

### Electric System Solutions with IndraDrive ML



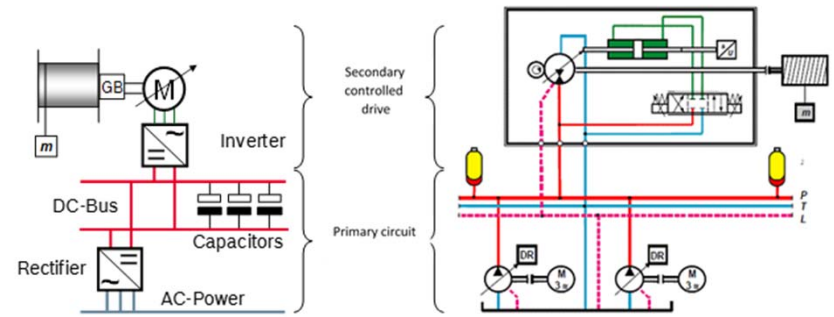
Powerful, Flexible, Intelligent

Jan Hein van den Broek

1 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



### Electric System Solutions with IndraDrive ML Electrics versus Hydraulics

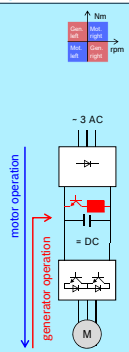


2 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



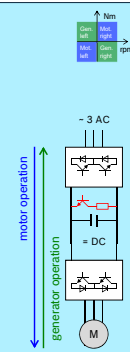
### Technology Basic – Frequency Converters Types of Frequency Converters

- Frequency converter
  - feeding
  - less amount of braking energy



generator operation  
motor operation

- Frequency converter
  - feeding & regenerating
  - large amount of braking energy, regulated DC-bus voltage, less mains distortion



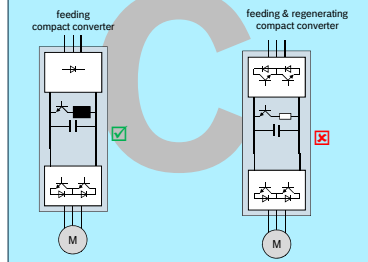
generator operation  
motor operation

3 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



### Technology Basic – Frequency Converters Types of Frequency Converters

- Compact frequency converter
  - all components in one compact housing
  - used in application with less numbers of drives

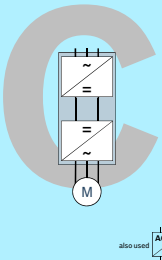


4 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



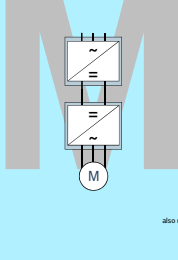
## Technology Basic – Frequency Converters Simplified Symbols

- **Compact frequency converter**
- Used for feeding converters
- Used for feeding/regenerating converters



also used

- **Modular frequency converter**
- Used for feeding power supply
- Used for feeding/regenerating power supply

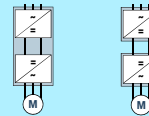


also used

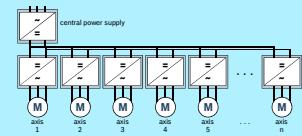
5 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

## Technology Basic – Frequency Converters Topology of Drive Systems

- **Single axis topology**
- each axis consist of a motor with a converter
- each axis consist of a motor with a motor-inverter and a power supply
- systems with less number of drives
- each drive needs the full power from the mains



- **Multi axis topology**
- each axis is one motor-inverter-combination
- all axes are supplied by one central power supply
- systems with many axes
- exchange of energy (between the axes) via DC bus is possible
- central DC bus components (brake resistors, capacitors...) can be used



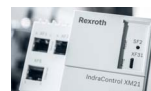
6 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

## Electric System Solutions with IndraDrive ML AGENDA



IndraDrive ML  
Highlights

System concepts



We are the benchmark  
for drives  
and controls

IndraControl & concepts



Next steps

11 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

## Electric System Solutions with IndraDrive ML Overview



Modular drive system for  
High power ranges  
from 110 kW up to 4 MW

High power density through  
efficient cooling

IndraDrive ML  
Powerful  
Flexible  
Intelligent

Universal use as power supply  
and as motor inverter.

Brains Inside



Efficient energy management

Flexibility in  
connectivity

Applications  
Metal forming  
Material handling  
Test stands  
Marine und Offshore

8 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

## Electric System Solutions with IndraDrive ML Highlights



Extensive interface options

Less automation components

Integrated Motion-Logic Control for single- and multi-axis solutions

Multi-Encoder-connection

Universal inverter type for use as motor inverter and power supply

Multi-Ethernet communication

Wide voltage range  
380...500 V | 520...690 V

Parallel connection for drive solutions up to 4 MW

5 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML Highlights



Safety on Board: from Safe Torque Off till Safe Motion

High power density through efficient cooling

More performance and higher productivity

Application specific technology functions

Extensive firmware functions available

Optimized energy saving solutions

High PWM frequency for maximum motor power

6 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML Highlights



Easy integration in LabView development environment

Fast engineering

Open Core Interface for development of IoT solutions

ePlan macros and CAD-Files available

Virtual commissioning with the drive integrated axis simulation

IndraWorks as engineering tool for the complete IndraDrive family

Powerful integrated power web server

Safest designing with IndraSize

7 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML Highlights

Coated circuit boards for corrosive environment

EMC protected iron housing

ML drive concept complete M&O certified

Power range up to 4MW to move heaviest loads

Marine certification



Robust mechanical design (both housing and components)

Prepared for the high temperature fluctuations

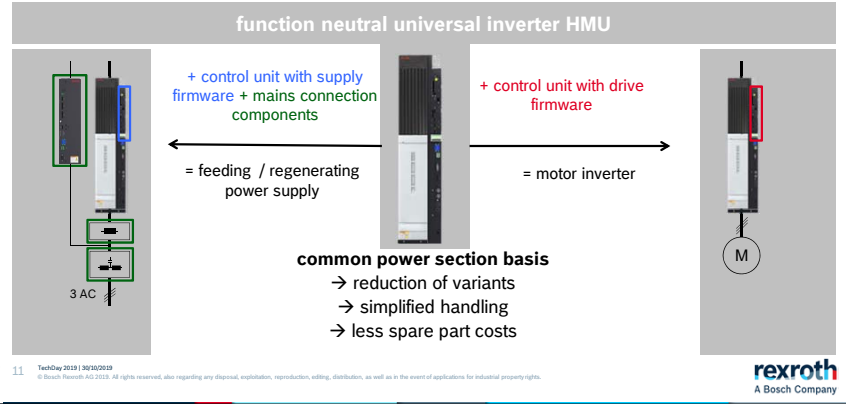
Cooling water up to 60°C

Shock resistant, according to the M&O rules

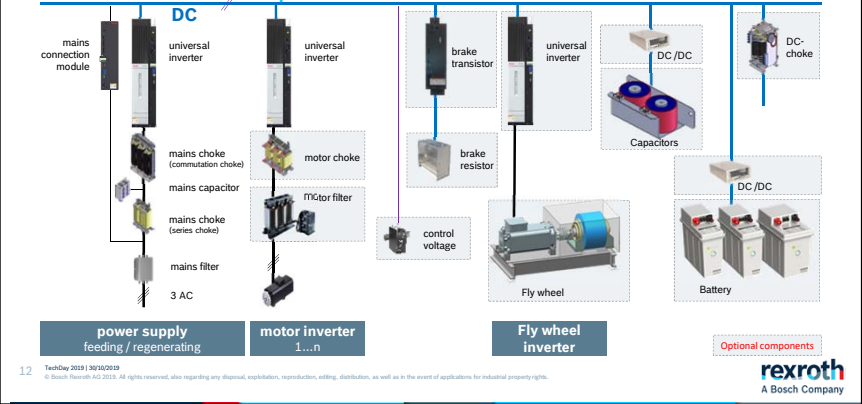
8 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



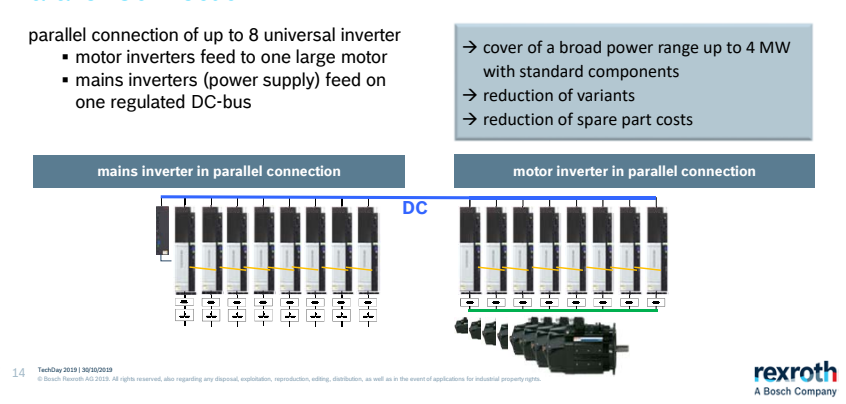
## Electric System Solutions with IndraDrive ML Universal Inverter



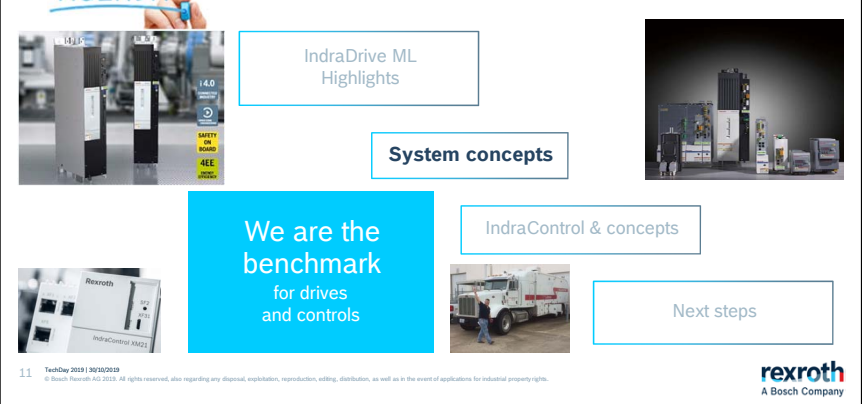
## Electric System Solutions with IndraDrive ML IndraDrive ML - Components Overview



## Electric System Solutions with IndraDrive ML Parallel Connection



## Electric System Solutions with IndraDrive ML AGENDA



## Electric System Solutions with IndraDrive ML Flexible – Drive Concept Variations

Single motor concept



Multi motor concept



Multi application concept



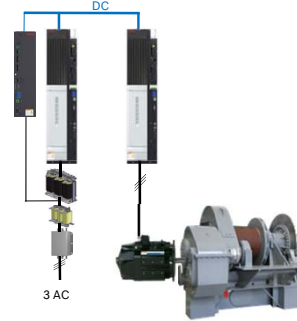
Modular machine concept



18 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML One application – Single motor driven



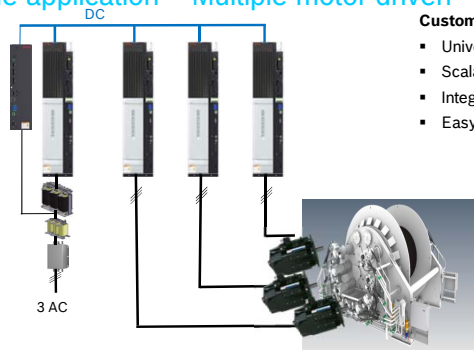
### Customer benefits

- Universal hardware on power and motor side
- Scalable power range due to parallel connection
- Integrated motion logic and/or Safety technology

17 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML One application – Multiple motor driven



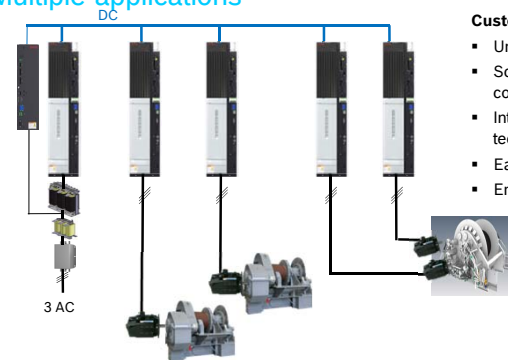
### Customer benefits

- Universal hardware on power and motor side
- Scalable power range due to parallel connection
- Integrated motion logic and/or Safety technology
- Easy motor synchronization

18 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML Multiple applications



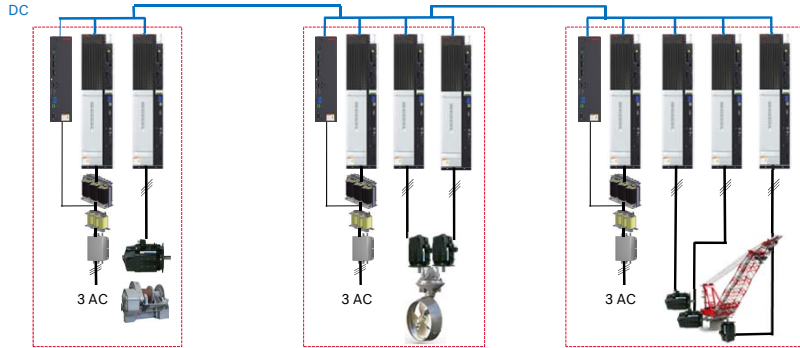
### Customer benefits

- Universal hardware on power and motor side
- Scalable power range due to parallel connection
- Integrated motion logic and/or Safety technology
- Easy motor synchronization
- Energy efficiency by central power supply

19 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



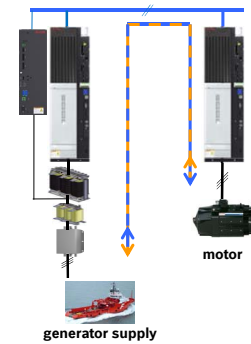
### Electric System Solutions with IndraDrive ML Modular machine concept



20 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### Electric System Solutions with IndraDrive ML Regenerating of Energy

4EE  
ENERGY  
EFFICIENCY



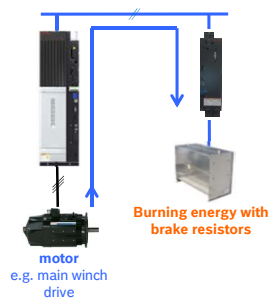
- regenerating of excessive energy in the mains supply
- high mains supply quality with least harmonic distortion
- Mains voltage independent DC-bus voltage (Controlled DC-bus)
- Robustness against voltage fluctuations

→ decrease of energy consumption especially in case of long periods in regenerating mode  
→ saving energy and costs

21 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### Electric System Solutions with IndraDrive ML Energy burning

4EE  
ENERGY  
EFFICIENCY



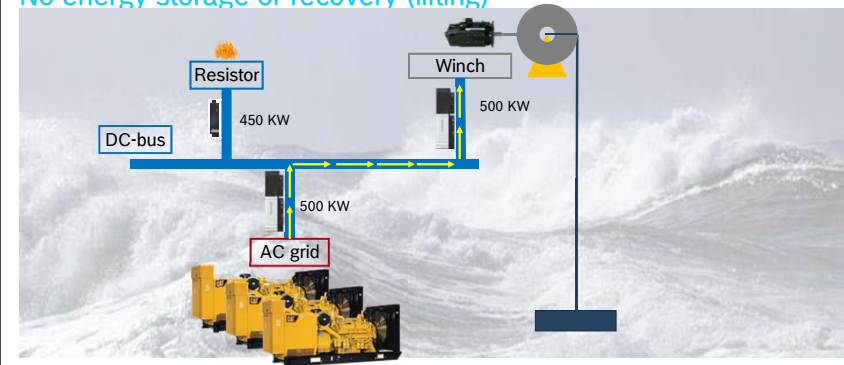
- simple possibility if regenerations of the energy is not possible or allowed.
- Combination with energy storage possible
- Scalable to energy amount

→ As safety function in case of power failure  
→ Flexible and scalable

22 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### Electric System Solutions with IndraDrive ML No energy storage or recovery (lifting)

4EE  
ENERGY  
EFFICIENCY



23 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

### Electric System Solutions with IndraDrive ML

#### No energy storage or recovery (lowering)

450 kW  
500 kW  
500 kW

Resistor  
Winch  
DC-bus  
AC grid

24 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

4EE ENERGY EFFICIENCY

rexroth A Bosch Company

### Electric System Solutions with IndraDrive ML

#### Electric Buffering

motor e.g. main winch drive  
DC capacitance (passive energy storage)

- simple possibilities for passive buffering of excessive energy
- DC-bus capacities up to 2,5 F loadable  
→ up to 700 kJ energy

→ Reduction of peak loads  
→ Decrease of energy consumption  
→ Smaller size of the mains connection components  
→ Saving of energy and costs

25 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

4EE ENERGY EFFICIENCY

rexroth A Bosch Company

### Electric System Solutions with IndraDrive ML

#### Electric Energy Storage (Batteries)

motor e.g. main winch drive  
Battery pack (slow energy storage)

- simple possibility for slow passive buffering of excessive energy
- Battery Control Unit integrated

→ Power peak compensation  
→ Decrease of energy consumption  
→ Smaller size of the mains connection components  
→ Saving of energy and costs

26 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

4EE ENERGY EFFICIENCY

rexroth A Bosch Company

### Electric System Solutions with IndraDrive ML

#### Smart Electric Energy storage (lifting)

0,4 MW  
2,5 MW  
2,5 MW  
2,0 MW

Resistor  
Winch  
DC-bus  
AC grid  
Energy Storage

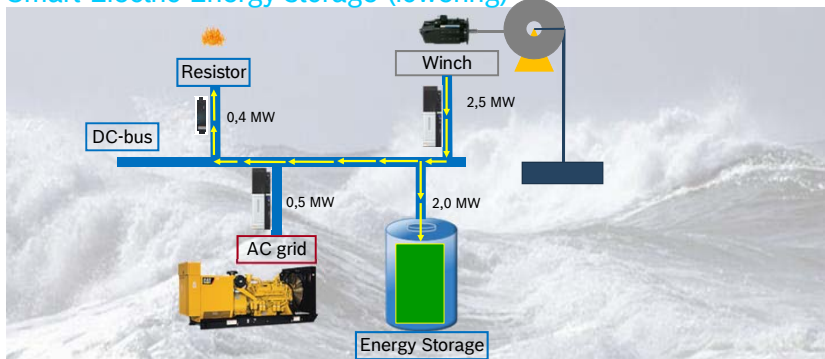
27 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

4EE ENERGY EFFICIENCY

rexroth A Bosch Company



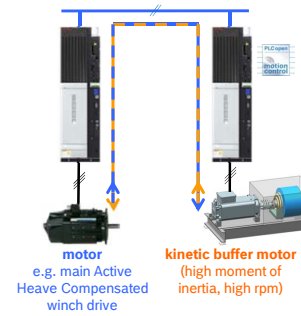
### Electric System Solutions with IndraDrive ML Smart Electric Energy storage (lowering)



28 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



### Electric System Solutions with IndraDrive ML Kinetic Buffering



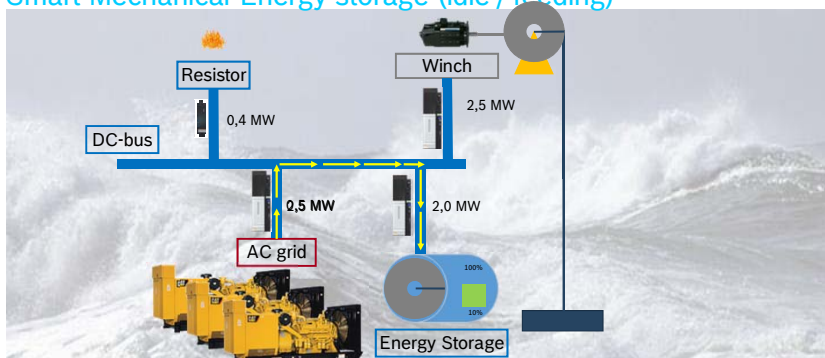
- Intelligent active energy management by a drive integrated MLD function
- requirement oriented control and interaction with the process

- Reduction of peak loads
- Decrease of energy consumption
- Smaller size of the mains connection components
- Saving of energy and costs

29 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



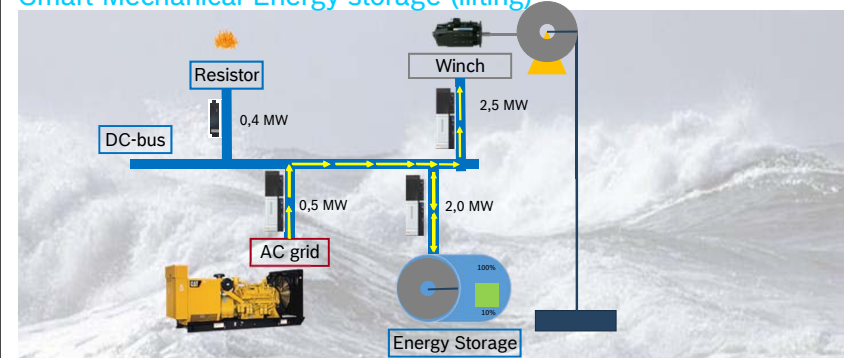
### Electric System Solutions with IndraDrive ML Smart Mechanical Energy storage (idle / feeding)



30 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



### Electric System Solutions with IndraDrive ML Smart Mechanical Energy storage (lifting)



31 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.





### Electric System Solutions with IndraDrive ML Smart Mechanical Energy storage (lowering)

32 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

**rexroth**  
A Bosch Company

### Electric System Solutions with IndraDrive ML

#### AGENDA

11 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

**rexroth**  
A Bosch Company

### Electric System Solutions with IndraDrive ML Highlights

A hardware-platform for all system-Software (SPS, CNC, IoT, Motion Control)

Flexible IPC-, Embedded control-, I/O- and safety Platform

Modular hardware for flexible machine-concepts

**Industrial control hardware**

Robust hardware for most demanding industrial environments

Reliable due to high long-term availability and serviceability

Universal communication interfaces for best connectivity

34 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

**rexroth**  
A Bosch Company

### Electric System Solutions with IndraDrive ML Highlights

General Automation Tasks

Winches

Cranes

**Flexibility in controls for every application**

Energy

System Complexity

RC28 IndraDrive MLD IndraControl XM2

Flexible in fieldbus communication; PROFINET, EthernetIP, EtherCAT

Diverse Marine & Offshore Equipment

35 TechDay 2019 | 30/10/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

**rexroth**  
A Bosch Company

## Electric System Solutions with IndraDrive ML Highlights

Various Inputs / Outputs onboard, fixed, programmable, digital, analog, fast .....

Integrated safety functions: watch dog, 2-channel-stop-function



Proven in numerous applications in harsh environment since many years

**R28: high performance, extremely compact**

Extremely robust against vibration, shock, temperature

4 independent CAN interfaces, for instance 1 to PLC, 1 for direct access for service and diagnosis, 2 for sensors

All graphical and textual programming languages specified according IEC 61131-3 available

## Electric System Solutions with IndraDrive ML Highlights



Modular I/O extensions (central and distributed I/O) via broad IndraControl S20 portfolio

Modular Rexroth control platform for PLC, Motion Control and CNC

Optional communication interfaces

**IndraControl XM – Next generation control platform**

- Operation with temperature range of -25 to +60 °C
- Extremely non-sensitive against EMV influences with adjustable filter times
- Robust and continuous shock-resistant electro mechanics to 10 g

Sercos Automation on-board

Powerful and flexible extensible hardware architecture

## Electric System Solutions with IndraDrive ML Marine applications in extreme conditions

ABS	American Bureau of Shipping	
BSH	Bundesamt für Seeschifffahrt und Hydrographie	
BV	Bureau Veritas	
DNV-GL	Det Norske Veritas – Germanischer Lloyd	
LR	Lloyd's Register	
RINA	Registro Italiano Navale	

**Certified control components**

- **XM22**
- XFE01.1-FB-20 (2x CAN Master)
- XFE01.1-FB-03 (PROFINET RT & EtherNet/IP Master)

**Certified I/O modules**

- S20-S3-BK+
- S20-AI-8
- S20-AO-8
- S20-DI-16/4
- S20-DO-16/3
- S20-AI-8-RTD
- S20-RS-UNI
- S20-CNT/INC 2/2
- S20-AI6-AO2-SSI2

## Electric System Solutions with IndraDrive ML Explosive atmospheres

**IECEX**  
International Electro technical Commission

Ex ec IIC T4 Gc  
 Ex ec IIC T4 Gc  
 ec  
 IIC  
 T4  
 Gc

Explosion protected label  
 Type of protection "increased safety"  
 Gas group hydrogen  
 Max. surface temperature 135 °C / 275 °F  
 Equipment protection level (EPL) – rare and momentary explosive atmosphere (zone 2); flammable gases, vapors, mists

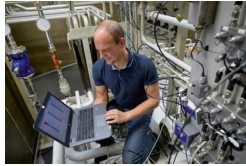
**Certified control components**

- **XM22**
- XFE01.1-FB-20 (2x CAN Master)
- XFE01.1-FB-03 (PROFINET RT & EtherNet/IP Master)

**Certified I/O modules**

- S20-PWM-2-T
- S20-PWM-4-T
- S20-AI6-AO2-SSI2

## Electric System Solutions with IndraDrive ML Highlights



Easy integration in LabView development environment

Free choice of programming language

Open Core Interface for the development of IoT applications

IEC61131 programming languages including object-oriented programming

Script-programming with Letter

High-level programming languages as C# und Java

PLCopen programming

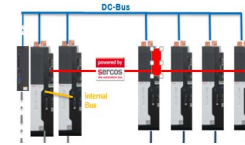
Open Core Interface Software Development Kit for easy extension

40 TechDay 2019 | 30/10/2019 © Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

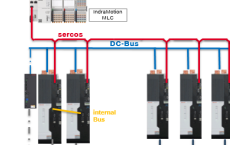


## Electric System Solutions with IndraDrive ML Flexible – Control Concepts

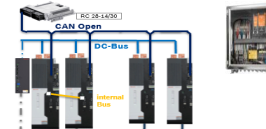
Integrated motion control concept



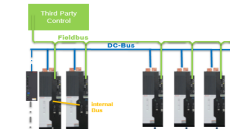
External motion control concept



Uniform winch control concept



Third party control concept



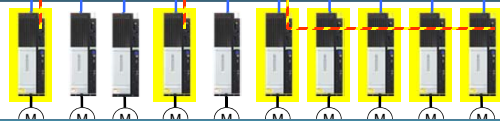
41 TechDay 2019 | 30/10/2019 © Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



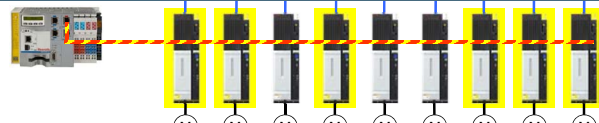
## Electric System Solutions with IndraDrive ML Flexible – Safety Concepts



Integrated Safety concept, single axis and zones



Safety concept, with external controller

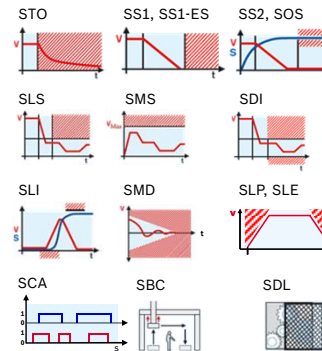


- simple discrete wiring per axis
- direct connection of multiple axes for creation of safety zones

44 TechDay 2019 | 30/10/2019 © Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML Extensive Drive Integrated Safety Functions



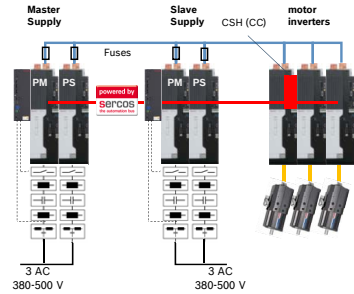
- Drive integrated safety functions for stopping, holding, moving and position monitoring
- Safe Torque Off, Safe Stop 1, Safe Stop 2, Safe Operating Stop, Safely Monitored Deceleration
  - Safely Limited Speed, Safe Maximum Speed, Safe Direction, Safely Limited Increment
  - Safely Limited Position, Safe Cam, Safely Limited End Position
  - Safe Brake Control
  - Safe Door Locking

- Maximum safety level for safety functions
- Cat. 4 **PL e** according to ISO 13849-1
  - **SIL3** according to IEC 61062

45 TechDay 2019 | 30/10/2019 © Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



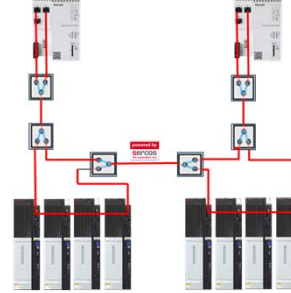
## Electric System Solutions with IndraDrive ML Redundancy concept in power supply



- Master Power Supply:**
- Control mode: DC bus voltage control
  - Calculation of mains current
  - Load distribution via CCD
- Slave Power Supply:**
- Control mode: mains current control
  - Command value via CCD

→ Everything included in the power supply units!

## Electric System Solutions with IndraDrive ML Redundancy concept in control



- Master Control:**
- Control mode: Function control of the system and the Sercos ring
- Slave Control:**
- Control mode: Free running
  - Activated by switches in the Sercos ring.

→ Sercos III controls a ring and a line communication, automatic switchable!

## Electric System Solutions with IndraDrive ML AGENDA



IndraDrive ML  
Highlights

System concepts



IndraControl & concepts

We are the  
benchmark  
for drives  
and controls

Next steps



## Electric System Solutions with IndraDrive ML Your Benefits

Universal inverter	
Advantage:	Universal use as feeding / regenerating power supply or as motor inverter
Customer benefit:	Reduction of variants & reduced stock costs, simplified handling
Parallel operation	
Advantage:	Parallel operation with up to 8 power units
Customer benefit:	Reaching of a broad power range with optimum number of devices
Wide voltage range	
Advantage:	380 - 690 V for wide range of applications
Customer benefit:	Reduction of variants & reduced stock costs

## Electric System Solutions with IndraDrive ML Your Benefits

<b>High PWM frequency (up to 250 kW with 4 kHz)</b>	
Advantage:	No over sizing of motors or inverters necessary
Customer benefit:	smaller motors / devices usable
<b>High coolant temperature</b>	
Advantage:	Efficient discharge of heat losses due to high coolant temperature of 60 °C
Customer benefit:	Less energy for discharging and utilization of the heat losses necessary
<b>Several concepts for energy saving (regeneration, electric &amp; kinetic Buffering, Smart Energy Mode...)</b>	
Advantage:	Optimum adaption to the application
Customer benefit:	Efficient operation in all applications

58 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML IndraDrive – One Complete Family

**IndraDrive ML:** Completes the IndraDrive drive family in the upper range

### One look and feel from 100 W up to 4 MW:

- Drive integrated Safety
- Drive integrated Motion Logic
- Intelligent firmware functions
- Open communication
- Uniform in:
  - Parameterization
  - Commissioning
  - Diagnostics



59 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.



## Electric System Solutions with IndraDrive ML



Thank you for your attention!

52 TechDay 2019 | 30/05/2019  
© Bosch Rexroth AG 2019. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

