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Library description

This library allows the programmer to create an array while the PLC is running (also known as *runtime*), without knowing beforehand its size or datatype.
An analogy can be made with the C default library functions "malloc" and "free".

Make sure to check the License agreement.

A list of current features and the library changelog can also be found in Library features and changelog.

> ⚠ **Warning**
>
> This library is still a work in progress. Therefore, expect many bugs, as well as interface and functionality changes.
> It is not yet meant to be used in a production environment, but to act as a proof-of-concept.

> ⚡ **Danger**
>
> This library will run for 2 hours for testing purposes. After the time is elapsed, the PLC will go to **STOP**.

Guides and examples

- Example project.

Function blocks overview

- LRA_CreateRuntimeArray.
- LRA_ReadRuntimeArray.
- LRA_WriteRuntimeArray.
- LRA_DeleteRuntimeArray.

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Library features and changelog

Current implemented features:

- Create, read, write and delete arrays with size supplied during runtime.
- Define array type during runtime.
- Type checking during runtime.
- Types supported: Byte, Word, DWord and LWord.
- Error codes for functions.

Changelog:

- 0.1.0 - Initial Release.

Example project

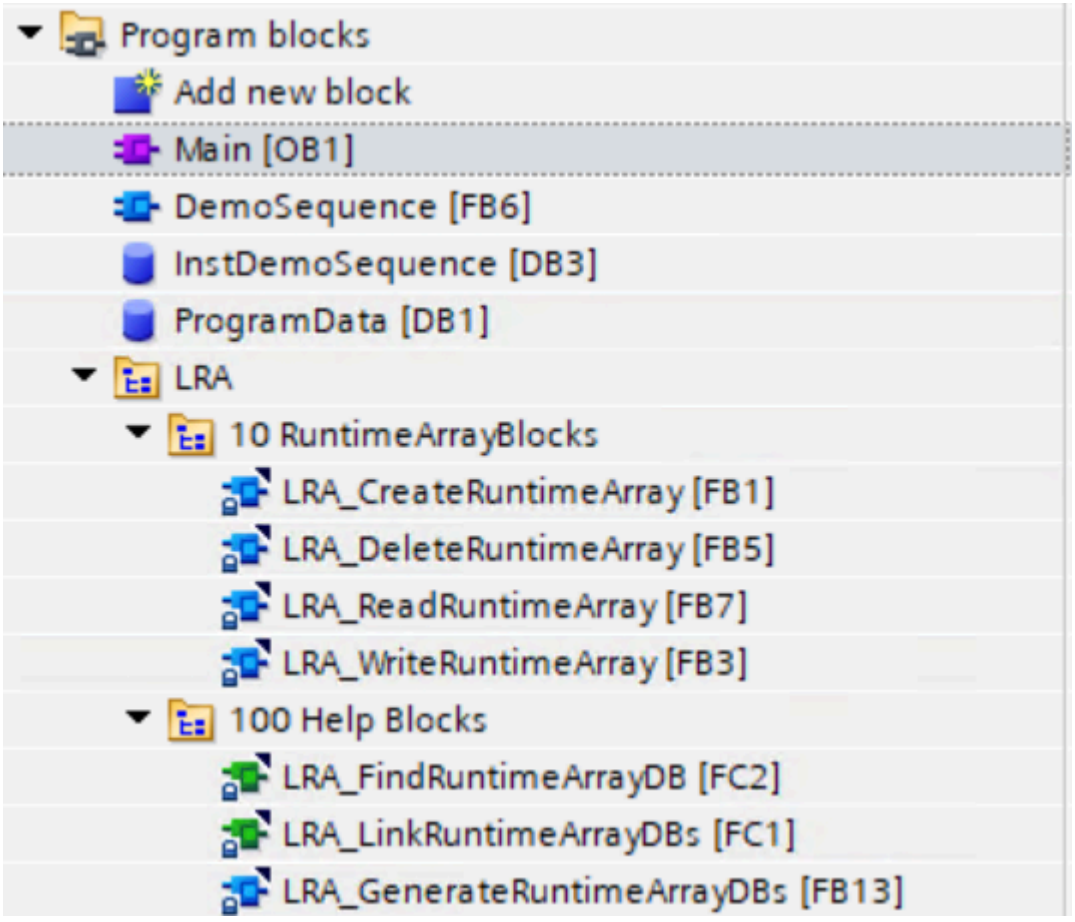
Current documentation version: 0.0.1

0.0.1 - Initial Release.

Introduction

A basic project showcasing the blocks of this library, as well as a possible workflow, where arrays can be created, read, written and deleted during runtime by the user.
The parameters present at the "ProgramData" DB allows the user to modify the demo sequence, defining the number of arrays to be created, as well as their data types and size.
Although the example is written using a state machine to call the library blocks and variants/references to transfer data around, this is not strictly necessary and it can be modified to better suit other scenarios.
All variables used to control the example can also be accessed using OPC UA, an HMI project or the Web API, none present in the current example project version.

Project organization



The "Main" OB is responsible for calling the "DemoSequence" FB, where the example itself resides.
Everything under the LRA folder belongs to the library itself, but the help blocks are not supposed to be called directly by the user. They are, instead, called by library functions themselves.
The "DemoSequence" FB contains the state machine where the arrays are created, written, read and then (optionally) deleted.
All example parameters can be modified offline or online in the "ProgramData" DB.

Demo sequence parameters: inputs and outputs

The following inputs and outputs for the example project are present:

ProgramData

	Name	Data type	Start value
1	Static		
2	demoSequenceInterface	"typeDemoSequenceInterface"	
3	inputs	"typeDemoSequenceInputs"	
4	startDemo	Bool	false
5	arraysUpperBound	UDInt	10
6	numberOfArrays	DInt	3
7	typeArray	String	'Byte'
8	deleteAtEnd	Bool	FALSE
9	stepMode	Bool	FALSE
10	nextStep	Bool	TRUE
11	outputs	"typeDemoSequenceOutputs"	
12	valueRead	LWord	16#0
13	currentStep	Int	0
14	currentError	Word	16#0
15	functionRuntime	Time	T#0ms
16	numberOfCycles	UInt	0

- Inputs (can be modified by user):
  - startDemo: Set to TRUE to start the demo sequence. Will be set again to FALSE when the sequence is over.
  - arraysUpperBound: define the upper bound of the arrays that will be created during the demo sequence[1]. The arrays always start at zero.
  - numberOfArrays: number of arrays of size "arraysUpperBound" to be created by the sequence.
  - typeArray: data type of created array. The following data types are currently supported: "Byte", "Word", "DWord", "LWord".
  - deleteAtEnd: if TRUE, the created arrays will be deleted before the sequence is over.

    - stepMode: if TRUE, it will be necessary to set the "nextStep" parameters to TRUE to let the sequence run for one more cycle. Note that it might be necessary multiple cycles to finish the sequence. This is used mostly to understand better how the example works.
    - nextStep: if TRUE, and stepMode is also TRUE, will let the sequence run for one more cycle.
- Outputs (modified by the software):
    - valueRead: last value read from the created array by the "LRA_ReadRuntimeArray" function.
    - currentStep: current step of the state machine responsible for the demo sequence.
    - currentError: last error output by any of the library functions. If more than one error is present, only the last one is shown.
    - functionRuntime: time spent by the PLC to complete the sequence. Can be used to benchmark different scenarios.
    - numberOfCycles: cycles run by the PLC to complete the sequence. Can be used to benchmark different scenarios.

Demo sequence steps overview

1. SM_IDLE: values used by the function are reset. Wait for "startDemo" to be TRUE to advance to next step.
2. SM_CREATE_ARRAYS: create all the runtime arrays. Number of arrays, upper bound and data type are taken from "ProgramData" DB input parameters.
3. SM_WRITE_ARRAYS: write to all positions of all created arrays. Value written is based on PLC time tick and is used simply as an example.
4. SM_READ_ARRAYS: read all positions of all created arrays.
5. SM_DELETE_ARRAYS: if "deleteAtEnd" parameter is TRUE, delete all created arrays.

Step-by-step instruction

1. Download the software either to PLCSIM, PLCSIM Advanced or to a real PLC from the S7-1500 family, modifying the hardware in the project if necessary.
2. Open the "ProgramData" DB, modify the "inputs" parameters.
3. Set "startDemo" to TRUE, so that the sequence can run.
4. Observe the effects through the "outputs" fields and the created DBs in the online PLC software.
5. Repeat from step 2, with new parameters if desired.

---

1. The created arrays can have different sizes, but the sequence would have to be modified for that or called multiple times with the desired size. ↩

LRA_CreateRuntimeArray

Current documentation version: 0.0.1

0.0.1 - Initial Release.

Description

The "LDA_CreateRuntimeArray" is used to create an array with size and datatype chosen during runtime in the work memory of the PLC. When created, a number will be output by the function and used for further operations with the *runtime array*.

Values can be read and written using the "LRA_ReadRuntimeArray" and "LRA_WriteRuntimeArray".

The created *runtime array* can be deleted with the "LRA_DeleteRuntimeArray" so that the work memory is made available again.

> ⚠ **Warning**
>
> The following limitations apply:
>
> - Max *runtime array* size is limited by available PLC work memory during its creation.
> - The created *runtime arrays* and the user created DBs share the same resource pool. Therefore, the max combined number of these blocks that might exist is 1000[1].
> - Array speed creation depends on the PLC and program load. Bigger *runtime arrays* take more calls to be created.
> - Created arrays are maintained when the PLC goes to STOP, but **deleted** in case of a POWER OFF. Retentive arrays are not yet supported.
> - All other specificities and limitations of the default function "CREATE_DB" also apply.

> ⚠ **Warning**
>
> In case there is an error during the array creation, the partially created array is not automatically deleted. The programmer is responsible for the detection and deletion trigger.

Functional description

This function works asynchronously. Therefore, depending on the size and array datatype, it might require multiple calls to complete its task.
If the done bit is set, the creation was successful and the *runtime array* number is available. A new trigger on "start" is needed if a new array creation is desired.
If the error bit is set, the creation failed and a new trigger on "start" is needed to try to create the *runtime array* again. It is recommended to delete the array if this happens.

> **Note**
>
> Always check the done and error bits to correctly evaluate if the job has been completed or failed.

Parameters

Parameter	*Declaration*	*Data type*	*Description*
start	Input	Bool	Positive edge triggers start of array creation.
arrayType	Input	String	Type of array to be created. Only the following datatypes are supported: "Byte", "Word", "DWord", "LWord".
arrayUpperBound[2]	Input	UDInt	Size of array defined by its upper bound. The array always start at 0.
runtimeArrayNumber	InOut	DB_DYN	Variable to store array identification number.
busy	Output	Bool	TRUE while array creation is ongoing.
error	Output	Bool	TRUE for one cycle when there was an error in the array creation.
errorId	Output	Word	Stores error code.
done	Output	Bool	TRUE for one cycle when the array creation was successful.

Parameter errorId

Error code (W#16#...)	**Description**
0000	No error.

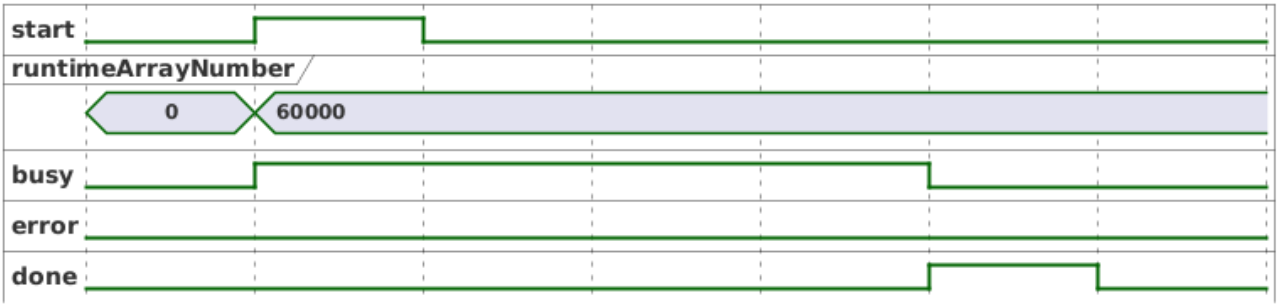
Error code (W#16#...)	Description
8001	User requested an array type that is not supported.
8002	Internal error.
8A92	Max number of DB blocks for CPU has been reached.
8AB1	No free DB number available.
8AB2	Insufficient free memory.
8ABB	Insufficient load memory.
8AC3	Max number of "CREATE_DB" instances was reached. In this case, the error bit is **not** set and a retry is done in the next block call.

Troubleshooting

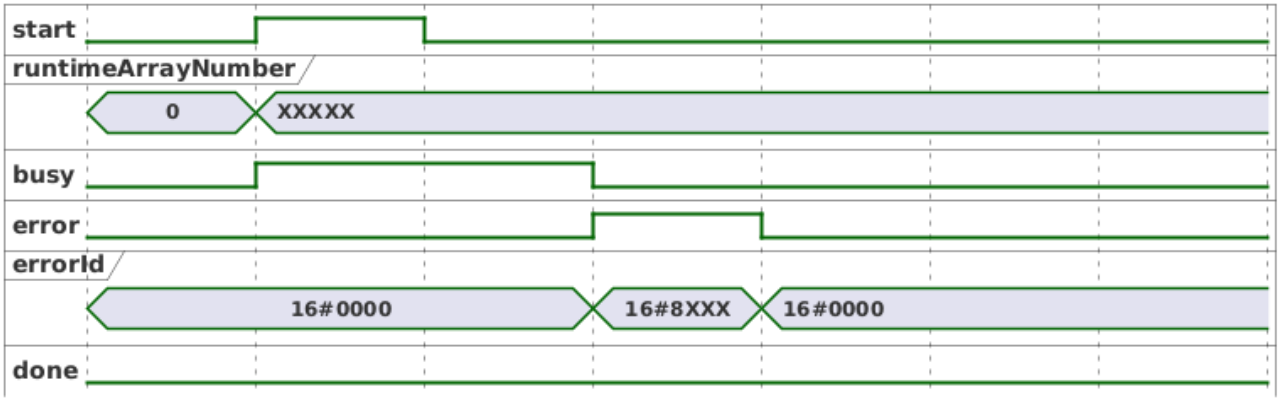
Error code (W#16#...)	Description
0000	No troubleshooting necessary.
8001	Check supported datatypes list and monitor function input during runtime.
8002	Inform library developer.
8A92	Reduce number of created blocks.
8AB1	Delete an user created DB or *runtime array*.
8AB2	Reduce work memory use or try again with a smaller *runtime array* size.
8ABB	Reduce load memory use.
8AC3	Wait for next function call.

Digital timing diagram

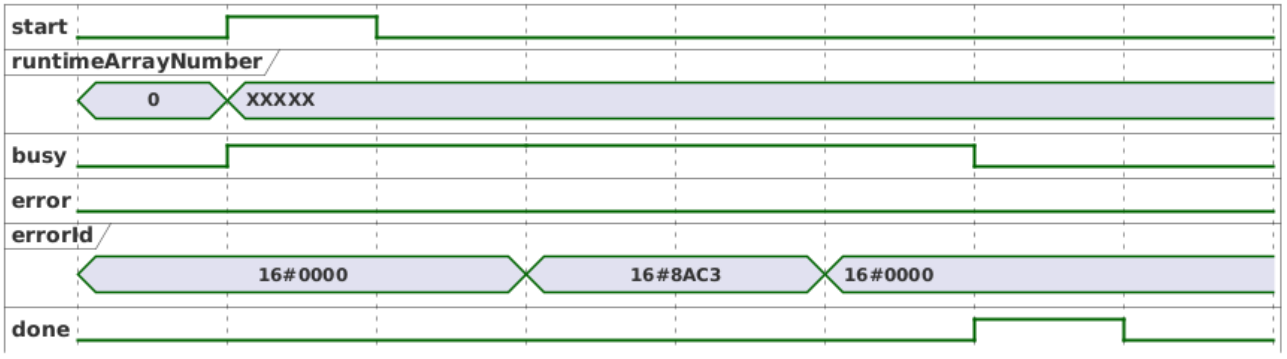
Array created successfully:



Error while creating array:



Max number of "create_db" instances reached:



See also

- LRA_ReadRuntimeArray
- LRA_WriteRuntimeArray.
- LRA_DeleteRuntimeArray.

---

1. Some PLCs might support an even smaller number. Check the hardware datasheet. ↩
2. It is recommended to use even array upper bounds, as odd sizes must be rounded up due to a limitation in the underlying function. ↩

LRA_ReadRuntimeArray

Current documentation version: 0.0.1

0.0.1 - Initial Release.

Description

The "LRA_ReadRuntimeArray" is used to read an index position of a *runtime array*.

Runtime arrays can be create with "LRA_CreateRuntimeArray" and written with "LRA_WriteRuntimeArray".

Functional description

This function works synchronously. Therefore, the operation is done in one block call.

Parameters

Parameter	***Declaration***	***Data type***	***Description***
start	Input	Bool	Continuous read of runtime array index while TRUE.
runtimeArrayNumber	Input	DB_DYN	Identifier of array as a number.
runtimeArrayIndex	Input	DInt	Array index to be read.
indexReadValue	InOut	Variant	Value read from runtime array index.
error	Output	Bool	TRUE for one cycle if there was a read error.
errorId	Output	Word	Stores error code.
done	Output	Bool	TRUE for one cycle if the array index was read without errors.

Parameter errorId

Error code (W#16#...)	**Description**
0000	No error.
8001	User requested an array type that is not supported.

Error code (W#16#...)	Description
8007	Array not found.
8008	Read index out of bounds.
8009	No array type found.
800A	Datatype mismatch.

Troubleshooting

Error code (W#16#...)	Description
0000	No troubleshooting necessary.
8001	Check supported datatypes list and monitor function input during runtime.
8007	Check function input and if the read DB exists.
8008	Check index value and array size.
8009	Make sure the array type identifier did not get modified by the user. If not, this is an internal error and the developer must be contacted.
800A	Check provided "indexReadValue" and array datatype.

See also

- LRA_CreateRuntimeArray.
- LRA_WriteRuntimeArray.
- LRA_DeleteRuntimeArray.

LRA_WriteRuntimeArray

Current documentation version: 0.0.1

0.0.1 - Initial Release.

Description

The "LRA_WriteRuntimeArray" is used to write to an index position of a *runtime array*.

Runtime arrays can be create with "LRA_CreateRuntimeArray" and read with "LRA_ReadRuntimeArray".

Functional description

This function works synchronously. Therefore, the operation is done in one block call.

Parameters

Parameter	***Declaration***	***Data type***	***Description***
start	Input	Bool	Continuous write of runtime array index while TRUE.
runtimeArrayNumber	Input	DB_DYN	Identifier of array as a number.
runtimeArrayIndex	Input	DInt	Array index to be written.
indexWriteValue	InOut	Variant	Value to be written to runtime array index.
error	Output	Bool	TRUE for one cycle if there was a write error.
errorId	Output	Word	Stores error code.
done	Output	Bool	TRUE for one cycle if the array index was written without errors.

Parameter errorId

Error code (W#16#...)	**Description**
0000	No error.

Error code (W#16#...)	Description
8001	User requested an array type that is not supported.
8007	Array not found.
8008	Read index out of bounds.
8009	No array type found.
800A	Data type mismatch.

Troubleshooting

Error code (W#16#...)	Description
0000	No troubleshooting necessary.
8001	Check supported data types list and monitor function input during runtime.
8007	Check function input and if the read DB exists.
8008	Check index value and array size.
8009	Make sure the array type identifier did not get modified by the user. If not, this is an internal error and the developer must be contacted.
800A	Check provided "indexWriteValue" and array data type.

See also

- LRA_CreateRuntimeArray.
- LRA_ReadRuntimeArray.
- LRA_DeleteRuntimeArray

LRA_DeleteRuntimeArray

Current documentation version: 0.0.1

0.0.1 - Initial Release.

Description

The "LDA_DeleteRuntimeArray" is used to delete a *runtime array* created by "LRA_CreateRuntimeArray". The memory is then freed for further use.

Values can be read and written using the "LRA_ReadRuntimeArray" and "LRA_WriteRuntimeArray".

> ⚠ **Warning**
>
> The following limitations apply:
>
> - The minimum number of necessary function calls for deletion is $n + 1$, where n is the number of DBs that must be deleted.
> - All other specificities and limitations of the default function "DELETE_DB" also apply.

Functional description

This function works asynchronously. Therefore, depending on the size and array datatype, it might require multiple calls to complete its task.
If the done bit is set, the deletion was successful.
If the error bit is set, the deletion failed. Check the error code for more details.

> 🖉 **Note**
>
> Always check the done and error bits to correctly evaluate if the job has been completed or failed.

Parameters

Parameter	*Declaration*	*Data type*	*Description*
start	Input	Bool	Trigger start of array deletion.
runtimeArrayNumber	Input	DB_DYN	ID of array to be deleted.
busy	Output	Bool	TRUE while array deletion is ongoing.
error	Output	Bool	TRUE for one cycle when there was an error in the array deletion.
errorId	Output	Word	Stores error code.
done	Output	Bool	TRUE for one cycle when the array deletion was successful.

Parameter errorId

Error code (W#16#...)	Description
0000	No error.
8007	Array was not found.
800B	Linked array not found.
8B0C	Internal error.
8BC3	Max number of "DELETE_DB" instances was reached. In this case, the error bit is **not** set and a retry is done in the next block call.

Troubleshooting

Error code (W#16#...)	Description
0000	No troubleshooting necessary.
8007	Check supported datatypes list and monitor function input during runtime.
800B	Check if the DB was deleted somewhere else in the software.
8B0C	Contact library developer.
8BC3	Wait for next function call.

Digital timing diagram

Array deleted successfully:

Error while deleting array:

See also

- LRA_CreateRuntimeArray.
- LRA_ReadRuntimeArray.
- LRA_WriteRuntimeArray.