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## PRACTICAL APPLICATIONS OF NANOCRYSTALLINE TO L3HARRIS MARITIME POWER AND ENERGY POWER CONVERSION EQUIPMENT

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August 17, 2023

This document consists of general capabilities information that is not defined as controlled technical data under ITAR Part 120.10 or EAR Part 772

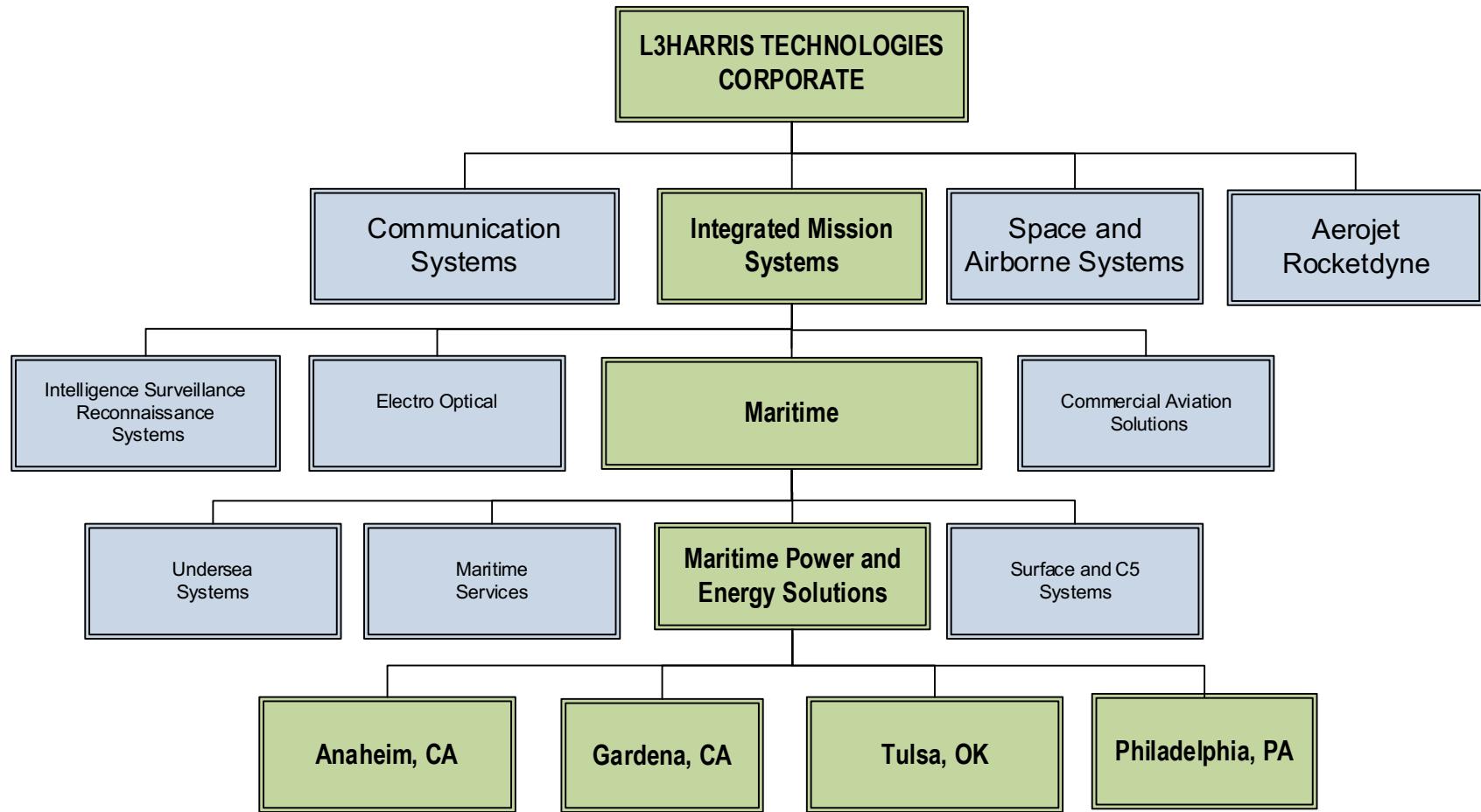
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# MPES At-A-Glance



# MPES At-A-Glance

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- ❖ **Our Mission:** Provide safe, reliable, innovative military power solutions to defend our nation and allies, and to support critical industrial infrastructure
- ❖ **Our Vision:** To be the preferred supplier for mission critical electrical power solutions
- ❖ **We Provide:** Major U.S. Navy shipbuilding programs with high-power quality, reliable, shock-hardened, EMI-compliant, electrical power distribution, conversion, protection and control systems
- ❖ **Our Markets and Customers are:**
  - U.S. Navy, International Navies, and industrial applications
- ❖ **We Distinguish Ourselves by:** Superior product quality and processes; Combat worthy products; 40 – 50 year life cycle; Full service and support

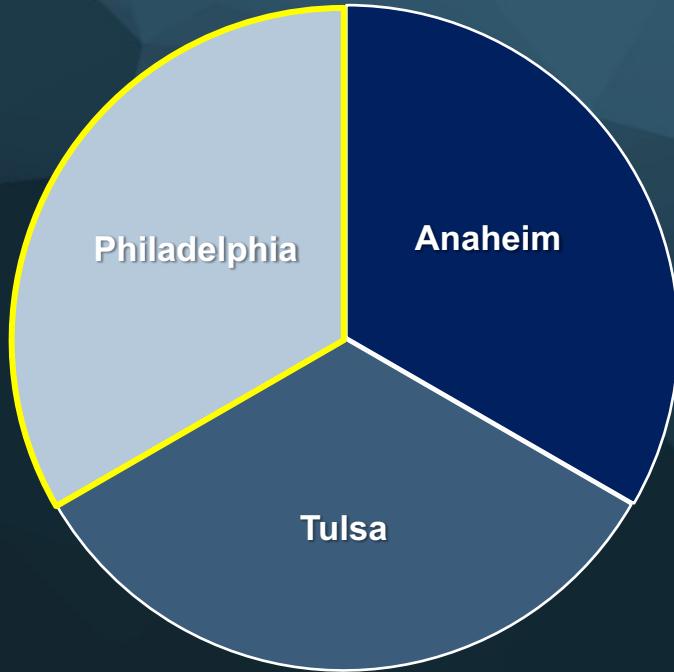


# MPES Site Locations

Anaheim, CA; Gardena, CA; Tulsa, OK; Philadelphia, PA



# Maritime Power & Energy Solutions (MPES) Division



## MPES-Anaheim

Power Conversion Modules,  
Frequency Converters, Advanced  
Degaussing Systems, Automatic  
Bus Transfer, Fault Isolation Unit,  
Medium Voltage Motor Drive



## MPES-Philadelphia

Power Node Control Centers,  
Switchboards, Circuit Breakers,  
Power Converters, Motor  
Controllers, Bus Transfer &  
Isolation Relay



## MPES-Tulsa

Switchboards, Load Centers,  
Power & Lighting Panels, Arc Fault  
Detection

# MPES Sites Anaheim, Philadelphia, and Tulsa



- Manufacturing & Engineering Capabilities
- Electrical Power Conversion and Distribution Equipment for Shipboard applications
  - AC/DC Converters of all types – 10 kW up to 6MW
  - Circuit Breakers
  - Switchboards and Load Centers
  - 400 Hz supplies for weapons systems
  - Aircraft starting systems
  - Arc Fault Detection Systems
- Test Capabilities
  - EMI (MIL-STD-461 rated)
  - Airborne and Structureborne Noise
  - Thermal
  - Humidity
  - Vibration
  - Lightweight Shock



# Engineering Opportunities



**ELECTRICAL/POWER  
MECHANICAL/THERMAL  
SOFTWARE/CONTROLS  
DIGITAL/ANALOG/PCB  
SYSTEMS**

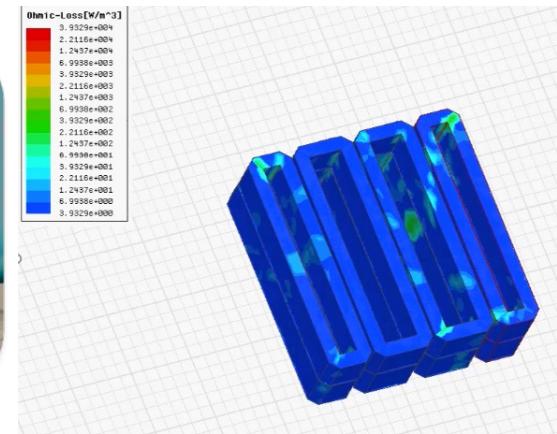
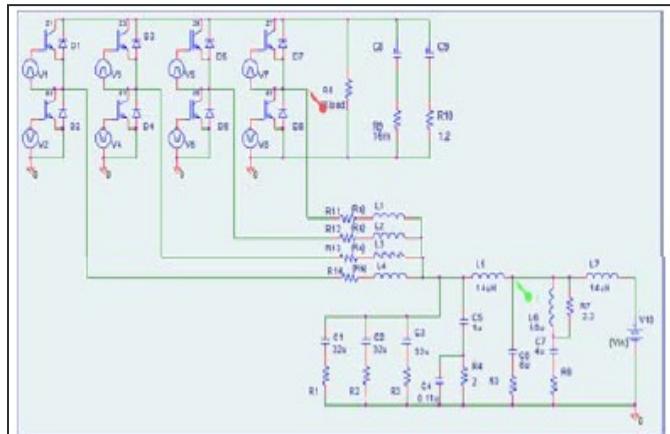


# Engineering Opportunities



## ❖ Key Tasks In Engineering

- State of the Art Power Conversion, Conditioning, and Control
  - ❑ Power topology design/selection
    - High-power quality, bi-directional power conversion
  - ❑ Circuit analysis and advanced control algorithm modeling and simulation
  - ❑ Electromagnetic field modeling and simulation
  - ❑ Optimize components layout for electromagnetic compatibility (EMC)
  - ❑ Design development, integration, verification, and qualification

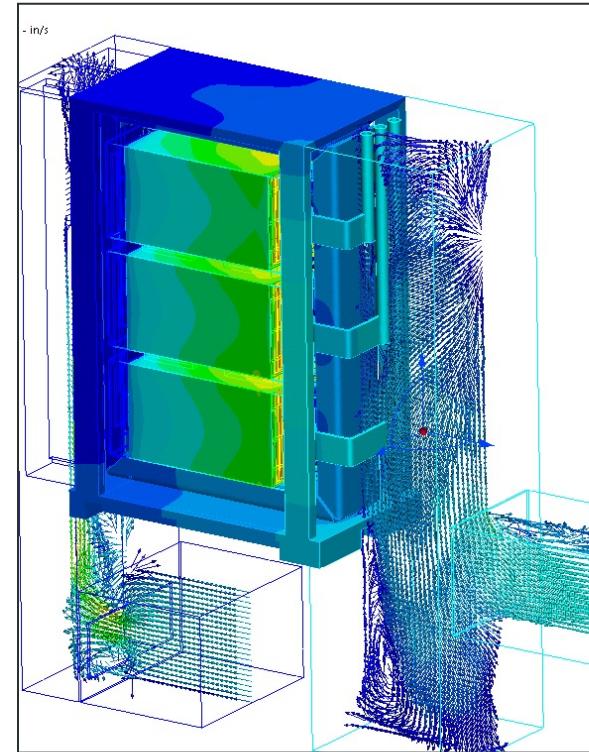


# Engineering Opportunities



## ❖ Key Tasks In Engineering (cont'd)

- Advanced Mechanical Design, Packaging, and Analysis
  - ❑ FEA structural analysis for high shock and vibration environments (incl. non-linear and dynamic analysis)
  - ❑ CFD airflow and thermal analysis, modeling, and simulation



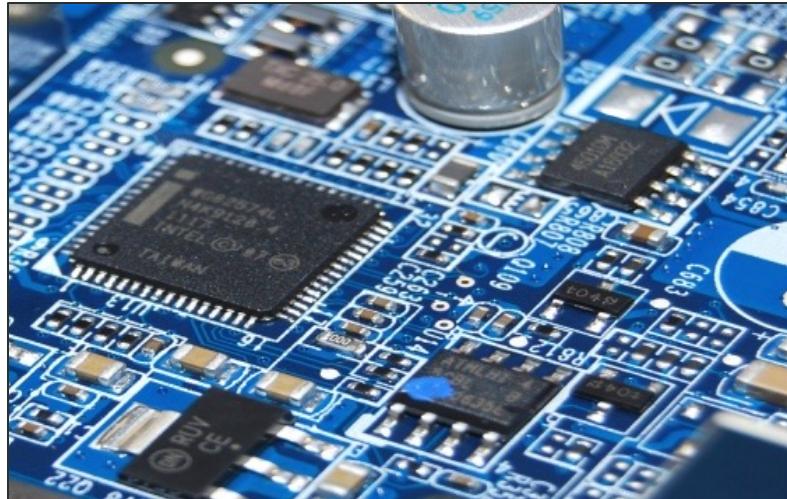
# Engineering Opportunities



## ❖ Key Tasks In Engineering (cont'd)

### ❖ SW/FW Architecture Design, Development, and Integration

- ❑ Embedded software for power conversion algorithms
- ❑ High-level applications interfaced with embedded modules
- ❑ Graphical User Interface (GUI) /Human-Machine-Interface (HMI) development and implementation
- ❑ Digital logic design for FPGAs; VHDL coding and timing simulations
- ❑ Digital signal processing algorithms for FPGAs and CPLDs



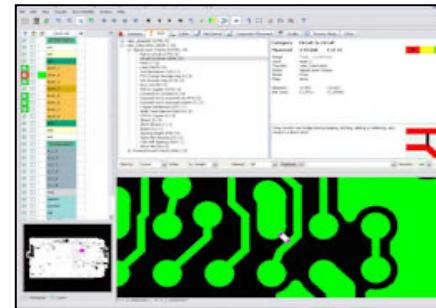
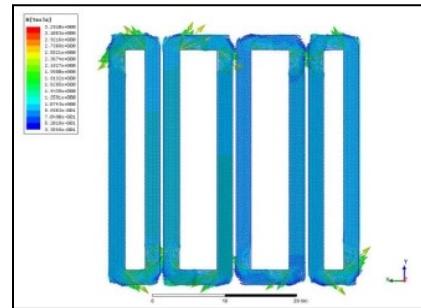
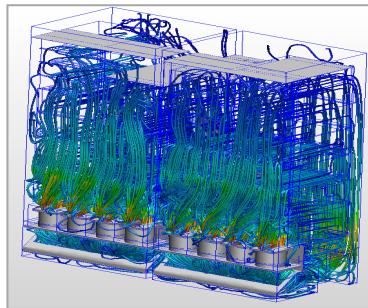
# Engineering Analysis Tools



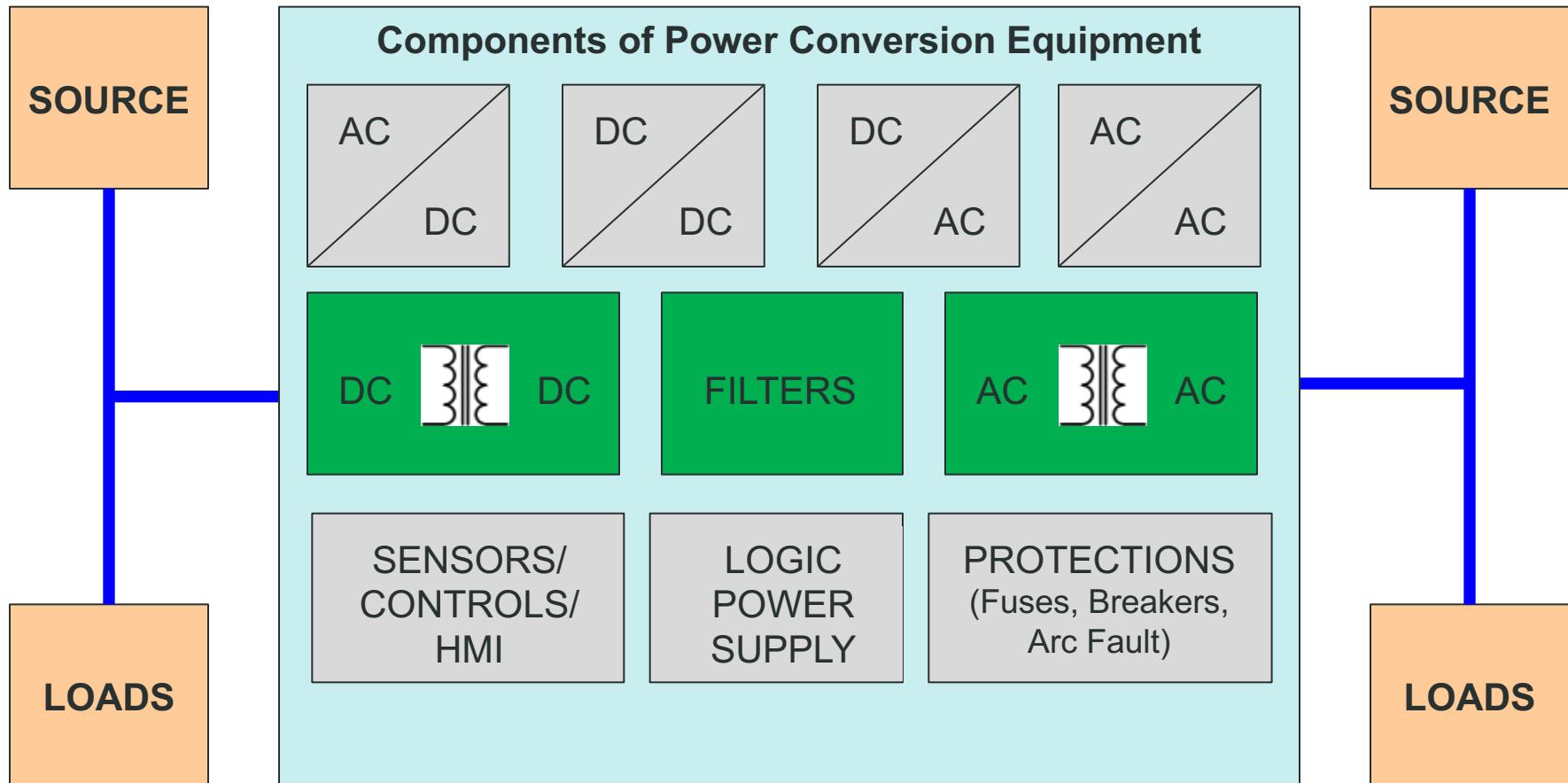
## ❖ Design to Manufacture

➤ Enhanced analysis tools to achieve design to manufacture in a short time

Mechanical Analysis Tools	Power, Elect, Digital, Controls Analysis Tools	PCB Design	Software Coding
<ul style="list-style-type: none"><li>• 3D Computer Aided Design (CAD) – Autodesk Inventor</li><li>• Structural / Dynamic Finite Elemental Analysis (FEA) – Ansys Mechanical</li><li>• Computational Fluid Dynamics (CFD) Analysis – Autodesk</li></ul>	<ul style="list-style-type: none"><li>• ORCAD PSpice Circuit and Analysis – Cadence</li><li>• Matlab / Simulink Controls Analysis – Mathworks</li><li>• Maxwell 2D/3D Magnetic Flux Analysis – Ansys</li><li>• Simplorer Circuit Analysis - Ansys</li><li>• FPGA Firmware and VHDL Coding and Analysis – Questa SIM</li><li>• LabView rapid prototyping – National Instruments</li></ul>	<ul style="list-style-type: none"><li>• Cadence Capture CIS / CIP</li><li>• Mentor Graphics Valor DfM / DfA</li><li>• PCB Library Expert</li><li>• Cadence Allegro</li></ul>	<ul style="list-style-type: none"><li>• GSA Software</li><li>• WindRiver</li><li>• Rational Team Concert</li><li>• Code Warrior</li><li>• Visual Studio</li></ul>



# Power Electronics Building Blocks



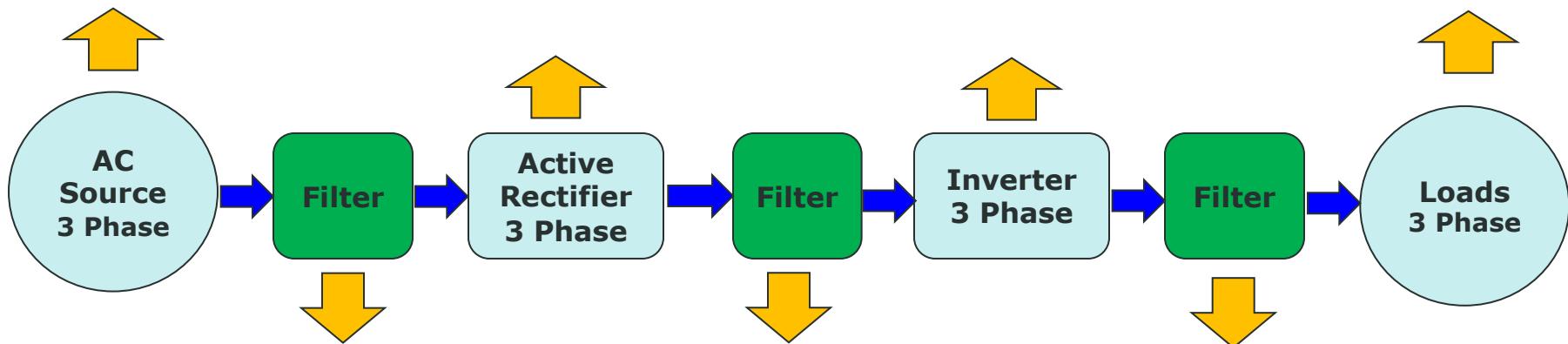
Establishing the basic components of Power Electronics and utilizing these as building blocks for Power Conversion to expedite maturity level

# Power Electronics Building Blocks



## Common building blocks for Power Conversion (AC/AC)

- Prime Mover
- 440Vac/60 Hz, 3 Phase
- Cooling
- Fuses
- Breakers
- Transfer Switches
- Full Bridge, Interleaved
- Voltage/Current Control
- Harmonic Elimination
- Power Factor Correction
- Cooling
- Fuses
- Full Bridge, Interleaved
- Voltage/Current Control
- Harmonic Elimination
- Cooling
- Fuses
- Linear Load
- Non-Linear Load
- Motor Load
- Fuses
- Breakers
- Cooling



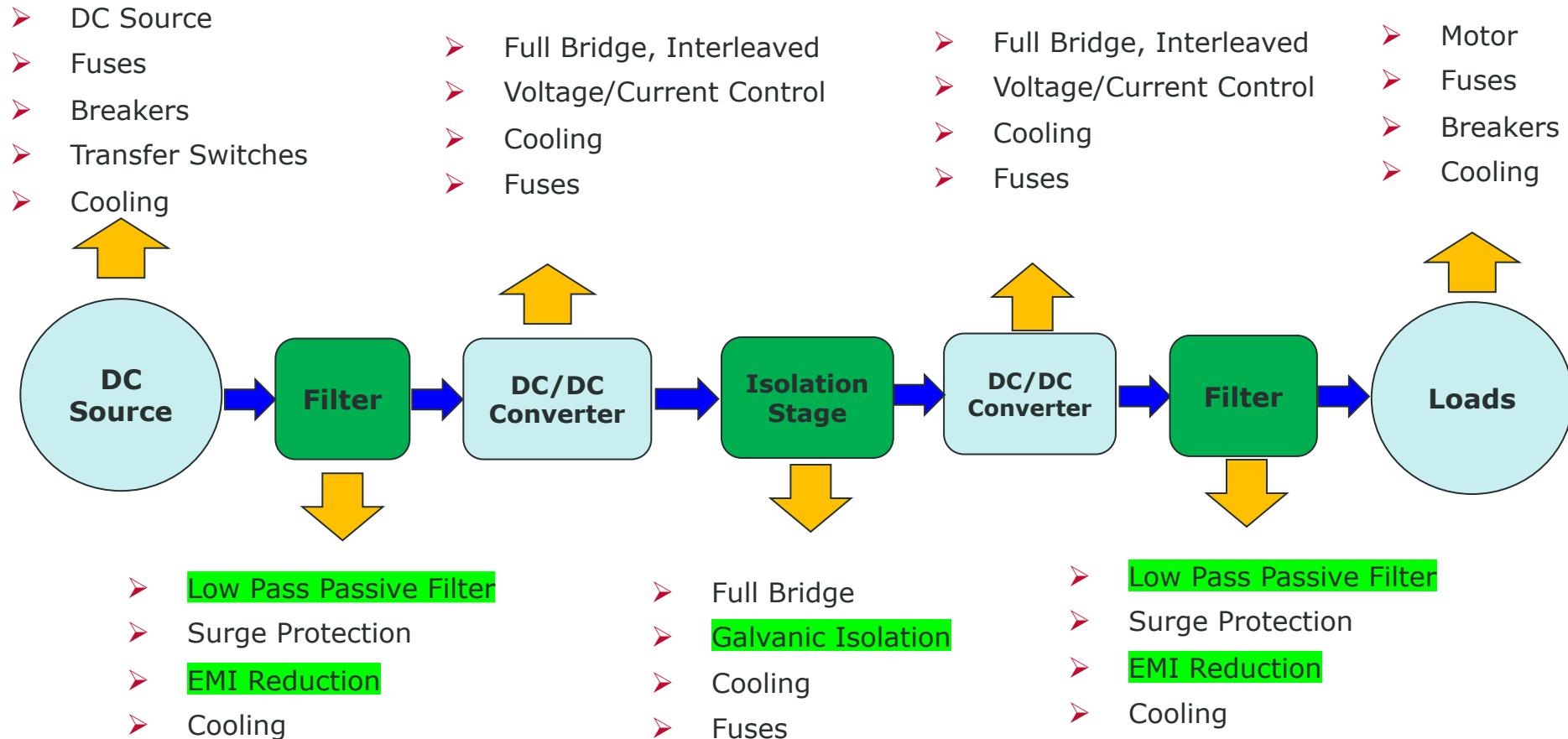
- Low Pass Passive Filter
- Surge Protection
- EMI Reduction
- Cooling
- Low Pass Passive Filter
- Bulk Capacitance
- Cooling
- Low Pass Passive Filter
- Surge Protection
- EMI Reduction
- Cooling

**Establishing common power architectures to avoid reinventing the wheel**

# Power Electronics Building Blocks



## Common building blocks for kW Power Conversion (DC/DC)



Establishing common power architectures to avoid reinventing the wheel

# Requirements

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## Power Conversion Equipment Requirements to be Considered

- Cost
- Power density
- Size and volume
- Efficiency
- Topology
- Technology available
- Ratings (voltage, current, and power)
- Thermal management
- Reliability
- Manufacturability
- Environmental robustness
- Maintainability
- Equipment support

# Additional Requirements

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Other parameters from component Suppliers to be considered

- Time to Market
- Multiple Suppliers or Sole Source for components
- Component lead times
- Annual product demand
- ITAR requirements
- US Citizenship requirements

# Magnetics Requirements

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## Magnetics Applications at MPES

- Transformers
- Inductors

## Needs from Magnetics Material

- Low no-load losses
- Extended overload capacity
- Increased efficiency
- Low environmental impact
- Higher permeability
- Consistency performance over temperature range
- High saturation
- Manufacturing flexibility
- Low Magnetoresstriction

# Processes for Considerations



Design Considerations	Core Considerations	Coil Considerations	Magnetics Build Considerations
<ul style="list-style-type: none"><li>• Power rating</li><li>• Voltage rating</li><li>• AC current rating</li><li>• DC current rating</li><li>• Overload ratings</li><li>• Inductance</li><li>• Leakage inductance</li><li>• Magnetizing inductance</li><li>• Turns ratio</li><li>• Gap</li><li>• Core architecture<ul style="list-style-type: none"><li>• Shell type</li><li>• Core type</li></ul></li><li>• Materials<ul style="list-style-type: none"><li>• Core type</li><li>• Core material</li><li>• Coil type</li><li>• Insulation</li><li>• Mechanical structure</li></ul></li><li>• Weight</li><li>• Size</li><li>• Copper loss</li><li>• Core loss</li><li>• Cooling</li><li>• Dielectric withstand voltage</li></ul>	<ul style="list-style-type: none"><li>• Core material</li><li>• Core supplier</li><li>• Annealing</li><li>• Integrity of gap</li><li>• Manufacturing process<ul style="list-style-type: none"><li>• Consistency</li><li>• Quality</li></ul></li><li>• Cost</li><li>• Lead time</li><li>• ITAR restrictions</li></ul>	<ul style="list-style-type: none"><li>• Coil supplier</li><li>• Quality</li><li>• Manufacturing process<ul style="list-style-type: none"><li>• Consistency</li><li>• Quality</li></ul></li><li>• Cost</li><li>• Lead time</li><li>• ITAR restrictions</li></ul>	<ul style="list-style-type: none"><li>• Manufacturer</li><li>• Coil form</li><li>• Core stack</li><li>• Mechanical structure</li><li>• Insulation</li><li>• Varnish</li><li>• Test</li><li>• Manufacturing process<ul style="list-style-type: none"><li>• Consistency</li><li>• Quality</li></ul></li><li>• Cost</li><li>• Lead time</li><li>• ITAR restrictions</li></ul>

# Additional Factors to Consider



- ❖ Unique aspects of nanocrystalline soft magnetics
  - Magnetoresstriction force - Nanocrystalline has low magnetoresstriction force than Metglas
  - Temperature dependency – Nanocrystalline has a higher temperature rating than Metglas
  - Overload capacity – Nanocrystalline has a lower overload capability than Metglas
  - Flux density – Nanocrystalline has a lower flux density than Metglas
- ❖ Original Equipment Manufacturer (OEM) interests and needs
  - Networking through Distributors, Symposiums, and Conferences
  - Off-the-shelf solutions or custom design solution
  - Collaboration with OEMs from conceptual design to product delivery
  - User friendly website with product information, application notes, and simulation tools
  - Reachable and knowledgeable Technical Support Team
  - Lead time
  - Product reliability and consistent results
- ❖ Ways to engage OEMs
  - Engage OEMs in a 1-hour Teams seminar to discuss unique products, innovative solutions, and 5-year term goal
  - Annual local conferences and symposiums

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## ADVANCED NANOCRYSTALLINE CORES CASE STUDY HIGHLIGHTS

Project Name & Description	Developed processes to utilize newly available domestically supplied lower cost, wide width Nanocrystalline (Finemet® FT-3W). Other nanocrystalline materials available: Finemet® FT3 (Finemet® FT3 is a registered trademark of Hitachi Metals), Vitroperm800® (Vitroperm800® is a registered trademark of Vacuumschmelze).
Capabilities Applied/Processes	<ul style="list-style-type: none"><li>Custom computer controlled annealing and atmospheric conditions for optimal annealing of our cores</li><li>Superior bonding and cutting technology. Large sized processing equipment</li></ul>
Overall Part Dimensions	Large core sizes available up to approx. 84"
Material Used	Nanocrystalline (Finemet® FT-3W) Metglas Finemet® FT3-W is a registered trademark of Metglas Inc.
Industry for Use	Widest scope of industries for any material
In Process Testing/Inspection Performed	Core loss and other magnetic testing as required
Volume	From prototypes to mass production
Delivery/Turnaround Time	Typical 3-5 weeks delivery with expedites available
Delivery Location	Worldwide

<https://www.mkmagnetics.com/>

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# Transformers and Inductors Suppliers



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- Precision self supporting coils
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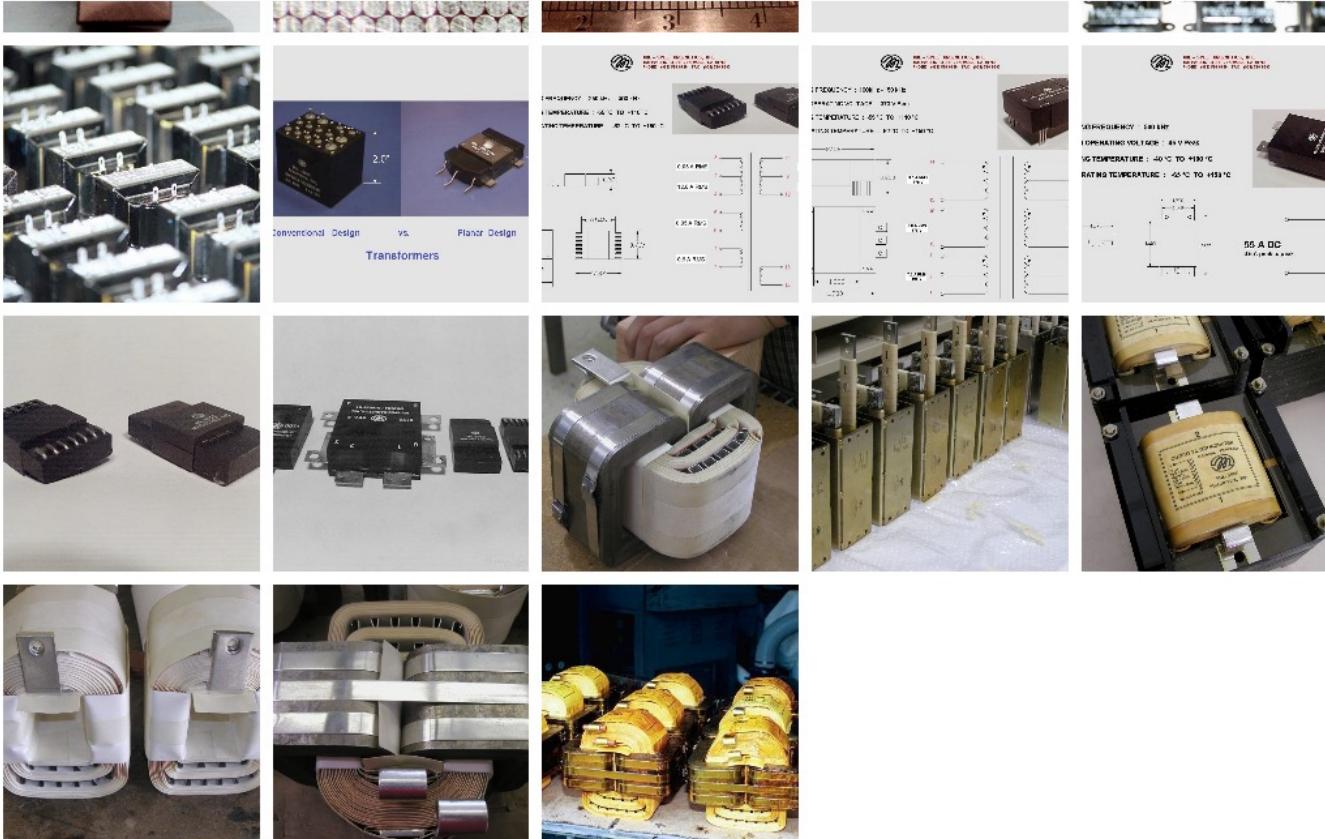
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# Questions

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## ❖ Questions