الهيئة السعودية للمياه
Saudi Water Authority

The role of automatic power factor toward enhancing reliability of desalination and pumping system

BY

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Desalination in Saudi Arabia : Why Energy matter

2 - 3 Kwh/m^3

- RO Energy consumption.

16.5 Mm^3/day

- Daily water production.

50 MT/year

- Annual co2 emissions Around.

Saudi vision aliment :

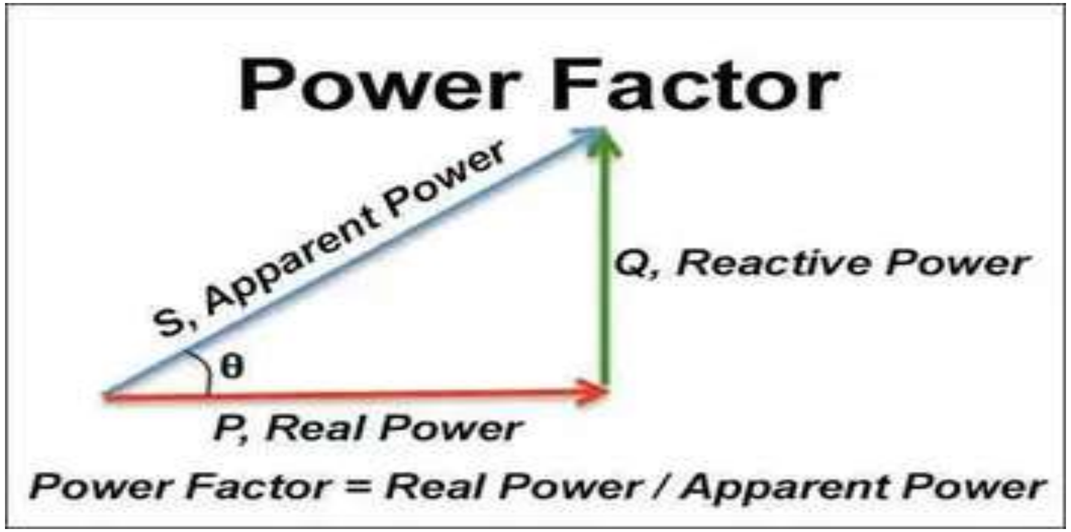
VISION رؤية 2030
المملكة العربية السعودية
KINGDOM OF SAUDI ARABIA

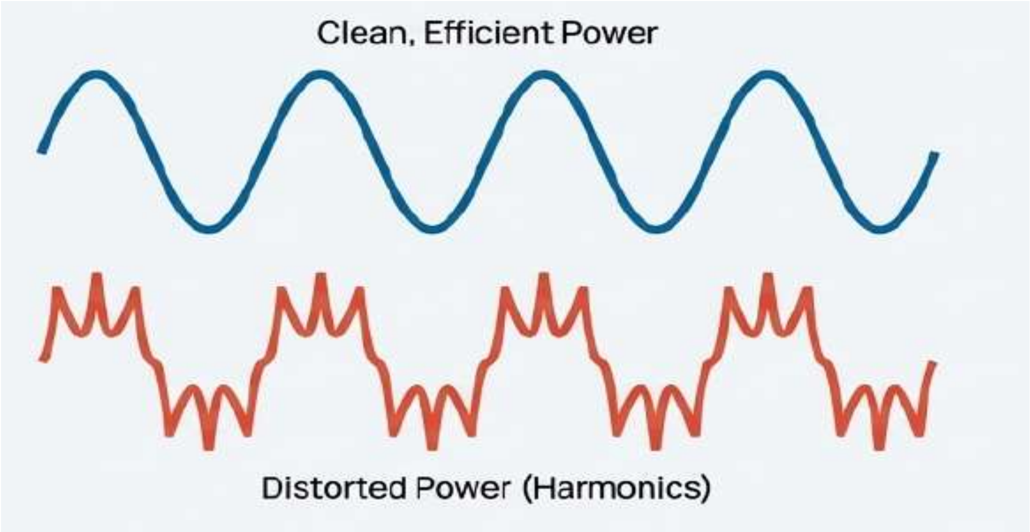
- ✓ Energy Efficiency & Waste Reduction
- ✓ Optimized Use of Existing Infrastructure
- ✓ Operational Cost Reduction
- ✓ Innovation & Local Technology Development
- ✓ Modern & Smart Energy Networks
- ✓ Net-Zero Emissions by 2060.

Invisible Enemies costing money

Poor Power Factor (Reactive Power)
system draws more power (Apparent Power) than it actually uses to do work (Real Power). The difference is "Reactive Power" – energy that sloshes back and forth, doing no work but straining your infrastructure.

Harmonic Distortion
VFDs and other modern electronics chop up smooth electrical waves, creating "noise" or pollution on your network. This "noise" is wasted energy that heats up equipment and causes malfunctions.





Introduction

The Drive for Efficiency Relies on Modern Technology

The water sector's pursuit of operational efficiency and system reliability is paramount. Variable Frequency Drives (VFDs) are a cornerstone of this strategy, optimising pump performance and energy consumption across the network.

VFDs are essential, but they introduce a complex and often overlooked challenge to the electrical system.

The Vicious Cycle of Inefficiency in Water Operations

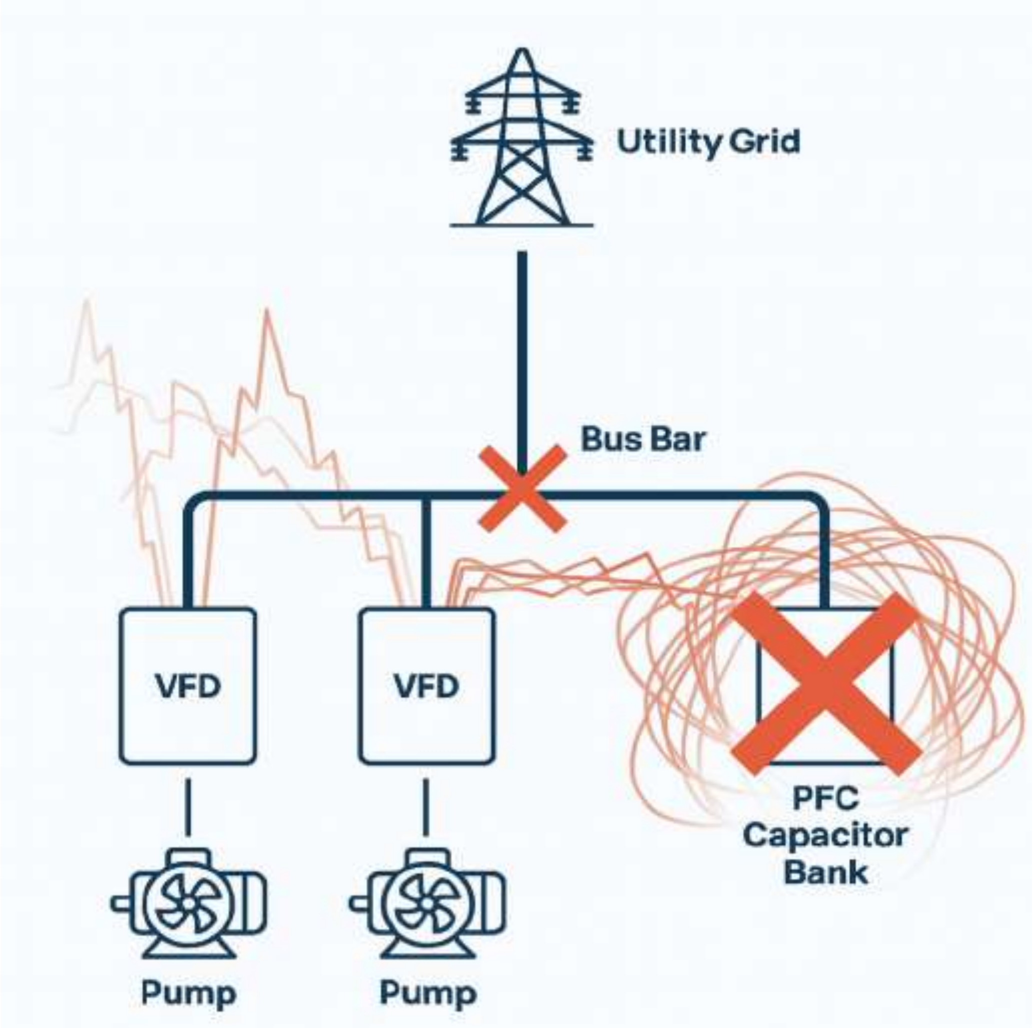
Modern Variable Frequency Drives (VFDs) are essential for controlling pumps, but they create two major types of electrical waste: poor power factor and harmonic distortion. When these nonlinear loads operate alongside traditional Power Factor Correction (PFC) capacitor banks, the system enters a cycle of instability and failures

⚠️ **Harmonic Resonance:** A dangerous interaction between VFDs and capacitor banks that destabilizes the electrical network and amplifies harmful harmonics

⚡ **Unexpected Equipment :** Failure Catastrophic damage to critical components such as capacitors, VFD drives, and pumping motors due to electrical stress created by distorted waveforms.

💸 **Poor Power:** Quality Leads to utility penalties, overheating of cables and transformers, and increased operational energy ⏱️ osses

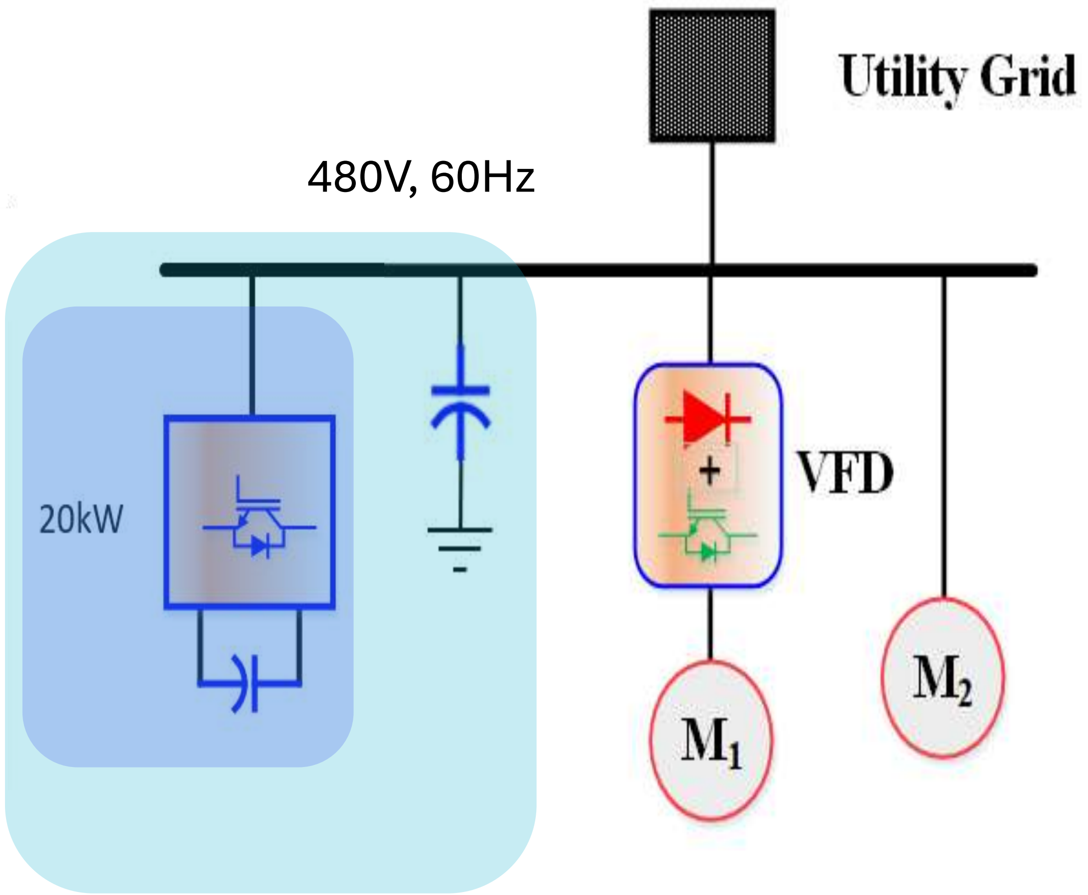
System Downtime : Unplanned outages that directly disrupt pumping operations and affect water distribution reliability.



The Proposed Solution: The Intelligent APFC Controller

We have designed and built a special control device that:

1. **Intelligently manages power factor** to achieve optimal efficiency (PF≈1).
2. **Actively monitors system harmonics** created by VFDs.
3. **Prevents harmonic resonance** by adapting its operation, protecting both the capacitors and the VFDs.
4. **Harvests Waste Energy,** Instead of just cancelling harmonics (which wastes them as heat), our system captures and converts the harmonic energy, reinjecting it as useful power at the fundamental frequency (60 Hz) back into the switchgear.

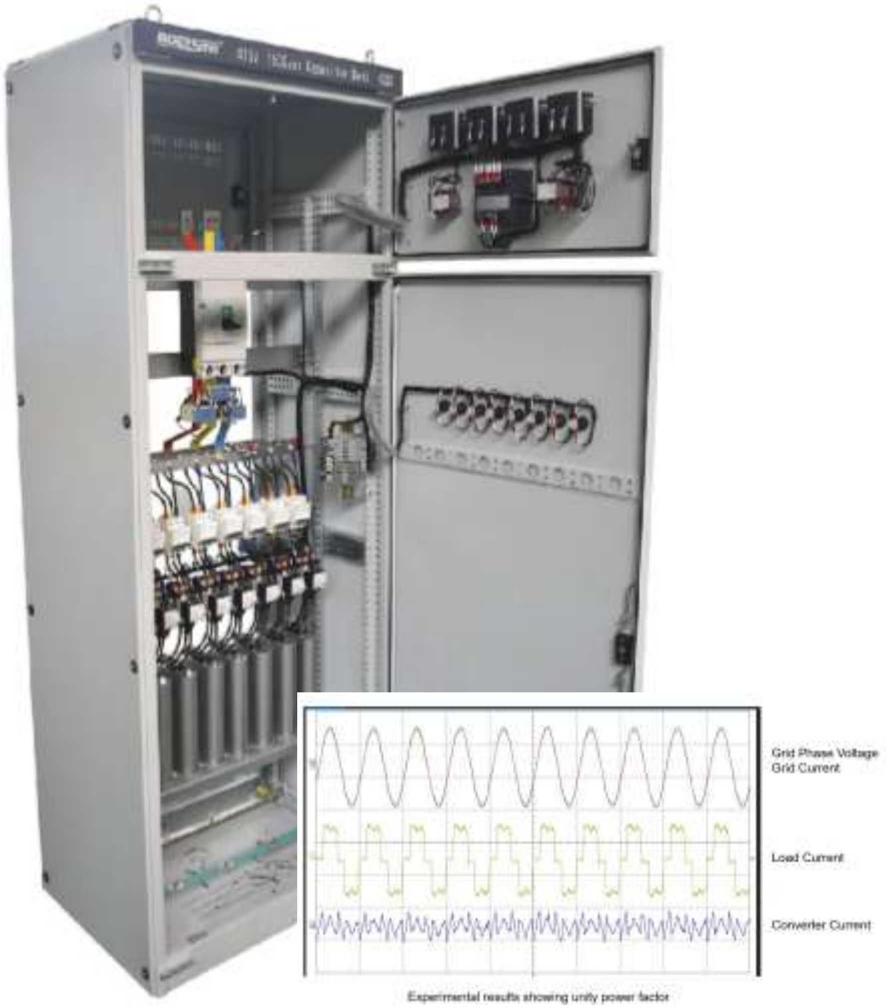


Project status : prototype validation

The prototype has been successfully built and will be tested in our pilot plant shortly.

Expected Key Achievements:

- Demonstrated stable operation under real-world load conditions.
- Successfully mitigated harmonic risks while correcting power factor.
- The control logic will be validated to be ready for upscaling.
- A **Patent** filed in the USPTO and SAIP

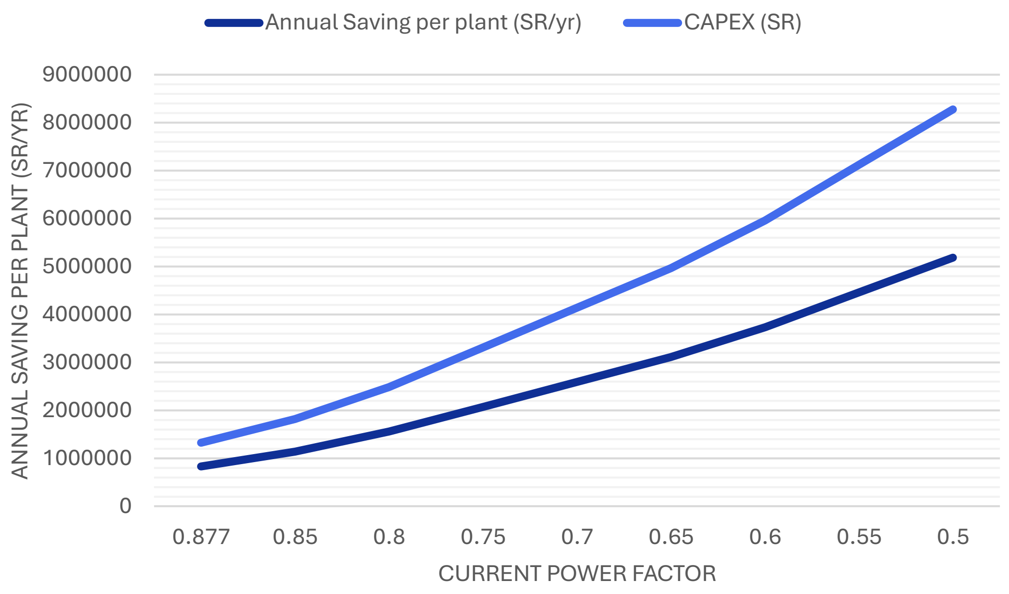


Experimental results showing unity power factor

A Sector-Wide Opportunity: Value & Benefits

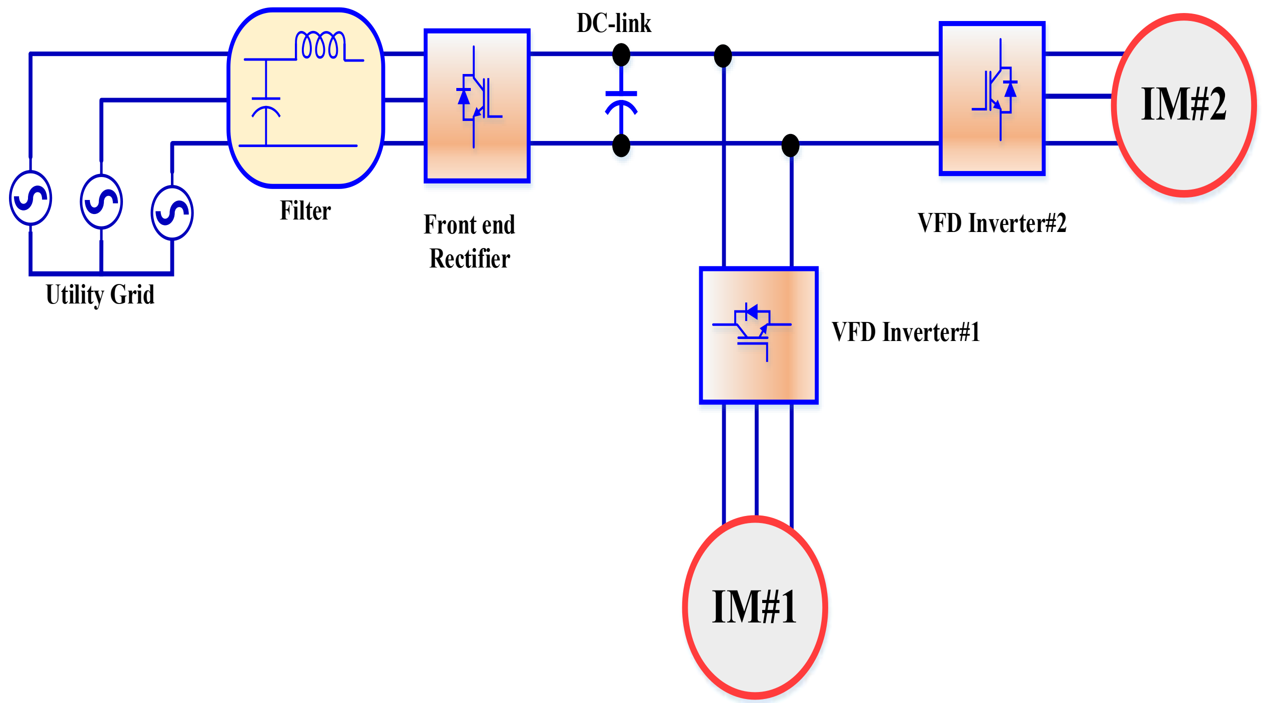
This technology offers significant, measurable advantages:

- **Enhanced Reliability:** Prevents critical equipment failure and unplanned downtime.
- **Dual Energy Savings:**
  1. **Reduces Costs** by eliminating power factor penalties.
  2. **Recycles Energy** by converting "wasted" harmonic distortion back into usable power.
- **Extended Equipment Lifespan:** Protects pumps, VFDs, and capacitors from harmonic distortion.
- **Increased System Capacity:** Frees up transformer and cable capacity currently wasted.



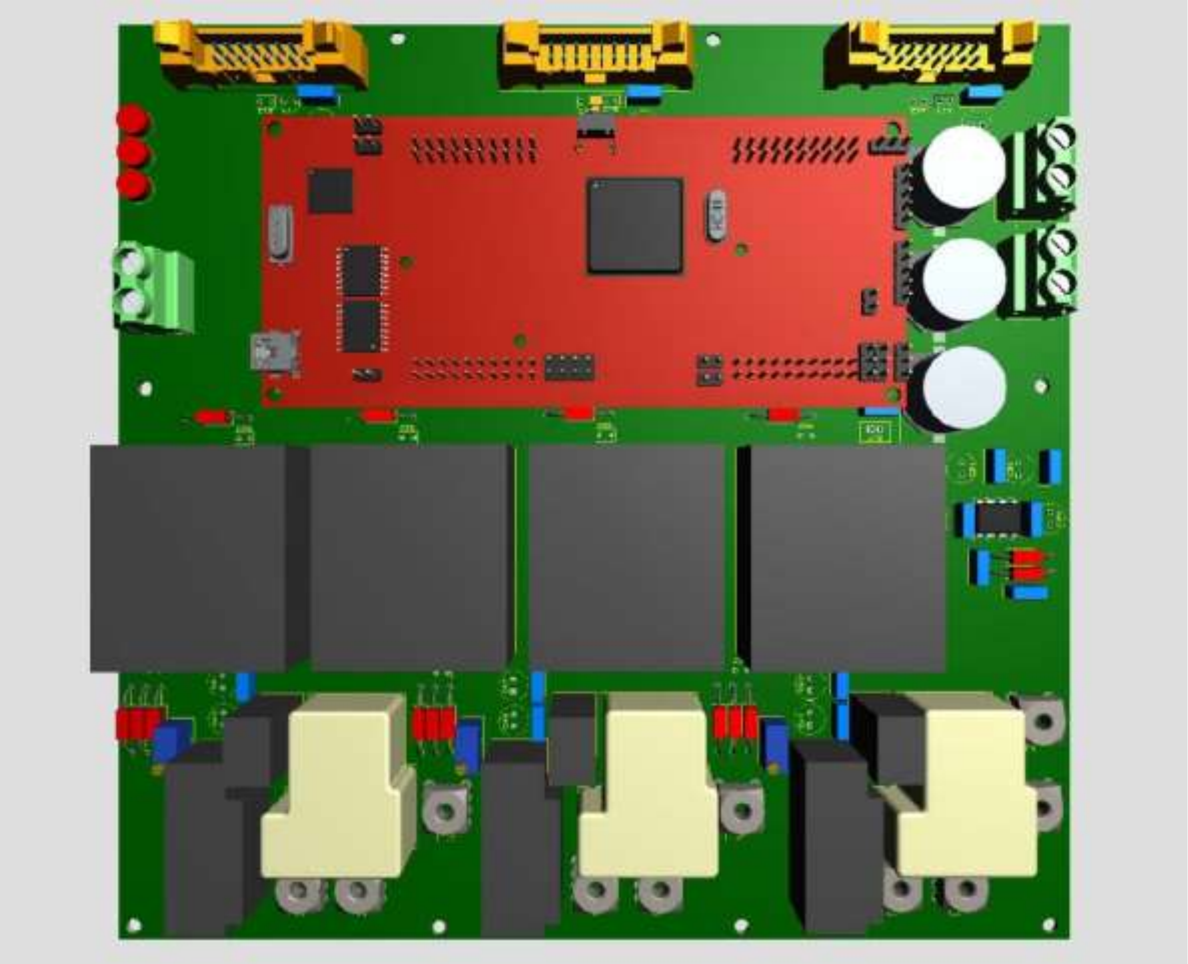
- Assumed 25 pumps in the plant
- The cost is 5 Halas/kVar below 0.95 pf

Proposed System



- Independent control for both motors
- No use of Capacitors for PFC
- Type of Front-end Rectifier and inverter
- Inverter and Rectifier Control
- Optimal sizing of converters

The innovation part in the system



- This innovation features a smart vibration dampener integrated within the electrical circuit, strategically positioned between the pumps and the regulators. The device continuously monitors vibrations across the system through real-time sensing technology and generates counter-vibrations to neutralize unwanted oscillations. This ensures a stable and consistent power flow, minimizes harmonic interference, and safeguards sensitive electrical components from damage or premature wear.
- We have submitted a patent application for this circuit design, marking a significant step toward advancing vibration control technology in electrical systems.

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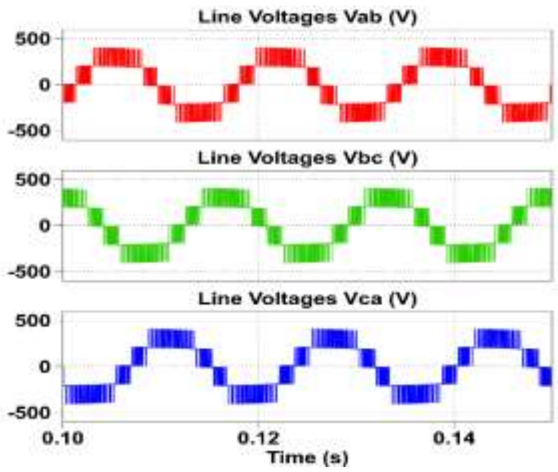
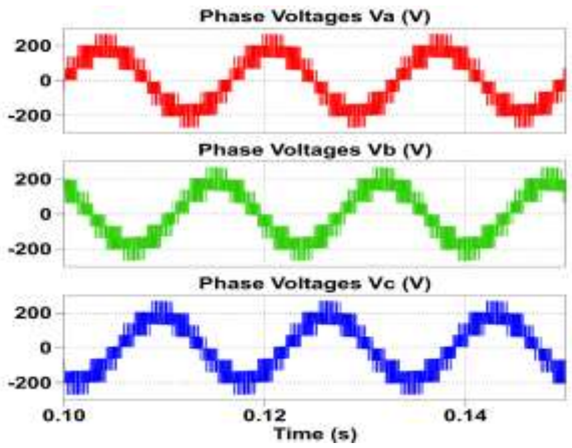
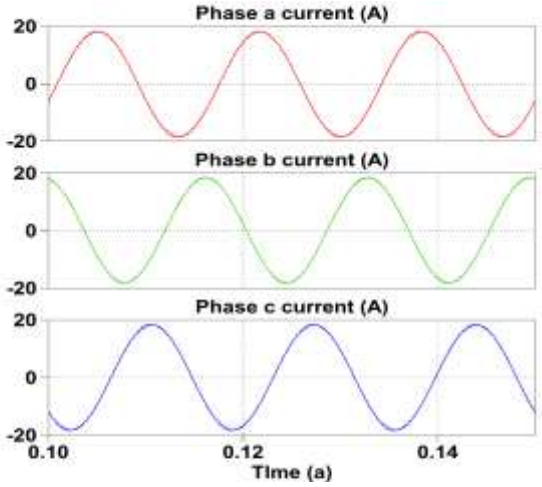
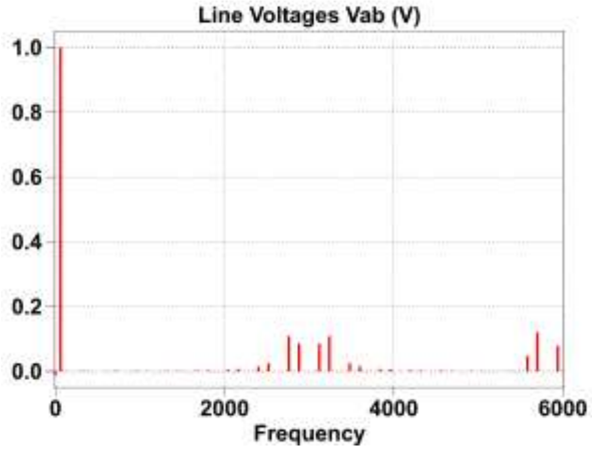
Achievements

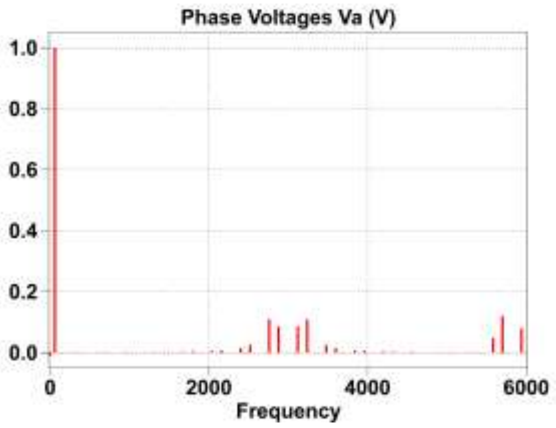
Simulation Results with Vdc = 200V, fo = 60Hz, fcr = 3kHz

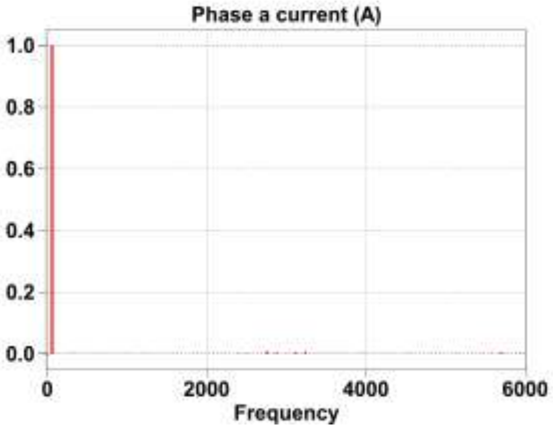












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