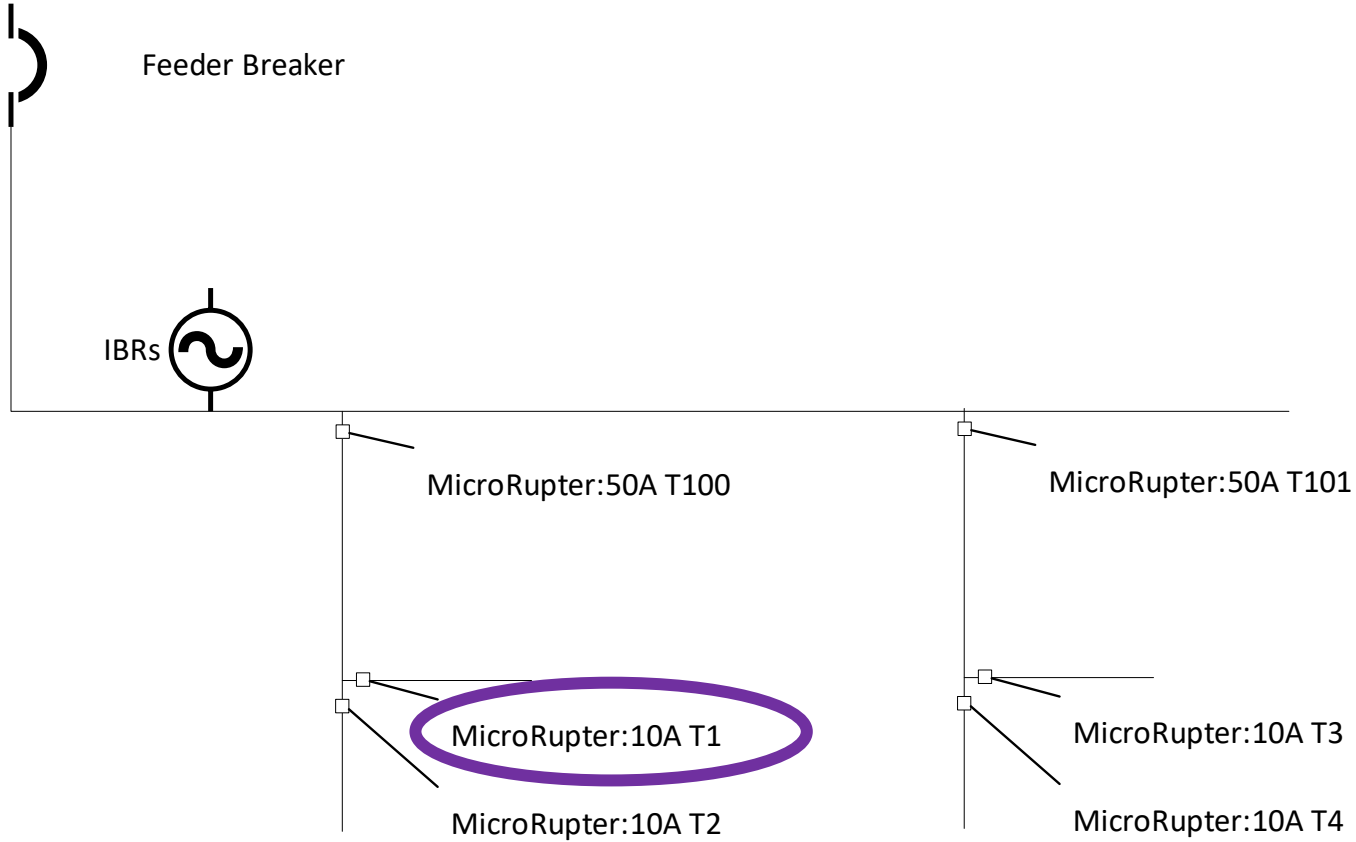
SYSTEM WITH FUSE PROTECTION



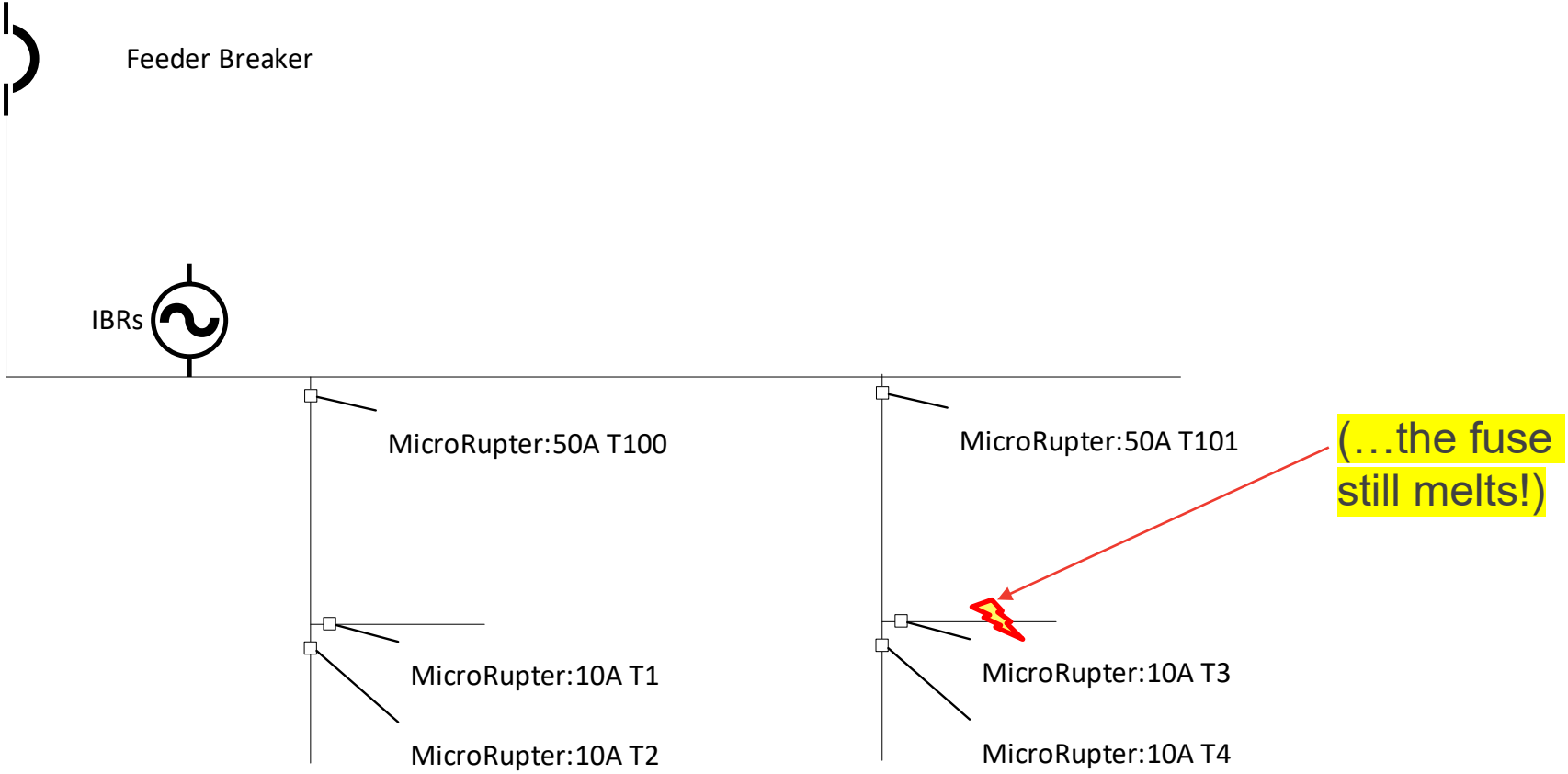
SYSTEM DISCONNECTED WITH FUSE PROTECTION



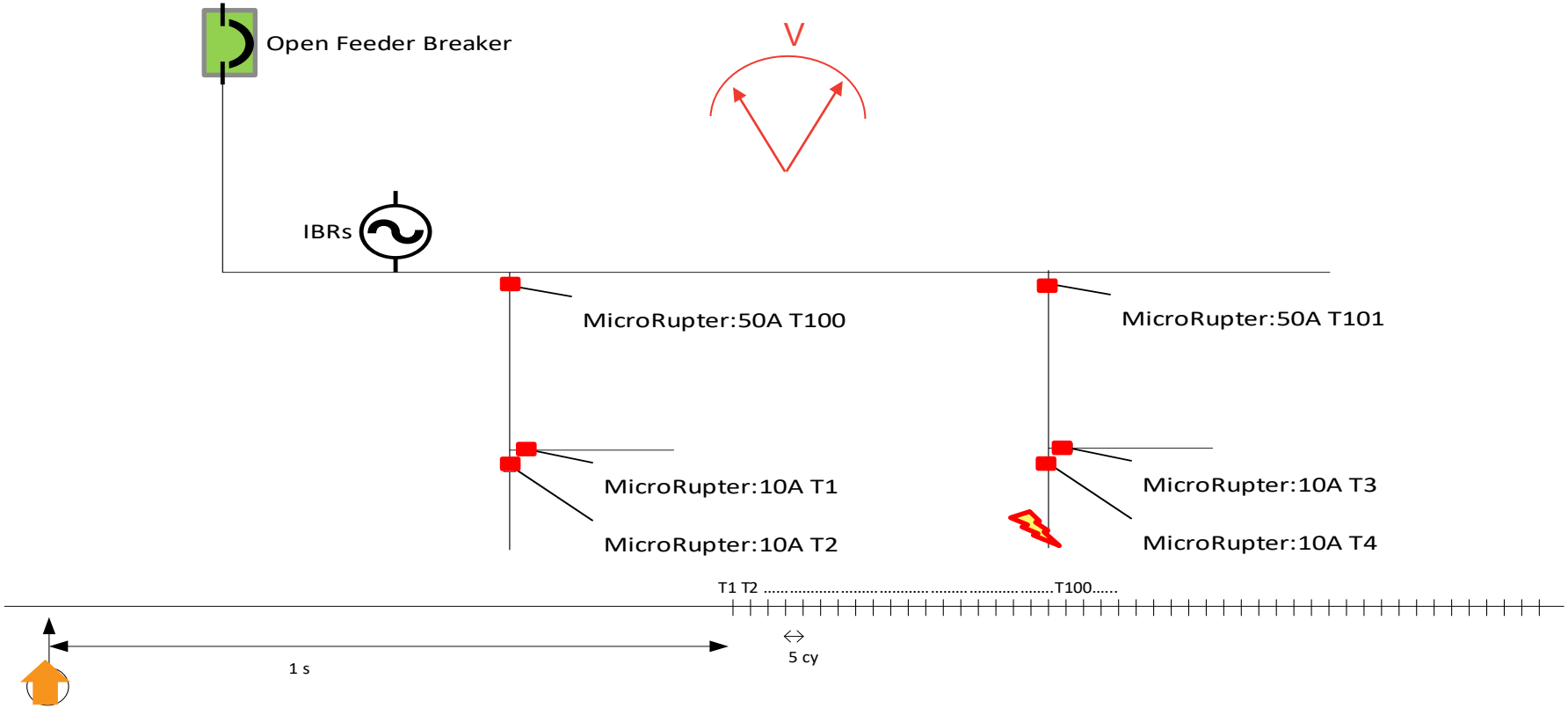
SYSTEM WITH MICRORUPTER PROTECTION



SYSTEM WITH MICRORUPTER PROTECTION



Microrupter Example (islanded)



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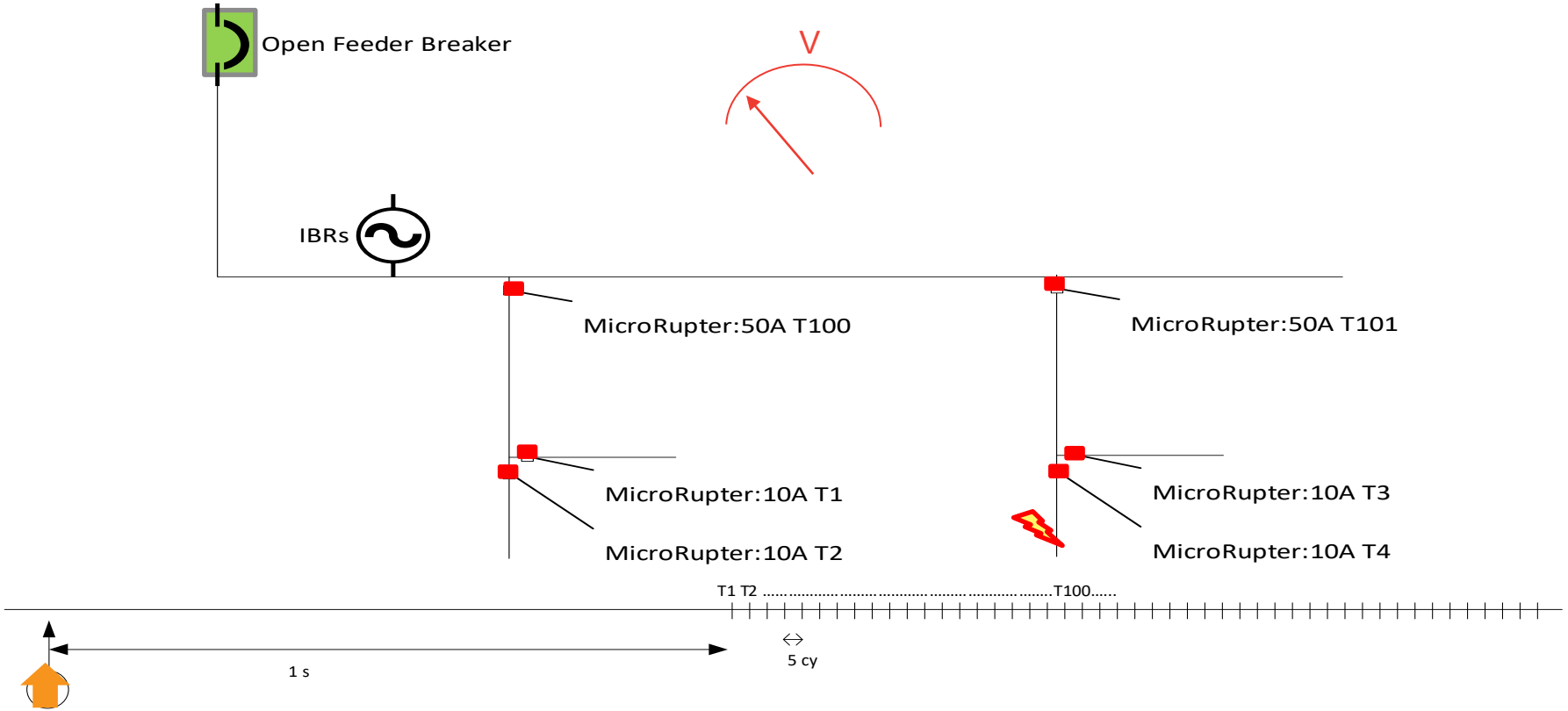

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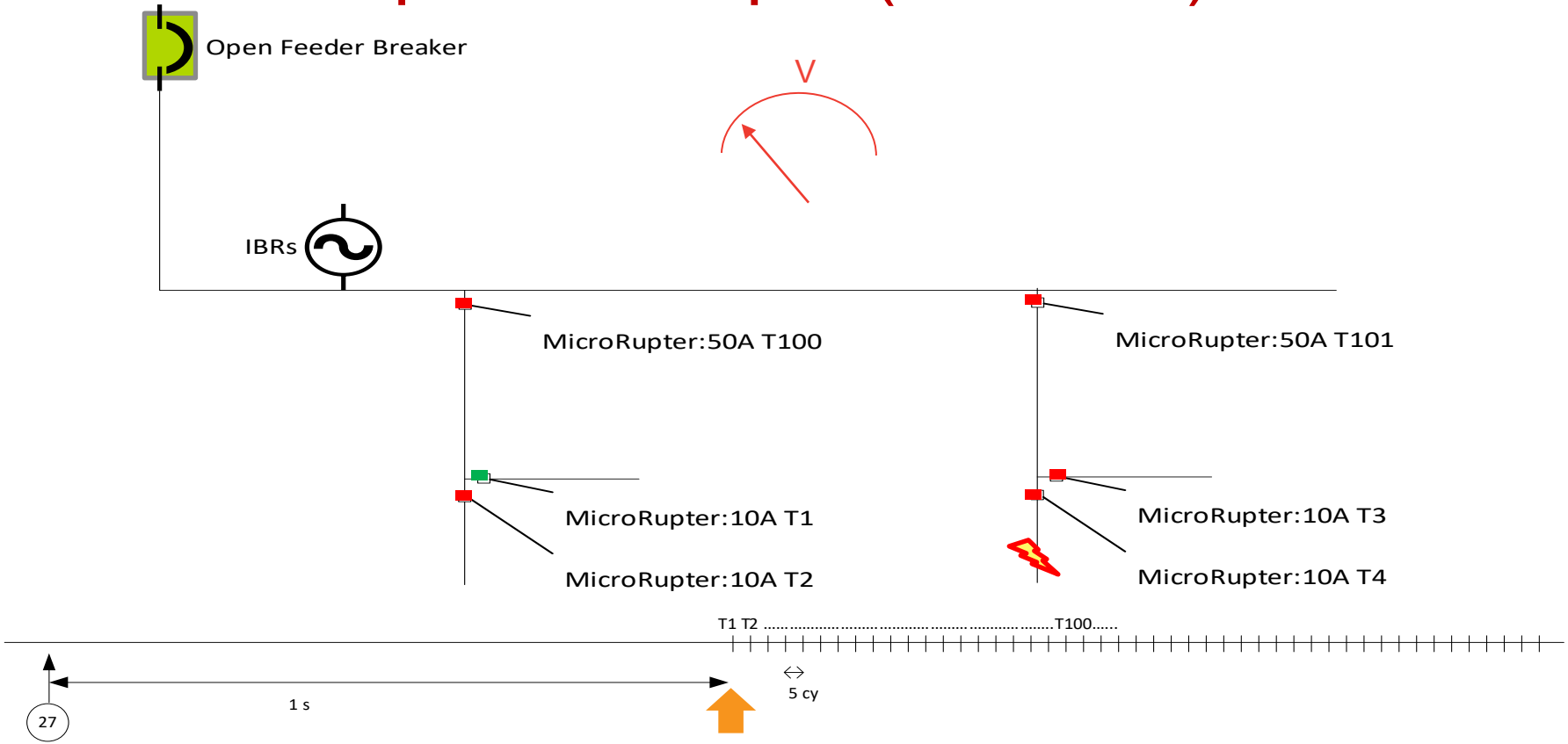

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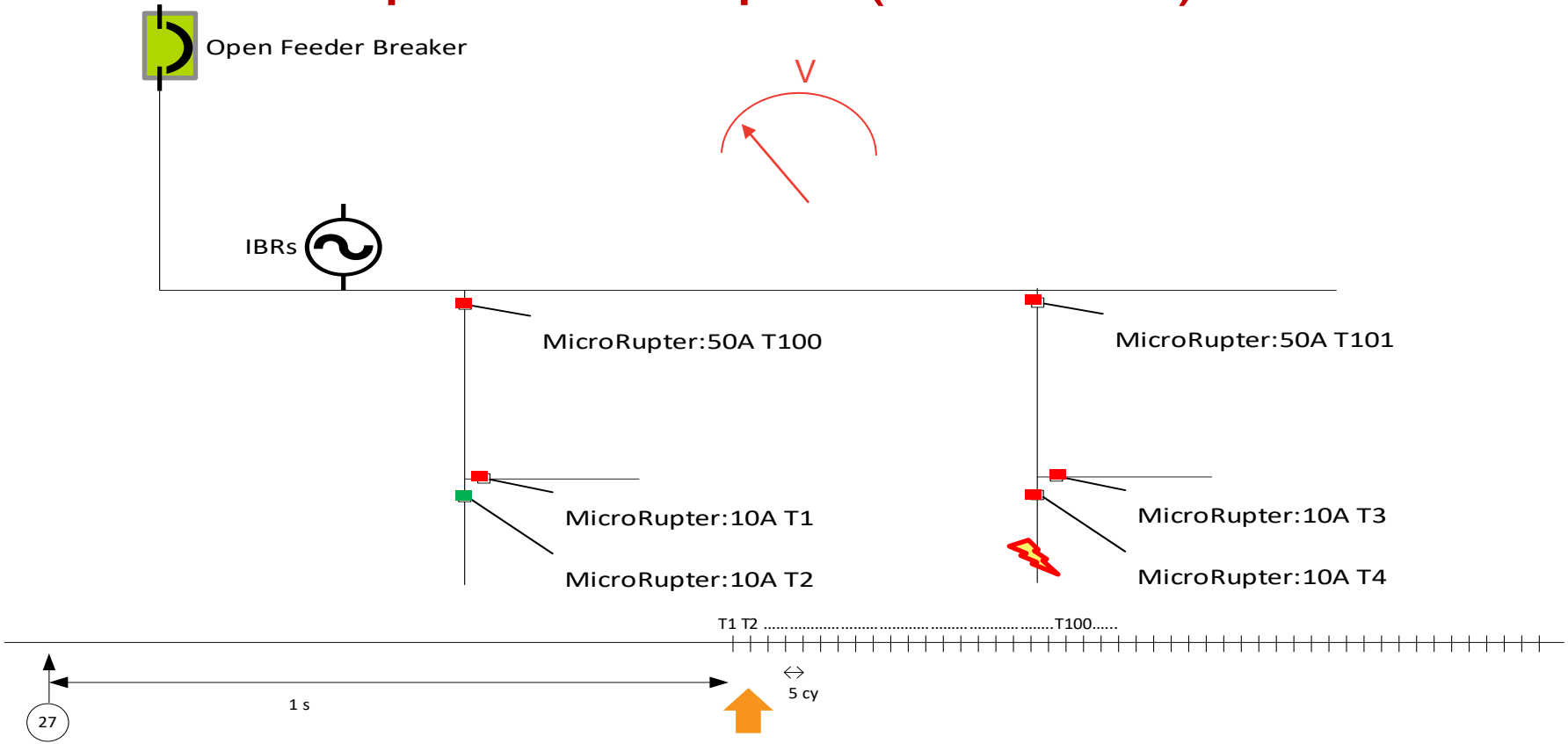

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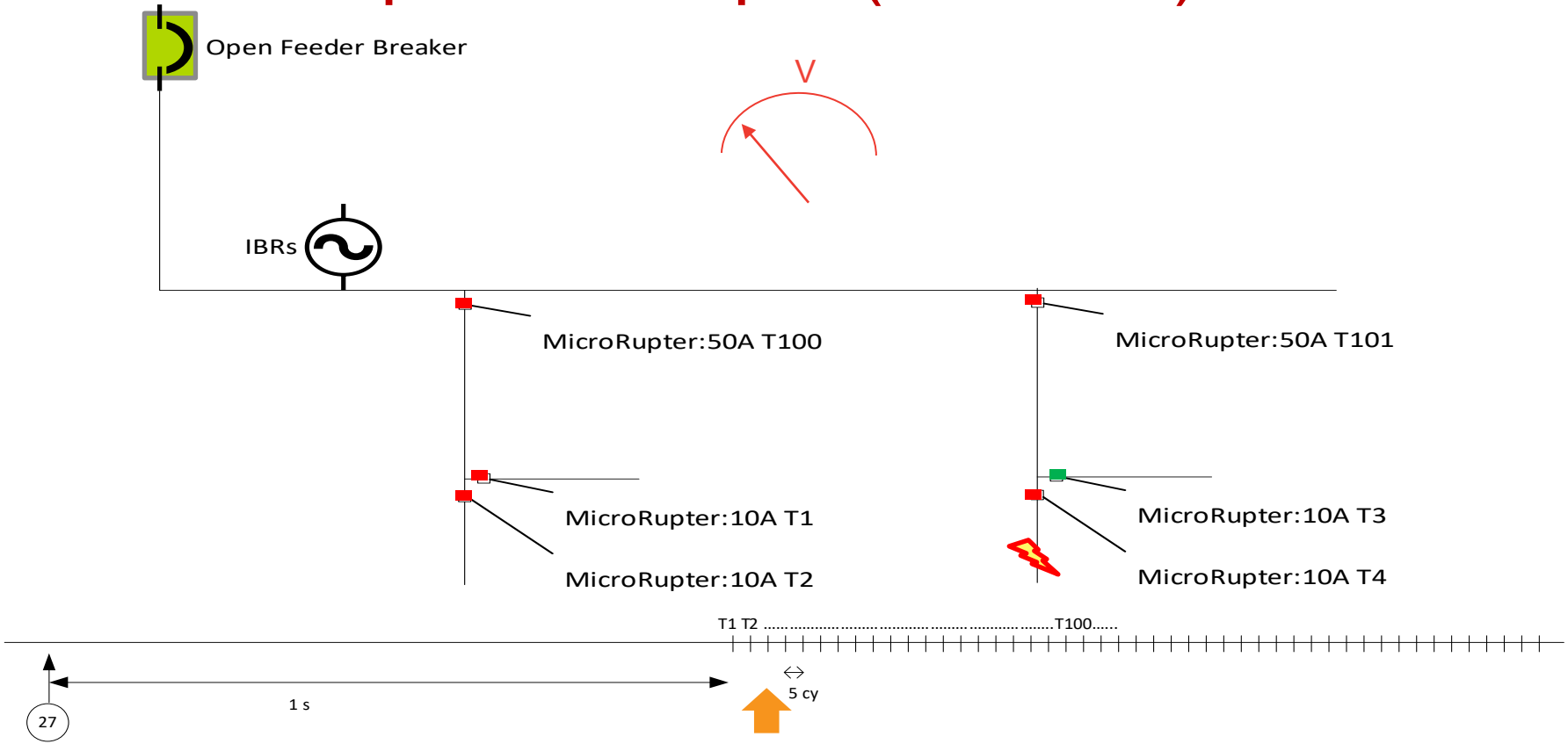

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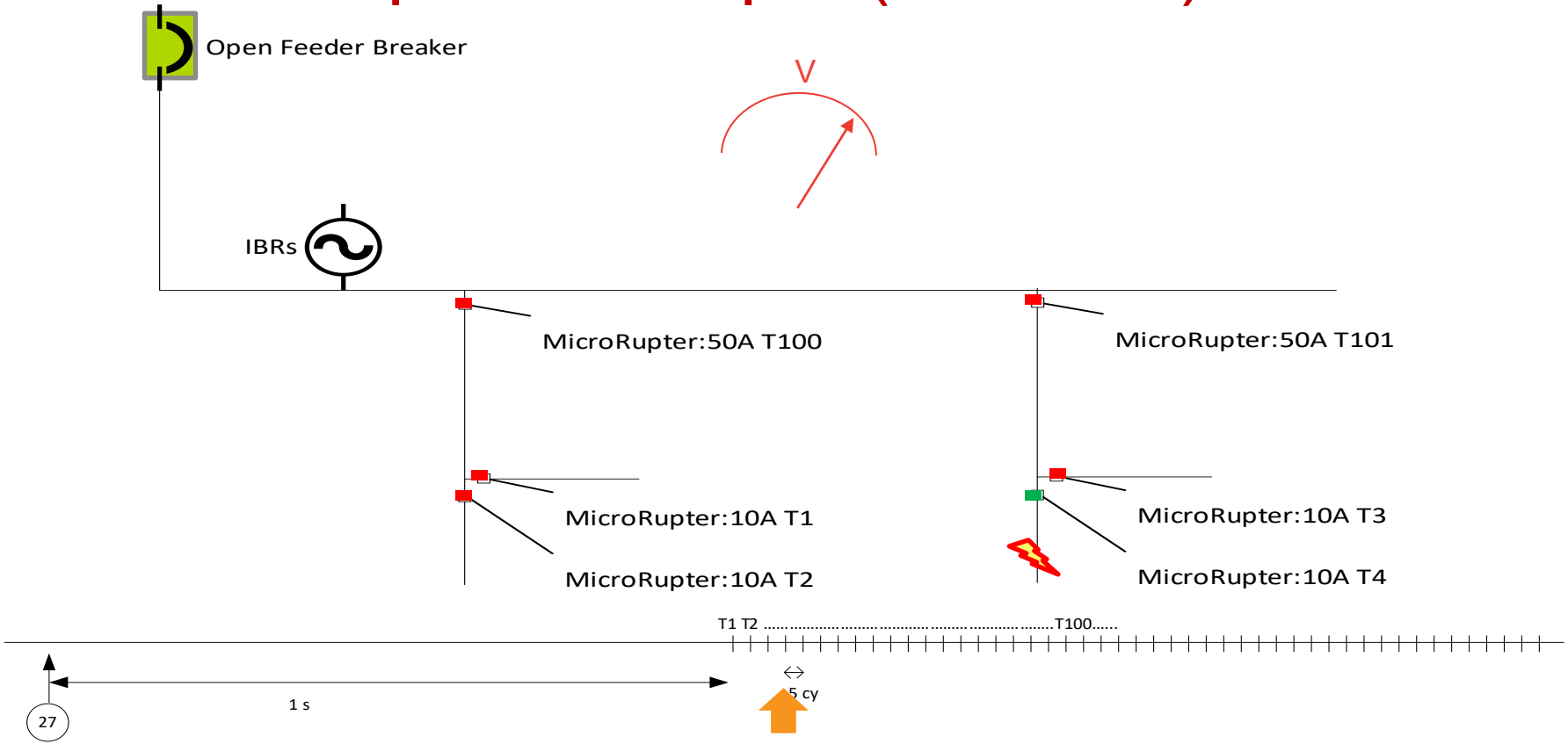
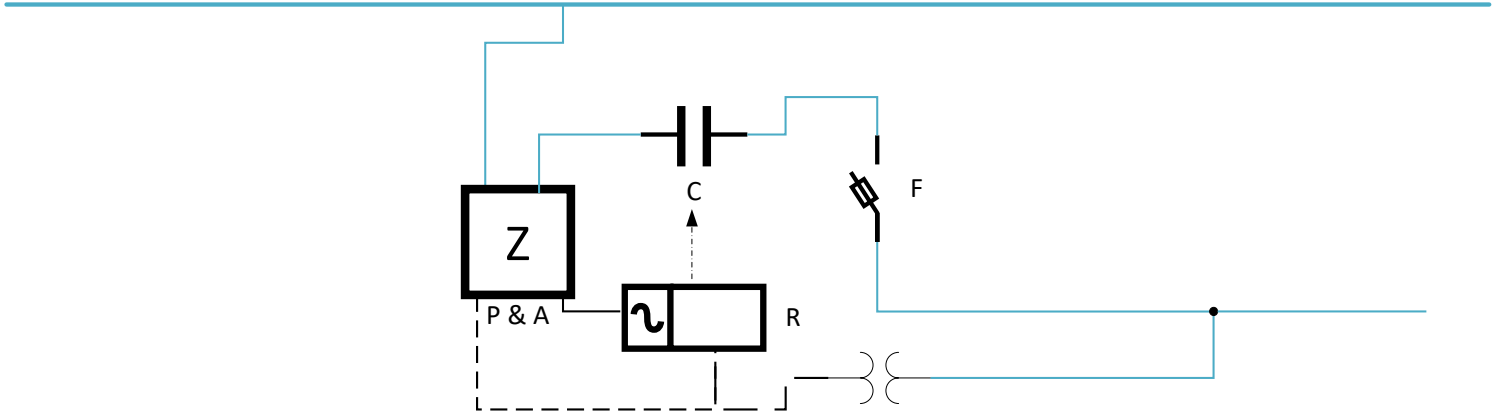
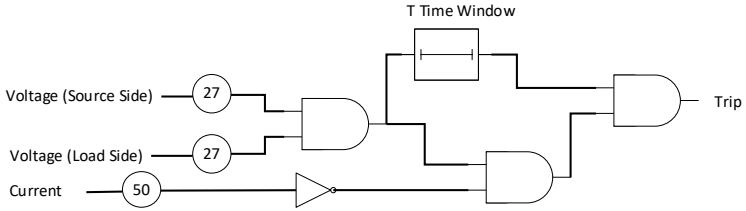
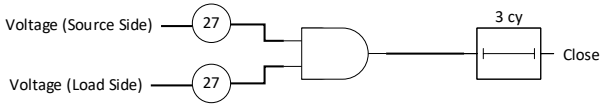


MICRORUPTER FEATURES



C: Contact with low interrupting capability (5 to 50A)
R: Relay with 27 element supervised with 50 element and Time window
Z: CT and PT (estimated 20VA … very small), inverter and Capacitor (provides Current, voltage and power supply)





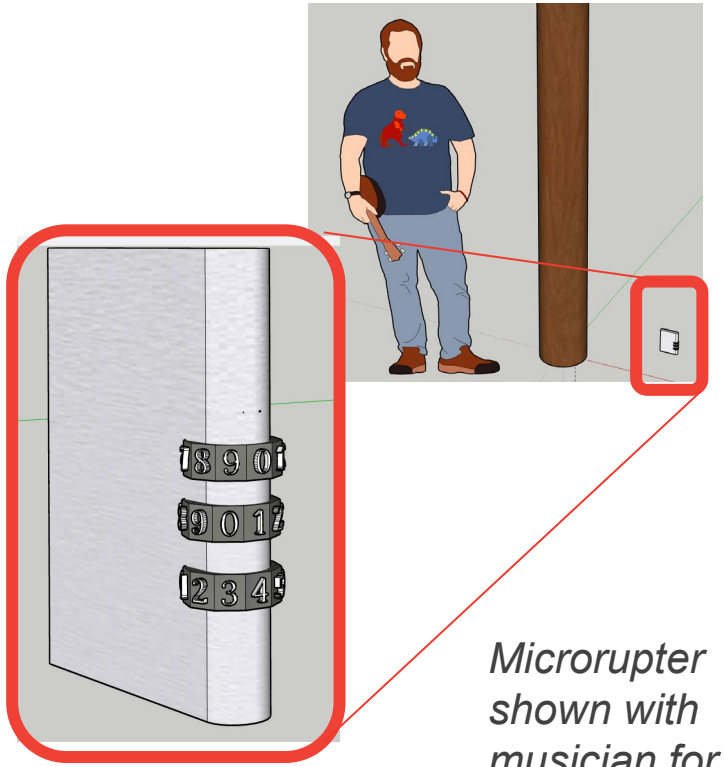
MICRORUPTER FEATURES

- Scalability

- Advanced reevaluation not required
- No costly comms infrastructure
- Reduced threat of cyberattack
- Integrates with existing protection

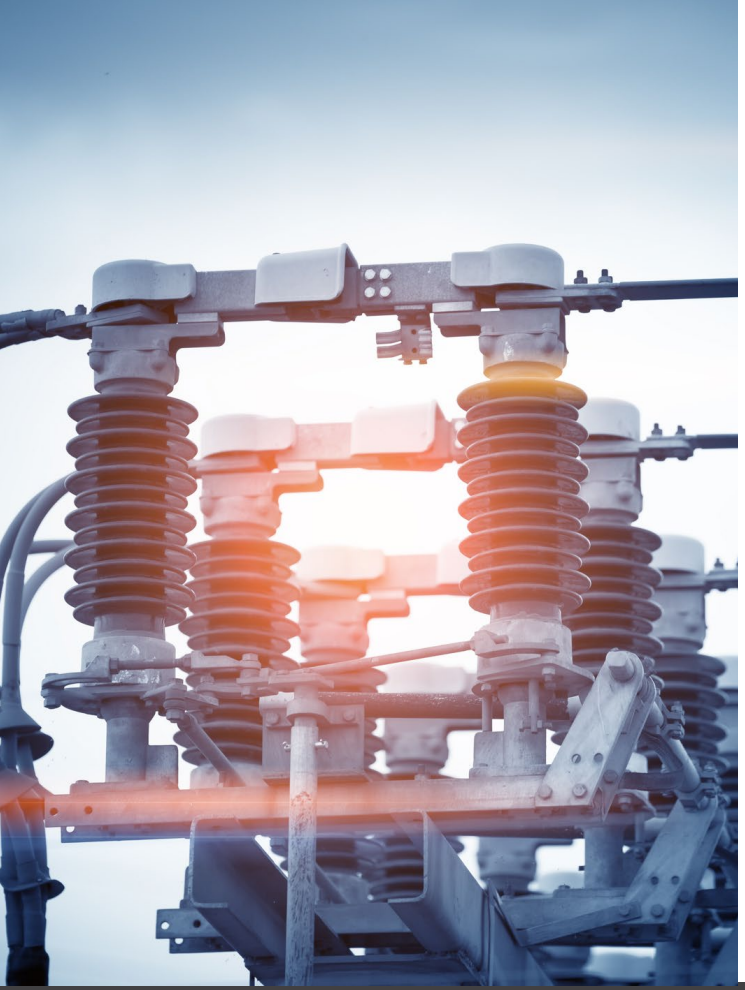
FUTURE WORK

- “Where’s my Microrupter?”
- Validated in power system modeling software
- Based on matured components
- Patent application #17/011538
- Distribution line sectionalizing + voltage + timers
- No real-world pilot deployment (yet)



Microrupter controller with manual time dials (left)

Microrupter shown with musician for scale (right)



THANK YOU!

Questions?

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MAKE A POWERFUL DIFFERENCE.