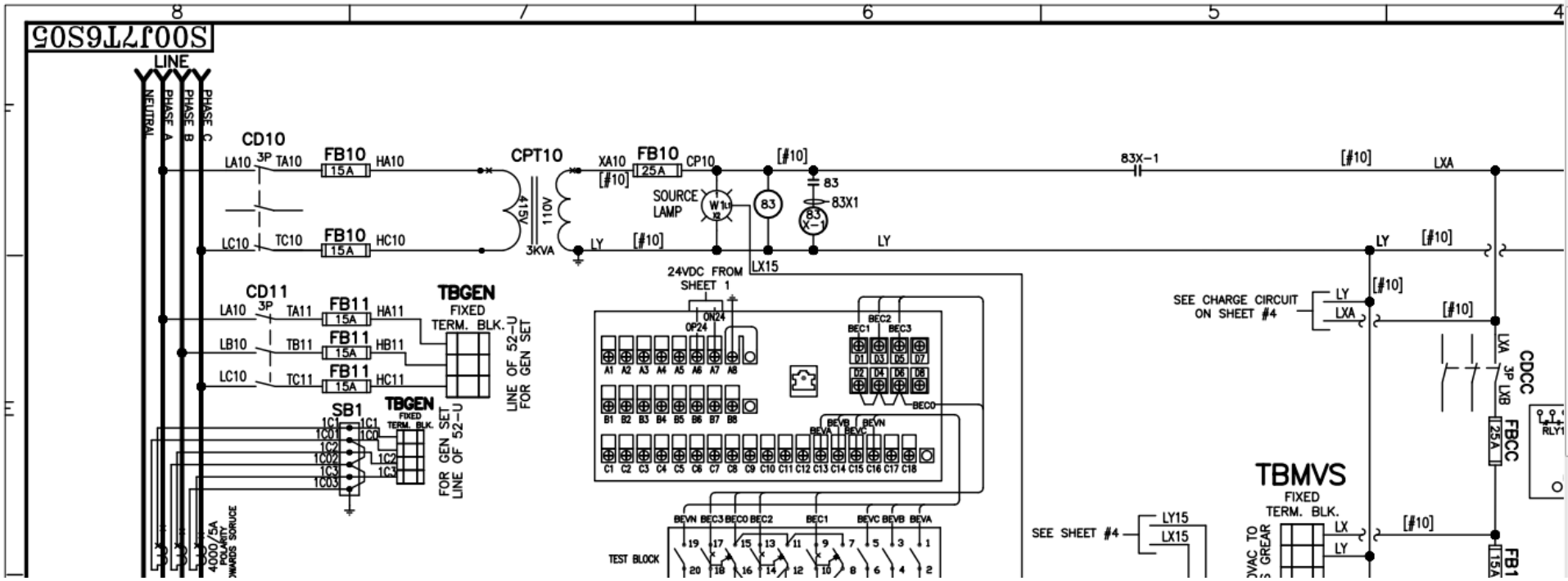


# Data Center / UPS:

## Applications / Demos

Dave Loucks, PhD, PE, CEM

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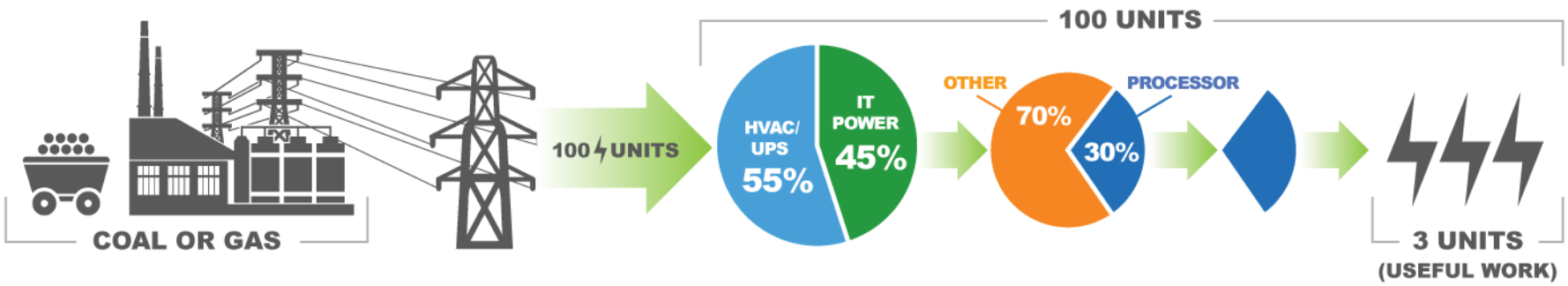
# Grid to Data Center – Room for Improvement

## Wasted energy burdens the environment and increases operational expenses

### Carbon Footprint in IT Computing

» Only 3% of the energy entering a data center is used for net computing creating opportunities for efficiency improvements

*(Source: IBM, 2009)*




| Item | Generation | The Grid | Data Center | Server | Processor | Server Load |
|---|---|---|---|---|---|---|
| Units Delivered | 65 Steam<br>35 Electric | 35 | 33<br>(45% DCiE, 2.2 PUE) | 15 | 5 | 0.1- 4*** |

*Data source: *U.S. Department of Energy, May 18, 2007,* ** Does not account approx 5 units to deliver coal or gas, *** IBM, 2008

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# Technology

- “Eco mode” Designs
- Harmonic Correction
- Integration with IT (“virtualization”)
- “3-Level” Inverter


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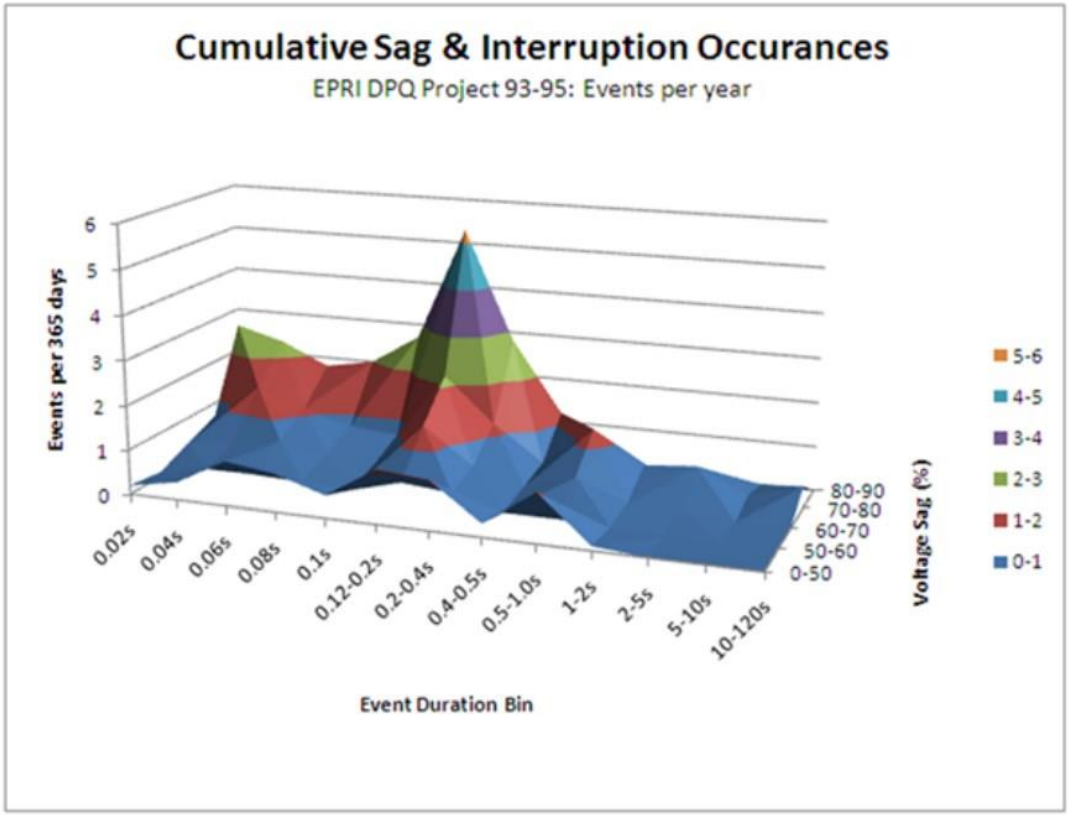
# Improving Efficiency

- > 99.9% of time power is acceptable

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# EPA Energy Star

- ***f*Single-normal-mode UPS**
  - A UPS that functions within the parameters of only one set of input dependency characteristics, i.e., a UPS that functions only as VFI. *f*
- **Multiple-normal-mode UPS**
  - A UPS that functions within the parameters of more than one set of input dependency characteristics, i.e., a UPS that can function as either VFI or VFD.


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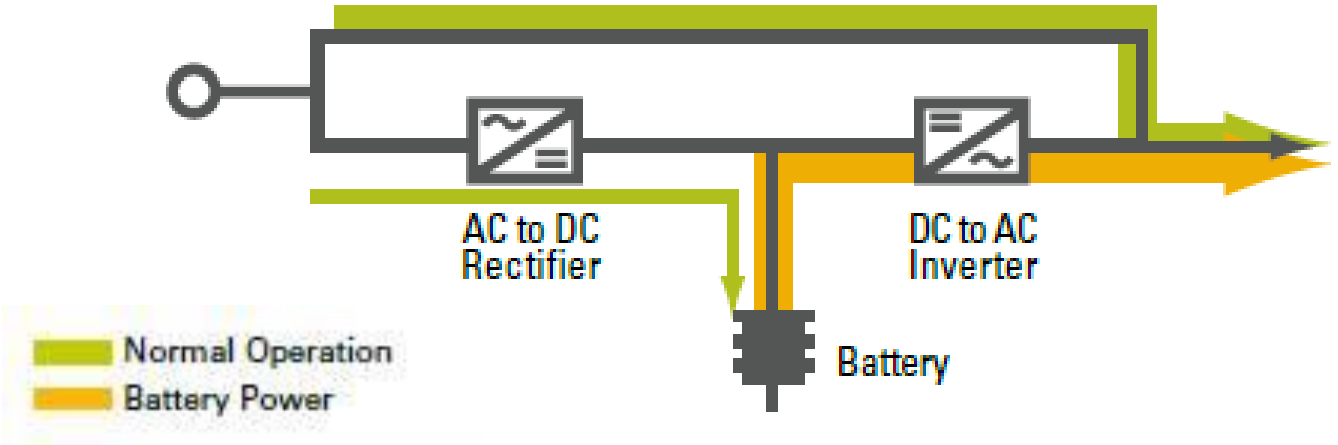
# UPS topologies: standby UPS




- Equipment uses utility power until UPS detects problem (sag, surge or outage)
- When problem occurs UPS switches to battery
- UPS uses batteries frequently
  - Reduces runtime and service life

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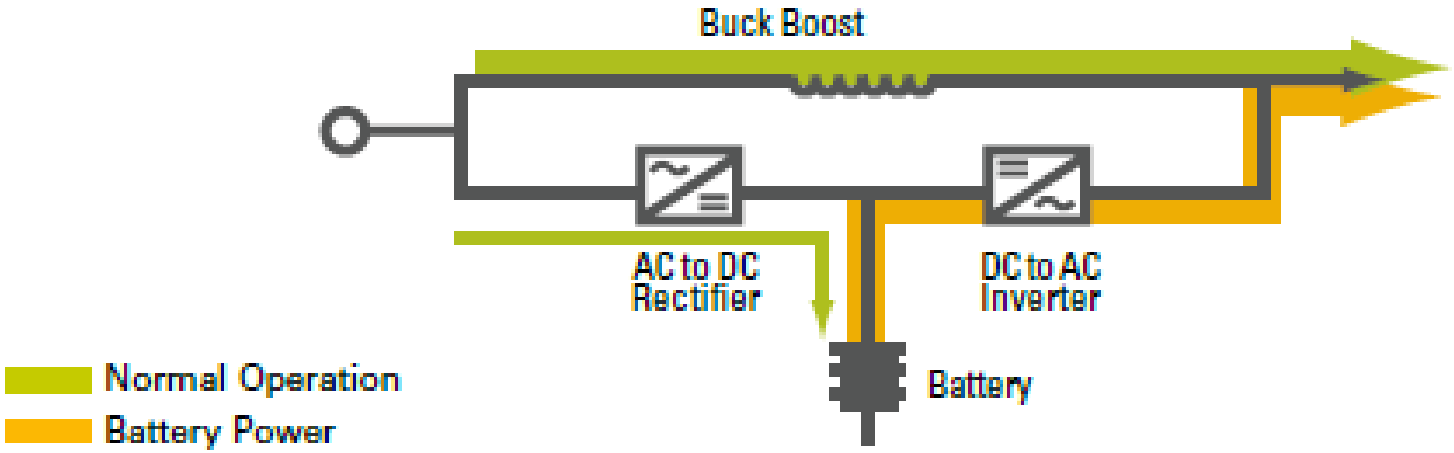
# UPS topologies: line interactive




- Regulates voltage by boosting/decreasing utility power or resorting to battery power
- Transfer to battery within 3-8 ms
- Battery use less than standby but greater than online

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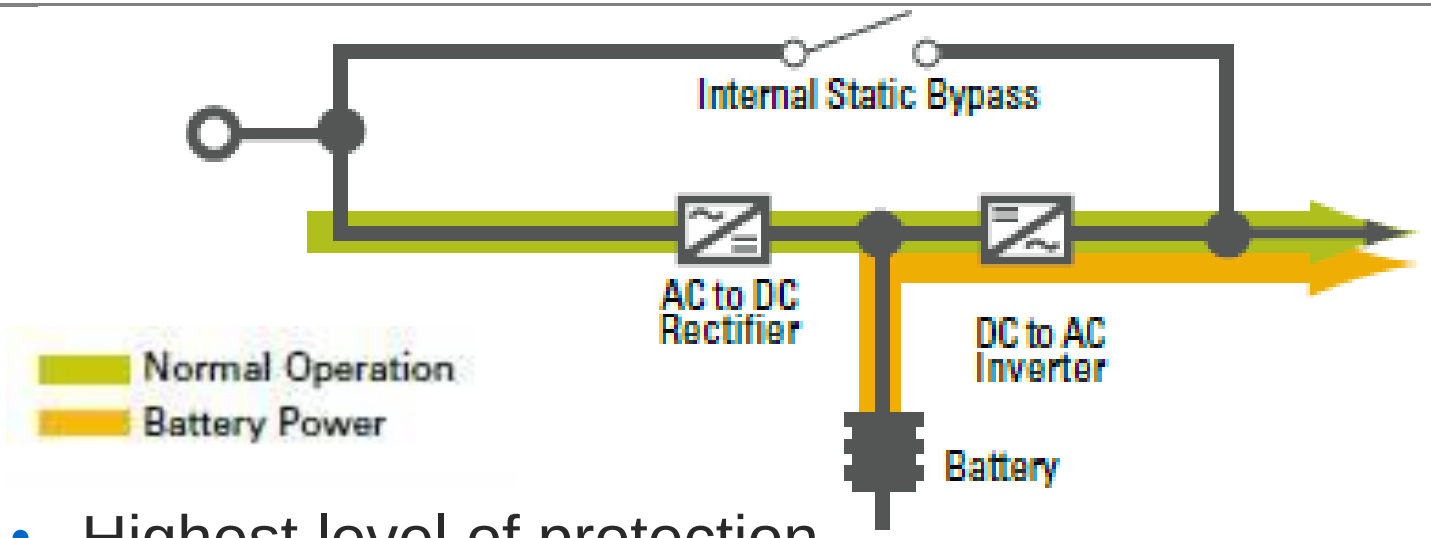
# UPS topologies: online




- Highest level of protection
- Isolates equipment from raw utility
- AC to DC to AC
- If input voltage within tolerances, output is regulated w/o battery
- Uses batteries < standby and line interactive

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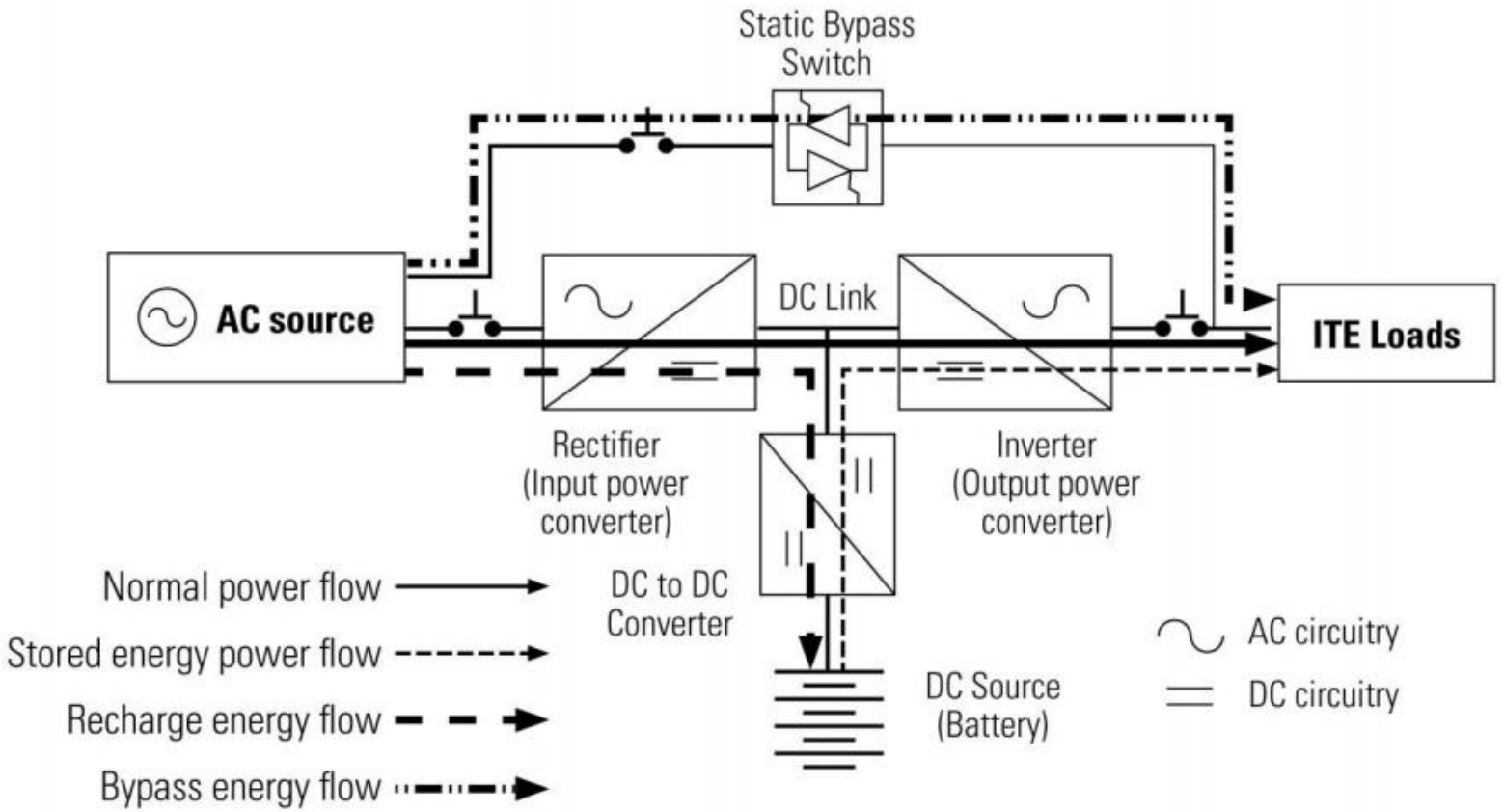
# Review Terminology

- Multi-Mode UPS topology

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# Tips to consider to improve efficiency

- Higher voltages to servers (e.g. 415Y/240, 480Y/277)
  - Removes transformer losses
- Powering dual corded servers on one side with raw utility power or eco-mode UPS – TGG: “Free Power Quality”
- Using “eco-mode” / “multi-mode” (“ESS”)
  - Be careful of the terminology
  - Some “eco-mode” UPSs require 12 ms to transfer
    - Can be a problem for downstream STSs
- Higher efficiency inverter (3-level)
- Multi-module, fast-transfer UPS designs (“VMMS”)
- Harmonic correction ( “ESS+”)


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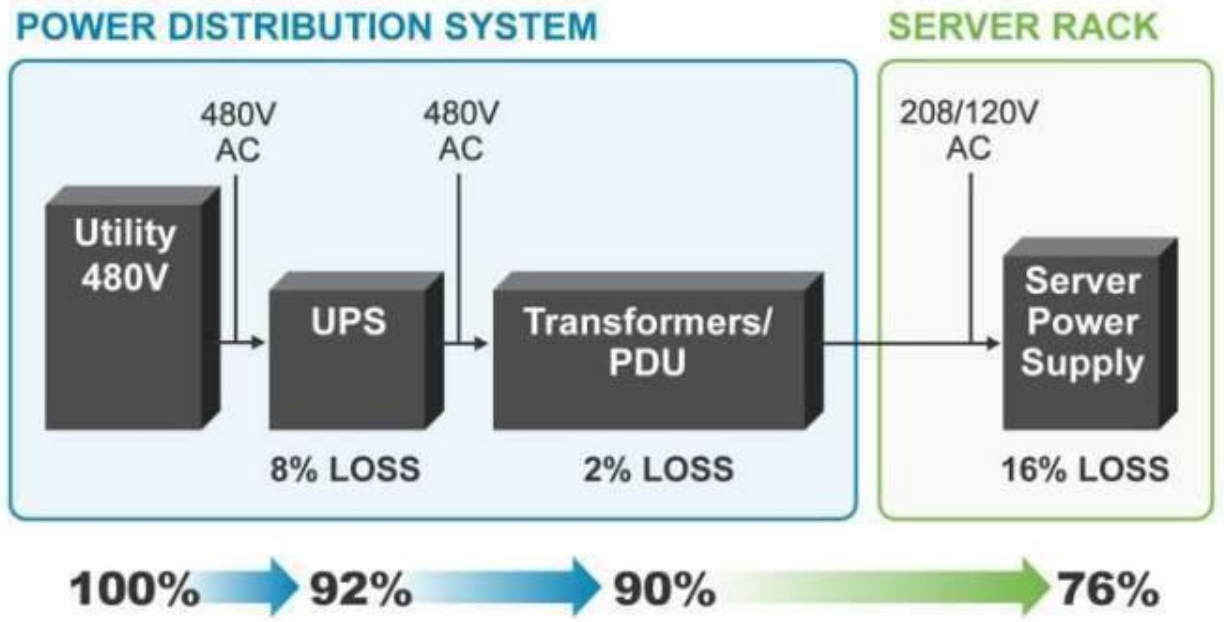
# Increasing Voltage / Removing Transformers

- Transformer losses are typically higher than published due to harmonic currents

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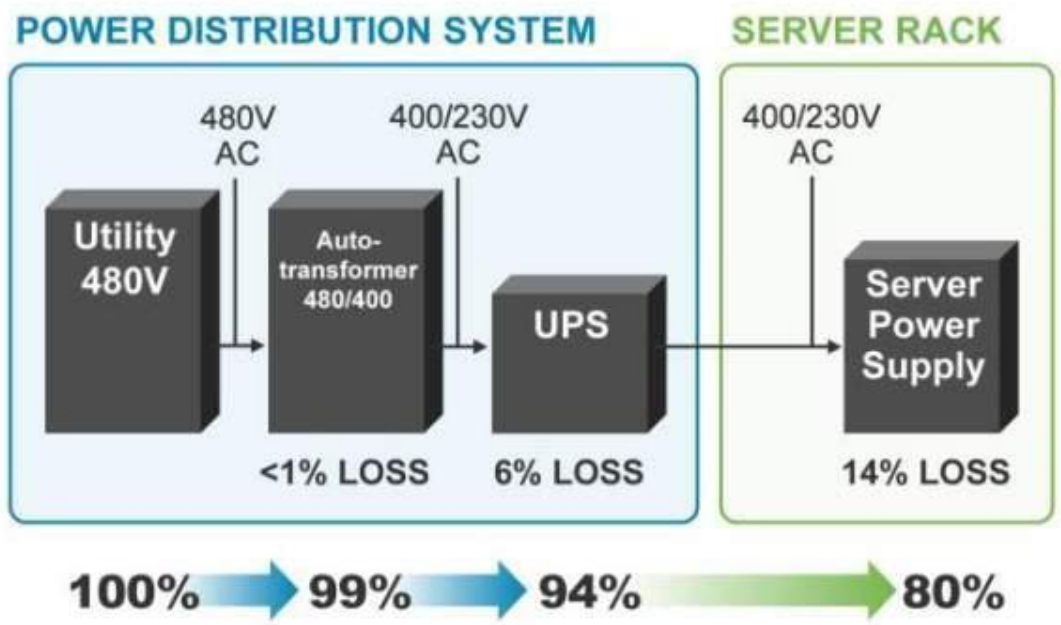
# Increasing Voltage / Removing Transformers

- Pro: Lower losses
- Con: Higher short-circuit currents

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# What is that worth?

- 1 MW data center load
  - $0.10/kWh, $12/kW, 8760 hrs./yr (continuous)
    - 17520000 kWh
  - **$36K/yr** savings **($277K**, 10 years, 5% cost of money)

| | %eff | Power Loss | Energy Loss | $ kWh Loss[1] | $ kW (demand)[1] |
|---|---|---|---|---|---|
| 208Y/120 | 0.76 | 240 kW | 2.1 MWh | $210K | $35K |
| 400Y/230 | 0.80 | 200 kW | 1.8 MWh | $180K | $29K |
| | | | Annual difference | $30K | $6K |

[1]annual

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# Understanding Operating Modes

- **Energy Saver System (ESS)**: UPS can switch between modes to reduce losses
- **Energy Saver System Plus (ESS Plus)**: Inject compensating harmonic currents to cancel distortion
- **Variable Modular Management System (VMMS)**: Switch on and off groups of paralleled rectifiers / inverters as needed.


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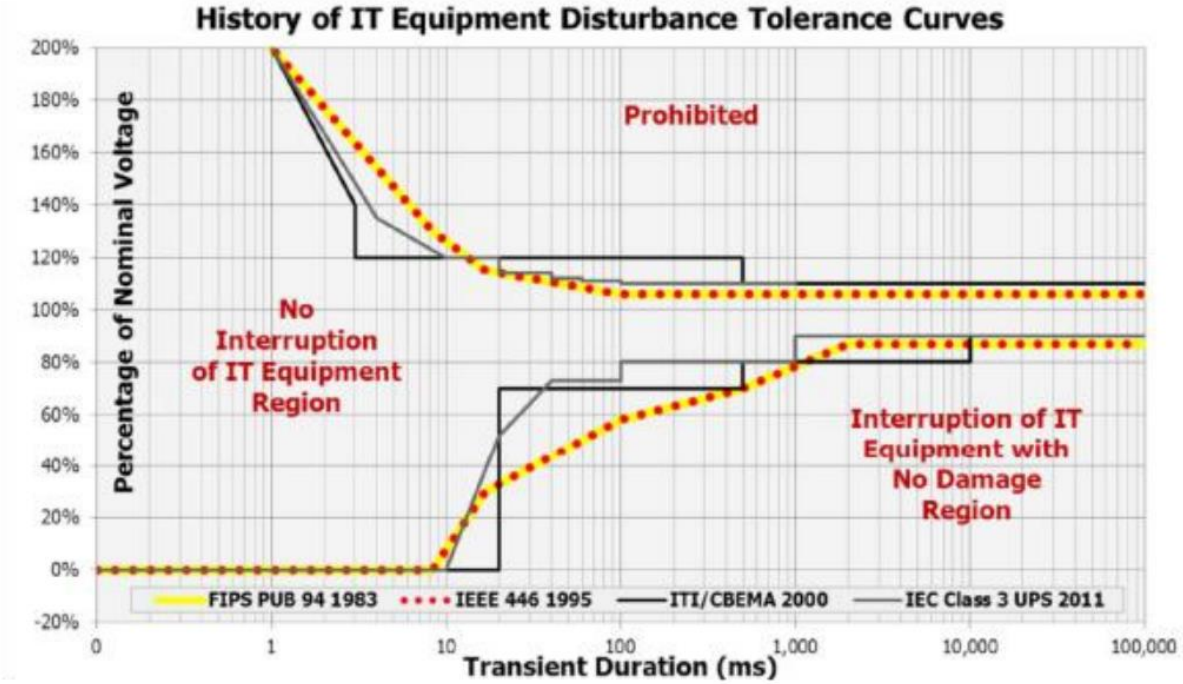
# ITIC / CBEMA / Green Grid

- How much time can a server tolerate 0 volts?
  - ITIC/CBEMA said 20 ms
  - Could be as short as 0.01 sec (10 ms)

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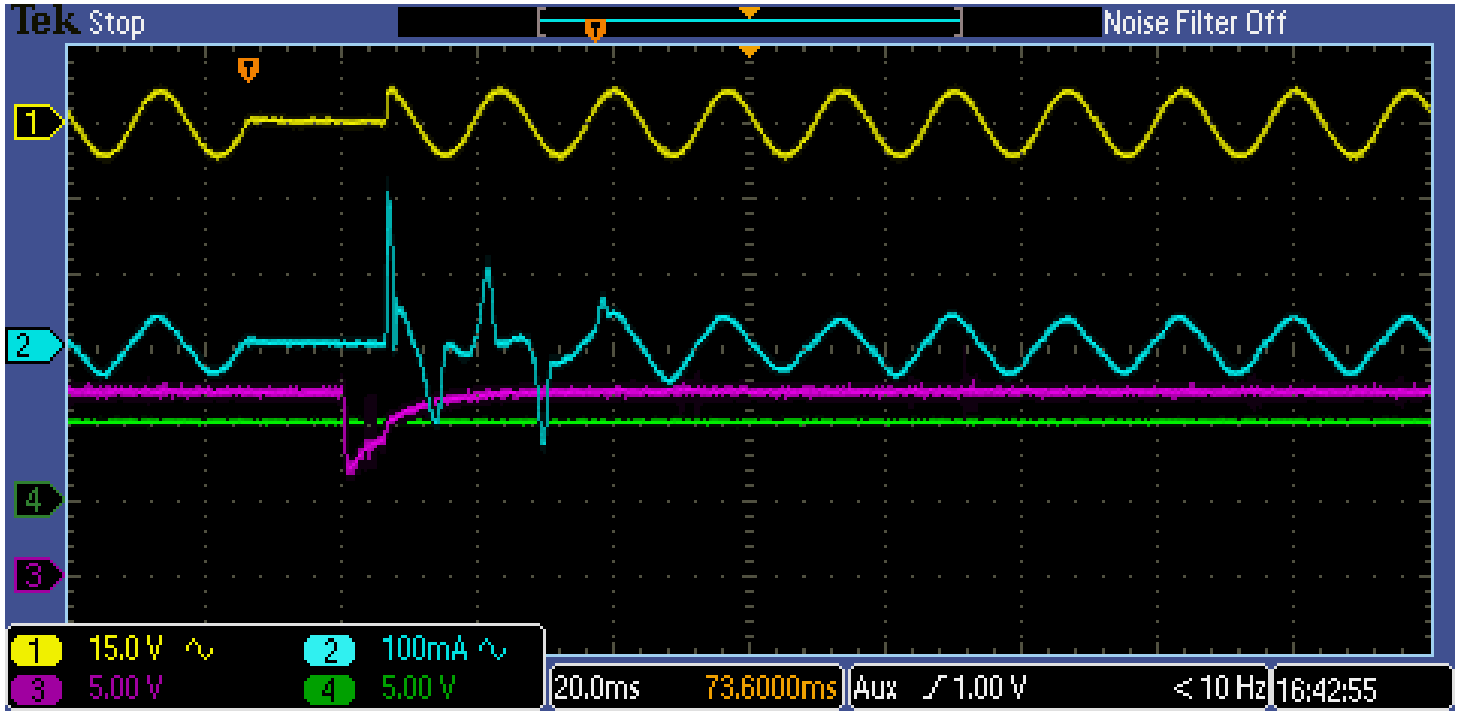
# PSU bench test

AC Voltage
AC Current
DC Main Voltage
Power OK Signal




- 400W supply, fully loaded
- At < 12 ms started dropping dc bus

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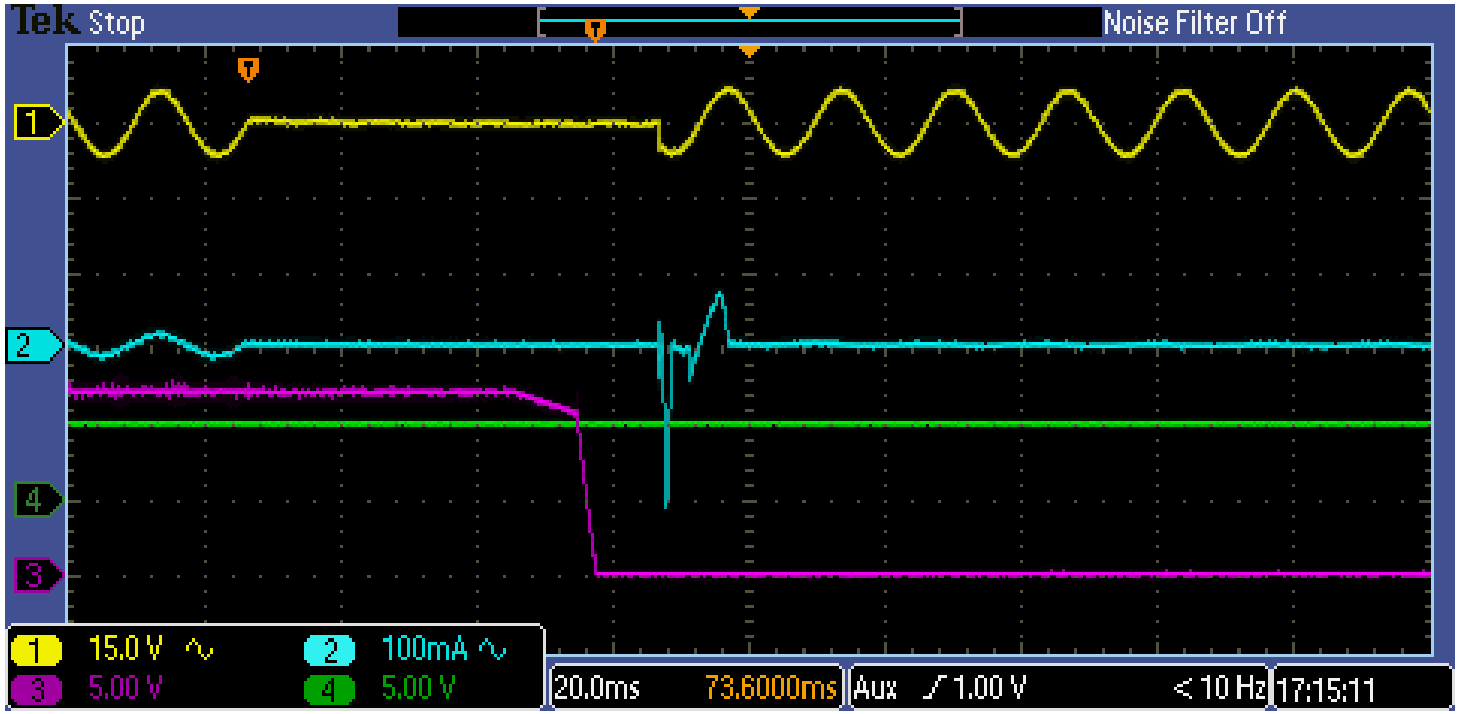
# PSU bench test

AC Voltage
AC Current
DC Main Voltage
Power OK Signal




- 400W supply, ½ loaded
- 40 ms started to drop dc bus (no restart, POK issues)

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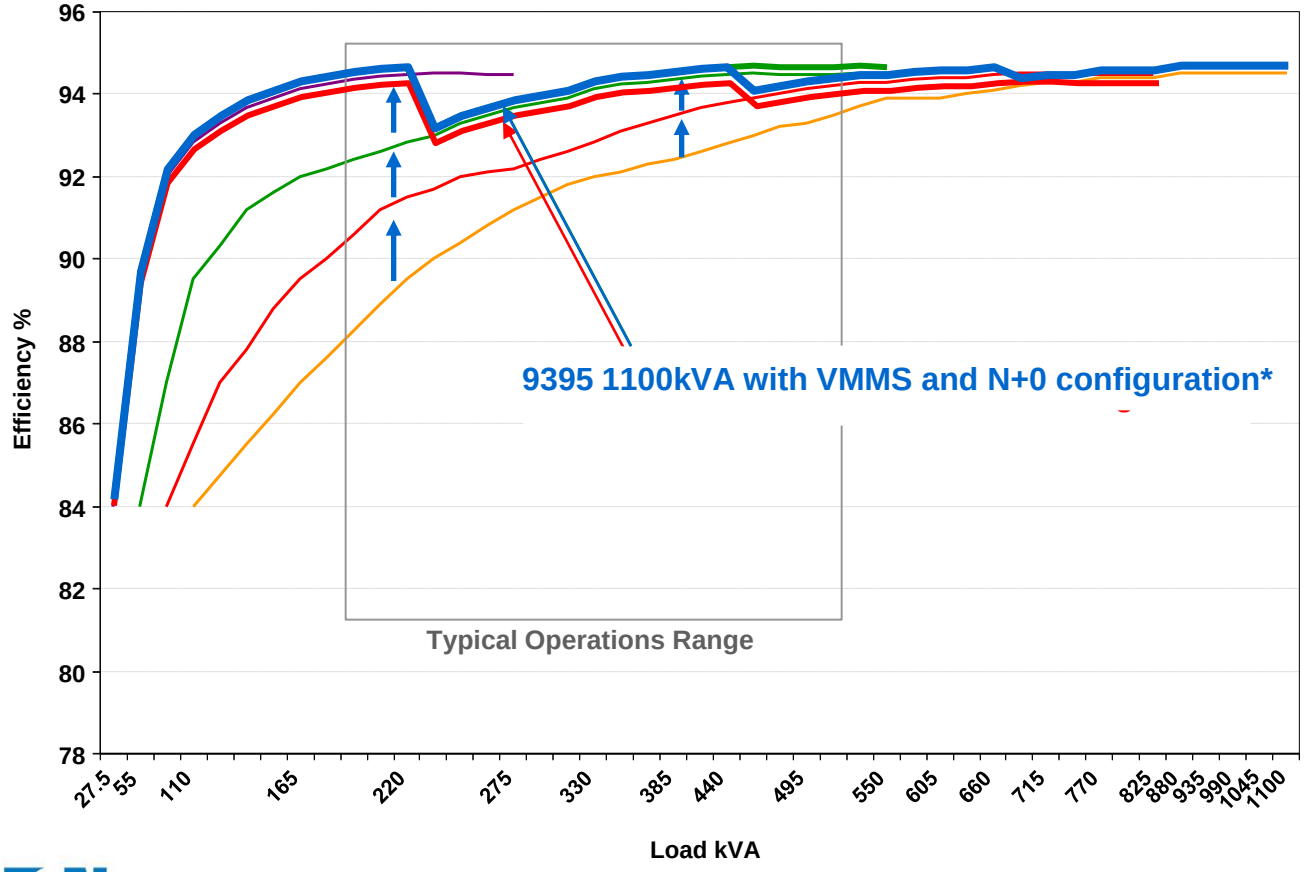
# Switched Inverter Blocks (e.g. VMMS)

- Dual bus data centers don't fully load a UPS
  - … but have to be ready to provide if called upon

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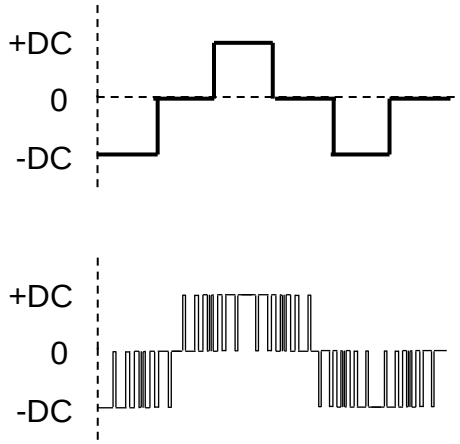
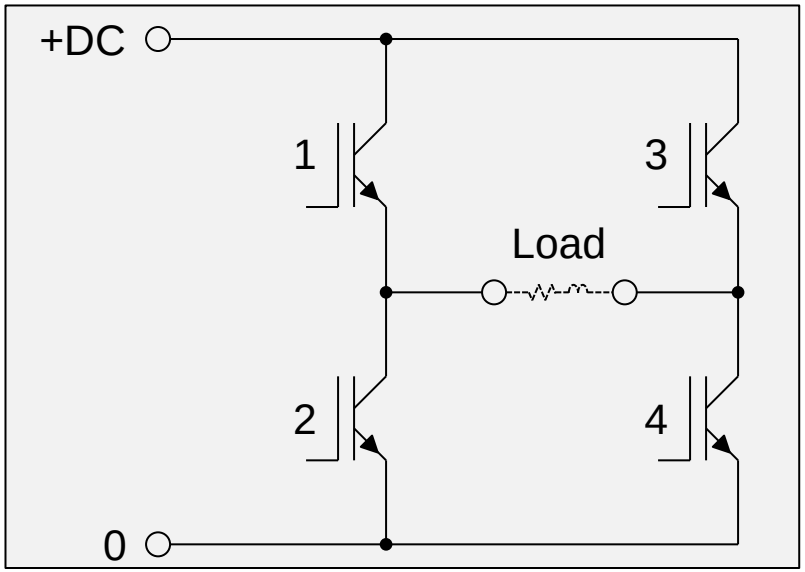
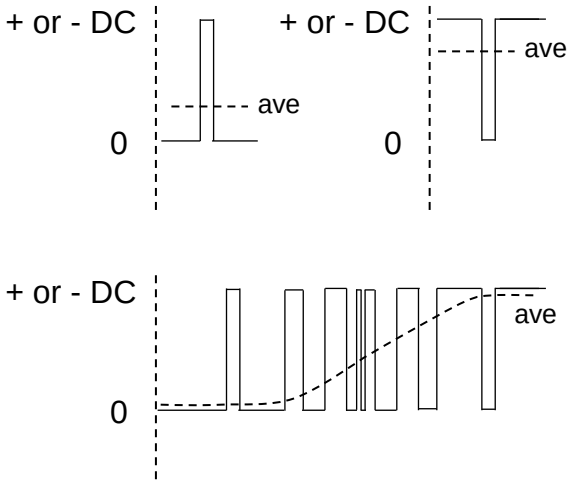
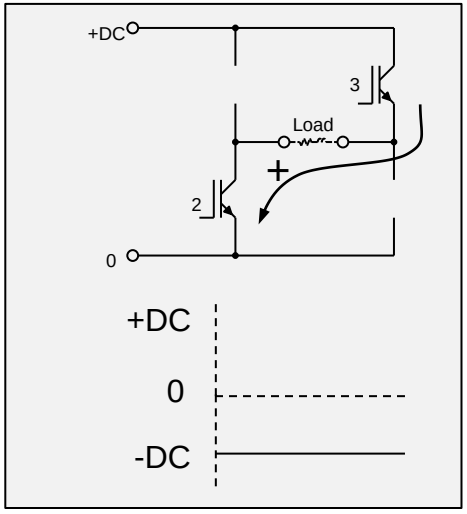
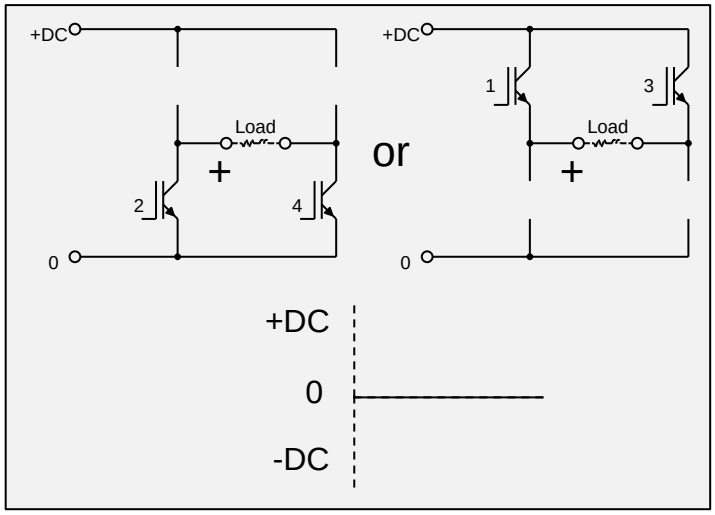
# PWM Inverter Design

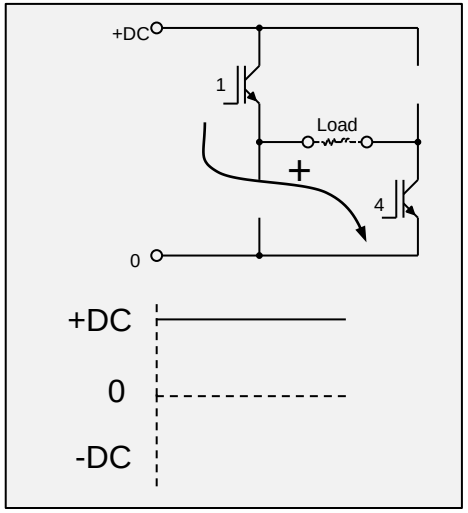
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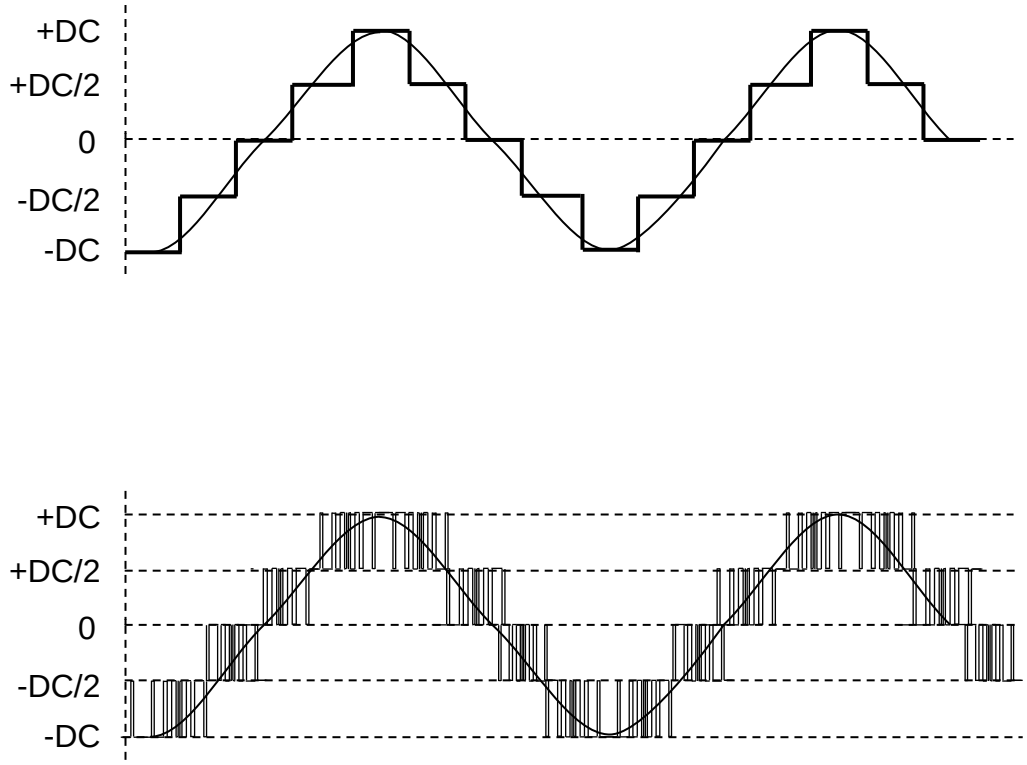
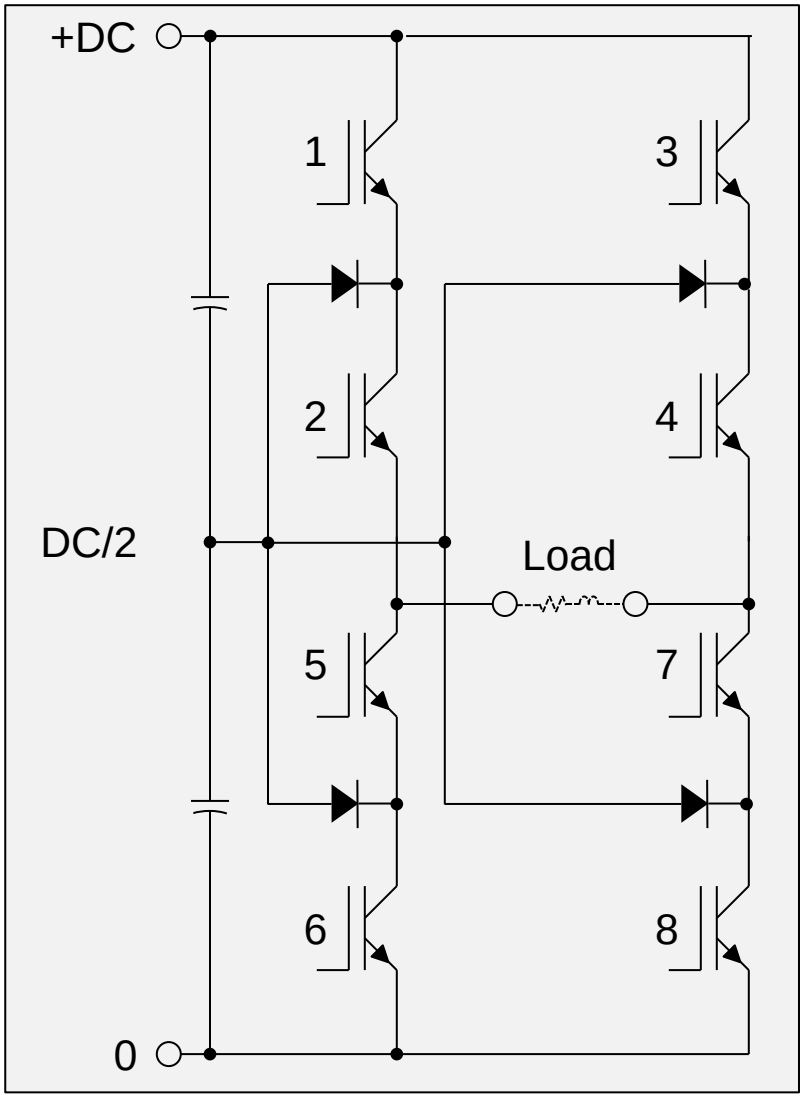
# 3-Level Inverter

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