

# Application note Flying Shear (PLCopen motion)

AN00245

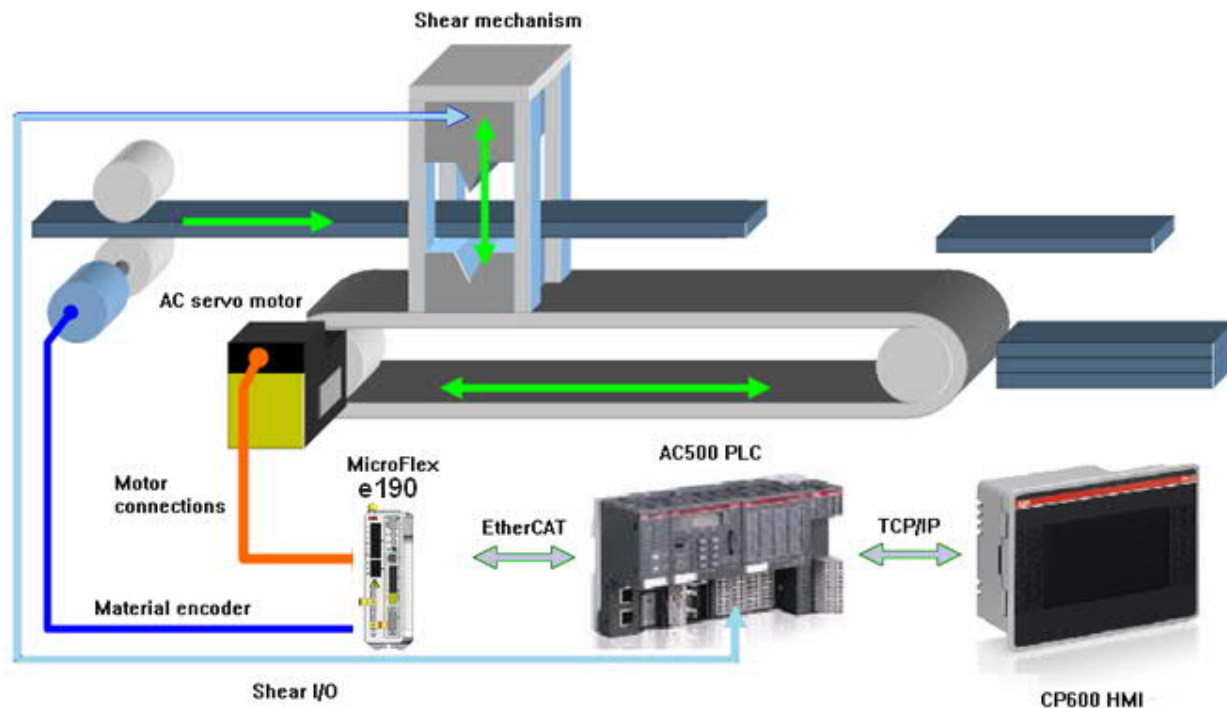
Rev A (EN)

ABB's PS552-MC-E PLCopen motion library makes it easy to synchronise the motion of two axes whilst cutting material and then return, with minimum energy, ready to start the next cut cycle



## Introduction

A typical linear flying shear application, cutting continuous feed material into predefined lengths, is illustrated by the figure below.



A set of nip rolls, possibly driven by an ABB ACS380 inverter drive and induction motor for example, moves the material through the machine. An encoder, often attached to the nip rolls or the back of the induction motor, but occasionally driven by the material via a measuring wheel, detects the position and speed of the material as it passes through the machine. This is usually termed the 'material encoder'. The system makes use of the flexibility of the ABB motion system to reduce costs by connecting this material encoder signal to encoder channel 2 on the MicroFlex e190 (or the master encoder input on the feedback module of a MotiFlex e180 if a three phase 400VAC drive is used) alleviating the need to use a separate encoder module on the PLC to accept the material encoder. This encoder data can then be mapped back to the PLC, at high speed, via the EtherCAT real-time Ethernet network.

A timing belt drive, with a shear knife mechanism attached to it, is driven by the MicroFlex e190 (or MotiFlex e180) AC servo drive and BSM AC servo motor (in this example the motor uses Smartabs feedback to allow the connection of the material encoder to encoder channel 2 on the drive). In the diagram above an ABB AC500 PLC (e.g. PM585-KIT, which comprises a PM585 processor and CM579-ETHCAT coupler) is used as the motion controller and has interfaces with other components such as the ACS355 inverter used to drive the material nip rolls and a CP600 HMI used to enter various system parameters.

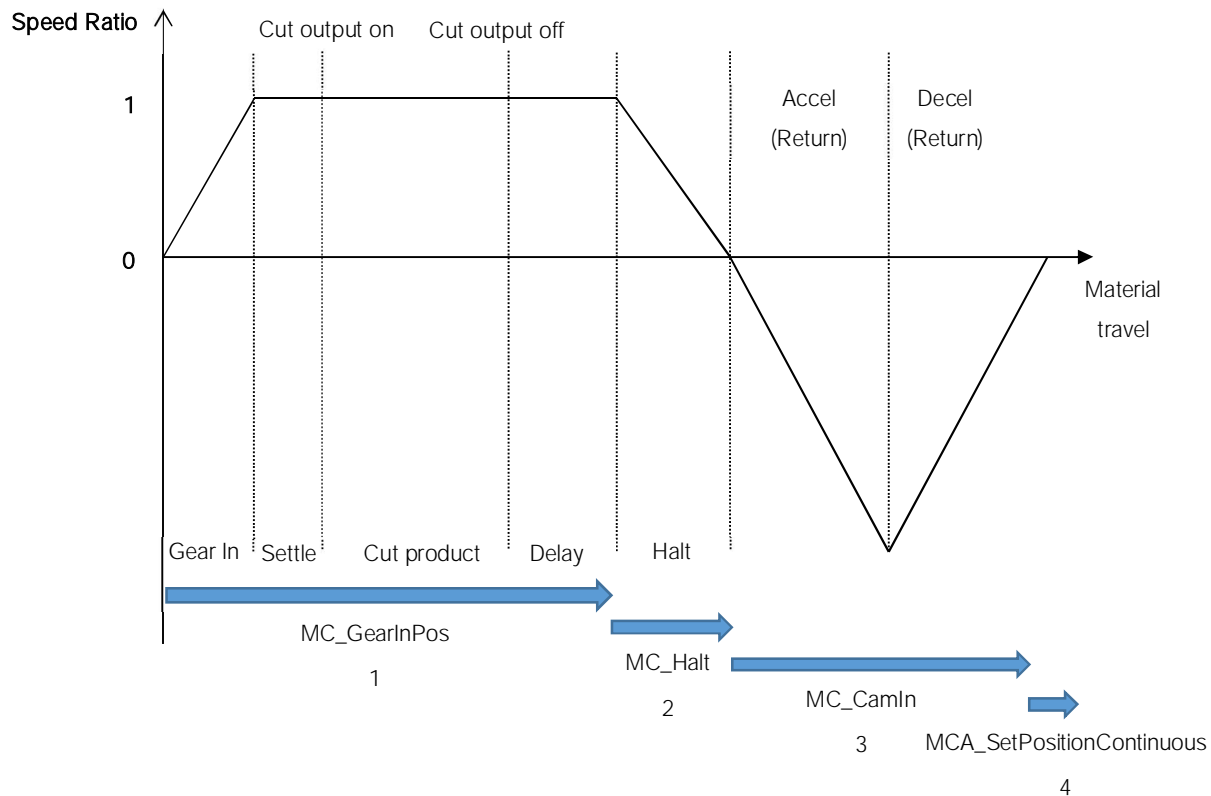
### General motion principles

The material encoder is connected to an encoder input on the ABB MicroFlex e190 (or MotiFlex e180) servo drive and this data is then mapped back to the PLC over EtherCAT and used to generate a position for a material/master axis within the application (this axis is then used as the master axis for any geared motion commands within the program).

A home sensor is used, wired to (fast) digital input 1 on the MicroFlex e190 (or MotiFlex e180) servo drive, to allow the shear axis to be initially datumed. The PLCopen application code uses a "home to touchprobe" function block to provide very accurate homing of the axis.

After initial homing of the shear mechanism (so the PLC knows the shear is at its reference/datum position) the shear and material axis positions are set to zero and the material is cut (any waste is removed at this point). When the material nip rolls are started and the next cut point in the material approaches, the shear is accelerated to a speed that exactly matches the material speed. Having reached synchronous velocity the system waits for a specified period of time (to allow the mechanics to "settle") before finally a cut is initiated (in this example by activating a solenoid for a fixed duration to actuate a blade). This is done in a way that allows the first cut length to be correct. After a defined period of time (adjustable by the operator) the cut output is de-energized and the system waits for a period of time for the knife to return to its "up" position (the speed of the shear cannot change from "synchronous" until the shear blade is out of contact with the material). Once the cut has taken place the shear is decelerated to a stop and then returned to its start position. This return move takes place over a specified material travel (slightly less than the remaining material travel before the next cycle should start) so as to minimize the speed, acceleration and deceleration (and hence energy) used as well as reducing the mechanical stress on the transmission elements. Once returned the material axis position can be adjusted (instantaneously) so that the next cycle's position always remains absolute to the start of a cut cycle.

The figure below illustrates the relationship between the speed ratio of the material and the shear axis (this diagram assumes for simplicity that the material is travelling at constant velocity) and also indicates where in the cycle the various PLCopen motion function blocks are called:



The motion profile for the operating cycle can be split into four main sections...

1. When the machine is homed, the shear axis and material axis positions are both set to zero and the shear mechanism is operated to make the first cut to trim off waste from the material. The program uses MC\_GearInPos to initially start the shear axis. Function block parameters MasterSyncPosition and SlaveSyncPosition are used to define the absolute positions the material and shear axes should be at when the defined speed ratio is reached (usually 1:1 but can be adjusted). When the synchronous speed has been reached (indicated by the 'InSync' output of the MC\_GearInPos function block) the program starts a timer to allow the axis time to "settle" before turning on the cut output. The cut output is energized for an (adjustable) amount of time before being turned off again. The program then waits for another adjustable amount of time (to give time for the knife blade to be withdrawn from the product and reach the "up" position) before proceeding with the next phase of the motion cycle
2. Once the shear blade/knife has been withdrawn from the material the shear axis can be stopped (via MC\_Halt). This is done with a fixed deceleration (the highest rate the axis can handle – to minimize the material travel during this period)
3. Once the MC\_Halt is complete the PLC samples the current material axis and shear axis positions to allow a Cam profile to be calculated that will return the shear axis to its datum position just before the next MC\_GearInPos needs to restart for the next cut cycle. This Cam is implemented via MC\_CamIn
4. When the MC\_CamIn completes (indicated by the MC\_CamIn EndOfProfile output activating) the MCA\_SetPositionContinuous function block is then used to shift the material axis position back by the required cut length. This ensures that the material axis position always remains within a fixed range and is always absolute to its original start position

### Example project

Available to accompany this application note is an example Automation Builder v1.2 project. This project has been written for a PM591 processor fitted with CM579-ETHCAT coupler and a MicroFlex e190 drive connected via EtherCAT (but is easily converted to suit other configurations – note that a PM585 or any PM59x processor must be used for EtherCAT motion applications).

The project uses version 3.2.0 of the PS552-MC-E PLCopen motion control library so you will need a licensed version of this installed. The project references the MicroFlex e190 as a device included in Automation Builder via installation of the Mint servo drives package (v1.2.4.0), so it may also be necessary to install this package via Tools>Installation Manager... before opening the example projects if you are not using a version of Automation Builder that ships with this package already installed. Please refer to the Automation Builder help system and application note AN00205 for further information about installing packages if needed. This application note includes the relevant Mint servo drives package file for convenience.

The project includes a DX561 eco I/O module to which an Emergency stop input (I0, active low) and a machine start input (I1, active high) are wired. Codesys can be used to force operation of these inputs if necessary. This module is used to provide two digital outputs, O0 is the Knife/Shear solenoid output, O1 is an output that would be used to start/stop an inverter (e.g. ACS355) that might drive the nip rolls feeding the material.

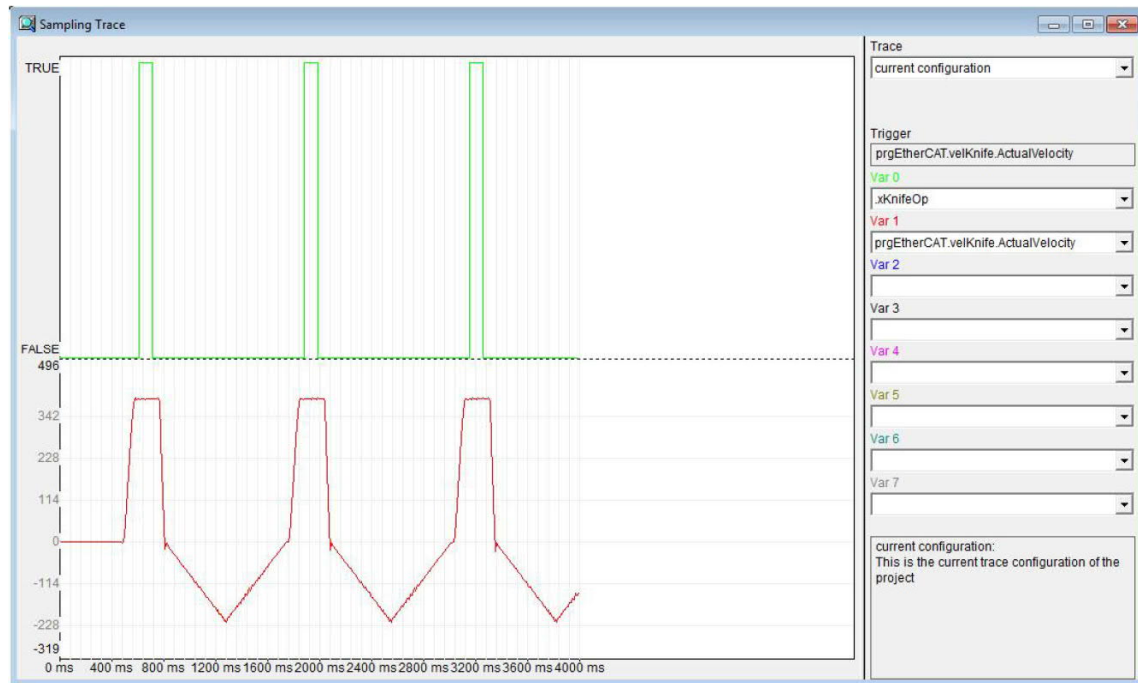
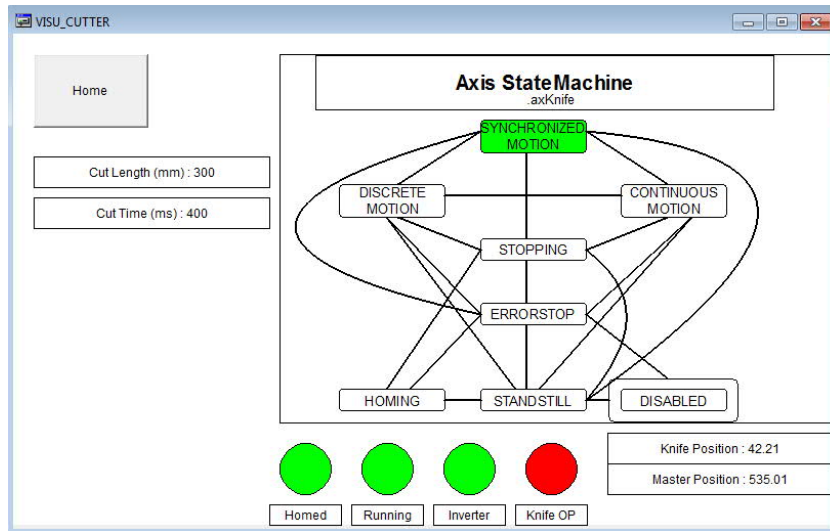
The project assumes that the material encoder is connected to encoder channel 2 on an ABB MicroFlex e190 servo drive. It assumes this encoder is fitted to a measuring wheel with a diameter of 50mm and that the encoder has a resolution of 10000 lines (40000 counts in quadrature).

The project assumes that the shear axis is driven by a BSM R series motor fitted with Smartabs encoder feedback (131072 counts per motor rev), driving the shear mechanism via a 5:1 gearbox and a 32 tooth pulley and timing belt with 5mm belt pitch (i.e. 1 motor rev = 32 mm of linear travel).

The project contains simple logic to start/stop an external inverter (to start the inverter the shear must have been homed, the emergency stop must be inactive and the start input must be turned on and then off – i.e. rising edge). To home the axis (triggered from a button in the included visualization) the emergency stop must be inactive, the servo drive must be enabled, the machine must be stopped and the material encoder must be indicating zero velocity.

The visualization allows the user to adjust the cut length and cut time during operation. Other parameters may be adjusted either via the programming environment at run-time or the visualization may be updated to allow access to these (e.g. acceleration distance, cut speed ratio).

The screenshots below show the visualization operating at runtime and the typical velocity profile for the EtherCAT axis (also showing the timing of the knife output) resulting from operation of this example program...



If you require a copy of this Automation Builder project please email [Motionsupport.uk@gb.abb.com](mailto:Motionsupport.uk@gb.abb.com) and we will be happy to send you this.

**Contact us**

For more information please contact your local ABB representative or one of the following:

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