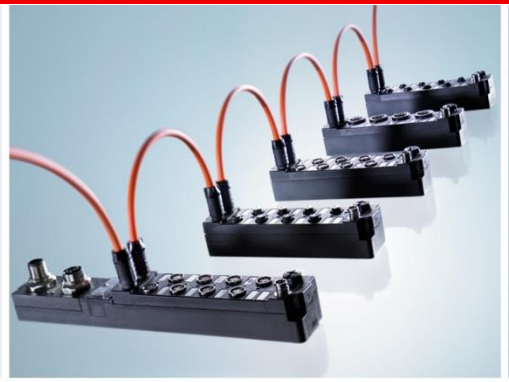
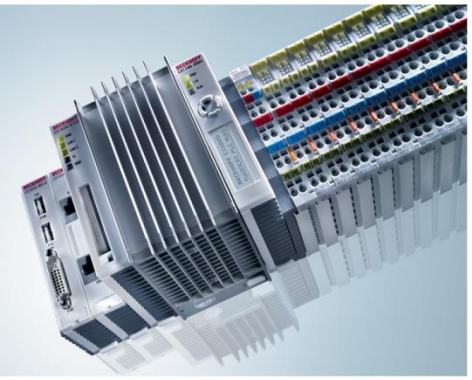
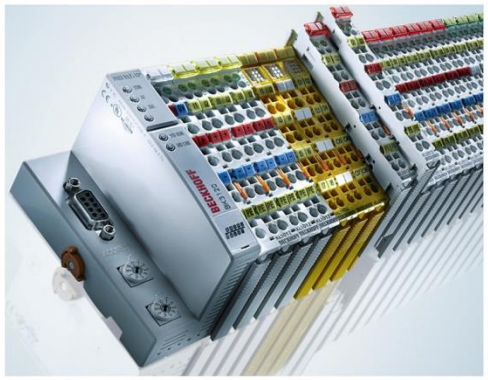
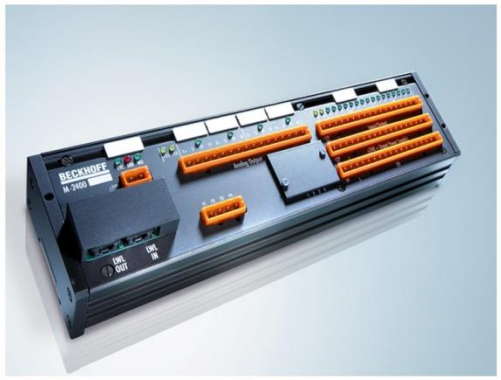
基于PLC OPEN的运动控制指令

I/O









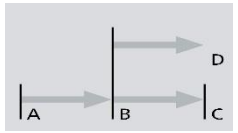
Automation

Motion

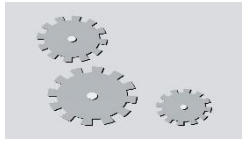
IPC

TwinCAT NC PTP 功能

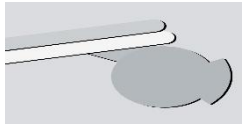
普通定位运动(Point to Point)



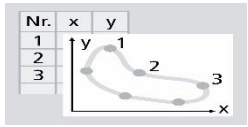
电子齿轮同步



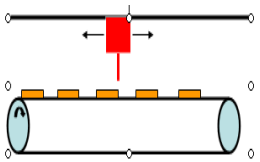
数字凸轮开关



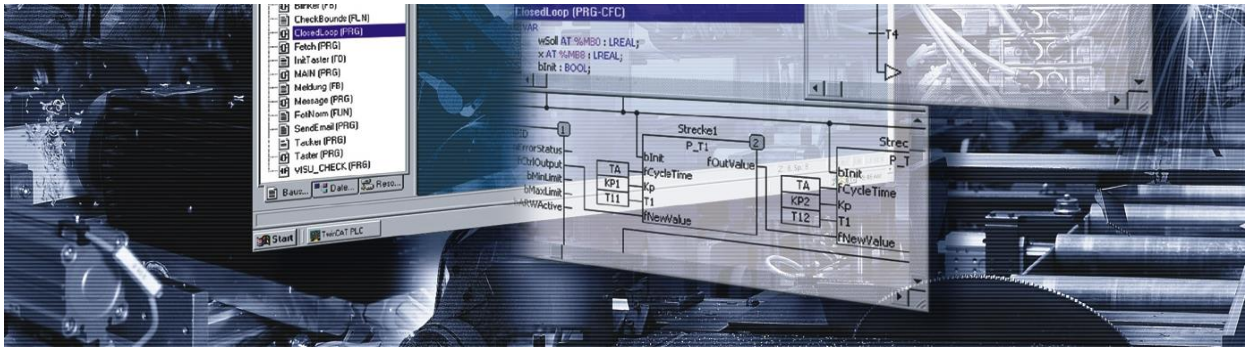
凸轮轴



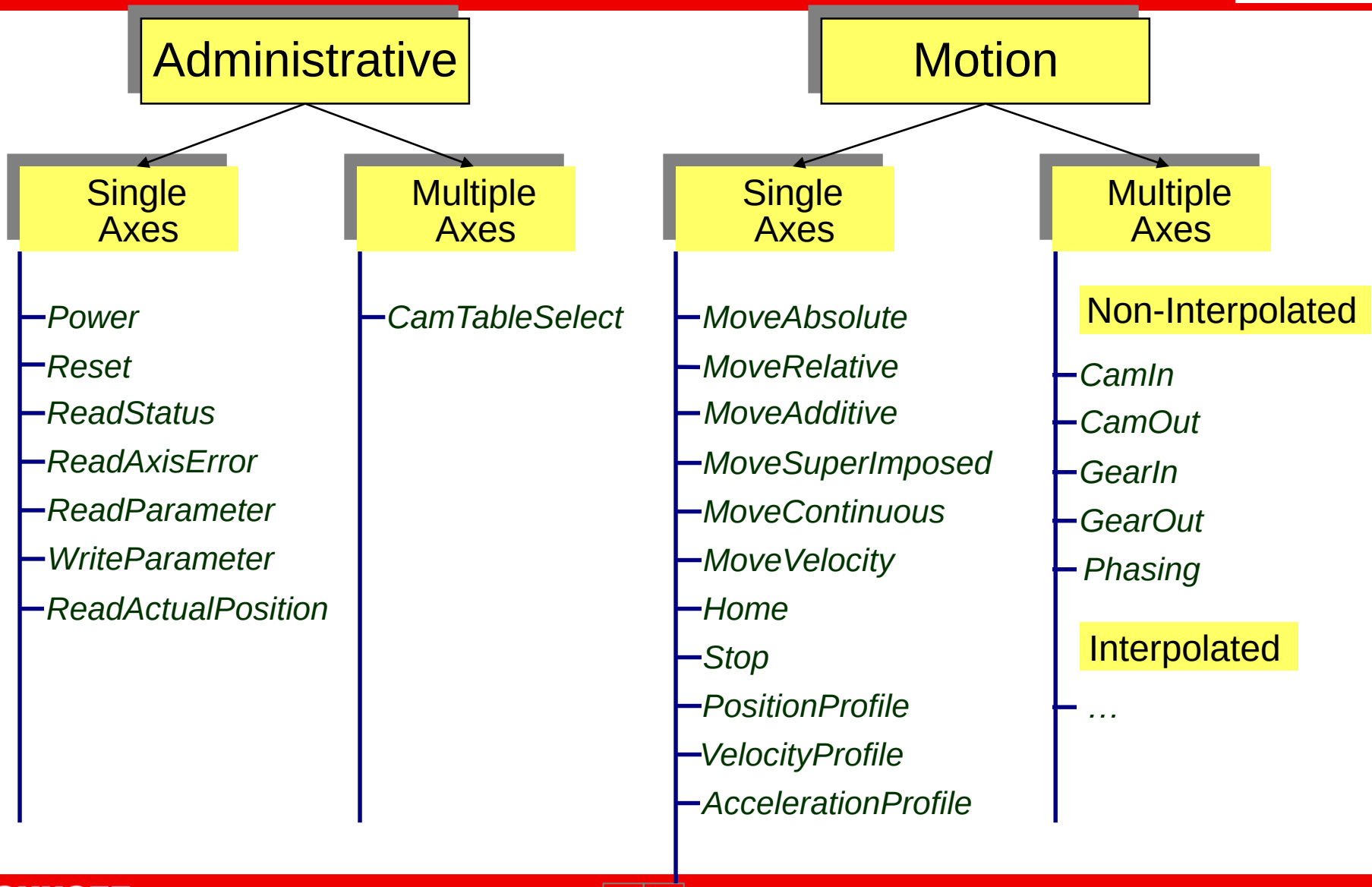
运动叠加（合成）



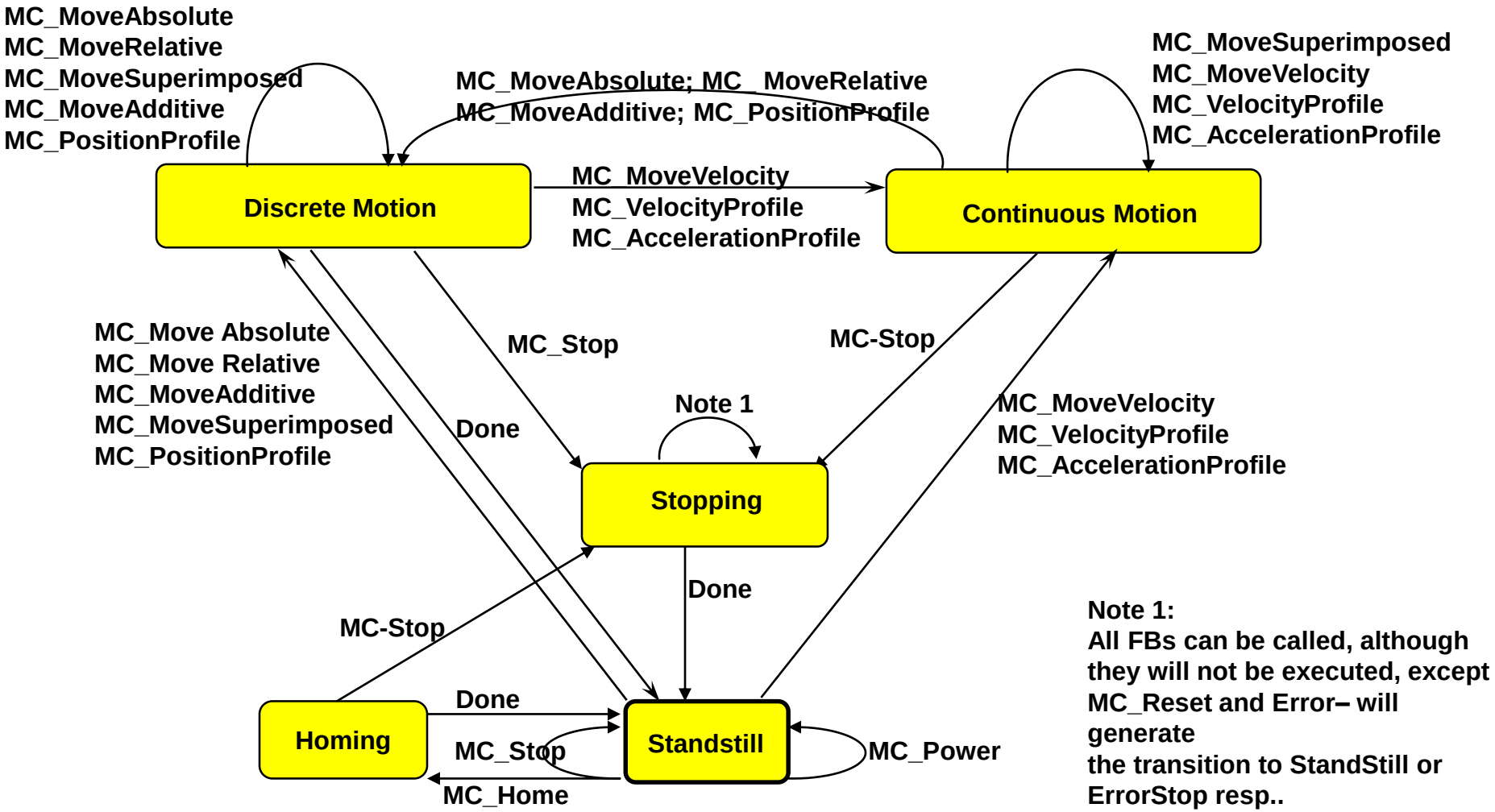
飞剪



TwinCAT NC PTP--PLCopen 功能块概览

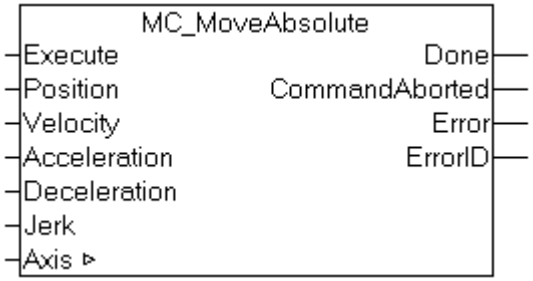


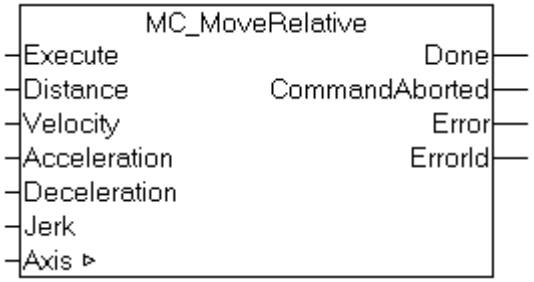
TwinCAT NC PTP- --PLCopen 功能块概览



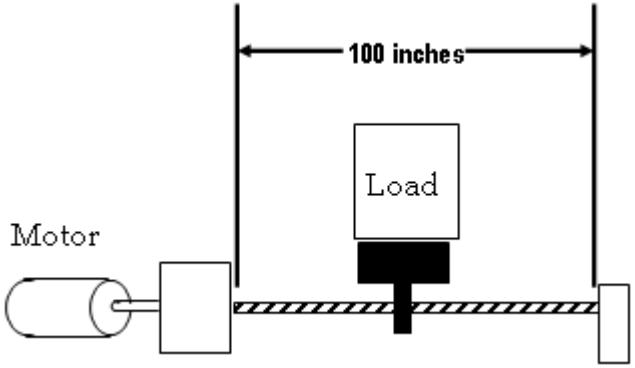
- Root: Task Force Motion Control presentation Version Febr2002. (www.plcopen.org)

TwinCAT NC PTP- --点到点运动

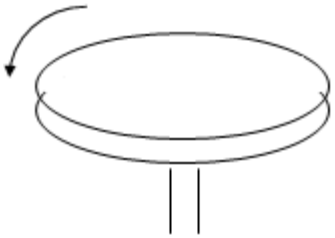




直线运动方式



旋转运动方式



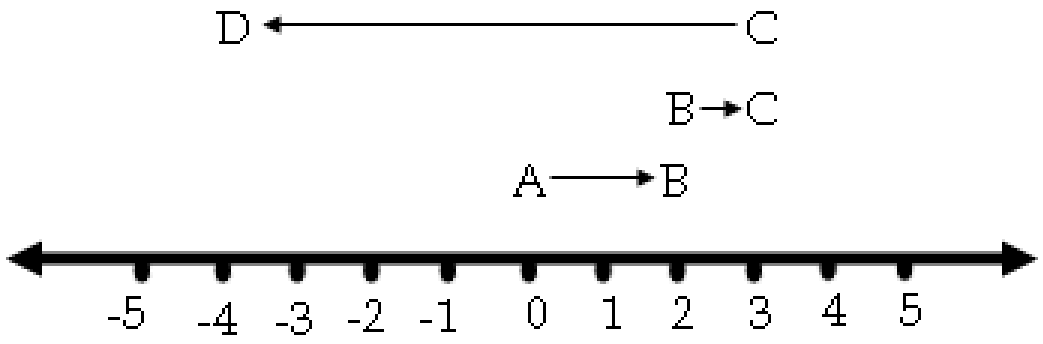
伺服点到点的定位指令分为两类：

- 绝对值定位
- 相对指定位

绝对值定位：执行机构移动到设定的坐标位置,实现绝对值定位。

相对值定位：执行机构移动设定的位置值,是一种增量的定位方式.

TwinCAT NC PTP- --点到点运动



绝对值运行:

A 到 B: 2

B 到 C: 3

C 到 D: -4

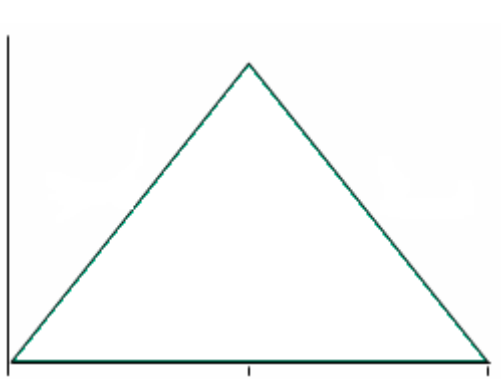
相对值运行:

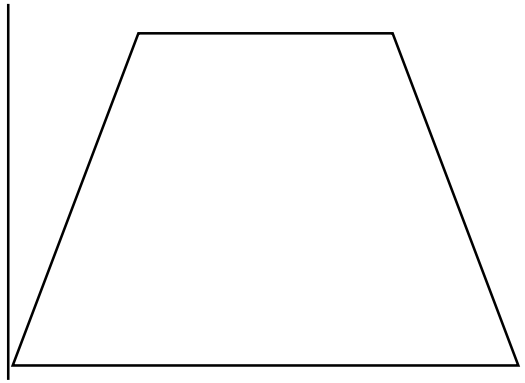
A 到 B: +2

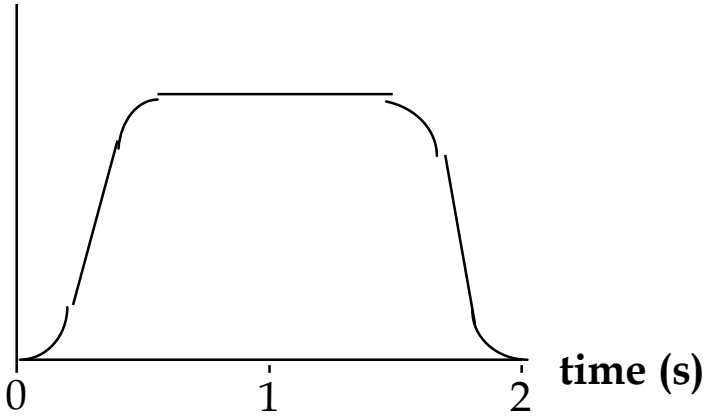
B 到 C: +1

C 到 D: -7

TwinCAT NC PTP- --点到点运动







点到点定位的速度曲线类型

- 梯形曲线,三角波曲线

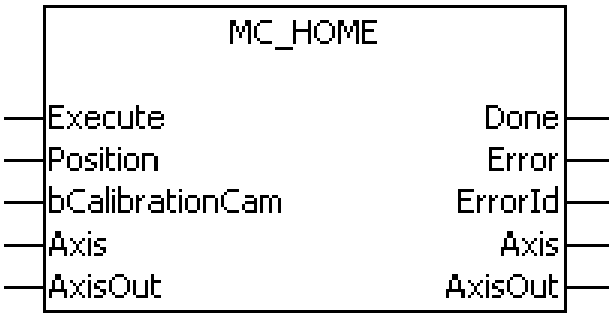
该曲线类型能够以最快的时间达到工艺所要求的速度,并走完定位.

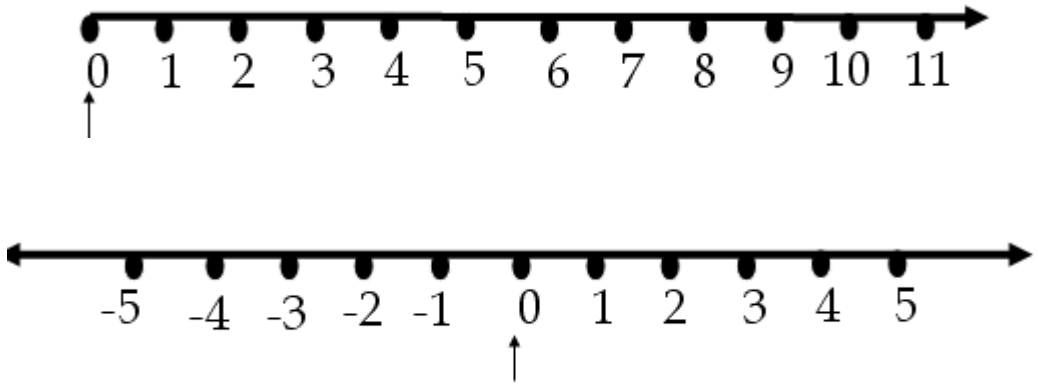
- S形曲线

该曲线类型能够减少执行元件对机械的冲击,即jerk值.

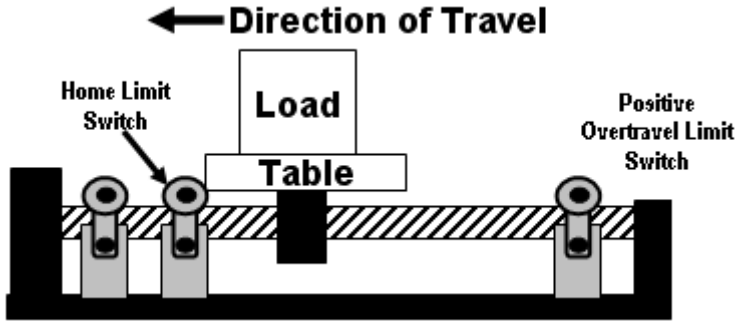
S曲线的柔滑度是可以修改的,用来调节点到点的运行时间和抗冲击性之间的平衡.

TwinCAT NC PTP- --回原点运动



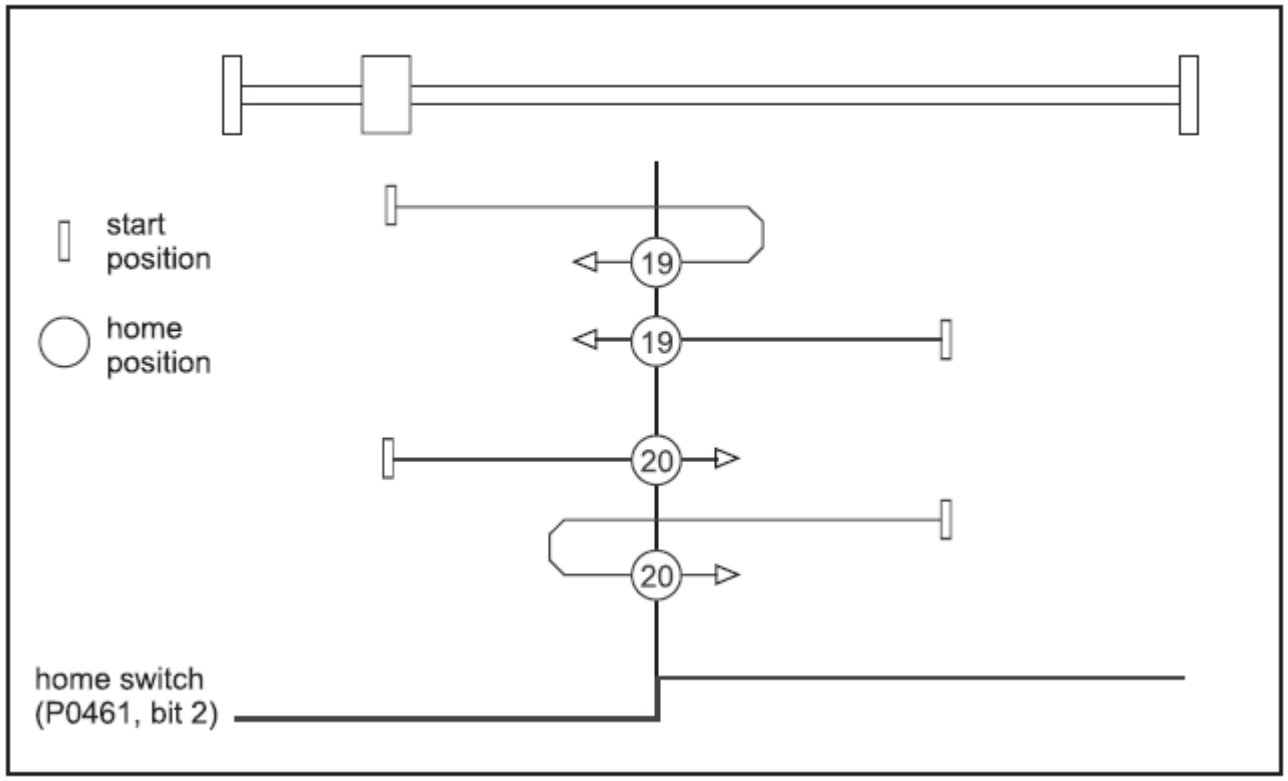


一些运动机构常常要用到回原点的方式.原因是一些机构必须要找到一个基准点,从基准点开始走绝对值运动或相对值运动.这个基准点就是原点.

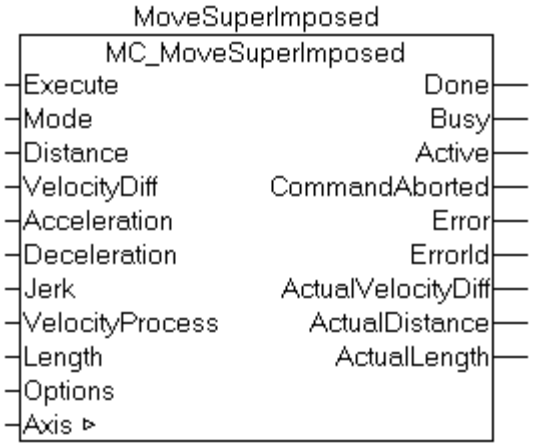


回原点的方式很多,可以根据工艺的需求进行选择.

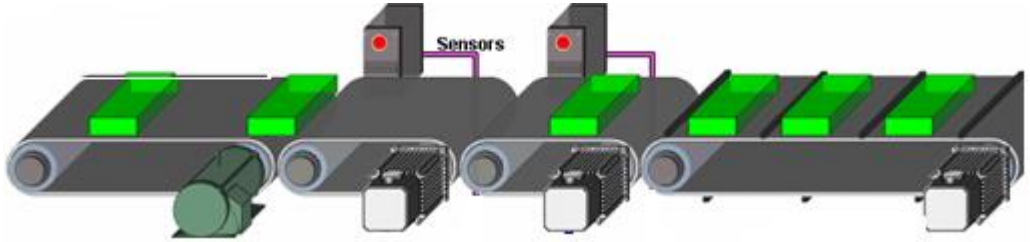
TwinCAT NC PTP- --回原点运动



TwinCAT NC PTP- --点到点叠加运动




```
TYPE E_SuperpositionMode :
(
    SUPERPOSITIONMODE_VELOREDUCTION_ADDITIVEMOTION := 1,
    SUPERPOSITIONMODE_VELOREDUCTION_LIMITEDMOTION,
    SUPERPOSITIONMODE_LENGTHREDUCTION_ADDITIVEMOTION,
    SUPERPOSITIONMODE_LENGTHREDUCTION_LIMITEDMOTION
);
END_TYPE
```



叠加运动指令

该指令主要用于伺服轴运动过程中进行一个点到点位置的叠加.

该指令运行模式E_SuperpositionMode有4种类型:

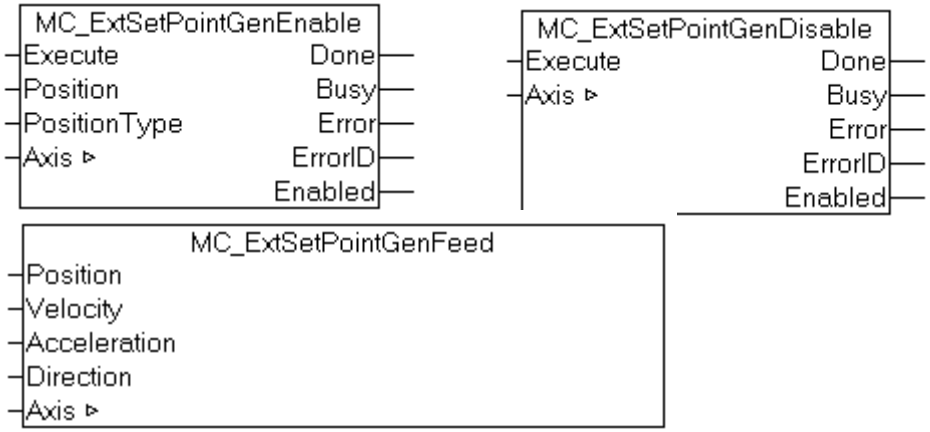
1.叠加区域内,走完长度Length后,叠加位置Distance刚好走完.区域行程为Length+ Distance.

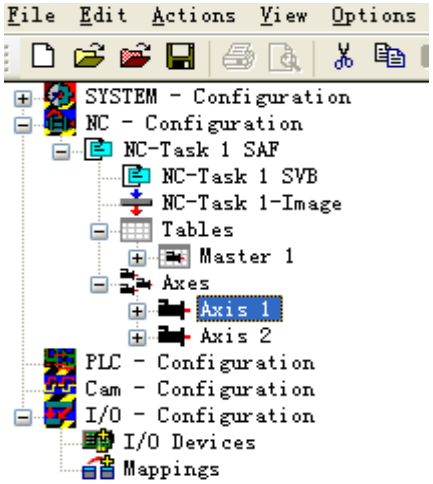
2.叠加区域内,走完长度Length后,叠加位置Distance刚好走完,包含在Length内.区域行程为Length.

3.叠加区域内,在区域行程Length+ Distance内,走完叠加位置Distance.

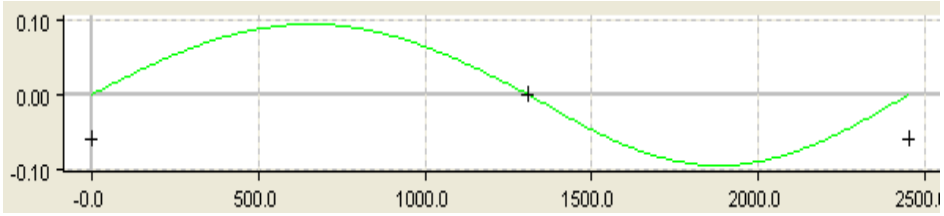
3.叠加区域内,在区域行程Length,走完叠加位置Distance.

TwinCAT NC PTP- --多个曲线的叠加运动

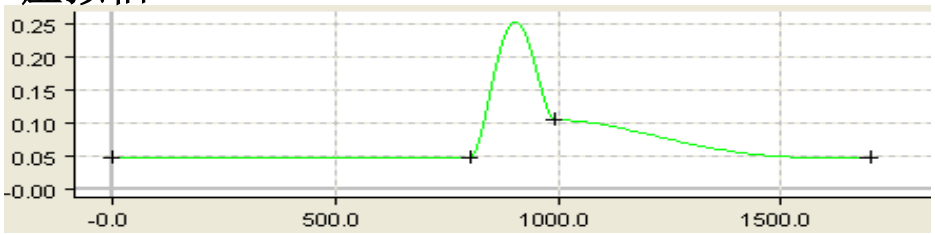




电机轴



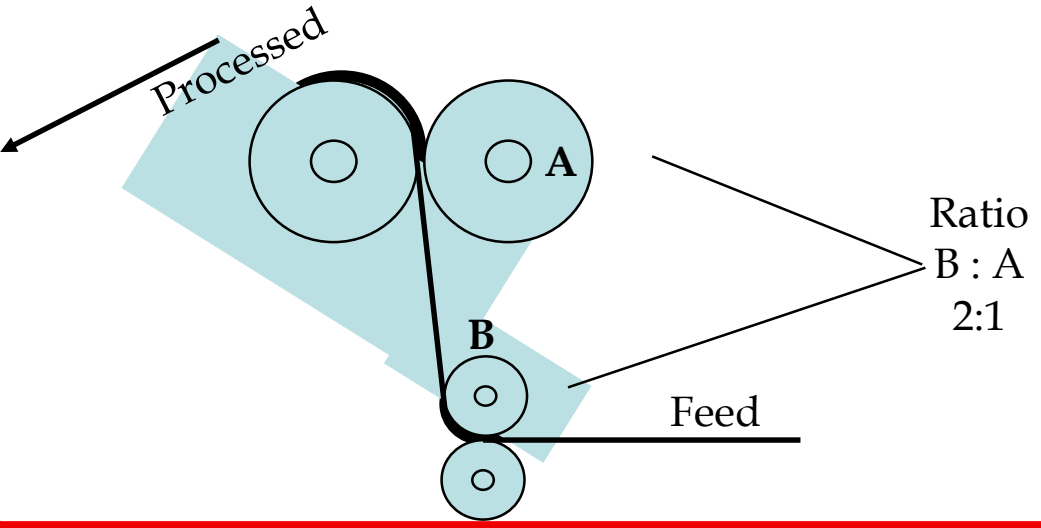
虚拟轴

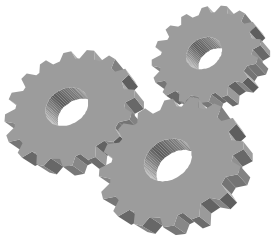


- 该系统指令的组合,可达到曲线叠加的效果.
- 在**system manager**中配一个电机轴,和一个虚拟轴.通过指令可以将右图的两条曲线叠加到一起,大大提高了电子凸轮控制的灵活性.
- 同样你仍然可以将多个虚拟轴和一个电机轴叠加在一起,实现两个以上曲线的叠加。

TwinCAT NC PTP- --电子齿轮同步

- 线性同步　耦合之后:
- 从轴 **set position = coupling factor*主轴 set position**
- 使用标准的功能块，简单方便
- **MC_GearInDyn是MC_GearIn的升级版,可以动态的修改电子齿轮比.**
- 电子齿轮是从机械齿轮转换过来的思路,而且更加灵活,电子齿轮是一种特殊的电子凸轮.





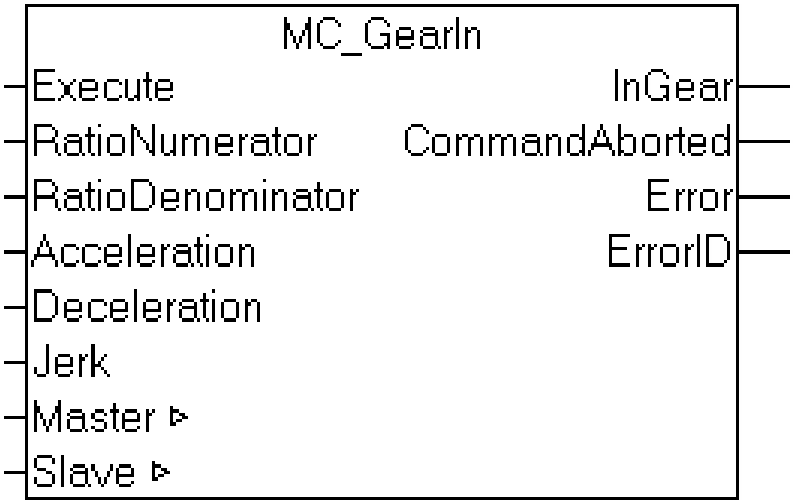
MC_GearIn

Execute	InGear
RatioNumerator	Busy
RatioDenominator	Active
Acceleration	CommandAborted
Deceleration	Error
Jerk	ErrorID
BufferMode	
Options	
Master ▷	
Slave ▷	

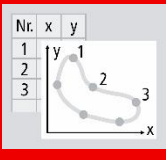
MC_GearInDyn

Execute	InGear
GearRatio	Busy
Acceleration	CommandAborted
Deceleration	Error
Jerk	ErrorID
Master ▷	
SlaveRefIn ▷	
SlaveRefOut ▷	

TwinCAT电子齿轮同步—龙门钻床

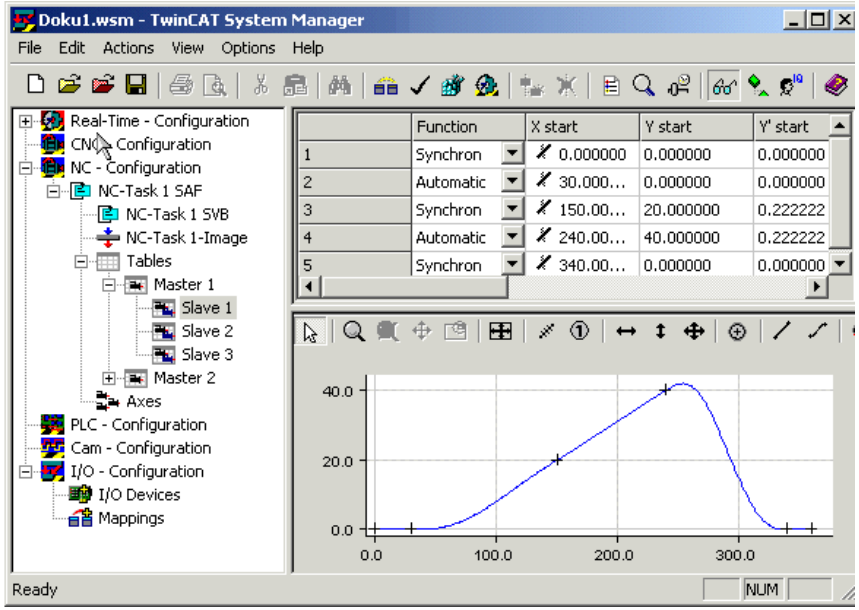


TwinCAT NC PTP—电子凸轮指令

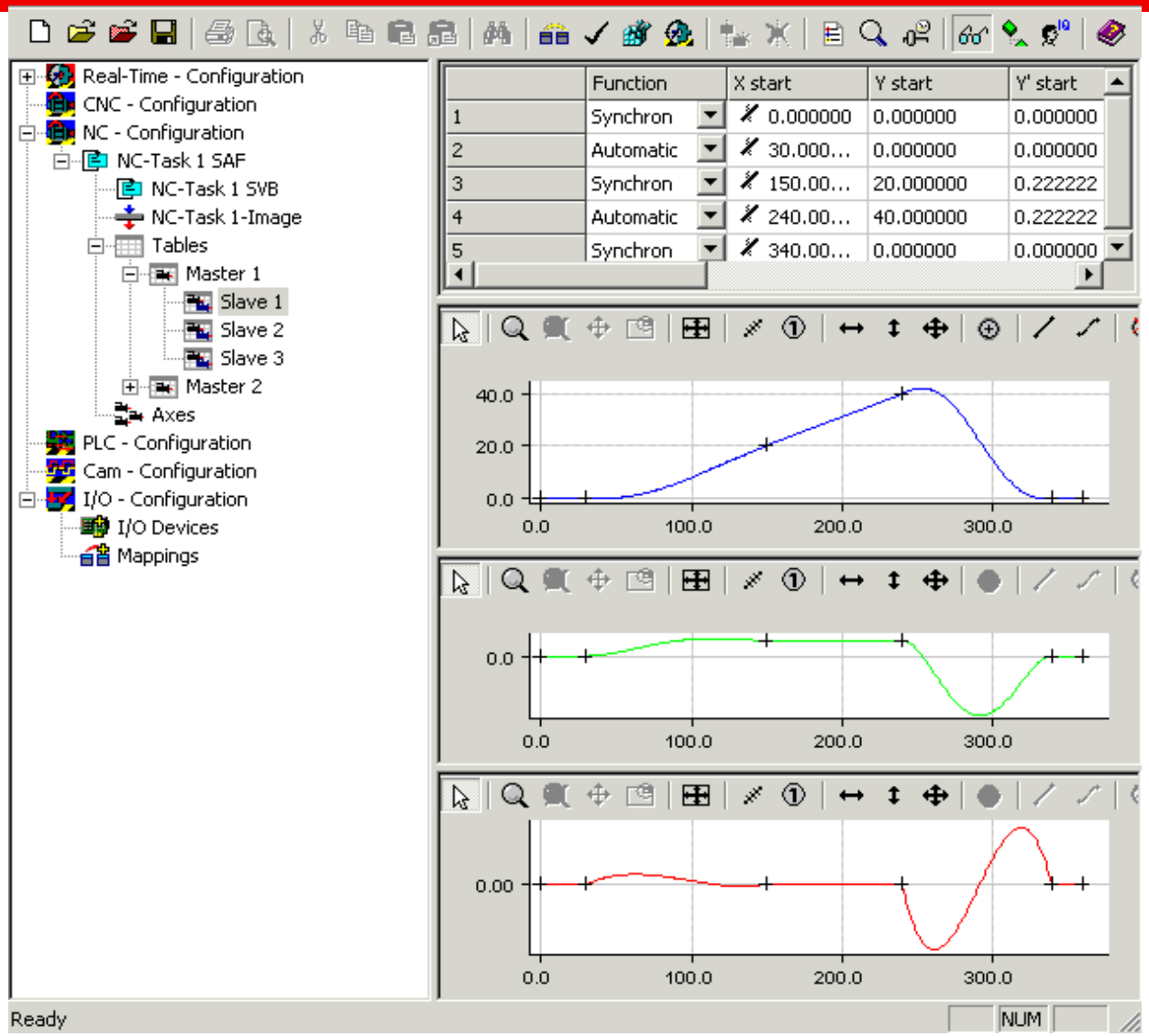


Camming

- 主从轴之间非线性耦合
- 凸轮设计遵循 **VDI guideline 2143**
- 凸轮设计工具 **TwinCAT cam design editor**



TwinCAT NC PTP—电子凸轮指令

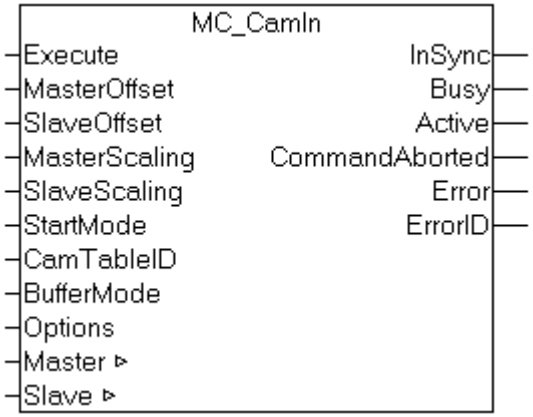


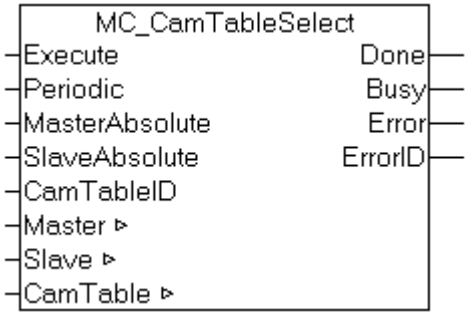
Position

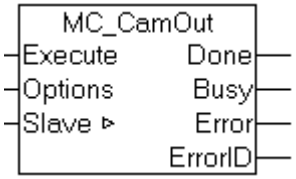
Velocity

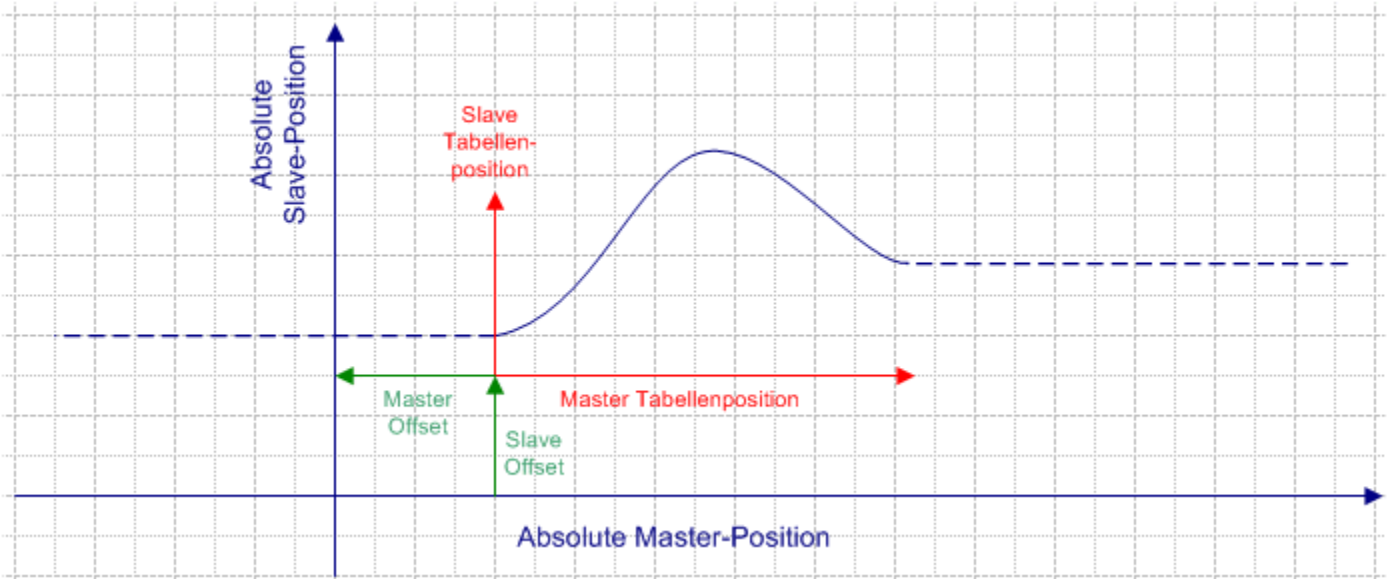
Acceleration

TwinCAT NC PTP—电子凸轮指令



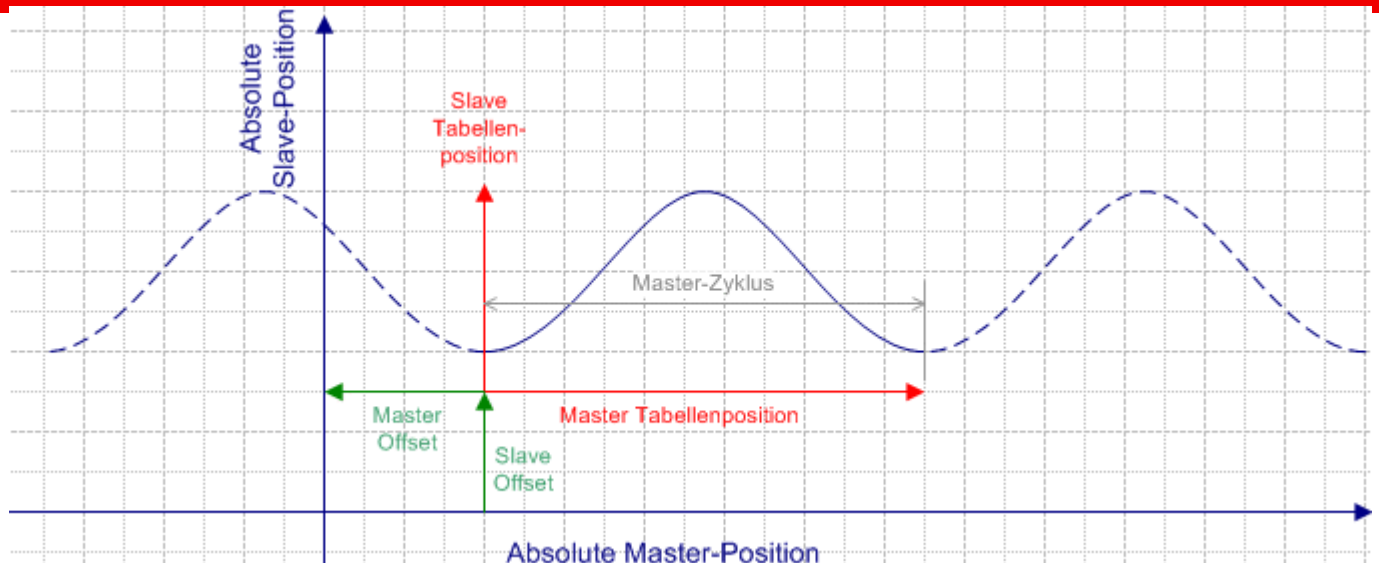




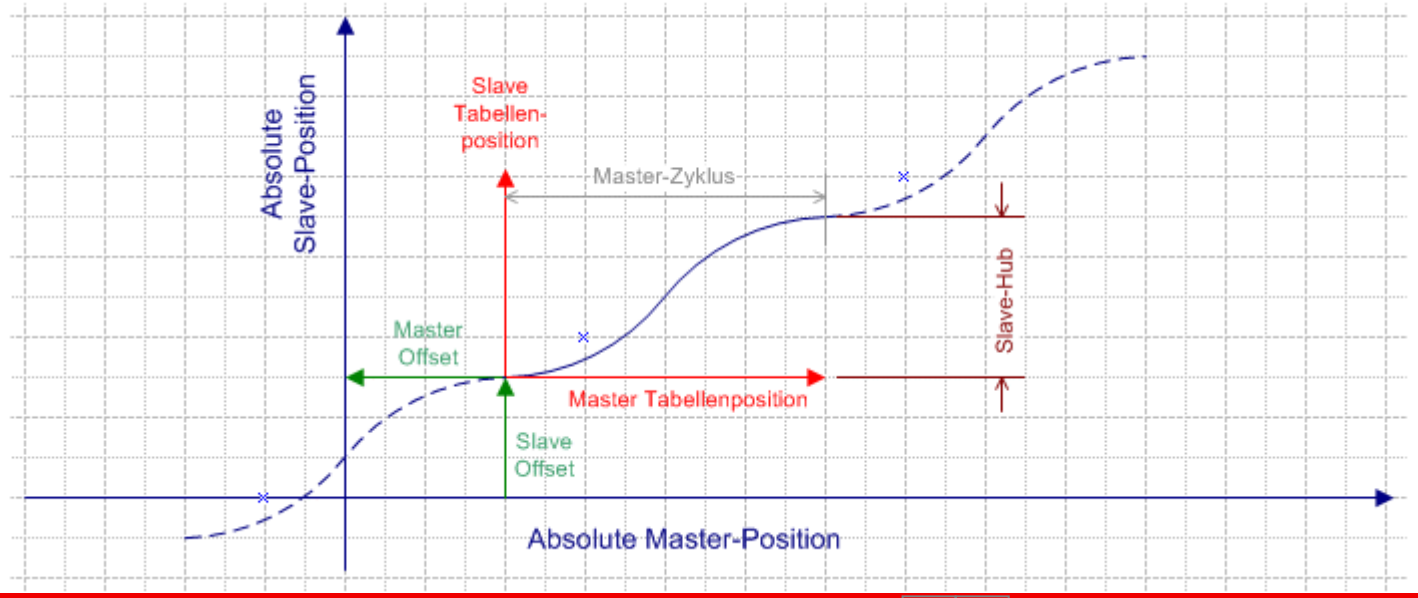


该类凸轮曲线类型完成一个周期.

TwinCAT NC PTP—电子凸轮指令



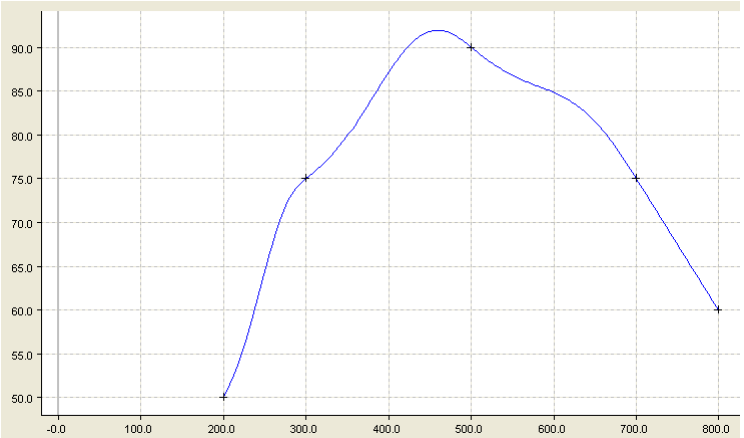
该类凸轮曲线类型是循环型的.
主轴和从轴都为绝对值坐标类型.

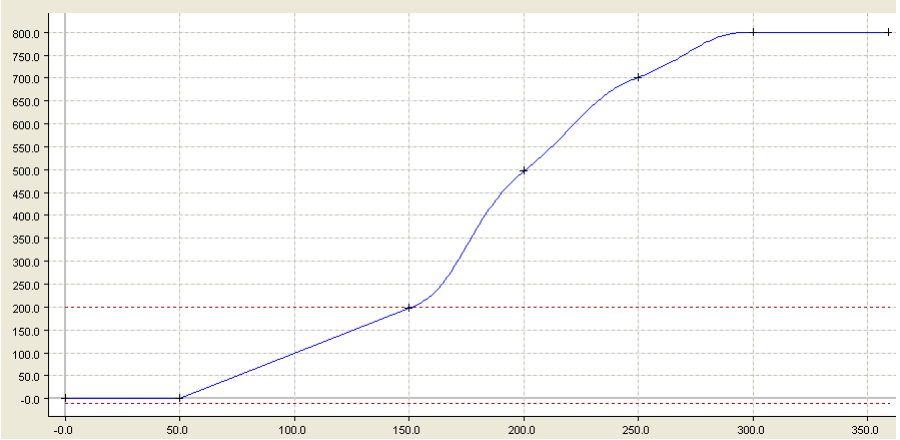


该类凸轮曲线类型是循环型的.
主轴为绝对值坐标类型,从轴回相对值坐标类型.

TwinCAT NC PTP—电子凸轮指令

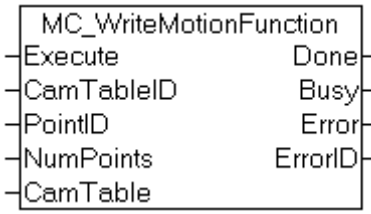
应用案例:膜包机,卸箱机





TwinCAT NC PTP-—WriteFunction

```
TYPE MC_CAM_REF :
STRUCT
        pArray          : UDINT;
        ArraySize       : UDINT;
        TableType       : MC_TableType
        NoOfRows        : UDINT;
        NoOfColumns     : UDINT;
END_STRUCT
END_TYPE
```




```
FOR i:=1 TO 4096 DO
MotionFunctionRead[i].PointIndex:=i;
MotionFunctionRead[i].MasterPos := i-1;
MotionFunctionRead[i].SlavePos := i-1;
MotionFunctionRead[i].PointType:=MOTIONPOINTTYPE_ACTIVATION;
MotionFunctionRead[i].FunctionType := MOTIONFUNCTYPE_POLYNOM1;
END_FOR
```

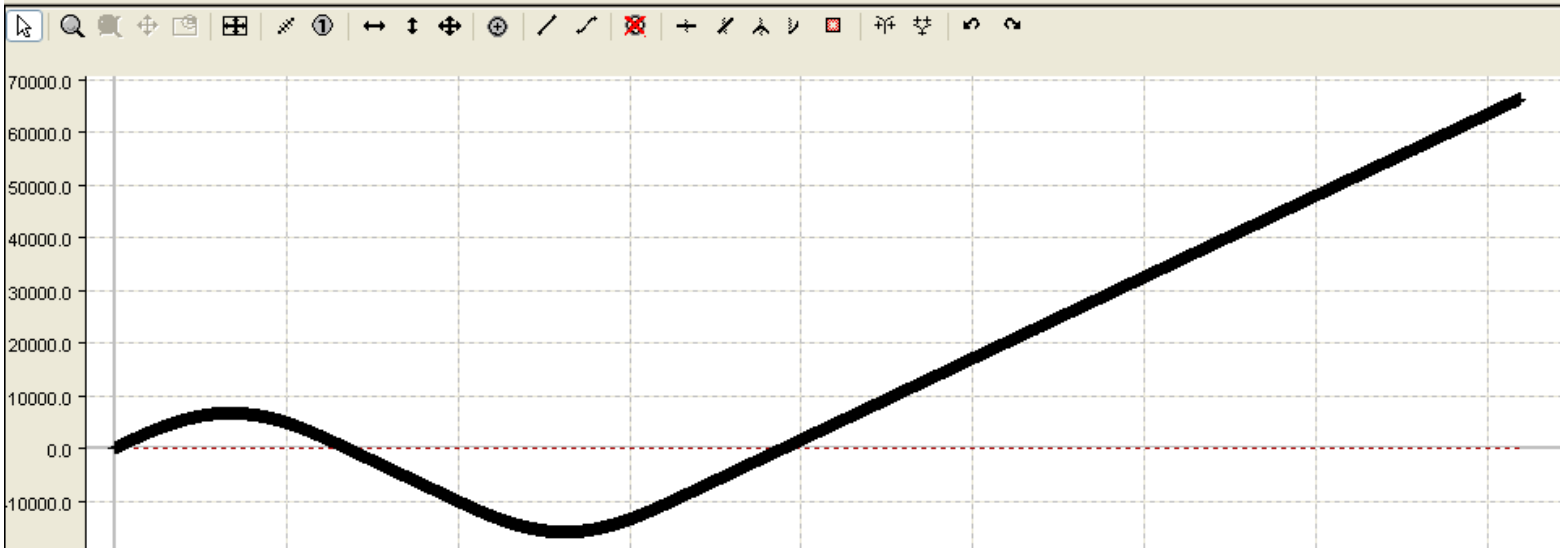
建立凸轮数据表的数组,该数组内数据的数量根据客户工艺曲线的需要.如**512,1024,4096**个.
通过自己进行数学建模,通过分段函数的方式,实现各类复杂曲线.本质上复杂的工艺曲线如旋切,追剪以及各类特殊工艺曲线都是由这种方法实现的.
将分段函数通过离散的方法赋值给如上所述的**512,1024**或**4096**点.
该类凸轮曲线的优点是:非常灵活,可以满足一切工艺曲线的需求.
缺点:要求客户有很强的数学建模能力,对高次函数和微积分有一定的造诣.

Example 1: Position table structure description

pArray	Address of a two-dimensional array. The first column contains an ascending list of master positions. The second column contains the associated slave positions. The address can be assigned with the ADR function. Example: Table1 : ARRAY[0..360, 0..1] OF LREAL; pArray := ADR(Table1);
ArraySize	Storage capacity of the two-dimensional array, which can be determined with the SIZEOF function. Example: ArraySize := SIZEOF(Table1);
TableType	The table type is TABULARTYPE_EQUIDIST, if the master positions have the same distance, or TABULARTYPE_NONEQUIDIST it the distance is variable.
NoOfRows	The number or rows corresponds to the number of table points.
NoOfColumns	The number of columns is 2.

TwinCAT NC PTP-—WriteFunction

1	Spline Natural	0.000000	0.000000	30.85...	0.000264	0.000000	1.000000	30.85...	30.85...	-0.00...	0.000000	0.500000
2	Spline	1.000000	30.85...	30.85...	-0.00...	0.000000	2.000000	61.71...	30.85...	-0.00...	0.000000	0.500000
3	Spline	2.000000	61.71...	30.85...	-0.00...	0.000000	3.000000	92.56...	30.85...	-0.00...	0.000000	0.500000
4	Spline	3.000000	92.56...	30.85...	-0.00...	0.000000	4.000000	123.4...	30.85...	-0.00...	0.000000	0.500000
5	Spline	4.000000	123.4...	30.85...	-0.00...	0.000000	5.000000	154.2...	30.84...	-0.00...	0.000000	0.500000
6	Spline	5.000000	154.2...	30.84...	-0.00...	0.000000	6.000000	185.1...	30.84...	-0.00...	0.000000	0.500000
7	Spline	6.000000	185.1...	30.84...	-0.00...	0.000000	7.000000	215.9...	30.84...	-0.00...	0.000000	0.500000
8	Spline	7.000000	215.9...	30.84...	-0.00...	0.000000	8.000000	246.7...	30.83...	-0.00...	0.000000	0.500000
9	Spline	8.000000	246.7...	30.83...	-0.00...	0.000000	9.000000	277.6...	30.82...	-0.00...	0.000000	0.500000
10	Spline	9.000000	277.6...	30.82...	-0.00...	0.000000	10.000000	308.4...	30.82...	-0.00...	0.000000	0.500000
11	Spline	10.000000	308.4...	30.82...	-0.00...	0.000000	11.000000	339.2...	30.81...	-0.00...	0.000000	0.500000
12	Spline	11.000000	339.2...	30.81...	-0.00...	0.000000	12.000000	370.0...	30.80...	-0.00...	0.000000	0.500000
13	Spline	12.000000	370.0...	30.80...	-0.00...	0.000000	13.000000	400.8...	30.80...	-0.00...	0.000000	0.500000
14	Spline	13.000000	400.8...	30.80...	-0.00...	0.000000	14.000000	431.6...	30.79...	-0.00...	0.000000	0.500000
15	Spline	14.000000	431.6...	30.79...	-0.00...	0.000000	15.000000	462.4...	30.78...	-0.01...	0.000000	0.500000
16	Spline	15.000000	462.4...	30.78...	-0.01...	0.000000	16.000000	493.2...	30.77...	-0.01...	0.000000	0.500000

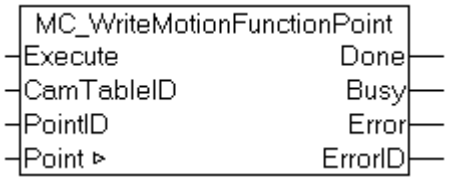


该凸轮表中定义了**4096**个点

该凸轮曲线是在程序中进行数学计算，然后生成到凸轮表中的

TwinCAT NC PTP-—WriteFunctionPoint

```
TYPE MC_CAM_REF :
STRUCT
        pArray          : UDINT;
        ArraySize       : UDINT;
        TableType       : MC_TableType;
        NoOfRows        : UDINT;
        NoOfColumns     : UDINT;
END_STRUCT
END_TYPE
```



适用于凸轮编辑表中若干点连接所组成的凸轮曲线.
该类凸轮曲线是通过凸轮表编辑所得到的.
使用该指令可以改变这类凸轮表中的任何点的位置,从而达到改变曲线的效果.

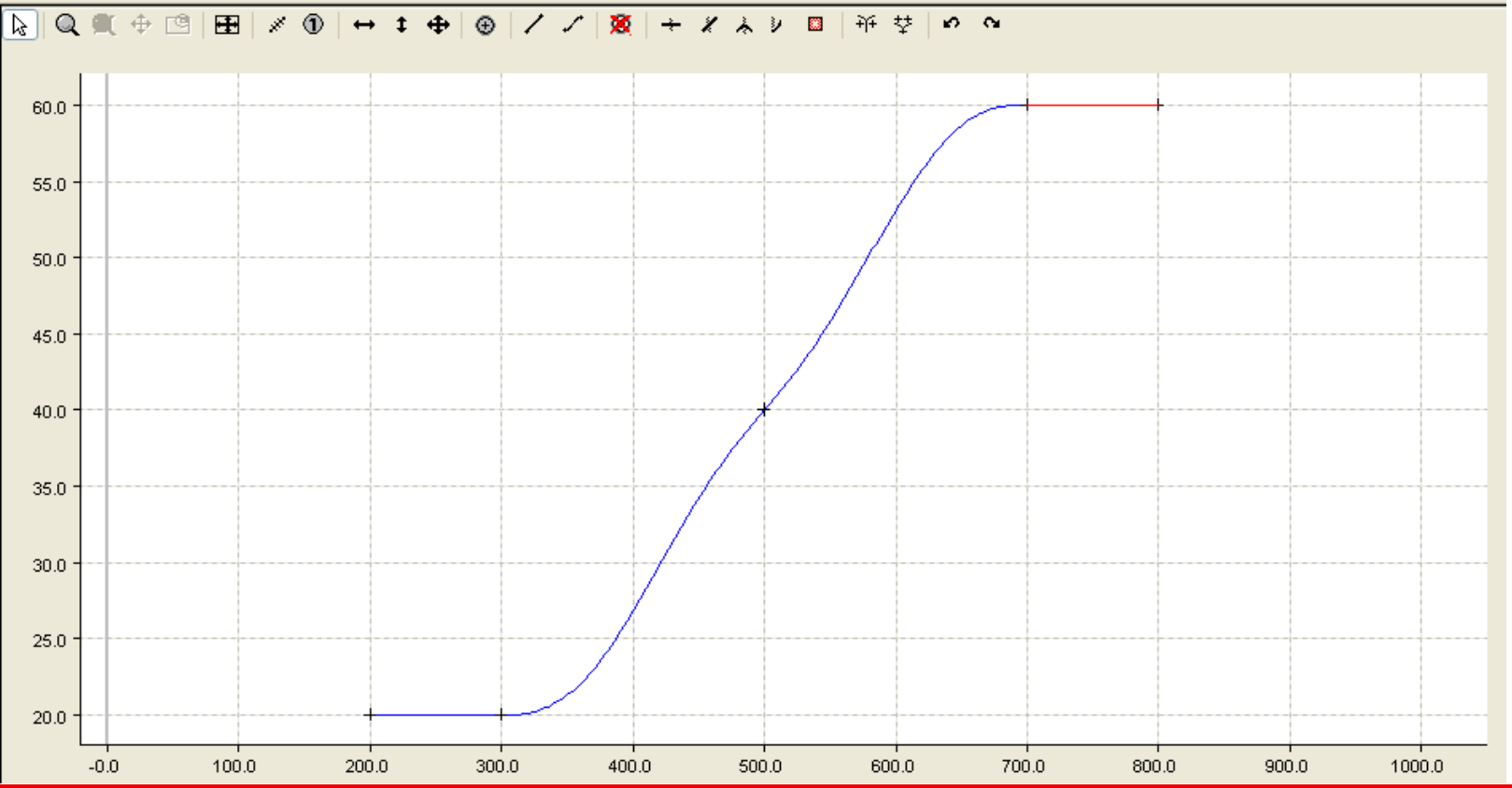
优点:该方法曲线的实现方法比较简单,不需要编程者有数学建模能力,在凸轮编辑中根据工艺描点即可
缺点:不能满足复杂工艺曲线的需求.

Example 2: Structure description of a motion function

pArray	Address of a one-dimensional array of type *MC_MotionFunctionPoint*. Each array element contains a description of a cam plate interpolation point. Example: MotionFunction : ARRAY[1..10] OF MC_MotionFunctionPoint; pArray := ADR(MotionFunction);
ArraySize	Storage capacity of the one-dimensional array, which can be determined with the SIZEOF function. Example: ArraySize := SIZEOF(MotionFunction);
TableType	The table type is TABULARTYPE_MOTIONFUNC.
NoOfRows	The number or rows corresponds to the number of table points.
NoOfColumns	The number of columns is 1.

TwinCAT NC PTP-—WriteFunctionPoint

	Function	X start	Y start	Y' start	Y'' s...	Y''' ...	X end	Y end	Y' end	Y'' end	Y''' end	Symmetry
1	Synchron	200.00...	20.00...	0.000000	0.000000	0.000000	300.00...	20.00...	0.000000	0.000000	0.000000	0.500000
2	Automatic	300.00...	20.00...	0.000000	0.000000	0.000000	500.00...	40.00...	0.100000	0.000000	0.000000	0.500000
3	Automatic	500.00...	40.00...	0.100000	0.000000	0.000000	700.00...	60.00...	0.000000	0.000000	0.000000	0.500000
4	Synchron	700.00...	60.00...	0.000000	0.000000	0.000000	800.00...	60.00...	0.000000	0.000000	0.000000	0.500000



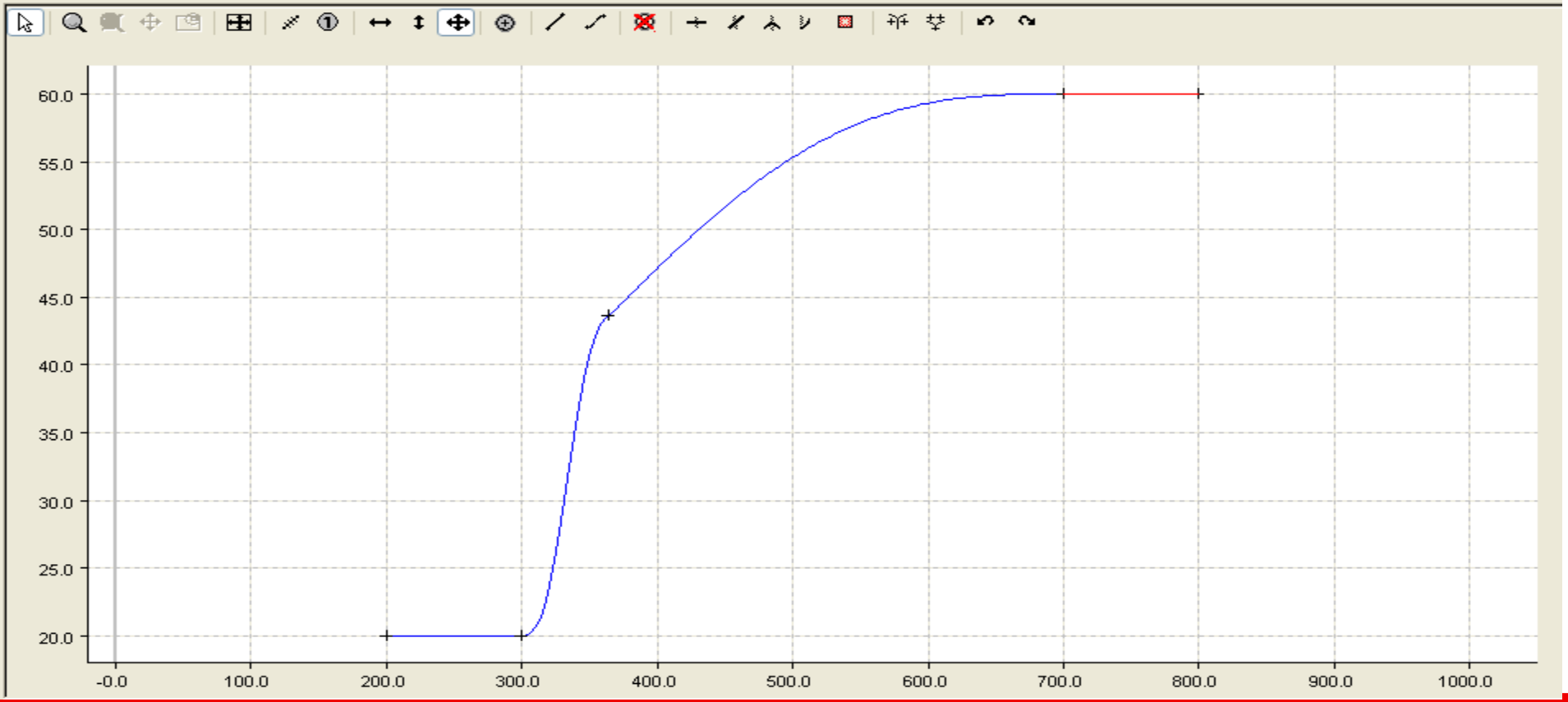
该凸轮表中定义了4个点

该凸轮曲线是通过凸轮工具描点法实现的,比较简单.

该凸轮表的每个位置点都可以在程序中修改其位置,以满足曲线的变化

TwinCAT NC PTP-—WriteFunctionPoint

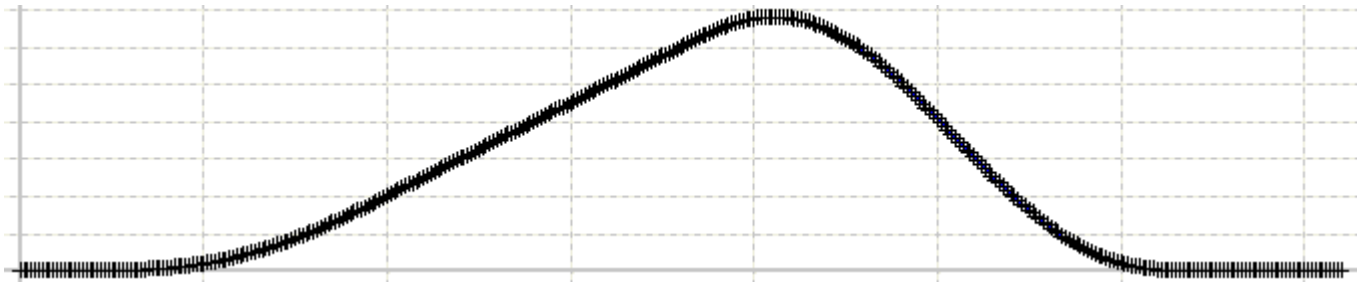
	Function	X start	Y start	Y' start	Y'' s...	Y''' ...	X end	Y end	Y' end	Y'' end	Y''' end	Symmetry
1	Synchron	200.00...	20.00...	0.000000	0.000000	0.000000	300.00...	20.00...	0.000000	0.000000	0.000000	0.500000
2	Automatic	300.00...	20.00...	0.000000	0.000000	0.000000	364.56...	43.70...	0.100000	0.000000	0.000000	0.500000
3	Automatic	364.56...	43.70...	0.100000	0.000000	0.000000	700.00...	60.00...	0.000000	0.000000	0.000000	0.500000
4	Synchron	700.00...	60.00...	0.000000	0.000000	0.000000	800.00...	60.00...	0.000000	0.000000	0.000000	0.500000



TwinCAT NC PTP—凸轮设计工具

数据表

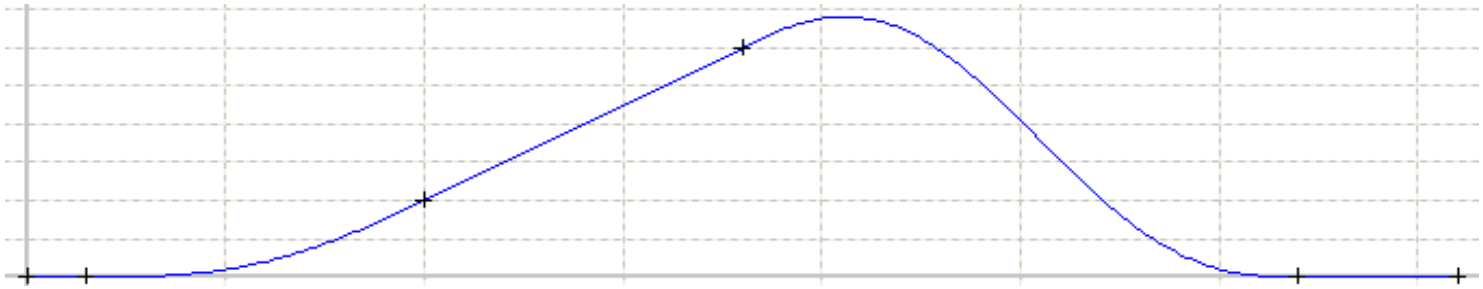
Positiontable



The position values of a slave depending on a master value are interpolated in the NC

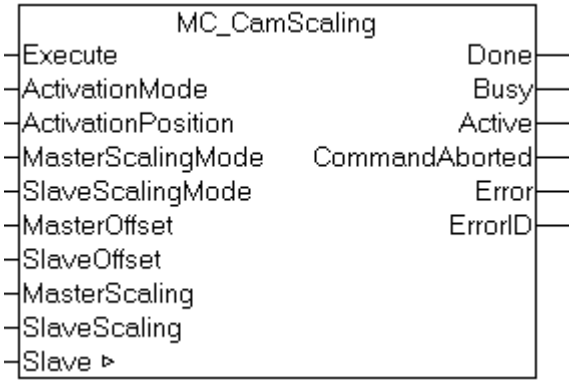
动态修改

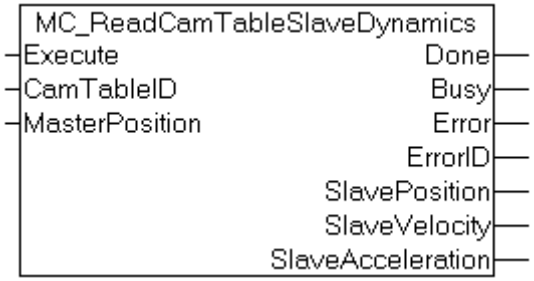
Motion Function



Only segment points needed. The intermediate points are calculated depending on the actual function in the NC

TwinCAT NC PTP—电子凸轮指令





- **MC_CamScaling的指令的功能**

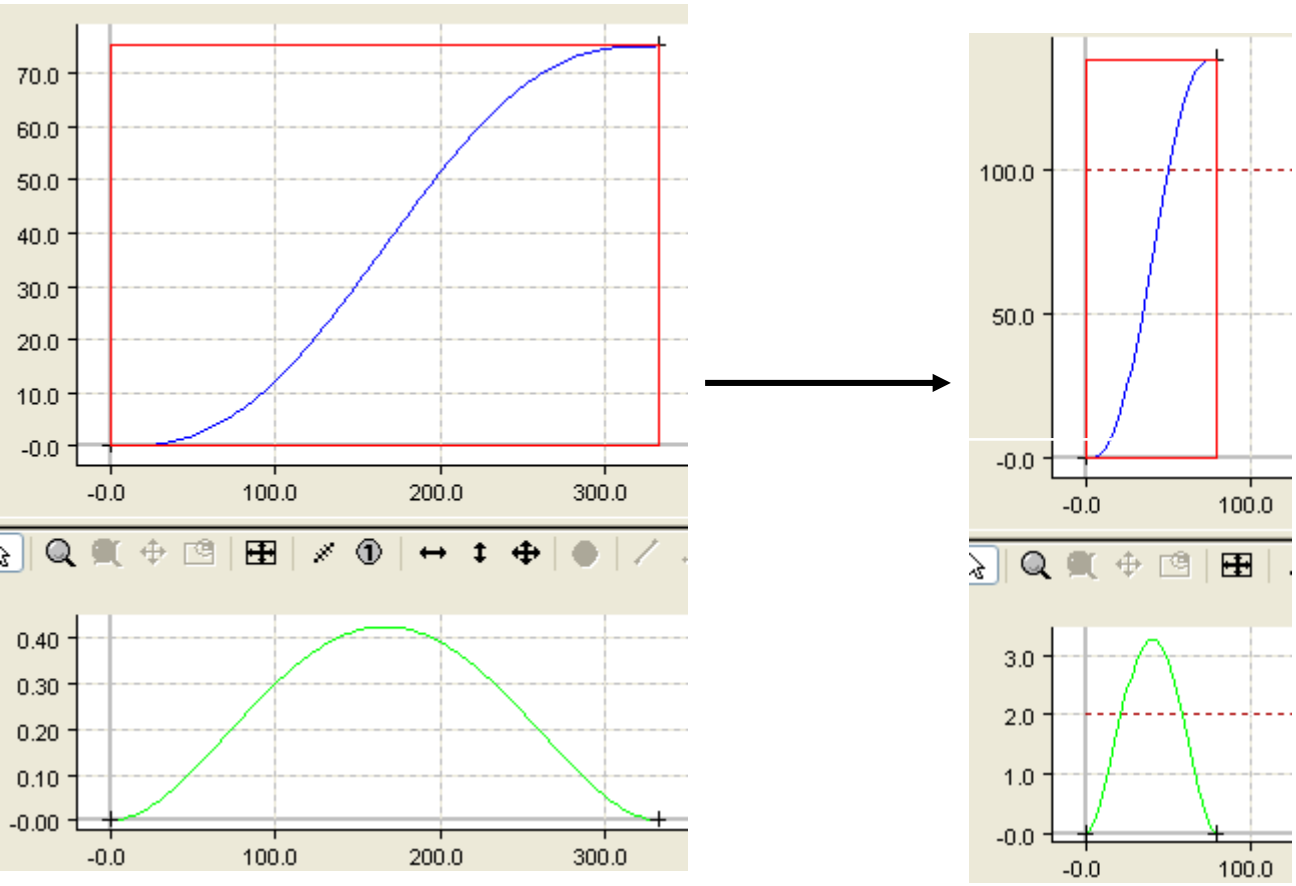
1.能够动态的拉伸或收缩X轴和Y轴大小.
2.能够灵活的修改X轴或Y轴的起始位置.
3.可以灵活的选择何时生效变化结果.

- **MC_ReadCamTableSlaveDynamics.**

1.通过输入主轴位置,计算出相应Cam Table表的从轴位置.
2.由以上得到从轴位置,可以在凸轮表的任一位置去启动凸轮曲线.

TwinCAT NC PTP—MC_CamScaling

MC_CamScaling的指令的效果



CamScaling可以看成是动态修改曲线的指令.

不仅仅是使用offset,主从轴scaling的方式改变凸轮曲线.

还可以通过上述的WriteFunctionPoint或WriteFunction改变曲线.

TwinCAT NC PTP—MC_CamScaling

通过MC_CamActivationMode,可以让camscaling更加灵活的动态改变曲线.

Data type MC_CamActivationMode

```
TYPE MC_CamActivationMode :
(
    MC_CAMACTIVATION_INSTANTANEOUS,     (* instantaneous change *)
    MC_CAMACTIVATION_ATMASTERCAMPOS,    (* modify the data at a defined master
                                           position referring to the cam tables
                                           master position *)
    MC_CAMACTIVATION_ATMASTERAXISPOS,   (* modify the data at a defined master
                                           position referring to the absolute
                                           master axis position *)
    MC_CAMACTIVATION_NEXTCYCLE,         (* modify the data at the beginning of
                                           the next cam table cycle *)
    MC_CAMACTIVATION_NEXTCYCLEONCE,     (* not yet implemented!
                                           modify the data at the beginning of
                                           the next cam table cycle, activation
                                           is valid for one cycle only *)
    MC_CAMACTIVATION_ASSOONASPOSSIBLE,  (* modify the data as soon as the
                                           cam table is in a safe state to
                                           change its data *)
    MC_CAMACTIVATION_OFF,               (* don't accept any modification *)
    MC_CAMACTIVATION_DELETEQUEUEDDATA   (* delete all data which was written
                                           to modify the cam table but is
                                           still not activated *)

);
END_TYPE
```

有以下一些动态改变曲线的类型:

立即修改曲线.

主轴在凸轮表的指定位置时修改曲线.

在主轴绝对值的指定位置时修改曲线.

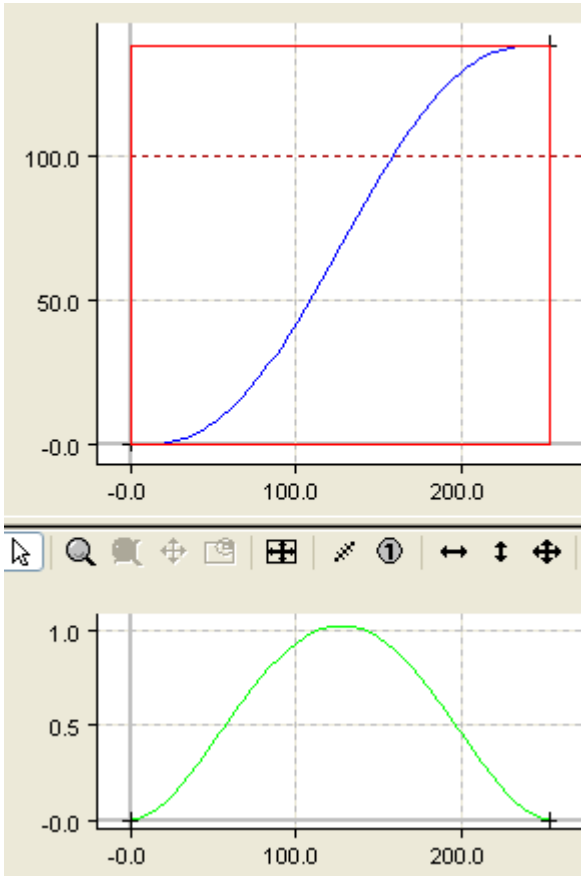
在下一个周期的开始修改曲线.

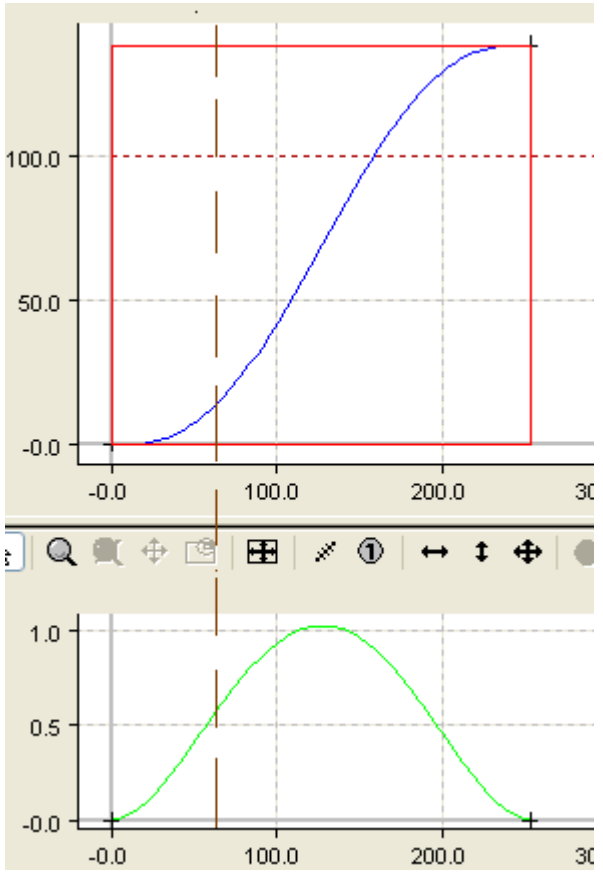
凸轮表在一个安全的状态时修改曲线.

取消修改的曲线的计划.

TwinCAT NC PTP—MC_ReadCamTableSlaveDynamics

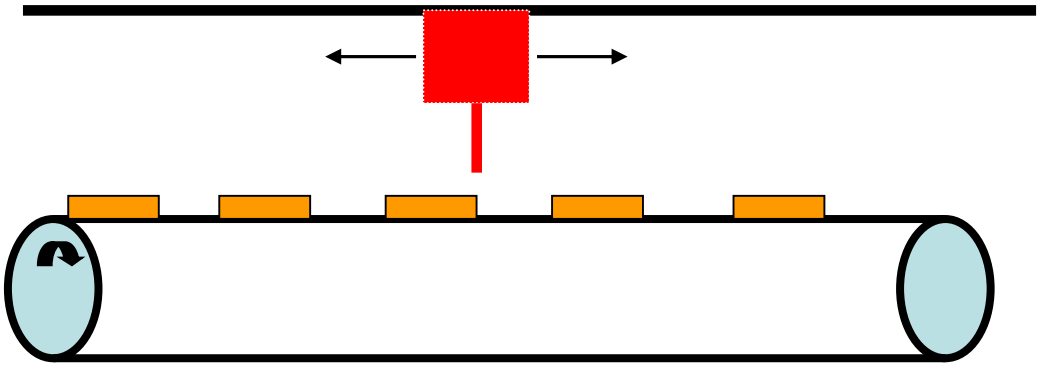
MC_ReadCamTableSlaveDynamics的指令的效果

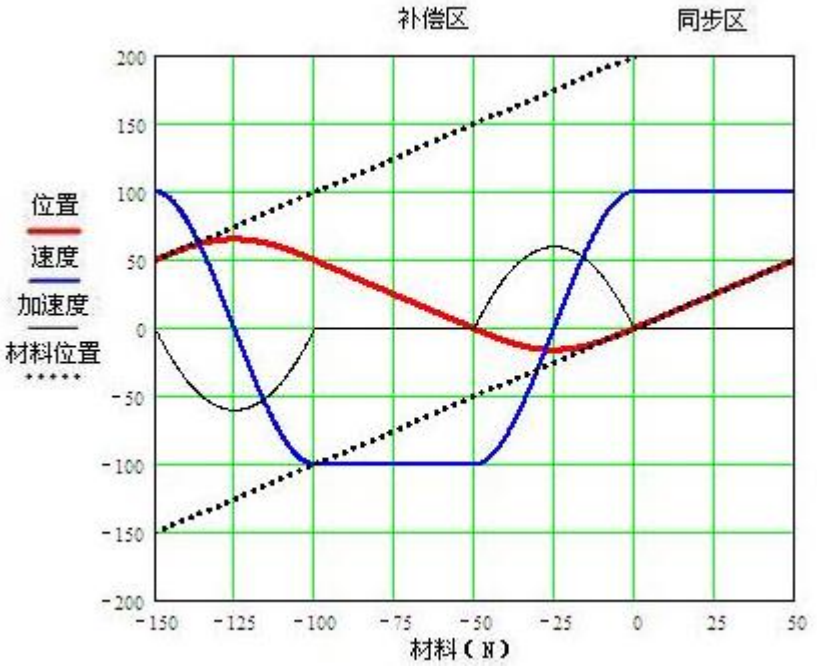


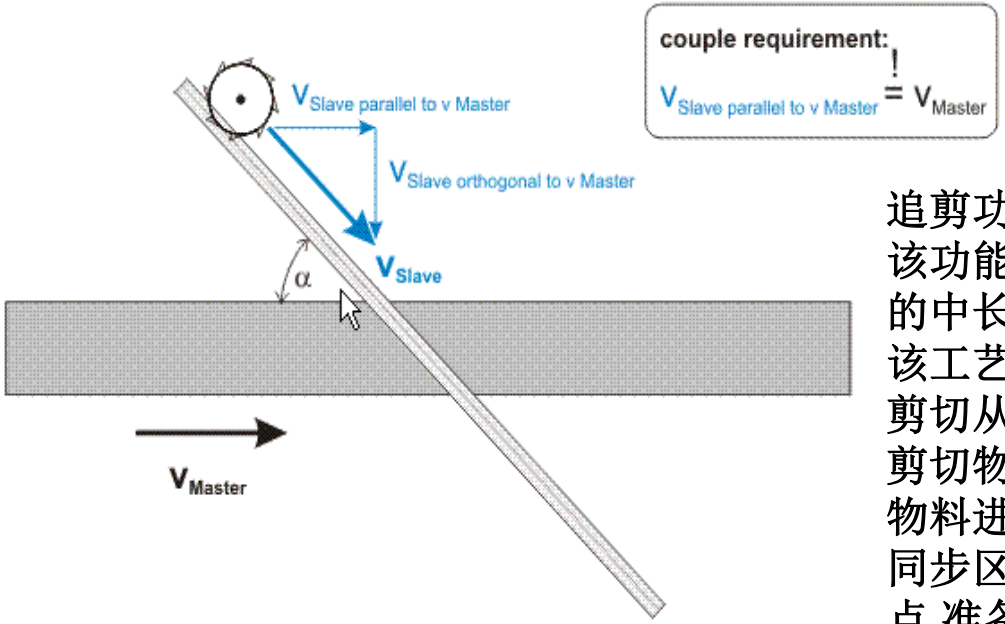



```
MasterCamTablePos := (MasterPosition + MasterOffset) / MasterScaling;
SlaveCamTablePosition := ReadSlaveDynamics.SlavePosition;
Lift number := MODTURNS( (SlavePosition - SlaveOffset), SlaveHub );
NewSlaveOffset := SlaveOffset + (SlaveHub * lift number);
SlavePosition := (SlaveCamTablePosition * SlaveScaling) + NewSlaveOffset;
```

TwinCAT NC PTP : 追锯

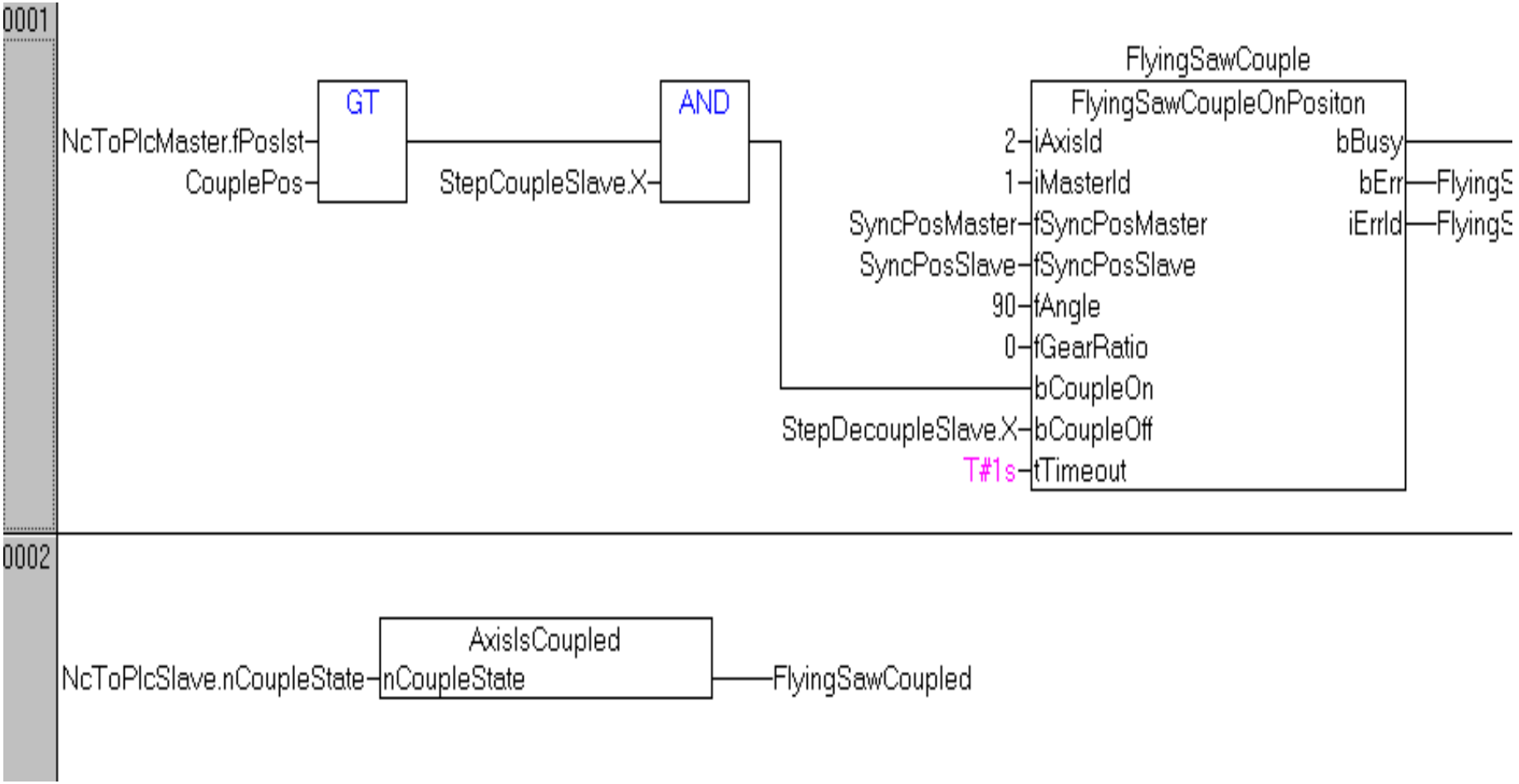




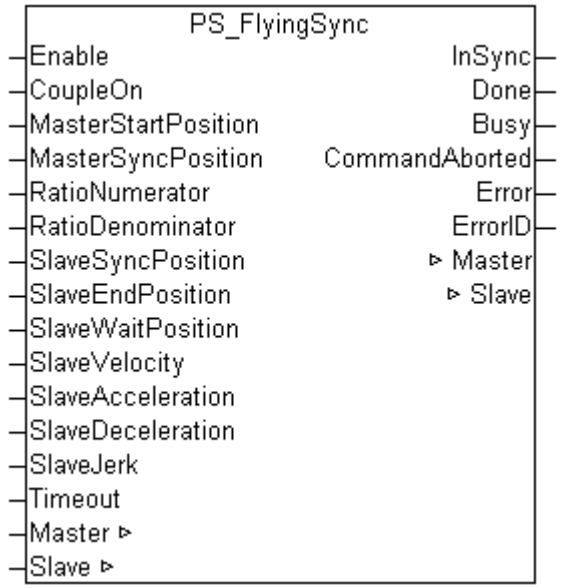


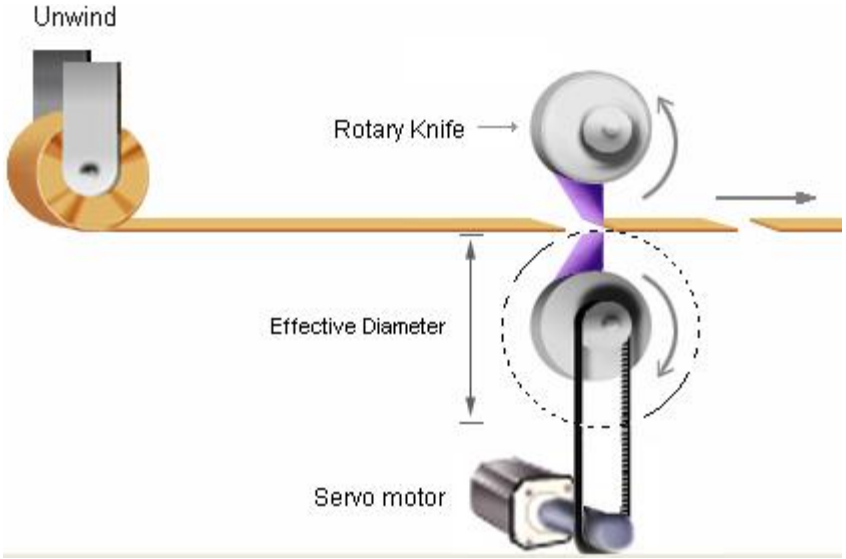
追剪功能块:
该功能块常用于物料剪切.(通常用在一些比较厚的中长物料的场合,如钢板剪切等)
该工艺的特点是:
剪切从轴追上物料以后,和物料保持速度同步后,剪切物料,并保持同步一段时间.(可以充分的对物料进行剪切).
同步区结束以后,剪切从轴反向,回到当初的起始点,准备下一次的追锯.

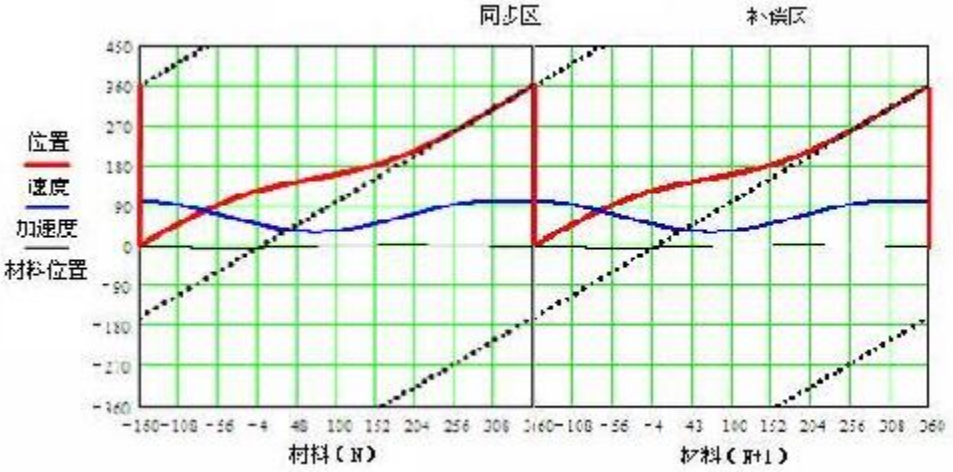
TwinCAT NC PTP :追锯功能块



TwinCAT NC PTP : 旋切功能块

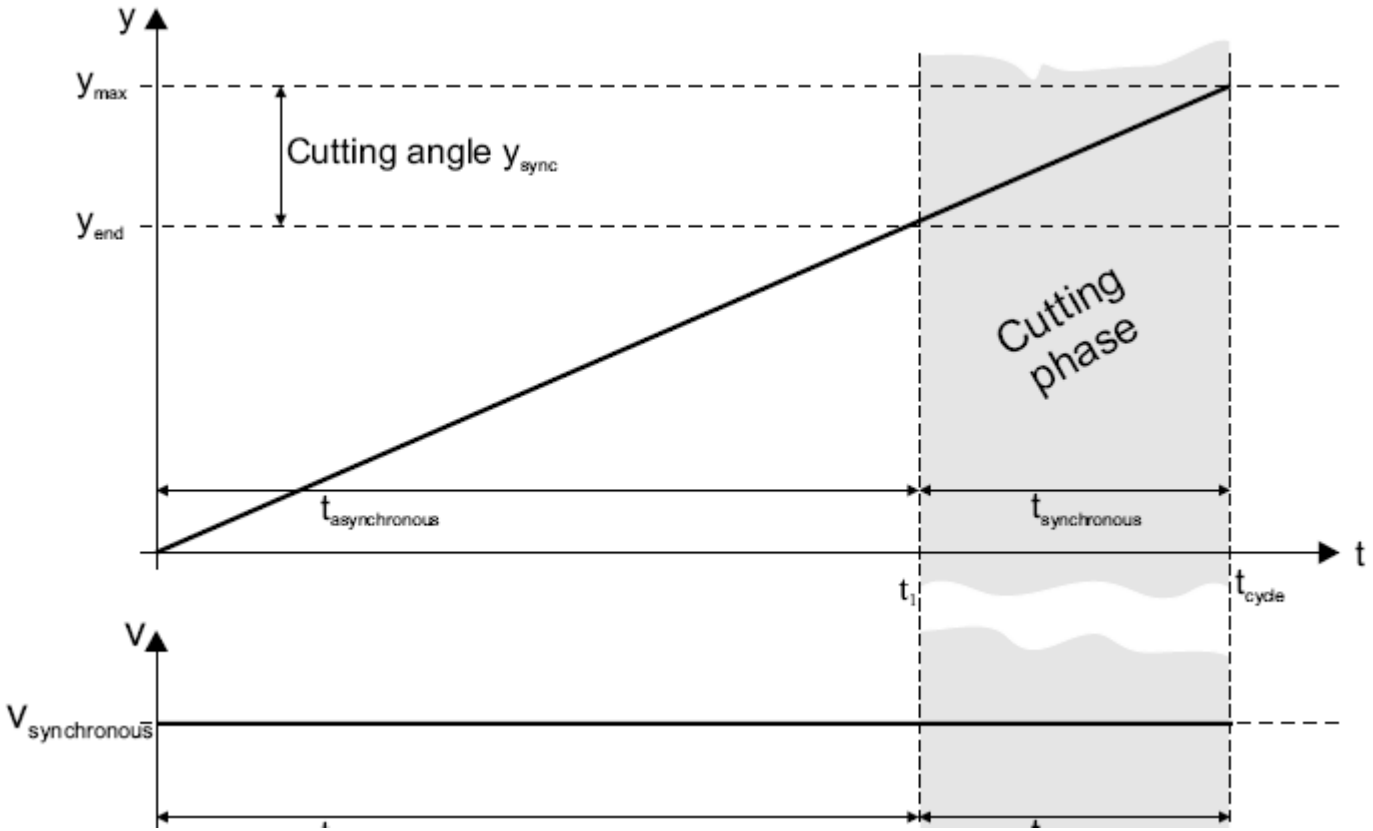




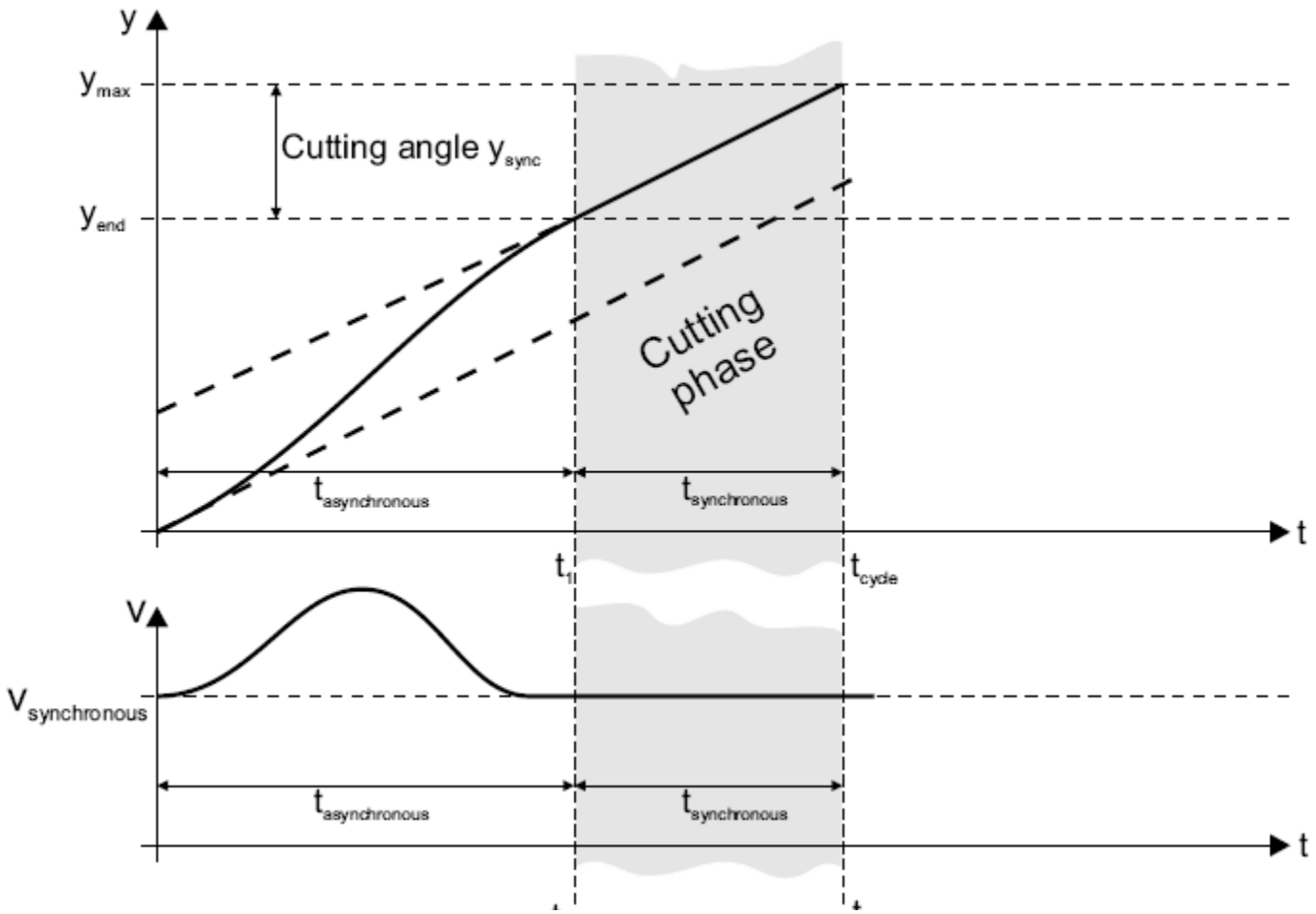


旋切功能块:
一种应用非常广泛的物料剪切案例.如钢板剪切,瓦楞纸剪切,连续式包装机的薄膜剪切.通常和收放卷配合使用.
特点是:旋刀在运行过程中不停止(长料剪切除外),比停剪的速度快很多.曲线特点主要为在剪切的同步区速度保持一致,其他区域为补偿区,用来解决不同长度物料的位置补偿.

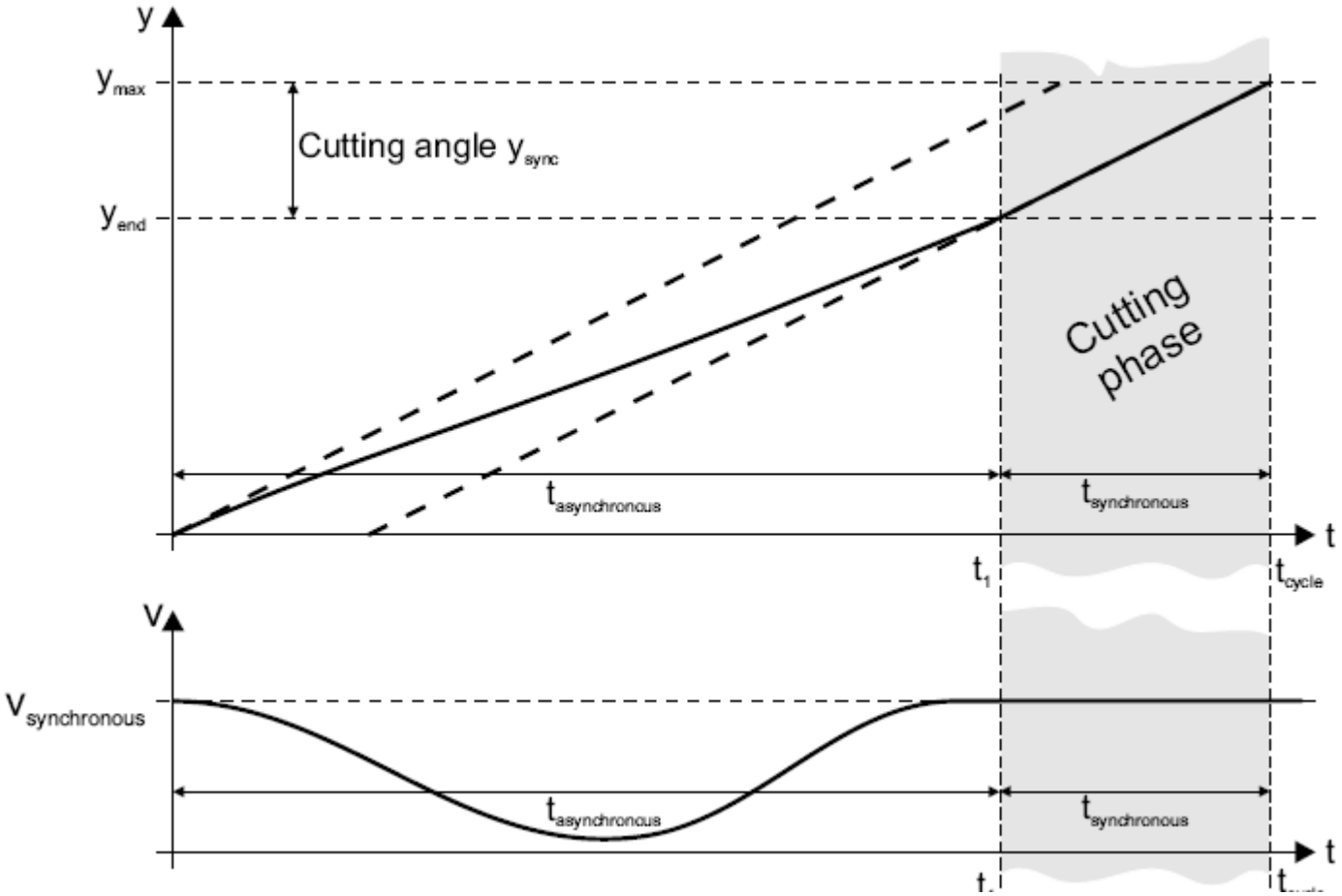
TwinCAT NC PTP : 旋切功能块



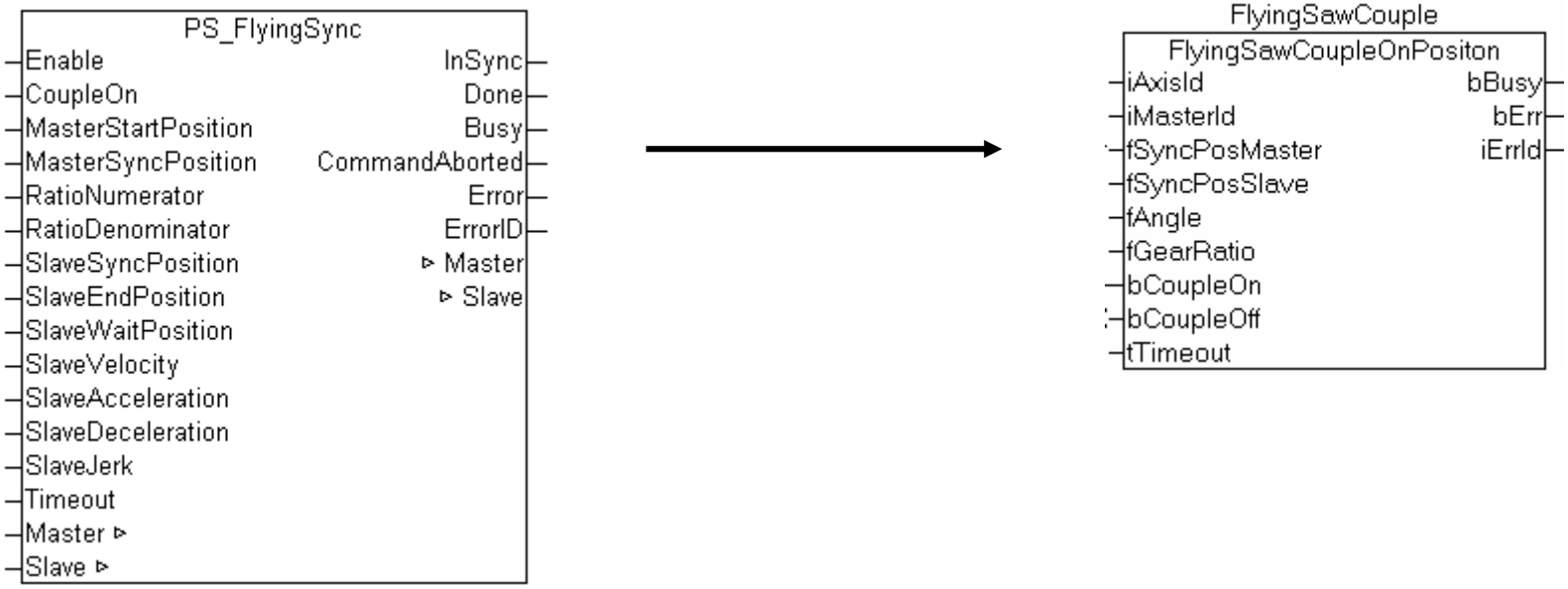
TwinCAT NC PTP : 旋切功能块



TwinCAT NC PTP : 旋切功能块

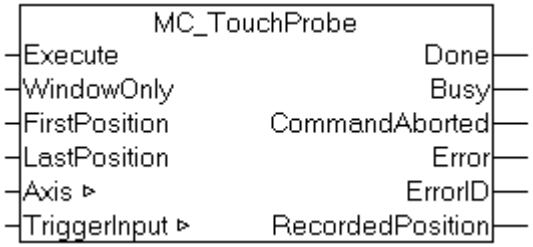


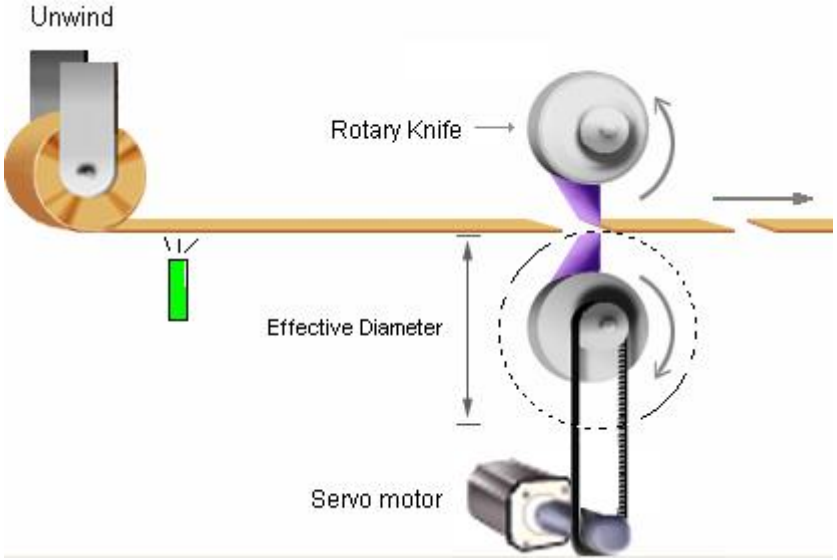
TwinCAT NC PTP : 旋切功能块



该功能块也可以通过参数的修改
完成飞锯的功能

TwinCAT NC PTP : 动态捕捉功能块





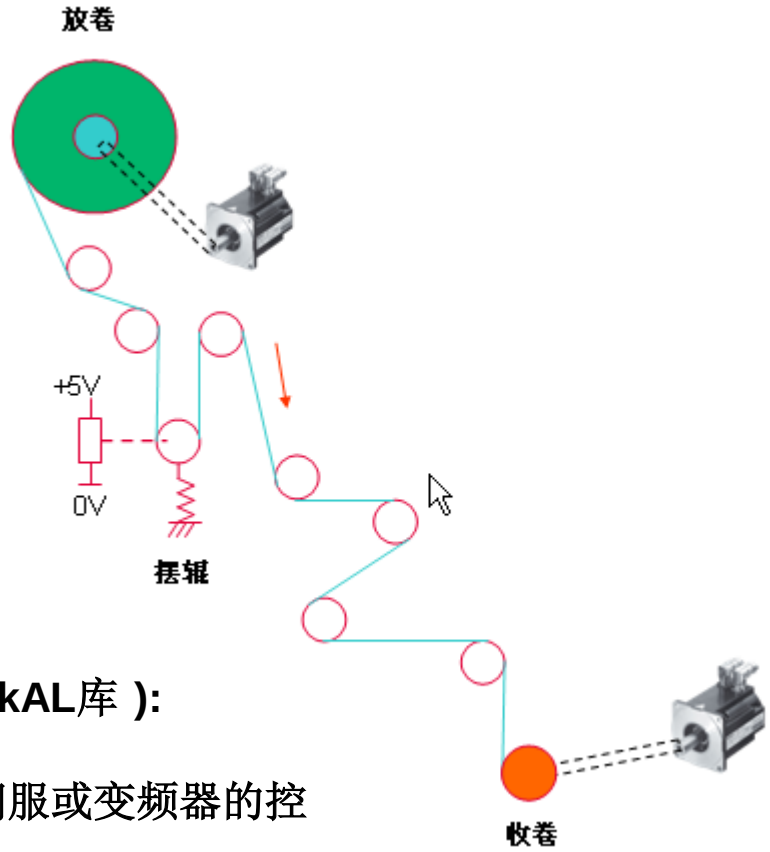
动态捕捉功能块:
该功能块的特点:当通过旋切功能块去剪切薄膜或纸张时,如果材料上有色标,而旋刀必须剪在旋刀上时,就必须用TouchProbe功能.

此时TouchProbe的作用是色标传感器检测到材上的色标后,将此时电机轴的位置记录下来.
该位置记录是不受嵌入式PC扫描周期的影响,是微秒级别的.

该数据走的是Ethercat process data的通道,是real time的数据,动态记录的位置非常精确.

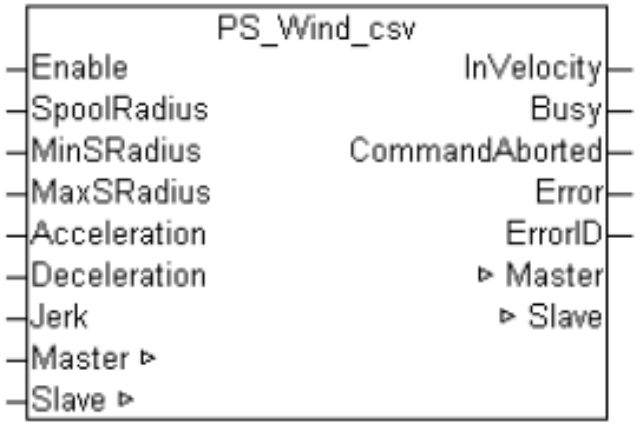
将前后两个色标的位置记录下来,相减,就可以得到下次剪切所需要的长度.

TwinCAT运动控制: 自动收放卷



TwinCAT PLC Library: TcPackAL

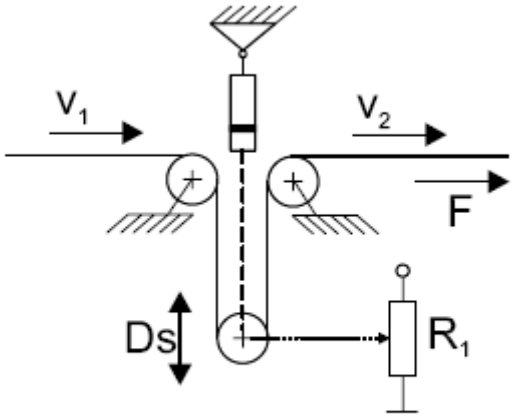
FUNCTION_BLOCK PS_Wind_csv



收放卷功能(TcPackAL库):
应用非常广泛.
该库适用于NC对伺服或变频器的控制.
在收放卷的过程中,随着卷径的不断变化,根据指令算法,通过修改电机角速度的方法,来达到收放卷材料线速度不变.

计算卷径的方法有
1.通过计算伺服或变频器实际走过的距离进行累加,再根据材料的厚度,进行卷径的计算.
2.根据外部传感器,进行实际卷径的测算,并反馈给上位.

TwinCAT运动控制: **Dancer**



a) Dancer

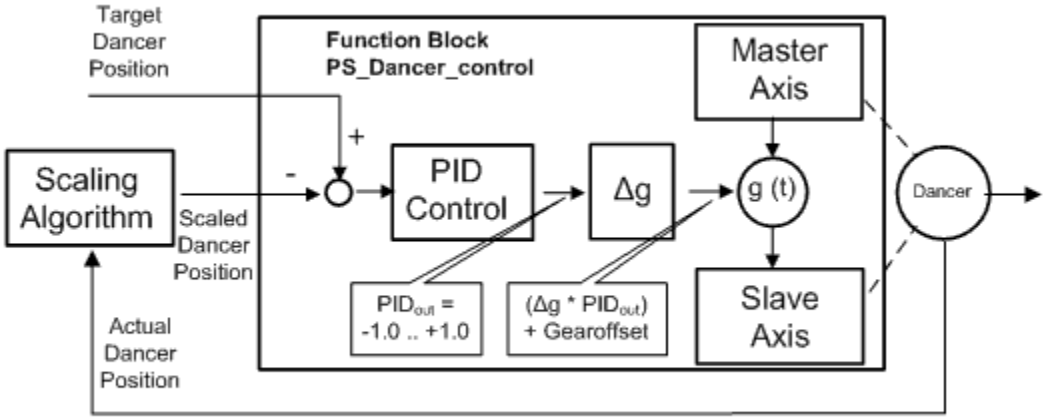
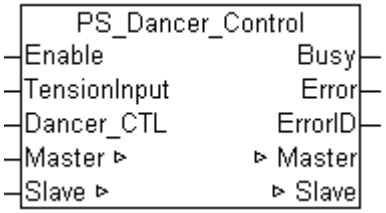
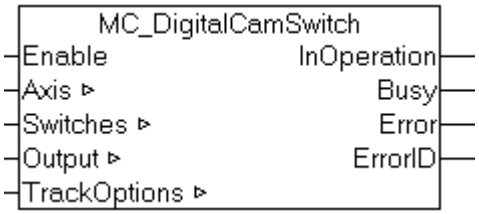


Figure: PS_Dancer_Control_Structure_Diagram



Dancer功能(TcPackAL库):
是张力控制的一个典型应用.
通过修改主轴电机和从轴电机的速度齿轮比的方法,根据能够反应张力变化的模拟量输入反馈,通过PID调节来修改电子齿轮比,从而达到张力控制的效果.

TwinCAT运动控制:MC_DigitalCamSwitch



CamSwitch功能(XFC库):

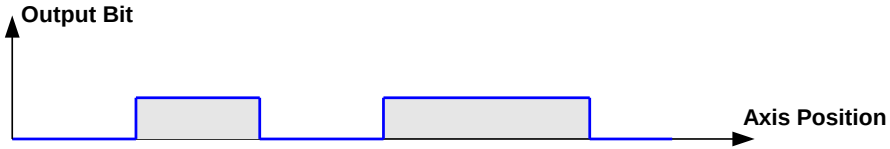
凸轮开关功能.

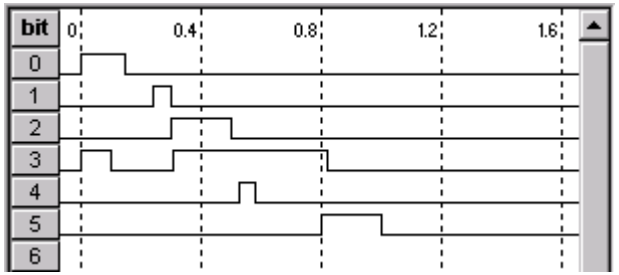
所谓凸轮开关,就是当伺服轴达到一个初始位置时,数字量输出打开.

就是当伺服轴达到一个终点位置时,数字量输出关闭.

配合**XFC**使用,可以让系统的数字开关量输出的场合在最精确的伺服轴位置打开,关闭,满足对时间极其苛刻场合的应用.

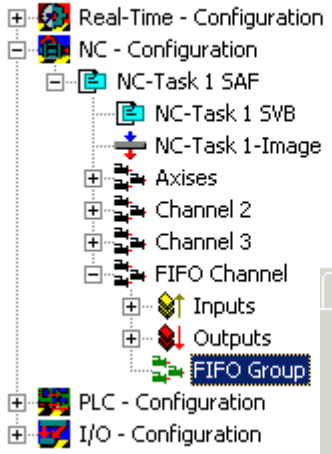
可以考虑使用该功能来提高包装机械的运行速度.

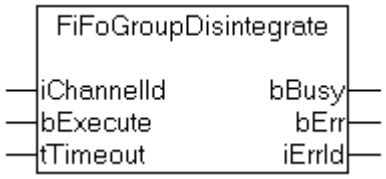


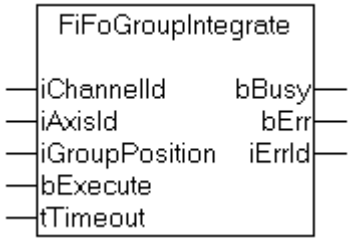


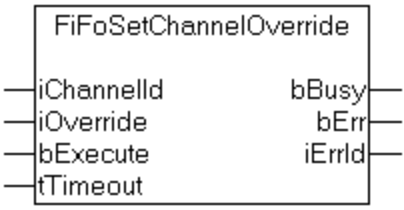
TwinCAT运动控制:FIFO

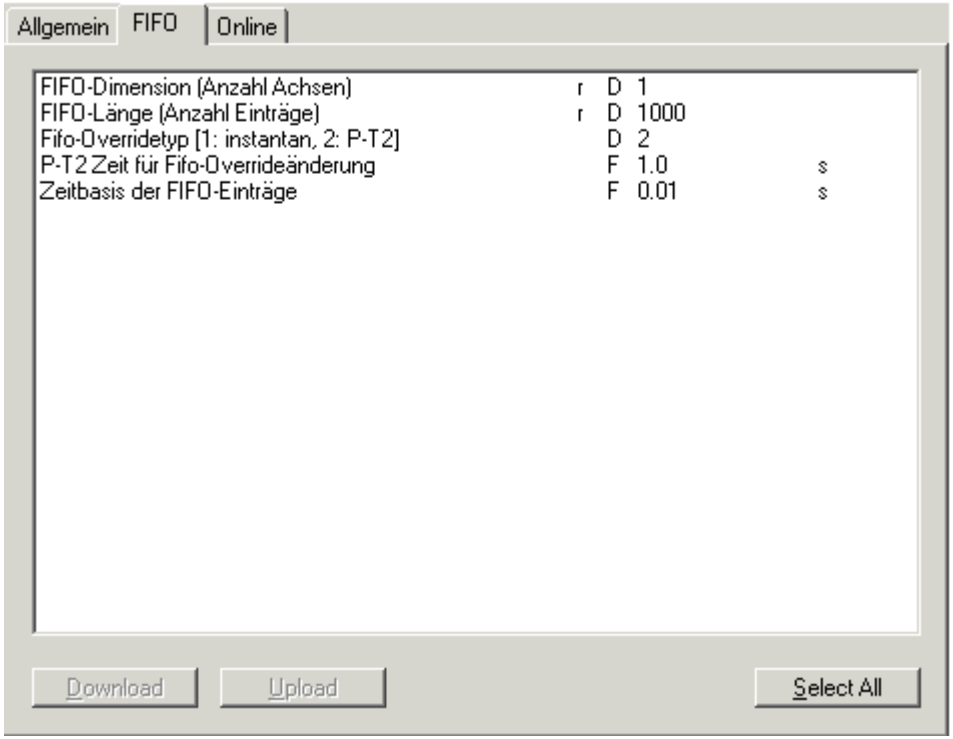
Parameterisation of the FIFO Group











FIFO的特点:可以将它理解成一个电子凸轮.
将需要走的点存在一个文件里,也就是说一个特殊的**File.**这点和凸轮表的存储方式比较类似.

和凸轮不同之处它可以更加灵活的修改所要走的位置点.例如:只需修改存储文件中的数据就可以改变下一个**PC**扫描周期的位置.

适用范围:一些随时都有可能改变位置目标的应用.一些无规则的曲线.

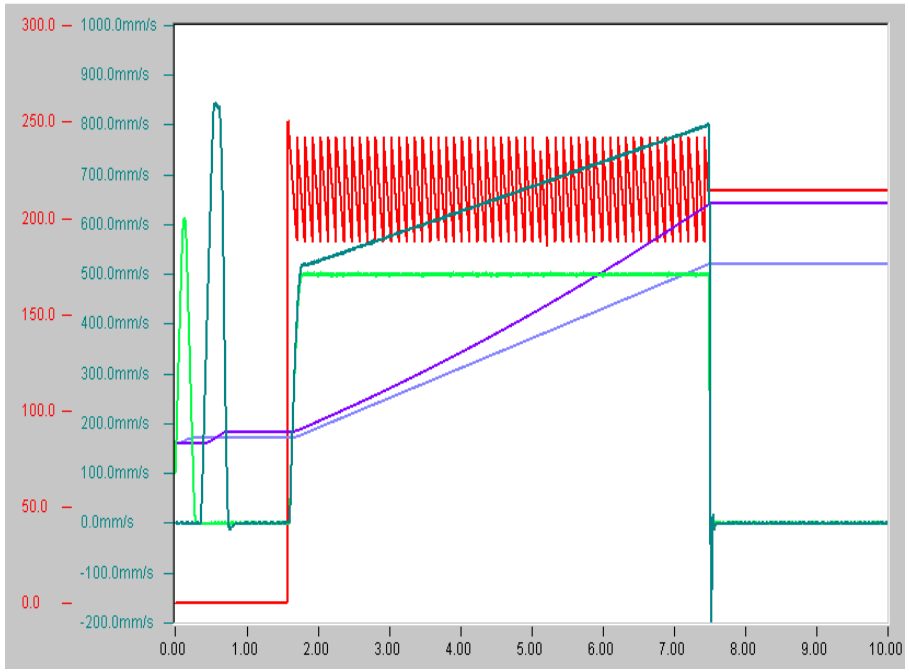
TwinCAT运动控制:FIFO

下列的两个图表,非常形象的将图表中相邻两个点的变化类型表示了出来.

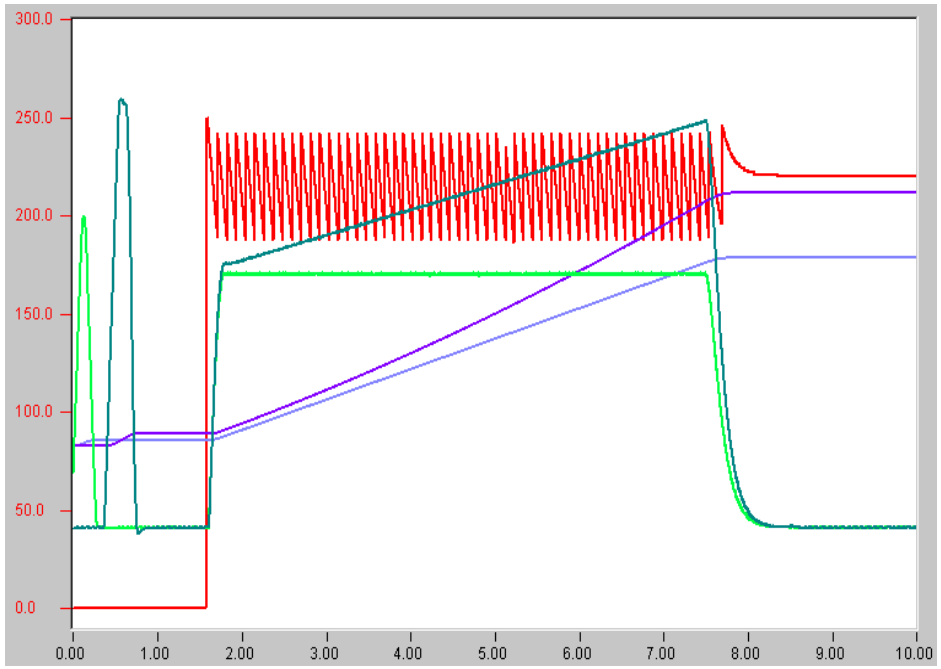
Instantaneous override:立即修改，以最快的速度从一个点切换到其相邻位置点.

PT-2 Override override:PT-2的修改类型,该类方式更加柔滑,减少了机械系统的冲击.

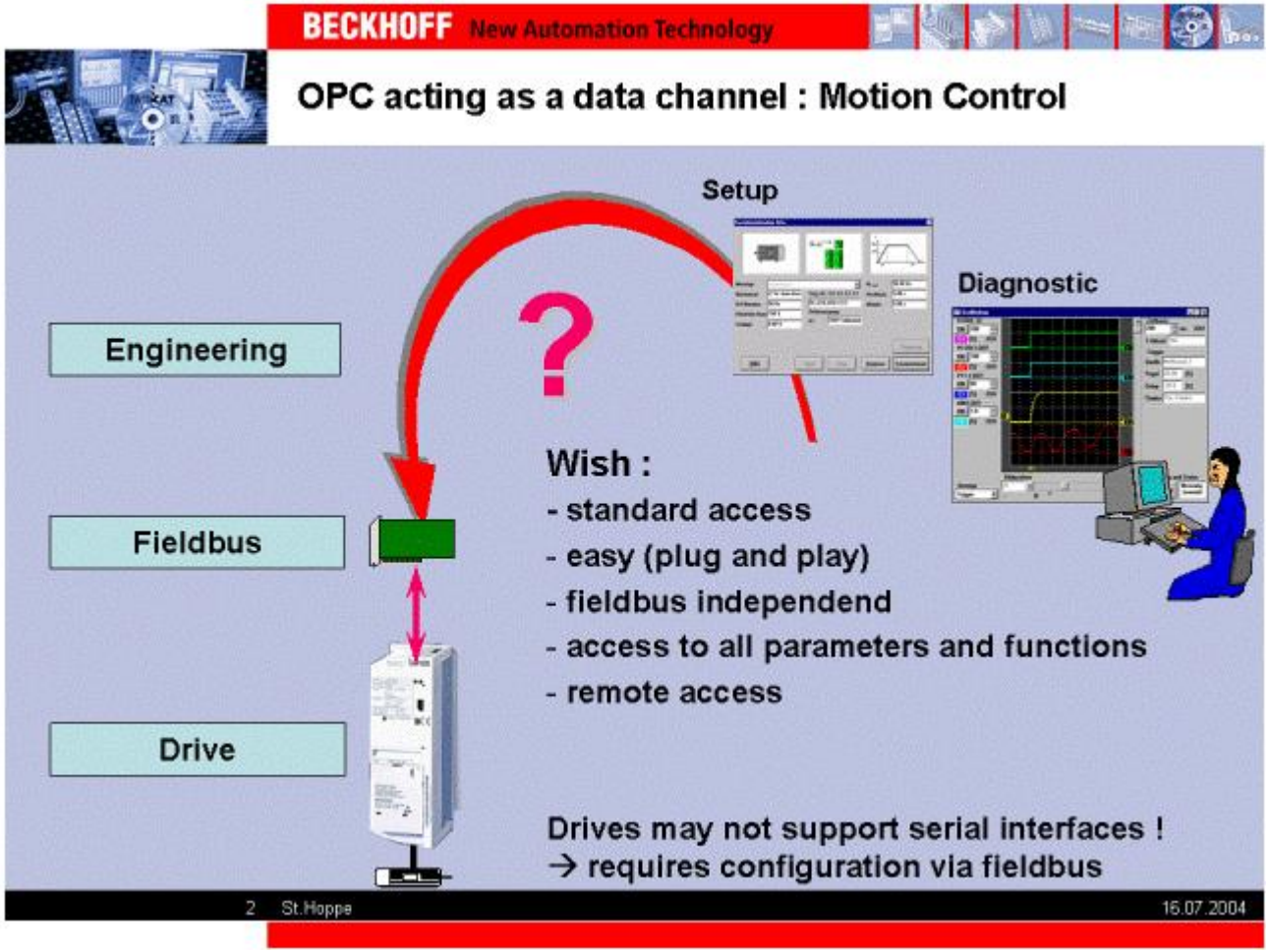
Instantaneous override



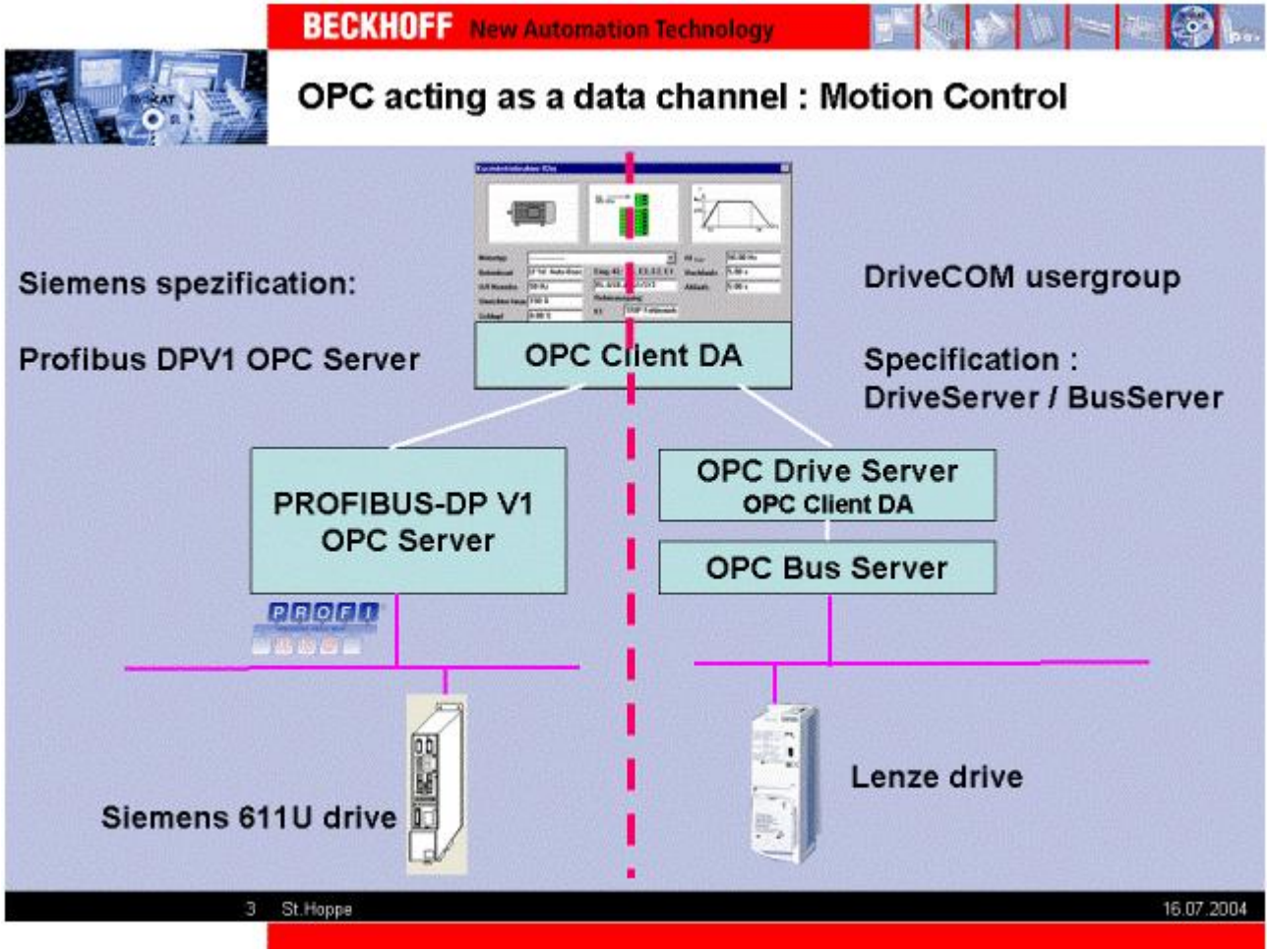
PT-2 Override



TwinCAT运动控制:TwinCAT DriveCOM **OPC**

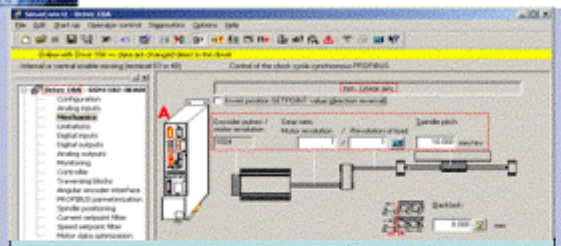


TwinCAT运动控制: TwinCAT DriveCOM **OPC**



TwinCAT运动控制: TwinCAT DriveCOM **OPC**

OPC acting as a data channel : Motion Control



OPC Client

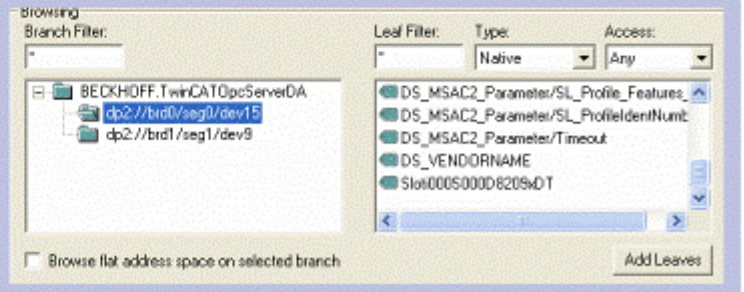
PROFIBUS-DP V1
OPC Server

Siemens Spec:

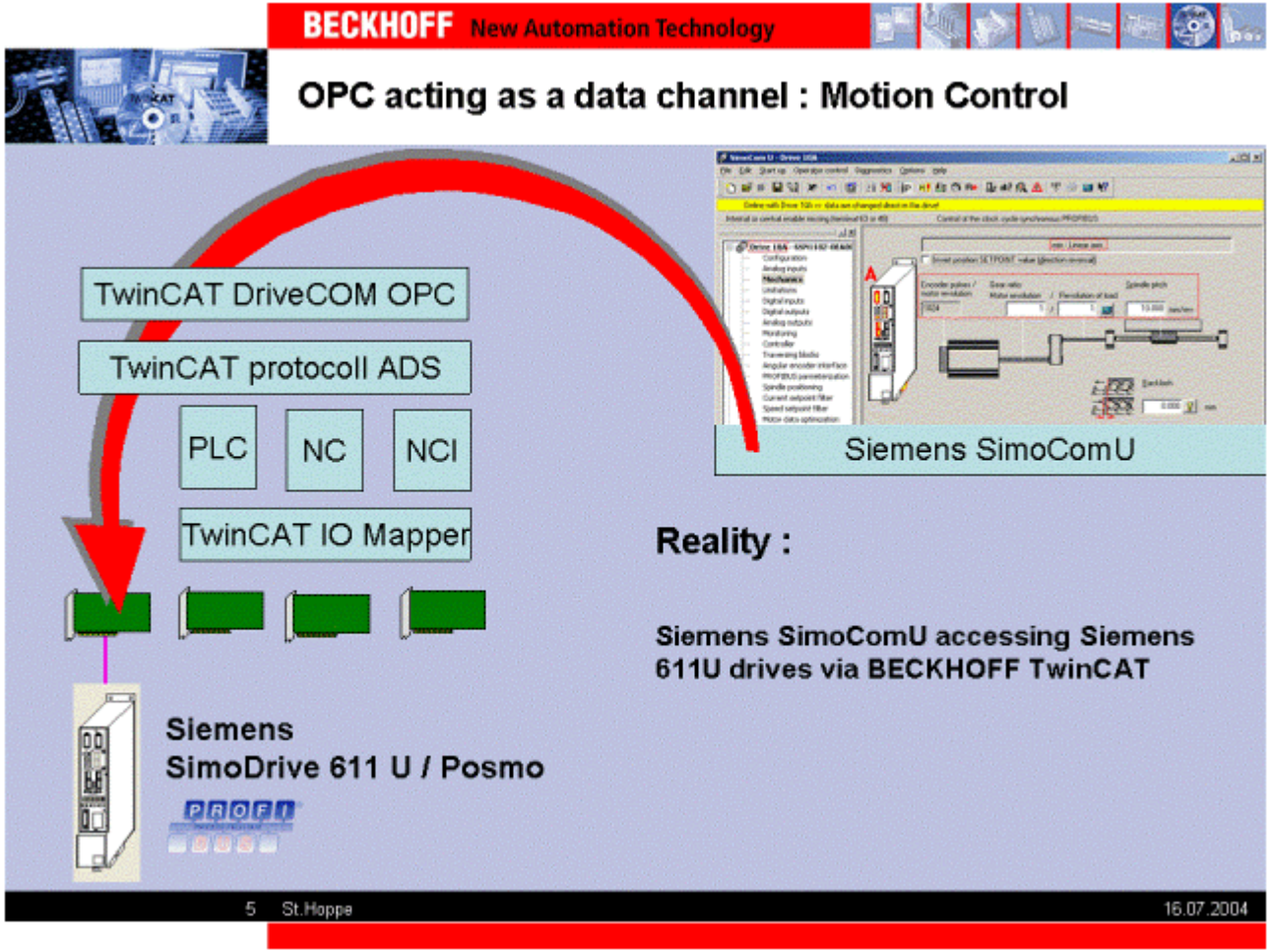
Profibus DPV1
OPC Server

Sample namespace :

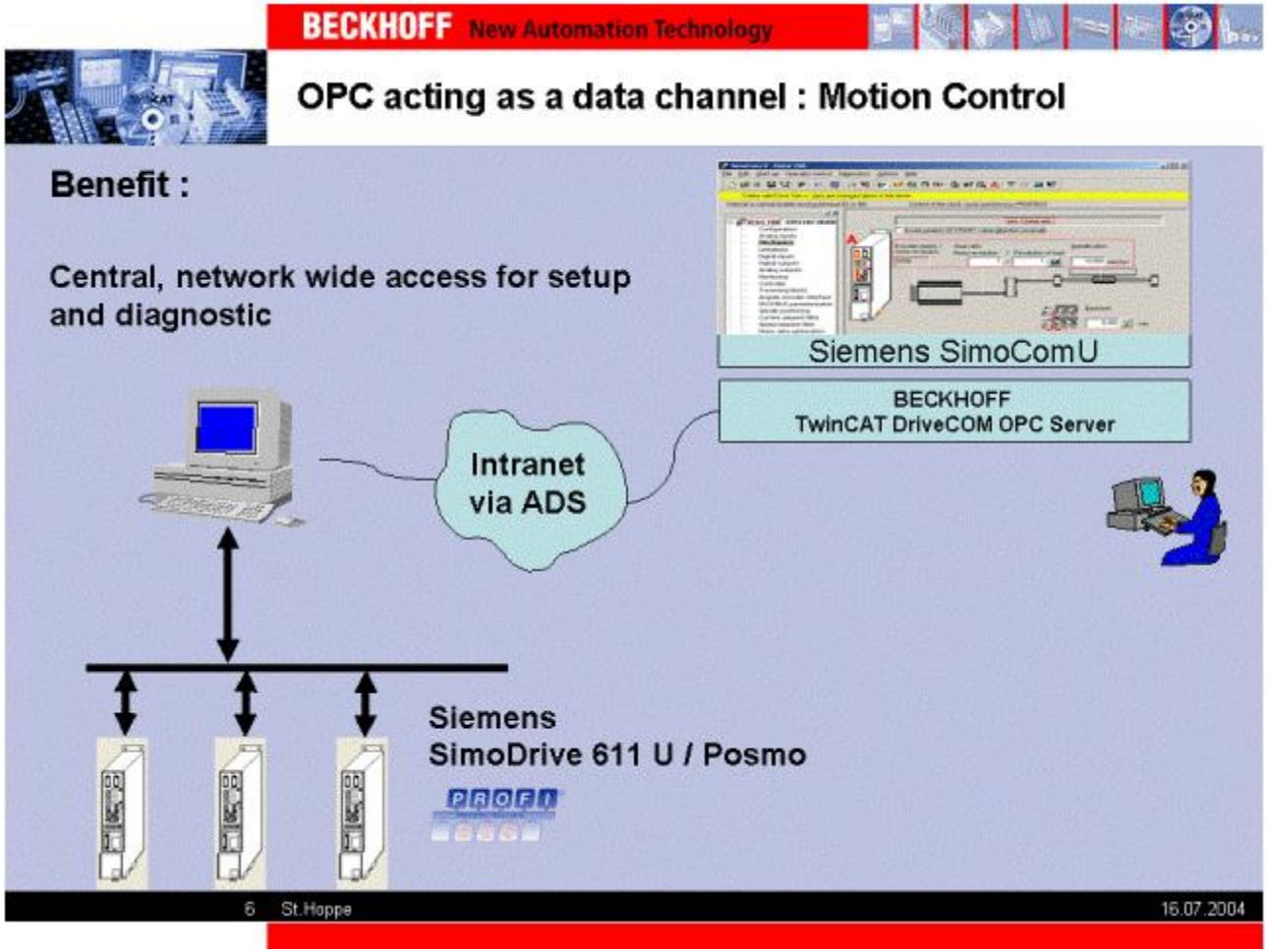
DPV1 OPC Server offers a specific profile in his namespace



TwinCAT运动控制: TwinCAT DriveCOM **OPC**



TwinCAT运动控制: TwinCAT DriveCOM **OPC**



谢谢大家!