Electric drives in agricultural machinery
An approach from the tractor side

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Agenda

• Introduction
• Motivation
• History of electric drives in agriculture
• Tractor electrification
• Tractor - Implement electrification
• Summary & Vision
Motivation – Why higher voltage on agricultural tractors?

- Optimized controllability of power flows across agricultural machines and between machines
- Generate sufficient electrical power
- Reduced parasitic loads caused by engine auxiliaries to improve complete machine efficiency
- Increased flexibility in arrangement of components
- Increase productivity and operator comfort
From the October 23, 1937

TWO-WAY ELECTRIC PLOW IN USE IN SOVIET RUSSIA

The large hydroelectric plan on the Dnieper River in Russia’s Dnepropetrovsk province makes it possible for them to use electric farm equipment like the two-way plow shown on the front cover of this week’s Science News Letter.

No tractor is attached to the plow, which can reverse and travel in either direction. It is particularly useful on large areas of flat ground without rock like that on which the implement is pictured.

Source: http://www.sciencenews.org/
1954

**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.

(Above) When the power line fails, just plug in Electrall to prevent financial loss and inconvenience. It supplies power to keep the farm stand fully electrified.

(Below) Electrall powered baler is started and stopped by an on-off switch. Electrall motor is completely enclosed and waterproof, readily transferred to other jobs.
1998

Eltrac

• E CVT concept
• Control units located on the roof

Source: http://www.eltrac.de/
2000

MELA

- E-CVT functionality
- Providing DC to the implement
- Electric driven Auxiliaries

Source: A. Szajek, Motivation und Konzepte zum Einsatz elektrischer Antriebstechnik im Ackerschlepper am Beispiel MELA, Tagung Hybridantriebe für mobile Arbeitsmaschinen, Karlsruhe 2007
2009

ZF Terra+

- Drive train mounted Generator
- 50 kW or 70 kW rated power

Source: ZF Press Kit Agritechnica 2009
2009

John Deere
Infinite Variable PTO

- Diesel engine speed independent PTO speed
- Change of PTO rotation direction
- Generating electric power for further consumers

Source: Gugel R., John Deere, Infinitely variable PTO transmission, VDI Congress, Transmissions in Vehicles, Friedrichshafen 2010
2009

Belarus Tractor 3023

• Prototype at Agritechnica 2009
• 220 kW diesel engine
• 172 kW generator
• diesel-electric drive train
• electrically driven front PTO

Source: www.landwirt.com; www.farmphoto.com; www.fwi.co.uk
John Deere E Premium 7530
Crankshaft Generator

Technical Data
480V 3~
Power: 20kW
Water cooled
AC Induction machine
Fan Drive

Technical Data

Fan motor
- Reversible
- 480 V 3~
- Power: 10 kW
- Air cooled

Air compressor
- electro-magnetic clutch (12V)
A/C Compressor

Technical Data

Power: 5 kW
Liquid Coolant cooled
IP67
External Power Supply

**Technical Data**

- 400 V 3~
- 230 V 1~
- CEECON Connector
- Max. Power 5 kW
Power Electronic Devices

**Technical Data**

- 700 V DC Link Voltage
- DC/DC Converter 4.2 kW
- Water Cooled
Power Characteristic Comparison
E Premium – Premium Tractor

7530 E Premium Intelligent Power Management aktiv

7530 Premium Intelligent Power Management inaktiv
7530 E Premium Intelligent Power Management inaktiv
E Premium tractor - Benefits for the operator

- Electrical power supply 230/400 V
- Reversible fan to clean front grille
- 7.5 kW additional intelligent power
- Additional power available at lower engine speed
- Improved AC system functionality
- Improved air brake system functionality
- Increased alternator power
- Reduced fuel consumption
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
Tractor – Implement electrification
The next level of electrification

Electric power for Implements

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

Electrification: Control and Distribution of Power
Implement example – Sprayer

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)

ISOBUS

Mech. Power (e.g. 150kW)

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

Electric drives have entered the arena of Ag machinery

➢ Tractor
  • Provide just the required power to auxiliary drives independent from the combustion engine speed
  • Intelligent control of auxiliary drives helps to reduce fuel consumption
  • Power available for electrical driven tools / implements

➢ Implement (tractor related items)
  • Optimized attachment, plug & play
  • Enhancement to ISOBUS and automation
Summary & Vision

➢ **Tractor/implement system electrification**

- Technology transfer from automation industry possible
- Agricultural System Engineering apply technology to optimize processes and reduce input costs
- Standardized interface is one key element for success
- Mitigation scenarios to be provided for existing equipment
This technology has the potential to become a new milestone in the history of agricultural equipment.
E Premium – Tractor line

- Models available: 7430; 7530
- Rated Engine Power*: 121 kW; 132 kW
- Engine Emission Level: TIER III
- Transmission: Infinite Variable Transmission
- A/C System in Base Configuration
- Max. Speed: 40 K or 50 K (optional)

* acc. 97/68 EC
## Introduction - Scope of this presentation

### In scope:
- Generating the power - Generator
- Managing the power - System/Controller
- Using the power - Engine Auxiliaries
- Provide electrical power to implements/attachments

### Out of scope:
- Traction Drives
- Implements
- Storage of electrical power – Fuel Cells