STNASPROG-E

B&R AUTOMATION STUDIO™
PROGRAMMING

Model No.: **STNASPROG-E**

Version: **2.0**
MP/SP/ZR 04/2001

SEMINAR START

1 INTRODUCTION

General Information

In the next few days - for the duration of this seminar - you will be working together with your seminar leader.The technical expertise of your seminar leader is not the only factor responsible for your personal success during this seminar.

Success depends on cooperation and interaction between the course members and the seminar leader, as well as the attitude and application of individual course members towards teamwork and the course in general.

Introduction Seminar Leader

Please allow the seminar leader to introduce him/herself. Make notes if necessary.

Introduction Course Members

You should get to know your colleagues as you will be working together as a group and also in smaller groups during the seminar (name, company, product, application area).

Your personnal success on this course also depends on your expectations.

2 SEMINAR OVERVIEW

- B&R Automation Studio
- B&R Automation Runtime
- B&R Automation Target
- B&R Automation Net
- Project Guidelines
- SFC Seqential Function Chart
- AB Automation Basic
- Data Handling
- TPU Code Linker
- Library Manager Introduction
- ANSI C

3 SCHEDULE

The time available during the seminar is a very important factor.

Start ______________________________

Lunch Braek ______________________________

End ______________________________

Breaks We will taking short breaks at various intervals through out the seminar for tea and coffee and to give the smokers the chance to light up!

Successful teamwork not only relies on your personnal motivation, but also on meeting the expectations of your seminar leader.

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The seminar leader expects:

That all course members are prepared to take an active role and cooperate with other course members during the course of the seminar. “Nobody is perfect”, this includes your trainer, constructive feedback is always welcome.

B&R AUTOMATION STUDIO

1 OVERVIEW

During the ASINT course, we got to know Automation Studio as a general tool. Our task in this course is to learn about AS features in greater detail, which will help you use the full range of advantages for many different types of applications.

B&R Automation Studio

A brief overview of the B&R Automation concept with B&R Automation Studio, B&R Automation Net, B&R Automation Runtime and B&R Automation Targets.

AS Directory Structure

The question: “Where can I find it?”, will be answered in this chapter. Finding header files, archive files, system files, etc.

Project Directory Structure

The question: “Where should I save it ?” is answered in this chapter. Storing source files, executable BR files, project info files, etc.

AS Project

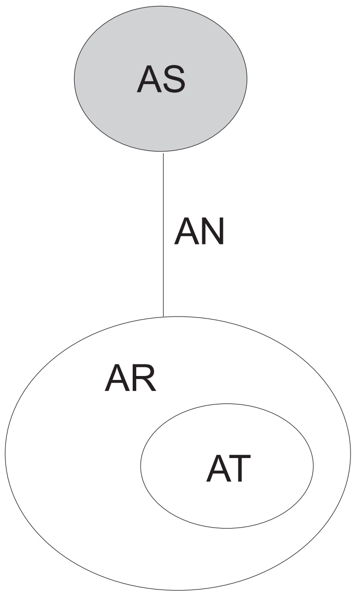
Brief description of the AS project structure and an overview of the most important points from creation to downloading a project.

Project Settings

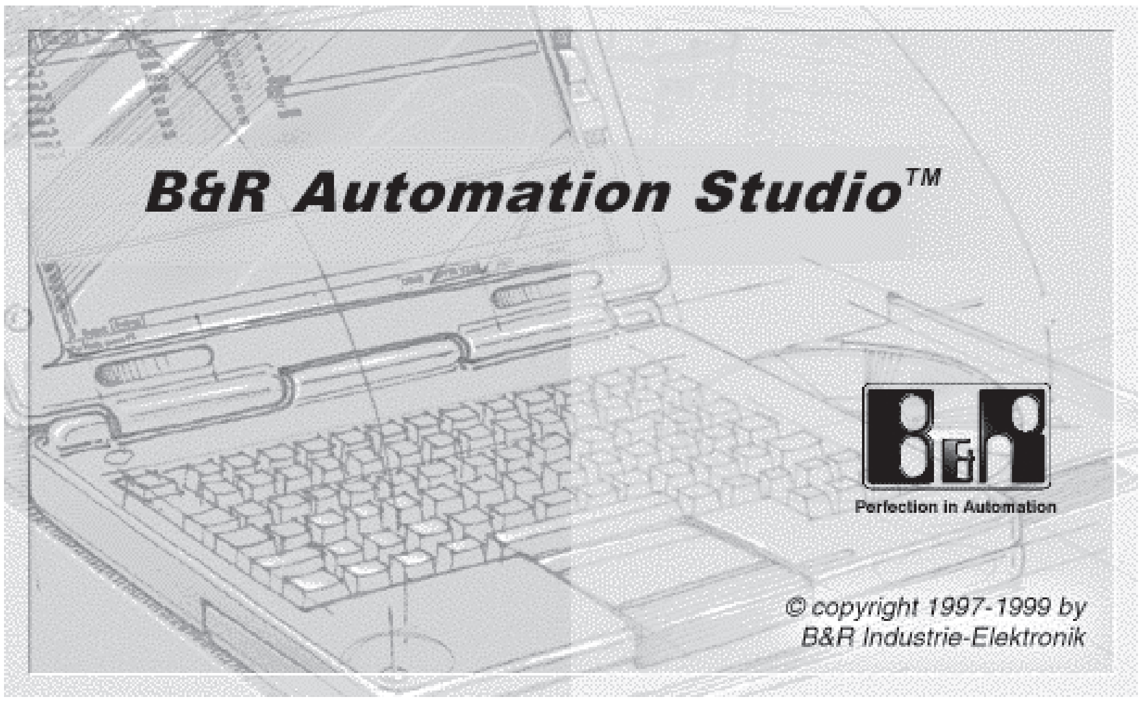
Overview of the global project parameters.

2 B&R AUTOMATION STUDIO

2.1 One Tool Many Targets

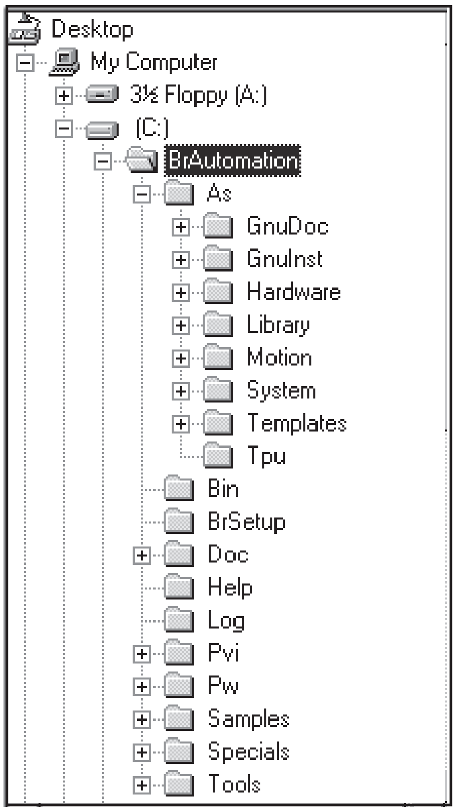


There is a programming tool, B&R Automation Studio, that can be used with many different target systems. This enables simple scaling and optimal compatibility with the automation platform. B&R Automation Studio communicates via B&R Automation Net using B&R Automation Runtime. B&R Automation Runtime runs on various B&R Automation targets.



3 AS DIRECTORY STRUCTURE

You can find your way around the AutomationStudio structure quickly and easily using the following directory list which provides an overview of the directory contents. This structure is set up when you install Automation Studio.



Desktop	
My Computer	
3½ Floppy (A:)	
(C:)	
BrAutomation	Automation Studio installation path
As	AS main directory
GnuDoc	GNU documentation “Index.html”
GnuInst	ANSI C specific files
Hardware	B&R hardware configuration files
Library	B&R library files
Motion	B&R motion components
System	B&R system modules, operating systems
Templates	Templates for DOS/AS project conversion
Tpu	B&R TPU components
Bin	AS executable files
BrSetup	Install / uninstall information
Doc	Documentation
Help	Help files
Log	PVI Logger – log files
Pvi	PVI executable files
Pw	Panel Studio files
Samples	Examples
Specials	Files for special modules
Tools	Tools

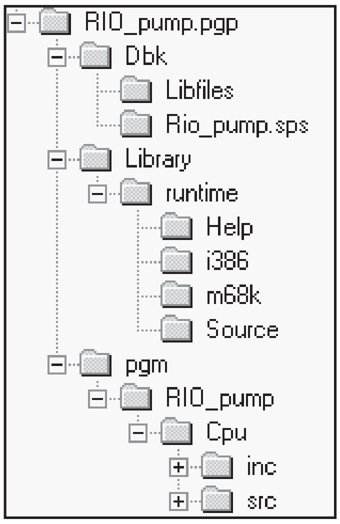
Fig. 2.1: B&R Automation Studio directories

4 PROJECT DIRECTORY STRUCTURE

When you create a new project with AutomationStudio, it automatically creates a project structure and gives it the directory name: “*Project name*.pgp”.

All project specific data, information, sources, etc. are stored in a directory structure under this directory. This allows you to move or copy the project directory at a later date, and to make it easily accessible for other programmers.

The project directory has the following structure:



RIO_pump.pgp	Project „RIO_2005“
Dbk	Database information
Libfiles	Database infos about libraries used
Rio_pump.sps	Project specific data for AS
Library	Libraries used in the project
runtime	Library „Runtime“
Help	Help files for the library
i386	Compiled library for Intel platform
m68k	Compiled library for Motorola platform
Source	Source codes for the library
pgm	AS program modules
RIO_pump	Rack name for this project
Cpu	CPU name in this rack
inc	Include directory for C tasks
src	Source directory for C tasks

Fig. 2.2: AS project directory structure

Note

The last two directories “inc” and “src” can be created by the user if C tasks are used.

5 AS PROJECT

5.1 Opening Projects

In order to be able to open an existing project, select the main menu item **File: Open Project.**

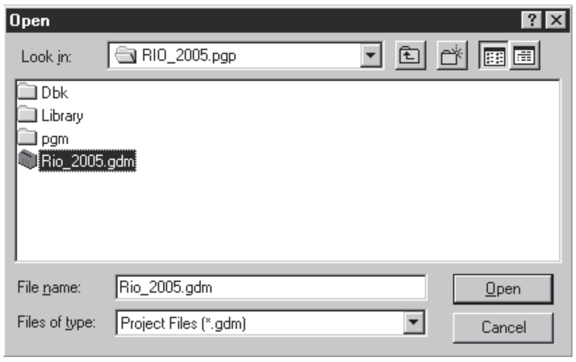


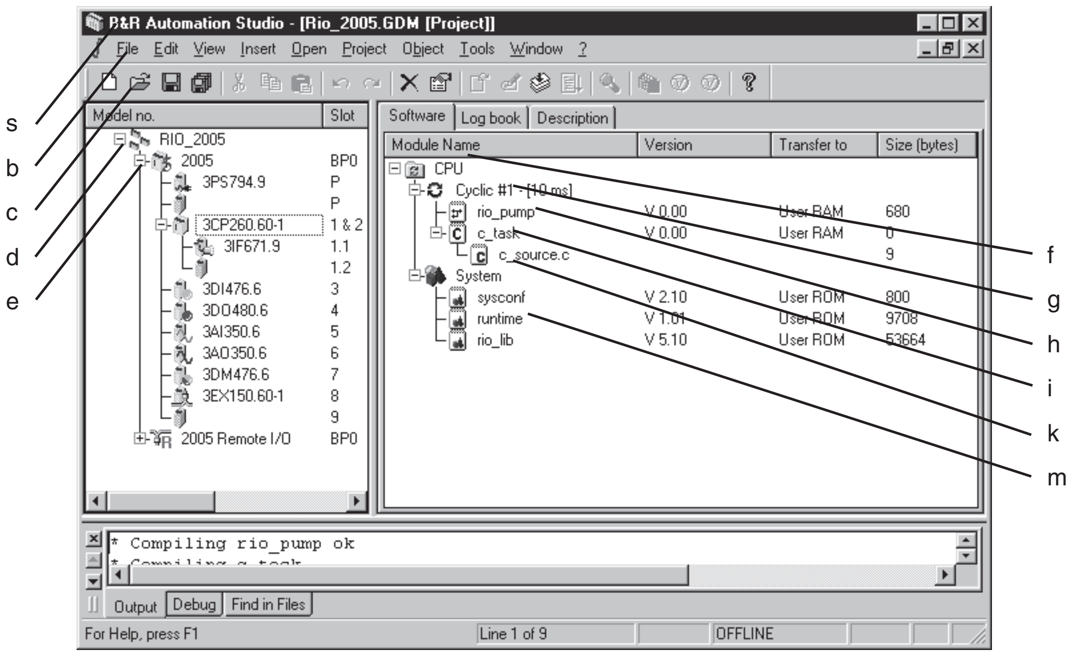
Fig. 2.3: Open Project dialog box

Select the respective GDM file, e.g.: "RIO_2005.GDM" and activate it with [Open]. GDM stands for Graphic Design Method.

This GDM file is in the project directory and has the name "`prj_name.pgp`".

A project is an entire system or machine and can be separated in the hardware configuration into Project, PCC, and CPU layers. On the software page, the CPU is separated into the individual task classes with their tasks and system modules.

This has a tree structure in the project window.



Model no.	Slot
RIO_2005	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4
3AI350.6	5
3AO350.6	6
3DM476.6	7
3EX150.60-1	8
	9
2005 Remote I/O	BP0

Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
rio_pump	V 0.00	User RAM	680
c_task	V 0.00	User RAM	0
c_source.c			9
System			
sysconf	V 2.10	User ROM	800
runtime	V 1.01	User ROM	9708
rio_lib	V 5.10	User ROM	53664

```
* Compiling rio_pump ok
* Compiling c_task
```

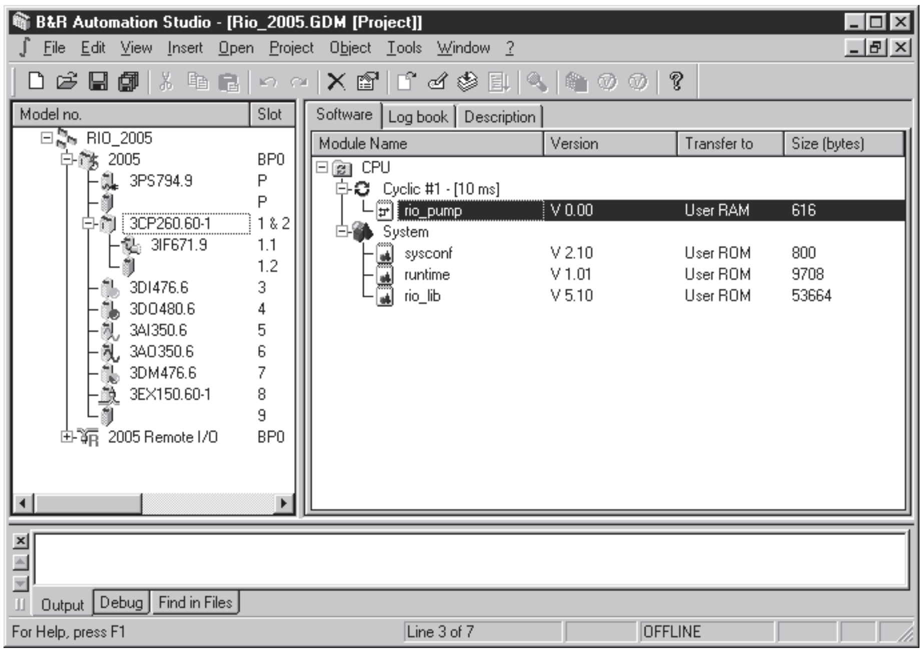
Fig. 2.4: Overview of Automation Studio project

a ... Title bar with name of the open project
b ... Menu bar
c ... Toolbar
d ... Root directory of the project tree is the project name
e ... Controller name, PCC name

f ... The root directory of the software tree is the selected CPU
g ... Task classes with defined cycle time
h ... LAD Task
i ... C task, can consist of several files
k ... C task source file
m ... System modules

5.2 LAD Task

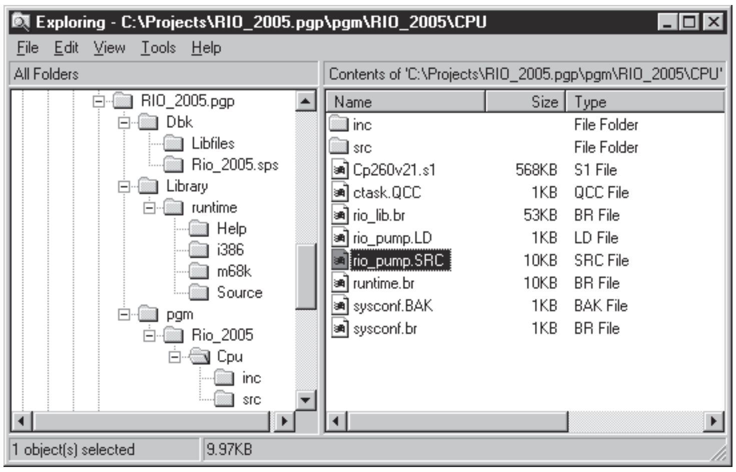
A new task can be created using the Object Wizard by selecting **Insert: New Object: LAD Task**. The source code for a LAD task (*.SRC extension) is always placed in the CPU program module directory:


B&R Automation Studio - [Rio_2005.GDM [Project]]
File Edit View Insert Open Project Object Tools Window ?
Software
Log book
Description
Output
Debug
Find in Files
For Help, press F1
Line 3 of 7
OFFLINE

Model no.	Slot
RIO_2005	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4
3AI350.6	5
3AO350.6	6
3DM476.6	7
3EX150.60-1	8
	9
2005 Remote I/O	BP0

Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
rio_pump	V 0.00	User RAM	616
System			
sysconf	V 2.10	User ROM	800
runtime	V 1.01	User ROM	9708
rio_lib	V 5.10	User ROM	53664

Fig. 2.5: New LAD task in the software tree


Exploring - C:\Projects\RIO_2005.pgp\pgm\RIO_2005\CPU
File Edit View Tools Help
All Folders
Contents of 'C:\Projects\RIO_2005.pgp\pgm\RIO_2005\CPU'
1 object(s) selected
9.97KB

- RIO_2005.pgp
  - Dbk
    - Libfiles
    - Rio_2005.sps
  - Library
    - runtime
      - Help
      - i386
      - m68k
      - Source
  - pgm
    - Rio_2005
      - Cpu
        - inc
        - src

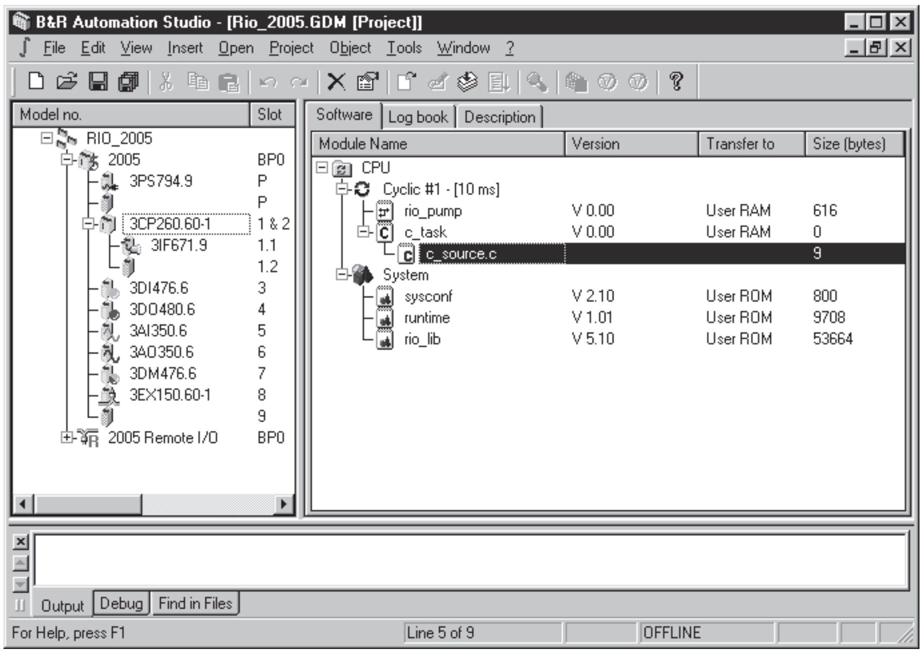
Name	Size	Type
inc		File Folder
src		File Folder
Cp260v21.s1	568KB	S1 File
ctask.QCC	1KB	QCC File
rio_lib.br	53KB	BR File
rio_pump.LD	1KB	LD File
rio_pump.SRC	10KB	SRC File
runtime.br	10KB	BR File
sysconf.BAK	1KB	BAK File
sysconf.br	1KB	BR File

Fig. 2.6: Source code in the project structure

5.3 C Task

Using **Insert: New Project: C Task.**
When inserting a C task, the C files are normally copied to the CPU program module directory (*.c/*.h/*.s/*.a/*.o). Save the C files in a subdirectory to improve clarity of the project.

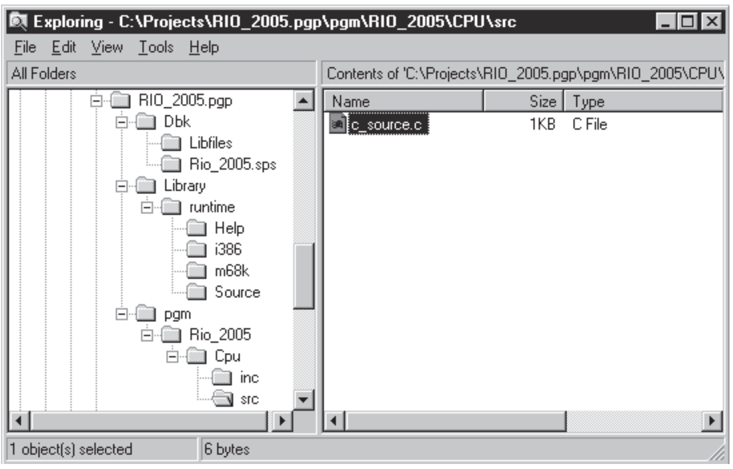
Also see **Project Guidelines II** or chapter ANSI C.


B&R Automation Studio - [Rio_2005.GDM [Project]]
File Edit View Insert Open Project Object Tools Window ?
Software Log book Description
Output Debug Find in Files
For Help, press F1
Line 5 of 9
OFFLINE

Model no.	Slot
RIO_2005	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4
3AI350.6	5
3AO350.6	6
3DM476.6	7
3EX150.60-1	8
	9
2005 Remote I/O	BP0

Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
rio_pump	V 0.00	User RAM	616
c_task	V 0.00	User RAM	0
c_source.c			9
System			
sysconf	V 2.10	User ROM	800
runtime	V 1.01	User ROM	9708
rio_lib	V 5.10	User ROM	53664

Fig. 2.7: New C task in the software tree

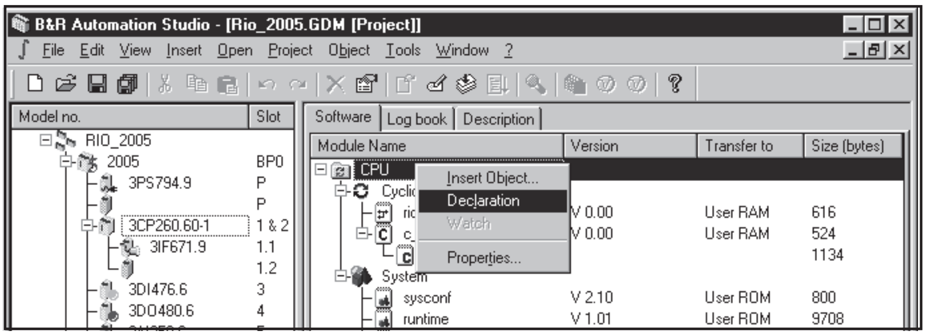

Exploring - C:\Projects\RIO_2005.pgp\pgm\RIO_2005\CPU\src
File Edit View Tools Help
All Folders
Contents of 'C:\Projects\RIO_2005.pgp\pgm\RIO_2005\CPU\
RIO_2005.pgp
Dbk
Libfiles
Rio_2005.sps
Library
runtime
Help
i386
m68k
Source
pgm
Rio_2005
Cpu
inc
src
1 object(s) selected
6 bytes

Name	Size	Type
c_source.c	1KB	C File

Fig. 2.8: Source code of the C task in the project structure

5.4 Variable Declaration

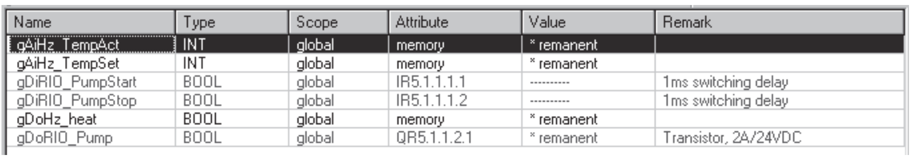
The menu **Open: Declaration** opens the respective variable declaration. If the CPU is selected, all global variables are shown.


B&R Automation Studio - [Rio_2005.GDM [Project]]
File Edit View Insert Open Project Object Tools Window ?
Software
Log book
Description
Insert Object...
Declaration
Watch
Properties...

Model no.	Slot
RIO_2005	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4

Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic			
ric	V 0.00	User RAM	616
c_	V 0.00	User RAM	524
			1134
System			
sysconf	V 2.10	User ROM	800
runtime	V 1.01	User ROM	9708

Fig. 2.9: CPU variable declaration pop-up dialog box



Name	Type	Scope	Attribute	Value	Remark
gAiHz_TempAct	INT	global	memory	* remanent	
gAiHz_TempSet	INT	global	memory	* remanent	
gDiRIO_PumpStart	BOOL	global	IR5.1.1.1.1	----------	1ms switching delay
gDiRIO_PumpStop	BOOL	global	IR5.1.1.1.2	----------	1ms switching delay
gDoHz_heat	BOOL	global	memory	* remanent	
gDoRIO_Pump	BOOL	global	QR5.1.1.2.1	* remanent	Transistor, 2A/24VDC

Fig. 2.10: All global variables

- Name
  All variables are accessed using their symbolic names.
- Type
  Types are automatically assigned for I/O. The programmer has to enter the type for internal variables used in tasks.
- Scope
  Internal variables should always have the smallest possible scope.
  I/O and variables for communication between task must be global.
- Attribute
  Defines hardware assignments, internal variables or constants.
- Owner
  The owner e.g.: of a L structure or constant is shown.
- Value
  Initialization value. Should be remnant. Variables should be initialized in the INIT SP for the task.
- Remark
  Additional information or standard text.

5.5 Transferring Projects

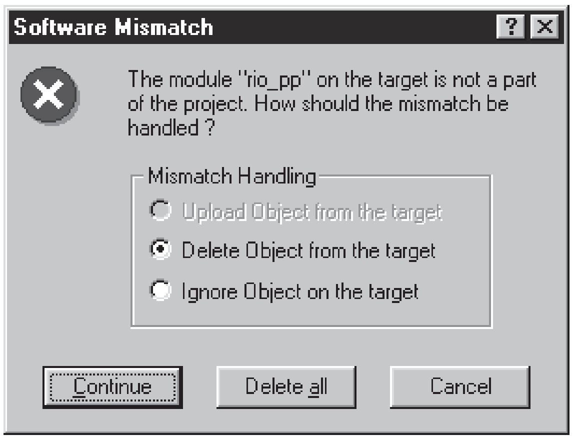
The main menu item **Project: Transfer to Target** transfers all the software modules to the controller. An automatic software compare is carried out between the PCC and the project before the transfer is made. Only modules currently not available or with newer creation dates are transferred to the controller.

The target memory for each individual module can be selected by marking the object with the cursor and selecting the main menu item
Object: Transfer to: Target Memory.

If AS finds one or more differences between the project contents and the PCC, it informs the programmer with the info message "Software Conflict" and displays the following dialog box.

Note

Software Conflict Recognition


Software Mismatch

The module "rio_pp" on the target is not a part of the project. How should the mismatch be handled ?

Mismatch Handling
- Upload Object from the target
- [✓ Delete Object from the target]
- Ignore Object on the target

Fig. 2.11: Software Conflict dialog box

- Delete Object from the target
  The module identified as being different is deleted from the controller.

IMPORTANT

modules identified as "disabled" are also deleted from the controller.

- Ignore Object on the target
  The module is not changed. If it is a task with I/O operations, conflicts can occur.

Example

- Create a LAD task with a latch.
- Transfer the project and test the task.
- Rename the task and transfer the project again.

Original Task:

Project Name:	as_rev
Ladder Diagram Name:	**re_latch**
Resource:	C#2
Target memory	**FLASH PROM**

Changed Task:

Project Name:	as_rev
Ladder Diagram Name:	**wd_new**
Resource:	C#2
Target memory	**RAM**

6. PROJECT SETTINGS

The parameters described in the following sections are globally valid for the current project.

The project settings can be found under **Project: Settings**.

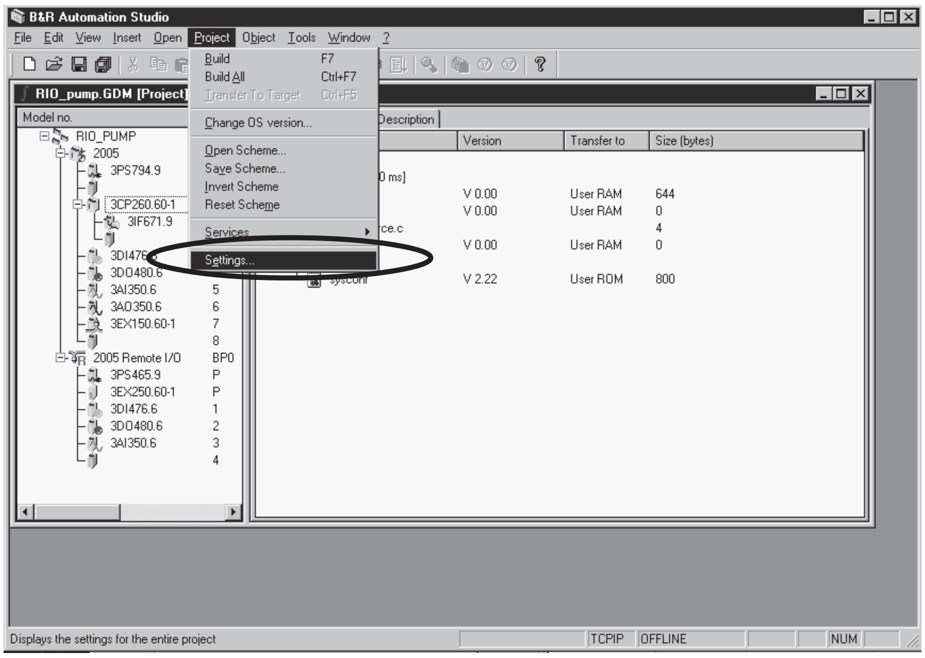
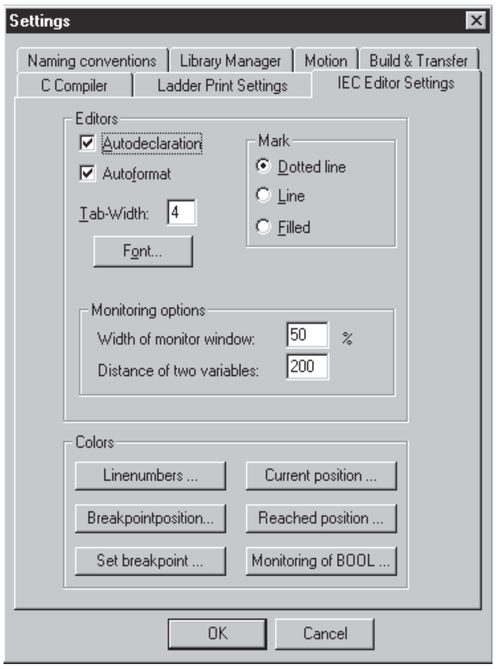


Fig. 2.12: Opening project settings

6.1 IEC Editor



Editors
[✓] Autodeclaration
[✓] Autoformat
Tab-Width: 4

Mark
[✓ Dotted line] Line Filled

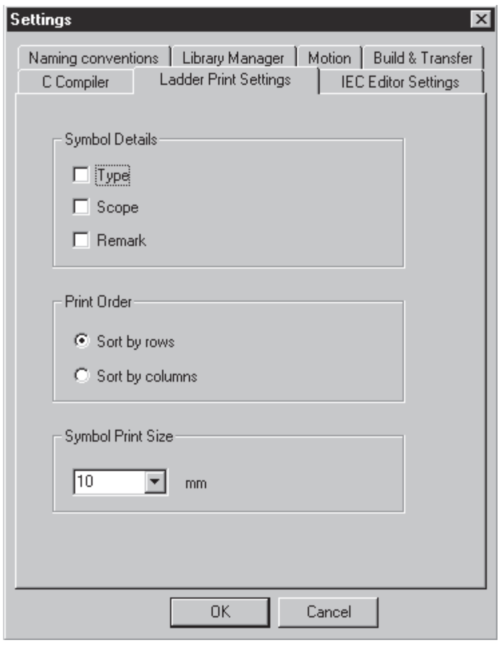
Monitoring options
Width of monitor window: 50 %
Distance of two variables: 200

Fig. 2.13: IEC Editor settings

- Autodeclaration
  If new variables are entered, the variable declaration for these variables is automatically opened when Autodeclaration is activated.
- Autoformat
  The source code is automatically formatted, indentation and colored highlighting of keywords.
- Tab-Width
  Width of the tabulator.
- Font
  Font to be used in the editors.
- Mark
  Representation of marked text.

- Monitoring options
  If monitor mode is active, the editor window is split in two sections. The right section of the window shows the variables and their values. With „Width of monitor window“, you can set the width of the right section of the window as a percent of the total width of the window. The value „Distance of two variables“ determines the distance between two variables in the right section of the window if several variables are shown in a line.
- Colors
  You can define different colors for clear representation of line numbers, breakpoints, etc.

6.2 Ladder Printer Settings


Settings

Naming conventions | Library Manager | Motion | Build & Transfer | C Compiler | Ladder Print Settings | IEC Editor Settings

Symbol Details
- [ ] Type
- [ ] Scope
- [ ] Remark

Print Order
- [✓ Sort by rows]
- Sort by columns

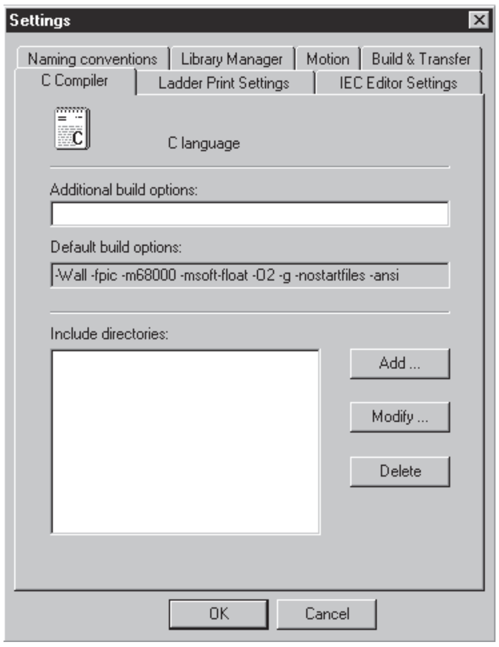
Symbol Print Size: 10 mm

OK Cancel

Fig. 2.14: Ladder Print Settings

- Symbol Details
  Which details should be printed for symbols.
- Print Order
  Order of the printout if the LAD does not fit on a page, is either too wide or too long.
- Symbol Print Size
  Size of the symbols in millimeter

6.3 C Compiler



Additional build options:

Default build options:

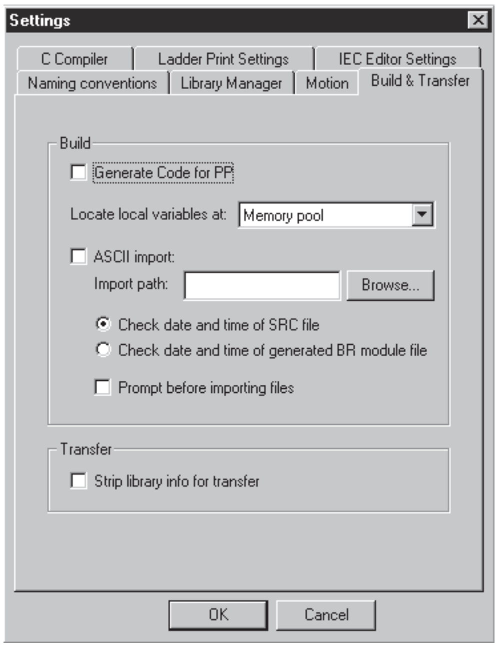
-Wall -fpic -m68000 -msoft-float -O2 -g -nostartfiles -ansi

Include directories:

Fig. 2.15: C Compiler

- Additional build options
  Information concerning options can be found in the GNU compiler documentation
- Include directories
  The list contains all include directories used by the compiler.

6.4 Build and Transfer



Build

- [ ] Generate Code for PP

Locate local variables at: Memory pool

- [ ] ASCII import:

Import path:

- (●) Check date and time of SRC file
- ( ) Check date and time of generated BR module file
- [ ] Prompt before importing files

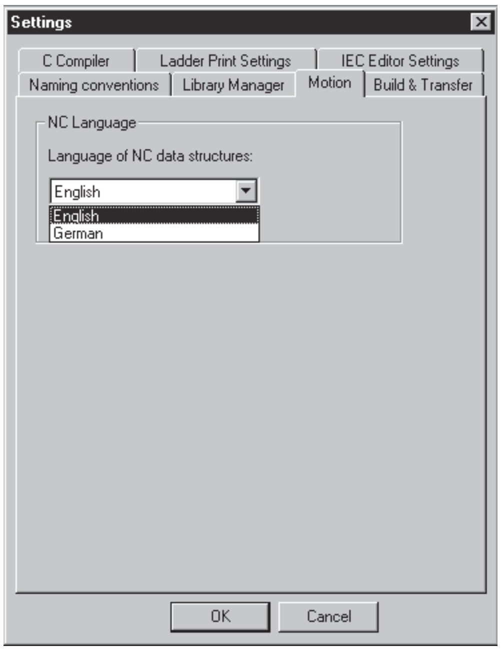
Transfer

- [ ] Strip library info for transfer

Fig. 2.16: Build and Transfer

- Generate Code for PP
  All PP specific compiler options are used.
- Locater local variables at
  variable area = DPR or USR RAM
- ASCII import
  Options for ASCII import
- Transfer
  Do not transfer library information to target system. The library information contains descriptions for calling FBKs which are only required for project creation. This information is not needed on the target system.

6.5 Motion



NC Language

Language of NC data structures:

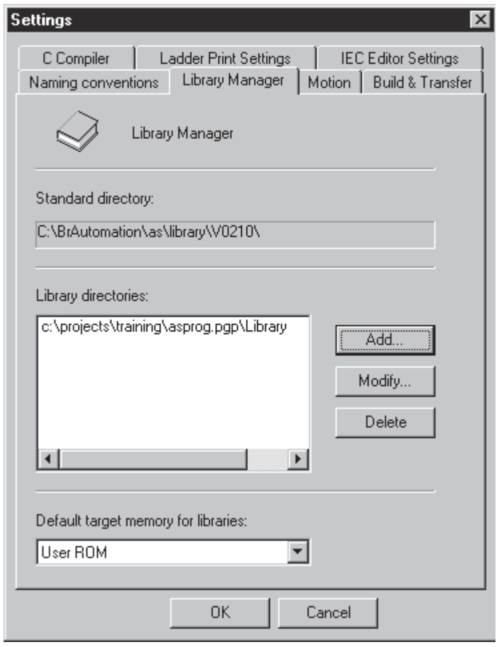
English

English
German

Fig. 2.17: Motion

- NC language
  Language of the NC structures (Englich or German).

6.6 Library Manager


Settings

Standard directory:
C:\BrAutomation\as\library\V0210\

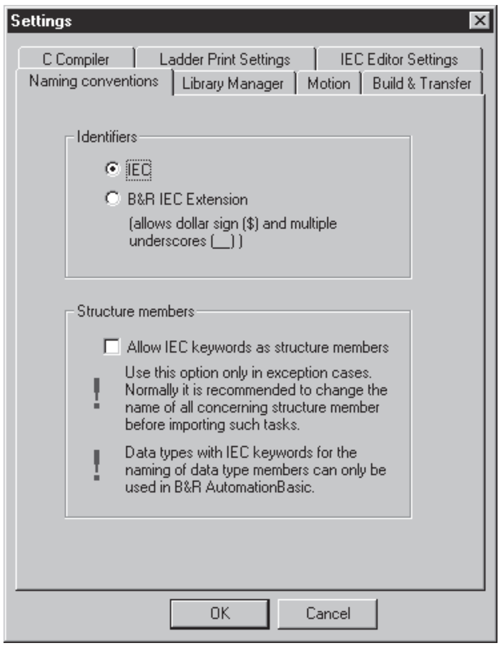
Library directories:
c:\projects\training\asprog.pgp\Library

Default target memory for libraries:
User ROM

Fig. 2.18: Library Manager

- Library directories
  List of directories to be used when searching for libraries.
- Standard directory
  The target memory for the libraries on the target system can be set here.

6.7 Naming Conventions



Settings

C Compiler | Ladder Print Settings | IEC Editor Settings | Naming conventions | Library Manager | Motion | Build & Transfer

Identifiers

(● IEC)
( ) B&R IEC Extension
(allows dollar sign ($) and multiple underscores (__))

Structure members

☐ Allow IEC keywords as structure members

! Use this option only in exception cases. Normally it is recommended to change the name of all concerning structure member before importing such tasks.

! Data types with IEC keywords for the naming of data type members can only be used in B&R AutomationBasic.

OK Cancel

Fig. 2.19: Naming conventions

- Identifiers
  Rules only according to the IEC standard or with B&R extensions.

B&R AUTOMATION RUNTIME

1 OVERVIEW

B&R Automation Runtime

B&R Automation Runtime represents the layer between B&R Automation Studio and the B&R Automation Target.

Individual System Configuration

The PCC system is preconfigured by B&R. The task class times and memory sizes offered can be easily configured by the user. However, further adaptations should only be made by experienced users under B&R's guidance. Also see online help.

Error Logbook

System messages are automatically entered in the error logbook. They can also be entered by an application using standard functions.

Online Information

General system, time and memory information can be requested and changed here.

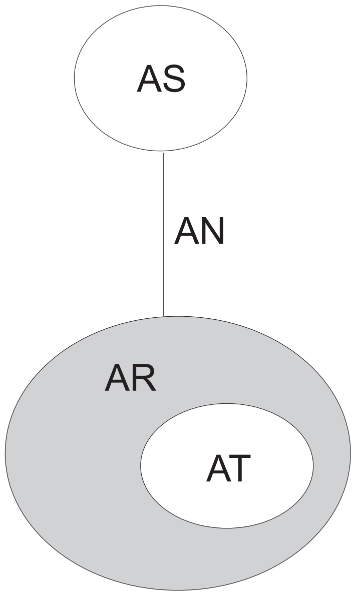
I/O Timing

B&R provides customers with a big advantage, all systems can be programmed in the same way with the same program. This makes it easy for the user to make changes within the B&R2000 Family.

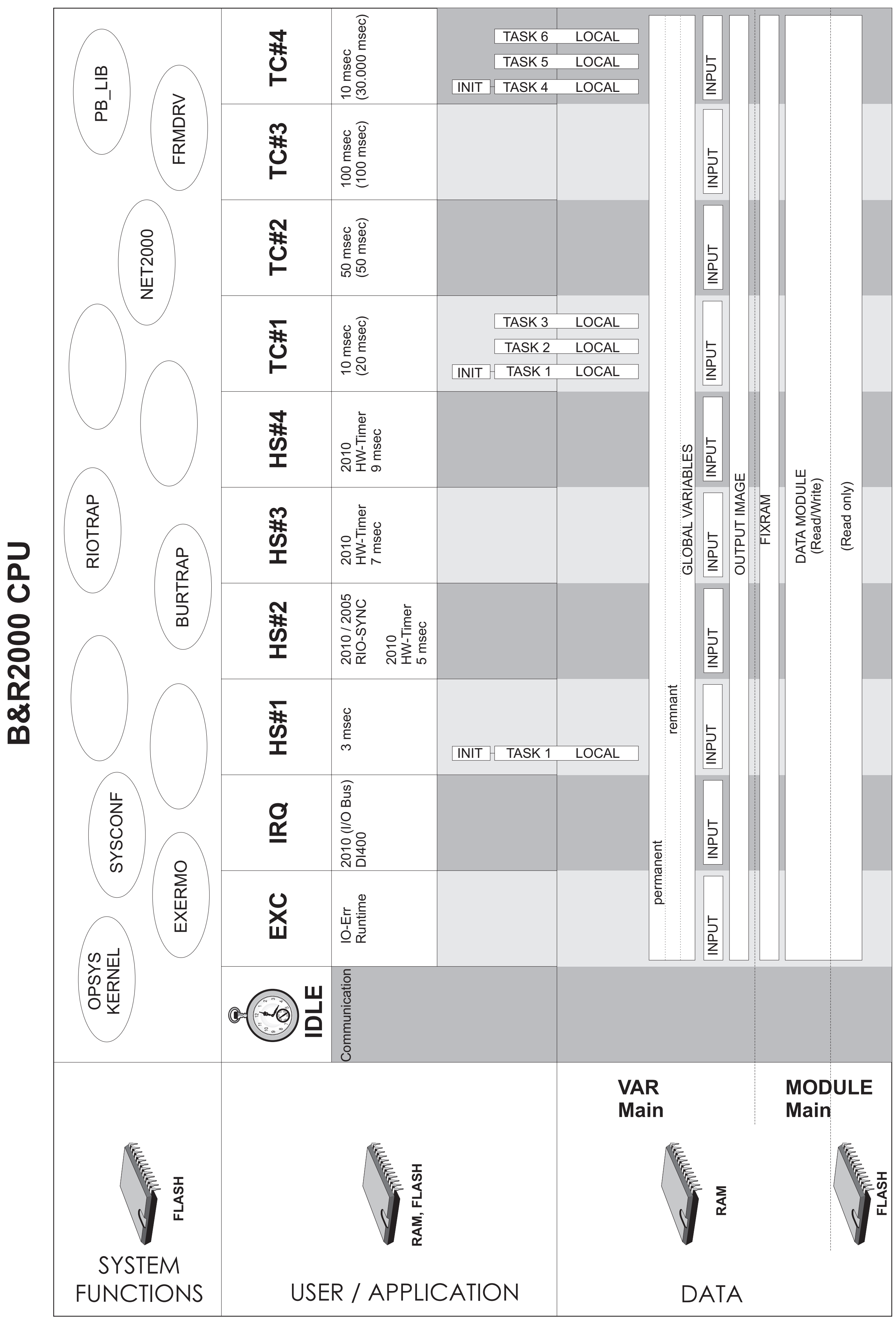
System Strengths

B&R Highlights

2 AUTOMATION RUNTIME



B&R Automation Runtime represents the layer between B&R Automation Studio and the B&R Automation Target. The connection is established via B&R Automation Net. The physical media used for communication is not important.


B&R2000 CPU
OPSYS KERNEL
SYSCONF
EXERMO
RIOTRAP
BURTRAP
NET2000
PB_LIB
FRMDRV
IDLE
Communication
EXC
IO-Err Runtime
IRQ
2010 (I/O Bus) DI400
HS#1
3 msec
INIT TASK 1 LOCAL
HS#2
2010 / 2005 RIO-SYNC
2010 HW-Timer 5 msec
HS#3
2010 HW-Timer 7 msec
HS#4
2010 HW-Timer 9 msec
TC#1
10 msec (20 msec)
INIT TASK 1 LOCAL
TASK 2 LOCAL
TASK 3 LOCAL
TC#2
50 msec (50 msec)
TC#3
100 msec (100 msec)
TC#4
10 msec (30.000 msec)
INIT TASK 4 LOCAL
TASK 5 LOCAL
TASK 6 LOCAL
permanent
remnant
GLOBAL VARIABLES
INPUT
OUTPUT IMAGE
FIXRAM
DATA MODULE (Read/Write)
(Read only)
FLASH
SYSTEM FUNCTIONS
RAM, FLASH
USER / APPLICATION
VAR Main
MODULE Main
RAM
FLASH
DATA

3 INDIVIDUAL SYSTEM CONFIGURATIONS

Each user has the possibility with Automation Studio to easily configure the PCC according to individual requirements:

- Memory, e.g.: PCC global variable pool, digital and analog, FIX RAM, temporary memory
- Stack , e.g.: Task class stack C#1..C#4, operating system data stack
- Task class timing, e.g.: Duration and tolerance, idle time

We normally work with the standard settings. But if it is necessary to change one of the items listed above, make the change in the Object Properties **Edit: Properties**.

Note

Here, we also recommend using the shortcut menu by clicking on the object with the right mouse button !

Now we will discuss some important configurations. Information concerning the other configurations can be found in the online help.

If you lose track of the changes you have made, click on the [Default] button to reset the defaults.

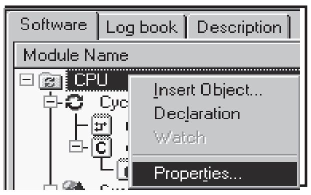
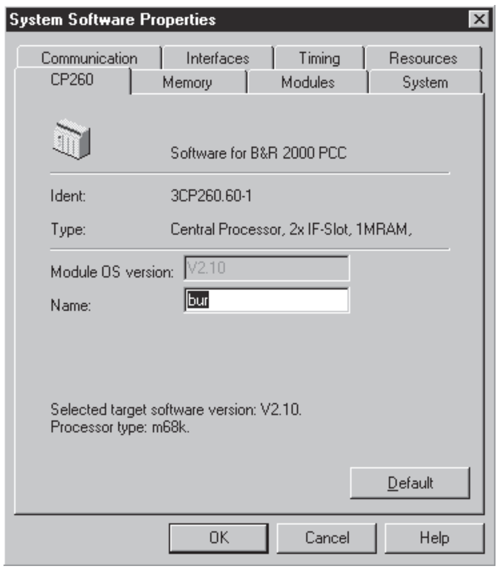


Fig. 3.1: Open the CPU properties



Software for B&R 2000 PCC

Ident: 3CP260.60-1

Type: Central Processor, 2x IF-Slot, 1MRAM,

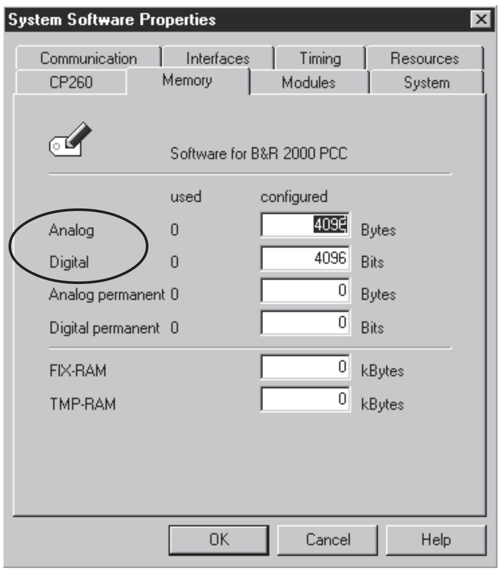
Module OS version: V2.10

Name: bur

Selected target software version: V2.10.
Processor type: m68k.

Fig. 3.2: System configuration

3.1 Memory Configuration



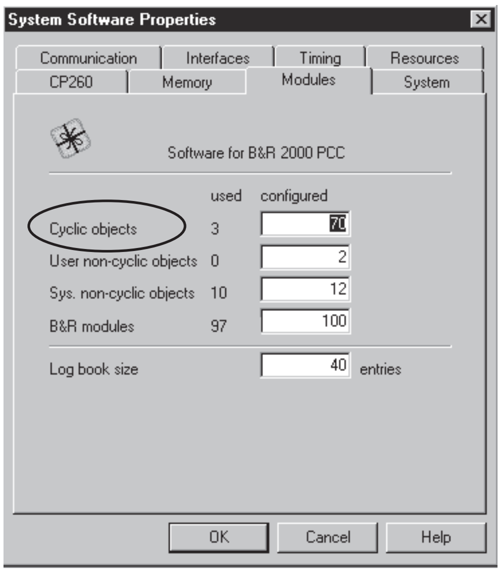
Software for B&R 2000 PCC

	used	configured	
Analog	0	4096	Bytes
Digital	0	4096	Bits
Analog permanent	0	0	Bytes
Digital permanent	0	0	Bits
FIX-RAM		0	kBytes
TMP-RAM		0	kBytes

Fig. 3.3: Memory properties

- **Analog**
  PCC global PVs > Bit
- **Digital**
  PCC global PVs, Bit
- Analog/Digital permanent
  Permanent memory = cold restart safe.
- FIX RAM
  Cold restart safe RAM memory. The size is a multiple of 16 kByte.
- TMP RAM
  Temporary RAM memory. Initialized with 0 during each warm restart.

3.2 Software Object Configuration



System Software Properties

Communication | Interfaces | Timing | Resources
CP260 | Memory | Modules | System

Software for B&R 2000 PCC

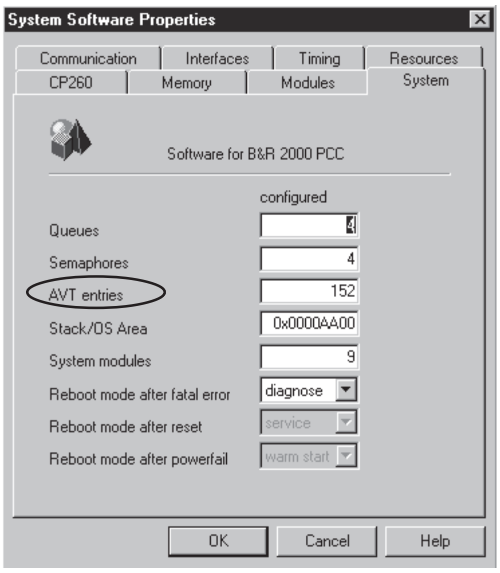
	used	configured
Cyclic objects	3	70
User non-cyclic objects	0	2
Sys. non-cyclic objects	10	12
B&R modules	97	100
Log book size		40 entries

OK Cancel Help

Fig. 3.4: Software object properties

- **Cyclic objects**
  Cyclic objects are application tasks.
- User non-cyclic objects
  are required for special system expansions. Can only be created together with B&R.
- Sys. non-cyclic objects
  Operating system expansions.
- B&R objects
  all modules that can be transferred to the controller, e.g.: tasks, data modules, etc.
- Logbook size
  certain system messages are also saved in the system logbook.

3.3 System Configuration


System Software Properties

Communication | Interfaces | Timing | Resources | CP260 | Memory | Modules | System

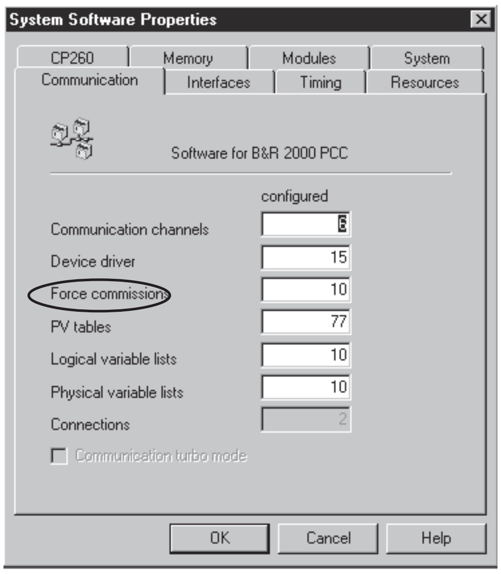
Software for B&R 2000 PCC

	configured
Queues	4
Semaphores	4
AVT entries	152
Stack/OS Area	0x0000AA00
System modules	9
Reboot mode after fatal error	diagnose
Reboot mode after reset	service
Reboot mode after powerfail	warm start

Fig. 3.5: System properties

- Queues
  are used for communication between tasks.
- Semaphores
  are variables which can be used to synchronize access of common memory areas.
- **AVT entries**
  Address distribution tables. Used for library functions.
- Stack
  Operating system data memory. (automatically set starting with AR 2.22)
- System modules
  Number of hardware system modules.
- Reboot mode after fatal error
  If a fatal error occurs when starting the system, the system goes into diagnostic mode. That means the application is stopped.
  However, if “cold restart” is set, the system first attempts a cold restart. Then the application can continue running. If the error is still there, the system boots again in diagnose mode.

3.4 Communication Configuration



Software for B&R 2000 PCC

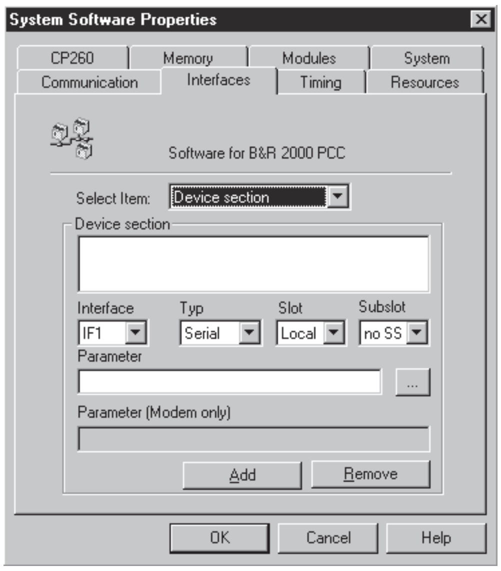
	configured
Communication channels	6
Device driver	15
Force commissions	10
PV tables	77
Logical variable lists	10
Physical variable lists	10
Connections	2

☐ Communication turbo mode

Fig. 3.6: Communication properties

- Communication channels
  Corresponds to the number of interfaces that should be used at the same time for communication.
- Device driver
  Drivers for the various protocols (Net2000, Frame Driver, etc.)
- **Force commissions**
  Number of force commissions that can be active at the same time.
- PV tables
  A table contains max. 256 variables
- Logical variable lists
  are used for network communication.
- Physical variable lists
  are used for online communication
- Connections
  The number of parallel connections (INA) allowed can be set here.
- Turbo Mode (starting with AR 2.20)
  When activated, the INA services are also handled during idle time.
  That means faster transfer of tasks, faster online communication, etc.
  However, this mode only makes sense if enough idle time is available.

3.5 Interfaces



Software for B&R 2000 PCC

Select Item: Device section

Device section

Interface: IF1
Typ: Serial
Slot: Local
Subslot: no SS
Parameter
Parameter (Modem only)

Add
Remove

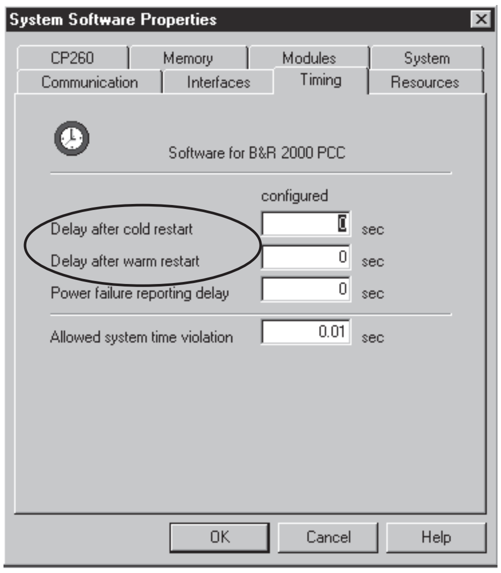
Fig. 3.7: Interface properties

As default, AutomationRuntime defines the **first three interfaces** on the local CP for communication with AutomationStudio.

If additional interfaces are required for online communication with AutomationStudio, or special parameters are needed, they can be configured as parameter sets in this dialog box.

- Interface
  Several interfaces can be available on an interface module. These interfaces are numbered. The desired interface is selected using this parameter.
- Type
  Entry for the physical connection, e.g.: RS232, CAN, ETHERNET, etc.
- Slot
  Entry for the module slot number where the selected interface is found.
- Subslot
  Entry for the subslot on the module where the desired interface is found.
- Parameter
  Each interface type has default parameter. Changes can be made here, e.g: Baudrate.
- Modem Parameter
  Special modem settings.

3.6 Timing Configuration



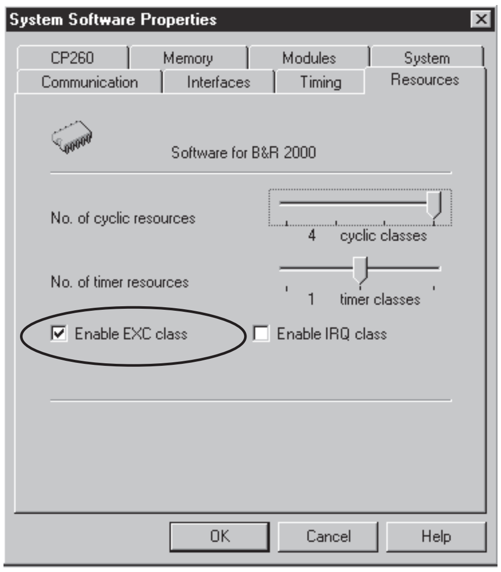
Software for B&R 2000 PCC

	configured	
Delay after cold restart	0	sec
Delay after warm restart	0	sec
Power failure reporting delay	0	sec
Allowed system time violation	0.01	sec

Fig. 3.8: Timing properties

- **Delay after cold/warm restart**
  These times are delays that must pass before
  I/O modules or system modules can be accessed. In this way, these modules can complete their initialization before being accessed by the CPU.
- Power failure reporting delay
  after a power failure, the CPU executes a warm restart. For applications with expansion, it is possible that the expansion drops out before the CPU and the CPU activates service mode.
  When the voltage returns, the CPU starts in service mode. If a time is entered here, the CPU waits before activating service mode.
- Allowed system time violation
  The operating system is also monitored for cycle time violations. A maximum system cycle time violation can be set here, in 10ms steps.

3.7 Resource Configuration


System Software Properties

Software for B&R 2000

No. of cyclic resources: 4 cyclic classes

No. of timer resources: 1 timer classes

[✓] Enable EXC class

[ ] Enable IRQ class

Fig. 3.9: Resource properties

- No. of cyclic resources
  Number of cyclic task classes possible.

- No. of timer resources
  Number of timer task classes.

- **Enable EXC class**
  Enable the exception task classes.

- Enable IRQ class
  Enable interrupt task classes, only possible on B&R2010.

4 ERROR LOGBOOK

All errors that trigger an EXCEPTION are entered in the system logbook. If an exception is triggered, all outputs are switched off. The application on the PCC is stopped. To determine the cause of the error, we will select:

- The **CPU** in the hardware tree
- The tab "**Logbook**" in the software tree

Then a window is opened which shows the last messages in plain text. The top message is the newest.

Some user actions are entered in the logbook, but the application continues running, e.g.: changing the time. Such entries are called WARNINGS.

Time	Error	Information	Module	Description
10.12.98 15:45:23.00	2075	16#00000000	Syss	Warning: Time/date changed

Tab. 3.1: System entry – changed CPU time

If the operator exceeds defined limit values, a user entry can be created using a function and the PCC boots in service mode.

Time	Error	Information	Module	Additional Information
??.??.?? ??:????.??	2222	16#12345678	????	Warning: ????????

Tab. 3.2: User entry in logbook

In this case, the service technician must have a reference list of these entries. An action list is to be added to this reference list.

Example

Read the last entries from the system logbook and analyse the entries with your trainer.

- Read the entries
- Remove an I/O module accessed by the task with power applied. Then read the system logbook again.

5 ONLINE INFORMATION

5.1 System Information

If you click on the CPU symbol with the right mouse button in the hardware tree, the following dialog box is shown.

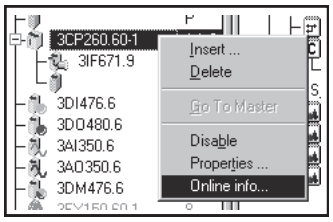
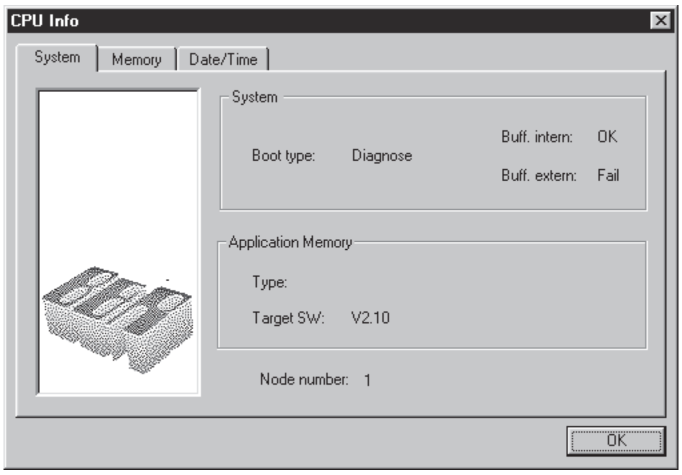


Fig. 3.10: Online PopUp



System

Boot type: Diagnose

Buff. intern: OK

Buff. extern: Fail

Application Memory

Type:

Target SW: V2.10

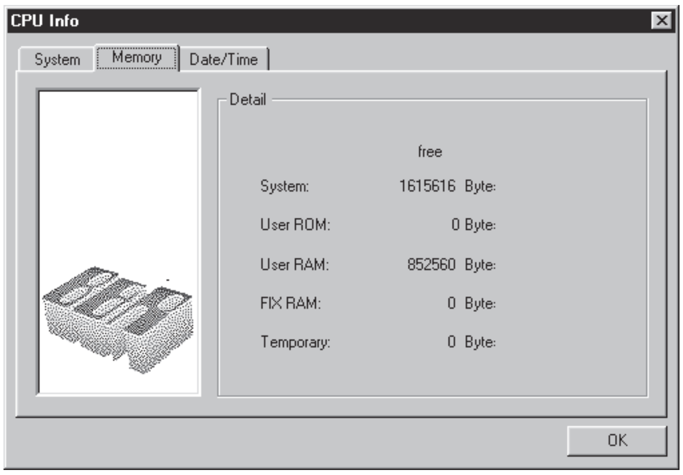
Node number: 1

Fig. 3.11: CPU Info System dialog box

In the System dialog box, information concerning the boot mode, battery, operating system and node number are shown if available.

5.2 CPU Memory Information

Information concerning free memory is output here.



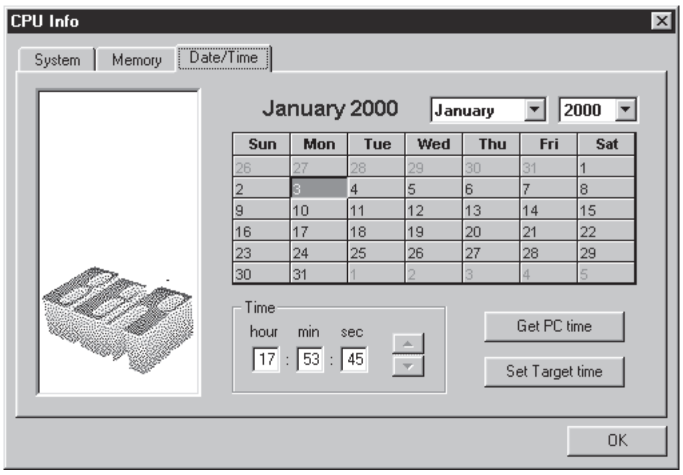
Detail

	free	
System:	1615616	Byte:
User ROM:	0	Byte:
User RAM:	852560	Byte:
FIX RAM:	0	Byte:
Temporary:	0	Byte:

Fig. 3.12: CPU memory properties

5.3 Real-time Clock

The time can be changed on the controller in the Date/Time dialog box. This dialog box shows the current time on the controller. This is not necessarily the same as the time on PC.



Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

Fig. 3.13: CPU Info Date/Time properties

With [Get PC time], the current PC time is set in the dialog box. The settings can transferred to the target using [Set Target time] and the time change is entered in the system logbook.

6 I/O HANDLING AND TIMING

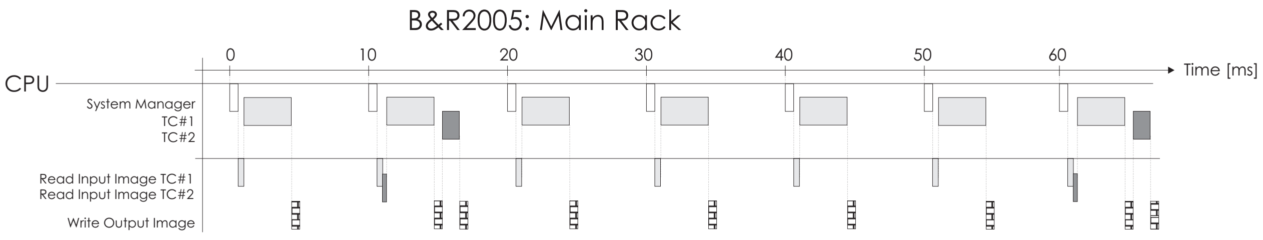
We will discuss the IO Handling and Timing here. The following points will be covered:

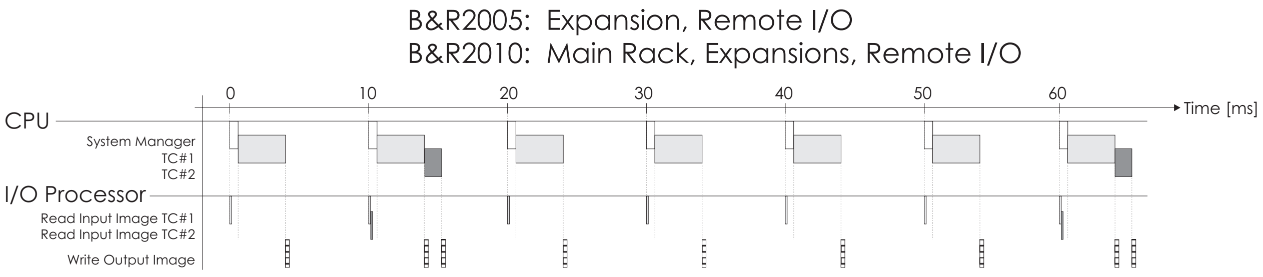
- I/O Image Handling
- Timing B&R2003
- Main Rack
  - CAN I/O
  - RIO
- Timing B&R2005 / B&R2010
  - B&R2005 Main Rack
  - B&R2010 Main Rack, B&R2005 and B&R2010 Expansion
  - B&R20xx CPU with Remote B&R2005 / B&R2010 Slaves

6.1 I/O Image Handling

Input images are read separately for each task class.
All task classes have a common **output image**.

Several tasks are executed in two task classes on a PCC:





The representations above show the following points clearly:

- The respective input images are read at the beginning of the task class.
- The output image is written at the end of run time for the task class.
- Differences between timing with and without an I/O processor.

6.1.1 B&R2003 / B&R2005 Main Rack

In this case, the main processor has to emulate the I/O processor. The main processor processes the system manager, then emulates the I/O processor and reads the inputs

After this, the task class is processed.

During run time, the main processor emulates the I/O processor again and writes the outputs. The main processor is also responsible for I/O transfer.

6.1.2 B&R2005 Expansion and Remote I/O, B&R2010 with I/O Processor

This I/O processor reads the inputs parallel to system manager processing and writes the outputs at the end of the task class parallel to processing the next task class.

This multiprocessor concept in the CPU reduces load on the main processor caused by data transfer.

The I/O processor is responsible for I/O transfer. The remote IO master is responsible for remote IO transfer.

Note

If exact I/O times are required for an application, the exact information can be calculated by referring to the user's manual or using an Excel file.

7 SYSTEM STRENGTHS

7.1 Strengths of the B&R Multitasking System

- **Deterministic Multitasking**
  Predictable task timing

- **Different Task Classes**
  Task classes are called in different, fixed time axes.
  Additional tasks do not change the timing.

- **Variable Task Class Cycle Times**
  Optimal timing settings for the different task classes.

- **Optimal Processor Load**

- **Priorities for Task Classes**
  Timer task class 1 has the highest priority of the cyclic task classes.

- **Flexible System Software Updates for the Operating System**

- **System Logbook**
  In the system logbook, an entry is always written describing the cause for a system reset. This logbook can also be used by the programmer, to check certain defined limits. If a limit is exceeded, an entry is made. In this way, the cause of a system standstill can always be determined.

- **Testing Individual Tasks**
  Start and stop tasks online, etc.

7.2 Strengths of the B&R I/O System

- **Separation of the I/O Bus**
  The I/O bus can be built with a decentralized structure using expansions and remote I/O.

- **Secure Protocol for I/O Bus**
  I/O data is transferred using a secure protocol and stored in the DPR.

- **Reducing Load on the CPU**
  I/O data transfer is handled by the I/O processor (B&R2010).
  Bit and byte masking is carried out by the DPR controller.
  Servicing the interfaces is carried out by the RISC.
  In this way, the maximum CPU capacity is available for application tasks.

- **Consistent I/O Images**
  The input states available at the beginning of the task class and remain available for the entire task class.

- **Symbolic Process Variables**
  I/O points are accessed in the program using symbolic names. The link between symbolic names and the I/O points can be defined at any time:

    - Taken from CAD programs
    - Predefined during programming
    - When creatig code in LAD, C files, or when compiling

B&R AUTOMATION TARGETS

1 OVERVIEW

B&R Automation Target

A brief overview of the B&R Automation concept with B&R Automation Studio, B&R Automation Net, B&R Automation Runtime and B&R Automation Targets.

B&R Automation Target 2003

The most important data for the B&R2003 PCC System. Hardware possibilities, expansion possibilities with RIO and CAN I/O.

B&R Automation Target 2005

The most important data for the B&R2005 PCC System. Hardware possibilities, expansion possibilities with expansion and RIO.

B&R Automation Target 2010

The most important data for the B&R2010 PCC System. Hardware possibilities, expansion possibilities with expansion and RIO.

B&R Automation Target Logic Scanner

The combination of an IPC and LS251 results in a very powerful device for visualization and control tasks.

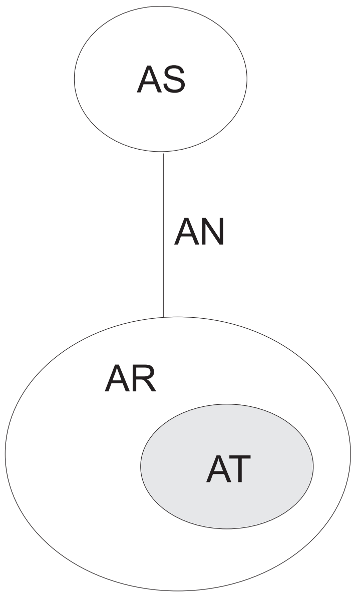
B&R Automation Target IPC2xxx

The most important data and hardware possibilities.

B&R Automation Target IPC5xxx

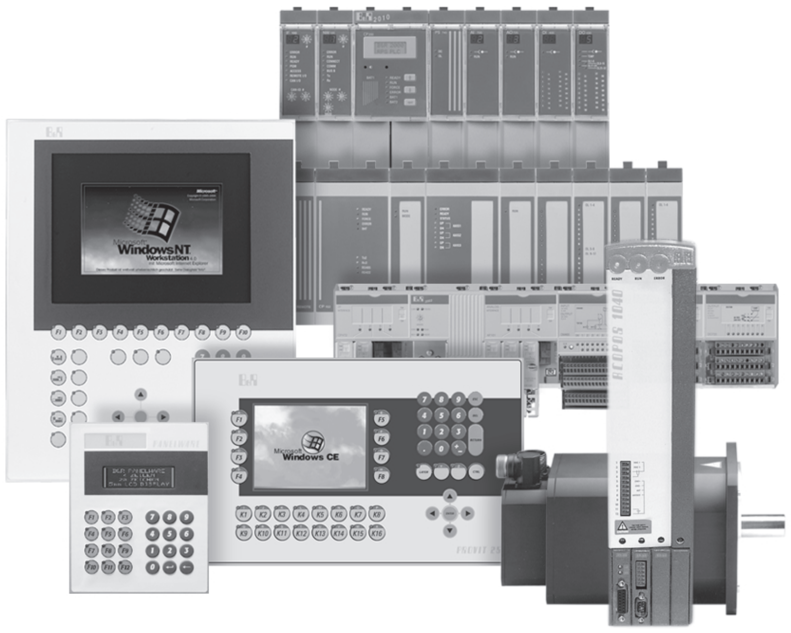
The most important data and hardware possibilities.

2 B&R AUTOMATION TARGET



B&R Automation Target refers to the **hardware platform**, where B&R Automation Runtime is running.
This can be a B&R2003, B&R2005, B&R2010, IPC with Logic Scanner, IPC with B&R Automation Runtime (AR010).

Possible Automation Targets:



3 B&R AUTOMATION TARGET 2003

3.1 Main Unit

- The B&R2003 is used as an intelligent terminal because of ist structure and connection technology.
- You can select between the intelligent PCC version and the unintelligent remote I/O version which reduces cabling costs.
- The special terminal blocks, which have separate terminals for signal, ground and supply, allows fast and easy cabling.
- The combination of different screw-in modules on a CPU or analog interface module guarantees the highest degree of modularity and the smallest size.

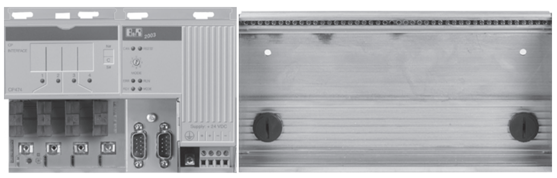


Fig. 4.1: Module rack + CPU with CP interface

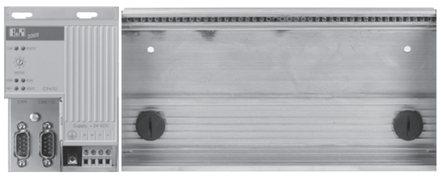


Fig. 4.2: Module rack + CPU

3.1.1 Power Supply

CPU / CAN Bus Slave Module / RIO Slave Module
Supply voltages in the DC range from 18-30V and in the AC range from 82-264V, 47-63Hz. The power supplies are protected on the **primary side** by a **fuse** and on the **secondary side** by an internal **current limiter**.

3.1.2 Operating System

All B&R Automation Targets are **compatible** with regard to operating system functions and programming. A modem capable RS232 and a CAN interface are available.

3.1.3 Online

The first three interfaces can be used as online interface by the operating as default.

3.1.4 Application Program Memory

The application memory is on board. SRAM and FPROM are available as memory media. The SRAM is used for program development. The FIXRAM as part of SRAM for data that must remain after a cold start. The FPROM is used to store the operating system and completely tested projects including documentation.

3.1.5 I/O Modules and Terminals

The B&R2003 system offers a palette of

Digital Modules	Relay or transistor version		
Analog Modules	0-20mA and ±10V	...	Resolution:12Bit
	PT100 / FeCuNi	...	Resolution: $^1/_{10}$ or $^1/_{100}$°C
	Interface and Counter Modules		

3.2 Expansion

3.2.1 RIO

The B&R2003 can be used as **Remote I/O Slave for long distances**, in a 1200m segment, **with 3 repeaters up to 4800m** and provides very fast communication, up to **2MBaud**. The connection is made using RS485 twisted pair lines.

RIO SLAVE	I/O bus with secure data transfer; max. 8 logic modules

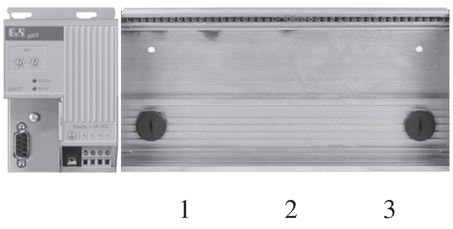


Fig. 4.4: Module rack + RIO

3.2.2 CAN I/O

The B&R2003 can be used as master and also as slave for **CAN I/O** expansions. The maximum distance extends over **1000m**. The max. transfer speed is **500kBaud**. The connection is made using a
3 conductor CAN cable.

The CAN bus slave module has ist own configuration memory for CAN node parameters. If this memory is not used, the node is started using the **standard configuration.**

CAN SLAVE	I/O bus with secure data transfer; max. 8 logic modules

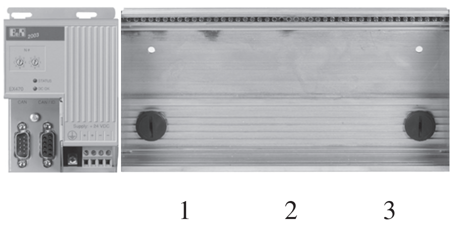


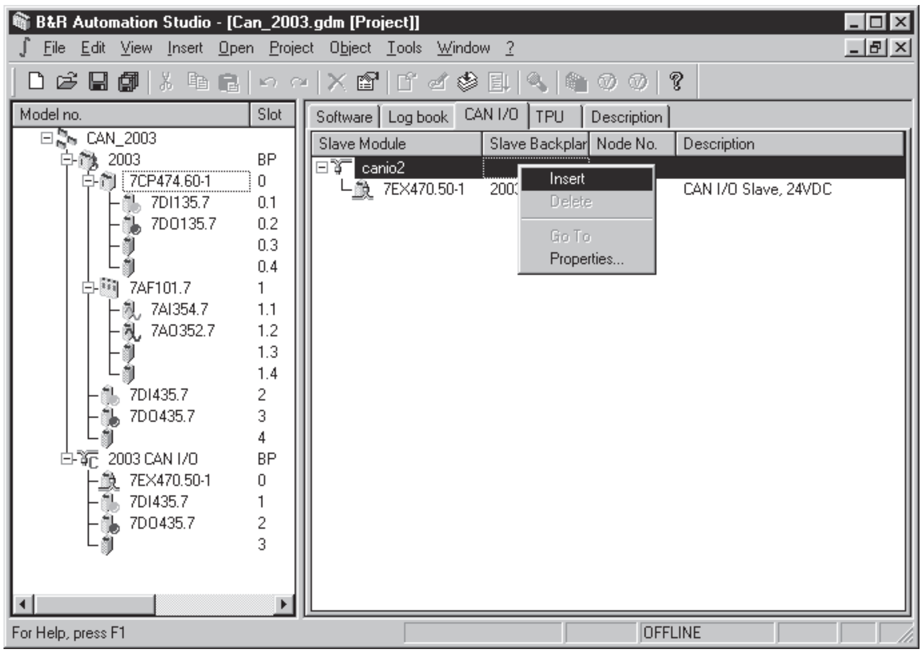
Fig. 4.3: Module rack + CAN I/O

3.2.3 Networks

- CAN with multimaster network
- B&R NET2000 as master/slave network with slave cross traffic
- ETHERNET to connect with higher level systems

3.3 CAN I/O Projects

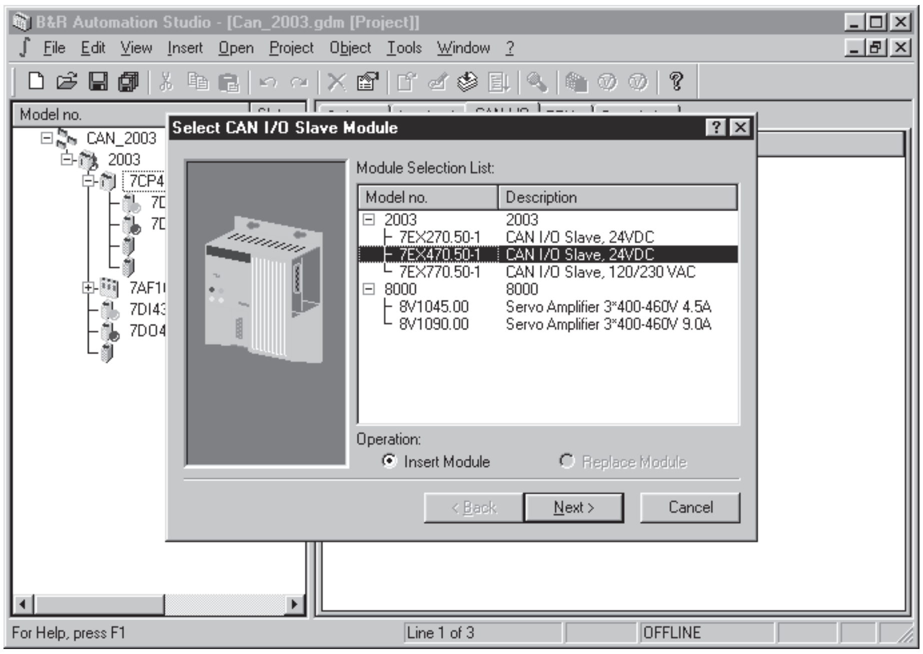
To work with CAN I/O, a EX470 module must be inserted in the CPU.


B&R Automation Studio - [Can_2003.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
Software Log book CAN I/O TPU Description
Insert
Delete
Go To
Properties...
For Help, press F1
OFFLINE

```
Model no.           Slot
CAN_2003
  2003              BP
    7CP474.60-1     0
      7DI135.7      0.1
      7DO135.7      0.2
                    0.3
                    0.4
    7AF101.7        1
      7AI354.7      1.1
      7AO352.7      1.2
                    1.3
                    1.4
    7DI435.7        2
    7DO435.7        3
                    4
  2003 CAN I/O      BP
    7EX470.50-1     0
    7DI435.7        1
    7DO435.7        2
                    3
```

Slave Module	Slave Backplan	Node No.	Description
canio2			
7EX470.50-1	2003		CAN I/O Slave, 24VDC

Fig. 4.5: Inserting a CAN slave

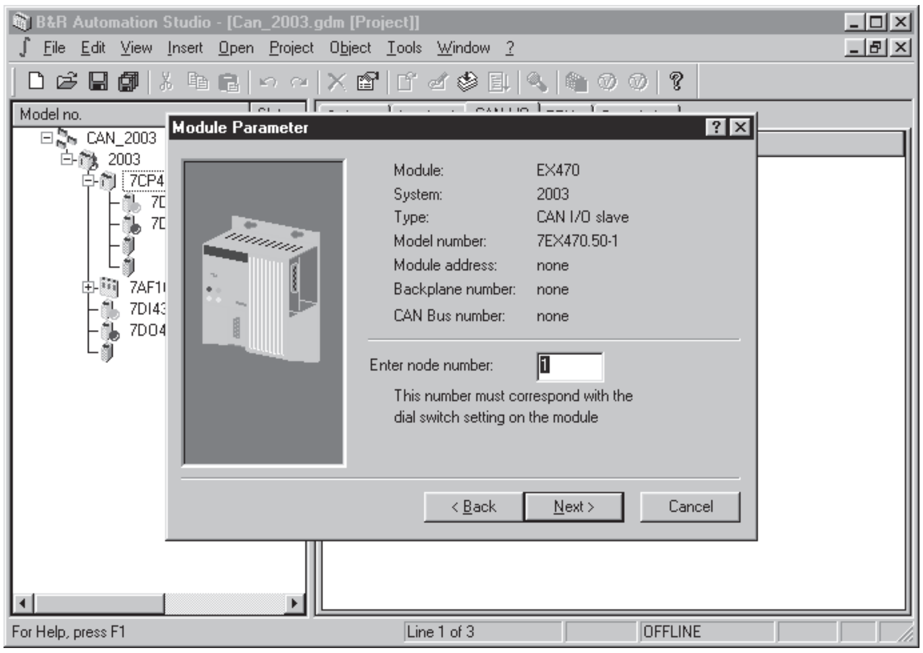

B&R Automation Studio - [Can_2003.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
Select CAN I/O Slave Module
Module Selection List:
Operation:
Insert Module
Replace Module
< Back
Next >
Cancel
For Help, press F1
Line 1 of 3
OFFLINE

Model no.	Description
2003	2003
7EX270.50-1	CAN I/O Slave, 24VDC
7EX470.50-1	CAN I/O Slave, 24VDC
7EX770.50-1	CAN I/O Slave, 120/230 VAC
8000	8000
8V1045.00	Servo Amplifier 3*400-460V 4.5A
8V1090.00	Servo Amplifier 3*400-460V 9.0A

Operation: [✓ Insert Module] Replace Module

Fig. 4.6: CAN I/O slave module selection dialog box

In order for the CAN I/O master to access nodes, the node number on the module has to correspond to the node number in the configuration.

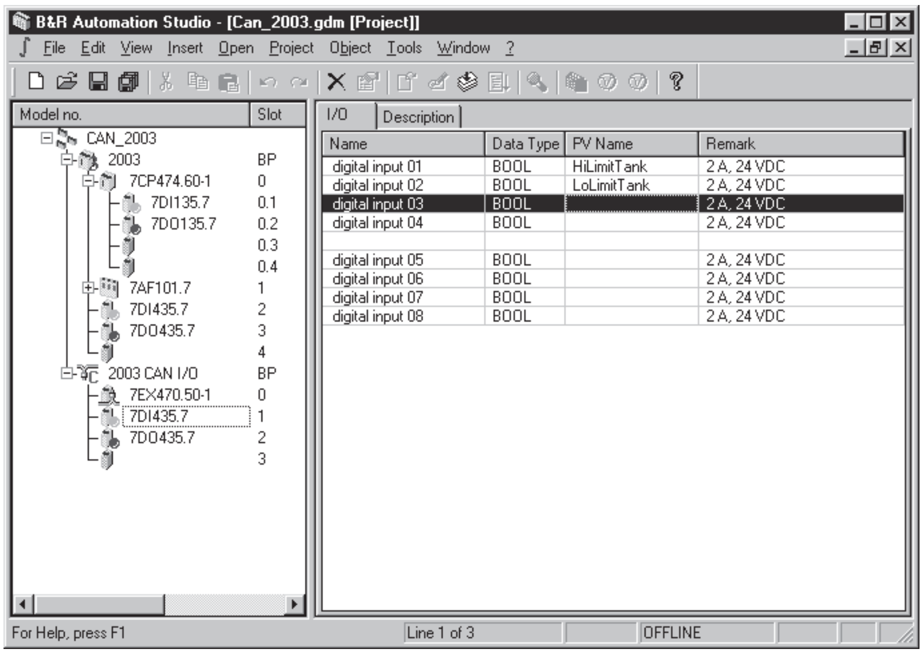

B&R Automation Studio - [Can_2003.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
Module Parameter
< Back
Next >
Cancel
For Help, press F1
Line 1 of 3
OFFLINE

Module: EX470
System: 2003
Type: CAN I/O slave
Model number: 7EX470.50-1
Module address: none
Backplane number: none
CAN Bus number: none

Enter node number: 1

This number must correspond with the dial switch setting on the module

Fig. 4.7: CAN node number dialog box

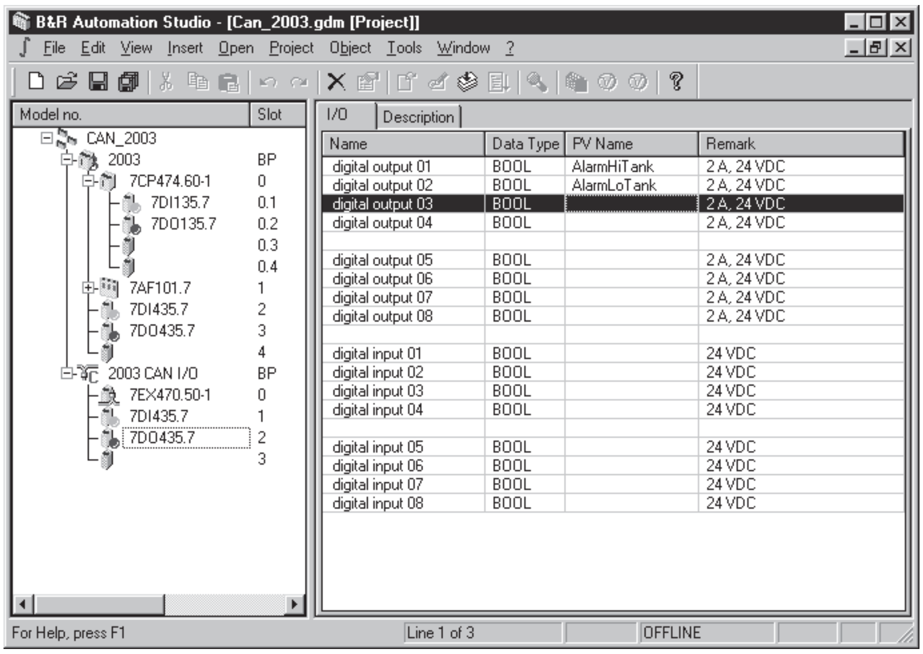

B&R Automation Studio - [Can_2003.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
I/O
Description
For Help, press F1
Line 1 of 3
OFFLINE

Model no.	Slot
CAN_2003	
2003	BP
7CP474.60-1	0
7DI135.7	0.1
7DO135.7	0.2
	0.3
	0.4
7AF101.7	1
7DI435.7	2
7DO435.7	3
	4
2003 CAN I/O	BP
7EX470.50-1	0
7DI435.7	1
7DO435.7	2
	3

Name	Data Type	PV Name	Remark
digital input 01	BOOL	HiLimitTank	2 A, 24 VDC
digital input 02	BOOL	LoLimitTank	2 A, 24 VDC
digital input 03	BOOL		2 A, 24 VDC
digital input 04	BOOL		2 A, 24 VDC
digital input 05	BOOL		2 A, 24 VDC
digital input 06	BOOL		2 A, 24 VDC
digital input 07	BOOL		2 A, 24 VDC
digital input 08	BOOL		2 A, 24 VDC

Fig. 4.8: Defining DI variables on a CAN slave

Working with CAN I/O (continued)


B&R Automation Studio - [Can_2003.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
I/O Description
For Help, press F1
Line 1 of 3
OFFLINE

Model no.	Slot
CAN_2003	
2003	BP
7CP474.60-1	0
7DI135.7	0.1
7DO135.7	0.2
	0.3
	0.4
7AF101.7	1
7DI435.7	2
7DO435.7	3
	4
2003 CAN I/O	BP
7EX470.50-1	0
7DI435.7	1
7DO435.7	2
	3

Name	Data Type	PV Name	Remark
digital output 01	BOOL	AlarmHiTank	2 A, 24 VDC
digital output 02	BOOL	AlarmLoTank	2 A, 24 VDC
digital output 03	BOOL		2 A, 24 VDC
digital output 04	BOOL		2 A, 24 VDC
digital output 05	BOOL		2 A, 24 VDC
digital output 06	BOOL		2 A, 24 VDC
digital output 07	BOOL		2 A, 24 VDC
digital output 08	BOOL		2 A, 24 VDC
digital input 01	BOOL		24 VDC
digital input 02	BOOL		24 VDC
digital input 03	BOOL		24 VDC
digital input 04	BOOL		24 VDC
digital input 05	BOOL		24 VDC
digital input 06	BOOL		24 VDC
digital input 07	BOOL		24 VDC
digital input 08	BOOL		24 VDC

Fig. 4.9: Defining DO variables

Set the “scope” in the pop-up menu so that the relationship between variable and hardware is immediately clear.

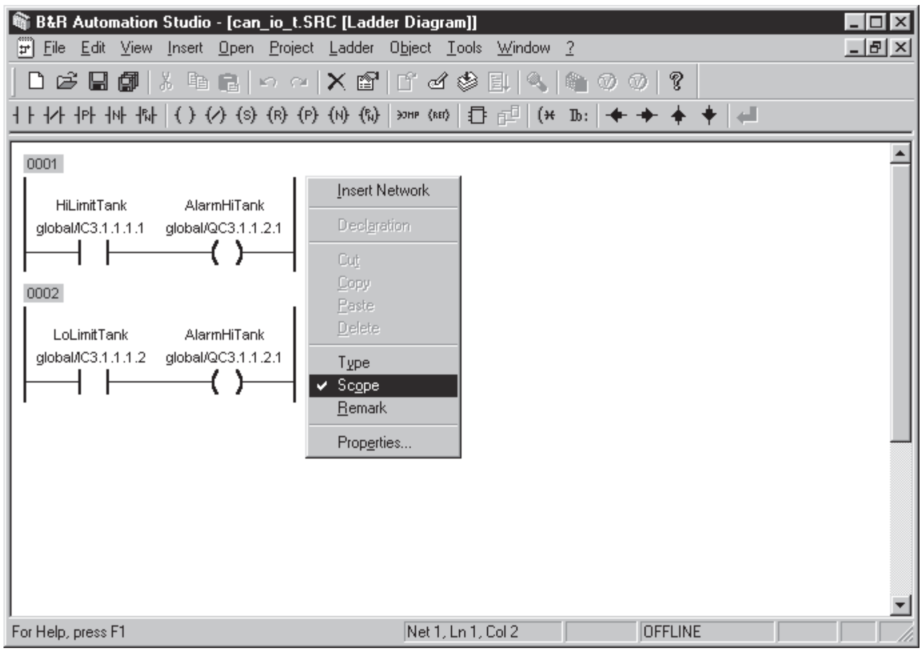
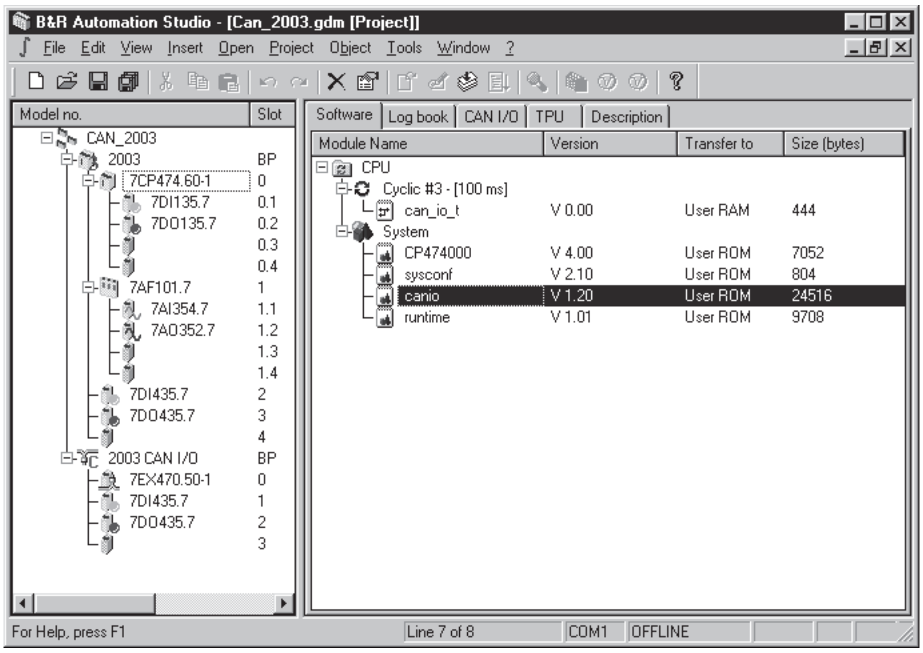


Fig. 4.10: Task with CAN I/O variables

Working with CAN I/O (continued)

If the task is compiled and transferred to the controller, the additional drivers are also automatically copied in the “System” area.


B&R Automation Studio - [Can_2003.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
Software
Log book
CAN I/O
TPU
Description
For Help, press F1
Line 7 of 8
COM1
OFFLINE

Model no.	Slot
CAN_2003	
2003	BP
7CP474.60-1	0
7DI135.7	0.1
7DO135.7	0.2
	0.3
	0.4
7AF101.7	1
7AI354.7	1.1
7AO352.7	1.2
	1.3
	1.4
7DI435.7	2
7DO435.7	3
	4
2003 CAN I/O	BP
7EX470.50-1	0
7DI435.7	1
7DO435.7	2
	3

Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #3 - [100 ms]			
can_io_t	V 0.00	User RAM	444
System			
CP474000	V 4.00	User ROM	7052
sysconf	V 2.10	User ROM	804
canio	V 1.20	User ROM	24516
runtime	V 1.01	User ROM	9708

Fig. 4.11: System area with “canio” master

Example

- Read an analog input from the CAN I/O and output it somewhere else.
- Watch the LEDs to see when the analog values **do not change**
- Watch the LEDs to see when the analog values **change**
- Remove the CAN cable and watch the output

Project Name:	can_2003
LAD Name:	av_can
Resource:	C#3

4 B&R AUTOMATION TARGET 2005

4.1 Main Unit

- The system performance is is exceptionaly high because of cooperation between the processors on the CPU and **parallel processor capability**.
- The parallel processors extend the performance palette of this system in various directions, e.g.: very fast I/O in the µs range, interface expansions as well as positioning and CNC applications.
- Expansions are possible using local expansions, remote slaves for longer distances up to 4800m or network and field bus system connections, e.g.: CAN.

4.1.1 Backplane

A backplane can have a maximum of **15 slots.**
Slots that are not used should be covered by dummy modules.

4.1.2 Power Supply

Supply voltages in the DC range from 18-30V and in the AC range from 82-264V, 47-63Hz. **The power supplies are protected on the primary side by a fuse and on the secondary side by an internal current limiter.** The power supply is always on the outer left of the backplane module.

4.1.3 CPU, User Memory and Parallel Processors

The high performance is reached using a processor with integrated RISC. All PCC systems distinguish themselves by their **real-time capable, multitasking operating system**. SRAM and FPROM are available as application memory. The user is provided a modular IF concept. The interfaces can be switched using software and be operated as either **online or data interrface**.

4.1.4 Configuration Possibilities

Parallel processors are special features of the B&R2005 system which can be used as a CPU if no CPU is inserted.

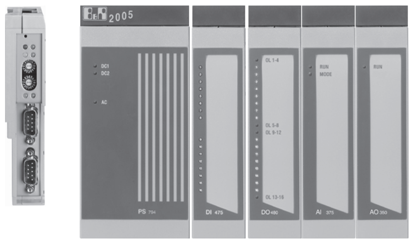


Fig. 4.12: Rack with XP152

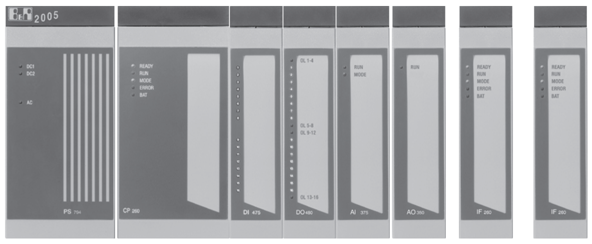


Fig. 4.13: Rack with CPU and parallel processors

4.1.5 I/O Modules and Terminals

The B&R2005 system offers an extensive palette of:

Digital Modules	Relay or transistor version		
Analog Modules	0-20mA and ±10V	...	Resolution:12Bit
	PT100 / FeCuNi / NiCrNi	...	Resolution: $^1/_{10}$ or $^1/_{100}$°C
			$^1/_{10}$ F

Interface, Counter and Network Modules

Positioning and CNC Modules

4.2 Expansion

The B&R2005 can use both local and remote expansion.

4.2.1 Expansion

The **expansion** system is used for **local expansions**. The expansion master is an EX350 in the power supply. The expansion slave is a power supply. With local expansions, there can be a maximum of **2m** between the individual stations and up to **4 B&R2005 expansions**, max. 52 IO modules can be used. The expansion cable is used as transfer media.

4.2.2 RIO

The **remote I/O** system consists of a remote I/O master, the system module EX150, and a remote I/O slave, as power supply. Remote networks can have max. 32 stations in a segment and can be used for distances up to 1200m. The transfer rate that can be obtained is 2 MBaud. Using 3 repeaters, a max. of 121 stations can be connected at a distance of 4800m.

RS485 twisted pair is used as transfer media.

4.2.3 CAN I/O

The **CAN I/O** system consists of at least one master, as CPU or parallel processor with CAN interface, and up to 63 CAN slaves, as B&R2003 with CAN bus slave module. The maximum expansion can have 63 stations. Several masters can be used. Distances up to a max of 1000m can be reached. The max. transfer rate is **500kBaud**. A 3 conductor CAN cable is used as transfer media.

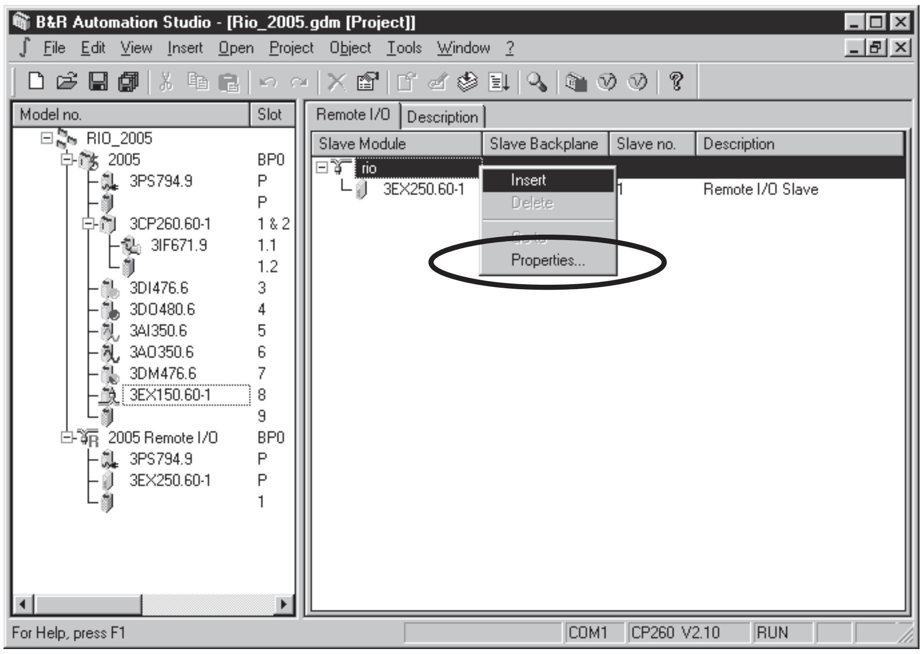
4.2.4 Networks

The networks supported include the following **networks**:

- ETHERNET
- PROFIBUS
- B&R NET2000
- CAN
- Frame Driver
- Connections to systems from other manufacturers

4.3 RIO Projects

In order to work with B&R RIO, a 3EX150 RIO master must be installed on the rack. A RIO slave can be connected there.

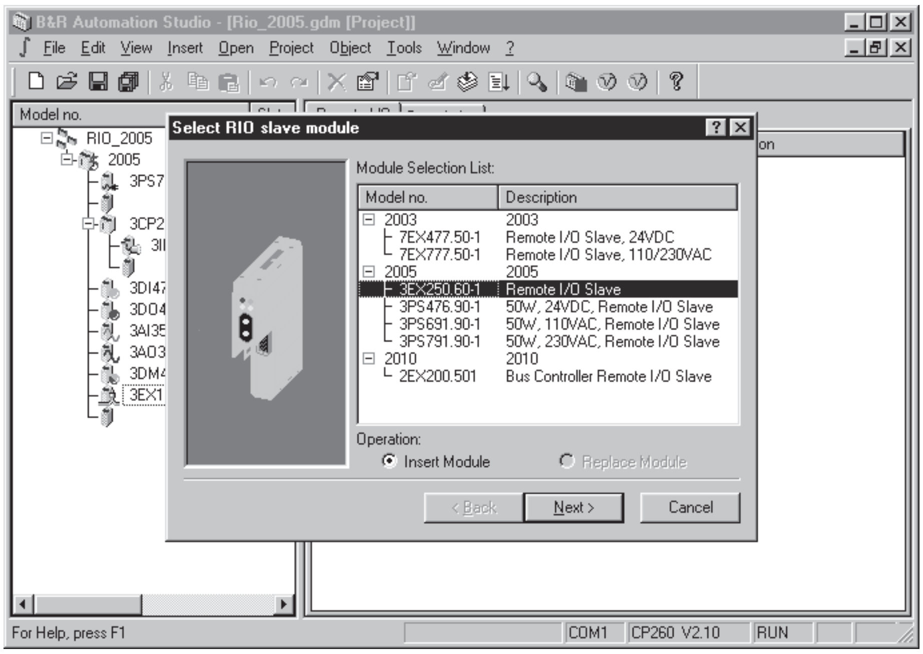

B&R Automation Studio - [Rio_2005.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
Remote I/O
Description
Insert
Delete
Go to
Properties...
For Help, press F1
COM1
CP260 V2.10
RUN

Model no.	Slot
RIO_2005	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4
3AI350.6	5
3AO350.6	6
3DM476.6	7
3EX150.60-1	8
	9
2005 Remote I/O	BP0
3PS794.9	P
3EX250.60-1	P
	1

Slave Module	Slave Backplane	Slave no.	Description
rio			
3EX250.60-1		1	Remote I/O Slave

Fig. 4.14: Inserting a RIO slave

The settings used for the configuration of the RIO stations can be found in the shortcut menu item **RIO Properties**.

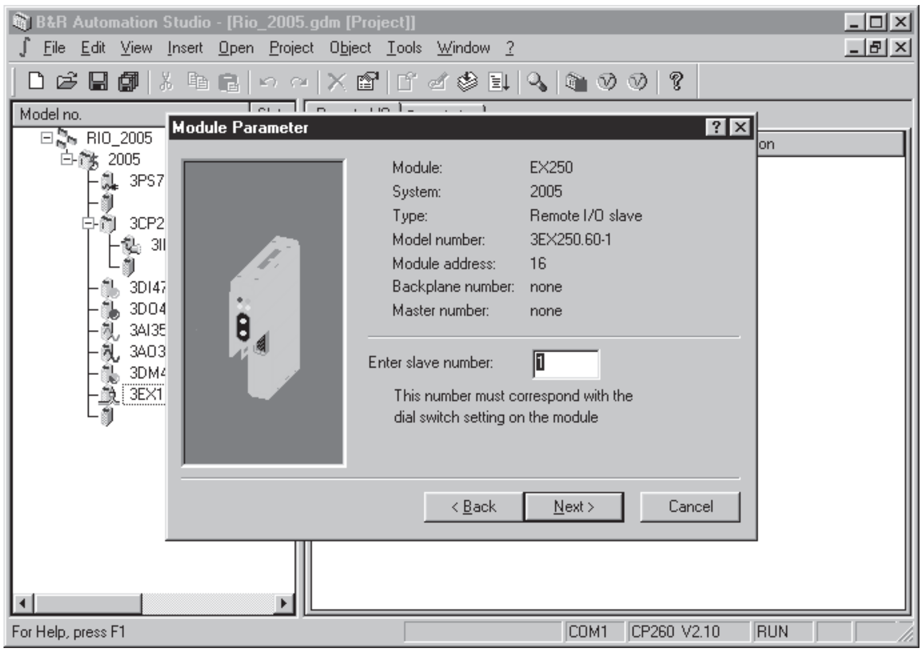


Model no.	Description
2003	2003
7EX477.50-1	Remote I/O Slave, 24VDC
7EX777.50-1	Remote I/O Slave, 110/230VAC
2005	2005
3EX250.60-1	Remote I/O Slave
3PS476.90-1	50W, 24VDC, Remote I/O Slave
3PS691.90-1	50W, 110VAC, Remote I/O Slave
3PS791.90-1	50W, 230VAC, Remote I/O Slave
2010	2010
2EX200.501	Bus Controller Remote I/O Slave

Fig. 4.15: RIO I/O slave module selection dialog box

Working with B&R RIO (continued)

In order for the RIO master to access the slave nodes, the node number on the module has to correspond to the node number in the configuration.

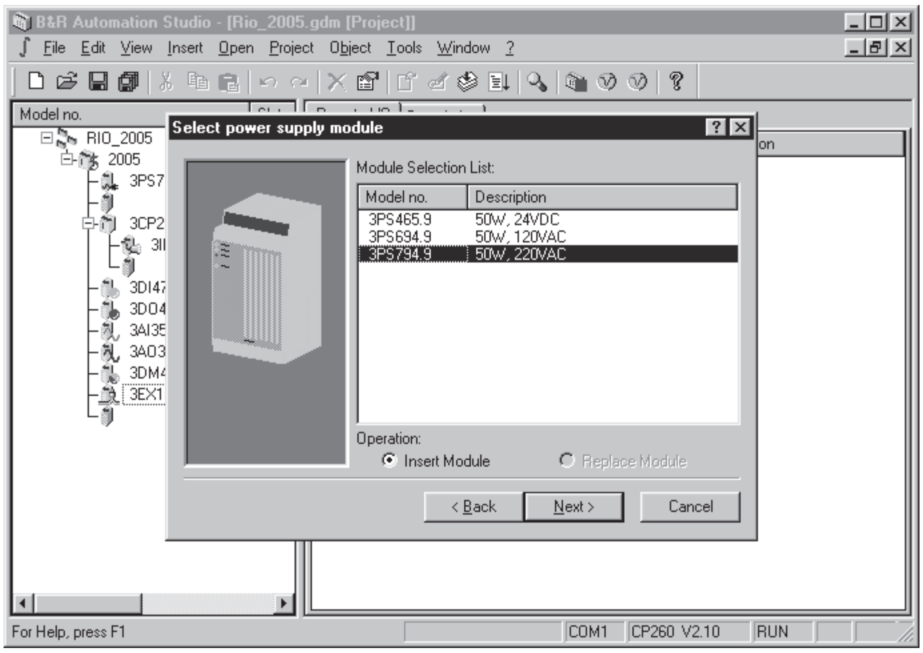


Module:	EX250
System:	2005
Type:	Remote I/O slave
Model number:	3EX250.60-1
Module address:	16
Backplane number:	none
Master number:	none

Enter slave number: 1

This number must correspond with the dial switch setting on the module

Fig. 4.16: RIO node number dialog box


B&R Automation Studio - [Rio_2005.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
Model no.
RIO_2005
2005
3PS7
3CP2
3II
3DI47
3DO4
3AI35
3AO3
3DM4
3EX1
Select power supply module
< Back
Next >
Cancel
For Help, press F1
COM1
CP260 V2.10
RUN

Module Selection List:

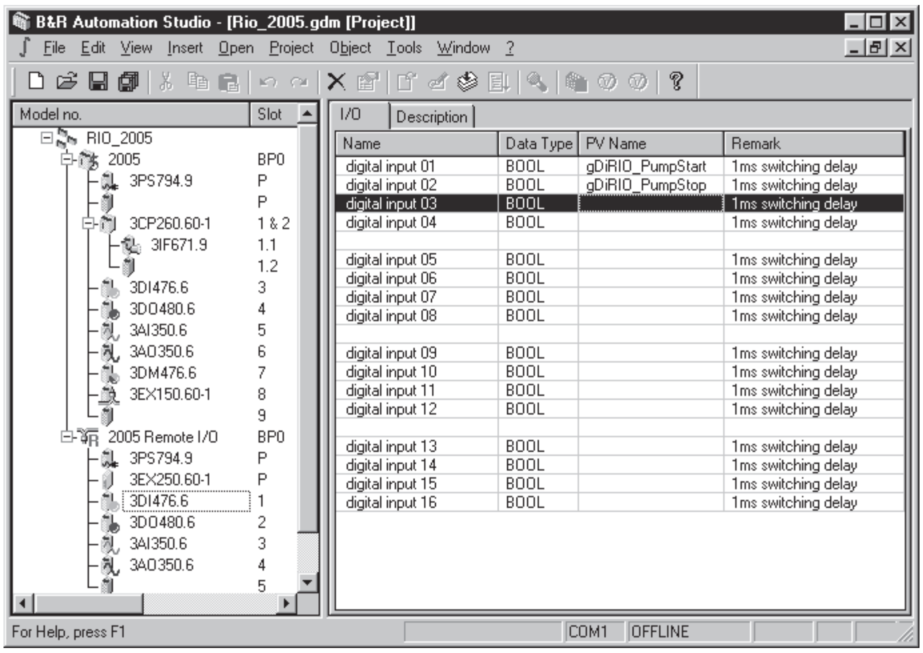
Model no.	Description
3PS465.9	50W, 24VDC
3PS694.9	50W, 120VAC
3PS794.9	50W, 220VAC

Operation:
[✓ Insert Module] Replace Module

Fig. 4.17: Selecting the power supply for the RIO slave module

Working with B&R RIO (continued)

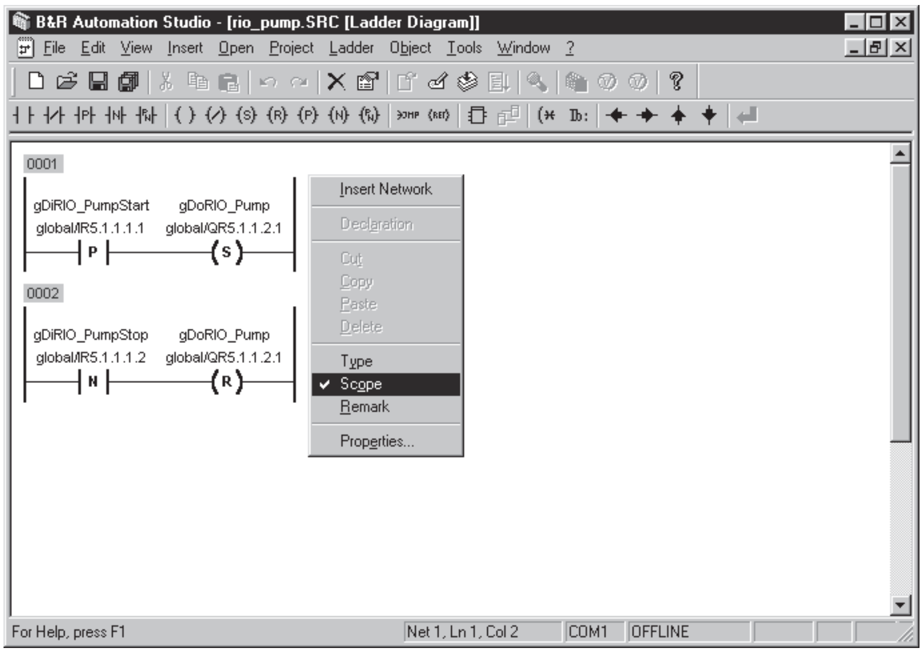
Assigning variable names for inputs and outputs.


B&R Automation Studio - [Rio_2005.gdm [Project]]
File Edit View Insert Open Project Object Tools Window ?
I/O
Description
For Help, press F1
COM1
OFFLINE

Model no.	Slot
RIO_2005	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4
3AI350.6	5
3AO350.6	6
3DM476.6	7
3EX150.60-1	8
	9
2005 Remote I/O	BP0
3PS794.9	P
3EX250.60-1	P
3DI476.6	1
3DO480.6	2
3AI350.6	3
3AO350.6	4
	5

Name	Data Type	PV Name	Remark
digital input 01	BOOL	gDiRIO_PumpStart	1ms switching delay
digital input 02	BOOL	gDiRIO_PumpStop	1ms switching delay
digital input 03	BOOL		1ms switching delay
digital input 04	BOOL		1ms switching delay
digital input 05	BOOL		1ms switching delay
digital input 06	BOOL		1ms switching delay
digital input 07	BOOL		1ms switching delay
digital input 08	BOOL		1ms switching delay
digital input 09	BOOL		1ms switching delay
digital input 10	BOOL		1ms switching delay
digital input 11	BOOL		1ms switching delay
digital input 12	BOOL		1ms switching delay
digital input 13	BOOL		1ms switching delay
digital input 14	BOOL		1ms switching delay
digital input 15	BOOL		1ms switching delay
digital input 16	BOOL		1ms switching delay

Fig. 4.18: Assigning I/O variables


B&R Automation Studio - [rio_pump.SRC [Ladder Diagram]]
File Edit View Insert Open Project Ladder Object Tools Window ?
Insert Network
Declaration
Cut
Copy
Paste
Delete
Type
Scope
Remark
Properties...
For Help, press F1
Net 1, Ln 1, Col 2
COM1
OFFLINE

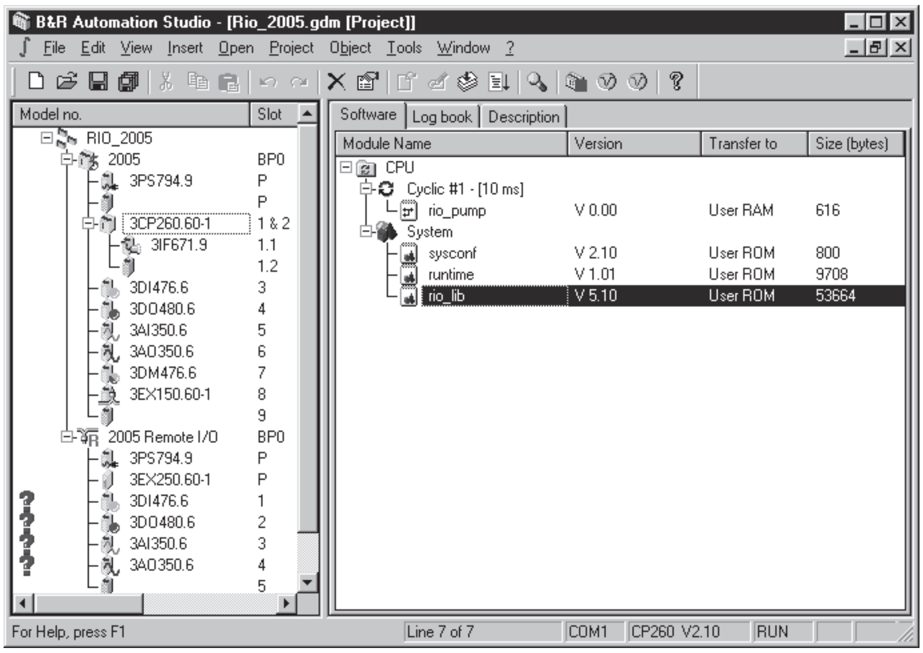
```
0001
gDiRIO_PumpStart       gDoRIO_Pump
global/IR5.1.1.1.1     global/QR5.1.1.2.1
----| P |--------------( S )----

0002
gDiRIO_PumpStop        gDoRIO_Pump
global/IR5.1.1.1.2     global/QR5.1.1.2.1
----| N |--------------( R )----
```

Fig. 4.19: Task with B&R RIO variables

Working with B&R RIO (continued)

If the task is now compiled and transferred to the controller, the additional drivers are also automatically copied in the "System" area and also transferred to the target.


B&R Automation Studio - [Rio_2005.gdm [Project]]

File Edit View Insert Open Project Object Tools Window ?

```
Model no.               Slot
RIO_2005
  2005                  BP0
    3PS794.9            P
                        P
    3CP260.60-1         1 & 2
      3IF671.9          1.1
                        1.2
    3DI476.6            3
    3DO480.6            4
    3AI350.6            5
    3AO350.6            6
    3DM476.6            7
    3EX150.60-1         8
                        9
  2005 Remote I/O       BP0
    3PS794.9            P
    3EX250.60-1         P
?   3DI476.6            1
?   3DO480.6            2
?   3AI350.6            3
?   3AO350.6            4
                        5
```

Software | Log book | Description

Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
rio_pump	V 0.00	User RAM	616
System			
sysconf	V 2.10	User ROM	800
runtime	V 1.01	User ROM	9708
rio_lib	V 5.10	User ROM	53664

For Help, press F1 | Line 7 of 7 | COM1 | CP260 V2.10 | RUN

Fig. 4.20: System area with "rio_lib" (Remote I/O Library)

Example

- An output is activated when a positive edge occurs on an input.
- The output is deactivated again when a negative edge occurs on a second input.
- Break the connection to the slave by unplugging the cable. What happens to the slave? What happens to the master?

Project Name:	rio_2005
LAD name:	rio_pump
Resource:	C#2

5 B&R AUTOMATION TARGET 2010

5.1 Main Unit

- The high end system of the B&R2000 series.

- The system performance is a result of cooperation between several processors and the CPU,
    - **I/O Processor** to read from / write to IO simultaneously
    - **RISC** to service interfaces simultaneously
    - **DPR Controller** to mask / negate digital I/O points

  the modular application memory which can be sent in for a project update if a modem service is not available and parallel processor capability.

- Up to **99 modules** can be installed on the I/O bus. Each module shows a separate module number on the **status display**. The **terminal blocks** are monitored and directly **coded** to the **module** which prevents mix-ups when a large number of I/O modules are used.

- The **parallel processors** extend the performance palette of the system in various directions:
    - IPs, as intelligent peripherals: drum sequencers, injection molding applications
    - PPs, as parallel processors: Multiprocessor, interface expansions, etc.

- The supply principle allows a **system with redundant power supplies** to be created.

- Expansions are possible using local **expansions**, **remote** slaves for longer distances up to 4800m or network and field bus system connections.

5.1.1 Backplane

The system has a modular system and I/O bus.
An I/O bus segment can be up to 20 slots long.
The system bus and the I/O bus both require a terminating resistor.
Slots that are not used should be covered by dummy modules.

5.1.2 Power Supply

Supply voltages in the DC range from 18-30V and in the AC range from 82-264V, 47-63Hz.
The power supplies are protected on the primary side by a fuse and on the secondary side by an internal current limiter.
The power supplies are then connected to the I/O bus.
Supply redundancy can be obtained by using twice as many power suplies as needed.

The 24V secondary voltage can be switched forward to a terminal using the toggle switch on the AC power supply, PS740.

5.1.3 CPU, User Memory and Parallel Processors

The high performance is reached using **several processors** (main processor, RISC, I/O processor and DPR controller). All PCC systems distinguish themselves by their **real-time capable, multitasking operating system** . The application memory (SRAM and FPROM) is modular and can therefore also be sent in if a modem service is not available.

The CPU is available in different versions. The only differences between the CP100 and the CP104 are the interfaces. Depending on the CPU, an RS232, a modem capable RS232 and RS422/485 interface or an RS232, a modem capable RS232 and CAN interface are available. The CP200 has a much higher calculation performance,4 to 8 times, and more interfaces, an RS232, a modem capable RS232, a CAN and RS422/485 interface.

The **interfaces** can be **switched using software** and operated as either **online or data interface**.

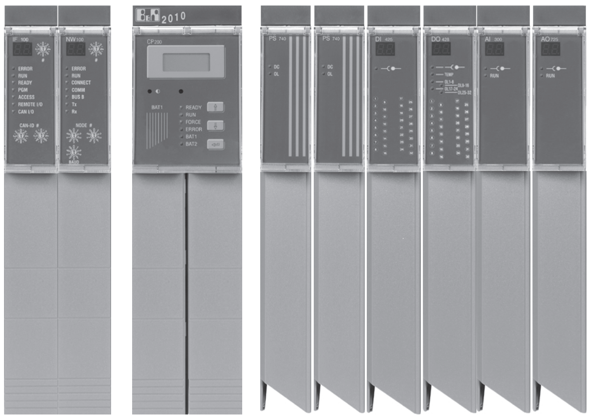


Fig. 4.21: B&R2010 rack with system and I/O bus

5.1.4 I/O Modules and Terminals

The B&R2010 system offers an extensive palette of:

Digital Modules Relay or transistor version

Analog Modules	0-20mA and ±10V	...	Resolution:	12Bit
	PT100 / FeCuNi / NiCrNi	...	Resolution:	$^1/_{10}$ or $^1/_{100}$°C

Interface counter modules and network modules
Multifunction module, drum sequencer,
Positioning module, parallel processors, interfaces

5.2 Expansion

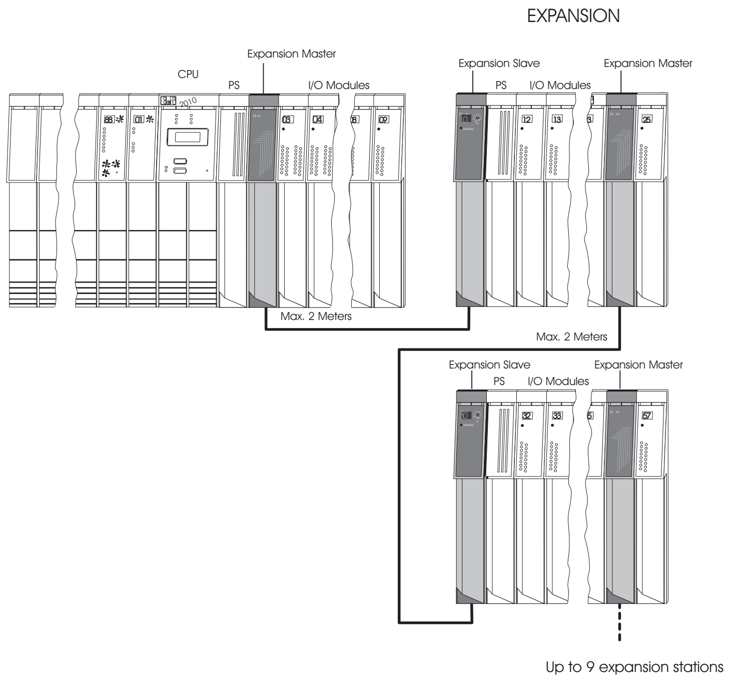
5.2.1 Expansion

The B&R2010 can use both local and remote expansion.

The expansion system is used for local expansions.
The expansion master is an I/O module, EX302.

The **expansion slave**, EX301, is the **first module in the expansion station** and must be inserted on a **terminated backplane**, BP202.
Local expansions can have a max. of 20 modules and there can be a max. of 2m between the individual stations.

Up to 9 B&R2010 expansions with a max. of 99 modules can be used.
The expansion cable is used as transfer media.



5.2.2 RIO

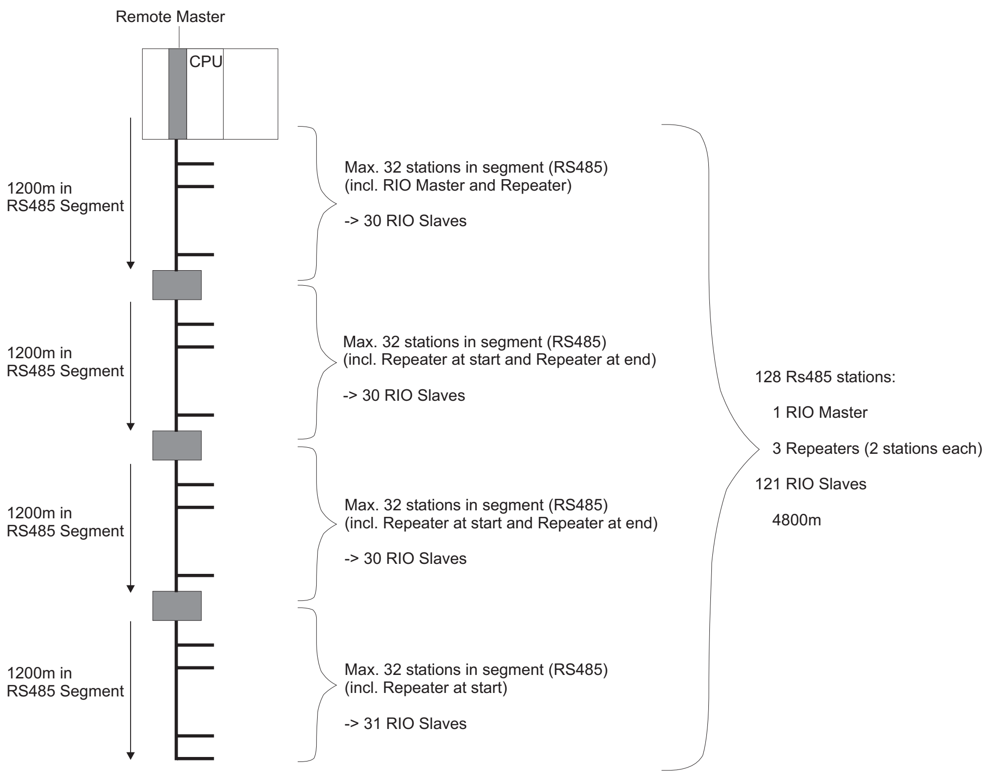
Two different remote systems can be used, Remote I/O and CAN I/O.

The **remote I/O** system consists of a remote I/O master, the system module EX100, and a remote I/O slave, EX200.
The remote I/O slave is the first module on the remote station and must be installed on a terminated backplane, BP202.
Remote networks can have max. 32 stations in a segment and can be used for distances up to 1200m. The transfer rate that can be obtained is 2 MBaud.

A max. of 121 stations can be connected at distances up to 4800m using a max. of 3 repeaters.

RS485 twisted pair cabling is used as transfer media.

Rs485 Network


Remote Master
CPU
1200m in RS485 Segment
Max. 32 stations in segment (RS485) (incl. RIO Master and Repeater)
-> 30 RIO Slaves
1200m in RS485 Segment
Max. 32 stations in segment (RS485) (incl. Repeater at start and Repeater at end)
-> 30 RIO Slaves
1200m in RS485 Segment
Max. 32 stations in segment (RS485) (incl. Repeater at start and Repeater at end)
-> 30 RIO Slaves
1200m in RS485 Segment
Max. 32 stations in segment (RS485) (incl. Repeater at start)
-> 31 RIO Slaves
128 Rs485 stations:
1 RIO Master
3 Repeaters (2 stations each)
121 RIO Slaves
4800m

5.2.3 CAN I/O

The **CAN I/O** system consists of at least one master. A CPU or parallel processor with CAN interface, and up to 63 CAN slaves, as B&R2003 with CAN bus slave module. The maximum expansion can have 64 stations. Distances up to a max of 1000m can be reached. The max. transfer rate is 500kBaud.

A 3 conductor CAN cable is used as transfer media.

5.2.4 Networks

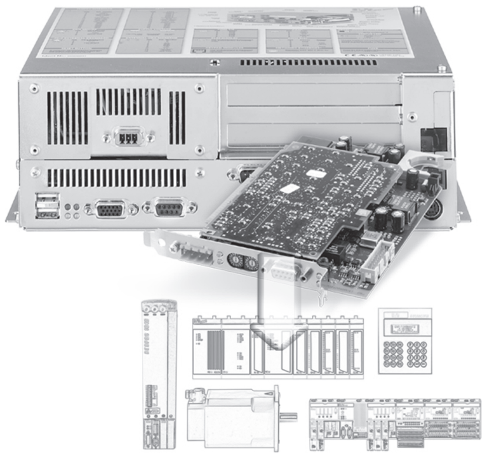
The following networks are also supported for data transfer:

- ETHERNET
- PROFIBUS
- CAN
- B&R NET2000
- Frame Driver
- Connections to systems from other manufacturers

6 B&R AUTOMATION TARGET LOGIC SCANNER

6.1 Main Unit

- Combination of control and visualization tasks compact in a single device.
- IPC5xxx handles visualization tasks.
- LS251 handles control tasks and is completely independent of the IPC5xxx operating system.
- High speed data exchange between LS251 and IPC5xxx via the PCI bus.
- Expansion possibilities exist for IO using RIO or CAN to connect to a network.



6.1.1 PCI Bus

The PCI bus is connecting element between the LS251 and IPC5xxx. It is used as a high speed data exchange media.

6.1.2 Power Supply

The LS251 uses either the IPC5xxx power supply directly or an external supply (independent of the IPC5xxx supply) provided by the LS079 expansion card.

6.1.3 CPU, Application Memory

The high performance is reached using a processor with integrated RISC. All PCC systems distinguish themselves by their **real-time capable, multitasking operating system** . SRAM and FPROM are available as application memory. The user is provided a modular IF concept, with the LS071. The interfaces can be switched using software and operated as either **online or data interface**.

6.2 Expansion

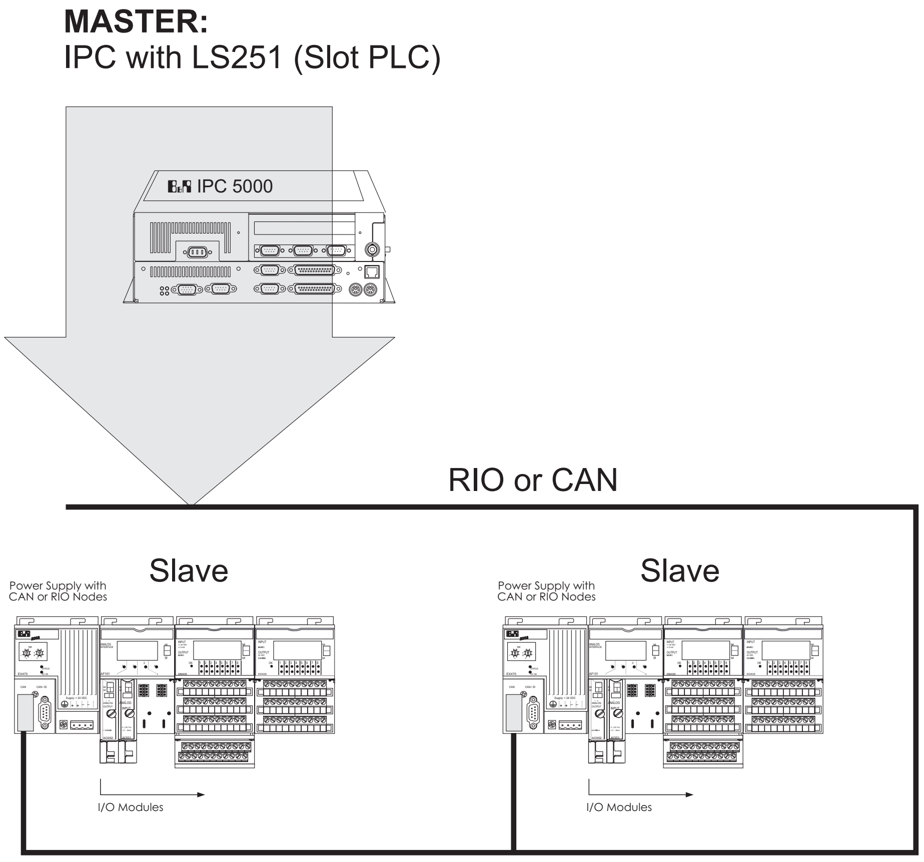
The LS251 can be connected to I/O using RIO or CAN

6.2.1 RIO

The LS251 has a RIO interface onboard for a connection to IO modules from the B&R 2003/2005/2010 families.

6.2.2 CAN IO

The LS251 has a CAN interface onboard for a connection to IO modules from the B&R 2003 family.


MASTER:
IPC with LS251 (Slot PLC)
IPC 5000
RIO or CAN
Slave
Power Supply with CAN or RIO Nodes
I/O Modules
Slave
Power Supply with CAN or RIO Nodes
I/O Modules

7 B&R AUTOMATION TARGET IPC2XXX

7.1 Main Unit

- Increased processor performance with support of an FPU
- Large supply of memory with possibility for file management
- Compact design with flexible network connections

7.1.1 Power Supply

Integrated DC power supply with a supply voltage of 24V.

7.1.2 CPU, Application Memory

The IPC2xxx, having an Intel 486/DX5 with FPU and memory in the megabyte range, provides high performance. The user now also has PC resources, such as floppy disk and hard disk with a file management system for effective development of applications. The interfaces can be switched using software and operated as either online or data interface.

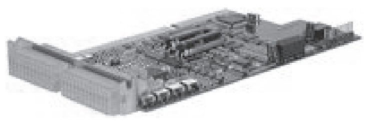
7.1.3 AutomationRuntime

To use the **IPC2xxx** as AutomationTarget, **AutomationRuntime AR102** is installed as real-time operating system from a set of diskettes. These installation diskettes are created by the AutomationSoftware install kit.

7.2 Expansion

7.2.1 ISA I/O

With the LS301.4 card, 16 DI, 16 DO, 4AI, 2AO can be connected directly to the IPC2xxx via the ISA bus.



7.2.2 CAN IO

With the LS172.4 card, B&R CAN IO can be connected to the IPC2xxx via the ISA bus. The LS172.4 has two CAN interfaces.

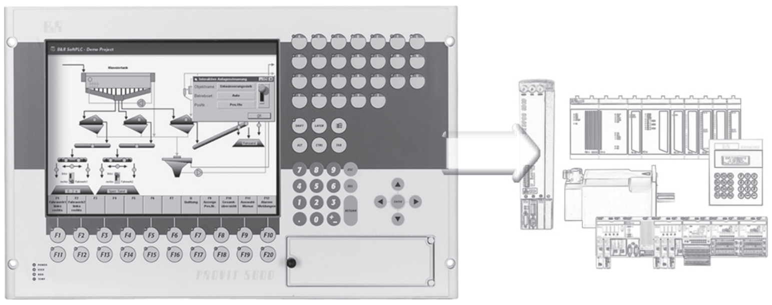
7.2.3 Networks

- CAN
- Ethernet
- Serial

8 B&R AUTOMATION TARGET IPC5XXX

8.1 Main Unit

- Increased processor performance with support of an FPU.
- Large supply of memory with possibility for file management.
- Compact and modular design with flexible network connections.



8.1.1 Power Supply

Integrated AC or DC power supply. 24V DC supply voltage and 100-240V AC supply voltage, 47-63Hz.

8.1.2 CPU, Application Memory

The IPC5xxx, having a Pentium processor with FPU and memory in the megabyte range, provides the highest performance. The user now also has PC resources, such as floppy disk and hard disk with a file management system for effective development of applications. The interfaces can be switched using software and operated as either online or data interface.

8.1.3 AutomationRuntime

The following AutomationRuntimes are available for use with **IPC5xxx** as AutomationTarget:

- **AR105 - embedded**. The AT only executes control tasks.
- **AR010 - NT**. The AT executes high priority and deterministic control tasks. NT is handled in the idle time which makes it possible to run the visualization on the same target.

AutomationRuntime is installed as real-time operating system from a set of diskettes. These installation diskettes are created automatically by the AutomationSoftware install kit.

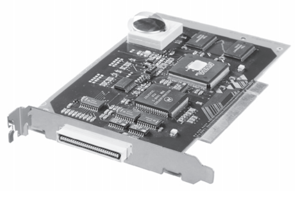
8.2 Expansion

8.2.1 ISA I/O

With the LS301.4 card, 16 DI, 16 DO, 4AI, 2AO can be connected directly to the IPC5xxx via the ISA bus.

8.2.2 Expansion

With the LS191 card, B&R 2005/2010 IO can be connected to the IPC5xxx as local expansion via the PCI bus.

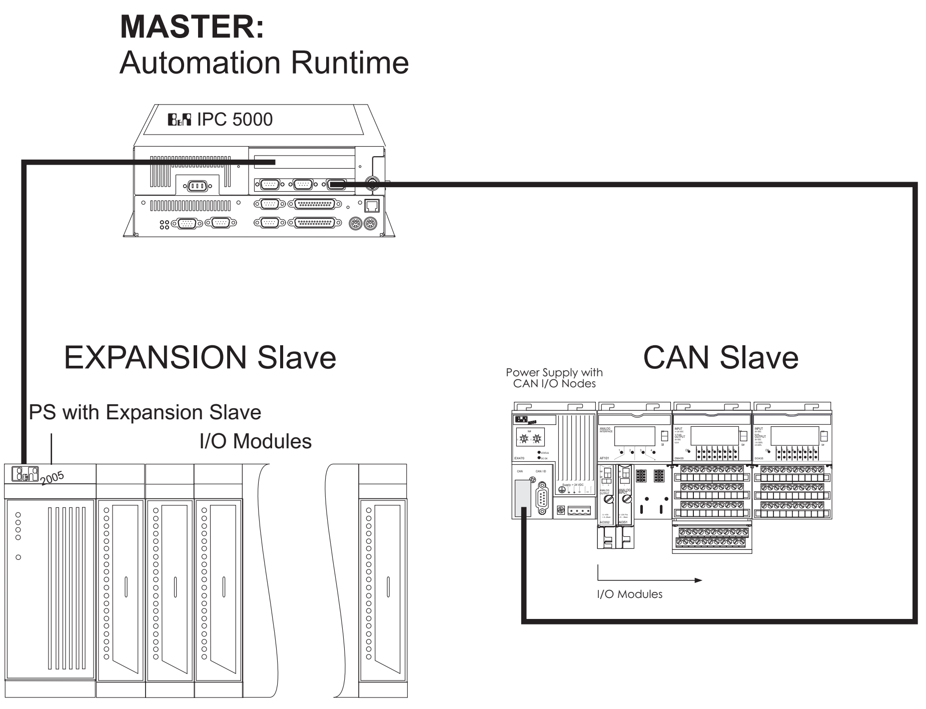


8.2.3 CAN IO

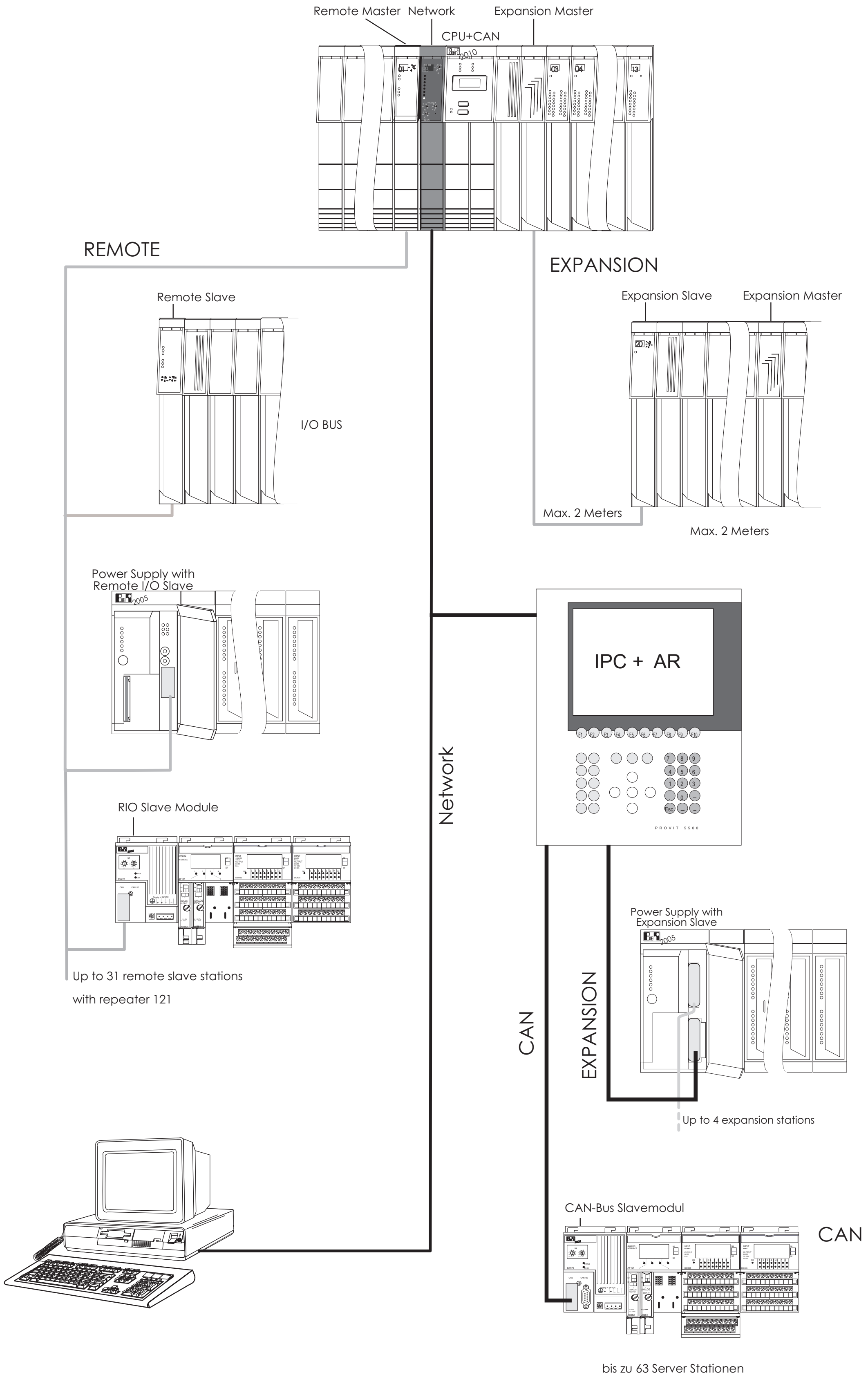
With the LS172.4 card, B&R CAN IO can be connected to the IPC5xxx via the ISA bus. The same possibilities are offered by the LS172.6 using a faster PCI bus connection.

8.2.4 Networks

- CAN
- Ethernet
- Serial



9 B&R2000 OVERVIEW



B&R AUTOMATION NET

1 OVERVIEW

B&R Automation Net

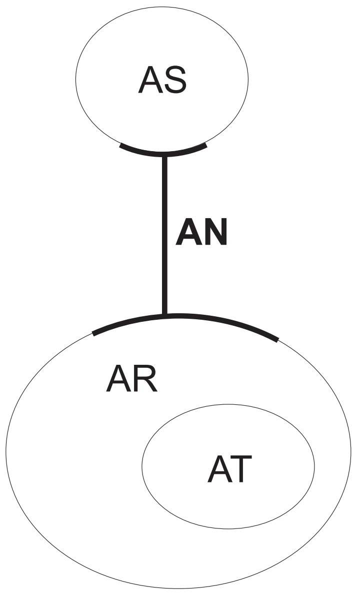
Overview of the communication model for B&R Automation Net and ist components.

Communication Principles

Access to B&R Automation Net

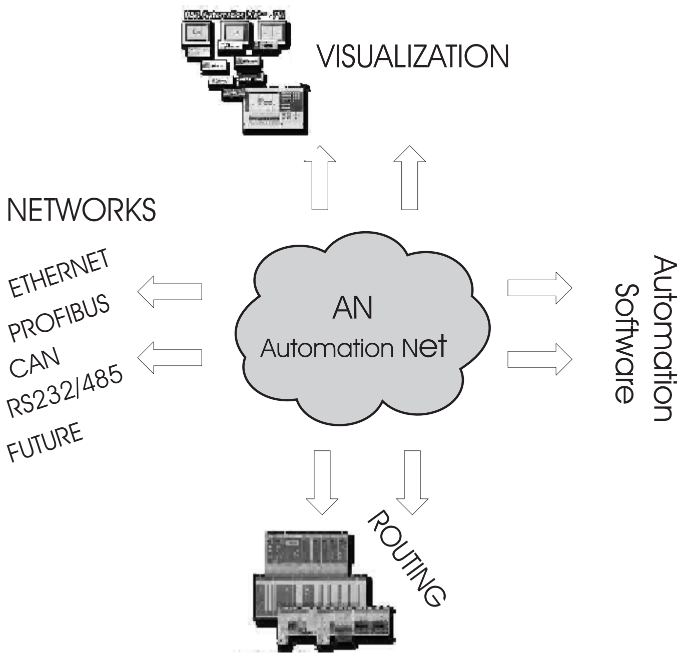
The user can access Automation Net for visualization and for the programming device via PVI. From the application, access takes place using INA Client FBKs. Routing possibilities are offered which allow new solution methods for simple handling of network tasks.

2 B&R AUTOMATION NET



B&R Automation Net (AN) allows **communication** between B&R Automation Runtime, B&R Automation Target and also other stations on the network. In general, B&R AN represents a cloud of communication between B&R and other components.

3 COMMUNICATION PRINCIPLES



B&R Automation Net makes it possible for every communication station to exchange and edit all types of program objects and/or process variable objects.

B&R Automation Net is:

- independent of the operating system used
  B&R Automation Runtime,Windows 95/98/NT/2000, etc.
- independent of the media used
  RS232,CAN,Ethernet,Profibus,Modem,Memory,etc.
- independent of the transfer protocol used
  INA2000, NET2000, Mininet, etc.

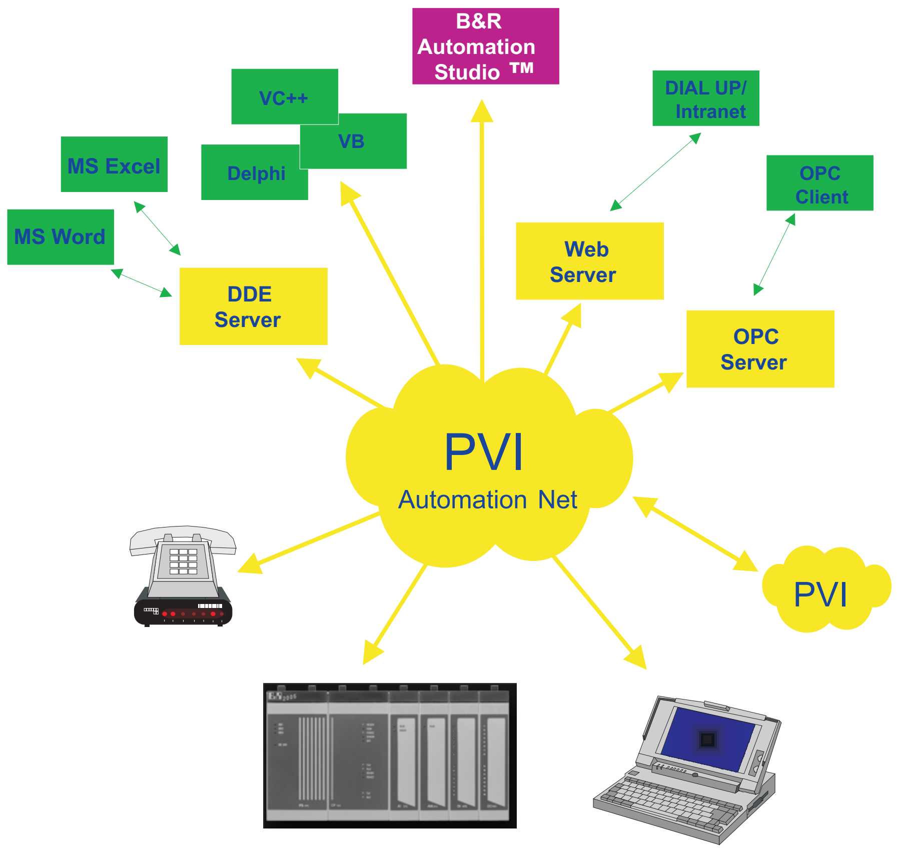
4 ACCESS TO B&R AUTOMATION NET

Communication within AN can be transparent, but different interfaces must be used at the end points where the information is actually processed on the respective operating system.

Therefore, the corresponding access method is required for each operating system.

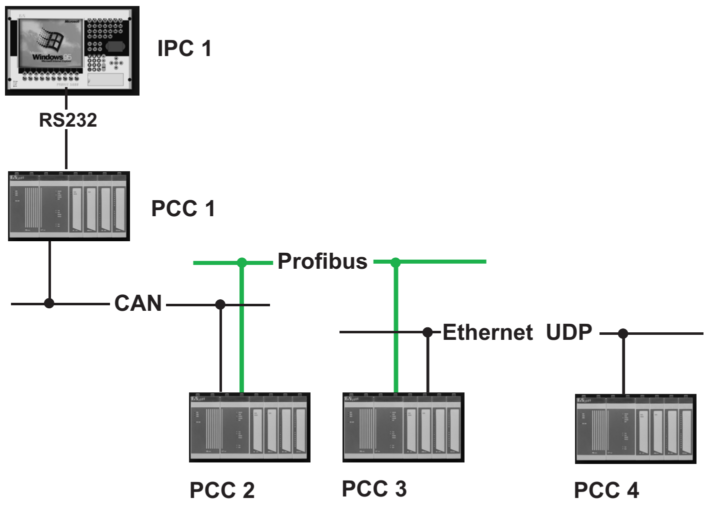
4.1 B&R Automation Net - PVI

The Process Visualization Interface (PVI) is a component of AN and establishes the connection to the B&R Industrial PC's environment as common interface for all Windows based programs.



4.2 B&R Automation Net - Routing

Routing generally refers to a connection between several PCCs for programming. Its main task is forwarding data addressed on another PCC.



The interface settings are made in AS using menu item
Extras: Options

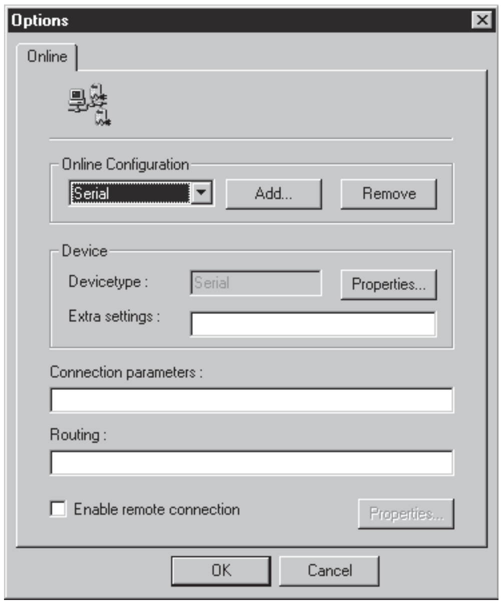


Fig. 5.1: Connection settings

4.2.1 Online Configuration

Select the online configuration for communication to the local PCC. Automation Studio provides the following preprogrammed configurations:

- Serial = RS232
- CAN
- SHARED = LS251

Additionally, the user can save other, specific configurations under different names.

4.2.2 Interface

Here, parameters for the selected online interface can be defined in a dialog box. The parameters can also be entered as text using “Extra Settings”.

4.2.3 Connection Parameters

Additional settings for the device parameters when using CAN, Profibus and TCP/IP Ethernet.

e.g. node number for CAN or TCP/IP Ethernet

4.2.4 Target System Path

Settings for routing between controllers
e.g.: “/CN=CAN.3”

This setting means that a CAN connection will be created from the local controller to the next controller. The ending “.3“ is the set node number of the next station.

4.2.4 Activate Remote Connection

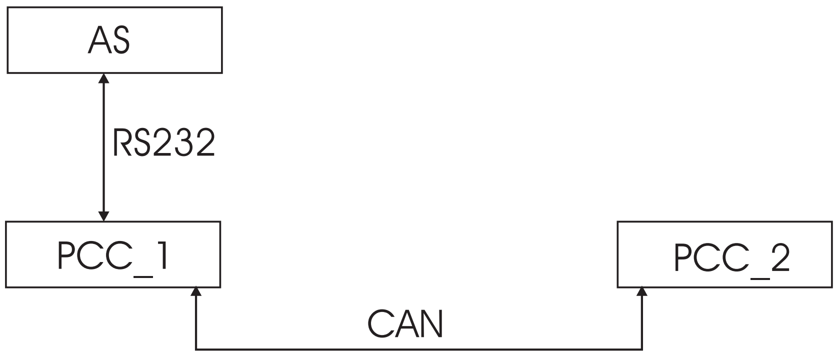
The user can make settings for a remote connection between PCs via TCP/IP.

Note

More than one routing path can be entered !!

Example

Create the network shown belong with the help of your trainer and establish communication between the controllers and Automation Studio.



- Create the network
- Program a tasks with a toggle output
- Transfer and test the program

Project Name:	rout_can
Task Name:	toggle
Resource:	?

4.3 B&R Automation Net - INA Client FBKs

Today, many automation solutions use distributed intelligence. Tasks are distributed over several automation targets. The connection between the automation targets is made using Automation Net.

The communication services, such as reading or writing PVs, are already provided to the programmer by Automation Runtime. This communication provided by Automation Runtime is called the INA Server.

Access of the communication services by the application takes place using function blocks, INA Client FBKs.

With INA Client FBKs, PVs can now be read from or written to by another automation target using their names via Automation Net. This makes exchanging data between B&R controllers much easier and more transparent for the user.

Advantages of the INA Services:

- Connections are made by setting parameters and no longer need to be programmed
- Complete performance of the INA2000 protocol
- Change the physics simply by changing the parameters
- Fast and simple use of network technologies without having to make extensive changes to source code

PROJECT GUIDELINES I

1 OVERVIEW

For larger projects, it is important that uniform guidelines are followed during development and programming.

This should make it easier for several programmers to work together on a project.

This should also make programs more clear for the programmer and for others. The ability to expand and maintain the programs is improved considerably.

Project Creation

Short overview of the process of creating projects. This information also depends on the branch and the respective projects, but can be used as a basis and adapted for the project being created.

If guidelines already exist for projects, they should be followed !

Programming Conventions

This concerns assigning names to tasks and also variables. Variable names and constant names are designed for 32 characters. These characters should be used in as meaningful a manner as possible. Task names are limited to 8 characters. The nesting depth for structures is limited to 16.

Notes on Literature

This chapter is a exert from the B&R application programming guidelines which is described in detail in the appendix.

Further Literature:

```
Code Complete :  A Practical Handbook of Software Construction
                 by Steve C McConnell

Paperback - 857 Pages (May 1993)

Microsoft Press;
ISBN: 1556154844
```

2 PROJECT CREATION

Details concerning the individual points can be found in **Project Guidelines II**

- Internal preliminary discussions
- Creating a project
- Project discussions
- Software conception phase
  Defining or adjusting the programming conventions
- Coding
- Testing
- Startup
- Documentation
- Archiving

Note

In this chapter, only the software conception phase will be looked at in detail.

3 PROGRAMMING CONVENTIONS

3.1 Identifier

AS is a programming tool that makes it possible to assign meaningful variable names.

● Variable name	32 characters
● Constant name	32 characters
● Task names	8 characters
● File names	W95/W98/WNT naming conventions
● Nesting depth for structures	16 levels

Programming conventions for B&R AutomationStudio are described in the following sections.

They should be followed when creating software, during startup and also for later software changes.

3.2 Data Types

In all programming languages supported by AutomationStudio, the **IEC Data Types** should be used. Also ANSI C !!!

This simplifies changing to other architectures considerably because only the platform specific sections have to be rewritten.

3.3 Directory Structure

As standard, AutomationStudio saves all source files in the CPU path for the project.

With the programming language ANSI C, it is possible to create subdirectories for source and include files which makes them much clearer.

```
../Cpu/SRC
../Cpu/INC
```

3.4 Software Module Names

3.4.1 General Information

During the software conception phase, the application is divided into smaller and smaller units which provide the required functionality.

This type of software module should be a closed unit. It handles a certain task and has a precisely defined interface to other software modules.

A software module can consist of one or more tasks and data modules.

The module concept should also be used for function blocks and functions.

3.4.2 Guidelines for Module Names

A module is defined using a combination of three characters.
This character combination can consist of letters and/or numbers.

The character combination is found in all elements that belong to this module such as tasks, data modules, global variables, function block names and function names.

3.5 Task Names

It should be clear that a tasks belongs to a software module from its name. Task names are presently limited to 8 characters and are defined as follows:

Abbreviation:	**Description**
mm_	Code for the module
ttttt	Code for the task in the module

Tab. 6.1: mm_ttttt

To improve clarity, module and task identification codes should be separated by an underline.

Example: `mi_drv ...` **m**achine **i**nterface, **dr**i**v**er

3.6 Data Module Names

It should be clear that a data module belongs to a software module from its name.

In certain cases, it can be necessary to enter the memory type for the data module in the name. For example: Backup copy in Flashprom, if the data module is written to by the application.

Data module names are presently limited to 8 characters and are defined as follows:

Abbreviation:	**Description**
mm_	Code for the module
s	Memory type
tttt	Code for the data module

Tab. 6.2: mm_stttt

Prefix s	**Description**
_	No entry
p	Eprom/Flashprom
x	Fix Ram
r	Ram

Tab. 6.3: Memory type

Example

`mi_para`
Data module in the MI module with the name Para, the memory type is not entered.

`mi_xpara`
Data module in the MI module with the name Para, which is in FIX RAM.

3.7 Variable Names

AutomationStudio differentiates between variables with the following scope:

- global variables
- local variables
- C variables (see chapter ANSI C)

Variable names can have up to 32 significant characters.

Variable should always be defined with the **smallest possible scope**. When using PCC global variables, very complex structures can easily be created which makes the application logic difficult to understand. Additionally, PCC global variables make it considerably more difficult to reuse and maintain codes.

As the size of the project increases, it becomes more important to be able to quickly recognize the scope of variables. This can be made easier by using a type prefix with variable names.

3.7.1 Global Variables

Applications for global variables:

- Communication between Tasks
- IO Connection to Hardware

Global variables are to be defined with "_GLOBAL" in ANSI C.

pttMMMnnnnnnnnn...

The separation of the sections can be shown using underlines or capitalization.

Abbreviation:	Description
p	Type prefix for scope of the variable
tt	Type of variable
MMM	Code for the module (only capitals and/or numbers)
nnnnnnnnn..	Variable name consists of letters, numbers and underline. The name must begin with a lower case letter or an underline.

Tab. 6.4: Names of Global Variables

Type Prefix p	Description
g	PCC global variable
None	C local variable and local variables in IEC languages

Tab. 6.5: Description of the type prefix p

Type tt:	Description
Di	Digital input (BOOL)
Do	Digital output (BOOL)
Ai	Analog input (INT)
Ao	Analog output (INT)
P_	Pointer (only meaningful in “C”)

Tab. 6.6: Type description of variables

Example

IO Inputs/Outputs:

`gDiHTGStart, gDoHTGStop, gAiHTGzyTemp, gAoHTGzyClock, etc.`

3.7.2 Access of Hardware IO

The **access** of**hardware data points** can occur in each software module **exactly once**.

An **exception** to this is **LAD programming**. Here, inputs can be accessed more often. Outputs can only be written to once.

For all other programming languages, the following is valid:

- At the beginning of the module, the hardware IOs in the hardware data point buffer are copied to the local module status structure.
- At the end of the module, the buffer is written to the outputs.
- A substructure HwIO in the local module status structure is used as buffer.

This also has the advantage that changing the hardware data points between normally open to normally closed contacts only affects one location in the program.

IMPORTANT

Outputs are only allowed to be written to by a module **one time**!

3.7.3 Local Variables

- Names for local variables can contain all number and letter combinations.
- Exchanging local data and commands can take place using the respective prefixes “C_” and “S_”.
- Local variables are to be defined with “_LOCAL” in ANSI C.
  This variable type can be viewed with “Watch”.

Additionally, they have to begin with the prefix „1“ in ANSI C, the prefix is not needed in all other IEC languages.

Example in IEC languages:

```
resAverage, intCounter, ...
```

3.7.4 Initializing Variables

Variables are principally only to be initialized in the “INIT SP” for the main task or module.

The variable initialization in the variable declaration window is always to be set to “**remanent**”.

3.8 Constant Names

- Constant names can have up to 32 significant characters.
- Self-defined constants are always written in capitals.

Constants defined by B&R standard software, e.g. NC software are exceptions. They are not allowed to be changed during the creation of the application!

3.8.1 Constant Definition in ANSI C

In ANSI C, there are three possibilities to define constants.

- Constants that are valid throughout the system
  These are always written in capitals and are not allowed to have underlines.

  Example: `TRUE, FALSE, UNDEF, ...`

- Constants with software specific validity
  Constants are principally always valid throughout the system, but the use of a specific code allows them to be assigned to a program.

- Commands
  Constants belonging to a spezial module are labeled with the module code and an underline,

  Example: `MI_START, MI_STOP, C_START, C_STOP`

3.8.2 Reserved Constants

These constants are writtenin capitals but are labeled mit ”nc” in lower case at the beginning.

Example: `ncON, ncOFF, ncINIT`

These constants are not allowed to be changed by the user.

3.9 Alias Process Variables for Function Blocks

In alias names of function blocks, the function block name always has to be first. The description is separated by an underline.

Example: `TON_valve, TOF_motor`

3.10 Assigning Revision Numbers

In all headers where version numbers are assigned, the following procedure should be used:

The version number consists of 4 characters.

`xx.yy:`

`yy` .. increased by 1 with each change
`xx` .. increased by 1 for major changes. **`yy`** becomes **0**.

Version numbers are assigned in hex format.

IMPORTANT

Detailed literature concerning this topic is available.

SEQUENTIAL FUNCTION CHART

1 OVERVIEW

B&R offers the right programming language for every application and for every programmers preference. This includes:

- Ladder Diagram (LAD)
- Instruction List (IL)
- Structured Text (ST)
- Sequential Function Chart (SFC)
- B&R Automation Basic (AB)
- ANSI C

LAD	Contact, logic and function operations are combined here in a single user interface. Ladder diagram is the simplest form of programming digital and analog processes because of its similarity to a circuit diagram.
IL	Instruction list is similar to a machine language. It can be used like LAD for logic operations.
ST	This high level language is a clear and powerful programming language for automation systems. Simple standard constructs guarantee fast and efficient programming.
SFC	**A sequential language that was developed to separate a task into clear units. Sequential Function Chart (SFC) is well suited for processes where states change in steps, for example: automatic carwash**
AB	This B&R high level language is a clear and powerful programming language for automation systems of the newest generation. Simple standard constructs guarantee fast and efficient programming. Previously PL2000
ANSI C	This high level language is a powerful programming language for automation systems of the newest generation. Simple standard constructs guarantee fast and efficient application programming.

2 SFC SYNTAX

In this chapter, we will have a detailed look at the language Sequential Function Chart (SFC).

SFC ist a **graphically structured language** which eases sequential control.

This IEC61131-3 language is based on GRAFCET, an important French programming language.

The SFC programming symbols are divided into the following groups:

- Initialization step
- Steps – sequential states
- Actions – for IEC steps
- Defining characters for actions
- Branches
- Transitions
  Transfer conditions between steps

2.1 Steps

2.1.1 Init Step

Every SFC program contains a special step. The initialization step.
This INIT step is symbolized by a double rectangle. The sequence begins with this step each time the controller is started.

2.1.2 Normal Steps

„Normal“ steps are symbolized by a rectangle. The rectangle contains the name of the respective step.

A variable exist for each step with the name of the step. The status of the step can be read from this variable.

For simplified steps, this variable has data type “BOOL”.
For IEC steps, this is a structure variable.

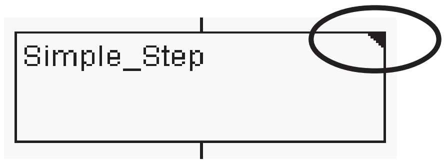
2.2 Actions

- Actions contain the actual program code
- Actions are always assigned to a step

They are several types of actions:
The languages IL, ST, LAD, AB and SFC can be selected.

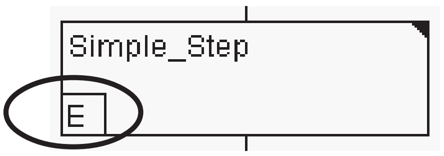
2.2.1 Simple actions

The simple form of actions are called “Action”. The code contained in them is always executed when the action is active. You can see that an action is assigned to a step because a **small triangle on the top right** of the symbol appears.



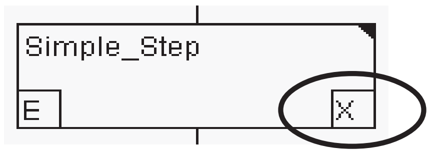
2.2.2 Entry Action

The code for the entry action is executed once when the step becomes active. That means whenever the step status changes from inactive to active. If a step contains an entry action, a small square with the letter “E” is shown in the bottom left corner of the step symbol.



2.2.3 Exit Action

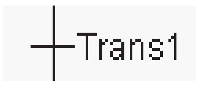
The code is executed once when the action status changes from active to inactive. The exit action has an “X” in the lower right corner.



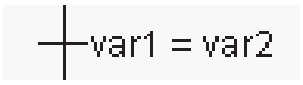
Steps can contain both **“entry actions”,** and **“exit actions”** !

2.3 Transitions

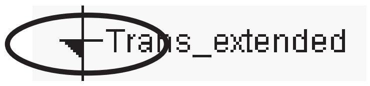
Transitions are symbolized by "┼" symbols at the connection point between the steps. The transition conditions are on the right next to the symbol.



The transition conditions can be a simple BOOL variable or logically linked variables where the result must be TRUE or FALSE!



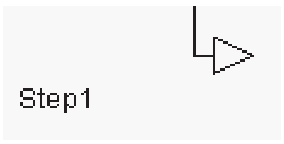
The space next to the transition is limited, therefore transitions canbe entered in a separate editor. Only one link can be entered in this editor. Command sequences are not allowed. If the transition is the result of a logical link, this is shown by a small triangle.



Languages IL, ST, LAD and Automation Basic can be selected.

2.4 Jumps

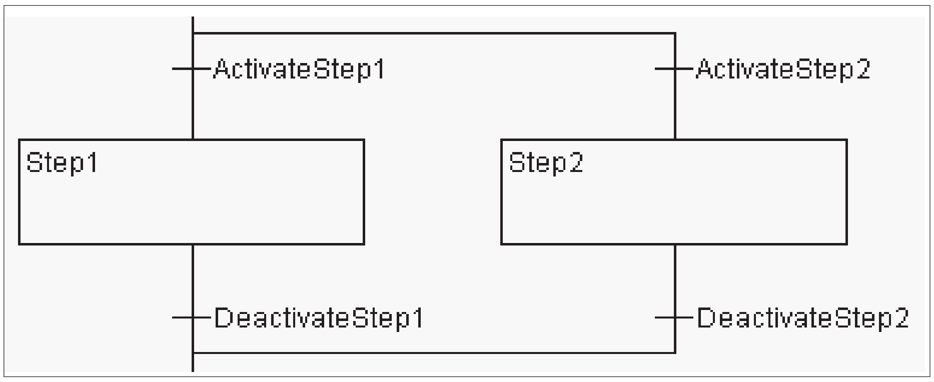
Jumps are used to create loops and repeats. Jumps are represented by a jump symbol. The name of the jump target is shown under the jump symbol.



2.5 Branches

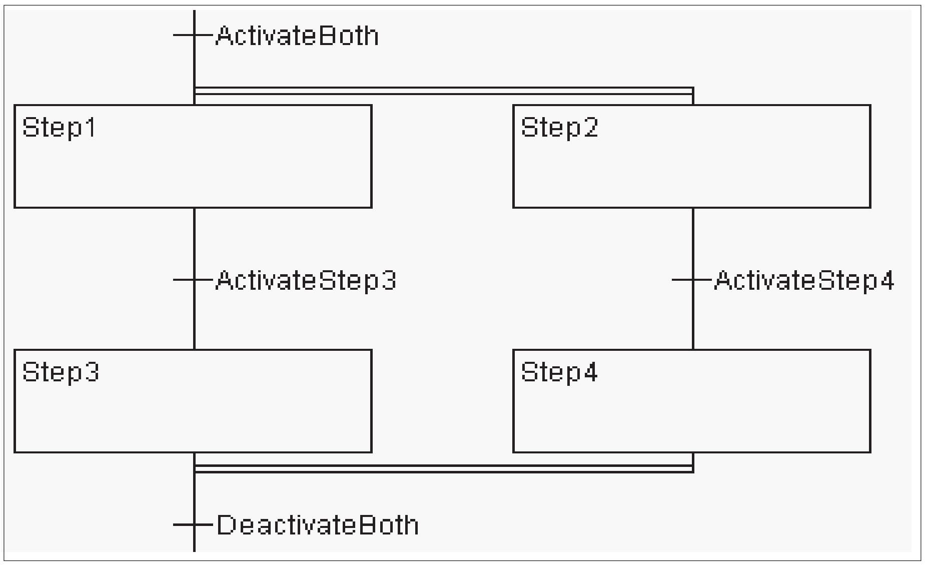
2.5.1 Alternative Branch

Using alternative branches, it is possible to continue processing in one of several branches depending on the transition condition. If several transition are TRUE, then the left branch is processed. To make things clearer, transitions should be selected so that only one is active at all times.



2.5.2 Parallel Branch

Using parallel branches, it is possible to process several branches in “parallel”. The steps in the respective branches are naturally processed one after the other. The order moves from left to right. The transition which where the branches come together is evaluated when the last step is active in each branch.



Example

Use the editor to create a sequence with normal steps, transitions, alternative branches and parallel branches to get used to the editor.

Add steps and transitions.

Delete steps and transitions, etc.

IMPORTANT

To select steps and transitions, you **must** work with the **<SHIFT>+<Cursor>** keys.

Project Name:	sfc_pro1
Task Name:	sfc_edit
Resource:	C#2

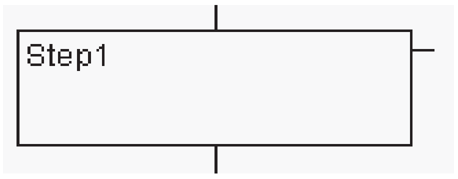
Note

Variables are requested directly by the editor and should be defined as local.

2.6 IEC Steps

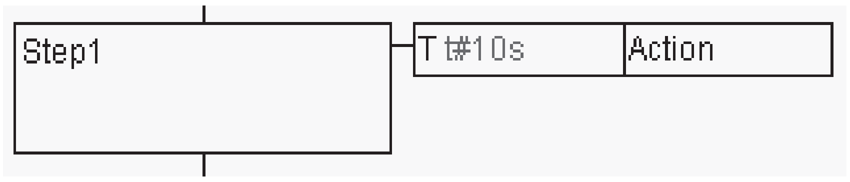
2.6.1 IEC Actions

IEC actions can only be connected to IEC steps. They are recognizable by the horizontal line on the right corner.

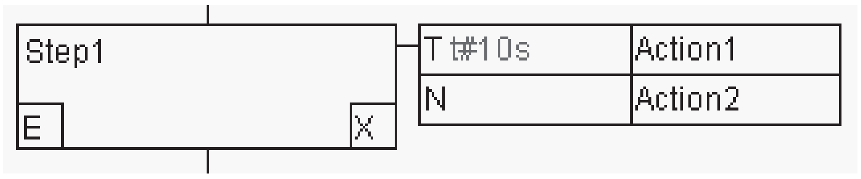


The actions are represented by “banners” which are connected to the horizontal line.

The “banner” is divided into 2 columns. The first column contains a letter that specifies the execution rate. Some types of execution require a time entry which is entered next to the letter. Constants, variables and literals of type “TIME” are valid as time entries. The second column shows the name of the action being executed.



Several IEC actions can be connected to IEC steps. For example, an IEC action can be continually activated in a step using execution type “S” and then deactivated in another step with “R”.



“Entry actions” and “exit actions” are also possible in IEC steps.

2.6.2 Execution Types for IEC Actions

The folowing execution types are possible for IEC actions:

Qualifier	Description
N	Not stored Action is executed as long as the step is active
R	Reset Action is not executed. Stored status of the action is deleted.
S	Set Action executed until reset with R.
L t#Time	Limited Action executed as long as step is active and the set time has not passed (according to IEC format).
D t#Time	Delayed Action executed if the set time has passed (according to IEC format) and the step is still active.
P	Pulse Action executed once when the steps becomes active.
SD t#Time	Stored and Delayed Action becomes active after set time, independent of if the step is still active.
DS t#Time	Delayed and Stored Action becomes active if the step was active for at least the set time, status is stored after the step has ended.
SL t#Time	Stored and Limited The action remains active for exactly the set time, independent of if the step remains active.

Tab. 7.1: IEC actions

2.6.3 Executing IEC Actions

Each IEC action has a structure variable with the name of the action.
Element **.x** of the structure can be used to read the activation status of the action.

Evaluating this value <action name>.x can be done to determine, if an action is active or inactive.

IEC actions are executed as long as they are active. After changing from active to inactive, the actions executed one more time.

During the last execution of the action, the value of <action name>.x = FALSE.

3 PLANNING WITH SFC

Example

Application:

Press start...
Open water valve

Water OK reached...
Close water valve,
Switch on stirring mech.,
Open color valve

Sensor Full reached...
Close color/dispersion valve, Wait 30 sec.
Open drain valve
Switch on drain pump

Sensor Low reached...
Switch off pump, switch off stirring mech.
Close drain valve

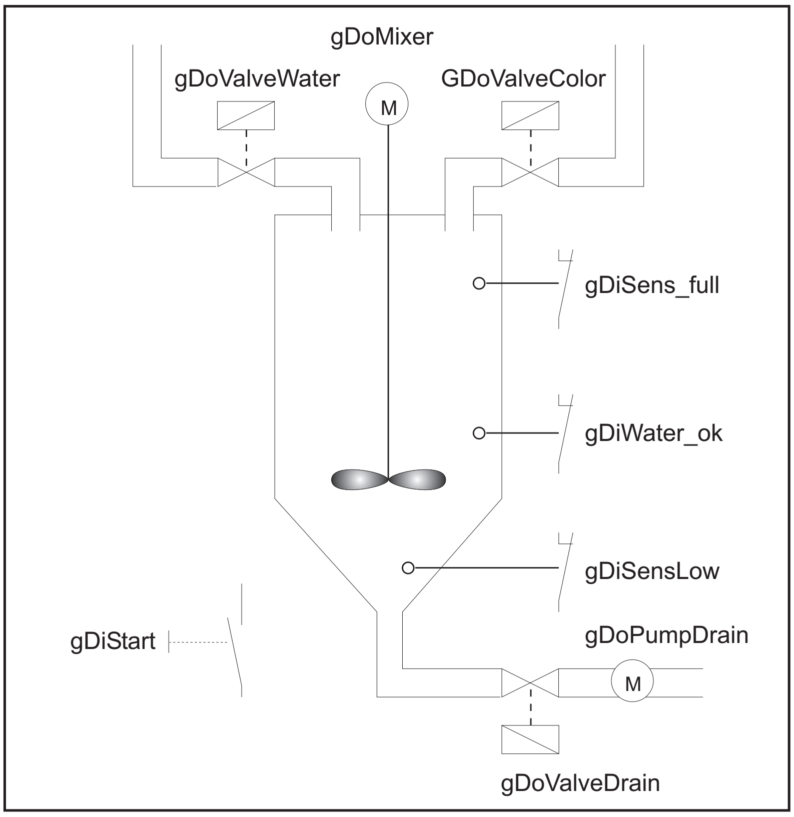
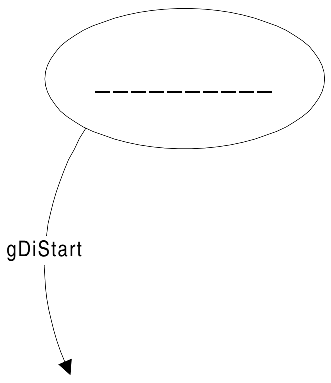


Fig. 7.1: Chemical system section

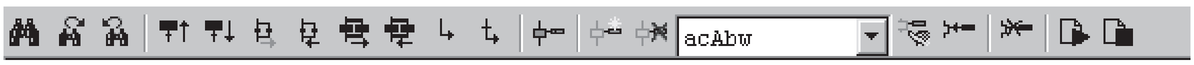
Procedure:

- Determine the necessary steps
- Determine the transition conditions, transitions
- Define further programming conventions if necessary, for variable names, etc.
- Create SFC task
- Program steps
- Program transitions
- Test steps
- Define outputs
- Enter code in the steps and test the function

3.1 Planning on Paper



3.2 SFC Tools



Search **<ctrl><f>**	Search forwards **<F3>**	Search backwards. <shift>**<F3>**	
Prev. step transition **<ctrl><t>**	Next step transition **<ctrl><e>**	Alternative branch right **<ctrl><a>**	Alternative branch left
Parallel branch right **<ctrl><l>**	Parallel branch left	Jump **<ctrl><u>**	Transition with jump
Use IEC steps	Add action	Delete action	
acAbw Select actions	Edit action	Link action	Break/delete action/step/ transition
Start object	Stop object		

Tab. 7.2: SFC Toolbar

3.3 SFC Application

Mixer in SFC.

The steps should always be defined first.

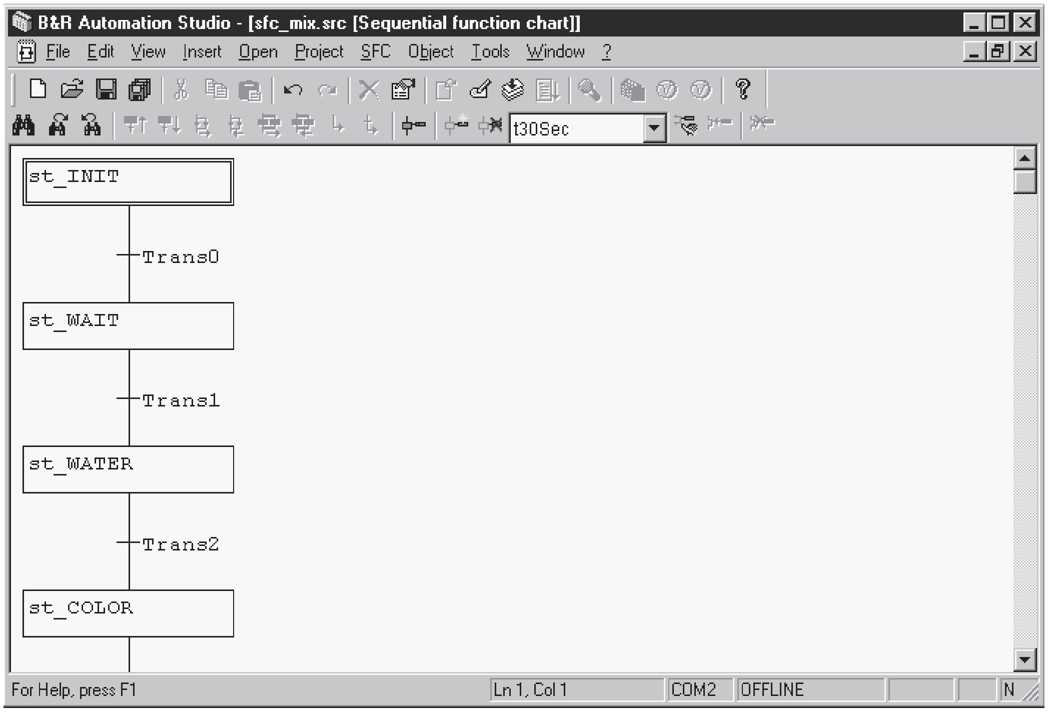

B&R Automation Studio - [sfc_mix.src [Sequential function chart]]
File Edit View Insert Open Project SFC Object Tools Window ?
t30Sec
st_INIT
Trans0
st_WAIT
Trans1
st_WATER
Trans2
st_COLOR
For Help, press F1
Ln 1, Col 1
COM2
OFFLINE
N

Fig. 7.2: Defining the steps in SFC

Then the transition conditions are defined.

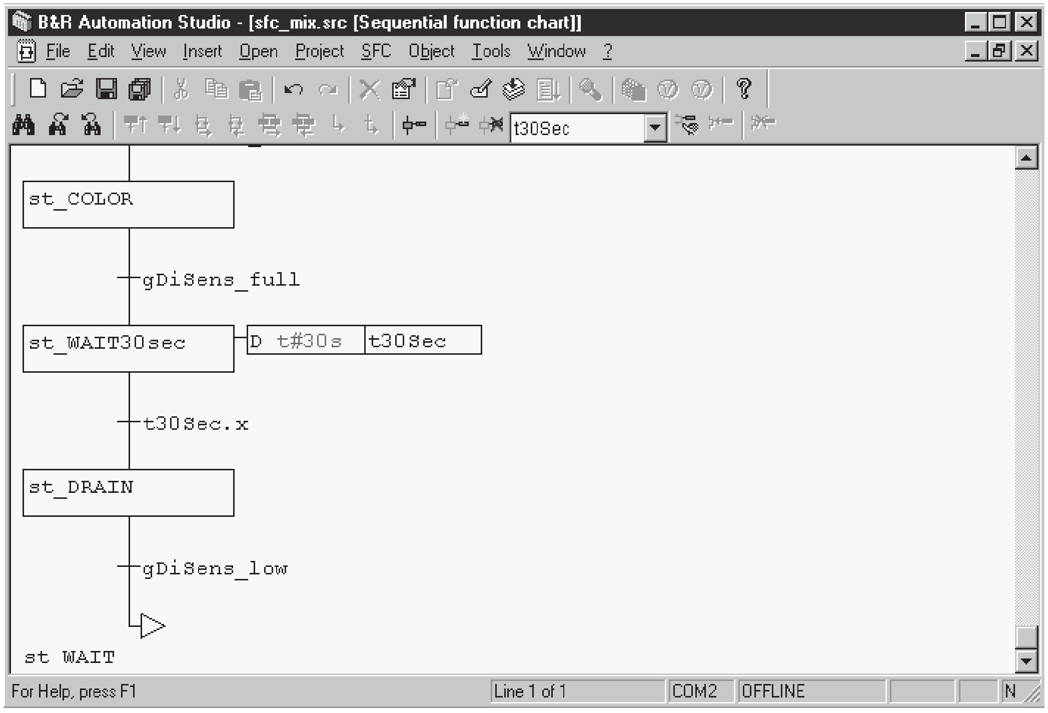
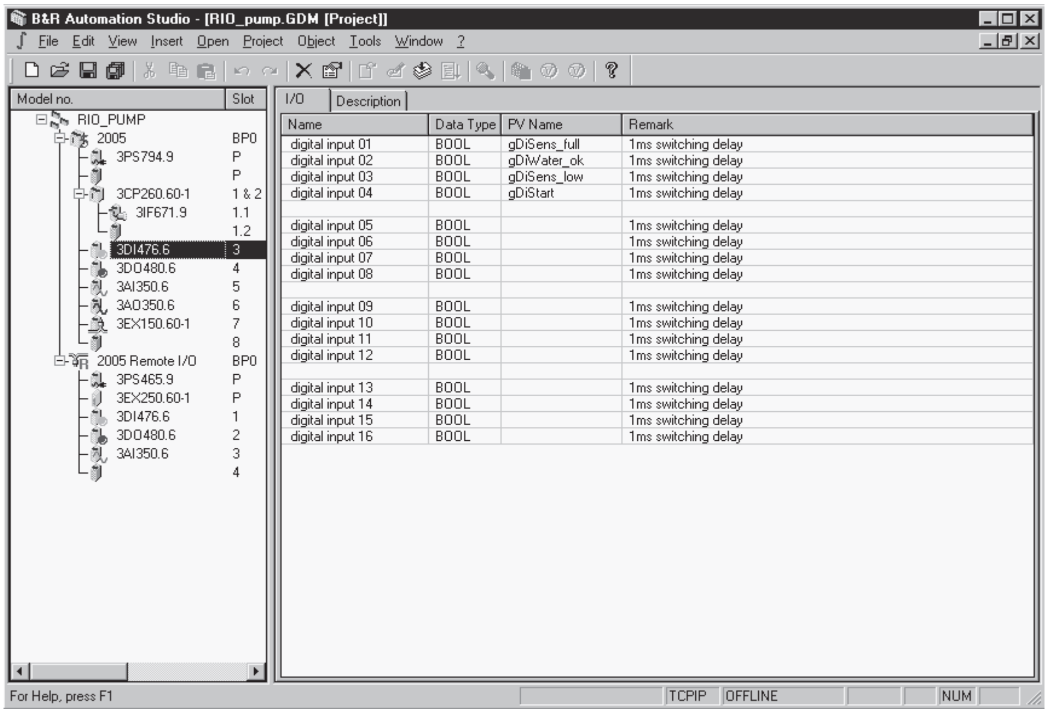


Fig. 7.3: Steps with transitions

Mixer in SFC (continued)

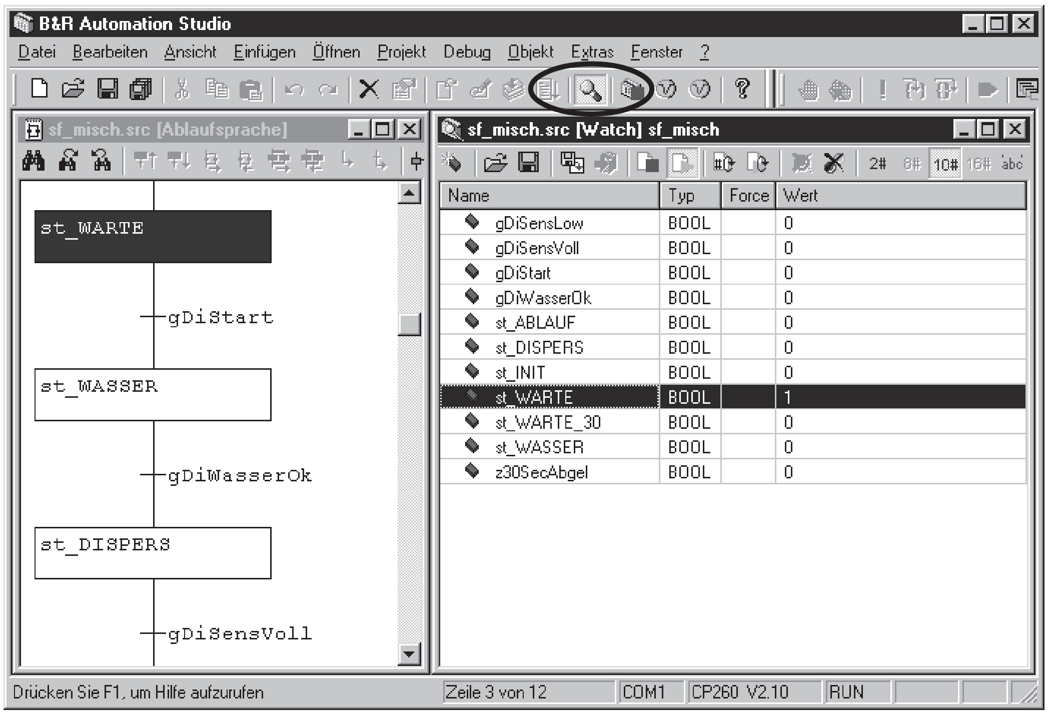
When the inputs have been defined, the SFC program can be tested in ist basic form.


B&R Automation Studio - [RIO_pump.GDM [Project]]
File Edit View Insert Open Project Object Tools Window ?
I/O
Description
For Help, press F1
TCPIP
OFFLINE
NUM

Model no.	Slot
RIO_PUMP	
2005	BP0
3PS794.9	P
	P
3CP260.60-1	1 & 2
3IF671.9	1.1
	1.2
3DI476.6	3
3DO480.6	4
3AI350.6	5
3AO350.6	6
3EX150.60-1	7
	8
2005 Remote I/O	BP0
3PS465.9	P
3EX250.60-1	P
3DI476.6	1
3DO480.6	2
3AI350.6	3
	4

Name	Data Type	PV Name	Remark
digital input 01	BOOL	gDiSens_full	1ms switching delay
digital input 02	BOOL	gDiWater_ok	1ms switching delay
digital input 03	BOOL	gDiSens_low	1ms switching delay
digital input 04	BOOL	gDiStart	1ms switching delay
digital input 05	BOOL		1ms switching delay
digital input 06	BOOL		1ms switching delay
digital input 07	BOOL		1ms switching delay
digital input 08	BOOL		1ms switching delay
digital input 09	BOOL		1ms switching delay
digital input 10	BOOL		1ms switching delay
digital input 11	BOOL		1ms switching delay
digital input 12	BOOL		1ms switching delay
digital input 13	BOOL		1ms switching delay
digital input 14	BOOL		1ms switching delay
digital input 15	BOOL		1ms switching delay
digital input 16	BOOL		1ms switching delay

Fig. 7.4: Defining the hardware assignments

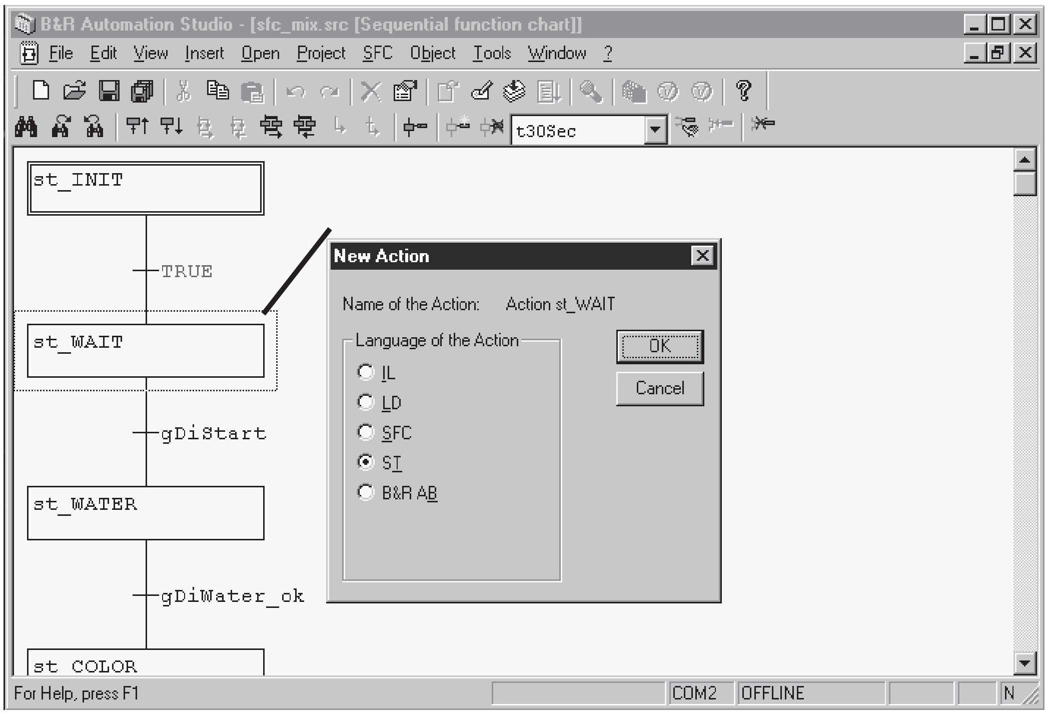

B&R Automation Studio
Datei Bearbeiten Ansicht Einfügen Öffnen Projekt Debug Objekt Extras Fenster ?
sf_misch.src [Ablaufsprache]
st_WARTE
gDiStart
st_WASSER
gDiWasserOk
st_DISPERS
gDiSensVoll
sf_misch.src [Watch] sf_misch
2# 8# 10# 16# abc
Drücken Sie F1, um Hilfe aufzurufen
Zeile 3 von 12
COM1
CP260 V2.10
RUN

Name	Typ	Force	Wert
gDiSensLow	BOOL		0
gDiSensVoll	BOOL		0
gDiStart	BOOL		0
gDiWasserOk	BOOL		0
st_ABLAUF	BOOL		0
st_DISPERS	BOOL		0
st_INIT	BOOL		0
st_WARTE	BOOL		1
st_WARTE_30	BOOL		0
st_WASSER	BOOL		0
z30SecAbgel	BOOL		0

Fig. 7.5: Testing the steps and the transition conditions

Mixer in SFC (continued)

Double-clicking on the step symbol opens a dialog box that can be used to define the source type for the block.

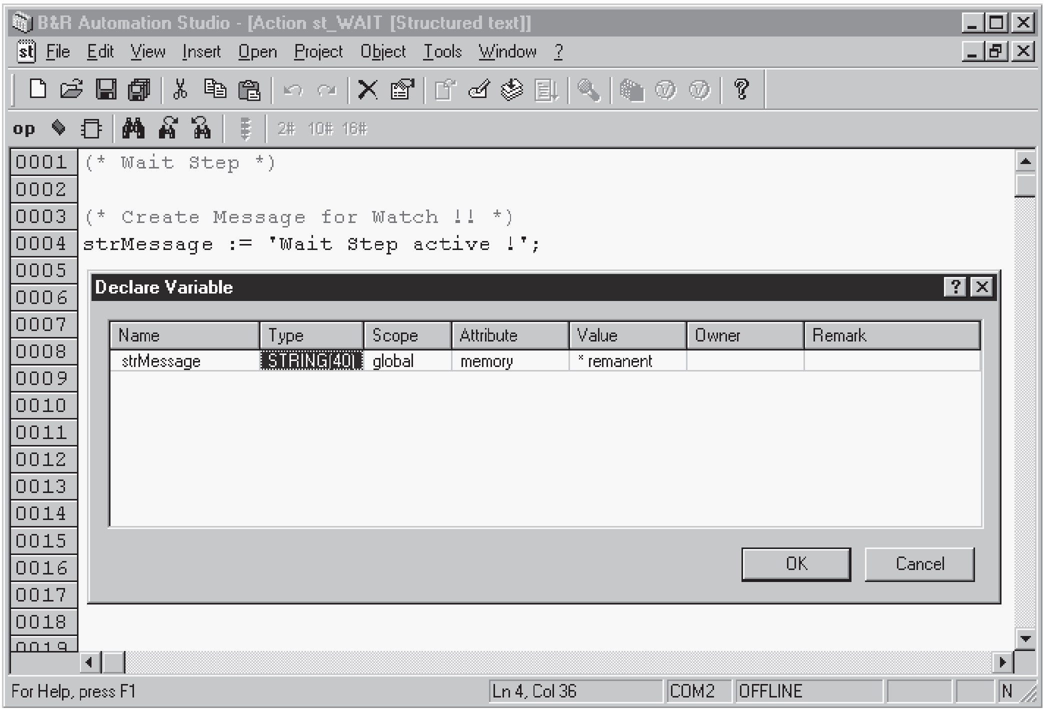

B&R Automation Studio - [sfc_mix.src [Sequential function chart]]
File Edit View Insert Open Project SFC Object Tools Window ?
t30Sec
st_INIT
TRUE
st_WAIT
gDiStart
st_WATER
gDiWater_ok
st_COLOR
New Action
OK
Cancel
For Help, press F1
COM2
OFFLINE
N

Name of the Action: Action st_WAIT

Language of the Action: ( ) IL ( ) LD ( ) SFC [✓ ST] ( ) B&R AB

Fig. 7.6: Defining the code type

The outputs are defined in the block according to the plan made previously.


B&R Automation Studio - [Action st_WAIT [Structured text]]
File Edit View Insert Open Project Object Tools Window ?
op
2# 10# 16#
Declare Variable
OK
Cancel
For Help, press F1
Ln 4, Col 36
COM2
OFFLINE
N

```
(* Wait Step *)

(* Create Message for Watch !! *)
strMessage := 'Wait Step active !';
```

Name	Type	Scope	Attribute	Value	Owner	Remark
strMessage	STRING[40]	global	memory	* remanent		

Fig. 7.7: Code for step st_WAIT

Mixer in SFC (continued)

Comments can be added to the individual steps. The local menu can be opened with the **right mouse button**.

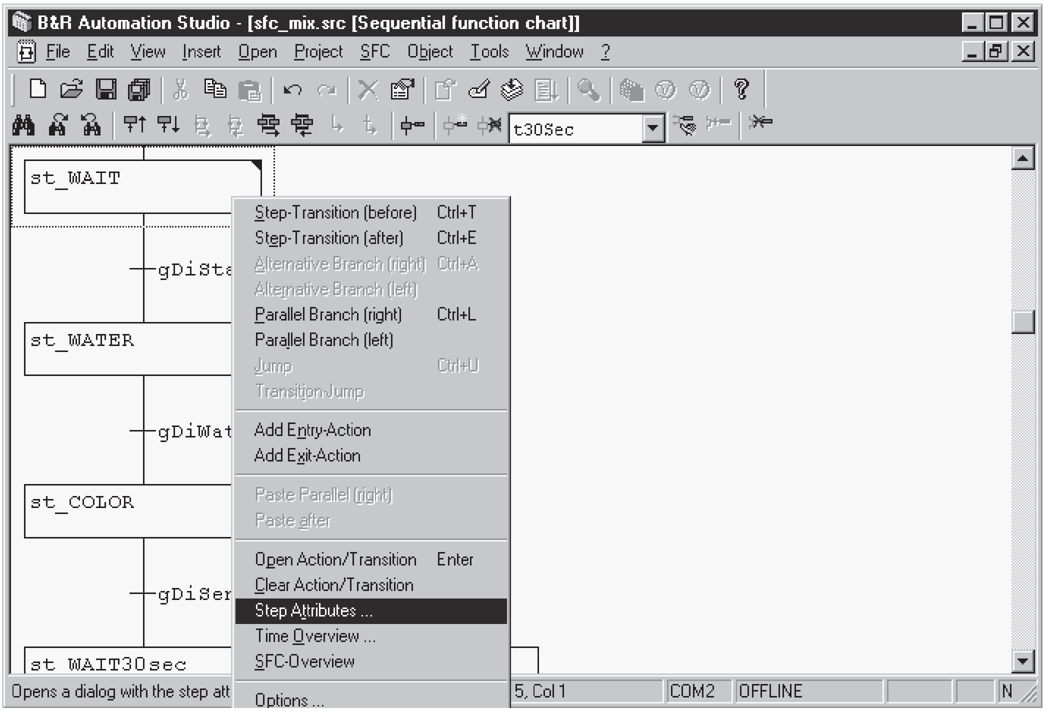
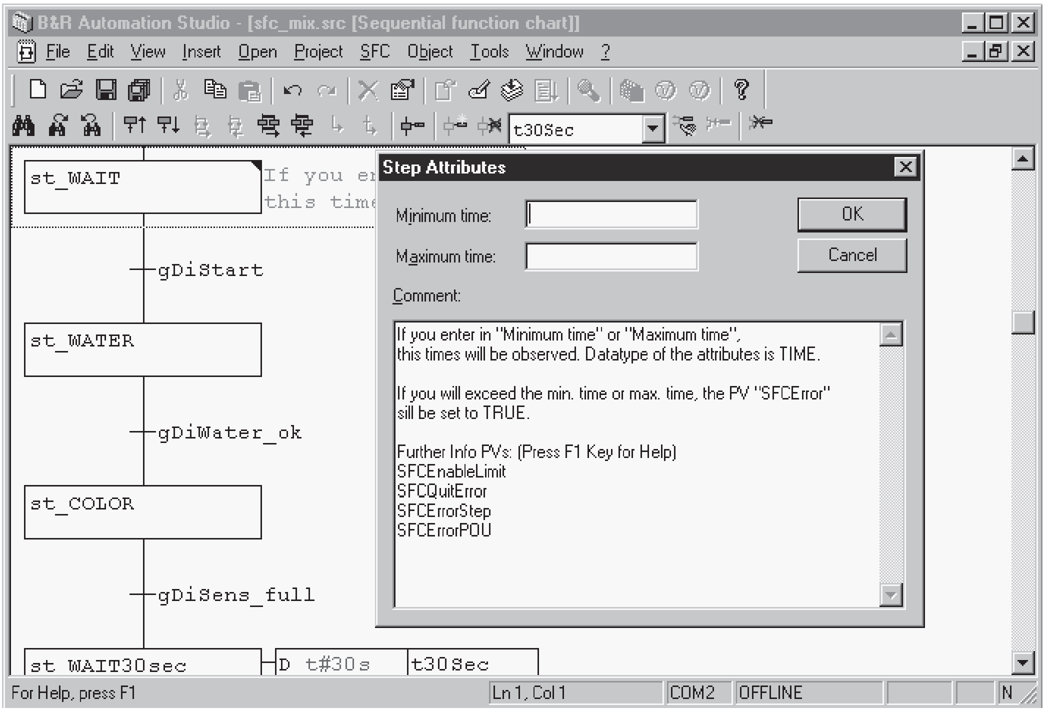

B&R Automation Studio - [sfc_mix.src [Sequential function chart]]
File Edit View Insert Open Project SFC Object Tools Window ?
t30Sec
st_WAIT
gDiSta
st_WATER
gDiWat
st_COLOR
gDiSer
st_WAIT30sec
Step-Transition (before) Ctrl+T
Step-Transition (after) Ctrl+E
Alternative Branch (right) Ctrl+A
Alternative Branch (left)
Parallel Branch (right) Ctrl+L
Parallel Branch (left)
Jump Ctrl+U
Transition-Jump
Add Entry-Action
Add Exit-Action
Paste Parallel (right)
Paste after
Open Action/Transition Enter
Clear Action/Transition
Step Attributes ...
Time Overview ...
SFC-Overview
Options ...
Opens a dialog with the step att
5, Col 1
COM2
OFFLINE
N

Fig. 7.8: Enter comments for step



If you enter in "Minimum time" or "Maximum time",
this times will be observed. Datatype of the attributes is TIME.

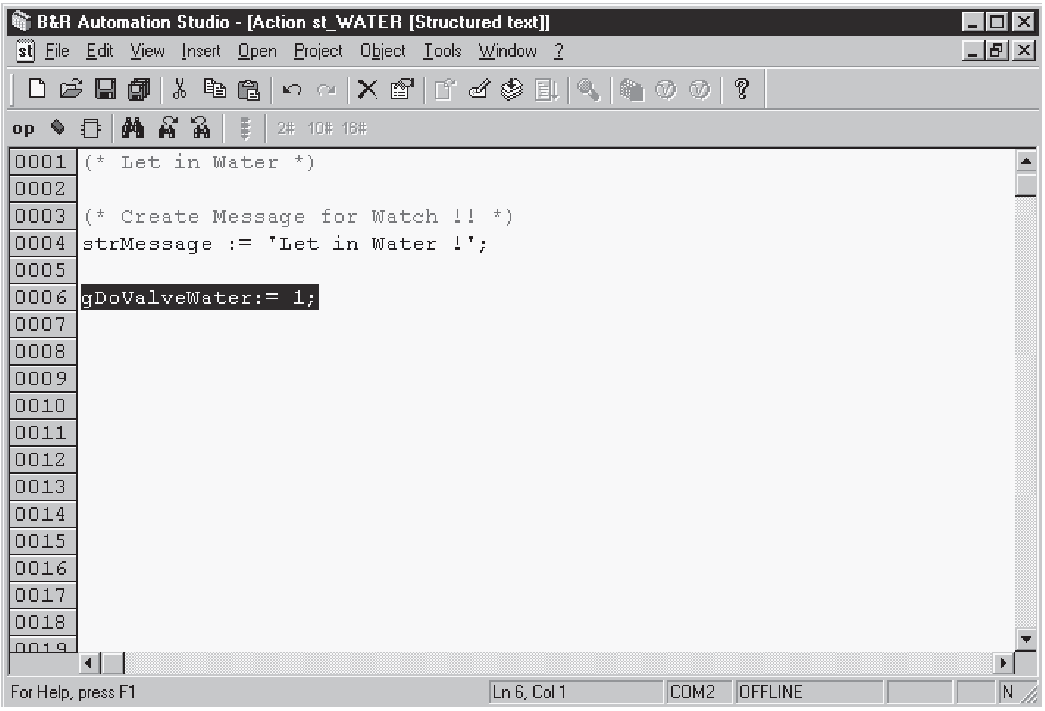
If you will exceed the min. time or max. time, the PV "SFCError"
sill be set to TRUE.

Further Info PVs: (Press F1 Key for Help)
SFCEnableLimit
SFCQuitError
SFCErrorStep
SFCErrorPOU

Fig. 7.9: "Step Attribute" dialog box

Mixer in SFC (continued)

Code for step “**st_WATER**”


B&R Automation Studio - [Action st_WATER [Structured text]]

```
(* Let in Water *)

(* Create Message for Watch !! *)
strMessage := 'Let in Water !';

gDoValveWater:= 1;
```

For Help, press F1 | Ln 6, Col 1 | COM2 | OFFLINE | N

Fig. 7.10: Defining the outputs in the step

If an output is set in a step, it can be reset when exiting the step if required by the application.

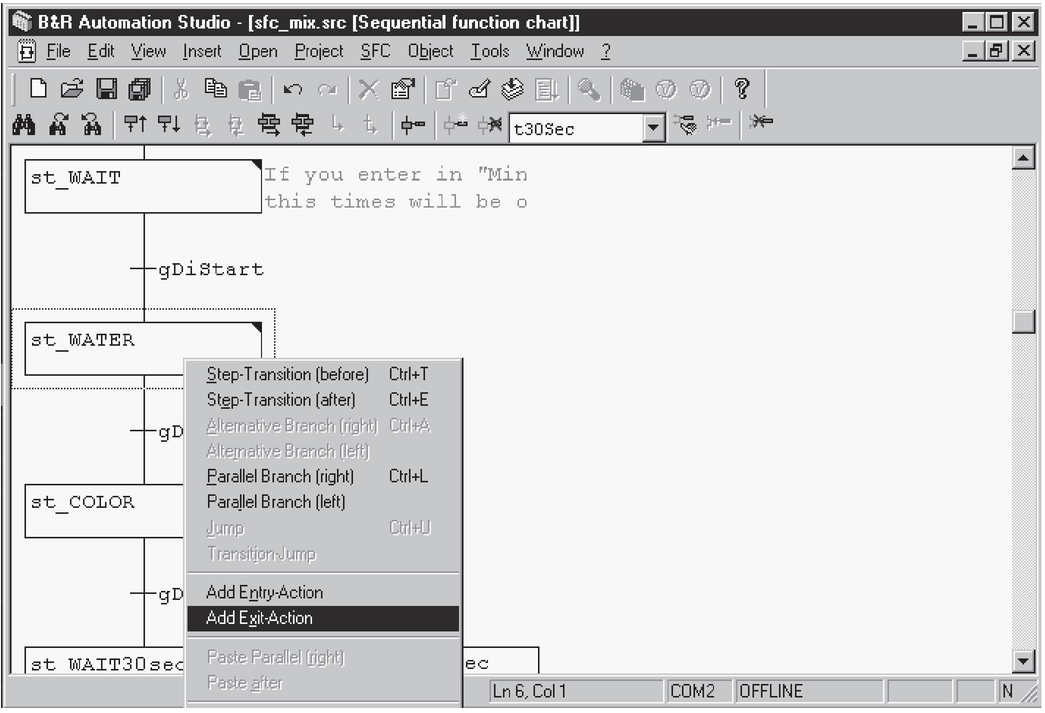
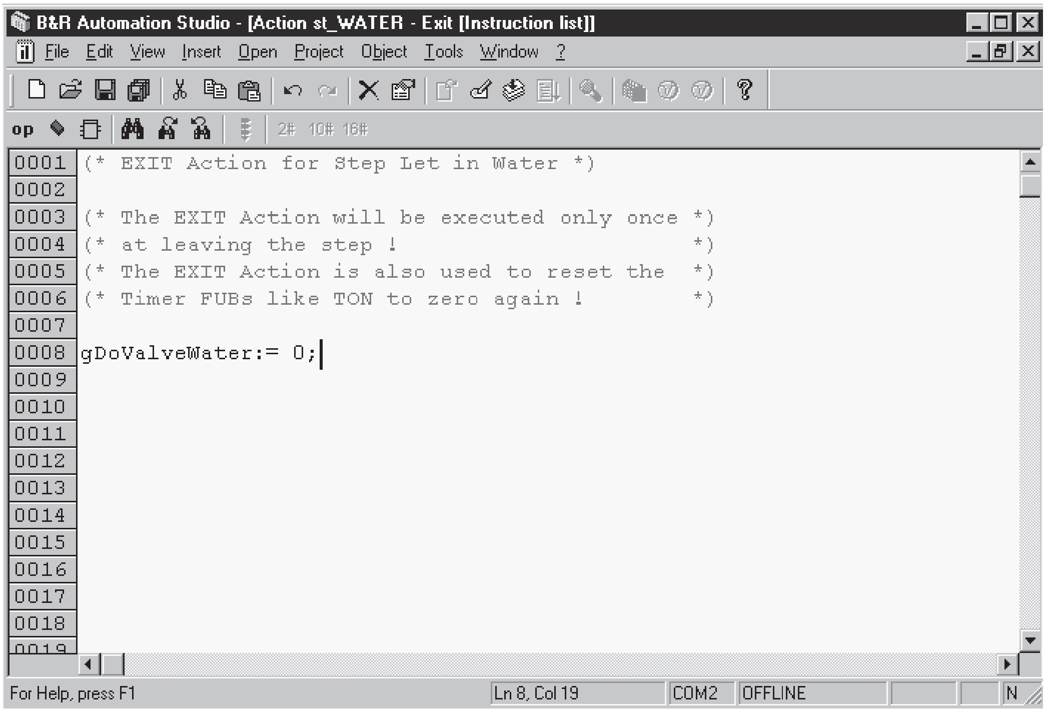

B&R Automation Studio - [sfc_mix.src [Sequential function chart]]

Fig. 7.11: Defining an “exit action”

Mixer in SFC (continued)

Source code for the exit action.

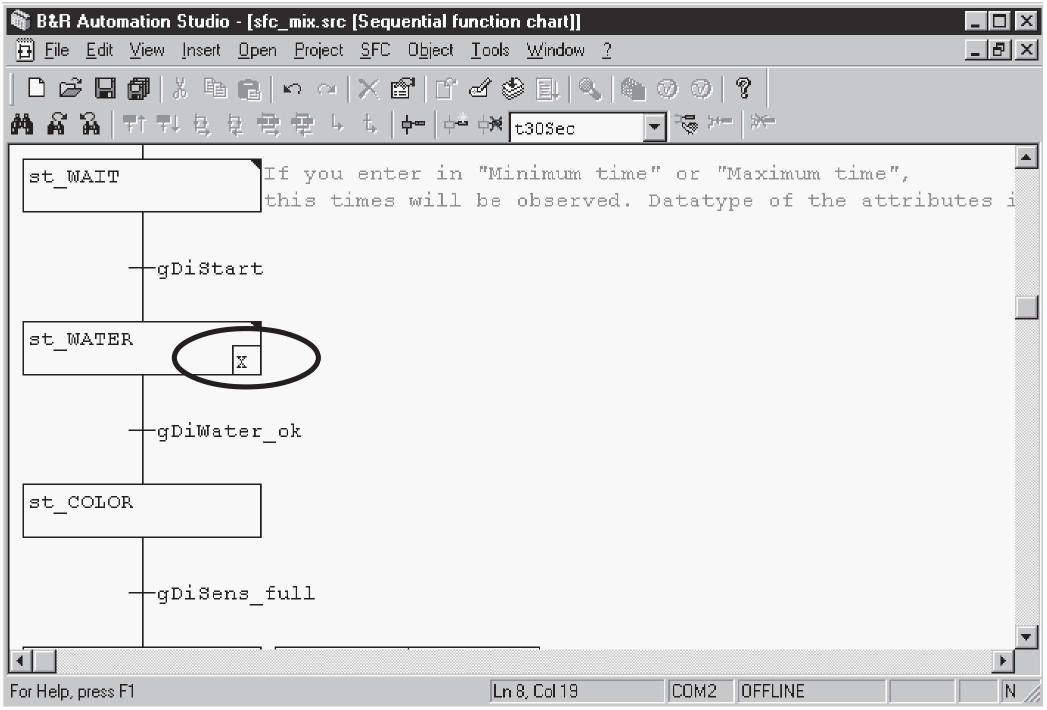

B&R Automation Studio - [Action st_WATER - Exit [Instruction list]]
File Edit View Insert Open Project Object Tools Window ?
For Help, press F1
Ln 8, Col 19
COM2
OFFLINE

```
(* EXIT Action for Step Let in Water *)

(* The EXIT Action will be executed only once *)
(* at leaving the step !                       *)
(* The EXIT Action is also used to reset the   *)
(* Timer FUBs like TON to zero again !         *)

gDoValveWater:= 0;
```

Fig. 7.12: Code for the exit action

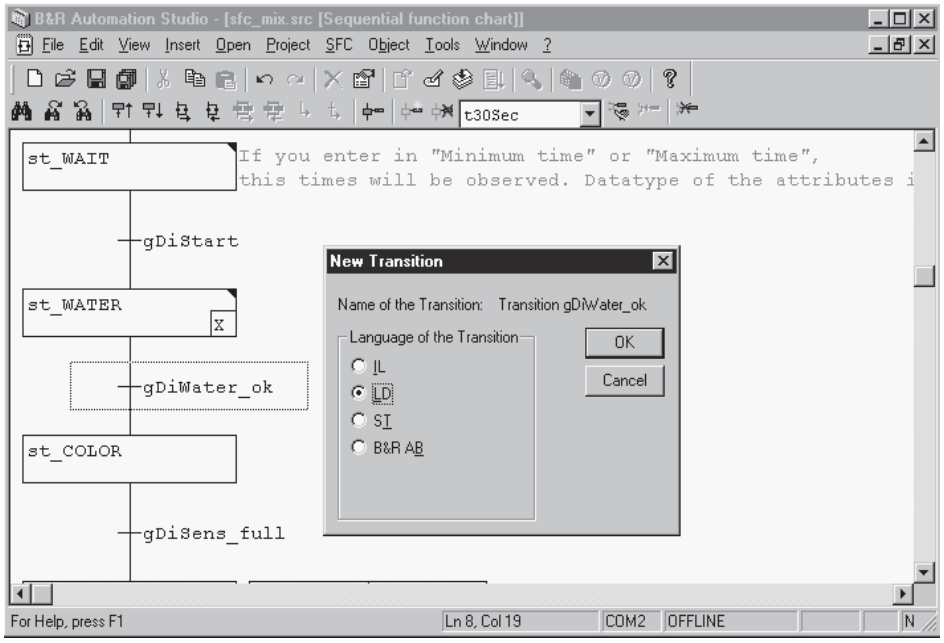

B&R Automation Studio - [sfc_mix.src [Sequential function chart]]
File Edit View Insert Open Project SFC Object Tools Window ?
t30Sec
st_WAIT
gDiStart
st_WATER
X
gDiWater_ok
st_COLOR
gDiSens_full
For Help, press F1
Ln 8, Col 19
COM2
OFFLINE

If you enter in "Minimum time" or "Maximum time",
this times will be observed. Datatype of the attributes i

Fig. 7.13: Indication of the exit action

Mixer in SFC (continued)

If we check the settings for the example again, we will see that the sensor inputs are wired as normally closed contacts. That means they must be inverted. For the transitions, it is possible to create this type of simple connection directly. The result of this type of connection must be TRUE or FALSE. Other connections are not allowed.


B&R Automation Studio - [sfc_mix.src [Sequential function chart]]
File Edit View Insert Open Project SFC Object Tools Window ?
t30Sec
st_WAIT
If you enter in "Minimum time" or "Maximum time", this times will be observed. Datatype of the attributes i
gDiStart
st_WATER
gDiWater_ok
st_COLOR
gDiSens_full
New Transition
Name of the Transition: Transition gDiWater_ok
Language of the Transition
IL
LD
ST
B&R AB
OK
Cancel
For Help, press F1
Ln 8, Col 19
COM2
OFFLINE
N

Name of the Transition: Transition gDiWater_ok

Language of the Transition: IL [✓ LD] ST B&R AB

Fig. 7.14: Defining a transition connection

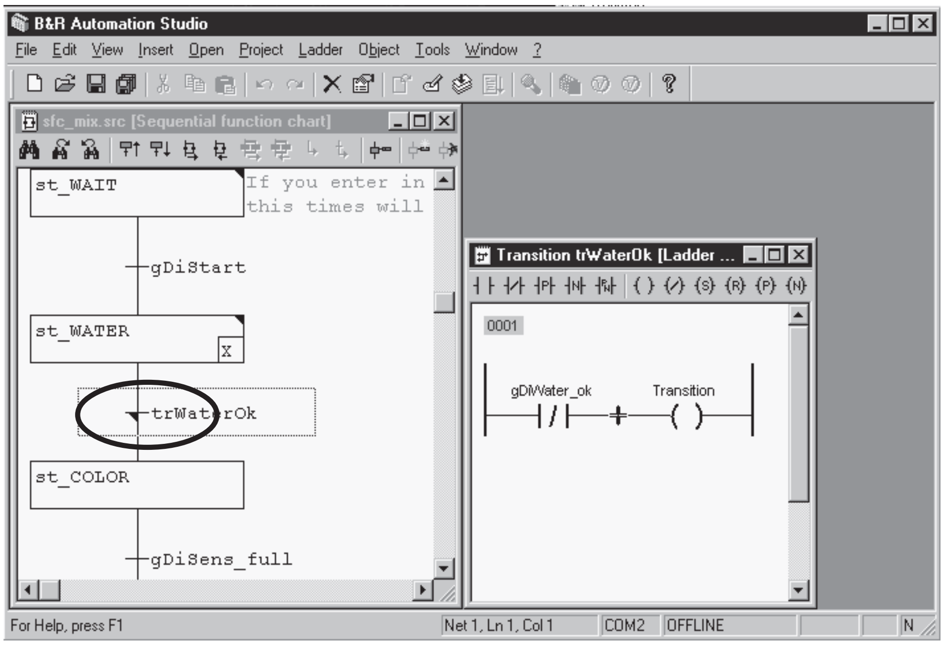

B&R Automation Studio
File Edit View Insert Open Project Ladder Object Tools Window ?
sfc_mix.src [Sequential function chart]
st_WAIT
If you enter in this times will
gDiStart
st_WATER
trWaterOk
st_COLOR
gDiSens_full
Transition trWaterOk [Ladder ...
0001
gDiWater_ok
Transition
For Help, press F1
Net 1, Ln 1, Col 1
COM2
OFFLINE
N

Fig. 7.15: Code and indicator for a transition link

AUTOMATION BASIC

1 OVERVIEW

B&R offers the right programming language for every application and for every programmers preference. This includes:

- Ladder Diagram (LAD)
- Instruction List (IL)
- Structured Text (ST)
- Sequential Function Chart (SFC)
- B&R Automation Basic (AB)
- ANSI C

LAD	Contact, logic and function operations are combined here in a single user interface. Ladder diagram is the simplest form of programming digital and analog processes because of its similarity to a circuit diagram.
IL	Instruction list is similar to a machine language. It can be used like LAD for logic operations.
ST	This high level language is a clear and powerful programming language for automation systems. Simple standard constructs guarantee fast and efficient programming.
SFC	A sequential language that was developed to separate a task into clear units. SFC is well suited for processes where states change in steps, for example: automatic carwash
AB	**This B&R high level language is a clear and powerful programming language for automation systems of the newest generation. Simple standard constructs guarantee fast and efficient programming. Previously PL2000**
ANSI C	This high level language is a powerful programming language for automation systems of the newest generation. Simple standard constructs guarantee fast and efficient application programming.

2 SYNTAX

2.1 Command Groups

- Logical Links
- Arithmetic Operations
- Logical Comparison Expressions
- Decisions
- Loops
- Select Statements
- Function Blocks

2.2 Operator Priorities

The use of several operators in a line brings up the question of priority.

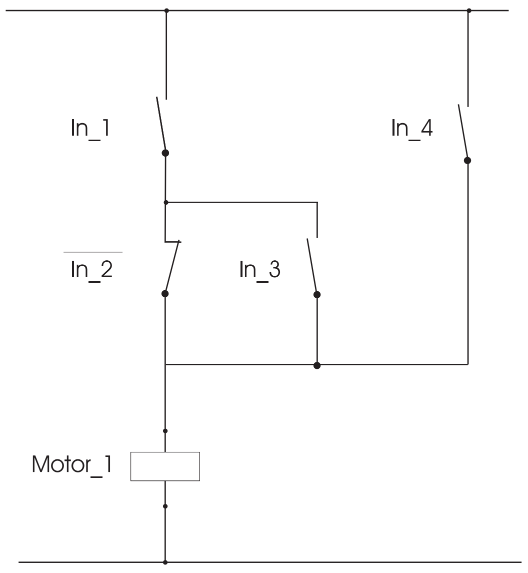
Operation	**Symbol**	**Priority**
Brackets	()	highest
Function Evaluation	Qualifier Argument List	
Exponential	EXP(IN1,IN2)	
Negation Complement	NOT	
Multiplication Division Modulo	* / MOD	
Addition Subtraction	+ -	
Comparison	<, >, <=, >=	
Equal Unequal	= <>	
Boolean AND	AND	
Boolean Exclusive OR	XOR	
Boolean OR	OR	lowest

Tab. 8.1: Operator priorities

2.3 Logical Links

Symbol	Logical Links	Example
NOT	Unary Negation	`a := NOT b;`
AND	Logical UND	`a := b AND c;`
OR	Logical OR	`a := b OR c;`
XOR	Exclusive OR	`a := b XOR c;`

Tab. 8.2: Logical links



```
Motor_1 := (In_1 AND (NOT In_2 OR In_3) ) OR In_4;
```

2.4 Arithmetic Operations

A decisive factor when deciding to use a high level language is the simplicity when handling arithmetic operations.

Automation Basic provides the basic arithmetic functions for your application such as:

Symbol	Arithmetic Operations	Example
:=	Assignment	`a := b;`
+	Addition	`a := b + c;`
-	Subtraction	`a := b - c;`
*****	Multiplication	`a := b * c;`
/	Division	`a := b / c;`
mod	Whole number division remainder	`a := b mod c;`

Tab. 8.3: Arithmetic operators

2.5 Data Type Conversion

2.5.1 Implicit Data Type Conversion

If different data types come together in operations, the compiler carries out an **implicit data type conversion**.

Data type	BOOL	SINT	INT	DINT	USINT	UINT	UDINT	REAL
BOOL		x	x	x	x	x	x	x
SINT	x		INT	DINT	USINT	UINT	UDINT	REAL
INT	x	INT		DINT	INT	UINT	UDINT	REAL
DINT	x	DINT	DINT		DINT	DINT	UDINT	REAL
USINT	x	USINT	INT	DINT		UINT	UDINT	REAL
UINT	x	UINT	UINT	DINT	UINT		UDINT	REAL
UDINT	x	UDINT	UDINT	UDINT	UDINT	UDINT		REAL
REAL	x	REAL	REAL	REAL	REAL	REAL	REAL	

Tab. 8.4: Implicit data type conversion

2.5.2 Explicit Data Type Conversion

Explicit data type conversion takes place using functions from the STANDARD library.

e.g.: **`DINT(`**`bool_var`**`)`**

2.6 Logical Comparison Expressions

High level languages such as Automation Basic allow branches to be easily create using comparison operations.

Symbol	Logical Link Expression	Example
=	Equal	`IF a = b THEN ...`
<>	Unequal	`IF a <> b THEN ...`
>	Greater than	`IF a > b THEN ...`
>=	Greater than or equal	`IF a >= b THEN ...`
<	Less than	`IF a < b THEN ...`
<=	Less than or equal	`IF a <= b THEN ...`

Tab. 8.5: Logical comparison expressions

2.7 Decisions

Decision	Example	Description
	`a := b * c;`	Calculations
IF		Introduction
THEN	**`IF`** `a > 0` **`THEN`**	**1st Condition**
	`    result := 1;`	Condition met
ELSE IF	**`ELSE IF`** `a = 0` **`THEN`**	**2nd Condition**
	`    value := 100;`	
ELSE	**`ELSE`**	**Otherwise ...**
	`    result := 0;`	No condition met
ENDIF	**`ENDIF`**	End of decision

Tab. 8.6: IF statements / decisions

- First condition true:
  Execute the THEN branch
- Second condition true:
  Execute the ELSE IF THEN branch
- Conditions are false:
  Execute the ELSE branch

The **ELSE IF BRANCH** and the **ELSE branch** of an IF statement are **optional**.

2.8 Case Statements

CASE statements all fast access of various actions depending on the value of a variable. We will clarify the use of CASE statements using a display switch with a selection dial that has several positions:

Case Statement	Example	Description
CASE OF	**CASE** Position **OF**	Introduction

ACTION 1:	**ACTION** 1:
	Display := OVERVIEW;
	ENDACTION
		Only for one position

ACTION 2,5:	**ACTION** 2:
	ACTION 5:
	Display := NOT_SUPPORTED;
	ENDACTION
		Valid for position 2 **or** 5

ACTION 6..10:	**ACTION** 6..10:
	Display := SET_VALUE;
	ENDACTION
		Valid for positions 6 **to** 10

ACTION 11..20:	**ACTION** 11..20:
	Display := ACT_VALUE;
	ENDACTION
		Valid for positions 11 **to** 20

ELSEACTION	**ELSEACTION:**
	Display := ERROR;
	ENDACTION
		All other positions

ENDCASE	ENDCASE	End of the CASE statement

Tab. 8.7: Case statements

The **expression,** between **CASE** and **OF** must be a **UINT** data type and can have a value between 0 and 65535 !

Only **whole number values** can be used as steps.

A **colon** must be placed after the step number.

Several numbers can follow the same statement block:

- Fields with **progressive numbers** e.g.: 6..10**:**
  can only have 2 points between the numbers !
- **Lines in a list** of number lines must be directly below the previous line
  e.g.:
  ```
  ACTION 2:
  ACTION 5:
  ```

The **ELSEACTION** STATEMENT BLOCK PROCESSES ALL NUMBERS THAT ARE NOT LISTED. ONLY **ONE STEP PER CYCLE** is executed.

Example

The CASE statement is often used when making selections. In this example, we want to use the CASE statement for simple elevator control.

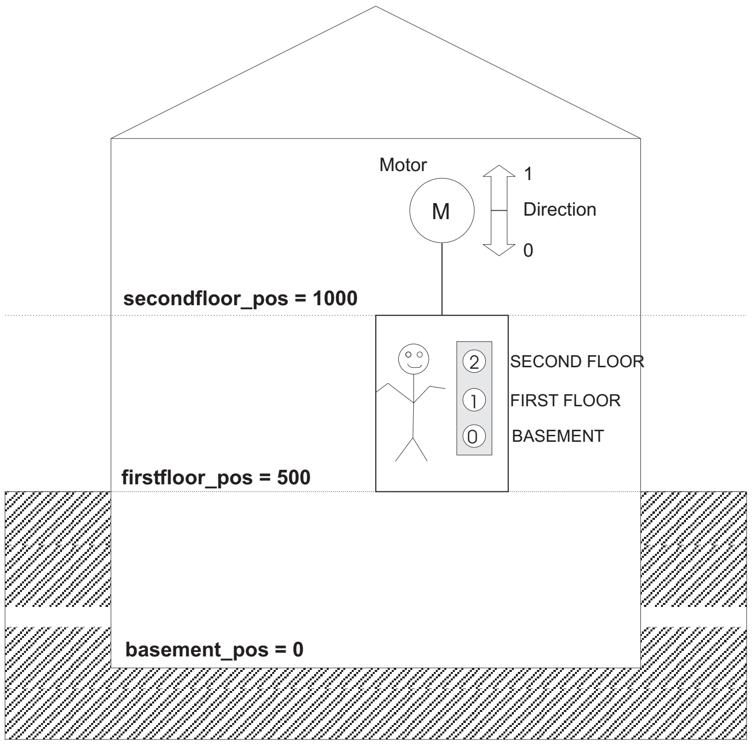
The elevator control should be created for a building with 3 floors.
The following steps must be used:

- Definition of the constants for the ACTIONS

BASEMENT	UINT	0
FIRST FLOOR	UINT	1
SECOND FLOOR	UINT	2

- Initialization of the floor positions

basement_pos	=	0
firstfloor_pos	=	500
secondfloor_pos	=	1000



- Programming the cyclic program

  The current set position is set to the selected floor in the individual steps.

  e.g. set_pos = basement_pos

Monitoring and control of the positions is handled outside of the step. If the current position is smaller than the set position, it must be increased until it is equal to the set position. The direction of the movement and the motor must be considered.

```
if ( act_pos > set_pos ) then
   motor = 1                     ; Switch motor on
   direction = 0                 ; Downwards directions
   act_pos = act_pos - 1
else if ( act_pos < set_pos ) then

; the program should be completed here
```

If the set position is the same as the actual position, then the motor should be switched off.

Project Name:	proj_ab
Task Name:	elevator

Resource: ?

2.9 Loops

Loops working together with a condition, allow one or more statements to be executed repeatedly. In Automation Basic, all types of loops are created with a single construct.

Key Words	Program	Description

LOOP
TO/DOWNTO
DO
 	
ENDLOOP
	`LOOP i := 0 TO 4 DO`
	
	`    res := value + i;`
	
	`ENDLOOP`
		Introduction
		
		Statement block
		
		Loop End

Tab. 8.8: Loop variant 1

The statement block is only executed when conditions are not met.

Key Words	Program	Description

LOOP
 	
EXITIF
 	
ENDLOOP
	`LOOP`
	
	`    EXITIF res > 2000;`
	`    res := value + i;`
	
	`ENDLOOP`
		Introduction
		
		Exit Condition
		Statement block
		
		Loop End

Tab. 8.9: Loop variant 2

The statement block is executed at least once.

Key Words	Program	Description

LOOP
 	
EXITIF
 	
ENDLOOP
	`LOOP`
	
	`    res := value + i;`
	`    EXITIF res > 2000;`
	
	`ENDLOOP`
		Introduction
		
		Statement block
		Exit Condition
		
		Loop End

Tab. 8.10: Loop variant 3

IMPORTANT

Make sure that endless loops are not created because they will cause a cycle time violation.

Example

In a house, the temperature is measured at 10 different locations. To improve monitoring of the heating costs, the average value should always be calculated.

The solution should be created using a loop !!!

If a temperature is outside the limits,

TEMP_MAX	=	80 ° C
TEMP_MIN	=	10 ° C

then an error bit should be set.

Project Name:	proj_ab
Task Name:	temp_1
Resource:	C#1

2.10 Select Statements

Select statements allow sequential control to be easily programmed and later monitored.

We will clarify sequential control programming using the following electrically operated punch machine.

Select Statement	Example	Description
SELECT	**SELECT** sStep	Introduction (optional with step number variable)
	Variable := 1	Global statement
	WHEN StopKey = 1	Global condition
	cmdMotor := 0	
	NEXT DELAY	
STATE	**state** DELAY	State block qualifier
	cmdMotor := 0	
WHEN	**WHEN** UpKey = 1	Continue condition
NEXT	**NEXT** UPWARDS	Next step
	WHEN DownKey = 1	
	NEXT DOWNWARDS	
	state UPWARDS	
	WHEN EndTop = 1	
	NEXT DELAY	
	cmdMotor := 1	
	CmdDirection := 1	
	state UPWARDS	
	WHEN EndBottom = 1	
	NEXT DELAY	
	CmdMotor := 1	
	CmdDirection := 0	
ENDSELECT	**ENDSELECT**	End of loop

Tab. 8.11: Select statement

2.10.1 Syntax Descriptions

- A select statement can consist of any number of states !
- **One state** is executed **per task cycle** !
- The first state in the select construct has number 0.
- For each **next** statement, there must be a **corresponding state** !
- If an exit condition is met, the folowing commands are no longer executed!
- Number code of the state (Data type: UINT, Scope: local)
  The **step number** which is always visible and the best possible **monitoring** which results from it. Writing to this PV can also influence the process.
- **Global statements** and transfer conditions
  They are executed in each cycle and can therefore be used for error monitoring and to quickly react to special events and high priority queries.
- The **structure** of the Select construct **must** be used, i.e. a state cannot be exited using an IF statement !

Example

```
WHEN LowEnd = 1

   motor = 0

NEXT DELAY
```

- **Nesting** Select statements is possible!
- **Outputs** should only be written to **once** !

Example

Create a program in AB for the following chemical system. The solution should be created using a Select statement.

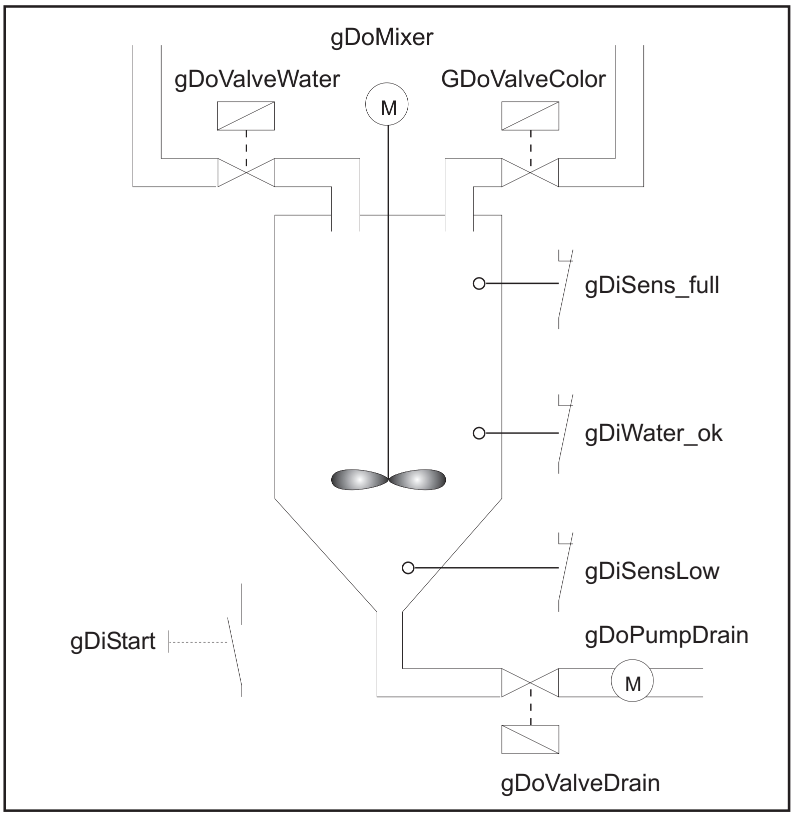
Description of the process:

Press start...
Open water valve

Water OK reached...
Close water valve,
Switch on stirring mech.,
Open color valve

Sensor Full reached...
Close color valve,
Wait 30 sec.
Open drain valve
Switch on drain pump

Sensor Low reached...
Switch off pump
Switch off stirring mech.
Close drain valve



Example: Chemical system section

- Program the individual steps in AB
- Test the program
- How should E_STOP handling look ?

Project Name:	proj_ab
Task Name:	mix_lq

Resource: ?

2.11 Working with Function Blocks

2.11.1 FBK Call

The function blocks are called like commands. They are accessed using their name. In brackets, then input and output variables follow in order beginning with the first input.

Example of a 2 second turn-on delay:

```
(* Function block call *)

Preset := T#2s;

TON(Input, Preset, Off, Elapse)

or:

TON(Input, T#2s, Off, Elapse)
```

IMPORTANT

All input and output parameters must be entered !

2.11.2 Alias FBK Call

The main difference between an alias call and the procedure used previously is that values are assigned using a freely selectable structure name / alias name and structure elements with the same name as the FBK parameters.

Example: Alias call for TON function block (Library: Standard)

```
time = T#2m_30s_500ms           ;  Value assignment

TON_xx.IN := Input              ;  Alias input parameter
TON_xx.PT := time               ;  Order is not critical

                                ;  Any program section

TON_xx FUB TON()                ;  Alias FBK call

                                ;  Any program section

Elapse  := TON_xx.ET            ; Alias output parameter
Output  := TON_xx.Q             ; Alias output parameter
```

Example

Use a 16-bit up/down counter

The count procedure should be carried out by the CTUD function block (Library: Standard).

The CTUD FBK requires the following parameters:

Input/Output	**Parameter**	**Type**	**Description**
⇨	CU	BOOL	Up counter input
⇨	CD	BOOL	Down counter input
⇨	RESET	BOOL	Reset counter to 0
⇨	LOAD	BOOL	Load counter with preset value
⇨	PV	UINT	Preset value and compare value
⇦	QU	BOOL	TRUE, if CV >= PV
⇦	QD	BOOL	TRUE, if CV <= 0
⇦	CV	UINT	Current count

Tab. 8.12: Parameter list for CTUD FBK

The function block is to be called using a normal and an alias call.

Project Name:	proj_ab
Program Name:	ab_fbk
Resource:	?

DATA HANDLING

1. OVERVIEW

Process Variables

For optimal control and separation of information, the user is provided various "Basic Containers" to store data. They can be combined as desired. Simple and flexible access possibilities are available.

Data Modules

Information should often be clearly structured as tables, lists, recipes. Compact and simple access possibilities are provided.
Data modules have overwrite protection.

Memory

Different conditions make it necessary for programmers to store data using suitable memory media with respective physical properties.

2. PROCESS VARIABLES

2.1 General Information

Basic Data Types
BOOL, USINT, UINT, UDINT, SINT, INT, DINT and REAL with an array length of one in the variable declaration.

User Data Types
Organization of data in clear units, arrays, structures, arrays of structures.

Function Block Data Types
Grouping input/output data and internal FBK information using alias PVs.

Dynamic Process Variables
A powerful tool used for simple solutions to complex applications.

2.2 Data

We will begin with the question: “What do we want to save ?”

- Program code
- Recipes
- Tables
- Machine options
- **Process variables**
- IO information
- Internal variables
- Parameters
- Status values
- ...
- ...

This is information with very different uses for the contents.

In order to describe this information using a common term, we will refer to it as data to be processed.

This data is stored in memory.

Memory is the sum of all **containers** where information can be placed.

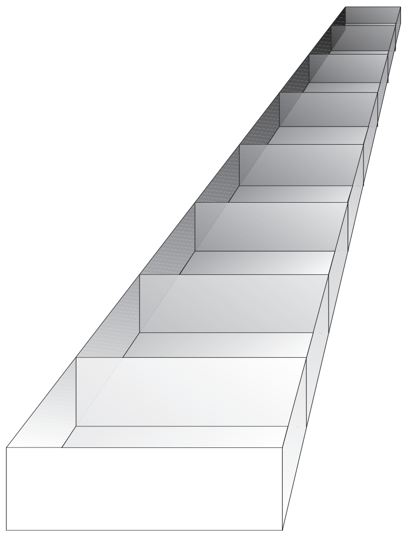


Fig. 9.1: Memory = containers

2.3 Basic Data Types

2.3.1 What is a basic data type ?

Our data can be placed in memory. This consists of a certain number of consecutive units.

Such a unit consists of 8 bits and is referred to as a byte or USINT according to IEC61131.

Each of these USINTs = memory locations, has a unique number similar to the address of a house. Using this address, the **memory address**, AutomationRuntime or our application can access the content of this memory address (read or write).

In our programs, we do not use direct addresses. Instead we use a symbolic names as synonyms for the addresses (PV names).

A memory location interpreted as USINT has a value range from 0...255,
or interpreted as SINT from -128..0..+127.

If the information we want to save in memory has a larger values, we have to separate it over several memory locations and interpret it accordingly.

To do this, the compiler provides **different container sizes**, the **basic data types** defined in the IEC61131 standard.

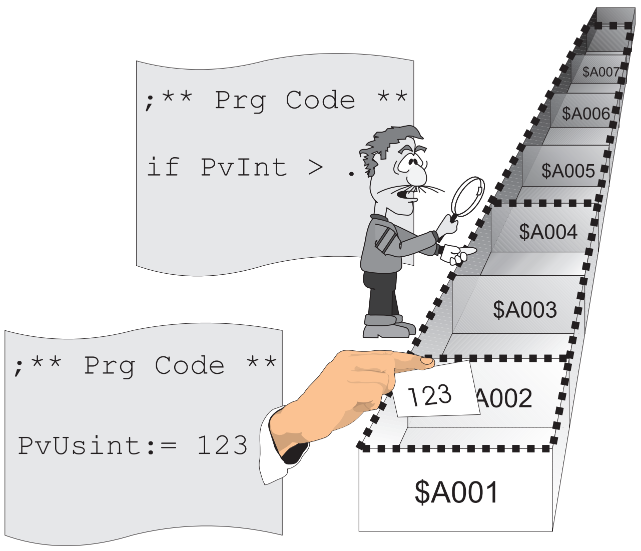
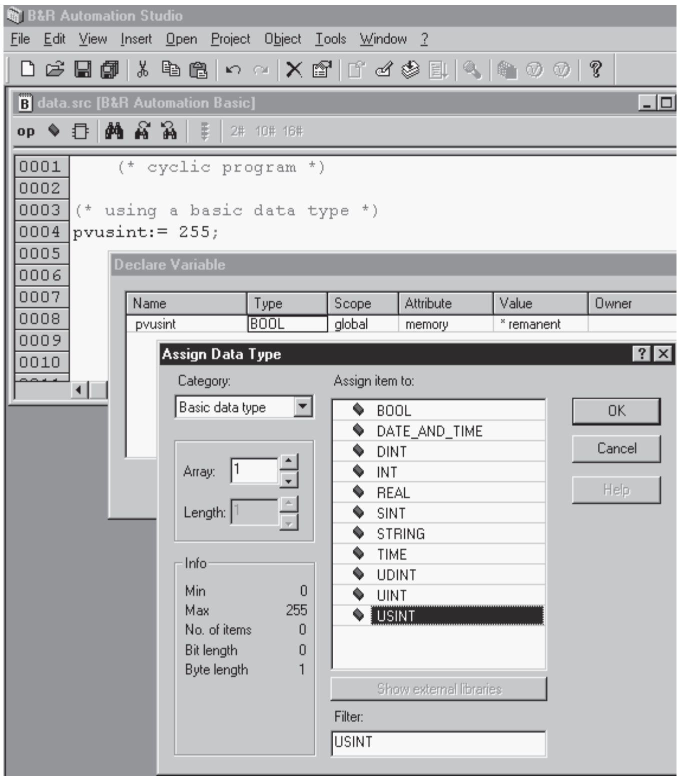


Fig. 9.2: Basic data types

2.3.2 How do I use basic data types ?

In the declaration, the AutomationStudio is informed of how much memory is should reserve in AutomationRuntime for a static PV.

When using a PV which is not yet recognized in AS, the programmer is requested to select a suitable data type in the declaration using
Project: Create or **Project: Create all**.



```
(* cyclic program *)

(* using a basic data type *)
pvusint:= 255;
```

Name	Type	Scope	Attribute	Value	Owner
pvusint	BOOL	global	memory	* remanent	

Assign Data Type

Category: Basic data type

Array: 1

Length: 1

Info

Min	0
Max	255
No. of items	0
Bit length	0
Byte length	1

Assign item to: BOOL, DATE_AND_TIME, DINT, INT, REAL, SINT, STRING, TIME, UDINT, UINT, USINT

Filter: USINT

B&R Automation Studio
File Edit View Insert Open Project Object Tools Window ?
data.src [B&R Automation Basic]
Declare Variable
OK
Cancel
Help
Show external libraries

Fig. 9.3: Selecting a basic data type

Note

Relationship between type and bit size:

SINT	..	8 BIT	“S” stands for short
INT	..	16 BIT	No special format
DINT	..	32 BIT	“D” stands for double

2.4 User Data Types

Arrays

An array is the grouping of PVs with the same data type that belong together. This grouping has two major advantages:

- One variable name, access various contents using index
- The PVs are all alligned consecutively and can therefore be easily accessed using a pointer

A string is a special form of array.
A string is a zero terminated USINT array.

Structures

A structure is the grouping of PVs with different data types that belong together. This grouping has some major advantages:

- Help with the organization of complex data sets
- The PVs are all alligned consecutively and can therefore be easily accessed using a pointer

Arrays of Structures

A combination of arrays and structures. If a structure is needed often e.g.: positioning several axes, an arrays is placed over it and the structure is applied several times consecutively.

2.4.1 What is an array ?

If you need to manage several units of information with the same size (same data type) that belong together, an array is the simplest solution.

If e.g.: several temperatures are to be saved as INT, an array with a PV name and a corresponding number of elecments can be used as user data type instead of individual variables.

The selection of the desired elements takes place using an index between square brackets. This index provides programming advantages when handling this array variable e.g.: access using loop commands !

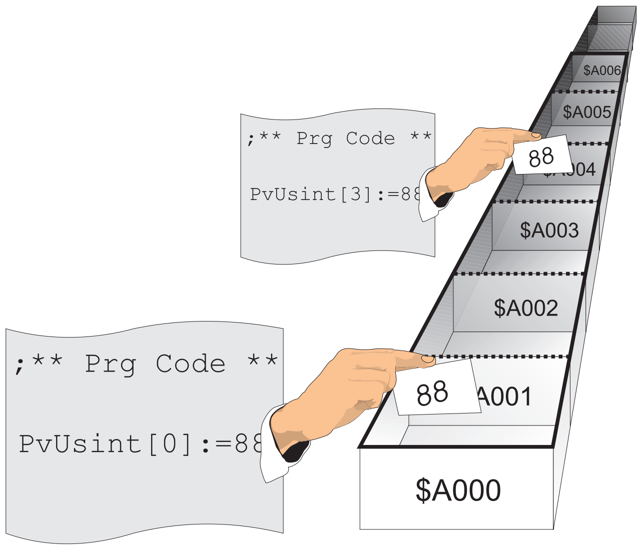
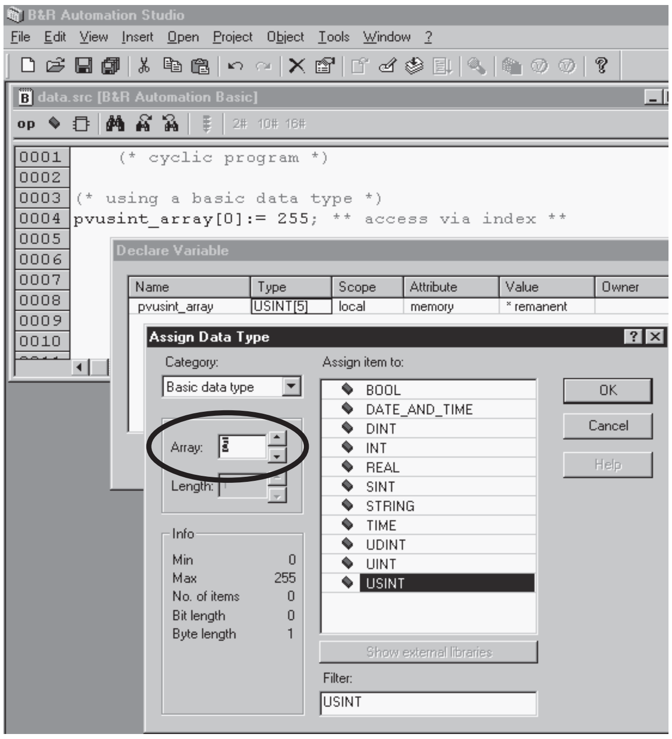


Fig. 9.4: User Data Type Array

2.4.2 How do I create an array ?

In the declaration, the programmer defines the data type of the PV and also the array length which corresponds to the number of elements desired.



```
    (* cyclic program *)

(* using a basic data type *)
pvusint_array[0]:= 255; ** access via index **
```

Name	Type	Scope	Attribute	Value	Owner
pvusint_array	USINT[5]	local	memory	* remanent	

Category: Basic data type

Array: 5

Length:

Info

Min	0
Max	255
No. of items	0
Bit length	0
Byte length	1

Assign item to: BOOL, DATE_AND_TIME, DINT, INT, REAL, SINT, STRING, TIME, UDINT, UINT, USINT

Filter: USINT

Fig. 9.5: Defining the array length

2.4.3 Tips for Arrays

- The largest index possible is always the array length - 1 !
- Begin with array index 0.

Note

The defined array range can be exceeded by entering an index that is too large.

In the following example, the reserved memory for the array PV “pvusint_array“ exceeded and a PV which may follow is overwritten !

```
pvusint_array[5] := 123;
```

Such errors (which are difficult to find) should be avoided by careful programming!!

From Library	**Function Name**	**Short Description**
AsString	memcpy()	Copying an array, length is to be entered explicitly
----------	sizeof()	Determine array length

Tab. 9.1: Corresponding functions

2.4.4 Strings are also Arrays

- A string is a special type of array.
- A USINT is required for each character.
- Strings are to be declared in the variable declaration as USINT arrays.
- The end of a string is coded using a 0 in the last element (zero termination).
- Therefore an additional array element must be reserved for zero termination.

From Library	**Function Name**	**Short Description**
AsString	strcpy()	Copy a string up to zero termination
AsString	strcat()	Combine two strings
AsString	strlen()	Determine string length
AsString	itoa()	Convert an integer value to a string
SYS_LIB	DIS_str()	Output a string on the 2010 status display
SYS_LIB	DIS_chr()	Output a character on the 2010 status display
SYS_LIB	DIS_clr()	Clear the status display on the 2010
STANDARD	str3= concat(str1,str2)	Combine 2 strings after str3
STANDARD	str2=delete(str1,L,P)	Delete L character from str1 beginning at P
STANDARD	P=find(st1,str2)	Find position P of string str2 in string str1
STANDARD	str3=insert(str1,str2,P)	Insert str2 after str1 at position P, save in str3
STANDARD	str2=left(str1,L)	L on left of str1 character to str2
STANDARD	str2=right(str1,R)	R on right of str1 character to str2
STANDARD	str2=mid(str1,L,P)	L character from position P from str1 to str2
STANDARD	L=len(str1)	Determine string length L of str1
STANDARD	str3=replace(str1,str2,L,P)	Replace L characters starting at position P from str1 to str2

Tab. 9.2: Corresponding functions

2.4.5 What is a structure ?

Units of information with the same size or even with different sizes often belong together e.g.: the date elements Day, Month and Year belong together.

The structure user data type can be used to clearly show that these elements belong together in the program code.

A structure consists of basic data type elements which belong to a higher level PV, the PV with data type structure. These elements are separated from the higher level PV by a ".".

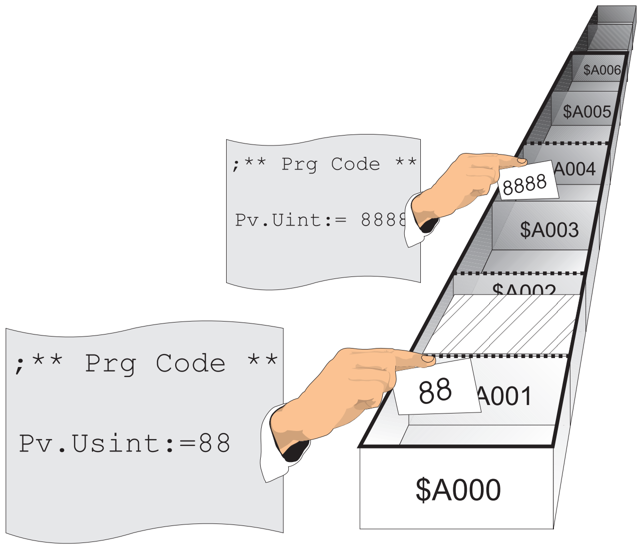
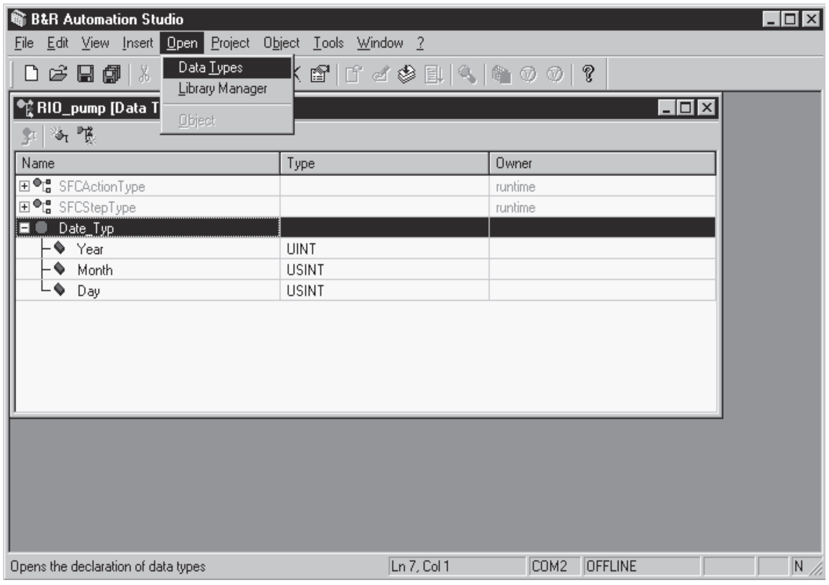


Fig. 9.6: User Data Type Structure

2.4.6 How do I create a structure ?

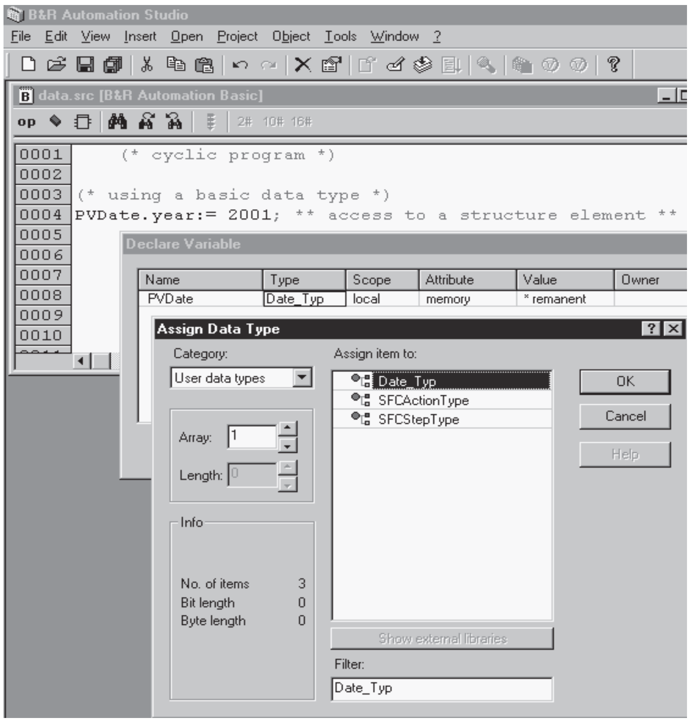
Structure data types are clearly handled in a separate editor.
Using menu item **Open: Data Types**, a new structure can be created using the toolbar and its elements can be entered or changed.


B&R Automation Studio
File Edit View Insert Open Project Object Tools Window ?
Data Types
Library Manager
Object
RIO_pump [Data T
Opens the declaration of data types
Ln 7, Col 1
COM2
OFFLINE
N

Name	Type	Owner
SFCActionType		runtime
SFCStepType		runtime
Date_Typ		
Year	UINT	
Month	USINT	
Day	USINT	

Fig. 9.7: Handling structures

In the declaration, the programmer selects the structure type:



```
     (* cyclic program *)

(* using a basic data type *)
PVDate.year:= 2001; ** access to a structure element **
```

Name	Type	Scope	Attribute	Value	Owner
PVDate	Date_Typ	local	memory	* remanent	

Category: User data types

Array: 1

Length: 0

Info

No. of items	3
Bit length	0
Byte length	0

Assign item to:
- Date_Typ
- SFCActionType
- SFCStepType

Filter: Date_Typ

Fig. 9.8: Selecting the structure data type

2.4.7 Tips for Structures

The compiler automatically (implicitly) follows the **memory access rules** when reserving memory for PVs required by AutomationRuntime or AutomationTarget.

An example of such a rule is:
PVs with a data type larger than USINT always beging in a structure on an **even memory location** !

Therefore this rule, which is called **allignment behavior** of the compiler in the programming language, must be followed by the compiler during memory management.

If necessary, the compiler will insert **filler bytes** in the structure. However, they remain **hidden** from the user i.e. memory is reserved but cannot be directly accessed using a PV name.

Note

To make these filler bytes visible, the programmer should handle the allignment behavior **explicitly** using **reserve bytes**.

Advantages:

- If the structure needs to be expanded later, a reserve byte can be used without changing the structure size !
- On different platforms, different alignment rules could be required. Explicit alignment allows platform independent,
  portable code !

From Library	Function Name	Short Description
AsString	memcpy()	Copy a structure, length is to be entered explicitly
AsString	sizeof()	Determine structure length

Tab. 9.3: Corresponding functions

Example

An axis should be positioned.

The following data is required for positioning:

●	Name	[USINT]
●	Target position	[INT]
●	Speed	[INT]
●	Acceleration	[INT]
●	Active	[USINT]

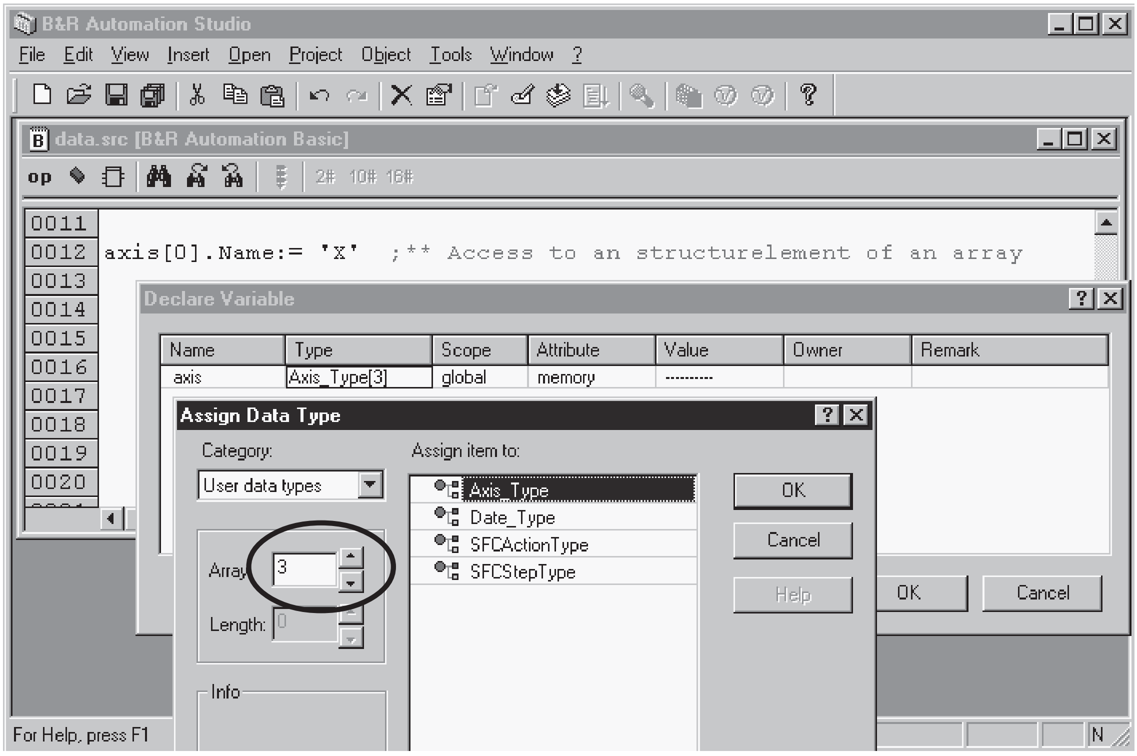
Organize the elements under a common topic as a structure and then use it as data type for a PV that you assign values to in the INIT SP of the program.

Check the results in Watch !

Project Name:	Data
Program Name:	dt_ex
Resource:	C#4

2.4.8 Combination of Array and Structure

In the declaration, the programmer selects a structure data type and defines the array length for the desired number of elements.


```
axis[0].Name:= 'X'  ;** Access to an structurelement of an array
```

Name	Type	Scope	Attribute	Value	Owner	Remark
axis	Axis_Type[3]	global	memory	---------		

Assign Data Type

Category: User data types

Array: 3

Length: 0

Assign item to: Axis_Type, Date_Type, SFCActionType, SFCStepType

B&R Automation Studio
File Edit View Insert Open Project Object Tools Window ?
data.src [B&R Automation Basic]
Declare Variable
Info
OK
Cancel
Help
For Help, press F1

Fig. 9.9: Selecting the structure data type with array length

2.5 Function Block Data Types

Function blocks process input data and create output data using internal variables.

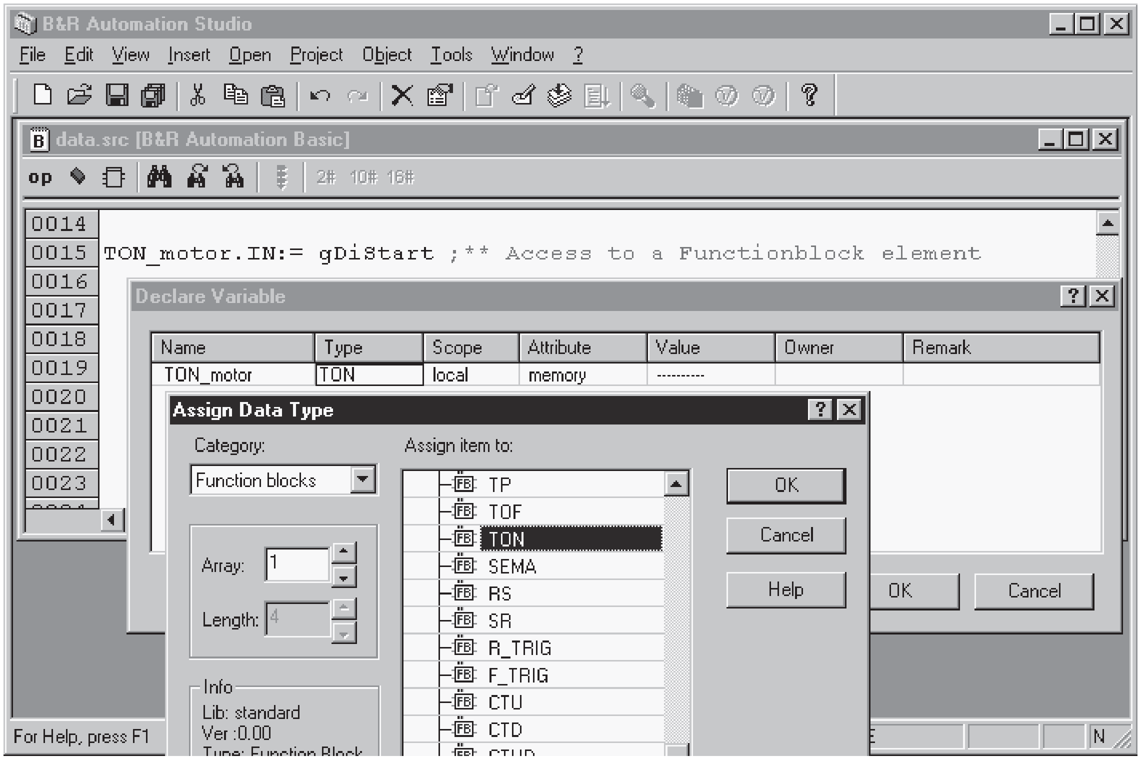
In order to have a clear overview of the data, it can be organized with a structure.

The data type is provided to the programmer by the LibraryManager in AutomationStudio according to the respective FBK.

2.5.1 Declaration of an Alias PV

In the declaration, the programmer has to select the data type belonging to the FBK. Using the data type, the compiler recognized which FBK code should be called for text-based IEC languages and AB.

A PV with function block data type is called an Alias PV.



```
TON_motor.IN:= gDiStart ;** Access to a Functionblock element
```

Name	Type	Scope	Attribute	Value	Owner	Remark
TON_motor	TON	local	memory	----------		

Category: Function blocks

Assign item to:
- TP
- TOF
- TON
- SEMA
- RS
- SR
- R_TRIG
- F_TRIG
- CTU
- CTD
- CTUD

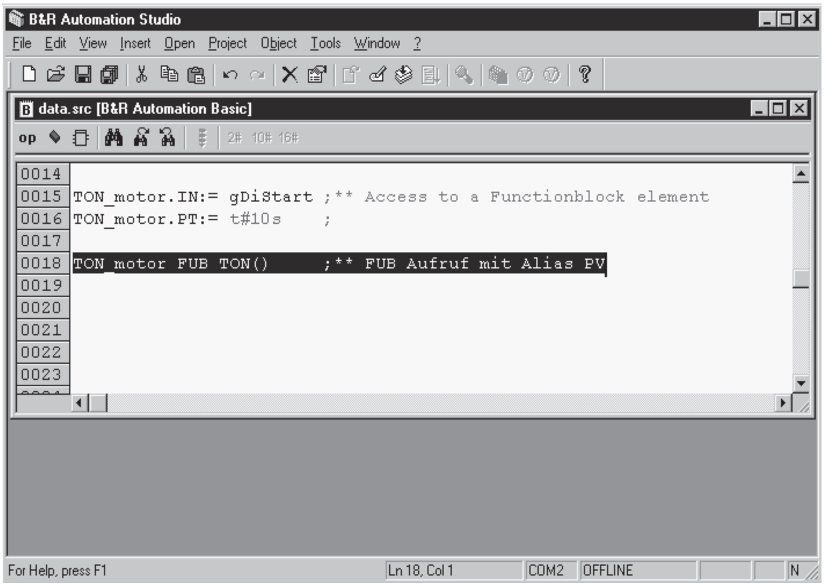
Array: 1

Length: 4

Info
Lib: standard
Ver :0.00
Type: Function Block

Fig. 9.10: Selecting a function block for an Alias PV

The FBK call can be made from the main menu item **Insert: Function**.


B&R Automation Studio
File Edit View Insert Open Project Object Tools Window ?
data.src [B&R Automation Basic]
For Help, press F1
Ln 18, Col 1
COM2
OFFLINE

```
TON_motor.IN:= gDiStart ;** Access to a Functionblock element
TON_motor.PT:= t#10s    ;

TON_motor FUB TON()     ;** FUB Aufruf mit Alias PV
```

Fig. 9.11: Inserting a FBK call

Example

Controlling the external fan for a spindle motor.

When switching the spindle motor off by resetting the PV gDoMotor to 0, the fan motor, which is controlled by the PV gDoFan, should continue running for 10 seconds.

Program a turn-off delay using the TOF FBK in AB and check the behavior.

Project Name:	Data
Program Name:	dt_ex
Resource:	C#4

2.6 Dynamic Process Variables

2.6.1 What is a dynamic process variable ?

The PVs used up til now have a fixed location in memory. The content of these memory locations can be referenced by name and processed.

If you want to access a different memory location, you have to use the name of the PV that is assigned to this memory location.

When compiling, this PV is assigned a fixed address which cannot be influenced by the user during runtime.

These types of PVs are called static variables !

However, a PV name should often be used that can access different memory locations. To do this, the **PV is declared as pointer** and a **fixed address is not assigned** when compiling !

The memory location that the point should access can be defined by the user during runtime, this is referred to as “defining a **reference** for the pointer”.

These types of PVs are called dynamic variables !

The content of the memory locations is interpreted according to the selected data type beginning at the start address. The data type of the dynamic PV functions as a **mask**.

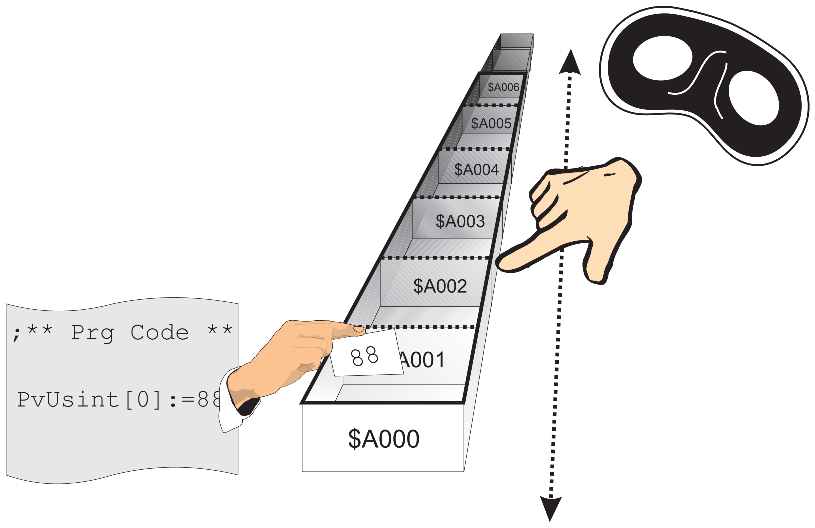


Fig. 9.12: Dynamic process variables

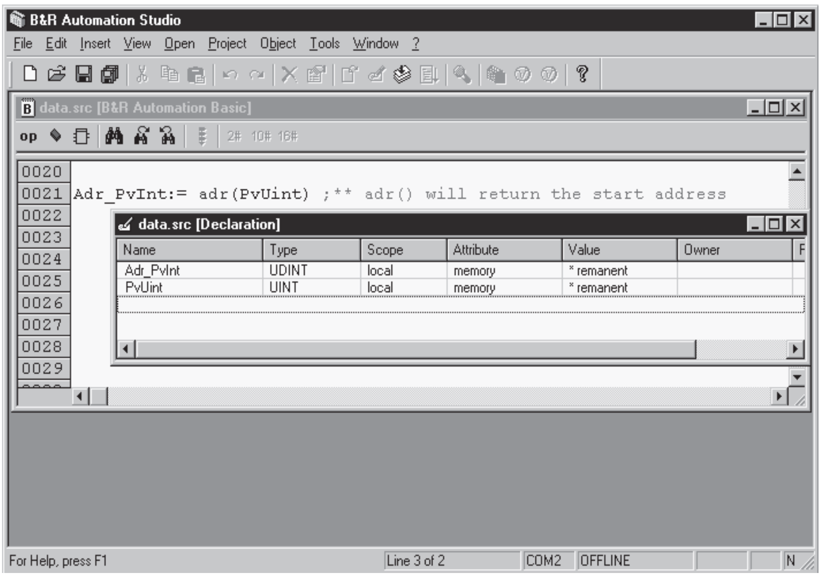
2.6.2 Determining the Address

AutomationStudio assigns each static PV an address offset which is linked to free memory addresses on the AutomationTarget by AutomationRuntime.

The memory address for a PV can be determined in the application program in language AB using the operator “adr()”.

It returns the address as a UDINT value.

```
;** Example **
Adr_PvInt:= adr(PvUint)
```


B&R Automation Studio
File Edit Insert View Open Project Object Tools Window ?
data.src [B&R Automation Basic]
data.src [Declaration]
For Help, press F1
Line 3 of 2
COM2
OFFLINE
N

```
Adr_PvInt:= adr(PvUint) ;** adr() will return the start address
```

Name	Type	Scope	Attribute	Value	Owner	F
Adr_PvInt	UDINT	local	memory	* remanent		
PvUint	UINT	local	memory	* remanent		

Fig. 9.13: Determining the address of a PV using operator adr()

Example

Create an array of axis structures with array length 3 to provide X,Y,Z axis coordinates for a CNC system.

Analyze the division of memory for the axis structure using the “adr()” operator and enter the information in the following sketch.

In the column “Address”, enter the memory addresses that have been determined. In the column “Memory Content”, indicate the alignment fillers using hatch marks in the memory locations. In the column “PV Name”, enter the corresponding structure element.

Note

Determining the memory address of a structure element using “adr(Topic.Element)”

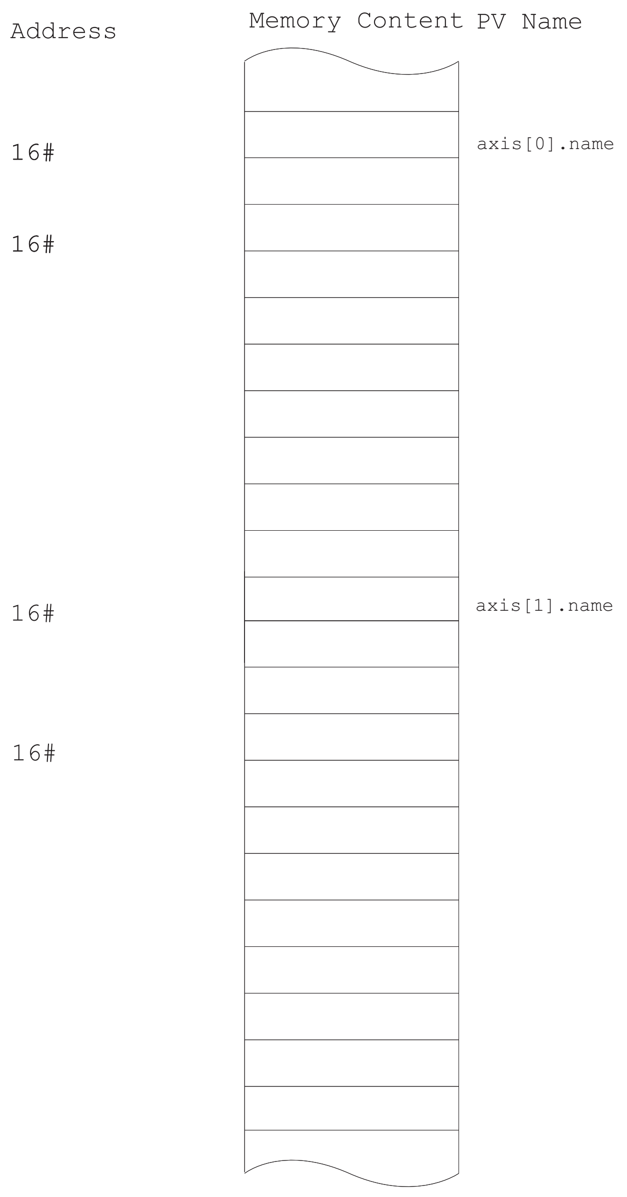
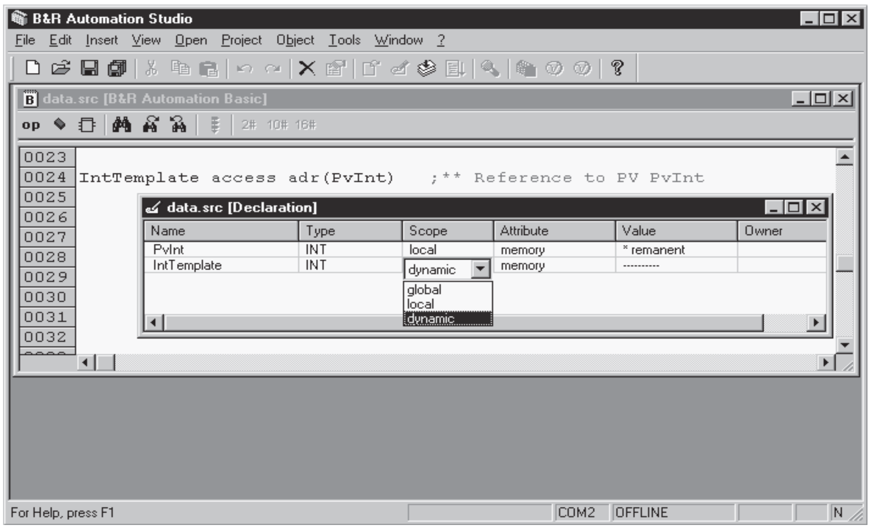


Fig. 9.14: Memory content

2.6.3 How do I create a dynamic process variable ?

In the declaration, the programmer defines two points:

- Data type
  Defines the “mask” used later to interpret the contents of the referenced address
- Dynamic scope
  The address offset is assigned to the PV during runtime



```
IntTemplate access adr(PvInt)   ;** Reference to PV PvInt
```

Name	Type	Scope	Attribute	Value	Owner
PvInt	INT	local	memory	* remanent	
IntTemplate	INT	dynamic	memory	---------	

Fig. 9.15: Defining a dynamic PV

2.6.4 Access

A dynamic PV can be assigned a memory address during runtime, this procedure is called referencing or initializing.

As soon as a dynamic PV is initialized, it can access the contents of the memory location it is "pointing" to according to the data type.

In the program code, a dynamic PV is used like a static PV after initialization.

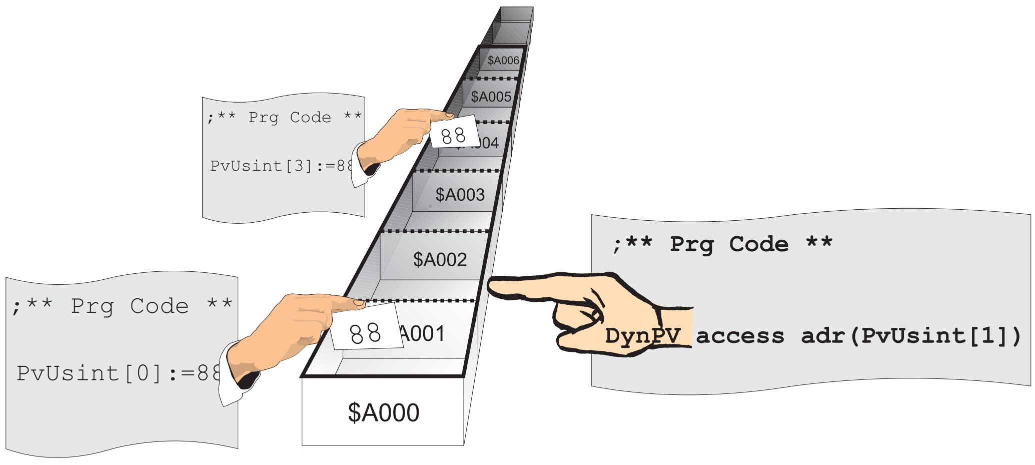


Fig. 9.16: Access

Example

Create an array variable with length 30 and data type USINT.
Enter the values in the elements using the PV Monitor.

Create a dynamic PV with data type:

- USINT
- UINT
- INT

and “place” it over the array variable as mask.

Begin with the start address of the array variable and then „shift“ the mask by increasing an offset !

Compare the value interpreted using the mask with the value in the array variable !

Example

AutomationRuntime receives positioning data AutomationNet.
This data should be saved in an array variable “receive”, data type USINT[30].
Enter the values in the array variable using the PV Monitor.

Create a dynamic PV with the axis data type for an axis and use it as a mask to evaluate the data received from the array “receive”.

Initialize the dynamic PV with the start address of the array PV and handle the selectable data set number using an additive offset.

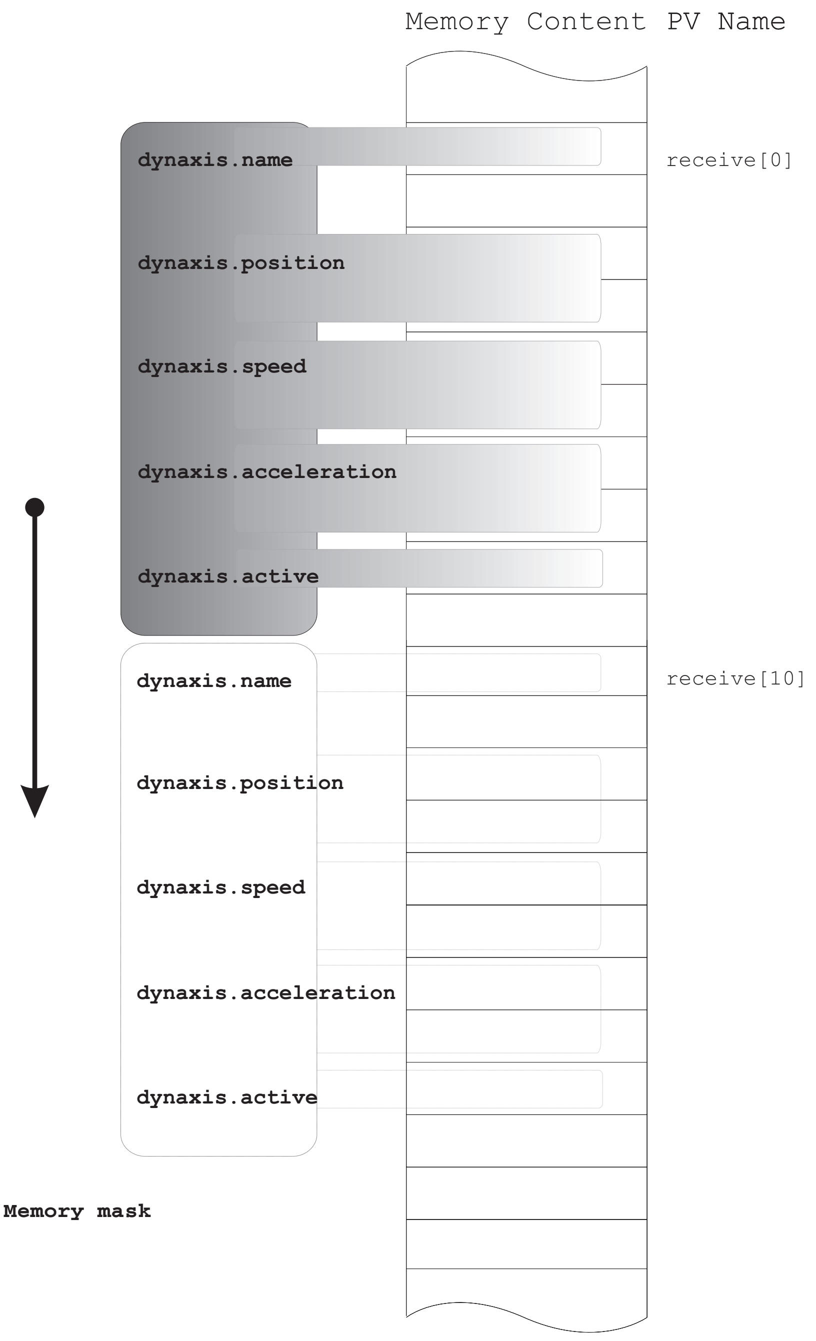


Fig. 9.17: Memory mask

2.6.7 Programming Techniques for Dynamic PVs

Preparing dynamic PVs provides the programmer all the possibilities needed to create flexible, compact and high performance code for automation solutions.

Using pointers, it is possible to access and evaluate the entire application memory.

It is important to guarantee correct, controlled initialization of dynamic PVs.

Humans make mistakes, and programmers are human so certain steps should be taken when using dynamic PVs to prevent uncontrolled memory manipulation.

Note

Discuss the possibilities for **control** of dynamic memory access in the group and keep in mind the need to correctly use this powerful tool – “Dynamic PVs” !

3. DATA MODULES

3.1 General Information

What is a data module ?

What advantages does a data module offer ?

Creating a Data Module in AS

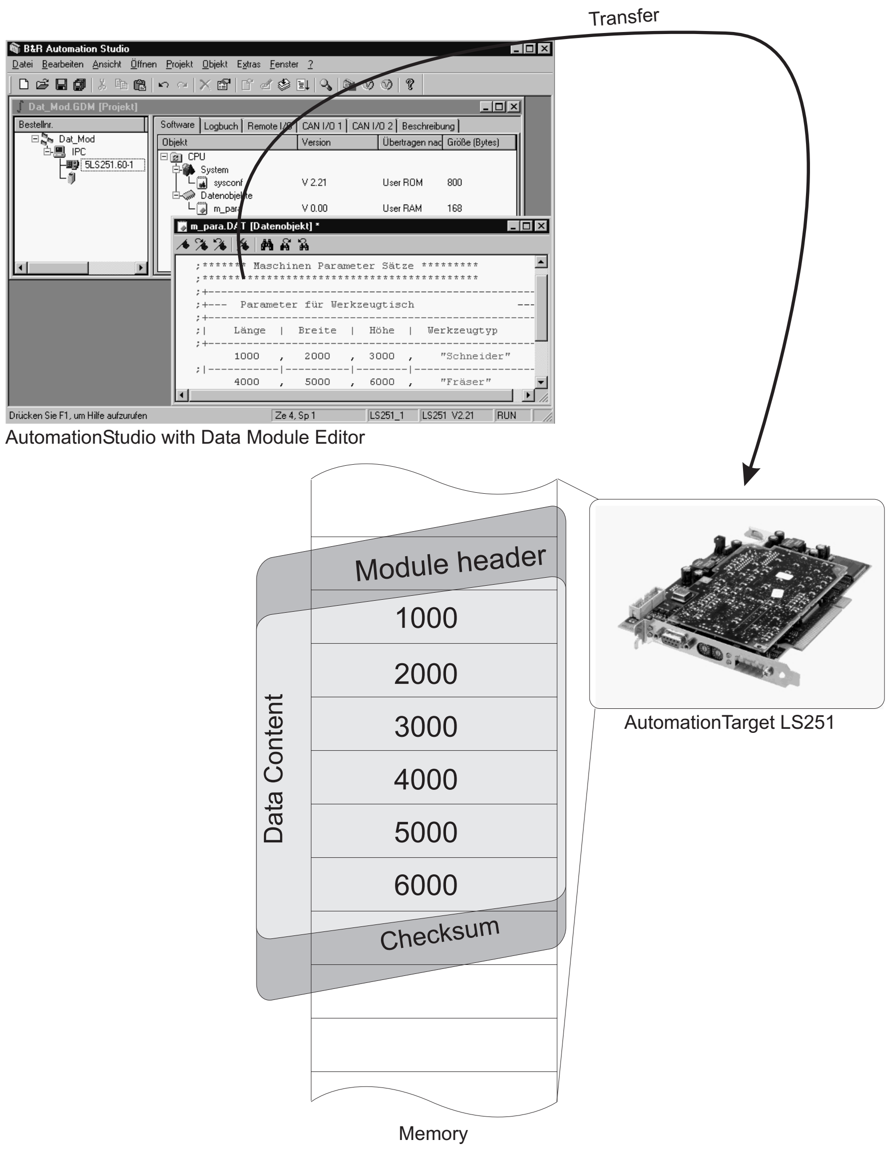
Reading a Data Module from the Application

Creating and Writing to a Data Module from the Application

Autonomous Data Module Memory

3.2 What is a data module ?

Data modules make it easier to manage information and increase flexibility. A data module is a memory area which is reserved in a continuous section. The content of this data module (memory area) can be entered using a simple ASCII editor, the Data Module Editor using a user defined mask. The content of the data module can also be written to by the application. The data in the module can be transferred from AutomationStudio to AutomationRuntime or from AutomationRuntime to AutomationStudio!


Transfer
B&R Automation Studio
Datei Bearbeiten Ansicht Öffnen Projekt Objekt Extras Fenster ?
Dat_Mod.GDM [Projekt]
Bestellnr.
Dat_Mod
IPC
5LS251.60-1
Software Logbuch Remote I/O CAN I/O 1 CAN I/O 2 Beschreibung
m_para.DAT [Datenobjekt] *
Drücken Sie F1, um Hilfe aufzurufen
Ze 4, Sp 1
LS251_1
LS251 V2.21
RUN
AutomationStudio with Data Module Editor
Module header
1000
2000
3000
4000
5000
6000
Checksum
Data Content
Memory
AutomationTarget LS251

Objekt	Version	Übertragen nac	Größe (Bytes)
CPU			
System			
sysconf	V 2.21	User ROM	800
Datenobjekte			
m_para	V 0.00	User RAM	168

```
;******* Maschinen Parameter Sätze *********
;*****************************************
;+------------------------------------------------------
;+---  Parameter für Werkzeugtisch                   ---
;+------------------------------------------------------
;|    Länge   |  Breite   |  Höhe   |  Werkzeugtyp
;+------------------------------------------------------
      1000    ,   2000    ,  3000   ,    "Schneider"
;|-----------|----------|--------|---------------------
      4000    ,   5000    ,  6000   ,    "Fräser"
```

Fig. 9.18: What is a data module ?

3.3 What advantages does a data module offer ?

We are already farmiliar with managing information in process variables which are physically stored in RAM.

The following questions are often asked concerning the special requirements for data management in modern automation applications:

- How can I protect against data loss during a warm start or power failure if a backup battery is not available ?
- How can I protect against data loss during a cold restart ?
- How can I increase the amount of data in a simple and flexible manner ?
- How can I define or limit read and write access rights for a section of my data ?

The following flowchart shows possible solutions:

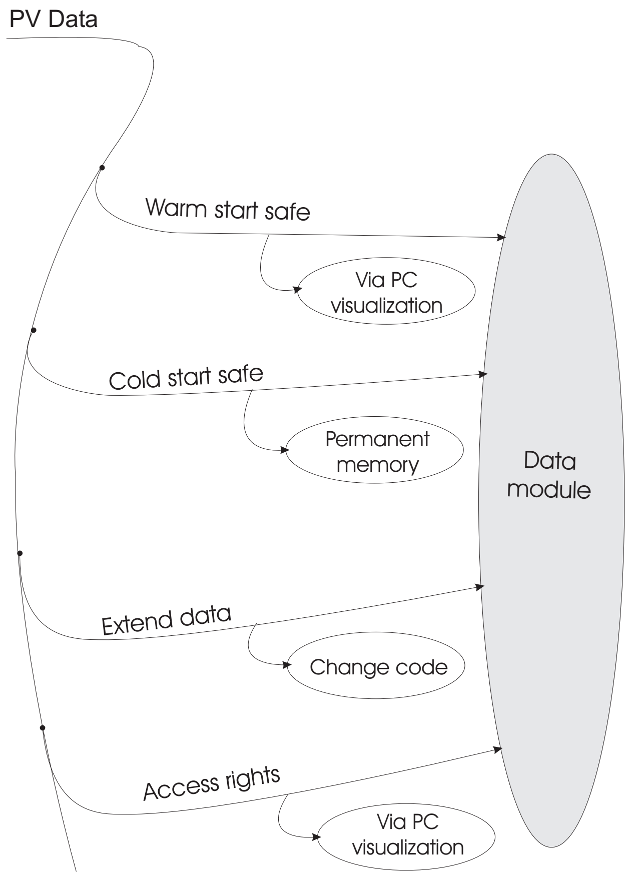
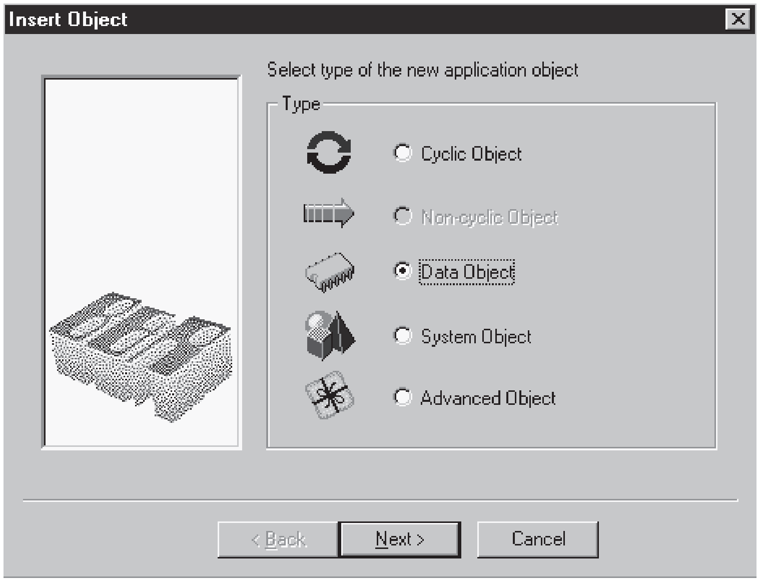


Fig. 9.19: Data module solutions

3.4 Creating a Data Module in AutomationStudio

Create a data module in a software tree using **Insert:New Object** and making the selection Data object = Data module.

Like every other module, give the data module a unique name which can be used by the application to read or write data during runtime.


Insert Object

Select type of the new application object

Type

Cyclic Object

Non-cyclic Object

[✓ Data Object]

System Object

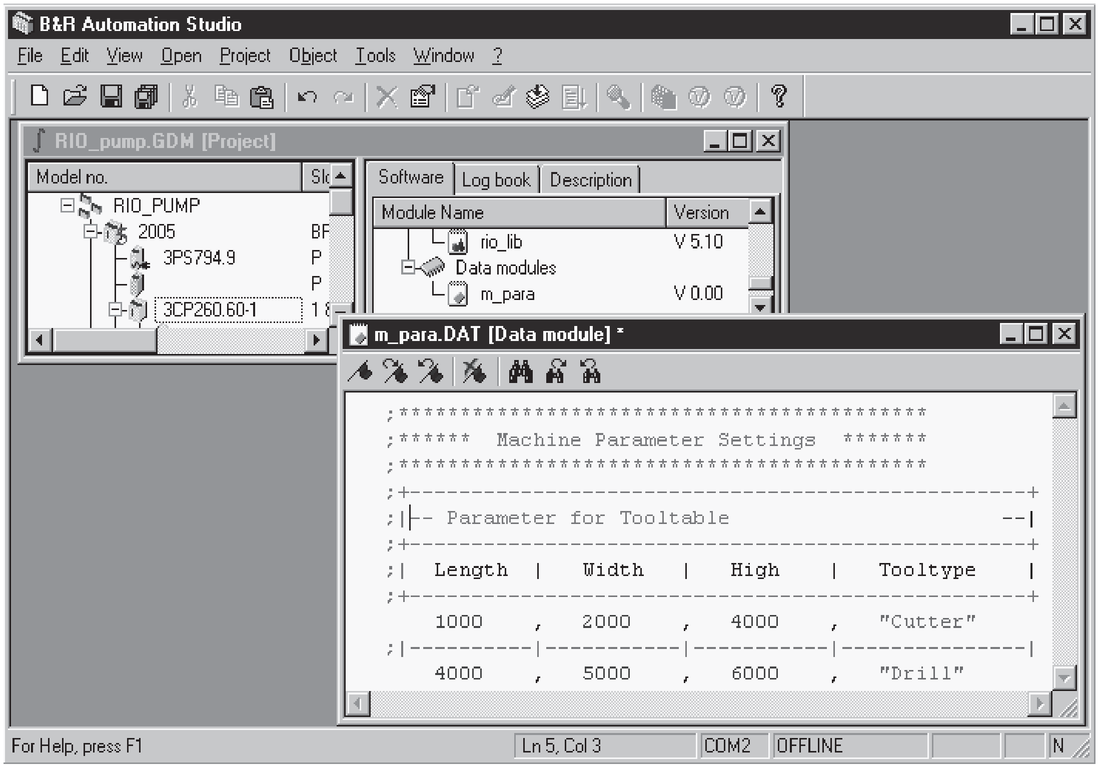
Advanced Object

Fig. 9.20: Creating a data module

By double-clicking on the object, an easy to use ASCII editor with syntax coloring is opened to enter data in the data module.

The user enters data or comments here.

Comments are all started with a semicolon and allow flexible construction of a mask, e.g.: represented as follows for a table



```
;********************************************
;*******  Machine Parameter Settings  *******
;********************************************
;+--------------------------------------------------+
;|├- Parameter for Tooltable                      --|
;+--------------------------------------------------+
;|  Length  |   Width   |   High    |   Tooltype    |
;+--------------------------------------------------+
    1000    ,   2000    ,   4000    ,   "Cutter"
;|----------|-----------|-----------|---------------|
    4000    ,   5000    ,   6000    ,   "Drill"
```

Fig. 9.21: Data Module Editor

Data is separated in a line by a comma or line break.

Data can be entered as follows:

- Numerical in decimal, hexadecimal or binary format
- as ASCII text **without** zero termination between ‘text’
- as ASCII string **with** zero termination between **“**string**“**

Numerical values can be entered as whole numbers or real values with decimal point.

Note

The memory reserved for the value, the data type, is determined by the value range and the number of characters !

Example

Data module handling

- Create the following data module with the name “table”:

```
;───────────────────────────
,──── Positioning data──────
;+──────────────Positioning variant
;|                                  A/R..Absolute/Relative
;|      +──────────Target pos./Positioning path
;|      |                          [DINT]
;|      |       +──────Positioning speed
;|      |       |                   [UINT]
;|      |       |       +──Acceleration
;|      |       |       |           [UINT]
;|      |       |       |       ───────────
"A", 00020000, 30000, 10000  ; 1st positioning step
"R", 00000100, 00200, 10000  ; 2nd positioning step
```

- Transfer the data module to the PCC and check if the module is on the PCC.

- Create another data module with the name “t_text”.
  Make sure that the second line is NOT zero terminated.

```
;         1         2         3
;1234567890123456789012345678901234
;
"This is our second data module!   "
'This is the second line           '
```

- Transfer the data module to the PCC and check if the module is on the PCC.

Data module name: table, t_text

Resource: DAT

3.5 Reading a Data Module from the Application

The B&R “Syslib” library provides the function blocks needed to allow simple data module access so the application can read the contents. They can be used as shown in the following diagram:

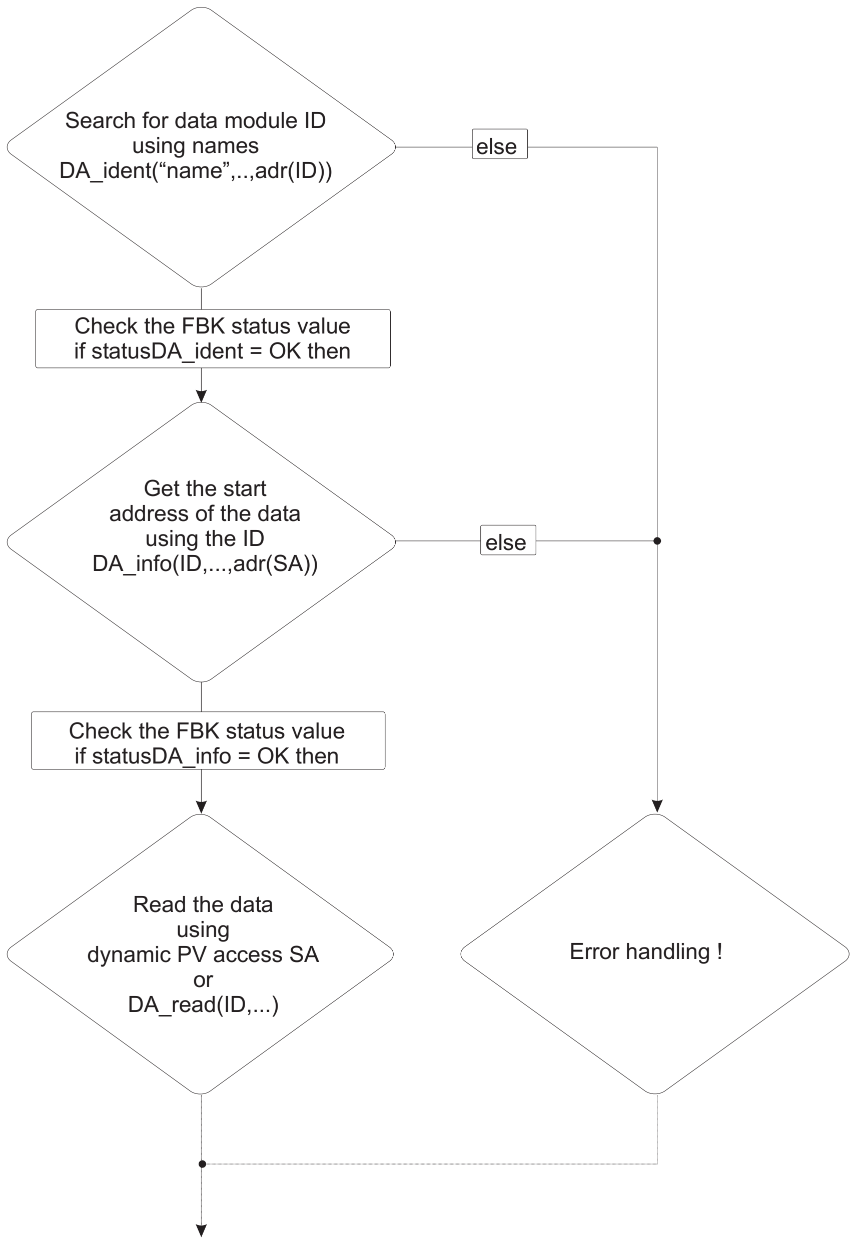
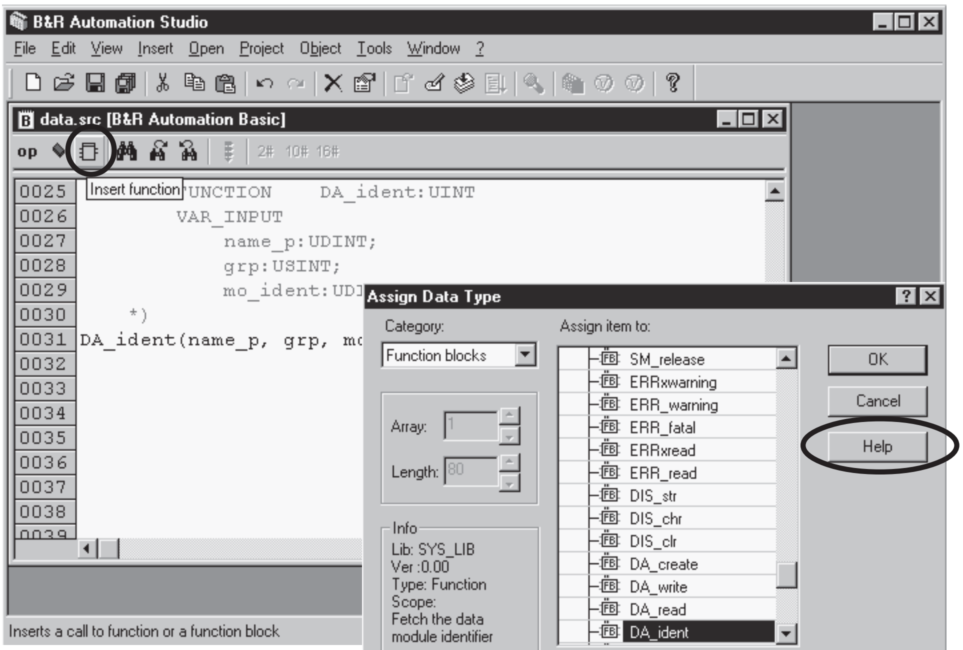

Search for data module ID using names DA_ident(“name”,..,adr(ID))
else
Check the FBK status value if statusDA_ident = OK then
Get the start address of the data using the ID DA_info(ID,...,adr(SA))
else
Check the FBK status value if statusDA_info = OK then
Read the data using dynamic PV access SA or DA_read(ID,...)
Error handling !

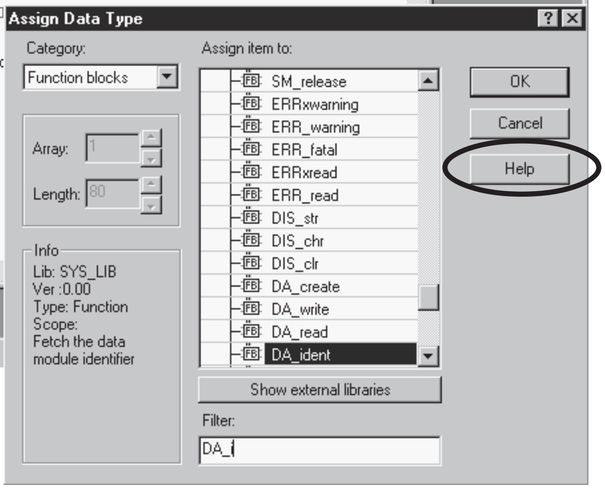
Fig. 9.22: Reading a data module

Detailed information about function block parameters can be found in the AutomationStudio online help.


B&R Automation Studio
File Edit View Insert Open Project Object Tools Window ?
data.src [B&R Automation Basic]
Insert function
Inserts a call to function or a function block

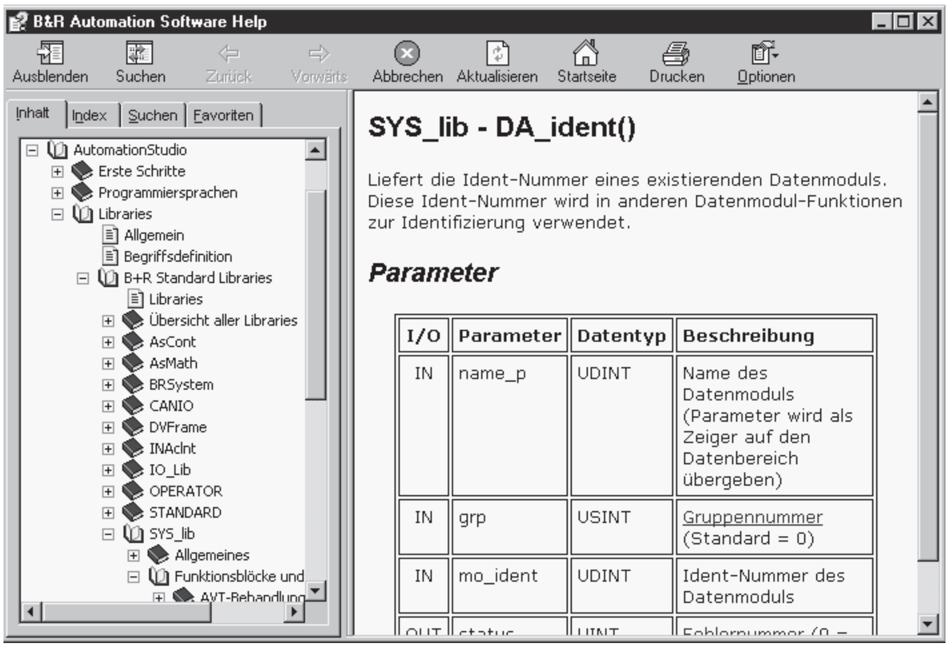
```
FUNCTION     DA_ident:UINT
       VAR_INPUT
           name_p:UDINT;
           grp:USINT;
           mo_ident:UDI
   *)
DA_ident(name_p, grp, mc
```

Fig. 9.23: Step 1



Info
Lib: SYS_LIB
Ver :0.00
Type: Function
Scope:
Fetch the data module identifier

Fig. 9.24: Step 2



SYS_lib - DA_ident()

Liefert die Ident-Nummer eines existierenden Datenmoduls. Diese Ident-Nummer wird in anderen Datenmodul-Funktionen zur Identifizierung verwendet.

Parameter

I/O	Parameter	Datentyp	Beschreibung
IN	name_p	UDINT	Name des Datenmoduls (Parameter wird als Zeiger auf den Datenbereich übergeben)
IN	grp	USINT	Gruppennummer (Standard = 0)
IN	mo_ident	UDINT	Ident-Nummer des Datenmoduls

Fig. 9.25: Help information

Example

Write a task to read positioning data from the data module “table”.

- To do this, create a dynamic structure with length 2 over the table.
- The data should be copied to a static PV with positioning structure type. The following possibilities are available:
  ```
          memcpy(...)
          DA_read(...)
  ```
  Read the respective online information concerning the function blocks and select one of the possibilities.
- Use the INIT SP to determine the data module system information
- Overwrite one of the values from the static structure PV and then from the dynamic structure PV in the PV Monitor and check the reaction of AutomationRuntime !

Program name:	da_struc
Resource:	C#4

Example

Write a task that reads the following information from the data module “t_text”.

- Copy the first line of your data module to the byte array “ASCII_1” using the function:
  ”strcpy(target address, source address)”.

- Read the 3rd byte from the data module and write it to the variable “spec_byte”.

- Copy the second line of your data module to byte array “ASCII_2”. To do this, use a loop and the dynamic PV “DYN_PV”.

Program name:	da_read
Resource:	TC#4

3.6 Creating and Writing to a Data Module from the Application

The B&R "Syslib" library provides the function blocks needed to allow the application to create a data module used to save user parameters during runtime. Write access to the data module takes place in a controlled manner using a write function which automatically carries out the checksum correction. These functions can be used as shown in the following diagram:

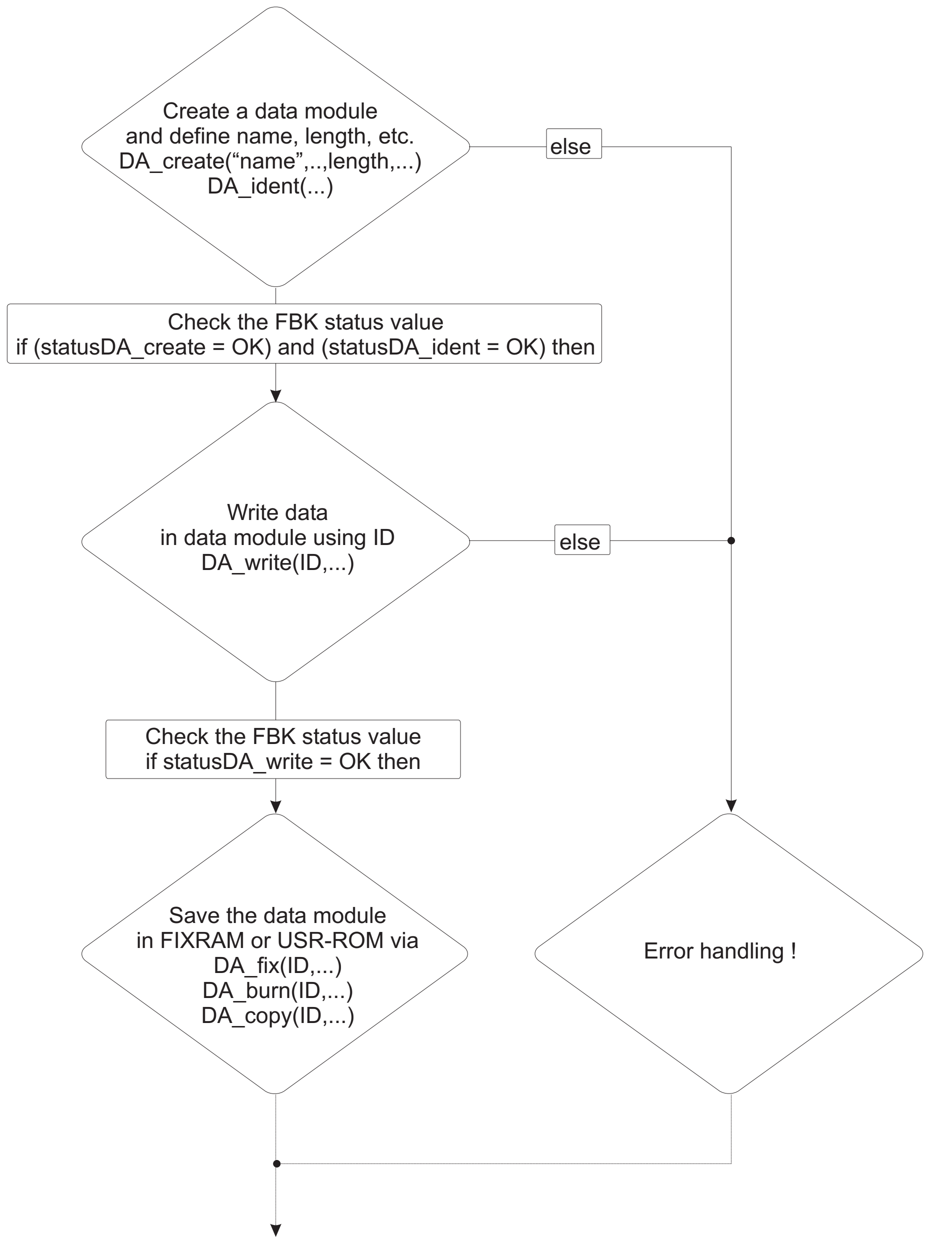

Create a data module
and define name, length, etc.
DA_create("name",..,length,...)
DA_ident(...)
else
Check the FBK status value
if (statusDA_create = OK) and (statusDA_ident = OK) then
Write data
in data module using ID
DA_write(ID,...)
else
Check the FBK status value
if statusDA_write = OK then
Save the data module
in FIXRAM or USR-ROM via
DA_fix(ID,...)
DA_burn(ID,...)
DA_copy(ID,...)
Error handling !

Fig. 9.26: Creating, writing to and saving a data module

Example

To practice creating and writing to data modules, write a task that carries out the following actions:

- A data module which is initialized by a structure should be created when a positive edge occurs on an input.

  Struktur: init_da

.USINT_var:	USINT	1	
.UINT_var:	UINT	1	
.USINT_array:	USINT	10	(String)

  If the data module was already created, all necessary parameters, e.g.: module length, should be requested from AutomationRuntime.

- The structure has to fit in the data module 3 times.

- The entire data module should be created using initialization values, with values <> 0

- The values are read using dynamic variables to check the content of the data module.

- Check the length of the data module. Does it correspond to the length you expected?

- Change the element UINT_var in the data module when a positive edge occurs on an input. An analog value should be written to the variable.

Program name:	da_first
Resource:	??

3.7 Autonomous Data Module Memory

A data module created by the application using DA_create(...) is normally placed in USR RAM so that the data can be manipulated.

If it is also necessaray to protect the information in the data module during a warm and cold start, the data module can be copied to USR ROM.

If the information in the data module should be changed again, it must be saved in USR ROM again and the old memory is marked as being bad. Memory that is marked as being bad can be released again by deleting the USR ROM, but all tasks are normally lost.

Therefore, AutomationRuntime provides the application a special area in FLASH (DM_USER_FLASH) for autonomous management of data modules on the following AutomationTargets:

● B&R2003:	CPx70, CPx74
● B&R2005:	XP152, IF152, IP161, CP260, IF260
● B&R2010:	IF100, IF101

This 64 kByte memory area can be manipulated by the user. The user can delete this area of the FLASH independent of the USR ROM.

AutomationRuntime provides the following services in the library “DM_LIB.BR” to manage this memory:

● DMclear()	..	Delete DM USER FLASH
● DMstore()	..	Store data module in DM USER FLASH
● DMfree()	..	Information, how much DM USER FLASH is still free

4. MEMORY MANAGEMENT

4.1 General Information

We will summarize memory management using the folowing questions.

Memory Access

Who can save data ?

Location

Where can data be saved ?

Memory Organization

How can information be saved ?

Who can reserve and allocate memory ?

4.2 Memory Access

Who can read, write and store data ?

In general, there are two possibilities for memory access:
access by the user and by the system.

User

- Application
  Programs work with PVs
- AutomationStudio
  Install modules, watch, etc.
- Operator + Visualization
  Human-Machine Interface (HMI)

System

- Internal variables/data from AutomationRuntime
- Input data from hardware modules
- Communication using Interfaces

These two types of tasks are very different and therefore have different requirements for storing and accessing data.

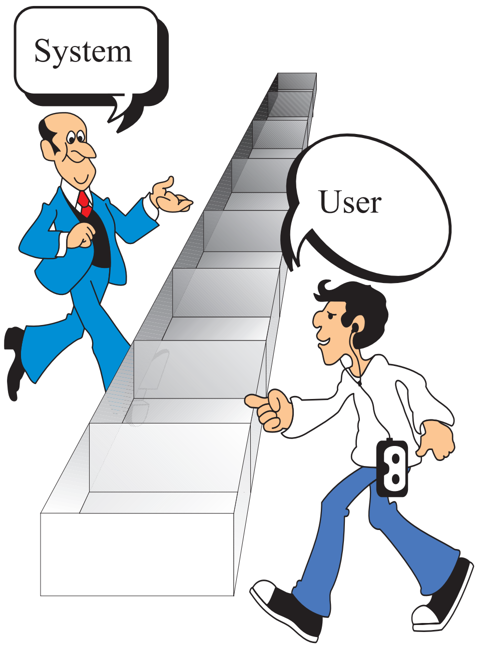


Fig. 9.27: Memory access

4.3 Location

We have found out that data are needed by different users to complete their tasks.

The data is stored in memory according to the requirements mention previously. Two subdivisions exist:

- Physical location
- Logical location

The characteristics and purposes of these two locations will be repeated and summarized in the following sections.

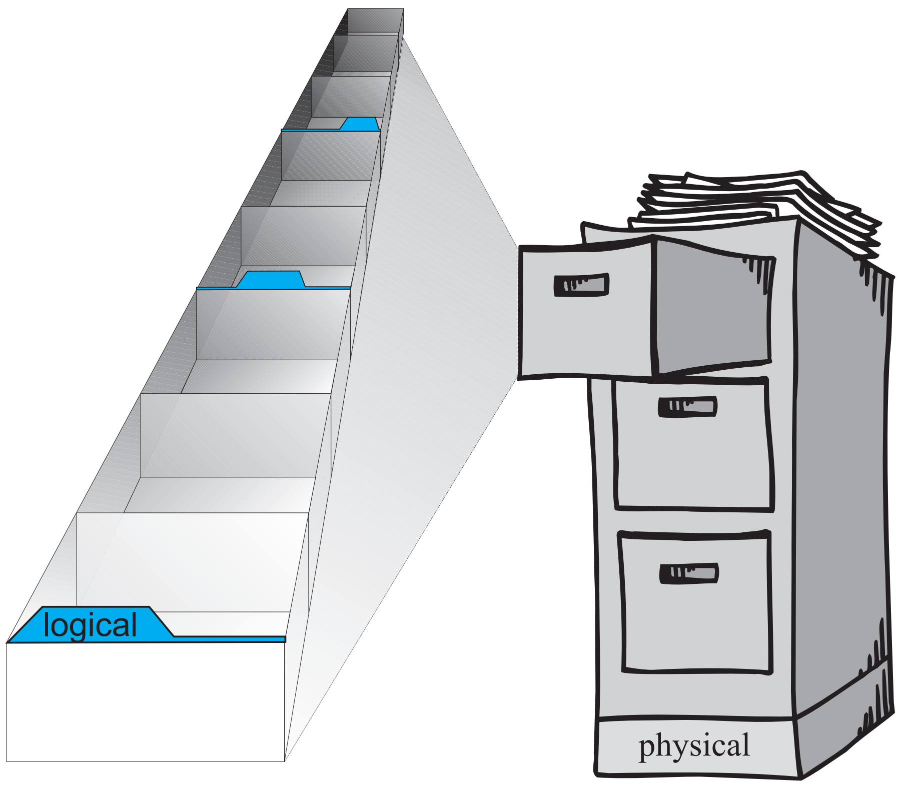


Fig. 9.28: Memory locations

4.3.1 Physical Memory Locations

An AutomationTarget has various physical memory media.

	modular	**onboard**	**Effect after: Warm Start**	**Effect after: Cold Start**	**Special Properties**
DRAM		✓	All memory locations have the value 0	All memory locations have the value 0	Very fast access
SRAM	✓	✓	Memory is remnant	All memory locations have the value 0	Each bit can be reset individually
FLASH	✓	✓	Memory is remnant	Memory is remnant	Nonvolatile
...	...	...	...	...	...

Tab. 9.4: Physical memory

Notes

Concerning the terms above:

- modular.............. modular user memory, e.g.: Memcard or MExxx
- onboard...............memory is directly in the AutomationTarget module
- remanent..............memory is not changed by AutomationRuntime

A detailed description can be found in the hardware manual, the AutomationStudio online help or on the Internet homepage.

4.3.2 Logical Memory Location

The memory is provided to AutomationRuntime using physical blocks. AutomationRuntime separates the physical memory into logical units. It separates the RAM and FLASH into a User and System area. The User and System areas are also separated into smaller, independent areas.

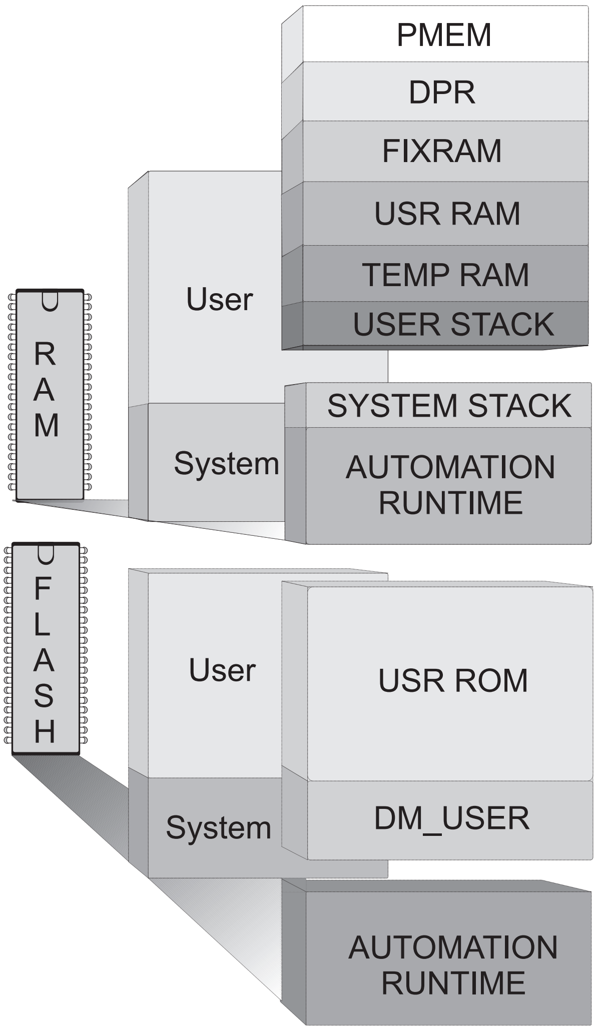


Fig. 9.29: Physical and logical memory locations

In the following table, the locations are summarized again including typical content and warm and cold start behavior.

	Name	Content	Effect after Warm Start	Effect after Cold Start	Special Properties
User	USR RAM	Program + Data modules	Memory is remanent	All memory locations have the value 0	Data in modules has checksum protection
	USR ROM	Program + Data modules	Memory is remanent	Memory is remanent	Data in modules has checksum protection
	FIX RAM	Program + Data modules	Memory is remanent	Memory is remanent	Cold start safe
	DM_USER	Data modules	Memory is remanent	Memory is remanent	Flash can be organized and deleted by the application
	DPR	Local + global PVs	Memory is remanent	All memory locations have the value 0	Access of PVs also possible from other automation targets & PVI
	Permanent Memory	Freely configurable	Memory is remanent	Memory is remanent	Cold start safe
	Temporary Memory	Freely configurable	All memory locations have the value 0	All memory locations have the value 0	Large memory blocks can be reserved during runtime
	Stack	FBKs & Freely configurable	All memory locations have the value 0	All memory locations have the value 0	For user function blocks
System	SYS ROM	System + Data modules	Memory is remanent	Memory is remanent	Modules are also activated in diagnose mode
	Static RAM	Automation Runtime	All memory locations have the value 0	All memory locations have the value 0	Area protected from the user for logbook, system tables, etc.
	Stack	Automation Runtime	All memory locations have the value 0	All memory locations have the value 0	For system function blocks

Tab. 9.5: Logical memory

4.4 Memory Organization

B&R AutomationRuntime provides various easily implimented methods for storing data.

This allows various requirements to be met e.g.: data with defined access rights.

All AutomationRuntime versions offer the following possibilities:

- Process variables
- Dynamic memory allocation
- Data modules

Process variables allow simple and direct access of data memory using symbolic names.

Dynamic memory allocation allows flexible memory organization during runtime.

Data modules capsule data in protected areas which include all B&R module characteristics e.g.: checksum test, download, upload, data editor in AutomationStudio, etc.

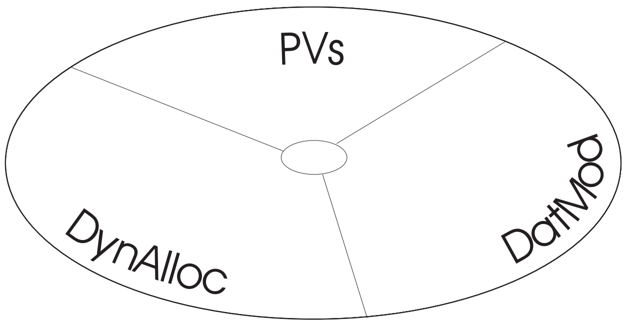


Fig. 9.30: Memory management

Before we can access the memory (use it), someone has to reserve it for us. The memory must be organized.

This is important so that each user receives a separate, assigned area.

Memory can be organized in two ways:

- static
- dynamic

Static memory is automatically reserved by the compiler when using PVs and the relationship between PV name and the reserved memory address is entered in a PV table.

Dynamic memory is requested from AutomationRuntime by the user in the application using FBKs and referenced using a dynamic PV. For programming, requesting memory is referred to as "Allocation". Dynamic memory can be requested during runtime with a selected size, therefore the user has very flexible memory organization which can be changes as desired during runtime.

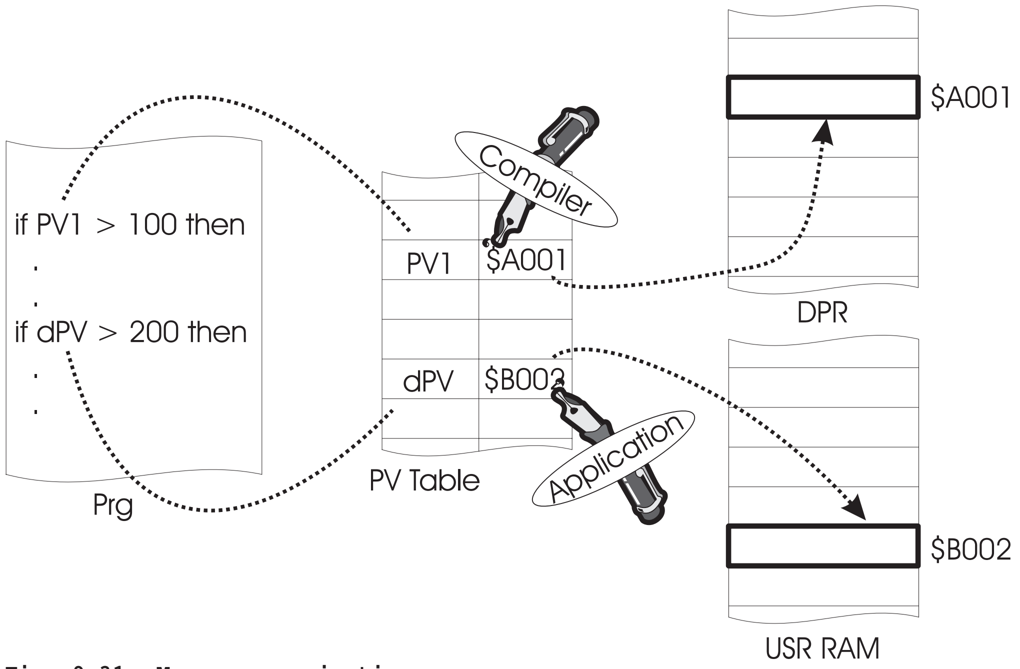


Fig. 9.31: Memory organization

TIMING PROCESSING UNIT

1 OVERVIEW

Timing Processing Unit

A Timing Processing Unit is used when creating solutions for time critical applications because it allows certain events to be reacted to in the µs range.

TPU Modules

This chapter provides an introduction to the major parts of a TPU and an overview of the hardware available for such applications.

LTX Functions

Selecting and inserting functions used to operate a TPU in Automation Studio are explained in detail here. Examples are also provided.

2 TIMING PROCESSING UNIT

2.1 What is a Timing Processing Unit ?

A Timing Processing Unit, (**TPU**) is an additional hardware unit which supports the CPU. It can be used to execute simple and also time critical functions without loading the CPU.

With each action that occurs, e.g. positive edge on an input, an LTX function is called. These functions are processed by the TPU. This allows reaction times in the µs range.

LTX ... Logic Timing Functions

2.2 Block Diagram of a Processor with TPU

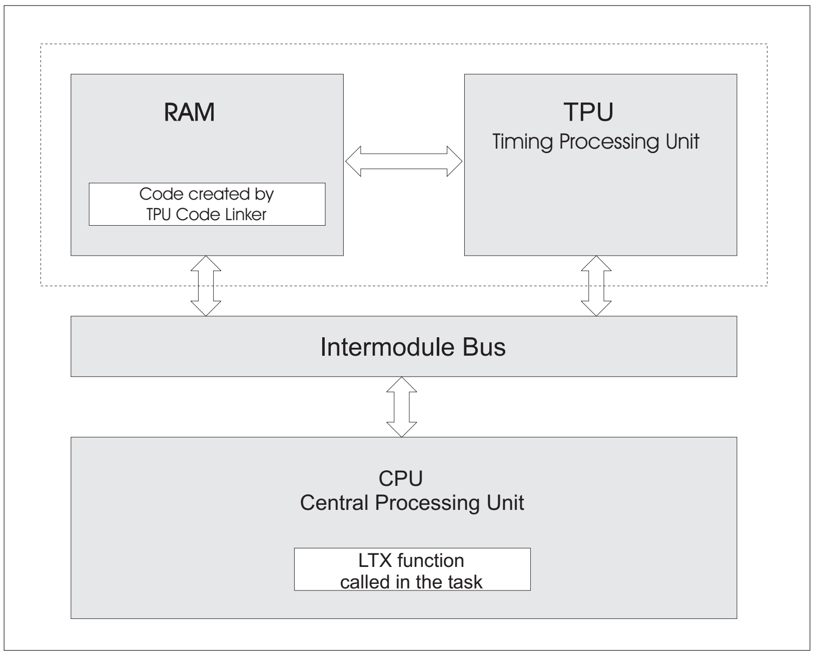


Fig. 10.1: Block diagram of a processor with TPU

After selecting the desired functions , the TPU Code Linker in Automation Studios creates code which is placed in TPU RAM during a warm start by the CPU on TPU capable modules.

Then this memory area can only be accessed by the TPU.

2.3 Functions

- Input recognition / input edge counter
- Output comparator
- Pulse width modulation
- Synchronized pulse width modulation
- Period measurement
- Period measurement with edge recognition
- Position synchronized pulse generator
- Stepper motor control
- Gate measurement

3 TPU MODULES

3.1 B&R AutomationTarget 2003

DI135, DO135, AI261, AI294, AI351, AI354, AI774, AO352, NC161

These screw-in modules can also be operated on the left of the CPU. However, the integration of LTX functions is only possible on the CP interface.

3.1.1 DI135

Features:

- 4 high speed digital inputs 24VDC
- Incremental encoder operation 50 kHz
- Event counter operation 100 kHz
- 1 comparator output 24 VDC

Area of use:

- Period measurement
- Gate measurement
- Incremental encoder / encoder

Typical applications:

- Bottling system, etc.

3.1.2 DO135

Description:

- Digital output module with 4 FET outputs
- Switching voltage 12-24VDC
- Continuous current max. 0.1A
- Max. switching frequency 100 kHz

Area of use:

- Pulse width modulation
- Stepper motor control
- Absolute encoder (SSI)

Typical applications:

- Temperature control for extruders
- Stepper motor control, etc.

Note

All other modules and detailed information are contained in the **2003 User's Manual**.

3.2 B&R AutomationTarget 2005

- IP151
- IP152
- IP161
- IP350

All of these modules have **high speed analog / digital inputs and outputs** which can be accessed using TPU functions. Detailed information and areas of use can be found in the **2005 User's Manual**.

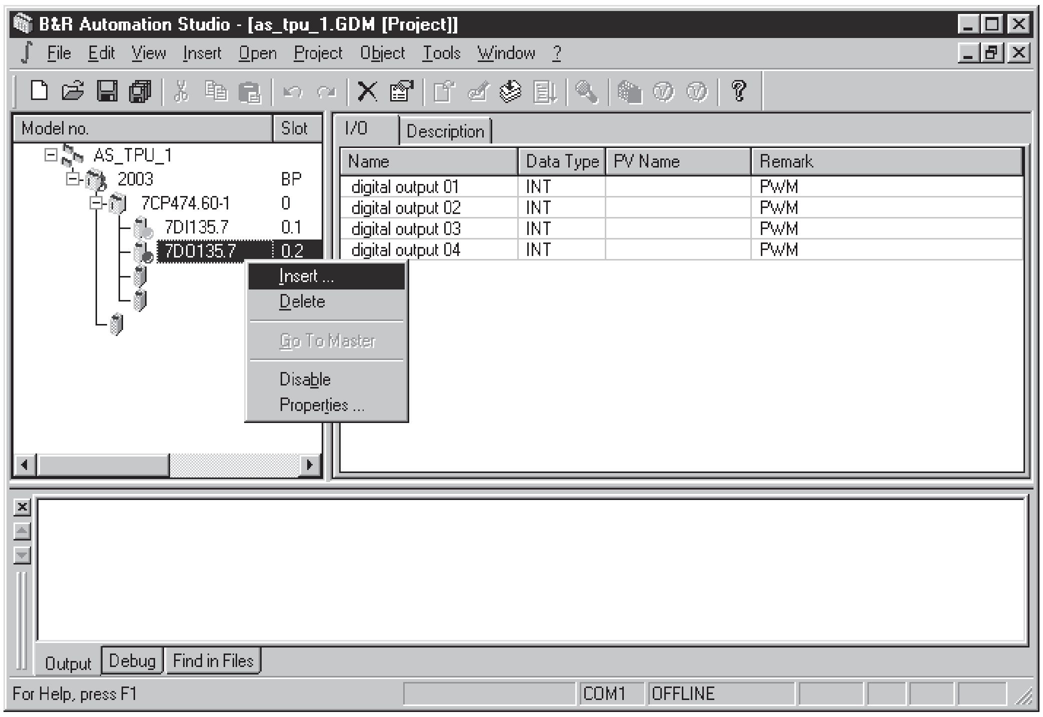
4 LTX FUNCTIONS

4.1 Configuration of the Hardware

In order to work with LTX functions, the required hardware modules must be inserted in AS. The hardware definition can take place in two ways.

- Load hardware configuration from target system
  This method can always be used,
  if the hardware is already available during project creation.

- Insert hardware manually

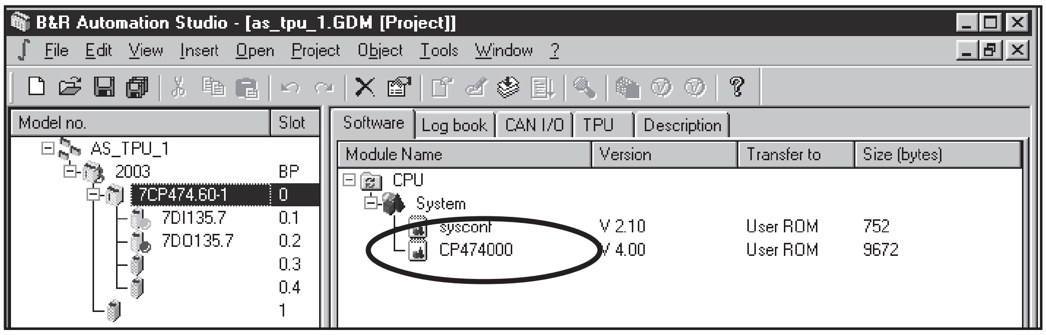


Name	Data Type	PV Name	Remark
digital output 01	INT		PWM
digital output 02	INT		PWM
digital output 03	INT		PWM
digital output 04	INT		PWM

Fig. 10.2: Inserting hardware in AS

4.2 Use of LTX Functions

AS provide the user with a large selection of LTX functions. After inserting such a function block, code is generated which is stored in the folder **CPU -> System**. This code is copied to TPU RAM after a warm start.



B&R Automation Studio - [as_tpu_1.GDM [Project]]

File Edit View Insert Open Project Object Tools Window ?

Model no.	Slot
AS_TPU_1	
2003	BP
7CP474.60-1	0
7DI135.7	0.1
7DO135.7	0.2
	0.3
	0.4
	1

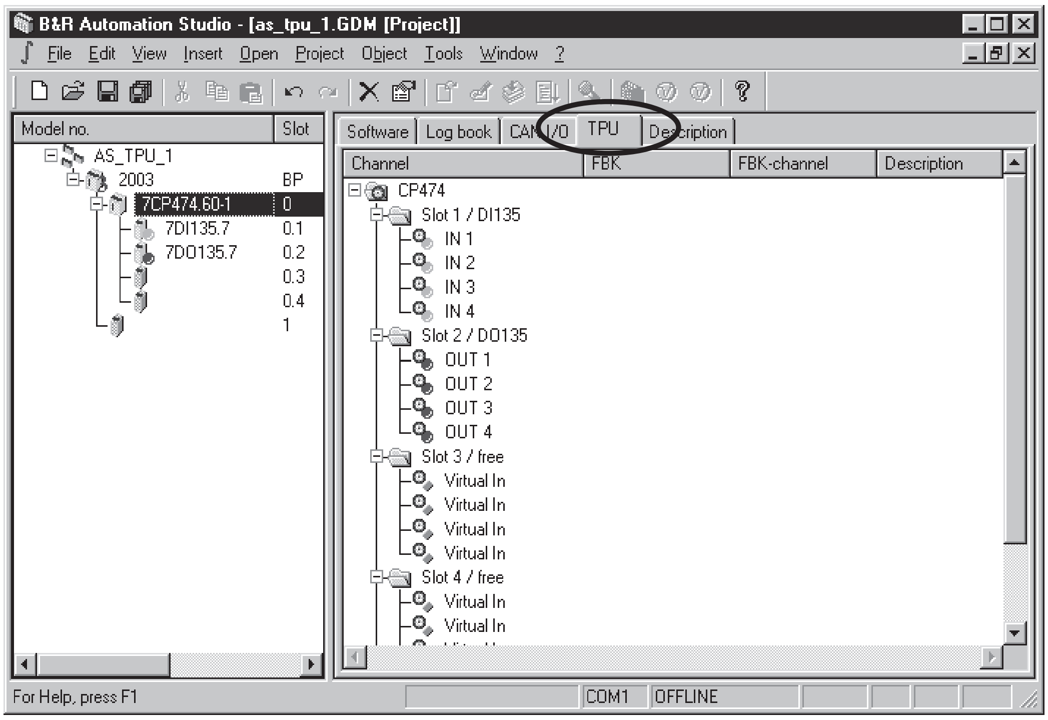
Software | Log book | CAN I/O | TPU | Description

Module Name	Version	Transfer to	Size (bytes)
CPU			
System			
sysconf	V 2.10	User ROM	752
CP474000	V 4.00	User ROM	9672

Fig. 10.3: Importing the library

4.2.1 Inserting LTX Functions

To integrate this FBK, select the TPU tab.



B&R Automation Studio - [as_tpu_1.GDM [Project]]

File Edit View Insert Open Project Object Tools Window ?

Model no.	Slot
AS_TPU_1	
2003	BP
7CP474.60-1	0
7DI135.7	0.1
7DO135.7	0.2
	0.3
	0.4
	1

Software | Log book | CAN I/O | TPU | Description

Channel	FBK	FBK-channel	Description
CP474			
Slot 1 / DI135			
IN 1			
IN 2			
IN 3			
IN 4			
Slot 2 / DO135			
OUT 1			
OUT 2			
OUT 3			
OUT 4			
Slot 3 / free			
Virtual In			
Virtual In			
Virtual In			
Virtual In			
Slot 4 / free			
Virtual In			
Virtual In			

For Help, press F1 | COM1 | OFFLINE

Fig. 10.4: Integrating TPU functions

Note

The TPU tab is only available for modules with TPU functionality.

4.3 Example Gate Measurement

The frequency of a signal should be determined.

The signal comes from a digital output which toggles and is connected with the DI135 input.

- Select a suitable LTX function block
- Calculate the frequency in a timer task class
- Create task with toggle output

Project Name:	tpu_pro1
Task Name:	frq_cnt
Resource:	T#1

Task Name:	toggle
Resource:	???

4.3.1 Gate Measurement Instructions

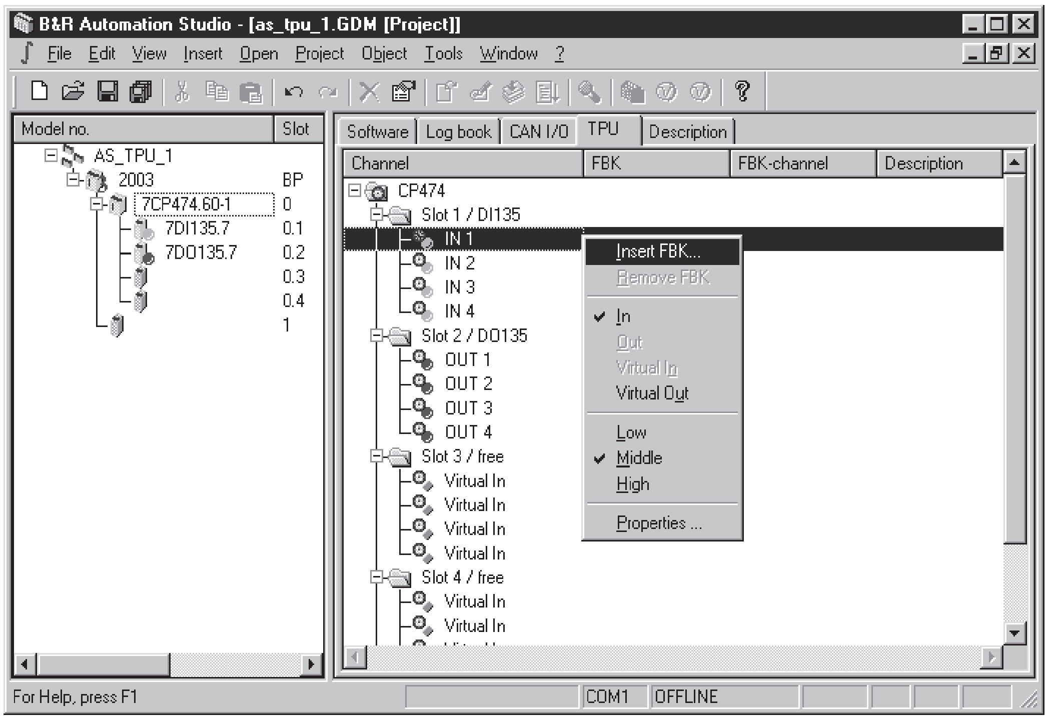


Fig. 10.5: Insert an LTX FBK

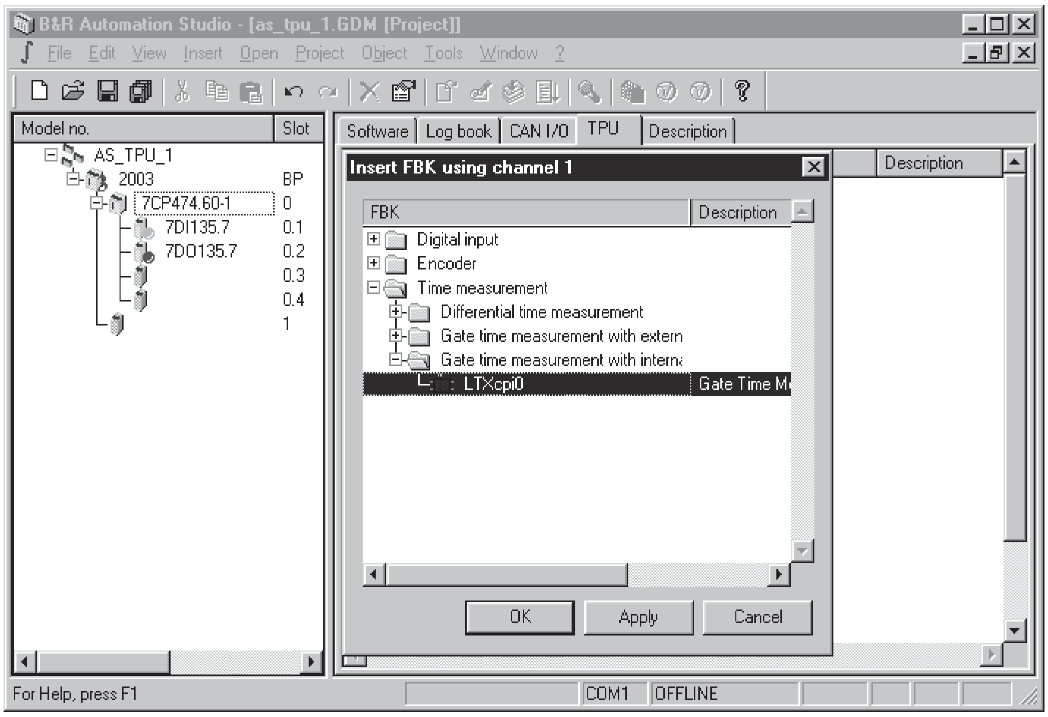

B&R Automation Studio - [as_tpu_1.GDM [Project]]
File Edit View Insert Open Project Object Tools Window ?
Model no. Slot
AS_TPU_1
2003 BP
7CP474.60-1 0
7DI135.7 0.1
7DO135.7 0.2
0.3
0.4
1
Software Log book CAN I/O TPU Description
Description
Insert FBK using channel 1
FBK Description
Digital input
Encoder
Time measurement
Differential time measurement
Gate time measurement with extern
Gate time measurement with interna
LTXcpi0 Gate Time M
OK Apply Cancel
For Help, press F1
COM1
OFFLINE

Fig. 10.6: Select the LTX function

Note

After selecting the FBK, select the CPU tab again for programming. In this way, the code for this function is automatically generated and integrated in CPU->System. The extended help can be opened by pressing the F1 key with the TPU tab selected.

Additionally, a library is imported where the FBKs used are entered. Now it is possible to insert the function blocks in the program.

Inserting a Function in LAD

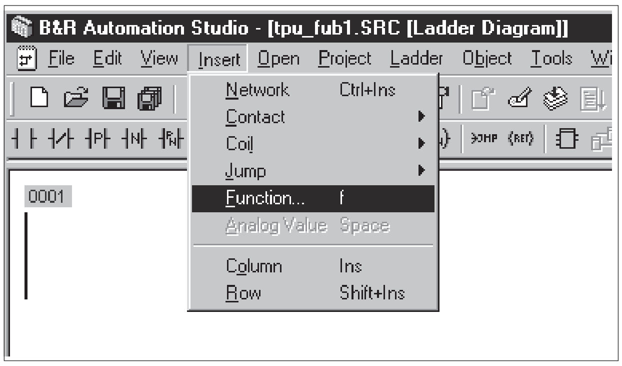
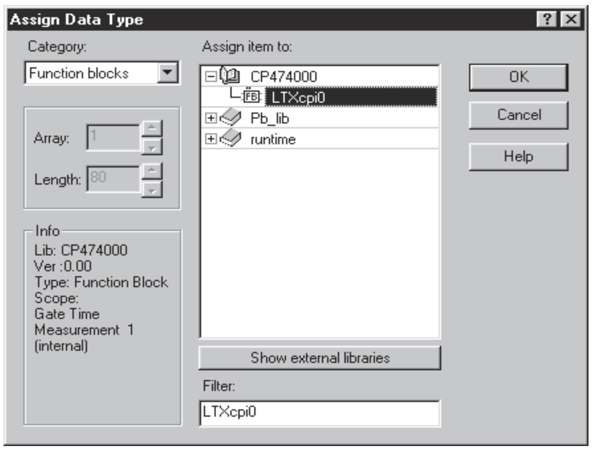

B&R Automation Studio - [tpu_fub1.SRC [Ladder Diagram]]
File Edit View Insert Open Project Ladder Object Tools Wi
Network Ctrl+Ins
Contact
Coil
Jump
Function... f
Analog Value Space
Column Ins
Row Shift+Ins
0001

Fig. 10.7: Inserting the FBK in LAD



Info
Lib: CP474000
Ver :0.00
Type: Function Block
Scope:
Gate Time
Measurement 1
(internal)

Fig. 10.8: Select the desired LTX FBK

Calculating the Frequency:

Using the FBK for gate measurement, the frequency of the signal can nopw be calculated.

Note

The entire solution can be found in help

LIBRARY MANAGER

1 OVERVIEW

Library Manager

The Library Manager is used to manage all libraries used in a project. This chapter provides a detailed description of the characteristics and possibilities of this tool.

B&R Libraries

This chapter contains an overview of the B&R Standards Libraries and an explanation of how they can be inserted in a project and managed.

User Libraries

In addition to the standard B&R functions, the user also has the possibility to create function. These functions can be grouped in libraries.

PG2000 Libraries

How can I add PG2000 Libraries to AS ?

1.1 Functions

1.1.1 Advantages of Functions

Automation Studio provides many standard functions for the user. It is also possible to create functions. The use of functions has the following advantages.

- **Saves time**
  It is possible to use existing functions instead of having to create them.

- **Programs are clearer and easier to service**
  The program code contains parameters which are easy to understand and check.

- **Prevents unnecessary errors**
  B&R standard function blocks are already tested, which prevents possible typing errors or mistakes.

- **Standardization of complex tasks**
  Large or commonly used program sections (positioning, control algorithms, etc.) are thought through once and written in a form that allows users to easily define parameters later.

- **Multiple usage in further projects**
  A function is often used multiple times in a project which allows the solution to be standardized and simplified.

2 LIBRARY MANAGER

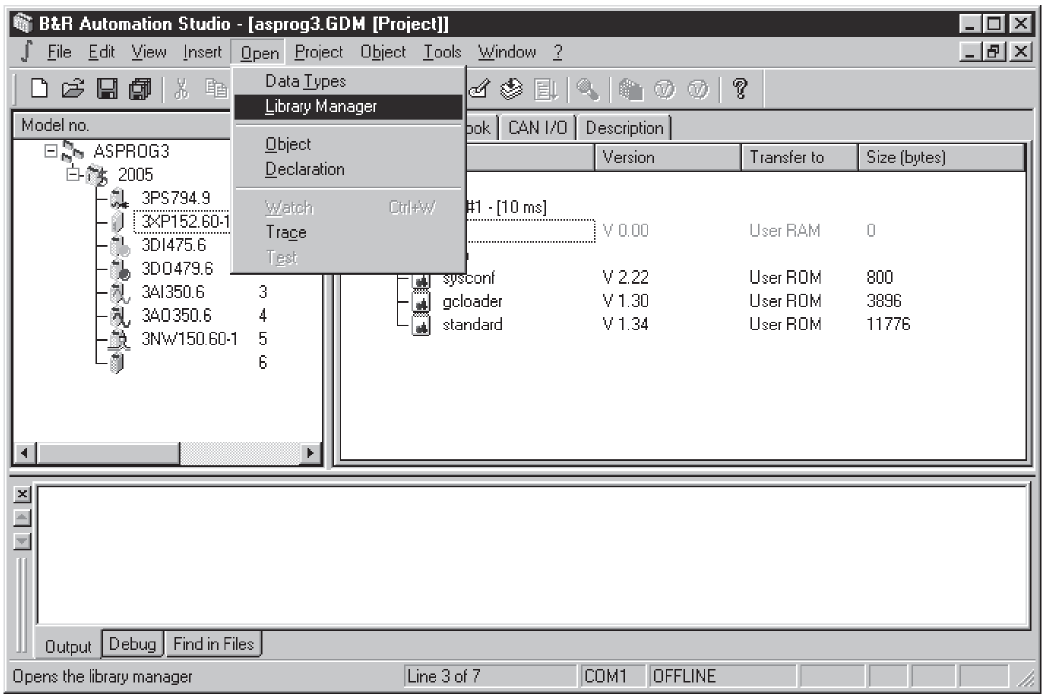
2.1 General Information

The Library Manager (LibMan) is used to manage all libraries which are integrated and defined in project.

With Library Manager, you can:

- Insert B&R standard libraries in a project
- Insert other libraries in a project
- Create and manage libraries
- Manage libraries created in PG2000 with AS

The Library Manager is started using the menu item **Open: Library Manager**.



	Version	Transfer to	Size (bytes)
#1 - [10 ms]			
	V 0.00	User RAM	0
sysconf	V 2.22	User ROM	800
gcloader	V 1.30	User ROM	3896
standard	V 1.34	User ROM	11776

Opens the library manager | Line 3 of 7 | COM1 | OFFLINE

Fig. 11.1: Opening the Library Manager

2.2 Term Definitions

Function

A function is a program organizational unit which returns exactly one value. A function has one or more inputs but only one output. Therefore it can be called in programs in a high level language directly as operand.

```
e.g.: if edgepos(gDiMotorStart) = 1 then
```

Function Block

The FBK ist a program organizational unit which returns one or more values. It has one or more inputs and outputs.

Component

Function or FBK

Library

A library is a group of several components.

B&R Library

The libraries supplied by B&R which are used for B&R system software and hardware functions are described as standard libraries.

User Library / Third Library

Library created by the user or by a third party.

Binary Library

A library without source text.

Source Library

A source library contains the source text for the components. The source code can be changes at any time.

IEC Library

A library with components which are written in the languages B&R AB, ST, etc. When creating such libraries, one of these of these languages can be used for each component.

C Library

A library which is only written in ANSI C. All components are coded in this language.

2.3 Library Guidelines

Libraries are designed to be used again and again. Therefore it is especially important that they are well planned. This chapter shows a short section of the library guidelines. The complete chapter is contained as an appendix.

2.3.1 Assigning Library Names

In order to make libraries easier to identify and service, they should be assigned clear and meaningful names.

- A library should start with three characters which clearly identify the designer (company) of the library. This character combination can consist of letters and/or numbers.
- This character combination should be used for all libraries from the company.
- Library names are presently limited to a maximum of 8 characters and are defined as follows:

dddLllll

Abbreviation:	**Meaning**
ddd	Code for the designer
Lllll	Name of the library

Tab. 11.1: Library name

To improve clarity, the part of the name after the designer should begin with a capital letter. The company code should begin with a small letter so that library names also comply with the format for for variables.

Examples

`br_Arith`

br_	..	Code for B&R
Arith	..	Name of the library

`brTrRGL`

br	..	Code for B&R
Tr	..	Code for training
RGL	..	Code for control components. RGL is written in capital letters because this will also be the code for the components.

2.3.2 Assigning Component Names

Assigning function block and function names plays a very important roll in the appearance of a library. The names should indicate the library that the component belongs to and also has to indicate the functionality.

- Principally, 32 characters are available in AS for component names.
- The first word indicates the library. At least two characters and a maximum of four characters must be used.
- All components in a library begin with the same characters
  e.g.: ctrlValve, ctrlMotor, etc.
- Only the first letter of the individual words are capitals
- The functionality is then written in a clear form

Examples: ArithSum,

ctrlHeatValve

2.3.3 Version Management

Version numbers should be assigned to all libraries. The following format should be used for the version entry.

The version number consists of four characters.

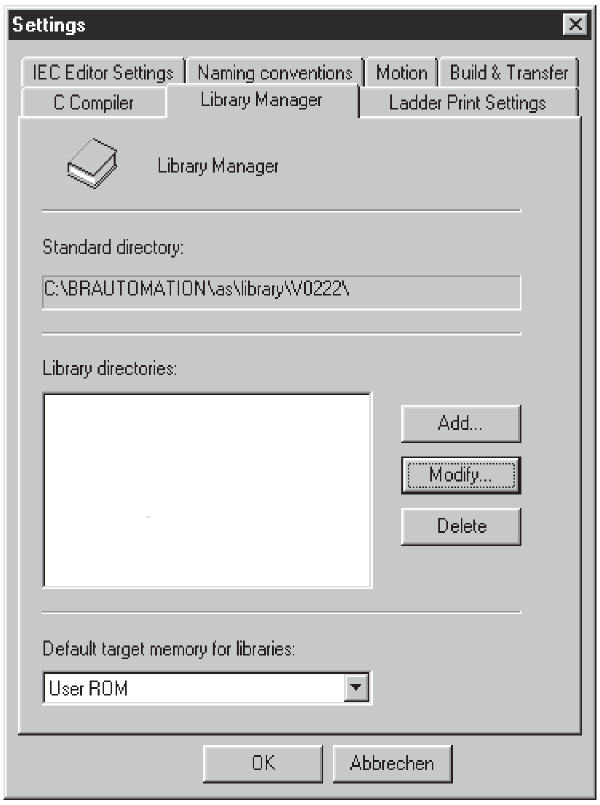
`x.yy.ß:`

x.. Increased by one for large changes. (**yy** becomes **0**)
yy.. Increased by one for all changes

ß.. Used for Beta versions

2.4 Global Settings

General LibMan settings can be made for the project using the menu item **Project: Settings**. The dialog box can also be reached using the menu item **Edit: Properties** if a library is selected in the left LibMan area.



Standard directory:
C:\BRAUTOMATION\as\library\V0222\

Library directories:

Default target memory for libraries:
User ROM

Fig. 11.2: LibMan settings

- **Standard directory**
  Shows the valid library standard directory. The libraries for the project are be taken from here. The path is automatically set by AS and depends on the defined operating system version.
- **Library Directories**
  Additional directories can be entered where LibMan can search for libraries.
- **Standard Target Memory for Libraries**
  The target memory for libraries can be set here.

3 B&R LIBRARIES

3.1 Overview of Standard Libraries

Library	**Short Description**
ASControl	Support of hardware modules
ASMath	Mathematics functions not covered by the Operator library
ASString	Functions for memory manipulation and string handling
BRSystem	Functions for CPU operation
C220man	Functions for panel controller operation
CAN_lib	Functions for CAN controller operation
CANIO	Functions for B&R2003 CAN node operation
Convert	Conversion functions according to IEC61131-3
DM_lib	Storage of data modules in nonvolatile memory
DRV_3964	3964R protocol
DRV_mbus	Modbus protocol
DRV_mn	MiniNet protocol
DVFrame	Frame driver library for serial interface operation
FDD_lib	Serial floppy drive operation
IF361	Operation of IF361 interface module (Profibus DP Slave)
IF661	Operation of IF661 interface module (Profibus DP Slave)
INAclnt	INA2000 client communication
IO_lib	Functions for I/O module operation
NET2000	NET2000 protocol
Operator	IEC61131-3 standard functions
PB_lib	Profibus protocol (FMS)
PPdpr	Functions for exchanging data between CPU and PP
RIO_lib	Functions for remote I/O operation
Runtime	Functions for internal support
Spooler	Allows spooling of data on IPs
Standard	IEC61131-3 standard functions
SYS_lib	Various system functions
TCPIPMGR	Functions for exchanging data using UDP or TCP

Tab. 11.2: Library overview

3.2 Online Help

In AS, an online help system is available for the user with detailed descriptions of all libraries. The help can be opened by pressing the **F1 key in LibMan** .

The online help offers the user various possibilities to search for topics.

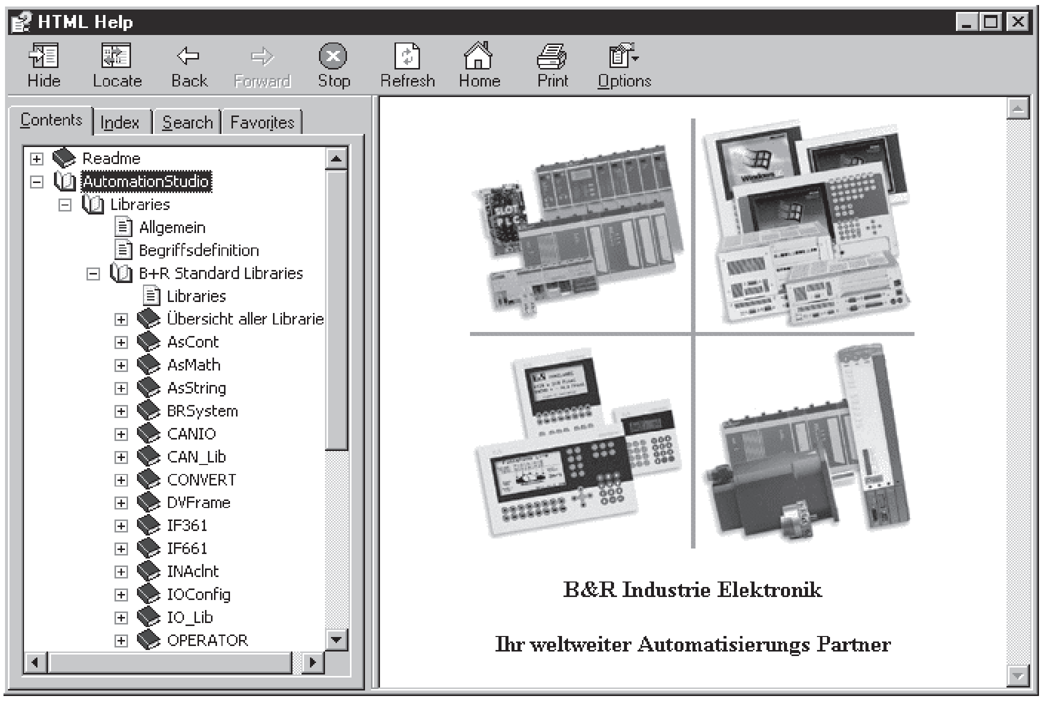


Fig. 11.3: Online help system

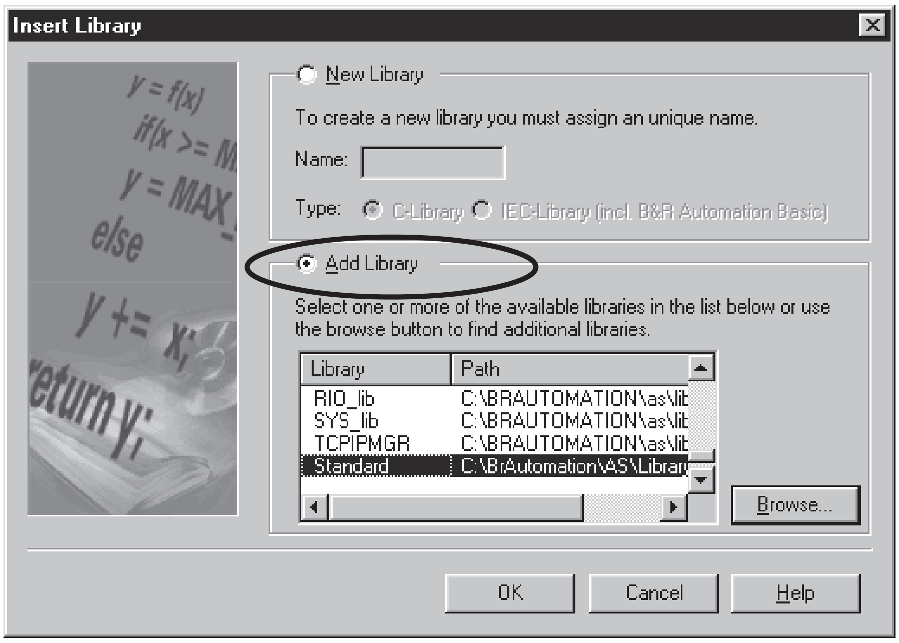
- **Contents**
  Shows an overview of the help topics. Clicking on the main topics opens the lower level topics. Figure 11.3 shows a sample of this page.
- **Index**
  Makes it possible to search for functions or topics.
- **Search**
  Search for certain terms in all topics.
- **Favorites**
  The path to commonly used help topics can be saved here. Simply click on the topic and the corresponding help page is opened.

Example

Open the online help and search for information concerning the function block TON_10ms.

3.3 Insert Library

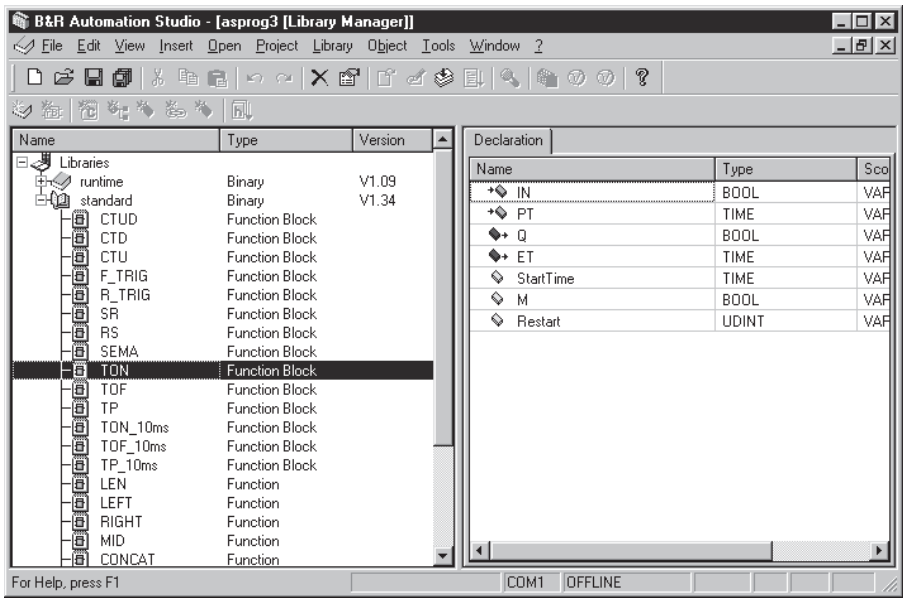
Using the menu item**Insert: Library** or by clicking on the symbol , the required dialog box is opened.


Insert Library
New Library
To create a new library you must assign an unique name.
Name:
Type: C-Library IEC-Library (incl. B&R Automation Basic)
Add Library
Select one or more of the available libraries in the list below or use the browse button to find additional libraries.
Browse...
OK
Cancel
Help

Library	Path
RIO_lib	C:\BRAUTOMATION\as\lib
SYS_lib	C:\BRAUTOMATION\as\lib
TCPIPMGR	C:\BRAUTOMATION\as\lib
Standard	C:\BrAutomation\AS\Library

Fig. 11.5: Insert B&R library

The list only shows libraries found in the standard directory and library directories. However, it is possible to search for libraries in other directories using the **Browse** button. The dialog box that is opened is used to navigate in the directory tree. The “OK” button is only activated when a valid library structure is found in the directory.


B&R Automation Studio - [asprog3 [Library Manager]]
File Edit View Insert Open Project Library Object Tools Window ?
Declaration
For Help, press F1
COM1
OFFLINE

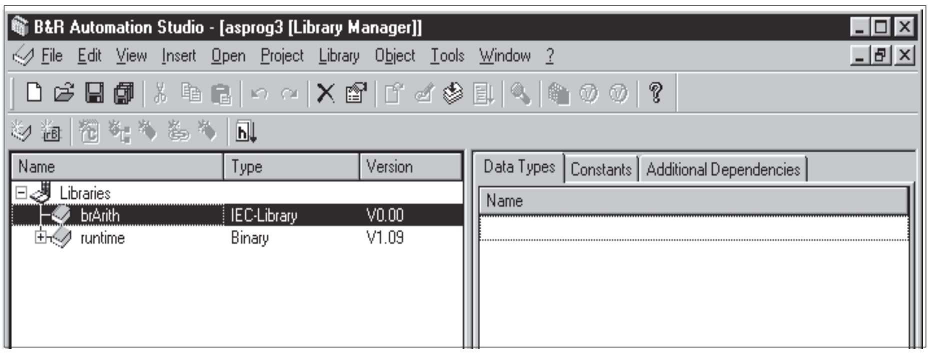
Name	Type	Version
Libraries		
runtime	Binary	V1.09
standard	Binary	V1.34
CTUD	Function Block	
CTD	Function Block	
CTU	Function Block	
F_TRIG	Function Block	
R_TRIG	Function Block	
SR	Function Block	
RS	Function Block	
SEMA	Function Block	
TON	Function Block	
TOF	Function Block	
TP	Function Block	
TON_10ms	Function Block	
TOF_10ms	Function Block	
TP_10ms	Function Block	
LEN	Function	
LEFT	Function	
RIGHT	Function	
MID	Function	
CONCAT	Function	

Name	Type	Sco
IN	BOOL	VAF
PT	TIME	VAF
Q	BOOL	VAF
ET	TIME	VAF
StartTime	TIME	VAF
M	BOOL	VAF
Restart	UDINT	VAF

Fig. 11.6: Standard library inserted

If you select the library on the left side, the following tabs are shown on the right side:

- **Data Types**
  The data types that come with the library are shown here. They can then be used throughout the entire project.
- **Constants**
  The constants required by and included with the library

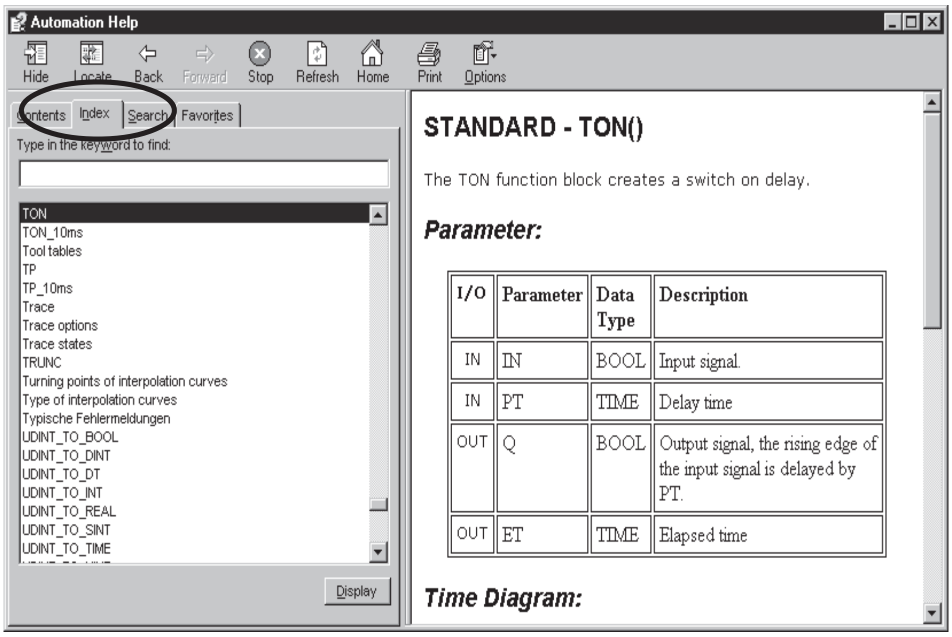

B&R Automation Studio - [asprog3 [Library Manager]]
File Edit View Insert Open Project Library Object Tools Window ?
Data Types
Constants
Additional Dependencies
Name

Name	Type	Version
Libraries		
brArith	IEC-Library	V0.00
runtime	Binary	V1.09

Fig. 11.12: Data types/constants

If a component is selected from a library (see Fig. 11.11), then the respective variable declaration and I/O assignments are shown on the right side.

If detailed information is needed concerning a function block, it can be found in the online help. If the FBK is selected, then the respective page is shown immediately.



STANDARD - TON()

The TON function block creates a switch on delay.

Parameter:

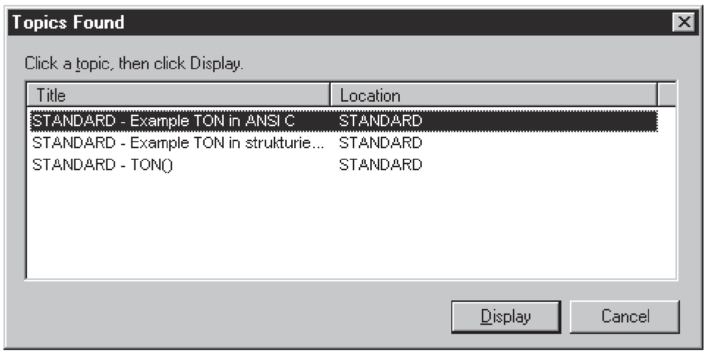
I/O	Parameter	Data Type	Description
IN	IN	BOOL	Input signal.
IN	PT	TIME	Delay time
OUT	Q	BOOL	Output signal, the rising edge of the input signal is delayed by PT.
OUT	ET	TIME	Elapsed time

Time Diagram:

Fig. 11.7: Online help for TON

Additionally, B&R provides customers the possibility to view an example program for inserting the respective component. This is done as follows.

- Search for the component in the online help using the Index tab (see Fig. 11.7)
- Now the program example can be selected in the desired programming language by pressing the Enter key



Title	Location
STANDARD - Example TON in ANSI C	STANDARD
STANDARD - Example TON in strukturie...	STANDARD
STANDARD - TON()	STANDARD

Fig. 11.8: Select programming language

The example shown can then be inserted into the project using copy and paste. The help can be printed at any time.

4 USER LIBRARIES

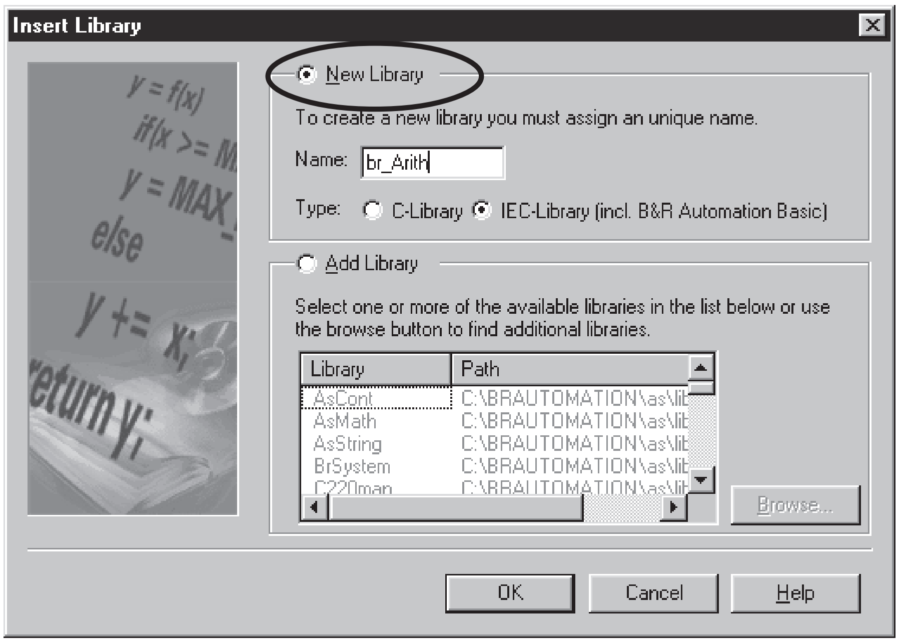
4.1 Creating a Library

LibMan makes it possible for the user to create libraries, in addition to the existing B&R libraries.

4.1 Inserting a Library

After opening LibMan, the dialog box can be opened using menu item **Insert: Library**, or by clicking on the respective symbol. After activating "New Library", the name of the new library can be entered in the input field. It must be a name that was not yet used for any other purpose in the entire project. If a name has already been used, it will not be accepted.

The programming language to be used to create the components in the new library also has to be selected. You have to select if you want to use **ANSI C** or one of the **IEC languages**, including B&R Automation Basic to program the components.


Insert Library

[✓ New Library]

To create a new library you must assign an unique name.

Name: br_Arith

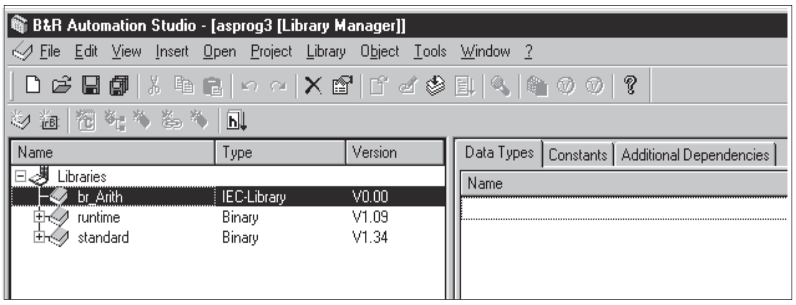
Type: C-Library [✓ IEC-Library (incl. B&R Automation Basic)]

Add Library

Select one or more of the available libraries in the list below or use the browse button to find additional libraries.

Library	Path
AsCont	C:\BRAUTOMATION\as\lib
AsMath	C:\BRAUTOMATION\as\lib
AsString	C:\BRAUTOMATION\as\lib
BrSystem	C:\BRAUTOMATION\as\lib
C220man	C:\BRAUTOMATION\as\lib

Fig. 11.9: Insert Library dialog box


B&R Automation Studio - [asprog3 [Library Manager]]

Name	Type	Version
Libraries		
br_Arith	IEC-Library	V0.00
runtime	Binary	V1.09
standard	Binary	V1.34

File Edit View Insert Open Project Library Object Tools Window ?
Data Types
Constants
Additional Dependencies
Name

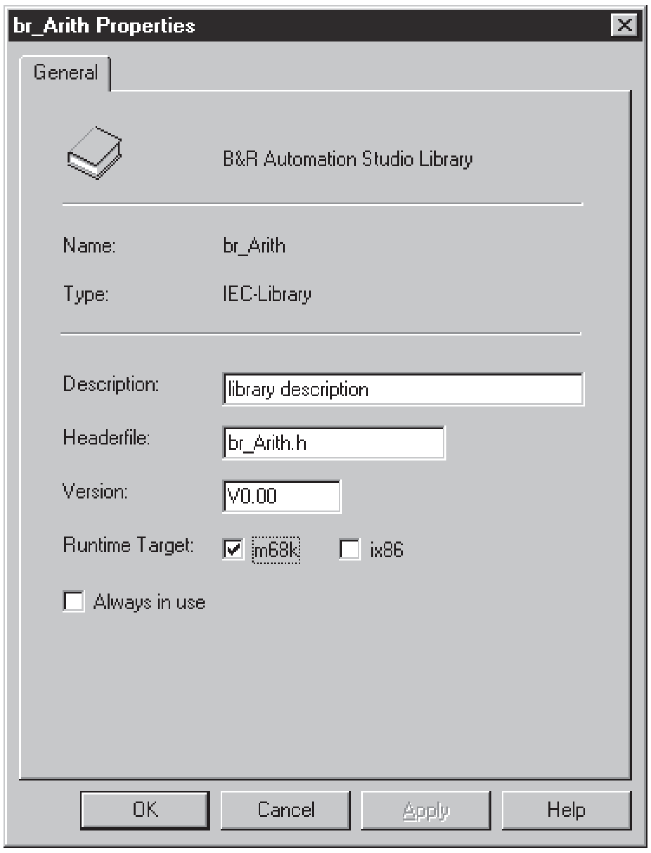
Fig. 11.10: Inserted library

4.1.2 Library Properties

Properties for a library can be reached using menu item **Edit: Properties**. The desired library must be selected on the left side. For source libraries, the dialog box is used to enter and change these properties. For binary libraries, it is only used to display the properties.

If the source code is available in the project, the parameters can be changed. Otherwise the current settings are displayed.

Only the “General” properties are to be set for IEC libraries. For libraries written in ANSI-C, this dialog box contains further registers which will be described later.


br_Arith Properties

B&R Automation Studio Library

Name: br_Arith
Type: IEC-Library
Description: library description
Headerfile: br_Arith.h
Version: V0.00
Runtime Target: [✓ m68k] ix86
Always in use: ☐

Fig. 11.11: Library Properties dialog box

Description:
A short description of the library should be entered here.

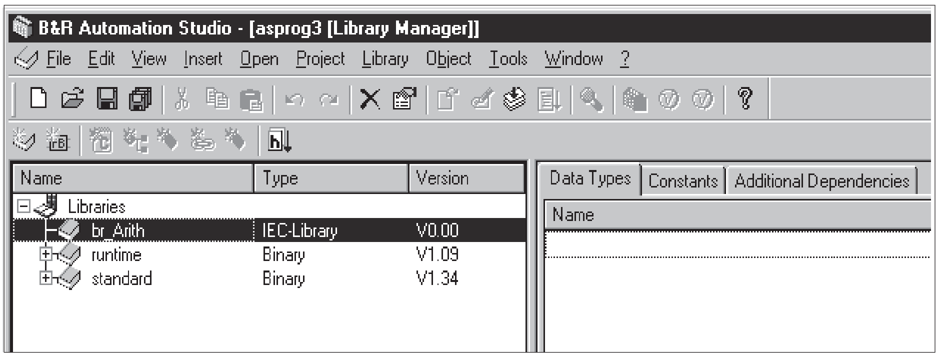
Header File:
Name of the *.h file created for a library. Preset to the name of the library for a new library.

Version:
Version number

Target Platform:
Target platform for which the library was or should be created.

4.1.3 Library Parameters

The parameters can be seen when the desired library is selected on the left side of LibMan.


B&R Automation Studio - [asprog3 [Library Manager]]
File Edit View Insert Open Project Library Object Tools Window ?
Data Types
Constants
Additional Dependencies
Name

Name	Type	Version
Libraries		
br_Arith	IEC-Library	V0.00
runtime	Binary	V1.09
standard	Binary	V1.34

Fig. 11.12: Library parameters

- Data Type
  Here, user data types belonging to the library can be added by clicking on the symbol or using the <Insert> key. However, they must be created first using the menu item **Open: Data Types** so that they can be selected. If a variable is declared as a structure in a library component, this user data type is automatically added.

- Constants
  The constants needed for the library are shown here. Additional constants can be added by clicking on the symbol or using the <Insert> key.

- Additional Dependencies
  When adding a library that other libraries have declared as dependent this will automatically be inserted in the project. When using B&R standard functions, the libraries are automatically added as a dependency. However, only the system module e.g.: standard.br for the library will be copied to the software tree of the project desktop here.

4.2 Creating an IEC Function Block

Before a component can be created, a library must be inserted.

Then select the library that has been created on the left side of LibMan where the component should be added. A new component can be added to the library using the right mouse button or the symbol.

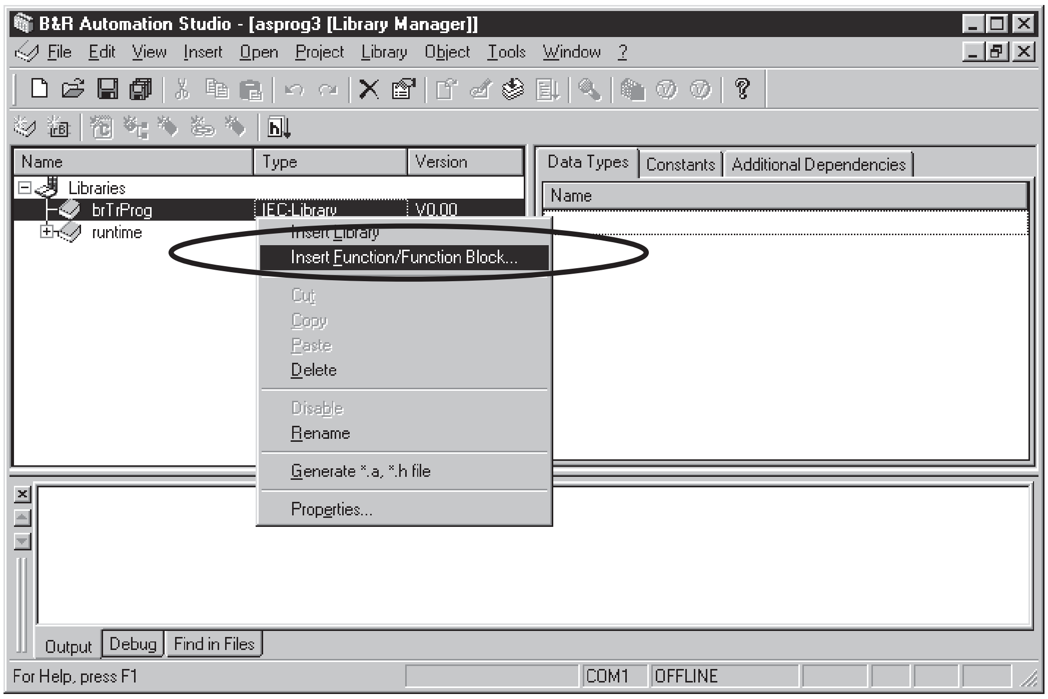
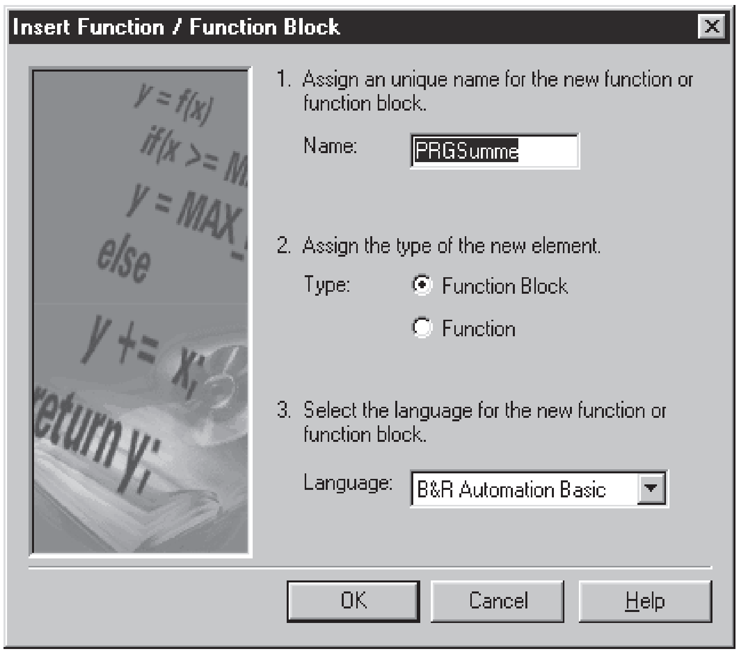

B&R Automation Studio - [asprog3 [Library Manager]]
File Edit View Insert Open Project Library Object Tools Window ?
Name Type Version
Libraries
brTrProg IEC-Library V0.00
runtime
Insert Library
Insert Function/Function Block...
Cut
Copy
Paste
Delete
Disable
Rename
Generate *.a, *.h file
Properties...
Data Types Constants Additional Dependencies
Name
Output Debug Find in Files
For Help, press F1
COM1 OFFLINE

Fig. 11.13: Inserting a function / function block


Insert Function / Function Block

1. Assign an unique name for the new function or function block.

Name: PRGSumme

2. Assign the type of the new element.

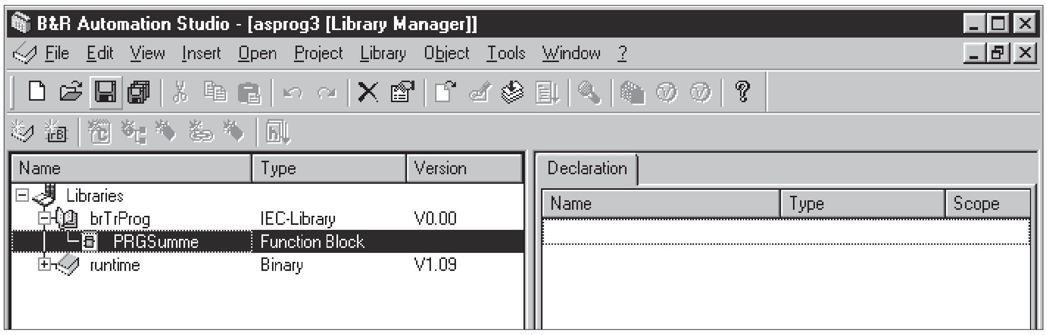
Type: [✓ Function Block] Function

3. Select the language for the new function or function block.

Language: B&R Automation Basic

Fig. 11.14: Inserting Sum FBK

The new component is now shown in LibMan.


B&R Automation Studio - [asprog3 [Library Manager]]
File Edit View Insert Open Project Library Object Tools Window ?
Declaration

Name	Type	Version
Libraries		
brTrProg	IEC-Library	V0.00
PRGSumme	Function Block	
runtime	Binary	V1.09

Name	Type	Scope

Fig. 11.14: Component that was inserted

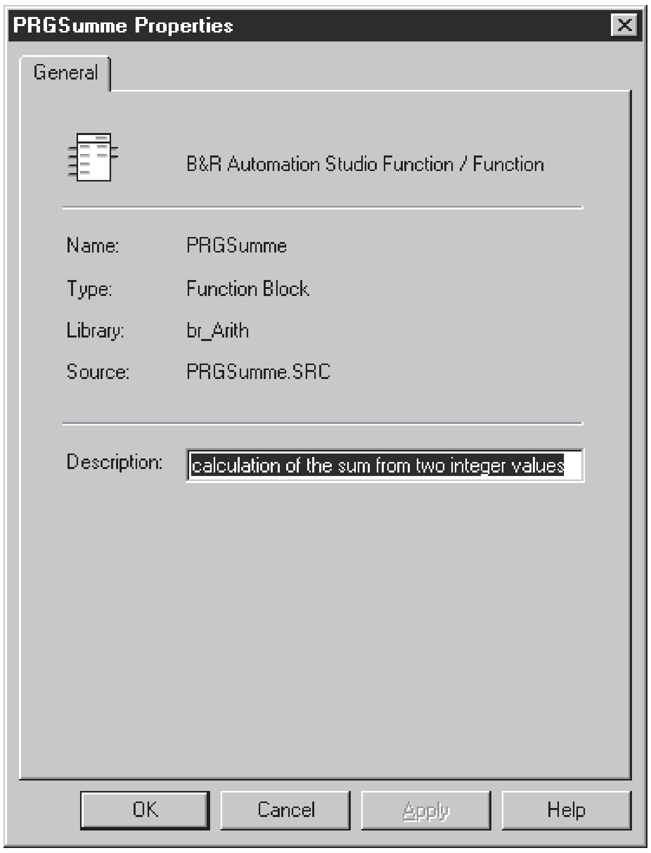
4.2.1 Selecting the Language

With IEC libraries, the user can select between languages STL, ST and AB.

4.3 Function Block Properties

A short “public” description can be added for each component using the menu item **Edit: Properties**

.



B&R Automation Studio Function / Function

Name:	PRGSumme
Type:	Function Block
Library:	br_Arith
Source:	PRGSumme.SRC
Description:	calculation of the sum from two integer values

Fig. 11.15: Component properties

4.4 FBK Interface

The interface for a component is principally the same as the variable declaration in cyclic program sections. The required variables can be entered here. Unlike a “normal variable declaration“, there are additional possibilities to declare a variable here.

- **VAR_INPUT**
  Input paramters

- **VAR_OUTPUT**
  Output parameters

- **VAR**
  Static variables / FBK local

- **VAR_DYNAMIC**
  Dynamic variable in Automation Basic. This variable is only valid in the FBL and has no affect on outside activities.

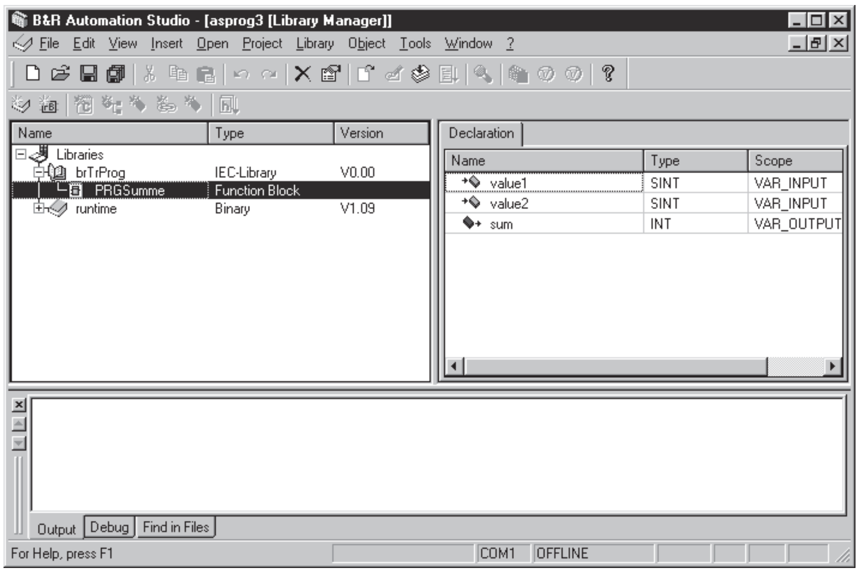
- **VAR_INPUT_DYNAMIC**
  Dynamic input/output parameters:
  They are assigned the respective pointer by the ADR function. That means that an address must be connected to this input. Access using the pointer takes place automatically in the FBK.

Note

If variables are used in the component source code which are not yet entered in the declaration, the “Auto Declaration Dialog Box” is shown.

4.5 Source Code for the Function Block

To enter the source code, simply select the desired component on the left side of LibMan and press the <Enter> key.

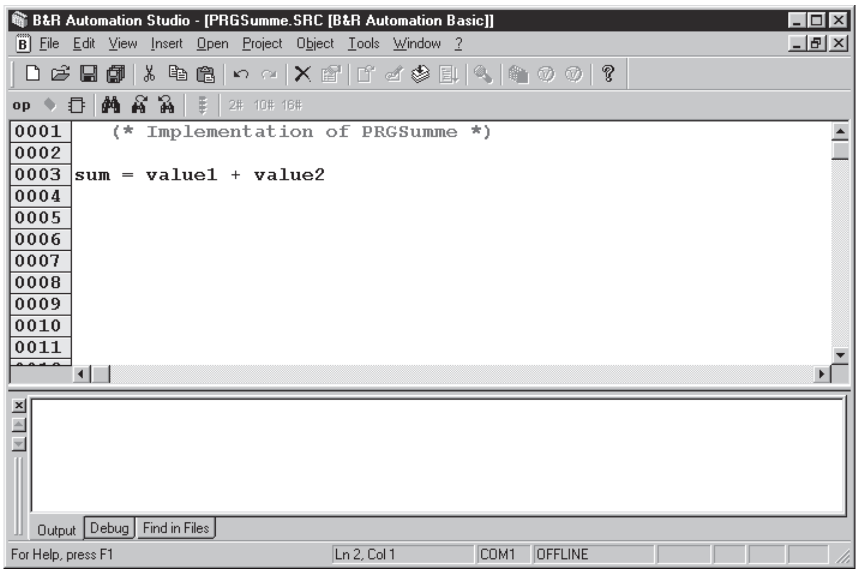

B&R Automation Studio - [asprog3 [Library Manager]]
File Edit View Insert Open Project Library Object Tools Window ?
Declaration
Output Debug Find in Files
For Help, press F1
COM1 OFFLINE

Name	Type	Version
Libraries		
brTrProg	IEC-Library	V0.00
PRGSumme	Function Block	
runtime	Binary	V1.09

Name	Type	Scope
value1	SINT	VAR_INPUT
value2	SINT	VAR_INPUT
sum	INT	VAR_OUTPUT

Fig. 11.16: Selected FBK

The editor will be opened according to the language selected for the component. The code for the FBK can now be entered.


B&R Automation Studio - [PRGSumme.SRC [B&R Automation Basic]]
File Edit View Insert Open Project Object Tools Window ?
Output Debug Find in Files
For Help, press F1
Ln 2, Col 1
COM1 OFFLINE

```
   (* Implementation of PRGSumme *)

sum = value1 + value2
```

Fig. 11.17: Source code for the Sum FBK

After closing the editor, the component is saved and is complete.

Now the component can be used in the project just like the standard components.

4.5.1 Heating Example I

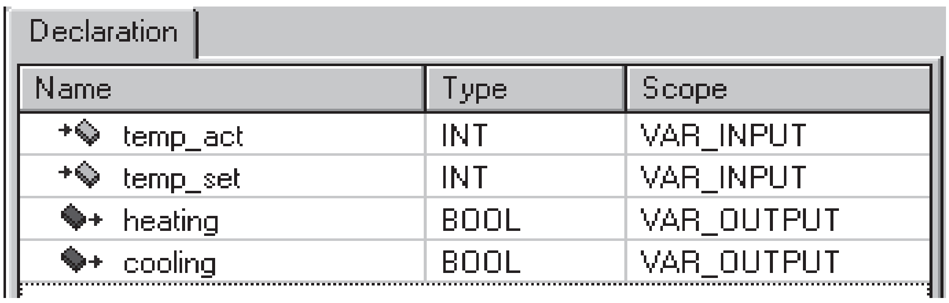
The temperature of a room should be monitored.

If the actual temperature “temp_act” is higher than the set temperature “temp_set”, then the variable “cooling” should be set to one.

If the actual temperature “temp_act” is lower than the set temperature “temp_set”, then the variable “heating” should be set to one.

Heating control should be integrated in a FBK which is then called in a LAD task.

- **Creating the heating control FBK in B&R AB**


Declaration

Name	Type	Scope
temp_act	INT	VAR_INPUT
temp_set	INT	VAR_INPUT
heating	BOOL	VAR_OUTPUT
cooling	BOOL	VAR_OUTPUT

Fig. 11.18: FBK Interface

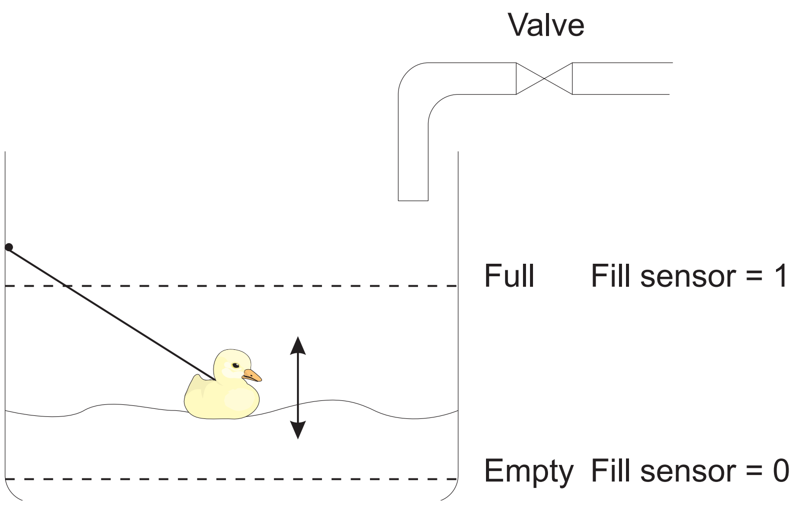
- **Using the FBK in a LAD task**

FBK Name:	PRGHeating
Task Name:	test_fbk
Resource:	?
Project:	libman.pgp

4.5.2 Fill Level Monitoring

Procedure:
A container should be filled with a liquid. The fill level constantly changes when adding the liquid, therefore make sure that the valve is only closed when the fill level is over the switch off level for at least 10 seconds.

Diagram:



- Handle monitoring in a FBK
- Test the FBK in B&R AB

FBK Name:	PRGSwimmer
Task Name:	?
Project:	libman.pgp

4.6 Creating Online Help

It is relatively easy to create online help for user libraries.

An HTML editor and the program “Html Help Workshop” which can be download free of charge from Microsoft via the Internet

```
http://msdn.microsoft.com/library/tools/htmlhelp/chm/hh1start.htm
```

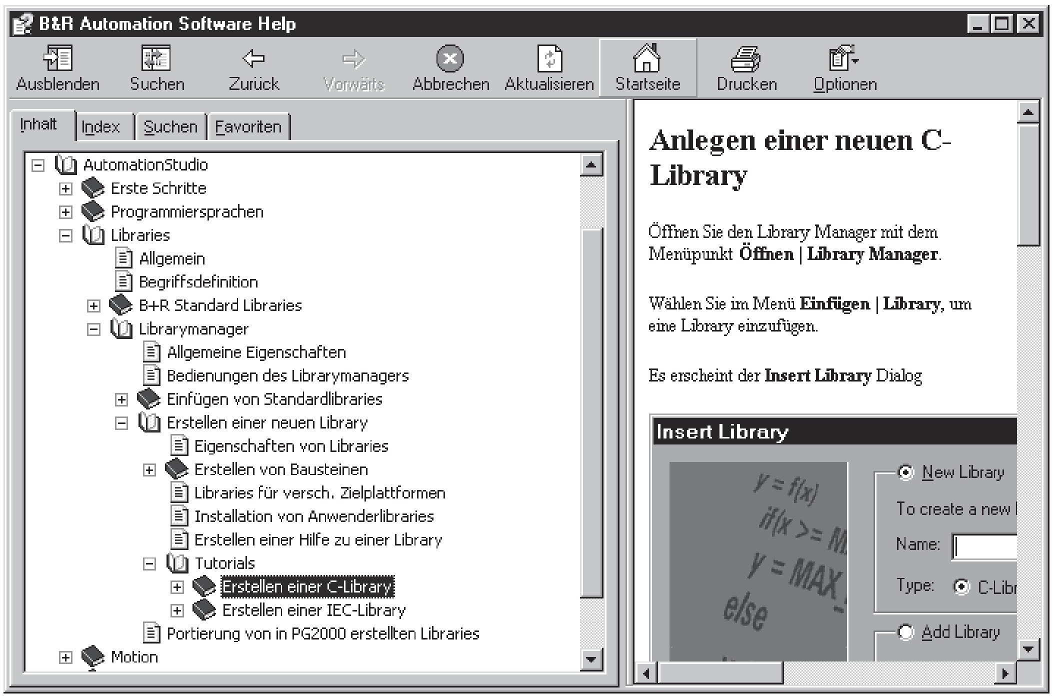
.

It is even easier to create help with tools like “Robohelp” or **“FAR”**, but they are not free of charge.

4.7 Creating a C Library

The procedure is almost the same as with IEC libraries. The main difference is that the source code for the component is not added directly by double clicking on the function, instead must be added as source files.

Detailed information can be found in the online help. There is a tutorial that explains the exact procedure.


B&R Automation Software Help
Ausblenden
Suchen
Zurück
Vorwärts
Abbrechen
Aktualisieren
Startseite
Drucken
Optionen
Inhalt
Index
Suchen
Favoriten
AutomationStudio
Erste Schritte
Programmiersprachen
Libraries
Allgemein
Begriffsdefinition
B+R Standard Libraries
Librarymanager
Allgemeine Eigenschaften
Bedienungen des Librarymanagers
Einfügen von Standardlibraries
Erstellen einer neuen Library
Eigenschaften von Libraries
Erstellen von Bausteinen
Libraries für versch. Zielplattformen
Installation von Anwenderlibraries
Erstellen einer Hilfe zu einer Library
Tutorials
Erstellen einer C-Library
Erstellen einer IEC-Library
Portierung von in PG2000 erstellten Libraries
Motion

Anlegen einer neuen C-Library

Öffnen Sie den Library Manager mit dem Menüpunkt **Öffnen | Library Manager**.

Wählen Sie im Menü **Einfügen | Library**, um eine Library einzufügen.

Es erscheint der **Insert Library** Dialog

Fig. 11.18: Tutorial for creating a C library

4.8 Reusing Libraries

To reuse a library, the following steps must be carried out.

- **Copy the library from the current project**

  C:\Projekte\ASProg.pgp\Library\ “Name of the library“

  This library directory, which exists in all projects, contains all libraries included in the project.

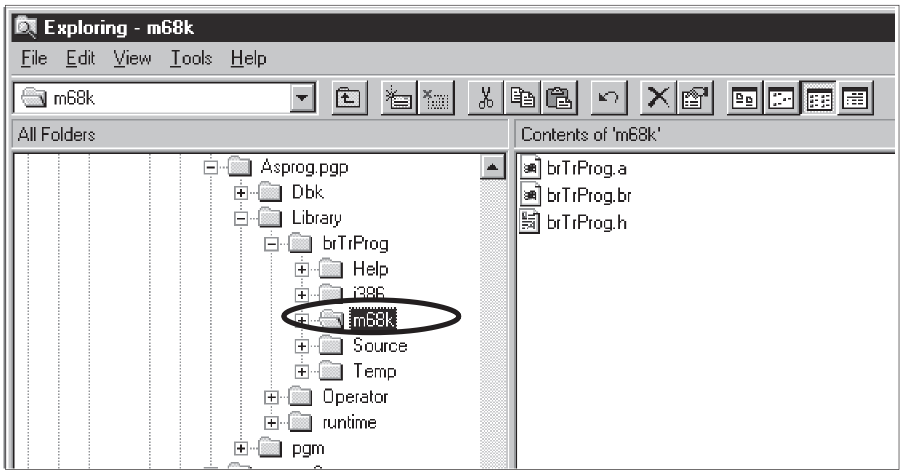


Fig. 11.19: Library directory structure

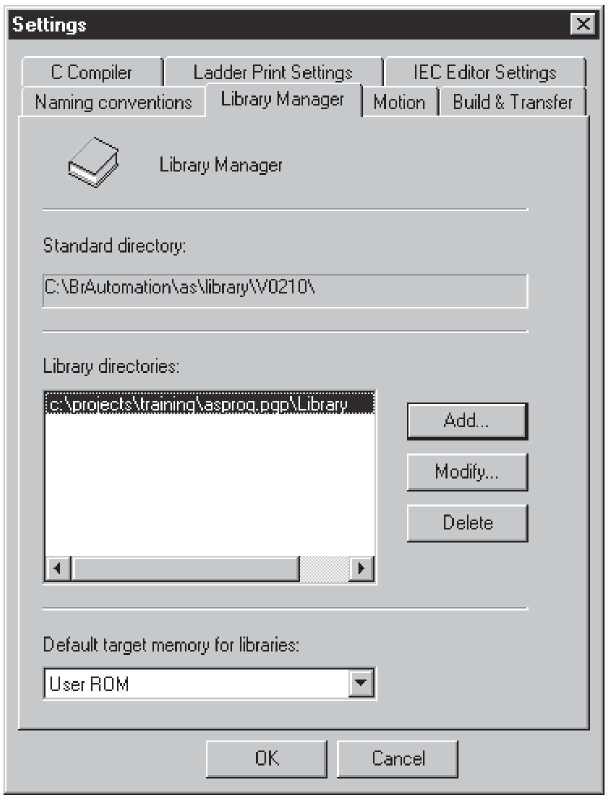
The library directory is divided into five subdirectories:

Help:	Online help, if available
i386:	Library files for Intel platform (*.br, *.h, *.a File)
m68k:	Library files for Motorola platform (*.br, *.h, *.a File)
Source:	Source files for the component are stored here. If these source files are deleted, the component can no longer be edited.
Temp:	Temporary directory

- **Inserting the library in a standard directory**
  In order to be able to manage libraries correctly, it makes sense to create a separate directory in the AS path.

  e.g.: C:\BrAutomation\AS\Library\User\ "Name of the library"

- **Add library directory to LibMan**
  In the new project, the path for the user libraries has to be entered. Now the library can be inserted like standard libraries.



Standard directory: C:\BrAutomation\as\library\V0210\

Library directories: c:\projects\training\asprog.pgp\Library

Default target memory for libraries: User ROM

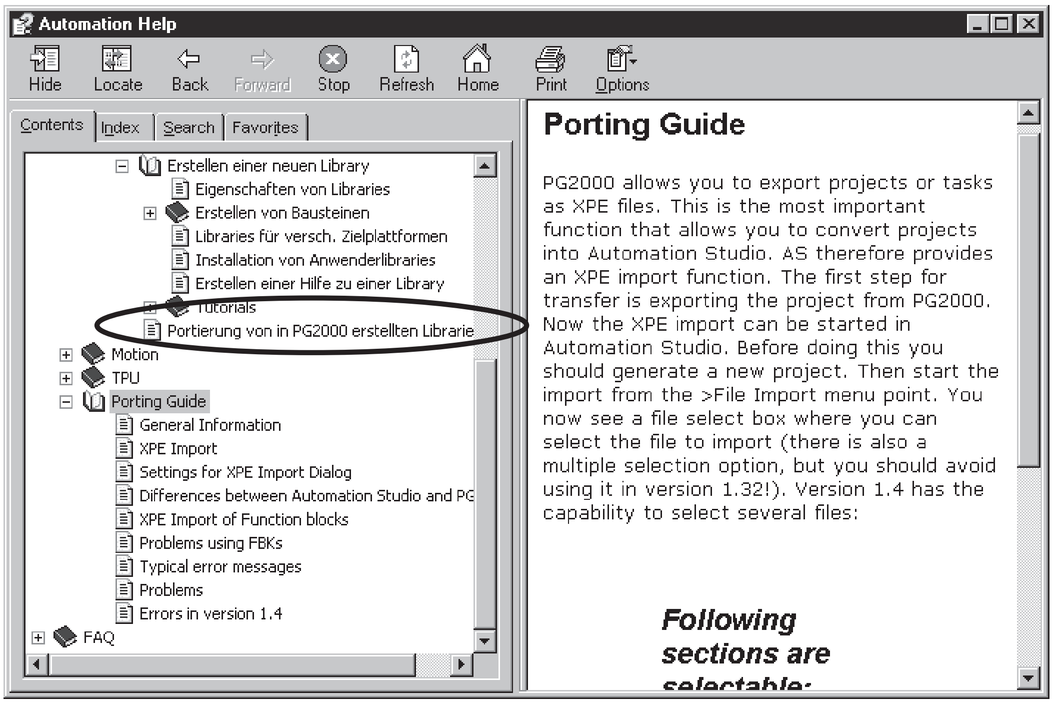
Fig. 11.20: Path settings in LibMan

5 PG2000 LIBRARIES

There are some differences between Automation Studio and PG2000, therefore instructions are available to simplify conversion from PG2000 to Automation Studio. Automation Studio provides a function which allows these libraries to be imported.

5.1 PG2000 Porting Guide

This tool can be found in the online help for LibMan. The Porting Guide provides detailed instructions for converting PG2000 libraries.


Automation Help
Hide
Locate
Back
Forward
Stop
Refresh
Home
Print
Options
Contents
Index
Search
Favorites
Erstellen einer neuen Library
Eigenschaften von Libraries
Erstellen von Bausteinen
Libraries für versch. Zielplattformen
Installation von Anwenderlibraries
Erstellen einer Hilfe zu einer Library
Tutorials
Portierung von in PG2000 erstellten Librarie
Motion
TPU
Porting Guide
General Information
XPE Import
Settings for XPE Import Dialog
Differences between Automation Studio and PG
XPE Import of Function blocks
Problems using FBKs
Typical error messages
Problems
Errors in version 1.4
FAQ

Porting Guide

PG2000 allows you to export projects or tasks as XPE files. This is the most important function that allows you to convert projects into Automation Studio. AS therefore provides an XPE import function. The first step for transfer is exporting the project from PG2000. Now the XPE import can be started in Automation Studio. Before doing this you should generate a new project. Then start the import from the >File Import menu point. You now see a file select box where you can select the file to import (there is also a multiple selection option, but you should avoid using it in version 1.32!). Version 1.4 has the capability to select several files:

Following sections are

Fig. 11.21: PG2000 Porting Guide

ANSI C

1 OVERVIEW

B&R offers the right programming language for every application and for every programmers preference. This includes:

- Ladder Diagram (LAD)
- Instruction List (IL)
- Structured Text (ST)
- Sequential Function Chart (SFC)
- B&R Automation Basic (AB)
- ANSI C

LAD	Contact, logic and function operations are combined here in a single user interface. Ladder diagram is the simplest form of programming digital and analog processes because of its similarity to a circuit diagram.
IL	Instruction list is similar to a machine language. It can be used like LAD for logic operations.
ST	This high level language is a clear and powerful programming language for automation systems. Simple standard constructs guarantee fast and efficient programming.
SFC	A sequential language that was developed to separate a task into clear units. SFC is well suited for processes where states change in steps, for example: automatic carwash.
AB	This B&R high level language is a clear and powerful programming language for automation systems of the newest generation. Simple standard constructs guarantee fast and efficient programming. Previously PL2000
ANSI C	**This high level language is a powerful programming language for automation systems of the newest generation. Simple standard constructs guarantee fast and efficient application programming.**

2 ANSI C

2.1 Development History

C is a programming language which was developed in the 70s together with UNIX at AT&T Bell Laboratories by Dennis M. Ritchie. It uses and expands on the language “B” which was developed by Ken Thompson. This is how “C” came to be. Since then, this programming language has continued its course of success in all areas of programming.

In 1978, Brian Kerninghan and Dennis Ritchie wrote the “K&R White Book” “The C Programming Language”. Kerninghan wrote the main text and Ritchie wrote the technical sections.

Because it is used in many different areas, it became necessary to standardize the language. Tis was done by the **A**merican **N**ational **S**tandards **I**nstitute **ANSI** in 1983. Then is became possible to implement the language on different platforms.

2.1.1 Why use a high level language?

Using language constructs eases programming of control tasks and makes a program created with this language much easier to read. Programs can be achieve much higher performance than with normal PLC programming languages.

2.2 Definition of Terms

High Level Language	Common term for programming languages which allow problem oriented formulation and function independent of the computer type where they are running. e.g.: C, PASCAL, ST, AB
C	Structured Programming Language.
ANSI	Abbreviation for: **A**merican **N**ational **S**tandards **Institute**.
ANSI C	Standardized “C”
Source Code	Consists of programming commands created by the programmer with a text editor and saved in a file. This file contains the source code. This code is compiled and can then be transfered and executed on controllers, PCs etc.
Source	Short form of source code.
File / Program / Document	The basic memory unit on a PC. Documents and programs are files. Different data types are possibly assigned different symbols.
Folder	A folder can contain files and other folders. To make things clearer, place your work in folders just like you would in your office or at home. Your directories are shown as folders.
Directory / Path	In text oriented operating systems, directory names or paths are used to store files instead of graphic symbols (folders).
Directory Tree	In order to display directories in a clear manner, programs (e.g.: Windows Explorer) show directories as tree structures.

Editor The C editor is a text editor for C source code. The programmer is shown possible entry errors when programming using syntax coloring. This signiicantly reduces programming times because syntactic programming errors are ruled out.

CommandsEach command in C must be terminated with a semicolon.

e.g.: res = a + b;

Comment

Meaningful comments placed in the program make orientation easier for longer source codes. Additionally, the code is clear and easy to follow, even after a long period of time.

Comments are terminated using "/*" and "*/".

Comments can be written over several lines.

```
e.g.: /*    This is a comment.
            And this is the second line.  */
```

2.3 Command Groups

An overview of the operator types:

- Primary operators
  e.g.: Brackets: a = (b+c) * d;

- Unary operators
  e.g.: Negation: a = !b;

- Arithmetic operators

- Shift operators

- Compare operators

- Bit oriented operators

- Logic operators

- Ternary operators
  Operator for conditional expressions

- Assignment operators

- Comma operator

Note

In this section, we will only explain the operators that are meaningful for getting started in C with B&R controllers.

Primary operators

Instruction	Description	Example

( )	Brackets	value = a * b - c; or
		value = a * (b - c);

Unary operators

Instruction	Description	Example
!	Unary Negation	a = !b;

Arithmetic operators

Instruction	Description	Example
=	Assignment	a = b;
+	Addition	a = b + c;
-	Subtraction	a = b - c;
*	Multiplication	a = b * c;
/	Division	a = b / c;
%	Modulo (remainder of division)	a = b % c;

Compare operators

Instruction	Description	Example
<	less than	if (a < b)
>	greater than	if (a > b)
<=	less than or equal to	if (a <= b)
>=	greater than or equal to	if (a >= b)
==	equal to	if (a == b)
!=	not equal to	if (a != b)

Bit oriented operators

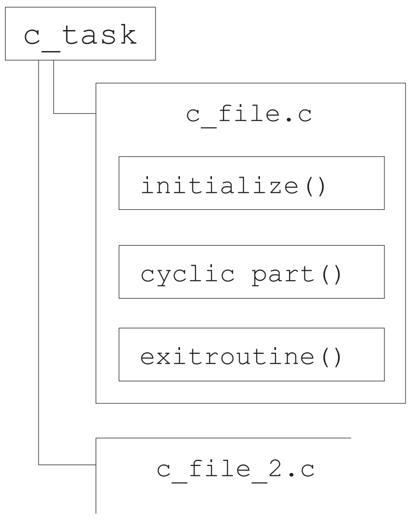
Instruction	Description	Example
&	And - bit mode	a = b & c;
|	Or - bit mode	a = b | c;
^	Or - exclusive	a = b ^ c;

Logic operators

Instruction	Description	Example
&&	And	if (a > 0) && (b > 0)
||	Or	if (a > 0) || (b > 0)

3 STRUCTURE OF C PROGRAMS

Like any other task, a C task can consist of several functions.



Code blocks are represented in C using curved brackets.

{ Start code block

} End code block

Now we will show the individual possibilities using an example:

The following C code increases a counter variable each time the function with the name "CyclicFunction(..)" is called, or is set to a start value by calling the function "Initialization(..)" and is set then to an end value when starting the function "Terminate(..)".

```
INT  variable;                     /* Declaration of the variables */

void Initialization(void)

{
     variable =    1;              /* Assign start value   */
}

void CyclicFunction(void)

{
     variable = variable + 1;      /* Value increased by 1 */
}

void Terminate(void)

{
     variable = 0;                 /* Reset value          */
}
```

3.1 B&R Expansions

3.1.1 Include Files

In order to use certain possibilities on the PCC, we will first include the header file: "**plc.h**" which contains definitions for all necessary macros using the following instruction:

```
#include <bur\plc.h>
```

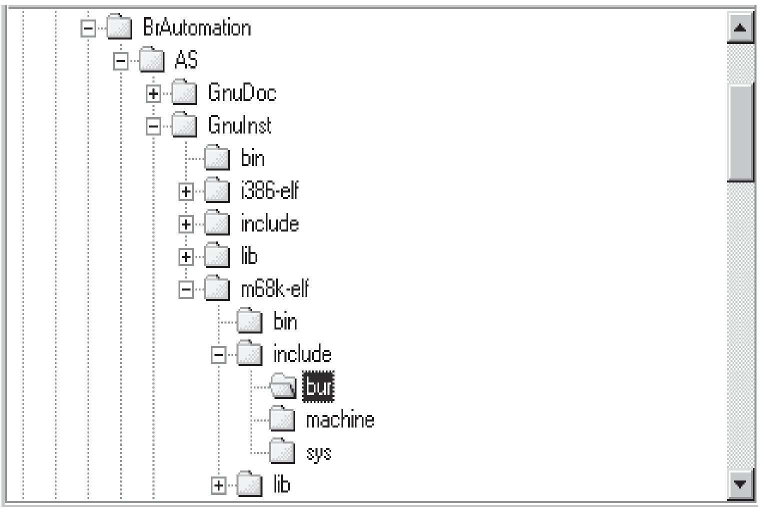


Fig. 12.1: Directory structure

Like all other B&R system header files, the header file "plc.h" is found in the AS install directory:

```
BrAutomation\AS\GnuInst\m68k-elf\include\bur\plc.h
```

and can be added to the C task by marking the C task name and pressing the [ENTER] key, or using the main menu item **Insert: File**. This is not absolutely necessary, but has the advantage of continually monitoring the header file for changes.

3.1.2 Analyzing the Entries in the Header File “plc.h”

- Definition of the Variables:

Macro name/ Attribute	**Function**
_GLOBAL	Code for a PCC global variable.
_LOCAL	Code for a task local variable.

- Definition of the Functions:

Macro name/ Attribute	**Function**
_INIT	Code for an INIT routine. Only executed when booting the PCC with a cold start, warm start, or when transferring a task.
_CYCLIC	Code for the function which is called cyclically. The function name **cannot be “main”**
_EXIT	Code for the EXIT routine. Called once when deinstalling the task. Also executed when the task is transferred again.
_NONCYCLIC	Code for a function which is executed in the system idle time. (only for special applications)

Using this macro in our C program results in the following code:

```
#include “plc.h“                /** B&R-Standard files     **/


_GLOBAL INT   variable;         /** PCC-global variables   **/



/**  This function is only used when booting the PCC,
     or when downloading the task             **/
_INIT void Initialization(void)
{
     variable = 1;     /** Assign start value              **/
}



/** This function is executed cyclically                   **/
_CYCLIC void CyclicFunction(void)
{
     variable = variable + 1;   /** Value increased by 1   **/
}



/**       This function is only called when deinstalling
          the task                                         **/
_EXIT void Terminate(void)
{
     variable = 0;     /** Reset value                     **/
}
```

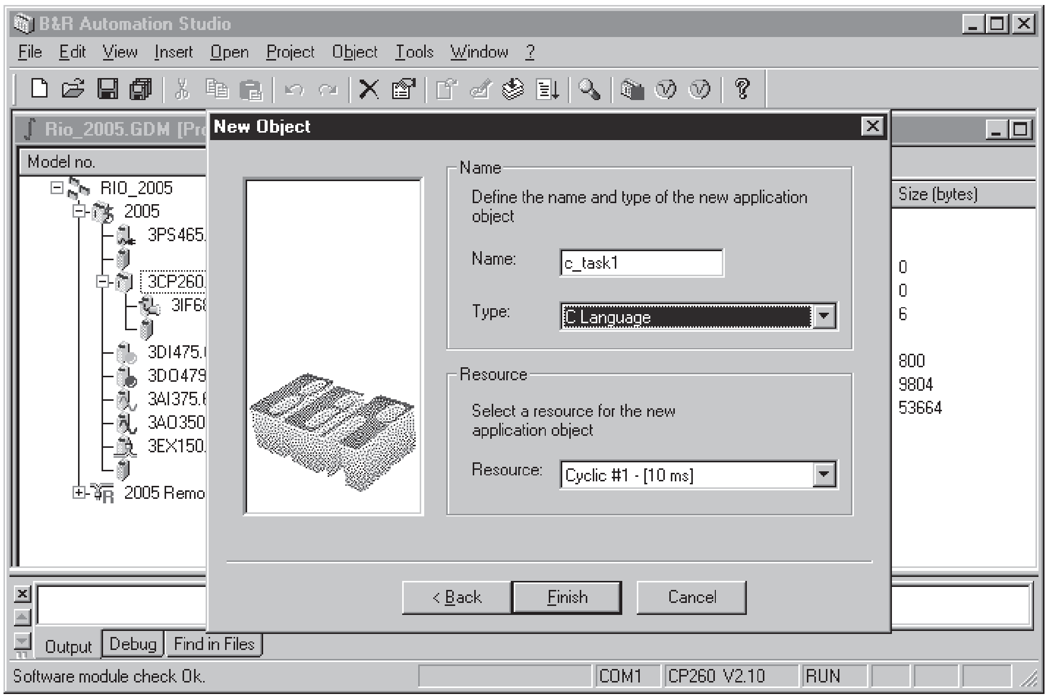
Example

Create a new project and test the previous example using line coverage.

Project Name:	c_proj
Task Name:	c_task1
Resource:	C#3

3.2 Creating a C Task

C tasks are inserted in the project just like LAD tasks.


B&R Automation Studio
File Edit View Insert Open Project Object Tools Window ?
New Object
< Back
Finish
Cancel
Output Debug Find in Files

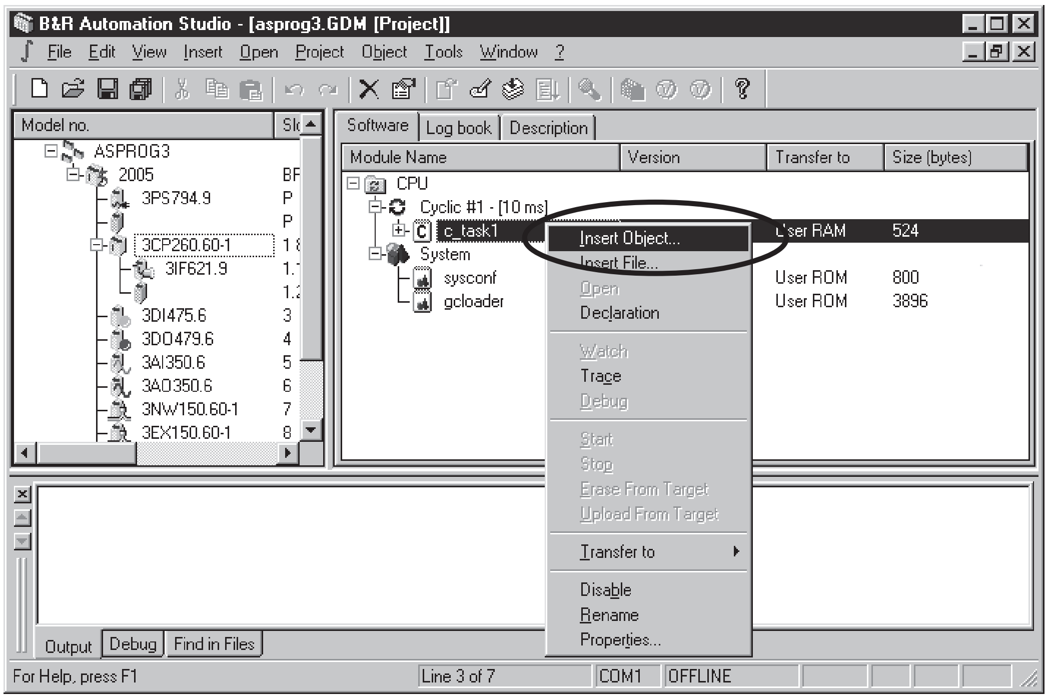
Name
Define the name and type of the new application object
Name: c_task1
Type: C Language

Resource
Select a resource for the new application object
Resource: Cyclic #1 - [10 ms]

Software module check Ok. COM1 CP260 V2.10 RUN

Fig. 12.2: C Task dialog box

This type of task can consist of several files, therefore these source files are added under the task symbol using “**Insert File**”.



Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
c_task1		User RAM	524
System			
sysconf		User ROM	800
gcloader		User ROM	3896

For Help, press F1 Line 3 of 7 COM1 OFFLINE

Fig. 12.3: C task, Insert File dialog box

In order to manage the project in a clearer manner, all source files are grouped together in a “Source” directory. A new folder can be created by simply clicking on the marked symbol.

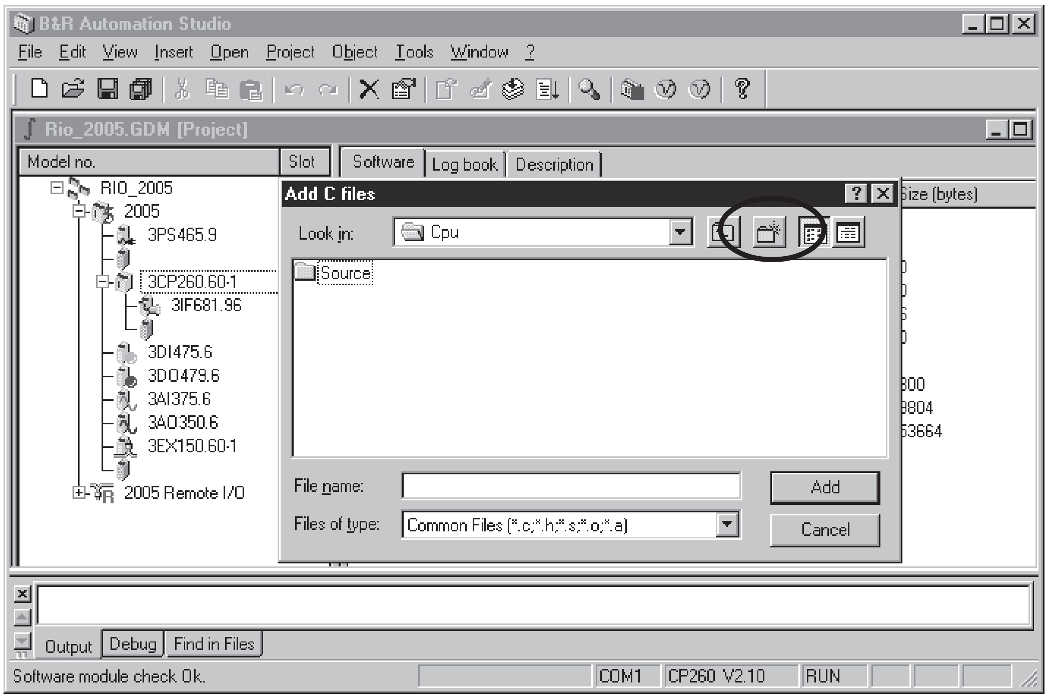
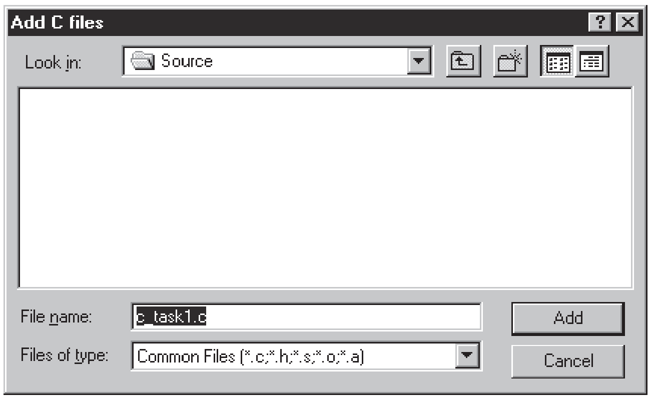


Fig. 12.4: Create new folder

Then the file name is entered.

Note

The extension “.c” also has to be entered !

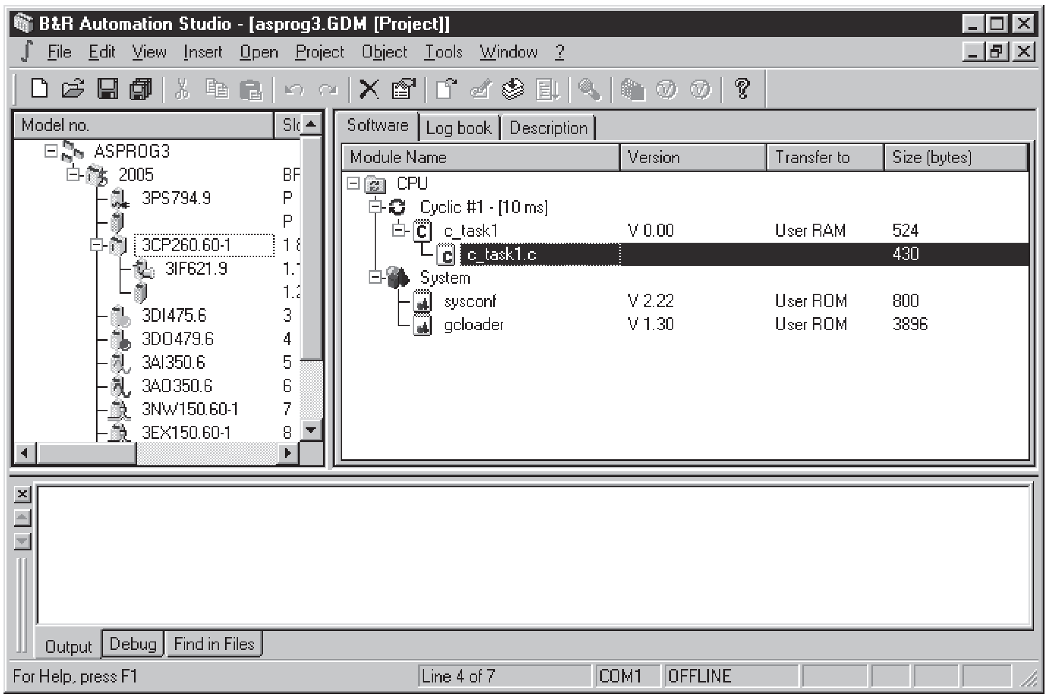


File name: c_task1.c

Files of type: Common Files (*.c;*.h;*.s;*.o;*.a)

Fig. 12.5: Enter file name

Double-clicking on the file opens the editor.



Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
c_task1	V 0.00	User RAM	524
c_task1.c			430
System			
sysconf	V 2.22	User ROM	800
gcloader	V 1.30	User ROM	3896

Fig. 12.6: Opening the C editor

3.3 Variable Declaration

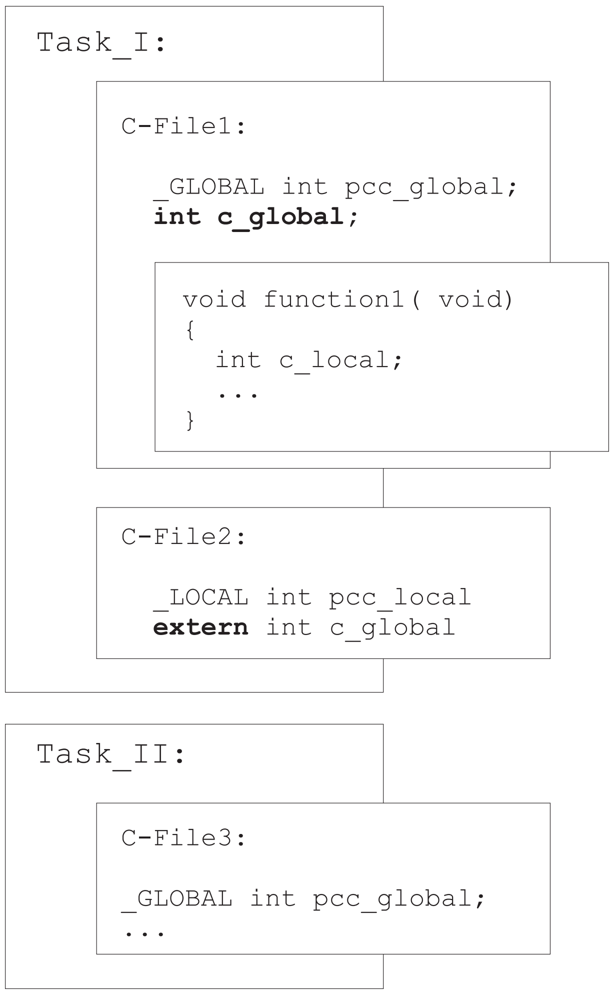
In addition to the macros for "_GLOBAL" or "_LOCAL" shown above, the variable declaration in the C file also provides the possibility to use C global or C local variables.

The difference between PCC PVs and C variables is the target memory.
PCC PVs which are entered in the AS database,
Main menu item**Open**: **Declaration**, are stored in Dual Ported Ram.
C variables are defined in User RAM (freely available).

DPR PVs: _GLOBAL / _LOCAL	**C Variables: C global / C local**
The variable values are remanent	C variable are initialized with 0 when switching on the controller.
The max. size of an analog PV is limited to approx. 30kByte.	The size of a C variable only depends on the memory available.
_GLOBAL PVs can be assigned to the hardware.	C variables cannot be assigned to the hardware.
_GLOBAL, _LOCAL PVs can be displayed (e.g.: using PVI, NET2000, etc.).	C variables cannot be referenced via PVI, NET2000, etc. That means: They are not visible in the WATCH window.
Initialization of PVs in the variable declaration or in the INIT routine.	Initialization possible directly during definition in the C file (e.g. : int variable = 123;).
No multidimensional arrays (matrix).	Multidimensional arrays are allowed
Structures have a max. of 16 layers.	No limits for structures.
Enumerations data types are not available.	Enumeration data types are supported.
When using pointers, only the address is entered as UDINT in variables / structures.	In C, pointers can be used as normal.[1]

1 With the exception of PCC variables declared with _LOCAL (first reference is a dynamic variable).

3.3.1 Scope of the Variables


```
Task_I:

  C-File1:

    _GLOBAL int pcc_global;
    int c_global;

      void function1( void)
      {
        int c_local;
        ...
      }

  C-File2:

    _LOCAL int pcc_local
    extern int c_global

Task_II:

  C-File3:

  _GLOBAL int pcc_global;
  ...
```

- A PV defined with _LOCAL is local in the task and global for the task files.
- A PV defined with _GLOBAL is PCC global and also global for the task files.
- A variable declared as C global is global for all C files and its scope is limited within a task.
- A local C variable is only valid in the function where it was defined.

In order to use a global C variable in a tasks in several files, it must be declared in a file without the attribute “external”. In this way, the memory for this variable is reserved. In all other files where this variable is accessed, it have the attribute **”external”**. The attribute external indicates to the compiler that the variable is already declared in another file.

IMPORTANT

- For each PCC task, **one function must** have the attribute **”CYCLIC”**. But **only one function** can have this attribute.
- For each PCC task, a function can have the attributes “_INIT”, “_EXIT” if required.
- DPR PVs have the attribute “_GLOBAL” or “_LOCAL”. In this way, these variables are managed by AS in the project variable declaration
  Open: Declaration.
- If one or more DPR PVs are no longer used in the programs, they remain in the project and reserve memory in the DPR until a “Build All” **Project: BuildAll**.
- DPR PVs are referenced using a max. of 32 characters. C variables can be longer.
- For the variable types, make sure that C does not have any rules regarding bit length for an integer variable (int). Therefore this length depends on the processor and is 32 bit for the B&R PCC.

In order to work with IEC1131 data types in C, the user is provided the B&R header file named: “plctypes.h”.

Directory for plctypes.h:

```
BrAutomation\AS\Gnuinst\m68k-elf\include\bur\plctypes.h
```

3.4 Data Types

Various data types are defined in IEC61131-3. Some of these data types do not have a corresponding type in the ANSI C standard. Therefore B&R Automation Studio has declared some data types in the file “plctypes.h” so that all IEC1131 data types can be used in C.

Resolution	IEC1131-3	B&R C	ANSI C
1 bit	BOOL	plcbit[1]	unsigned char
8 bit with sign	SINT	signed char	signed char
8 bit without sign	USINT	unsigned char	unsigned char
16 bit with sign	INT	short	short
16 bit without sign	UINT	unsigned short	unsigned short
32 bit with sign	DINT	long	long
32 bit without sign	UDINT	unsigned long	unsigned long
32 bit time difference in milliseconds	TIME	plctime[1]	signed long
32 bit date in seconds since 1970[2]	DT DATE_AND_TIME	plcdt[1]	unsigned long
Zero terminated string with length x[3]	STRING(x)	plcstring[1] [x+1]	char [x+1]
Floating point representation 32 bit	REAL	float	float

IMPORTANT

In order for the compiler to view plcbit variables as unsigned char, the user must make sure that only 0 or 1 is assigned.

[1] Defined by B&R in plc.h
[2] Unix standard format for date entries
[3] In IEC1131-3, the final 0 byte is not counted, it is in ANSI C

Example

Create a solution to the following task in C.

Check “TempAct”. If “TempAct” is smaller than “TempSet”, then bit variable „heating“ should be set to 1. Otherwise “heating” should be cleared.

Name	**Type**	**Scope**	**Attribute**	**Value**	**Description**
TempAct	INT	global	IP5.0.5.1	-------------	Analog IN, Chan. 1
TempSet	INT	global	IP5.0.5.2	-------------	Analog IN, Chan. 2
heating	BOOL	global	QP5.0.4.11	* remnant	Dig. OUT, Chan. 11

Project Name:	c_proj
Task Name:	c_task2
Resource:	C#3

3.5 Line Coverage

View: Monitor or **<Ctrl><M>**

AS is first switched to Monitor Mode.

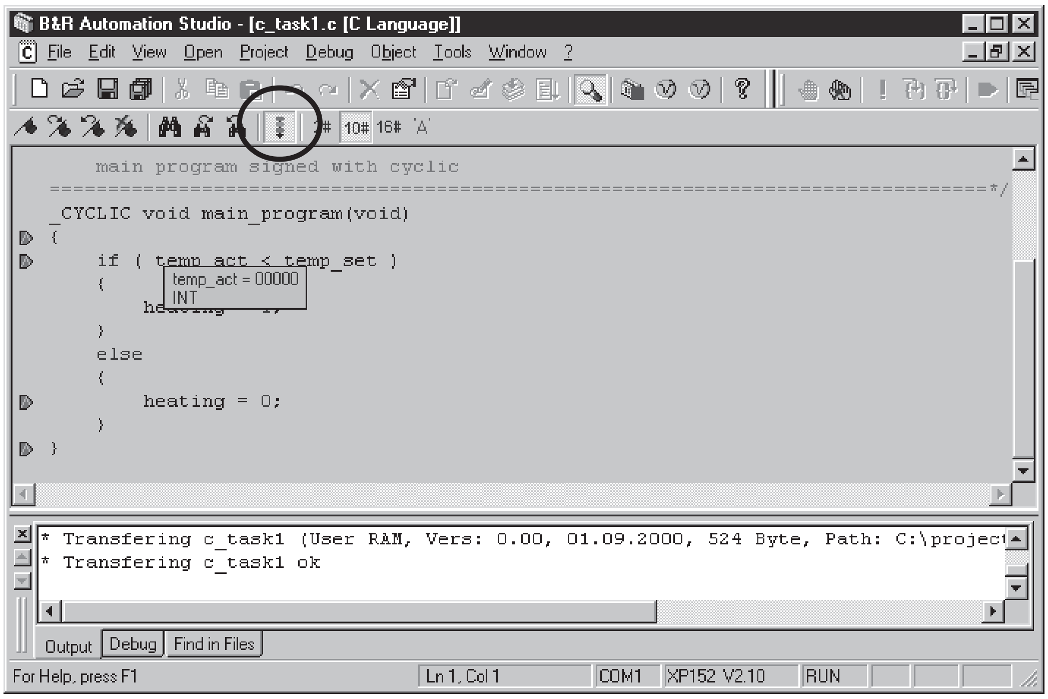
Object: Start Line Coverage

Start -> by clicking on the "green" lamp symbol

With Line Coverage, the values are taken from the controller and shown in the respective program context.

The arrows on the left indicate that a line is being processed. Figure 11.7 the line „heating = 0" is not currently being processed.

If the mouse cursor is placed over a variable, then a
„Tool Tip" is opened which shows the current value of the variable on the controller.


B&R Automation Studio - [c_task1.c [C Language]]
File Edit View Open Project Debug Object Tools Window ?
10# 16# 'A'
Output Debug Find in Files
For Help, press F1
Ln 1, Col 1
COM1
XP152 V2.10
RUN

```
    main program signed with cyclic
=============================================================================*/
_CYCLIC void main_program(void)
{
    if ( temp_act < temp_set )
    {
        heating = 1;
    }
    else
    {
        heating = 0;
    }
}
```

```
temp_act = 00000
INT
```

```
* Transfering c_task1 (User RAM, Vers: 0.00, 01.09.2000, 524 Byte, Path: C:\project
* Transfering c_task1 ok
```

Fig. 12.7: Line Coverage

Example

Test “c_task2” using Line Coverage.

3.6 Functions

3.6.1 General Information

Sub-programs which are referred to as functions are a major part of C. They are used to structure the program in a clearer manner. These sub-programs are very similar to function blocks, but can only be used by C tasks.

3.6.2 Structure of a Function

Return value	Function name	Arguments

e.g.:

```
void CyclicFunction(void)

{
     ...
}
```

- Returned value
  Provides the function the possibility to return a value to the function where it was called. In our example, we don't have a return value, therefore **void** (void = empty).

- Functions name
  Name used to call the function in the program.

- Arguments
  Values given to the function. In our example, no values are provided, therefore: **void**

3.6.3 Providing an Arguments as a Value

Program sections which are often reused should be placed in sub-programs (=functions). The arguments provided are processed in these functions. If necessary, the result can be given back to the function that made the call as a return value.

For example, the operating system provides the Init function the current boot information.

```
#include <bur\plc.h>        /* B&R Standard files  */
#include <bur\plctypes.h>   /* B&R Standard files  */

_LOCAL DINT Boot information;

/* This function is only used when booting the PCC,
   or when downloading the task                    */


_INIT void Initialization (DINT PCC_info)
{
     Boot information = PCC_info;
}
```

Argument: (**DINT PCC_info**)

The argument is saved in a local C variable in the function and can only be used by this function.

To provide **several** arguments for a function, they must be separated by **commas**.

3.6.4 File Local Function

We want to add two numbers with a function and save the result in a „_LOCAL“ variable.

```
#include <bur\plc.h>             /* B&R Standard files       */
#include <bur\plctypes.h>        /* B&R Standard files       */

_LOCAL DINT   Boot information;
_LOCAL DINT   Result;

_LOCAL INT    Value1,
              Value2;

/* Declaration of the function prototypes                    */
DINT Add(INT Value1, INT Value2);


/* This function is only used when booting the PCC,
   or when downloading the task                              */

_INIT void Initialization (DINT PCC_info)
{
     Boot information = PCC_info;
}


_CYCLIC void Cyclic(void)
{
     /* Call the function   */
     Result = Add(Value1, Value2);
}

/*——————————————————————————————*/

DINT Add(INT Value1, INT Value2)
{
     DINT Res;     /* Definition of a local C variable      */

     Res = Value1 + Value2; /* Calculating the sum          */

     return( Res );         /* Return the result to the
                            functionthat made the call      */
}
```

Example

Create a local function, which multiplies 3 values. Test the function in a task.

Task Name:	calc
Resource:	C#1

3.6.5 Task Global Function

All functions in a task can access this sub-program (File 2).

```
Task_1:

C-File1:
   #include <bur\plc.h>        /* B&R Standard files    */
   #include <bur\plctypes.h>   /* B&R Standard files    */


   _LOCAL DINT    Result;

   _LOCAL INT     Value1,
                  Value2;

   /* Declaration of the function prototypes */
   external DINT Add(INT Value1, INT Value2);

   _CYCLIC void CYCLIC(void)
   {
      /* Call the function */
      Result = Add(Value1, Value2);
   }

C-File2:

   #include "plc.h"            /* B&R Standard files    */
   #include "plctypes.h"       /* B&R Standard files    */

   DINT Add(INT Value1, INT Value2)
   {
   DINT Res;     /* Definition of a C local variable    */

   Res = Value1 + Value2;      /* Calculation           */

   return( Res );              /* Return value          */
   }
```

In C File1, sub-program Add()) is called in function Cyclic().
The **function code** is contained in C File2. Therefore the compiler in C File1 must be informed that the code for Add() is **external**.

Example

Change task “calc” so that the addition is coded in a separate file.

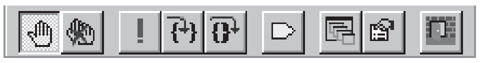
Task Name:	calc
Resource:	C#1

3.7 Debugger

3.7.1 Set / Clear Stop Point

With this function, break points are set on the controller **which stop the system.**

The Debug output window on the lower edge of the AS window shows Debugger information. The toolbar for the Debugger is opened.



The program can be tested in single step mode with the “single step” or “procedure step“ function.

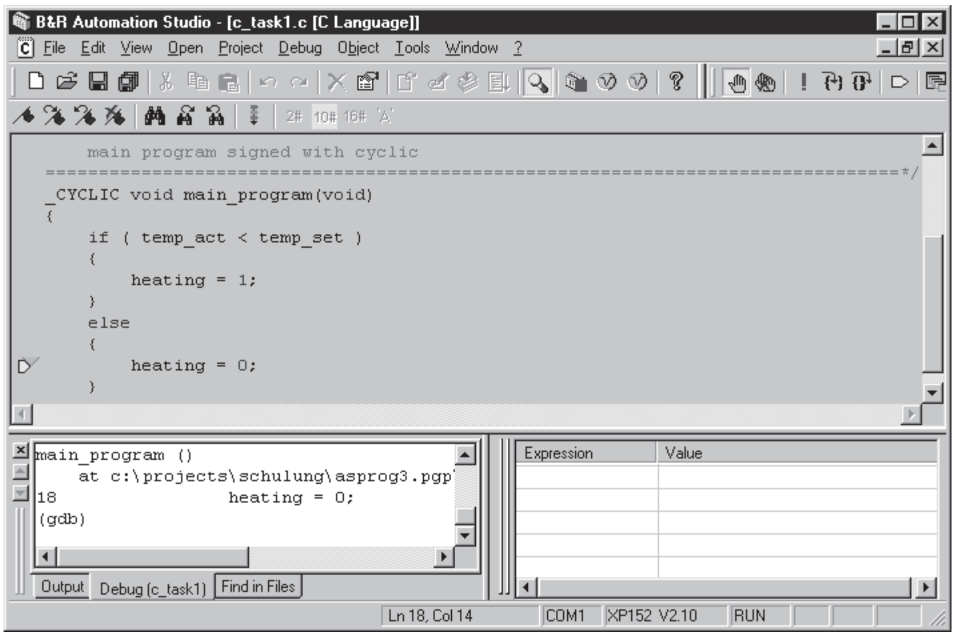
“Next” causes processing to continue to the next stop point or cycle.

3.7.2 Single Step

All instruction lines are executed. If functions are called, they are executed if the source code is available.

3.7.3 Procedure Step

Functions are completely executed. Then the program counter Stopps after the function call.


B&R Automation Studio - [c_task1.c [C Language]]
File Edit View Open Project Debug Object Tools Window ?
2# 10# 16# 'A'
Output
Debug (c_task1)
Find in Files
Expression
Value
Ln 18, Col 14
COM1
XP152 V2.10
RUN

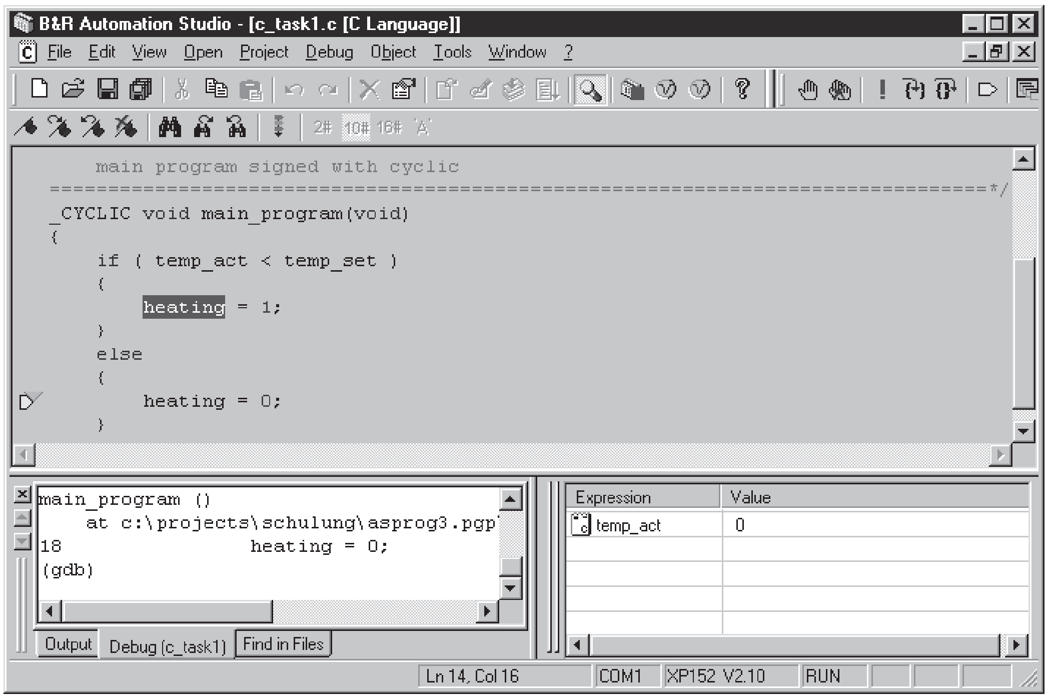
```
    main program signed with cyclic
==================================================================================*/
_CYCLIC void main_program(void)
{
    if ( temp_act < temp_set )
    {
        heating = 1;
    }
    else
    {
        heating = 0;
    }
```

```
main_program ()
    at c:\projects\schulung\asprog3.pgp
18              heating = 0;
(gdb)
```

Fig. 12.8: C Task Debugger

3.7.4 Debugger: Watch Fenster

This window is opened if the program on the controller gets to a breakpoint. If a variable in the source window is marked and pulled into the Watch window (Drag & Drop), then the value of the variable, the array or the structure is shown.


B&R Automation Studio - [c_task1.c [C Language]]
File Edit View Open Project Debug Object Tools Window ?

```
     main program signed with cyclic
==============================================================================*/
_CYCLIC void main_program(void)
{
    if ( temp_act < temp_set )
    {
        heating = 1;
    }
    else
    {
        heating = 0;
    }
```

```
main_program ()
    at c:\projects\schulung\asprog3.pgp`
18                  heating = 0;
(gdb)
```

Output
Debug (c_task1)
Find in Files

Expression	Value
temp_act	0

Ln 14, Col 16
COM1
XP152 V2.10
RUN

Fig. 12.9: C Task Debugger Watch Window

Example

Test the Debugger using an example.

3.8 Using Arguments with Complex Data Types

3.8.1 Application Example 1

Creating a slave pointer. (Slave pointer => A function that determines the maximum using a current value).

Note

If a function should return more than one value to the function that made the call, or if a function should work directly with the memory for the function that made the call, this cannot take place using the function return().

```
#include <bur\plc.h>        /** B&R Standard files              **/
#include <bur\plctypes.h>   /** B&R Standard files              **/

/**-------------------------------------------------------------**/
/** Constant definition                                          **/
/**-------------------------------------------------------------**/
#define TRUE  1
#define FALSE 0

/**-------------------------------------------------------------**/
/** TYPE DEFINITION FOR MEASSTRUCTURE
**/
/**  init: Used to set max_value to 0.                          **/
/**  current_value: Current value to be evaluated.              **/
/**  max_value: Maximum value of current_value                  **/

struct MEASSTRUCTURE   {
                       BOOL init;
                       INT   current_value;
                       INT  max_value;
                       };

/**--------------------------------------------------------------**/
/** VARIABLE DECLARATION                                          **/
/**--------------------------------------------------------------**/

/** Variable given to the slave pointer                          **/
_LOCAL struct MEASSTRUCTURE fillstatus;

/**--------------------------------------------------------------**/
/** FUNCTION PROTOTYPES                                           **/
/**--------------------------------------------------------------**/

/** The function slavepointer() does not make a copy of the
    variable given, instead works directly with the variable for
    the function that made the call, therefore a star must be
inserted before
    "data" in the function header                                **/

void slavepointer(struct MEASSTRUCTURE *data);
```

```
/**-------------------------------------------------------------**/
/** INITIALIZATION OF THE TASKS (INIT-SP)                         **/
/**-------------------------------------------------------------**/
_INIT    void initup(DINT OS_info)
{
     fillstatus.init = 1;
     slavepointer(&fillstatus);
}

/**-------------------------------------------------------------**/
/** CYCLIC SECTION OF TASK                                        **/
/**-------------------------------------------------------------**/
_CYCLIC  void cyclic_func(void)
{
     /** Maximum evaluation using slave pointer                  **/
     slavepointer(&fillstatus);
}

/**-------------------------------------------------------------**/
/** If the current value is > the maximum value,
    the current value is set to the maximum value.               **/
/**-------------------------------------------------------------**/
/** void slavepointer(struct MEASSTRUCTURE *data)                 **/
/**-------------------------------------------------------------**/

/** The function slavepointer() does not make a copy of the
    variable given, instead works directly with the variable for
    the function that made the call, therefore a star must be
    inserted before "data" in the function header                **/

void slavepointer(struct MEASSTRUCTURE *data)
{
     if (data->init == TRUE)
     {
          data->max_value = 0;
          data->init      = 0;
     } /** end if (data->init .. **/



     if(data->current_value > data->max_value)
     {
          data->max_value = data->current_value;
     } /** end if(data->current_value > data->max_value)  **/


     /** return without return value **/
}
```

Note

Detailed information concerning working with pointers can be found in the respective C literature.

3.8.2 Application Example 2

Determine the length of a strings in a function.

```
#include <bur\plc.h>
#include <bur\plctypes.h>

/** Constant definition **/

#define TRUE  1
#define FALSE 0

#define END_OF_TEXT    0    /** Strings are zero terminated     **/

/** VARIABLE DECLARATION **/

_LOCAL STRING     text[20];
_LOCAL INT        length;

/** FUNCTION PROTOTYPES **/

INT string_len(STRING string[]);


/** INITIALIZATION OF THE TASKS (INIT-SP) **/

_INIT    void init(void)
{
     text[0]= END_OF_TEXT;
}

/** CYCLIC SECTION OF TASK **/

_CYCLIC  void cyclic_func(void)
{
     length = string_len( &(text[0]) );
}

/** C strings are zero terminated, therefore the loop searches for
    the first 0. Then the length is known.                        **/

INT string_len( STRING string[])
{
     INT  len = 0;

     while (string[len] != END_OF_TEXT)
     {
          len++;
     }
     return(len);
}
```

4 USING B&R LIBRARIES

4.1 General Information

Libraries or standard functions are used to efficiently create programs and offer a simple, complete solution for often required functions.

The following components are needed to use B&R standard functions in a C task:

- Library Header File e.g.: “standard.h”
  Contains the variable type declaration and the function type declaration.
- Library Archive File e.g.: „standard.a“
  Contains the link information for the start address in the library code of the system files

The files for various libraries are found directly under the library path for the project. Libraries imported in the project are copied by LibMan directly into this directory.

4.2 Example

4.2.1 Inserting the Library in the Project

A standard function from the STANDARD library should be used,
and the following settings must be made in the project.

- Insert the desired library in the Library Manager. Inserting the library according to the set operating system version copies the necessary files to the path:

  e.g.: `C:\projects\prj_name.pgp\Library`

- Inserting the library header files and the archive files

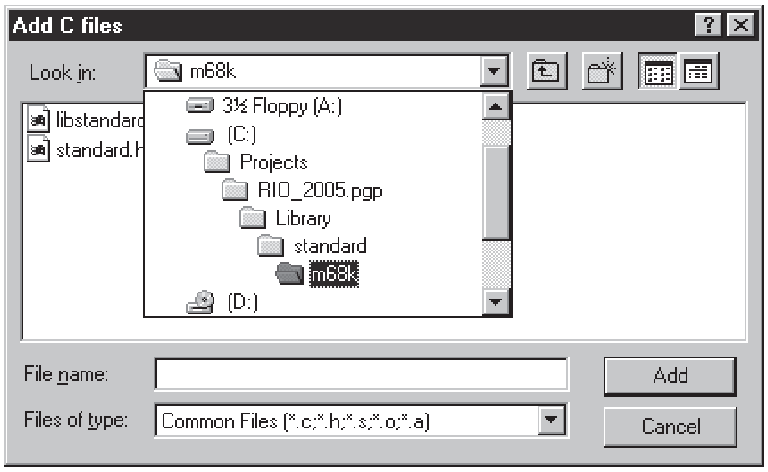
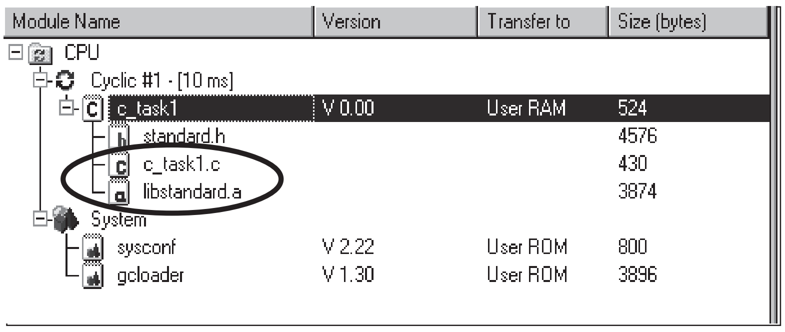


Fig. 12.12: Insert header file and archive file

IMPORTANT

The library **archive file** must be **placed** in the tree structure **after the C file** that accesses a corresponding library function.



Module Name	Version	Transfer to	Size (bytes)
CPU			
Cyclic #1 - [10 ms]			
c_task1	V 0.00	User RAM	524
standard.h			4576
c_task1.c			430
libstandard.a			3874
System			
sysconf	V 2.22	User ROM	800
gcloader	V 1.30	User ROM	3896

Fig. 12.13: Complete C task tree

4.2.2 Inserting the Header File

Only the library header file: “standard.h” has to be included in the C code. The library archive file “libstandard.a” is only added to the task using **Insert: File**.

If e.g.: the function TON(..), a turn on delay function from the standard library, should be used, this results in the following program:

```
#include <bur\plc.h>
#include <bur\plctypes.h>
#include <standard.h>              /** Library Header File       **/

_LOCAL TON_10mstyp     ton_para;   /** TON parameter variable    **/

_GLOBAL BOOL  gDiStart,            /**    start TimerOnDelay     **/
              gDoRelay;            /**    Output                 **/

_CYCLIC void use_standard_func(void)
{
     ton_para.PT = 100;            /** set preset-time to 1sec.  **/
     ton_para.IN = gDiStart;

     TON_10ms(&ton_para);

     gDoRelay = ton_para.Q;        /** set output                **/
}
```

Example

Use the B&R standard library and the function block TOF

4.2.3 Using C Standard Libraries

This example shows the use of the mathematics library.
Monitor the progress of “x” and “y” with the Tracer.

```
#include <bur\plc.h>
#include <bur\plctypes.h>
#include “math.h“

/**-------------------------------------------------------------------**/
/** Constant definition                                               **/
/**-------------------------------------------------------------------**/

#define TRUE  1
#define FALSE 0

#define SCANTIME 0.01      /** Task class cycle time            **/

/**-------------------------------------------------------------------**/
/** VARIABLE DECLARATION                                              **/
/**-------------------------------------------------------------------**/

_LOCAL REAL   x, y, freq, t;

/**-------------------------------------------------------------------**/
/** INITIALIZATION OF THE TASK (INIT-SP)                              **/
/**-------------------------------------------------------------------**/

_INIT    void init(void)
{
    freq = 1.0;
}

/**-------------------------------------------------------------------**/
/** CYCLIC SECTION OF THE TASK                                        **/
/**-------------------------------------------------------------------**/

_CYCLIC  void cyclic_func(void)
{
    t = t + SCANTIME;

    x = sin( M_TWOPI * freq * t );
    y = cos( M_TWOPI * freq * t );
}
```

5 COMPILER INFO

5.1 File Types

*.c	C Source Files Definition of the variables. Implementation of the functions
*.h	C Header Files Prototypes of functions and declaration of variables that should be used for several C source codes. These files are included in the C source code using the preprocessor instruction #include.
*.s	Assembler source code text.
*.o	Object Files: Compiled source file.
*.a	Library Files Archive made up of several compiled source files. Often simply called library. Take note that archive files always have to be included at the end of the task.

5.2 Compile Procedure

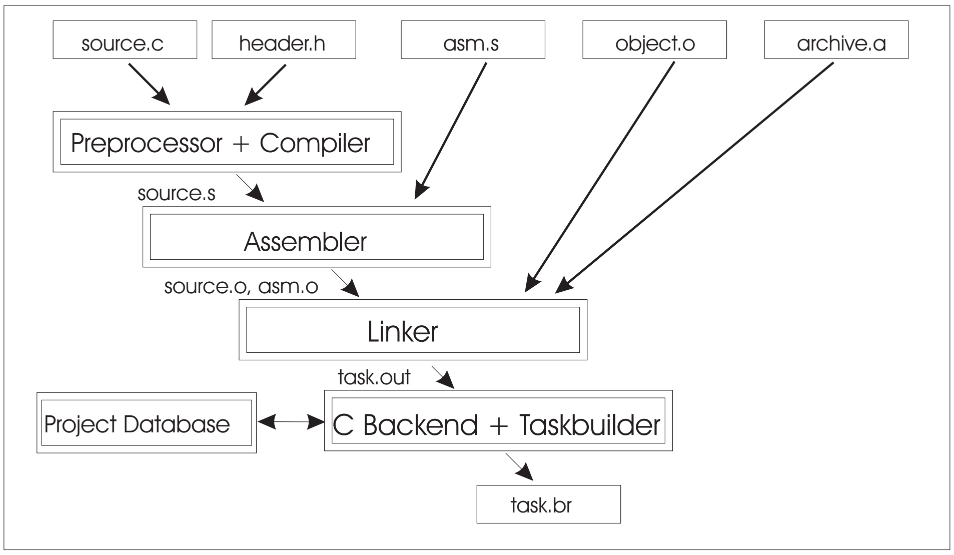


Fig. 12.14: Compile procedure

- Preprocessor
  The preprocessor includes the header files in the source code and replaces the macros. Macros are special instructions for the preprocessor. The #include instruction is also a preprocessor instruction.

- Parser
  The parser is a program element which divides the source code into individual sections, so that it can be processed by other areas of the compiler. The parser is also often used to check syntax. That means, the amount and type of parameters given to the functions.

- Compiler
  The compiler is a program that converts the source code to an assembler file (*.s). At the beginning of the compile procedure, the source code is checked by the parser.

- Assembler
  The assembler creates machine code with linker information from the assembler code. The Object File (*.o). For most systems, this file must be processed further e.g. to group several object files or to correctly call functions contained in libraries. This is done by the Linker.

- Linker
  The Linker creates a single code file from the various object files and libraries, the “task.out” file.

- Backend, Taskbuilder:
  The output file from the Linker can be converted to a “task.br” File with AS database information and some hardware specific modifications. This file can then be processed by the PCC.

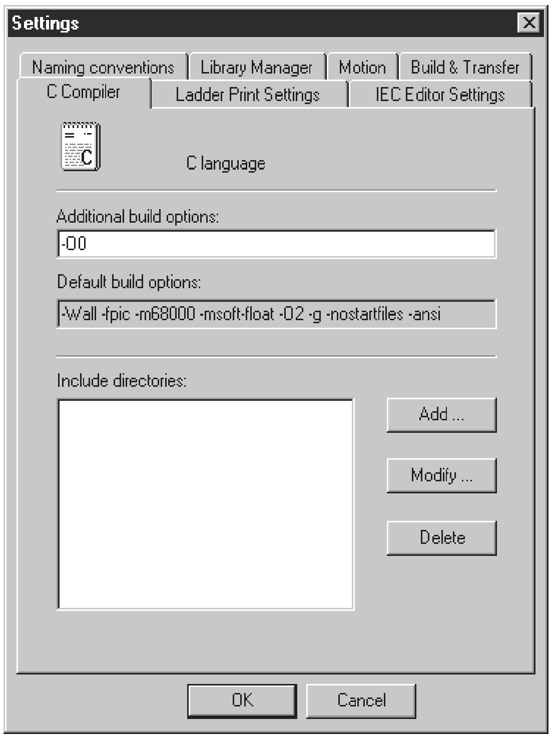
5.3 GNU C Compiler

We use a ported GNU C compiler as C program compiler. GNU originates from the UNIX world and has proven to be a reliable code generator that is used worldwide.

To be able to use the many possibilities offered by this compiler, documentation is provided in universal HTML format in the directory BrAutomation\AS\Gnudoc\index.htm.

Default values for general use are defined in AS. The user only has to make additional settings if required.

Changes can be made by positioning the marking cursor on
the task and selecting the main menu item **Edit: Properties**. The properties menu can also be reached using the right mouse button when the task is selected.



Additional build options: -O0

Default build options: -Wall -fpic -m68000 -msoft-float -O2 -g -nostartfiles -ansi

Fig. 12.15: C task settings

Compiler Option:

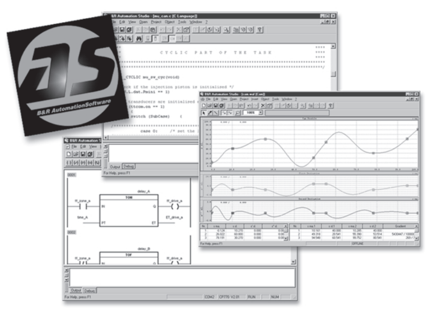
- -O0 Code optimization off (useful for Debugging)
- -Dmacro Define Macro (conditional code generation)

SEMINAR REVIEW

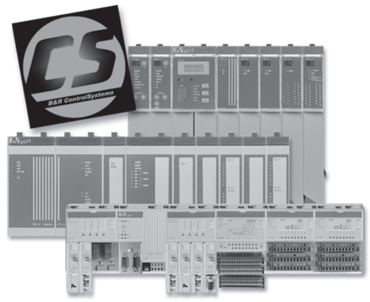
1 SEMINAR REVIEW

- B&R Automation Studio
- B&R Automation Runtime
- B&R Automation Target
- B&R Automation Net
- Project Guidelines
- Sequential Function Chart
- AB Automation Basic
- Data Handling
- TPU Code Linker
- Library Manager Introduction
- ANSI C

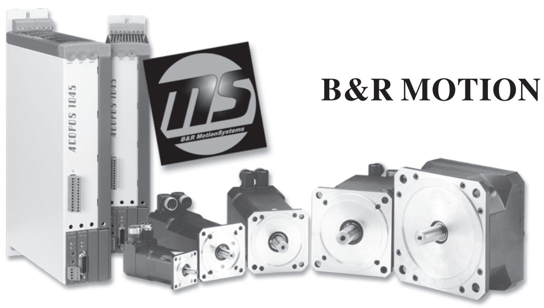
2 SEMINAR OVERVIEW



B&R AUTOMATION SOFTWARE



B&R CONTROL SYSTEMS



B&R MOTION SYSTEMS

B&R PANEL SYSTEMS

3 SALES LOCATIONS

The most current addresses and product information can be found at:

HTTP://WWW.BR-AUTOMATION.COM