Training Document for Comprehensive Automation Solutions

Totally Integrated Automation (TIA)

MODULE A5

Programming the CPU 314C-2DP

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The following symbols provide guidance through this module:



1. FOREWORD

In terms of its contents, module A5 belongs to the teaching unit entitled **"Basic Principles of STEP 7 Programming'**.



Learning Objective:

In this module, the reader learns how to create a hardware configuration for the CPU 314C-2DP and how to write and test a STEP 7 program. Based on the steps below, the A5-module explains the procedure in principle, using a very brief example:

- Setting up a STEP 7 project
- Creating the hardware configuration for the 314C-2DP CPU
- Writing a STEP 7 program
- Testing the program

Requirements:

The following knowledge is a precondition for successful utilization of this module:

- Knowledge in the use of Windows
- Basic principles of PLC programming with STEP 7 (e.g. Module A3 'Startup' PLC Programming with STEP 7)

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Hardware and software needed

- PC, operating system Windows 2000 Professional starting with SP4 /XP Professional starting with SP1/Server 2003 with 600 MHz and 512 RAM, free hard disk memory approx. 650 to 900 MB, MS Internet Explorer 6.0
- 2 Software: STEP7 V 5.4
- 3 MPI interface for the PC (e.g. PC adapter for USB)
- 4 SIMATIC S7-300 PLC with the CPU 314C-2DP
 - Configuration example:
 - Power supply unit: PS 307 2A
 - CPU: CPU 314-2DP



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2. NOTES ON THE USE OF THE CPU 314C-2DP



The CPU 314C-2DP is shipped with an integrated PROFIBUS DP interface and integrated inputs/outputs.

The following PROFIBUS protocol profiles are available for the CPU 314C-2DP:

- DP interface as master according to EN 50170.
- DP interface as slave according to EN 50170.

PROFIBUS-DP (decentralized peripherals) is the protocol profile for connecting decentralized peripherals/field units with very fast reaction times.

The addresses of the input and output modules of this CPU can be parameterized.

Due to the following performance data, this CPU is especially suitable for training purposes:

- 48 kByte RAM, load memory in the form of a plug-in MicroMemoryCard (MMC), 64 kByte to 4 MByte

- 8192 bytes DI/DO, including 992 bytes central
- 512 bytes Al/AO, including 248 bytes central
- 0.1 ms / 1 K commands
- 256 counters
- 256 timers
- 256 clock memory bytes

- 24 DIs, including 16 which can be used for integrated functions; all can be used as alarm inputs as well

- 16 DOs, integrated; 4 of which are fast outputs
- 4 Als for current/voltage, 1 Al resistor integrated
- 2 AOs for current/voltage, integrated
- 4 pulse outputs (2.5 kHz)
- 4-channel counting and measuring with 24 V (60 kHz) incremental encoders
- Integrated positioning function

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2.1 OPERATING THE CPUS 31XC



Operator control and display elements

The following illustration shows the operator control and display elements of a CPU 31xC. The arrangement and number of elements in some CPUs differ from this illustration.



The following illustration shows the digital and analog inputs/outputs integrated on the CPU.



The figure shows the following integrated I/Os: (1) Analog I/Os (2) each with 8 digital inputs (3) each with 8 digital outputs

(4) Front connectors (front doors are open)

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Status and fault/error displays

The CPU has the following LED displays:

LED designation	Color	Meaning
SF	red	Hardware or software error
BF (for CPUs with DP interface only)	red	Bus error
DC5V	green	5-V power for CPU and S7-300 bus is OK
FRCE	yellow	Force job is active
RUN	green	CPU in RUN
		The LED flashes during STARTUP at a rate of 2 Hz, and in HOLD state at 0.5 Hz.
STOP	yellow	CPU in STOP and HOLD or STARTUP
		The LED flashes at 0.5 Hz when the CPU requests a memory reset, and during the reset at 2 Hz.

Slot for the SIMATIC Micro Memory Card (MMC)

A SIMATIC Micro Memory Card (MMC) is used as a memory module for the CPU 31xC. The MMC can be used as a load memory and as a transportable data carrier. The MMC **must** be plugged in before the CPU can be operated because the CPUs 31xC do not have an integrated load memory.

Mode selector

The mode selector can be used to choose the current operating mode of the CPU. The mode selector is designed as a toggle switch with 3 positions.

Positions of the mode selector

The positions of the mode selector are explained in the same sequence as they occur on the CPU:

Position	Description	Comments
RUN	RUN mode	The CPU is processing the user program
STOP	STOP mode	The CPU is not processing a user program
MRES	Memory Reset	Button position of the operating mode switch for a memory
		reset of the CPU. A CPU memory reset requires a specific
		operating sequence (refer to the Installation Manual,
		Chapter Commissioning)

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2.2 MEMORY AREAS OF THE CPU 31XC

Introduction

The memory of the CPU 31xC can be divided into three areas:

Memory of the CPU





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Note

Only with the MMC plugged in is it possible to load user programs and therefore operate the CPU 31xC

Load memory

The load memory is located on a SIMATIC Micro Memory Card (MMC).

Its size is exactly the same as that of the MMC. It is used for storing code blocks and data blocks as well as system data (configuration, connections, module parameters, etc.).

Blocks that are marked as not being relevant to program execution are exclusively stored in the load memory.

In addition, the complete planning data for a project can be stored on the MMC.

RAM

The RAM is integrated on the CPU and cannot be expanded. It is used for processing the code and processing the data of the user program. The program is executed exclusively in the RAM and the system memory.

Once the MMC has been plugged in, the RAM of the CPU is retentive.

System memory

The system memory is integrated on the CPU and cannot be expanded. It contains

- the operands area for clock memories, timers and counters
- the process images of the inputs and outputs
- the local data

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Retentivity

Your CPU 31xC has retentive memory. Retentivity is implemented on the MMC and on the CPU. Due to this retentivity, the contents of the retentive memory are retained even after the mains supply has been switched off and the CPU has been restarted (warm restart).

Load memory

You program in the load memory (MMC) is always retentive. During loading, it is stored on the MMC, is powerfail-proof and cannot be cleared.

Work memory (RAM)

Your data in the work memory are backed up on the MMC in the event that the mains supply is switched off. The contents of data blocks are therefore always retained.

System memory

With regard to clock memories, timers and counters, you configure (properties of the CPU, Retentivity tab) which parts are to be retentive and which are to be initialized with "0" when the system is restarted (warm restart).

The diagnostic buffer, MPI address (and baud rate) as well as the runtime meter are generally stored in the retentive memory area on the CPU. The retentive area for the MPI address and the baud rate ensure that your CPU is still able to communicate after a power failure, a complete memory reset or loss of the communication parameters (because the MMC was removed, or the communication parameters were deleted).

Retention of the memory objects

The following table shows which memory objects are retained when transitions between operating modes occur.

Memory Object	Operating Mode Transition		
	PowerOn/PowerOff	STOP →	Memory
		RUN	Reset
User Program/User Data (load memory)	Х	Х	Х
Actual values of the DBs	Х	Х	-
Flags, timers and counters configured as	Х	Х	-
retentive			
Diagnostic buffer, hours run meter	Х	Х	Х
MPI address, baud rate	Х	Х	Х

X = retentive; - = not retentive

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3. **CREATING THE HARDWARE CONFIGURATION FOR THE CPU 314C-2DP**

In Step 7, files are managed with the 'SIMATIC Manager'. Here, program blocks can be copied, for example, or called for further processing with other tools by clicking on them with the mouse. Use of the SIMATIC Manager is in line with the usual Windows standards (e.g. right-clicking on a component causes its selection menu to appear).

In STEP 7, each project is created with a fixed specified structure. The programs are stored in the following directories:



*¹ Designations from STEP 7 Version 2.x

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The hardware configuration of the PLC is mapped in the 'SIMATIC 300 Station' and 'CPU' folders. This is done in the special case where a configuration is created with the CPU 314C-2DP. Also, a clock memory is configured and the addresses of the input and output modules are set in this case.



The user must perform the following steps in order to set up a project and create the hardware configuration.

1. The central tool in STEP 7 is the 'SIMATIC Manager', which is started by double-clicking on the icon. (\rightarrow SIMATIC Manager)



STEP 7 programs are managed in projects. Such a project will now be set up (\rightarrow File \rightarrow New) 2.

Vew Ctrl+N New Project' Wizard Open Open Ctrl+O 57 Memory Card > Memory Card File > Delete Reorganize Reorganize Manage Archive Archive Retrieve > Page Setup L L Erreichbare Teilnehmer MPI 2 2 S7 Memorycard Alt+F4	SIMATIC Manager	Help	
New Project' Wizard Open Ctrl+O 57 Memory Card A Memory Card File Delete Reorganize Manage Archive Retrieve Page Setup L Erreichbare Teilnehmer MPI 2 57 Memorycard Exit Alt+F4	New		
Open Ctrl+O 57 Memory Card > Memory Card File > Delete Reorganize Reorganize Manage Manage Archive Archive Retrieve Page Setup I L Erreichbare Teilnehmer MPI 2 57 Memorycard	'New Project' Wizard		
S7 Memory Card Memory Card File Delete Reorganize Manage Archive Retrieve Page Setup 2 S7 Memorycard Exit	Open	Itrl+O	
Memory Card File Delete Reorganize Manage Archive Retrieve Page Setup L Erreichbare Teilnehmer MPI 2 57 Memorycard Exit Alt+F4	57 Memory Card	•	
Delete Reorganize Manage Archive Retrieve Page Setup 2 age Setup t Erreichbare Teilnehmer MPI 2 57 Memorycard Exit Alt+F4	Memory Card File	•	
Reorganize Manage Archive Retrieve Page Setup 1 Erreichbare Teilnehmer MPI 2 S7 Memorycard Exit Alt+F4	Delete		
Manage Archive Retrieve Page Setup L Erreichbare Teilnehmer MPI 2 57 Memorycard Exit Alt+F4	Reorganize		
Archive Retrieve Page Setup 1 Erreichbare Teilnehmer MPI 2 S7 Memorycard Exit Alt+F4	Manage	_	
Retrieve Page Setup I Erreichbare Teilnehmer MPI 2 57 Memorycard Exit Alt+F4	Archive		
Page Setup I Erreichbare Teilnehmer MPI 2 S7 Memorycard Exit Alt+F4	Retrieve		
1 Erreichbare Teilnehmer MPI 2 57 Memorycard Exit Alt+F4	Page Setup		
2 S7 Memorycard	1 Erreichbare Teilnehmer MPI		
Exit Alt+F4	2 S7 Memorycard		
	Exit	Alt+F4	

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3. The project is now assigned the name 'CPU314C_2DP' under 'Name' (\rightarrow CPU314C_2DP \rightarrow OK)

Name Storage path	
Add to current multiproject	
Add to current multiproject	Туре:
Add to current multiproject Name: CPU314C_2DF	Type:
Add to current multiproject Iame: CPU314C_2DF itorage location	Type: Project

4. A 'SIMATIC 300-Station' station is now inserted. (\rightarrow Insert \rightarrow Station \rightarrow SIMATIC 300 Station)



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Open the configuration tool by double-clicking on 'Hardware'. (\rightarrow Hardware) 5.

SIMATIC Manager - [CPU314C_2DP D:\0_57_Projekte\CPU314C_]	×
	1
CPU314C_2DP SIMATIC 300(1)	
Press F1 to get Help. PC Adapter(MPI)	11.

Open the hardware catalog by clicking on the \mathbb{B} symbol. (\rightarrow 6. The catalog is divided into the following directories:

- PROFIBUS-DP/PA, SIMATIC 300, SIMATIC 400 and SIMATIC PC Based Control -

and provides you with all the module racks, modules and interface modules for designing your hardware configuration.



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7. Insert a rail by double-clicking on **'Rail'** (\rightarrow SIMATIC 300 \rightarrow RACK-300 \rightarrow Rail).

Big HW Config - [SIMATIC 300(1) (Configuration) CPU314C_2DP] Big Station Edit Instatic PIC View Options Window Hale		_	
		L	
	Eind:	Standard	□× ↑#↓
×		ROFIBUS DP ROFIBUS-PA ROFINET 10 IMATIC 300 C7 CP-300 FM-300 FM-300 Gateway IM-300 M7-EXTENSION PS-300 RACK-300	
SIMATIC 300(1) Slot Designation		MATIC 400 IMATIC 400 IMATIC HMI Station IMATIC PC Based Control 3 IMATIC PC Station	300/40
	6ES7 390 Available)-1???0-0440 in various lengths	<u>}</u> ₹
Press F1 to get Help.		ſ	- //

A configuration table for designing Rack 0 is then displayed.

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From the hardware catalog, you now can select any of the modules that are also plugged into 8. the real rack and insert them in the configuration table.

To do this, you must click on the name of the respective module, hold down the mouse button and drag the module into a row of the configuration table using the Drag & Drop function. We are starting with the power supply unit 'PS 307 2A'. (\rightarrow SIMATIC 300 \rightarrow PS-300 \rightarrow PS 307 2A)

		a 🔁 🏜 🏜 🚯 🖻	I 🔡 №?							
😑 (0) U 1	R							<u> </u>		- = = 2 n† n
2								<u>Profile:</u>	Standard	5
5 6 7 8 9 10 11	(0) UR					ļ	•		HOFIBOS-FA OFINET IO MATIC 300 C7 CP-300 CPU-300 FM-300 MATIC S00 MASON MASON M-SXTENSION PS-307 10A PS 307 5A	
	Module	Order number	Firmware	MPI address	I address	Q C		± 🚊	RACK-300	
							-		I SM-300 MATIC 400	
								🗄 🛄 SI	MATIC HMI Station	
1 2 3									MATIC PC Based Cor	
2 3 4				-				E 🔛 SI		ntrol 300/4
1 2 3 4 5								I ⊕ - <mark>∭</mark> SI ⊕ - ≌ SI	MATIC PC Station	ntrol 300/4
1 2 3 4 5 6								⊞-∰ SI ⊞-⊒ SI	MATIC PC Station	ntrol 300/4
1 2 3 4 5 6 7 8									MATIC PC Station	ntrol 300/4



Note: If your hardware differs from that shown here, just select the corresponding modules from the catalog and insert them into your rack.

The order numbers of the individual modules are noted on the components and are also shown in the footer of the catalog.

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In the next step, we drag the CPU 314C-2DP onto the second slot. When this is being done, the 9. order number and the version of the CPU can be read on the front of the CPU. (\rightarrow SIMATIC $300 \rightarrow \text{CPU-}300 \rightarrow \text{CPU} 314\text{C-}2\text{DP} \rightarrow 6\text{ES7} 314\text{-}6\text{CF00-}0\text{AB0}$).

HW Config - [S]	MATIC 300(1) (Co insert PLC View	onfiguration) CP Options Window	U314C_2DP] Help							×
	\$1 6 6 6	🟜 🎕 📳 🛙	⊐ 🔡 🕅							
() UB		1					-	-		
1 PS 3	20 20							Eind:		nț ni
2								Profile:	Standard	•
4 6 7 8 9 10 11									ATIC 300 C7 CP-300 CPU 312 CPU 312 CPU 312C CPU 313C CPU 313C-2DP CPU 313C-2PP CPU 313C-2PP CPU 313C-2PP CPU 314	
(0) UR								÷-(CPU 314 IFM CPU 314C-2 DP 6ES7 314-6CE00	-04B0
Slot Modu 1 PS 307 2 3 4 5 6 7	le 0 2A 6E	rder number (\$7.307-18A00-04A0	Firmware	MPI address	l address	Q	E		EES7 314-6CF01 EES7 314-6CF02 CPU 314C-2 PtP CPU 315 CPU 315-2 DP CPU 315-2 PN/DP CPU 315-2 PN/DP FCF02-0480	
Selecting the hardwa	re							Work men instruction integrated	nory 64KB; 0.1ms/1000 s; DI24/D016; AI5/AO2 ; 4 pulse outputs (2.5kHz)	

10. In the following dialog box, we now want to set up the integrated PROFIBUS interface. Because we will not use the interface here, we accept the settings with 'OK'(\rightarrow OK).

Address:	2 💌	If a subnet is selected, the next available address is suggested.
Subnet: not i	networked	New
		Properties
		Delete



Note: Slot No. 3 is reserved for interface modules and therefore remains empty. Other modules which are not interface modules (IM) are therefore placed on slots 4 to 11.

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The properties of some modules can be altered
 (→ Click on module→ Change properties → OK).
 For example, a clock memory can be specified for all CPUs (→ Cycle/Clock memory → ∨ Clock
 memory → Memory Byte 100).

HW Config - [SIMATIC 300(1) (Configurat	on) EPU314C_2DP] Window Help	_ D _ 8_
☐ ☐ ☐ PS 307 2A	₩ 	=== xm†m
2 CPU 314C-2 DP X2 DP 2.2 D/24/D016 2.3 A/5/A02 2.4 Count 2.5 Position 3	Time-of-Day Interrupts Cyclic Interrupts Diagnostics/Clock Protection Communication General Startup Cycle/Clock Memory Retentive Memory Interrupts Cycle Image: Cycle Update 0B1 process image cyclically Scan cycle monitoring time [ms]: 150 Minimum scan cycle time [ms]: 0 Scan cycle load from communication [%]: 20 Size of the process image Image: Cycle I	M PPP M CDP
Slot Module Order number 1 PS 307 2A 6ES7 307-1BA 2 ICPU 314C-2 DP 6ES7 314-6 22 DP 22 DP 2.2 DP 2.3 A/5/A02	Clock Memory Clock memory Memory Byte: 100	4-6CF00-0AB0 4-6CF01-0AB0 4-6CF02-0AB0 PtP DP PN/DP
24 Count 25 Photicin 3 4 	OK Cancel Help	Tms/1000

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12. With most S7-300 CPUs, the addresses of the I/O modules can be altered.

This is done by double-clicking on the corresponding modules and altering their settings in the **'Addresses'** tab.

A note should always be made of these addresses (addresses assigned automatically are usually tied to a specific slot). (\rightarrow Dl24/DO16 \rightarrow Addresses \rightarrow Deselect System Default \rightarrow 0 \rightarrow OK)

HW Config - [SIMATIC 300(1) (Configuration)	CPU314C_2DP]	
Count Count Count Count Count 1 PS 307 2A 1 Count Count 2 CPU 314C-2 DP Count Count 2.3 Alfs/AO2 Count 2.5 Position 3 4 5 5 0	Operties - D124/D016 - (R0/52.2) General Addresses Inputs Start: 0 Process image: End: 2 Outputs Start: 0 Process image: End: 2 Outputs Start: 0 Process image: End: 125 OBT PI System Default	
(0) UR Slot Module Order number 1 PS 307 2A 6ES7 307-18A00-0AAC 2 CPU 314C-2 DP 6ES7 314-6CF02-04 X2 DP 23 DI24/D016 23 A/5A02 24 Count 25 Position 3 4 -	OK Cancel Help 174128 124125 0 0 178783 755 0 0 0 178783 788783 0 0 0 0 178793 784799 0 0 0 0 0 178793 784799 0 0 0 0 0 0 1 1 1 1 0<	

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13. By clicking on the 📖 and 🖮 buttons, the configuration table is now first stored and converted, and then loaded into the PLC. When this is being done, the key switch on the CPU should be in the Stop position! (\rightarrow



Loads the current station into the load memory of the current module.

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WRITING A STEP 7 PROGRAM 4.



We are writing the program to be tested in the statement list language (STL), and it only contains two lines.

Here, the frequencies of the MB100 clock memory byte activated in the hardware are to be read out on an output byte.

Assignment list:

MB100	Clock	Clock memory byte
AB0	AB	Display



A cycle duration/frequency is assigned to each bit of the clock memory byte. Assignment is as follows:

Bit:	7	6	5	4	3	2	1	0
Clock duration (s):	2	1.6	1	0.8	0.5	0.4	0.2	0.1
Frequency (Hz):	0.5	0.625	1	1.25	2	2.5	5	10



14. In the 'SIMATIC Manager', mark the 'Blocks' folder.(\rightarrow SIMATIC Manager \rightarrow Blocks)



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15. In the SIMATIC Manager, double-click on the **'OB1'** block to open it (\rightarrow OB1)

SIMATIC Manager - [CPU314C	_2DP D:\0_57_Projekte\CPU314C_] Options Window Help	
File Edit Insert PLC View File Edit Insert PLC View CPU314C_2DP CPU314C_2DP File Edit Insert C300(1) File Edit Insert PLC View File Edit Insert PLC Vi	Options Window Help	
Press F1 to get Help.	() () () () () () () () () () () () () (Adapter(MPI)

16. As an option, you can enter the properties of the OB1 for documentation purposes and accept them with 'OK'.

(→OK)

Properties - Organizatio	on Block	<u>×</u>
General - Part 1 Genera	al - Part 2 Calls Attributes	,
Name:	OBI	
Symbolic Name:		
Symbol Comment:		
Created in Language:	STL	
Project path:		
Storage location of project:	D:\0_S7_Projekte\CPU314C_	
	Code	Interface
Date created:	01/04/2007 06:05:53 AM	
Last modified:	02/07/2001 03:03:43 PM	02/15/1996 04:51:12 PM
Comment:	"Main Program Sweep (Cycle)"	×
OK		Cancel Help

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17. **'LAD/STL/FDB Program S7 Blocks'** is an editor which allows you to create your STEP 7 program as you require. To this end, the OB1 organization block with the first network has already been opened. In order to create your first logic operations, you must mark the first network. Now you can write your first STEP 7 program. Individual programs are usually divided

into networks in STEP 7. You open a new network by clicking on the network symbol,



Note: Comments regarding program documentation are separated from the program commands by the characters "//".

LAD/STL/FBD - [OB1 CPU314C]	2DP\SIMATIC 300(1)\CPU 314C-2 DP]	
		-8- 1-1-1- <u>1</u>
Co D Interface D TEMP	ntents Of: 'Environment\Interface' Name TEMP	New network
OB1 : "Main Program Sweep Comment:	(Cycle)"	
Network 1: Clock memory byt Comment:	e	
L MB 100 T QB 0	//load clock memory byte MB100 //transfer to output byte QB0	<u> </u>
	×	Program eleme
BYTE 2: Inf	o 🔨 3: Cross-references 👌 4: Address info. 👌 5: Modify 👌 6: Di	iagnostics λ 7: Comparison /
Press F1 to get Help.	(m) □ offline Abs < 5.2 Nw 1	Ln 2 Insert Chg
The network	L MB 100	

L MB 100 T AB 0

loads the clock memory byte activated in the hardware configuration and transfers it to an output byte. As a consequence, the 8 bits of the output byte flash in the different frequencies of the clock memory bits.



Note: The address of the output byte can be different from case to case, depending on the hardware configuration.

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5. TESTING THE STEP 7 PROGRAM



The STEP 7 program to be tested can now be loaded into the PLC. In our case, this is only OB1.

18. Save the organization block with 🔲 and load it into the PLC by clicking on 🎰. When this is

being done, the key switch on the CPU should be in the STOP position! (\rightarrow) \rightarrow)

🔀 LAD/STL/FBD - [OB1 CP	U314C_2DP\SIMATIC 300(1)\CPU 314C-2 DP]	
🕞 File Edit Insert PLC De	bug View Options Window Help	<u>_ 8</u>)
	BE > ~ (# 🚵 🗢 📲 & !<>! 🗖 🖻 📫 H H - ()
Interface E- TEMP	Contents Of: 'EnDownload ht\Interface' Name TEMP	Kew network Gr FB blocks FC blocks
OB1 : "Main Program : Comment:	Sweep (Cycle)"	SFC blocks ∭ Multiple instances ⊕-∰ Libraries
Comment:	-, -, -, -, -, -, -, -, -, -, -, -, -, -	
L MB 100 T QB 0	//load clock memory byte MB100 //transfer to output byte QB0]
< <u> </u>	2	Program eleme
BYTE	2: Info \bigwedge 3: Cross-references λ 4: Address info. λ 5: Modify λ	6: Diagnostics λ 7: Comparison /
ads the current block to the PLC	. 📾 🗣 offline Abs < 5.2	Nw 1 Ln 2 Insert

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19. To start the program, move the key switch to the RUN position. Click on the symbol to view the program in **'OB1'**.

$(\rightarrow 60^{\circ})$	
CAD/STL/FBD - [@0B1 CPU314C_2DP\SIMATIC 300(1)\CPU 314C-2 DP_ONLINE]	
🕣 File Edit Insert PLC Debug View Options Window Help	_ & ×
Contents Of: 'Environment\InMonitor(on/off)	
E Interface Name	
OB1 : "Main Program Sweep (Cycle)" Comment: Network 1: Clock memory byte Comment:	
L MB 100 //load clock memory byte MB100 0 1 fe	
T QB 0 //transfer to output byte QB0 0 1 fe	
■ EVTB	arison /
Starts/Stops the monitoring of the current block.	1.

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