High availability in difficult application conditions
Rotational speed detection in mobile machines

Application example HOLMER exxact harvester

Thank you!

Parts of this presentation have been realized with the friendly support of

Company HOLMER Maschinenbau GmbH

Mr. Dr. Ing. Michael Gallmeier

Content

- **RHEINTACHO Messtechnik GmbH**
- **Rotational speed sensors – System overview, definition, function**
- **Detection possibilities – Target geometries, detection position**
- **Rotational speed sensors in mobile machines – Special requirements**
- **Application example HOLMER Terra Dos (beet harvester)**

Content

- **RHEINTACHO Messtechnik GmbH**
- Rotational speed sensors – System overview, definition, function
- Detection possibilities – Target geometries, detection position
- Rotational speed sensors in mobile machines – Special requirements
- Application example HOLMER Terra Dos (beet harvester)

RHEINTACHO

Facts

Established:	1901 in Cologne, Head office in Freiburg since 1922
Employees:	64 (2015)
Turnover:	11,4 Mio. € (2014)
Qualification:	Design, production and sales of systems for measurement, control, display and diagnostics of rotation speed

RHEINTACHO

Products

We design, manufacture and distribute:

- Speed sensors (pick up‘s)
- Stationary and portable stroboscopes with LED technology
- Stationary and portable stroboscopes with XENON technology
- Digital and mechanical hand-tachometers

- Switching devices and converters
- Electrical and mechanical indicators
- Tacho-generators
- Customized solutions

Content

- RHEINTACHO Messtechnik GmbH
- **Rotational speed sensor – System overview, definition, function**
- Detection possibilities - Target geometries, detection position
- Rotational speed sensors in mobile machines – Special requirements
- Application example HOLMER Terra Dos (beet harvester)

Rotational speed sensors

Overview, definition

Non-contact measurement of rotational speed impulses

Measuring principles

- Hall-effect
- Magneto-inductive
- Oscillatory
- Magneto-resistive

Rotational speed sensors

Overview, definition

Topic: Non-contact measurement of rotational speed impulses

Measuring principles

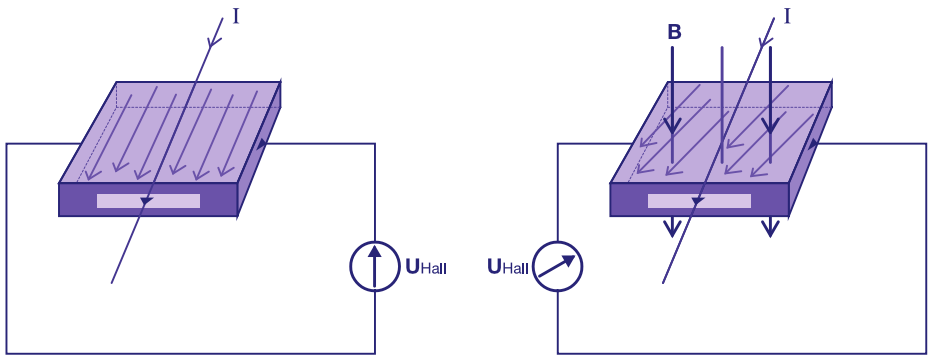
- **Hall-effect**
- Magneto-inductive
- Oscillatory
- Magneto-resistive

<< will not be considered in detail, since these are not in operation in described application

Rotational speed sensors

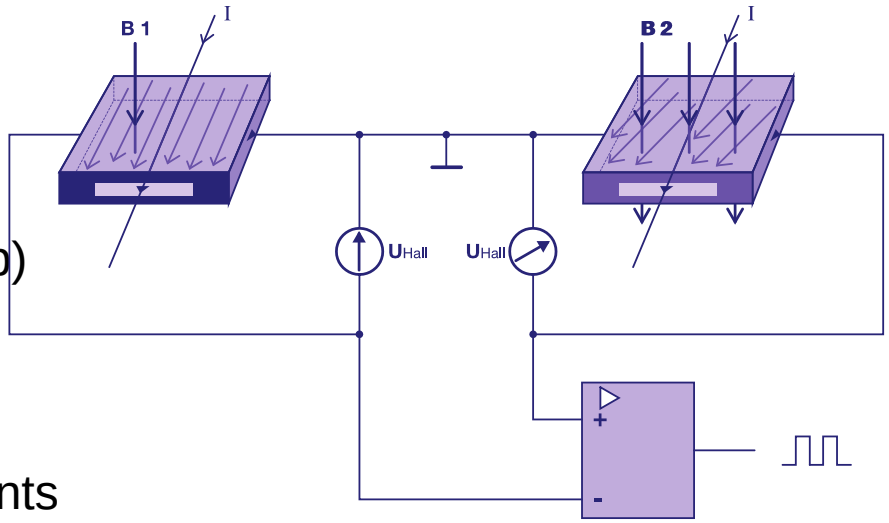
Hall-effect

- Named after the inventor Edwin Hall (USA) in 1879.
- Detects the movement of ferro-magnetic structures through changes in the magnetic flow.
- The sensor element is preloaded with a permanent magnet.
- A tooth or a gap moving past the sensor influence the magnetic field in different ways.
- The magnetic field changes are transformed into electrical values by the Hall IC.
- Output signal: **square waves** which represent the magnetic field change.



Rotational speed sensors

Differential-Hall

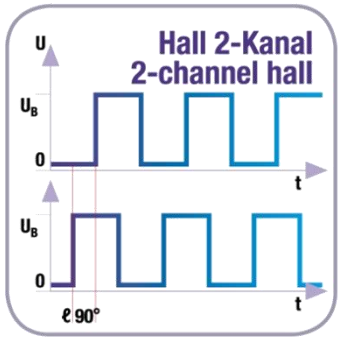


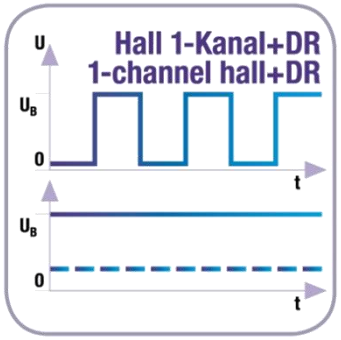
- 2 Hall Elements (integrated in one Chip)
- Shifted positioning (gap <> tooth)
- Signal difference from both Hall Elements
- By turning the target >> Polarity change
- Output signal: **square waves** which represent the magnetic field change

Rotational speed sensors

Detection of rotational direction

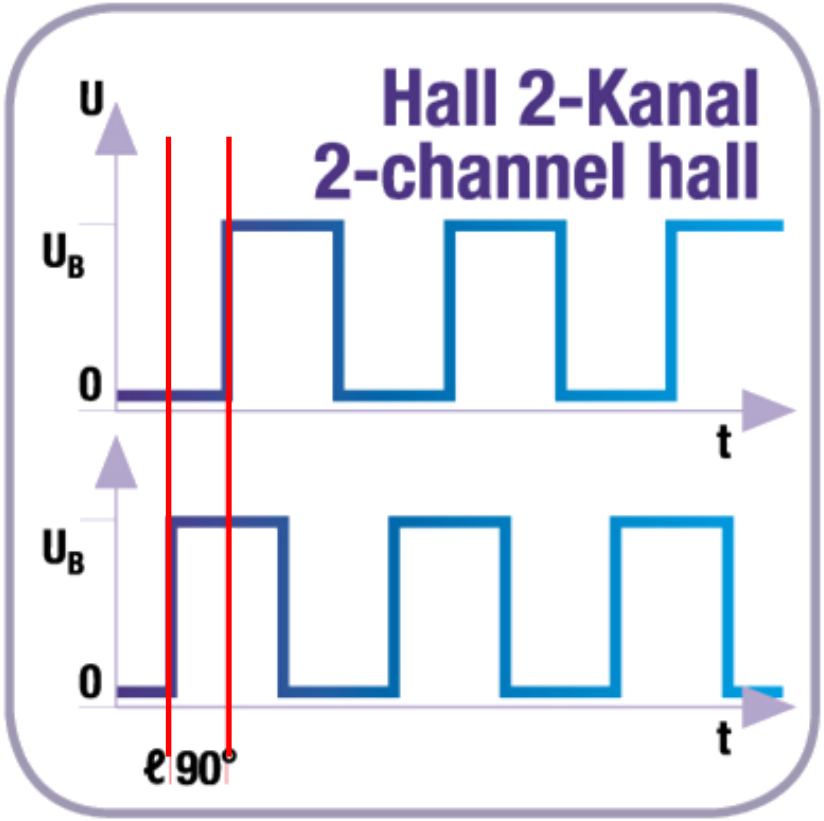
- 2 Hall Elements
- Shifted positioning (gap <> tooth)
- Output signal: 2 phase-shifted square signals which represent the magnetic field change of each Hall element.
- The **direction of rotation** is recognized by the order of the signals A > B or B > A.
- Special version:
  - Rotation signal as square signal
  - Direct rotational direction information

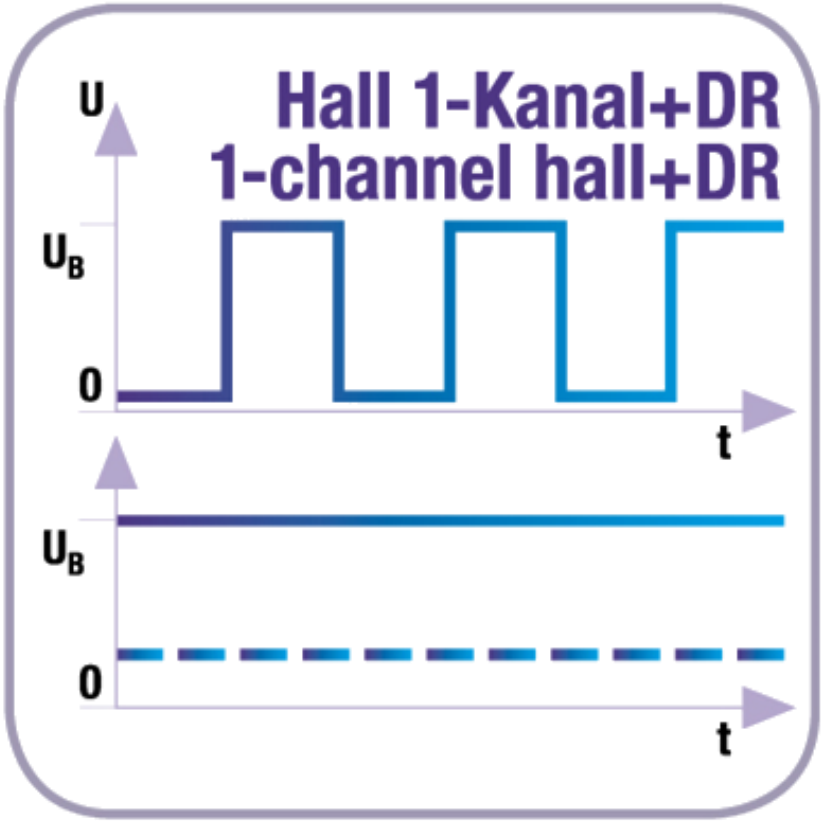




Rotational speed sensors

Detection of direction



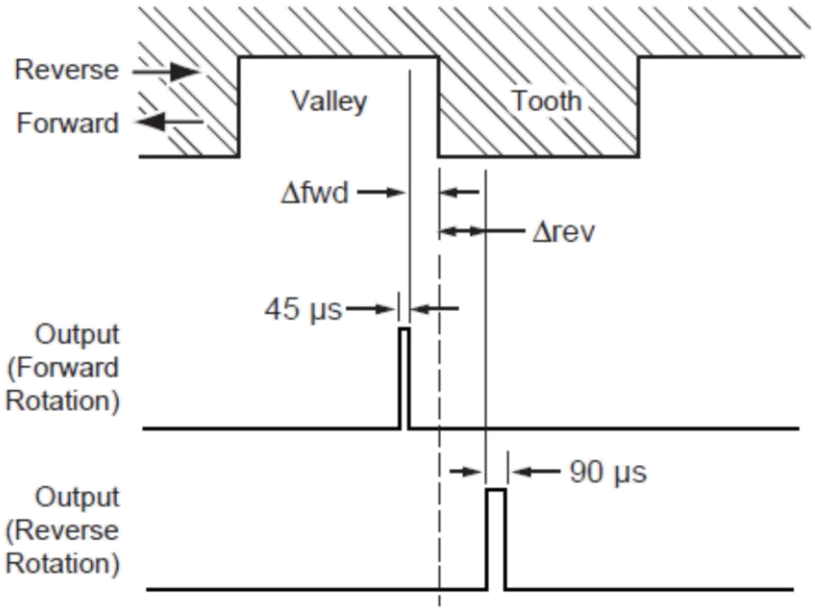


Rotational speed sensors

PWM - Signal

PWM = **P**ulse **w**ide **m**odulation Signal

Current signal



Advantages
- Highly reliable with 2-wire-design
- Detection of cable breaks included
- Good electromagnetic compatibility (EMC)

Disadvantages
- Frequency range limited
- Low application possibilities (and Knowhow) apart from automotive

Rotational speed sensors

System comparison

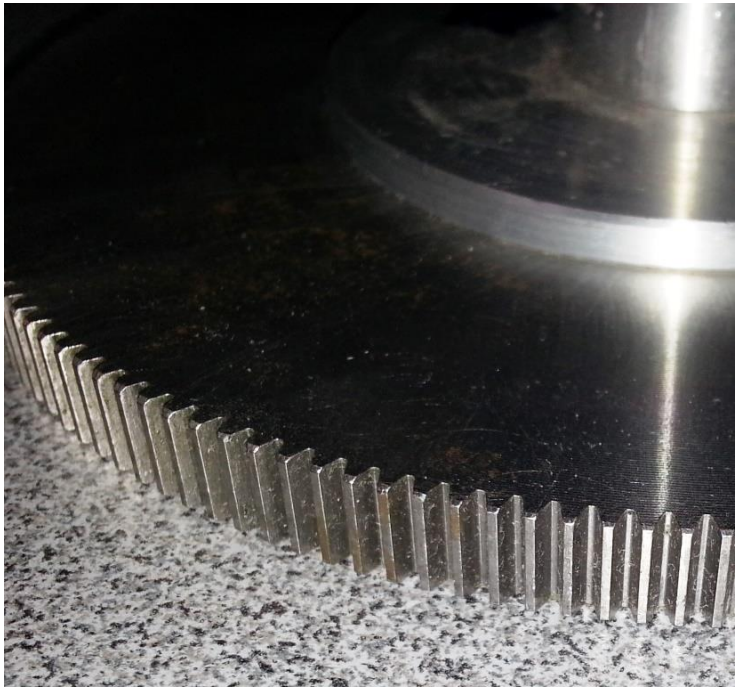
	Hall-effect	Differential-Hall
Frequency range	0 Hz - approx. 15 kHz	0 Hz – approx. 20 kHz
Scanning distance	0.5 mm – 3 mm	0.5 mm – 4 mm
Interference field sensitivity	higher	low
Max. operating temperature	150 °C	150 °C
Alignment required	no	yes

Content

- RHEINTACHO Messtechnik GmbH
- Rotational speed sensors – System overview, definition, function
- **Detection possibilities – Target geometries, detection position**
- Rotational speed sensors in mobile machines – Special requirements
- Application example HOLMER Terra Dos (beet harvester)

Detection possibilities

Target geometries



Detection possibilities

Target geometries

Basics to take into consideration:

The finer the structures, the:

+ higher the resolution

- lower the scanning distance

Measuring unit >> Module (the finer the structure, the smaller this value is)

Formula: The **module** *m* is a measurement for the size of the teeth of gears. It is defined as the quotient of the gear pitch p (the distance between 2 adjacent teeth) and *π (Pi)*: $m = \frac{p}{\pi}$

Detection possibilities

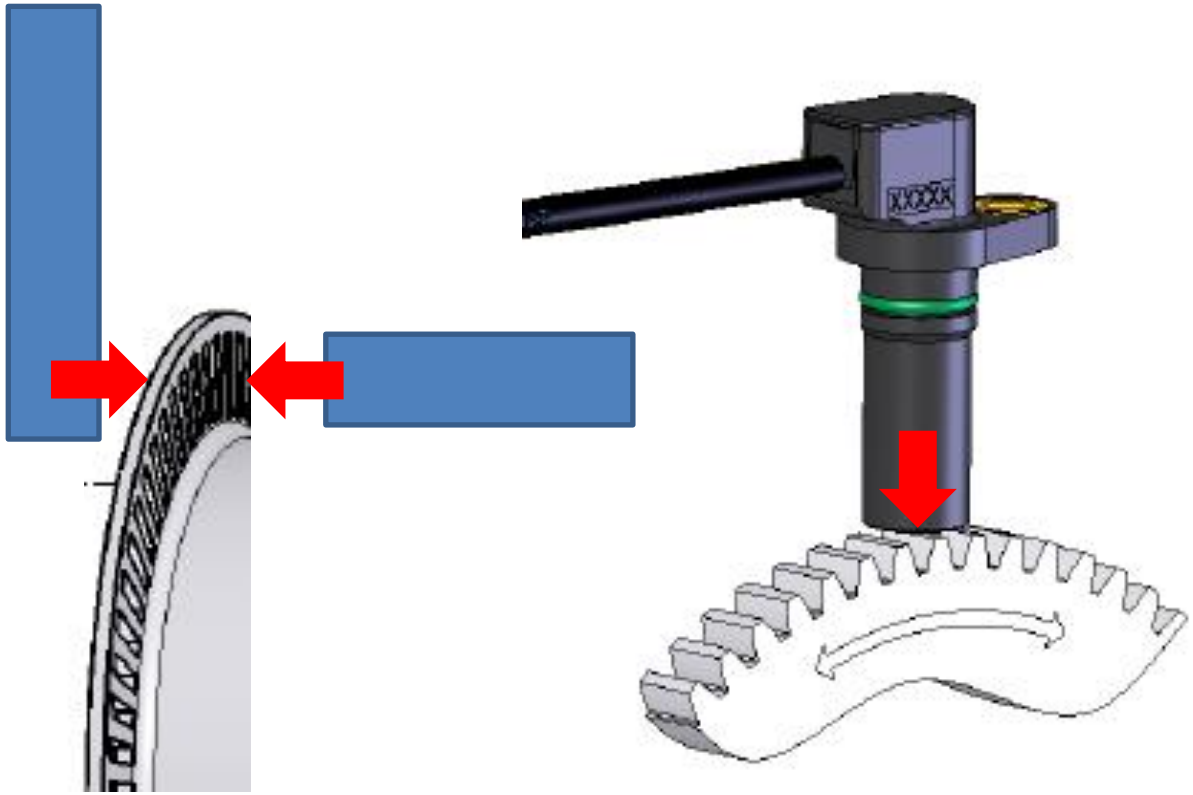
Target geometries

Basics to take into consideration for *rotational speed measurement* with Hall ICs:

- Clear change between “tooth” and “gap” >> steep edge
- As symmetrical configuration of “tooth and “gap” as possible
- Often change from “tooth” to “gap”
- Module 1.0 – 4.0 (benchmark)

Detection positions

Sensor geometries



Content

- RHEINTACHO Messtechnik GmbH
- Rotational speed sensors – System overview, definition, function
- Detection possibilities – Target geometries, detection position
- **Rotational speed sensors in mobile machines – Special requirements**
- Application example HOLMER Terra Dos (beet harvester)

Requirements

Protection class / IP class / ISO20653

In mobile outdoor applications >> **IP69K** is considered standard!

IP**6K**9K >> dust-proof, complete protection against contact

IP6K**9K** >> Protection against water under high-pressure or steam-jet cleaning especially for road vehicles

Alternatives: IP66, 67, 68 >> not automatically included in IP69(K)!

Which areas?
- Sensor housing
- Cable outlet / plug
- Plug on cable

In general: **EVERYTHING is possible**. The aim is to provide an application-specific compromise between technology and economics!

Requirements

Temperature / Temperature changes

Electrical drives 140 °C – 150 °C
Hydraulic drives 100 °C – 120 °C

Sensor components are to be considered separately:

- Housing / Plug / Cable
    - Housing material: Metal or plastic
    - Plug -40 °C / -55 °C - 125 °C
    - Cable
- Electronic components / PCB material
- Potting materials
    - Thermal expansion to be considered

Temperature changes (EN60068-2-14): an example

100 cycles -40 °C to +125 °C @ reconfiguration period < 10 s

Requirements

Mechanical load

Vibration, Shock, Noise

- e.g. according to IEC 60068-*-*

Max. pressure

- Measuring surface / Sensing surface
  - Plastic = low
  - Metal = 5 bar – 20 bar
  - High-pressure version = approx. 500 bar
- Sealing function, if sensor is installed in fluid atmosphere
  - Washer seal

Requirements
ESD / EMC

- Construction machines standards DIN EN13309
- Motor vehicle impulses: ISO 7637
- ESD: ISO 10605
- Immunity: ISO 11452 (electrical disturbances through narrow-band radiated electromagnetic energy)

Content

- RHEINTACHO Messtechnik GmbH
- Rotational speed sensors – System overview, definition, function
- Detection possibilities – Target geometries, detection position
- Rotational speed sensors in mobile machines – Special requirements
- **Application example HOLMER Terra Dos (beet harvester)**

Application

HOLMER sugar-beet harvester Terra Dos

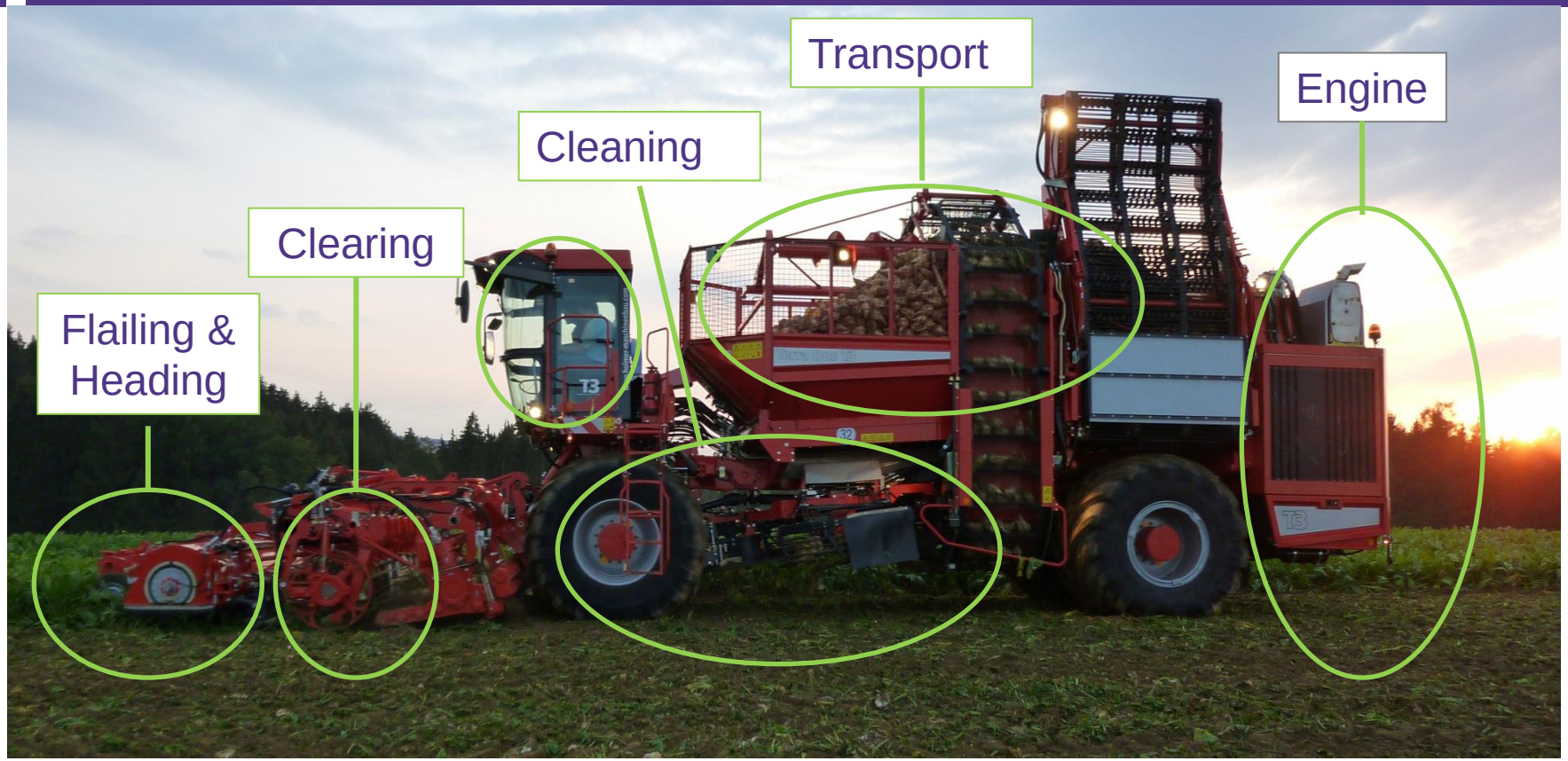
Task: - Harvest sugar beets without any loss
- Best possible cleaning of leaves and earth

HOLMER exxact

History:	HOLMER Maschinenbau GmbH founded by Alfons Holmer in 1969 Owned by Exel Industries (Fam. Ballu) since 2013 as HOLMER exxact
Employees:	330 (2014)
Turnover:	115 Mio. € (2014)
Qualifications:	Development, production and sales of self-propelled harvesting machines (focus: beet harvest technology)

Application

HOLMER sugar-beet harvester Terra Dos



High availability under difficult conditions (HOLMER beet grubber Terra Dos)

- Use on possible to due external conditions which cannot be influenced and are therefore only possible within a small time window

- High investment expenses, precise planning of usage >> Back-up-solutions are only difficult or too expensive

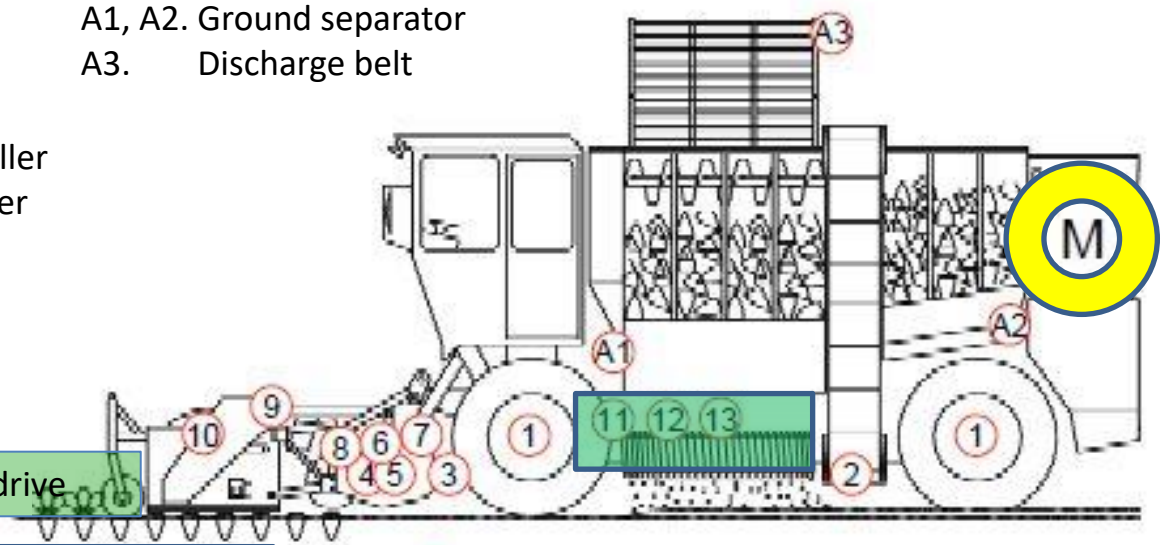
- 3-shift usage during harvest phase

Power Train devided component drives

1. Travel drive
2. Elevator
3. Screen belt
4. Short right clearing roller
5. Short left clearing roller
6. Paddle drive
7. Rolling pass drive
8. Forced feeder
9. Vibroridger
10. Topper drive

11. 12. 13. Screening star drive

A1, A2. Ground separator
A3. Discharge belt



M Diesel engine

Hydraulic component drive

Challenge: Harvest quality

Different conditions require different settings!

-> different loads on the components
-> different rotational speeds on the components

Challenge: Drive technology

- **Non-stationary, flexible operating points**

  - Rotational speed used to parameterize the machine
  - Load requirement from process

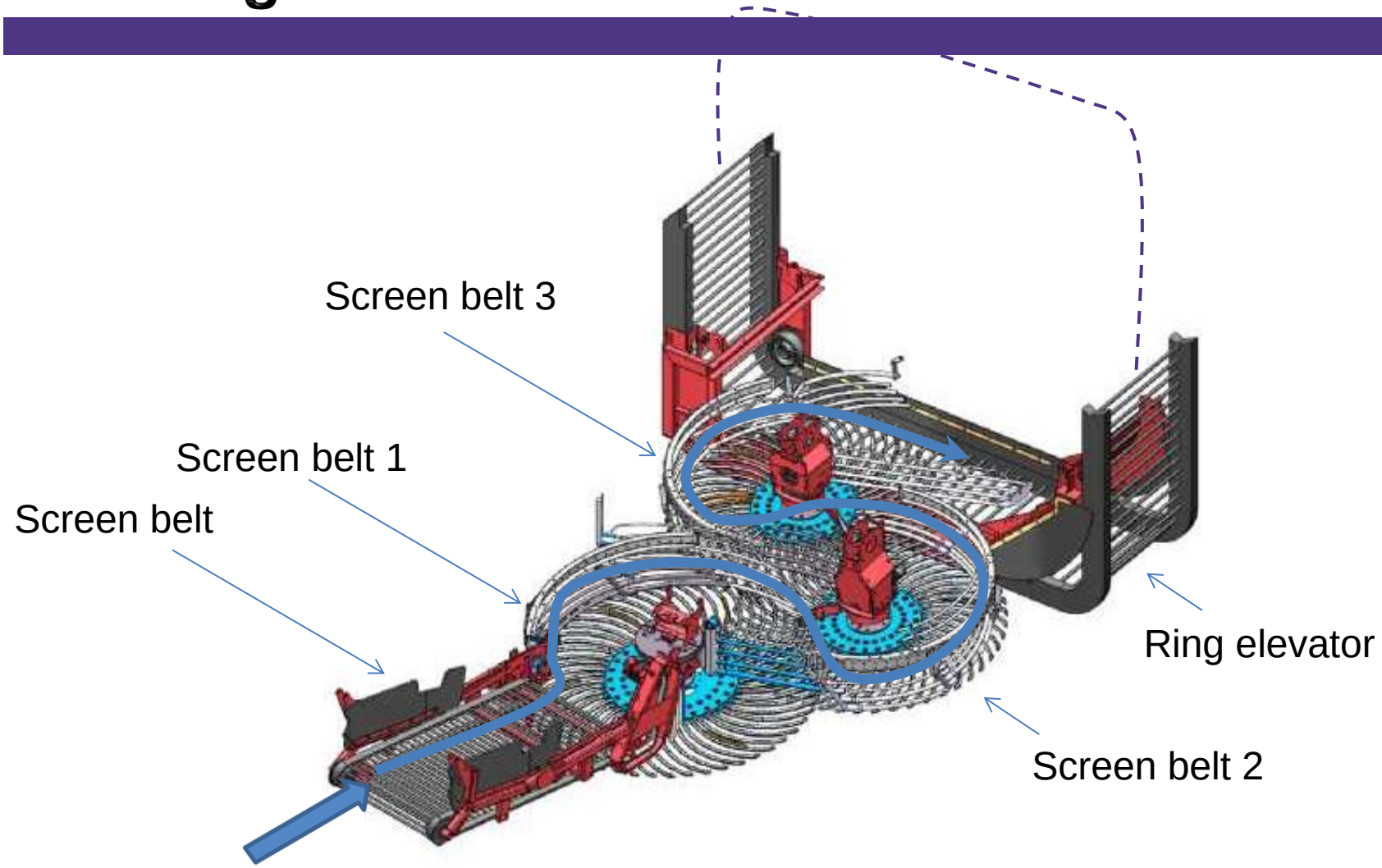
  => Feedback of rotation torque and rotational speed to monitor process

-„Drive train management“ in the harvest machine requires the **integration** of **several components** (control and feedback)

- **Requirements on „mobile“ operation**

  - Protection class / Sealing
  - Performance weight
  - Temperature resistance
  - Mechanical loads

Structure / Function of the screen belt cleaning



Drive with screen belt cleaning

Practical requirements:

- Total performance peak of approx. 90 kW
- Stable rotational speed with differing loads as a basis for process safety
- Adjustable rotational speed differences between the screen belts
- Self-adjusting behavior at limits (overload)

Drive screen belt cleaning

Drive solution:

- Closed circuit with electrical load sensing
- Electro hydraulic adjustment pumps, 4 Orbital motors
- Elektro magnetic proportional valves BUCHER LVS 12
- For stable start-up, software-controlled flow-matching, between pump and user.
- Rotational speed control of all individual component drives
- Overlapped pressure monitoring of all individual component drives
  => Automatic rotational speed adaptation at threatening overload

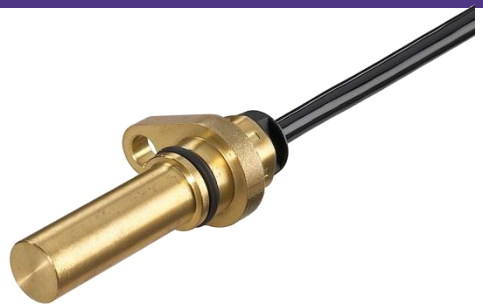
HOLMER adaptive cleaning

Why?

- Relieves driver of monitoring tasks
- Makes existing capacity usable
- Avoids breakdown interruptions due to too high rotational speeds

Better efficiency > higher turnover > higher profitability!

Applied rotational sensors



RHEINTACHO FC-series

- 2-Channel Differential-Hall
- Insertion depth 35mm or 45mm
- Various connections (plug; cable ends,…)
- IP69K, IP67

RHEINTACHO FE-series

- 1 or 2-Channel Hall, also with PWM output signal
- Insertion depth 18,4mm or 32mm
- Various connections (plug; cable ends,…)
- IP6K9K, IP67

Money makes the world go round …

… and the rotational speed is detected by …

RHEINTACHO !

Thank you for your attention!