Novel Principle of Reactive to True Power Conversion for AI, Data Centers, and BTC Mining

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Abstract— **The exponential rise of AI, data centers, and other non-linear loads is burdening the global electrical grid, requiring the delivery of record levels of electricity. Such power converter-based loads inject harmonics, stray currents, and distorted power across the AC distribution system, resulting in equipment breakdown, expensive downtime, and reduced energy efficiency. Here, details of the novel method to convert reactive power into true power are revealed for the first time, deviating away from the conventional approach to deploy passive-active harmonic filters, by exclusively treating the magnetic circuit without the presence of electrical potential (i.e. passive-parallel). Real world case studies validate the method's ability to improve overall power quality, power utilization efficiency (PUE), and other electrical parameters by double digits.**

Keywords*— *Power quality, Polyphase system, Harmonics, EMI, Ground current loops, Common-mode choke, Magnetism.

I. INTRODUCTION

An aging global electrical infrastructure is undergoing unprecedented transformations, driven by the integration of renewables and non-linear loads [1, 2]. Traditionally, the grid transmitted and distributed electrical power, from centralized power generation to linear loads, for example, incandescent bulbs and induction motors. The polyphase system ensured a stable, unidirectional power flow and high system inertia from large rotating generators, reliably regulating the voltage and frequency [3]. In contrast, today's grid must accommodate multiple decentralized renewable energy sources to cut carbon emissions and meet the exponential electricity demand from the upcoming global industry of digital services [4]. International Energy Agency (IEA) projects data center electricity consumption in the United States to double by 2026, with 300 million MWh consumed in 2022, propelled by the rapid expansion of digital algorithms that require 10 times more electricity. Adopting AI-driven data centers will set record levels of computational power in the U.S., where IEA projects a worst-case scenario 166% load increase from 2023 to 2030 [5]. Despite ongoing investments towards renewables to reduce the deficit, it pales compared to the estimated $2.5 trillion required for modernizing the electrical grid by 2035 [6].

The changing power landscape of increasing non-linear loads (i.e. AI, data centers, etc.) are exacerbating existing power quality issues as various sectors struggle with harmonic power. [7]. Harmonics represent a significant source of electrical distortion, which originates from high-frequency switching of power converters that reduce the efficiency of a power system. The disturbance causes non-sinusoidal voltage and current components to propagate across the distribution system, presenting power losses that deviate from the 60Hz fundamental frequency. It leads to secondary power-related effects on electrical components, potentially causing equipment to overheat, shortening their lifespan, and increasing the facility's energy cost [8]. Data centers have determined such power-related issues to be the cause of critical service disruptions 43% of the time, according to the Uptime Institute, emphasizing the need for developing effective harmonic mitigation solutions [9].

Researchers have explored designing passive harmonic filters, leveraging their cost-effectiveness and simplicity [8,10]. It is paramount that solid-state electronics and switch-mode power supply (SMPS) technology used in servers meets regulatory conducted emissions standards [11]. Authors in [8] demonstrated the effectiveness of applying a series of single-tuned passive filters, creating a low impedance path for a targeted harmonic, to an 11kV distribution feeder based on the work performed in [12]. The MATLAB simulation of connected non-linear loads led to the current harmonic distortion of the electrical network violating the IEEE-519 standards, which the filter attenuated to acceptable levels. However, no other power quality parameters were discussed, unlike [10], where they investigated harmonic phase angles and reactive power of a 20kV distribution similar to the load profile in [8]. The iterative use of genetic algorithms optimized the passive filter at the expense of $13,545.35. Despite its benefits, this type of filter heavily depends on the load's impedance and lacks the feedback mechanism that active filters provide.

Active harmonic filters compensate for the changing impedance of the load by generating a canceling current waveform of equal and opposite polarity to the induced harmonics. Authors in [13] have acknowledged its versatility in improving other relevant electrical parameters, proposing a shunt topology that includes adaptive neural network logic and a DSP controller unit. The designed filter did not allow the THD of the simulated electrical network to exceed 10%, regardless of the frequency and load. The technique has also effectively mitigated common-mode high-frequency noise [14], but it requires complicated control schemes, causes downtime, and is expensive to implement.

Currently, no equivalent filter technology attempts to recycle and convert these acceptable losses, such as harmonic power. Stray Systemes has deployed a CSA-certified and UL-listed novel technology that recovers previously unusable power. The core breakthrough stems from discovering a method to convert reactive into true power, equivalent to changing the foam portion of the beer into liquid. This unprecedented achievement promises to unlock grid-wide premium power conditions, exhibiting and surpassing the performance characteristics of active and passive filters. Hence, this paper will touch upon the non-propriety working principles and acquired real world case studies while keeping sensitive information confidential.

II. Quanitfying The power quality Problem

Poor power quality stems from voltage and current diverging from their AC nominal values, such as frequency or magnitude, causing customer equipment to malfunction [3]. Power quality issues arise from the changing nature of non-linear loads, where the variation in their impedance leads to disproportionality between voltage and current. It distorts the power distribution system, inducing imbalances and reflects odd harmonics back toward the transformer.

A. Voltage and Current Unbalances

A perfectly balanced 3-phase electrical system implies 120-degree phase separation and equal magnitude to reduce losses. The inherent symmetry of a delta-to-wye step-down polyphase system favors equally distributed loads with matching impedance across the three phases. The arrangement will result in positive-sequence voltage and current flowing through each branch, eliminating zero and negative-sequence harmonic components that would add resistance to the natural rotation of the magnetic fields at the fundamental frequency. It would significantly minimize neutral leakage, represented by the summation of the three phases, and maximize power transfer efficiency to the electrical loads. It prevents electronic equipment failures caused by the breakdown and overheating of components. As these ideal conditions are impractical, (1) mathematically represents a more accurate distribution system for distorted voltage and current interchangeably [15].

$$\begin{cases} v_a = |v_a| \angle\, (\theta_{V,a}) \\ v_b = |v_b| \angle\, (\theta_{V,b}) \\ v_c = |v_c| \angle\, (\theta_{V,c}) \end{cases} \quad (1)$$

Where,

$$|v_a| \neq |v_b| \neq |v_c|$$

$$\angle\, (\theta_{V,a}) \neq \angle\, (\theta_{V,b} + 120°) \neq \angle\, (\theta_{V,b} - 120°)$$

B. The Power Factor & Harmonic Relationship

Power factor (PF) is a crucial measure of electrical efficiency in AC systems, expressed by the phase shift between voltage and current [16]. Power factor correction (PFC) techniques, such as converters and LC circuits, are critical and required by utilities for customers to achieve a power factor between 0.9 (lagging) and 0.95 (leading) [15]. In the case of electrifying inductive loads that absorb reactive power, it causes a perfect sinusoidal electrical wave to lag behind the voltage. Adding a capacitive bank to a three-phase distribution system will attenuate the phase shift, operate close to unity, and stabilize the neutral leakage [8]. Achieving a power factor of 1 will translate to obtaining the highest possible efficiency from (2) since the power consumption [kW] of electrical loads will match the apparent power [kVA] supplied by the grid.

$$P.F = \cos(\theta) = \frac{P_o}{VA} \quad (2)$$

However, adding impedance to the load will comprise the initial PFC solution and make the system imbalanced, consuming unnecessary amounts of true power. Power electronic switching devices and non-linear loads will inject current harmonics into the distribution system, making them difficult to model and predict [17]. Harmonics can be even or odd integer multiples of the fundamental component and cause undesirable power losses, reducing power usage efficiency. It introduces distorted reactive power and leads to apparent power possessing a harmonic component. Therefore, the true power factor combines distortion and displacement factors, mathematically expressed in (3) [16, 18].

$$tP.F = k_d \cdot \cos(\theta) \quad (3)$$

The distortion factor is the ratio between the root mean square (RMS) fundamental component and the total current, which includes harmonics in (4) and results in (5) through substitution.

$$k_d = \frac{I_{rms\,(1)}}{I_{rms}} = \frac{1}{\sqrt{1+\left(\frac{THD\ (\%)}{100}\right)^2}} \quad (4)$$

$$tP.F. = \frac{1}{\sqrt{1+\left(\frac{THD\ (\%)}{100}\right)^2}} \cdot \cos(\theta) \quad (5)$$

Therefore, mitigating input current distortions formulated in (6) prevents high-frequency currents from traveling down to low impedance paths, which leads to secondary power-related issues.

$$I_{(THD)} = \frac{\sqrt{\sum_{h=2}^{\infty} I_h^2}}{I_1} \quad (6)$$

C. Circulating Leakage Phenemona.

Electronic equipment is 10 to 100 times more sensitive to common-mode noise, fundamentally different from differential-mode noise [19]. The high-frequency switching of semiconductors generates sharp changes in voltage, subjecting the fundamental component to distortions. It is a significant source of differential-mode noise, which flows between a conductive phase and neutral. Deploying a harmonic filter attenuates the undesirable frequencies, but there will also be common-mode noise due to unaccounted parasitic capacitance [20]. These circulating currents, flowing through the neutral and phase conductors, utilize the ground as the return path. Therefore, the term common mode stems from electrical currents having the same magnitude and direction shown in Figure 3. Improper ground treatment, neutral wire faults, and parallel cables acting like antennas induce additional stray currents to manifest through circulating ground loops [21].

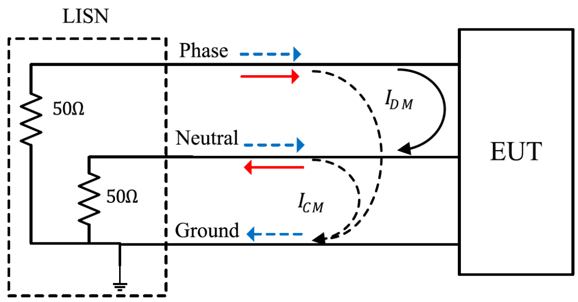

Fig. 1. Circulating stray currents

They directly correlate to the load reactive operation, mathematically represented as losses in (7-10) for single-phase [20].

$$I_p = I_{dm} + I_{cm} \tag{9}$$

$$I_N = I_{dm} - I_{cm} \tag{10}$$

$$I_{dm} = \frac{1}{2}(I_p + I_N) \tag{11}$$

$$I_{cm} = \frac{1}{2}(I_p - I_N) \tag{12}$$

The derivations show that neutral current leakage combines unwanted differential and common-mode currents, which reveals an inverse relationship regarding the phase. The concept extends to the electrical sub-panel level in (13) and (14).

$$\begin{cases} I_A = I_{dm}^A + I_{cm}^A \\ I_B = I_{dm}^B + I_{cm}^B \\ I_C = I_{dm}^C + I_{cm}^C \end{cases} \tag{13}$$

$$I_N = \sum_{n=1}^{3} I_{dm}^n - \sum_{n=1}^{3} I_{cm}^n \tag{14}$$

The inverse correlation articulates that the stray currents, contributing to distorted power and poor power factor, will converge on the phases and diverge from the neutral. Therefore, the increase in combined electrical noise will result in a higher phase current and a lower neutral current downstream, which is reinforced in (9-10) for single-phase. It conforms to the inherent nature of a polyphase system that desires to be perfectly balanced and undisturbed. Electrical engineers have deployed filters to suppress rising levels of electromagnetic interference (EMI), but the method to continuously convert these electrical losses, specifically harmonics, into a renewable, carbon-free power source was out of reach until now.

III. The Reactive To True Power Recovery Revelation

A. Common-mode Chock

A standard common-mode choke is an electrical passive component that attenuates common-mode currents and lets the desired differential mode current pass through at 60 Hz [22]. It is an equivalent transformer with an equal number of primary and secondary turns wound on a ferrite core that connects to phase and neutral, which are the hot lines. The common-mode current that flows in both inductors will have a compounded magnetic field, as shown in Figure 2 [23].

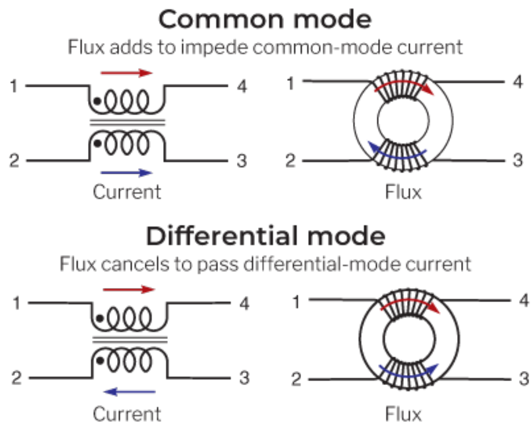

Fig. 2. Common and differential mode chock

The common-mode flux will establish a net clockwise rotating magnetic field on the core, and the noise will see a large inductance. The large impedance will block common-mode current and let differential-mode (normal-mode) current propagate due to the canceling effect of counter-rotating magnetism. Within specific configurations these field dynamics, achieved through manipulating the magnetic flux lines, modulate distinct electrical parameters of the connected circuit, such as inductance and impedance. Therefore, it can be considered a Field Effect Conversion (FEC), and a proprietary application of this process enabled Stray Systemes to achieve the novelty.

B. Unvealing The Breakthrough

The groundbreaking discovery converts reactive and distorted components of apparent power into true power. The scientific accompaniment resembles the invention of the operational amplifier, where a specific arrangement of FETs dictates its electrical characteristics and performance. The building block of the FEC innovation in part leverages nano crystalline doped amorphous CM chokes, shown in Figure 3.

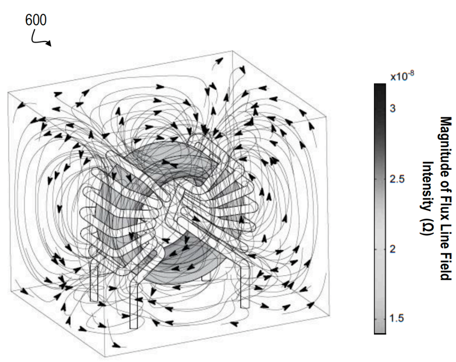

Fig. 3. CM chock magnetic flux analysis

Figure 6 illustrates the general principle behind the method of mutual induction to separate and rectify the distorted current component, with the direction of noise represented in blue through time, along with dedicated wye-side neutral and ground busbars.

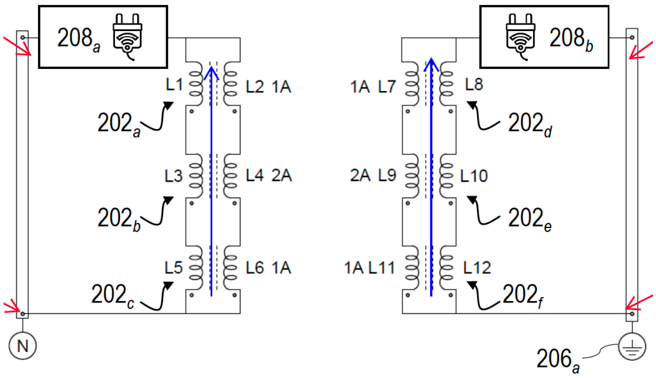

Fig. 4. Basic FEC circuit configuration

Functioning like a magnetic buffer that intercepts and converts noise to the fundamental frequency at 60 HZ (US) through a series of selective attenuations. Notably, the game-changing mechanism operates on the "cold side" of the electrical distribution subpanel, only requiring neutral and ground. It is a paradigm shift in the mainstream approach to mitigating Electromagnetic Interference (EMI) and harmonic power losses by exclusively treating the magnetic aspect of electricity. The following text, extracted from the patent, provides additional insight into the conversion method.

The quasi-CM array passively engages odd harmonic field activity at the return-path.

↓

Captured odd harmonics are routed into a custom-engineered waveguide where they undergo cancellation and reshaping.

↓

Distorted magnetic field is then reshaped into a phase-corrected fundamental waveform.

↓

The localized harmonic-to-fundamental conversion facilitates real-time magnetic field redistribution and phase rotation corrections across the upstream Wye-side transformer supply, while actively improving every known parameter of power quality downstream,

The perfected FEC technology is a novel passive-parallel equivalent filter that contemplates reactive operation of the load. What was once unusable power, driven by the non-sinusoidal characteristics of the non-linear loads, has been converted into fundamental at 60Hz (US). It provides a recovered magnetic flux downstream and subsequently optimizes the upstream wye-side power consumption based on Faraday's laws of induction. Bringing true and apparent power closer together will improve the power factor while reducing distorted power. Therefore, sectors with applications that utilize dense computational loads that exhibit high consumption and generate odd harmonics will reap the benefits of adopting such capability, alongside experiencing the secondary effect of balancing the three phases, with nominal current and voltage achieving greater operational efficiency.

IV. Case Studys

A. Data Centers

A power quality study was performed at MULTACOM, a 0.5MW downtown Los Angeles content delivery network (CDN) data center. A delta/wye step-down transformer delivered electric power to 15 identical electrical distribution subpanels rated at 400A. The invention was connected to one (1) such subpanel through standard mounting screw termination and required zero deployment downtime for the 31kW(s) of operating blade servers. This single subpanel represented 6.6% of the total load hosting fifty (50) blade servers. The Fluke Power Quality Analyzer 1777 Class A instrument measured key power quality parameters at the "edge of the network."

The primary loads of all such data centers are converters and fast processing units, which result in electrical noise, that unmanaged can have a negative impact on electrical operations. Power usage effectiveness (PUE) determines the data center's energy efficiency and indicates the power consumption of the IT equipment concerning energy usage. The electronic hardware represents the highest consumption load within such a facility, along with cooling systems that regulate the server's temperature [24]. This case study measured substantial leakages of 37.4A and 0.217V, with a harmonic contribution of 31.1A, which the technology significantly improved from Table 2.

Table 1: Improved Electrical Parameters

Parameters	**Power Quality Metrics**		
	No FEC Filter	***FEC Filter***	***Improvement***
Power Factor	0.954	0.966	1.26%
True Power [kWh]	3.113	3.110	Stabilized
Apparent Power [kVA]	7.699	5.725	25.64%
Neutral Voltage Leakage [V]	0.217	0.112	48.39%
Neutral Currnet Leakage [A]	37.4	27.3	27.01%
Neutral (THC) [A]	31.3	18.3	41.53%

Lowering the overall reactance and impedance led to upstream ~19.1% kWh consumption reduction at the transformer. It yields secondary computational benefits quantified in Table 2 for the connected hardware.

Table 2: Improved Computing Parameters

Variables	**Improvement Range**
CPU Speed [Hz] and Stability	1.5% - 3.5 %
Instruction throughout (IPS)	0.5% - 1.5%
Memory Bandwidth [Gb/s]	2% - 5%
DRAM read/latency [ns]	1 - 3
Latency jitter [μs]	3 - 10
Network throughput	1.5% - 4%

The dual benefits mark a shift in power management strategy by amplifying the product's computational output. A sustained +1.5% to +3.5% increase in frequency and up to +1.5% improvement in instruction throughput (IPS) directly enhance execution speed and reduce stall events. The enhancements are critical in multi-core AI inferencing or high-frequency trading workloads. Memory subsystems benefit from 1–3 ns reductions in DRAM latency and +2% to +5% gains in bandwidth, improving paging, cache coherence, and error correction overhead in large-scale datasets. At the network layer, cleaner power translates into +1.5% to +4% improved throughput and 3–10 µs reduction in jitter, giving a crucial advantage in distributed AI training or CDN edge delivery, where packet timing impacts determinism. The effects compound into a +6% improvement in FLOPs-per-watt, allowing the system to power more servers.

B. Bitcoin Mining

The business strives for faster computing and machines that operate within their nominal values. The purpose of the miners is to solve complex cryptographic puzzles, requiring extensive processing that equates to hash rate. Two additional studies were conducted in Bitcoin mining facilities in Texas, obtaining consistent power quality improvements. It effectively reduced the harmful byproducts of the load's noisy operation, generating substantial leakage, ground current loops, and transient spikes. The first study involved four operating Whatsminer M60S miners connected to a BixBit PDU, with the optimized electrical parameters summarised in Table 3.

Table 3: Improved Electrical Parameters

Parameters	Power Quality Metrics		
	No FEC Filter	***FEC Filter***	***Improvement***
Power Factor	0.666	0.731	9.76%
True Power [Wh]	215.1	215.8	Stabilized
Apparent Power [kVA]	19.38	17.69	8.72%
Neutral Voltage Leakage [V]	0.233	0.138	40.77%
Neutral Currnet Leakage [A]	26.23	18.34	30.08%
Neutral (THC) [A]	1.42	1.02	28.17%

Operational energy efficiency increases by approximately 11%, energizing 1 of every 9 connected M60S miners at no additional upstream transformer cost, with the recovered true power.

Software settings limit the power intake for this class of machines, enabling stabilized computing in the presence of optimized overlocking overclocking settings alongside the FEC will further improve the energy cost of computational work. Power quality improvements in a 700MW Bitcoin mining data center enabled an isolated miner pool of 484 miners to improve the hash rate from the baseline of 89.47 PH/s to 92.257 PH/s. It reduced the energy exerted to solve mathematical computations by a 7.28% improvement in (J/TH), driven by increasing current availability at the subpanel by 4.85% and reducing upstream kWh consumption at the transformer by 2.43%.

The passive-parallel device possesses a fine-tuning intrinsic active mechanism that brings the electrical power closer to the nominal rating of the load in Table 4, for example, voltage unbalances [25].

Table 4: Improved Electrical Stability

Parameters	Subpanel Voltage and Current		
	No FEC Filter	***FEC Filter***	***Improvement***
L1	238.4V	238.9V	2.09%
	201.6A	201.7A	0.49%
L2	238.1V	238.3V	0.83%
	189.1A	204.8A	8.30%
L3	237.9V	238.7V	3.36%
	190.6A	192.9A	1.20%

Therefore, extending computational capabilities will lower operational costs by decreasing the likelihood of lockups. Daily BTC production probability will increase by >1.5% by powering additional miners utilizing the recovered power from the connected loads at no additional upstream cost.

V. Conclusion

This paper presents a breakthrough passive-parallel method for converting the reactive components of apparent power into true power. This highly scalable engineered solution is poised to redefine the future of energy efficiency, particularly in high-speed trading, high-performance computing (HPC), and AI-enhanced data centers, by delivering improved power quality that reduces performance limitations and enhances operational resilience. Traditionally, operators on the supply and demand side have implemented active or passive harmonic filters to attenuate harmonics without considering their potential to convert electrical losses into gains as carbon-free, recoverable assets. This grid-enhancing technology (GET) innovation contributes an immediate 20 GW of increased capacity in three-phase power for US commercial and industrial activity, equating to approximately 70 million mt. of CO_2 avoidance annually [26, 27]. At a fraction of the cost, it supports the energy transition alongside the trillion-dollar grid upgrade projects currently under consideration [28].

With over 15 real-world case studies acquired across diverse load profiles, including data centers, high-precision manufacturing facilities, skyscrapers, and distribution warehouses, this novel technology consistently delivers premium power quality. It reduces mounting pressure on global grid operators to rapidly increase energy capacity in response to rising demand from globally competitive, investment-driven markets while establishing a new benchmark for modern, high-performance electrical infrastructure.

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