IndraDrive, Ethernet, PLCopen, Sercos
Технические характеристики

IndraDrive Mi:
Maximum flexibility in minimum space with the intelligent IndraDrive Mi

Consumer habits are changing faster than ever. New or modified products must be brought to market at an increasing rate. This poses a challenge to manufacturers and to plant engineering as a whole. Today's machines must be modular and scalable. Intelligent drive systems are in demand: compact, highly efficient, easy to integrate and, to save the most space, ideally cabinet-free. And this is exactly why Rexroth has developed the most flexible drive system in the world: IndraDrive Mi. The ideal gateway to Industry 4.0.

With the release of IndraDrive Mi in 2007, Rexroth revolutionized mechanical engineering. Since then, this cabinet-free drive technology has seen use across the globe. IndraDrive Mi has proven itself on the market countless times over with its flexibility when integrating into decentralized machine concepts and how easy it is to install and set up. And all this along with continuously adding new functions and models that place the expertise of Rexroth, the leading Motion Control provider, at the customer's fingertips.

Reduce wiring around 90% and optimize power balance
With the intelligent IndraDrive Mi drive system, machine manufacturers today can transfer all of their drive technology, including mains connection and power supply, from the control cabinet directly into their machines. This saves space, reduced wiring effort by up to 90%, and optimizes power balance for the machine user.

Forget up to 100% of the control cabinet
With Ethernet-based communication and integrated Motion Logic, machine manufacturers have a complete automation system with the most certified safety functions. Rexroth is the first to consistently utilize all avenues of decentralized drive technology to even go as far as eliminate the control cabinet altogether.

Save 100% of external cooling
The cost effectiveness and sustainability of the IndraDrive Mi system lies not just in its flexibility and intelligence, but also in that it does not require any external cooling.

IndraDrive Mi:
All advantages at a glance

IndraDrive Mi enables machine manufacturers to integrate all electrical drive components directly into the machine. The result are entirely cabinet free, modular machines with a minimized required space.
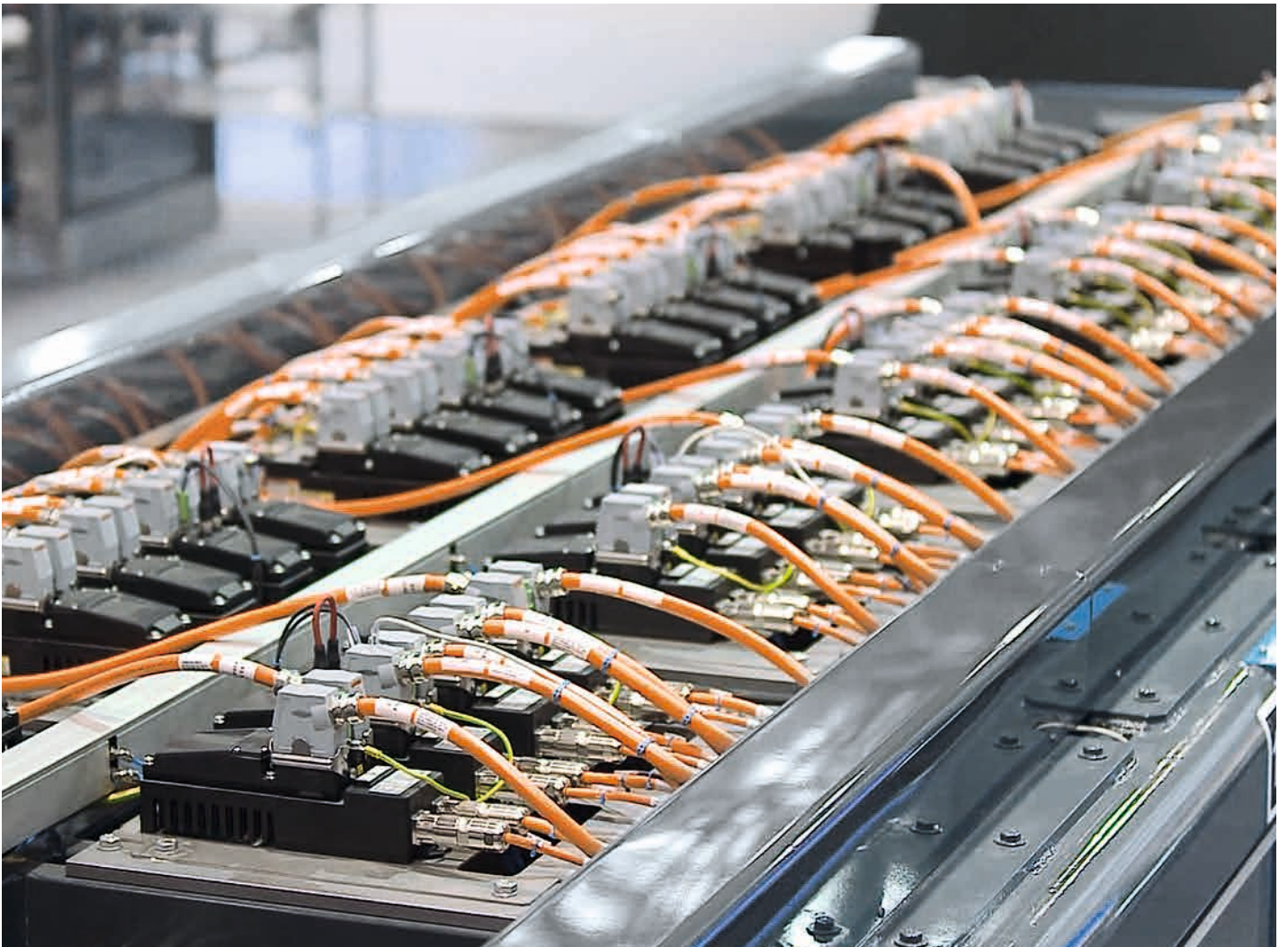
Energy-efficient power supply
▶ Compatible and freely combinable with the IndraDrive
drive system
▶ Energy saving by using the common DC bus, power
recovery, energy buffering, power for other drives
▶ Supply multiple drive strings with a single unit

Intelligent communication
▶ Supports all relevant Ethernet-based communication
protocols (Sercos, PROFINET IO, EtherNet/IP, EtherCAT,
POWERLINK)
▶ Uniform hardware, protocol selection via software
▶ Communication ports for integrating sensors and actua-
tors (I/O, pneumatics, hydraulics, third party)

Time-saving installation
▶ Cabinet-free
▶ Up to 90% less wiring with hybrid cable technology for
supply and communication
▶ No external cooling needed
▶ Simple drive string expansion with hybrid cable tech-
nology

Flexible control functions
▶ Drive-integrated Motion Logic for axis-based tasks in
the drive string
▶ Ready-made, industry-specific technology functions for
fast parameterization
▶ Programming in accordance with IEC 61131-3

**Drive-integrated safety technology to effectively protect
man, machine, and work piece**
▶ Safe Torque Off
- Simple mapping of safety zones
- Certified Cat 4, PL e under EN ISO 13849-1
and SIL 3 under EN 62061

▶ Safe motion functions with safety controller
- Functions without encoder certified Cat 4, PL e
under EN ISO 13849-1 and SIL 3 under EN 62061
- Functions with encoder certified Cat 3, PL d
under EN ISO 13849-1 and SIL 2 under EN 62061

Optimal design
▶ Easy to clean
▶ IP65 protection type
▶ Various hybrid cables for minimized cabling effort or
for tight spaces
▶ Option for rotating applications with slip-ring systems
▶ Option for potentially explosive atmospheres (ATEX)

**Application-optimized concept for energy efficient
production**
▶ DC bus capacities (KLC) for dynamic energy storage
at Smart Energy Mode
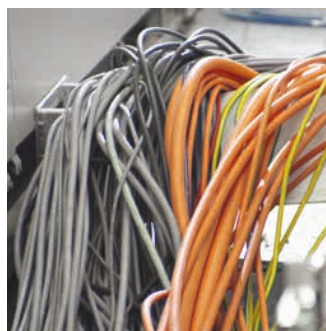
▼ **Real example from the packaging industry: The difference between conventional wiring (top) and hybrid cabling (bottom) is obvious. Several hundred meters less cable, several hours less work**
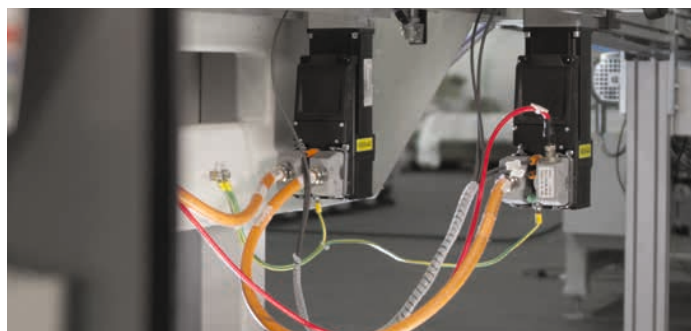
System design:
As simple as it is cost-effective

The unique system design of the IndraDrive Mi drive solution is the key to high cost effectiveness and flexibility. Make your drive technology completely self-sufficient and cabinet-free with IP65 system components. Or use existing converters and supply modules in a control cabinet and power up to 30 drives in one cable harness with control electronics. Whichever you choose, installation and cooling will be minimal. Control cabinet volume is reduced substantially. Or even eliminated altogether.

Control cabinet volume reduced ...

IndraDrive Mi adapts easily to all modular frameworks like no other system. The cabinet-reducing variant uses an existing converter (HCS) or modular supply unit (HMV) to provide power. All variants feature a DC bus for optimal energy exchange between regenerative and motorized axes. The power stays in the system.

IndraDrive Mi only requires drive connection box (KCU) placed in the control cabinet next to a supply unit for operation. It provides voltage and communication supply for a drive string with up to 30 nodes and protects them against short circuit. Additional IndraDrive Mi strings, each up to 200 meters in length, can be connected using more KCUs.

... or eliminated altogether

However, the IndraDrive Mi system can also be completely self-sufficient and cabinet-free with the IP65 supply module. The mains module (KNK) is connected directly to the power grid. The supply module (KMV) replaces the regenerative power supply and control electronics in the control cabinet. This means the entire drive system can be integrated directly into the machine. Any power supply components still in the control cabinet (mains filter, mains contactor, mains throttle, supply unit) are eliminated.

The result:
▶ **100% cabinet-free**
▶ **100% flexible**

A hybrid cable directly daisy-chains the serial drives. Up to 30 in one string. No distributor boxes needed. The motor-integrated servo drives (KSM) consist of a Rexroth servo motor with an integrated inverter. The motor casing surface cools the system.

Near-motor servo drives (KMS) can be used where space is tight or motors without integrated inverter electronics are required. The inverter electronics are installed elsewhere in the system and connected to the motor.

▶ **Compared to conventional variants, the IndraDrive Mi can not only reduce control cabinet volume, it can eliminate the control cabinet altogether. This saves up to 90% of the wiring and no control cabinet cooling system is necessary**

Conventional system

Control cabinet | Power grid

Machine

Controller

Module 1

Module 2

Module 3
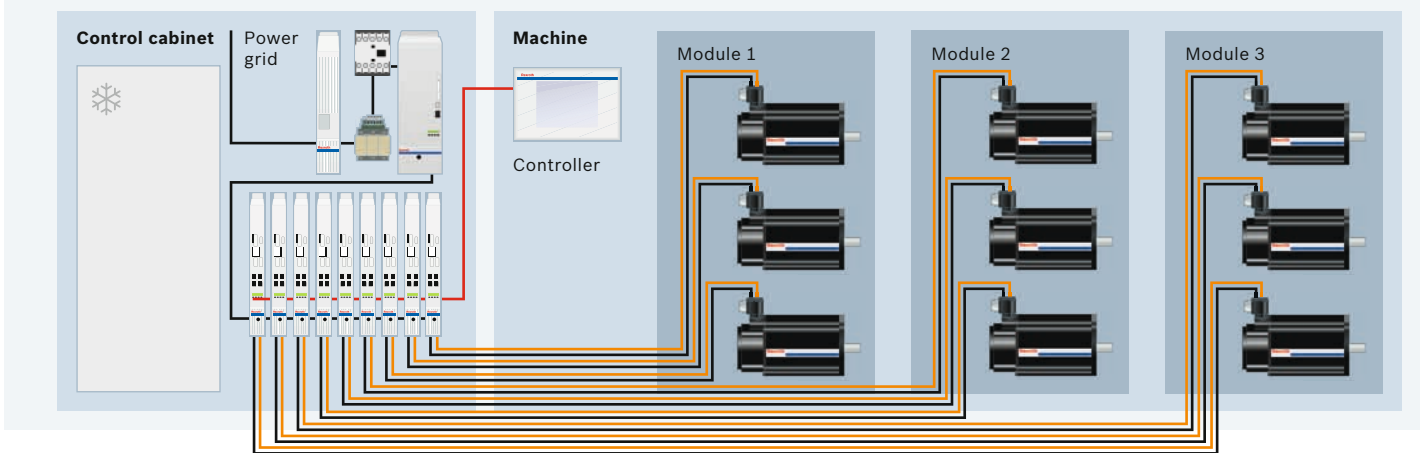
Cabinet-reduced system

Control cabinet

Power grid

Machine

Controller

Module 1

Module 2

Module 3

Cabinet-free system

Machine

Controller

Power grid

Module 1

Module 2

Module 3
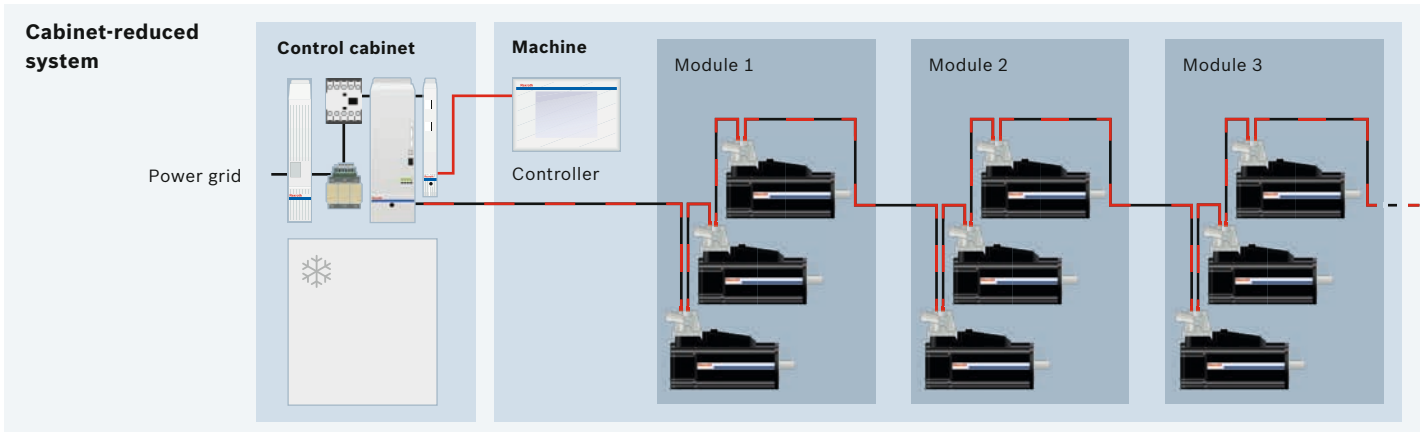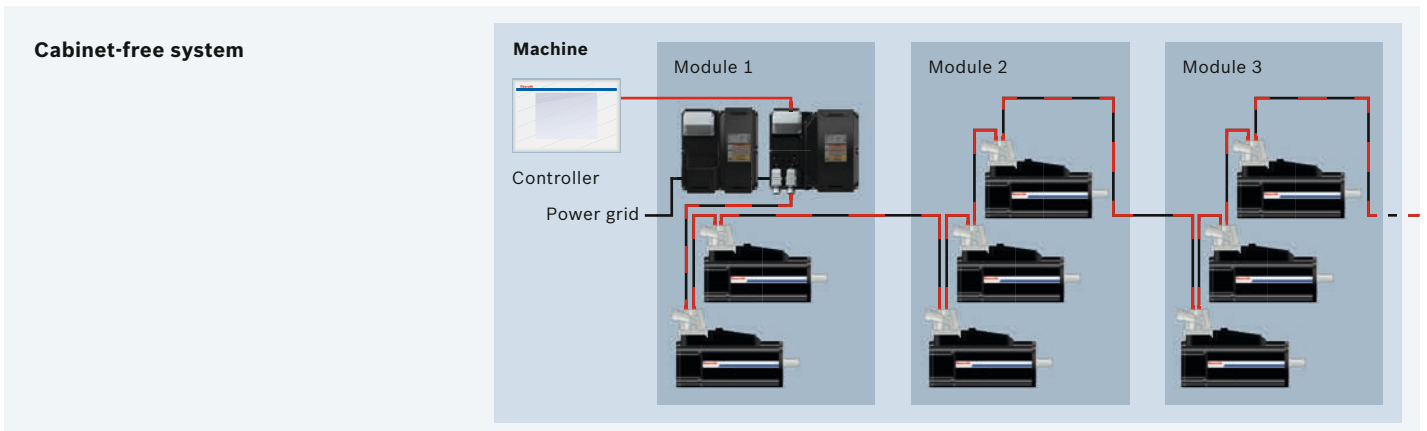
Installation:
Unrivaled simplicity and
trouble-free expansion

With the simple system design of the IndraDrive Mi, you not only save on components, but above all on installation. Up to 90 % less wiring, minimal control cabinet volume, and drastically reduced cooling load. This is what Rexroth offers – and in the area of expandability, Rexroth offers even more.

Only one cable is needed to connect drives in series. This saves big compared to conventional installations: For example, a system with 60 servo drives no longer requires 120 cables to be routed several meters through the machine, it only requires two hybrid cable – this immediately saves you several thousand meters of cable in addition to the costs, labor, and restricted flexibility.

If the system needs drives later on, e.g., in the form of an additional machine module, they are simply integrated at the end or wherever they are needed. Done. And all without affecting existing installations or the rest of the system.

At the same time, you can also connect sensors, I/Os, and fieldbus components directly to the IndraDrive Mi drives. This even saves on wiring costs beyond just the drive system itself. It does not get any easier.

For special circumstances, e.g., extremely tight spaces or peripherals that need to be connected individually, Rexroth also offers another wiring alternative in the form of a thin cable for power and internal signals and another one for communication. This allows the cables to be bent very tightly.

All in all, installation with numerous advantages:
▶ Control cabinet volume reduced by up to 100%
▶ Up to 90% less wiring
▶ Control cabinet cooling output reduced by up to 100%
▶ Easier integration of additional machine modules, sensors, I/Os and fieldbus components

Module n

Power grid | Controller

Module 1

Module 2

Module 3
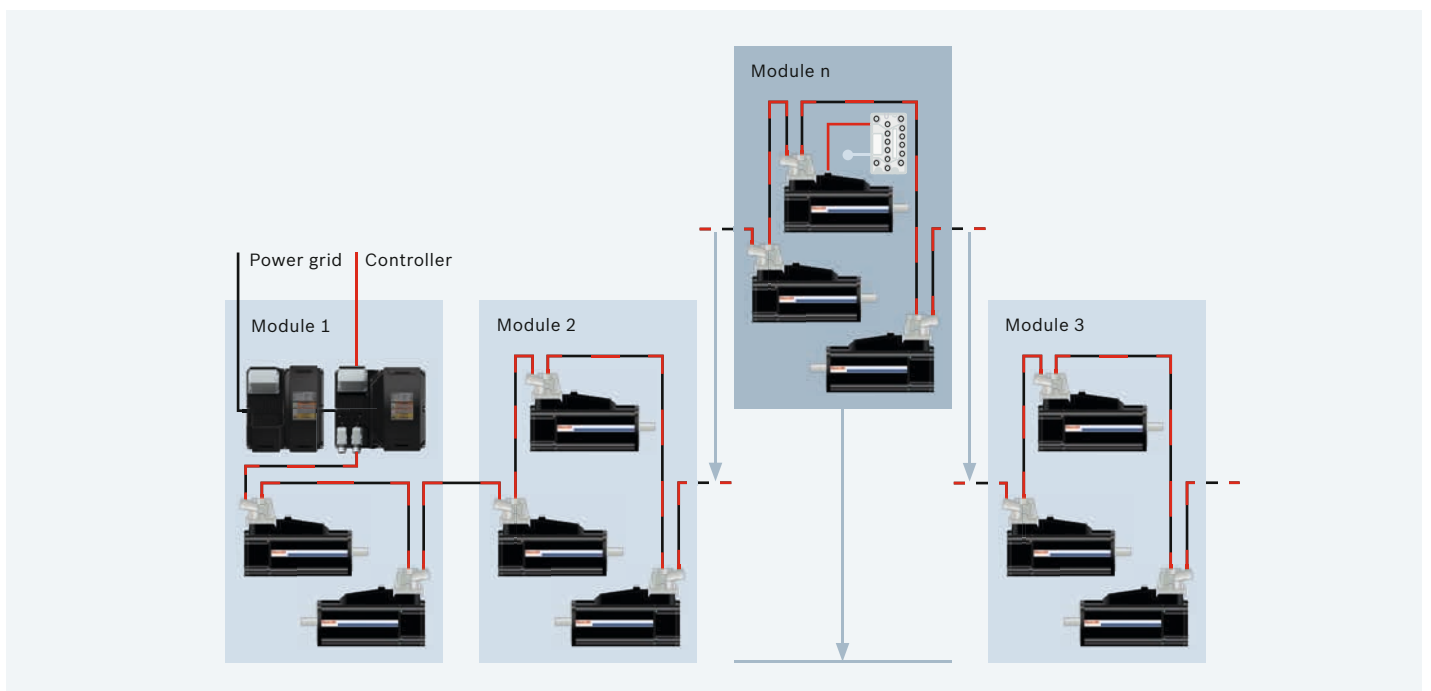
Communication:
Built-in intelligence

Automation needs communication. That is why it is our job to advance communication in systems and design a wide variety of applications to be user-friendly through multi-protocol-capable hardware and software that greatly increase the flexibility and modularity of machines, as well as through seemingly small details, such as a single hybrid cable that intelligently consolidates power and communication.

The multiprotocol-capable communication hardware in IndraDrive Mi meets the growing demand for openness and integration. It can be operated with all standard industrial controllers. The protocol for the Ethernet-based interfaces is selected in the software.

The following protocols are available:
- ▶ Sercos
- ▶ PROFINET IO
- ▶ EtherNet/IP
- ▶ EtherCAT
- ▶ POWERLINK

- ▶ CIP Safety on Sercos (CSoS)
- ▶ Safety over EtherCAT (FSoE)
- ▶ PROFIsafe on PROFINET

Control communication can be optionally extracted to inexpensively integrate I/O units or pneumatic and hydraulic actuators into an IndraDrive Mi cable harness.

IndraDrive Mi – the most communicative drive in the world
The result of so much intelligence in a system speaks for itself: You are getting the most communicative decentralized drive solution on the market today.

The automation bus Sercos fulfills all requests of interlaced machines with its openness, flexibility and standardization. It connects all devices of a production system in a horizontal network by hard real time functions and opens by the integration of open Ethernet-protocols new possibilities for vertical networking.

Control functions: More options for each application

i 4.0 CONNECTED INDUSTRY

IndraDrive Mi also sets the course for controllers for advancing to Industry 4.0: With IndraMotion MLD, Rexroth's drive-integrated controller, the drive functions, motion control and PLC logic merge into an open automation platform for modular machine concepts. This allows for applications to be easily implemented regardless of the controller.

MLD-S

Higher-level controller

Drives with integrated single-axis Motion Logic
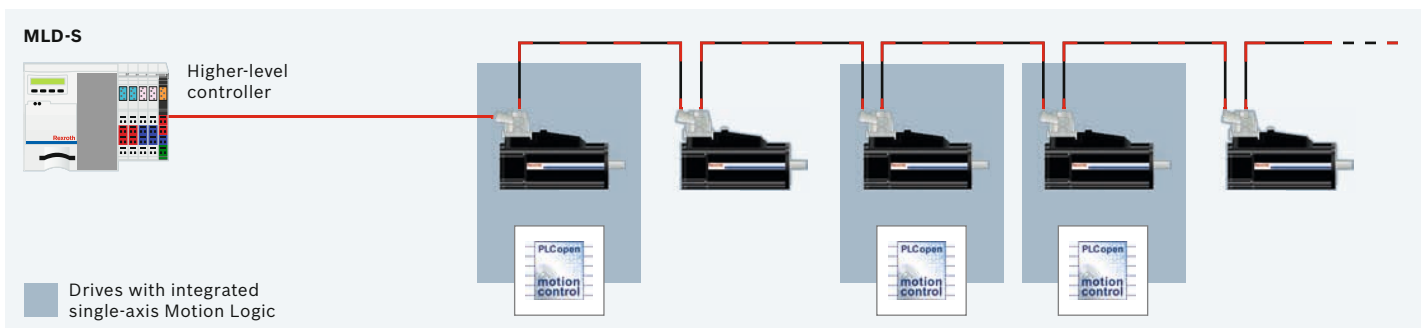
IndraMotion MLD-S single-axis Motion Logic
In order to execute axis-based drive tasks and thereby relieve the higher-level controller, the system comes with the option of transferring individual functions to individual drives. Extensive, predefined technology functions can also be used, or a separate application flexibly created.

IndraMotion MLD-M multi-axis Motion Logic
For applications with a limited number of axes, a Sercos master drive can coordinate up to nine additional Mi drives. Even more complex motion tasks can simply be executed at the drive level without a higher-level controller.

MLD-M

sercos the automation bus

Sercos master with integrated multi-axis Motion Logic

Energy efficiency: Optimized and adapted to each application

4EE ENERGY EFFICIENCY

With IndraDrive Mi, you benefit from a consistently application-optimized concept for thoroughly energy-efficient production. A variety of static and rotative energy accumulator options, Smart Energy Mode options, and numerous other options are at your disposal to save energy and reduce peak loads in the power grid.

Power recovery
The recovery of excess energy to the power grid drastically reduces energy consumption, especially in regenerative mode over longer periods, while maintaining top power quality.

Smart Energy Mode
In Smart Energy Mode, the supply module is regulated to provide a DC bus voltage regardless of line voltage. This prevents peak loads and greatly reduces average energy consumption. The result: better grid compatibility, and the same machine performance with smaller components.

Electric and kinetic buffering
Large amounts of energy can also be stored in a buffer: With electric buffering, DC capacity is simply stored; with kinetic buffering, excess energy is converted into kinetic energy, buffered, process-optimized and provided to the system.

DC bus coupling
It is possible to exchange energy between all axes and utilize the central energy accumulators since the drives are inherently connected through the DC bus.

Smart Energy Mode

Motor rating

With/without
Smart Energy Mode

Power supply capacity

Without Smart Energy Mode
With Smart Energy Mode
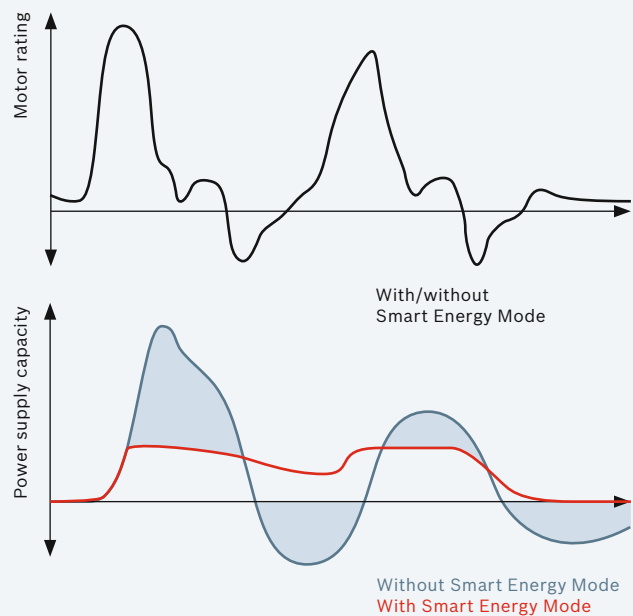
Reactive current control
Regulating the reactive current eliminates losses in the power supply string caused by reactive current. Other inductive and capacitive consumers can also be offset.

Safety functions:
Dynamics always under control

It is paramount in any kind of application for persons to be protected from uncontrollable machine movements. IndraDrive Mi offers flexible solutions for integrating safety technology into the overall system: While the Safe Torque Off safety function cuts of the torque on the drives within a few milliseconds, the Option Safe Motion safety technology provides a broad range of safety functions. They range from safe stops to safe movements.

The drive-integrated Safe Torque Off saves on hardware and reduces wiring costs, since no higher-level controller is required. In addition to simultaneously disabling the torque in all drives, any number of various safety zones can be mapped by IndraDrive Mi. The IndraDrive Mi STO function is certified Cat 4, PL e under EN ISO 13849-1 and SIL 3 under EN 62061. The Safe Motion safety function is controlled by a safety controller.

The functions that do not require an encoder are certified CAT 4, PL e under EN ISO 13849-1 and SIL 3 under EN 62061. Functions that inherently require encoder feedback comply with Cat 3, PL d under EN ISO 13849-1 and SIL 2 under EN 62061. For these, IndraDrive Mi uses the CIP Safety on Sercos, Safety over EtherCat and PROFIsafe on PROFINET safety standards for protocol backup.

Safe Torque Off

STO signal   STO signal

To controller

Safe Motion

CIP Safety

Safety over EtherCAT

PROFINET

Safety controller
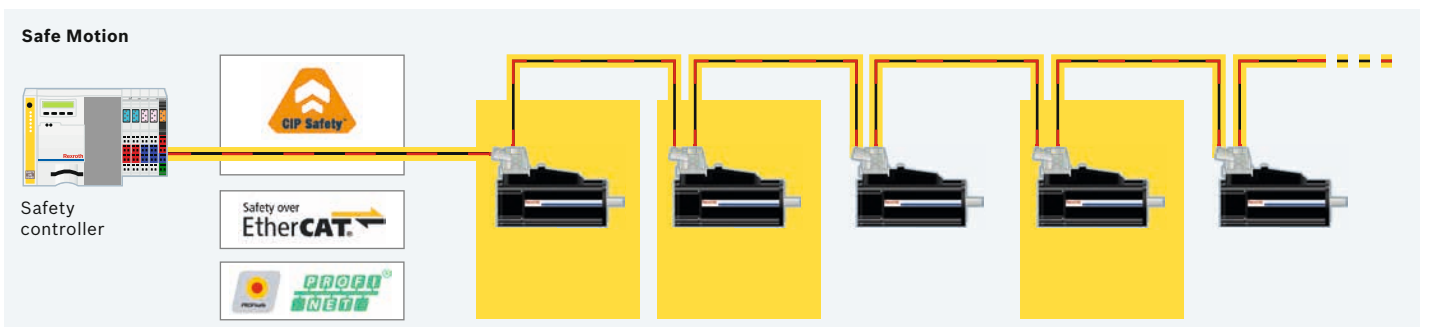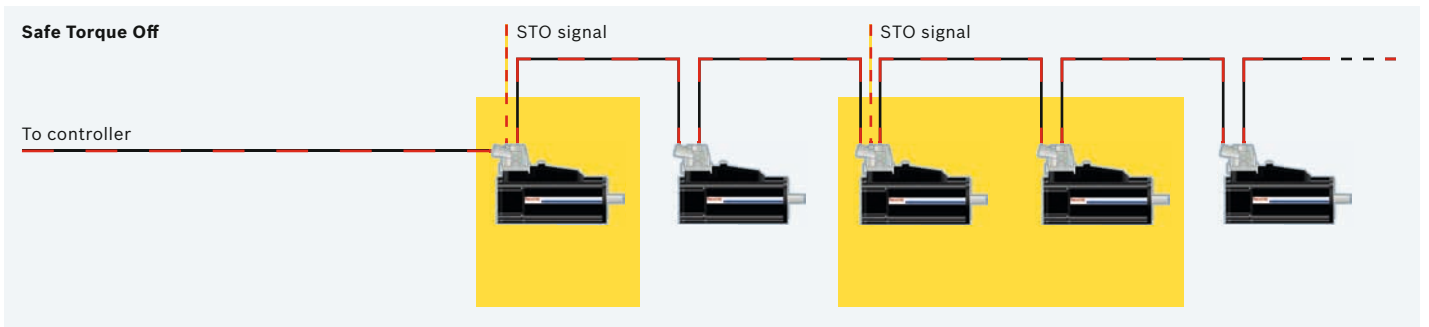
Servo drives:
Motor-integrated servo drive KSM
and near-motor servo drive KMS

The compact power and control electronics of the KSM motor-integrated servo drive uses the casing surface of an MSK servo motor as the cooling element. This reduces the overall volume by more than 50 % compared to classic servo drive solutions and up to 30 % compared to other integrated solutions.

KSM motor-integrated servo drive
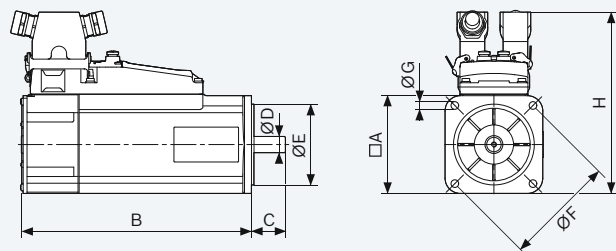
Motor-integrated servo drive			Maximum speed	Permanent torque	Maximum torque	Continuous stall current	Maximum current	Moment of inertia	Dimensions								Mass
			n_{Max}	$M_{0\,60\,K}$	M_{Max}	I_0	I_{Max}	J_R	A	B	C	ØD	ØE	ØF	ØG	H	m
			[rpm]	[Nm]	[Nm]	[A]	[A]	[kgm²]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[mm]	[kg]
KSM02.1B	-041	C-42	5500	2.2	9.4	1.5	6.8	0.00017	82	252	30	14	50	95	6.6	194	5.6/5.9
KSM02.1B	-061	C-35	4300	6	25	3.3	14.9	0.00087	115	271	40	19	95	130	9	219	9.6/10.1
KSM02.1B	-061	C-61	6000	5.5	18	5.2	17.7	0.00087	115	271	40	19	95	130	9	219	9.6/10.1
KSM02.1B	-071	C-24	3400	10.5	35	4.6	17.7	0.00173	140	307	58	32	130	165	11	247	14.1/15.2
KSM02.1B	-071	C-35	4700	10	28	6.0	17.7	0.00173	140	307	58	32	130	165	11	247	14.1/15.2
KSM02.1B	-076	C-35	4700	8.7	29	5.2	17.7	0.0043	140	290	50	24	130	165	11	247	14.6/15.7

The KMS near-motor servo drive allows a wide range of motors to be integrated into an IndraDrive Mi drive string. It is designed to be used when integrating other Rexroth servo motors or 3rd-party motors.

KMS02.1B-A018
near-motor servo drive
(natural convection)

KMS03.1B-A036
near-motor servo drive
(natural convection)

KMS03.1B-B036
near-motor servo drive
(thermal interface for coldplate mounting)
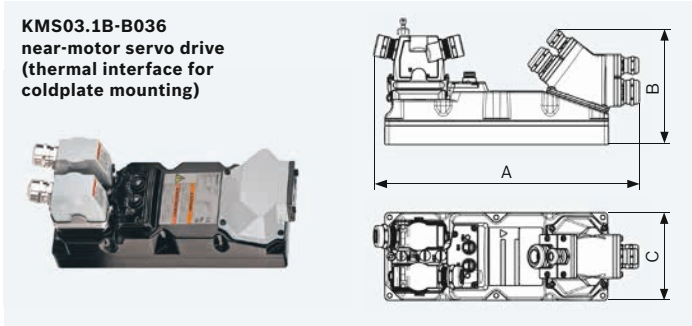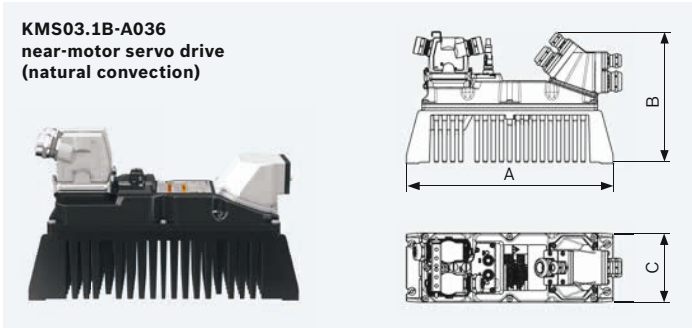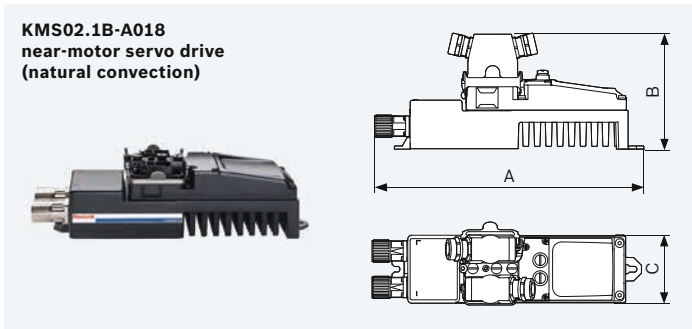
	KSM02	KMS02	KMS03
Single-turn optical encoder	●	–	–
Multi-turn absolute optical encoder	●	–	–
Single-turn capacitive encoder	●	–	–
Multi-turn absolute capacitive encoder	●	–	–
Smooth shaft	●	–	–
Keyway	○	–	–
Safe Torque Off (STO)	○	○	○
Safe Motion (SS1, SS1-ES, STO, SS2, SOS, SLS, SMS, SMD, SLI, SDI, SBC)	○	○	○
Multi-Ethernet communication (Sercos, PROFINET IO, EtherNet/IP, EtherCat, POWERLINK)	●	●	●
Multi-Ethernet extraction	●	●	●
Separate Multi-Ethernet	●	●	●
4 digital inputs/outputs (2 can be used as quick probes)	●	●	●
Motion Logic in acc. with IEC 61131	○	○	○
Encoder interface	–	○	–
Multi-encoder interface	–	–	●
Natural convection	●	●	●
Thermal interface	–	–	●

● Included　● Alternative　○ Optional　– Not available

| Near-motor servo drive	Continuous stall current	Maximum current	Dimensions			Mass
	I_0	I_{Max}	A	B	C	m
	[A]	[A]	[mm]	[mm]	[mm]	[kg]
KMS02.1B-A018	6	18	341	147	86	2.5
KMS03.1B-A036	12	36	344	209	110	
KMS03.1B-B036	22	36	320	144	110	

Mains and DC bus components

The main target for the power supply and control components is the same: as cabinet-free as possible, as little wiring as possible. For technically optimized and cost-effective engineering – and individual applications. The complete package becomes still much more flexible with the new cooling options. In addition to the thermal interface for cold plate (B) or insulated mounting (I), models that utilizes convection through a ribbed cooler (A) and forced air cooling (W) are now available.

KNK03 mains module
Thermal interface for coldplate mounting
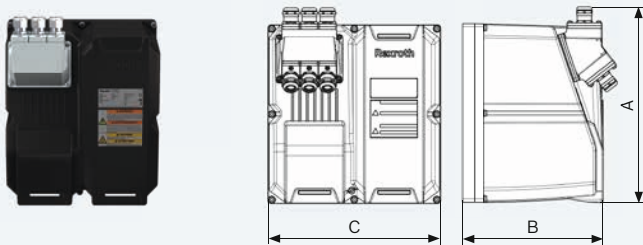
KMV03 supply module
Thermal interface for coldplate mounting
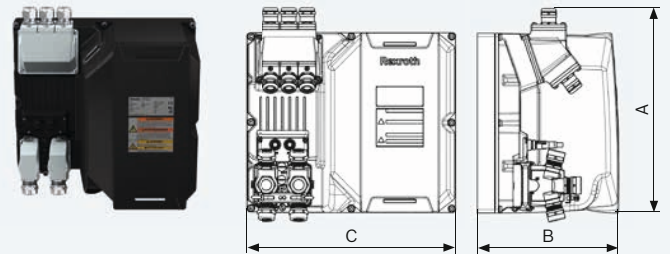
KNK mains module
For direct power from the grid. With integrated mains filter, mains choke and mains contactor. Available in IP65 protection type and connectable to the KMV supply module.

KMV supply module
The feeding and regenerating KMV module is also IP65-compliant and has an integrated brake chopper, braking resistors for 13.5 kW maximum power and a 24/42 V DC converter.

	Mains connection voltage	Mains frequency	Continuous mains input current	Dimensions		
	V_{mains}	f_{mains}	I	A	B	C
	[V]	[Hz]	[A]	[mm]	[mm]	[mm]
KNK03.1A-NR-**B**	3 AC 380–500	50/60	12	306	243	270
KNK03.1A-NR-**I**	3 AC 380–500	50/60	2.3	306	243	270
KNK03.1A-NR-**A**	3 AC 380–500	50/60	8.1	360	283	274
KNK03.1A-NR-**W**	3 AC 380–500	50/60	9.5	360	283	274

	DC bus voltage (regulated)	Continuous DC bus power	Maximum power	Dimensions		
	V_{DC}	P_{cont}	P_{max}	A	B	C
	[V]	[kW]	[kW]	[mm]	[mm]	[mm]
KMV03.1R-**B**	750	7.5	15	318	220.5	325
KMV03.1R-**I**	750	1.5	15	318	220.5	325
KMV03.1R-**A**	750	5	15	360	280	330
KMV03.1R-**W**	750	6	15	360	280	330

KLC03 capacity module
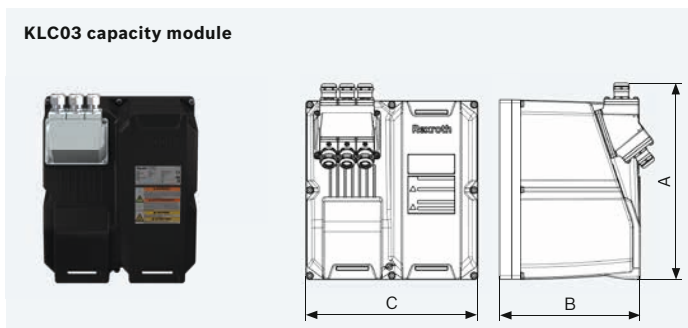
KLC03 capacity module

The capacy module KLC03 is used to avoide power peaks on the mains. Further it enables the storage of energy for backwards movement in case of mains failure or allows to increase the peak power within the DC bus.

KCU drive connection box

KCU drive connection box

The compact KCU drive connection box provides all the necessary connections from the IndraDrive Mi drive string to a common connection point and protects them against short circuit. It also transmits status and diagnostic messages between the drives and the supply unit. A KCU is only necessary when the control cabinet already has a power supply.

	Cycle time	DC bus voltage	DC bus capacity	Dimensions		
	t_{cyc}	U_{DC}	C_{DC}	A	B	C
	[s]	[V]	[mF]	[mm]	[mm]	[mm]
KLC03.1-**B**	i.p.	540–750	4.7	306	243	270
KLC03.1-**A**	i.p.	540–750	4.7	360	283	274
KLC03.1-**W**	i.p.	540–750	4.7	360	283	274

	Rated voltage	Rated current	Dimensions			Mass
	$V_{LN\,rated}$	I_{LN}	A	B	C	m
	[VDC]	[A]	[mm]	[mm]	[mm]	[kg]
KCU02.2N	540–750	25	352	50	252	3.8

Accessories

Hybrid cable with communication
For minimized cabling effort in the IndraDrive Mi drive chain.

Hybrid cable without communication
For tight spaces and minimized bending radius. A separate communication-cable between the servo drives is needed.

Hybrid cable with round connector
Very compact design useful for small cable tubes or cable feedthrough in machines.
Compatible for the connection with RIE-TECH slip-rings to transmit energy and communication to rotating machines.

Hybrid connector
To connect motor-integrated servo drives KSM and near-motor servo drives KMS when mounted directly side by side.

End plug
For terminating each drive string.

Interface cable
Pre-assembled, for connecting sensors to the IndraDrive Mi digital I/Os and for the input of the safe torque off signal.

Plug for safety zone subscriber
For easy creation of security zones when using the safety function Safe Torque Off.

Best practice:
Numerous drives in tight spaces

IndraDrive Mi systems are in use in factory automation across the world by machine manufacturers in all sectors who want or need to transfer all of their drive technology, including controller intelligence and power, from the control cabinet to the machine to save space and wiring, especially in the packaging and printing industries and when it comes to installation and handling. The plant construction and engineering sectors benefit in particular. See three real examples to learn how.

KBA Kammann: Changing over in under 60 minutes
Changing over a screen printing press normally takes up to four hours. Kammann uses Rexroth automation systems to implement a new, modular machine concept with up to 155 drives, reducing changeover times by a factor of four. A slip-ring system for rotating applications which can be integrated in the drive chain, allows a compact machine design.

CAMA Group: Controlling robots without collision
The latest high-end loading unit at CAMA uses 12 robots in the smallest of areas. The near-motor drives are directly installed on the machine and outside of the clean area. Supported by patented CAMA anti-collision software, they provide for extremely dynamic movements. The result: an extremely clever co-flow loading unit.

Wave generator: Precisely and flexibly simulating
For the precise simulation of sea conditions, Hamburger Schiffbau-Versuchsanstalt (HSVA), a shipbuilding laboratory, relies on cabinet-free IndraDrive Mi drives. The individual sections of the wave generator can be modularly expanded at any time, and can be flexibly installed and removed with unrivaled ease and without the usual wiring chaos. For precise, reproducible, high-dynamic and high-accuracy waves every time.

IndraDrive ML:
Electric drive technology for powers in the megawatt range

Now more than ever before, machine users are focusing on productivity and costs, sales growth generated by new products and markets, and safeguarding future competitiveness by reducing response times. The machines used and the drive technologies they employ must therefore maintain a high level of availability, energy efficiency, and maximum flexibility in production. The new large electric drives from the Rexroth IndraDrive family offer flexible solutions with intelligent functions for powerful drive solutions that extend into the megawatt range.

Application-specific, modular machines are the key objective, and optimized drive technologies are the way to achieve it. Electric solutions can provide a valuable alternative to other technologies, especially when high power outputs are required. Investment decisions for the suitable, under circumstances more economic technology, should be balanced as best as possible.

To this end, machine and automation systems manufacturers are continually being asked to come up with alternative concepts. Application-specific and preprogrammed drive solutions are needed to minimize engineering outlay and facilitate potential adaptations within the application itself. An in-depth understanding of the industry and application know-how are also beneficial in contributing to a wide variety of drive engineering tasks, including those that are highly complex and sophisticated.

Rexroth is the only automation specialist in the market that fulfills a complete range of hydraulic, electric, and hybrid drive solutions (e.g. variable-speed pump drives) extending into the megawatt range from a single source. Profit from our vast industry and application know-how – from metal forming to marine and offshore applications, as well as applications in many other sectors in which large electric drives from Rexroth offer new possibilities for innovative machine concepts.

- ▶ Metal forming: Presses, bending machines
- ▶ Metallurgy: Rolling mill technology
- ▶ Plastics processing technology: Extruders, injection molding machines
- ▶ Marine and offshore: Trawler and anchor winches, ship cranes
- ▶ Materials handling equipment: Container cranes, conveyor belts
- ▶ Test rig equipment: Transmission and engine/motor test stands, test rigs for hydraulics
- ▶ Print and paper: Flexo printing, winders, cross-cutters, central dc supply
- ▶ Civil engineering: Lift bridges, hydropower generators

Megawatt universal power inverters

The new IndraDrive ML units extend the IndraDrive family to include the higher output range, by which individual units are capable of generating up to 500 kW. Up to 8 units can be connected in parallel to reach outputs as high as 4 MW. These space-saving, modular inverters are therefore somewhat of an all-rounder and can be used as mains or motor inverters to minimize the number of variants, simplify handing and reduce storage costs.

Efficient, universal, intelligent

The modular universal power inverters are predestined for all types of multi-axis applications as they are powerful and versatile drives that can be used in the megawatt range. Universally deployable for standard and servo implementations, with comprehensive additional options to align on-demand output with a wide variety of applications. The inverters also incorporate all the aspects that the IndraDrive family is known for, from certified safety technology, to drive-integrated motion logic solutions, through to multi-encoder interfaces and multi-Ethernet communication.

Advantages resulting from special product features

▶ Modular universal power inverters for multi-axis applications: Minimize variant diversity, simplify handling, and reduce storage costs
▶ Application-specific concepts for saving energy: Adaptable to any application, they not only save energy, but also reduce line loads
▶ High power density: The compact design minimizes the installation space required in the control cabinet
▶ Low coolant quantities at high operating temperatures: Enable compact heat exchangers and efficient heat recovery
▶ Wide application range due to numerous certifications for industrial applications pursuant to CE, UL, CSA as well as type approved in typical marine applications according to the ship classification authorities DNV GL, ABS and LR

Technical key data

▶ Individual unit outputs of 110 kW to 500 kW in up to 8 graduated increments
▶ System outputs of up to 4 MW via parallel connection
▶ Mains voltage: 3 AC 380 - 500 V or 525 - 690 V / 50 - 60 Hz / TN, TT and IT networks
▶ Types of cooling: Liquid cooling, air cooling
▶ 1.5 x overload for 60 seconds

Optimal device topology

For reducing storage costs via a scaled hardware concept

▶ Universal power inverter can be used as a motor inverter or a mains inverter with energy-recovery function
▶ Optimally graduated power range from 110 kW to 500 kW
▶ Parallel connection to boost output capacity up to 4 MW
▶ Wide voltage range of 380 - 500 V and 525 - 690 V
▶ High pulse width modulation frequency (PWM) for optimal utilization of the motor
▶ Low harmonic emissions for good compatibility with the network
▶ Regulated DC bus voltage – independent of the mains voltage and resistant to fluctuations in voltage

Alternative cooling concepts

From basic dissipation of heat loss to active utilization in heat-recovery systems

▶ Air cooling
▶ Air cooling with separate air duct
▶ Liquid cooling

Application-optimized energy concepts

The optimal function for lowering consumption and reducing peak loads that are taken into account in almost every application

▶ Energy regeneration into the power grid
▶ Distribution of drive energy via DC links
▶ Kinetic buffering with rotating energy storage
▶ Electric buffering with static energy storage
▶ Smart Energy Mode for soft mains regeneration
▶ Regulation of reactive current for reducing power loss in the power supply

Performance control units with intelligent firmware

▶ Scalable performance
  - BASIC – Basic and standard servo applications
  - ADVANCED – High-end servo applications
▶ Multi-Ethernet and multi-encoder interface
▶ Interface options for fieldbus, I/O, etc.
▶ Firmware options as expansion package

Integrated control functions

▶ Motion logic drive-integrated (IndraMotion MLD)
  - IndraMotion MLD-S single-axis control
  - IndraMotion MLD-M multi-axis control
▶ Application-specific, predefined technology functions
▶ Productivity Agent for preventative maintenance
▶ IEC 61131-3-compliant programming

Certified safety technology

▶ Drive-integrated safety systems to protect man, machine, and tooling
▶ Certified according to EN ISO 13849-1 and EN 62061
▶ Safe Torque Off for safe interruption of applied torque
▶ Safe Motion for safe movements

Optimal device topology for a broad area of applications

The universal power inverters in the IndraDrive ML modular system can be used as motor inverters to operate synchronous and asynchronous motors or as mains inverters with energy-recovery capacity. This not only reduces inventory, but also system complexity. The drive series offers a good balance of incremental power outputs. The wide voltage range facilitates applications in many different industries and regions.

HMU universal power inverter

+ Control unit with firmware for supply

+ Mains connection components

+ Control unit with firmware for motor inverter

Mains inverter supply

Motor inverter

3 AC
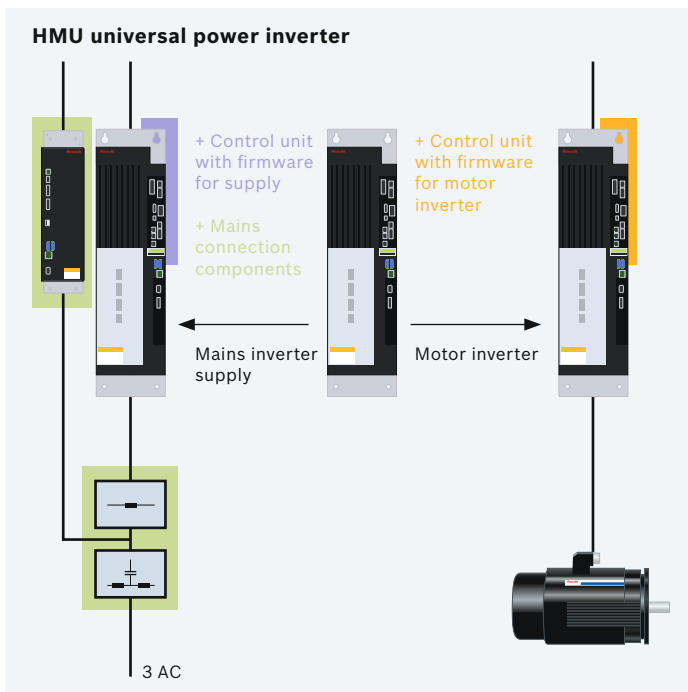
**Universal power inverter as a shared power output basis**
Large electric drives from Rexroth can either be used as motor inverters or mains inverters with regenerative power capacity (supply unit); the control unit is what defines the operative function. This reduces variant diversity and storage costs.

Power electronics for ultra-high demands
Configured as a mains inverter with regenerative power capacity, the active inverter keeps mains feedback to a minimum while the regulated DC bus voltage ensures independence from the supply voltage across a wide range of 380 V to 500 V or 525 V to 690 V as well as a high level of tolerance for balancing out fluctuations in voltage. Cycling with high PWM ensures that the motors are optimally used and noise emissions are kept as low as possible.

Connection in parallel

3 AC
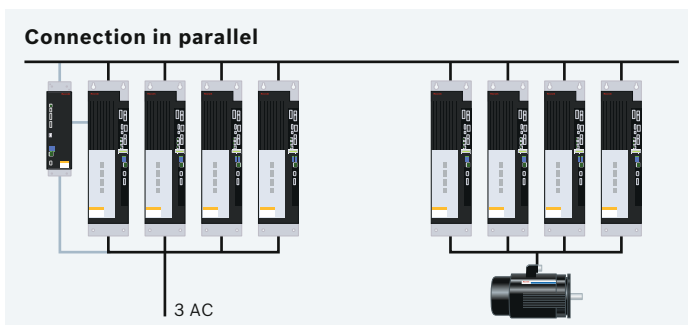
Parallel connection for ultra-high output in optimal increments
Large electric drives from Rexroth offer individual power outputs of 110 kW to 500 kW in up to 8 graduated increments and a combined system output of 4 MW where as many as 8 units are operated in parallel. Output can also be fine tuned to the requirements of the application at hand during parallel operation, including at the highest level of output for supply unit and inverter configurations.

Alternative cooling concepts for maximum energy efficiency

4EE ENERGY EFFICIENCY

IndraDrive ML units can be cooled by air or liquid, and, as required, there are different options available for dissipating and utilizing heat.
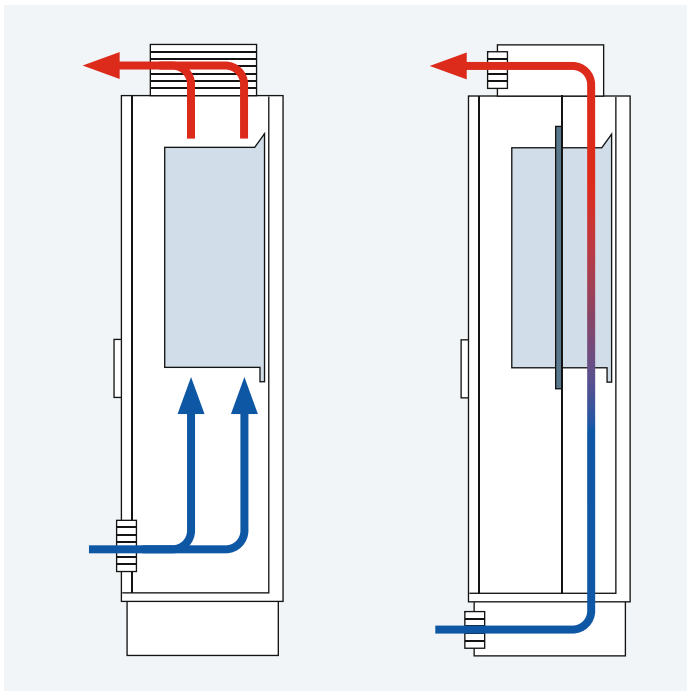
Air cooling

Installed in the control cabinet, the air-cooling design is the most cost-effective variant for dissipating heat loss at low output levels. To reduce energy and noise levels, air-cooled IndraDrive ML variants are fitted with fan assemblies that operate based on load. Air cooling via a separate air duct allows the control cabinet to achieve a higher rated protection class, while targeted heat dissipation through an air ducting system is simplified outside the cabinet.
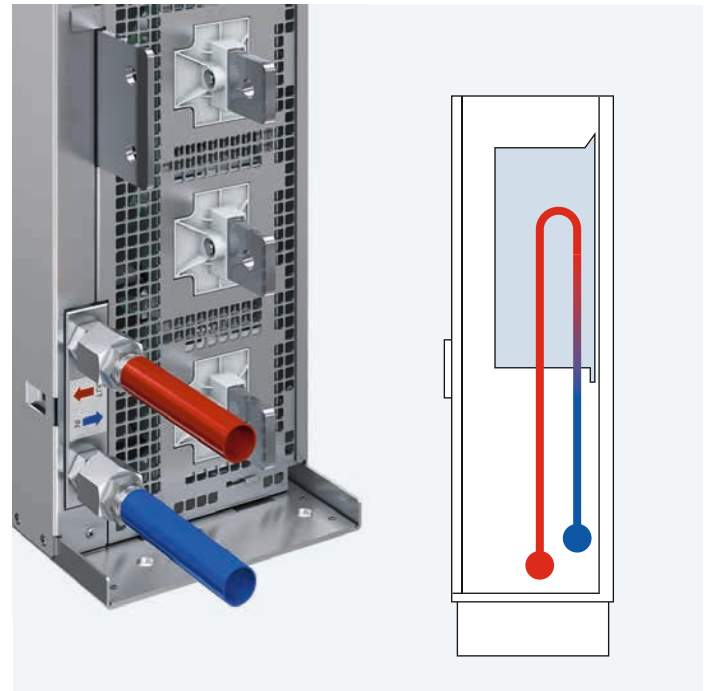
Liquid cooling

Liquid cooling is the most efficient method of dissipating heat, or channeling heat loss. The high inflow temperature of the coolant enables energy to be used effectively in heat-recovery systems. Noise levels are also reduced to a minimum. Control cabinets that have a high rated protection type are easy to accomplish.

Application-specific concepts for energy-efficient production

4EE ENERGY EFFICIENCY

Designed to meet the requirements of the target application, the IndraDrive ML always offers the best possible solution for plant operation in an energy-efficient manner. A wide variety of concepts for storing energy in static or rotary configurations as well as a Smart Energy Mode and further options are available for saving energy and reducing peak loads in the power grid.
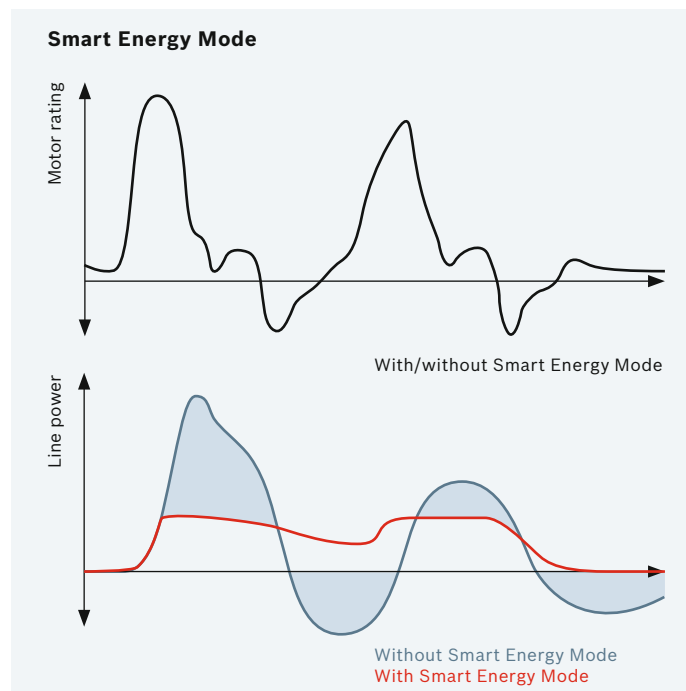
Mains regenerative power

Feeding surplus energy back into the power grid considerably reduces consumption, especially during generator operation over an extended period. This, in turn, leads to a high power quality with almost zero harmonic emissions. Regulated DC bus voltage ensures maximum independence from the supply voltage as well as a high level of tolerance for balancing out fluctuations in the voltage.

Smart Energy Mode

Actively regulating the mains inverter in smart energy mode ensures a reliable supply of DC bus voltage that is independent from the mains voltage while utilizing the DC link capacitors for energy storage. The benefits offered by this are particularly apparent when generator and motor power modes are frequently switched as is the case with intermittent acceleration and braking cycles. Peak loads on the line side are also avoided, and average energy consumption

Mains regenerative power

3 AC   Drive   M

Smart Energy Mode

Motor rating

With/without Smart Energy Mode

Line power

Without Smart Energy Mode
With Smart Energy Mode

DC links

M   M   M M M

is reduced. This improves network compatibility and allows smaller components to be used without compromising machine performance.

Electric and kinetic buffering

Two possibilities exist for buffering large amounts of energy:

▶ Electric buffering: With electric buffering, large DC-bus capacitor units can be charged to conveniently buffer as much as 700 kJ of energy.
▶ Kinetic buffering: Kinetic buffering is the process of converting surplus energy into kinetic energy and storing it in a buffer device. By optimizing this energy for the respective production process, the energy supply can be made available to the system on demand and as required thanks to a host of configurable functions.

DC links

A modular filter concept allows the IndraDrive ML to connect several drives via the DC bus so that energy can be exchanged in multi-axis systems. Central energy storage devices can also be used together.

Regulation of reactive current

Regulating reactive current eliminates the losses produced by the current in the mains connection configuration. Inductive or capacitive consumers can likewise be compensated without the need for additional reactive current compensation systems.

Intelligent energy management at a glance
▶ Lower average energy consumption
▶ Reduction in peak grid loads
▶ Reduction in power loss in the control cabinet
▶ Reduced control cabinet space required thanks to smaller power supply components
▶ Minimal outlay expended to cool the control cabinet

Electric buffering

Drive

Energy storage: Capacitor

Kinetic buffering

Drive

Energy storage: Motor with flywheel mass

Regulation of reactive current

— Voltage
— Current with reactive current regulation
— Current without reactive current regulation
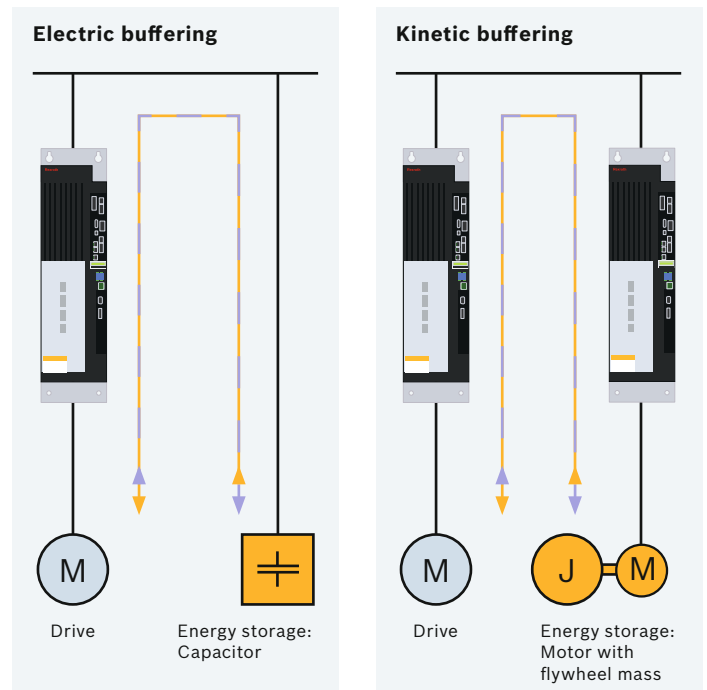
Voltage/current
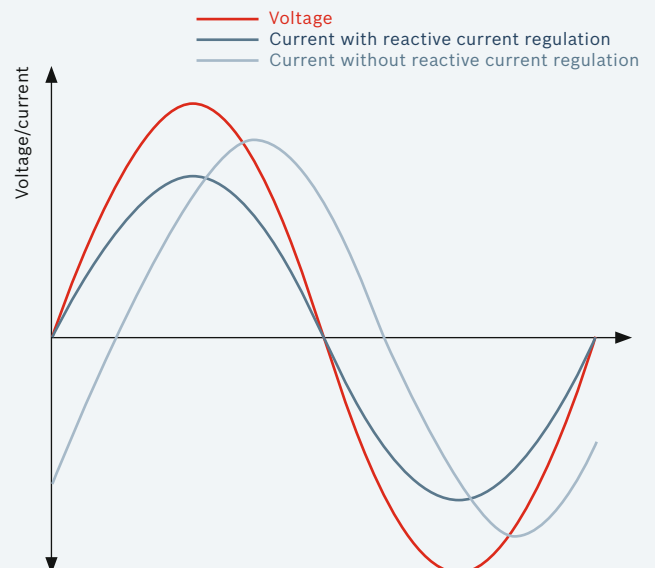
Control units:
Scalable performance and functions

Scalable control units and application-specific firmware options allow IndraDrive ML from Rexroth to cover a wide range of standard applications up to and including high-end servo applications that require a high level of dynamic response and precision. We can supply the control unit you need for the application scenario you have in mind. Standardized interfaces, comprehensive firmware functions, integrated motion logic, a host of technology functions, and certified safety technology leave nothing to be desired.

BASIC control unit

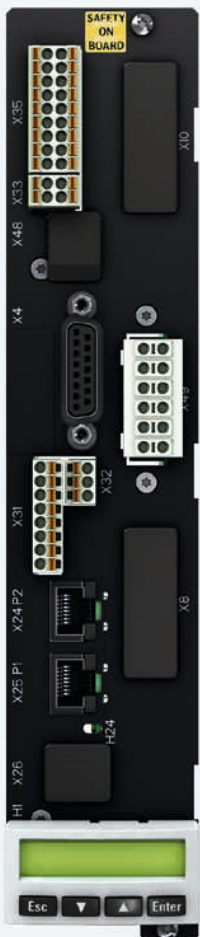**ADVANCED control section**

BASIC control units – the scalable standard

These units constitute the economic solution for all applications involving standard requirements in terms of control quality and interface flexibility. The BASIC control unit includes a multi-Ethernet, a multi-encoder, and an optional safety technology interface. Two additional interface options allow additional fieldbuses, encoders, or analog/digital I/O extensions to be integrated.

ADVANCED control units – for maximum freedom and performance

These units meet the highest requirements in terms of performance, and a high level of computing power greatly reduces cycle times. Customers can also integrate a Sercos master to serve as a basis for a drive-integrated control system in addition to the options afforded by a BASIC control unit.

Multi-protocol capable hardware

The protocol used for Ethernet-based interfaces is selected in a software application. Available protocols include Sercos, PROFINET IO, EtherNet/IP, POWERLINK and EtherCat. PROFIBUS and CANopen can also be chosen as optional interfaces.

Multi-encoders

The control units provide base support for all commonly used encoder types thanks to their built-in multi-encoder interface. This gives you maximum freedom in choosing your encoder and motor system.

Communications interface

sercos the automation bus	**PROFI NET**®	ETHERNET **POWERLINK**	**CAN**open
EtherNet/IP™	**EtherCAT.**	**PROFI BUS**®	
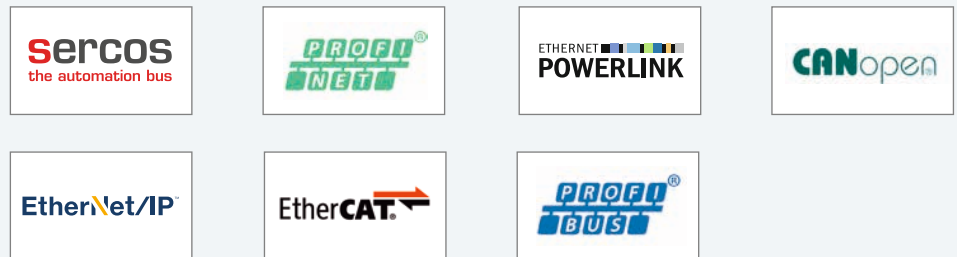
Flexible firmware configuration

Optimally adapted BASIC and ADVANCED firmware variants are available for the control unit hardware. This firmware can be configured in line with the requirements of your applications:

▶ Basic packages
  - OPEN LOOP (frequency converter applications)
  - CLOSED LOOP (servo and frequency converter applications)
▶ Extension packages (option)
▶ Motion logic (IndraMotion MLD, option)

The basic package is already adequate to perform the majority of standard drive functions, from simple V/f control right through to positioning block mode. Various extension packages provide you with the options of electronic synchronization, additional servo functions or main spindle 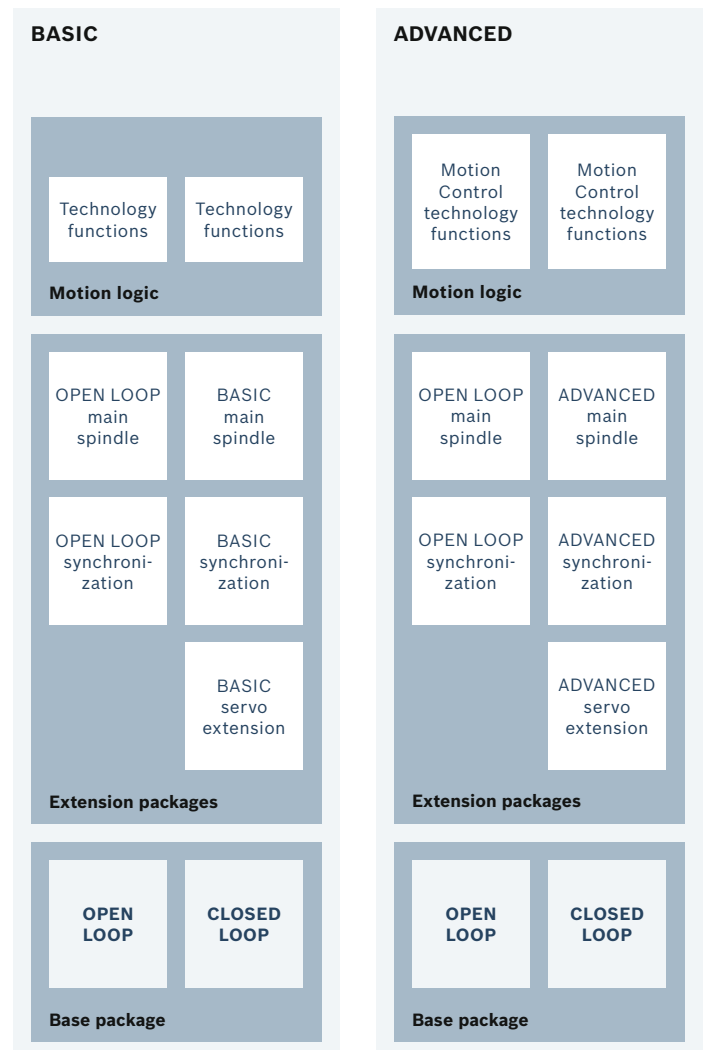operation. The freely programmable motion logic with integrated PLC conforming to IEC 61131-3 requirements and ready-to-use technology functions facilitate simple execution of complex machine processes.

BASIC

Technology functions	Technology functions

Motion logic

OPEN LOOP main spindle	BASIC main spindle
OPEN LOOP synchronization	BASIC synchronization
	BASIC servo extension

Extension packages

OPEN LOOP	**CLOSED LOOP**

Base package

ADVANCED

Motion Control technology functions	Motion Control technology functions

Motion logic

OPEN LOOP main spindle	ADVANCED main spindle
OPEN LOOP synchronization	ADVANCED synchronization
	ADVANCED servo extension

Extension packages

OPEN LOOP	**CLOSED LOOP**

Base package

Control functions:
More options for every application

With IndraMotion MLD, the drive-integrated control system from Rexroth, drive functions, motion control, and processing logic merge to form a modern, open automation platform for modular machine concepts. As a result, you can realize applications independently, without higher-level control.

IndraMotion MLD-S

Higher-level control

Drives with integrated single-axis motion logic
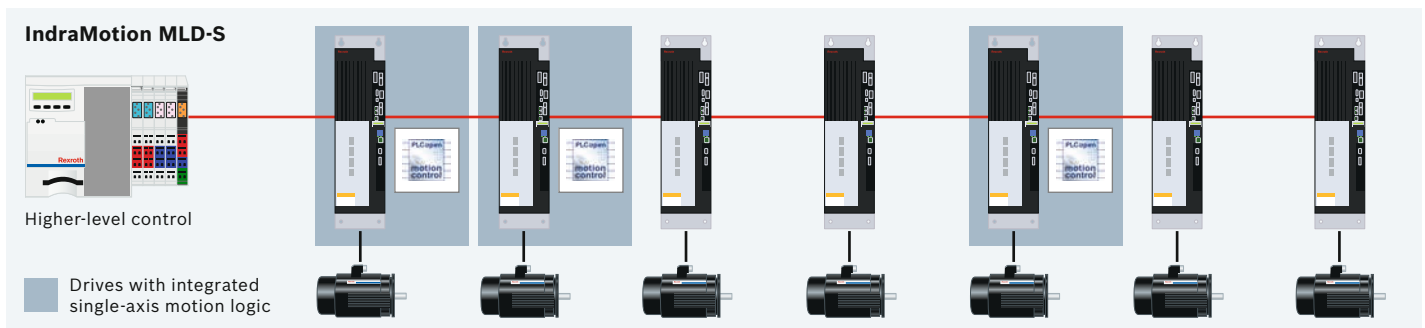
IndraMotion MLD-S single-axis motion logic
In order to carry out drive engineering tasks that target a specific axis and relieve the load placed on the higher-level control, this system offers the option of moving individual functions to specific drive units. To this end, a wide variety of predefined technology functions can be leveraged, or a separate application can be created as required.

IndraMotion MLD-M multi-axis motion logic
For applications involving a limited number of axes, a Sercos master drive can be used to coordinate up to 9 additional drives. Motion tasks with greater levels of complexity can also be done at the drive level, without the need to integrate the higher-level control.

IndraMotion MLD-M

Sercos master drive with integrated multi-axis motion logic
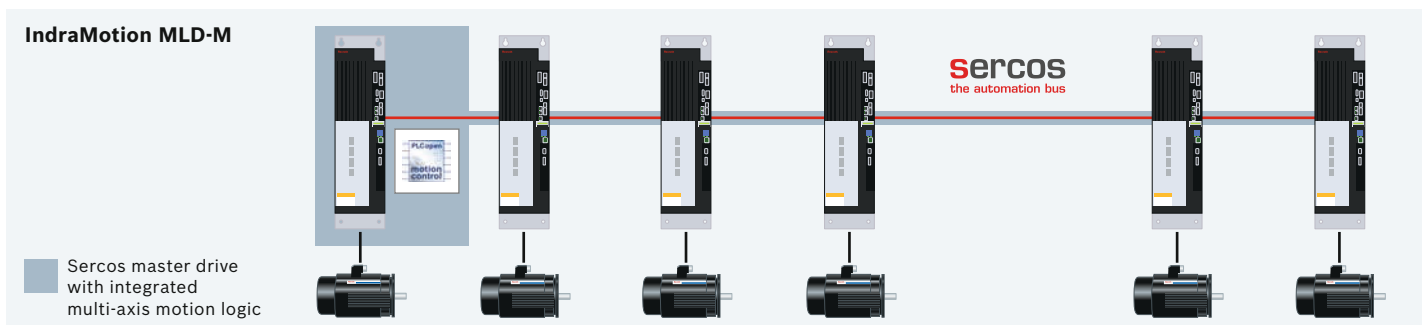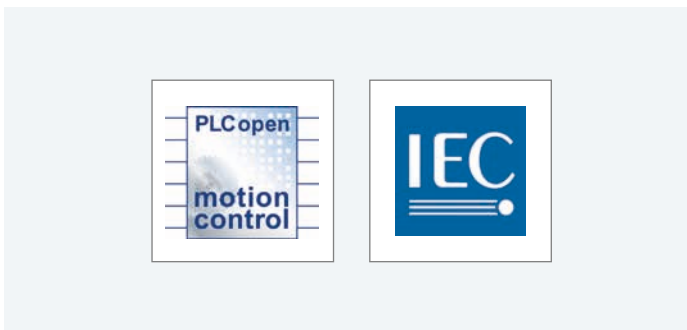
Open to standards

Standardized programming languages and the IndraWorks universal engineering framework simplify project planning, programming, parameterization, operation, and diagnosis. In the process, they integrate valuable know-how directly in the drive to give users an additional competitive edge. Programming is in conformity with IEC 61131-3 in the following languages:

▶ Instruction List (IL)
▶ Structured Text (ST)
▶ Function Block Diagram (FBD)
▶ Ladder Diagram (LD)
▶ Sequential Function Chart (SFC)
▶ Continuous Function Chart (CFC)

Standardized modules from the function library in conformity with PLCopen give you access to a multitude of motion functions.

Flexible programming

User-defined programming makes it possible to design applications in a flexible, versatile manner. Innovative drive functions, extensive functions libraries, and process-oriented technology packages combine to form a perfect automation solution.

Predefined functions

Large-scale and sophisticated applications in particular can also be handled with our ready-to-use, predefined technology functions. These applications can then be added to the individual user program or utilized as configurable functions.

Examples of items included in the range:
▶ PLCopen modules
▶ Tension control
▶ Loop control
▶ Winder
▶ Demand processing
▶ Productivity Agent
▶ Extended drive functions
  - Variable retraction motion
  - Adaptive feed rate control
  - Analog force control
  - And much more

Productivity Agent

The properties and characteristics of machines and plants change during daily operation as a result of contamination, wear, and other influences associated with harsh industrial environments. Using the Productivity Agent helps operators detect these changes in good time so that they can respond quickly and effectively. To this end, the Productivity Agent includes various online and offline monitoring and analysis functions for mechanicals and processes to improve the performance and availability of the machines:

▶ Mechanical analysis
▶ Outer circle monitoring
▶ Vibration damping and avoidance
▶ Collision monitoring
▶ Frequency response analysis
▶ S1 characteristic curve analysis
▶ Process controller

Certified safety:
For protecting man,
machine, and work pieces

SAFETY ON BOARD

The extremely short response times of the large electric drives from Rexroth are proof of what modern safety technology can do to protect man, machine, and work pieces, as all motions are monitored right where they start. The Safe Torque Off and Safe Motion functions can also be implemented, depending on requirements.

Safe Torque Off diagram with Standard controller, STO signal, and Control communication

Safe Torque Off: For safe interruption of applied torque

The Safe Torque Off (STO) safety function reduces the amount of hardware needed as well as wiring costs. Axes equipped with STO ensure a high level of safety without taking the longer route through the higher-level control system.

When the STO function is activated, the drive responds with-in milliseconds by interrupting the torque and current supply to the motor connected. This, in turn, prevents the motor from starting up again after having come to a stop. The STO function is certified with Cat. 4 PL e in conformance with EN ISO 13849-1 and with SIL 3 in conformance with EN 62061.

Safe Motion: For safe movements

The optional Safe Motion safety technology offers a comprehensive list of safety functions that range from Safe Stopping through to Safe Travel Moments.

Functions requiring no encoder, such as SS1, SS1-ES, STO, SBC, and SDL, are certified with Cat. 4 PL e in conformance with EN ISO 13849-1 and with SIL 3 in conformance with EN 62061. Functions requiring encoder feedback, such as SS2, SOS, SLS, SMS, SMD, SLI, and SDI, are certified with Cat. 3 PL d in conformance with EN ISO 13849-1 and with SIL 2 in conformance with EN 62061.

For logging purposes, IndraDrive uses the safety standard CIP Safety. Signals are simply pulsed in along with the standard data of the Sercos network in real time. Integrating drive, peripheral, and safety buses as well as standard Ethernet communication into a single network simplifies handling and reduces hardware and installation costs.

With CIP Safety on Sercos, up to 64 axes can be operated in a safe manner. The signals can also be provided by way of a zone module for selecting the safety functions. This eliminates the need for a higher-level safety controller, and up to 25 axes can be operated safely.

Safe Motion diagram with Safety controller, CIP Safety, Safety over EtherCAT, and PROFINET
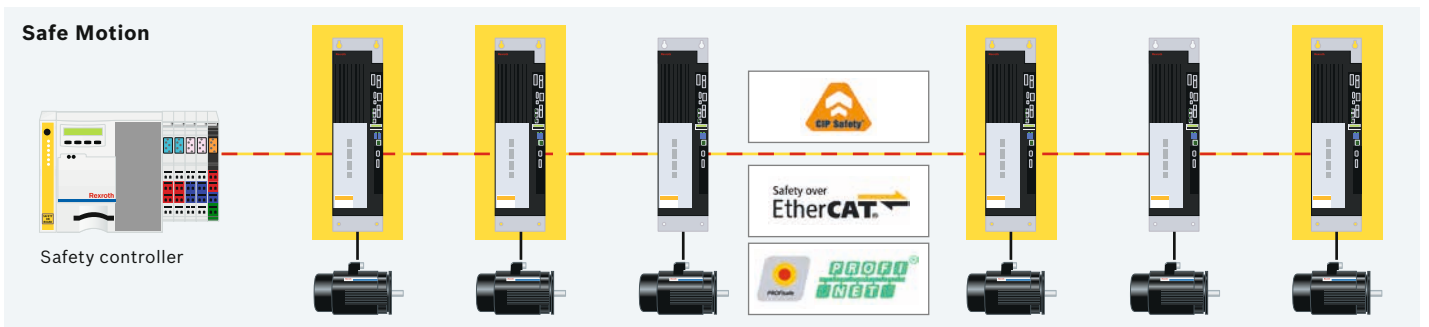
Technical Data: HMU universal power inverter 380 - 500 V

Universal power inverter, liquid-cooled		HMU05.1N-F0140-0350-N-A4-D7-___-_NNN	HMU05.1N-F0170-0430-N-A4-D7-___-_NNN	HMU05.1N-F0220-0510-N-A4-D7-___-_NNN	HMU05.1N-F0270-0660-N-A4-D7-___-_NNN	HMU05.1N-F0340-0820-N-A4-D7-P_-_NNN	HMU05.1N-F0430-1040-N-A4-D7-P_-_NNN	HMU05.1N-F0540-1300-N-A4-D7-P_-_NNN	HMU05.1N-F0680-1690-N-A4-D7-P_-_NNN
Power data as mains inverter		Low degree of overload capacity [1] | High degree of overload capacity [2]							
DC bus baseline power	[kW]	144 | 120	173 | 144	216 | 173	270 | 216	339 | 270	430 | 339	535 | 430	672 | 535
DC bus overload power	[kW]	158 | 180	190 | 216	238 | 260	297 | 324	373 | 405	473 | 509	589 | 645	739 | 803
Line input current (baseline power)	[A]	216 | 180	260 | 216	324 | 260	405 | 324	509 | 405	645 | 509	803 | 645	1,009 | 803
DC bus continuous power	[kW]	145	174	219	273	342	435	540	679
Mains connection voltage	[V]	3 AC 380 to 500 (-15 % / +10 %)							
Supply frequency	[Hz]	50 / 60 (± 2Hz)							
DC bus voltage	[V]	Regulated, configurable 1.5 x U_{supply} up to 750 V							
Power data as motor inverter		Low degree of overload capacity [1] | High degree of overload capacity [2]							
Typical motor rating [3]	[kW]	132 | 110	160 | 132	200 | 160	250 | 200	315 | 250	400 | 315	500 | 400	630|500
Base-load current	[A]	251 | 209	303 | 251	388 | 303	485 | 388	610 | 485	763 | 610	992 | 763	1,173|992
Overload current	[A]	276 | 314	333 | 377	427 | 454	533 | 582	671 | 727	839 | 915	1,091 | 1,144	1,291 | 1,488
Continuous current	[A]	254	306	392	490	616	771	1,002	1,185
Maximum current	[A]	355	427	515	660	825	1,037	1,297	1,686
Nominal switching frequency	[kHz]	4	4	4	4	2	2	2	2
Switching frequency / max. output frequncy	2 kHz	200							
	4 kHz	400							
	8 kHz	800							
Derating factor 2 to 4 kHz [5]		–	–	–	–	0.89	0.81	0.77	0.77
Derating factor 4 to 8 kHz [5]		0.72	0.85	0.80	0.71	0.67	0.75	0.68	0.65
Other data									
Can be connected in parallel up to 8 units [4]		●	●	●	●	●	●	●	●
Derating parallel operation		0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
DC bus capacity	[mF]	4.95	4.95	6.6	8.25	9.9	13.2	16.5	19.8
Mains contactor		External							
Braking transistor/resistor		External							
Control voltage data									
Control voltage, external	[V]	DC 24 (±20 %)							
	[V]	DC 24 (±5 %) when supplying motor holding brake							
Power consumption (without control unit and motor brake)	[W]	41	48	53	46	48	55	58	65
Continuous current (without control unit and motor brake)	[A]	1.7	2	2.2	1.9	2	2.3	2.4	2.7

All data applies to nominal rating at 3 AC 400 V mains voltage and nominal switching frequency
● Possible
– Not possible

[1] Base load for 9 min., 10 % overload for 1 min.
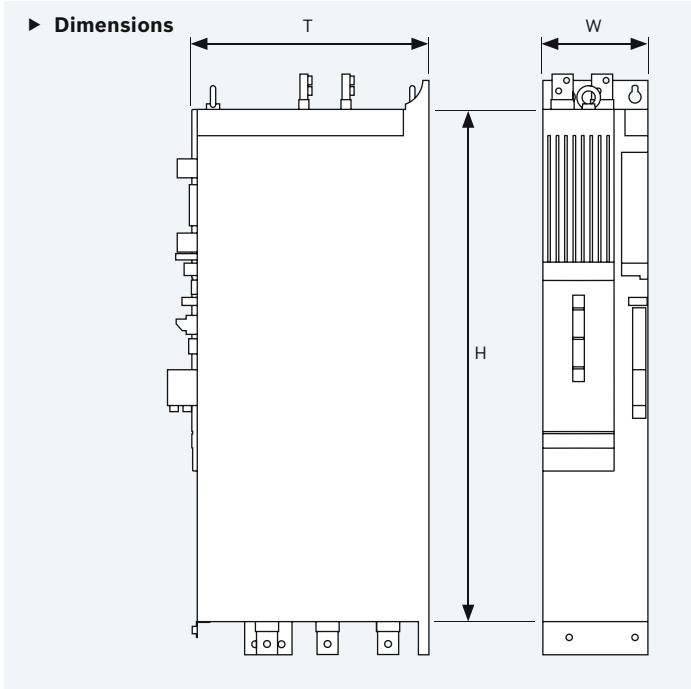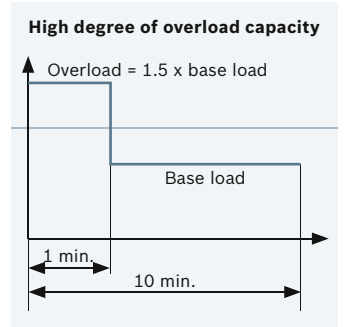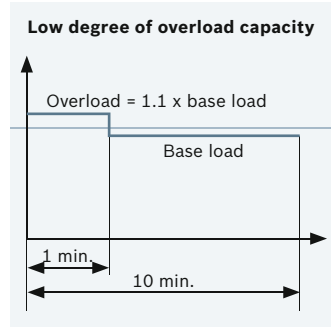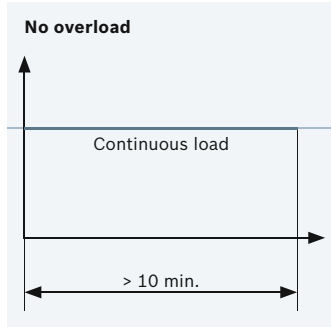[2] Base load for 9 min., 50 % overload for 1 min.
[3] 4-pole asynchronous motor, 400 V, 50 Hz
[4] up to 4 kHz, units of identical power
[5] regarding to continuous current
[6] balancing choke needed

▶ **Performance**

| No overload | Low degree of overload capacity | High degree of overload capacity |

No overload

Continuous load

> 10 min.

Low degree of overload capacity

Overload = 1.1 x base load

Base load

1 min. | 10 min.

High degree of overload capacity

Overload = 1.5 x base load

Base load

1 min. | 10 min.

▶ **Dimensions**

T   W

H

Universal power inverter, liquid-cooled		HMU05.1N-F0140-0350-N-A4-D7-___-_NNN	HMU05.1N-F0170-0430-N-A4-D7-___-_NNN	HMU05.1N-F0220-0510-N-A4-D7-___-_NNN	HMU05.1N-F0270-0660-N-A4-D7-___-_NNN	HMU05.1N-F0340-0820-N-A4-D7-P_-_NNN	HMU05.1N-F0430-1040-N-A4-D7-P_-_NNN	HMU05.1N-F0540-1300-N-A4-D7-P_-_NNN	HMU05.1N-F0680-1690-N-A4-D7-P_-_NNN
Mechanical data									
Height H	[mm]	687	687	791	895	973	1,181	1,389	1,389
Width W	[mm]	200	200	200	200	200	200	220	220
Depth T	[mm]	440	440	440	440	440	440	440	440
Mass	[kg]	51	51	58	65	70	83	103	i. p.
Protection type, device/connections						IP20 / IP00			

Technical Data:
HMU universal power inverter
525 - 690 V

Universal power inverter, liquid-cooled		HMU05.1N-F0140-0210-N-A5-11-___-MNNN	HMU05.1N-F0170-0250-N-A5-11-___-MNNN	HMU05.1N-F0220-0300-N-A5-11-___-MNNN	HMU05.1N-F0270-0370-N-A5-11-___-MNNN	HMU05.1N-F0400-0600-N-A5-11-___-MNNN	HMU05.1N-F0540-0750-N-A5-11-___-MNNN
Power data as mains inverter		Low degree of overload capacity [1] | High degree of overload capacity [2]					
DC bus baseline power	[kW]	144 | 120	173 | 144	216 | 173	270 | 216	400 | 315	535 | 430
DC bus overload power	[kW]	158 | 180	190 | 216	238 | 260	297 | 324	440 | 473	589 | 645
Line input current (baseline power)	[A]	125 | 105	151 | 125	188 | 151	235 | 188	349 | 274	466 | 375
DC bus continuous power	[kW]	144	173	216	270	400	535
Mains connection voltage	[V]	3 AC 525 to 690 (-15 % / +10 %)					
Supply frequency	[Hz]	50 / 60 (± 2Hz)					
DC bus voltage	[V]	Regulated, variable 1.56 x U_{supply} or fix 1,100 V					
Power data as motor inverter		Low degree of overload capacity [1] | High degree of overload capacity [2]					
Typical motor rating [3]	[kW]	132 | 110	160 | 132	200 | 160	250 | 200	355 | 315	500 | 400
Base-load current	[A]	146 | 122	175 | 146	216 | 175	281 | 216	365 | 353	575 | 442
Overload current	[A]	160 | 182	193 | 218	238 | 263	309 | 324	402 | 530	633 | 663
Continuous current	[A]	147	177	227	284	374	581
Maximum current	[A]	207	248	298	367	600	751
Nominal switching frequency	[kHz]	4	4	4	2	2	2
Switching frequency / max. output frequncy	2 kHz	200					
	4 kHz	400					
	8 kHz	800					
Derating factor 2 to 4 kHz [5]		–	–	–	i. p.	0.72	0.65
Derating factor 4 to 8 kHz [5]		0.68	0.56	0.44	i. p.	0.52	0.33
Other data							
Can be connected in parallel up to 8 units [4]		●	●	●	●	●	●
Derating parallel operation		0.95	0.95	0.95	0.95	0.95	0.95
DC bus capacity	[mF]	2.2	2.2	3.3	3.3	4.4	6.6
Mains contactor		External					
Braking transistor/resistor		External					
Control voltage data							
Control voltage, external	[V]	DC 24 (±20 %)					
	[V]	DC 24 (±5 %) when supplying motor holding brake					
Power consumption (without control unit and motor brake)	[W]	i. p.	i. p.	i. p.	i. p.	i. p.	i. p.
Continuous current (without control unit and motor brake)	[A]	i. p.	i. p.	i. p.	i. p.	i. p.	i. p.

All data applies to nominal rating at 3 AC 690 V mains voltage and nominal switching frequency
● Possible
– Not possible

[1] Base load for 9 min., 10 % overload for 1 min.
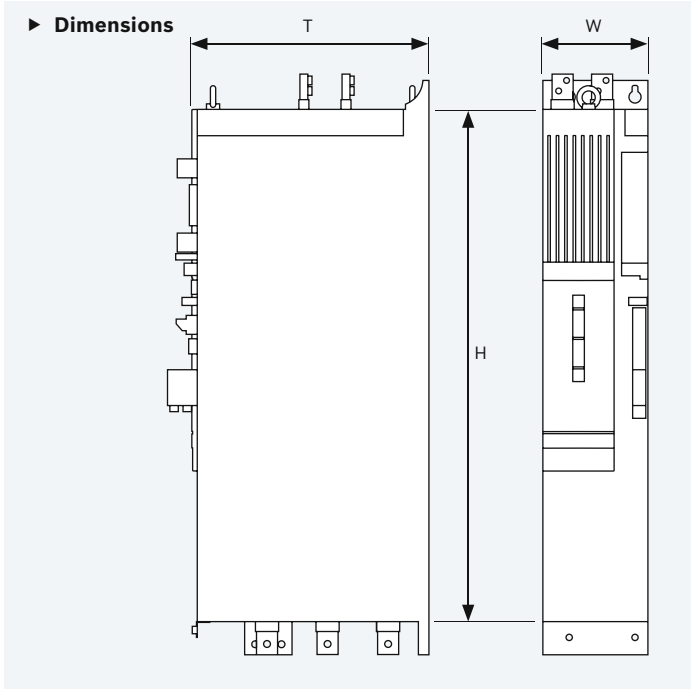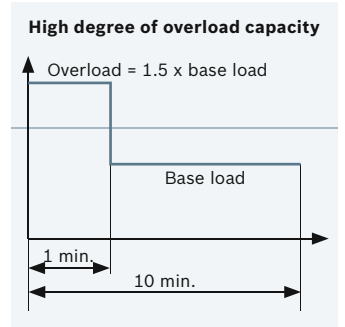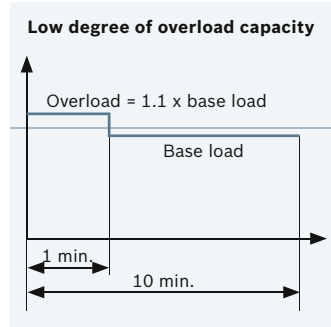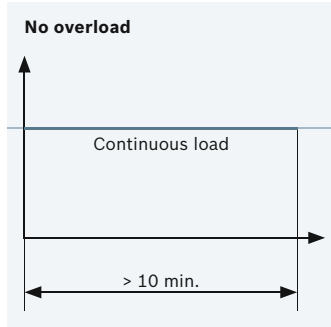[2] Base load for 9 min., 50 % overload for 1 min.
[3] 4-pole asynchronous motor, 690 V, 50 Hz
[4] up to 4 kHz, units of identical power
[5] regarding to continuous current
[6] balancing choke needed

▶ **Performance**

No overload

Continuous load

> 10 min.

Low degree of overload capacity

Overload = 1.1 x base load

Base load

1 min.

10 min.

High degree of overload capacity

Overload = 1.5 x base load

Base load

1 min.

10 min.

▶ **Dimensions**

Universal power inverter, liquid-cooled		HMU05.1N-F0140-0210-N-A5-11-___-MNNN	HMU05.1N-F0170-0250-N-A5-11-___-MNNN	HMU05.1N-F0220-0300-N-A5-11-___-MNNN	HMU05.1N-F0270-0370-N-A5-11-___-MNNN	HMU05.1N-F0400-0600-N-A5-11-___-MNNN	HMU05.1N-F0540-0750-N-A5-11-___-MNNN
Mechanical data							
Height H	[mm]	687	687	791	791	895	1.181
Width B	[mm]	200	200	200	200	200	220
Depth T	[mm]	440	440	440	440	440	440
Mass	[kg]	i. p.	i. p.	i. p.	i. p.	i. p.	i. p.
Protection type, device / connections		IP20 / IP00					

Technical Data:
CSB and CSH control units

BASIC control unit
Performance hardware for basic applications and standard servo applications
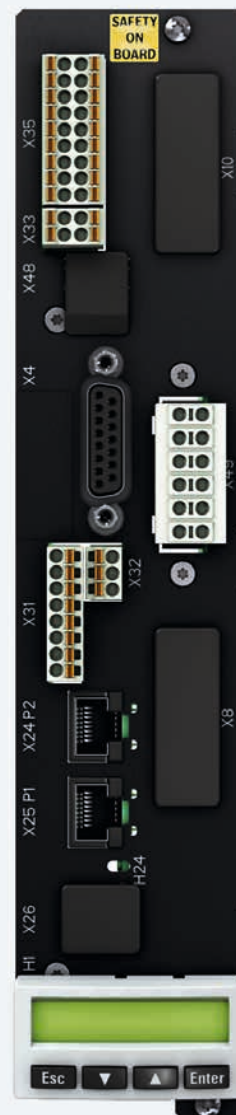
ADVANCED control unit
Hardware with ultra-high performance for high-end servo applications and master for multi-axis motion logic

Onboard interfaces	BASIC CSB02.5B	ADVANCED CSH02.5B-ET	ADVANCED CSH02.5B-CC
Multi Ethernet	●	●	–
Sercos master	–	–	●
Multi-encoder	●	●	●
Engineering port	–	–	●
Operating panel	Standard	Advanced	Advanced
Digital inputs	●	●	●
Probe inputs	●	●	●
Digital I/Os (configurable)	●	●	●
Analog input, ±10 V	●	●	●
Analog input, 0 - 20 mA	●	●	●
Analog output, ±10 V	●	●	●
Optional interfaces			
CANopen	●	–	●
PROFIBUS DP	●	–	●
Multi Ethernet	–	–	●
Multi-encoder	●	●	●
Encoder emulation	●	●	●
I/O extension, digital/analog	●	●	●
Safe Torque Off	●	●	●
Safe Motion	●	●	●

● Possible   – Not possible

Accessories

Power line connection module
Required to operate the universal power inverter as a mains inverter with the following functions:
▶ Precharge DC bus capacitors
▶ Measure supply voltage
▶ Actuate line contactor
▶ Exchange messages with the entire drive system

Line choke and line filter
Coordinated unit comprising a commutating reactor and filter for high noise immunity and low emissions.

DC bus choke
Allows the number of axes to be increased with high leakage capacitance for motors and cables.

Braking transistor unit and braking resistor
For converting braking energy if energy cannot be channeled back to the power supply network.

Control voltage power supply unit
Generates the 24 V control voltage from the power supply and DC bus. Ensures continued operation of all devices and units connected, including after a power failure.

Motor chokes
For reducing the rate of voltage rise (dv/dt). Allows motors to be operated with limited dielectric strength.

Motor filter
Smooths the output voltage to an almost sinusoidal waveform. This reduces the discharge currents of shielded cables while keeping the interference emissions of unshielded cables to a minimum.

Balancing chokes
Ensure optimal use of motor inverters connected in parallel for achieving high outputs of up to 4 MW.

Assembly aid
The assembly and disassembly aid alleviates handling when installing the universal inverter in the control cabinet.

Heat exchanger
For cooling liquid-cooled devices
▶ Water-water heat exchangers for dissipating heat loss in process water or for use in heat recovery systems
▶ Water-air heat exchangers for simple dissipation of lost heat into the air
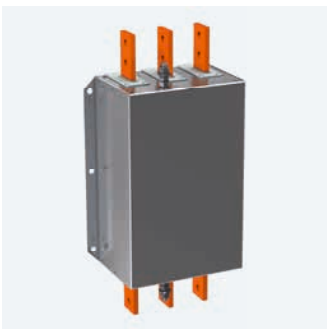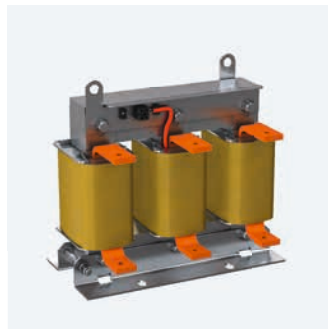
Control cabinets:
Overall package for optimal solutions

Complete control cabinet solutions

Upon request, we also supply the IndraDrive ML drive systems up to the Megawatt range fully installed and wired. Complete control cabinet solutions are produced based on customer- and application-specific requirements – for powers of up to 4 MW and in the voltage range of 380 - 690 V. Depending on the desired cooling type and protection class of the control cabinet, various designs are feasible for cooling any energy loss arising depending on the situation.

For the drive components:
▶ Water-water heat exchanger
▶ Water-air heat exchanger

For additional air-cooled components in the cabinet:
▶ Air-water heat exchanger
▶ Air conditioners
▶ Open-circuit ventilation

In accordance with the regional requirements, the control cabinet receives a CE declaration of conformity or for instance a UL certification for the North American market. Of course with additional documentation such as circuit diagram in EPLAN, components parts list etc. Additional options or alternative designs may be supplied in accordance with customer requirements, for example:
▶ DC-outgoing feeders for connecting smaller drives
▶ Panels for control technology of additional components
▶ Individual wire designation
▶ Various mechanical cabinet designs
▶ Network contactor or other controllable main switches

Benefits of packages
▶ Coverage of the entire process from a single source – from planning, development and design, through preliminary acceptance of switch cabinet construction right up to commissioning on the customer's premises
▶ Comprehensive package tailored to the application guarantees optimal solution
▶ Coverage of a wide surrounding area – from installation in spaces for electrical operating material right up to deployment in the machine environment

Motors:
As diverse as the applications

Motors for the entire power and requirements range

The requirements on the motor's torque-speed characteristics are highly diverse due to the wide operating range in various applications. They inevitably result in characteristics which are optimized in terms of:

▶ High torques at low speeds
▶ High powers in a broad speed range
▶ High dynamics with small moments of inertia

We cover the entire power and requirements range with solutions from a single source, both for motors from our own IndraDyn production range as well as motors from collaborations with other manufacturers. From design right up to commissioning.

Optimized operation is achieved depending on motor design, both synchronous and asynchronous, by means of a high level of control dynamics and PWM frequency in various control types:

▶ Voltage-frequency-control, without encoder (U/f)
▶ Flux-controlled operation, without encoder (FXC)
▶ Field-oriented current control, without encoder (FOCsl)
▶ Field-oriented current control, with encoder (FOC)

Depending on the ambient conditions, various designs are possible with respect to protection class and type of cooling as well as mechanical design with respect to casing, bearing etc.

Upon request, existing motors can also be run using output chokes or filters.

Benefits

▶ Coordinated motor-inverter combination from a single source
▶ Efficient operation by means of high PWM frequency and intelligent drive functions
▶ Broad spectrum of motor designs and options

Ethernet – the simplest is the best

The increasing number of sensors, actuators, and control components in industrial automation plants gives rise to more complex control networks. Adapting powerful, versatile, and cost-effective Ethernet standards to industrial automation requirements is the key to the future of industrial communication solutions. Specialized fieldbus systems were initially used to simplify networking. These were replaced by the popular Fast Ethernet technology, which offers a variety of benefits:

- Recognized, widespread, and forward-looking technology
- 10 to 100 times higher data throughput rates than with fieldbuses
- Costs comparable with analog interfaces:
  - No expensive or proprietary hardware required
  - Based on widespread standard components: Double-shielded CAT5e copper cable, standard connectors and controllers with high production quantities (e.g. FPGAs)
- Broad-reaching IT concepts with an integrated transmission medium from office to field level
- Flexible and compatible automation systems thanks to transparent international standard
- Possibility of global networking for diagnostics and maintenance purposes

Field buses can also be connected to an Ethernet system, depending on the functionality of the control hardware. This allows you to continue using your current investments.

PLCopen - the standard in motion programming

Founded in 1992, PLCopen is an international manufacturer- and product-independent interest group of control suppliers, software providers and institutes. Technical committees define new standards in accordance with the global PLC standard IEC 61131-3, which enable a substantially increased efficiency for the development of application software. Here, the centre of attention is the desire expressed by users for simplicity, flexibility, conformity, and manufacturer-independence.

In November 2001, for example, the first specification of a status machine and of a library with a function block was passed on the basis of IEC 61131-3, in order to standardize the interface between PLC logic and motion control architectures. A further example: in February 2006 the PLCopen organization adopted the first specification based on the safety standard IEC 61508 with defined user groups, data types and function modules as the basis of programmable safety controls. They are already regarded as quasi-standards for future safety solutions by control manufacturers.

Bosch Rexroth has been actively involved in the PLCopen technical committees for years which enables an early integration of the current PLCopen specifications into its products. Today, on the basis of PLCopen standards, Bosch Rexroth offers innovative and complete PLCopen-certified automation solutions which create important competitive advantages for machine manufacturers:

- simplified programming of processes through the use of consistent functional modules for all motion tasks
- faster realization of applications due to reusable standardized software modules
- increased software quality and efficiency for engineering
- reduced effort for commissioning, troubleshooting and maintenance
- little effort for the training of eg. the service staff
- increased flexibility concerning adjustments to machine variations
- standardized automation concepts for various applications
- reduced production costs and time-to-market for machines and plants

By using the PLCopen standards you can return to focussing on the essentials - your machine processes and their functionality.

The Quick Route to Sercos

Sercos® is one of the most powerful Ethernet-based real-time communications systems on the market and its characteristics meet the requirements of even the most high-end factory automation systems.
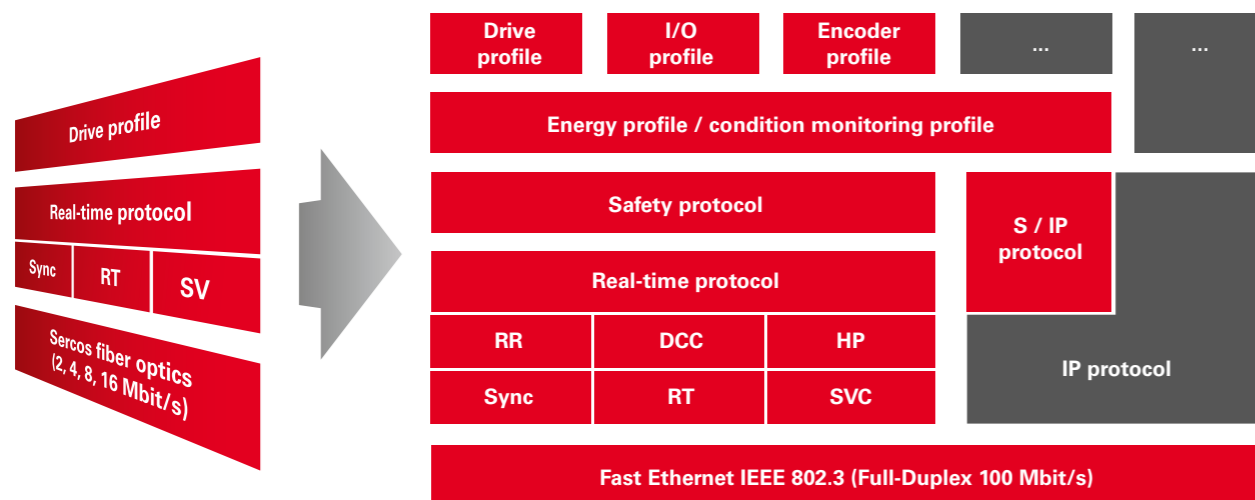
There are a wide variety of options for implementing the Sercos interface. Device manufacturers can choose in-house developments. Development partnerships are also possible, for which a service provider's basic components and knowledge can be used. In addition, complete modules which encapsulate the Sercos functionality are available from a number of companies.

The information contained in this brochure and the presentation of selected companies which have many years' experience with the conception of communications interfaces will help you, as a device manufacturer, to find the optimum solution for your projects.

Advantages and benefits at a glance

Mechanical engineers and users benefit from a wide range of advantages:

✓ Proven
- Sercos is an open, international standard (IEC 61784, IEC 61158, IEC 61800-7).
- Complete backwards compatibility ensures that it is a long-term investment.
- Leading suppliers of automation systems back Sercos with broad product portfolios.
- Sercos technology is widely accepted in many industries, in particular for high-end applications.
- More than four million real-time nodes are currently being used in more than 500,000 applications – and the numbers are growing every day.
- Ethernet-standard IEEE 802.3 physics and protocol are used.

Simple
- Sercos devices are easy to configure and put into use.
- The cables are easy to connect as neither the physical order of the devices nor the order of the connection to the two Sercos ports is important.
- Maintenance is easy because the devices and their position within the topology are recognized automatically.

⚡ Fast
- High speed due to the use of Fast Ethernet (100 Mbps full duplex).
- Short run times: the summation frame procedure, the on-the-fly processing and the direct cross communication reduces run times in the network to a minimum.
- Configurable cycle time: The communication cycle can be set between 31.25 µs and 65 ms – synchronization accuracy << 1 µs.

Efficient
- Hot plugging can be done without impacting real-time or synchronization characteristics.
- Optimized use of bandwidth through a summation frame procedure and multiplexing mechanisms.
- All Ethernet-based protocols (including TCP/IP communication) can be transmitted in the same communications cycle using the same cable.

Reliable
- Redundant data transmission ensures high machine and plant availability.
- Synchronization which is accurate far below than one micro-second ensures deterministic and synchronized communication across the entire Sercos network.
- Sercos allows fail-safe communication: Cable breaks are recognized within 25 µs which means that data is lost for a maximum of one cycle.
- Robust cables made from copper or fiberoptic.

Economical
- Sercos energy: save energy and maximize productivity at the same time.
- Machine controls can set components to idle mode.
- Fast and efficient data transmission allows for shorter cycle times and a higher output.

Flexible
- Flexible network topologies (ring, line, star/tree structures).
- Comprehensive choice of device profiles for all types of automation devices.
- Innovative communication functions, for example direct cross communication and ring redundancy.

Safe
- Safety functions up to SIL3 that are in accordance with IEC 61508 can be implemented with CIP Safety on Sercos.
- Safety-relevant and non-safety-relevant data is transferred over the same cable.
- Devices can safely communicate outside of network boundaries thanks to CIP Safety's routing capability.

Independent
- Sercos technology is independent from manufacturers. The user organization Sercos International e.V. owns all rights to Sercos technology.
- Specifications are maintained and developed by multi-vendor working groups.
- All specifications are freely available.
- You do not have to be a member to use Sercos technology.

Analysis

To begin developing a Sercos interface a component manufacturer must first understand the basic operation of Sercos. The basics include setting up a Sercos III network (cabling/topology), the phase run-up, the mechanisms for exchanging real-time and other data, the assignment of roles between master and slave devices and the procedure for network-wide synchronization.

Sercos International regularly hosts events to provide interested groups with comprehensive information, including:

■ User Seminars:
The user seminars provide an overview of the general operation of Sercos, an overview of applications, implementation options and general information about the range of products and providers.

■ Development Seminars:
The technical operation of Sercos is explained in the development seminars. In addition, the available hardware components and the best way in which these can be integrated into a field device are explained. Furthermore, the certification process is described and certain testing and certification tools are presented.

■ Webinars:
Sercos International holds online seminars on certain topics (e.g. energy, safety, blended infrastructure, etc.). Only a computer with internet access is needed to take part in these seminars, which are usually one hour long.

■ User Conference:
Providers and users meet once a year at the Sercos User Conference to learn and discuss about current topics and trends.

In addition to Sercos International's events and e-learning opportunities, several centers of excellence and service providers also offer seminars and customer-specific training on Sercos.

Sercos system architecture

Implementation

Before implementing and integrating a Sercos interface, the following information is usually collected:

■ What are the basic connection possibilities?

■ Which manufacturers offer hardware and software components which are compatible with Sercos?

■ Which tools are available to accompany development?

■ Which service providers support integrating, testing and certifying Sercos devices etc.?

Which communications protocol functions and/or function profiles need to be implemented and which are optional and what the testing and certification processes look like are also typical questions in order to begin implementation. These will now be looked into.

Controller and Communication Modules

A large range of hardware options is available including FPGA components, ASICs and microprocessors with integrated Sercos functionality.

Device type	Controller type			
	FPGA	ASIC	Micro-processor	Ethernet IC
Master (Hard)	■	■	■	
Master (Soft)				■
Slave	■	■	■	
EasySlave	■			

Controller for master/slave connection

On the **slave** side, specific hardware which takes on the fast telegram processing, the synchronization, the topology switching, the direct linking up of any Ethernet node, the hot plugging and the direct cross-communication is always used.

On the **master** side, either specific hardware ("hard master") or, alternatively, a standard Ethernet controller ("soft master") is used.

Different versions of **FPGA** components for Sercos III are offered by the manufacturers Altera, Lattice and Xilinx. The FPGA components are either used purely as Sercos III communications controllers or as universal SOPC solutions (system on a programmable chip) with integrated Sercos III logic.

The IP core for the FPGA components can be licensed from Sercos International as **netlist** or **bit stream**. Different license models are available (single payment or run-time license). Companies which are a member of Sercos International, Sercos North America or Sercos Asia receive a discount. Upon request, manufacturers who are interested will receive a price list and the license agreement which must be signed.

A license for the **IP source code**, e.g., for the development of an ASIC, is also available. In this case, a suitable license is agreed upon based on the focus of the project. Maintenance and technical support is provided by the company Automata.

Particularly time-saving and inexpensive implementation is possible with the **EasySlave**. The FPGA-based EasySlave can be used for simple peripheral I/O devices, e.g. encoders, measuring probes or valve terminals. To be able to achieve this, single chip implementation is used which eliminates the additional CPU and which can be integrated into slave devices with minimal development and integration costs. Maintenance and technical support for the EasySlave is provided by the Steinbeis Transfer Center in Esslingen, Germany.

In addition to FPGA-based controllers, various manufacturers offer ASIC and processor solutions with different ranges of function and performance. Some controllers are simply communication controllers that only contain hardware-related Sercos functions. In addition to the hardware-related Sercos functions, other controllers also incorporate other interfaces and user logic.

Device manufacturers can integrate the Sercos controllers into their own hardware or, alternatively, can use ready-made designs or communication modules. The first option requires more development expense but optimizes manufacturing costs. The second option shortens the development phase considerably, but leads to higher manufacturing costs.

Standard PCs can be equipped with ready-made expansion cards. Both active boards with their own CPU and passive boards without CPU are available. The cards are connected via PC buses, e.g. PCI. If a soft master is implemented, the "on board" Ethernet controller can be used.

Various manufacturers offer **evaluation** and/or **starter kits** which include sample codes and make it easy to start developing Sercos interfaces.
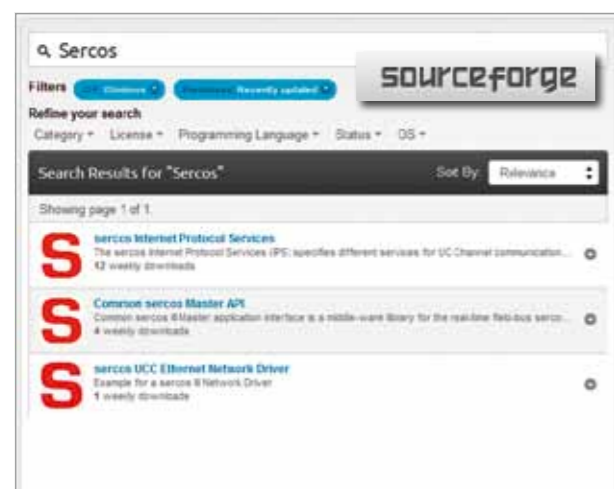
Driver Software

Driver software is used to connect the controller to the device logic. Interested parties can either develop this thermselves or obtain a license from a manufacturer. For self-development, it is possible to draw on various basic drivers which are available as open source software.

The following open source software is available:

- **Common Sercos Master API (CoSeMa):**
  This master function library contains API routines for initializing, phase sequencing, timing calculation and functions for cyclical and acyclic communication.

- **Sercos Internet Protocol Services (IPSS):**
  This software contains the information needed to implement various S/IP protocol services which enable data exchange with Sercos devices so that set-up, remote maintenance or diagnostics can be carried out without the need for a Sercos master or a Sercos communication to already be initialized.

- **Sercos UCC Ethernet network driver:**
  An Ethernet network driver's sample code connects the UC channel and a TCP/IP stack via the CoSeMa API. This allows any TCP/IP protocol to be transferred in parallel to the Sercos real-time protocol.

Various manufacturers offer complete driver software to connect master and slave device logics. These drivers are sometimes independent from the secondary hardware controllers; sometimes they are coordinated with and optimized for specific hardware implementations.

Open Source driver software for Sercos via Sourceforge.net

In order to develop **CIP Safety on Sercos** devices simply and quickly, a pre-certified protocol software is available. This software can be used to equip not only Sercos devices but also EtherNet/IP devices with the appropriate safe logic up to SIL3.

The safety protocol software uses the SMP (Sercos Messaging Protocol) which allows CIP data and services to be mapped in configured, cyclic data containers in the Sercos telegram. Due to the modular architecture of the CIP safety protocol software, unlimited use of EtherNet/IP devices alongside Sercos is possible. This reduces the development costs and investment risks for the device manufacturer to a minimum.

In addition to the protocol software for Sercos and EtherNet/IP, the software package offered by IXXAT contains a safety manual and unit tests. As all components for the ANSI-C code are available, a transfer to customer-specific safety platforms is possible with little effort. The included unit tests make the re-certification of the CIP safety protocol software which is necessary after a transfer to a safe platform considerably easier.

IXXAT offers services involving the CIP safety software, including initial advice, introduction to code and integration workshops, support for customer-specific hardware and software integration of the safety software, and device certification.

Tools

Various tools which can be used during development are also available. In addition to the possibilities listed below, various member companies and service providers also offer additional configuration, testing and development tools.

Sercos Monitor

The Sercos Monitor is a powerful diagnosis tool for Sercos III networks which is available for free download from the Sercos homepage and allows a comprehensive and detailed analysis of data traffic in Sercos III networks.

The Sercos Monitor supports the operating systems Windows XP and Windows 7. The tool, which is based on the WinPcap interface, allows a retrospective evalu-

ation of network records saved in pcap format, as well as real-time analysis of network traffic. The user-friendly interface and overview functions which are characteristic of Sercos III networks, such as topology, communication phases and service channel transfers, allow the analysis process to be started quickly and in a targeted manner.

The Sercos Monitor – a powerful diagnosis tool for Sercos networks

Experienced users also have comprehensive protocol and analysis functions available to them. Various views and filters allow an evaluation of Sercos III real-time telegrams and other Ethernet telegrams which is tailored to meet the user's requirements. If required, the functionality of the Sercos Monitor can also be expanded by the user with user-specific plug-ins.

MultiSlave Emulator

The PC-based Sercos MultiSlave Emulator allows the emulation of a Sercos network with multiple slave devices. The tool supports the operating systems Windows XP and Windows 7 and uses an active Sercos PCI plug-in card from Automata. A user-friendly interface allows the emulation of a complete Sercos network and connected Sercos slave devices. The emulated Sercos devices can be freely configured. By reading out the available parameters from the physical devices and importing these into the MultiSlave Emulator, the emulation of the individual devices, as well as the complete network configuration, can be executed with a minimum of effort.

Test Master

Sercos International offers a test master to ensure the compatibility of Sercos III slave devices. This reference software helps to ensure that Sercos III slave implemen-

tation is carried out correctly so that slaves from different manufacturers are compatible and interoperable. Using this, the certification of a slave device can be carried out with the minimal amount of time and expense. The Sercos III Test Master is offered as a complete test and development environment for Sercos slave connections. It contains an active PCI Sercos III interface card, and the original reference software which runs on Windows XP without any additional real-time extensions.

Slave Conformizer

The Sercos Slave Conformizer is used for official conformity tests of slave implementations which form the basis for formal certification. It can be purchased by manufacturers in order to check a product's conformity to specifications during the development phase or to carry out a complete quality control inspection over the course of development. This helps reduce development time and optimizes conformity testing. A PCI plug-in card is used as test hardware for the Sercos Conformizer. The test cases can be configured with a scripting language and be processed automatically. The test results provided in a protocol document can immediately be used to prove conformity. The scripting language and configurable ID number-based data makes it easy to adapt and expand test scenarios and to integrate manufacturer-specific tests.