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Assembléon

LEADERS IN ELECTRONIC MANUFACTURING TECHNOLOGY

March 2003

GemLine
Opal-X^{II}
SPECIFICATIONS

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PA 1314/03 Opal-X^{II}

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Printed in The Netherlands.

Date of release: March 2003

9498 392 0020.1

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1.0 INTRODUCING THE GEM OPAL-X^{II}

The new Opal X^{II}, part of the Modular High Speed Production Machines, belongs to the top-of-the-line Assembléon' SMD pick & place machines.

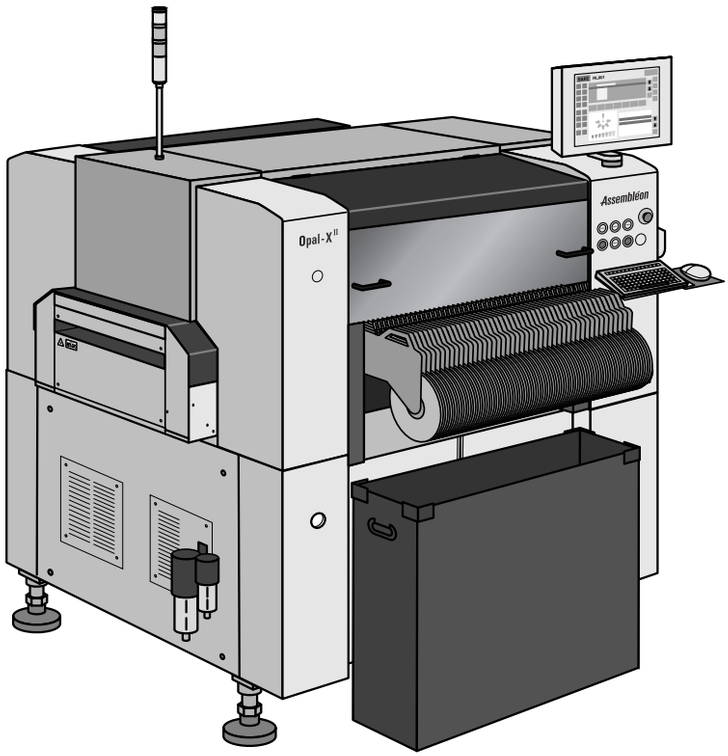

Figure 1 *Front view GEM Opal-X^{II}*

The Opal-X^{II} is a High Speed flexible machine that can handle a wide range of components at speeds up to 12,500 SMDs per hour. The machine is built around a very rigid, vibration-free frame for improved accuracy and long-term stability and is perfectly suitable for round-the-clock production.

The Opal-X^{II} features a high precision single placement beam carrying 4 Super Fine heads with exchangeable nozzles. The placement beam moves in X/Y and Z direction, while the board and component feeders are stationary. A flexible board transport system enables the Opal-X^{II} to handle virtually any type of PCB, with or without tooling pins. Board conveyor width is automatically adjustable, allowing board dimensions up to 460 x 440mm (17.9" x 17.2") to be handled.

The newly designed vision system with Line Array camera allows fast and accurate "on-the-fly" alignment of a wide range of components from 0201 up to 45mm square PLCC, including 45mm square QFPs with lead pitches down to 0.5mm (20 mil). Dark background BGAs, µBGAs and CSPs with ball pitches down to 0.5mm (20 mil) and ball diameters down to 0.3mm (12 mil) can be recognized with the use of new developed illumination unit which allows measurement of ball positions and dimensions.

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An optional single area CCD camera extends the component range to 32mm square ICs with lead pitches down to 0.4mm (16 mil). The vision system detects missing, bent or irregular spaced leads or BGA balls; faulty components are rejected.

A separate camera system monitors fiducial marks at the board, circuit and component level, using a combination of white-light and IR LEDs with multi-angle diffusers to provide optimal illumination.

Just six nozzle shapes are required to cover the specified SMD range. High output levels are therefore achieved, as the need for nozzle exchanges is minimal. An optional 20 position nozzle exchange station enables additional special nozzles to be accommodated.

Up to 100 tape feeders can be loaded on the Opal-X^{II}. The machine supports tape, stick, bulk and tray feeders.
The tape feeder design for the Opal-X^{II} allows simultaneous picking from any mix of tape feeders ranging from 8 to 56mm.

A Windows NT based controller, running an user-friendly Graphical User Interface, allows the Opal-X^{II} to be used stand-alone or in-line. The controller includes a Management Information System (MIS) that continuously gathers production data for management feedback. The unique bad mark sensing capabilities allow a multi-circuit panel to be run as one large board, thus maximizing placement speed while still using bad mark information. A laser-based verification system, which guarantees correct feeder latching, is standard.

The Opal-X^{II} is fully compatible with the other-X^{II} serie machines which use the same feeders, feederbars, software and controller. Off-line feeder changeover can be achieved by using a 20 position Feederbar Exchange System (FES). An entire feederbar can be conveniently loaded off-line, minimizing change-over time.

A basic program optimization function is also included in the machine as standard which can be used during production. For more advanced machine optimization and/or line balancing, the new Production Preparation System allows you to create and optimize SMD machine programs on a PC instead of using the SMD machine.

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2.0 General Specifications

Opal-X[II]		
		REMARKS
Tact time:	0.30 sec/chip with line array camera	Simultaneous pick with 4 heads
	0.36 sec/SO with line array camera	Simultaneous pick with 4 heads
	1.4 sec/QFP with line array camera	Sequential pick with 4 heads
	1.7 sec/QFP with line array camera	With 1 head
	3.7 sec/QFP with area CCD camera	In fine mode with 1 head
Optimal placement rate:	11,600 cph	Simultaneous pick with 4 heads (at best conditions)
IPC 9850 placement rate:	9,600 cph	C0603; all heads, all angles
Nominal placement rate:	8,000 – 9,000 cph	Real mounting time
Applicable Components:	0201 - SOP, SOJ, PLCC 45mm square (1.77") 6mm - QFP 20mm ⍁ (0.78" with pin pitch down to 0.4mm (16 mil) 20mm - QFP 45mm ⍁ (1.77" with pin pitch down to 0.5mm (20 mil) Dark background BGA, µBGA, CSP with regular pitches; 6mm – 45mm: Min. ball pitch down to 0.50mm (20 mil), Min. ball diameter down to 0.3mm (12 mil)	Line array camera system (45mm)
	6mm - QFP 32mm ⍁ (1.26") with pin pitch down to 0.4mm (16 mil) Dark background BGA with regular pitches; 6mm – 32mm ⍁: Min. ball pitch down to 0.50mm (20 mil), Min .ball diameter down to 0.3mm (12 mil)	Optional 32mm area CCD camera system with fore and side illumination unit
Mounting accuracy (X,Y) 3 σ:	± 50µ for chips 0201 - 0402 ± 75µ for chips - SOIC ± 60µ for QFP's (6mm – 45mm ⍁ with pin pitch down to 0.5mm (20 mil))	Line array camera system (all placement heads and all placement angles)
	± 40µ for QFP's (6mm- 32mm ⍁ (1.26") with pin pitch down to 0.4mm (16 mil)	Optional 32mm area CCD camera system (in fine mode)
Mounting accuracy (φ) 3 σ:	For Chips and SOIC this is Lead dependent ± 0.2° for QFP's (6mm – 32mm ⍁ (1.26") with pin pitch down to 0.5mm (20 mil))	Line array camera system (all placement heads and all placement angles)
	± 0.10° for QFP's (6mm- 32mm ⍁ (1.26") with pin pitch down to 0.4mm (16 mil)	Optional area CCD camera system (in fine mode)
Mounting repeatability 3 σ:	X, Y 30µ for QFPs (6mm - 32mm ⍁ 1.26") pitch 0.4 Phi 0.075°	Optional 32mm area CCD camera
Mounting angle:	0 up to 360 (progammable in steps of 0.01)	
Number of heads:	One single beam with 4 standard heads	The Standard heads can exchange nozzles with the use of the optional Nozzle Exchange Station

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Opal-X^{II}		
		REMARKS
Alignment system:	One line array camera with fore and side illumination system for Vision on the Fly using the VICS 3200 processing system	Standard
	Area CCD camera for QFP 32mm ⌀ (1.26") with pin pitch down to 0.4mm (16 mil)	Optional
	Moving CCD camera for Fiducial alignment	Standard
Type of nozzles for X^{II}:	Type 71 Type 72 Type 73 Type 75 Type 76A (Melf nozzle) Type 77	Standard for the Opal -X^{II} will be delivered: 1x nozzle 72, 1x nozzle 73, 1x nozzle 76A, 1x nozzle 77
Nozzle exchange station:	20 nozzle positions	Optional (No nozzles included) Nozzle station can hold: 4 x 71, 4 x 72, 4 x 73A, 2 x 75, 4 x 77, 1 x 76A and 1 special nozzles
Component weight:	Max: 20 gr.	With the use of Nozzle type 75
Component height:	Max: 6.5mm	Placing of higher parts is possible if certain conditions are met
Component mounting interdistance:	Chip: 0.5mm or more SOP: 0.7mm or more	
Placement system:	Pneumatic or servo controlled for component height compensation	
Placement force:	24 gram/mm (for nozzles with buffer this value is different)	Pre-tension is 200 gr. (spring loaded)
Number of feeders:	Pneumatic Tape Feeders: 8mm: 100 positions 12mm: 48 positions 16mm: 48 positions 24mm: 32 positions 32mm: 22 positions 44mm: 21 positions 56mm: 20 positions Stick feeders: Depends on stick dimensions Bulk feeders: 100 x 8mm positions	72mm Tape feeders are available on special request
Component Packaging:	Tape according to IEC/EIA-J/JEDEC: 8-56mm *For larger tape feeders such as,* *72mm please contact your local sales representative*	Tape reel diameter max: 380mm (15")

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Opal-X^{II}		
		REMARKS
	Manual Tray feeder: Max. tray size is board width dependent: Max tray size: 330mm x 300mm (12.8" x 11.7") Max tray size by max board width 440mm (17.2"): 330mm x 175mm (12.8" x 6.8") Min tray size: 50mm x 50mm (2.0" x 2.0")	Optional: Manual tray feeder Max. number of feeders 75
	Double shuttle LCS Tray Feeder:: Max. tray size: 350mm x 440mm (13.7" x 17.2") Min tray size: 50mm x 50mm (2.0" x 2.0")	Optional: Double shuttle LCS tray feeder (no restrictions) Max: 120 Jedec trays
	Stick and bulk:	Many solutions possible
Maximum height pre-mounted components:	6.5mm on placement side (0.26") 18mm on non placement side (0.7")	Before transport
PCB Dimensions (x,y):	Min: 50 x 50mm (2.0" x 2.0 ") Max: 460 x 440mm (18" x 17.2") *Special applications upon request*	Using PCB pin fixation
PCB Weight:	Max. 1.2 Kg Max. 2.0 Kg	Without components With components
PCB Thickness:	Min: 0.4mm (0.015") Max: 4.0mm (0.15") *Special applications upon request*	
Non-mountable area:	Board top side: 3mm from rear side board edge (0.12") 0mm from front side board edge	Component height restrictions apply in the 10mm (0.40") area from front side edge depending on board thickness
	4mm around reference holes (0.16") (locate pins)	Flat edge of 30mm (1.2") is required on bottom right corner for the use of the main stopper, sub and exit stopper
	Board bottom side: 5mm from front and rear side board edge (0.2")	
		For Ceramic PCBs (optional) the non-mountable area can be different.
PCB Material:	Phenolic/FR4/Composite Materials	Ceramic PCB's requires special conveyor section (optional)
PCB positioning:	Locate pin fixation	Adjustable second pin
	Z servo controlled push up system	Software controlled by PCB thickness
	Push up pins	Adjustable positions

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Opal-X^{II}		
		REMARKS
	Board clamping	Optional
	Sub stop (PCB waiting buffer)	Adjustable position
	Exit stop	Fixed position
PCB Transport height:	900mm ± 10mm (35.4" ± 0.4")	Standard
	SMEMA 953mm ± 12.5mm (37.5" ± 0.5")	Standard
PCB Transport direction:	Left to Right	Right to Left is optional
PCB Transport width:	Automatic	Front rail fixed Rear rail moving
PCB Loading time:	Approximately 3 sec.	PCB loading concurrent to SMD picking and alignment
PCB Ratio width/length:	Max. 1:3	
Control system:	Celeron 566 MHz controller	128Mb intern memory
	Windows NT operating system	
	256 Mb flash disk	
	1.44 Mb floppy drive 3.5"	
	CD-ROM	
	RS 232 Serial Interface + LAN interface	
	15" Color User Interface Monitor	12" Flat/touch screen optional
LAN interface:	Based on IEEE802.3u, IEEE802.3	
Communication protocol:	TCP/IP, NetBEUI	
User Interface	VGOS (Visual Graphical Operating System)	
	Enhanced PC/AT keyboard for data editing functions	
Control system functions:	Max. 127 PCBs	12,800 Components per PCB
	Backup and restoring data using floppy	
	Data conversion Text ⇔ VIOS	
	MIS data gathering	
	Data teaching	
	Data tracing	
	Component database	3000 Component packages; user can define and teach vision files
	Mark database	300 Mark shapes
	SMEMA electrical interface	
	On line calibration	
	On line help functions	
	Feeder lock verifier	Optional

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Opal-X^{II}		
		REMARKS
Machine dimensions and weight:	Length: 1650mm (5.4 ft)	
	Height: 1850mm (6.1 ft)	
	Width: 1408mm (4.5 ft)	Width including feeders; pneumatic feeders 2244mm (7.36 ft)
	Weight: 1600 kg (3526 Lbs)	
Safety standards:	EN 292, EN 294, EN 349, EN 614, EN 1050, EN 55011, EN 50082-1, EN 60204-1	CE-safety is part of system design. Safety measurements are tested on each product in the factory.
	Electrical safety according IEC 204	
Warning lights :	White: Emergency stop, safety cover interlock Blue: Error made,e.g. pick up error, out of components Green: In automatic operation	
Audio warning signal	Operational errors	
Electric Power:	Voltage AC: 200/208/220/240/380/400/416 V ± 10%, 3 Phase	More than 3.5mm^2 cables are needed
	Frequency: 50/60 Hz	
	Consumption: 4.4 kVA max.	
Air supply:	Pressure: > 5.5 .10^5 Pa (5.5 bar, 80 PSI)	
	Quality: dust and oil free	
	Consumption: min.350 Nl/min	
Operating Temperature:	15-35˚ C (59˚ - 95˚ F)	Specification guaranteed: 20˚ - 28˚ C (68˚ - 82˚ F)
Humidity:	20 - 90%, (no dew)	
Noise:	< 78dba	
Clean Room:	Class 10,000 (10 K)	

Table 1

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3.0 FEATURES, ACCESSORIES AND OPTIONS

3.1 FEATURES

The standard GEM Opal-X" includes the following features:

- On the fly alignment using a vision system with a Line Array Camera standard equipped with a side illumination unit for BGA's, µBGA, CSP components.
- Placement beam with 4 Super Fine heads.
- Simultaneous picking is possible by all 4 heads from any mix of tape feeders (except for 0201 components). This allows a much higher nominal placement rate and board throughput.
- Complete component range can be handled with only 6 nozzles shapes.
- Fiducial alignment camera with improved software controlled illumination unit (white + IR Leds), that also can be used as teaching/tracing device and for Bad Mark sensing.
- Automatic width adjustment. The PCB dimension is included in your PCB data.
- PCB pin-positioning. Second pin is easily adjustable for fast changeover.
- PCB push up plate (Z servo controlled)with 12 push up pins, for PCB support. PCB thickness is included in the PCB data.
- Substopper, allowing a second PCB to enter the machine for reducing transport time.
- Exit Substopper, allowing a new PCB to enter the work area of the machine while the downstream machine is still not ready to accept a new PCB.
- 3.5" FDD for backup purposes.
- CD-ROM drive for software installation
- Operation panel with push buttons
- Component dump box.
- Operator manual, available in different languages.
- User manual.
- Service manual.
- Toolset.
- First aid spare parts kit.
- CE safety.
- ESD safety.
- Electrical and Mechanical SMEMA.

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Standard Software features.

- Variable XY axis speed per component
- Datum angle functionality (especially for stick components, there is no pick angle necessary to recognize the component which results in higher output.)
- User Friendly Graphical Human interface VGOS (Visual-Graphical-Operating-System) with touch screen capability
- An On-line help function allows display of detailed descriptions of operations and functions on screen.
- Management Information System (MIS) to gather production history data.
- 4 point fiducial correction, to maintain accuracy for stretched/distorted boards.
- Template (pattern) matching for PCBs that have no fiducials.
- Different mark shapes for fiducial pair possible.
- Box teaching to recover fiducial recognition error.
- Data editing functions with the use of the fiducial camera (teaching,tracing).
- A Component database, that can hold up to 3000 component packages, with the most frequently used components already predefined.
- A Mark database, that can hold up to 300 mark shapes, with the most frequently used mark shapes already predefined.
- Precede pick-up, allowing to pick up components before the PCB is fixed, reducing cycle time.
- Alternative feeder function, reducing operator intervention (empty feeder switching).
- Automatic program change over for family boards (self production control).
- Automatic rework cycle to improve operator efficiency and online optimization, to keep mounting speed during production in case of empty feeders. Detected empty feeders are automatically skipped until end off programs, to allow one time replenishment.
- Product preparation can be done on the machine including basic optimization of the mount program. (nozzle and feeder set-up) during production.
- Multi-section PCBs can be either be mounted block-by-block or the block data can be combined to achieve the fastest mounting sequence. In the latter case, block bad-marks still remain in effect.

3.2 ACCESSORIES AND OPTIONS

ACCESSORIES AND OPTIONS Opal-X^{II}	
PA 1912/00	CSM/GEM Glass Adjustment Kit
PA 2505/26	Board Clamping system Opal-X^{II}
PA 2505/57	Feederbar exchange system front side, including two FES 20 position cart for FV/GEM ^{II} series
PA 2505/58	Feederbar exchange system rear side, including two FES 20 position cart for FV/GEM ^{II} series
PA 2505/59	FES (feeder bar exchange) cart 20 positions for ^{II} series
PA 2506/30	Rear site CRT monitor, keyboard and mouse
PA 2506/31	Flat/touch screen monitor front side
PA 2506/33	Flat/touch screen monitor front and rear side
PA 2506/35	Operation panel rear side
PA 2506/40	Maintenance lamp

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PA 2695/12	Manual Tray Feeder Topaz-X/Emerald-X
PA 2699/24	Double shuttle Tray Feeder (LCS) for Opal-X^{II}
PA 2903/27	16mm Tape Feeder, 15 inch reelholder CL
PA 2903/38	24mm Tape Feeder, 15 inch reelholder CL
PA 2903/41	32mm Tape Feeder, 15 inch reelholder FV/GEM PSA
PA 2903/51	44mm Tape Feeder, 15 inch reelholder FV/GEM PSA
PA 2903/68	56mm Tape Feeder, 15 inch reelholder CL
PA 2903/77	8mm Tape Feeder for 0201, 2mm pitch, 15 inch reelholder CL
PA 2903/78	8mm Tape Feeder, 2mm pitch, 15 inch reelholder CL
PA 2903/79	8mm Tape Feeder, 4mm pitch, 15 inch reelholder CL
PA 2903/88	12mm Tape Feeder, 15 inch reelholder CL
PA 2904/51	Gem bulk cassette feeder C0603 long
9466 920 10921	Reject belt feeder GEM
PA 2923/00	Set of 20 dummy feeders
PA 2930/15	Empty tape waste bin (front and rear)
PA 2932/40	Feeder Floating detection Opal-X^{II} (front and rear)
PA 2962/45	Nozzle Type 73 (1812-SOP/4532-SOP)
PA 2962/46	Nozzle Type 76A Cylindrical chip (MELF)
PA 2962/47	Nozzle Type 71 (0201-0402/0603-1005)
PA 2962/48	Nozzle Type 72 (0603-1206/1608-3216)
PA 2962/49	Nozzle Type 75 (Large size QFP)
PA 2962/50	Nozzle Type 77 (Middle size QFP)
PA 2963/27	Nozzle Exchange System Opal-X^{II} (20 position no nozzles included) factory built in only
PA 2969/85	Area CCD camera 32mm (including fore and side illumination unit) for ^{II} series
PA 2981/15	Pallet for LCS Tray Feeder FV/GEM (PA 2699/22/23/24)

Table 2

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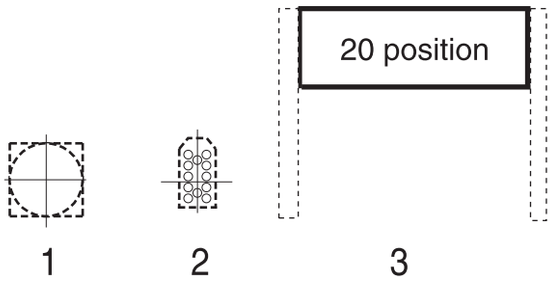
3.3 MACHINE CONFIGURATION EXAMPLES

On the following page you can find a machine configuration example for the Opal-X II

Remark 1: In the example the dotted lines pictures indicate the physical position of the area CCD camera , large component sequencer, nozzle exchange station and FES 20. These can be ordered as an option.



1. 32mm Area CCD camera Opal-X^{II}
2. Nozzle exchange station for Opal-X^{II}
3. Feederbar Exchange System 20 position

Remark 2: By ordering a Feederbar Exchange System for the front and/or rear side of the machine, the 50 position feederbar will be replaced by two FES 20 position carts.

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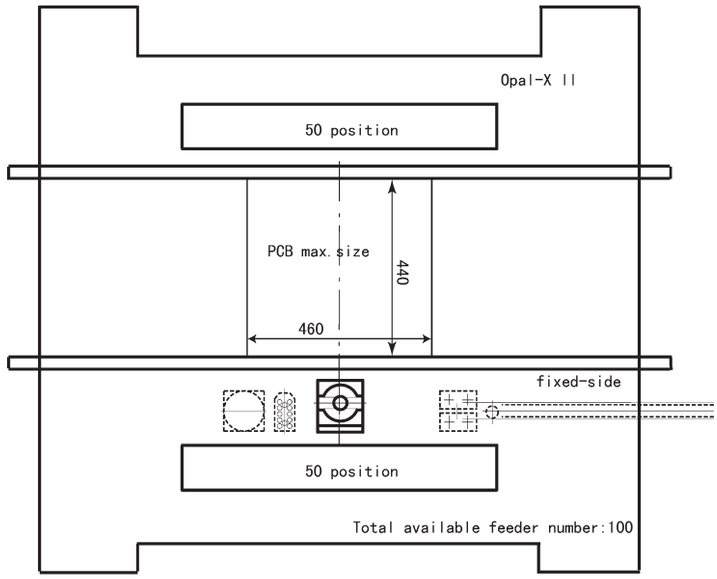
EXAMPLE 1: OPAL-X^{II}



PA 1314/03	Opal-X^{II} with 4 SF heads
PA 2505/26	Board clamping for Opal-X^{II}
PA 2699/24	Double shuttle LCS for Opal-X^{II}
PA 2932/40	Feeder lock verification system for Opal-X^{II} (front and rear)
PA 2963/27	Nozzle Exchange System Opal-X^{II} (18 positions/no nozzles included)
PA 2969/85	Area CCD camera 32mm (including lighting unit) for ^{II} series

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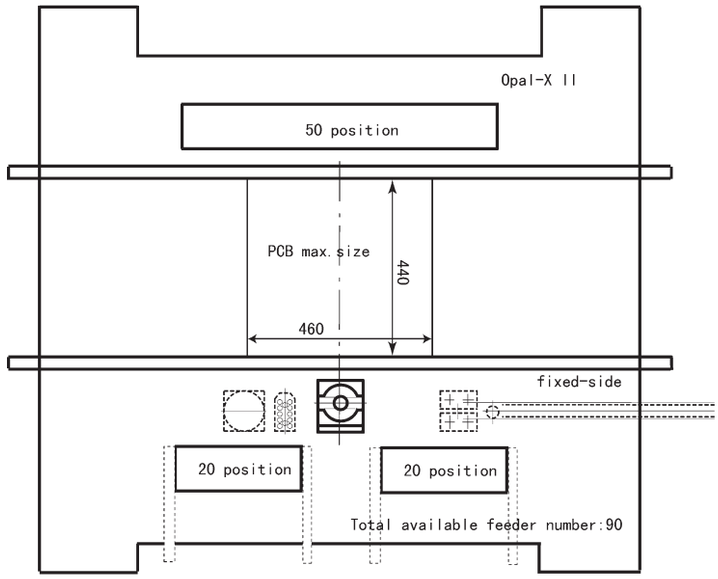
EXAMPLE 2: OPAL-X^{II}



PA 1314/03	Opal-X^{II} with 4 SF heads
PA 2505/58	Feederbar exchange system front side, included FES 20 position carts ^{II} serie
PA 2505/26	Board clamping for Opal-X^{II}
PA 2699/24	Double shuttle LCS for Opal-X^{II}
PA 2932/40	Feeder lock verification system for Opal-X^{II} (front and rear)
PA 2963/27	Nozzle Exchange System Opal-X^{II} (18 positions/no nozzles included)
PA 2969/85	Area CCD camera 32mm (including lighting unit) for ^{II} series

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4.0 Mounting Heads Configuration

The Opal-X[II] features a high precision single placement beam carrying 4 Super Fine heads with exchangeable nozzles. On the head a separate camera system is attached that monitors fiducial marks at the board, circuit and component level, using white + IR light LEDs and multi-angle diffusers to provide optimal illumination. High placement rates are achieved by simultaneous component picking which reduces head beam travel and thus shortens the mounting cycle.

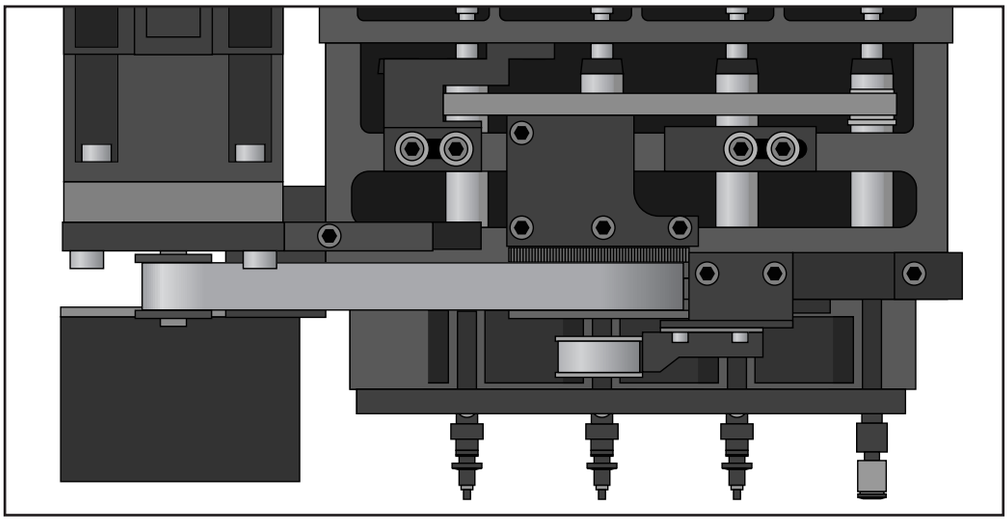

Figure 2 *Configuration of head section*

The high-precision dual Y drive Opal-X[II] features four-axis (X,Y,Z,R) servo control for accurate, stress-free component mounting. Direct drive, brushless AC motors controlling heavy duty lead screws allow optimal accuracy and high reliability.

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Specifications	
Number of axis:	7
Axis configuration:	X axis AC servo Double Y axis AC servo Z, R axis AC servo W (automatic width) axis AC servo Push up plate AC servo
Z axis sequence:	Air and AC servo motor
R axis sequence:	AC servo motor
Pick-up error detection:	Vacuum check (256 level digital setting)
Mounting angle:	0° – 360° (0.01° step)
Number of mounting head:	4 in-line multi head
Nozzle types:	6 different shapes
Encoder resolution:	X,Y = 0.0012mm/pulse
	Phi = 0.0146° /pulse
	Z = 0.00048mm/pulse
Head position accuracy:	X = 0.010mm
	Y = 0.010mm
Speed:	X = 1500mm/sec.
	Y = 1500mm/sec.
Acceleration:	X = 36600mm/sec^2
	Y = 27000mm/sec^2

Table 3

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5.0 ALIGNMENT

5.1 LINE ARRAY CAMERA ALIGNMENT

The high speed of the Opal-X[II] is achieved by fast on-the-fly component alignment using a revolutionary Line Array camera system, equipped with a newly developed multi angle illumination unit, that is four times faster than conventional vision systems.

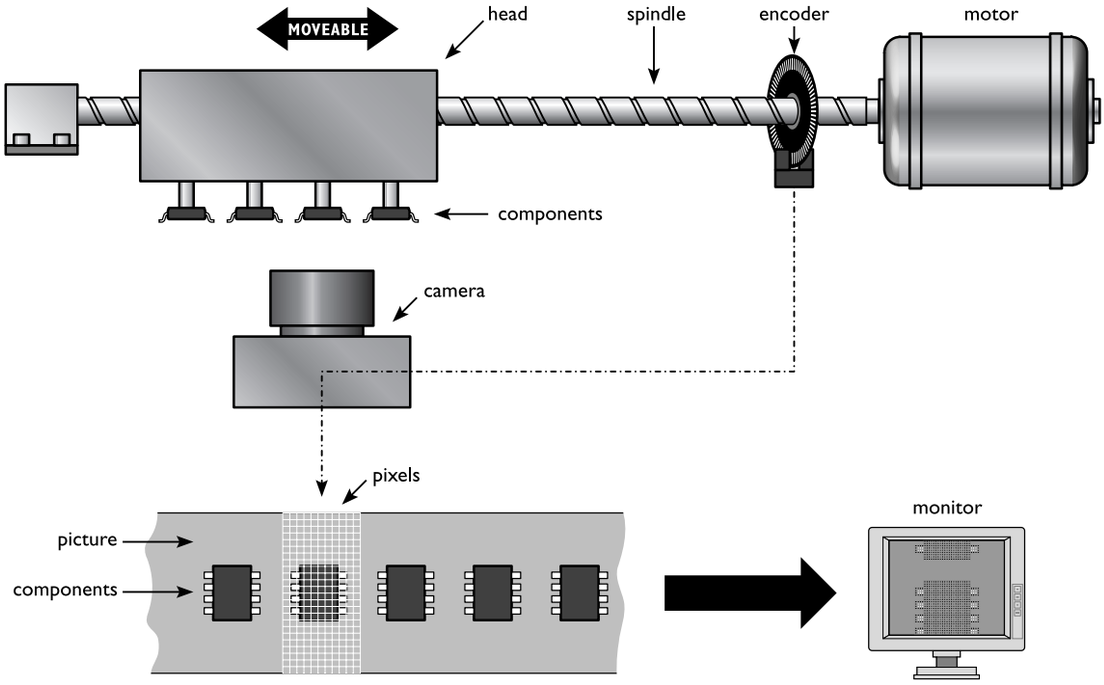

Figure 3 *Line sensor vision principle*

While moving the beam over the camera, the encoder triggers the camera to capture consecutive lines of pixels. All these lines form the total picture of the components. This picture is processed by a sophisticated vision system. The vision system algorithms inspect the components and calculate position and orientation of the components on the heads.

The SMD components are illuminated by a new developed multi angle side illumination unit which allows high speed recognition of CSP's, µBGA's. The leads of the components are imaged on the line sensor.

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Specifications	
Line array camera:	CCD 1024 x 1 pixels
Max. component size:	45mm ⍁ (1.77")
Min. component size:	0201
Min. lead pitch:	0.5mm (20 mil)
Min. lead width:	0.2mm (0.008")
Grey scale:	256 levels
Lighting:	Multi angle Fore/side illumination (red LED array) Light intensity is software controlled for each component separately
Recognition:	Reflection. Pattern recognition on all leads
Max. number of lead sides:	4
Max. number of lead groups:	2 per side
Check on:	Lead/ball pitch
	Lead/ball location
	Bent/missing leads/balls
	Total number of leads/balls
	Cumulative lead/ball pitch

Table 4

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5.2 SINGLE AREA CCD ALIGNMENT

An optional single area CCD camera extends the component range for the Opal-X^{II}

Component illumination is performed by means of fore/reflective lighting and side illumination. The lighting source reflects the lead of QFP and the balls of BGA components on the CCD camera. The single area CCD camera grabs the image of the component in one frame and presents it to the vision system for recognition and measurements purposes.

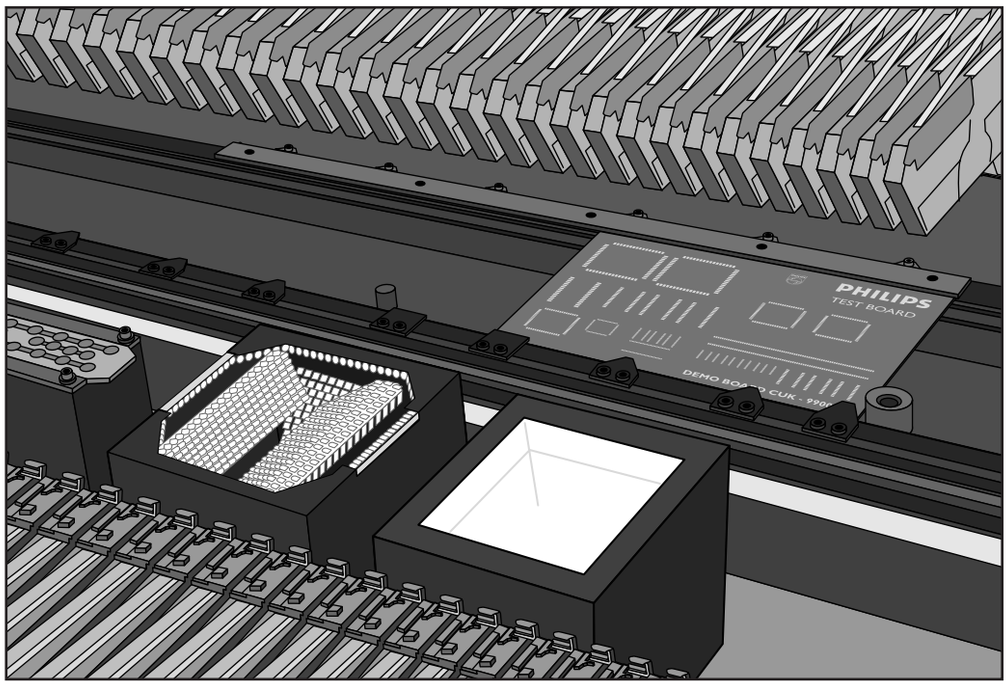

Figure 4 *GEM Opal-X^{II} working area*

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Specifications	
Area CCD camera:	CCD 512 x 480 pixels
Max. component size:	32mm ⌀ (1.26")
Min. component size:	6mm ⌀ (0.24")
Min. lead pitch:	0.4mm (16 mil)
Min. lead width:	0.2mm (0.008")
Grey scale:	256 levels
Lighting:	Fore/side lighting illumination
Recognition:	Reflection. Pattern recognition on all leads
Max. number of lead sides:	4
Max. number of lead groups:	2 per side
Check on:	Lead/ball pitch
	Lead/ball location
	Bent/missing leads/balls
	Total number of leads/balls
	Cumulative lead/balls pitch

Table 5

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5.3 FIDUCIAL ALIGNMENT

The Opal-X^{II} is standard equipped with a fiducial camera. This camera is used to compensate for variations in the position of the circuit pattern relative to the expected position. The fiducial alignment system is an opto-electronic system which performs geometric measurements of fiducial marks on the PCB in order to calculate the deviations from their expected positions. The system can use two or four fiducials per board. Each sub-circuit can also be aligned using two fiducials. For placement of fine-pitch components two local fiducials per component may be used. The individual shapes of a fiducial pair can be different to allow for maximum application flexibility. Also pattern recognition algorithms can be used on traces or pads on the PCB board for cases where fiducials are not available.
The fiducial camera can also be used as a high accurate teaching device for PCB data (if CAD data is not available), automatic calibration and inspection purposes.

Specifications	
Fiducial camera:	CCD
Fiducial camera functionality	Fiducial detection, Bad mark detection, teaching device (2 or 4 point teaching)
Fiducial illumination:	White + IR LEDs in conjunction with a wide-angle diffuser
Compensation for: (with two fiducials)	Translation Rotation Linear stretch and shrink
Compensation for: (with 3 or 4 fiducials)	Non-linear stretch and shrink
Type of compensation:	PCB , Block, Local
Fiducial size:	Max. 3.0mm (0.12") Min. 0.8mm (0.03")
Fiducial material:	Copper Gold Lead-tin
Fiducial clearance area:	2 x Fiducial size
PCB warpage at fiducial:	Max. 0.5mm (0.02")
Pattern offset:	Max. 1mm (0.04")
Number of different Fiducial pairs per PCB:	128
Number of Fiducial shapes in Mark Database:	300
Examples of Fiducials:	Solid circle (preferred) Square Triangle Donut Binary cross Bow-tie (connected) Template matching
Fiducial definition:	According CAD data

Table 6

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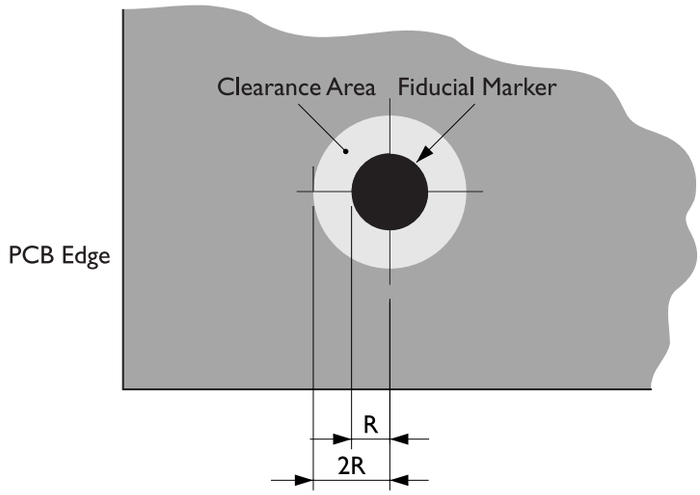
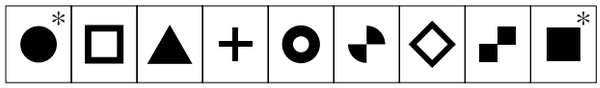


Figure 5 *Fiducial free space*



* Preferred; others possible but not preferred

Figure 6 *Fiducials*

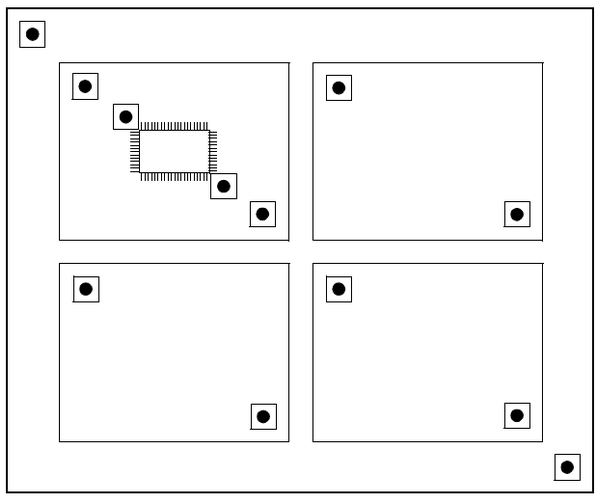


Figure 7 *Examples of PCB, block and local fiducials*

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5.4 MASTER, BAD MARK SENSING

If the PCB contains sub-circuits, one or more of these subcircuits can be skipped for placement by giving them a “Bad Mark” on a designated position on the subcircuit. No parts will be placed on a circuit that has a Bad Mark. Bad Mark sensing, with the use of the fiducial camera, is based on recognition of a difference in contrast in a certain area. This area can be defined in the machine software (position and area-dimensions). This gives maximum freedom in choosing the process or technique to add Bad Marks, for example:

- white or light colored labels of any dimension,
- white paint,

... or any other material that can be fixed as long as it contrast with the PCB surface.

Before checking the Bad Marks on all circuits, the Master Mark may be checked first. Presence of a Master Mark means that one or more Bad Marks are present on the circuits. This allows the machine to skip the Bad Mark sensing process for all circuits if no Bad Marks are located on the circuits, therefore, saving valuable production time.

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6.0 BOARD HANDLING

PCB boards can be located in the machine by either tooling pins or board clamping if tooling holes are not available. With pin location, one location pin is fixed on the machine while the other locate pin is easily adjustable when the board length changes. Change over to a different board size is just a matter of seconds by using the automatic adjustment (servo controlled) of the conveyor width and the PCB thickness.

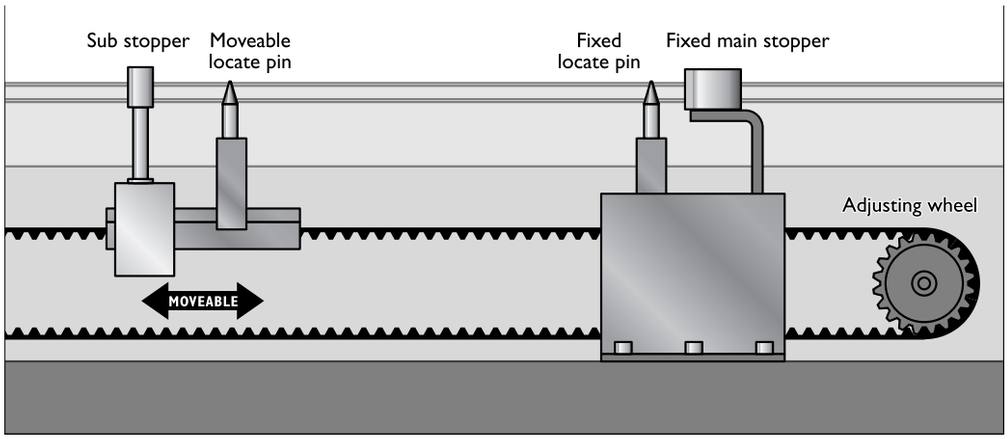

Figure 8 *Pin fixation system*

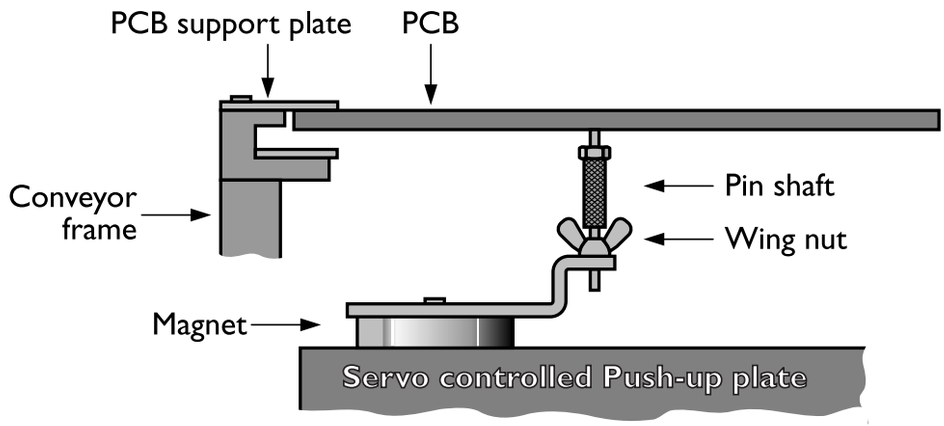

Figure 9 *Push up system*

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A sub-stop enables an additional PCB to enter the machine while the current board is being populated. This reduces time loss during transport and is very useful when operating the machine in a flowline. An exit sub-stop, which can be seen as a transport buffer function, links the entrance sub-stop and main stopper, shortening the PCB transport time and reducing loss from inefficient operation.

When using the machine in a flowline it communicates with the unit upstream and downstream over a SMEMA-connection.

Specifications	
PCB Dimensions (x,y):	Min: 50 x 50mm (2.0" x 2.0") Max: 460 x 440mm (18" x 17.2") using PCB pin fixation or PCB board clamping system
PCB Thickness:	Min: 0.4mm (0.015") Max: 4.0mm (0.15")
Reference hole position:	5mm (0.2") in X and Y from lower right corner
Reference hole diameter:	Ø 2.0mm - Ø 4.0mm (0.08" - 0.157")
PCB Maximum warpage:	0.5mm up (0.02") 1.0mm down (0.04")
Maximum height pre-mounted components:	6.5mm on placement side (0. 26") 18mm on non placement side (0.7")
Non - Mountable area:	Board Top side: 3mm from rear side board edge (0.12") 0mm from front side board edge (Component height restrictions apply in the 10mm (0.40") area from front side edge depending on board thickness) 4mm around reference holes (0.16") (locate pins)
	Board Bottom side: 5mm from front and rear side board edge (0.2")
PCB Material:	Phenolic/FR4/Composite Materials Ceramic PCB transport is optional
PCB weight:	Max. 1.2 Kg without components Max. 2.0 Kg with components

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PCB positioning:	Locate pin fixation (adjustable second pin) Z servo controlled push up system (software controlled by PCB thickness) Push up pins (adjustable positions) Optional Board clamping (sandwich) Sub stop (PCB waiting buffer) adjustable position Exit stop (fixed position)
PCB Transport height:	900mm ± 10mm (35.4" ± 0.4") SMEMA 953mm ± 12.5mm (37.5" ± 0.5")
PCB Transport direction:	Left to Right standard, optional Right to Left
PCB Transport width:	Automatic
PCB loading time:	Approximately 3 sec.
PCB ratio width/length	Max. 1:3

Table 7

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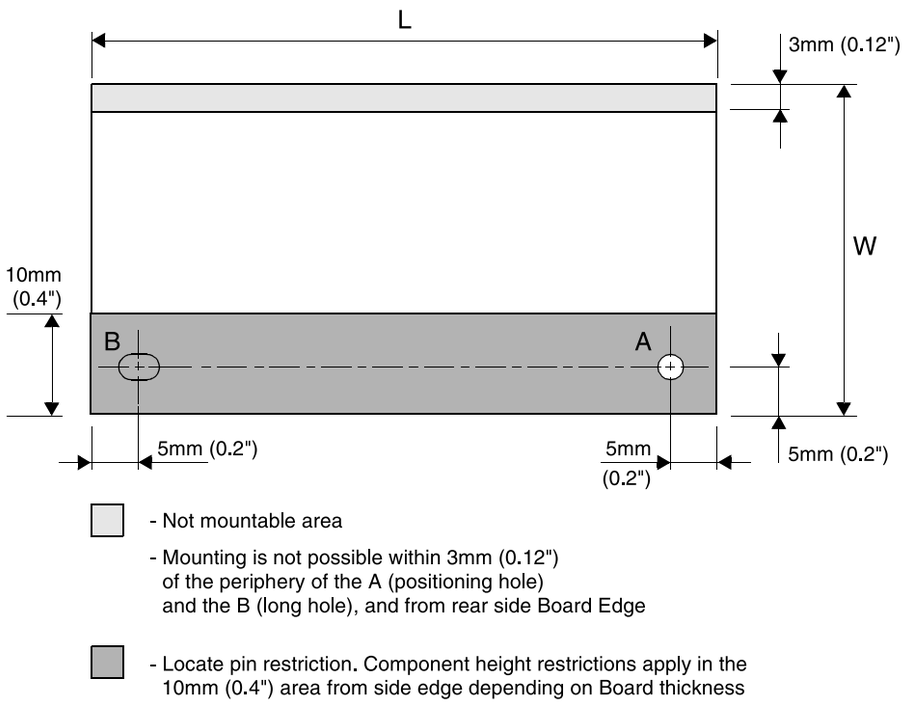

Figure 10 *Mountable area*

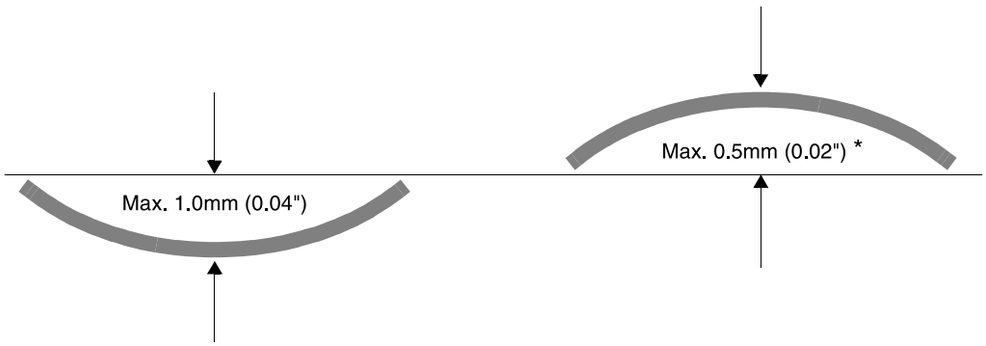

Figure 11 *Warp of fixed PCB*

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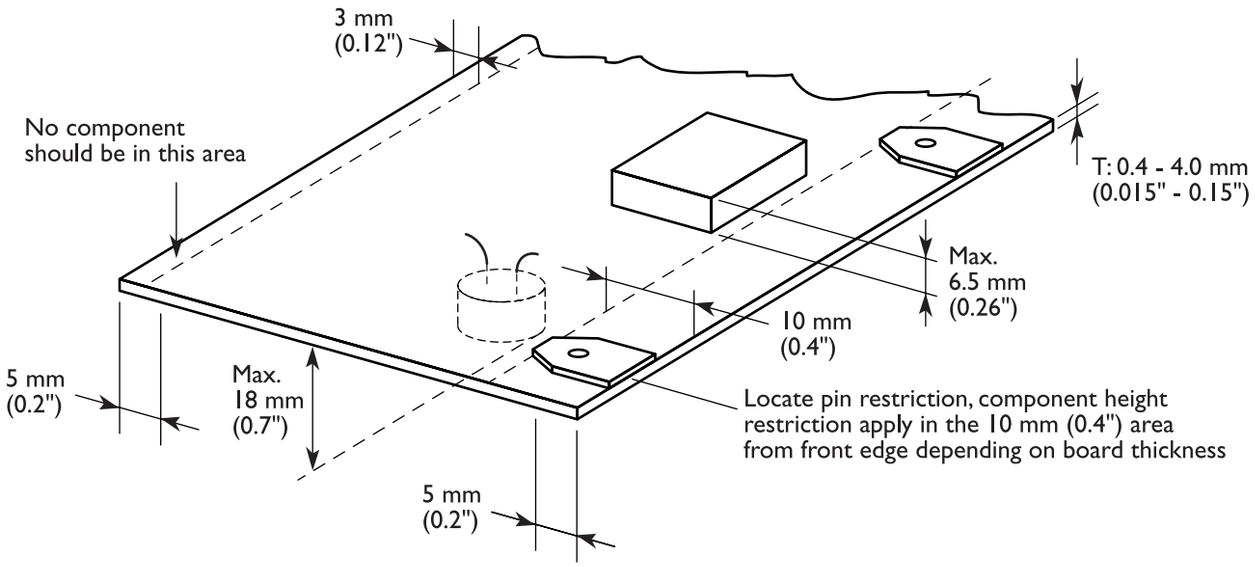

Figure 12 *Mountable area*

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7.0 Feederbar Exchange System

7.1 PA 2505/59

The Feederbar Exchange System (FES) allows fast change-over by switching the complete 20 position feederbar on an Opal-X^{II}.

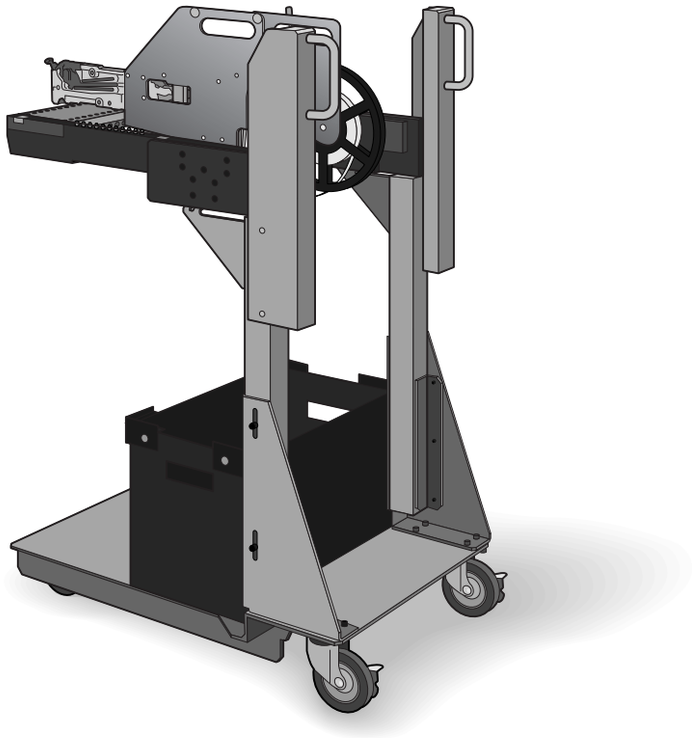

Figure 13 *FES-cart X*

Feederbars are mounted on carts to off-line feeder Set-up. These carts are easily moved from set-up area to the mounting machines and back. This option is available for the front (PA 2505/57) and rear side (PA 2505/58) of the machine. At the front and rear side of the machine the standard 50 position feederbar will be replaced by two FES 20 position carts.
The Opal-X^{II} FES carts are compatible with those of the X^{II} serie machines. An empty tape bin will be delivered with each FES cart.

FES 20 specifications	
	PA 2505/59
FES change over time:	≤ 60 sec.
FES repeatability:	Pick position ≤ 0.05mm
Applicable feeders:	Tape, stick, bulk feeders

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Number of feeders on FES carriage:	8mm: 20 positions 12/16mm: 9 positions 24mm: 6 positions 32mm: 6 positions 44mm: 4 positions 56mm: 4 positions Stick: depends on stick dimensions
Air and Electrical interface:	Quick coupling (one action)
Electrical power:	Supplied by main system
Air supply:	Supplied by main system
FES 20 dimensions, stand alone without feeders:	Length: 750mm (2.5 ft) Width: 460mm (1.5 ft) Height: 1000mm (3.3 ft)
Weight without feeders:	65 kg (143 Lbs)
Tape waste bin :	Included
Compatibility:	XII serie machines
Min. component size:	0402 (1.0mm x 0.5mm) Smaller components should be used with pick-up teaching function.

Table 8

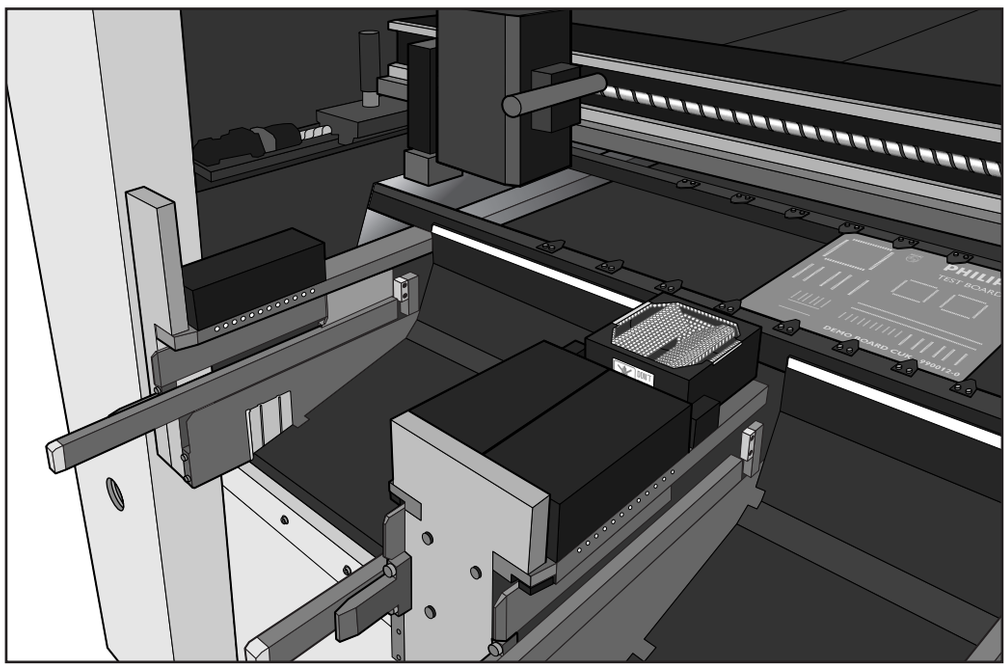

Figure 14 *Clamping system*

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8.0 Component Feeding

8.1 Pneumatic Tape feeders

The Opal-X" has a fully compatible feeder platform with all GEM machines. Depending on the machine configuration up to 100 tape feeders (8mm) can be loaded.
The tape feeder design allows simultaneous picking from any mix of tape feeders ranging from 8 to 56mm. To achieve high speed feeding all feeder types are air driven.
To prevent incorrect feeder latching, a laser-based verification system is used

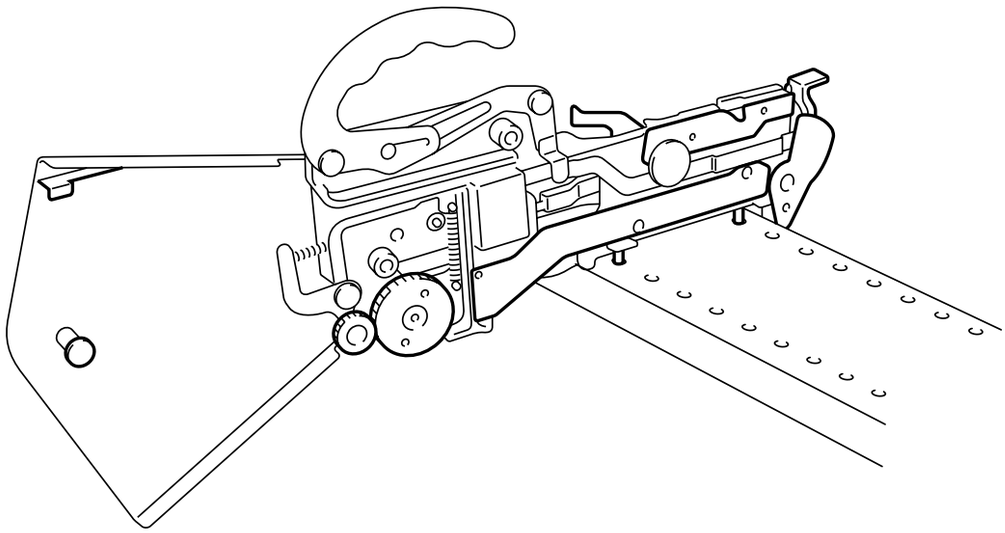

Figure 15 *Pneumatic tape feeder*

Available tapefeeders		
Tape Feeder	**Feeding pitch (mm)**	**PA#**
Tape Feeder 8mm 15" for 0603 (0201) component CL	2	PA 2903/77
Tape Feeder 8mm 15" for 1005 (0402) CL	2	PA 2903/78
Tape Feeder 8mm 15" CL	4	PA 2903/79
Tape Feeder 12mm 15" CL	4,8,12	PA 2903/88
Tape Feeder 16mm 15" CL	4,8,12,16	PA 2903/27
Tape Feeder 24mm 15" CL	4,8,12,16,20,24	PA 2903/38
Tape Feeder 32mm 15" (PSA)	8,12,16,24,32	PA 2903/41
Tape Feeder 44mm 15" (PSA)	8,12,16,24,32,36	PA 2903/51
Tape Feeder 56mm 15" CL	4,8,12,16,24,32,36	PA 2903/68
For larger and special tape feeders such as 72mm please contact your local sales representative		

Table 9 *The feeding pitch can be adjusted on the feeder side.*

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Feeder occupation	
Feeder type	**Required feeder position equivalent to tape feeder 8mm**
Tape feeder 8mm,	1
Tape feeder 12mm, 16mm, 24mm	3
Tape feeder 32mm	4
Tape feeder 44mm	5
Tape feeder 56mm	6

Table 10 *The above feeder conversion number may differ according to the installation combination.*

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8.2 DOUBLE SHUTTLE TRAY FEEDER (PA 2699/24)

The double shuttle Tray feeder is an additional pallet sequencer feeding parts from a tray. This feeder can be equipped with maximum 40 pallets, each being able to hold different trays.

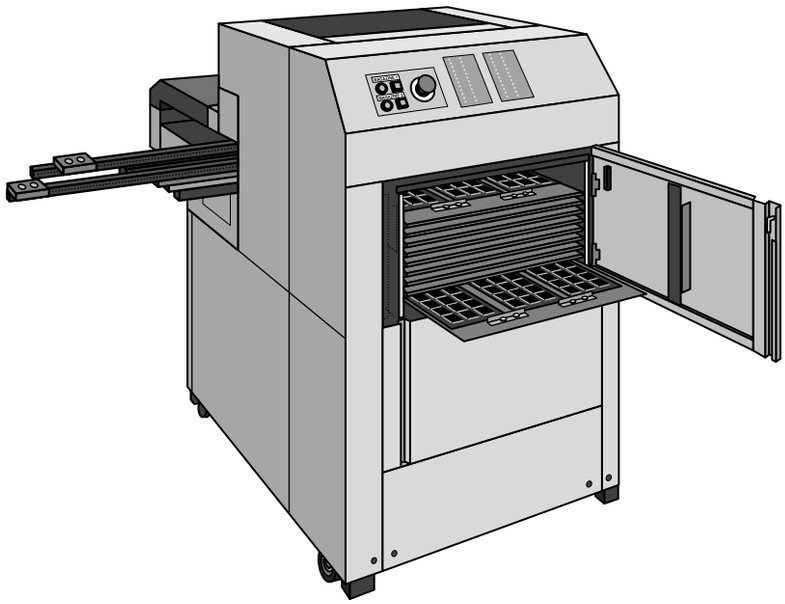

Figure 16 *Double shuttle tray feeder*

Two components are picked up from the tray with a double head, and placed simultaneously on a shuttle. This shuttle then moves into the machine where the components are picked by the placement head. The part is then aligned by vision and placed on the PCB. At the same moment when the components are picked by the placement head a second shuttle will be supplied with the next components which minimize the feeding time.

The component feeding time of the double shuttle Tray feeder is 3.5 seconds for 2 parts when using the same tray (pallet 1) and 8.5 seconds when changing the tray (pallet 40). However, in practice no time is lost because of the simultaneous operation of Tray sequencer and Opal-X^{II}: while the machine is picking from on-board feeders, the shuttle brings in new components. A part that is rejected by vision will be placed back on the reject conveyor which means no loss of expensive parts.

The PCB conveyor on the double shuttle Tray feeder offers the possibility for visual PCB inspection.

- A tray container is fixed and separated into two sections with each 20 pallets. This allows tray replenishment while the machine is running.
- A buffer conveyor is standard equipped, so a reflow oven can be connected without additional conveyors.

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LCS Tray feeder specifications	
GENERAL	
Max. Tray size (L x W):	350mm x 468mm (13.7" x 18.4") which can hold 3 Jedec trays
Min. Tray size (L x W):	50mm x 50mm (2.0" x 2.0")
Component feeding time:	3.5 sec. for 2 parts (picking from pallet 1) 8.5 sec. for 2 parts (picking one from pallet 1 and one from pallet 40)
Power and air supply:	Delivered by Opal-X^{II}
LCS Tray feeder dimensions :	Length: 826mm (2.8 ft) Height: 1165mm (3.8 ft) (with top cover open 1545mm (5.2 ft)) Width: 1650mm (5.2 ft) (with door open 2292mm (7.6 ft))
Opal-X^{II} + Tray feeder dimensions:	Length: 2476mm (8.3 ft) Height: 1850mm (6.1 ft) Width: 1898mm (6.3 ft) (with LCS door open and feeders on Opal-X^{II} (2942mm (9.8 ft)
Weight:	± 280 kg (617 Lbs)
Power supply, air supply:	Supplied from main machine
APPLICABLE COMPONENTS	
Min. Component dimension:	8mm x 8mm (0.31" x 0.31") Mold size
Max. Component dimension:	45mm x 45mm (1.8" x 1.8")
Max. Tray height included component height:	8.5mm (0.33") from pallets at pitch of 12.5mm (0.5"), total 40 pallets possible
	20mm (0.78") from pallets at pitch of 25mm (0.98"), total 20 pallets possible
FEED CAPACITY	
Number of shuttles:	2
Number of pads on each shuttle:	2 (with a pitch of 48mm)
STANDARD COMPONENT CAPACITY	
Max. number of component types:	120 (3 x 40 Jedec)
Number of pallets:	Standard 40 pallets included (additional pallets available PA 2981/15)

Table 11

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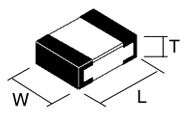
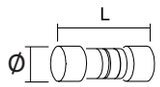
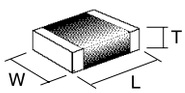
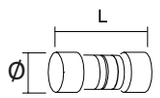
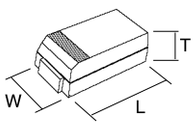
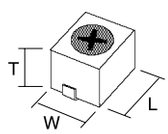
8.3 COMPONENT FEEDING

Just six nozzle shapes are required to cover the specified SMD range. High output levels are therefore achieved, as the need for nozzle exchanges is minimal. An optional 20 position nozzle exchange station enables additional special nozzles to be accommodated.

Components		Dimension (mm)			Required nozzle type
		L	W	T	SF
	Solid resistor	0,60	0,30	0,25	71
		1,00	0,50	0,50	71
		1,60	0,80	0,50	72
		2,00	1,25	0,50	72
		3,20	1,60	0,60	72
	Solid resistor	2,00	Ø 1.25		72
		3,45	Ø 1.35		72
		5,9	Ø 2.2		72
	Multi-Layered ceramic capacitor	0,6	0,3	0,3	71
		1,0	0,5	0,5	71
		1,50	0,80	0,80	72
		2,00	1,25	1,25	72
		3,20	1,60	1,25	72
		3.20~4.50	2.50~3.20	1.50~1.90	73
		5,60	5,00	1,90	73
	MELF ceramic capacitor	3,40	Ø 1.50		73
		5,9	Ø 2.2		76A
	Tantalium electrolytic capacitor	2,90	1,60	1,60	72
		3,80	2,90	1,60	73
		4,70	2,60	2,10	73
		6,00	3,20	2,50	73
		7,30	4,30	2,80	73
	Aluminium electrolytic capacitor	4,3	4,3	5,7	73
		6,6	6,6	5,7	73
		10	10	10,5	77

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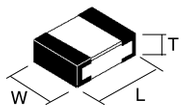
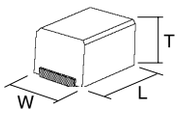
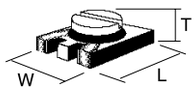
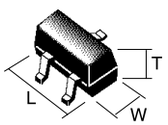
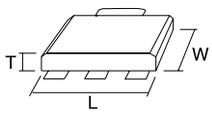
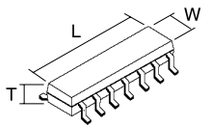
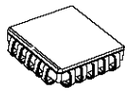
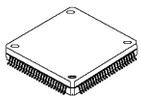
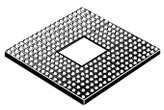
Components		Dimension (mm)			Required nozzle type
		L	W	T	SF
	Chip film capacitor	7,3	5,3	3,25	73
	Chip inductor	3,2	2,5	2,0	73
		4,5	3,2	3,2	73
	Semi-variable resistor	4,5	3,8	2,4	73
	Transistor (SOT)	2,90	1,5	1,10	72
		4,0	3	1,8	73
	Power transistor	4,6	2,6	1,6	73
	SOP (6~28 pin)	5,00	4,50	1,50	73
		7,60	4,50	1,50	73
		10,10	4,50	1,50	73
		12,60	5,70	1,50	73
		15,30	7,50	2,00	77
		17,80	7,50	2,00	77
	PLCC	⌀ 5~16			73
		⌀ 15~20			77
		⌀ 15~32			77
		⌀ 15~45			75
	QFP	⌀ 5~16			77
		⌀ 15~20			77
		⌀ 15~32			77
		⌀ 15~45			75
	BGA	⌀ 10~26			77
		⌀ 10~30			77
		⌀ 10~45			75

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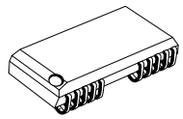
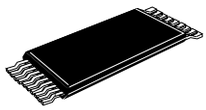
Components		Dimension (mm)			Required nozzle type
		L	W	T	SF
	SOJ (20~42 pin)	⍁ 10~20			73
		⍁ 15~30			77
	TSOP (20~32 pin)	⍁ 10~20			73
		⍁ 15~30			77

Table 12

For your information on CSP, µBGA, bare chip and other types of components, please consult your local sales representative.

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9.0 OPAL-X^{II} SUMMARY

	Model	Opal-XII
	PA number	**PA 1314/03**
Head	Super Fine head 4 x SF	•
	Nozzle Exchange station 20 position	○
	Special order nozzles	*
Recognition system	Line Array camera 45mm	•
	Area CCD camera 32mm including illumination unit	○
	Fiducial camera	•
Feeding	Pneumatic Tape Feeder	•
	Bulk Feeder	○
	Stick Feeder	○
	Double Shuttle Tray Feeder (LCS)	○
	Reject station	○
	Manual Tray Feeder	○
	Feeder Exchange System (FES 20)	○
PCB positioning/transport	Main Stopper	•
	Locate Pin	•
	Board Clamp System	○
	Z servo controlled Push Up Plate	•
	Entrance Sub Stopper	•
	Exit Sub Stopper	•
	Automatic Width Adjustment	•
	High Speed soft-stop conveyor	•
	Reverse transfer Right to Left	○
	Ceramic PCBs	○
	Special sized PCBs	*
Safety	Feeder Floating Detection	○
	Conveyor Entrance/Exit covers	•
	Safety cover for feeder exchange	•
	Dummy Feeders	•
	Safety specifications according CE standards	•
	Spare parts kit + tools	•
	SMEMA kit	•
	Front and rear anti-static covers	•
	Signal tower + warning buzzer	•
Software	Windows NT Graphical User interface	•
	Multiple Accuracy Compensation System	•
	Fiducial Recovery function	•
	Bad Mark / Master Mark Sensing	•
	On-line teaching	•
	Alternative Feeder Function	•
	Automatic program change	•
	Variable XY axis speed per component	•
	On-line Help function	•
	Management Information System	•
	Template (pattern matching)	•
	Automatic rework cycle	•
	On-line data generator	•

Table 13
• = *Standard*
○ = *Optional*
* = *Special order*

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