New Energy-Saving Technology

Energy Efficient Hydraulics and Pneumatics Conference

28 November 2012

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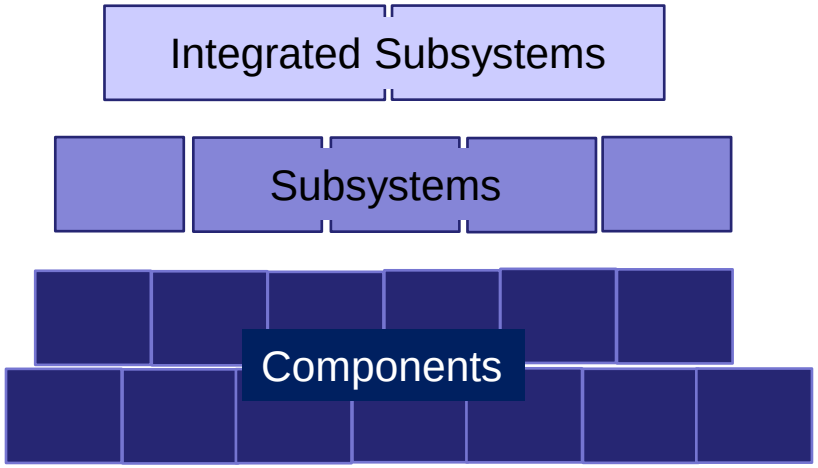
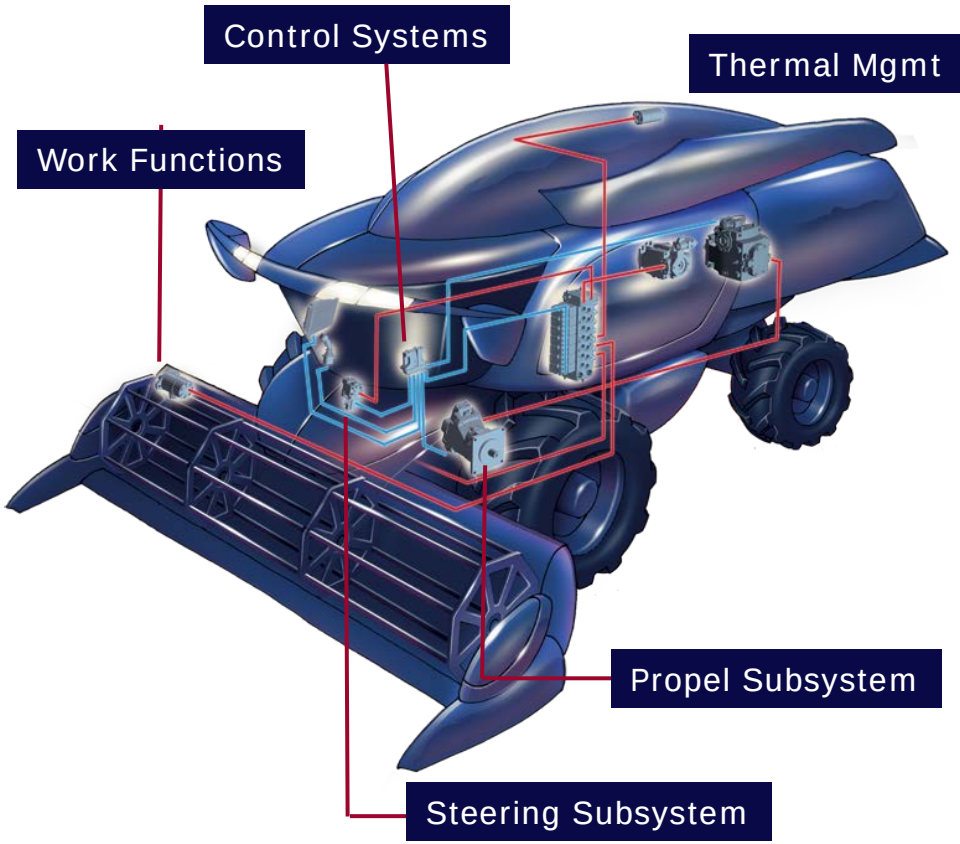
Energy Efficiency – Lots of Opportunity!

3 layers for machine efficiency improvements



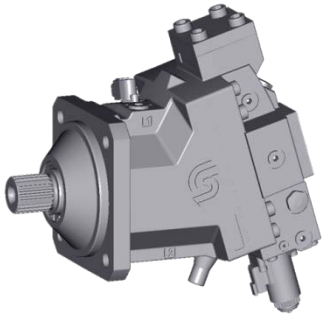


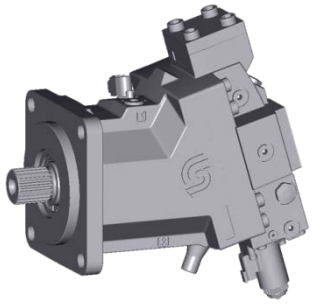
Component Technology

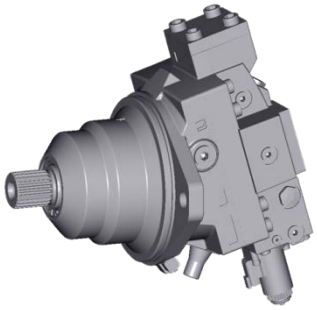
Modern Piston Pumps/Motors

Efficiency Elements

- Major update of ’80s technology driven by increasing customer focus on efficiency and controllability
- Parasitic loss reductions in charge circuit, controls, and kits
- Enabler for efficient subsystem solutions thru electronic interface, onboard electronics







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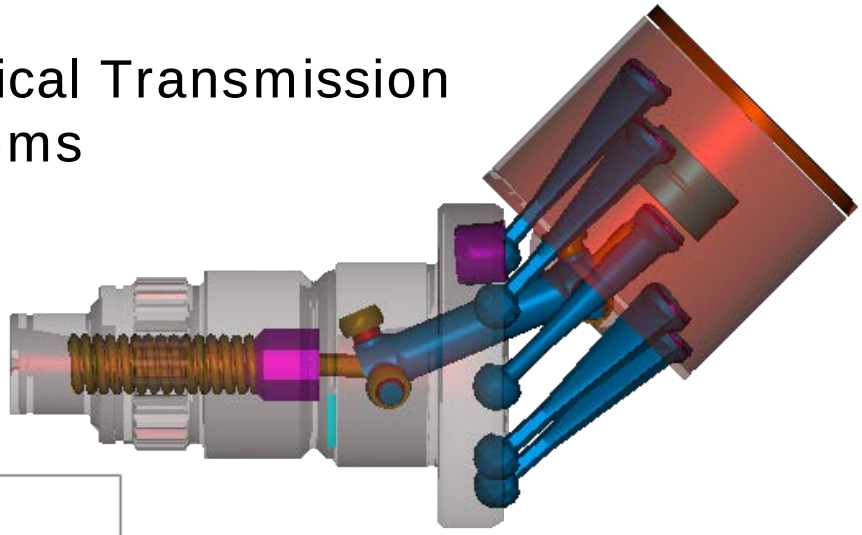
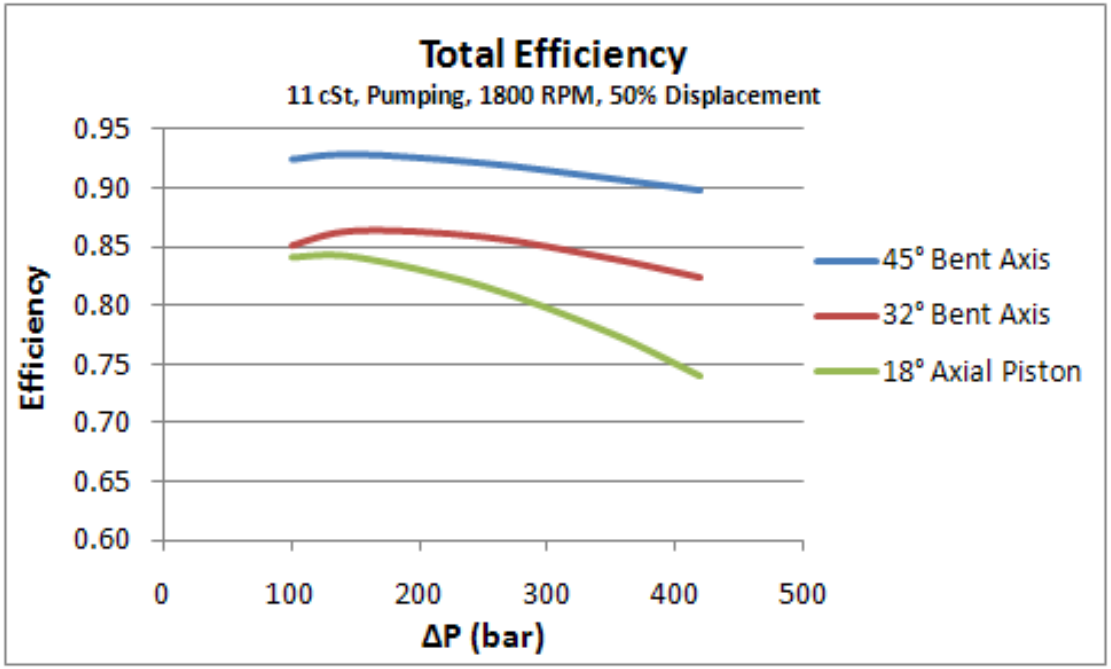
45° Rotating Kit Technology

- Critical Enabler for Hydro-Mechanical Transmission (HMT) and Hydraulic Hybrid Systems
- Designed for Best Efficiency
  - Lamellar piston seal rings – low leakage
  - Dry case operation – low torque loss
  - Large angle (45 deg) – increased torque without increased leakage





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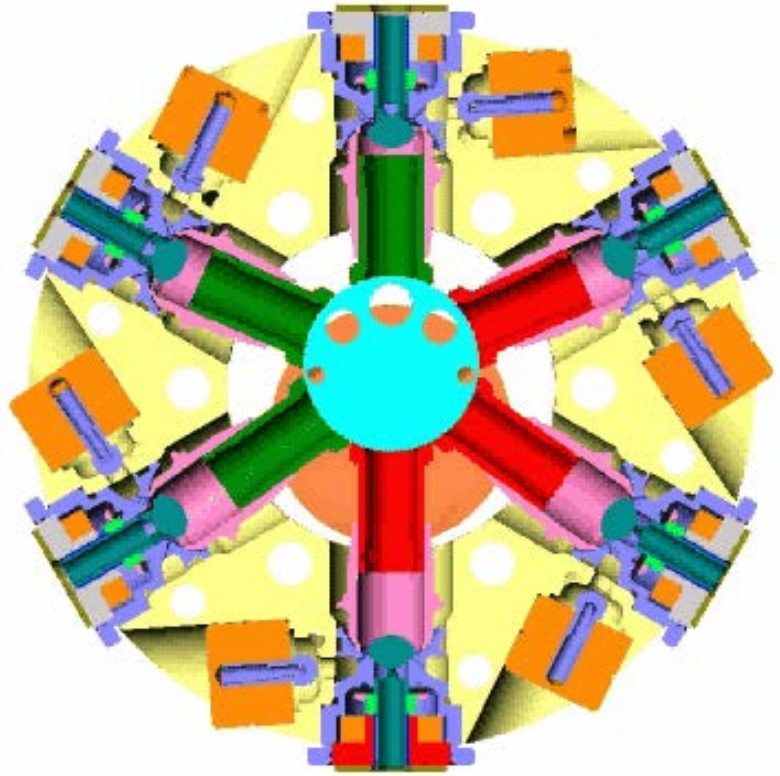
Digital Displacement® Pumps and Motors

- Digital Displacement® Technology first invented in early ’90s at Artemis Intelligent Power
- Precise digital control of each pump displacement chambers individually
- Very low parasitic losses
- Manifolding of individual chamber control enables new energy-efficient sub-system architectures



ARTEMIS INTELLIGENT POWER LTD

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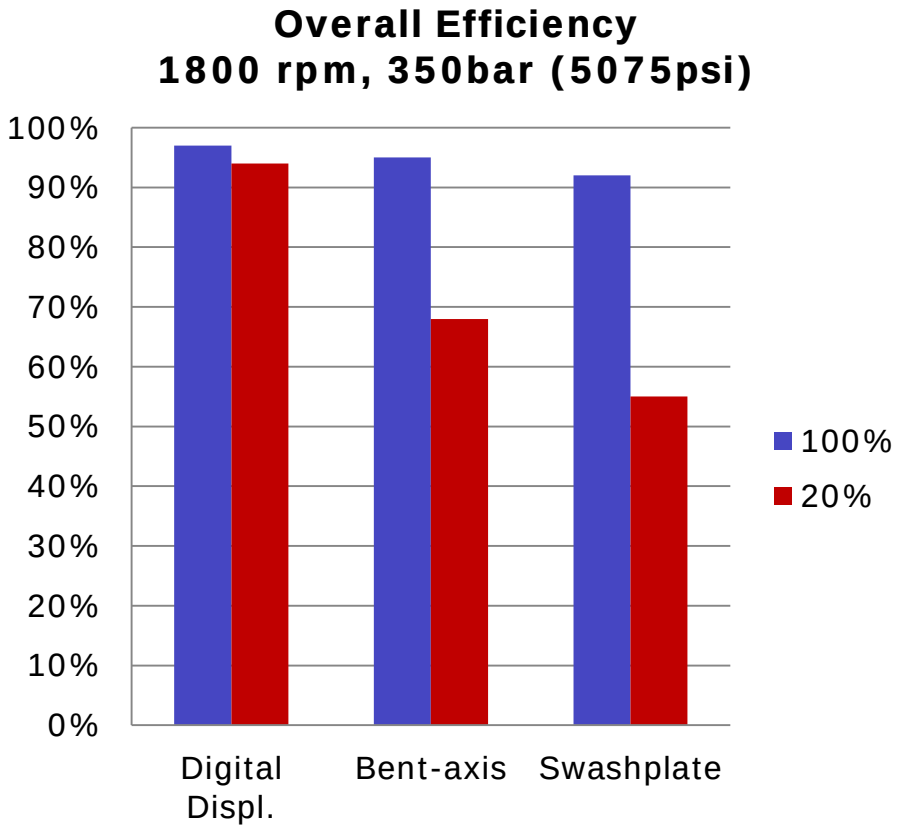
Digital Displacement® Pump

Power Loss Reduction Example

- Example: Benefit from low losses
  - At 2000 rpm
  - At 20% displacement
  - At 350 bar (5075 psi)
  - A 100cc pump
  - Consumes ~**17 kW (23HP) less** than a traditional swashplate pump



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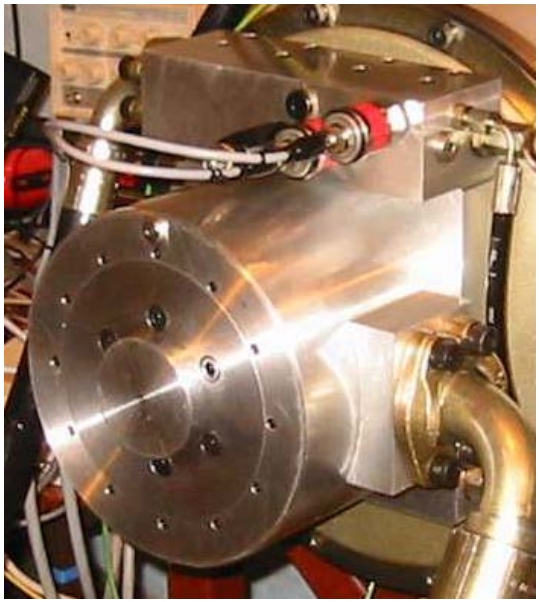
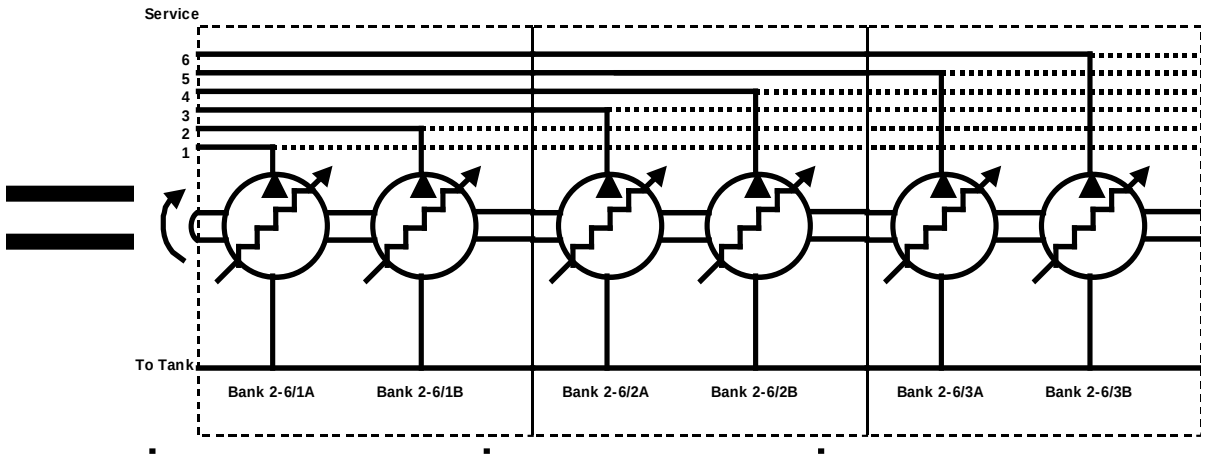
Systems Technology

Integrated Digital Subsystems

Hydraulic Power on Demand



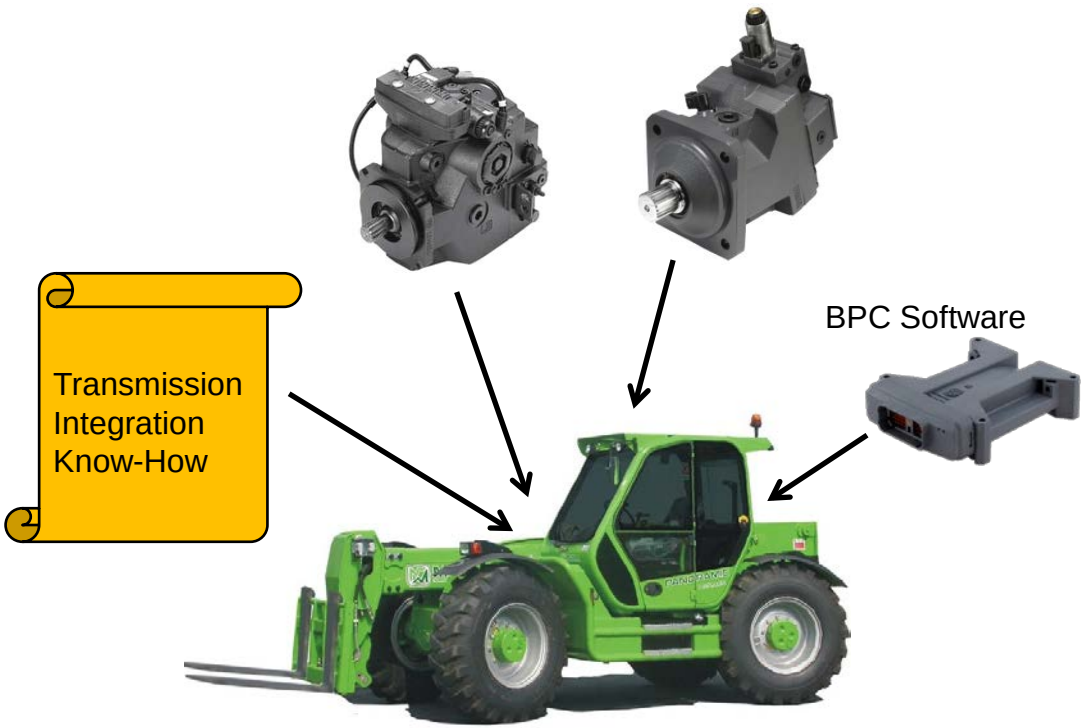


- Each service can be at different flow and pressure (independent)
- Fast response – total installed pump capacity can be dynamically allocated (combined) without interruption
- “Hydraulic Power on Demand”

Hydraulics-Engine Integration

Best-Point Control

- **What is Best-Point Control?**
  - Management of the hydrostatic drive train incl. engine speed command to achieve the “Best” overall efficiency



- **Benefits**
  - Fuel consumption reduction
  - Emissions reduction
  - Noise reduction
  - Operating improvement

“The driver still commands the vehicle movements, but BPC controls the engine speed and drive train ratio”

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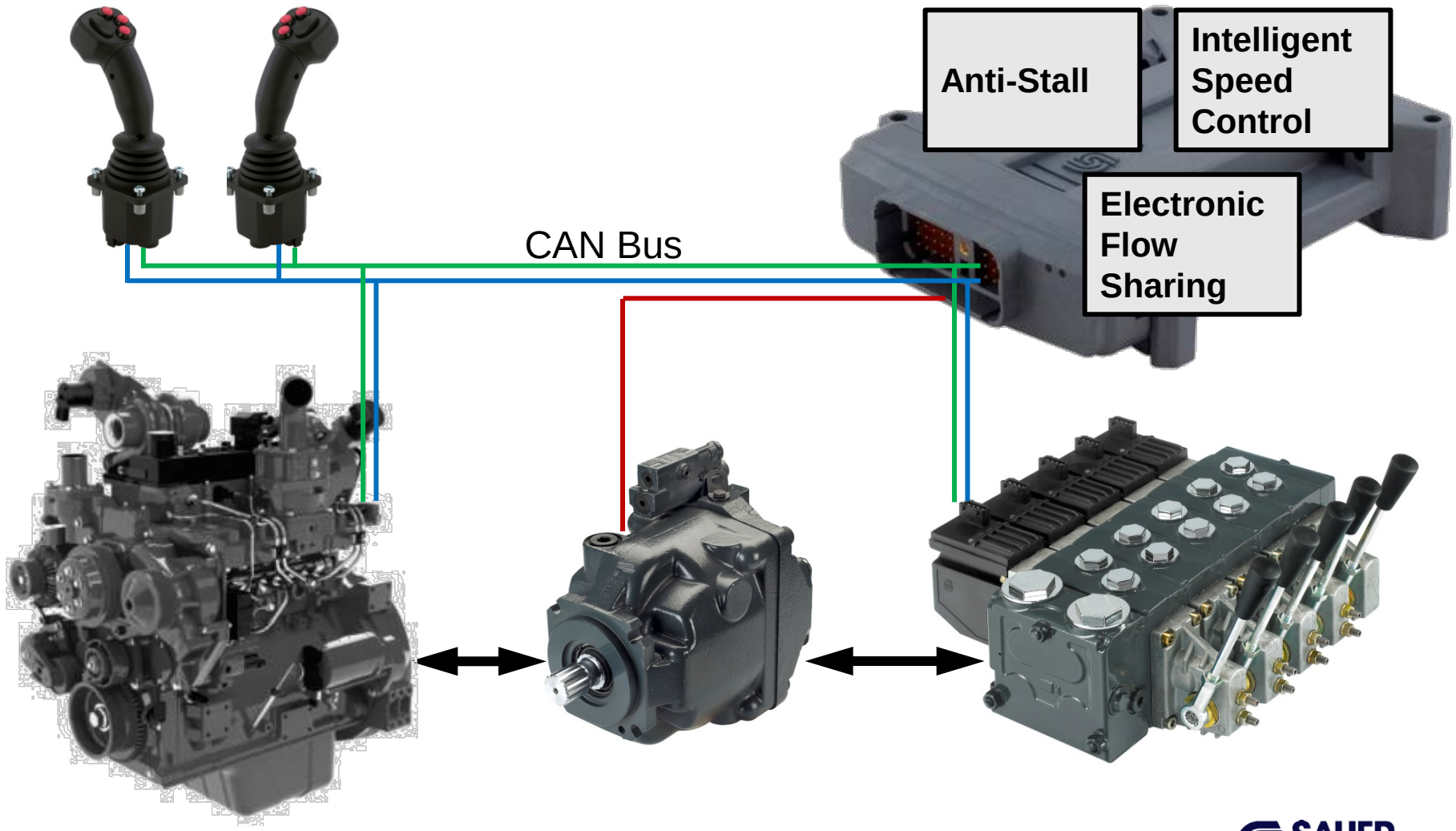
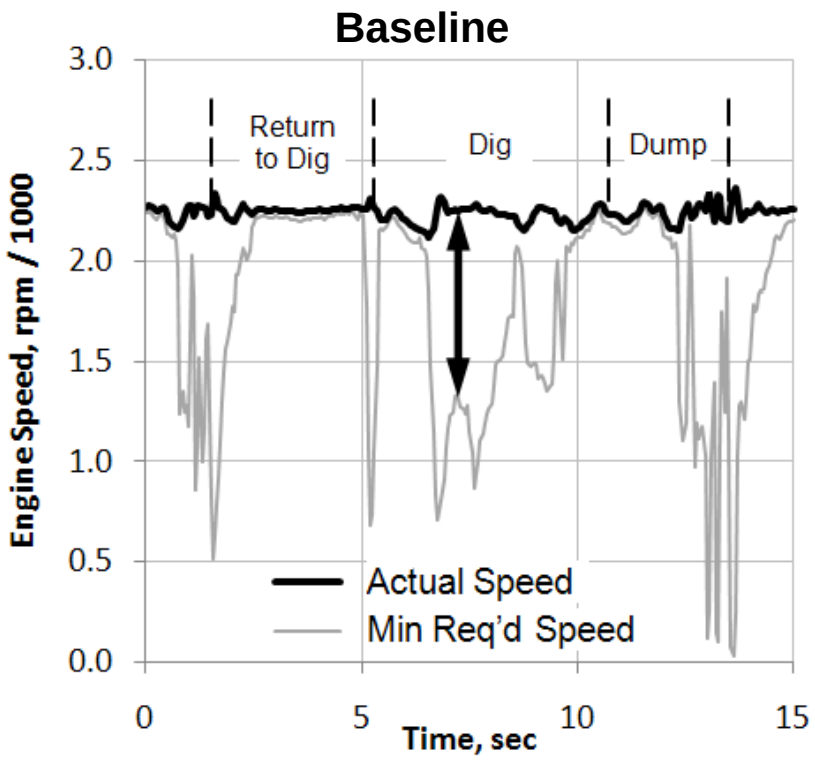
Hydraulics–Engine Integration

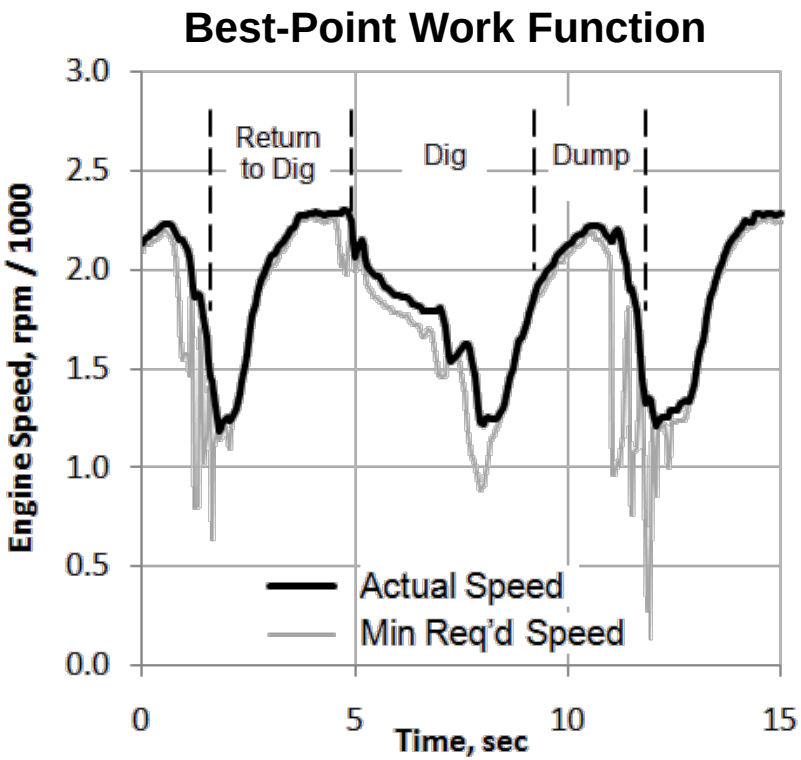
Best-Point Work Function System



Best-Point Work Function

Improved Machine Efficiency Thru Intelligent Control





Benefits: fuel reduction (15-20%) with no compromise in productivity
potential engine downsizing by improved limit management

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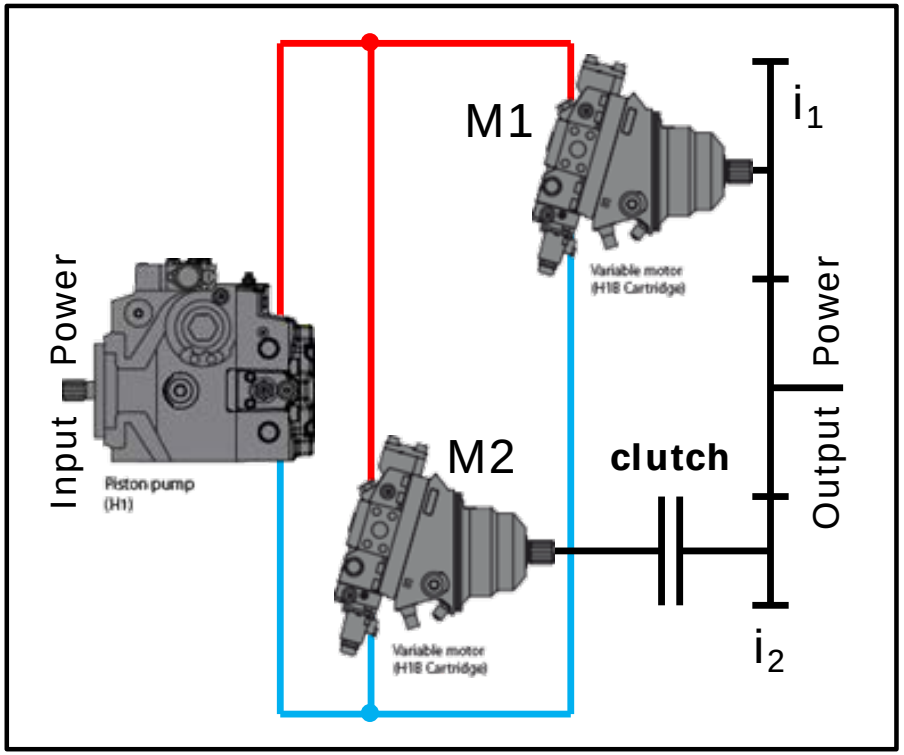
2-Motor Transmission (2MT)

→ Design & Components



- 1 pump & 2 motors operate in two ranges:
  - LOW: 2 active Motors
  - HIGH: 1 active Motor (M1)
- Motor **M1** for high travel speed
- Motor **M2** for high tractive effort
- Mode shift w/o gap in tractive effort for seamless acceleration
- Motor M2 de-clutched:
  - Reduced power loss in the complete system
  - Motor M2 over-speed protection
  - Increased final drive ratio i_2 for motor M2 possible
  - Low losses in open clutch required

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Summary

- Off-highway machines can be best optimized for energy efficiency, without losing performance, thru
  - Modern hydraulic components with minimal parasitic losses across the operational cycle
  - Subsystems that only deliver hydraulic power when you need it
  - Integrated Subsystems that dynamically adjust all power producing and transmitting components to best-point system operating positions