



**L3HARRIS**

FAST. FORWARD.

# **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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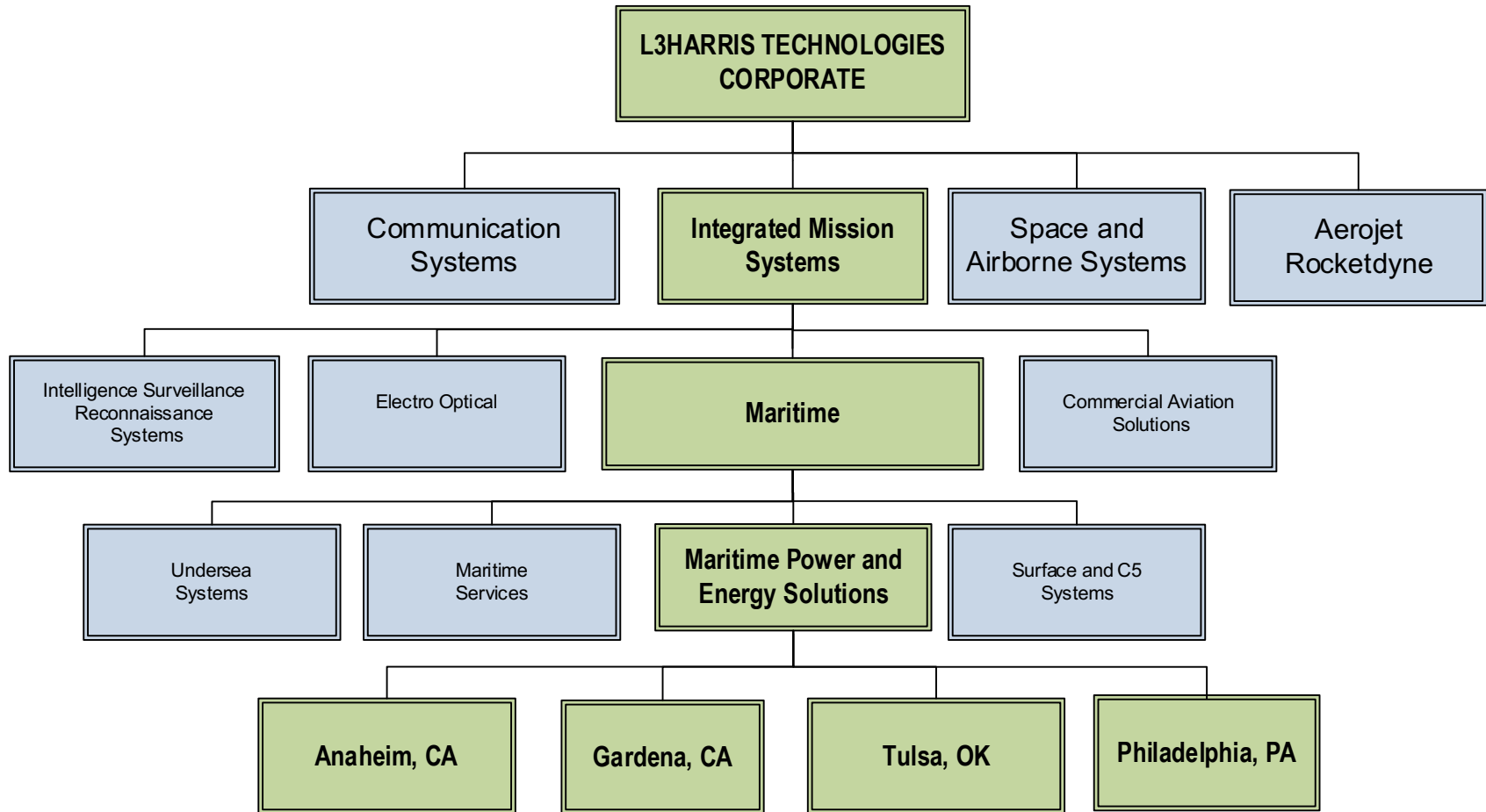
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# MPES At-A-Glance



# MPES At-A-Glance

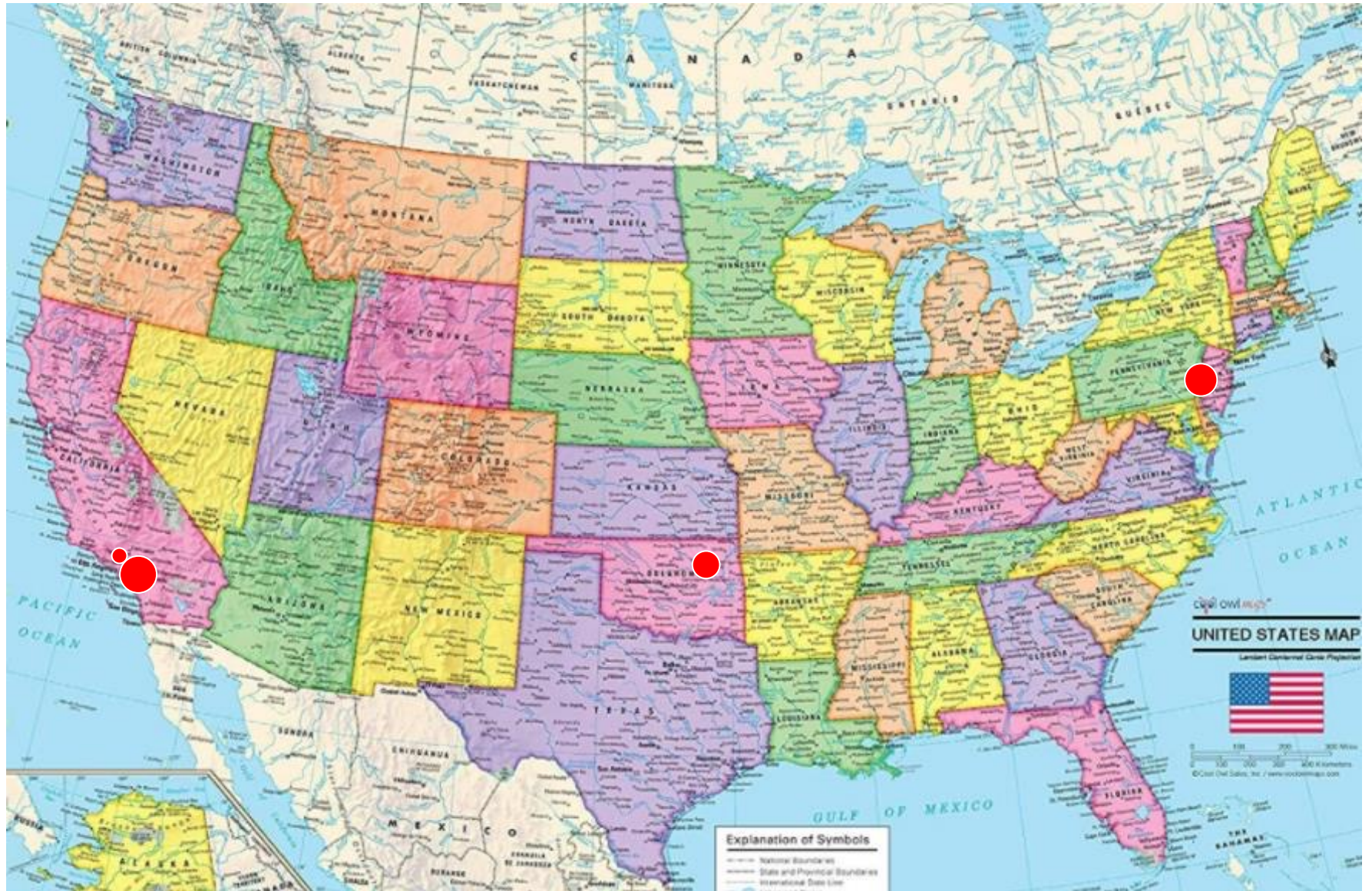


- ❖ **Our Mission:** Provide safe, reliable, innovative military power solutions to defend our nation and allies, and to support critical industrial infrastructure
- ❖ **Our Vision:** To be the preferred supplier for mission critical electrical power solutions
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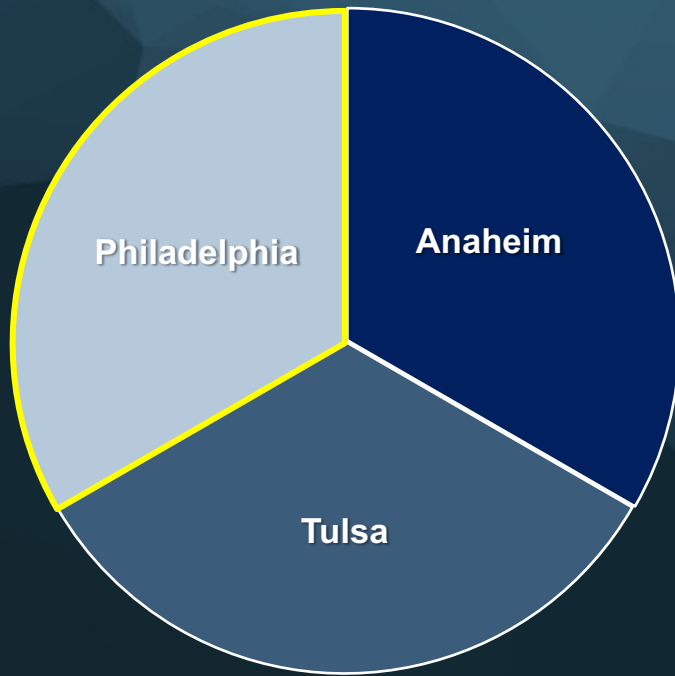


# MPES Site Locations

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



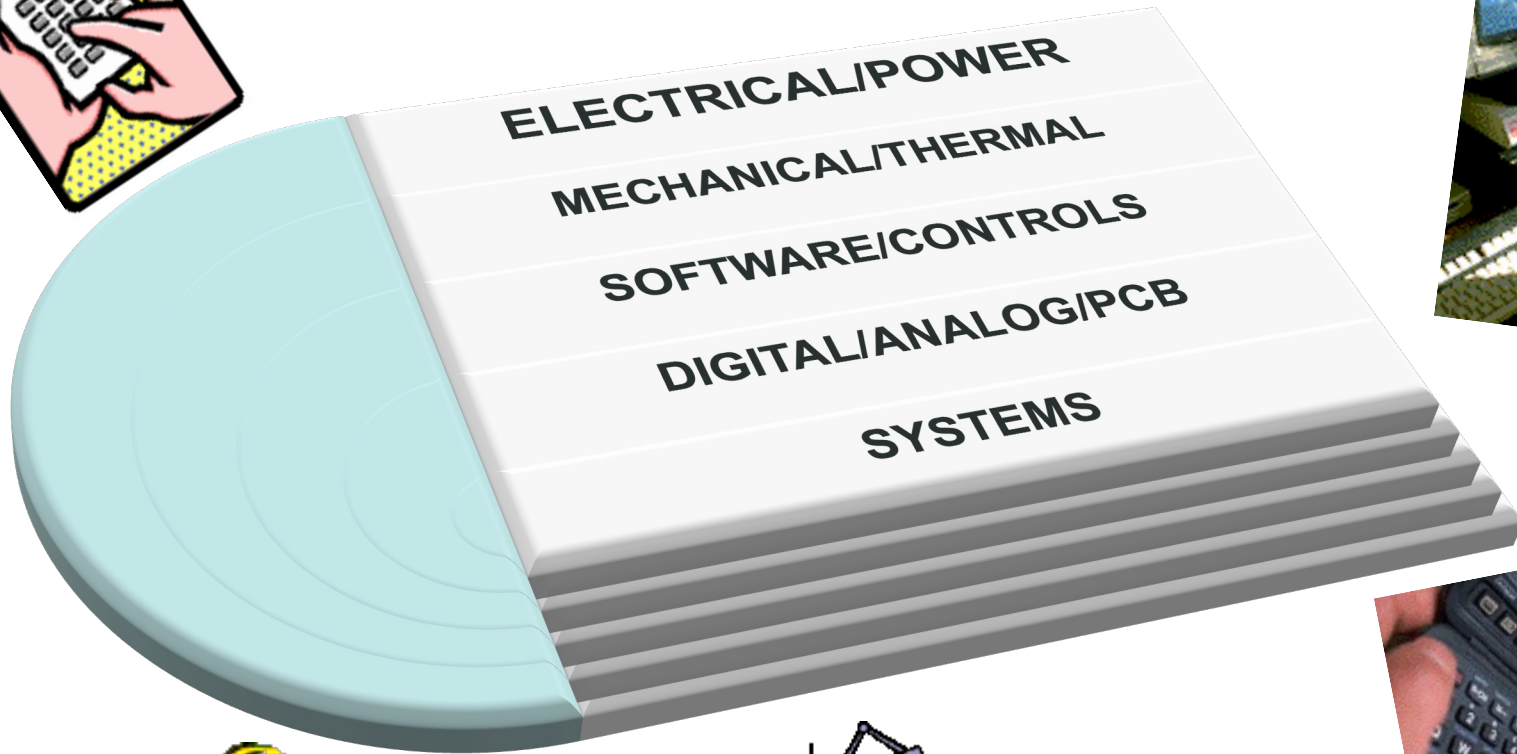
# MPES Sites Anaheim, Philadelphia, and Tulsa



- **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

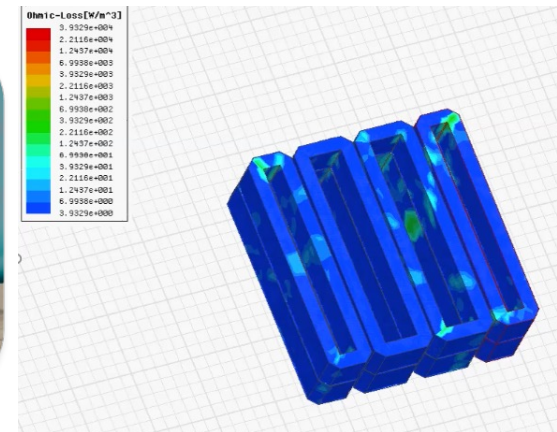
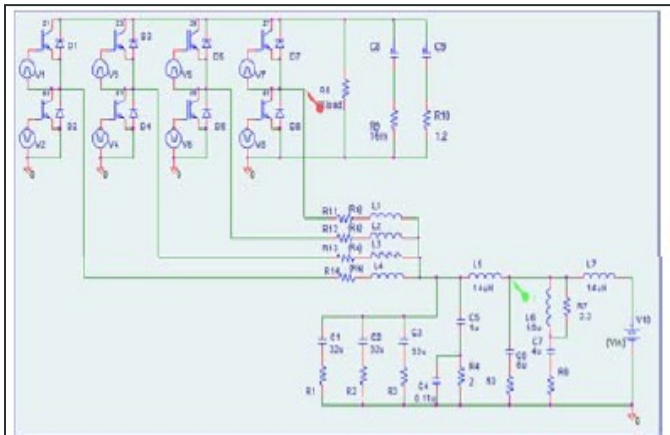






## ❖ Key Tasks In Engineering

- 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

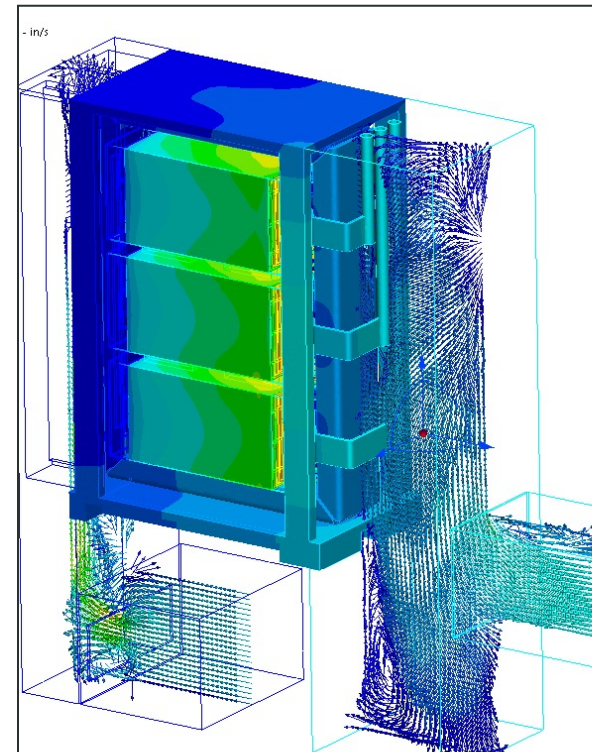


# Engineering Opportunities



## ❖ 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



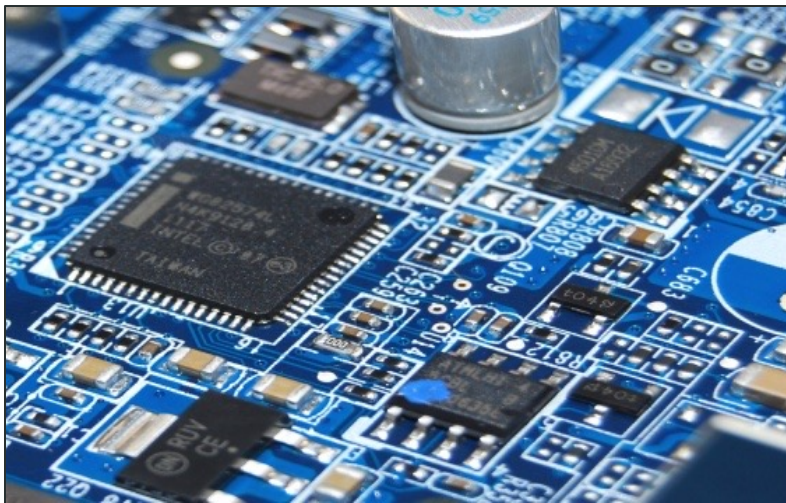
# Engineering Opportunities



## ❖ 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



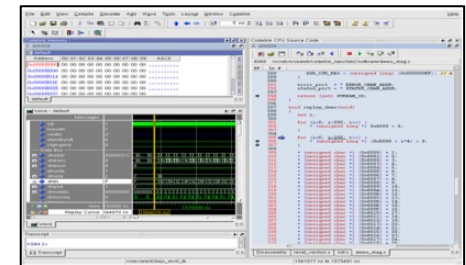
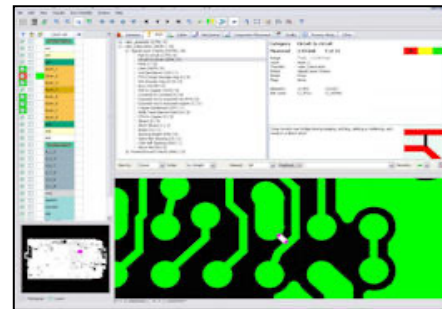
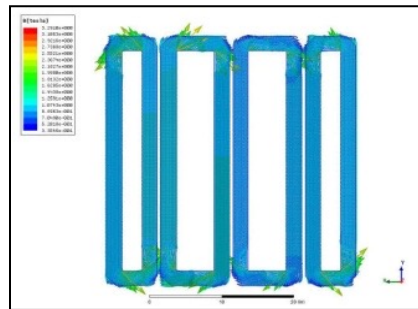
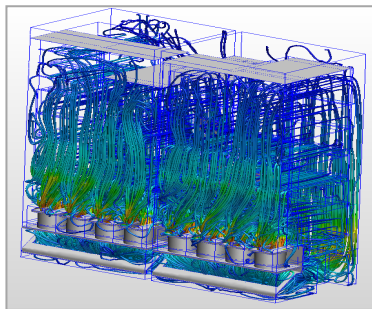
# Engineering Analysis Tools



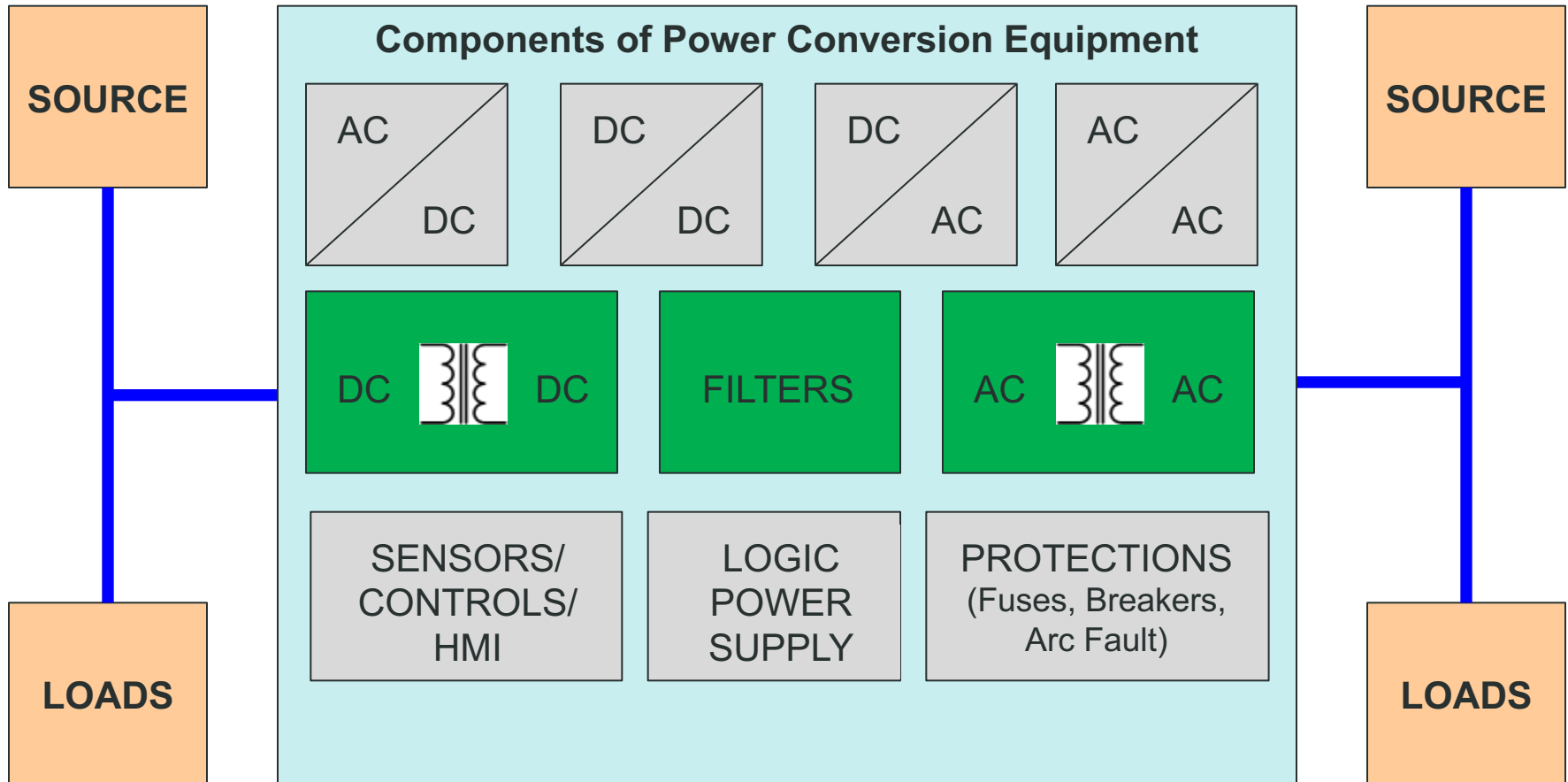
## ❖ Design to Manufacture

➤ 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



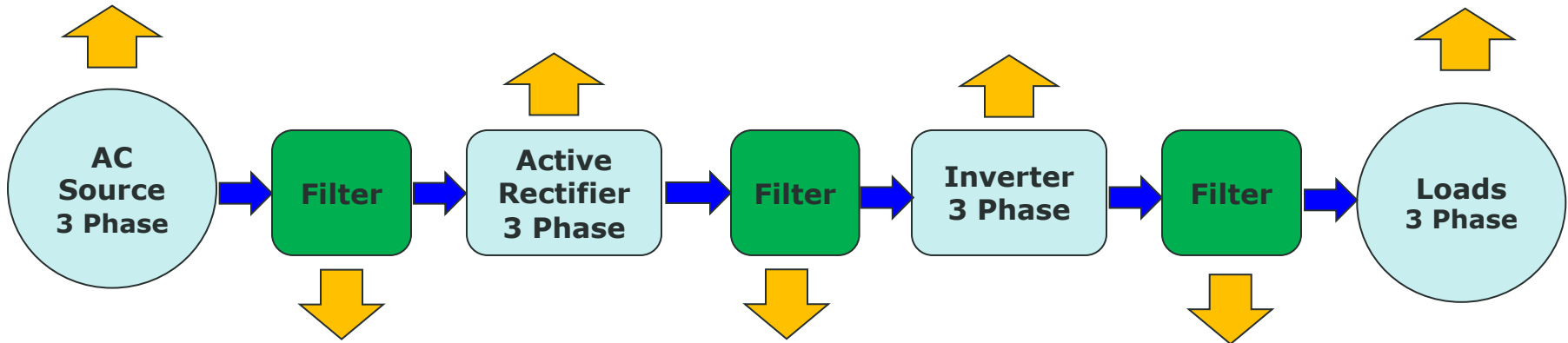
Establishing the basic components of Power Electronics and utilizing these as building blocks for Power Conversion to expedite maturity level

# Power Electronics Building Blocks



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

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



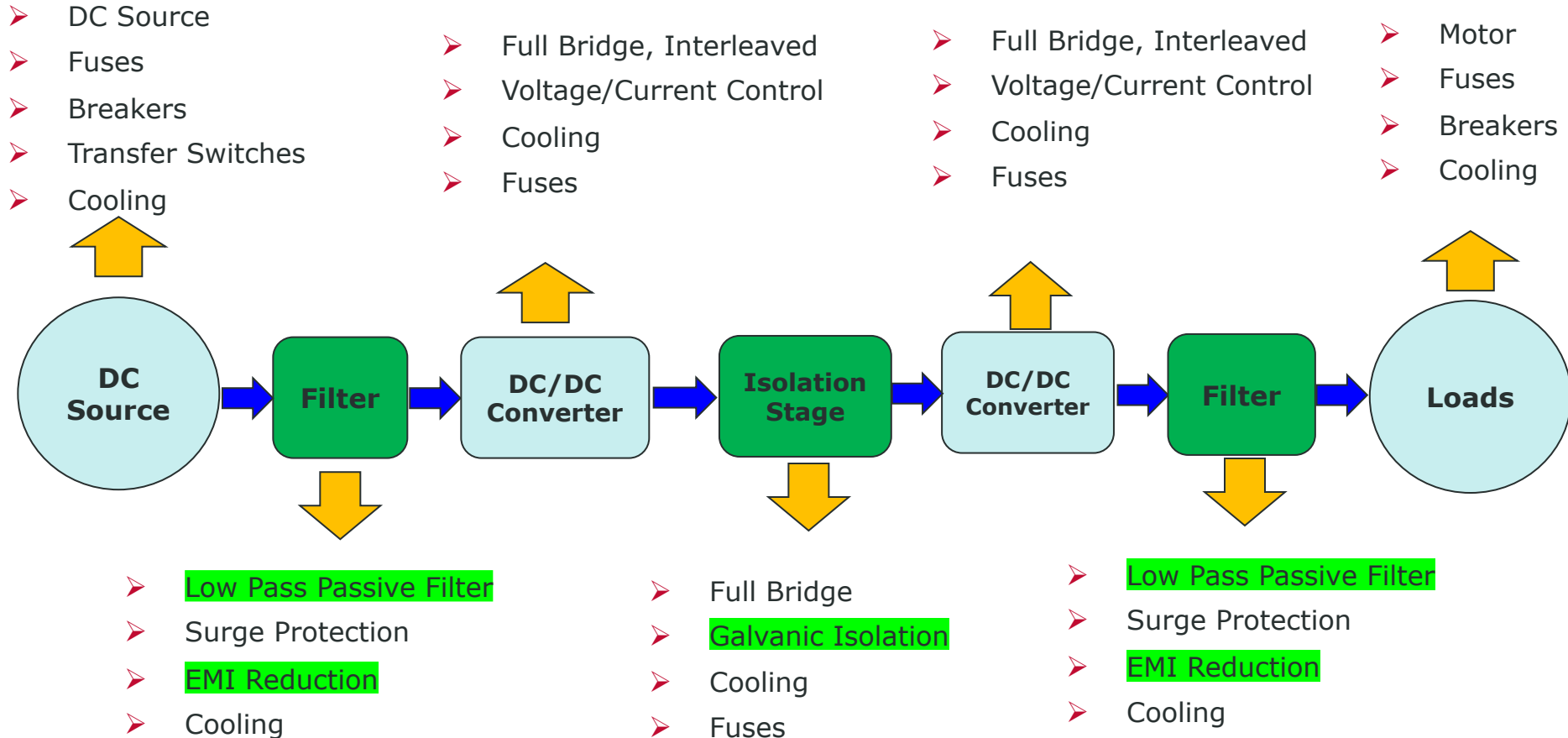
- |                                  |                                  |                                  |
|----------------------------------|----------------------------------|----------------------------------|
| ➤ <b>Low Pass Passive Filter</b> | ➤ <b>Low Pass Passive Filter</b> | ➤ <b>Low Pass Passive Filter</b> |
| ➤ Surge Protection               | ➤ Bulk Capacitance               | ➤ Surge Protection               |
| ➤ <b>EMI Reduction</b>           | ➤ Cooling                        | ➤ <b>EMI Reduction</b>           |
| ➤ Cooling                        |                                  | ➤ 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



## 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



## 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



## 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 Magnetorestriction

# Processes for Considerations



## Design Considerations

- Power rating
- Voltage rating
- AC current rating
- DC current rating
- Overload ratings
- Inductance
- Leakage inductance
- Magnetizing inductance
- Turns ratio
- Gap
- Core architecture
  - Shell type
  - Core type
- Materials
  - Core type
  - Core material
  - Coil type
  - Insulation
  - Mechanical structure
- Weight
- Size
- Copper loss
- Core loss
- Cooling
- Dielectric withstand voltage

## Core Considerations

- Core material
- Core supplier
- Annealing
- Integrity of gap
- Manufacturing process
  - Consistency
  - Quality
- Cost
- Lead time
- ITAR restrictions

## Coil Considerations

- Coil supplier
- Quality
- Manufacturing process
  - Consistency
  - Quality
- Cost
- Lead time
- ITAR restrictions

## Magnetics Build Considerations

- Manufacturer
- Coil form
- Core stack
- Mechanical structure
- Insulation
- Varnish
- Test
- Manufacturing process
  - Consistency
  - Quality
- Cost
- Lead time
- ITAR restrictions

# Additional Factors to Consider



- ❖ Unique aspects of nanocrystalline soft magnetics
  - Magnetorestriction force - Nanocrystalline has low magnetorestriction 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

# Magnetic Cores Suppliers



## 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/>


# Magnetic Cores Suppliers




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# Magnetic Cores Suppliers



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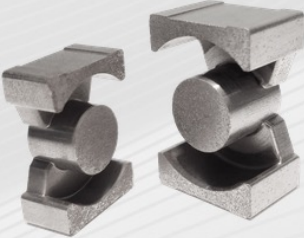
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# Transformers and Inductors Suppliers



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- High voltage
- High frequency
- Telemetry coils
- Precision self supporting coils
- Surface mount and through hole
- Miniature to medium size

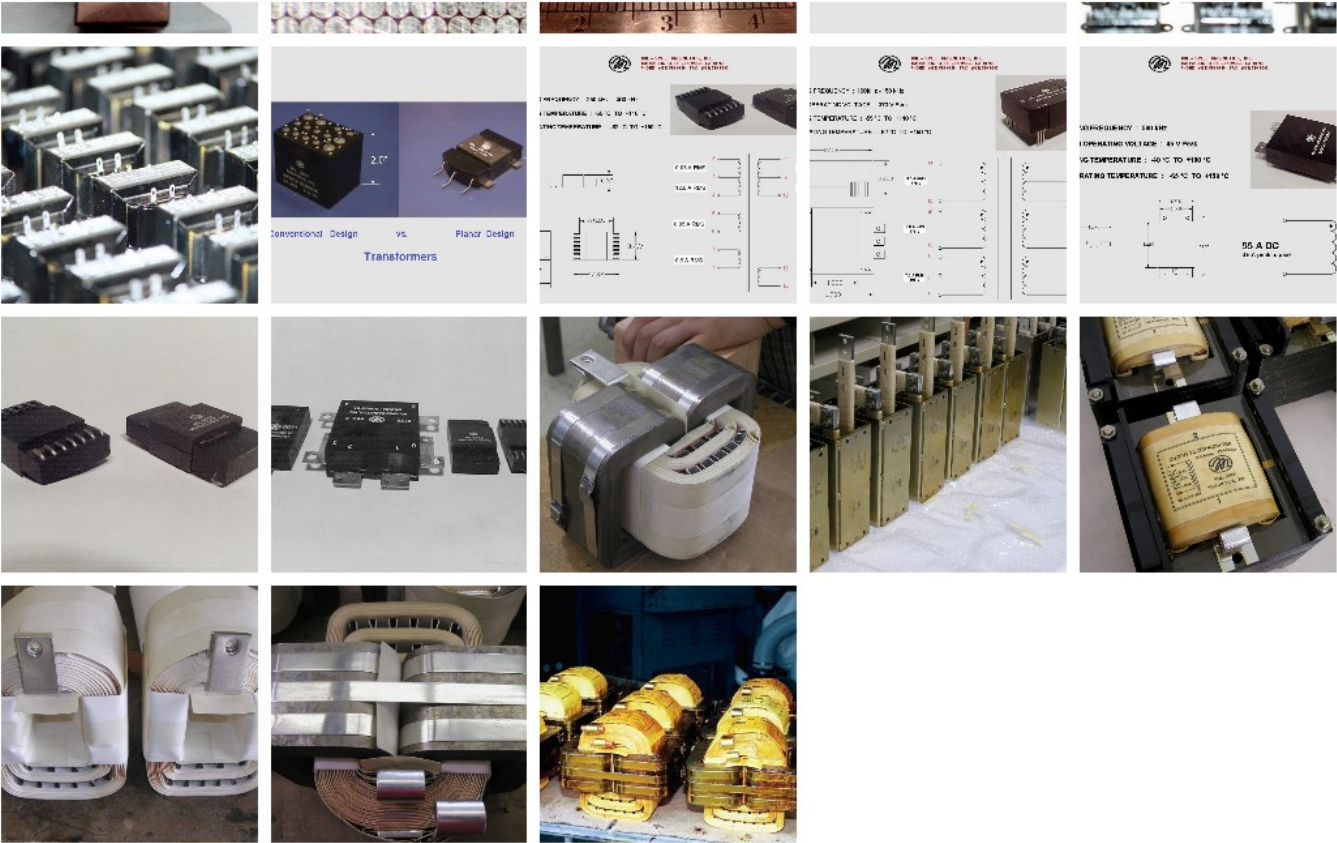
<http://www.corona-magnetics.com/>

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# Questions



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## ❖ Questions