

WHITE PAPER

Advanced Harmonic Mitigation

MPTS versus Passive and Active Filters

1. Executive Summary

This paper evaluates the harmonic mitigation performance of the impedance matching technology (MPTS) against conventional passive and active harmonic filters. Harmonic distortion is a growing concern in modern electrical systems, primarily due to nonlinear loads such as VFDs, LED lighting, UPS systems, inverters, electronics, and computing equipment. While traditional filters reduce distortion by targeting specific frequencies or load segments, MPTS offers a holistic, intelligent solution that dynamically suppresses harmonics in real time while simultaneously optimizing voltage, power factor, and load balance. The analysis concludes MPTS delivers superior adaptability, broader harmonic coverage, and a significantly lower total cost of ownership.

2. Introduction

Harmonics are distortions in electrical waveforms caused by nonlinear loads that draw current in abrupt pulses rather than smooth sine waves. The distortions reduce system efficiency, increase heat losses, interfere with sensitive electronics, and trigger penalties and equipment failures. Effective harmonic mitigation is essential for maintaining power quality, reliability, and energy efficiency.

This paper compares three technologies:

- MPTS: An innovative, solid-state platform with real-time harmonic suppression.
- Passive Filters: Tuned L-C networks block or absorb specific harmonic frequencies.
- Active Harmonic Filters: Power electronics-based systems inject inverse harmonics to cancel distortion.

3. Overview of Harmonic Mitigation Technologies

3.1 Maximum Power Transfer Solution (MPTS)

MPTS is a power management control system that offers dynamic harmonic mitigation using high-frequency switching and control logic. It continuously samples current and voltage waveforms, detects harmonic content, and injects counteracting signals to flatten waveform distortions. MPTS covers many harmonic orders (3rd to 55th+) and compensates in real time without needing external filter banks or bypass circuits. It also provides voltage stabilization, power factor correction, and load balancing in a single integrated platform.

3.2 Passive Harmonic Filters (PHFs)

Passive filters are inductors, capacitors, and resistors tuned to absorb specific harmonic frequencies—typically the 5th, 7th, or 11th. They are cost-effective and straightforward, but only effective for

predictable, steady-state harmonic content. Their performance drops sharply in dynamic environments or if the load harmonic profile shifts.

3.3 Active Harmonic Filters (AHFs)

AHFs are intelligent electronic devices that measure harmonic content and inject corrective waveforms in real time. They are highly effective across multiple harmonic orders and can adapt to changing load conditions. However, they are expensive, complex, and typically dedicated to specific load segments, limiting their scalability and integration.

4. Feature-by-Feature Comparison: Harmonic Mitigation

Feature	MPTS	Passive Harmonic Filters	Active Harmonic Filters
Harmonic Orders Mitigated	3rd to 50th+ (adaptive)	Fixed (e.g., 5th, 7th)	Wide spectrum (3rd to 50th)
Response Time	Real-time correction	Static (no active correction)	Real-time correction
Load Adaptability	Fully dynamic, high	None	High
System-Level Coverage	Facility-wide (main/sub)	Load-segment only	Usually load-segment only
Integration with PFC/Volt	Yes –fully integrated	No	Sometimes available
Maintenance Requirement	Zero (Passive solid-state)	Moderate	High (power electronics)
Heat Generation	Minimal	Moderate	High
Space Required	Compact	Large passive L-C units	Moderate
Cost (TCO)	Low lifecycle cost	Low upfront, high hidden	High upfront/maintenance

5. Use Case Scenarios

Case 1: Data Center with Sensitive Electronics

A Tier III data center with dozens of UPS systems experienced waveform distortion, causing frequent alarms. Passive filters were ineffective due to variable harmonic content. Post MPTS installed, THD dropped from 13% to <4%, power quality indices stabilized.

Case 2: Industrial Plant with VFDs and Induction Furnaces

Heavy harmonic pollution from VFDs and furnaces led to transformer overheating and motor failures. Active filters were installed on key panels, but only mitigated partial distortion. MPTS provided system-wide mitigation, balancing harmonic content, and eliminating interference across the plant.

Case 3: Commercial Building with LED Lighting

The facility's lighting upgrades increased 3rd and 9th harmonics, reducing power factor and increasing kVA demand. Passive filters caused resonance under light load conditions. MPTS mitigated all odd harmonics without resonance or instability while correcting power factor and stabilizing voltage.

6. Performance Evaluation

THD Reduction: MPTS reduced Total Harmonic Distortion (THD) from 10–14% to <4% in real-time operation. Active filters achieved similar results, while passive filters reduced specific harmonic peaks but had minimal impact on overall THD under variable loads.

Stability & Scalability: MPTS showed high stability under fluctuating load conditions and could be deployed centrally to manage multiple downstream loads, unlike AHFs, which required individual load placement.

System Efficiency: MPTS reduced apparent power demand, transformer heating, and unnecessary reactive power flows. The absence of moving parts contributed to lower cooling requirements and operating noise.

7. Benefits of MPTS Over Traditional Filters

- **Unified Solution:** Harmonic mitigation, power factor correction, voltage balancing, and surge suppression.
- **Intelligent Adaptation:** Real-time learning of load behavior and waveform distortion.
- **Resonance-Free:** MPTS does not create resonance issues with existing inductive or capacitive components.
- **Facility-Wide Impact:** Mitigates harmonics system-wide rather than at individual nodes.
- **Longer Lifecycle:** Solid-state design reduces wear-and-tear, extending service life with zero maintenance.

8. Considerations and Limitations

- **Initial Investment:** MPTS costs more than passive filters, but avoids the need for separate systems and reduces long-term O&M.
- **Complex Load Profiles:** Highly chaotic systems may require additional transient suppression.
- **Installation Planning:** Optimal results depend on placement at key distribution nodes or main switchboards.

9. Conclusion

MPTS is a next-generation platform for harmonic mitigation that combines real-time waveform correction, voltage control, and reactive power management in one intelligent system. Compared to traditional passive and active filters, MPTS offers superior flexibility, zero maintenance, and broader protection against harmonic distortion. For facilities aiming to protect sensitive equipment, reduce penalties, and enhance energy efficiency, MPTS represents a strategic investment.

10. Appendices

Glossary

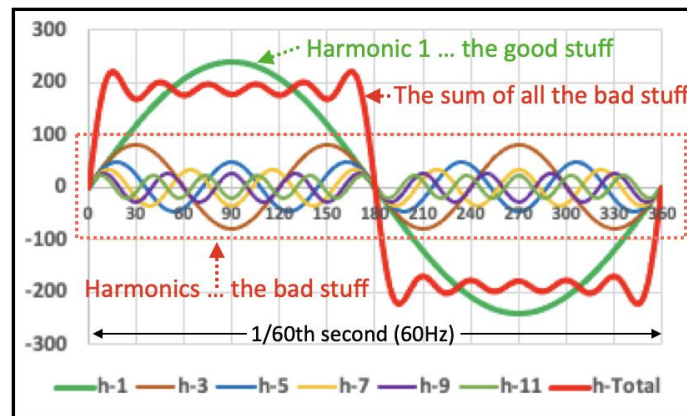
- THD (Total Harmonic Distortion): A measure of waveform distortion.
- VFD (Variable Frequency Drive): A nonlinear load that introduces harmonics.
- Resonance: Harmonic interaction that amplifies voltage/current distortions.
- Passive Filter: An LC circuit designed to block specific harmonics.
- Active Filter: Inverter-based system injecting counter-harmonics.

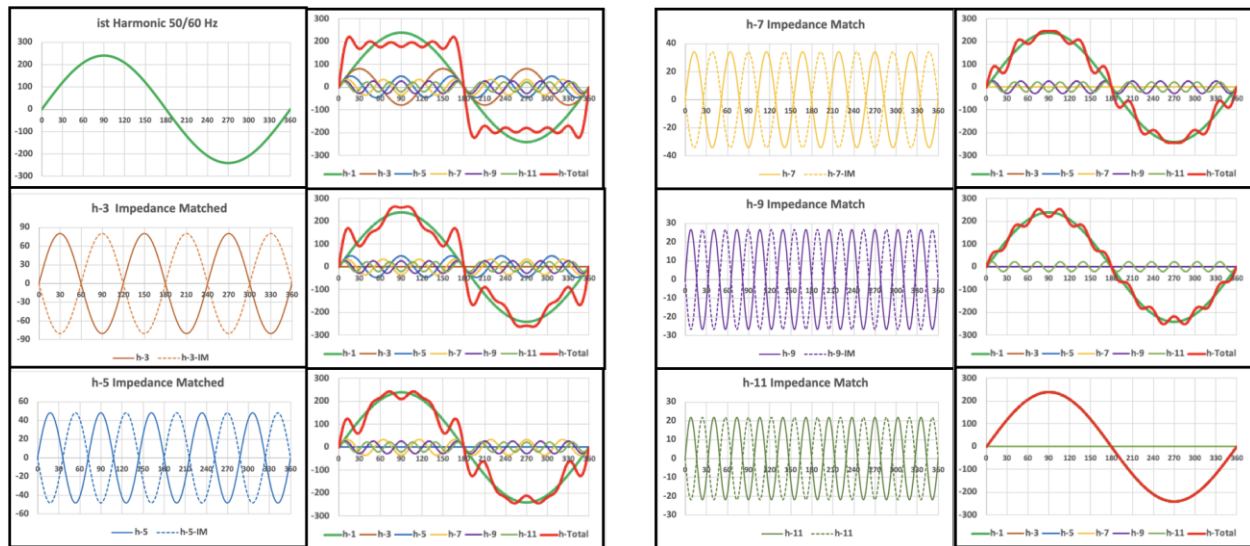
Harmonic Performance Snapshot

Time	Load Type	THD (pre-MPTS)	THD (post-MPTS)	Passive Filter THD	AHF THD
9:00 AM	VFD Cluster	13.2%	3.8%	9.1%	4.1%
12:00 PM	LED System	10.6%	3.2%	7.5%	3.9%
4:00 AM	Mixed Load	11.9%	3.6%	8.2%	4.2%

11. References

- IEEE 519-2022 – Recommended Practices for Harmonic Control
- IEC 61000-4-7 – General Guide on Harmonic Measurement
- MPTS Performance Data Sheets
- Manufacturer Case Studies and Independent Field Measurements
- Power Quality Magazine – Harmonic Filtering Trends (2023)





MPTS Impedance Matching Harmonics

- Each 360-phase degree graph = 1/50 or 1/60 of a second (50Hz/60Hz)
- Sampling and matching occur 20,000/second = $5\mu\text{s}$ = 5 microseconds
- The dotted line impedance matches the opposite solid line harmonic
- The sum of all the harmonic levels 1 - 3 - 5 - 7 - 9 - 11 THD angles = 0°