Product Specification
PickMaster

3HAC 5842-1
For BaseWare OS 3.2

ABB Flexible Automation

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1 Introduction

Thank you for your interest in the PickMaster. This manual will give you an overview of the characteristics and handling of this product.

PickMaster is the name used for the application software for the FlexPicker. It is providing a task oriented programming and execution of fast pick and place operations.

PickMaster controls an installation of one or more robot cells where each robot picks up items at one location and places them at another. The cells are located along conveyor belts feeding random items and packages. Cameras are identifying the items before they arrive in the working area of the robots. PickMaster sends the position information to the S4C controllers which executes the pick and place operation in less than 0.5 s.

PickMaster is delivered on a CD-ROM which is ready to install on a PC with Windows NT 4.0. To run the PickMaster with an S4C controller PickWare is the only additional option required together with the standard RobotWare. Hardware boards for conveyor tracking and camera acquisitions boards are also part of the product offer.

PickMaster includes the following functional components:

- PickMaster: Pick and place application software.
- Vision software for visual recognition of random items. Contains Cognex OMI software and an interface software for distributed vision programming and program execution.
- Vision hardware to install in a PC.
- RobComm: robot controller interface.
- PickWare: RobotWare software option in the S4C controller interfacing the PickMaster.

How to use this manual

The characteristics of the application and the most important technical data is listed in Chapter 2 *Technical specification*.

Other manuals

A detailed step-by-step description of the programming can be found in *User's Guide PickMaster/PickWare*.

The S4C programming language is described in the *RAPID Reference Manual*.

2 Technical specification

2.1 Pick and Place process

The task of a FlexPicker application is to pick up single items at one location and to move them to a new location. The place location is usually a relative position in a package. The process result is a correctly filled pattern in a package or assembled items.

Both items and packages may have random position and orientation. This means that both positions and orientations are unknown in advance, i.e. not pre-programmed. The random orientation may be random within limited angle values or fully 360° random. To identify the random items and patterns a vision system with shutter cameras is used.

In some cases the positions of the items and patterns are known in advance and can therefore be pre-programmed. This is the case when they are placed in well defined fixtures or other guiding mechanism.

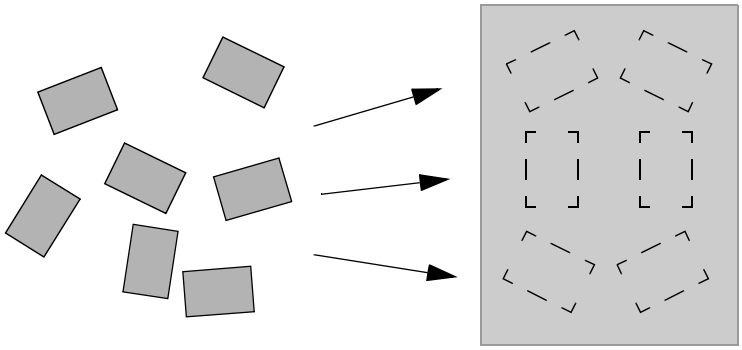

Figure 1 Arranging random items of the same type in a pattern as a blister, box or imaginary borders.

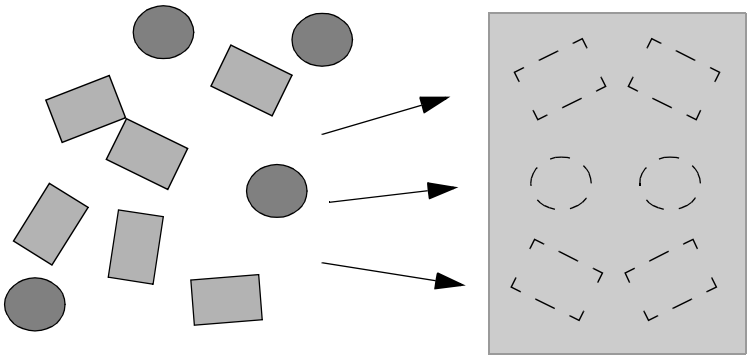

Figure 2 Arranging random items of different types in a pattern, box or imaginary borders.

A pattern can be filled with several types of items, but one robot can handle only one type of item at the time. One camera however can identify two or more types of items.

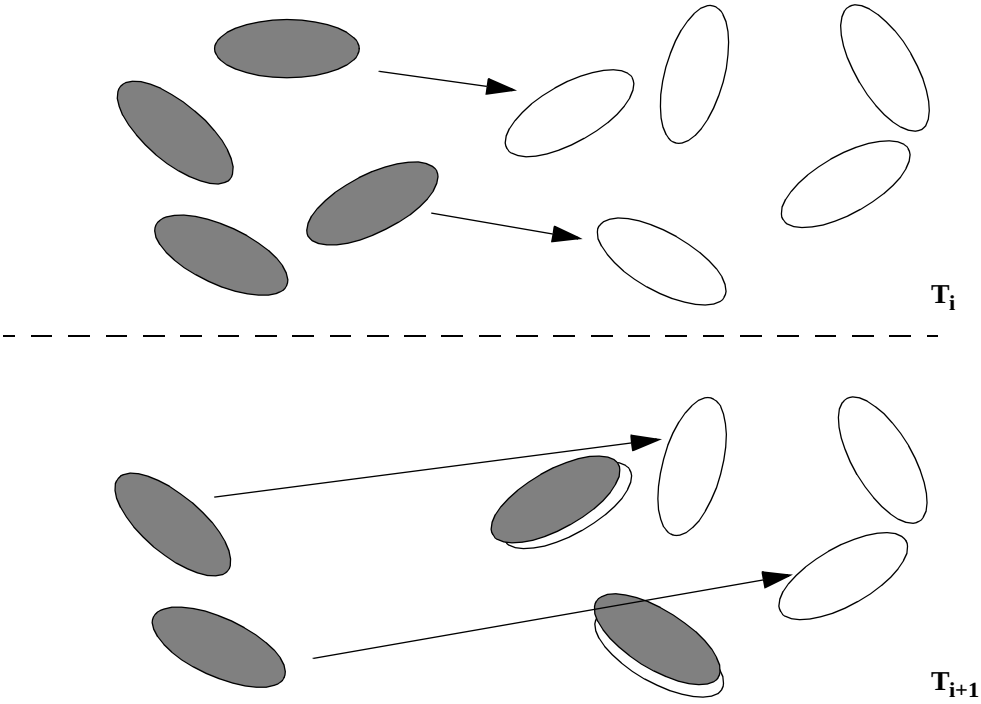

Figure 3 Mixing: Assembling random items together.

Two or more items can be assembled together. Both items may be random placed and their positions identified by the vision system.

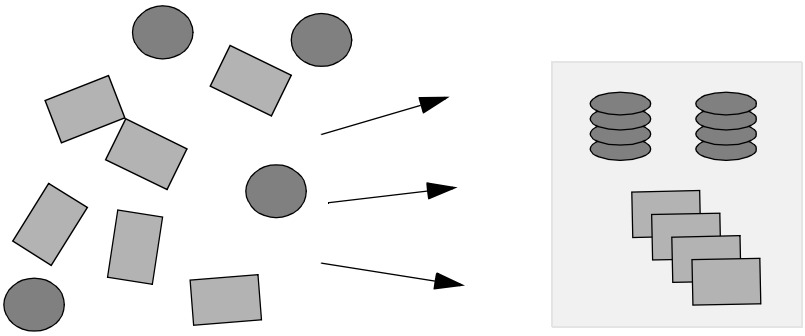

Figure 4 Tiled items in a package.

The items which are combined to a common pattern may be of various types, including height, weight, grayscale level, structure, etc.

The place positions in a pattern may have different z-offset values.

2.2 Application description

PickMaster manages one or more high-speed robots which share the work to achieve the final process result. Each of the robots has a dedicated predefined task to perform. Maximum flexibility is gained when each robot is picking and placing the items one by one.

The items and patterns are transported to the robots on continuous conveyor belts and the robots are mounted above the belts. This lay-out forms a joint process flow where the result is collected at the end of the placing belt.

The most common cases of conveyor layout's are parallel or perpendicular organizations.

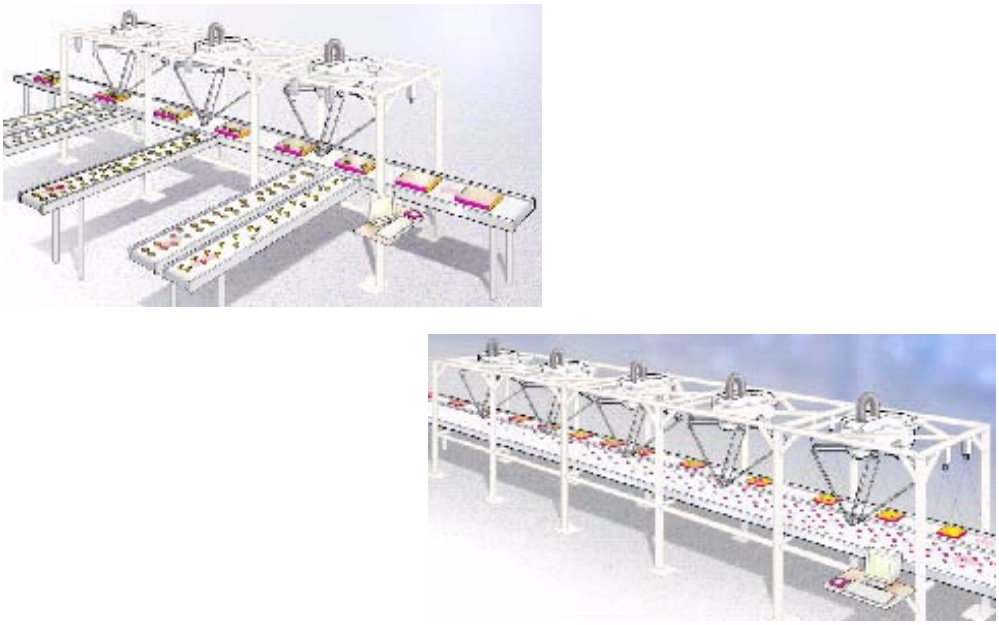

Figure 5 Line descriptions[1].

PickMaster solution - flexible design

PickMaster provides a flexible solution for many pick and place applications where random objects are fed and single picked on the fly. PickMaster is the connection point for cameras for object identification and robot controllers. PickMaster takes care of the process flow from identification to path execution.

The PickMaster philosophy is a network of distributed robot controllers and vision systems, yet the programming, process control and logging is centralized to one or more PickMasters. The program is launched by Microsoft Internet Explorer.

PickMaster is programmed in a task oriented way close to the application description. Vision models are easily programmed in a visual point-and-click style. Each camera can be addressed

All programming except for calibrations can be done off line.

A pick and place process of a single robot is performed as a repetitive path pattern. A typical cycle (back and forth) will finish in less than 0.5 s. See the Product Specification IRB 340 for details.

1. PickMaster 1.0Beta1 does not support double in-feed conveyors attached to one robot.

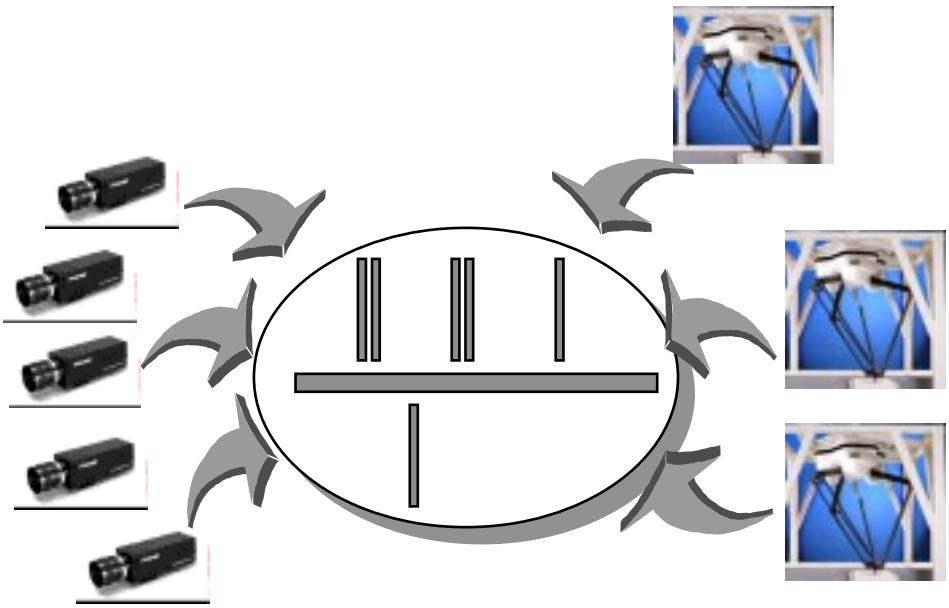

Figure 6 Cameras and robots gathered along a set of feeders to perform a joint pick and place operation.

List of PickMaster features

Programmable features:

- attached robots
- attached vision systems and cameras
- identification areas
- robot operational area
- objects and packages
- vision models of objects and packages
- pick and place strategies
- robot path parameters
- image acquisition type

Calibration features:

- conveyor to robot
- vision pixels to mm with parallax compensation
- vision to robot

The accuracy of the pick and place operation is dependent of the calibration, the speed of the robot, the speed and the speed variation of the conveyor belt.

The accuracy of a pick and place operation where an IRB340 runs at full speed and two belts are running at a constant speed of 150 mm/s is +/- 2mm. As the speed of the belt increases and the speed varies the accuracy will deteriorate.

The PickMaster software consists of run-time application components implemented as a component Gallery using Microsoft COM/DCOM interfaces. The program packages are:

- PComGLib: Picker COM Gallery
- PickerSrv: Picker server, basic instance container
- RCom: RobComm wrapped to COM
- PFServer: “PickFinder” server: Vision API

The objects in this COM Gallery can be instantiated and integrated in an integrator’s application software written in VisualBasic or C++.

Such an integration called *FlexPicker* and written in Visual Basic is delivered with the product. A property sheet programming interface guides the user through the installation and the application configuration is stored in text files.

Further more FlexPicker contains a run-time program which reads the program text files and starts-up the complete application and all robots.

Run-time user interaction features

- start/stop of the application and separate robots and vision engines
- override of position, path z-offset, pick/place time
- search result screens

Conveyors

Continuously moving conveyor belts are the preferred way to feed items and packages. It gives a high flexibility since the robot can operate on the items on the fly for the entire time they are within the working area of the robot.

The recommended maximum conveyor speed is 150 mm/s. The accuracy decreases as the speed gets higher and a conveyor belt should not run faster than 350 mm/s. The tracking error according to Tabell 1 is valid for each pick and place separately and under the assumption that the speed is kept constant.

Belt speed [mm/s]	**Tracking error [+/-mm]**
150	**0.5**
350	**1.1**

Tabell 1 Conveyor accuracy.

The above figures are considering a belt with small speed deviations. For a change in speed by 15 mm^2/s an additional deviation of +/-0.1 mm is added to the tracking error.

The encoder measurement sample rate is configured in the S4C and by default 20 ms. A lower value is not possible due to CPU-time considerations.

The conveyors are operated by external drive units by I/O controls. Drive units like the ABB AC300 has a 24V I/O interface allowing forward, backwards, and stop operations, speed preset, and increment and decrement.

The position of a conveyor is measured by one or more encoders. Usually an encoder is placed close to an identification and operation area in order to minimise errors caused by the elasticity and inaccurate guidance.

Conveyor set-up cases

Conveyors may be placed in any orientation to the manipulator.

There is no limitation for the pick or place object feeding they can be passed on any of the conveyors. There is no limitation for the direction of the product flow, i.e. the pick and place direction. However the most commonly used are described below. The number of repetition of the same set-up is defined by the required throughput requirement of the line.

Mixing

In the following set-up, boxes fed on the belt *A* are filled with items from the belts *B* and *C*. Usually the items on the belts B and C are of different types which results in a mixing result in the boxes[1]. Each position in the boxes has the property to be filled by either type X or Y. The products are not mixed on each belt.

The task of the robots is to fill a defined number of each item type in defined positions in each box. There is no need for the second robot to inherit the result of the first one. This means that an upstream error, like a missed position filling, cannot be made up by the next robot unless it has access to the same item type.

In this “perpendicular” orientation the in-feed belt can run as a slave conveyor of the robot cell, i.e. it can be stopped and started depending on products available or not. Therefore the in-feed usually has a surplus of products but the conveyor is stopped by the application if the product pass a warning limit. The main belt runs as master belt and is controlled externally without respect to the robot cell.

1. In PickMaster 1.0 Beta1, one robot can not distinguish between items of different types on the same in-feed belt.

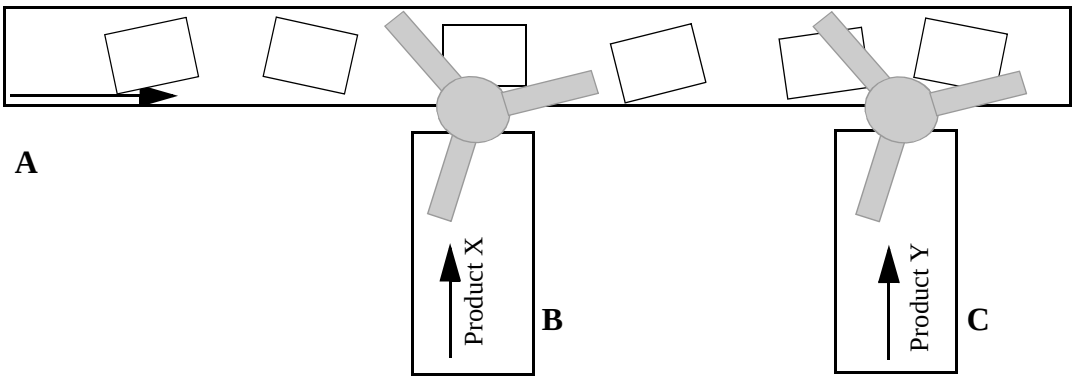

Figure 7 Mixing: one conveyor passing, the other ending at the robot cell.

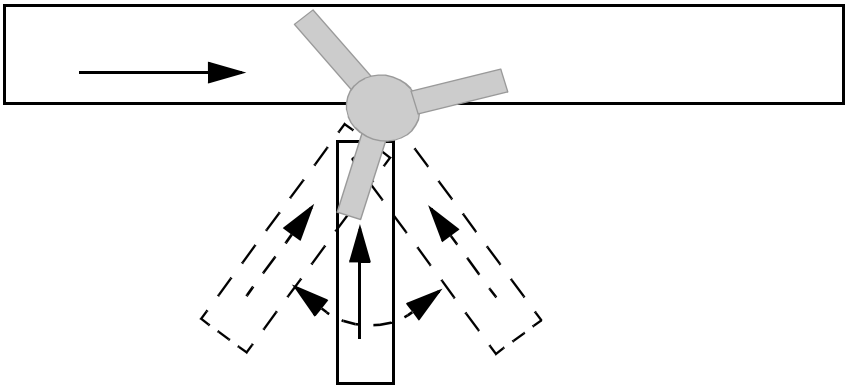

Figure 8 Variation of the perpendicular case.

Even a perpendicular conveyor belt can serve more than one robot as in Figure 9 when the output conveyor passes over the input conveyor.

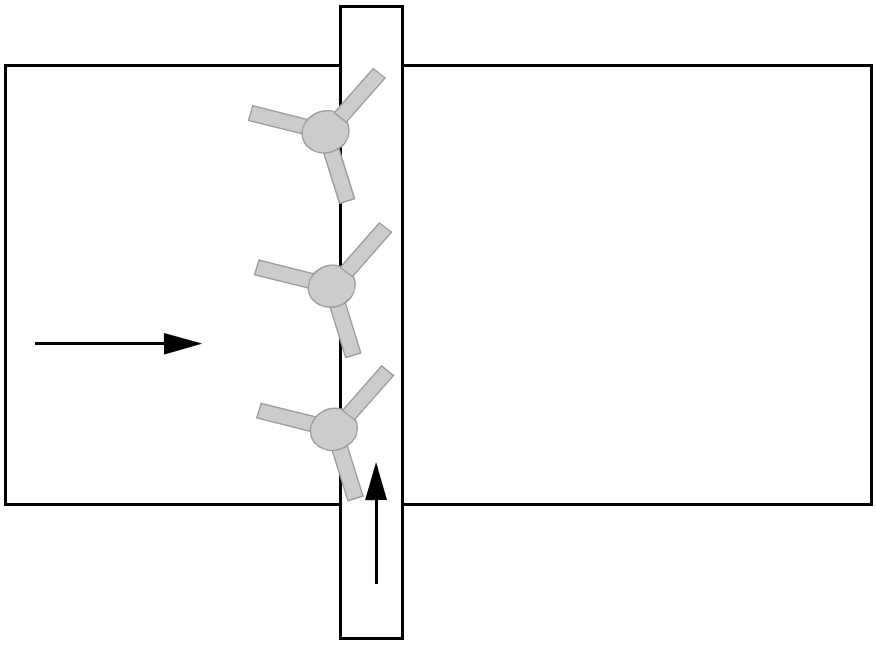

Figure 9 Multiple passing conveyors solution for large conveyors.

Sorting and collating

In this case both pick and place conveyor pass all robots and the products can be mixed on the in-feed. Each robot can pick one item type and pass the remaining to the following robots[1]. It is also possible to split the area where each robot is allowed to pick if the items are all of the same type.

The set-up has two implications:

- there are two master conveyors for each robot and therefore none of the belts are controlled by the cells
- matching input of items and boxes flow is required, otherwise there will be excess or shortage on either side.
- the belts can also run in opposite direction which can simplify the coordination

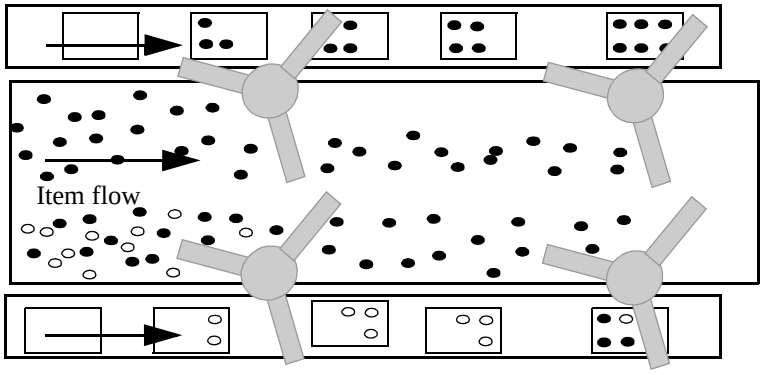

Figure 10 Parallel double passing conveyors.

A sorting or assembly operation can also be performed on the same belt

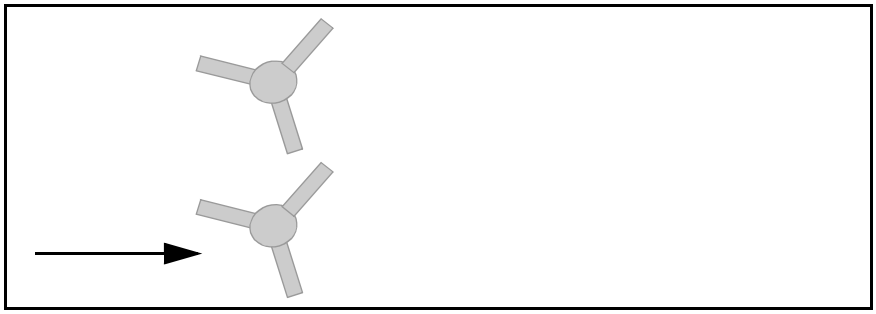

Figure 11 Single passing conveyor operation.

Putting items on the feeders

An item may have a predefined or random position and orientation.

For the random case, identification by a vision system is needed. The position and the orientation may be random within limits (+/- angle variation) or completely random.

1. In PickMaster 1.0 Beta1 the process result can not be inherited to the downstream robots.

Guiding devices on the belts may secure well defined positions. This is apparently the case for boxes sliding along guides and synchronising on a certain position by breaking a light beam.

An identification must be made close to the operation position of the robot to avoid too large errors from stretching and translating belts. This means that for highest accuracy an identification is needed for each robot and that the identification area and the robot operation area must be as close to each other as possible.

2.3 Network connections

The communication between PC's and S4C controllers uses EtherNet. One PickMaster can handle one or more remote or local vision servers and one or more distributed S4C controllers. There is never a one-to-one hardware connection between vision system and robot controller. The connection is established by the configuration of the PickMaster.

PickMaster and PickWare include all the necessary communication software.

More than one PickMaster may work together in a line mastering their own group of vision servers and S4C controllers.

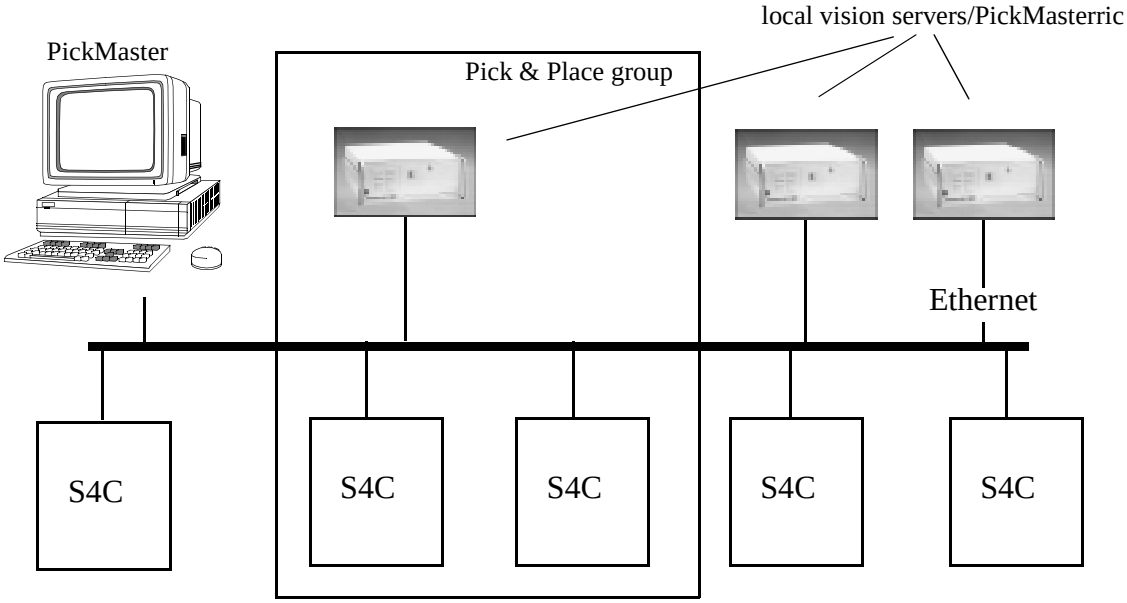

Figure 12 Local FlexPicker EtherNet network.

2.4 Principles of operation

Position transfer between PC and S4C

If the item flow on a conveyor belt is random, a vision system is used to identify their position and type. The vision system then acquires images at regular intervals and sends the relevant information for each item, such as position and type, to the PickMaster. For ordered flows, such as blisters into which items are to be placed, the positions may be read from a file during initialization of the line.

The PickMaster pairs each pick target with a place target. In order to reduce the CPU load, a number of such pairs are accumulated and then sent to the appropriate robot in one message. The robot receives the pick and place targets and routes them into buffers for storage. The robot then retrieves a pick position and a place position from the buffers, moves to the item and triggers the vacuum system to pick it up. After this it moves to the place location and drops the object by reversing the air flow in the vacuum system. PickWare then notifies the PC whether the pick and place targets were successfully processed or not.

Figure 13 shows the different components of a pick and place application:

- vision system used to identify items
- conveyor belts used to feed items and blisters
- PC running the PickMaster software
- S4C controller used to run the robot.

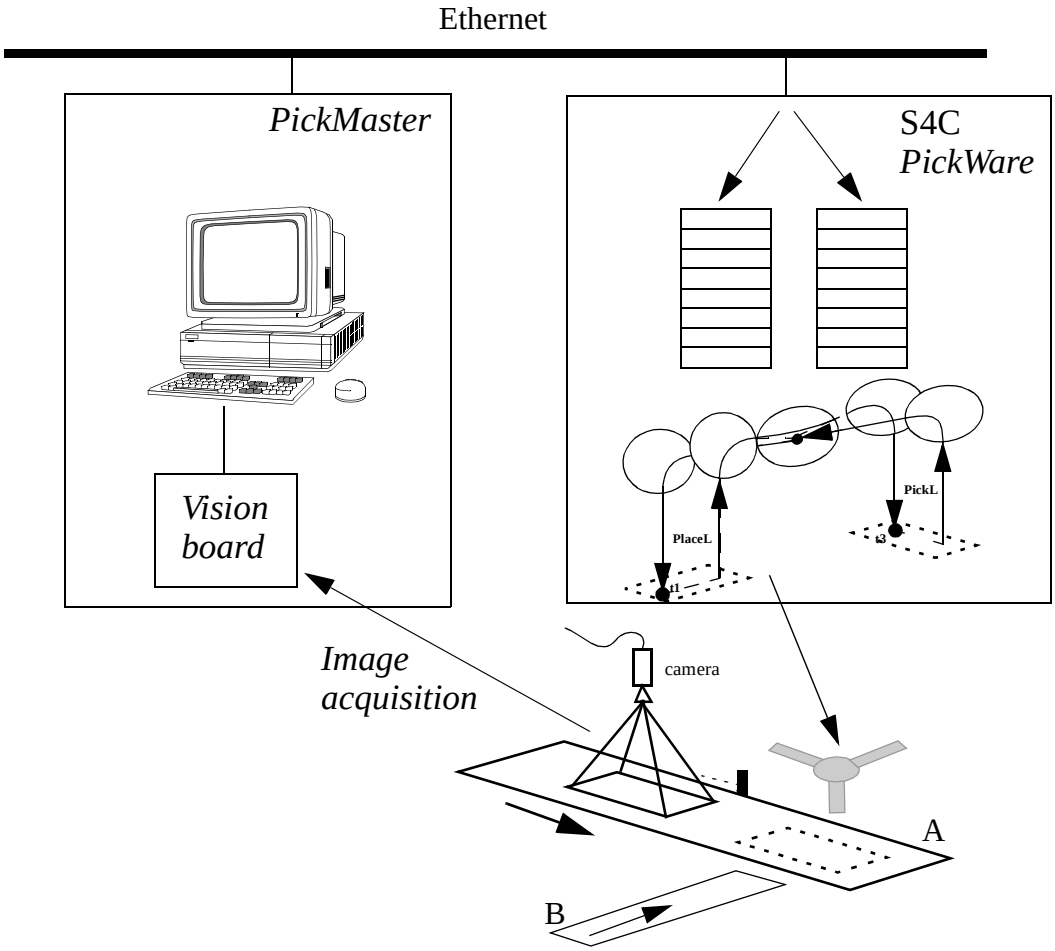

Figure 13 Flow of information during a pick and place operation.

Conveyor tracking

At the trig instance the position value of the encoder is stored in the S4C. By the conveyor calibration the trig position and the conveyor direction is also known in relation to the base frame of the robot. The S4C is sampling the current encoder position and speed and is able to track the trig position. All items which belong to the same trig event have a position information relative to the trig position.

Item selection order

The items are picked in direction of increasing x-value, i.e. the items closest to the robot are picked first. The items from an engine can be split and sent to different robots. The criteria for a split can be programmed dependent on each of an item targets properties. The most common are:

- position: makes it possible to define sub areas of the engine
- item type

Trig mechanism

A trigger for a camera acquisition goes to the vision board which issues a strobe pulse at the very moment the camera is acquiring a new image. The strobe is connected to the S4C encoder board where the encoder value at the trig moment is stored.

The trigger can be synchronous with the conveyor position or asynchronous each time an item passes a synchronization switch.

For synchronuos trigging an extra counter board is required. The board is counting the encoder pulses and issues a trig after a predefined number of pulses[1].

In case of pre-programmed positions on a belt each trigger generates a predefined number of item targets with fixed relative positions.

2.5 Vision

Vision identification

For locating random products a vision system from Cognex is integrated with the PickMaster.

The vision cameras are mounted upstream in relation to the robots and above the conveyors. The camera may be triggered by an asynchronous signal when objects are presented or synchronously with the conveyor belt.

Different types of objects may be identified in the same image.

The vision function is provided by a frame grabber board plugged into a PCI slot in a PC. The vision algorithm software requires NT 4.0 operating system and an MMX accelerated processor.

2.6 Installation

The PickMaster software is installed by running the Install.exe program on the PickMaster CD ROM. Just follow the instructions in the installation script.

PickWare is installed by the RobotWare boot sequence on the S4C.

1. PickMaster 1.0 Beta1 contains a windows interface to a counter board. The board is not part of the product offer. See Chapter 3.4.

2.7 Programming

A programming interface provides visual task oriented off-line programming of the entire application[1].

A working RAPID program is included with the offer and is prepared for picking and placing on two conveyors. There is a minimum of special encapsulating RAPID instructions for the picking application. The main feature is initializing internal item reception buffers and run-time reading the targets from the buffers. The run-time program executes an endless loop and uses standard move and trig instructions once the targets are read. The loop is kept as short as possible in order to be as efficient as possible considering the very short cycle times. See User's Guide PickMaster.

Movements

The motion pattern is controlled by only two positions, usually relative to a tracking frame. The rest of the path is defined by relative offsets and other parameters.

2.8 Logging

PickMaster is logging error and warnings coming from the PickMaster to log domain files separated in directories for each URL.

All S4C-log events of the controllers connected to the PickMaster are stored on the PC.

Logging of the positions which are sent to the S4C-controllers are activated for test purpose from the operators interface.

2.9 Production

The FlexPicker program is started from the operator's menu. From here the "Run" panel is chosen. The actual project file is asked for and as it is entered the complete format run is loaded and the application is initiated accordingly. The RAPID programs are also down-loaded to the S4C as PickWare is initiated.

Note: The S4C must be in AUTO mode when a new application project is launched.

1. In PickMaster 1.0 Beta1 the programming of the "router" is done by editing a text file.

When it is up and running the operator's panel shows all current PickMaster routers and attached robots and vision engines.

Simply push the "Start All / Stop All" buttons to start or stop the application.

For more information or commands a right hand click on the displayed instances of the application reveals the possibilities.

In order to track the operations all vision views can be displayed or one single search result can show the scores of the recognition together with the captured image.

2.10 Hardware connections

The following chapter shows how cabling can be put together to integrate an application.

Warning: It is important that the acquisition strobe and the conveyor trig cable to the S4C are well protected against signal bumps and disturbances. The application will fail to find the objects if these signals are not triggered simultaneously or with too high trigger frequency as these are internally filtered by the S4C. It is important that the 5V signals have a common stable 5V DC level and a common ground. Keep the 5V signals as short as possible and use the 24V signal cables for longer distances.

8120: max four cameras

The following scheme shows the hardware connections needed for the 8120 board where max four cameras can acquire images asynchronously.

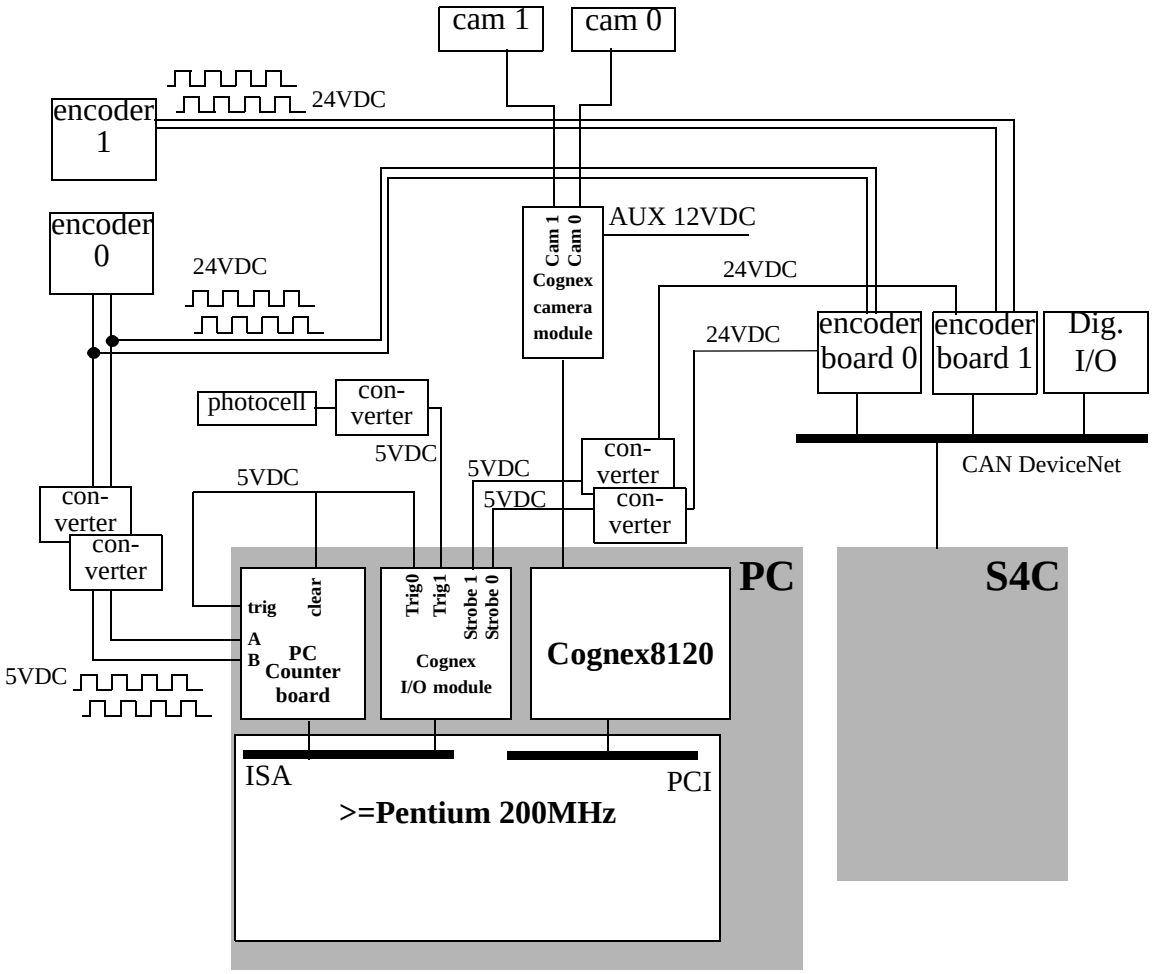

Figure 14 Hardware connections of the 8120 vision board and auxiliary modules.

The above solution shows a system where two cameras are identifying random positions, one is triggered synchronously by the conveyor belt position, the other asynchronously by the random object itself as it breaks a light beam. The about line layout shows an example of such a case. As the 8120 allows max four cameras, one vision board can serve two robot cells as described below.

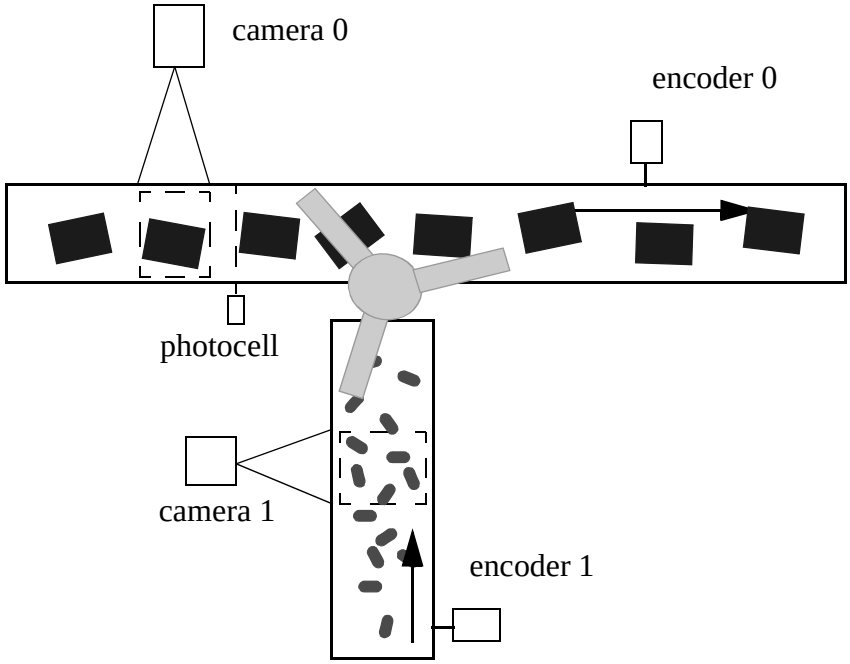

Figure 15 Double camera cell layout.

8100: maximum one camera

The 8100 board is used where only one camera recognition area is needed. It has on board I/O and camera connection points, see below and Cognex hardware description.

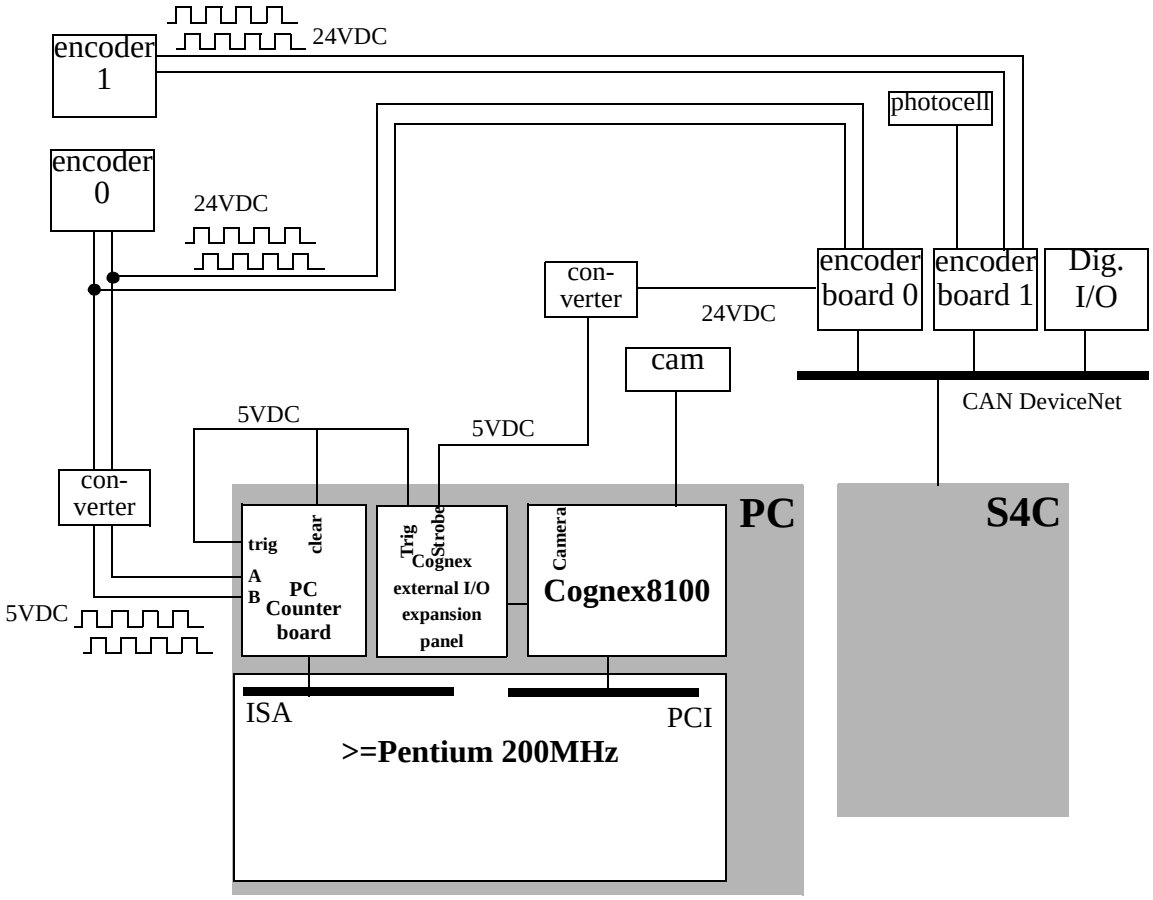

Figure 16 Connections for Cognex 8100.

The below associated drawing shows the one camera system. The boxes are guided and their positions at the very trig instance are well known. Consequently there is no need for image recognition.

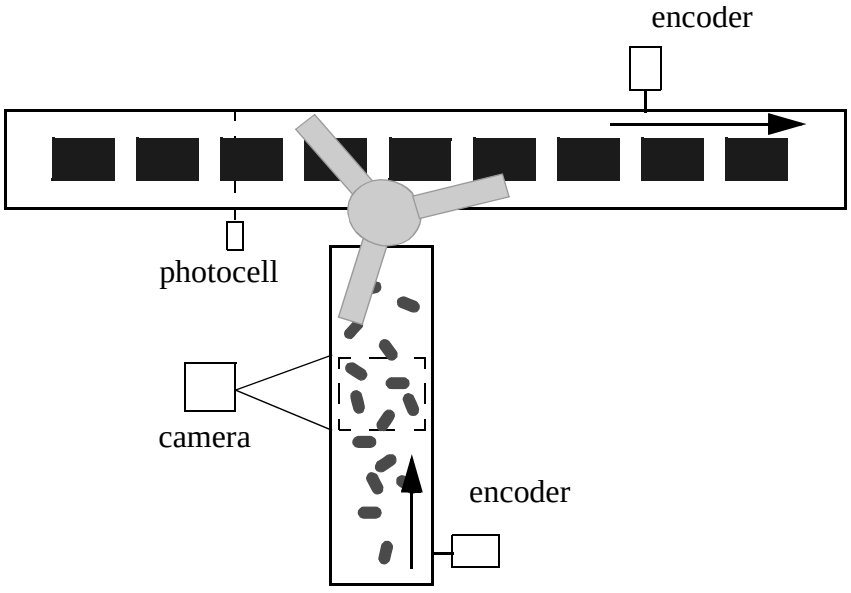

Figure 17 Single camera layout.

3 Hardware specification

3.1 Application equipment required on S4C

S4C Encoder board	DSQC354	One board per tracking function
S4C Digital I/O-board	DSQC327/328	One board required as default per robot
Ethernet communication board		

3.2 Vision

The vision core functions are provided by Cognex. They include a vision PCI board from the 81xxx series and the vision algorithms and driver software OMI featuring PatMax and PatQuick search engines which are included on the PickMaster CD-ROM.

The Cognex vision system is available in two different hardware configurations, the 8100 for one camera acquisition and the 8120 for four simultaneous image acquisitions:

• Cognex Vision Sys. Hardware 8100	3HAC 4876-1	ABB-8100X-00
- MVS-8100 PCI	3HAC 6211-1	801-8112-01
- Cable, Power Adapter 8100	3HAC 6210-1	300-0175
• Vision Sys. Hardware 8120	3HAC 4877-1	ABB-8120X-00
- MVS-8120 PCI	3HAC 6212-1	801-8414-01
- I/O-board 8120 (4 TRIG/4 STRB)	3HAC 6213-1	801-002-01
- Camera break out box 8120	3HAC 6214-1	800-5637-2
- Cable, Power Adapter 8120	3HAC 6215-1	159-0015

More than one type of objects can be identified in the same image and sent to different robots.

The image recognition time for one type of object is typically about 100-500 ms. Variations occur depending on the objects' variations from the model.

The number of vision boards installed on the PCI-bus is limited to one.

EMC approval	the disturbance level inside the PC	< ...

For detailed descriptions of the required connections, see also the Cognex documentation.

3.3 Robot communication

RobComm HW key[1]	Hardware key with design time licence	Required for application customizing of the PickMaster

3.4 Accessories

The following components are recommended components which have been tested by ABB Robotics.

PC	>=Pentium 200MMX Two free ISA bus slots One free PCI bus slot	min. one per line
PC software	NT4.0, Service Pack 3, Internet Explorer 4.0	
Cameras	Sony XC55/Pulnix TM-9701AN	

Warning: The 8100 vision board does not run with Sony XC55

Camera cables	adapted to Sony XC55	<=10 m, one per camera
Acquisition trig/strobe signals	max length	<=5 m
External pulse counter board, 4 channels	CNT24-4(PC)[2]	Hardware board on the ISA-bus, one per 4 encoder channels
Pulse counter SW	API-CNT (98/PC)NT[3]	NT4.0 driver routines, one per hardware board
Opto coupler	24-5V	Connects to Cognex' 81xx trig input (or PC pulse counter), one per trig
Opto coupler	5-24V	Connects to Cognex' 81xx strobe output and S4C encoder board, one per strobe

1. Not delivered with the FlexPicker.
2. Company ref. www.contec.com/service.htr
3. Company ref. www.contec.com/service.htr

EtherNet environment	local network	
Conveyors	external position measurement	Max two per S4C controller, i.e. one in, one out See also S4C conveyor tracking manual for specification requirements

4 Software specifications

PickMaster 3HAC 2702-1

PickMaster covers all software running on a PC. It includes

- application master
- vision server
- Cognex OMI
- robot communication
- operator’s panel interfaces
- Programming interfaces
- Documentation in Acrobat format: PickMaster and OMI
- Documentation in ScreenCam format

PickMaster

Each FlexPicker line needs at least one PickMaster which masters the application, a number of vision identifications and a number of S4C controllers.

Vision Server

Each vision function needs to be connected to a vision server which is installed on the PC where the vision board is mounted. The vision server internally runs the Cognex OMI software specially adapted to interface PickMaster.

Operator’s panel

A soft operator’s panel runs FlexPicker. The operator’s panel is written in VisualBasic and can be enhanced for customer needs.

Note: Any customer add-on programming requires a RobComm hardware key with a design time licence.

PickWare

PickWare is the name of the RobotWare option installed in the S4C. Each S4C controller in a FlexPicker line needs the PickWare option which includes all necessary functions for conveyor tracking, communication with PickMaster and running stereotype pick and place movements. Maximum two conveyors can be tracked by one robot controller.

5 Safety

The Vision hardware board conforms to the following standards:

Not yet approved.

Safe application stop via input or soft production panel

The FlexPicker application is pre-configured to handle an application related safe stop When a safe stop is performed the current path is abandoned and the robot goes to a pre-programmed position away from the conveyors in order to avoid crashes with products on the belt.

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