HIWIN PCI-4P Motion Library User's Manual

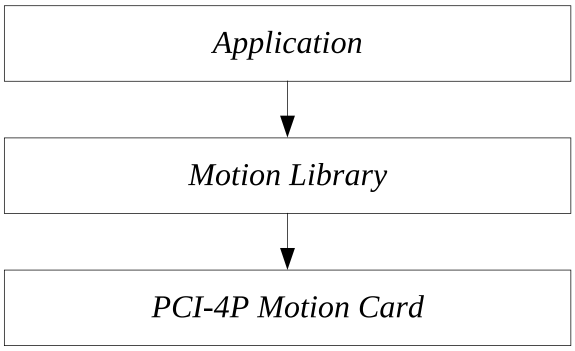
Mar. 3. 2005

Contents

1. Introduction to MCCL Motion Library

HIWIN PCI-4P provides Motion Control C Library (MCCL) and supports Windows 98/2000/XP operating system.

It is to notice that for normal operation of motion library, we fixed some hardware configuration. The relationship of application program with motion library and hardware is shown below.



MCCL provides point to point, linear, arc, and circular trajectory position control; and there are furthermore motion delay, motion dry run, homing, short stroke/pulse/continuous JOG, motion halt and motion abort operations. Position control provides different acceleration/deceleration, feeding speed, maximum speed, and maximum acceleration; besides there are software, hardware limit protection, velocity blending, speed override and error message process to user's requirement.

Regarding I/O signals, users make use of MCCL to read in the home and limit switch signals, and also output servo on/off signal.

To use this motion library, users don't need to understand in depth complicated trajectory planning, position control and real time multiplex environment, through this function library users call functions directly to develop an integrated system in a very short time.

In all documentation of PCI-4P, there are two major categories of position control:

1. Point to point motion, which characterize that axes start their motions at the same time, however they do not necessarily stop at the same time.

2. General motion includes linear, arc and circular trajectory position control. In this case, motions of axes are related and start and stop at the same time.

RELATED MANUALS:

HARDWARE RELATED

HIWIN PCI-4P hardware user's manual

MOTION LIBRARY

HIWIN PCI-4P motion library reference manual
HIWIN PCI-4P motion library example manual
HIWIN PCI-4P motion library user's manual

2. MCCL Features

2.1 Software Specification

■ **Operation System Environment**

✓ WINDOWS 98

✓ WINDOWS 2000/XP

■ **Development Environment**

✓ Visual C++ (VC++)

✓ Visual Basic

■ **Library Name**

MCCL.h, MCCL_Fun.h (for VC++)

MCCLPCI_45.bas (for VB)

MCCLPCI_45.lib (for VC++)

MCCLPCI_45.dll

ACTADrv.dll

2.2 Hardware Specification

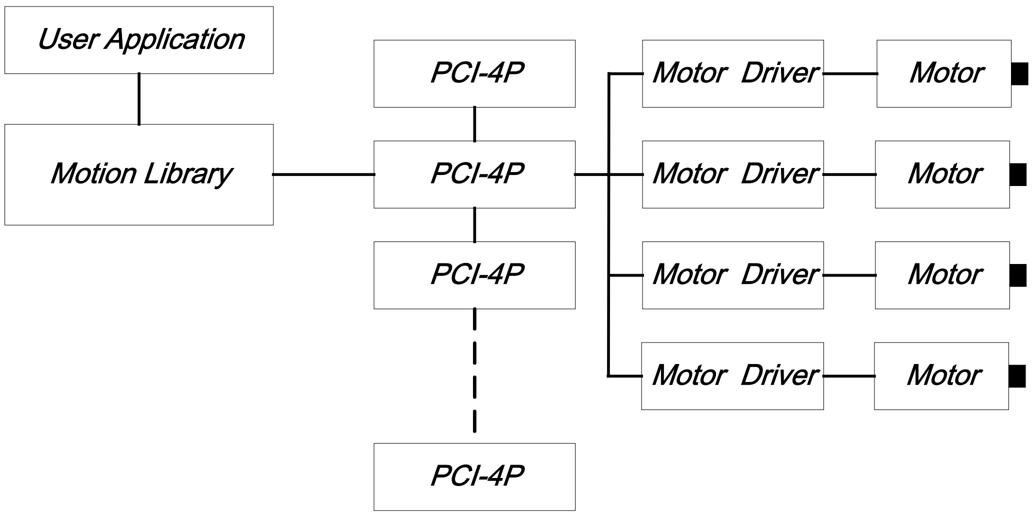


Figure 1 MCCL supports up to 12 PCI-4P cards

MCCL is used with HIWIN PCI-4P card, every HIWIN PCI-4P card controls 4 axes at most; HIWIN PCI-4P card sends out pulses as position command. The basic structure is shown in Figure 1.

2.3 Definition of Control Axes

MCCL is designed for 3 rectangular axes (**X-Y-Z**), plus one extra axis for motion control applications.

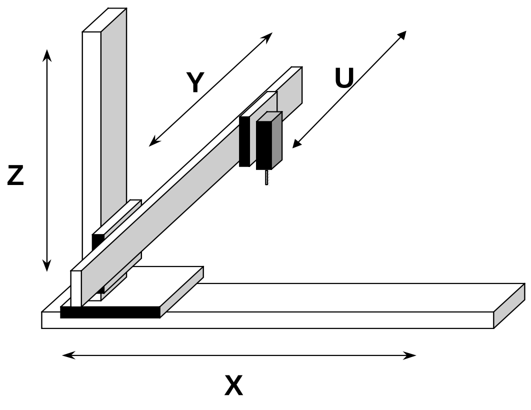


Figure 2 3 Rectangular axes (X-Y-Z), plus auxiliary axis (U)

MCCL provides axes synchronized or unsynchronized control. Motion commands may be given as absolute or relative coordinate values. MCCL internally records positions in absolute coordinates (relative to the origin).

2.4 Mechanism Parameter Setting

MCCL provides the following mechanism parameters to match user's actual mechanism configuration. Each parameter corresponds to origin, coordinate boundary and so on for each axis.

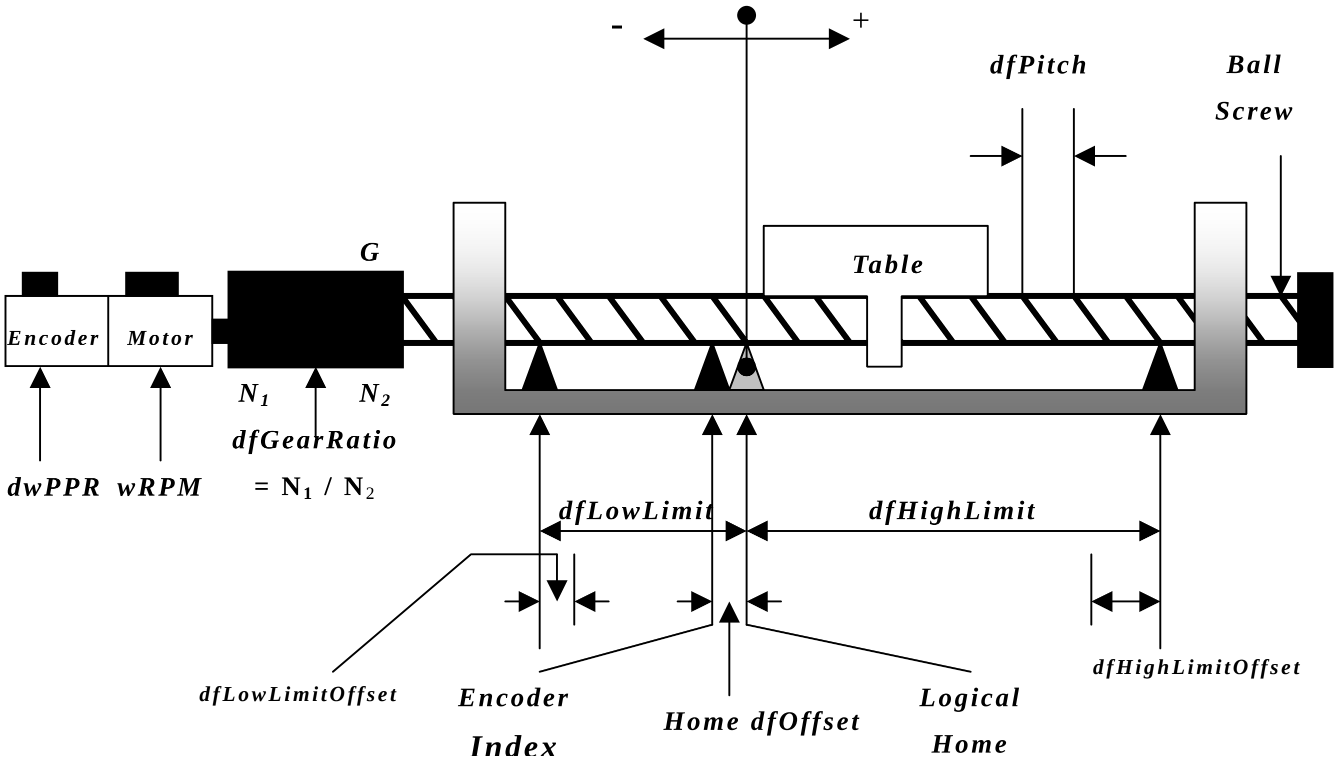


Figure 3 Mechanism parameter setting

Contents of mechanism parameters are explained as follows:

```
typedef struct _SYS_MACH_PARA
{
    WORD                wPosToEncoderDir;
    WORD                wRPM;
    DWORD               dwPPR;
    double              dfPitch;
    double              dfGearRatio;
    double              dfHighLimit;
    double              dfLowLimit;
    double              dfHighLimitOffset;
    double              dfLowLimitOffset;
    WORD                wPulseMode;
    WORD                wPulseWidth;
    WORD                wCommandMode;
    WORD                wPaddle;

    HOME_CONFIG         stHome;
    ENCODER_CONFIG      stEncoder;
    WORD                wOverTravelUpSensorMode;
    WORD                wOverTravelDownSensorMode;
} SYS_MACH_PARAM;
```

wPosToEncoderDir : Direction adjustment parameter.

0	not reverse direction of output command
1	reverse direction of output command

This parameter is used when motion command direction is different from the expected mechanism motion direction. For example if positive motion command was sent but the motor moves in negative direction. Then setting this parameter to ”1” will make motion command direction consistent with the direction of mechanism.

wRPM : Maximum safe speed of motor.

Maximum safe speed. For **point to point motion and jog motion, *wRPM* parameter is used as reference speed.**

➔ *See Also MCC_SetPtPSpeed*()

dwPPR : Pulse per revolution of rotary encoder.

For rotary servomotor, it is set to pulse number of encoder per revolution, after considering 1x, 2x, and 4x encoder mode. The 1x, 2x, and 4x encoder mode is set by *MCC_SetENCInputRate*().

For open loop stepping motor, there is no encoder; it is set to the number of pulses, with which motor would turn one revolution.

For linear motor, this parameter could be set to any value. The recommended value is 3000. However, notice that moving distance is calculated with the following formula:

(Pulse × *dfPitch*)/(*dwPPR* × *dfGearRatio*)

For MCCL function call, the unit is always mm or inch except *MCC_JogPulse*().

dfPitch : Ball screw pitch value. (lead)

This parameter is the table displacement for one revolution of the ball screw; its unit is mm. For linear motors, this value should be set 1.

dfGearRatio : Gear ratio

This is the number of revolutions of rotary motor when ball screw makes one revolution.

dfHighLimit : Set value for positive software limit

This value is the maximum allowable displacement in the positive direction relative to the logical home; its unit is mm.

➔ *See Also MMC_SetOverTravelCheck*()

dfLowLimit : Set value for negative software limit

This value is the maximum allowable displacement in the negative direction relative to the logical home; its unit is mm. This value must be negative.

dfHighLimitOffset： Offset value for *dfHighLimit*

This value must be positive and can't be greater than *dfHighLimit*. After setting in the designated axis, its effective working interval in the positive direction = *dfHighLimit* – *dfHighLimitOffset*

dfLowLimitOffset： Offset value for *dfLowLimit*

This value must be positive and can't be greater than absolute value of *dfLowLimit*. After setting in the designated axis, its effective working interval in the negative direction = *dfLowLimitOffset* + *dfLowLimit*

wPulseMode： Pulse output mode.

0	Pulse/Direction
1	CW/CCW
2	A/B phase

wPulseWidth： Output pulse width.

Set the width of output pulse to satisfy driver's specification. The real output pulse width is the set value multiplied by system cycle width (25 ns). Please follow the driver's specification to set the output pulse width.

wCommandMode： Motion command output mode.

0	pulse command

wOverTravelUpSensorMode： Type of positive limit switch.

0	Normal Open (NO)
1	Normal Close (NC)
2	No limit switch is installed

wOverTravelDownSensorMode： Type of negative limit switch.

0	Normal Open (NO)
1	Normal Close (NC)

3 No limit switch is installed

wPaddle

Reserved data, users don't need to set.

Users should call *MCC_EnableLimitSwitchCheck*() to enable checking limit switch ;but when *wOverTravelUpSensorMode* and *wOverTravelDownSensorMode* are set to 2, then calling *MCC_EnableLimitSwitchCheck*() will have no meaning.

There are two modes to call *MCC_EnableLimitSwitchCheck*().

Mode0: direction sensitive limit switches. For example move in the positive direction and touch the positive limit switch or move in the negative direction and touch the negative limit switch, it will stop outputting pulses (but that command is still in calculation).

Mode1: Not direction sensitive limit switches. As long as the limit switch is engaged, it will stop outputting pulses.

In general,*MCC_EnableLimitSwitchCheck*() and *MCC_GetLimitSwitchStatus*() are used together. If limit switch was engaged, users should call *MCC_AbortMotion*() to abort the motion command in execution.

Homing Parameters (*HOME_CONFIG*):

This defines necessary homing parameters. Format and explanation are as follows. Regarding homing related detailed explanation, please refer to later sections.

```
typedef struct _HOME_CONFIG
{
    WORD    wType;
    WORD    wPhase0Dir;
    WORD    wPhase1Dir;
    WORD    wSensorMode;
    double  dfOffset;
} HOME_CONFIG;
```

***wType*:** Homing mode.

0	NORMAL_MODE	Use the encoder index closest to the home sensor as the mechanism origin. (Mechanism origin is also called electrical origin. Mechanism origin and logical origin will be explained later.)
1	HOME_ONLY_MODE	Home sensor as mechanism origin.
2	INDEX_ONLY_MODE	Use the first encoder index as mechanism origin.

***wPhase0Dir*:** Motion direction for homing phase 0

0	positive direction
1	negative direction

***wPhase1Dir*:** Motion direction for homing phase 1

0	positive direction
1	negative direction

***wSensorMode*:** Type of home sensor

0	Normal Open (NO)
1	Normal Close (NC)

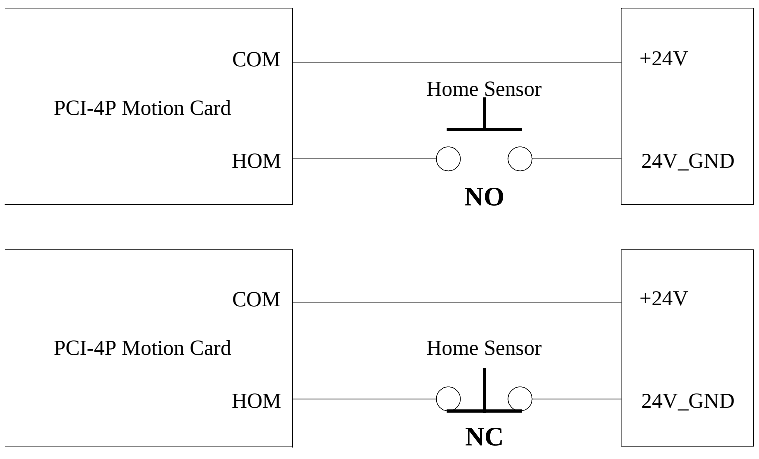


Figure 4 Type of home sensor

***dfOffset*:** Position offset of logical origin.

During homing process and after mechanism origin was found, PCI-4P would move a distance of *dfOffset* and stops. The point of stop is called logical home. Notice that *dfOffset* could be positive or negative value. If it is set to 0, mechanism origin is equal to logical home.

Set Encoder Format (*ENCODER_CONFIG*)：

```
typedef struct _ENCODER_CONFIG
{
    WORD        wType;
    WORD        wAInverse;
    WORD        wBInverse;
    WORD        wCInverse;
    WORD        wABSwap;
    WORD        wPaddle[3];
} ENCODER_CONFIG
```

wType：Encoder type

0	A/B Phase
1	CW/CCW

2	Pulse/Direction

wAInverse： Whether to inverse phase A of encoder

1	Inverse
0	Not Inverse

wBInverse： Whether to inverse phase B of encoder

1	Inverse
0	Not Inverse

wCInverse： Whether to inverse phase Z of encoder

1	Inverse
0	Not Inverse

wABSwap： Whether to swap phase A and B of encoder

0	Swap
1	Not Swap

wPaddle： Reserve data, users don't need to set.

After collecting all the mechanism parameters, use *MCC_SetMachParam*() to set them; an example is shown as follows:

```
SYS_MACH_PARAM      stAxisParam;

stAxisParam.wPosToEncoderDir        = 0;
stAxisParam.dwPPR                   = 500; //    3000 for Linear Motor
stAxisParam.wRPM                    = 3000; // 32767 for Linear Motor
stAxisParam.dfPitch                 = 1.0;
stAxisParam.dfGearRatio             = 1.0;
stAxisParam.dfHighLimit             = 50000.0;
stAxisParam.dfLowLimit              = -50000.0;
stAxisParam.dfHighLimitOffset              = 5.0;
stAxisParam.dfLowLimitOffset               = 5.0;
stAxisParam.wPulseMode                     = 0;//    Pulse/Direction
stAxisParam.wPulseWidth                    = 100;
stAxisParam.wCommandMode                   = 0;//    P-cmd
stAxisParam.wOverTravelUpSensorMode        = 2;//    Not Check
stAxisParam.wOverTravelDownSensorMode      = 2;

stAxisParam.stHome.wType                   = 0;//    NORMAL_MODE
stAxisParam.stHome.wSensorMode             = 0;//    Normal Open
stAxisParam.stHome.wPhase0Dir              = 1;
stAxisParam.stHome.wPhase1Dir              = 0;
stAxisParam.stHome.dfOffset                = 0;

stAxisParam.stEncoder.wType                = 0;//    A/B Phase
stAxisParam.stEncoder.wAInverse            = 0;//    Not Inverse
stAxisParam.stEncoder.wBInverse            = 0;
stAxisParam.stEncoder.wCInverse            = 0;
stAxisParam.stEncoder.wABSwap              = 0;

MCC_SetMachParam(&stAxisParam, 0, 0);//set parameters for axis 0 of 0th-card
```

The mechanism parameters have to be set individually for every axis. Once *MCC_InitSystem*() is called to initialize MCCL and you use *MCC_SetMachParam*() to change mechanism parameters again, it is necessary to call *MCC_UpdateMachParam*() to update them.

➔ *See Also MCC_GetMachParam*()

2.5 Initialize and Close MCCL

2.5.1 Initialize MCCL

Two steps have to finish before using motion library (MCCL): the first is mechanism parameter setting and the second is to initialize MCCL. This is shown as Figure 5.

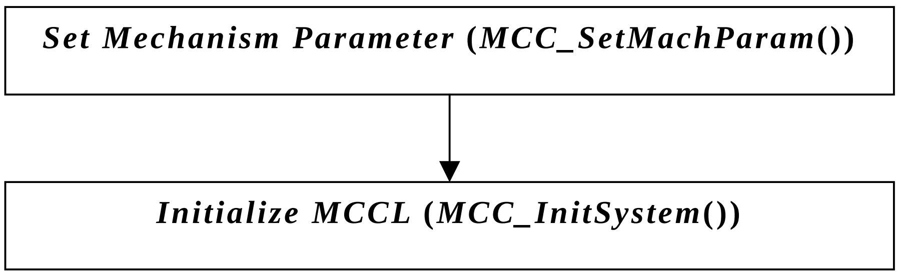

Set Mechanism Parameter (MCC_SetMachParam())
Initialize MCCL (MCC_InitSystem())

Figure 5 Steps before using MCCL

It is not possible to use other functions in MCCL unless the steps are done and no error code is returned. Regarding mechanism parameter please refer to the previous section and **PCI-4P motion library example manual,** the procedure of initializing MCCL is explained as follows:

Set Group Parameter

Before using MCCL, it is necessary to set groups. MCCL uses group operation concept. Most of the functions provided by MCCL use group as operation object. Every group includes x, y, z, u four axes. Groups are dispatched to channels on PCI-4P card. MCCL supports up to 12 PCI-4P cards, and every card can define up to 4 groups. MCCL supports 72 groups. Every group is independent of each other, and won't affect each other's operation. **But to guarantee system's execution efficiency, the less group used the better.** Group related parameters are defined as follows:

```
typedef struct _SYS_GROUP_CONFIG
{
    int                      nGroupUsed[72];
    SYS_GROUP_INFO           stGroupInfo[72];
} SYS_GROUP_CONFIG;
```

nGroupUsed[]

0	Use this group
-1	Not use this group

stGroupInfo[]

Use this to dispatch which channels on which card to a group, please refer to the explanation as below:

typedef struct _*SYS*_GROUP_INFO
{
int *nCardIndex*;
int *nChannel*[6];
} *SYS_GROUP_INFO*;

nCardIndex

Set card number (0 ~ 11) used by group.

***nChannel*[]**

This dispatches channel on the PCI-4P with *nCardIndex* to x, y, z, u axes of a group.

nChannel[0]	*nChannel*[1]	*nChannel*[2]	*nChannel*[3]	*nChannel*[4]	*nChannel*[5]
X	Y	Z	U	not used	not used

Set each according variable in the array to the channel number to dispatch. Setting a value of –1 means that axis is not dispatched and thus no use of that axis. Please set *nChannel*[4] and *nChannel*[5] to –1.

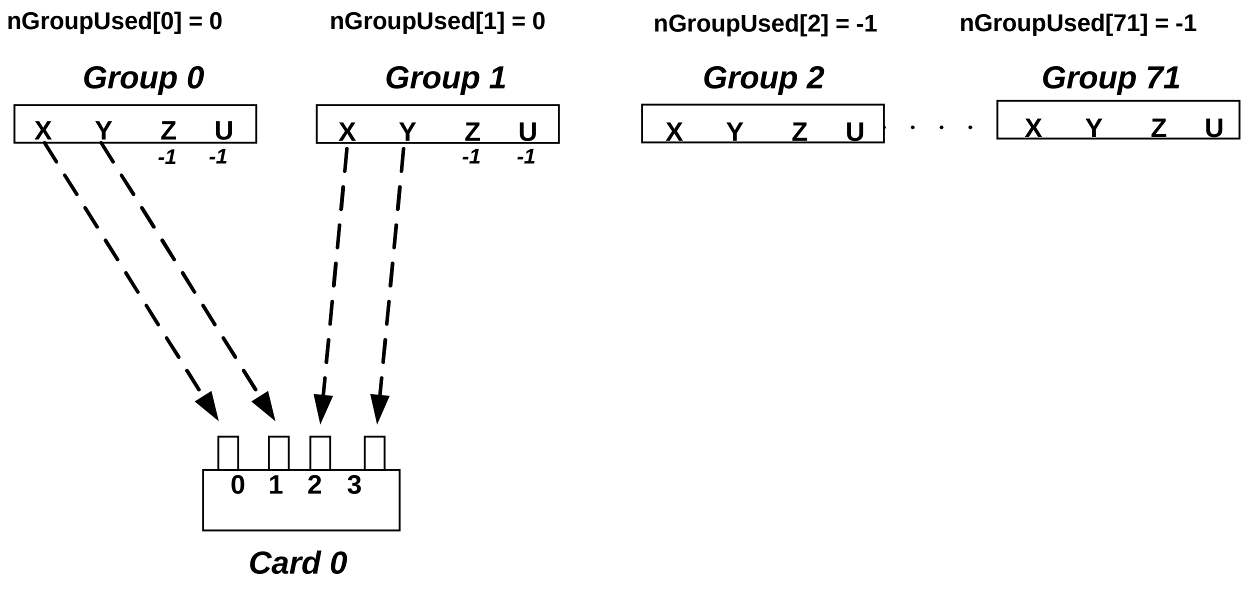


Figure 6 Example of group parameter setting

An example is shown in Figure 6. Two groups are used and one PCI-4P card is inserted. The x, y axis of group 0 are dispatched to channel 0,1 of card 0 and z, u axis in group 0 are not used. The x, y axis of group 1 will be dispatched to channel 3, 4 of PCI-4P card 0 and z, u axis in group 1 are not used. Group parameters are set as follows:

```
SYS_GROUP_CONFIG stGroupConfig;

for (WORD nIndex = 0; nIndex < 72; nIndex++)
      stGroupConfig.nGroupUsed[nIndex] = -1;

stGroupConfig. nGroupUsed[0]                    = 0;
stGroupConfig.stGroupInfo[0].nCardIndex         = 0;
stGroupConfig.stGroupInfo[0].nChannel[0]        = 0;      //X
stGroupConfig.stGroupInfo[0].nChannel[1]        = 1;      //Y
stGroupConfig.stGroupInfo[0].nChannel[2]        = -1;     //Z is not used in example
stGroupConfig.stGroupInfo[0].nChannel[3]        = -1;     //U is not used in example
stGroupConfig.stGroupInfo[0].nChannel[4]        = -1;
stGroupConfig.stGroupInfo[0].nChannel[5]        = -1;
stGroupConfig.nGroupUsed[1]                     = 0;
stGroupConfig.stGroupInfo[1].nCardIndex         = 0;
stGroupConfig.stGroupInfo[1].nChannel[0]        = 2;     //X
stGroupConfig.stGroupInfo[1].nChannel[1]        = 3;     //Y
stGroupConfig.stGroupInfo[1].nChannel[2]        = -1;    //Z is not used in example
stGroupConfig.stGroupInfo[1].nChannel[3]        = -1;    //U is not used in example
stGroupConfig.stGroupInfo[1].nChannel[4]        = -1;
stGroupConfig.stGroupInfo[1].nChannel[5]        = -1;

//   At last call this function to finish setting group parameter.
MCC_SetGroupConfig(&stGroupConfig);
```

Let's take the example of MCC_Line(20, 20, 0, 0, 0, 0, 1), in which the last argument 1 means group number. Thus channel 2, 3 of PCI-4P card 0 will output phases for axis x, y in group 1. Furthermore：

```
MCC_Line(10, 10, 0, 0, 0, 0, 0);     //----    command 0
MCC_Line(15, 34, 0, 0, 0, 0, 0);     //----    command 1
MCC_Line(20, 20, 0, 0, 0, 0, 1);     //----    command 2
MCC_Line(73, 54, 0, 0, 0, 0, 1);     //----    command 3
```

These 4 lines will go into queue for motion executions. The queue for group 0 and group 1 are separate. This means command 0 and command 2 are first command in their queue and will start at the same time. Command 0 and 1 are in queue of group 0. Command 2 and 3 are in queue of group 1.

Without setting group parameters, preset value use group 0 only and x, y, z, u axis of group 0 corresponds to channel 0 ~ 3 of card 0.

Set Hardware Parameter of Motion Control Card

Hardware parameter of motion control card is used to set the type of PCI-4P card. The hardware parameters have to be set before calling *MCC_InitSystem*().

They are defined as follows:

```
typedef struct _SYS_CARD_CONFIG
{
      WORD wCardType;
      WORD wCardAddress;   //not used
      WORD wIRQ_No;        //not used
      WORD wPaddle;        //reserved
} SYS_CARD_CONFIG;
```

***wCardType*:**
For PCI-4P motion control card it is always 2.

***wCardAdress*:** Not used.
This parameter can be any value.

***wIRQ_No*:** Not used.
This parameter can be any value.

***wPaddle*:** Reserve data, users don't need to set.

Initialize MCCL

Use *MCC_InitSystem*() to initialize MCCL，it is declared as follows:

```
int MCC_InitSystem (  int                      nInterpolateTime,
                      SYS_CARD_CONFIG          *psCardConfig,
                      WORD                     wCardNo);
```

nInterpolateTime is interpolation time(please refer to explanation in later section), the unit is ms, range is between 1 ms ~ 1000 ms, in general set to 5ms. *PsCardConfig* is the hardware parameter of PCI-4P motion control card explained earlier. *wCardNo* is the number of totally installed PCI-4P motion control card. The following is an example of using two PCI-4P motion control cards:

```
SYS_CARD_CONFIG stCardConfig[] = {{2, 0x200, 5, 0},{2, 0x240, 7 0}}
MCC_InitSystem(5, stCardConfig, 2);
```

2.5.2 Close MCCL

Call MCC_CloseSystem() to close MCCL.

2.6 Motion Control

2.6.1 Coordinate System

This category includes the following functions:

I. To choose between absolute command relative coordinate system.

➔ *See Also MCC_SetAbsolute*(), *MCC_SetIncrease()*, *MCC_GetCoordType()*

II. To set the unit: inch or mm

➔ *See Also MCC_SetUnit()*, *MCC_GetUnit()*

III. To get current coordinates

➔ *See Also MCC_GetCurPos()*, *MCC_GetPulsePos()*

No matter which coordinate system is selected, MCCL internally use absolute coordinate (relative to logical home).

IV. To enable/disable software limit check

When software limit check is enabled, MCCL will check if the coordinate exceeds limit at each interpolation time. If limit is exceeded, the card will stop. Users can refer to error code by calling MCC_GetErrorCode().

➔ *See Also MCC_GetOverTravelCheck()*, *MCC_ClearError()*

V. To enable/disable limit switch check

➔ *See Also MCC_EnableLimitSwitchCheck(),*
MCC_ DisableLimitSwitchCheck(),
MCC_GetLimitSwitchStatus()

2.6.2 Basic Trajectory Planning

MCCL provides point to point motion and general motion including linear, arc and circular motion. Users should set feeding speed, acceleration/deceleration type (S-curve or T-curve) and acceleration/deceleration time according to the mechanism inertia and special demand. (See also 2.6.3 for setting)

I. Point to point motion

Point to point motion applies to multi axis. Each axis starts simultaneously with its own acceleration/deceleration time and speed, but doesn't have to arrive at the same time (see Figure 7). This is different from general motion. In case of multi axis point to point motion MCCL waits till all the axes have stopped then it proceeds to next motion command.

Call *MCC_PtP*() to do point to point motion. It takes target position or displacement of each axis as arguments. Each axis will move in the given feed speed. If the returned value of *MCC_Pt*P() is smaller than 0, this means command was not accepted. Regarding the reason of rejection of command, please refer to PCI-4P motion library reference manual. If the returned value is greater than or equal to 0, it means command code for this motion command. Use *MCC_ResetCommandIndex*() to reset command code value.

Use *MCC_SetPtPSpeed*() to set the feeding speed of point to point motion for axes in a group, one argument needed is speed ratio. i.e.

feeding speed for axes= maximum safe speed of each axis × (speed ratio / 100)
(Unit: %)

In which the maximum safe speed (mm/sec) = (*wRPM* × *dfPitch)* / (*dfGearRatio* × 60). For example for a speed ratio of 30, the feeding speed for axes are ((*wRPM* × *dfPitch)* / (*dfGearRatio* × 60*))* × 30 / 100 (mm/sec). For linear motor, the feeding speed for axes is ((*wRPM* × *dfPitch* × *wPPR)* / (*dfGearRatio* × 60*))* × 30 / 100 (pulses/sec).

The default feeding speed ratio is 10 %. And the default acceleration/deceleration time is 20 × Interpolation Time.

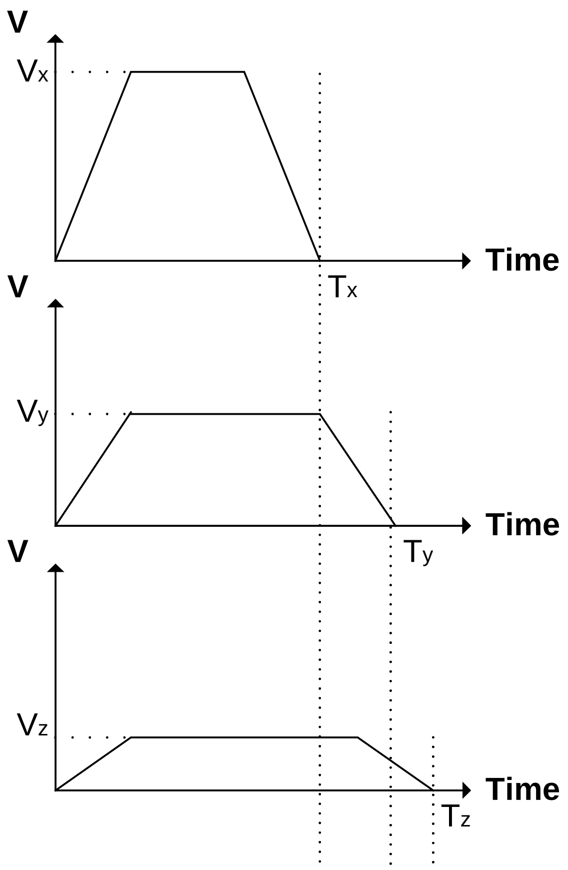


Figure 7 Point to point motion

II. General Motion (Linear, Arc, Circular motion)

General motion includes linear, arc, circular multi axis synchronized motion. If the returned value of general motion function is smaller than 0, this means command was not accepted. Regarding the reason of rejection of command, please refer to PCI-4P motion library reference manual. If the returned value is greater than or equal to 0, it means command code for this motion command. Use *MCC_ResetCommandIndex*() to reset command code value.

A. Linear motion

When using this, users provide target position or displacement for each axis. Regarding speed and acceleration, they are set by *MCC_SetFeedSpeed*() and *MCC_SetAccStep*(). The default acceleration/deceleration time is 20 × interpolation time.

➔ *See Also MCC_SetFeedSpeed*(), *MCC_Line*()

B. Arc motion

When using this, users provide a reference point (center) and a target point. Regarding speed and acceleration, they are set by *MCC_SetFeedSpeed*() and *MCC_SetAccStep*(). The default acceleration/deceleration time is 20 × interpolation time. MCCL also provides **3-D arc motion**.

➔ *See Also MCC_SetFeedSpeed*(), *MCC_ArcXYZ*(), *MCC_ArcXY*(), *MCC_ArcYZ*(), *MCC_ArcZX*()

C. Circular motion

When using this, users provide a center point and motion direction (clockwise or counterclockwise). Regarding speed and acceleration, they are set by *MCC_SetFeedSpeed*() and *MCC_SetAccStep*(). The default acceleration/deceleration time is 20 × interpolation time.

➔ *See Also MCC_CircleXY*(), *MCC_CircleYZ*(), *MCC_CircleZX*()

D. Set feeding speed for General motion

The feeding speed for general motion is set by *MCC_SetFeedSpeed*(). The value should not exceed the value for *MCC_SetSysMaxSpeed*(). The speed is in target direction of motion.

➔ *See Also MCC_GetFeedSpeed*(), *MCC_GetCurFeedSpeed*(), *MCC_GetSpeed*()

III. Jog

There are 3 types of jog.

A. Pulse Jog

Jog with a distance designated in pulses (maximum pulse number= 2048); this command can only be used when there is no motion. For example:

```
MCC_JogPulse(10,                        0,                 0)
             Displacement (pulse),      axis number,       group index
```

B. Short stroke Jog

Jog with a distance designated in mm or inch. Its speed is set as speed ratio (similar to point to point motion); use *MCC_AbortMotion*() to stop. For example:

```
MCC_JogSpace(1,                  20,                0,            0)
             Displacement (mm), feed speed ratio,axis number,group index
```

C. Continuous Jog

Jog continuously. Its speed is set as speed ratio (similar to point to point motion). When it moves to the border, which is set by mechanism parameter, it will stop. When software limit or limit switch are reached and their checks are enabled, it will also stop; use *MCC_AbortMotion*() to stop. For example:

```
MCC_JogConti(0,               20,                   0,              0);
             Direction,       feed speed ratio,     axis number,    group index
             (0: positive, 1: negative)
```

IV. Hold, continue, and abort motion

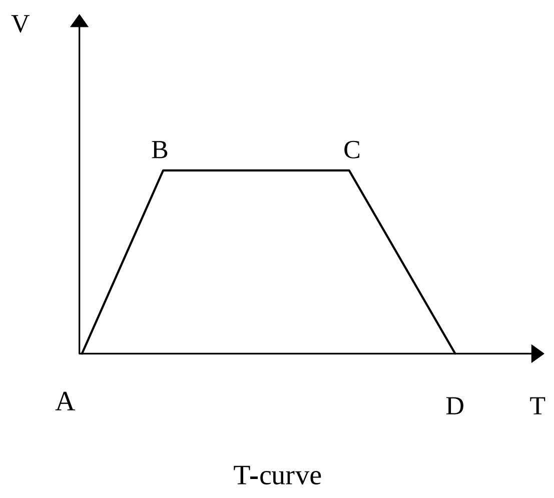
Use *MCC_HoldMotion*() to halt current command in execution (it slows with constant deceleration and then stop motion). Then use *MCC_ContiMotion*() to resume and finish executing the undone motion. Use *MCC_AbortMotion*() to abort a motion in execution or to discard a hold motion.

➔ *See Also MCC_GetMotionStatus*()

2.6.3 Advanced Trajectory Planning

For more flexible, more efficient position control, MCCL provides advanced trajectory planning. There are two types of velocity profile, namely T-curve and S-curve. There is also velocity blending between different motion command, and reach the designated position quicker. There is also speed override to adjust feeding speed.

I. Acceleration/deceleration type



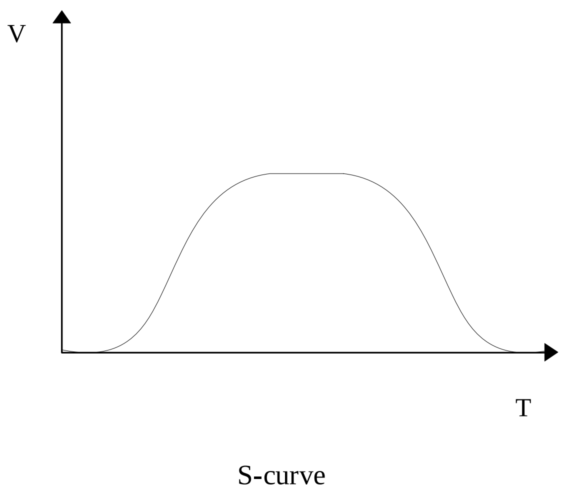


Figure 8 Acceleration/deceleration type

There are trapezoidal curve or S curve velocity profile. For general motion, the acceleration/deceleration type is the same for each axis in a group. However, for point to point motion it is possible to set different type for different axis. In S curve velocity profile, the s-factor is 1; this means the acceleration profile is triangular curve.

➔ *See Also MCC_SetAccType*(), *MCC_GetAccType*()
MCC_SetDecType(), *MCC_GetDecType*()
MCC_SetPtPAccType(), *MCC_GetPtPAccType*()

MCC_ SetPtPDecType(), *MCC_ GetPtPDecType*()

II. Velocity blending

Use *MCC_EnableBlend*() to enable velocity blending function; this function provides smooth transition in velocity between different motion commands. There are:

✓ Line-line, line-arc, arc-arc motions:
It makes tangent speed and trajectory continuous.

✓ Continuous trajectory of point to point motion:
It makes each axis's speed and trajectory continuous.

In set continuous trajectory motion, let constant speeds in different part motion commands to become a continuous speed from one region to the second region as in Figure 9, after the first constant speed region directly use S curve to accelerate continuously to the second constant speed region of motion command, thus the execution time of all the trajectory is faster, but in the connection of commands there is some distortion exist. The diagram is shown in Figure 10. As shown in Figure 9, the velocity transition between two motion commands is smooth. The deceleration of first command and acceleration of second command is no more there. This shortens the time to target. However the path deviates from their original path.

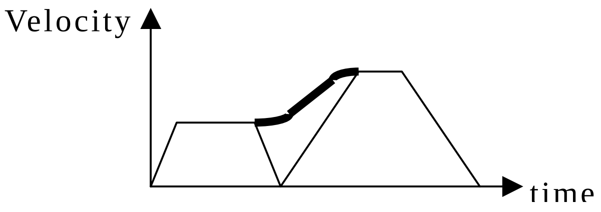
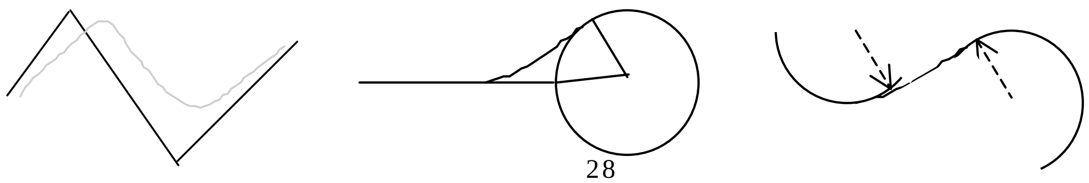


Figure 9 Speed graph of velocity blending



line-line line -arc arc-arc

Figure 10 line-line, line-arc, arc-arc motion

➔ *See Also MCC_DisableBlend*(), *MCC_CheckBlend*()

III. Speed override

In motion system, there are situations, where speed override becomes important. Flying scissor mechanism is an example. When speed override is executed, MCCL behaves like a new command is received. It accelerates from current speed V_1 to the override speed V_2 (when $V_1 < V_2$), or from current speed V_1 decelerates to the override speed V_2 (when $V_1 > V_2$), as in Figure11.

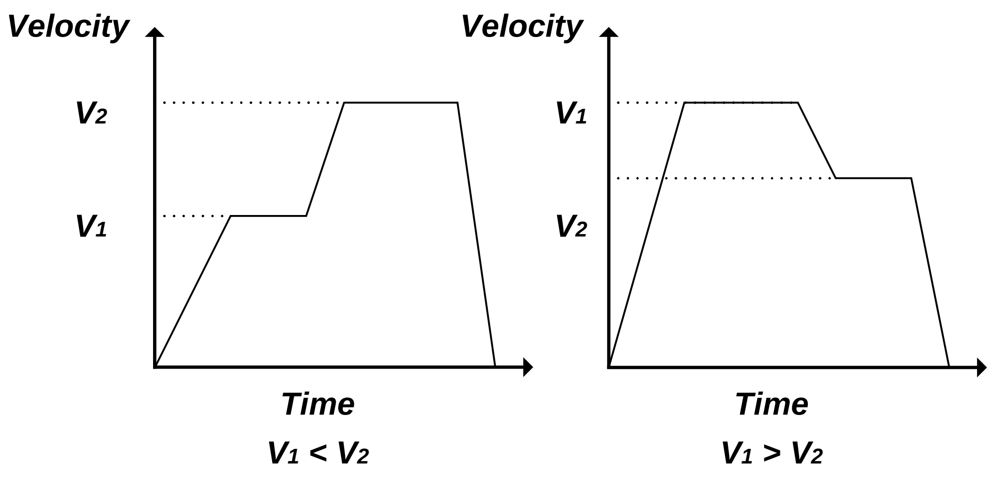


Figure 11 Speed override

✓ For general motion:

Call *MCC_SetOverSpeed*() to set the speed override ratio and enforce changing the tangent speed instantly. The speed ratio is

speed ratio = new speed / original speed × 100 in which original speed means the speed set by *MCC_SetFeedSpeed*().

➔ *See Also MCC_GetOverSpeed*()

✓ For point to point motion:

Call *MCC_SetPtPOverSpeed*() to set the speed override ratio and enforce changing every axis's speed. Please refer to the last section for definition of speed ratio.

➔ *See Also MCC_GetPtPOverSpeed*()

IV. Motion dry run

Use *MCC_EnableDryRun*() to enable motion dry run. When this is enabled, pulses won't be sent out. But the users can use *MCC_GetCurPos*() and *MCC_GetPulsePos*() to get the interal result of trajectory planning. Together with proper graphic routines, the function can help users to get motion trajectory to simulate on the screen.

➔ *See Also MCC_DisableDryRun*(), *MCC_CheckDryRun*()

V. Motion delay

Use *MCC_DelayMotion*() to get delay between motion commands. The unit of delay time is the interpolation time (interpolation time is explained in coming section); an example is shown as follows:

```
MCC_Line(10, 10, 10, 0, 0, 0);---------A
MCC_DelayMotion(200);
MCC_Line(15, 15, 15, 0, 0, 0);---------B
```

After finishing the motion command A, it will delay 200 × interpolation time, then the motion command B will be executed.

➔ *See Also MCC_CheckDelay*()

VI. Error code

There are errors like over travel, exceeding the maximum set speed, acceleration, arc command error and error during arc command execution etc. Users can use *MCC_GetErrorCode*() to get the error codes. (Please refer to "HIWIN PCI-4P motion library reference manual" about error codes.) When errors occur, MCCL stops execution of all motion commands. Therefore, users have to call *MCC_GetErrorCode*() to identify the error reason, and use *MCC_ClearError*() to clear errors after which system will return to its normal state.

2.6.4 Interpolation Time and Acceleration/Deceleration Step Setting

I. Interpolation time

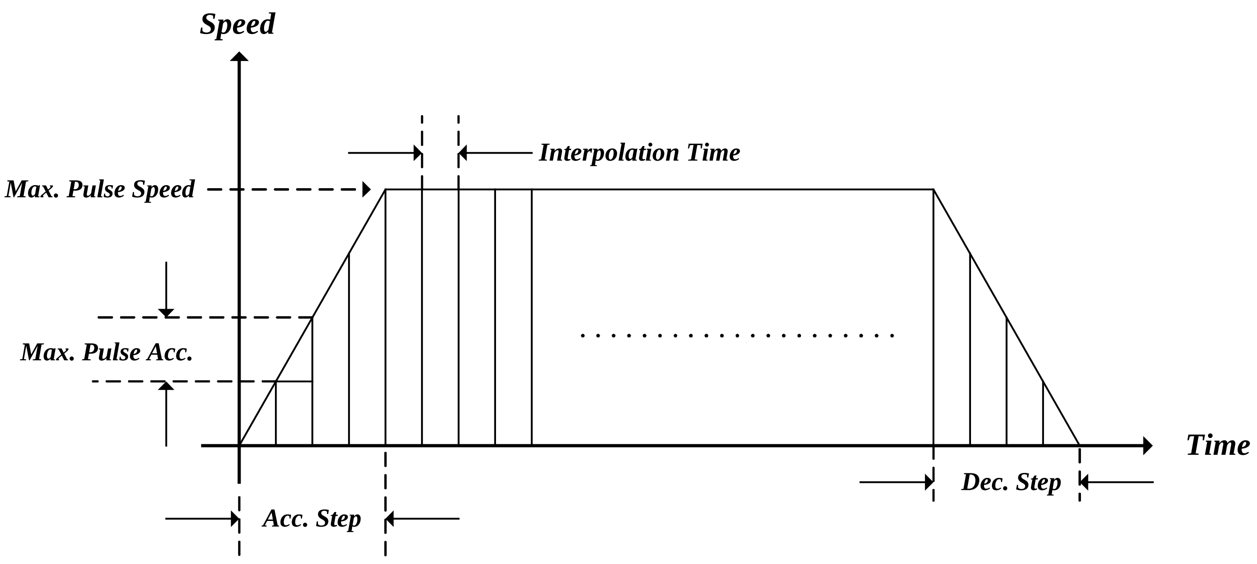


Figure 12 Interpolation time and related parameters

Interpolation time means the time between two interpolation points, as in Figure 12. This is important for MCCL internal calculation. Minimum value is 1 ms, maximum value is 1000 ms. Users can call *MCC_InitSystem*() to set interpolation time, or also use *MCC_SetInterpolationTime*() to set it later any time.

Interpolation time will affect acceleration/deceleration time, interpolation accuracy, maximum speed, minimum speed and maximum acceleration/deceleration. The maximum speed in pulse/ms is calculated by:

Max. Pulse Speed = (32768 / interpolation time) (pulse / millisecond)

➔ *See Also MCC_SetMaxPulseSpeed*(), *MCC_SetMaxPulseAcc*()

The minimum pulse sent in every interpolation time is 1. The minimum speed in pulse/ms is calculated by

Min. Pulse Speed = (1 / interpolation time) (pulse / millisecond)

II. Set maximum pulse speed

Maximum pulse speed is used to restrict maximum pulse numbers that can be sent out in every interpolation time and thus restrict feed speed of axis. Use *MCC_SetMaxPulseSpeed*() to set it. The valid value can be set among 1~32768 and its default value is 30000 pulses.

➔ *See Also MCC_GetMaxPulseSpeed*()

III. Set maximum pulse acceleration/deceleration

Maximum pulse acceleration/deceleration is used to restrict the difference of sent pulses between two neighbored interpolation times, thus the tracking error will be reduced. If acceleration/deceleration time is set too small, acceleration/deceleration will become too big for mass of the mechanism. Users can use *MCC_GetErrorCode*() to diagnose if the acceleration/deceleration is too large in motion. Users can set maximum pulse acceleration/deceleration by *MCC_SetMaxPulseAcc*(); the value range is 1~32768 and its default value is 30000 pulses.

➔ *See Also MCC_GetMaxPulseAcc*()

IV. Acceleration/Deceleration step

The acceleration/deceleration time is calculated as follows:

Acceleration time = acceleration step × interpolation time

Deceleration time = deceleration step × interpolation time

Use *MCC_SetAccStep*() and *MCC_SetDecStep*() for general motion. Use *MCC_SetPtPAccStep*() and *MCC_SetPtPDecStep*() for point to point motion. Normally for higher feeding speed, users should set bigger acceleration time. Therefore, *MCC_SetAccStep*() and *MCC_SetDecStep*() are usually used with *MCC_SetFeedSpeed*(), so are *MCC_SetPtPAccStep*(), *MCC_SetPtPDecStep*() and *MCC_SetPtPSpeed*().

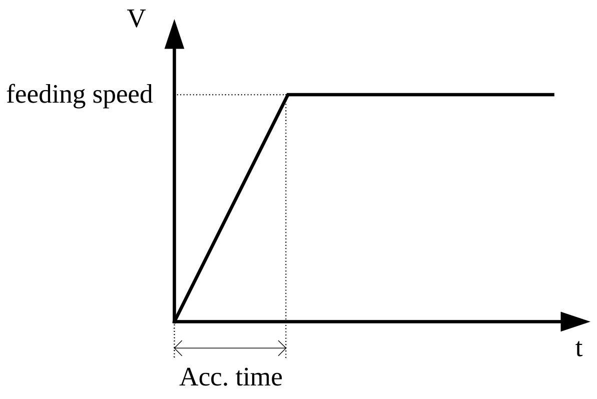


Figure 13 Acceleration

To calculate the acceleration, use the formula:

a = feeding speed / Acc. Time

in which feeding speed is in m/s and Acc. Time is in second, thus the acceleration is in m/s^2. Use F = m × a to calculate the thrust force.

2.6.5 System Status

Use *MCC_GetCurPos*() to get current command position in mm or inch unit. Users can also use *MCC_GetPulsePos*() to get current command position in pulse unit. If the system includes an encoder, use *MCC_GetENCValue*() to get feedback position (unit: pulse).

Users can use *MCC_GetPtPSpeed*() to get the feeding speed ratio of point to point motion.

For general motion use *MCC_GetCurFeedSpeed*() to get current feeding speed; use *MCC_GetSpeed*() to get speed component of each axis in a group; use *MCC_GetFeedSpeed*() to get feeding speed.

Use the return value of *MCC_GetMotionStatus*() to get current motion status. If the return value is 0 system is normal; if the return value is 1 motion is stopped; and if the return value is 2 motion is hold by *MCC_HoldMotion*(),.

Use *MCC_ GetCurCommand*() to get information of the motion command in execution. The prototype of *MCC_GetCurCommand*() function is as follows:

```
MCC_GetCurCommand(COMMAND_INFO *pstCurCommand,
                                WORD wGroupIndex)
```

COMMAND_INFO saves information of the motion command in execution. It is defined as follows:

```
Typedef struct _COMMAND_INFO
{
     int       nType;
     int       nCommandIndex;
     double    dfFeedSpeed;
     double    dfPos[6];
} COMMAND_INFO;
```

***nType*: ** Motion command type

0	point to point motion
1	linear motion
2	clockwise arc or circular motion
3	counterclockwise arc or circular motion

***nCommandIndex*: ** motion command index

***dfFeedSpeed*:** feeding speed for general motion; speed ratio for point to point motion

***dfPos*[]:** target position; *dfPos*[4] and *dfPos*[5] are not used

Use *MCC_GetCommandCount*() to get the number of motion commands which have not been executed. The motion command in execution is not counted. If the return value of *MCC_GetMotionStatus*() were 1, the number of motion commands in stock would be 0.

2.7 Homing

Users can set the order, speed, direction and mode of homing for each axis. The order of homing for each axis is defined by parameters *nXOrder* ~ *nUOrder* in *MCC_GoHome*(). Homing process of PCI-4P motion card is divided into phase 0 ~ phase 3 and explained as follows:

Phase 0: search and enter into home sensor area

In this phase, it searches home sensor (HOM0 ~ HOM3) with the speed (*dfXSpeed* ~ *dfUSpeed*) in *MCC_GoHome*() and the direction *wPhase0Dir* in mechanism parameter. When home sensor is ON then it starts to decelerate and stop. At the position where it stops, **home sensor must be ON, otherwise users should lower *homing speed* and call *MCC_GoHome*() again.** Call *MCC_SetGoHomeDecStep*() and *MCC_SetGoHomeAccStep*() to set acceleration/deceleration steps.

Phase 1: leave home sensor area

Leave home sensor area in the direction of *wPhase1Dir* set by mechanism parameter. When home sensor is OFF, phase 1 is finished.

Phase 2: search encoder index

It moves in the direction of *wPhase1Dir* and finds the nearest index signal and stops.

Phase 3: move to logical home

It moves a distance defined by *stHome.dfOffset* in mechanism parameter and stops. The position of stop is the logical home.

The speed for phase 1, 2, 3 is about 1/10 of that for phase 0.

The mode of homing is set by *stHome.dfType* in mechanism parameter.

1. *stHome.dfType* = 0 (NORMAL_MODE): It will execute phase 0~phase 3.

2. *stHome.dfType* = 1 (HOME_ONLY_MODE): It will execute phase 0, 1 and 3. (Phase 2 is not executed)

3. *stHome.dfType* = 2 (INDEX_ONLY_MODE): It will execute phase 2 and 3.

Function call procedure:

1. Set *stHome* in mechanism parameter (please refer to previous section)

2. Call MCC_GoHome(
   double *dfXSpeed*, double *dfYSpeed*, double dfZSpeed,
   double *dfUSpeed*, double *dfVSpeed*, double *dfWSpeed*,
   int *nXOrder*, int *nYOrder*, int *nZOrder*,
   int *nUOrder*, int *nVOrder*, int *nWOrder*,
   WORD *wCardIndex*)

Where

dfXSpeed ~ dfUSpeed:	Speed of homing for each axis (mm/sec)
dfVSpeed, dfWSpeed:	not used
nXOrder ~ nUOrder:	Order of homing
nVOrder, nWOrder:	not used
wCardIndex:	Motion control card index

During homing process, users can use *MCC_AbortGoHome*() to stop homing and also can use the return value of *MCC_GetGoHomeStatus*() to check if home is finished. If the return value is 1, homing is finished. If the return value is –1, homing is in process.

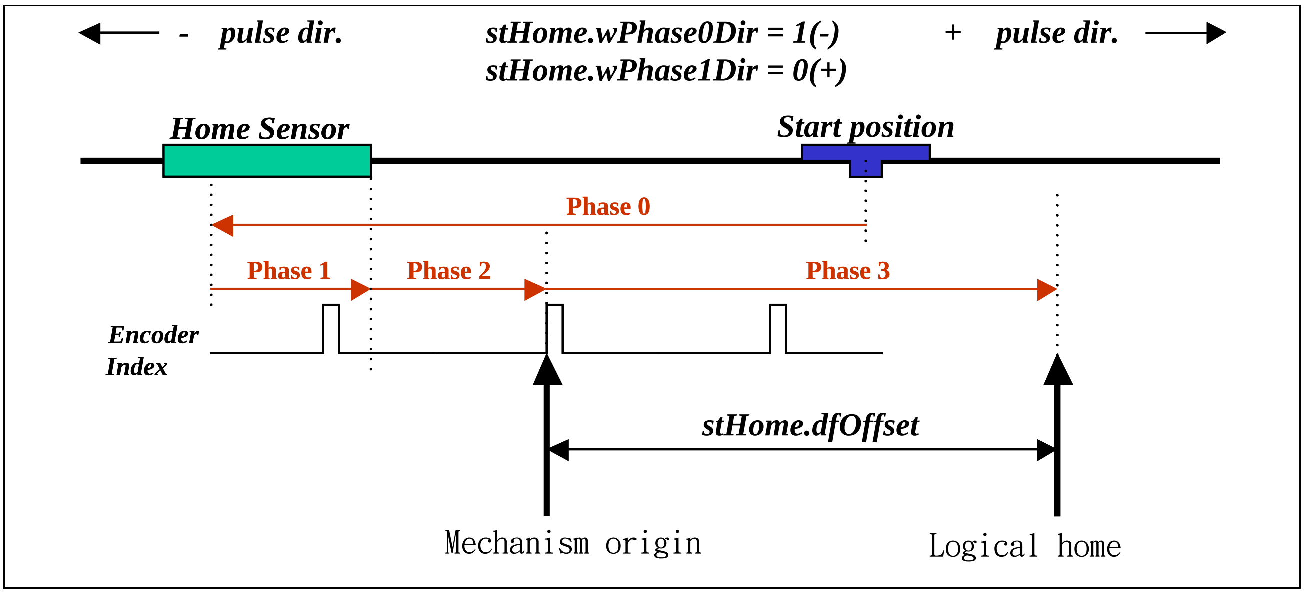


Figure 14 Homing example 1

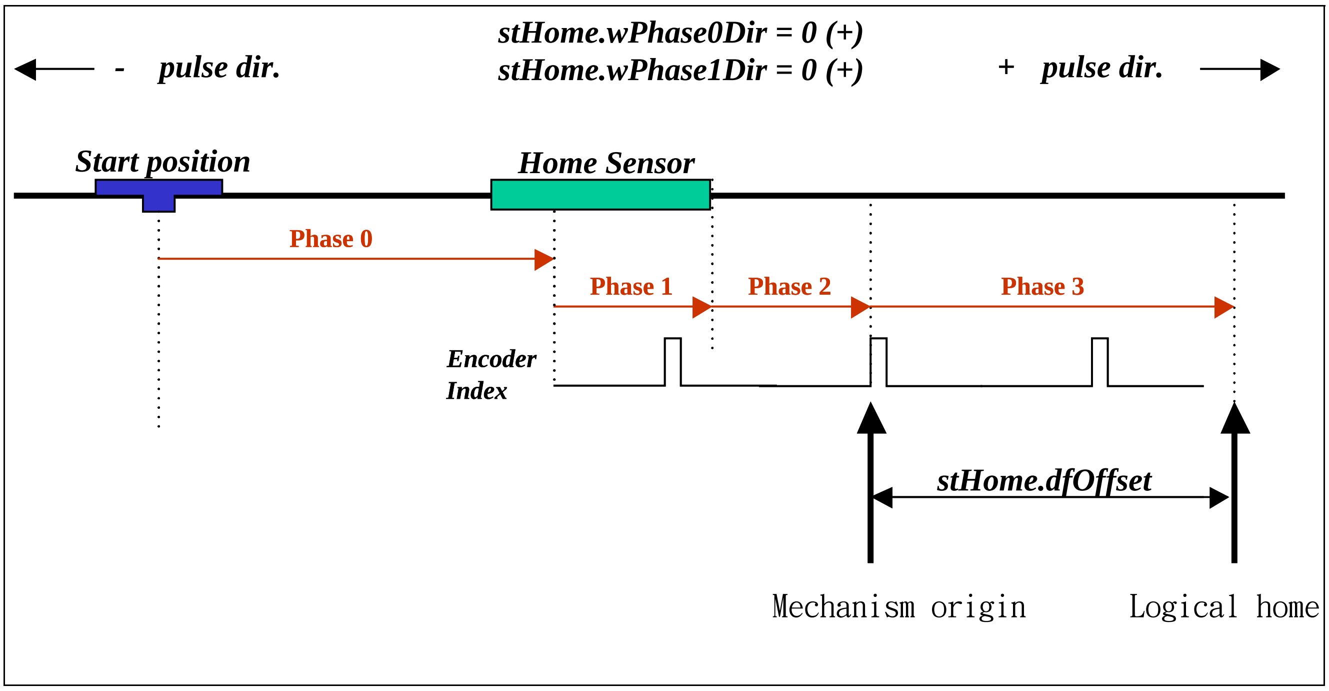


Figure 15 Homing example 2

2.8 Local Input/Output (I/O) Control

Local input and output include limit switch, home sensor, servo on and PRDY signals.

2.8.1 Input

The local input on PCI-4P:

a. There are 4 home sensor input pins (HOM0, HOM1, HOM2, HOM3), and users can use *MCC_GetHomeSensorStatus*() to read the signals.

b. There are 4 positive limit switch input (OT0+, OT1+, OT2+, OT3+) and 4 negative limit switch input (OT0-, OT1-, OT2-, OT3-). Users can use *MCC_GetLimitSwitchStatus*() to read the signals.

c. There is 1 emergency stop input. User must open JP6 to enable emergency stop function (JP6 Default: Short circuit). User can use *MCC_GetEmgcStopStatus*() to read the signal. If emergency stop signal is received, the motion card will stop outputting pulses. If user want to send pulses again, user must remove emergency stop signal and then call *MCC_InitSystem*() function to initialize the system.

2.8.2 Output

The local output on PCI-4P:

a. There are 4 servo on/off control pins (SVN0, SVN1, SVN2, SVN3), and users can use *MCC_SetServoOn*() and *MCC_SetServoOff*() to output servo on/off signals.

b. There is 1 position ready signal (PRDY) for one PCI-4P card, and users can use *MCC_EnablePosReady*() and *MCC_DisablePosReady*() to set or clear the signal.

2.9 Encoder Control

Users have to set correctly the according parameters for encoder in mechanism parameters.

If *stEncoder.wType* in mechanism parameters is set to 0 i.e. the input mode of encoder is set to A/B phase, users can use *MCC_SetENCInputRate*() to set the encoder mode. This value can be set to 1, 2 and 4 i.e. ×1, ×2 and ×4. The default encoder mode is ×4.

Use *MCC_GetENCValue*() to get the encoder count value.

NOTICE

Please confirm that motion command and Encoder feedback value has the same direction. If not, set Encoder mechanism parameter *AB_swap = YES*, so that motion command and Encoder feedback have the same direction definition.

2.10 Compensation and In-Position Control

2.10.1 Compensation

Due to reality of manufacturing, it may make the system inaccurate in position control. Foe examples pitch error, backlash error of ball screws and the scale error of linear encoder system.

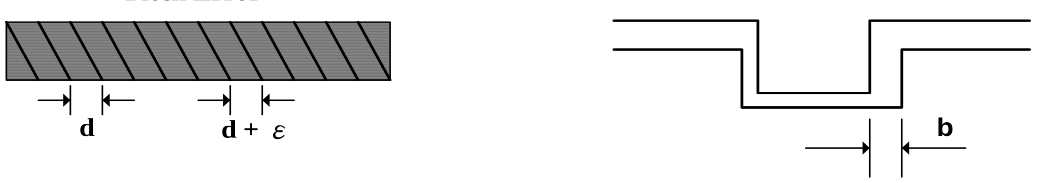


Figure 16 Pitch error, Backlash error

User can divide the whole stroke into several sections (see Fig.17). Use laser interferometer to measure the error of forward and backward direction and establish the compensation table. The compensation table consists of 2 arrays; forward and backward. User need to designate *dwInterval, wHome_No*, *nForwardTable* and *nBackwardTable* and call MCC_SetCompParam() and MCC_UpdateCompParam() to enable compensation. MCCL offers 256 compensation points for each axis; it means it can be divided into 255 sections. In each section, MCCL uses linear interpolation. **Notice also that the compensation range must cover the whole stroke of the system.**

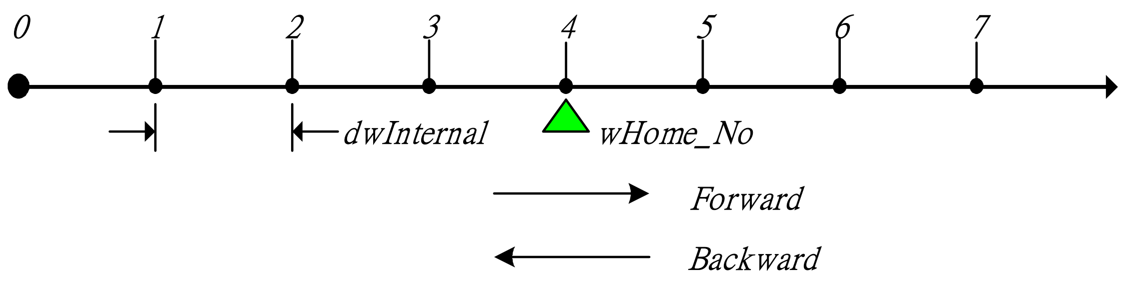


Figure 17 Compensation sections

Contents of compensation parameters are explained as follows:

```
typedef struct _SYS_COMP_PARAM
{
    DWORD    dwInterval;
    WORD     wHome_No;
    WORD     wPaddle;
    int      nForwardTable[256];
    int      nBackwardTable[256];
} SYS_COMP_PARAM;
```

dwInterval : measurement interval. Unit is pulse. If the value is less than or equal to zero, it means compensation is disabled.

wHome_No : This designates where the home is along the whole stroke.

wPaddle : Reseved.

nForwardTable[ ] : the forward compensation table.

nBackwardTable[ ] : the backward compensation table.

As shown in Fig.17, it divides the axis into 7 sections; it is necessary to measure 8 points (0 ~ 7). If the *wHome_No* is 4, this means that the home point is at the end of fourth section. The compensation value at home must be set 0. If *dwInterval* is set to 10000(pulse), it means the positive range is 10000 × (7 – 4) = 30000 (pulses) and the negative range is 10000 × (4 - 0) = 40000 (pulses). The mechanism parameters (*dwHighLimit*, *dwLowLimit*, *dwHighLimitOffset*, *dwLowLimitOffset)* must correspond to the compensation setting. The compensation parameter of each axis must be set separately. An example is shown as follows:

```
SYS_COMP_PARAM      stUserCompParam;

stUserCompParam.dwInterval              = 10000;
stUserCompParam.wHome_No                = 4;

stUserCompParam.nForwardTable[0]       = 22;//    Unit is pulse
stUserCompParam.nForwardTable[1]       = 20;
stUserCompParam.nForwardTable[2]       = 15;
stUserCompParam.nForwardTable[3]       = 11;
stUserCompParam.nForwardTable[4]       = 0;   //    Home position
stUserCompParam.nForwardTable[5]       = 10;
stUserCompParam.nForwardTable[6]       = 12;
stUserCompParam.nForwardTable[7]       = 15;

MCC_SetCompParam(&stUserCompParam, 0, CARD_INDEX);
```

MCC_UpdateCompParam();

MCCL uses linear interpolation within every section. For example, the motor of X axis stands at home position then user wants to move 15000 pulses. From the compensation table, it is known that the target is between nForwardTable[5] and nForwardTable[6] (Because the target position is between 10000 pulses and 20000 pulses). Since nForwardTable[5] = 10 and nForwardTable[6] = 12, the actual command is 15000 + 10 + round((15000 – 10000)/ 10000 × (12 – 10)) = 15000 + 10 + 1 = 15011 pulses.

2.10.2 Enable/Disable In-Position

User can use MCC_SetInPosTolerance() to set the in-position tolerance and call MCC_EnableInPos() to enable in-position check. When executing two consecutive commands, at the end of the first motion it ensures the error to be within the in-position tolerance before going on to the next motion.

If user enables in-position check, after MCCL completed compute and sent all pulses, then MCCL check whether the position error is within the tolerance. If it checks OK, it executes the next motion command. If there is certain axis which didn't become in-position after the check time has passed (the check time is set by MCC_SetInPosCheckTime()), the system error occurs and the following motion commands are stopped. User can call MCC_GetErrorCode() to read error code.

In Figure 18, the tolerance of X and Y axis is *Tolerance[0]* = 0.5mm, *Tolerance[1]* = 0.3mm respectively. If the target position is (100, 100) and current position is (99.7, 99), the X axis becomes in-position but Y axis is not. Thus it is not in-position.

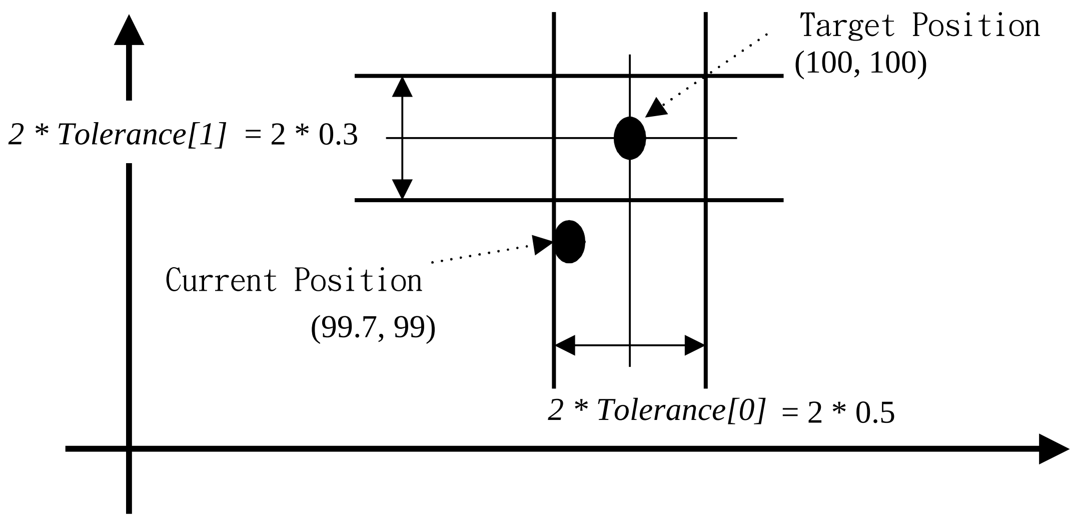


Figure 18 In-position tolerances setting

The larger the in-position tolerance, the shorter the execution time. But there is larger error between the actual trajectory and planned trajectory near the connect point (see Fig.19). Thus the range setting of in-position tolerance depends on the requirements of different systems. User can use MCC_GetInPosStatus() to check whether the error is within the tolerance.

➔ *See Also MCC_GetInPosToleranceEx*() *MCC_DisableInPos()*

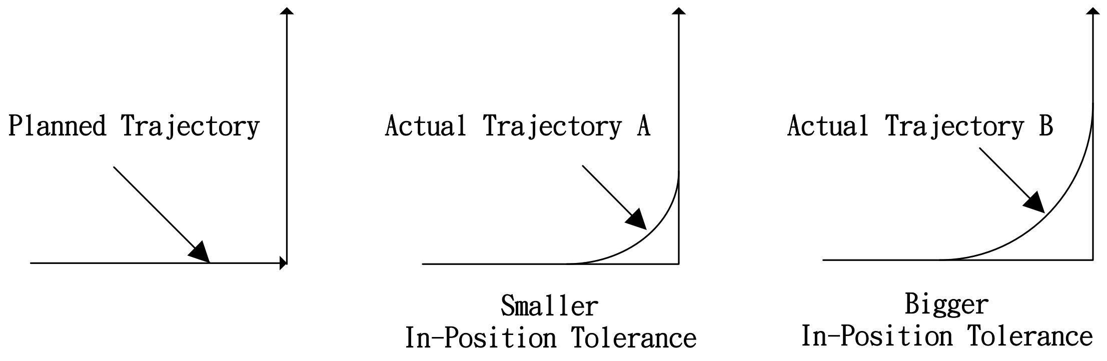


Figure 19 In-position tolerance effect

3. Compiler Environment

3.1 Using Visual C++

Including Files

MCCL.h

MCCL_Fun.h

Import Library **(users have to add this file into project)**

MCCLPCI_45.lib

Dynamic Library (dynamic link file for run-time)

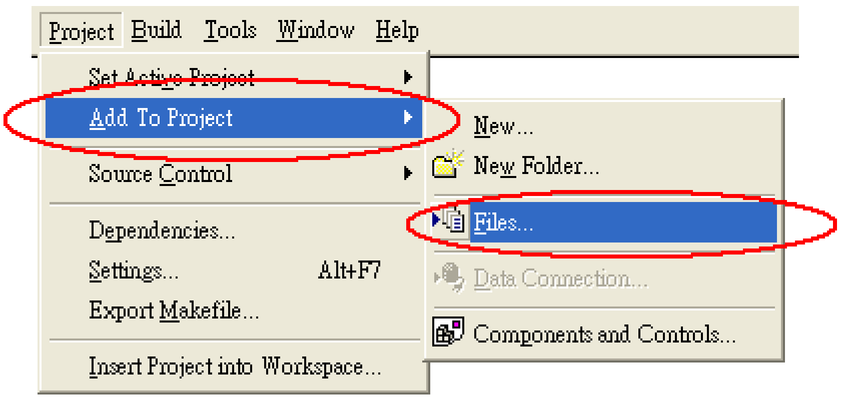
MCCLPCI_45.dll

ACTADrv.dll

It is shown below how to import Library i.e. the process of adding MCCLPCI_45.lib into project.

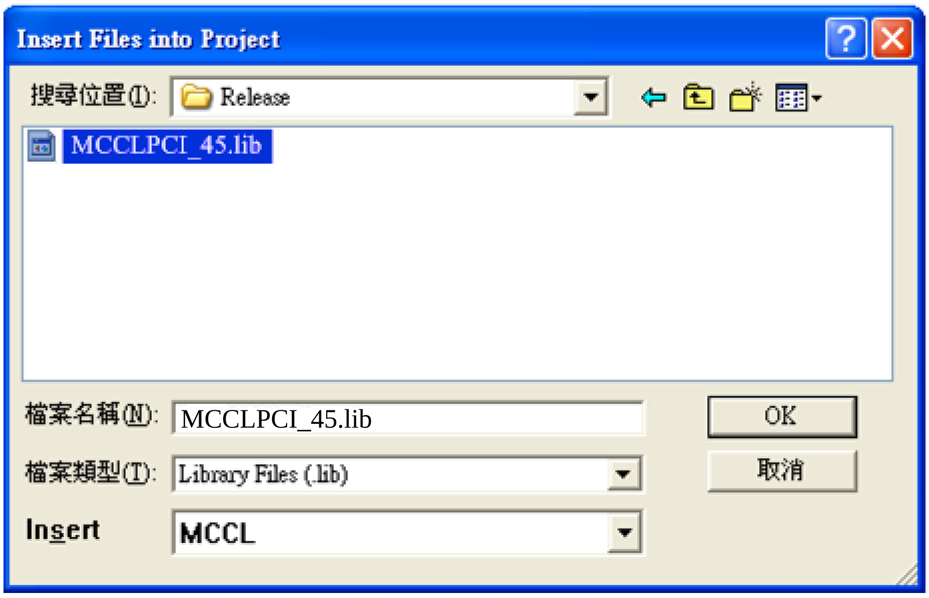
Step 1:

Use **[Add To Project]** under **[Project]**



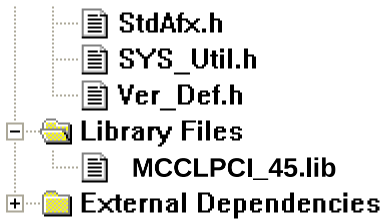
Step 2:

Select **MCCLPCI_45.lib** add into Project



檔案名稱(N): MCCLPCI_45.lib
檔案類型(T): Library Files (.lib)
Insert: MCCL

It shows that the MCCLPCI_45.lib has been added into project.



3.2 Using Visual Basic

Including Files

MCCLPCI_45.bas

Dynamic Library (dynamic link file for run-time)

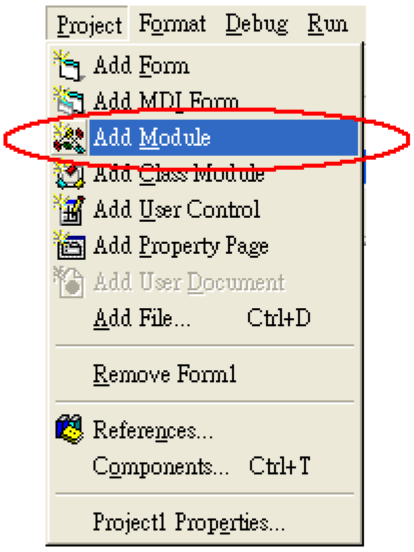
MCCLPCI_45.dll

ACTADrv.dll

It is shown below how to add the required module i.e. the process of adding MCCLPCI_45.bas into project.

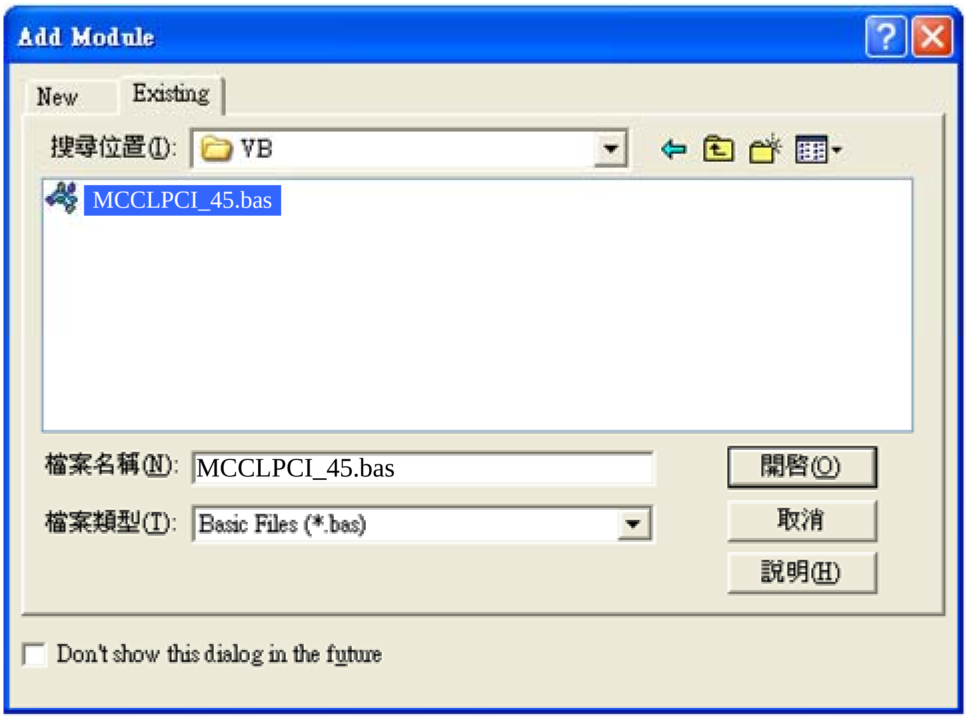
Step1:

Use [Add]->[Module] under [Project]

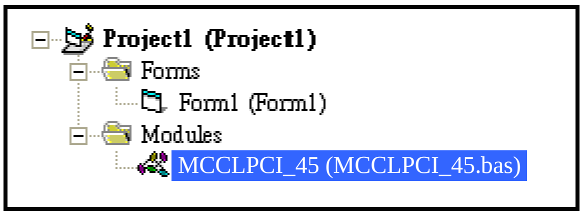


Step 2:

Select MCCLPCI_45.bas, and add into module,



It shows that MCCLPCI_45.bas has been added into project.


Project1 (Project1)
Forms
Form1 (Form1)
Modules
MCCLPCI_45 (MCCLPCI_45.bas)