ABB motion control products

Machine profile
Vertical form fill seal

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Vertical form fill seal machines
Overview

There are fundamentally two types of motion for Vertical Form Fill and Seal (VFFS) machines, though many variants of structure and control system approach exist.

Intermittent motion form fill seal

The typical machine is loaded with a continuous flat roll of plastic film, which has labelling or artwork applied to the interior or exterior of the film. The film is drawn to the back of a long hollow conical tube, which acts as a former. The film is formed around this conical shaped former to create a tube. The film is pulled downward around the outside of the tube and a vertical heat-sealing bar clamps onto the edges of the film, bonding the film by melting the seam edges together.

To start the bagging process, a horizontal sealing bar clamps across the bottom edge of the tube, bonding the film together, and cutting off any film below (previous bag). The sealed tube end is then lowered onto a precision weighing table or the correct weight of material is dispensed from above via a measuring system and the product to be bagged is dispensed through the long conical tube at the center of the bag.

When the target weight of the product-filled bag is reached, the horizontal sealing bar seals the top of the bag, and simultaneously forms the bottom of the next bag above. This bag is then cut off from the tube and is now a sealed package which is dispensed.

During the final seal process the bag maybe filled with air or an inert gas. Inflating the bag helps reduce the crushing of fragile products, while inflating with an inert gas helps drive out oxygen and retards the growth of bacteria.

Continuous motion form fill seal

To maximise throughput the process runs continuously without stopping. To achieve this the sealer must move with the material during the seal/cut process. Common solutions use mechanical cams or a moving axis which will accelerate up to the speed of the material. When the sealer has synchronized with the belt speed (material) the jaws are closed which seals, crimps and cuts the material, the jaws are then opened. It now decelerates and reverses back to the starting position. The reverse move takes the form of an acceleration and a deceleration.
There are many combinations with which this can be achieved both mechanically and electrically. Some manufacturers have specific patents on their solutions. In essence, the Cam or Fly functions can be used to provide specific complex motion profiles to match any scenario the manufacturer requires.
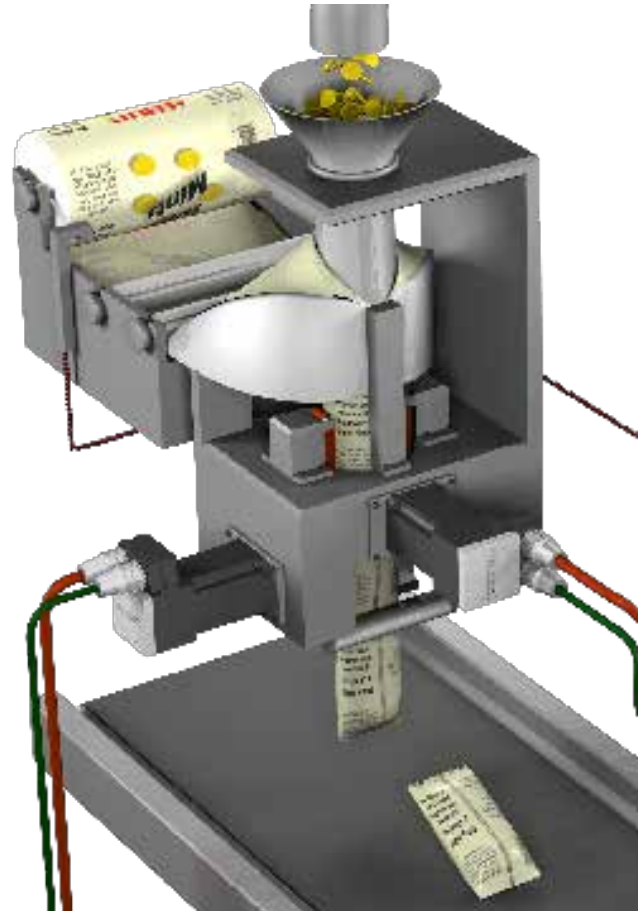
Most machine manufacturers have a range of solutions, low cost intermittent to high performance continuous. As a result of cost / performance trade-offs, different controllers and motor technologies are used in each design, providing opportunity for one or all machine performance levels.

Examples of products packaged in this way (or similar)
– Crisps, peanuts and similar snacks
– Sweets
– Cereals and multigrain products
– Pharmaceuticals
– Liquids such as milk and juice can also be packaged in a similar process to fill and form cartons

VFFS machines employ a wide range of material types and are used across numerous markets including food, drinks, cosmetics, electronics, stationary, tobacco, chemical, medical, and pharmaceuticals.

Vertical form fill seal machines
Terminology

Film unwind
Unwinding of the film into the machine sometimes using an AC servo, variable frequency drive or DC motor.

Dancer arm / Accumulator
Is a free moving idling roller(s) that change position to the tension of the film. When tension is OK the roller stays in a neutral position. But if tension is too high or low the roller is moved from that position. The controller's task is to return the roller to the neutral position maintaining tension. In some cases a more complex accumulator is used to isolate the unwind from the varying film speed of the machine cycle.

Former
A metal tubular construction which wraps and forms the film into a vertical tube shape. The tube also acts as a chute for product to be dropped through into the bag being formed.

Sealing bar / rollers
Usually a thermal process for joining the film and creating a seal. Vertical sealing bar normally pneumatically operated but may be servo on some very high spec machines. Roller systems also exist.

Film registration
Used primarily when the film has graphics printed on and is used to compensate for film slippage and stretch. Adjustments are made to the film index servo end position based on the latched position of the film and actual servomotor position.
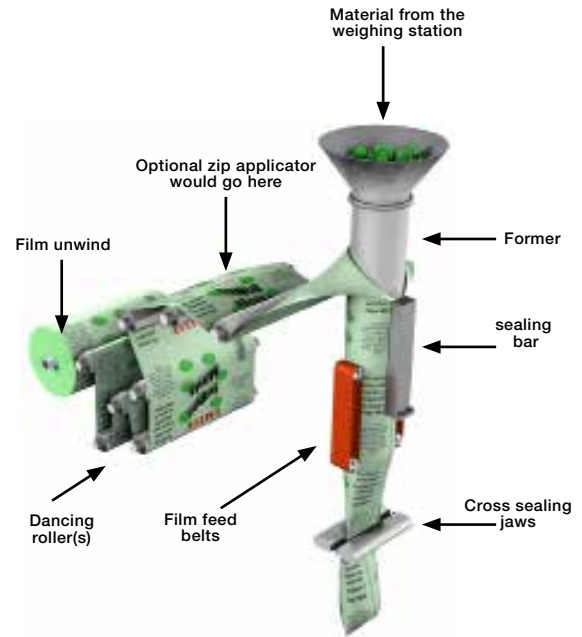
Cross sealing jaws
There are numerous types of cross sealing jaw and mechanical mechanisms that machine designers use. The main task is to seal and cut the bag. The jaws will normally contain a heating element and a knife which is normally fired pneumatically. Designers can use servomotors to close the jaws or closed loop induction.

Zip applicator (optional)
Is normally an independently controlled unit that can be retrofitted to an existing machine or ordered as an option. The zip strip is cut to length from a reel and then applied to the bagging material prior to the film reaching the former.

Multi head weigher
A multi-head weigher can generate precise measurements of product by controlling release of product from one or more chutes. This usually has a dedicated controller.

Material from the weighing station

Optional zip applicator would go here

Film unwind

Former

sealing bar

Dancing roller(s)

Film feed belts

Cross sealing jaws

Typical motion functions required for all machine types

 Homing

 Registration control

 IncR/A (Relative/Absolute incremental move)

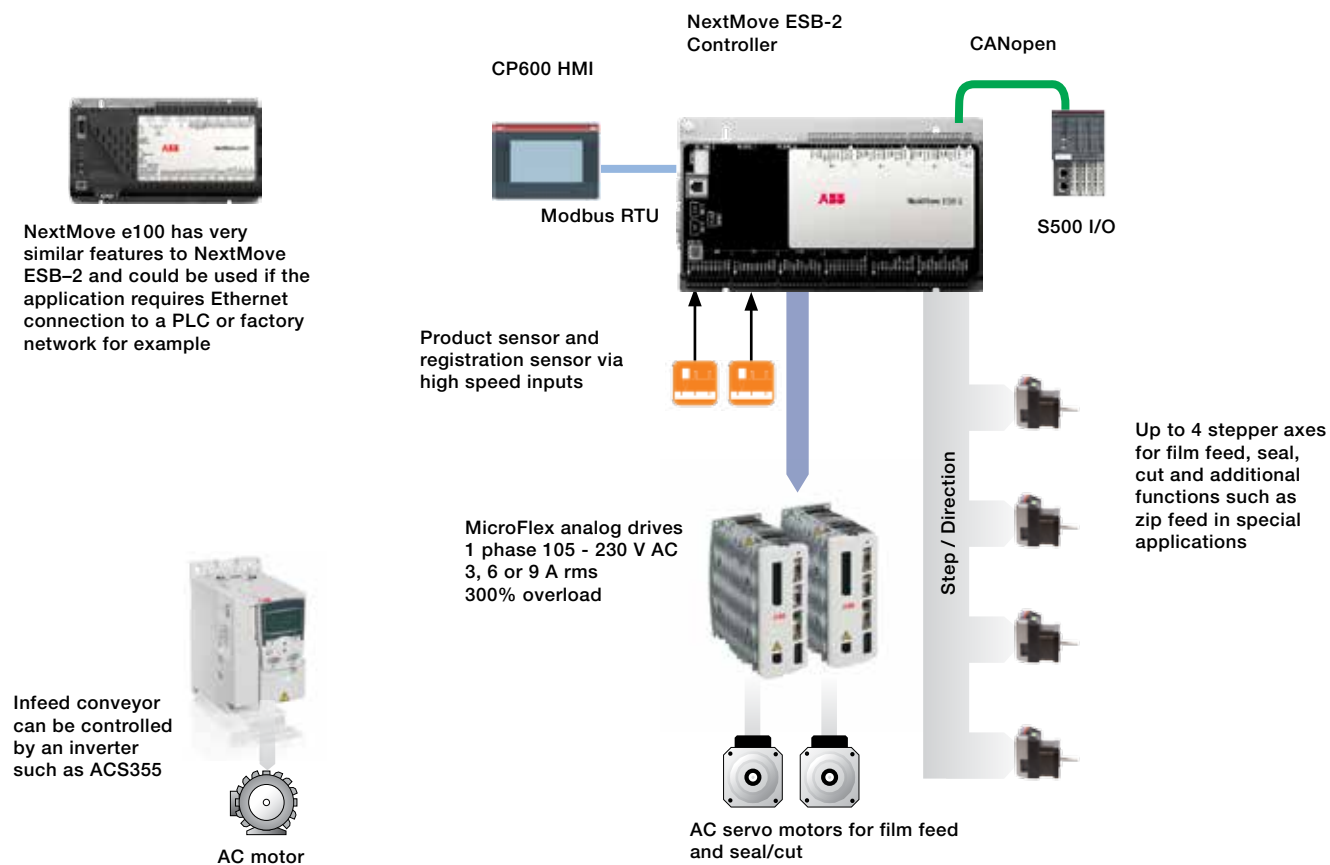### Typical motion required for continuous motion machines (high performance)

 Electronic gearing

 CAM motion

 Flying shear motion

Vertical form fill seal
ABB Solution 1& 2 - stepper and/or analog solutions

NextMove ESB-2 Controller

CP600 HMI

CANopen

Modbus RTU

S500 I/O

NextMove e100 has very similar features to NextMove ESB–2 and could be used if the application requires Ethernet connection to a PLC or factory network for example

Product sensor and registration sensor via high speed inputs

Step / Direction

Up to 4 stepper axes for film feed, seal, cut and additional functions such as zip feed in special applications

MicroFlex analog drives 1 phase 105 - 230 V AC 3, 6 or 9 A rms 300% overload

Infeed conveyor can be controlled by an inverter such as ACS355

AC servo motors for film feed and seal/cut

AC motor

In principle, solutions could be based on either stepper, analog demand drives or a mix of the two. In both cases NextMove ESB-2 can be used. Alternatively, NextMove e100 can be considered if an upstream Ethernet connection is required.

Stepper solution, features and benefits
– Stepper solutions are usually the lowest cost and therefore entry level control solutions for intermittent machine types.
– Usually aimed at basic filling machines, often non-printed film with low throughput rates.
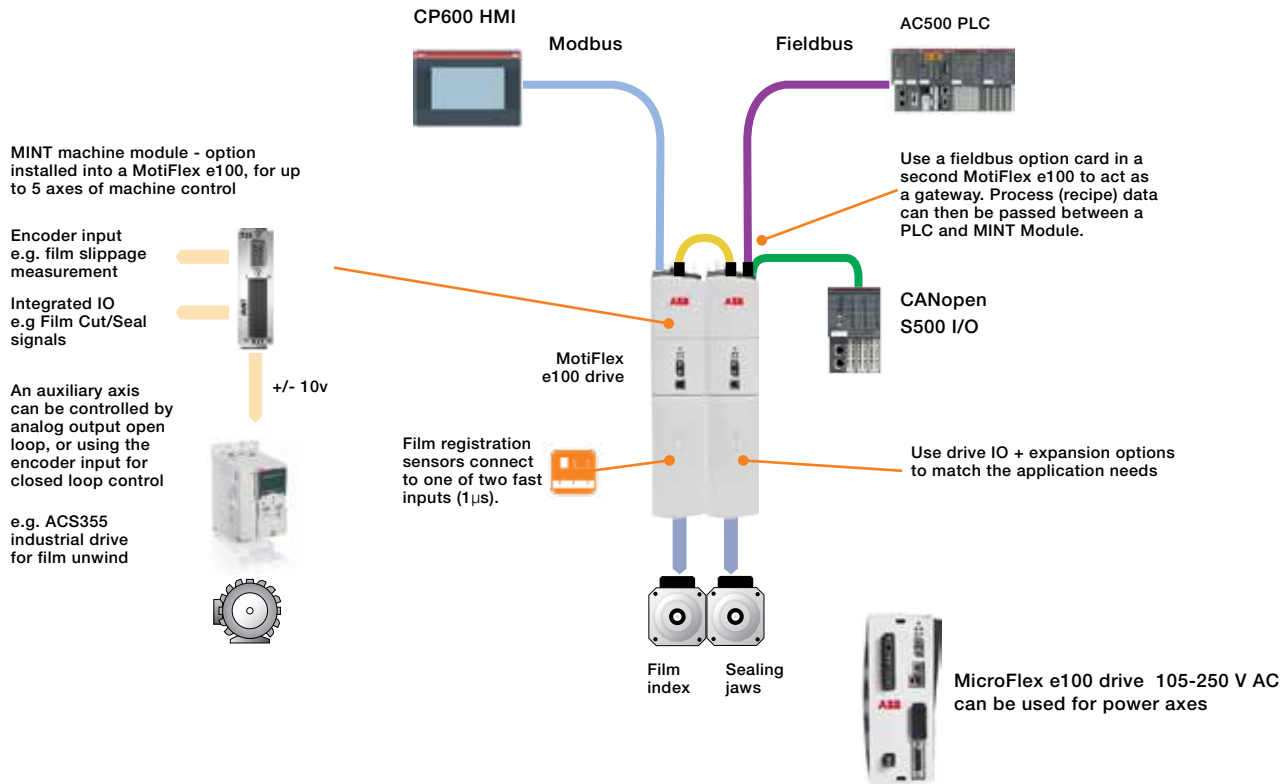
Analog servo solutions
– Device costs are generally lower than Ethernet technology, but higher than stepper systems
– Used for mid-range throughput in the intermittent machines category
– Remember that we offer ABB Ethernet product lines for higher performance with the same software tools
– MicroFlex analog drive supports resolver or encoder types such as incremental ABZ with Halls and Baumer SSI.
– MicroFlex or ACS355 drives could be used for film unwind.

NextMove ESB-2 controller features and benefits
– NextMove ESB-2 features advanced stepper control which provide smooth velocity control over a wide frequency range with micro-stepper drives/motors.
– In addition, s-ramping control of stepper axes is supported to reduce jerk and hence film slip.
– Digital and analog IO built in for machine logic
– IO easily expanded by the CANopen interface
– 4 x stepper axes for additional auxiliary axes
– 4 x analog axes of control with +/-10 V demand and incremental ABZ encoder feedback (10 MHz quadrature)
– 4 x fast inputs (1μs) for position latch functions such as registration of film
– Recipe data can be stored on board the controller or CP600 HMI panel.
– A single, easy to use software tool, MINT Workbench for configuration and programming of NextMove and MicroFlex products.
– MINT is easy to program, and provides multi-tasking for performance and Events for critical tasks.
– No software licenses. MINT is no charge.

Vertical form fill seal
ABB Solution 3 - MotiFlex e100 drive and MINT multi-axis module

CP600 HMI

Modbus

Fieldbus

AC500 PLC

MINT machine module - option installed into a MotiFlex e100, for up to 5 axes of machine control

Use a fieldbus option card in a second MotiFlex e100 to act as a gateway. Process (recipe) data can then be passed between a PLC and MINT Module.

Encoder input e.g. film slippage measurement

Integrated IO e.g Film Cut/Seal signals

CANopen S500 I/O

An auxiliary axis can be controlled by analog output open loop, or using the encoder input for closed loop control

MotiFlex e100 drive

+/- 10v

e.g. ACS355 industrial drive for film unwind

Film registration sensors connect to one of two fast inputs (1μs).

Use drive IO + expansion options to match the application needs

Film index

Sealing jaws

MicroFlex e100 drive 105-250 V AC can be used for power axes
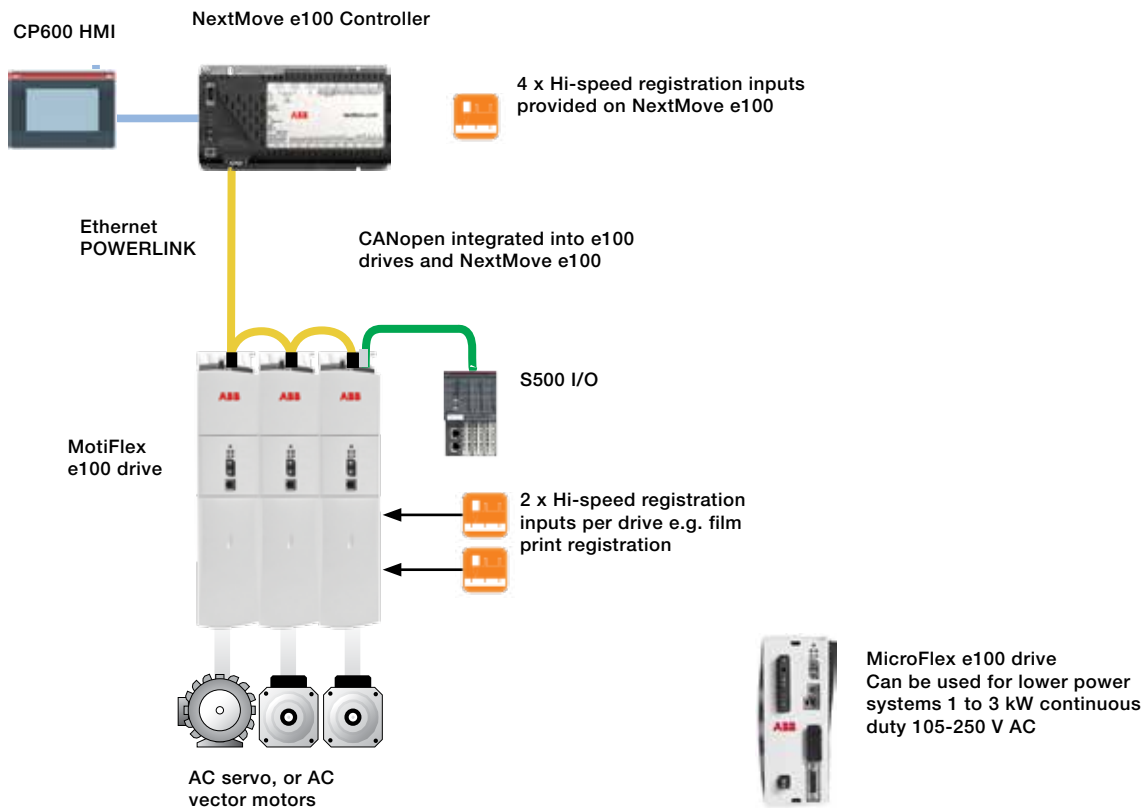
MINT machine module, features and benefits

– Fast processing of a motion controller card dedicated to the machine core motion competence.
– 'Flying Shear' and 'Cam' motion functions for synchronous motion in continuous mode form fill seal machines.
– Recipe data can be stored in the MINT module NV-ram or on the CP600 HMI panel.
– Code on the MINT module can be written in a modular format and reused in machine variants or used in NextMove controllers on similar machines
– Space saving – no external motion controller.
– A common motion solution that can be interfaced to many PLC types where end-user PLC specification exists.
– MINT is easy to program, and provides multi-tasking for performance and Events for critical tasks.
– No software licenses. MINT is no charge.

MotiFlex e100 drives, features and benefits

– MotiFlex e100 has a wide input voltage range
– MotiFlex e100 is capable of linear or rotary motor control.
– MotiFlex e100 universal encoder input – flexibility of a wide choice of feedback devices. Secondary feedback can be added as an option.
– Use servomotors with absolute feedback to eliminate homing requirements, and reduce downtime after product jam or power cycles.
– Plug-in fieldbus cards can provide gateways to PLC's or other devices.
– DC bus system to absorb and reuse regenerative energy, with internal fuses and simple DC link bars.
– CANopen for IO expansion which can be used by the system or the drive itself.

Vertical form fill seal
ABB Solution 4 - e100 based system

CP600 HMI

NextMove e100 Controller

4 x Hi-speed registration inputs provided on NextMove e100

Ethernet POWERLINK

CANopen integrated into e100 drives and NextMove e100

S500 I/O

MotiFlex e100 drive

2 x Hi-speed registration inputs per drive e.g. film print registration

MicroFlex e100 drive Can be used for lower power systems 1 to 3 kW continuous duty 105-250 V AC

AC servo, or AC vector motors

e100 Ethernet solutions, features and benefits

– Significantly reduced wiring costs – one Ethernet cable replaces the analog demand (2 core + Shield), the simulated encoder (minimum 7 wires + shield) and the error reset signal.
– Pure digital demand – no ADC/DAC dependency, no drift noise or offsets.
– Multiple high-speed (1µs) latch inputs on each device, provide accurate film registration.
– CANopen IO expansion on drives and controller.
– e100 products can be commissioned over the POWERLINK connection via the motion controller.
– A single, easy to use tool, MINT Workbench software for configuration and programming of all e100 products.
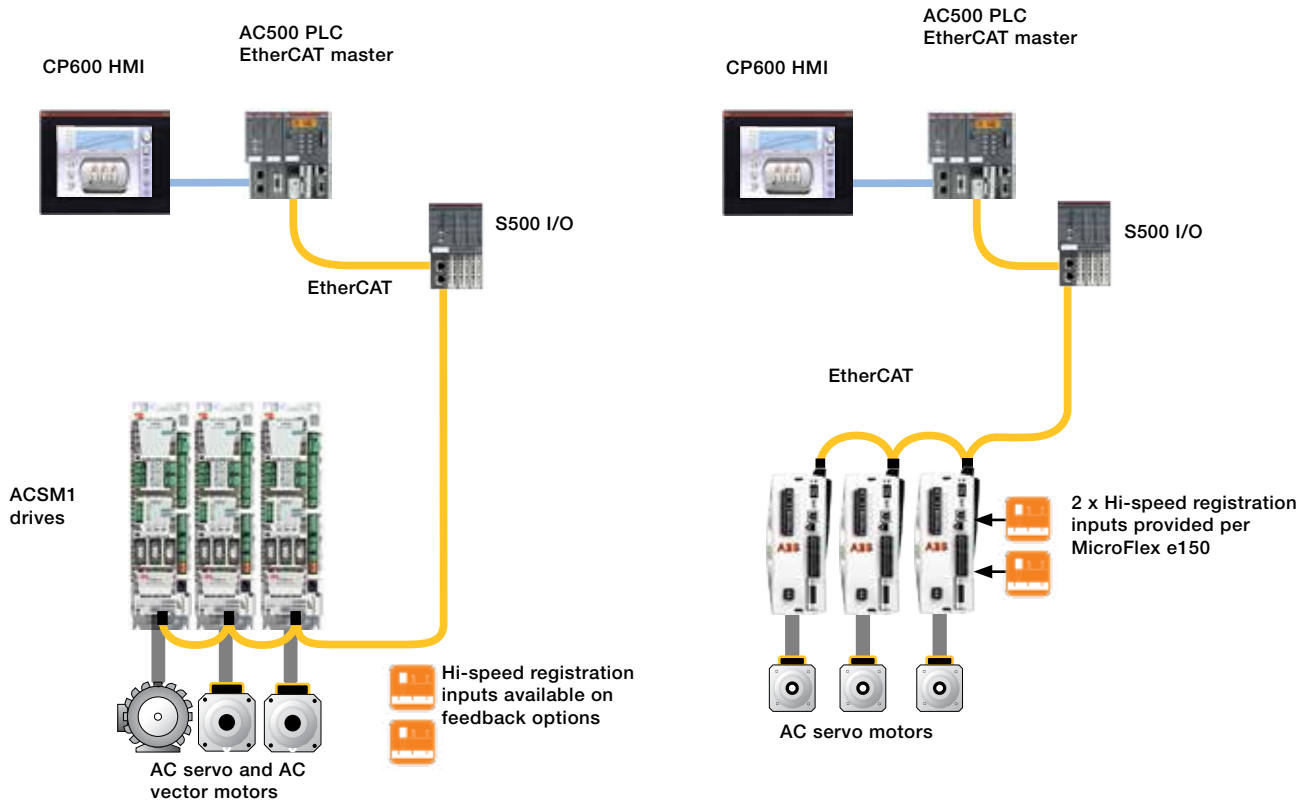
NextMove e100 controller features and benefits

NextMove e100 shares many of the MINT machine module benefits, is code compatible and provides additional integrated features including:

– Digital and analog IO for machine logic
– 4 stepper axes for additional auxiliary axes
– Control of up to 3 analog axes
– 3 x encoder inputs with position latch capability
– 4 x fast inputs (1µs)
– RS232/485 port for connection to HMI's, PLC's, and other devices
– CANopen expansion to a wide range of devices

Vertical form fill seal
ABB Solution 5 - AC500 PLCopen solution

CP600 HMI

AC500 PLC
EtherCAT master

S500 I/O

EtherCAT

ACSM1
drives

Hi-speed registration
inputs available on
feedback options

AC servo and AC
vector motors

CP600 HMI

AC500 PLC
EtherCAT master

S500 I/O

EtherCAT

2 x Hi-speed registration
inputs provided per
MicroFlex e150

AC servo motors

ACSM1 200- 500 V AC high power solution drives

MicroFlex e150 105-230 V AC mid power solution drives

AC500 PLC solutions, features and benefits
– PLC based solutions are increasingly popular in the packaging industry. Our AC500 PLCopen motion functionality is one of the most capable of all PLC vendors.
– Scalable and modular architecture allows the solution to be tailored to the application
– Industry standard IEC61131-3 programming and PLCopen motion function blocks are very popular in the packaging industry
– IO expansion by fieldbus or local expansion bus
– Many types of fieldbus and Ethernet technologies are supported

ACSM1 drive features and benefits
– Wide power range and 3 phase 240 - 480 V AC, up to 580 A
– Highly modular design, easily expanded
– Choice of resolver and encoder technologies
– DC bus sharing and line-regen option for energy efficiency
– Safe Torque Off (STO) SIL3 PL e
– Choice of fieldbus options including EtherCAT
– Use ACSM1 for higher power and/or supply voltage requirements. Some systems may require a mix of MicroFlex e150 and ACSM1. In these applications, EtherCAT should be the first choice.

MicroFlex e150 drive features and benefits
– 1 or 3 phase operation, 105 - 250 V AC
– 3, 6 and 9 A ratings
– Real-time EtherCAT control interface
– Universal encoder feedback supports many feedback types
– Servo performance with 300% overloads for dynamics
– e150 drives feature 2 x high-speed (1µs) latch inputs useful for registration
– Safe Torque Off (STO) SIL3 PL e

Vertical form fill seal
Solutions

		Entry level machines		Mid range		High performance	
Component	**Controller**	NextMove ESB-2		NextMove e100	MINT Module[3]	NextMove e100 MINT Module	AC500 PLC[2] with PLCopen Motion
	Drives	DMS Steppers motors with integrated drive	MicroFlex Analog	MotiFlex e100 MicroFlex e100	MotiFlex e100	MotiFlex e100 MicroFlex e100	MicroFlex e150 ACSM1
	Motors		BSM Servo Motors	BSM Servo Motors		BSM Servo Motors	
	HMI	KPD202-501	CP600	KPD202-501	CP600	CP600	
	IO	CAN IO + Drive IO + Controller I0		CAN IO + Drive IO + Controller IO		CAN IO + Drive IO + Controller IO	Various
	Other / optional	ACS355 for auxiliary axes, unwind, conveyor, etc. AC500 eCo PLC for logic and temperature control		ACS355 for auxiliary axes, unwind, conveyor, etc.		ACS355 for auxiliary axes, unwind, conveyor, etc.	
		AC500 eCo PLC for logic and temperature control		AC500 eCo PLC for logic and temperature control			
	Safety	Jokab safety		Jokab safety		Jokab safety / AC500S PLC	

[1] As per ESB-2 but adds Ethernet support for machine networking.

[2] PLCopen motion is increasingly popular as a standards based motion technology.

[3] MINT motion module is a plug-in controller option for MotiFlex e100 (5 axes).

Solutions

The table above shows possible configurations that could be used to solve VFFS machines (and similar). In addition, our solution capabilities are developing all the time and alternatives may exist.

ABB benefits as a supplier

– World's leading drives manufactured by volume
– Global presence with support and service infrastructure
– A broad product offering including motion, servo drives and motors, industrial drives, PLC systems, safety products, robots and much more

Frequently Asked Questions

Can we use an ABB PLC?

You have the choice to use our PLC or the specified PLC for logic. With a MINT Machine module, there is the added advantage that the core motion program on the MINT Machine Module will stay the same making your job easier. The MINT code can be written generically so that any fieldbus module can be added giving you the flexibility to adapt to PLC requirements. **Process data can be sent to the MINT program such as length of bag, number of bags in the production cycle and reading data back such as the number of bags produced.**

Can I protect the machine program using my current solution?

No problem. In a MINT controller, you can do exactly the same by downloading just the executable file from within Workbench and not including the source file. The program can even be tied to the serial number of the unit for unauthorized cloning of the application.

What experiences does ABB have in this application?

We have motion control, drives and PLC experts who have worked and served this industry for many years, specifically developing product features to address this type of application.

Do we need to learn a new programming system?

MINT is a very simple intuitive language in 'real English' terminology. Our customers often praise the ease of use and rapid development after a very short learning curve. We offer demonstrations, training classes, and many MINT application notes relevant for examples. Alternatively, ABB also offers IEC61131 and PLCopen motion functions with the ABB AC500 PLC range and solution based on this platform with the advantages of an industry standard based programming method and class leading motion functions.

Available promotional literature

The ABB motion product family is fully supported with literature - data sheets, Q & A, pricing, and catalogs. Commercial collateral is available at www.abb.com/motion and www.abb.com/plc.

Visit www.abb.com/motion/solutions for examples and application animations including VFFS machines and application notes relating to this type of machine and motion functions.

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