NEW LEAF TOOLS LLC

# SHE Designer

## Beyond Harmonic Elimination — Inverter Waveform Intelligence

The world's only deterministic SHE solver that exploits every degree of freedom to optimize the physical properties that determine inverter performance, efficiency, and reliability.

| 8 ms | 100% | 10+ DOF | 5 |
|---|---|---|---|
| N=17 Solve Time | Certification Rate | Extra Degrees of Freedom | Optimization Objectives |

## THE CORE INSIGHT

Why finding every solution changes everything

Selective Harmonic Elimination is widely understood as a constraint satisfaction problem: find switching angles that force specific harmonics to zero. The industry treats it as a search for *one* solution. SHE Designer treats it as something fundamentally different — a **complete enumeration of the entire solution space.**

When you target 6 harmonics using N=17 switching angles, you are using 6 of your 17 degrees of freedom to satisfy the elimination constraints. **The remaining 10 degrees of freedom are unconstrained.** Every solution in the space satisfies IEEE 519. But those solutions differ dramatically in torque ripple, DC bus stress, motor current quality, and iron losses. Standard solvers find one and stop. Our proprietary methodology finds them all — then lets you choose which physical property to optimize.

**Extra Degrees of Freedom Enable Multi-Objective Optimization**


Every solution in the pool eliminates the same targeted harmonics at mathematical zero. IEEE 519 compliance is guaranteed for all of them. What differs is everything else that determines how your inverter actually behaves in the field.

## FIVE OPTIMIZATION OBJECTIVES

Same harmonic elimination — radically different physical performance

**THD**
**Mathematical Best**
Lowest total harmonic distortion. Foundation for IEEE 519 compliance.

**WTHD**
**Motor Current Quality**
Inductive-load weighted distortion. True motor current predictor.

**Torque**
**Shaft Ripple Minimum**
Reduces mechanical vibration and acoustic noise in drives.

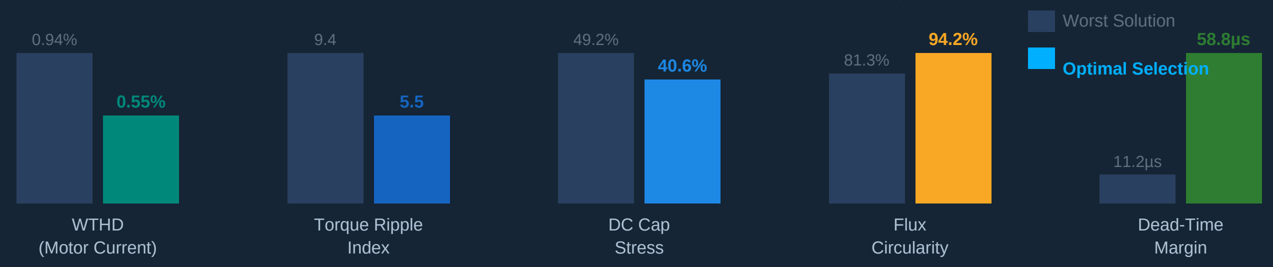
**DC Cap**
**Capacitor Lifetime**
Minimizes RMS ripple current. Smaller caps, lower temperature.

**Flux**
**Iron Loss / Grid-Forming**
ABB MP³C principle. Circular flux = lower iron losses, less EMI.

Each objective selects the solution with the best score for that physical property from the complete certified pool. The selection runs at solve time and updates live when you change objectives — no re-solving required.

**Same IEEE 519 Compliance — Different Physical Performance**

All solutions eliminate the same 6 harmonics. Choosing the right one changes everything.



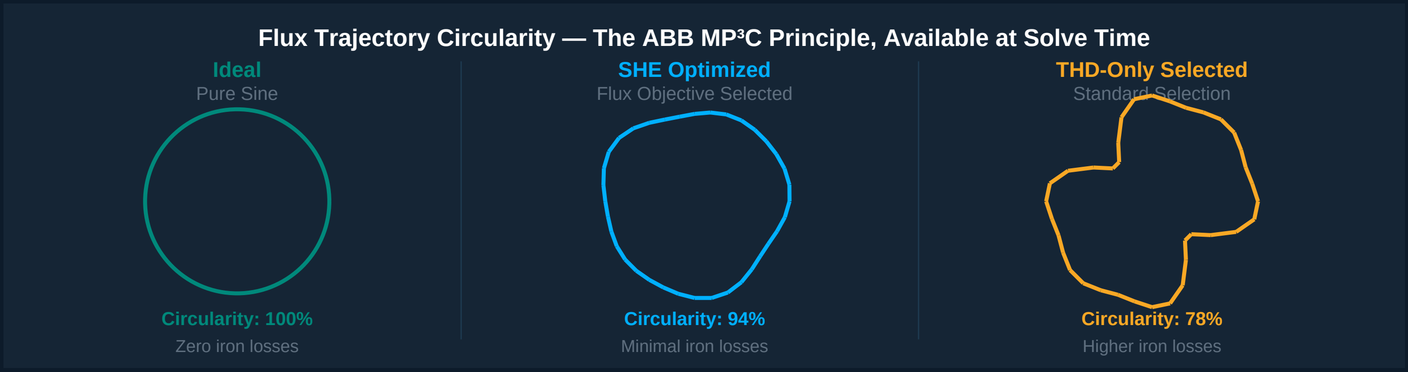

Real data from N=17, M=0.850, 2-Level VSI. Both solutions eliminate H5, H7, H11, H13, H17, H19 to mathematical zero. Both pass IEEE 519. The difference is entirely in secondary physical properties — and only visible when you have access to the complete solution space.

## THE FLUX TRAJECTORY OBJECTIVE

ABB MP³C principle — computed at solve time, no real-time control required

The stator flux vector traces a path in the complex plane over each fundamental cycle. For a pure sine wave this path is a perfect circle. For a switched inverter it deviates from that circle based on the harmonic content of the voltage waveform. Every deviation from a perfect circle drives iron losses, mechanical vibration, and bearing currents.

**ABB's MP³C** (Model Predictive Pulse Pattern Control) achieves near-circular flux by tracking an ideal trajectory in real time using model predictive control — a complex, computationally expensive approach requiring high-end DSPs. SHE Designer achieves the same result through a fundamentally different mechanism: **pre-selecting the switching angle set that produces the most circular flux trajectory before the inverter ever switches.** No real-time solver. No model. Just the right angles in a lookup table.

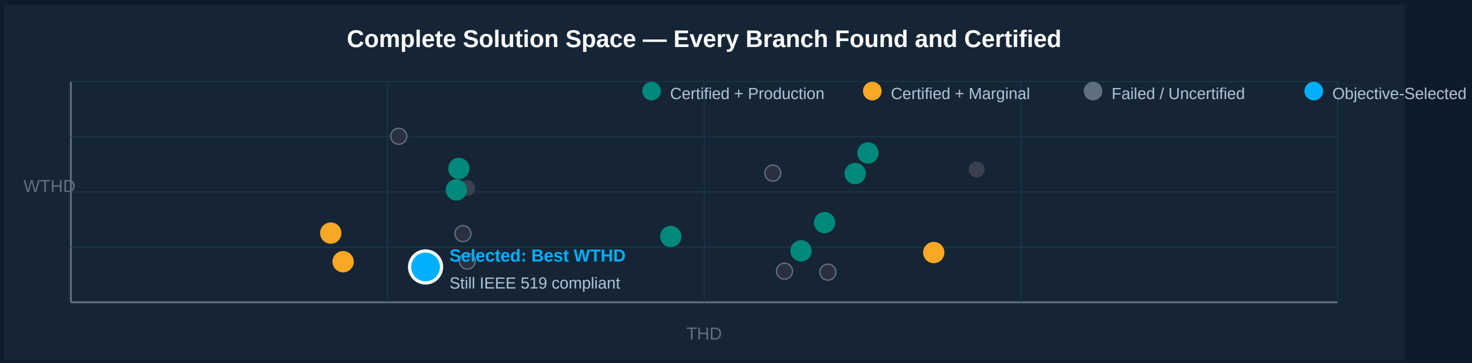



All three waveforms eliminate the same harmonics and pass IEEE 519. The flux trajectory objective selects the solution whose voltage waveform, when integrated, produces the most circular flux path — directly minimizing iron losses in transformers and motor cores.

## COMPLETE SOLUTION SPACE

Not one answer — every answer, certified and ranked

Published SHE methods using particle swarm optimization, genetic algorithms, or Newton-Raphson report a single solution per operating point. That solution may or may not be optimal. It cannot be proven optimal because the rest of the solution space was never examined. Our proprietary methodology exhaustively covers the space — guaranteeing that the solution selected by any objective is the global optimum for that objective, not a local minimum.

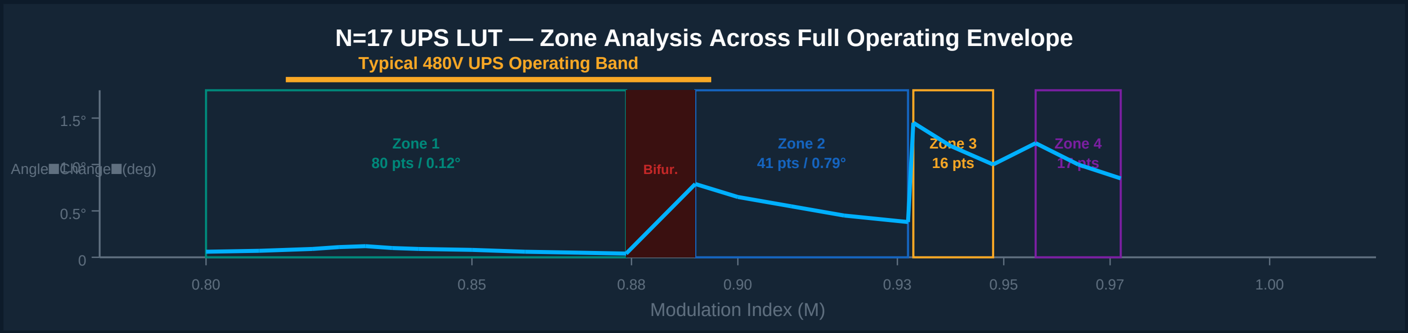



Each point represents a unique switching angle set. All certified solutions (colored) satisfy the five certification checks. The objective-selected solution (blue) is the global minimum for the chosen metric across the entire certified pool — not a local minimum from a random start.

## GRID-TIED & FIXED-FREQUENCY APPLICATIONS

Where SHE is the optimal modulation strategy

In fixed-frequency applications — grid-tied solar, wind, UPS, STATCOM — the output frequency is constant. The switching angles do not change with frequency; they simply execute faster or slower. This eliminates the real-time constraint entirely. A certified LUT computed once runs indefinitely with zero DSP computation. The modulation index changes slowly as DC bus voltage varies, and the 0.001-step resolution of the LUT provides smooth interpolation at every point.




N=17 zone analysis for UPS applications. Zone 1 (M=0.800–0.879) covers the standard 480V three-phase UPS operating band on an 800V DC bus with maximum transition of 0.12° between adjacent points. Sub-tenth-degree smoothness — zero torque transients during voltage regulation.

## APPLICATION MATRIX

Objective-optimized LUTs for every grid-tied topology

| Application | Operating M | Key Objective | Why It Matters | Best Zone |
|---|---|---|---|---|
| Online UPS<br>(480V / 800V bus) | M = 0.84–0.88 | **Flux Trajectory**<br>**DC Cap Stress** | Transformer efficiency<br>Capacitor lifespan | Zone 1<br>✓ Continuous |
| Solar Inverter<br>(Grid-tied) | M = 0.70–0.95 | **WTHD**<br>**Flux Trajectory** | IEEE 1547 compliance<br>Transformer iron loss | Zone 1–2<br>✓ Smooth |
| Wind Inverter<br>(Variable speed) | M = 0.40–0.90 | **WTHD**<br>**Torque Ripple** | Converter current quality<br>Drivetrain stress | All zones<br>✓ Full sweep |
| Data Center UPS<br>(Hyperscale) | M = 0.85–0.88 | **Flux Trajectory**<br>**DC Cap Stress** | PUE improvement<br>Capex reduction | Zone 1<br>✓ Certified |
| STATCOM / Grid Support | M = 0.80–0.92 | **THD**<br>**Flux Trajectory** | Grid code compliance<br>Reactive power quality | Zone 1–2<br>✓ Optimal |

Each application receives a LUT optimized for its specific operating profile and dominant performance requirement. The same elimination constraints apply to all — what differs is which degree of freedom is exploited to improve the physical behavior that matters most.

## SHE VS CONVENTIONAL PWM

A fundamental difference in switching architecture

| Metric | SHE Designer (N=17) | Conventional PWM (15 kHz) | Advantage |
|---|---|---|---|
| Switching events / half-cycle | **35** | ~15,000 | **430x fewer** |
| Switching losses | **Minimal** | Dominant at high power | **SHE wins** |
| Targeted harmonics at zero | **16 at mathematical zero** | 0 targeted specifically | **SHE wins** |
| H5 amplitude | **0.000%** | 2–8% typical | **SHE wins** |
| H7 amplitude | **0.000%** | 2–8% typical | **SHE wins** |
| Output filter requirement | **Single-stage LC above H49** | Multi-stage from H5 up | **SHE wins** |
| EMI generation | **Negligible (35 transitions)** | High (15,000 transitions) | **SHE wins** |
| IEEE 519 compliance | **Guaranteed by design** | Filter-dependent | **SHE wins** |
| Flux trajectory optimization | **Built-in objective** | Not applicable | **SHE only** |
| Objective-driven selection | **5 physical objectives** | None | **SHE only** |
| Runtime DSP computation | **Zero (table lookup)** | Continuous carrier generation | **SHE wins** |

## CERTIFIED PERFORMANCE

Every result independently verifiable — no black boxes

| Topology | N | M | Solutions Found | Certified | Best THD | HW Grade | Min Gap | Solve Time |
|---|---|---|---|---|---|---|---|---|
| 2-Level | 17 | 0.850 | 23 | 1 | 34.34% | **PRODUCTION** | 41.6 µs | 8 ms |
| 3-Level NPC | 17 | 0.850 | 18 | 3 | 34.34% | **PRODUCTION** | 41.6 µs | 85.6 s |

| Topology | N | M | Solutions Found | Certified | Best THD | HW Grade | Min Gap | Solve Time |
|---|---|---|---|---|---|---|---|---|
| 3-Level T-Type | 17 | 0.805 | 18 | 3 | 38.77% | PRODUCTION | 44.7 µs | 28.2 s |
| 2-Level | 21 | 0.875 | 18 | 3 | 32.14% | MARGINAL | 2.7 µs | 46.6 s |
| UPS LUT | 17 | 0.800–0.879 | 80 pts | 80/80 | 20.7–35.6% | PRODUCTION | 22.5 µs | 3 sec |
| VFD LUT | 3–17 | 0.050–1.000 | 951 pts | 951/951 | Variable | PRODUCTION | 3.2 µs | ~3 min |

LUT rows represent complete sweep deliverables. The UPS LUT covers the full steady-state operating envelope of three-phase 480V online double-conversion UPS on 800V DC bus — 80/80 points certified, Simulink hardware validated, FPGA-ready CSV output.

## FIVE-POINT CERTIFICATION PROTOCOL

Binary pass/fail — no exceptions, no overrides

| # | Check | What It Proves |
|---|---|---|
| 1 | **Residual Norm** | System of equations evaluates to less than 10■■. Proves angles satisfy the elimination equations. |
| 2 | **Per-Harmonic Elimination** | Each targeted harmonic individually verified below 10■■ of fundamental. Not a sum — each one. |
| 3 | **Angle Ordering** | All angles strictly ordered 0–90°. No overlaps, no quarter-wave symmetry violations. |
| 4 | **Minimum Pulse Width** | Gap between consecutive switching events meets hardware dead-time for safe IGBT/MOSFET operation. |
| 5 | **Switching Count** | Total switching events per cycle matches expected count for topology. Prevents invalid switching states. |

**SHE Designer does not ask you to accept harmonic elimination as a constraint and move on. It asks a deeper question: *given that every solution in this space meets your compliance requirements, which one makes your inverter run cooler, quieter, more efficiently, and longer?* That question was previously unanswerable because no one had all the solutions. Now you do.**

| 430x | 16 | 5 | 100% | 0 |
|---|---|---|---|---|
| **Fewer Switching■Events v** | **Harmonics at■Math Z** | **Optimization■Objectiv** | **Certification■Rate** | **Runtime DSP■Computation** |
| N=17 vs 15 kHz | H5 through H49 | User-selectable | All 951 VFD pts | Pure LUT lookup |

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