

Mint^{MT} Multi-Tasking Application Note

AN00116-002 - Flying Shear

Related Applications or Terminology

- **Cut to Length**
- **Flying Knife**
- **Synchronized motion**

Overview

Flying shears allow the position lock of master and slave axes over defined distances with imposed accelerations and decelerations.

Usually there is a requirement to synchronize the speed of these axes over a specific distance traveled by one of the axes.

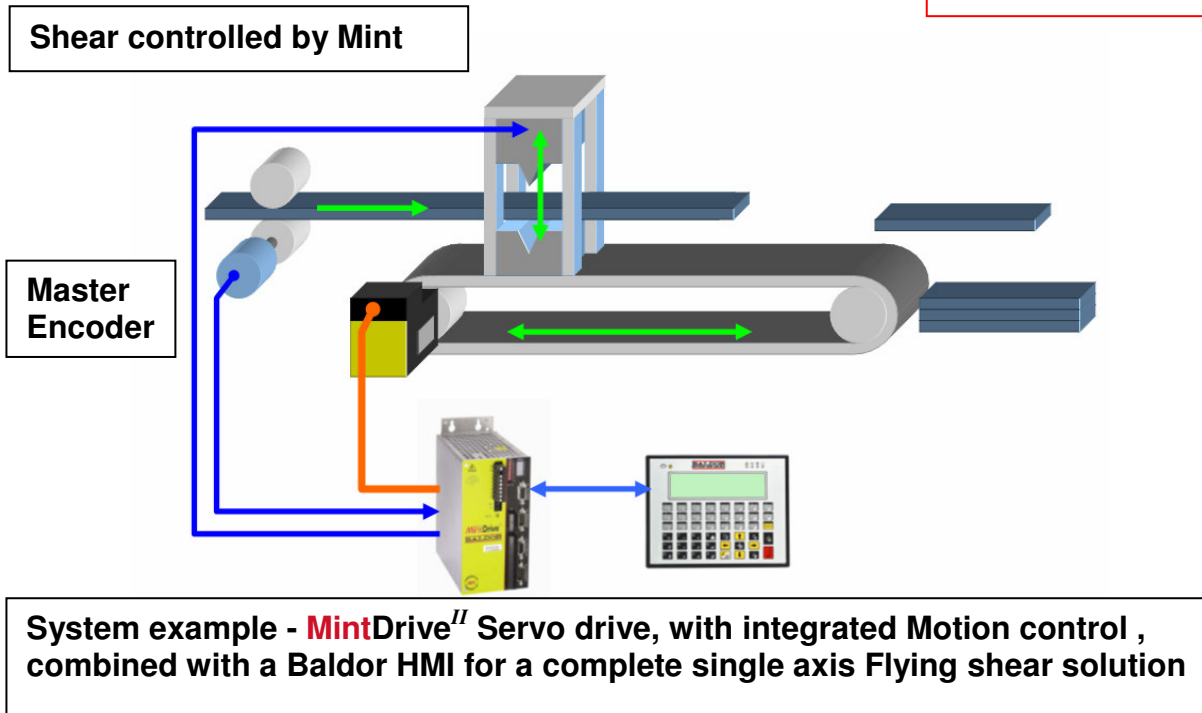
The classic flying shear application, cutting continuous feed material into predefined lengths, is illustrated by the figure below.

Supported Controllers

- | | |
|----------------------------------|-------------------------------------|
| NextMove PCI | <input checked="" type="checkbox"/> |
| NextMove BX ^{II} | <input checked="" type="checkbox"/> |
| NextMove ST | <input checked="" type="checkbox"/> |
| NextMove ES | <input checked="" type="checkbox"/> |
| NextMove ESB | <input checked="" type="checkbox"/> |
| NextMove e100 | <input checked="" type="checkbox"/> |
| MintDrive ^{II} | <input checked="" type="checkbox"/> |
| Flex+Drive ^{II} | <input type="checkbox"/> |

Relevant Keywords

FLY
MASTERDISTANCE
MASTERSOURCE
MASTERCHANNEL
MOVEBUFFERSIZE



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Description

A set of nip rolls moves the material to be cut at a constant linear velocity through the machine. These nip rolls may be driven by an induction motor and variable frequency drive system or may even be controlled by a servo drive/motor. An encoder, often attached to the nip rolls, 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 'master encoder'.

A timing belt drive, with a shear knife mechanism attached to it, is configured as a slave axis driven via a servomotor.

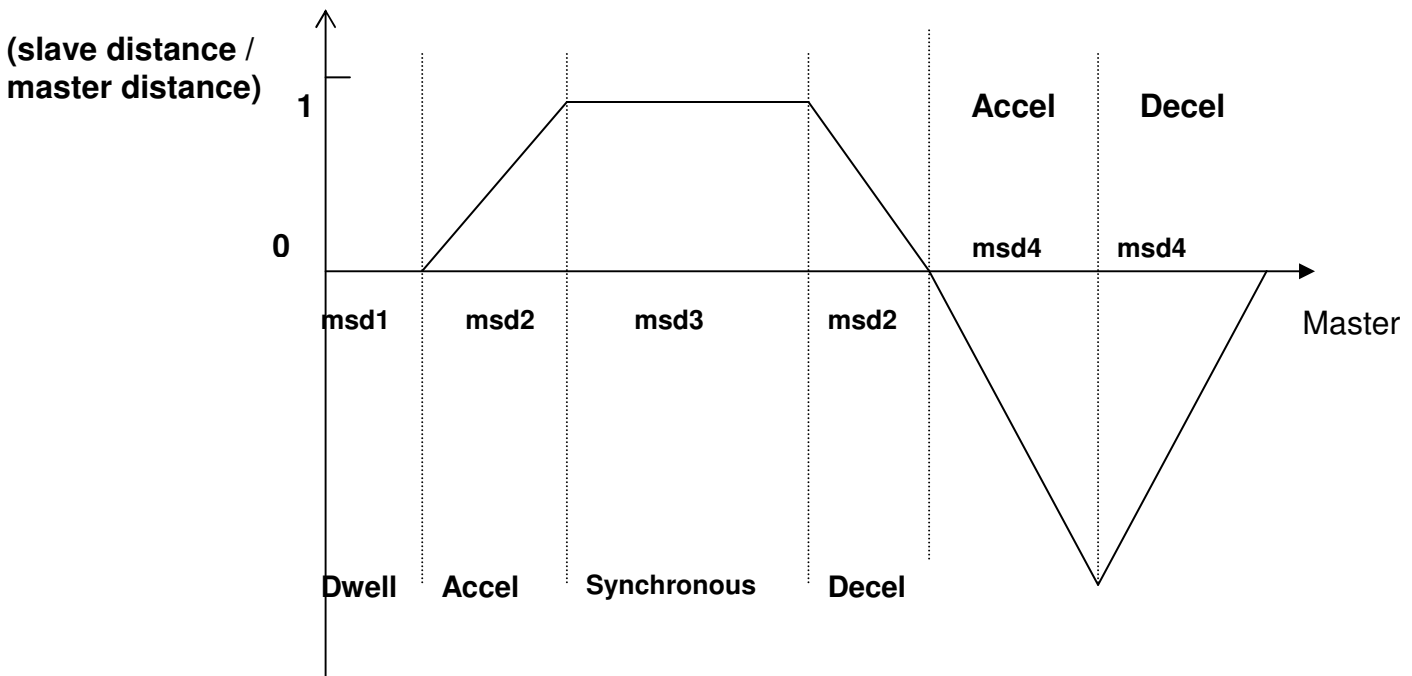
The motion controller (in the illustration above we have shown an integrated motion controller and servo drive – MintDrive^{II}) monitors the master encoder (wired to the auxiliary encoder input) and uses it to determine when the shear should begin its motion.

The shear is accelerated to a speed that exactly matches the material speed and a cut is initiated (in this example by activating a solenoid for a fixed duration to actuate a blade). This all takes place over a defined distance traveled by the material (master distance **msd**). Once the cut has taken place the shear is decelerated to a stop and then returned to its start position. Again these actions take place over a specified material travel or master distance.

The total distance traveled by the material for during this whole process is fixed and corresponds to the shortest possible cut length. One commonly used method for varying (increasing) the cut length is to add a dwell to the beginning of the process (during which time the shear remains stationary whilst more material passes through the machine).

The figure below illustrates the relationship between the speed ratio of the two axes and the distance traveled by the material referred to as master distance or **msd**):

Speed Ratio



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Each element of this profile can be split into what are termed 'segments' (this has also been illustrated on the figure above). For each segment the area under the curve corresponds to the distance traveled by the shear (slave) axis. In MintMT programs this distance/area can be specified using the **FLY** keyword.

The distance traveled by the material for each segment can be specified in MintMT by using the **MASTERDISTANCE** keyword.

If we examine a particular segment we can see that the segment area can be derived from:

$$\text{Area} = \text{Master Distance} * (\text{Initial Speed Ratio} + \text{Final Speed Ratio}) / 2$$

or put another way:

$$\text{FLY} = \text{MASTERDISTANCE} * (\text{Initial Speed Ratio} + \text{Final Speed Ratio}) / 2$$

This generic formula can be used to calculate FLY if only MASTERDISTANCE is known and vice-versa.

To return the shear axis to the start position the sum of the two return areas must equal exactly the distance traveled in the forward direction. It can be seen that each segment is half the total distance traveled in the forward direction (for a triangular return profile).

By selecting appropriate values for **MASTERDISTANCE** (e.g. to ensure the total distance traveled by the shear in one direction does not exceed the physical limitations of the axis) the whole motion profile for the application can be written with just a few lines of MintMT code.

Problems can arise if the synchronous speed segment results in a fractional value (at an encoder count level) for either **MASTERDISTANCE** or **FLY**. This can be overcome by splitting the synchronous section in half (this technique, in combination with the move buffer, also conveniently allows us to detect when the axis is traveling at synchronous speed and hence when best to trigger the cut).

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`Allow 3 moves to be loaded into the move buffer

MOVEBUFFERSIZE(0) = 3

Loop

` Calculate dwell distance (msd1) and wait

msd1 = ProductLength - (2 * msd2) + msd3 + (2 * msd4)

MASTERDISTANCE(0) = msd1

FLY(0) = 0 : GO.0

` Ramp from zero speed to 1:1 ratio

MASTERDISTANCE(0) = msd2

FLY(0) = msd2 / 2 : GO(0)

` Run at synchronous speed

MASTERDISTANCE(0) = msd3/2

FLY(0) = msd3/2 : GO(0)

MASTERDISTANCE(0) = msd3/2

FLY(0) = msd3/2 : GO(0)

` There will be two free spaces in the move buffer as the

` second half of the synchronous section starts

Pause MoveBufferFree(0) = 2

` Trigger the cut now...

Outx(0) = 1:Wait = 50:Outx(0) = 0

` Decelerate to zero speed

MASTERDISTANCE(0) = msd2

FLY(0) = msd2 / 2 : GO(0)

` Return segment 1

MASTERDISTANCE(0) = msd4

FLY(0) = -(msd2 + msd3) / 2 : GO(0)

` Return segment 2

MASTERDISTANCE(0) = msd4

FLY(0) = -(msd2 + msd3) / 2 : GO(0)

End Loop

The Fly keyword is one of the most powerful commands available in the MintMT programming language and it can be used in a wide variety of applications. Some of these include:

- Label feeders
- Replacement of mechanical clutches (with the added advantage of precision and repeatability)
- Press feeders (where the Press is the master axis)
- Replacing indexing gearboxes (packaging and food processing applications)

Look out for additional application notes in the MintMT series where we will discuss further uses for the Fly keyword.