

SOFTWARE-DEFINED
ELECTRICITY

OPTIMIZED
EFFICIENT
PRODUCTIVE
ELECTRIFICATION

SOFTWARE-DEFINED ELECTRICITY

Chapters

- I. Optimized Electricity
- II. Efficiency
- III. Productivity
- IV. Return on Investment
- V. Markets & Applications

Coming Soon, sign up for our newsletter to receive these chapters once released.

3DFS's mission is to pioneer transformative optimization of electrical systems with the Software-Defined Electricity (SDE) platform. Our vision is a future where SDE solutions revolutionize power quality as the new standard for efficiency through plug and play real-time electricity optimization.

We believe that by optimizing the electricity already produced enables the value of SDE to stand on its own through both enabling greater efficiencies that have been previously unobtainable and deliver operational gains through increased productivity.

This delivered value of SDE creates an return on investment for users ranging from near instantaneous to three years. We strive to perfect synchronization of electricity flows where the full potential of electrical systems is unlocked to meet present and future needs. We exist to break through limits and transform how the quality of electricity connects to performance, efficiency and sustainability.

Headquartered in the United States, 3DFS delivers transformative innovation to revolutionize power management and electricity flow dynamics. Backed by over a decade of R&D, 3DFS offers transformative SDE-based solutions ready for broad application and scaled implementation across commercial, industrial, military, utility and community power systems.

ABSTRACT

3DFS is pioneering a revolution in power quality and efficiency through Software-Defined Electricity (SDE) platform. This groundbreaking technology enables real-time optimization and coordination of electrical systems to unlock unprecedented capabilities.

Key benefits of SDE include:

I) Optimized Electricity - Increased resilience and uptime through self-healing networks that automatically detect and resolve issues.

II) Energy Efficiency - Reduced costs and environmental impact through system-wide efficiency gains.

III) Enhanced Productivity - Improved operations with less downtime and extended precision and performance.

3DFS's domestically manufactured SDE VectorQ controllers upgrade infrastructure into next-generation intelligent grids. By optimizing electricity management, organizations can realize significant economic, operational, and sustainability benefits.

3DFS is transforming the future of power quality. Its innovative SDE solutions pioneer new efficiencies and capabilities to meet present and future needs while revolutionizing the way electricity is utilized.

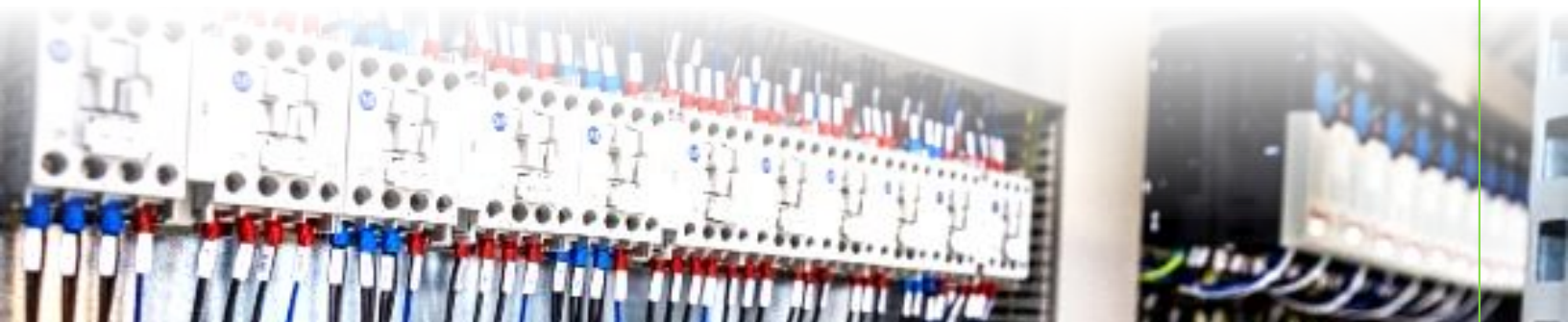
Optimized Electricity

- Why Change
- Introduction
- Power Quality
- SDE Controllers
- Methodology

As the vanguard of intelligent power quality management, 3DFS's Software Defined Electricity (SDE) is redefining energy resilience and intelligence. SDE transforms traditional electrical infrastructure into optimized, digitized networks capable of adaptive and predictive responses.

SDE provides plug-and-play compatibility with both legacy and next-generation systems. It dynamically balances phases, matches impedance, corrects power factor, reduces Total Harmonic Distortion (THD), and synchronizes phase angles. By optimizing electricity utilization in real-time, SDE strengthens resilience, enhances precision, and unlocks unprecedented capabilities from existing infrastructure.

At its core, SDE translates real-time analytics into automated, system-wide power optimization. This shift from static compensation to dynamic correction is the missing bridge between modern digital innovation and electrical networks anchored in the past century. SDE propels legacy investments into the future by unlocking adaptive, predictive, self-healing flexibility that matches tomorrow's challenges today.



Why Change? First Principles: Flexibility

Modern electricity infrastructure faces critical limitations, with approximately 70% of components dating back to the 1960s, built for an era of predictable loads and centralized control. These aging grids now contend with the variable and intermittency of renewable generation and digital loads.

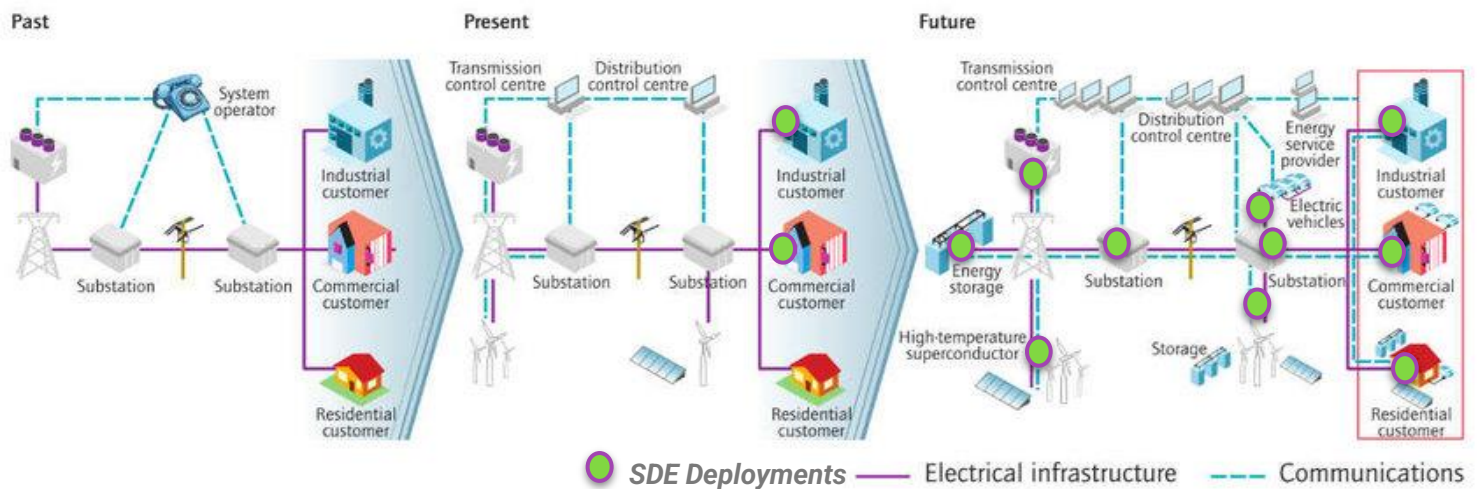
While increased data and automation provide greater visibility, power quality has emerged as a pivotal yet often elusive aspect of grid performance, economics, and reliability. Legacy control centers adequately managed systemic quality issues when supply and demand profiles were static. However, they lack the flexibility to rapidly identify and smooth localized fluctuations at the grid edge.

Localized systems capable of instant adjustment can balance real-time needs better than distant human operators using blanket policies. Grid modernization requires not just new centralized infrastructure but intelligently automated endpoints that together unlock responsive, resilient, and effective power quality.

The future of electricity reliability hinges on transitioning from reactive to proactive paradigms, with flexible and adaptive systems. This shift is essential to maintain quality through an era of unprecedented supply and demand variability.



(Top) legacy control centers and (bottom) Today's control centers



Electricity is indispensable to modern life, yet consistent power quality remains a persistent struggle. Aging infrastructure creates fluctuations and anomalies. While centralized grids manage systemic issues, they cannot rapidly adapt to optimize user needs at the grid edge or the flexibility needed for modern microgrids.

Software Defined Electricity (SDE) complements conventional paradigms by introducing localized intelligence and automation to the grid edge. SDE overlays distributed flexibility that benefits the power user while reducing stress on utility infrastructure. By dynamically optimizing power quality in real time, SDE attains adaptability unattainable solely from centralized systems focused on broadly maintaining adequacy.

Users gain autonomous responsiveness automatically tailored to their environments rather than one-size-fits-all utility control. Tight alignment of electricity supply with micro-level demand enhances efficiency more than any centralized authority alone could manage across endless variations in equipment. SDE delivers the user-centric flexibility essential for the future of reliable, resilient, and optimized power.

Why Change? First Principles: Balance & Speed

Load Balance As split phase and single phase loads switch on and off intermittently, the currents fluctuate across supply lines in an unbalanced manner. Per Kirchoff's Current Law, at any node the currents must sum to zero. So the difference between unbalanced phase currents returns to the source via the neutral. If phase currents substantially deviate from each other due to unbalanced loading, this leads to neutral currents carrying the difference.

Since the neutral line is often sized to only handle a fraction of the phase capacity, significant unbalanced loading can lead to neutral currents exceeding rated tolerances for extended periods. The resulting thermal stress accelerates ageing and risks failure of connection points and conductors not designed for the overload.

Such acute phase imbalances now often exceed legacy design tolerances. Additionally, uneven power utilization across phases leads to higher utility costs and increased capacity requirements. Outsized phase loads also mandate overrating downstream equipment like transformers, panels, and wiring to handle crest factors from the volatility. A single overloaded neutral line can cause excessive heat leading to fire and safety issues. Beyond stability, phase imbalance problems cascade into infrastructure inefficiencies, capacity issues, and expense risks for both utilities and customers.



*Thermal Images of unbalanced phases, Abrupt current surges can overload neutral line capacities, disrupt stability, and **substantially escalates the risks of electrocution and fires.***

Response Times AC power propagates at nearly the speed of light. Modern infrastructure relies on root mean square (RMS) data aggregation to average out the inherently dynamic AC parameters for system regulation and response.

$VRMS = \sqrt{(\sum(V(t)^2) / n)}$ $IRMS = \sqrt{(\sum(I(t)^2) / n)}$ *VRMS and IRMS are root mean square voltage and current respectively - V(t) and I(t) represent the instantaneous voltage and current values over the sinusoidal cycle t is the period of time n is the number of measurements over exactly 1 cycle (1/f seconds) Squaring makes all values positive, averaging removes variability, and the final square root returns an equivalent DC value, by principle RMS values must be averaged over time.*

While RMS provides helpful electricity usage averages over longer timespans, it struggles to capture transient events that affect equipment at faster timescales (*in real-time*).

Legacy approaches to electrical infrastructure succeed when loads are predictable, static, and moderately sized. Simply allocating sufficient wires and circuits during initial installation minimizes costs. However, accommodating shifting or expanding loads requires physical infrastructure upgrades like thicker neutral wires, larger transformers, or rewired panels. **Such overhauls disrupt service continuity and may not be anticipated as needed to address issues impacting operation and efficiency.**

SDE Automatically Balances Phases in Real-Time By charting an alternate path from conventional overhauls, SDE offers continuity through in parallel real-time phase balancing that fluidly answer variable demands while eliminating risks with high neutral line currents. As loads vary, SDE instantly optimizes and distribute current draw across phases continuously. This sustains equilibrium between supply and demand dynamically.

Why Change? First Principles: Impedance Matching

Impedance Mismatches. Impedance describes the total opposition to alternating current in an electrical circuit. It relates inductance, capacitance and resistance, incorporating into a single metric. Impedance mismatches occur when two parts of a circuit have different impedance values, causing some of the AC signal to reflect back rather than transmitting directly.

Although a complex technical parameter, impedance can be understood through an analogy with plumbing systems. When water flows through pipes and suddenly encounters resistance - from a kinked hose or rapidly closing valve - that resistance reflects back through the network. Causing water hammering, pressure spikes propagating through the pipes. Plumbers address this with hammer arrestors, shock absorber-like devices that dissipate the spikes.

Similarly, when an AC signal passes through an impedance mismatch between components, some signal reflects back rather than passing through. This causes distortions and losses. Tunable transformers and resistor banks act like electrical hammer arrestors, providing paths for the reflected signals. However, unlike the adaptable mechanical devices used in plumbing, these have fixed values that fail to adjust dynamically as system impedance varies. This is especially prevalent in RF engineering and microgrids where impedance, because the effects of inductance and capacitance varies with frequency, combined with resistance can't be overlooked any further.

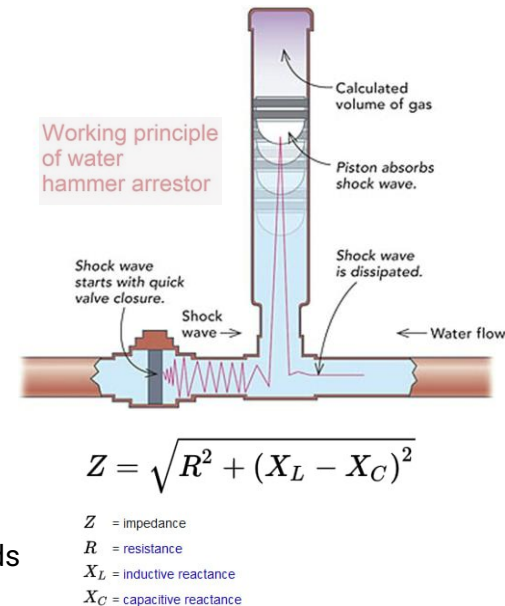
The ever-changing nature of impedance throughout AC networks makes it challenging to perfectly match components and minimize mismatches. This remains an ongoing issue for electrical engineers as they work to optimize power integrity and energy transmission quality especially prevalent with fast switching power supplies and large load profiles such as EV chargers, inverters and AC/DC power supplies.

The greater the mismatch of impedances the less power an electric network is able to effectively transfer.

SDE's real-time automation overcomes the challenges of impedance mismatches. As loads vary across electrical networks, causing reflection losses, **SDE provides instant response tuning to continually match the electrical networks impedances**. SDE reshapes waveforms to synthesize effective impedance matching for electrical infrastructure. This allows dynamically adapting components' apparent impedance to synchronize sources and loads. Effectively emulating tunable matching circuits in parallel to external loads, SDE smooths the innate variability of alternating current systems.

Where manual transformer taps or passive resistor banks fail to address transient impedance swings, SDE intervenes in real-time to maximize power transfer efficiency. This intelligent mitigation of reflection losses unlocks reliability and performance gains.

By dynamically tuning the impedance match, SDE overcomes the latent failures of static conventional compensation. It enhances transfer capability and efficiency across the complex impedance profiles inherent to modern bidirectional, intermittent and "peaky" system dynamics.



SDEs real-time impedance correction and matching is especially critical for:

- Microgrids, generator backup systems and renewables
- Communication systems where data integrity relies on consistent power and ground quality
- Motor loads subject to inrush currents and transient instability
- Long feeder lines crossing variable weather and seasoning conditions
- EV charging stations responding to spikes in demand

Why Change? First Principles: Power Factor

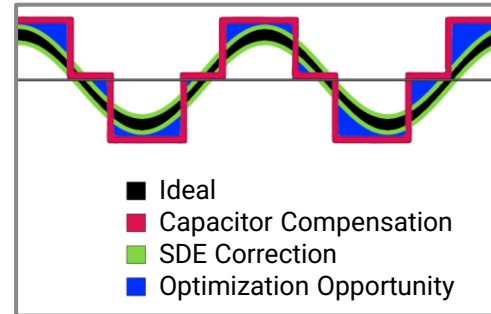


Switchable Capacitor Bank

Power Factor Compensation

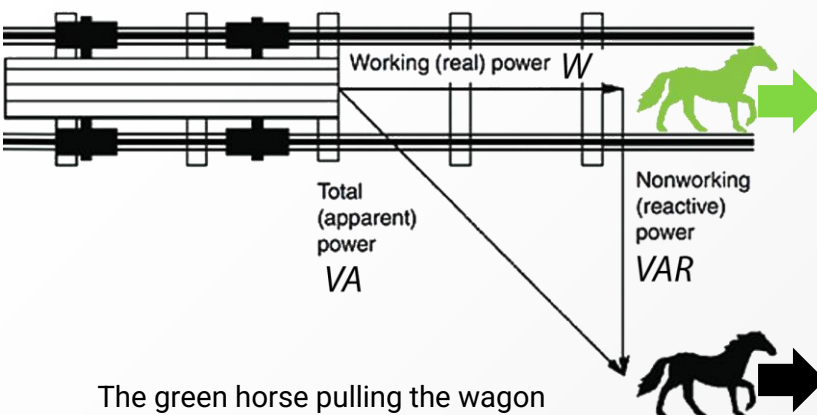
Capacitors are ubiquitous in electrical grids, from small appliances to massive substations. Banks of capacitors switch on and off to add or subtract reactive power, compensating for issues like low power factor. This traditional approach works, though imperfectly.

Capacitors wear out due to use, harmonics and environmental conditions, requiring replacement. Capacitors generate heat and harmonics when used and may require additional filtering when implemented. Finally, once installed, capacitors lack flexibility to adapt to changing grid and use conditions & lack sufficient efficiency gains.

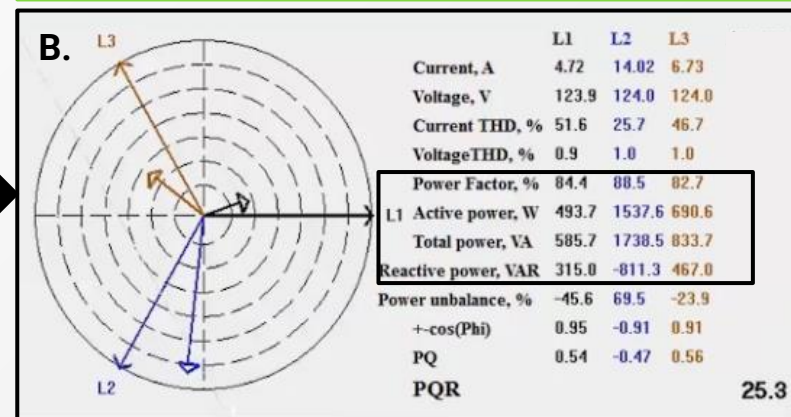
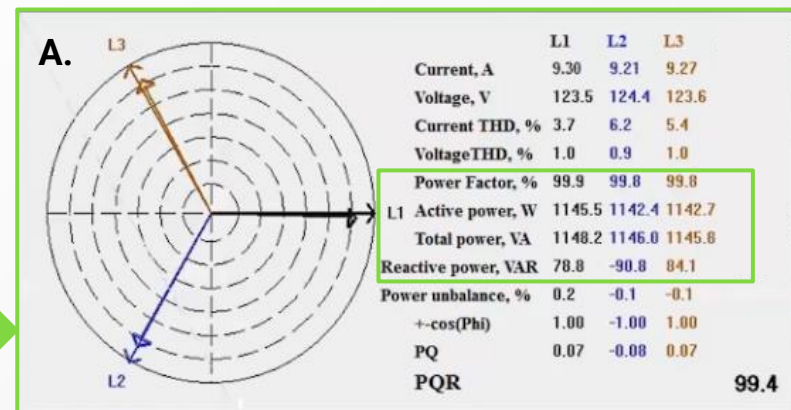


SDE offers an opportunity to move beyond the constraints of traditional capacitor systems and allows **Correction of Power Factor rather than mere **compensation**.** SDE leverages capacitors' strengths while overcoming their well-known downsides. By being more intelligent and flexible SDE builds on these traditional components to provide robust, responsive, and efficient power factor control.

$$\text{Power Factor (PF)} = \frac{\text{Real Power (W)}}{\text{Apparent Power (VA)}}$$



The green horse pulling the wagon straight along the tracks represents the optimal power factor of 1.0, where energy is efficiently transformed into motion (W). Conversely, the horse pulling at an angle represents a low power factor where reactive power (VAR) is wasted pulling sideways in addition to the power to pull the load forward. **SDE, akin to reins guiding a horse, optimizes electricity use by efficiently harnessing the available "horsepower".**



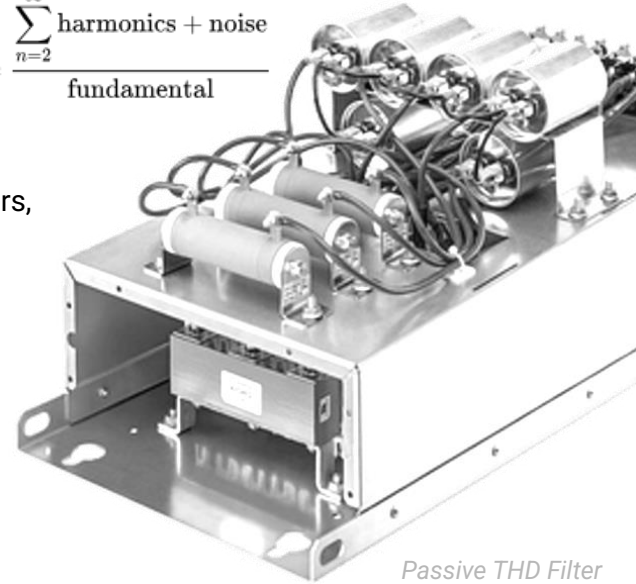
Dashboards from electrical network top: A. With SDE correction bottom: B: typical electrical network. Within the dashboard: showing on *left*: Vector (V & I) with angles that correlate real world data to horse pulling carriage example and numeric Power Factor values highlighted with a box on the right side.

Why Change? First Principles: THD

Filtering Total Harmonic Distortion (THD)

The proliferation of modern power electronics such as uninterruptible power supplies, electric vehicle chargers, and variable frequency drives, has led to increased distortion on electrical systems in the form of THD, referring to electrical noise that compromises efficiency and reliability of electricity.

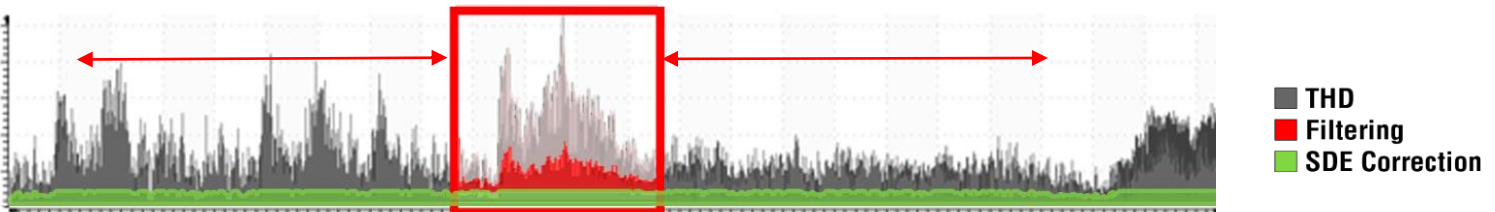
$$\text{THD+N} = \frac{\sum_{n=2}^{\infty} \text{harmonics} + \text{noise}}{\text{fundamental}}$$



Passive THD Filter

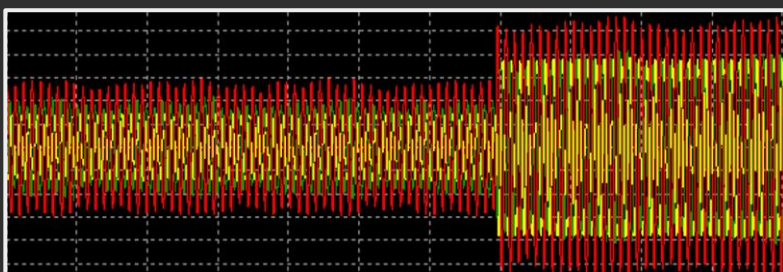
Traditional THD mitigation relies on hardware-based filtering solutions that divert the dirty power through tunable or constant filters, dissipating the interference as heat. However, the diversity and complexity of modern electronic loads results in THD becoming increasingly variable and intricate in nature. Recently, the emergence of 'supraharmonics' a term describing significant dynamic distortion to high-frequency currents and voltages distortion further complicates the THD landscape.

As a result, managing and mitigating THD has become a considerable challenge, necessitating advanced adaptive solutions that can address the multifaceted and rapidly-evolving nature of contemporary bidirectional digital grids. Hardware filtering alone has hit its limitations in this context of intricate and rapidly-changing power electronics.

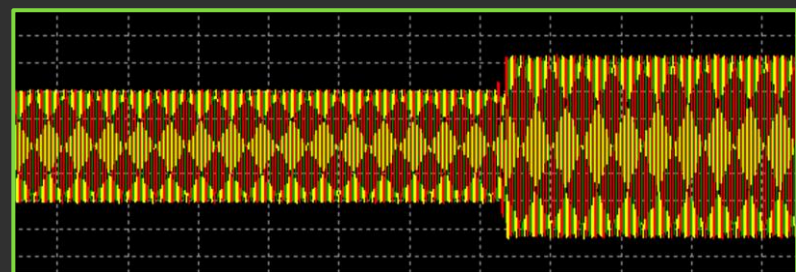


Traditional filtering selectively reduces harmonic distortion (THD) in fixed frequency ranges and turn it into heat. SDE substantially reduced overall THD and targets frequencies that have an outsized impact while generating negligible amount of heat and vibrations.

While passive filtering hardware provides a useful foundation, achieving sustainable power integrity now depends on augmenting these solutions with real-time harmonic correction capabilities. SDE systems that actively correct distortions rather than solely divert them, modern electrical networks can enable responsive and future-proofed harmonic immunity. **SDE's unique method of coordinated high-speed measurement and instantaneous power shaping unlocks the path to comprehensive mitigation amidst continuously evolving electronics-based THD and TDD interference.**



SDE Correction Off, THD across 3 phases over 50%, and increasing with varied load conditions



SDE Correction On, THD across 3 phases less than 3% and remaining steady with varied load conditions

Why Change? First Principles: Standards

Power quality standards are continuously evolving to keep pace with changes in technology and electrical infrastructure. The standards vary greatly depending on the region and the intended application. For example, IEC standards are commonly used as the basis for national standards, but specific requirements are adapted to local grids and conditions. The rapid integration of non-linear loads and renewable energy sources has intensified distortions, compelling updates to the mathematical formulas used for measurement and compliance criteria.

Furthermore, as equipment ages and degrades, power quality is impacted, requiring additional vigilance. Overall the field of power quality management is in a state of flux, as today's solutions may not suffice for tomorrow's electrical networks. Standards are thus living documents, subject to revision in step with new grid configurations, emission profiles, and immunity expectations.



International
Electrotechnical
Commission



IEEE



Power quality criteria continuously evolves in attempts to address distortions from modern equipment and renewable resources. However, even as standards advance, they inherently lag behind the rapid pace of grid changes. Yet SDE's comprehensive and flexible approach optimizes integrity in parallel with infrastructure upgrades and in real-time.

SDE responses outpace standards. Its agile optimization dynamically optimizes power quality in real-time, rather than waiting for periodic guideline updates. This both future-proofs stability amid shifting specifications and unlocks capability to integrate more renewables and modern equipment at higher efficiencies.

Rather than replacing or clinging to aging static infrastructure, SDE's modular approach overlays real-time responsiveness. It works in conjunction with conventional solutions, filling critical gaps in responsibility and speed to reliably stabilize power quality as grids transition. What SDE measures and fixes in microseconds would take minutes or longer to even observe and communicate using legacy paradigms.

SDE provides power quality optimization that exceeds existing or emerging criteria from standards bodies. The real-time adaptive response isn't limited to responding to occasional specification changes but rather constantly maintains power quality at theoretical optimum levels.

Automatically Intelligent Electrical Infrastructure

Software-Defined Electricity (SDE) by 3DFS revolutionizes AC power management by correcting power factor, harmonic distortion, and load imbalance, leading to an efficient and unified electrical network. SDE is essentially a catalytic converter for power, mitigating energy waste and enhancing system operations. It improves productivity and reduces downtime across diverse sectors resulting in direct economic and operational gains.

SDE seamlessly integrates with existing infrastructure, ensuring system resilience without creating points of failure and is scalable to meet a variety of organizational power needs. SDE's robust design functions without internet dependency, offering continuous real-time optimization of electrical networks to improve the efficiency and reliability of various energy systems.

This results in measurable business value through enhanced equipment performance, process improvements and increased output. SDE delivers these gains for diverse applications including military, industrial and commercial settings adding immediate value to both the end user and utility or distributed energy resource (DER) supplying power.

How does SDE achieve these comprehensive benefits?

By precisely measuring and instantaneously correcting electricity, combining ultra-efficient solid state hardware with real-time electricity modeling and expert system feedback. This hybrid software-hardware architecture enables rapid system-wide optimization that is ten times more compact compared to traditional approaches while delivering greater effectiveness. The tight coupling between software and hardware components is why it is called Software-Defined Electricity (SDE) - leveraging the strengths of each to revolutionize electrical network performance.

Software-Defined Electricity (SDE) enables resilient electrical systems through real-time optimization - whether deployed in industry, scientific research, in dense urban power grids, or on remote off-grid power systems

Electrical demands move at lightning speed, requiring a technology that can keep up with its rapid and dynamic nature. That's where SDE comes in. Embedded within the VectorQ series of power controllers is an ultra-fast, high-resolution data acquisition system. Measuring electricity at the nanosecond level allows the advanced solid-state power correction hardware to react with lightning speed to dynamic loads, harmonics, and interference.



Power Quality Redefined

Unlike piecemeal products that address power quality in a fragmented way, 3DFS's SDE delivers comprehensive and integrated power optimization. By digitizing and intelligently managing electricity in real-time, SDE provides complete power quality improvements across networks in one unified system. This includes seamlessly balancing loads, correcting distortions, strengthening resilience, and reducing size, weight and power requirements by 10x - all with ultra high efficiency.

The all-in-one SDE system enables real-time optimization that minimizes consumption while maximizing output in a way that piecemeal products cannot match. This makes 3DFS's breakthrough SDE technology an essential and unmatched tool for holistic power quality management, infrastructure optimization and driving revenue growth.

The Power Quality Rating (PQR), introduced by 3DFS, is a metric that quantifies the efficiency of electrical energy flow in power networks on a scale of 0-100%. It encompasses crucial power quality factors that contribute to overall system performance: $\cos(\varphi)$ to reflect power factor and THD in both current and voltage

Electrical networks with a PQR of 30-50% can be improved to achieve a PQR of 80-99% with SDE.

No other method or approach can achieve this level of improvement without an infrastructure overhaul.

$$\text{PQR} = \frac{\left(\frac{\cos \varphi}{\sqrt{1+(\text{THD})^2} \times \sqrt{1+(\text{THD})^2}} \right)_{L1} + \left(\frac{\cos \varphi}{\sqrt{1+(\text{THD})^2} \times \sqrt{1+(\text{THD})^2}} \right)_{L2} + \left(\frac{\cos \varphi}{\sqrt{1+(\text{THD})^2} \times \sqrt{1+(\text{THD})^2}} \right)_{L3}}{3}$$

3 Phase Power Quality Rating Formula

CRUCIAL POWER QUALITY FACTORS

Total Harmonic Distortion & TDD **THD**

By utilizing dynamic solid-state technology, SDE effectively corrects (THD) in voltage and current, addressing both harmonic and supraharmonic frequencies. This approach not only expands the range of performance but also offers the benefits of producing minimal heat.

Phase Load Balance **PB** & Neutral Current Nulling

In electrical networks, loads experience variations in on/off states and amplitudes across different phases. Imbalances in load distribution can result in neutral current. However, SDE effectively resolves this issue by automatically balancing phases in real time, enabling balanced electricity utilization without the presence of harmful neutral current.

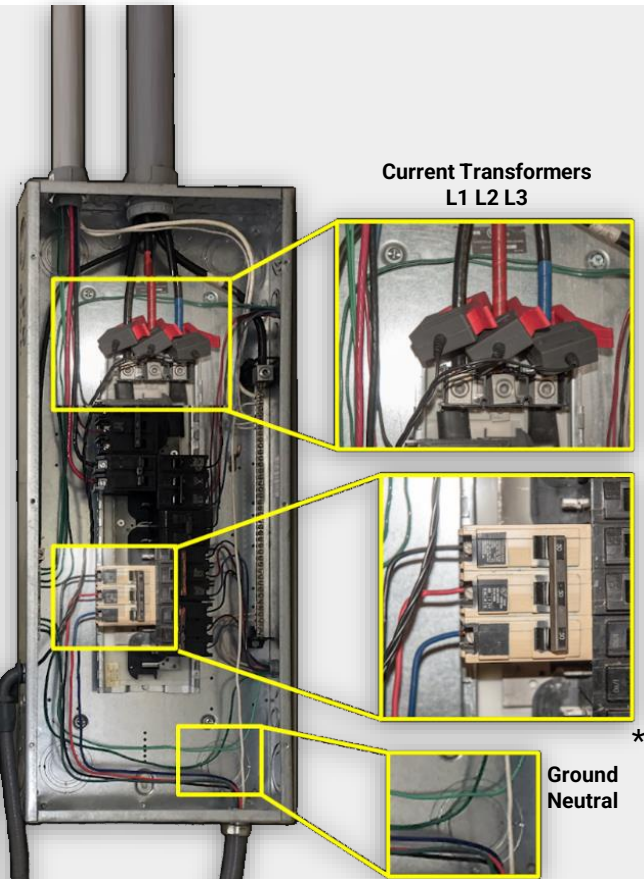
Power Factor **PF**

Comprehensive power factor (PF) correction for both capacitive and inductive loads, enabling a full range of +/- 90 degrees correction to achieve unity power factor.

Impedance Matching **IM**

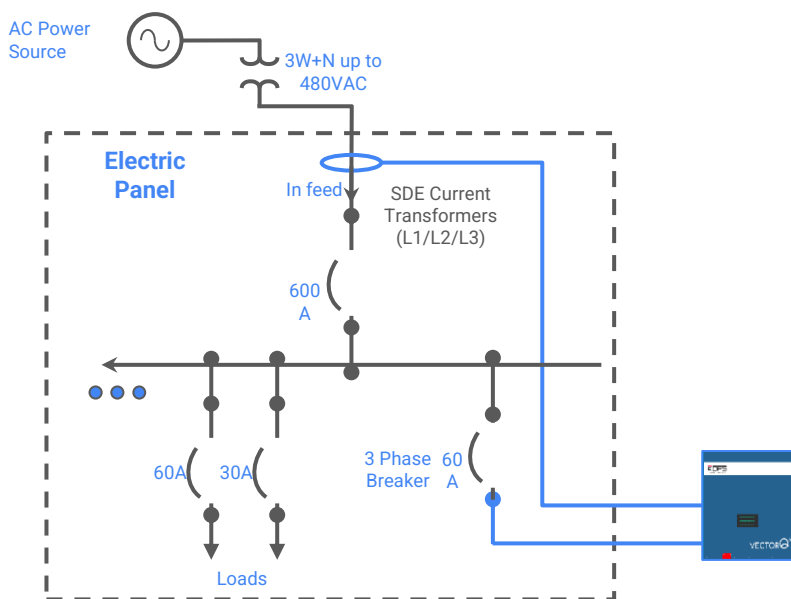
Impedance matching is of utmost importance in electrical systems as it facilitates the efficient transfer of power between various components. By achieving impedance matching, the system can transfer the maximum amount of power from the source to the load, resulting in reduced power losses and optimized overall performance. This becomes particularly valuable in systems involving generators, backup power, and microgrids where effective power transfer and interconnection are crucial for reliable efficient operation.

VectorQ Controllers pack the punch of software-defined electricity (SDE) in an astonishingly compact package. With a footprint comparable to a microwave, they deliver formidable capabilities on par with traditional large, high-maintenance systems of today. VectorQ leverages solid-state innovations to distill the functionality of an entire school bus full of equipment into a single unit— automated and optimized for next-gen efficiency.



* 30/40 A Circuit Breaker

VectorQ is Installed in parallel & does not interrupt power



One Line Diagram

In Production & Deployment:

VectorQ2 Controller
208 VAC 3-phase systems

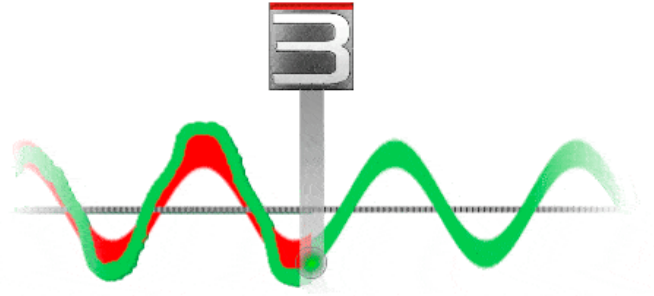
VectorQ5 Controller
480 VAC 3-phase systems

Market Engagement:

VectorQ1 – 240 VAC

VectorQ12 – 1.2 kVAC

SDE methodology Software Defined Electricity (SDE) upgrades power delivery via three (3) key principles: Holistic Correction, High Efficiency and Real-Time Adaptivity: Enabled by Digitally Full-Scale (DFS) correction, this methodology integrates beyond piecemeal filters and static capacitors to reshape power flow holistically. Discrete issues become collective opportunities.



Electricity moves at lightning speed, requiring a technology that can keep up with its rapid and dynamic nature on every phase in real time.

1 The Whole System, not just its symptoms

SDE takes a holistic approach by simultaneously addressing all the components of the Power Quality Rating (PQR). This approach recognizes the interconnectedness of each rating and the potential impact on other ratings. Unlike the conventional “fix what’s broken” approach, which can lead to deficiencies in other areas, SDE ensures the comprehensive improvement of the entire system. By optimizing power quality across the network, SDE enhances efficiency, reliability, and performance to their maximum potential. This eliminates the need for fragmented solutions and offers a comprehensive approach to improving power quality.

2 Round Trip Efficiency

SDE's compact and durable power quality correction devices utilize efficient solid-state technology, replacing traditional bulky and maintenance-intensive systems. Operating at an impressive 96% round-trip efficiency without needing dedicated air conditioning, SDE devices recover losses from heat and vibrations, transforming them into efficiency gains. The solid-state design revolutionizes power quality improvement through its small size, durability and its unmatched efficiency.

3 Dynamic and Real-Time

Traditional methods of measuring and working with electricity rely on averages and are ill-suited for the lightning-fast nature of electricity. These methods often rely on compensating trends using bulky, slow-acting analog capacitors or transformers, which can result in overcompensation or undercompensation. In contrast, SDE measures electricity at nanosecond speeds with exceptional accuracy, allowing it to dynamically and in real-time correct electricity based on the precise requirements of the electrical network. By adapting instantaneously to the actual needs of the system, SDE ensures optimal performance and reliability without the wasteful overcompensation or undercompensation.

OPTIMIZED ELECTRICITY

The digitization and optimization enabled by 3DFS's Software Defined Electricity serves as an indispensable optimization for electrical infrastructure. As we enter an era of increasing climate disruptions and changing energy demands, SDE provides the intelligence and resilience needed for behind the meter assets, in utility grids and microgrids of today and the future.

Already, SDE has proven its ability to smooth integration with existing infrastructure while enhancing efficiency, stability, and analytics. Its unique harmonization of modern analytics and traditional analog systems unlocks game-changing flexibility for utilities, end users and communities seeking to propel their grid capabilities into the 21st century. With SDE at the helm, outdated electricity networks can transform into agile, predictive, and self-healing engines of optimization. By pioneering adaptive power management today, 3DFS is defining the next generation of energy reliability and success.

References & Further Reading:

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<https://standards.ieee.org/ieee/519/10677> IEEE 1889-2018: IEEE Guide for Evaluating and Testing the Electrical Performance of Energy Saving Devices

https://www.researchgate.net/figure/Evolution-of-the-electricity-grid-in-terms-of-past-present-and-future-infrastructure_fig2_323604555

<https://standards.ieee.org/ieee/1889/5667/> IEEE 1547-2018 IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces

<https://sagroups.ieee.org/scc21/standards/1547rev/> IEC 61000-4-30:2015+AMD1:2021 CSV Consolidated version Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques - Power quality measurement methods / <https://webstore.iec.ch/publication/68642>

IEEE 1459-2010 - IEEE Standard Definitions for the Measurement of Electric Power Quantities Under Sinusoidal, Nonsinusoidal, Balanced, or Unbalanced Condition

ENERGY EFFICIENCY & DECARBONIZATION

- Carbon Footprint
- Energy/Utility Savings
- Appliance Efficiency
- Energy Generation Optimization
- Asset Life
- Efficiency ROI

Chapter Two Preview

Electricity underpins nearly all aspects of modern society – from lighting homes to powering industry and enabling communication networks. However, traditional infrastructure wastes massive amounts of energy. The Department of Energy estimates T&D losses alone cost the United States \$25 billion annually as of 2018, and this number has grown. This drives higher bills, but also needless CO₂ emissions from fossil fuels.

Rectifying such losses provides an immense opportunity to simultaneously cut costs, enhance reliability, and reduce environmental impacts without compromising delivery. Just a 5% efficiency gain could save over \$100 billion over the next two decades while avoiding huge carbon emissions. However, manual tuning of aging hardware will hardly make a dent. Instead, responsive detection and correction of waste in real-time is key to unlocking major efficiency gains.

Energy efficiency ranks among the lowest cost and most potent decarbonization tools. Unlocking existing asset potential via SDE both conserves resources and enables smoothing renewable integration without compromise. Every % gain compounds savings and emission cuts year after year while funding further modernization.