

Title: Non-retained Memory Allocation in MP3000iec Controllers**Product(s):** MP3200iec, MP3300iec, MotionWorks IEC**Doc. No.** TN.MPIEC.01**Summary:**

This document provides information on the MP3000iec family memory structure with particular emphasis on the non-retained space reserved for variables. At times, users have experienced compile error messages such as “**Error in Native Code Generation**” and “**Compile Error**”. Although there can be more than one trigger for these error messages, one of the more frequent causes is due to the configuration of user data types and the creation of user variables in the program.

Memory allocation conditions and limitations:

1. The maximum size of the non-retained memory space in the MP3000iec controllers is 20,971,516 bytes.
2. The limit for one object (POU or variable) is 4,194,303 bytes.
3. For variables, the *offset* to the variable from the start of memory space must be less than 4,191,304 bytes. Variables are mapped into memory according to their location in the variable list worksheet. The first variable will be mapped to the first available memory location and will occupy a certain space based on its data type size. The *offset* to the next variable down in the list is then the sum of the lengths of all the variables above it.
4. Best-practice dictates that all user-defined variables should be placed below the default System Variable group in the worksheet created by a New Project template. The variables in this group will be addressed into %M register space. Additional variable groups can be defined by the user for clarity of function.
5. It is possible to create a large array or data structure that is more than 4,194,303 bytes, so long as it is
 - a. the last variable in the variable grid
 - b. the offset to that variable (the sum of all variables prior variables in the list) is no more than 4,194,303 bytes.

Example: Maximum size of an example user-defined data type

An example data type is created to model a large amount of data storage for pieces of equipment.

An array of *Equipment* is created which contains an array of *Modules*, which contains an array of *Data*, which contains an array of *Elements*, each of which is an *LREAL number*.

The maximum designed size of a variable of this data type is 20Mb, an example layout of which is shown in Table 1. The IEC code to create this data type is shown in Figure 1.

Title: Non-retained Memory Allocation in MP3000iec Controllers

Product(s): MP3200iec, MP3300iec, MotionWorks IEC

Doc. No. TN.MPIEC.01

Description	Qty Declared	Bytes
LREAL Element		8
Element Array Size	1000	8,000
Data Array Size	10	80,000
Module Array Size	50	4,000,000
Equipment Size	5	20,000,000

Table 1: Example maximum data type size

```

TYPE

  Element_ARRAY: ARRAY[1..1000] OF LREAL; (* Max number for array is 32767 *)

  Element_STRUCT: STRUCT
    Element: Element_ARRAY;
  END_STRUCT;

  ElementSTRUCT_ARRAY: ARRAY[1..10] OF Element_STRUCT;

  Data_STRUCT: STRUCT
    Data: ElementSTRUCT_ARRAY;
  END_STRUCT;

  Data_ARRAY: ARRAY[1..50] OF Data_STRUCT;

  Equipment_STRUCT: STRUCT
    Module: Data_ARRAY;
  END_STRUCT;

  Equipment_ARRAY: ARRAY[1..5] of Equipment_STRUCT;

END_TYPE
    
```

Figure 1: MotionWorks IEC Data Type worksheet code to create the multiple-level data type

A variable of this data type *Equipment* is then defined in a structured-text POU as a global variable:

```

1  Equipment[1].Module[1].Data[1].Element[1] := LREAL#1.0;
2  |
    
```

This arrangement will compile correctly without error, *even though the length is almost five times bigger than the maximum object size*, as long as the variable *Equipment* is the last

Title: Non-retained Memory Allocation in MP3000iec Controllers

Product(s): MP3200iec, MP3300iec, MotionWorks IEC

Doc. No. TN.MPIEC.01

variable in the Global Variable list as shown in Figure 2. This is because the offset for this variable is under 4,194,304 bytes and there is no subsequent variable in the list that would require another offset.

System Variables				
PLC_SYS_TICK_CNT	DINT		VAR_GLOBAL	
PLC_TASK_DEFINED	INT		VAR_GLOBAL	
PLCMODE_ON	BOOL		VAR_GLOBAL	TRUE : current PLC mode is ON
PLCMODE_LOADING	BOOL		VAR_GLOBAL	TRUE : current PLC mode is LOADING
PLCMODE_STOP	BOOL		VAR_GLOBAL	TRUE : current PLC mode is STOP
PLCMODE_RUN	BOOL		VAR_GLOBAL	TRUE : current PLC mode is RUN
PLCMODE_HALT	BOOL		VAR_GLOBAL	TRUE : current PLC mode is HALT
PLC_TICKS_PER_SEC	INT		VAR_GLOBAL	
PLC_MAX_ERRORS	DINT		VAR_GLOBAL	
PLC_ERRORS	DINT		VAR_GLOBAL	
PLC_TASK_AVAILABLE	INT		VAR_GLOBAL	
PLC_SYSTASK_AVAILABLE	INT		VAR_GLOBAL	
PLCDEBUG_FORCE	BOOL		VAR_GLOBAL	TRUE : current PLC mode is POWER on
PLCDEBUG_BPSET	BOOL		VAR_GLOBAL	TRUE : one or more
PLCDEBUG_POWERFLOW	BOOL		VAR_GLOBAL	TRUE : current PLC mode is POWER on
User Variables				
Equipment		Equipment_ARRAY	VAR_GLOBAL	

Figure 2: Global variable list

Error if maximum size is exceeded

If the number of modules is increased from 50 to 60, then the maximum memory exceeded error shown in Figure 3 will result. (Although manual calculation of the variable size is 24,000,000 bytes exactly, the controller calculates the size to be 24,002,172. The extra bytes are due to internal padding from the compiler.)


 The compiled project will consume more memory for Data than available on the connected device! Available: 20971516 bytes / Required: 24002172 bytes.

Figure 3: Error message if maximum available memory is exceeded during compile

Title: Non-retained Memory Allocation in MP3000iec Controllers

Product(s): MP3200iec, MP3300iec, MotionWorks IEC

Doc. No. TN.MPIEC.01

If the number of Equipment pieces is *reduced* to stay under the maximum limit as in Table 2, then a successful compile can be achieved even though, within the variable, a sub item size exceeds 4,194,304 bytes.

Description	Qty Declared	Bytes
LREAL Element		8
Element Array Size	1000	8,000
Data Array Size	10	80,000
Module Array Size	60	4,800,000
Equipment Size	4	19,200,000

Table 2: Increased Module size, reduced Equipment size

Error if maximum offset is exceeded

If the variable is NOT the last in the list, as laid out in Figure 3, then the maximum object size applies as specified. Moving the *Equipment* variable above *PLCDEBUG_POWERFLOW* will cause the error in Figure 4 to occur at compile.

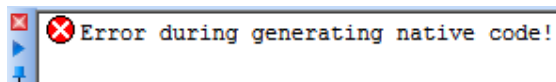


Figure 4: Error message due to a variable offset that exceeds 4,194,303 bytes

Title: Non-retained Memory Allocation in MP3000iec Controllers

Product(s): MP3200iec, MP3300iec, MotionWorks IEC

Doc. No. TN.MPIEC.01

System Variables				
PLC_SYS_TICK_CNT	DINT		VAR_GLOBAL	
PLC_TASK_DEFINED	INT		VAR_GLOBAL	
PLCMODE_ON	BOOL		VAR_GLOBAL	TRUE : current PLC mode is ON
PLCMODE_LOADING	BOOL		VAR_GLOBAL	TRUE : current PLC mode is LOADING
PLCMODE_STOP	BOOL		VAR_GLOBAL	TRUE : current PLC mode is STOP
PLCMODE_RUN	BOOL		VAR_GLOBAL	TRUE : current PLC mode is RUN
PLCMODE_HALT	BOOL		VAR_GLOBAL	TRUE : current PLC mode is HALT
PLC_TICKS_PER_SEC	INT		VAR_GLOBAL	
PLC_MAX_ERRORS	DINT		VAR_GLOBAL	
PLC_ERRORS	DINT		VAR_GLOBAL	
PLC_TASK_AVAILABLE	INT		VAR_GLOBAL	
PLC_SYSTASK_AVAILABLE	INT		VAR_GLOBAL	
PLCDEBUG_FORCE	BOOL		VAR_GLOBAL	TRUE : current PLC mode is POWER on
PLCDEBUG_BPSET	BOOL		VAR_GLOBAL	TRUE : one or more
Equipment	Equipment_ARRAY		VAR_GLOBAL	
PLCDEBUG_POWERFLOW	BOOL		VAR_GLOBAL	TRUE : current PLC mode is POWER on
User Variables				

Figure 5: Equipment variable not the last in the Global list

The compile fails because the offset to *PLCDEBUG_POWERFLOW* is now greater than the limit due to the large *Equipment* variable now before it in the list.

Title: Non-retained Memory Allocation in MP3000iec Controllers

Product(s): MP3200iec, MP3300iec, MotionWorks IEC

Doc. No. TN.MPIEC.01

Multiple variables of a large data type

Let us now consider the case where it is desired to create another variable of the same data type in the program as shown in Figure 6. Since BOTH cannot be the last in the list, as depicted in Figure 7, the total data type size will need to be under the 4,194,304 byte limit or 'Error during generating native code!' will result. See Table 3 for this data type declaration.

```

1 Equipment[1].Module[1].Data[1].Element[1] := LREAL#1.0;
2 Equipment2[1].Module[1].Data[1].Element[1] := LREAL#1.0;
3

```

Figure 6: Additional variable of the same data type

System Variables			
User Variables			
Equipment	Equipment_ARRAY	VAR_GLOBAL	
Equipment2	Equipment_ARRAY	VAR_GLOBAL	

Figure 7: Two variables in the Global list

Description	Qty Declared	Bytes
LREAL Element		8
Element Array Size	1000	8,000
Data Array Size	10	80,000
Module Array Size	10	800,000
Equipment Size	5	4,000,000

Table 3: Decreased Module size to accommodate two variables

The compile is successful because the offset to the variable *Equipment2* is the length of the variable *Equipment* plus the sum of the lengths of the variables in the System Variables group is under the limit of 4,194,304 bytes.

Formula for Data Type Length vs Number of Allowed Variables

If a third variable of the same data type is subsequently added, the compile fails because the total offset to the 3rd variable is more than the limit of 4,194,304 bytes (2 x 4Mb = 8Mb).

Title: Non-retained Memory Allocation in MP3000iec Controllers

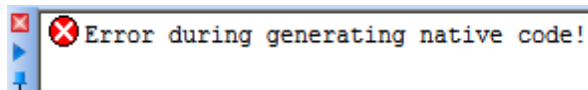
Product(s): MP3200iec, MP3300iec, MotionWorks IEC

Doc. No. TN.MPIEC.01

```

1 Equipment[1].Module[1].Data[1].Element[1] := LREAL#1.0;
2 Equipment2[1].Module[1].Data[1].Element[1] := LREAL#1.0;
3 Equipment3[1].Module[1].Data[1].Element[1] := LREAL#1.0;
4

```



PLCDEBUG_BPSET	BOOL	VAR_GLOBAL	TRUE : one or more
PLCDEBUG_POWERFLOW	BOOL	VAR_GLOBAL	TRUE : current PLC mode is POWER on
Equipment	Equipment_ARRAY	VAR_GLOBAL	
Equipment2	Equipment_ARRAY	VAR_GLOBAL	
Equipment3	Equipment_ARRAY	VAR_GLOBAL	

Figure 8: Error message with three variables of approx 4,000,000 byte size

Therefore, ***if the application requires two or more of these array variables, then the size of the data type structure must be reduced to approximately (4Mb / #of variables) so that the last one will remain under the 4,194,304 offset limit.***

In this example, if the *Equipment* data type size is set to be 1.0Mb, as in Table 4, then four variables can be accommodated successfully.

Description	Qty Declared	Bytes
LREAL Element		8
Element Array Size	500	4,000
Data Array Size	10	40,000
Module Array Size	5	200,000
Equipment Size	5	1,000,000

Table 4: Decreased data type size to accommodate 4 variables