Power Matters.™

Microsemi

Actuator Power Systems for MEA

Introduction to More Electric Aircrafts

WHY?

- **Reduce maintenance costs**
- **Reduce fuel burn and environmental impact**
- **Improve safety and reliability**

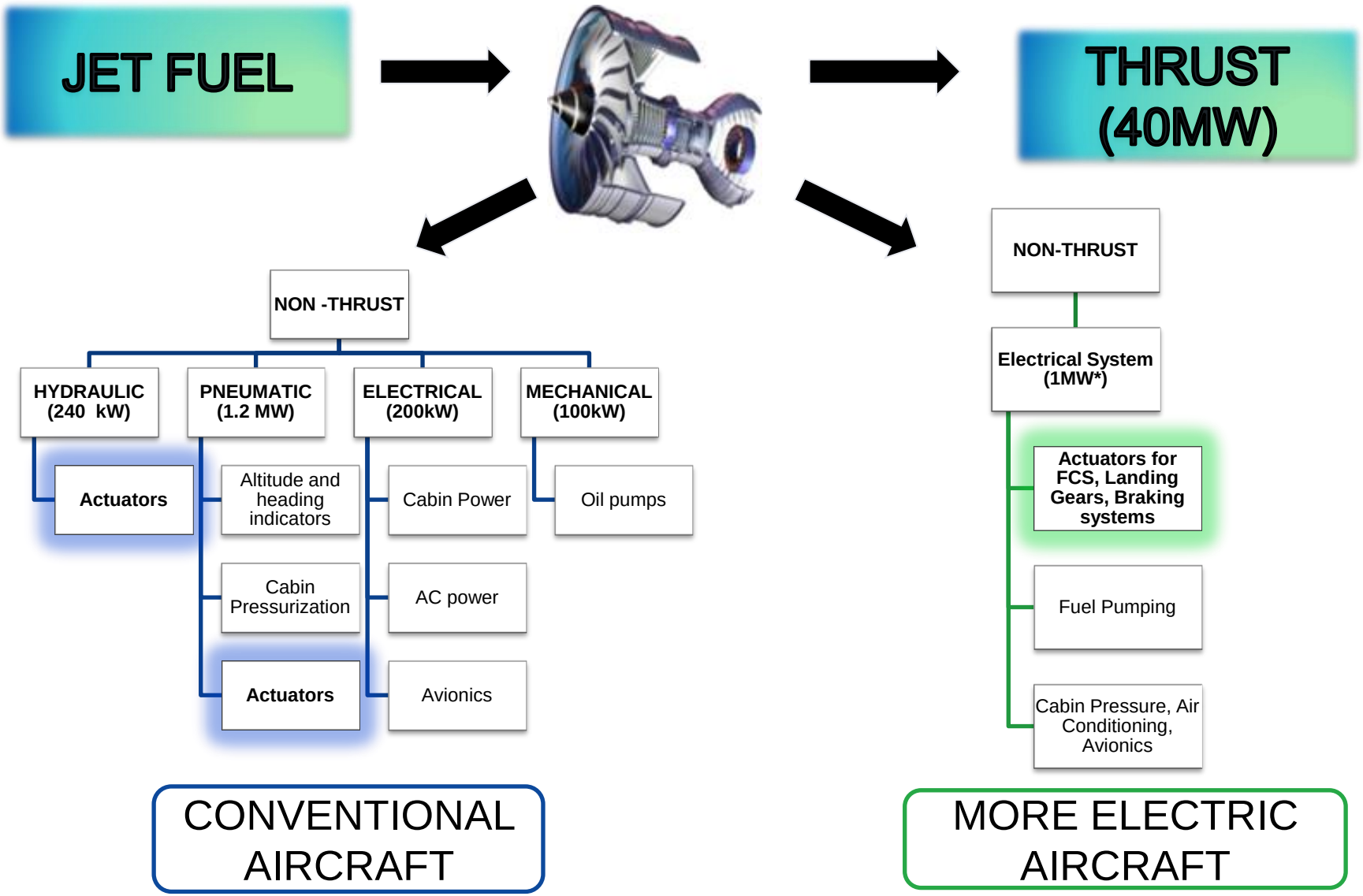
HOW are the above metrics achieved?

- Removal of Hydraulic and Pneumatic systems
  - Reduced system weight
  - Ease of maintenance
  - Reduced Costs
- "Bleedless" engine
  - Improved efficiency
- Desirable characteristics of Electrical systems
  - Controllability and Re-configurability
  - Advanced diagnostics and prognostics
  - More intelligent maintenance

WHERE?

- Actuators
- Landing and Braking Systems
- Engine Control
- Cabin Power Management
- Avionics

Power Systems for Aircrafts



*1MW is the maximum power for Boeing 787 MEA architecture

Actuator System for Conventional Aircrafts

1 AILERONS

2 FLAPS

3 SPOILERS

4 SLATS

5 RUDDER

6 ELEVATORS

7 LANDING AND BRAKING SYSTEM

8 HORIZONTAL AND VERTICAL STABILIZERS

HYDRAULIC

PNEUMATIC

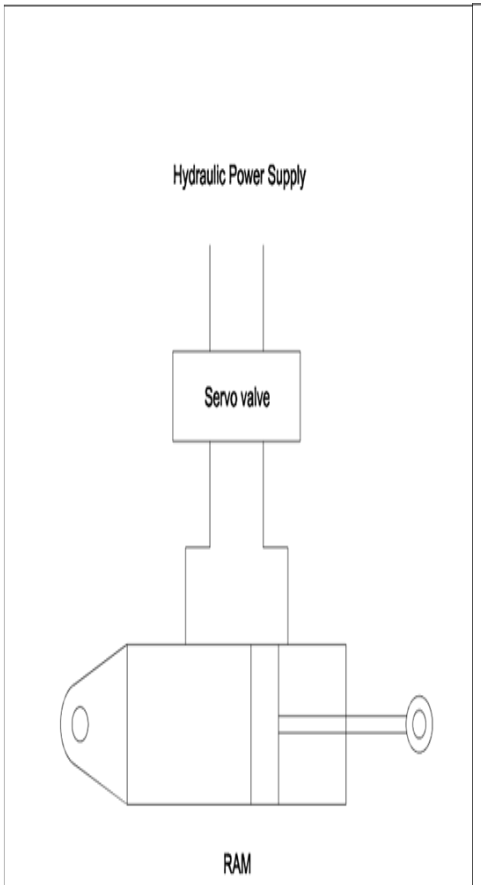
Transition of Actuators for MEA (Eg: A350)

1 AILERONS
2 FLAPS
3 SPOILERS
4 SLATS
5 RUDDER
6 ELEVATORS
7 LANDING AND BRAKING SYSTEM
8 HORIZONTAL AND VERTICAL STABILIZERS

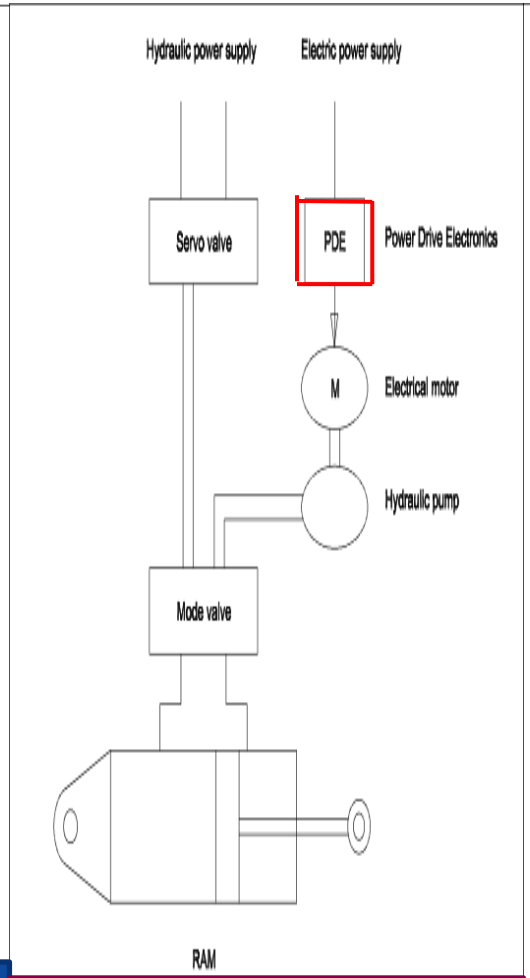
EHA
EBHA
EMA (E-THSA)
HYDRAULIC

- Actuator Configuration is a Combination of Hydraulic and Electrical Systems
- The Electric systems replaces the conventional Hydraulic and Pneumatic actuators along with its associated valves and control network.
- In general the estimated mass reduction for replacing a hydraulic actuator is approximately 220 lbs
- Provides the benefit of 2 additional seats . Results in overall increase in revenue

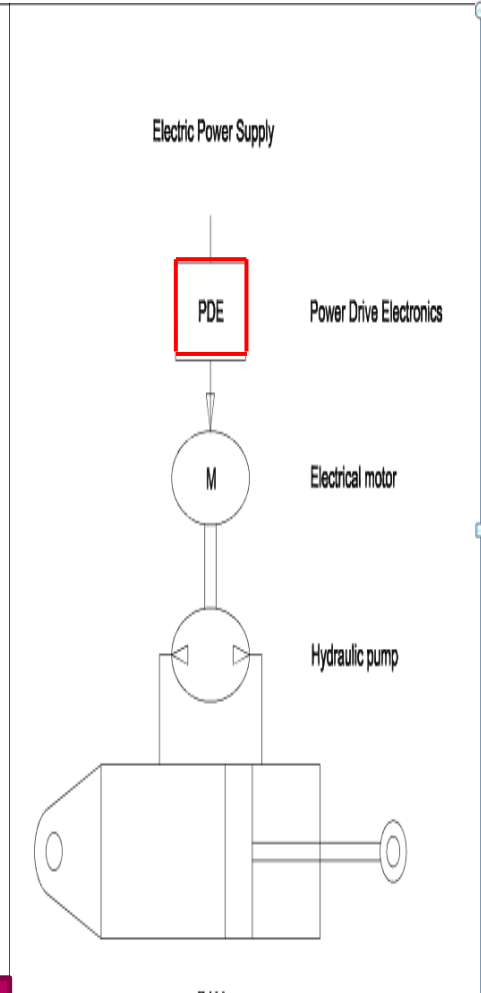
Actuator Design Evolution



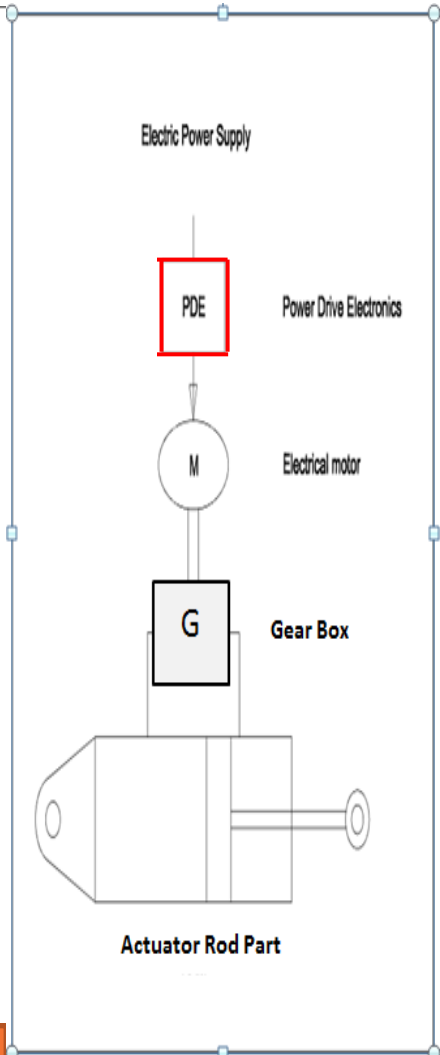
HYDRAULIC ACTUATOR



ELECTRIC BACK-UP HYDRAULIC ACTUATOR

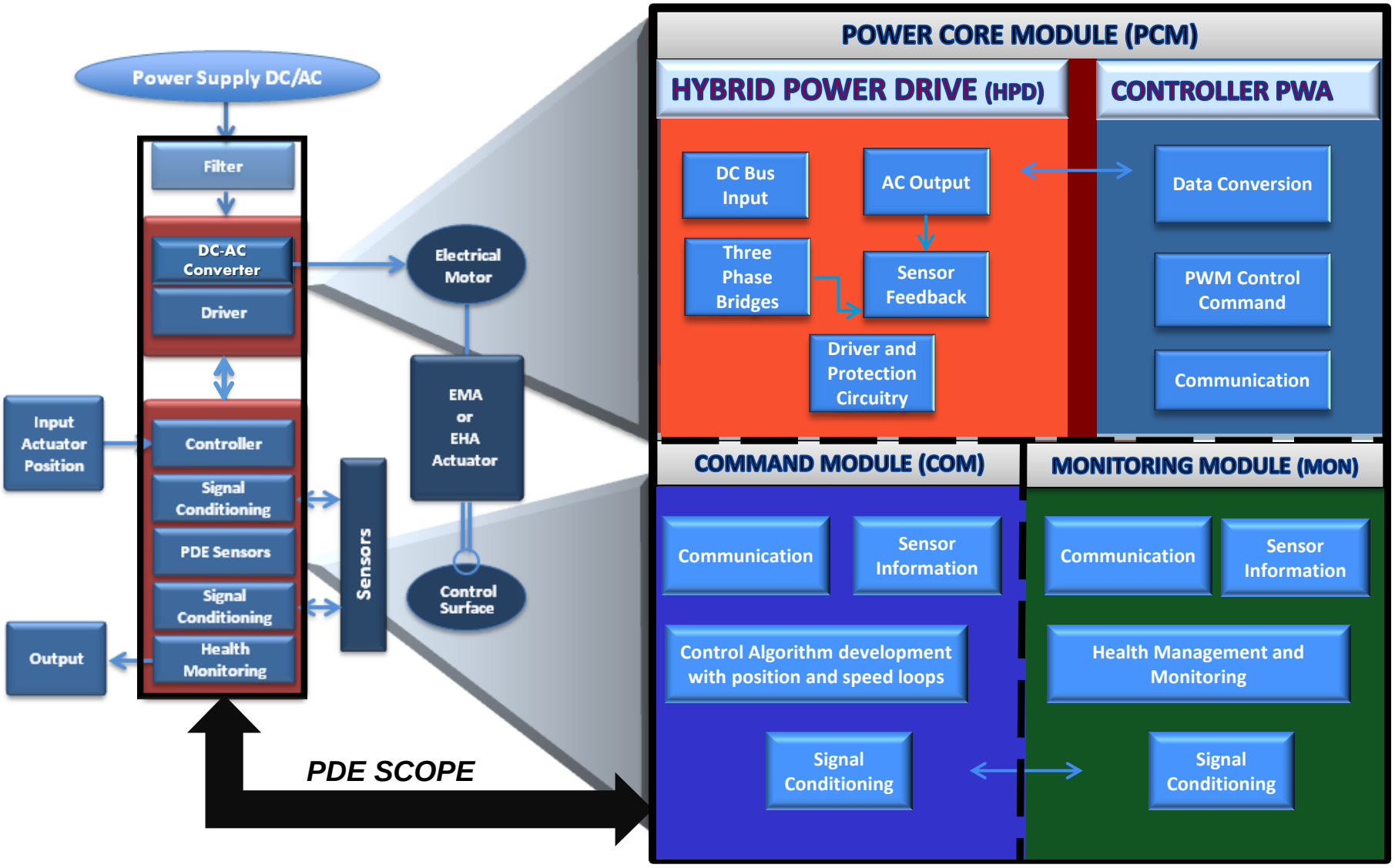


ELECTRIC HYDRAULIC ACTUATOR

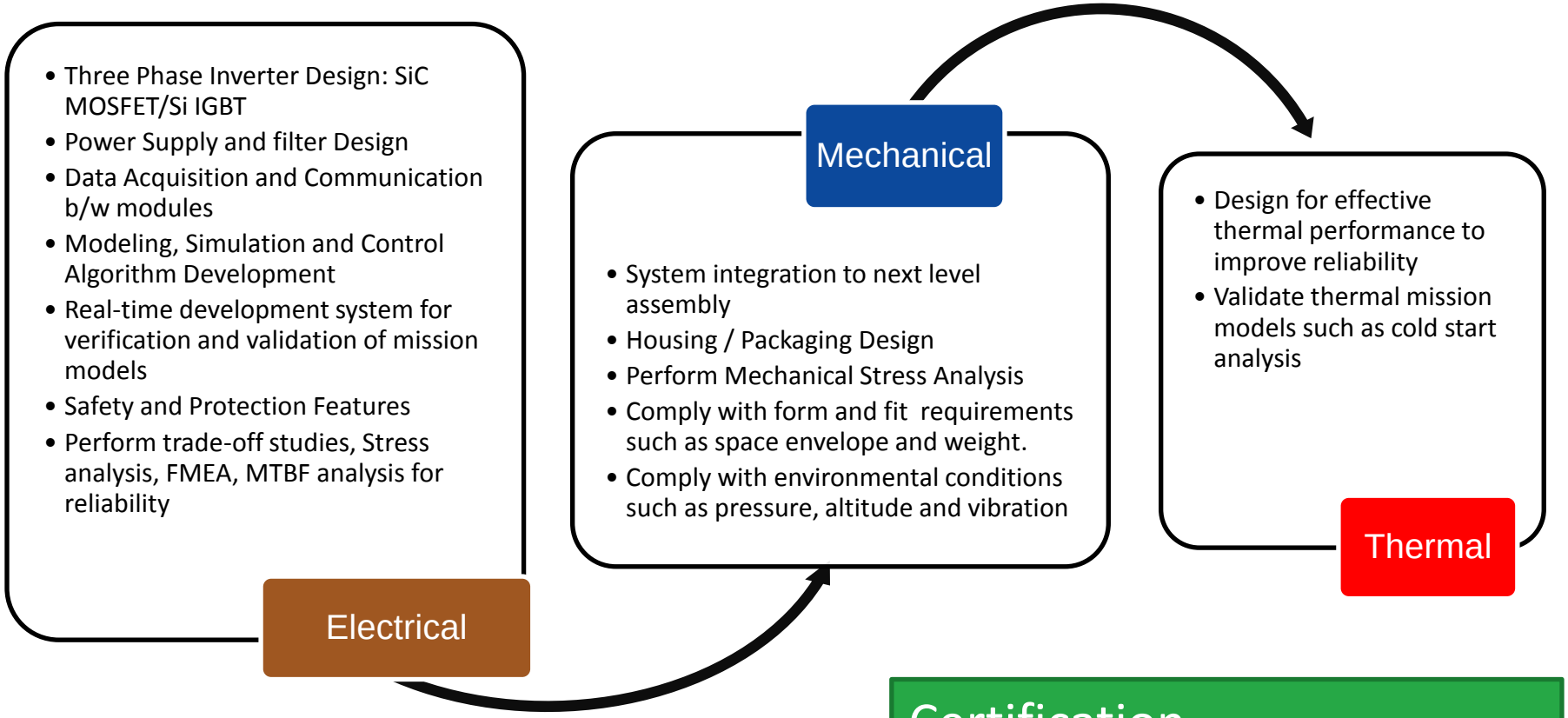


ELECTRO MECHANICAL ACTUATOR

Power Drive Electronics



Microsemi Scope of PDE Functions

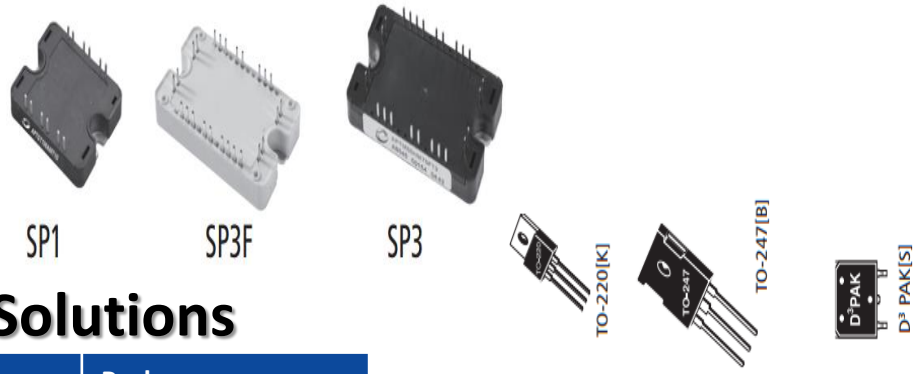


Certification

- Requirements Traceability
- DO-254 Certification of hardware design

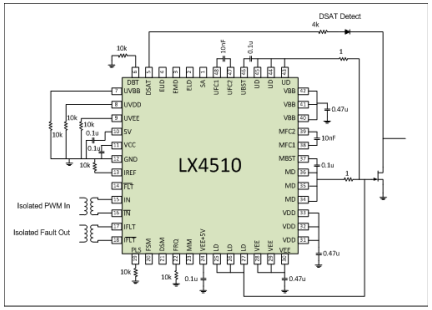
Portfolio for PDE – Electrical Power Conversion Components

- Requirements:
  - Minimum Peak Switch Current Rating: 20A
  - Minimum Switch Voltage Rating: 1200 V
  - Additional Power transistors for solenoid control
  - Gate Drivers for SiC MOSFETS / Si IGBTS



Microsemi Solutions

Type	Semiconductor	Part Number	Rating	Package
Power Modules	IGBT	**APTGT300A170D3G**	1700V, 300A	D3 (Single Phase Leg)
		APTGL40X120T3G	1200V, 40A	SP3 (3 Phase Bridge)
	MOSFET (with anti-parallel SiC schottky diode)	**APTMC170AM30CT1AG**	1700V, 80A, 30mΩ	SP1 (Single Phase Leg)
		APTMC120TAM17CTPAG	1200V, 100A, 17mΩ	SP6-P (3 Phase Leg)
Power Devices	SiC MOSFET	**APT40SM120B_S**	1200V, 40A, 80mΩ	TO-247 / D3
	Si IGBT	**APT85GR120L**	1200V, 85A	TO-264
	SiC Schottky	**APT30SCD120S**	1200V, 30A	D3

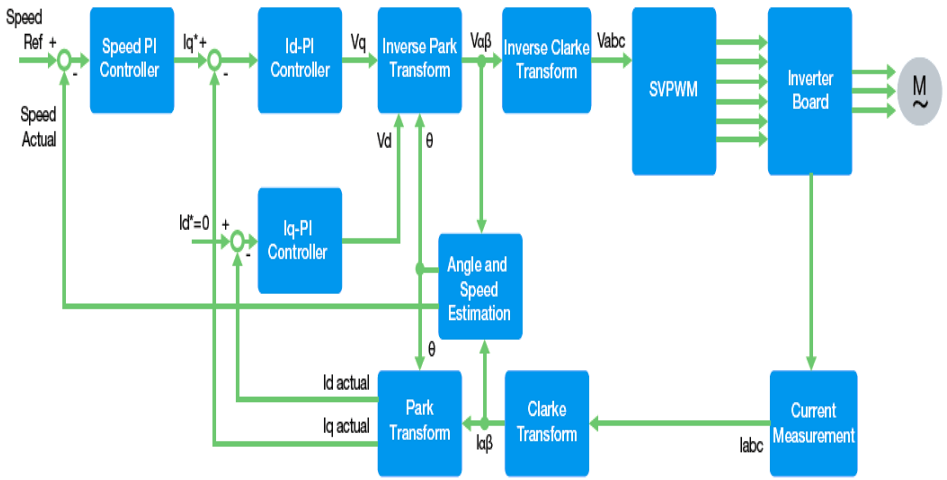


Gate Drivers: LX4510

- Suitable for high temperature operation up to 225°C
- Drives SiC transistors , JFETs, SJTs, MOSFETs and Si IGBTs
- Supports Galvanic Isolation, over current detection

Portfolio for PDE – Digital Control Components

- Requirements:
  - Control Algorithms and PWM generation for actuator motor control and health monitoring
  - High speed communication protocols such as LVDS
  - Immunity to failures due to atmospheric neutron radiation
  - Software and Hardware implementation. Requires DO-178 and DO-254 Certification



All Motor Control IP can be implemented in IGLOO2 Programmable Logic Fabric

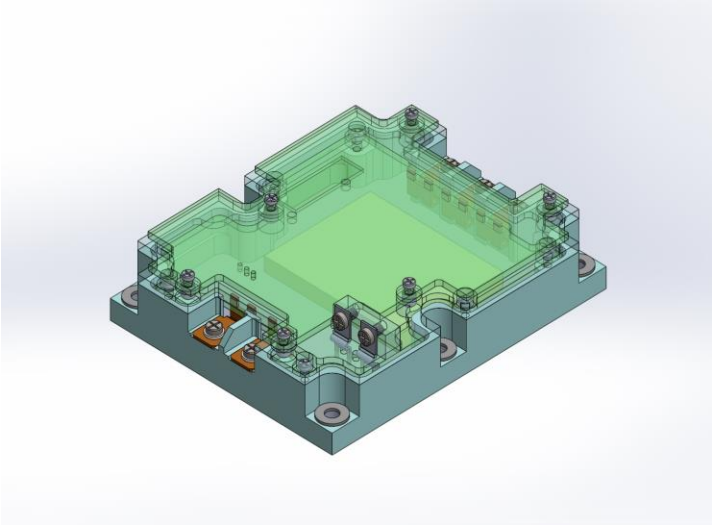
- **Microsemi Solutions**

- Highest number of GPIO and PCI compliant 3.3V I/O
- Up to 10X reduction in static power and up to 50% lower power than Competing FPGAs
- Only FPGA with SEU immune fabric to configuration failures due to atmospheric neutron radiation
- Extended temperature support (up to 125°C T_J)
- Microsemi currently proposes to use ProASIC3 on PCM design
- IGLOO2 is a compliant candidate to perform motor control for the COM/MON modules
- IP validation artifacts are available to assist with DO-254 certification
- Heritage in commercial aviation: **Airbus A380, Boeing 787 Dreamliner, Airbus A350 XWB**

Portfolio for PDE – Power Core Module (PCM)

- Requirements:
  - Power Rating: From 5 KVA to 50 KVA
  - Typical Operational temperature range: -55°C to 125°C
  - Minimum switching frequency: 10 kHz
  - Comply with mechanical and environmental requirements as per DO-160E
  - Provide detailed analysis and simulation/modeling with optimization of thermal and electric circuitry
  - Comply with form and fit using innovative packaging solutions.

- **Microsemi Solutions**



- Isolated and highly thermally conductive substrate with Aluminum wire bonding
- Speedgoat interface to validate the mission profiles using Hardware-in-the-Loop approach.
- Efficient circuit layout practices to minimize parasitics and optimize space.
- Reliability test capabilities: HALT and HASS.

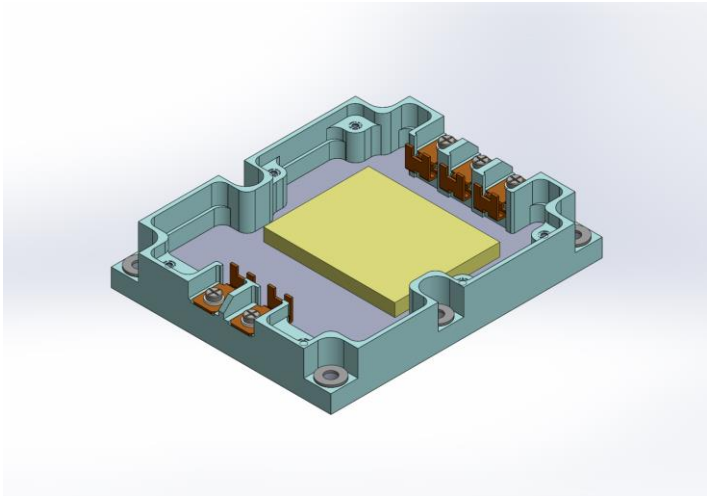
- The **PCM** comprises of two sub-systems:
  - **HPD**: Three half bridges embedded in the substrate with integrated Driver PWA
  - **Controller PWA:** comprising of A/Ds and FPGA circuits.
- Current design uses SiC power FETs to ensure maximum efficiency.
- Customization of module design based on requirements

Design Approach for PCM

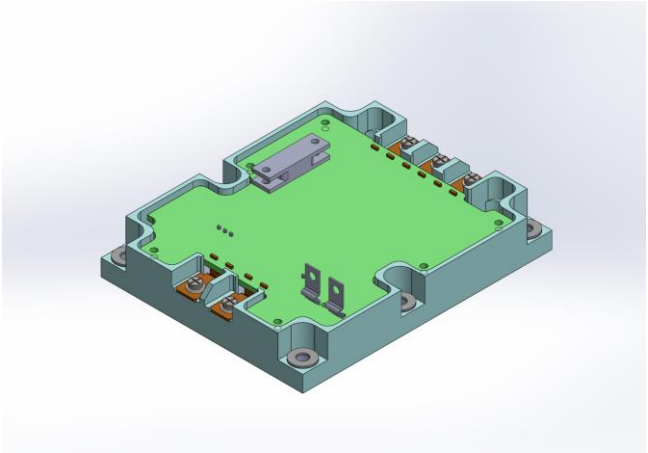
- **Hybrid Power Drive: Power Stage + Driver PWA**
  - **Power Stage**
    - Semiconductors : **SiC MOSFETs (APT40SM120) + SiC Schottky diodes (APT20SCD120)** (designed for 5KVA)
    - AlSiC baseplate provides substantial weight reduction with improved reliability and efficient heat transfer
    - Plastic package is used for housing. M3 Screw terminals for power connectors attached to the frame
    - Silicon gel is used for isolation of the power transistors on the substrate
  - **Driver Board:** Gate drivers from Infineon: **1EDI60N12AF .**
    - These gate drivers are chosen for their availability, compact size and integrated features such as galvanic isolation and simple interface
    - The driver board is mounted over the substrate. Input Power is routed from the driver board to the substrate through power pins
    - Can drive SiC MOSFETS and Si IGBTs. Common gate driver circuitry is implemented to facilitate design flexibility.
    - Power Transistors for solenoid drive (High Voltage). Same MOSFET and diode used in D3 package.
    - Hall Effect Sensors are used to measure the three phase current
    - Contains A/D and signal conditioning circuitry for data conversion
    - Layout is designed to minimize corona effects. PWB is conformal coated.
- **Power Core Module: HPD + Control PWA**
  - Controller board mounted over the driver board with an output signal connector to interface with the external unit.
  - ProASIC3 FPGA is used to perform data acquisition, communication and PWM generation

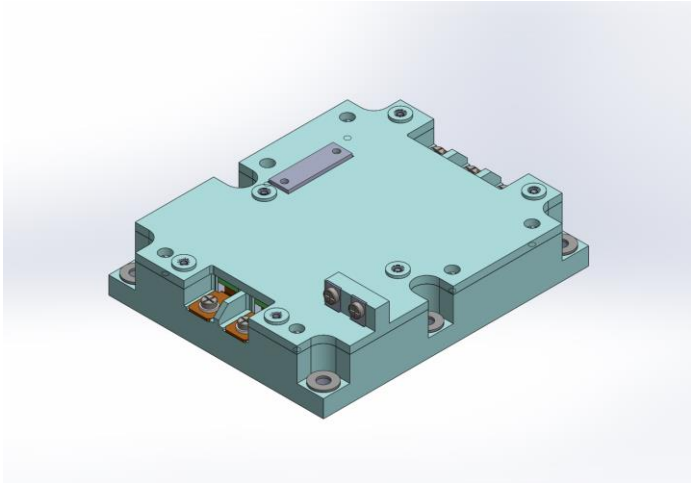
Power Core Module

1. Substrate View

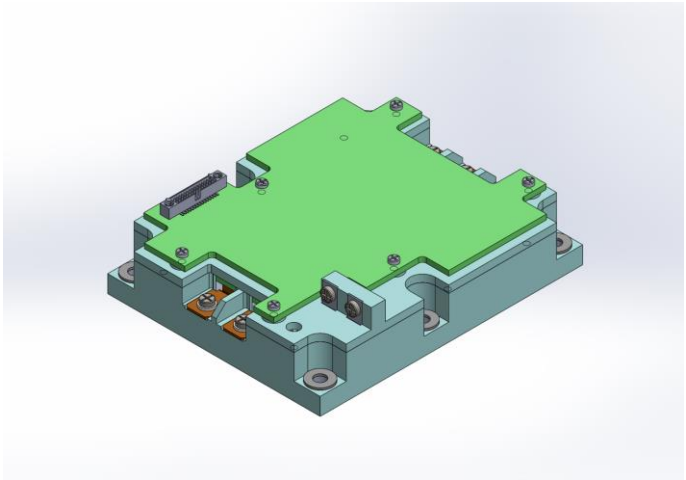


2. HPD view with Driver Board





3. HPD with cover

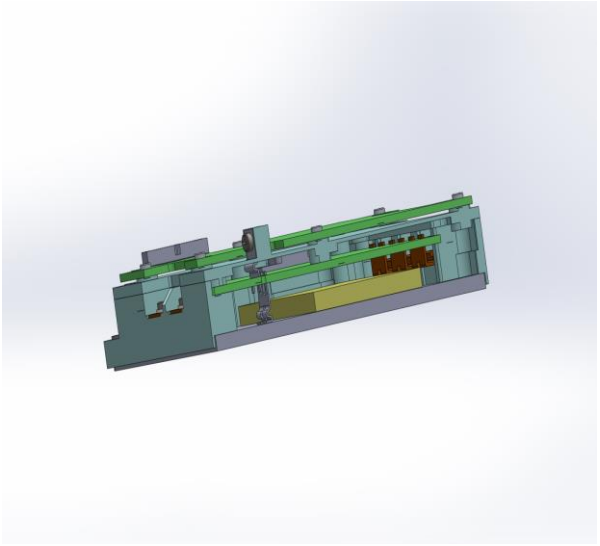


4. PCM with Controller PWA

Why Microsemi?

"Microsemi offers Flexible, Reliable and Cost effective solutions for the customer with a thorough understanding of the application and interface requirements between our module and the external environment."

Microsemi's Standard Module design for PCM offers excellent features in support of AIRBUS objectives for future PDE common module procurement



Flexibility and Customizability:

- The three levels of solutions offered by Microsemi i.e., **HPD and PCM** provides flexibility to integrate with the next level assembly.
- Offer SiC MOSFET or Si IGBT based power modules within the same package.
- Scalable power ratings starting at 5KVA.
- The module designs are suitable for other applications such as Power Generation and Distribution systems, SSPC, Fuel Pumps targeting motor drives.

Risk Mitigation:

- Dedicated to early discovery of issues impacting the development.
- Ensure suitable design measures to mitigate the impact of the risks at all levels.

Why Microsemi?

Reliability:

- Extensive testing (HALT, HASS) will be performed prior to production for the design module through the development stage.
- Analysis performed from lowest component levels to sub-system levels.
- Microsemi's wafer fabrication facility in Bend, Oregon is currently developing SiC technology and supplying products commercially. An extensive reliability assessment is being performed on SiC MOSFETs

Cost Effectiveness:

- Optimized assembly balancing cost, weight and volume against a need to fit within the next higher assembly space envelope

Extensive Design Analysis and reports: Perform an array of tests to ensure qualification of the unit with supported documentation

- Electrical and Mechanical Stress, Thermal , Reliability (MTBF), FMECA, Verification and Validation reports, Qualification and Acceptance test reports.

Microsemi considers that our design solutions for HPD, PCM and PDE are the ultimate value offerings from our "Tier 2" perspective. The products will be fully qualified to meet the requirements and will allow compliant integration into "Tier1" Electronic modules.

Microsemi

Thank You