Electric Drives
Potentials on Tractors and Implements

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Agenda

• John Deere E-Premium
• Tractor / Implement Electrification
• Design Criteria
• Summary & Vision
E-Premium 7430 and 7530

Intro at Agritechnica in 2007
First Electrification in series production within Ag
Catalyst for Electrification within Ag

Awards:
Agritechnika Gold Medal
FIMA Gold Medal
Royal Show Award
6030 E-Premium: vehicle features

- Flywheel mount 20kW generator
- High power 14 V system, 300amps cont.
- Full reversible radiator fan drive (screen cleaning)
- Mobile power generation
  - utility tools
  - emergency power supply
  - 230V 1-phase / 400V 3-phase
- Auxiliary power management to reduce parasitic power losses
- Engine rpm independant cab cooling
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6030 E-Premium: vehicle features

- 10 HP additional engine boost power
- Increased power density
- Optimized acceleration

Dedicated engine boost curve
- Starts at 1250rpm
- Extra high capacity cooling system
- Optimized fuel economy
Electrification of Auxiliaries: What’s next?
A Trend?

Innovative... From the Inside Out
Diesel-Electric Hybrid Technology

- Modular electric air conditioning system
- Larger cab with ergonomic controls
- Exclusive center-post cab
- Single lift cylinder
- Grouped service points
- Cat® SystemOne™ undercarriage
- Dedicated steering pump
- Beltless engine
- Hydraulic demand fan
- Electro-hydraulics
- Cat C9.3 engine with ACERT™ technology

Agritechnika 2009
Vision: Next level of Electrification

Electric power for Implements

Targets:
- Enhanced plug-n-play
- Increased power density
- Controlled power distribution
- Reduced input costs
- Optimized implements, better output quality

Electrification: Control and Distribution of Power
A New Idea?

PORTABLE POWER
Gives you “highline” power wherever your tractor will go

STANDBY POWER
Provides stand-by power in case of highline outage

MOBILE POWER
Drive balers and other machines with electric power

IH Electrall is a high-capacity electric generator that you can mount on your Farmall 450. It furnishes 115-volt and 208-volt single-phase service and 208-volt three-phase service. Output rating is 12.5 kva. This capacity lets you use your time-saving electric tools, and motors up to 10 hp, wherever your tractor will go; powers your house and barn equipment during highline failures; and drives a McCormick 55 baler, or other machines equipped with Electrall motor.
Farmall 400, 1954
… should we really continue this way?
... or is there a vision?
Electric Power Interfaces: A complement

**Electric Power** (e.g. 2x 150kW), integr. communication and 14V supply for controller on implement

**Hydraulic Power** (e.g. 40kW)

**Modes:**
- Implement sends demands
  - Tractor sets voltage / frequency
- Tractor provides constant U/f
  - Implement integrated power electronics
  - ...

**ISOBUS**
Tractor/Implement Electrification Architectures

„traditional“ tractors: Implement integrated generator Control and Distribution on Implement

Compatibility! Standardization!

most common case: Tractor integrated power generation Control and Distribution on Implement
Implement Example – Sprayer

Pneumatic Planter

12V metering drive

Hydr. Fan Drive

Hydraulic Pump

Source: N. Rauch: Mit elektrischen Antrieben Traktor-Geräte Kombinationen optimieren, VDI Profi Tagung, Feb. 2010
Rauch EDR fertilizer spreader

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Rauch EDR fertilizer spreader

Best efficiency with optimum control

Source: N. Rauch: Mit elektrischen Antrieben Traktor-Gerate Kombinationen optimieren, VDI Profi Tagung, Feb. 2010
Design Criteria

Voltage level
- power level to be considered
- technology from industrial automation
- components from automotive applications

Safety
- to be ensured during design, manufacturing, operation & service
- safety by system design
- system design has to avoid need for educated personal in service
Design Criteria: Voltage Level

- Costs for power electronics driven by current level
- same relations apply from 50…1000VAC (75…1500VDC)
- 400/480VAC common in industry/on farms
- e.g. 100kW @ 480VAC: 50A; 6mm²...10mm²
- Automotive e.g.: 300VDC (Prius 2002) to 700VDC (Lexus 2009)
Design Criteria: Automotive target costs

Automotive Industry:

Electric Propulsion System with a 15-year life capable of delivering at least 55 kW for 18 seconds and 30 kW continuous at a system cost of $12/kW peak by 2015.*

Susan Rogers, Manager Vehicle Technologies
Program: Energy Efficiency and Renewable Energy
U.S. Department of Energy
Feb 28, 2008
Design Criteria: Automotive target costs

Automotive Industry:

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<tr>
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<th>Power Electronics</th>
<th>Motor</th>
<th>Traction Drive System</th>
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<td>Targets</td>
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<td>3.3 14.1 13.4</td>
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*Traction Drive System Efficiency Target is for 10% - 100% speed @ 20% of Rated Torque*

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Summary & Vision

Electric drives have entered the arena of Ag machinery

• Tractor
  • Engine Auxiliaries
  • Traction Drives

• Implement
  • Control and Distribution
  • New Implement Topologies (compare to industrial automation)
  • Optimized attachment, plug&play
  • Enhancement to ISOBUS and Automation
Summary & Vision

- **Tractor/implement system electrification**
  - Technology transfer from automation industry
  - Agricultural System Engineering will apply technology to optimize processes and reduce input costs
  - Obvious system level benefits of electric drives will allow new types of machinery
  - For Ag a standardized interface is one key element for success
  - Mitigation scenarios have to be provided for existing equipment
  - The ideas for system-level opportunities in combination with automation, navigation and energy storage systems