Compensator Objects

Introduction

A **Compensator** object manages a single compensation table. Its primary function is to provide an interface to configure both the compensating axes and the compensated axis. It also provides an interface for loading the on-controller compensation tables. The Compensator object is a host-based object that has a corresponding compensator object embedded on the controller. The embedded compensator handles the real-time issues associated with axis position compensation.

Before creating the MPI Compensator object, the corresponding embedded compensator object on the controller must be enabled. Also, before configuring the MPI Compensator object, the controller's compensation table must be allocated with a sufficient size to hold all required compensation values (or points). Both of these items can be configured using mpiControlConfigGet/Set(...) methods.

NOTE: Configuring the compensator table size using mpiControlConfigSet(...) will reallocate the controller's dynamic memory. Reallocating dynamic memory on the controller affects multiple objects and should only be done at the very beginning of your application.

For more information on determining compensation table size please see Determining Required Compensator Table Size.

See Also:
Configuring the Compensator Objects for Operation
Determining Required Compensator Table Size
Loading the Compensation Table
Setting up an area for 2D Position Compensation

| Error Messages |

Methods

Create, Delete, Validate Methods

mpiCompensator**Create**	Create Compensator object
mpiCompensatorl**Delete**	Delete Compensator object
mpiCompensator**Validate**	Validate Compensator object

Configuration and Information Methods

mpiCompensator**ConfigGet**	Get Compensator configuration
mpiCompensator**ConfigSet**	Set Compensator configuration
meiCompensator**Info**	Get Compensator information
meiCompensator**TableGet**	Get Compensator table
meiCompensator**TableSet**	Set Compensator table

Memory Methods

meiCompensator**Memory**	Set address to be used to access Compensator memory
meiCompensator**MemoryGet**	Get bytes of Compensator memory and place it into application memory
meiCompensator**MemorySet**	Put (set) bytes of application memory into Compensator memory

Relational Methods

meiCompensator**Control**	Return handle of Control object associated with Compensator
meiCompensator**Number**	Get number of Compensator

Data Types

- MPICompensator**Config**
- MPICompensator**Dimension**
- MPICompensator**Info**
- MPICompensator**InputAxis**
- MPICompensator**Message**
- MPICompensator**Range**

Constants

- MPICompensator**DimensionsMAX**

mpiCompensatorCreate

Declaration

```
MPICompensator  mpiCompensatorCreate(MPIControl  control,
                                     long        number);
```

Required Header: stdmpi.h

Description

mpiCompensatorCreate creates a Host Compensator object associated with the compensation object identified by ***number*** located on motion controller ***control***. CompensatorCreate is the equivalent of a C++ constructor.

Valid compensator numbers are zero (0) to MPIControlMAX_COMPENSATORS.

Before creating a Compensator object, the controller compensation objects must be enabled using MPIControlConfig.compensatorCount, or the host object will be invalid.

Return Values	
handle	handle to a Compensator object
MPIHandleVOID	if the object could not be created

See Also

mpiCompensatorDelete | mpiCompensatorValidate | MPIControlConfig

mpiCompensatorDelete

Declaration

```
long  mpiCompensatorDelete(MPICompensator  compensator);
```

Required Header: stdmpi.h

Description

mpiCompensatorDelete deletes a host Compensator object (***compensator***) and invalidates its handle.

CompensatorDelete is the equivalent of a C++ destructor.

Return Values	
MPIMessageOK	

See Also

mpiCompensatorCreate | mpiCompensatorValidate

mpiCompensatorValidate

Declaration

```
long  mpiCompensatorValidate(MPICompensator  compensator);
```

Required Header: stdmpi.h

Description

mpiCompensatorValidate validates the Compensator object (***compensator***) and its handle. Always call mpiCompensatorValidate after creating a new Compensator object.

Return Values	
MPIMessageOK	
MPICompensatorMessageCOMPENSATOR_INVALID	
MPICompensatorMessageNOT_ENABLED	

See Also

mpiCompensatorCreate | mpiCompensatorDelete

mpiCompensatorConfigGet

Declaration

```
long  mpiCompensatorConfigGet(MPICompensator         compensator,
                              MPICompensatorConfig   *config,
                              void                   *external);
```

Required Header: stdmpi.h

Description

mpiCompensatorConfigGet gets the configuration of a Compensator object (***compensator***) and puts (writes) it in the structure pointed to by ***config***, and also writes it into the implementation-specific structure pointed to by ***external*** (if ***external*** is not NULL).

The configuration information in external is intended for future use and is not currently used. Set this value to NULL.

Return Values	
MPIMessageOK	
MPIMessagePARAM_INVALID	

See Also

mpiCompensatorConfigSet | MEICompensatorConfig

mpiCompensatorConfigSet

Declaration

```
long  mpiCompensatorConfigSet(MPICompensator        compensator,
                              MPICompensatorConfig  *config,
                              void                  *external);
```

Required Header: stdmpi.h

Description

mpiCompensatorConfigSet sets (writes) the configuration of a Compensator object (***compensator***) using data from the structure pointed to by ***config***, and also using data from the implementation-specific structure pointed to by ***external*** (if ***external*** is not NULL).

The configuration information in ***external*** is in addition to the configuration information in ***config***, i.e. the configuration information in ***config*** and in ***external*** is not the same information.

NOTE: ***config*** or ***external*** can be NULL (but both cannot be NULL).

Remarks

external either points to a structure of type **MEICompensatorConfig{}** or is NULL.

Return Values	
MPIMessageOK	
MPIMessagePARAM_INVALID	
MPIMessageARG_INVALID	See MPICompensatorConfig.
MPICompensatorMessageDIMENSION_NOT_SUPPORTED	
MPICompensatorMessageAXIS_NOT_ENABLED	
MPICompensatorMessagePOSITION_DELTA_INVALID	
MPICompensatorMessageTABLE_SIZE_ERROR	

See Also

mpiCompensatorConfigGet | MEICompensatorConfig

mpiCompensatorInfo

Declaration

```
long  mpiCompensatorInfo(MPICompensator      compensator,
                         MPICompensatorInfo  *info);
```

Required Header: stdmpi.h

Description

mpiCompensatorInfo reads the static information about the compensator object, and writes it into the structure pointed to by ***info***.

compensator	a handle to the Compensator object.
***info**	a pointer to a compensator information structure.

Return Values	
MPIMessageOK	
MPICompensatorMessageNOT_CONFIGURED	

See Also

MPICompensatorInfo | MPIControlConfig | mpiCompensatorTableGet | mpiCompensatorTableSet | mpiCompensatorInfo

mpiCompensatorTableGet

Declaration

```
long  mpiCompensatorTableGet(MPICompensator   compensator,
                             long             *table);
```

Required Header: stdmpi.h

Description

mpiCompensatorTableGet reads the NxM Compensator table stored on the controller whose dimensions are defined by the values in the MPICompensatorConfig structure. These values are written into the location specified by ***table***.

NOTE: The array pointed to ***table*** must have enough memory allocated to hold the entire size of the configured compensation table.

Return Values	
MPIMessageOK	
MPICompensatorMessageNOT_CONFIGURED	
MPIMessagePARAM_INVALID	

See Also

mpiCompensatorTableSet | MPICompensatorConfig

mpiCompensatorTableSet

Declaration

```
long  mpiCompensatorTableSet(MPICompensator   compensator,
                             long             *table);
```

Required Header: stdmpi.h

Description

mpiCompensatorTableSet writes the values stored in the location specified by ***table** to the Compensator table stored on the controller.

NOTE: The array pointed to ***table** must have a size large enough to fill the configured compensation table size (as defined by the MPICompensatorConfig structure) or memory access violations may occur.

Return Values	
MPIMessageOK	
MPICompensatorMessageNOT_CONFIGURED	
MPIMessagePARAM_INVALID	

See Also

mpiCompensatorTableGet | MPICompensatorConfig

mpiCompensatorMemory

Declaration

```
long  mpiCompensatorMemory(MPICompensator   compensator,
                           void             **memory);
```

Required Header: stdmpi.h

Description

mpiCompensatorMemory sets (writes) an address (used to access a Compensator object's memory) to the contents of ***memory***.

Return Values	
MPIMessageOK	

See Also

mpiCompensatorMemoryGet | mpiCompensatorMemorySet

mpiCompensatorMemoryGet

Declaration

```
long  mpiCompensatorMemoryGet(MPICompensator   compensator,
                              void             *dst,
                              const   void     *src,
                              long             count);
```

Required Header: stdmpi.h
Change History: Modified in the 03.03.00

Description

mpiCompensatorMemoryGet copies ***count*** bytes of a Compensator's (***compensator***) memory (starting at address ***src***) to application memory (starting at address ***dst***).

Return Values	
MPIMessageOK	

See Also

mpiCompensatorMemorySet | mpiCompensatorMemory

mpiCompensatorMemorySet

Declaration

```
long  mpiCompensatorMemorySet(MPICompensator   compensator,
                              void             *dst,
                              const   void     *src,
                              long             count);
```

Required Header: stdmpi.h
Change History: Modified in the 03.03.00

Description

mpiCompensatorMemorySet copies ***count*** bytes of application memory (starting at address ***src***) to a Compensator's (***compensator***) memory (starting at address ***dst***).

Return Values	
MPIMessageOK	

See Also

mpiCompensatorMemoryGet | mpiCompensatorMemory

mpiCompensatorControl

Declaration

```
MPIControl  mpiCompensatorControl(MPICompensator   compensator);
```

Required Header: stdmpi.h

Description

mpiCompensatorControl returns a handle to the Control object with which the compensator is associated.

compensator	a handle to the Compensator object

Return Values	
MPIControl	handle to a Control object
MPIHandleVOID	if *compensator* is invalid

See Also

mpiCompensatorCreate | mpiControlCreate

mpiCompensatorNumber

Declaration

```
long  mpiCompensatorNumber(MPICompensator   compensator,
                           long             *number);
```

Required Header: stdmpi.h

Description

mpiCompensatorNumber writes the index of a compensation object (object on the motion controller that the Compensator object is associated with) to the contents of ***number***.

Return Values	
MPIMessageOK	

See Also

mpiCompensatorCreate

MPICompensatorConfig

Definition

```
typedef struct MPICompensatorConfig {
    long                    dimensionCount,
    MPICompensatorInputAxis inputAxis[MPICompensatorDimensionMAX],
    long                    outputAxisNumber,
} MPICompensatorConfig;
```

Description

dimensionCount	The input dimension count of the compensation table. Valid values are from zero (0) to MPICompensatorDimensionsMAX. A value of zero (0) effectively disables the compensation object
inputAxis	The substructure used to configure each input dimension of the Compensator object.
outputAxisNumber	This specifies the axis number of the Axis to be compensated by the Compensator object. This number must correspond to a valid (existing) and enabled Axis on the controller.

See Also

MPIControlConfig | mpiCompensatorConfigGet | mpiCompensatorConfigSet | MPICompensatorDimension | MPICompensatorDimensionsMAX

MPICompensatorDimension

Definition

```
typedef struct MPICompensatorDimension {
    MPICompensatorDimensionX,
    MPICompensatorDimensionY,
} MPICompensatorDimension;
```

Description

MPICompensatorDimension an enumeration of valid Compensator dimensions.

MPICompensatorDimensionX	First Compensating Dimension
MPICompensatorDimensionY	Second Compensating Dimension

See Also

MPICompensatorConfig | MPICompensatorInfo

MPICompensatorInfo

Definition

```
typedef struct MPICompensatorInfo {
    long     tableDimensions[MPICompensatorDimensionMAX],
    long     tableSizeBytes,
} MPICompensatorInfo;
```

Description

tableDimensions	The dimensions along each axis of the table. This value is affected by the values set in the MPICompensatorConfig structure.
tableSizeBytes	The size (in Byte) required to store the entire compensation table in a host resident structure or array. This value is affected by the values set in the MPICompensatorConfig structure. This is NOT the amount of memory allocated on the controller by setting the MPIControlConfig. compensatorPointCount value.

See Also

MPICompensatorConfig | MPIControlConfig | MPICompensatorDimension | MPICompensatorDimensionMAX

MPICompensatorInputAxis

Definition

```
typedef struct MPICompensatorInputAxis {
    long                    axisNumber,
    MPICompensatorRange     range,
    long                    positionDelta,
} MPICompensatorInputAxis;
```

Description

axisNumber	This specifies the axis number of the compensating Axis object. The position from this Axis will be used to index a single dimension of the compensation table. This number must correspond to a valid (existing) and enabled Axis on the controller.
range	Used to configure the feedback positions along the compensation axis where compensation will start and end.
positionDelta	Spacing between compensation positions on the compensating axis: **positionDelta** must meet some specifications: • positionDelta must be an exact multiple of the range (i.e. ((range. positionMax – range.positionMin) / positionDelta) must be an integer value). • positionDelta must be greater than zero. • positionDelta must be greater than (range.positionMax - range. positionMin).

See Also

MPICompensatorConfig | mpiCompensatorConfigGet | mpiCompensatorConfigSet

MPICompensatorMessage

Definition

```
typedef enum {
   MPICompensatorMessageCOMPENSATOR_INVALID,
   MPICompensatorMessageNOT_CONFIGURED,
   MPICompensatorMessageNOT_ENABLED,
   MPICompensatorMessageAXIS_NOT_ENABLED,
   MPICompensatorMessageTABLE_SIZE_ERROR,
   MPICompensatorMessagePOSITION_DELTA_INVALID,
   MPICompensatorMessageDIMENSION_NOT_SUPPORTED,
} MPICompensatorMessage;
```

Description

MPICompensatorMessageCOMPENSATOR_INVALID

The compensator number is not valid. This message code is returned by mpiCompensatorCreate(...) if the compensator number is less than 0 or greater than MPIControlMAX_COMPENSATORS.

MPICompensatorMessageNOT_CONFIGURED

MPI Compensator object must be configured before calling mpiCompensatorTableGet/ Set or mpiCompensatorInfo(...).

MPICompensatorMessageNOT_ENABLED

The compensator is not available on the controller. This message code is returned by mpiCompensatorValidate(…) if the compensator number is not within the range of enabled compensators on the controller. To correct the problem, use MPIControlConfig to configure the compensatorCount to be greater than the required compensator number.

MPICompensatorMessageAXIS_NOT_ENABLED

The axis is not available on the controller. This message coder is returned by mpiCompensatorConfigSet(...) if the axisOutNumber or any of the inputAxis[n].axisNumbers are not within the range of enabled axes on the controller. To correct the problem, use MPIControlConfig to configure the axisCount to be greater than the required axis number.

MPICompensatorMessageTABLE_SIZE_ERROR

The host compenstation table will not fit within the controller's configured compensation table. See Determining Required Compensation Table Size.

MPICompensatorMessagePOSITION_DELTA_INVALID

The positionDelta is either out of range or is not a multiple of the range. This message code is returned by mpiCompensatorConfigSet(…). To correct the problem, check the valid range values for MPICompensatorInputAxis.

MPICompensatorMessageDIMENSION_NOT_SUPPORTED

The dimensionCount is out of range. This message code is returned by mpiCompensatorConfigSet(…). To correct the problem, check the valid range values for MPICompensatorConfig.

See Also

MPICompensatorRange

Definition

```
typedef struct MPICompensatorRange {
    double  positionMin,
    double  positionMax,
} MPICompensatorRange;
```

Change History: Modified in the 03.04.00.

Description

positionMin	The minimum feedback position (counts) along the compensation axis where compensation will occur.
positionMax	The maximum feedback position (counts) along the compensation axis where compensation will occur.

See Also

MPICompensatorConfig | mpiCompensatorConfigGet | mpiCompensatorConfigSet

MPICompensatorDimensionsMAX

Definition

```
#define MPICompensatorDimensionsMAX (MPICompensatorDimensionLAST)
```

Description

MPICompensatorDimensionMAX defines the maximum number of dimensions supported by the Compensator object's compensation tables. Currently, the maximum dimension value is 2.

See Also

MPICompensatorDimension | MPICompensatorInfo | MPICompensatorConfig

Determining Required Compensator Table Size

The compensator table size is dependent on the number of dimensions (1D or 2D), the position range, and the resolution (or granularity) of the compensation points. The compensator uses linear interpolation to calculate the compensation values between each distinct compensation point.

For each compensation axis there are three position values: Min, Max, and Delta. The compensating range for an axis is specified by the Min and Max positions along the axis. The range (Max – Min) divided by Delta, determines the number of required points for the compensator. You can calculate the number of required compensator points by using the following equations:

1D Compensation: Points = (positionMax-positionMin) / positionDelta + 1

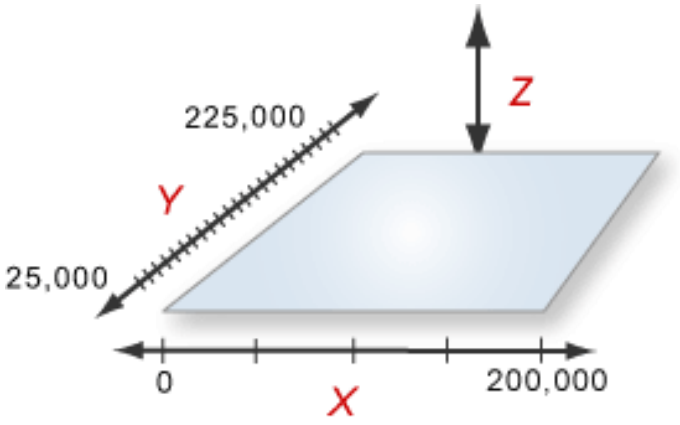
2D Compensation: Points = PointsX * PointsY

NOTE: Delta must be an exact multiple of the difference between Min and Max.

Example: (taken from comp.c sample application)

To compensate a Z (vertical) axis for X-Y surface irregularities, first define the X-Y area to be compensated (Xmin to Xmax, Ymin to Ymax). Then define the spacing of the measuring points (delta) for the X and Y axes to determine the compensation table size.

For the X-Y table diagram below we have:
Xmin = 0, Xmax = 200000, Xdelta = 50000
Ymin = 25000, Ymax = 225000, Ydelta = 10000



For this table our X & Y dimensions are:
X_DIM = (200000-0)/50000 + 1 = 5
Y_DIM = (225000-25000)/10000 +1 = 21

which requires a table point count of:
Points = X_DIM * Y_DIM = 105

With this information we can now configure the size of our compensation table on the controller using MPIControlConfig.compensatorPointCount = 105.

Configuring the Compensator Objects for Operation

After determining the required compensator table size, we need to configure both the embedded compensation tables on controller and the MPI Compensator object.

We will illustrate how to do this using the X-Y-Z system defined in the Determining Required Compensator Table Size section.

Configuring Controller Compensation Table
From our example in the previous section we have calculated that we need at least a point count of 105 to hold all of our measured compensation points (Acquiring and loading compensation points will be described in in the next section). First we need tell the motion controller to allocate memory space to hold the compensation table. We also need to enable a compensator since compensator objects are disabled on the controller by default. For an example, see the code below.

```
MPIControlConfig config;
long returnValue; returnValue =
    mpiControlConfigGet(control,
                        &config,
                        NULL);

if (returnValue == MPIMessageOK) {
    /* configure first compensator table size so our 2D array will fit */
    config.compensatorCount = 1;
    config.compensatorPointCount[0] = 105;

    /*
     * WARNING: this is a low-level configuration that will
     * reinitialize the controller's dynamic memory buffers!
     * Only preform this operation at system initialization.
    */
     returnValue =
         mpiControlConfigSet(control,
                             &config,
                             NULL);
}
```

The comment above reminds us that calling mpiControlConfigSet(...) will reallocate dynamic memory. Reallocation of dynamic memory affects other objects on the controller, so it should only be done during system initialization and not during the execution of a move.

Configuring the MPI Compensator Object
Continuing with our example, we will now assume that our axis numbers for axis X, Y, and Z are 0, 1, & 2 respectively. If we also assume that the MPI Compensator object has already been created, the code to configure the object would look like the following:

```
if (returnValue == MPIMessageOK) {
       MPICompensatorConfig config;

       returnValue =
              mpiCompensatorConfigGet(compensator,
                                      &config,
                                      NULL);
}

       if (returnValue == MPIMessageOK) {
              config.dimensionCount = 2;

              /* configure first compensating (input) axis */
              config.inputAxis[0].axisNumber = 0;
              config.inputAxis[0].range.positionMin = 0;
              config.inputAxis[0].range.positionMax = 250000;
              config.inputAxis[0].positionDelta = 50000;

              /* configure second compensating (input) axis */
              config.inputAxis[1].axisNumber = 1;
              config.inputAxis[1].range.positionMin = 25000;
              config.inputAxis[1].range.positionMax = 225000;
              config.inputAxis[1].positionDelta = 10000;

              /* configure compensated (out) axis */
              config.outputAxisNumber = 2;

              returnValue =
                  mpiCompensatorConfigSet(compensator,
                                          &config,
                                          NULL); }
```

Once we have the Compensation table allocated and have a configured Compensation object, the last step is to Load the Compensation Table.

Loading the Compensation Table

Next we need to somehow acquire high precision distance measurements (via interferometer, etc.) to the surface at each of the X-Y locations in the compensation area, and store the X and Y offset positions.

Once you've obtained these positions, they will need to be loaded into our previously configured compensation table (See Determining Required Compensator Table Size). Continuing with our original example let's assume that our measurements are as defined by the following table below (taken from the comp.c sample application):

```
long compensatorTable[21][5] =
{
      { 0,    0,    0,     0,     0, },
      { 100,  200,  -200,  -100,  0, },
      { 200,  400,  -400,  -200,  0 },
      { 300,  600,  -600,  -300,  0 },
      { 400,  800,  -800,  -400,  0 },
      { 500,  1000, -1000, -500,  0 },
      { 600,  1200, -1200, -600,  0 },
      { 700,  1400, -1400, -700,  0 },
      { 800,  1600, -1600, -800,  0 },
      { 900,  1800, -1800, -900,  0 },
      { 1000, 2000, -2000, -1000, 0 },
      { 900,  1800, -1800, -900,  0 },
      { 800,  1600, -1600, -800,  0 },
      { 700,  1400, -1400, -700,  0 },
      { 600,  1200, -1200, -600,  0 },
      { 500,  1000, -1000, -500,  0 },
      { 400,  800,  -800,  -400,  0 },
      { 300,  600,  -600,  -300,  0 },
      { 200,  400,  -400,  -200,  0 },
      { 100,  200,  -200,  -100,  0 },
      { 0,    0,    0,      0,    0 },
};
```

Interpreting compensator table above:

To compensate a Z (vertical) axis for X-Y surface irregularities, first define the X-Y area to be compensated (Xmin to Xmax, Ymin to Ymax).

Then define the spacing of the measuring points (delta) for the X and Y axes to determine the compensation table size.

For the X-Y table diagram below we have:

Xmin = 0, Xmax = 200000, Xdelta = 50000

Ymin = 25000, Ymax = 225000, Ydelta = 10000

Y Values	X Values				
	0	50000	100000	150000	200000
25000	0	0	0	0	0
35000	100	200	-200	-100	0
45000	200	400	-400	-200	0
55000	300	600	-600	-300	0
65000	400	800	-800	-400	0
75000	500	1000	-1000	-500	0
85000	600	1200	-1200	-600	0
95000	700	1400	-1400	-700	0
105000	800	1600	-1600	-800	0
115000	900	1800	-1800	-900	0
125000	1000	2000	-2000	-1000	0
135000	900	1800	-1800	-900	0
145000	800	1600	-1600	-800	0
155000	700	1400	-1400	-700	0
165000	600	1200	-1200	-600	0
175000	500	1000	-1000	-500	0
185000	400	800	-800	-400	0
195000	300	600	-600	-300	0
205000	200	400	-400	-200	0
215000	100	200	-200	-100	0
225000	0	0	0	0	0

To load the above compensation table, execute the following code:

```
returnValue = mpiCompensatorTableSet(compensator,
                                     (long*)compensatorTable);
```

Once the compensation positions are loaded, the compensation will be applied to the Z-axis' position feedback loop every servo cycle.

NOTE: No more interpolated compensation of the Z-axis will occur outside of the defined compensation range. Therefore, the compensation of the Z-axis will remain fixed outside of this range.

Setting up an area for 2D Position Compensation

The XMP has 2D compensation capabilities. The user-supplied compensation table is downloaded into XMP memory. The XMP automatically applies this compensation information to optimize motion profiles in real time.