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Cours AutB

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LAB 06 Gestion d'un mouvement discret.

Keywords: **PLCopen State Machine MC_Power MC_MoveAbsolute MC_ReadStatus**

Objectif

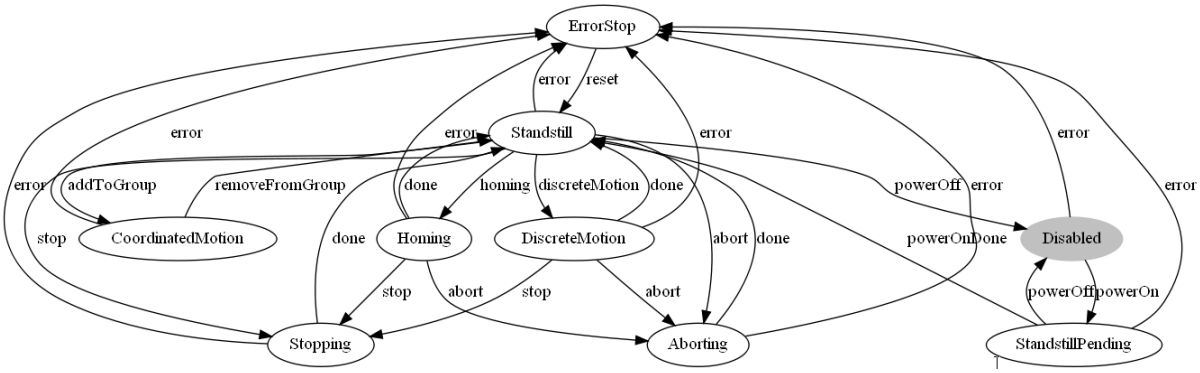
Piloter un axe avec des Function Blocs selon la norme PLCopen PLCopen Motion Control Specifications en utilsant une machine d'état robuste définie par des `Enum`.

Dans ce travail, nous effectuerons uniquement des mouvements absolus avec des trajectoires définies par un **MC_MoveAbsolute**.

Rappel Motion State Diagram

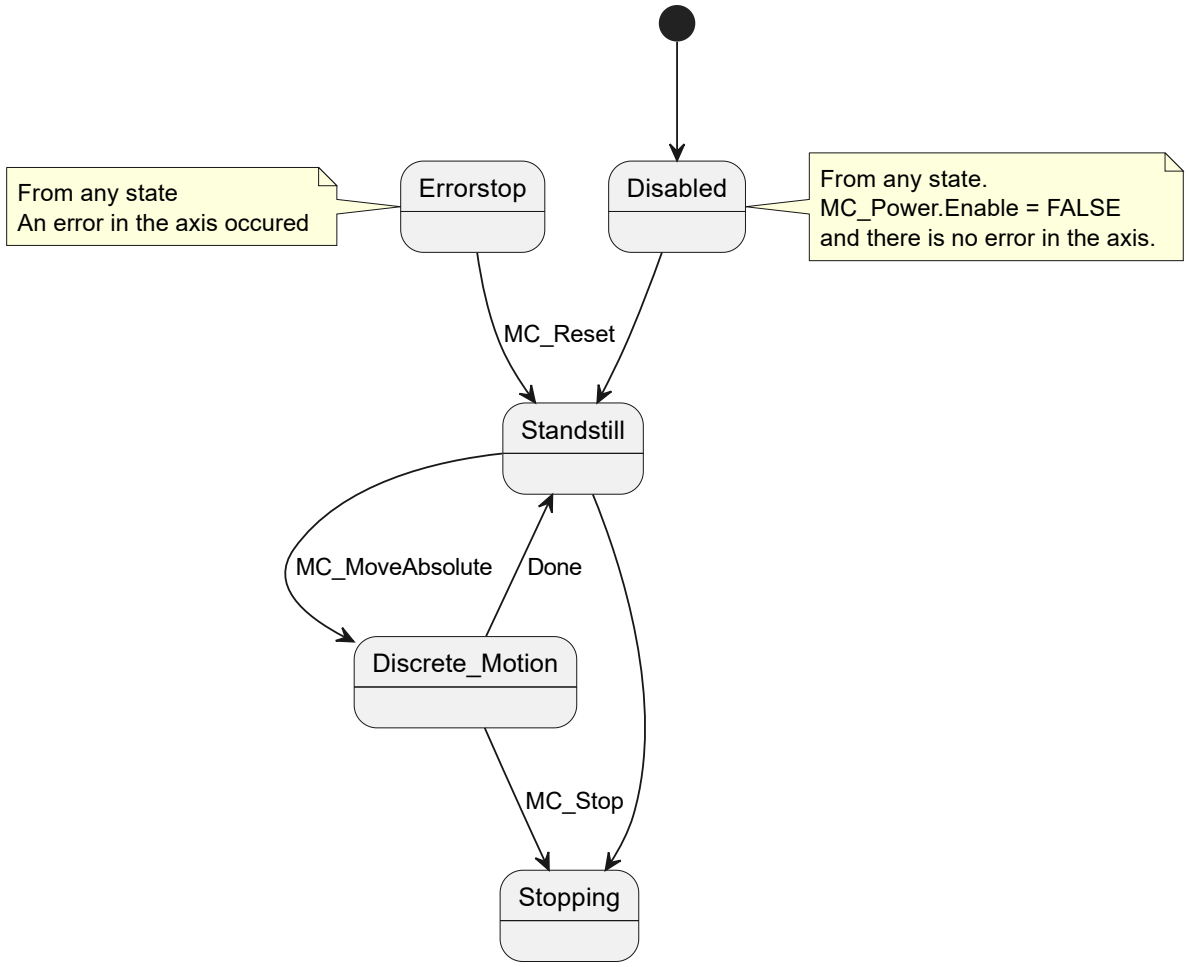
Il peut y avoir de légères différences d'un fabricant à l'autre, mais hormis `StandstillPending`, on retrouve toujours les autres états.

L'état **CoordinatedMotion** est spécifique à une machine avec plusieurs axes coordonnés.



PLCopen Axis State Machine

Dans le cadre du cours d'automation, nous utiliserons les états suivants:



Automation Lab State Diagram

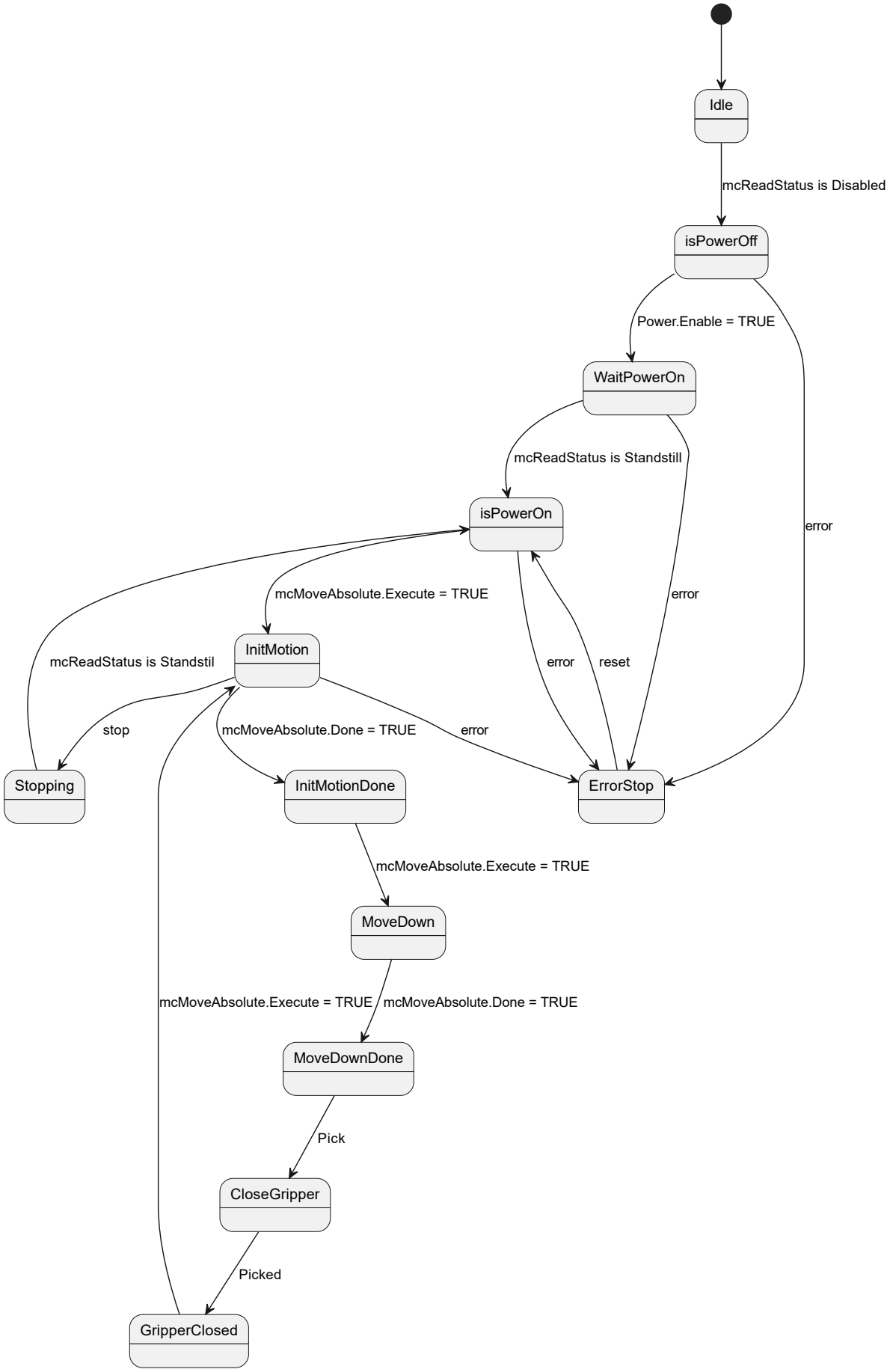
Le job

> Toutes les transitions vers ErrorStop ne sont pas représentées par soucis de lisibilité, mais dans la pratique, **n'importe quel état possède une transition vers ErrorStop**.

> **Aucune transition en dehors du `CASE..OF` n'est autorisée**, sauf pour réinitialiser le système sur Idle.

> **Les `Execute` et `Enable` des FB de commande ne dépendent que des états du `CASE..OF`**, excepté pour le mode manuel.

Certaines contraintes peuvent paraître exagérées, mais c'est un exercice de rigueur de programmation.



State Machine Practical Work Move Absolute

Available structures STRUCT.

List of commands for MoveAbsolute `ST_PlcOpenFbs`

```
TYPE ST_PlcOpenFbs :
STRUCT
    // If TRUE, the FB are driven manually from the HMI
    bEnableRemote        : BOOL;
    bEnableReadStatus    : BOOL;
    bEnableReadPosition  : BOOL;
    bEnableReadVelocity  : BOOL;
    bMoveAbs             : BOOL;
    bStop                : BOOL;
    bPowerOn             : BOOL;
    bReset               : BOOL;
    // From arAxisStatus_gb[1].Data.PLCopenState;
    // Exist in Data Layer too, s=motion/axs/Axis_X/state/opstate/plcopen
    strGetAxisStatus     : STRING;
END_STRUCT
END_TYPE
```

> Les variables `bEnableRemote`, `bMoveAbs`, `bStop`, `bPowerOn`, `bReset` sont conçues pour piloter manuellement les Function Block, par exemple avec un OR sur un Execute

```
mcStop(Axis := GVL_AxisDefines.X_Axis,
       Execute := (state = stateStop) OR
                  (stPlcOpenFbs.bEnableRemote AND stPlcOpenFbs.bStop));
```

List of dynamic parameters for `MC_MoveAbs`

```
TYPE ST_SetMotionParam :
STRUCT
    rPosition_mm        : LREAL;
    rVeloctiy_mm_s      : LREAL;
    rAcceleration_mm_s2 : LREAL;
    rDeceleration_m_s2  : LREAL;
    rJerk_m_s3          : LREAL;
END_STRUCT
END_TYPE
```

List of State Machine Status `ST_StateMachineInfo`

```
TYPE ST_StateMachineInfo :
STRUCT
    diState     : DINT;
    eState      : EN_MoveAbsStates;
    bIdle       : BOOL;
```

```
    bActive     : BOOL;
    bError      : BOOL;
    strState    : STRING;
END_STRUCT
END_TYPE
```

> Notez la variable `strState` de type `STRING` qui peut être utilisée dans le code pour documenter la machine d'état et simplifier le diagnostic de la machine.

```
(*
    Main State Machine.
*)
CASE stStateMachineInfo.eState OF
    EN_MoveAbsStates.eIdle :
        stStateMachineInfo.strState := 'Idle';
        ;
```

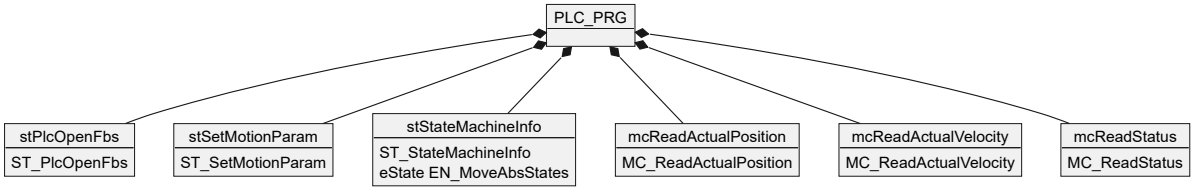
Enum for state

Integrated in `ST_StateMachineInfo`, to be completed.

```
TYPE EN_MoveAbsStates :
(
    eIdle := 999
)DINT := eIdle;
END_TYPE
```

HMI

Une interface par défaut est fournie. Elle utilise les structure ci-dessus intégrées dans programme principal ainsi que quelques fonctions utlilitaire.



Practical Work06 Base ClassObjects

On notera que ce diagramme n'intègre pas les `Function Blocks` nécessaires au **motion control**.

Main function blocks PLCopen

AXIS_REF

On a typiquement un accès de type `VAR_IN_OUT` qui fournit à chaque `Function Block` un axe référencé dans le noyau **Motion Control**.

Dans le système à notre disposition, on utilise une fonction spécifique qui permet de récupérer la référence à la structure pour `AXIS_REF`.

Voir dans `GVL_AxisDefines`

```
VAR_GLOBAL
      X_Axis: MB_AXISIF_REF :=(AxisName:='Axis_1',AxisNo:=1);
END_VAR
```

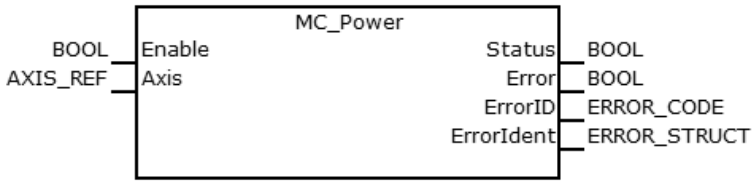
C'est cette valeur `X_Axis`, qui est utilisée obligatoirement lors de l'appel d'un FB pour le Motion Control, par exemple pour `MC_Stop`:

```
mcStop(Axis := GVL_AxisDefines.X_Axis,
       Deceleration := 1,
       Execute := stPlcOpenFbs.bStop);
```

MC_Power

Short description

The function block controls the power adding (on or off).



MC_Power, source: Bosch Rexroth

Functional description

The function block implements the transition between the PLCopen states **DISABLED** and **STANDSTILL**.

This function is prerequisite for every motion command which moves an axis.

There is no differentiation between real or simulated axes.

Possible error codes

The function block uses the CXA_TABLE, refer to CXA_Commontypes.ERROR_TABLE Error detail information please see CXA_MOTION_ERR.

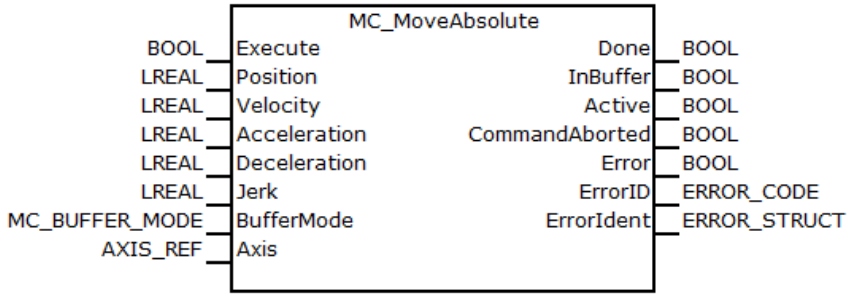
Scope	Name	Type	Comment

Scope	Name	Type	Comment
VAR_INPUT	`Enable`	BOOL	As long as `Enable` is true, power is being enabled
VAR_OUTPUT	`Status`	BOOL	Power state
VAR_OUTPUT	`Error`	BOOL	Indicates an error
VAR_OUTPUT	`ErrorID`	ERROR_CODE	Class of error
VAR_OUTPUT	`ErrorIdent`	ERROR_STRUCT	Detailed information about error
VAR_IN_OUT	`Axis`	AXIS_REF	Reference to the axis `CONST`

MC_MoveAbsolute

Short description

This Function Block commands a controlled motion to a specified absolute position.



MC_MoveAbsolute, source: Bosch Rexroth

Functional description

Prerequisite: The axis has to be in a powered state by **MC_Power**.

During the movement, the PLCopen state of the axis is set to DISCRETE_MOTION. When the commanded target position is reached, the function block is set to state Done and the PLCopen state of the corresponding axis is set to **STANDSTILL**.

You can use **MC_ReadStatus** to determine the current state.

In case an error occurred before execution (e.g. violated dynamic limits, invalid command parameters) the function block will be set to state `Error`. In case an error occurred during execution, the axis state is set to **ERRORSTOP**.

If the function block is set as a `mcAborting` mode, all previous commands are discarded and the currently executed commanded will be interrupted. In this case, the axis will still move continuously (within its new commanded dynamic limits) towards the new target position.

If the function block is set as a `mcBuffered` mode, this command will be buffered until all previous commands are executed done and the currently executed commanded will not be interrupted. In this case, the axis will still move to velocity-zero and then move (within its new commanded dynamic limits) towards the new target position.

If the function block is interrupted by another function block which is set as `mcAborting` mode or **MC_STOP**, it will be set to state `CommandAborted`.

If the function block works in `Active` state. It means current function block is executed

Possible error codes

The function block uses the CXA_TABLE, refer to CXA_Commontypes.ERROR_TABLE

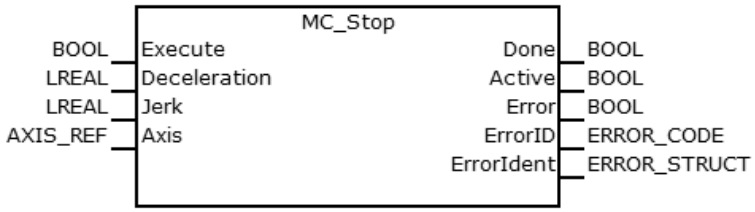
Error detail information please see CXA_MOTION_ERR.

Scope	Name	Type	Comment
VAR_INPUT	`Execute`	BOOL	Start the motion at rising edge
VAR_INPUT	`Position`	LREAL	Commanded `Position` for the motion, *in technical unit* `[u]`, negative or positive
VAR_INPUT	`Velocity`	LREAL	Value of the maximum `Velocity`, *not necessarily reached* `[u/s]`.
VAR_INPUT	`Acceleration`	LREAL	Value of the 'Acceleration', always positive, *increasing energy of the motor* `[u/s2]`
VAR_INPUT	`Deceleration`	LREAL	Value of the 'Deceleration', always positive, *decreasing energy of the motor* `[u/s2]`
VAR_INPUT	`Jerk`	LREAL	Value of 'jerk' (always positive) [u/s3]
VAR_INPUT	`BufferMode`	MC_BUFFER_MODE	defines this FB execute immediately or push into the buffer
VAR_OUTPUT	`Done`	BOOL	Commanded position finally reached
VAR_OUTPUT	`InBuffer`	BOOL	Command is queued and to be executed.
VAR_OUTPUT	`Active`	BOOL	Execution in progress
VAR_OUTPUT	`CommandAborted`	BOOL	`Command` is aborted by another command
VAR_OUTPUT	`Error`	BOOL	Indicates an error
VAR_OUTPUT	`ErrorID`	ERROR_CODE	Class of error
VAR_OUTPUT	`ErrorIdent`	ERROR_STRUCT	Detailed information about error
VAR_IN_OUT	`Axis`	AXIS_REF	Reference to the axis `CONST`

MC_Stop

Short description

This function block generates a slowdown, **within the given dynamic limits**, until the axis is stopped, **velocity zero**.



MC_Stop, source: Bosch Rexroth

Functional description

During slowdown, the axis in state of **STOPPING**.

After the axis is stopped, the output Done is set and the PLCopen statemachine of the corresponding axis is set to state **STANDSTILL**.

This function block abort any ongoing function block execution. When **STANDSTILL** is reached the position is kept active.

Possible error codes

The function block uses the CXA_TABLE, refer to CXA_Commontypes.ERROR_TABLE

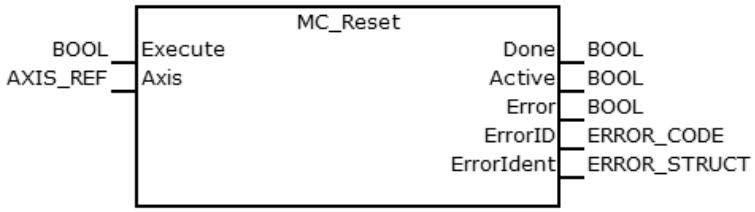
Error detail information please see CXA_MOTION_ERR.

Scope	Name	Type	Comment
VAR_INPUT	`Execute`	BOOL	Start the action at rising edge
VAR_INPUT	`Deceleration`	LREAL	Value of *deceleration*, always positive, `[u/s2]`
VAR_INPUT	`Jerk`	LREAL	Value of 'jerk' (always positive) [u/s3]
VAR_OUTPUT	`Done`	BOOL	Execution finished
VAR_OUTPUT	`Active`	BOOL	Execution in progress
VAR_OUTPUT	`Error`	BOOL	Indicates an error
VAR_OUTPUT	`ErrorID`	ERROR_CODE	Class of error
VAR_OUTPUT	`ErrorIdent`	ERROR_STRUCT	Detailed information about error
VAR_IN_OUT	`Axis`	AXIS_REF	Reference to the axis `CONST`

MC_Reset

Short description

The function block resets all reported errors of an axis



MC_Reset, source: Bosch Rexroth

Functional description

Prerequisite: The axis must not be added to an axes group.

Implements the transition from the **ERRORSTOP** state to the **STANDSTILL** or **DISABLED** depending on its previous power state.

Axis-internal errors are deleted.

If there is no error present, triggering **MC_Reset** has no effect.

Possible error codes

The function block uses the CXA_TABLE, refer to CXA_Commontypes.ERROR_TABLE

Error detail information please see CXA_MOTION_ERR.

Scope	Name	Type	Comment
VAR_INPUT	`Execute`	BOOL	Resets all internal axis-related errors
VAR_OUTPUT	`Done`	BOOL	Execution finished
VAR_OUTPUT	`Active`	BOOL	Execution in progress
VAR_OUTPUT	`Error`	BOOL	Indicates an error
VAR_OUTPUT	`ErrorID`	ERROR_CODE	Class of error
VAR_OUTPUT	`ErrorIdent`	ERROR_STRUCT	Detailed information about error
VAR_IN_OUT	`Axis`	AXIS_REF	Reference to the axis `CONST`

Pas suivant, en continu.

Une fois que le principe est aquis, le travail peut être continué avec la séquence suivante:

- Prendre une pièce.
- La lever
- Le reposer
- Revenir en état initial
- Continuer tant qu'il n'y a pas de commande stop.

Pas suivant, intégration de l'axe Y.

Si le principe est compris, on intégrera l'axe Y pour déplacer la pièce d'un endroit à un autre.

Intégration complète

On constatera que l'utilisation du principe pour un système complet devient rapidement ingérable. Une option consiste à développer un `Function Block` qui intègre un **Pick & Place** complet avec paramétrage de la position de départ, **Pick**, et la position d'arrivée, **Place**.