WHITE PAPER:

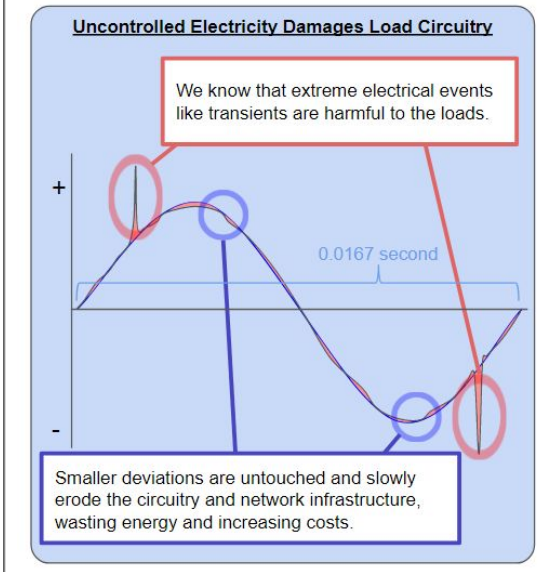
Incorporating Real Time Computing in Data Center Power Networks

Pittsboro, North Carolina, USA

3DFS.COM

What Does Electricity Reveal About the Power Network?

Nearly every device in a data center includes embedded sensitive electronics which use electricity in very specific ways to accomplish tasks that only machines can do. These machines are designed with the expectation that the electricity supplied to them will be uniform and steady, but that is never the case.



For sensitive electronics like computers and routers, any fluctuation in electricity is harmful and disrupts work performance.

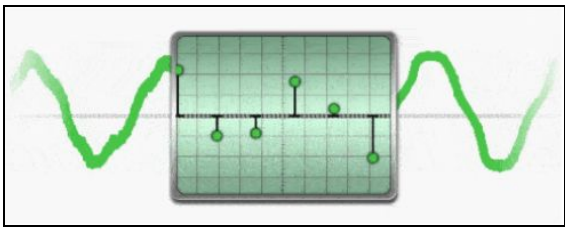
When a motor is operating and a transient comes through the network, the motor cannot convert that transient into useful work. Instead it must absorb it, which harms the motor and also disrupts its work performance. We understand this to be true with large events like transients, but what about the constant small electrical events that we do not pay much attention to?

In data centers, major effort is put into power network stability. There are built in redundancies, lots of backup equipment and tons of UPS devices to smooth out the power supply, but what does examining the electricity reveal about the true stability of the power network?

Computing Power vs. Electricity Measurement

Electricity is literally lightning fast, so in order to measure it accurately, a significant amount of computing power must be available at the point of data acquisition.

In order to see electricity, which means to actually have a detailed contour of each cycle (1/60 sec in the U.S.), to truly know what is going on, the computing power required is immense. What is more important is that this amount of computing power is conspicuously absent in our “smart meters” and all of the technology that we use to monitor our electricity consumption.



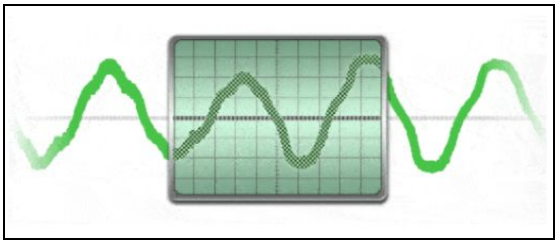
One cycle in the U.S. is 1/60 of a second. The RMS methodology is not sufficient for acquiring real time data on electricity.

In fact, the power electronics market is not trending this way either because computing power is expensive, so the market's visibility and therefore knowledge of electricity is limited to the averages and integrals of the RMS methodology of data acquisition.

Since electricity powers every device in a data center, this is a VERY UNFORTUNATE case of "you don't know what you don't know" and unsurprisingly it is the root of all data center power network instability.

Instead of relying on a data acquisition methodology with limited processing capacity, 3DFS Technology leverages real time computing from the point of data acquisition to generate an ultra high fidelity digital contour of every cycle using the mathematical principle of oversampling.

The system acquires more than two dozen electrical parameters at MHz frequencies in 24 bit resolution for absolute real time awareness.



Incorporating real time computing as a part of the data acquisition opens up an exact understanding of electricity flow.

The VectorQ Series of power controllers acquire 26 electrical parameters, each at MHz frequencies and in 24 bit resolution.

Real Time Electricity Analytics

This streaming high resolution electricity data is fed through a system of real time algorithms for data mining, predictive analytics, load disaggregation and more. The core differentiating functionality of 3DFS

Technology is Real Time Electricity Analytics; the ability to non-invasively extract the true absolute value electricity flow data in any electrical environment. This opens up the capability to fully and truly, digitally map electricity flow from the panel down to the circuit board level.

This previously inaccessible layer of electricity data takes what is today a black and white image and puts into full blown HD color.

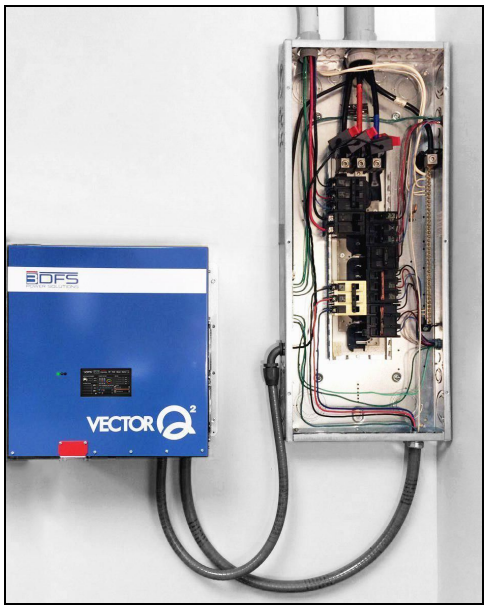
The 3DFS R&D group has been researching electricity all over the world with this level of visibility for well over a decade and has developed universal functionality related to electricity control that cannot be achieved in any other way.

Incorporating Real Time Electricity Analytics within power electronics is the only way to know for sure what is occurring in real time within a power network. We offer this functionality for sale to data centers in our VectorQ Series Power Controllers product line.

What is Real Time Digital Control of Electricity?

Take a minute to consider what is happening at the panel level of a power network; the centralized point of electricity distribution for multiple loads. Each load consumes electricity without consideration for other loads in the panel, so measurement of electricity at the panel is the collective load demand.

Now, let's slow the electricity flow at the panel down to microseconds. At this moment, the collective load demand of the whole panel is not balanced. There is some level of distortion present. The current and voltage are not synchronized and there is an imbalance across the phases.

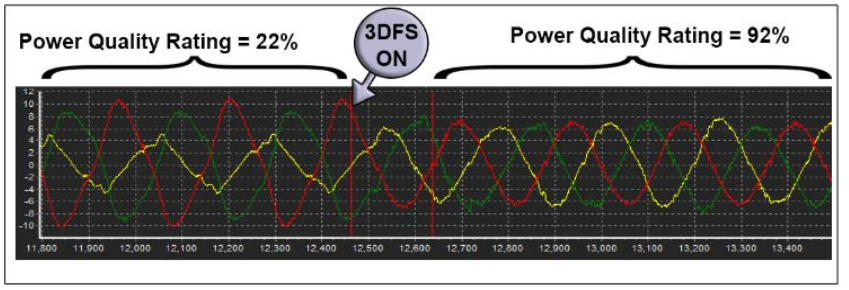


The VectorQ Series are installed at the panel level, in parallel within an hour and will operate continuously for at least 15 years.

Fast forward to the next microsecond and there is a different picture corresponding to that “in the moment demand” of electricity. There is still distortion present, but it has shifted. Current and voltage are still not synchronized and there is still an imbalance across the phases, but at different degrees. The amounts are entirely dependent on the instant and collective load demand of that moment.

In actuality, each microsecond, the loads are demanding an exact amount of electricity with a very specific balance of inductance and capacitance. The problem is, that need is not met at that moment, so the loads suffer. This is constantly occurring within power networks today. Every load in a power network is experiencing this constant over and underpowering at the subcycle level and the collective result is inefficiency at an obscene magnitude. Most of the heat we experience in electrical environments is this playing out in real time. Heat is a waste of electrical energy and an indicator of instability.

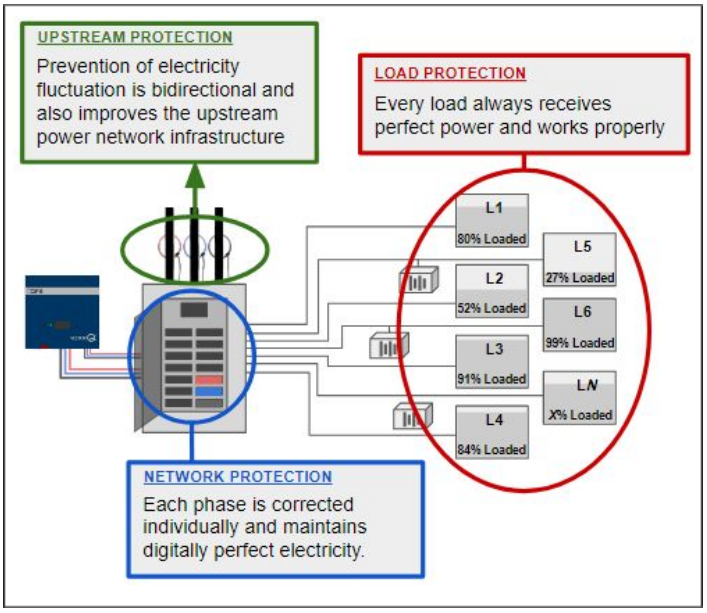
3DFS Real Time Electricity Analytics clearly reveal this to be the root cause of data center power network instability and we have incorporated an incredible functionality within our VectorQ Series Power Controllers to eliminate this problem within power networks.



Power Quality Rating represents electrical network efficiency. The higher the number, the more efficient the network, less energy is wasted as heat or other forces.

Embedded within the VectorQ is a Flash Energy Storage System (“FESS”). It has an inductive component and a capacitive component and is able to charge /discharge microamps at the microsecond level. It is directly connected to the real time computing system which is constantly analyzing the electricity on each phase in high fidelity at the nanosecond level. The parallel installation means that the FESS is powered by the panel.

Let's now revisit the microseconds that we discussed previously. At that moment, when the load profile is demanding the specific balance of capacitance and inductance, the FESS delivers the precise supplemental amount of either based on the hundreds of nanosecond level measurements that have preceded the event. The result is constant resynchronization of the electricity on that phase.



The VectorQ Series Power Controller takes into consideration the balance across the phases, automatically adjusting for ideal distribution of current, thereby zeroing the neutral current. The power controller repeats this process every microsecond for guaranteed Electricity Resiliency, which is the very seed of power network stability.

The result is real time electricity synchronization and balance that perfectly matches the load demand with the power source supply.

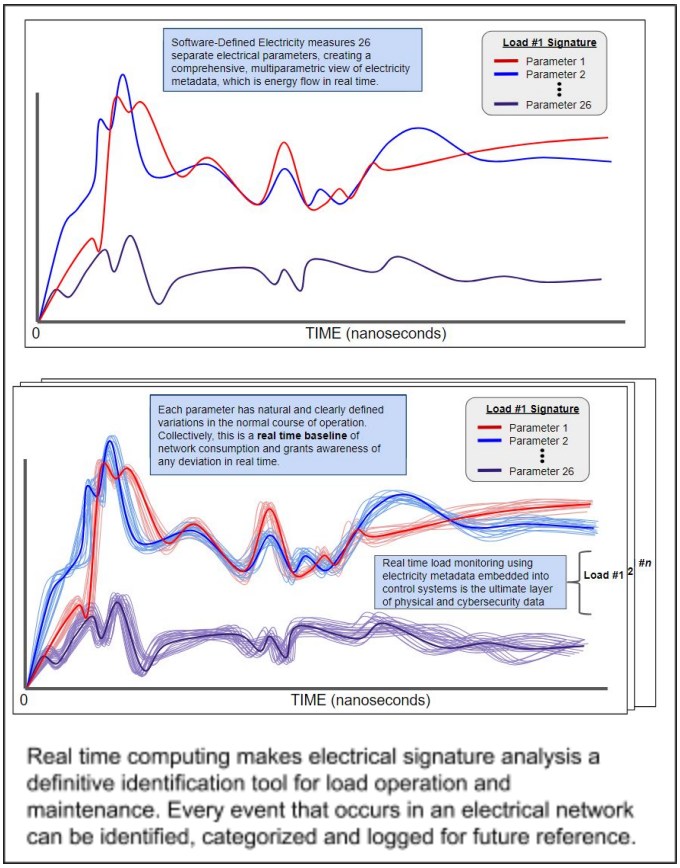
Efficiency matters. The VectorQ Series power controllers are 98+% efficient. For example, the VectorQ2 is designed for a 208/240V network. It is installed in parallel, so the power rating is unlimited. The capacity of correction is limited in each device by the reactive power. Each VectorQ2 consumes 120W of power and has a capacity of about 9.9 kVAR. That roughly translates to using 120W of power to perfectly clean and control 30-50kW. The expected life of a power controller is 15 years with no maintenance required.

Installation is easy and control is guaranteed. Unless otherwise specified by code, installation can be done without disrupting power.

As a data center facility stakeholder, digital control of electricity is a no brainer. The alternative is no control of the electricity; just connect loads to power sources with wires and expect the best.

New Layer of Data and Analytics

With over a decade of research on electrical signature analysis with this tool, we have developed very robust algorithms for real time data mining and load disaggregation. Each VectorQ Power Controller digitally maps the electrical network, tracking and logging events in constant preparation for changes in the load or source profile.



Real time computing makes electrical signature analysis a definitive identification tool for load operation and maintenance. Every event that occurs in an electrical network can be identified, categorized and logged for future reference.

The real time computing system is ultra efficient with data processing writing over 99% of the data acquired after a few microseconds, however portions of that data are compressed, encrypted and then sent through a virtual private network to our secure facility. From there we provide the owner of the power controller any information they want on their electrical network.

Every load is identifiable along with the health and real time operating status. Facility operators can digitally map the entire network and have an exact real time understanding of what is occurring without needing eyes on the network.

3DFS provides the appropriate data streams for the functionality that they desire and we work with clients to integrate this data into asset management, forecasting, security, and control platforms.

Benefits of Software-Defined Electricity

Digital control of electricity guarantees the most energy efficient consumption of electricity by the loads, always. The reduction in energy

consumption will be experienced in primary and secondary ways:

Primary Energy Savings

Your primary energy savings will be in reducing the kWh consumption (overall energy consumption) as well as your kW consumption (amount of energy demanded at any given point) and significantly reducing your demand charge, as well as other utility penalties.

> The heavy inductive loads like compressors or motors (i.e. HVAC, CRAC, pumps, etc.) will experience a reduction in energy consumption between 25-30%.
>
> The IT and lighting loads like power supplies, servers, routers, LED lights, etc., will experience a reduction in energy consumption between 10-15%.

Utility penalties are unique to every data center. They are calculated based on amount used, time of use and how much the electricity use distorts the grid. Installing Software-Defined Electricity guarantees that the amount used will be absolutely streamlined and there will be zero distortion to the grid, so the penalties should be the lowest possible.

Secondary Energy Savings

Your secondary energy savings will be two fold. Digital control of electricity prevents electrical energy losses, which are exhibited as heat. The data center will experience a significant 20+ degree temperature drop within most of the operating loads. This heat prevention will reduce the need for heat evacuation equipment to operate as often, reducing the energy requirement for environmental controls.

In addition, each load will operate as designed with the exact amount of power it demands at any given moment, so the work performance of the loads will be consistent and more efficient as well. This means the HVAC and CRAC units will dehumidify and cool off the environment with shorter cycles. Incidentally, this also means that the servers will operate with lower packet error and retransmission rates.

Big Picture

Each VectorQ Power Controller guarantees energy savings and electricity stability and will last at least 15 years. The reduction in energy consumption and wasted energy in conjunction with the improvement in work performance of all of the loads will guarantee a payback, which generally falls within a 2-3 year time period. When incorporating the electrical network awareness and digital mapping, the payback can be much sooner.

The payback is guaranteed, but the most important factor for your data center is the dynamic stability and asset performance improvement that your facilities will experience. Powering your organization with clean electricity will immediately boost in productivity and reduce the operational costs of every device within the power networks.

It all boils down to Real Time Electricity Analytics. Without it, it is impossible to know what is really going on within your data center power network.

Contact 3DFS to schedule a non-invasive assessment of your data center power network.

919.807.1884

POWER@3DFS.COM