Cat® Electric Power

UPS Detailed Overview

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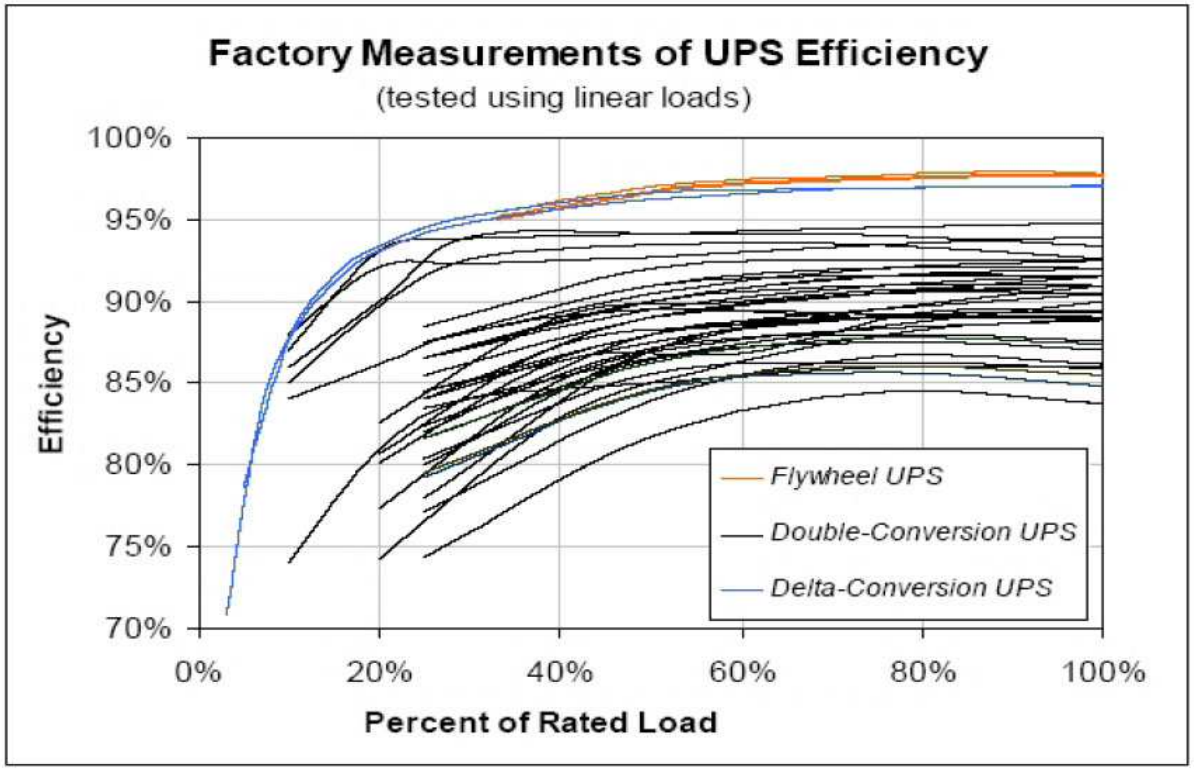
Why buy Cat® Flywheel UPS?

- Efficiency
- Footprint
- Maintenance
- Cooling
- Performance

Efficiency

- Cat Flywheel UPS uses an online active filtering design to provide exceptional performance with high efficiency



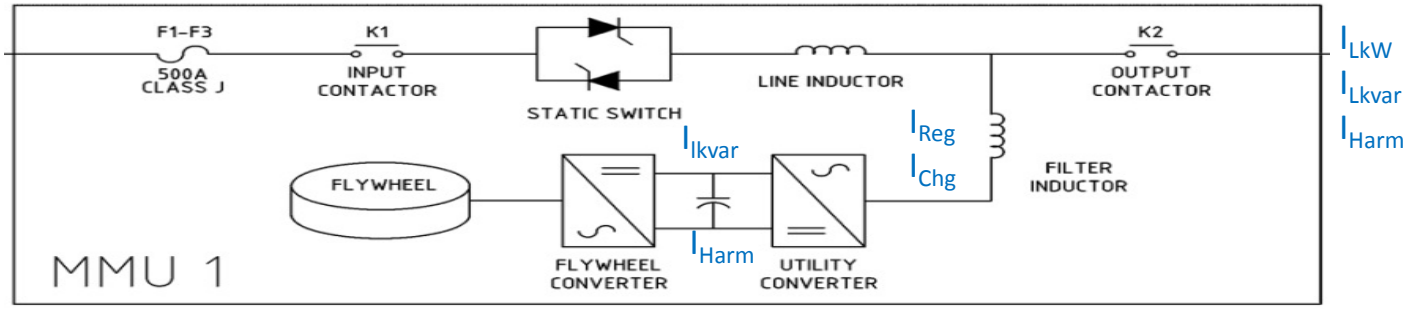
: Lawrence Berkeley National Laboratory
January 2007

Efficiency

- The online active filtering design passes the load current directly through the UPS
- kVAR and Harmonic current are provided to the load from the Utility Convert
- A small regulator current is managed between the input and utility convert to provide the active filtering of the input sine wave
- A small charging current (about 1kW) is drawn from the input to maintain the flywheel charge

$I_{IN} = I_{LkW} + I_{Chg} + I_{Reg}$

I_{IN} = Input Current
I_{LkW} = Real Load Current
I_{Lkvar} = Reactive Load Current
I_{Harm} = Harmonic Load Current
I_{Reg} = Voltage Regulation Current
I_{Chg} = Charging Current

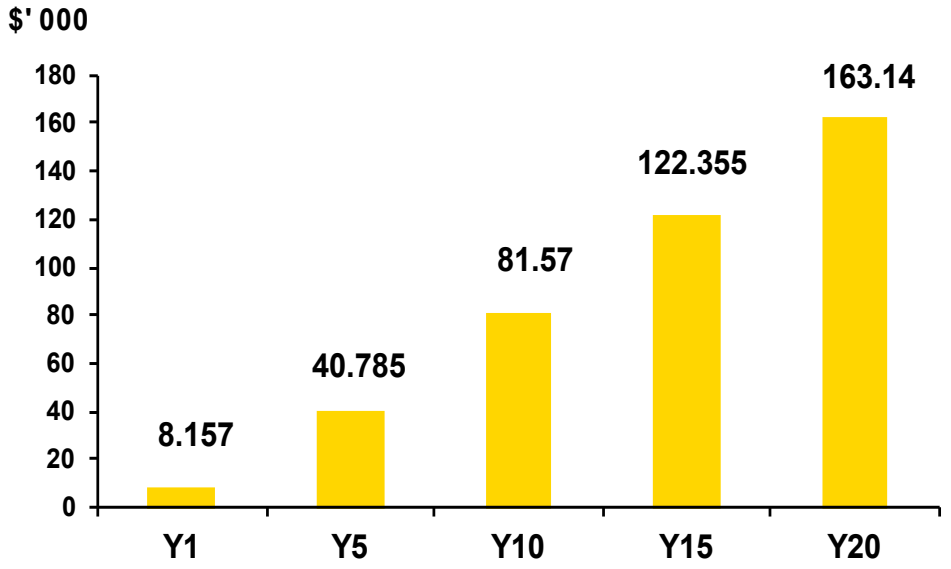


Efficiency

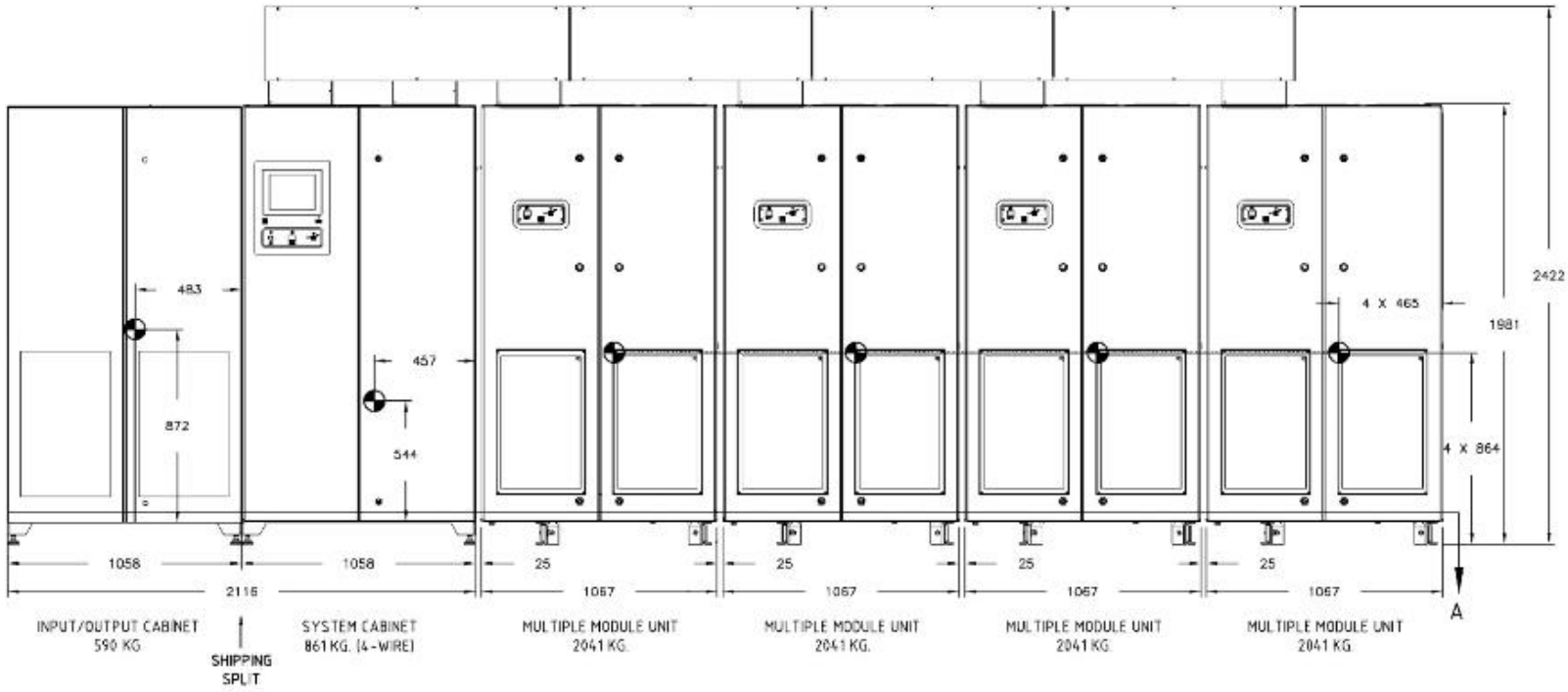
- For a 300kW UPS at $0.07 kWh the savings due to efficiency is $8,157 a year

$$\frac{.07(.07) \times 300 \times 8760}{.93} = \$\ 13{,}846$$

$$\frac{.07(.03) \times 300 \times 8760}{.97} = \$\ 5{,}689$$



Footprint



4 flywheel (6.5m or 255”)

3 Flywheel (5.4m or 212”)

2 Flywheel (4.3m or 169”)

1 Flywheel (3.2m or 126”)

Flywheel =
250kVA @ 50HZ
300kVA @ 60HZ

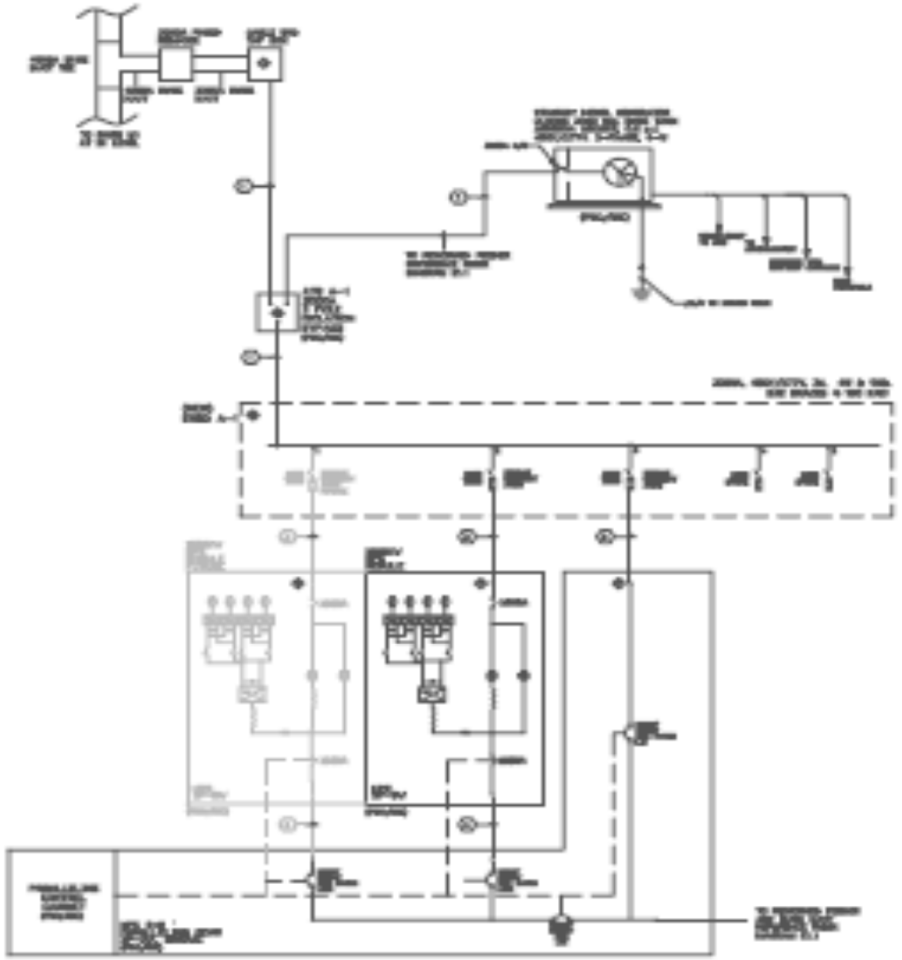
Footprint

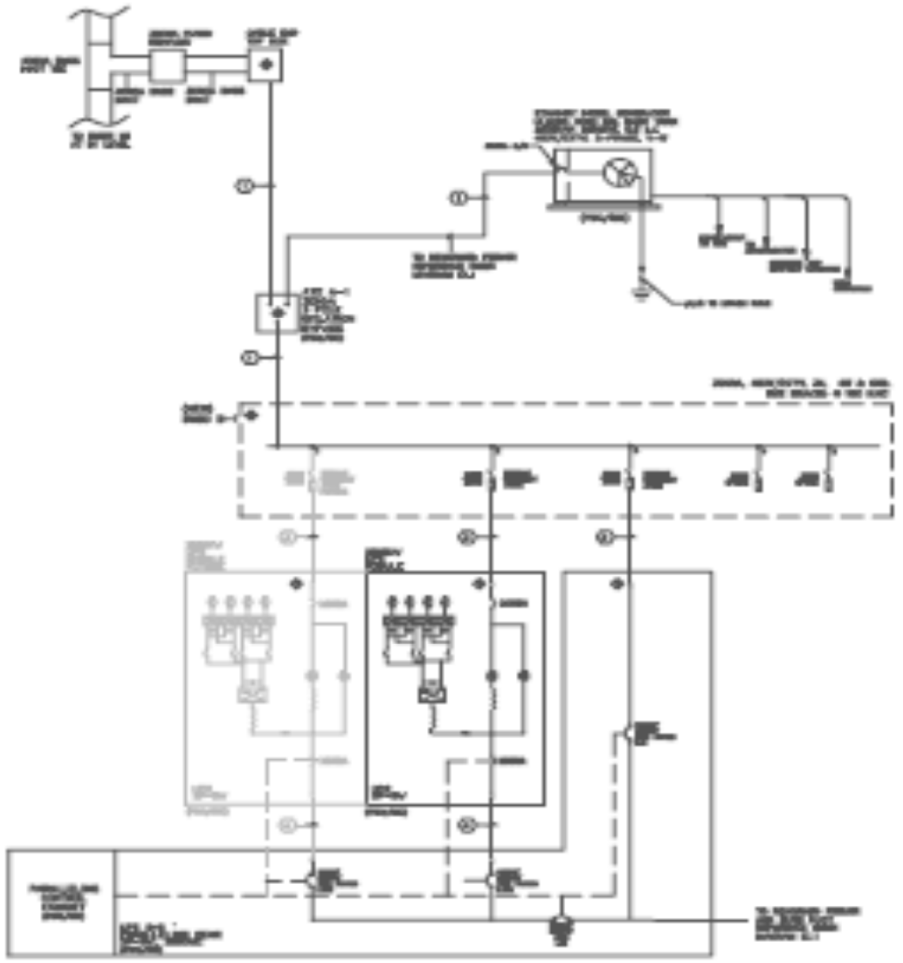
- Single Flywheel
- 480V @ 60HZ, 750KVA/675KW
- 400V @ 50/60HZ, 625KVA/625KW
- Parallel up to 8
  - 3.4m x 1m x 2m
    - 132” x 39.3” x 80”
  - 5,375 kg
    - 11,850 lbs

Datacenter Application

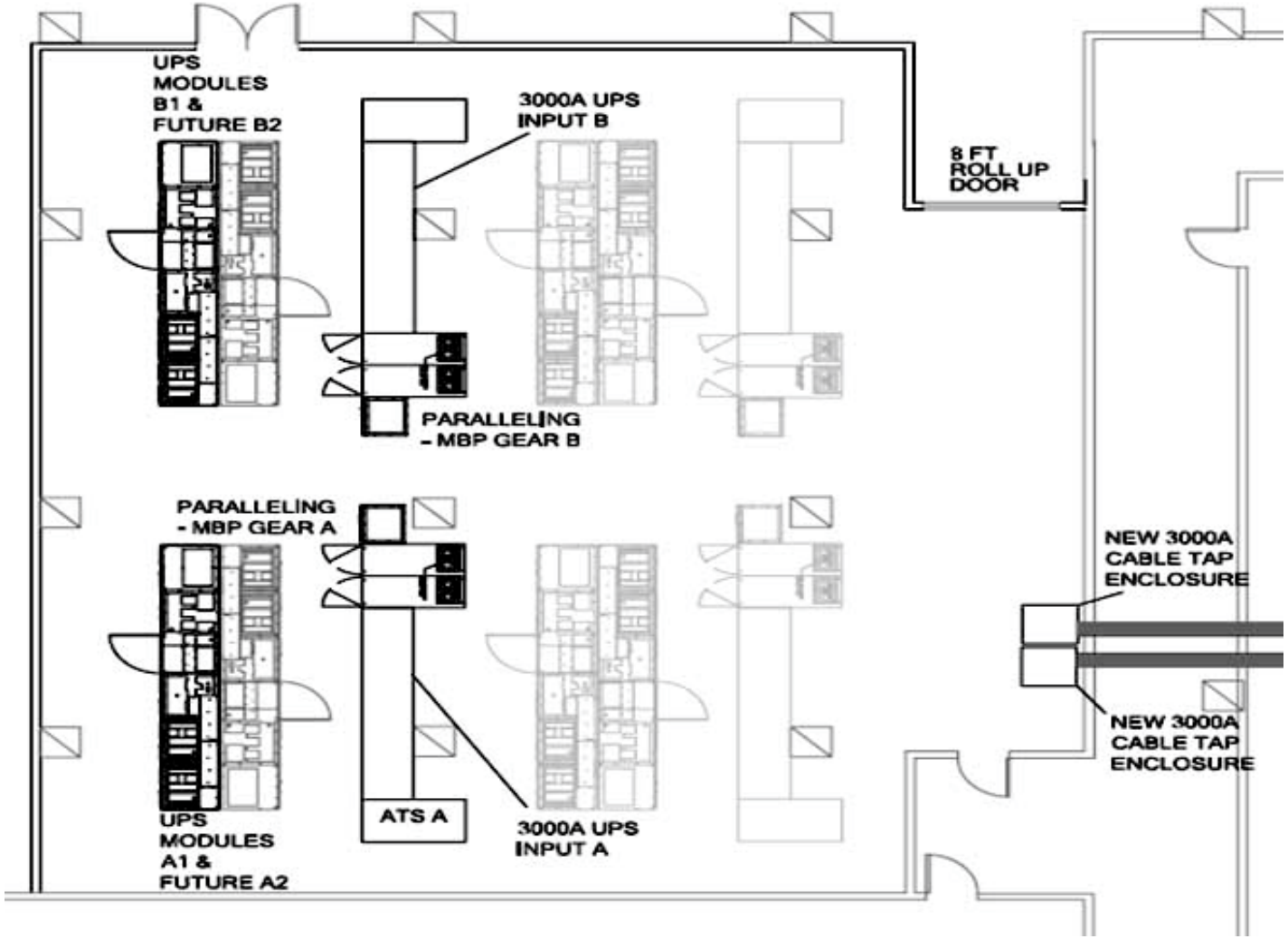
- Co-location Data Center
- Electrical architecture
  - A/B bus configuration with 1x engine on each side
- Cat 2 MW Generator sets
- Cat Switchgear
- Cat Flywheel UPS - 4800 kVA
  - 2x1200 CAT UPS in parallel per 2 MW engine
  - 4 total UPS systems

System Overview





System Layout



CAT Flywheel UPS Benefits

- 9.6MVA of Cat Flywheel UPS in less space than 3.5 MVA of Double Conversion UPS
- Additional capacity accounted for a potential of ~$500k of additional billable revenue a year
- For every 1 MW of load, $48,666/yr in utility costs is saved

Double Conversion UPS:

$$\frac{.08 \times .10}{.90} \times 1000 \times 8760 = \$77,866$$

Flywheel based UPS:

$$\frac{.08 \times .04}{.96} \times 1000 \times 8760 = \$29,200$$

Annual Electrical savings based on 1MW load = $48,666

- Customer received Utility Rebate of $50K

Total $750,000 per year

Maintenance Comparison

CAT Flywheel UPS

- When Required
  - **Clean the Flywheel housing**
  - **Clean the oil level site gauge**
  - **Check the oil level**
- Every 3 Months
  - **Clean/check Air Filter**
- Every Year
  - **Change the Vacuum Pump Oil**
- Every 3-4 Years
  - **Flywheel Bearing Replacement**
- Every 5 Years
  - **Replace Controller Battery**
- Every 10 Years
  - **DC Capacitor Replacement**

Double Conversion/Battery UPS

- Monthly
  - **Battery inspection/clean***
  - **Torque battery terminals***
  - **Clean internals**
- Every 3 Months
  - **Clean/check Air Filter**
  - **Battery Test – Ohmic***
- Every Year
  - **Battery Test – Resistance***
- Every 5 Years
  - **DC Capacitor Replacement**
  - **Battery Replacement**
- Every 10 Years
  - **AC Capacitor Replacement**

*Battery test intervals based on IEEE 1188

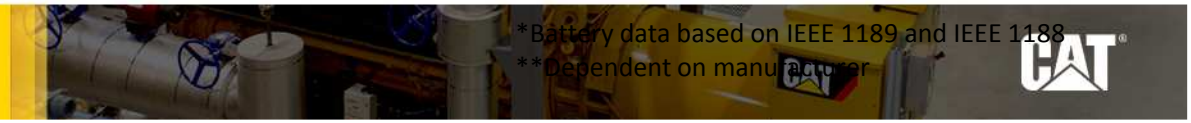
Cooling

CAT Flywheel UPS

- Heat Rejection of 1200kVA UPS
  - 83,967 BTU/HR
  - 24.6 kW
- UPS Temp Limits
  - 0-40° C (32° F - 104° F)
- Energy Storage Temp Limits
  - 0-40° C (32° F - 104° F)

Double Conversion/Battery UPS

- Heat Rejection of 1100kVA UPS
  - 250,000 - 339,000 BTU/Hr**
  - 74 - 99.35 kW**
- UPS Temp Limits
  - 0-40° C (32° F - 104° F)
- Energy Storage Temp Limits
  - 25 ° C (77 ° F)*
  - Life decreases 50% for every 8 ° C to 10 ° C increase*
  - Batteries have less capacity at colder temperatures*



*Battery data based on IEEE 1189 and IEEE 1188
**Dependent on manufacturer

Performance

Input

- Voltage Range +10% / -15% (programmable)
- Frequency 60 Hz +/- 10% max (programmable) +/- 3% (default)
- Power Factor 0.99 at rated load and nominal voltage
- Harmonic Current Distortion <2% at 100% linear load

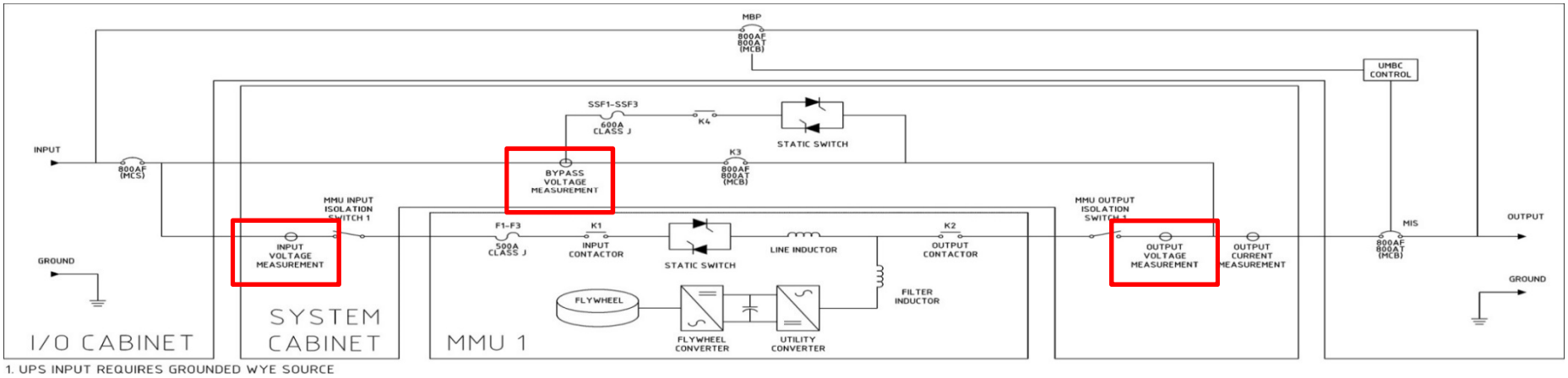
Output

- Steady state Voltage regulation +/-1%
- Voltage distortion <1% linear loads
- Frequency 60Hz (mains synchronized)
  - (normal operation +/- 0.2% free running)

Power Correction – Sample rate

Voltage is monitored at three locations within the UPS

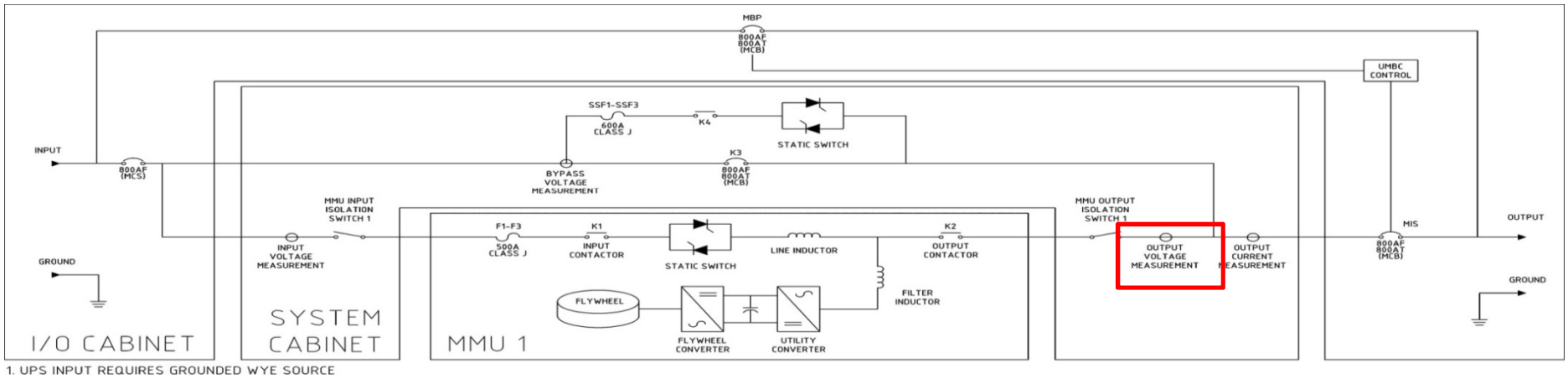
- Input, Bypass and Output



Bypass voltage is used to confirm voltage before transfer
Input voltage is used to determine disconnect
Output voltage is used for correction

Power Correction – Sample rate

- Sample rate of 20kHZ for 300 series
  - 333 samples per cycle at 60HZ
  - 400 samples per cycle at 50HZ



- Sample rate of 217kHZ for 750 series
  - 3616 samples per cycle at 60HZ
  - 4340 samples per cycle at 50HZ

Power Correction – Voltage

As Real Power is drawn across the Line Inductor a phase shift will occur

- The phase shift is kept to less than 10 degrees at full load

The phase shift creates a Reactive Current that is managed by the Utility Converter to control the Output Voltage

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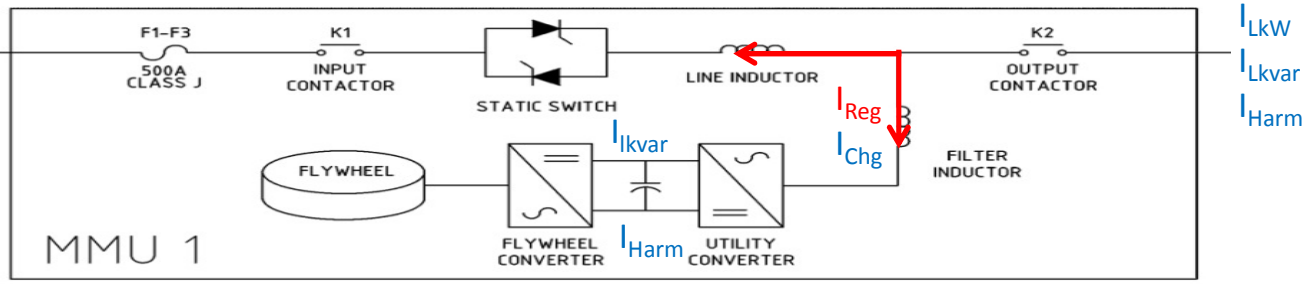

Power Correction – Voltage

- Leading reactive current causes a voltage boost
- Lagging reactive current causes a reduce voltage.

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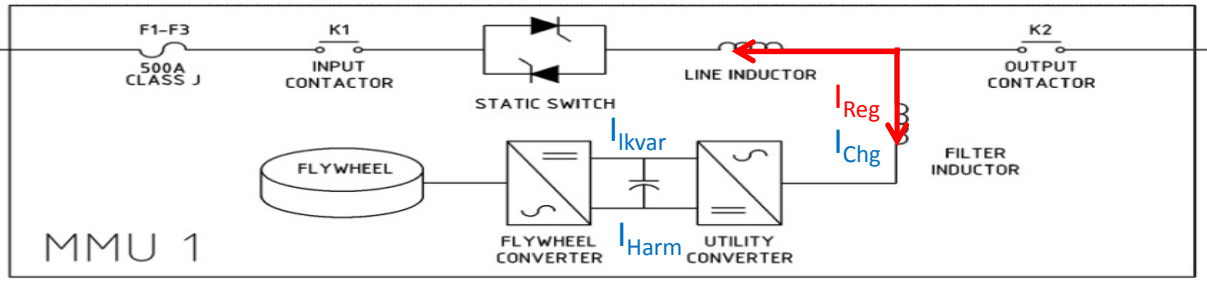
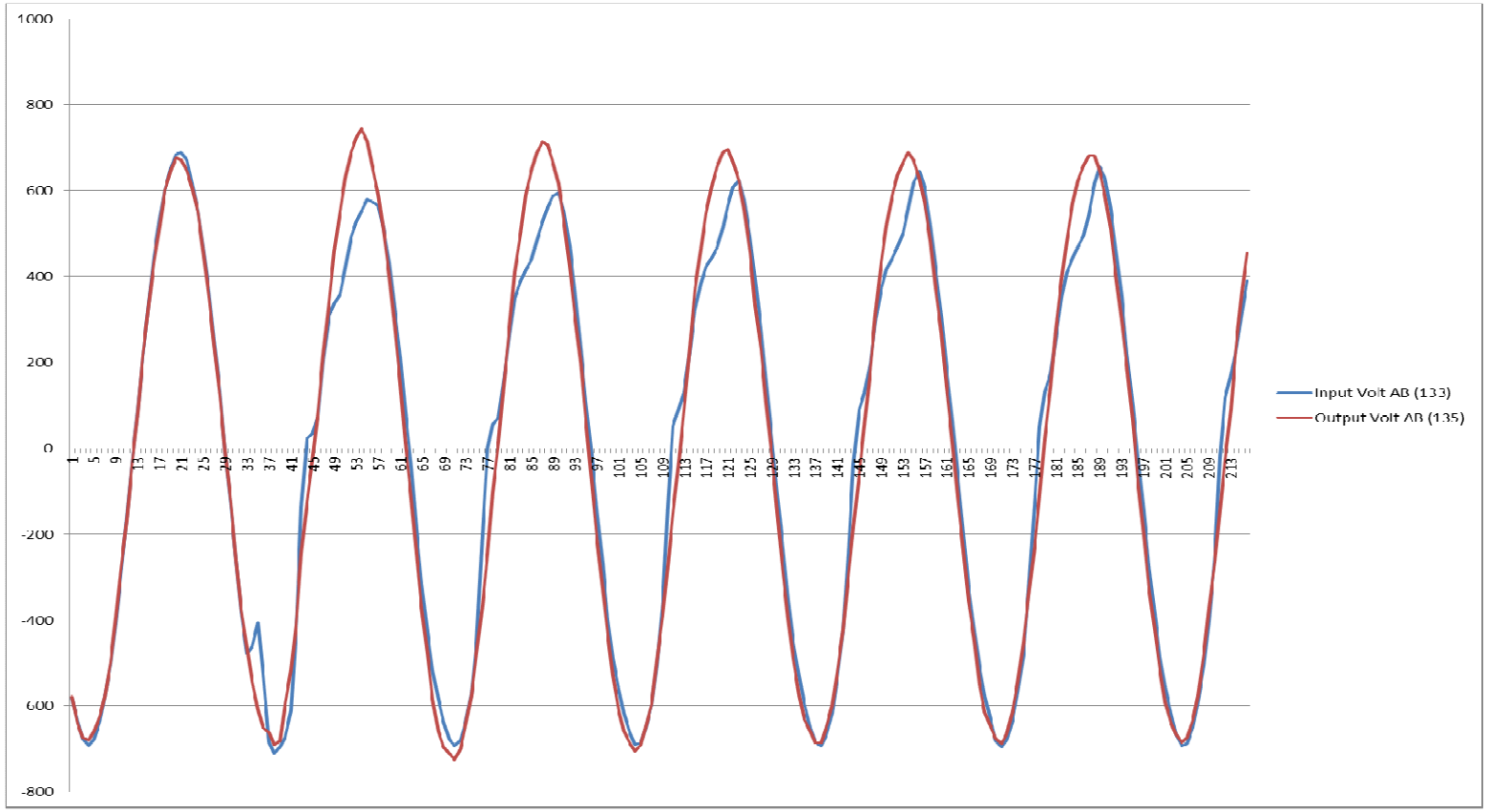


Power Correction

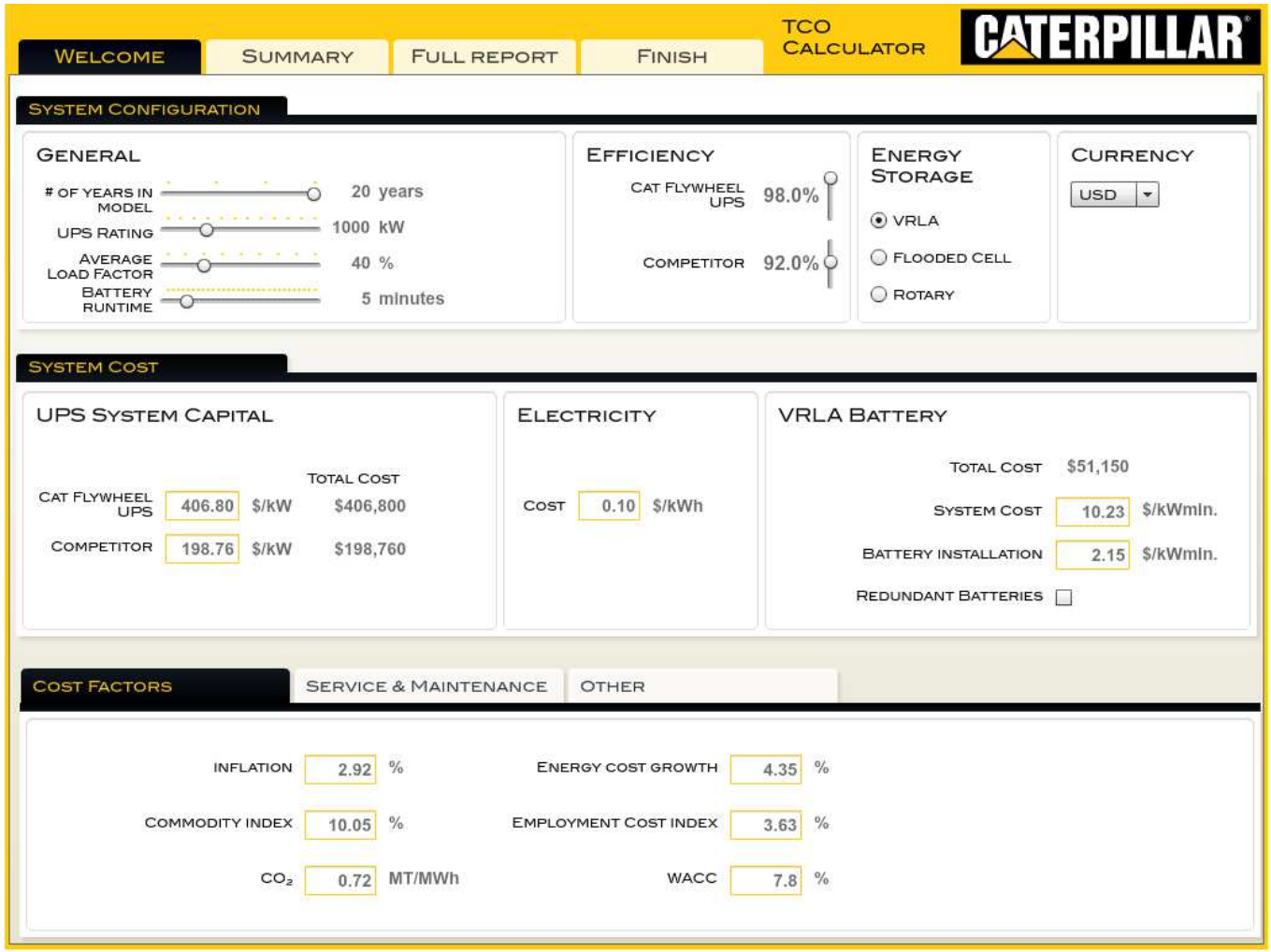
- Actual data demonstrating voltage correction



Why buy Cat® Flywheel UPS?

- Efficiency
  - $48,666/yr for 1 MW of load in electrical savings
- Footprint
  - More billable space to increase revenue
- Maintenance
  - Lower cost and Less down time
- Cooling
  - Lower heat rejection and cooling requirement
- Performance
  - Exceptional power quality

Total Cost of Ownership (TCO) Tool

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