YASKAWA

Collaborative Applications

www.yaskawa.eu.com

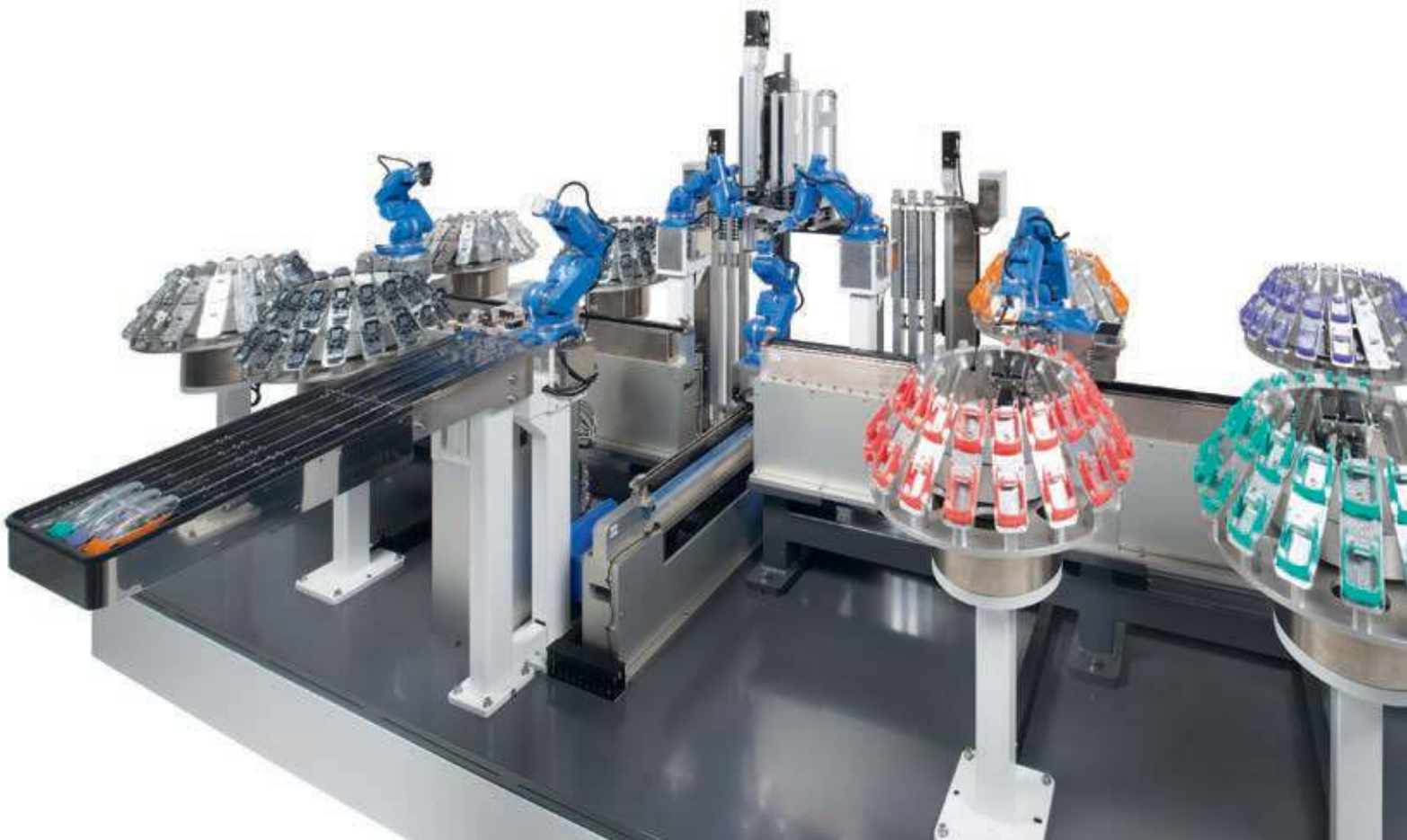
Masters of Robotics, Motion and Control

Content

Introduction

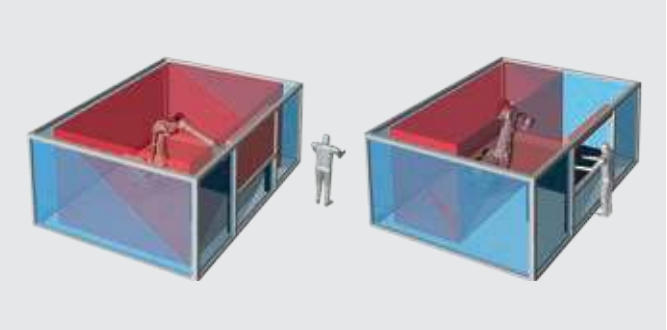
Collaborative applications have become widely discussed in the past few years. The idea behind this new concept is to create a flexible workplace in order to keep up with recent market trends and customer demands for more customized products in smaller batches.

YASKAWA offers a complete portfolio of products that meet customer requirements.



What a Collaborative Workstation is and how it differs from a Collaborative Robot

In a collaborative workplace, not only the actual robot interacting with a human worker is considered, but the entire concept of the workstation, equipment and application, as well as the extent and type of human-machine interaction. The result is a complex cell within the production facility that must comply with the standards defined for the given territory. In Europe, the applicable standard is Machinery Directive MD2006/42/EC and derived standards of ISO 10218-2.

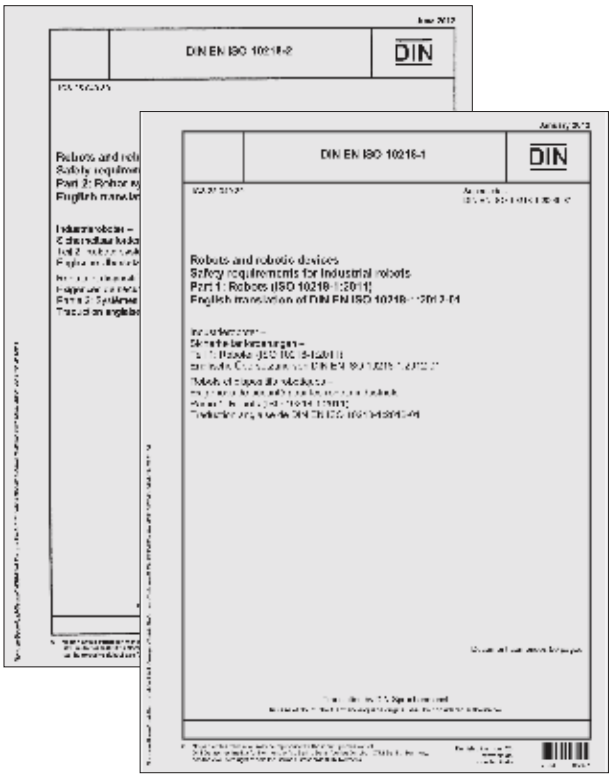


A collaborative robot, on the other hand, is a device that automatically performs complicated, often repetitive tasks; it is designed with smooth edges and surfaces to eliminate pinch points and is often equipped with additional sensors for detecting the human or other obstacles on collision. Collaborative robots comply with ISO 10218-1 and TS 15066 and achieve a minimum performance level of PLd, Cat. 3 according to ISO 13849-1.

Possible Modes of Collaboration

There are four modes of collaboration as defined by ISO TS 15066:

1. **Safety Monitored Stop**
2. **Hand Guiding**
3. **Speed and Separation Monitoring**
4. **Power and Force Limiting**

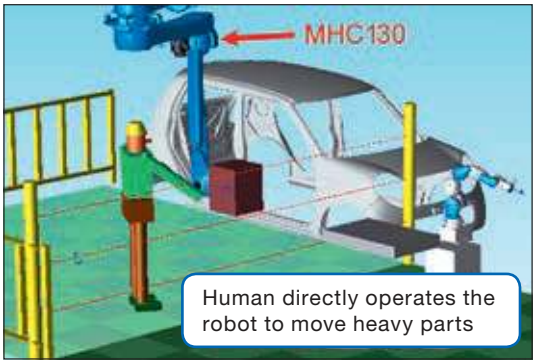


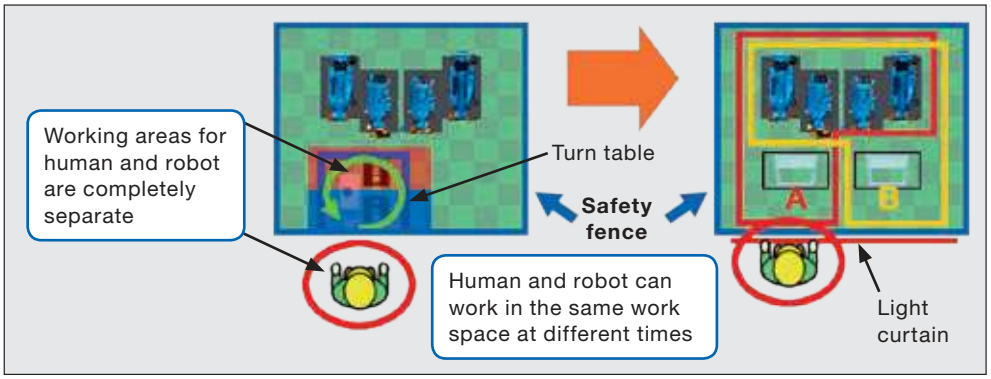
1. Safety Monitored Stop

- **Application type:**
  - Used when robot is working mostly alone
  - Human interaction with robot is occasional
- **Operation procedure:**
  - Human steps into the pre-defined restricted area and the robot stops all movements (servo is on but brakes are applied)
  - Robot restarts motion when safety parameters are reset (i.e. human presses the reset button, human leaves red zone of a safety scanner, etc.)
- **Robot type:**
  - Standard industrial robot
- **Example:**
  - Human performs a secondary operation on a workpiece while robot is holding it

2. Hand Guiding

- **Application type:**
  - Used for path teaching or hand guiding of the robot
  - Pick and place applications
- **Operation procedure:**
  - Human switches the robot to TEACH mode
  - Robot runs with safety guards in PLAY or REMOTE mode
- **Robot type:**
  - Standard industrial robot with additional sensing device (i.e. Kinetiq sensor)
- **Example:**
  - Quick and easy path teaching
  - Robot guiding during seat assembly in the car body





3. Speed and Separation Monitoring

- **Application type:**
  – Uses laser scanners, light curtains or vision systems to track the worker
- **Operation procedure:**
  – Robot works within pre-defined safety zones and acts accordingly when human is detected within the zones (e.g. slows down to 50 % speed, slows down to 20 % speed, stops)
- **Robot type:**
  – Standard industrial robot with additional sensing device for safety zone monitoring (e.g. safety eye from PILZ, safety scanner or light curtain from SICK, etc.)
- **Example:**
  – Loading jigs, removing finished products

4. Power and Force Limiting

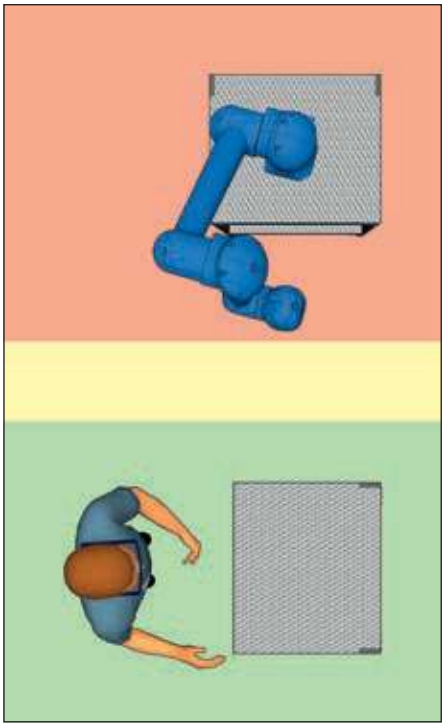
- **Application type:**
  – Robot works alongside a human without additional safety devices
- **Operation procedure:**
  – Robot monitors external forces applied to its body and performs action (e.g. stop, retreat)
- **Robot type:**
  – Not a standard industrial robot, but robot with special force-limited features
  – Robot has rounded shapes for dissipation of forces in case of impact
  – Depending on the results of a risk assessment, it may not require additional safety devices
- **Example:**
  – Machine tending, picking and packing, assembly, etc.

Benefits of Force-limited Robots

- **Easy programming:**
  – Hand guiding
  – User-friendly software interface (e.g. buttons, arrows, animation and visualization, etc.)
- **Easy operation:**
  – Easy start-up procedures
- **Easy installation into the environment:**
  – Lightweight arm
  – Fenceless cell (depending on Risk Assessment result)
- **Cheaper cell:**
  – No fence or no additional safety devices (depending on Risk Assessment result)
- **Cheaper operation:**
  – No special training of operators or workers is necessary

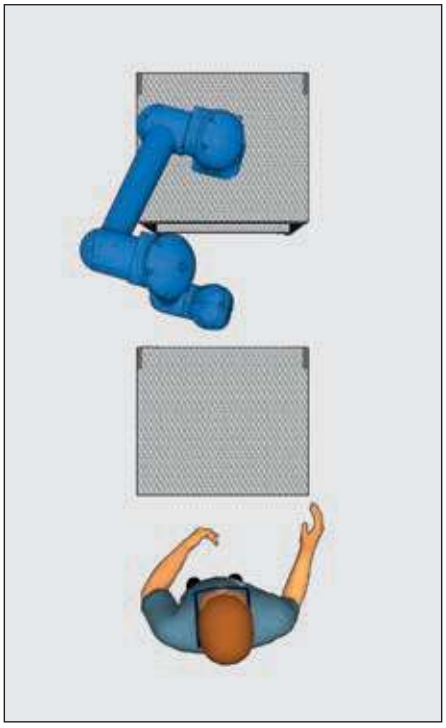
Forms of Collaboration

Coexistence



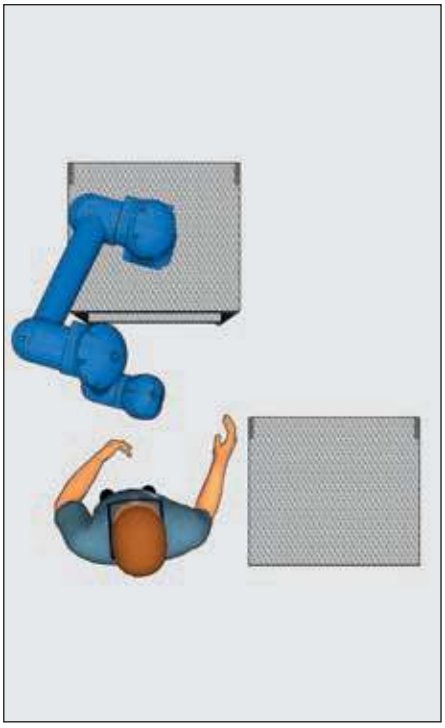
- Robot and human have separated working areas and do not interfere frequently
- Human can occasionally enter working zone of the robot

Cooperation



- Robot and human have shared working area
- Human can enter working zone of the robot regularly
- Both of them work on separate tasks

Collaboration

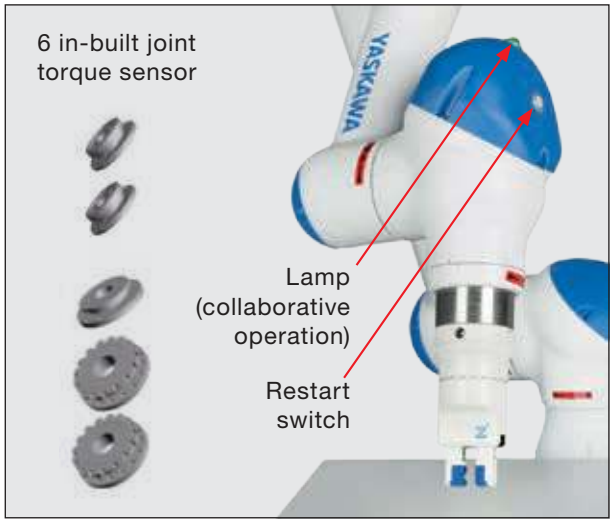


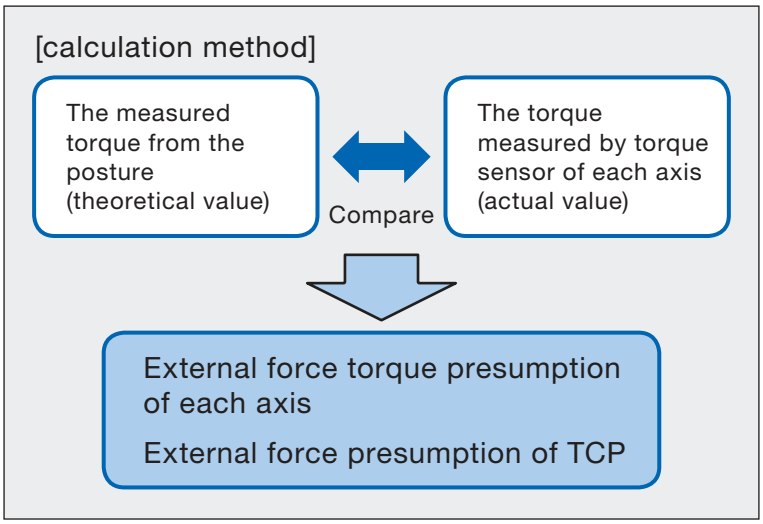
- Robot and human have shared working area
- Human enters working zone of the robot frequently or constantly
- Human dosely interfere with the robot


HC10
YASKAWA

PFL Function (Power and Force-limiting)

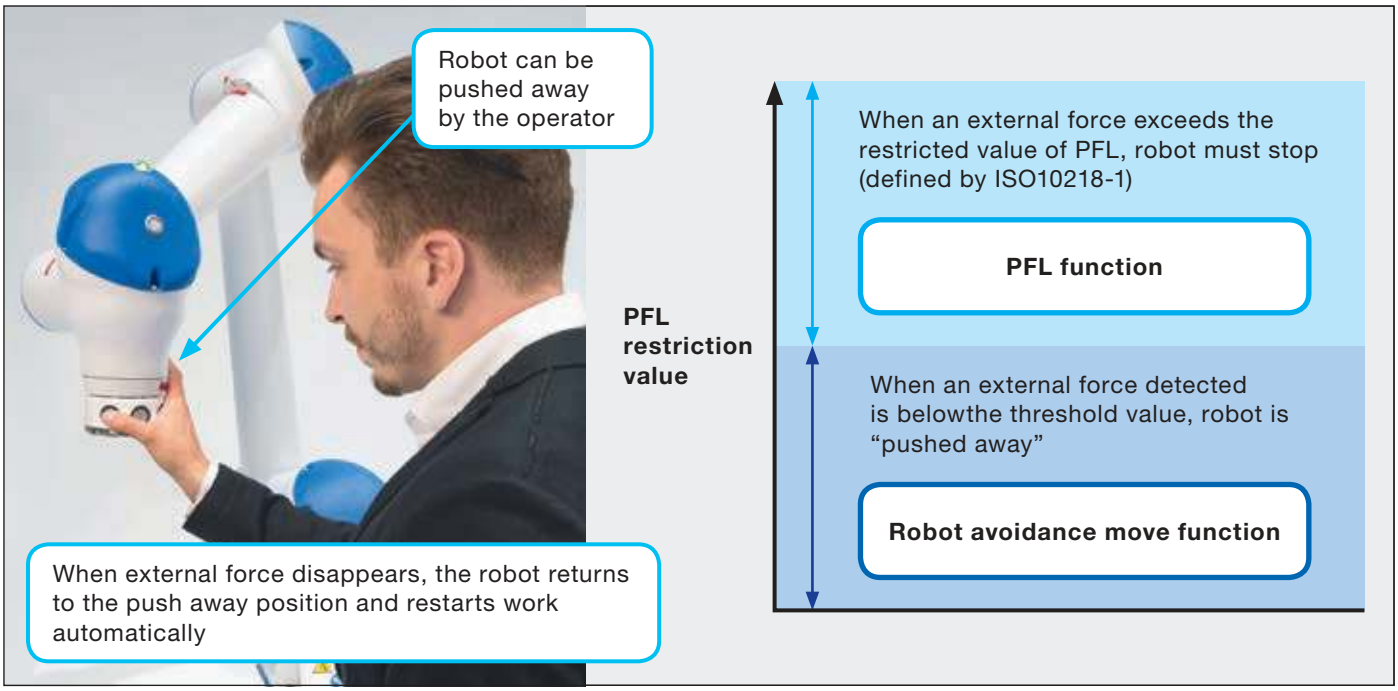
- Safety function based on information from 6 built-in torque sensors in the robot arm
- When the external force acting on a robot exceeds a limit level (each axis, TCP), the robot stops
- When the restart switch of the robot is pushed, the robot withdraws a protection stop and restarts movement





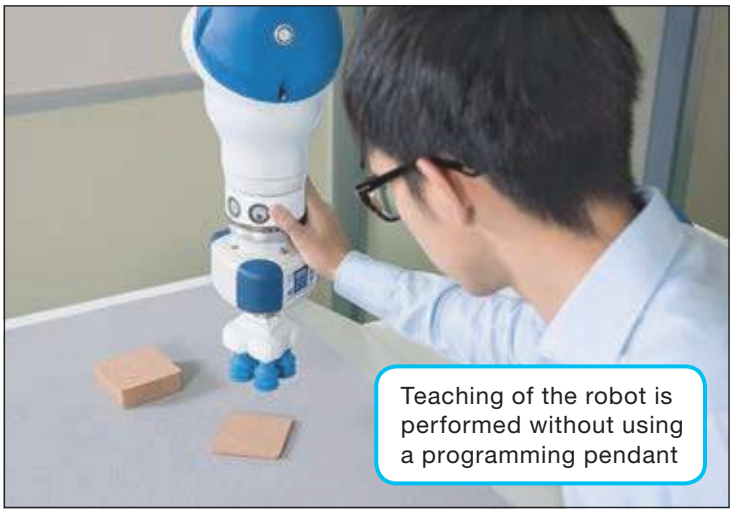
Robot Avoidance Motion Function

- Application function based on the value of an external force applied to the robot
- Decision based on the value of an external force applied to the robot arm
- Robot can be pushed away from the user in a vector of the applied external force
- When external force disappears, robot returns to the push-away point and resumes operation



Lead Through Function

- Application function allowing an operator to hand-guide the robot
- A robot moves in a chosen coordinate system (link motion, rectangular and joint coordinate system)



FSU Functions – Functions also valid for HC10

- Application function based on a value of an external force applied to the robot
- Decision based on the value of an external force applied to the robot arm
- Robot can be pushed away from the user in a vector of applied external force
- When external force disappears, robot returns to the push away point and continues its operation

Individual Axis Range Limitation

Safety Speed Limitation

Individual Axis Speed Monitoring

- with standstill monitoring

Tool Angle Monitoring

Safety Range Limitation

Tool Change Monitoring

PFL Function (Power and Force-limiting)

- setting and limitation of forces

Extra function for HC10

Smart Pendant

- **Smart Pendant reduces what the user needs to remember in order to enter instructions and values, and the procedures for doing so.**
- The main menu makes switching between screens more user-friendly, as all menus are listed in a sequence that requires minimal memorization.
- Easy access to all functions:
  The user can remember the location of each item in the navigation menu and safely return to the home menu in case of confusion.

- **Smart Pendant allows a user to quickly:**
  - **Trigger an action**
  - **Select an option**
  - **Adapt parameter options**
  - **Obtain assistance**
- Smart Pendant introduces a new type of coordinate frame: SMART FRAME
- Traditional teach pendant programming requires the operator to select the appropriate coordinate frame (joint, world, tool or user), which defines the direction in which the robot will move when a button is pressed. If the frame is not set correctly, moving the robot in the wrong direction or with the wrong trajectory can lead to problems and require time-consuming corrections.
- **Hand Guiding is a collaborative feature that allows an operator to hand-guide the robot to a desired position.**
- **This task can be achieved by utilizing additional external hardware mounted directly on the robot or by a robot specifically designed to support this feature, e.g. HC10.**
- Smart Pendant is YASKAWA's next generation programming pendant that makes no compromise between ease of use and capability.

- **Its key features are:**
  - Easy-to-understand operation and user interface designed with customer participation
  - Simplified INFORM programming without loss of functionality
  - Command Builder for automatic INFORM generation

    SMART FRAME jogging eliminates coordinate frames
  - Direct teaching with hand guiding for HC10
  - Built in Help function and "How-To" guides


YASKAWA
1
2
TEACH

Zimmer HRC Grippers

Safe Human Robot Collaborative Gripper

Zimmer HRC grippers meet the requirements of protection principles in accordance with ISO/TS 15066, including patented and BG-certified safety gripper jaws. The mechanical self-locking mechanism of the safety gripper fingers ensures safety even in the event of an emergency stop or loss of power. Integrated state monitoring thanks to a wrap-around LED display enables straightforward state monitoring. Process and service data can be exchanged bidirectionally between the gripper and higher-level control system; optional connections to robot-specific human-machine interfaces (HMI) round out the range of products.
Zimmer HRC grippers can be adapted directly to the HC10, both mechanically and electrically. As a result, MOTOMAN robots can be commissioned quickly and easily in combination with Zimmer grippers and the jointly developed “Plug & Play” HMI.

2-JAW PARALLEL GRIPPERS

COOPERATIVE

ELECTRIC

IO-Link

HRC-01-072797

Stroke per jaw:	60 mm
Gripping force:	820 N
Weight:	1.8 kg
IP class:	40
Maintenance free (max.):	5 mio. cycles

STO safety functions + mechanical self-locking mechanism in the event of a power drop

COLLABORATIVE

ELECTRIC

IO-Link

HRC-01-072794

Stroke per jaw:	60 mm
Gripping force:	120 N
Gripping force in accordance with ISO/TS 15066*:	≤ 140 N
Weight:	2.0 kg
IP class:	40
Maintenance free (max.):	5 mio. cycles

STO safety functions + mechanical self-locking mechanism in the event of a power drop + safety gripper jaws prevent 140 N from being exceeded

* Value based on the parameters described in the ISO/TS 15066, determined with a force measuring device certifi ed by the DGUV (German Social Accident Insurance).

IO-Link

HRC-03-080663

Stroke per jaw:	10 mm
Gripping force:	190 N
Gripping force in accordance with ISO/TS 15066*:	≤ 140 N
Weight:	0.9 kg
IP class:	40
Maintenance free (max.):	10 mio. cycles

Mechanical self-locking mechanism in the event of a power drop

PNEUMATICALLY INTELLIGENT

IO-Link

HRC-04-080644

Stroke per jaw:	6 mm
Gripping force:	130 N
Gripping force in accordance with ISO/TS 15066*:	≤ 140 N
Weight:	0.96 kg
IP class:	40
Maintenance free (max.):	10 mio. cycles

Gripping force safety device in case of pressure failure via integrated spring

2-JAW ANGULAR GRIPPERS

COLLABORATIVE

PNEUMATICALLY INTELLIGENT

IO-Link

HRC-05-080659

Stroke per jaw:	37,5°
Gripping force:	85 N
Gripping force in accordance with ISO/TS 15066*:	≤ 140 N
Weight:	0.96 kg
IP class:	40
Maintenance free (max.):	10 mio. cycles

Gripping force safety device in case of pressure failure via integrated spring

KEY BENEFITS

- DGUV-certified
- Mechanical safe-locking
- Integrated state monitoring
- Optional connections to robot-specific human-machine interface (HMI)

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www.zimmer-group.de

SCHUNK Co-act EGP

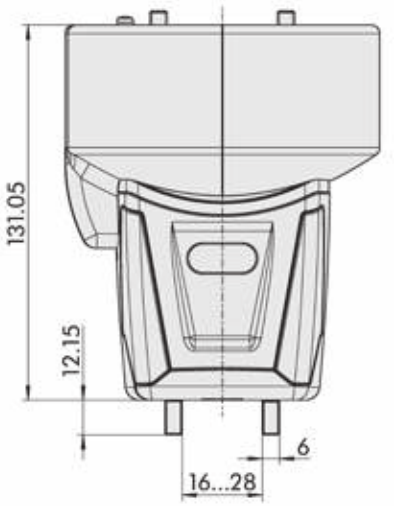
Customer specific gripping unit for YASKAWA MOTOMAN HC10 (PNP, NPN)

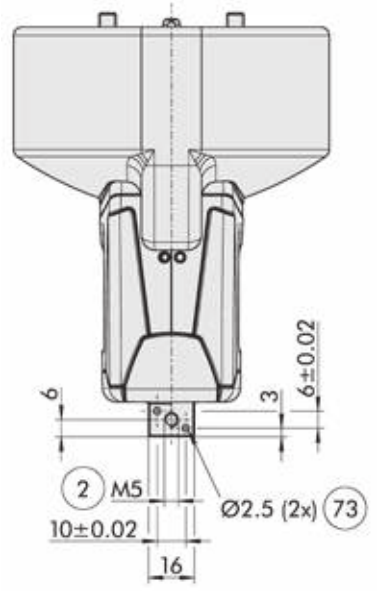
The Co-act EGP gripping unit is suitable for collaborating robots with the specific connection to YASKAWA MOTOMAN HC10 (PNP, NPN) robot.

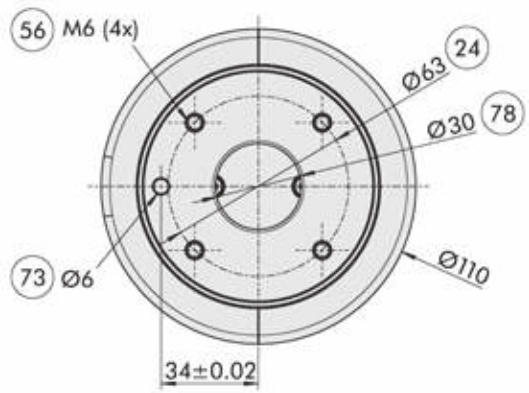
KEY BENEFITS

- Gripping unit for collaborative robot
- Plug & Work with MOTOMAN HC10 (PNP, NPN)
- Control via digital I/O

Technical data	
ID-Nr.	1325126 (PNP) or 1334003 (NPN)
Size	40
Stroke per jaw	6 mm
Min. / max. gripping force	35 / 140 N
Max. admissible finger length	50 mm
Weight	0.69 kg
Mechanical interface	Robot specific
Nominal voltage	24 V DC
Electrical interface	Internal plug (switching principle PNP or NPN)
Sensors	Inductive proximity switches







(2) Finger connection
(24) Bolt circle
(56) Included in the scope of delivery
(73) Fit for centering pins
(78) Fit for centering

Please contact us with your individual requirement.
You can reach the Co-act Team at:

Hotline Co-act Team +49 7133 103 3444
E-Mail co-act-team@de.schunk.com

SCHMALZ Electrical Vacuum Generator – ECBPi

Intelligent, autonomous and flexible

Vacuum Generation – for Collaborative Robots

SCHMALZ presents the CobotPump ECBPi – a new generation of intelligent vacuum generators that do not need compressed air. Their areas of application include mobile robotics, for example in autonomous warehouses or stationary handling tasks with collaborative robots (cobots).

APPLICATION

- Intelligent electrical vacuum generator for handling, airtight and slightly porous workpieces
- Integrated interface for controlling and monitoring the handling process
- For use in mobile robotics, fully automated small parts handling and stationary handling tasks

KEY BENEFITS

- Connection via IO-Link allows process monitoring and predictive maintenance from the machine to the cloud
- Condition monitoring reduces errors and downtime – this ensures the availability of the system
- NFC interface features direct access to processes and the device via smartphone
- Energy efficient thanks to integrated automatic adaptation of the performance to the handling process
- Individual flange plate for YASKAWA robot enables fast and effortless connection to robot

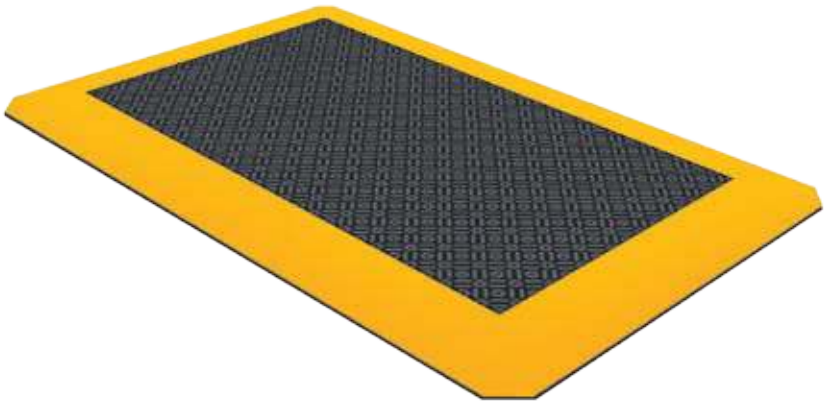
Ordering data	Type		Part no.	Further information
Vacuum generator ECBPi	ECBPi 12 24V-DC M12-8	with M12, 8-pin plug	10.03.01.00314	https://www.schmalz.com/en/10.03.01.00314
	ECBPi 12 24V-DC TB-8	with terminal strip	10.03.01.00364	https://www.schmalz.com/en/10.03.01.00364

The electrical vacuum generator ECBPi is delivered as a ready-to-connect product.
Available accessories: flange plate, connection cable, connection distributor

Technical data	Suction rate (max.) [l/min]	Rated power [W]	Voltage [V]	Rated current [A]	Operating temperature [°C]	Weigt [g]
Vacuum generator ECBPi	12	13	24 – DC	0.6	5 … 45	775

J. Schmalz GmbH
Johannes-Schmalz-Str. 1, 72293 Glatten, Germany, T. +49 7443 2403-0
HYPERLINK “mailto:schmalz@schmalz.de”
schmalz@schmalz.de
HYPERLINK “http://WWW.SCHMALZ.COM/ECBPI”
WWW.SCHMALZ.COM/ECBPI

PILZ pressure-sensitive safety mat PSENmat



KEY BENEFITS

- Pressure-sensitive safety mat (failsafe) and position detection (standard) in a single product; the first ever combination of area monitoring and virtual switch function
- Ergonomic workplace: thanks to the integrated switch functionality, PSENmat supports new machine concepts, hands-free working and an obstruction-free workspace
- Compliant with standard EN ISO 13856-1
- Integrated OSSD outputs for high flexibility and reduced cabling
- Series connection of up to 22 mats possible
- Extremely fast reaction time: ≤ 25 ms
- Robust safety mat designed for large mechanical loads: protection type IP67
- SIL 2 in accordance with EN ISO 61508, safety level PI d in accordance with EN 13849
- Can be used at ambient temperatures from 0 to +50°C

Pressure-sensitive safety mat PSENmat with integrated switch funktionality.

Safe monitoring and individual operation

The world-first PSENmat is a pressure-sensitive mat (failsafe) with integrated swich functionality (standard): It means you can now benefit from safe area monitoring and an operating function based on integrated virtual switches. PSENmat slows or stops the machine when personnel enter the hazardous area (access protection) and/or step behind.

Technical data	
Dimensions	1000 (L) x 600 (W) x 32 mm (H)
Approval	BG, CE, CULus listed
Supply voltage	24 VDC (SELV/PELV)
Power consumption	Max. 2.5 W (per signal encoder)
Reaction time	≤ 25 ms
Protection type	IP67
Static load	Max. 800 N/cm²
Environmental data **– Temperature** **– Humidity** **– EMC** **– Vibration**	 0 ... +50°C Max. 95 % Level/class 3 in accordance with EN ISO 13856-1, table 4 f = 10 ... 55 Hz, A = 0.15 mm, 10 cycles (EN 60060-2-6)
Signal encoder **– Surface material** **– Chemical resistance** **– Fire behaviour**	 PUR Resistant to the usual infuences at an exposure time of 24 h B2 in accordance with EN 13501-1

Order numbers	
Pressure-sensitive safety mat, black **– PSENmat 1000 600 32 PUR bk**	6U000001
Pressure-sensitive safety mat, light grey **– PSENmat 1000 600 32 PUR gr**	6U00002
Ramps	
– PSENmat ramp ec PUR	6U000003
– PSENmat ramp ic PUR	6U000004
– PSENmat ramp PUR 1000	6U000005
– PSENmat ramp PUR 862	6U000006
– PSENmat ramp PUR 724	6U000007
– PSENmat ramp PUR 600	6U000008
– PSENmat ramp PUR 462	6U000009
– PSENmat ramp PUR 324	6U000010
Terminator	
– PSENmat Terminator	560 100
– SDD ES ETH mat	540 140

Prospective introduction: June 2018

PILZ
THE SPIRIT OF SAFETY

We are represented internationally.
Please refer to our homepage
www.pilz.com for further details
or contact our headquarters.

Headquarters:
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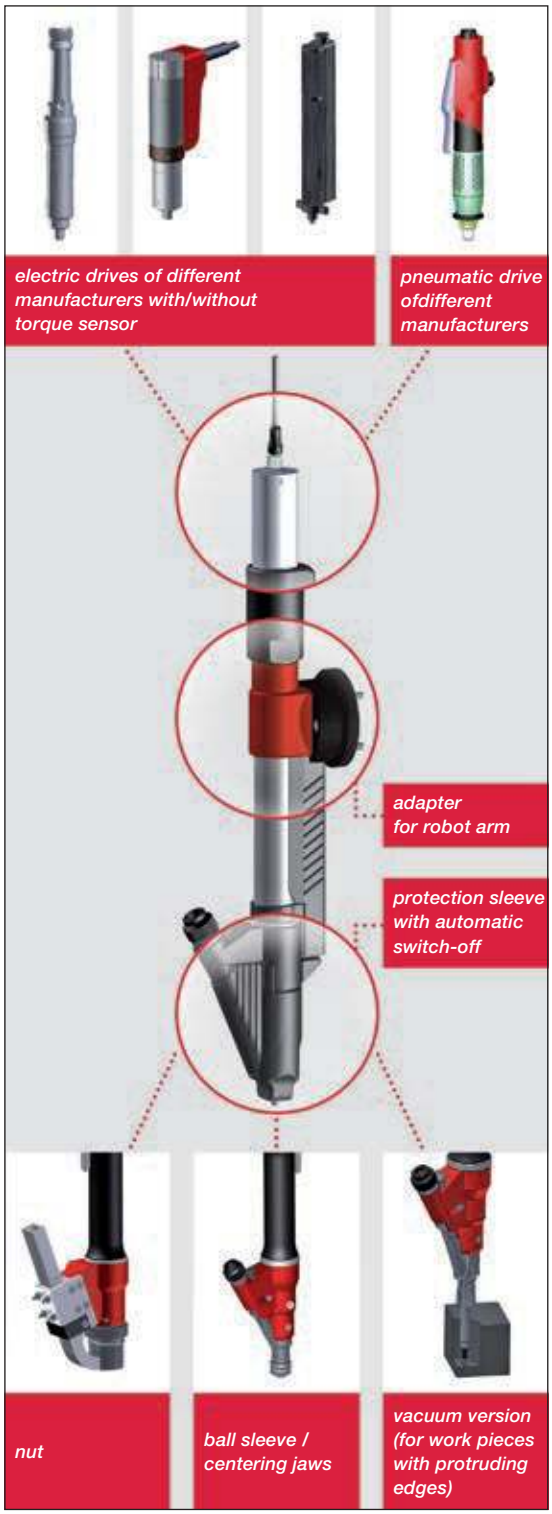
Telephone +49 711 3409-0, Telefax +49 711 3409-133
E-Mail info@pilz.de, www.pilz.com

STÖGER Automation Screwdriver CSX

Automatic Screwdriver for Human-Robot-Interaction with automatic Feeding

With its CSX STÖGER AUTOMATION has developed the first screwdriving unit specially designed for human-robot-interaction. As in all screwdriving units, the fasteners are automatically fed to the CSX. When this screwdriver was designed, special care was taken to eliminate possible risks for the operator.



KEY BENEFITS

- Rounded edges
- Automatic switch-off when protection sleeve is touched
- Short design
- Low weight
- Automatic feeding of fasteners
- Open interfaces for drives (electric/pneumatic), free choice of type and manufacturer
- Interfaces for signal and data exchange
- Analogue displacement-measuring system
- High availability
- Quick bit change without special tools
- Controlled by the robot controller
- Suitable for robots with load-bearing capacity > 5 kg

Technical data	
Screw size	M2 – M8 *
Nuts	Upon request
Weight (without drive)	Approx. 2.0 kg
Torque	Up to 16 Nm
Pressing force tool stroke	10 to 70 N
Noice level measurement	Approx. 50 dbA
Cycle time	From 0.8 sec.*
Vacuum version	Yes
Bit change	Downward, < 10 sec.
Lenght (without drive)	Approx. 450 mm (depending on fasener)

* Standard, weitere Größen auf Anfrage

CAD data available on www.stoeger.com/en/downloads.html under file “automatic screwdrivers”.

STÖGER AUTOMATION GmbH
Gewerbering am Brand 1, 82549 Königsdorf, Germany
Phone +49 8179 997 67-0, E-Mail info@stoeger.com, www.stoeger.com

Collaborative Programming

Hand in Hand

HRC-Applications

Trainings for **Collaborative Programming** cover all robotics applications which are collaborative or co-existent.

The industrial robots special kinematics and Human-Robot applications will be specially trained.
The specific hand guided or conventional programmed applications will be taught in compliance with safety regulations. Special working commands which activate the tools are beeing considered as far as possible.

- **Collaborative Operator Training – RB1CY**
- **Collaborative Basic Training – RB2CY**
- **Collaborative Crossover Training – RB3CY**
- **Collaborative Upgrade Training – HC RB4CY**

SMART Pendant Programming

Pretty well SMART

Smart Pendant programming training differs from others due to using the Smart Pendant.

Programming itself and the programming language is quite easy and very user-friendly.

With this training you will reach an easy and fast success.
This application will be taught using various examples.

- **Smart Pendant Operator Training – RB1S**
- **Smart Pendant Basic Training – RB2S**
- **Smart Pendant Crossover Training – RB3S**
- **Upgrade Smart Pendant Training – RB4S**

For detailed information see page 22 and 23 brochure “Training overview”.

YASKAWA and PILZ –
Case Study with MOTOMAN HC10

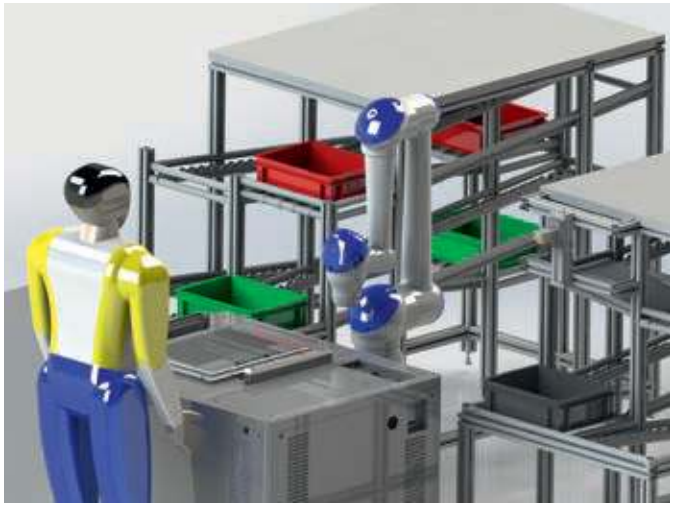
PILZ GmbH & Co. KG is a technology company in the area of safe automation with the head office in Ostfildern (Stuttgart Area). In this use case, functional testing of various circuit board types has to be executed.

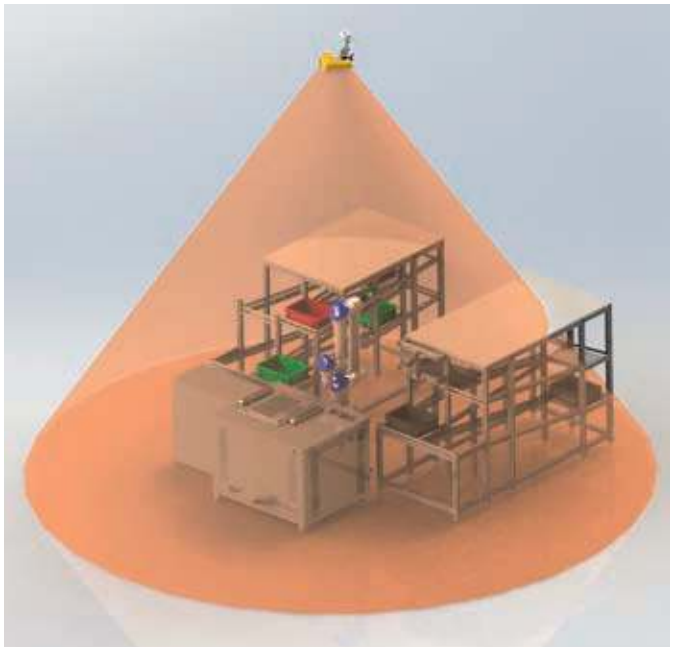
Challenge

- Automated Pick & Place application for in-circuit testing of conductor boards
- Manual adapter change for different product types

Solution

- Use of the collaborative MOTOMAN HC10 robot to combine automated and manual tasks without spatial separation
- Safety zone monitoring with PILZ “Safety Eye”
- Robot switches from full-speed to collaborative speed when a worker approaches
- Redesigned FIFO material provision for defined material in-feed and withdrawal
- Camera vision system (Cognex) mounted on a linear axis for component identification
- MOTOMAN HC10 robot picks components from small loading carrier and places them into the testing device
- Depending on testing results, component is positioned in respective small load carrier
- Robot pushes finished small load carriers down the flow rack lane
- Worker changes adapter manually, when product type changes





Results

- Flexible solution which combines the abilities of human and robot
- Direct Human-Robot Cooperation without spatial separation
- Maintaining high operation speed and productivity with safe area monitoring
- Smooth and secure speed change during adapter change, maintenance or error fixing
- Autonomous part detection and handling
- Minimally invasive conceptual changes at the manual work station decrease setup effort and maintain the previous logistic concept

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All dimensions in mm.
Technical data may be subject to change without previous notice.
Please request detailed drawings at robotics@yaskawa.eu.com.

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