SIEMENS

Technical Description
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IMC0x-PLC, Version 2.0

Order Number: 6AR1403-3AD00-2AA0

System Manual

SICOMP Industrial Microcomputers

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Product History of the Technical Description

Revision [1)]	Record of changes	Date
A0	First edition	07/97
A1	Technical Corrections	06/98
A2	V2.0 with PROFIBUS-DP Connection	05/99
A3	Addition of IMC01 information, designation changed to IMC0x-PLC	12/99

1) Corresponds to the 4th block of digits of the drawing number in the footer

Table of Contents

1 General Information about IMC0x-PLC Documentation

The IMC0x-PLC documentation has been split into three sections in the belief that this is the most helpful way of presenting all the necessary information for different types of users. It has been prepared with three user groups in mind: firstly, the absolute beginners who want to get a working grasp of IMC0x-PLC as quickly as possible, secondly, users writing STEP 5 programs who will use it mainly as a reference work and, lastly, system programmers who also need detailed information on how IMC0x-PLC fits into the RMOS operating system. We hope this documentation will help all three groups to begin working confidently with this product in as short a time as possible.

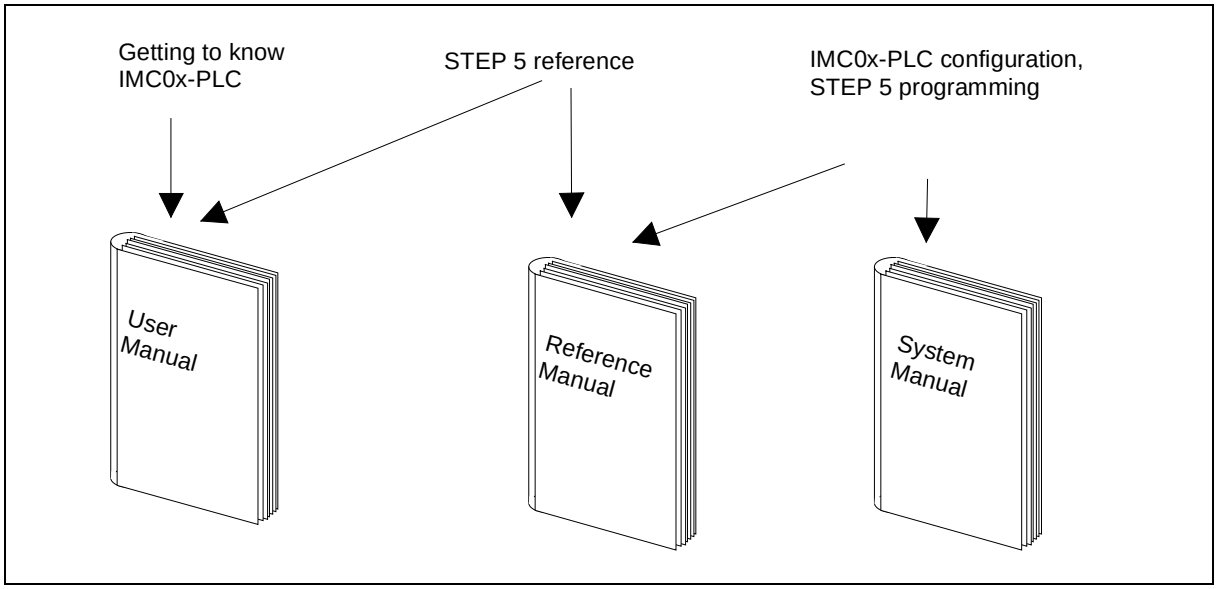


Figure 1. 1 Target uses for manuals

The User Manual is intended for getting acquainted with and gaining a general overview. The manual covers all the basics of installing, starting and using the IMC0x-PLC under the RMOS operating system.

The Reference Manual contains detailed information about STEP 5 commands, STEP 5 operation codes, the DB 1 configuration, the parameters of the IMC0x-PLC start calls, in short, everything required for IMC0x-PLC operation, mostly in tabular form. The Reference Manual is thus the standard reference work for both the application programmer and the system programmer.

The System Manual contains all the information required for operation of the IMC0x-PLC. The manual describes in detail all the special features and facilities of the IMC0x-PLC.

1.1 System Manual Overview

This manual covers the operation, programming and startup of a programmable logic control (PLC) based on the RMOS3-PLC software package.

Chapter overview

Chapter 1 explains the documentation concept.

Chapter 2 briefly describes a controller's functional units.

Chapter 3 explains the operating modes and the methods of changing them. It also covers retentivity and error handling.

Chapter 4 covers STEP 5 I/O addressing.

Chapter 5 describes test and startup functions using SIMATIC STEP 5 programmers.

Chapter 6 is an introduction to STEP 5 programming. It outlines the three display modes and discusses the modular program structure and the different types of module or block. STEP 5 number representation is also explained in some detail.

Chapter 7 looks at the user memory available under STEP 5 and at a conversion program which generates an MC5 binary file.

Chapter 8 covers HLL (high level language) blocks and how they are linked to STEP 5 programs.

Chapter 9 concentrates on data block 1 (abbreviated to DB 1) which always contains the PLC configuration data. It discusses the different data fields (masks) which make up DB 1 and gives an example of a typical DB 1.

Chapter 10 covers IMC0x-PLC configuration, memory areas used from IMC0x-PLC and the different IMC0x-PLC start calls. It also deals with the I/O interfaces and explains how the IMC0x-PLC handles them.

Chapter 11 covers the IMC0x-PLC operator and display elements. The function of an event flag and its use in manipulating the IMC0x-PLC is explained.

Chapter 12 is about the shared memory. It covers structure, uses and memory access.

Chapter 13 summarizes all details of the PROFIBUS-DP interface.

In chapter 14 you will find a discussion of aspects of the RMOS configuration which affect the configuration, installation and operation of the IMC0x-PLC. An important part deals with the driver responsible for serial communication between the IMC0x-PLC and the programming equipment.

Chapter 15 summarizes the differences between the IMC0x-PLC and a SIMATIC S5-115U.

2 IMC0x-PLC Overview

You can use the IMC0x-PLC to set up a programmable controller with the SICOMP-IMC05 and the SICOMP-IMC01. This manual concentrates on the programming language STEP 5, on IMC0x-PLC operation and on test and startup functions using the programmer. In addition, the manual describes IMC0x-PLC configuration in an RMOS environment and describes the interfaces to another RMOS task or to another CPU.

2.1 Performance Features

- 1024 input bits
- 1024 output bits
- 256 flag bytes
- 128 timers
- 128 counters
- 3.2 msec execution time for 1024 binary instructions
- STEP 5 command set corresponds largely to SIMATIC S5-115U CPU 944

2.2 Before You Start

2.2.1 Programmer (PG)

You can write, test and run your application programs on either of these programming systems:

- MS-DOS-compatible PC with Siemens STEP 5 programming package (STEP 5 Basic Package)
- SIMATIC S5 programmer, e.g., PG 720 with STEP 5 from V6.5 or PG 740 with STEP 5 from V7.12 under Windows 95

2.2.2 Controller (PLC)

You can use the IMC0x-PLC to implement programmable controllers based on the IMC05 or IMC01 compact process computer.

2.2.3 The Controller

A controller created using the IMC0x-PLC has almost all the functionality of a SIMATIC S5-115U controller. Because the IMC0x-PLC can be implemented on devices with different order options, it is obviously impossible to describe the final controller completely. The checklist below tells you where the controller description must be supplemented or modified:

- Serial interface for connection of the PG
  – With IMC05: RS 232-2
  – With IMC01: COM1 (RS 232)
- Number and addresses of inputs and outputs
- Memory configuration
- Retentivity
- Use of communication flags
- Integrated HLL blocks
- Reaction to power failure
- Second serial interface
  – With IMC05: RS 232-1
  – With IMC01: COM2 for `printf` outputs on the system console (RS 485, semi-duplex)

2.3 Functional Units

The figure below shows the typical structure of a controller created with the IMC0x-PLC.

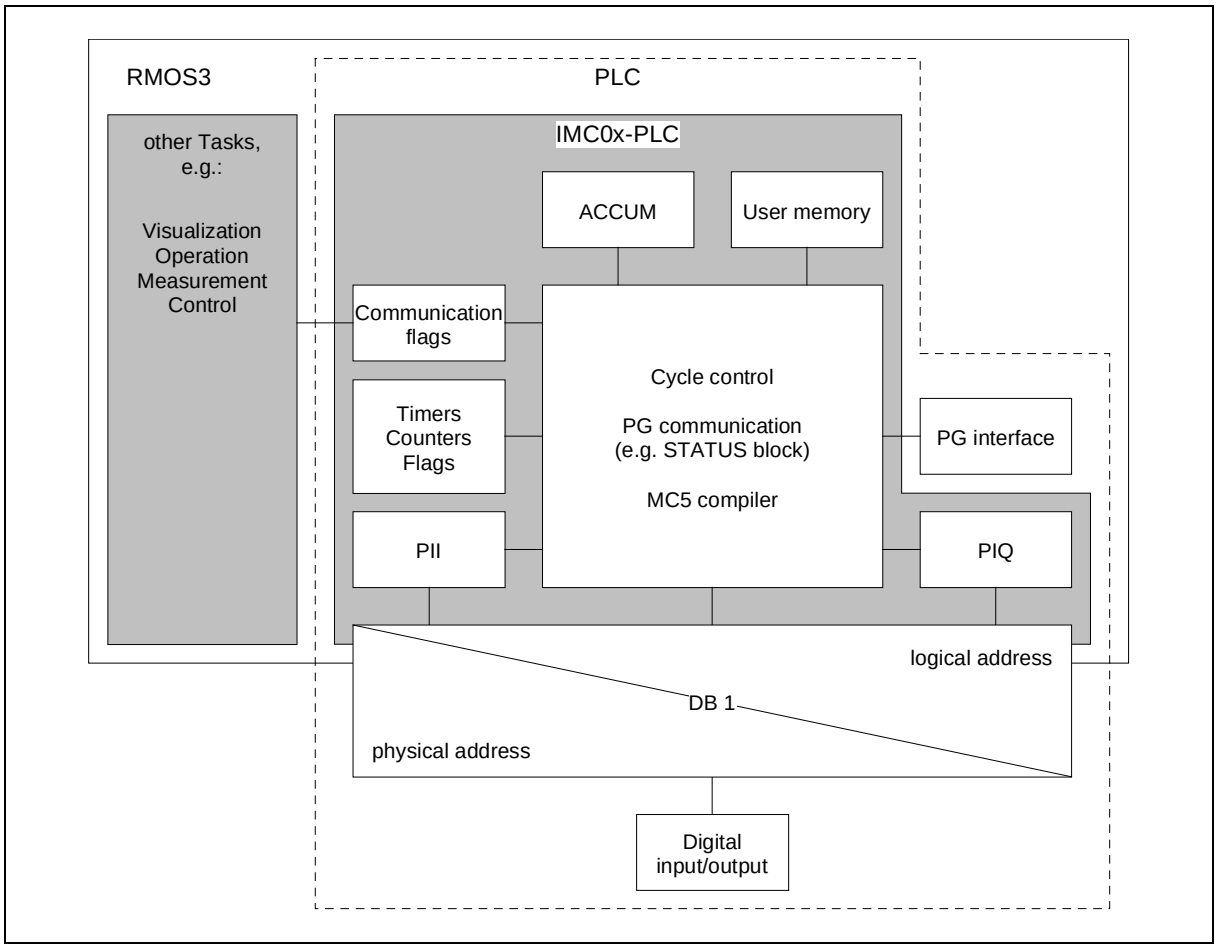


Figure 2. 1 Function units of a PLC

The controller is built up from a number of functional units which are briefly described here:

- Control unit
- Accumulator
- Counters, timers and flags
- Communication flags and shared memory
- Process image
- I/O units
- Program memory
- MC5 compiler
- PG interface

2.3.1 Control Unit

The control unit is responsible for executing control programs at a level where process control is:

- cycle-driven processing level
- timer-driven processing level

2.3.2 Accumulator (ACCUM)

The accumulator is an arithmetic register. Values from internal counters and timers, for example, are loaded via the accumulator. The accumulator also performs compare, convert and arithmetic operations.

2.3.3 Counters, Timers and Flags

The controller makes available internal counters, timers and flags. Flags are memories for storing signal states and intermediate results. Counters, timers and flags can be set to be retentive, so that their contents are not lost when power is switched off (see chapter 3.6).

2.3.4 Communication Flags

A contiguous flag area can be defined an output communication flag or an input communication flag. If another RMOS task or the CPU is in communication with the controller, these communication flags are available to them for both reading and writing.

This allows data to exchanged between the PLC and its communication partners, or specific operations of the control program to be synchronized with operations in other tasks.

2.3.5 Process Images

The controller stores the signal states of its inputs and outputs in process images. Process input images are treated differently from process output images:

- Process input images (PII):
  are read only at the beginning of a PLC cycle. During the cycle, the PII data is only accessed to check that the signal states have remained unchanged while the control program was executing.
- Process output images (PIQ):
  are written to only at the end of a PLC cycle. There is no output during the cycle to avoid changing the outputs unnecessarily with intermediate results from the control program.

2.3.6 Input/Output Units

Logical input units (input bytes) are read and logical output units (output bytes) are read from and written to peripheral devices. Logical inputs/outputs are allocated to physical inputs/outputs during DB 1 configuration.

2.3.7 Program Memory

There are different memory types which can be used to store control programs or to transfer program data from the PG to the controller:

- battery-buffered SRAM
- User flash memory (subsequently abbreviated as EPROM)

2.3.8 MC5 Compiler

The processor in the controller cannot process MC5 code unless it is compiled, i.e., translated into the appropriate 80386 code. The MC5 code is compiled into 80386 code at every restart of the PLC (after power-on or start of the IMC0x-PLC under RMOS), or when a program block is loaded from the PG.

2.3.9 PG Interface

The controller is connected to the PG via a serial interface. The PG is used to load, test and start control programs and in error diagnosis.

2.3.10 Shared Memory

When the controller communicates with another RMOS task it uses shared memory. The following data is exchanged via shared memory:

- controller operating mode
- process image PA, i.e., controller input (PII) and output state (PIQ)
- counters and timers
- communication flags to synchronize the controller with other tasks under RMOS

See chapter 12 for details of shared memory structure, configuration and programming.

3 Operating Modes

The PLC has two operating modes, RUN and STOP.

- In RUN mode, the process input image is read cyclically, the user program is executed and the process output image is written.
- In STOP mode, control is stopped and all outputs set to zero.

The transition from STOP to RUN is a restart. After power-on, a restart is executed, so that the necessary initialization functions are performed.

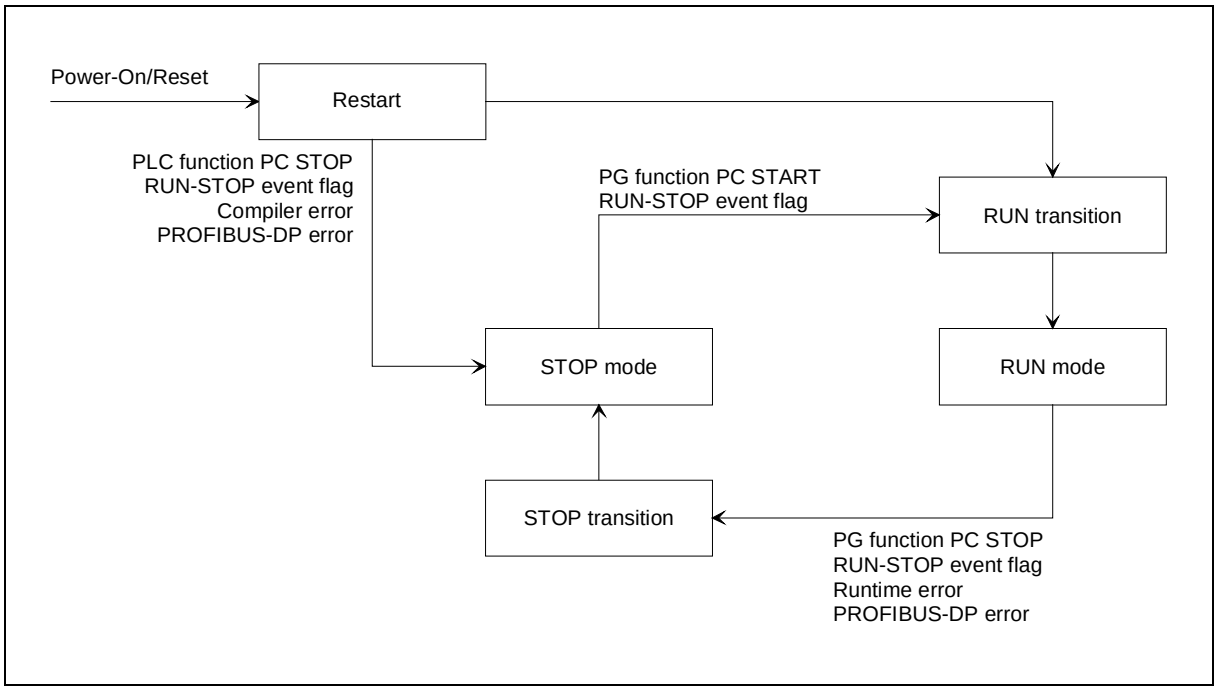


Figure 3. 1 PLC modes and operating mode transition

3.1 Operator Interface and Display Elements

IMC0x-PLC makes available an event flag group for operator control and indication (see chapter 11).

Control flags	- For RUN ↔ STOP change in operating mode - For overall reset of the PLC - For error acknowledgment
Indication flags	- For RUN and STOP operating modes - For runtime errors, compiling errors and warnings - For an overall reset request

The controller displays STOP/RUN modes as follows:

STOP mode	The STOP display is active and the RUN display inactive
RUN mode	The RUN display is active and the STOP display inactive

3.2 Restart

A controller restart is performed:

- when the power supply is switched on or
- after a hardware reset (from watchdog)

If the controller has retentive memory, the contents of this memory are checked during restart. Should this check show a loss of data, an overall reset request is automatically initiated. The controller cannot be switched into RUN mode until this request has been acknowledged and acted upon.

A restart executes all necessary initializations. The transition to RUN mode takes place only when the following conditions have been met:

- The controller was not stopped - before being switched off - with the PG function PC STOP (applies only to systems with retentive memory)
- If configured, the control flag must be set for operating mode RUN(see chapter 11)
- Error-free compilation of the MC5 codes (compiler run)

When the controller enters RUN mode for the first time after a restart, OB 22 is called as restart OB. It can be used to perform initializations.

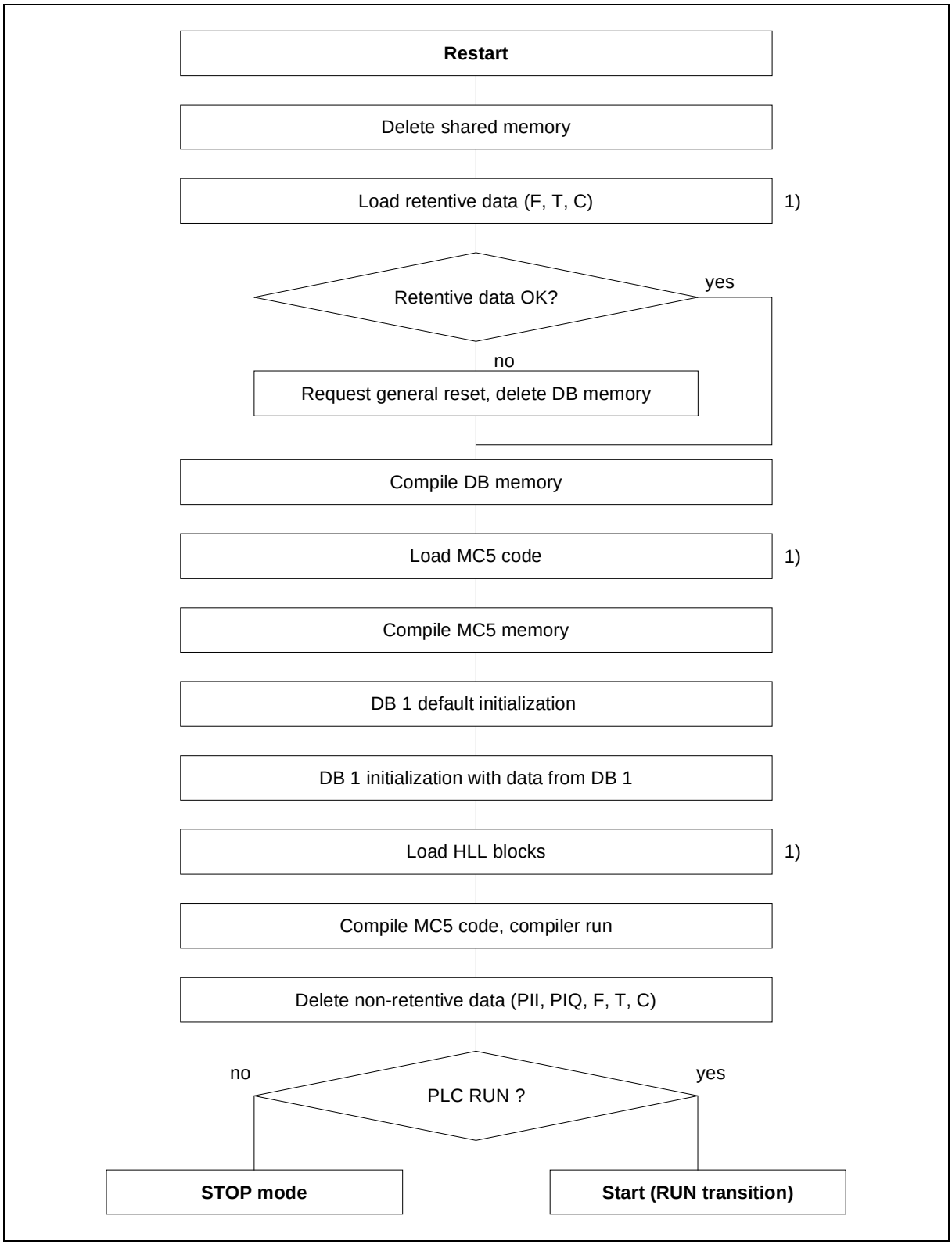


Figure 3. 2 Restart operation

1) If retentive mode is configured and retentive data are valid in the SRAM, these are used. Otherwise the applicable data areas are loaded from the EPROM.

3.3 Restart (RUN transition)

The restart is executed every time the operating mode changes from STOP to RUN.

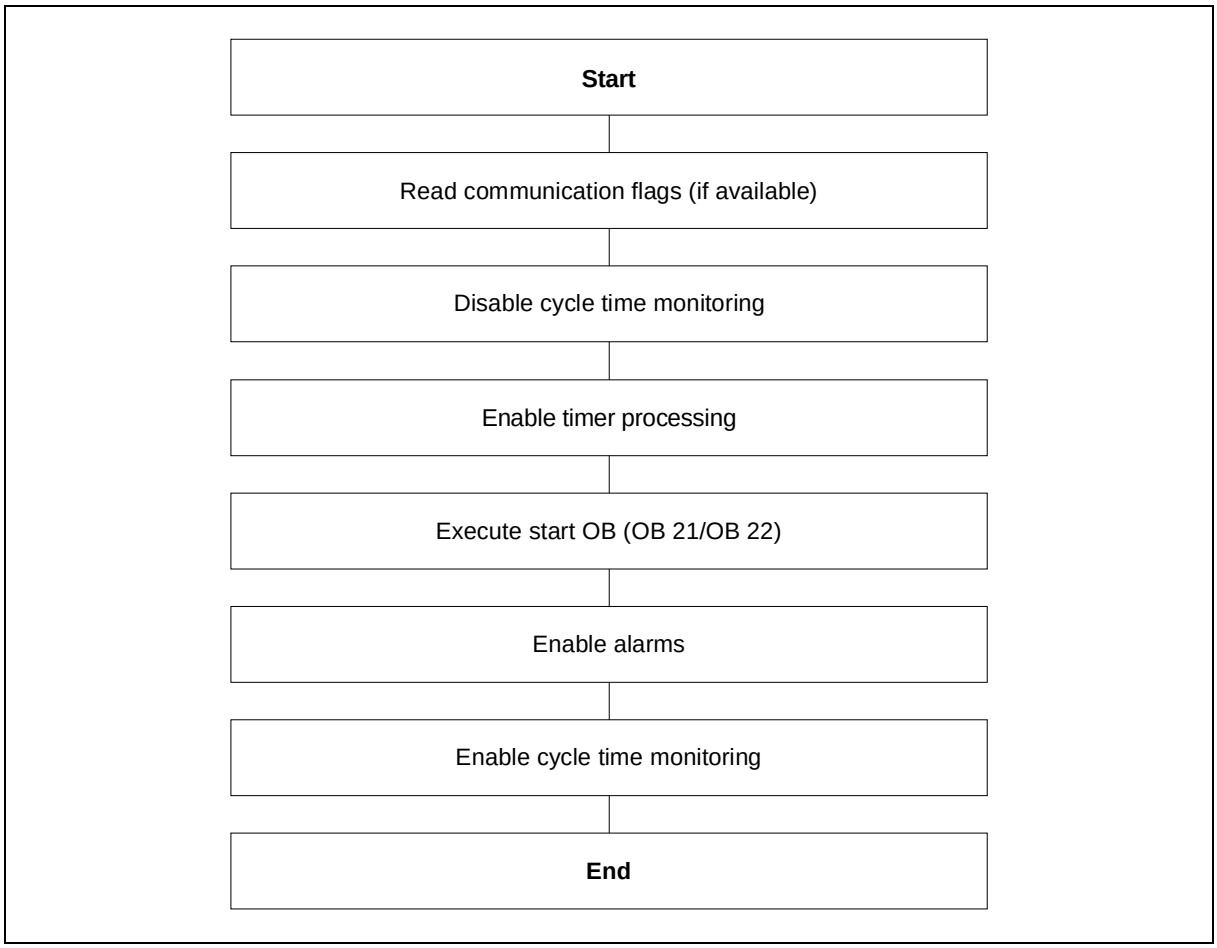


Figure 3. 3 Restart

The restart (RUN transition) is initiated by one of the following events:

- Executing the PG function PC START
- After a restart, if all RUN conditions have been met
- In response to an event flag (see chapter 11)

When the controller enters RUN mode for the first time after a restart, the restart OB 22 is executed. At each subsequent operating mode change from STOP to RUN, restart OB 21 is executed.

If the most recent controller STOP was initiated by the PG function PC STOP, then it can also be started again by using the event flag group, independently of the PG function PC START.

3.4 STOP Transition

A transition from RUN to STOP interrupts processing of the control program at the end of a PLC cycle, all outputs are set to zero. For application-specific requirements, STOP OB (OB 28) should be the last function to be called.

The PROFIBUS-DP communication remains, but in state "CLEAR".

Note:
All local and decentral outputs assume the value 0.

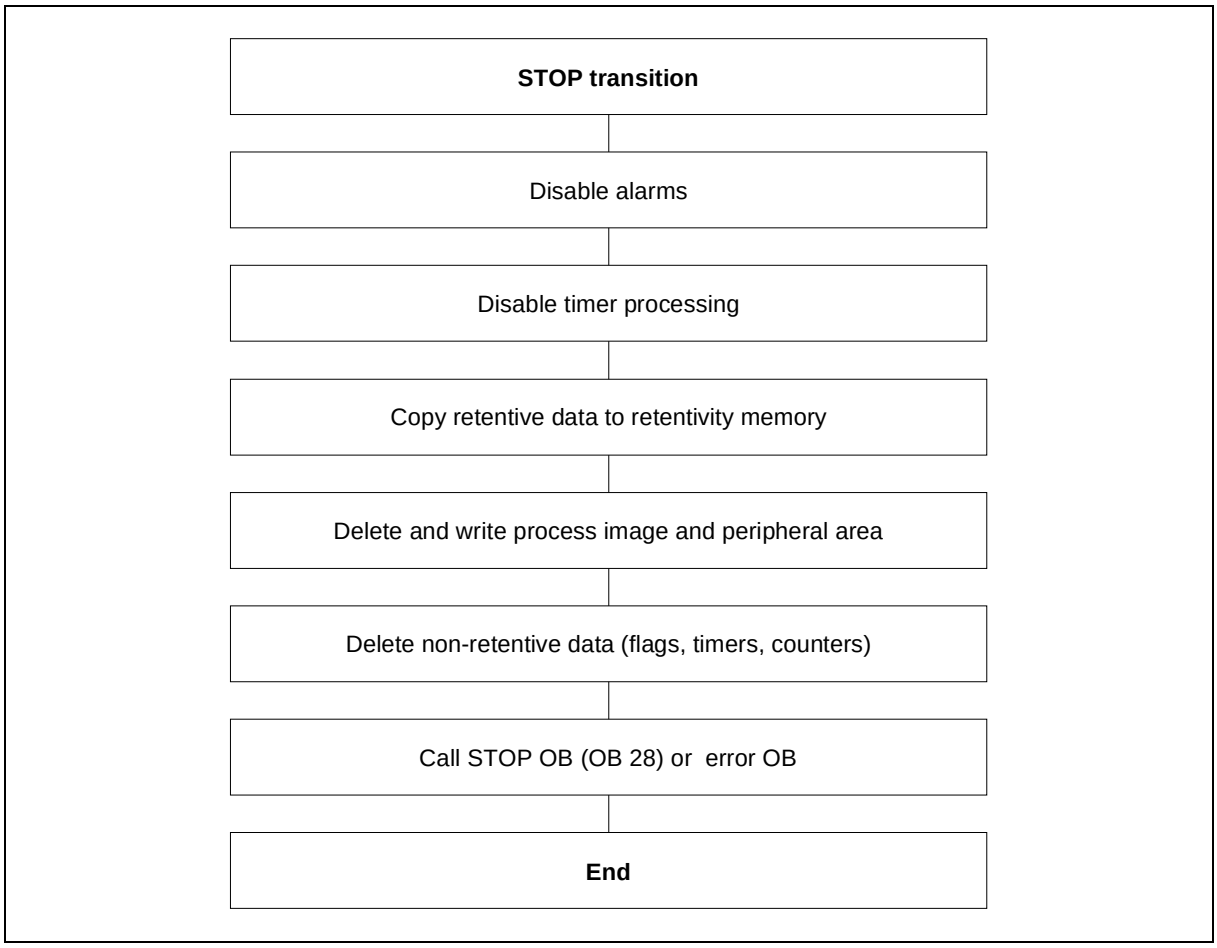


Figure 3. 4 STOP transition

The transition to STOP takes place after one of the following events:

- Execution of the PG function PC STOP
- Occurrence of a runtime error which is not caught by an error OB
- Resetting an RMOS event flag (see chapter 11)
- Occurrence of an error at a PROFIBUS-DP station for which "QVZ = J" is specified.

3.5 Operating Mode RUN

RUN is the operating mode in which control programs are executed. Control programs are executed at two processing levels:

- Cycle-driven processing level (PLC cycle)
- timer-driven processing level

3.5.1 Cycle-Driven Processing Level

This is the typical processing method for programmable controllers, i.e., read input - process control program - write to output. The organization block OB 1 is the interface for cyclic processing of a control program.

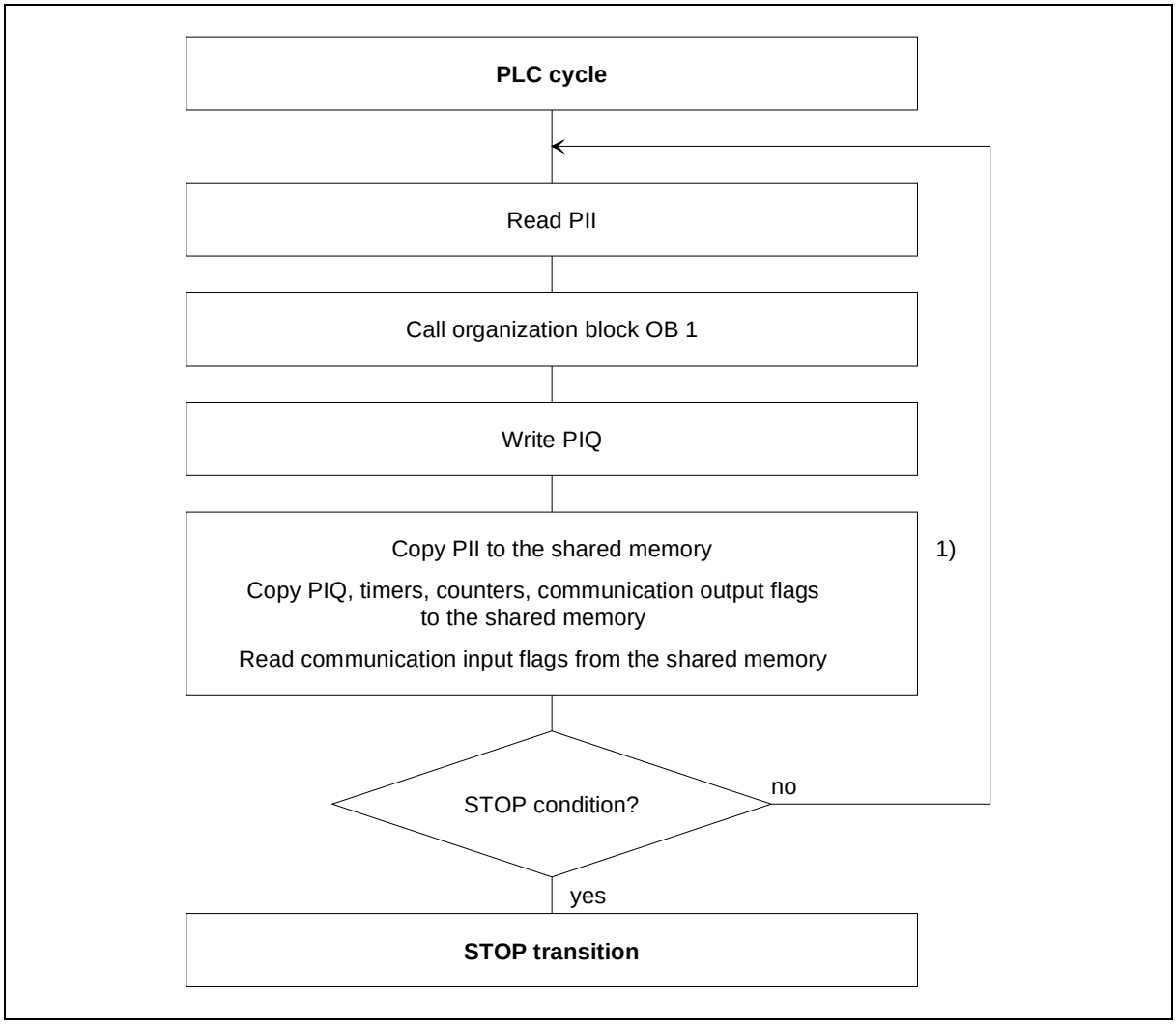


Figure 3. 5 PLC cycle, cycle-driven processing

1) See chapter 12

The accessibility of all decentral stations configured in the CP data base is monitored during both read and write accesses to the process image during the PLC cycle.

3.5.1.1 Scan Time Monitoring

Scan time is another way of saying "the runtime of the control program". It is directly dependent on the reaction time of the automation system at the cycle-driven processing level.

Scan time monitoring makes it possible to react to unexpected delays in program execution and to bring the control system into a defined mode. The maximum scan time is usually set in the restart organization blocks (OB 21 and/or OB 22) by writing a value to system data word SD 96 (see chapter 5). The value entered here is interpreted as a multiple of 10 msec. The default value for scan time monitoring is 500 msec. Cycle time monitoring can be switched off by entering a value zero in system data word 96.

Table 3. 1 Programming scan time monitoring

System data word	Absolute address	Time interval Programming	Default Setting
SD 96	EAC0	1 ... 0FFFFH * 10 msec (0 = no scan time monitoring)	0032H (500 msec)

Within a program, scan time can be retriggered by calling trigger OB 31. This makes it possible to adjust scan time monitoring to changing runtime situations.

If the set scan time is exceeded, error OB 26 is executed (if it is available) and the scan time retriggered. If OB 26 was not programmed, the controller switches to STOP mode.

A special case occurs when scan time monitoring is switched off and the user program is in an endless loop, so that it does not stop. If the operating mode flag is set to STOP, the controller will still be in RUN mode. In this case, the overall reset flag must be set in order to terminate the PLC cycle, because all the other conditions which would cause a STOP are only polled at the end of a cycle. When the reset button is used here, the controller displays the error message "scan time exceeded" and switches to STOP mode.

3.5.1.2 Scan Time Calculation

The controller provides data on user program runtime in a time base of 1 to 10 msec (resolution depends on the RMOS clock tick).

The values for current, minimum and maximum scan time are written to system data as listed below. They can be read with the PG function "output addresses".

System data word	Absolute address	Contents/meaning
SD 121	EAF2	Current scan time in msec
SD 122	EAF4	Maximum scan time in msec
SD 123	EAF6	Minimum scan time in msec

Current scan time is also written to the shared memory (see chapter 12). Scan time calculation, which takes up a certain amount of the processor's time, must be activated by an entry in DB 1 (see chapter 9). When SD 122 or SD 123 are set to the value 0, a new measurement is started.

3.5.1.3 Diagnosis While Reading/Writing the Process Image (Only with IMC05)

During the PLC cycle, accessibility of all decentral stations configured in the DP data base is monitored. If errors occur, error information is stored in system data words SD 124 to SD 126. See chapter 3.8.3. These system data words are cleared during the STOP → RUN transition.

Note:
When an error occurs on a station for which "QVZ = J" is specified in the PROFIBUS-DP data base, IMC0x-PLC assumes STOP status. When "QVZ = N" is specified for one or more stations, the error code must be evaluated in system data word SD 124 and then cleared.

The error code can contain all the error identifiers of the PROFIBUS-DP link. For the meaning of the error codes, see the technical description of IMC05-DP.

3.5.2 Timer-driven Processing Level

At the timer-driven processing level a program (block) can be processed cyclically within a time frame of 10 msec to 10 min, which you specify.

Timer-driven processing uses the organization blocks OB 10 to OB 13 (timer blocks). The time interval for each of the 4 organization blocks is set by an entry in the system data. The time frame can be set in steps of 10 msec. Time intervals can be set by commands in the restart organization blocks and also adjusted during program runtime by programming the system data words SD 100 to SD 97. Default time interval settings are: OB 13 100 msec and OB 10, OB 11 and OB 12 all set to zero. If a time interval is set to zero, calls to the corresponding OB are disabled.

If a timer block is activated during runtime by a programmed time interval, the first start of this timer block will have a fuzziness of 10 msec.

The following table shows how timer OBs are allocated to system data words:

Table 3. 2 Timer block settings

System data word	Absolute address	Time interval Programming	Default Setting
SD 100	EAC8	OB 10: 0 ... 0FFFFH * 10 msec (0 = disable OB 10 calls)	0 (disabled)
SD 99	EAC6	OB 11: 0 ... 0FFFFH * 10 msec (0 = disable OB 11 calls)	0 (disabled)
SD 98	EAC4	OB 12: 0 ... 0FFFFH * 10 msec (0 = disable OB 12 calls)	0 (disabled)
SD 97	EAC2	OB 13: 0 ... 0FFFFH * 10 msec (0 = disable OB 13 calls)	000AH (100 msec)

In the following example, the time interval for OB 13 is programmed in the restart OBs 21 and 22. Access to the system data word is only possible via function blocks (FB 21).

Table 3. 3 Setting of a time interval (1 sec period for OB 13 calls)

OB 21	**OB 22**	**FB 21**

`JU FB 21`
`Name : Time ON`
`.`
`.`
	`: JU FB 21`
	`Name : Time ON`
	`.`
	`.`
		`Name : Time ON`
		`: L KF 100`
		`: T RS 97`
		`: BE`

A cyclic program can be interrupted by a timer-driven processing level. The IA command disables calls to all timer OBs, and the RA command enables them again.

If the processing time for a timer OB is longer than the set time interval (i.e., the timer OB overtakes itself), then an timer error occurs (see chapter 3.8.1.2). A timer error also occurs when tasks with higher priority than the timer blocks take up too much processor time, impeding execution of the timer blocks. If the time OBs are delayed by the IA command, no time interrupt error occurs. To keep impact on the cyclic program execution as low as possible, execution time for timer-driven processing level should be kept small.

The flowchart below shows all these relationships:

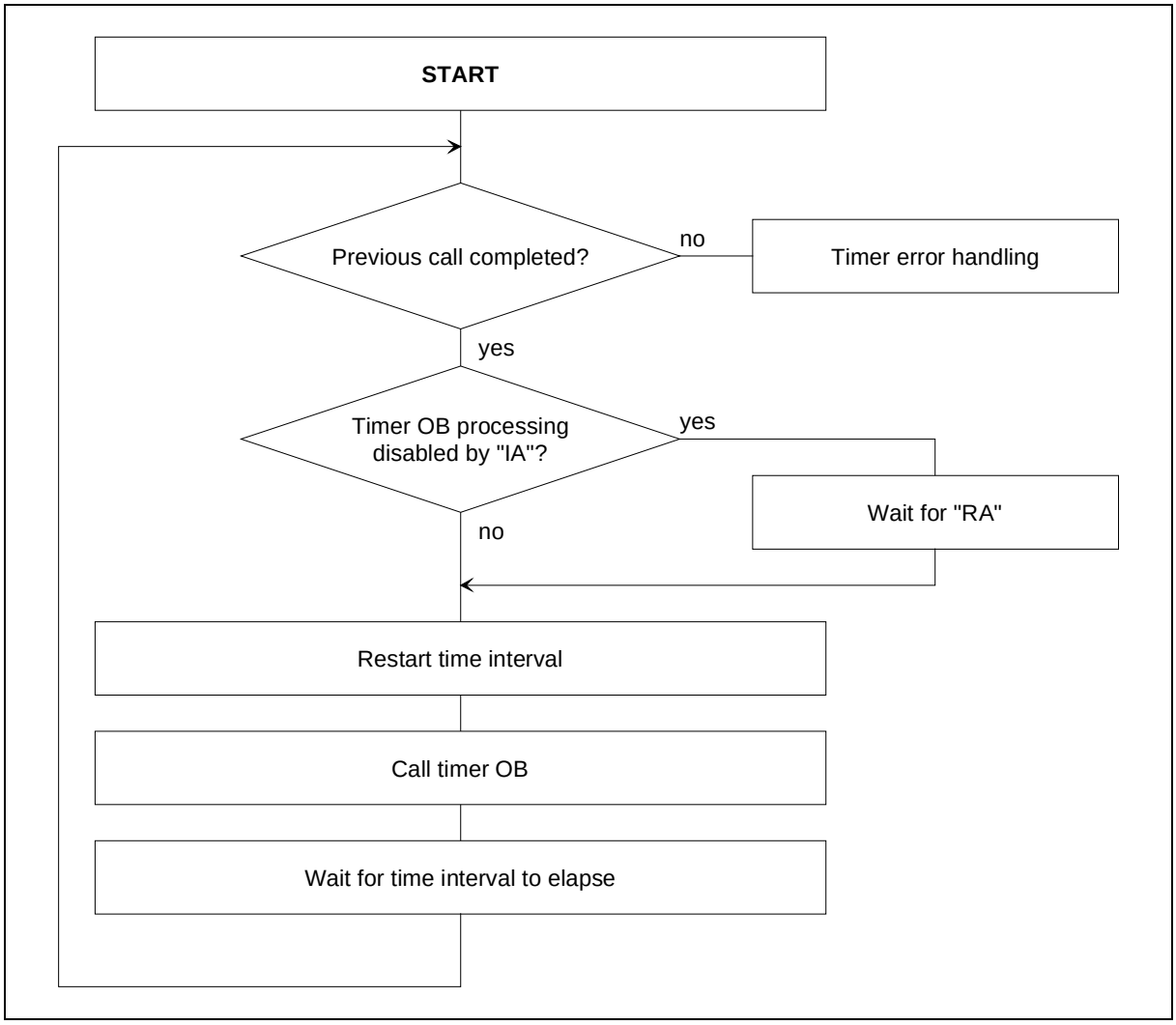


Figure 3. 6 Calling a program at the timer-driven processing level

3.6 Retentivity

Retentive data like flags, counters, timers and data blocks are stored in DB memory. The size of this memory is set during configuration (see chapter 10). For DB memory SRAM must be configured. Otherwise retentive data storage is not possible.

Since data blocks are generally stored in retentive memory, they are always retentive. Flags, timers and counters are saved to retentive memory only on a transition to STOP mode, or if there is a power failure.

Note:
The retentivity of the data blocks depends only on the type of memory configured. On the other hand, the retentivity of the operand areas - flags, timers and counters - must also be specially set in the DB 1 configuration. During restart the contents of retentive memory are checked. If there has been a data loss, an overall reset request is automatically issued.

An entry in the DB 1 configuration (see chapter 9) can define a flag area (FB 0 to FB 127) as retentive data. These data are retained even when program execution is interrupted and are available when the operating mode has changed back to RUN. If retentive flags have been configured, the operand areas C 0 to C 63, T 0 to T 63 are automatically made retentive too.

Note:
An overall reset deletes even retentive data.

3.7 Overall Reset

The "overall reset" function re-initializes the controller. All blocks previously loaded by the PG into RAM are lost, together with the retentive data blocks. After the overall reset, the MC5 code is loaded from EPROM again.

An overall reset can be requested in the following ways:

- Via the PG
- Automatically after data loss in retentive memory (after a restart)
- In response to an event flag (see chapter 11)
- Via a new start after a hardware reset.

The reset request is indicated by setting the overall reset flag.

3.7.1 Overall Reset by Event Flag

The following steps assume that the operating mode flag is at STOP.

1. Set control flag for overall reset.
   Indication flag for overall reset request is set.
2. Wait until indication flag for overall reset request is reset.
3. Set control flag for operating mode change to RUN.
   Indication flag for RUN operating mode is set.
4. Set control flag for operating mode change to STOP.
   Indication flag for STOP operating mode is set.
5. Set control flag for operating mode change to RUN.
   PLC begins operation.

If the controller is in RUN mode, an overall reset request made by the control flag does not take effect until the control flag for operating mode change is set to STOP or the PC STOP function is executed.

3.7.2 Overall Reset via the PG

An overall reset is requested with the function "Delete all blocks" and is executed immediately if the controller is in STOP mode. No acknowledgement is expected in this case.

After the overall reset the controller remains in STOP mode.

If the controller is in RUN mode the PG request is not passed on to the controller, i.e., it has no effect.

3.7.3 Overall Reset by the System

An overall reset request from the system can happen only with controllers where DB memory has been configured as retentive memory. An overall reset request must always have a positive acknowledgement. Only then can controller operation be continued.

An overall reset is requested by the system when the controller is switched on for the first time, because the required memory areas are not yet initialized. When the size of the MC5 memory (`mc5_size`) is changed, an overall reset is also requested.

3.8 Error Handling

Basically there is a difference between runtime errors (compatible to SIMATIC S5-115U, see below) and IMC0x-PLC-specific error code which is written to a reserved system datum, the error status word (see chapter 5). All errors are indicated by activating the error display (event flag).

3.8.1 Runtime Errors

Runtime errors can occur only while a user program is executing, i.e., in RUN mode, because their source is the STEP 5 program code. Runtime errors are usually read out at the PG by displaying the ISTACK.

The following runtime errors can occur when the IMC0x-PLC is running:

- scan time exceeded
- timer error
- substitution error
- transfer error
- call of nonexistent block
- block stack overflow
- STS command

Note:
The "SAC" indication always has the value 0 for errors TRF, SUF, STUEB and QVZ (i.e., SAC cannot be used for error localization here). The incorrect code location can be determined by BEF-REG.

Errors are indicated by setting the error flag. Digital outputs are deleted, processing of the controller program stops (exception: see chapter 3.8.1.5) and the controller goes into STOP mode.

Before processing can start again, the error must be acknowledged.

Acknowledgement by event flag:

Acknowledgement by event flag is application-specific and must be programmed as part of the controller realized with the IMC0x-PLC.

With the exception of block stack overflow, timer error and the special case of an STS command, an error reaction can be programmed for all runtime errors (error OB).

If no STS command (immediate stop) has been programmed in the error OB, the error OB is processed and then controller program processing is continued without any error display. In effect this suppresses error display.

If the appropriate error OB is not available, the controller switches into STOP mode as described above. During transition to STOP mode after a runtime error, the STOP OB (OB 28) is not called.

3.8.1.1 Scan Time Exceeded

Scan time is exceeded when the scan time entered in the system data word SD 96 is exceeded, i.e., when the PLC program does not reach the end of a cycle within this time. The scan time monitoring can be deactivated by entering the value 0 in the system data word SD 96.

3.8.1.2 Timer Error

A timer error occurs when a timer OB overtakes itself, i.e., when it is due to be started again although the previous processing has not yet finished. When a timer error occurs, the controller goes into STOP mode. An error OB cannot be programmed for timer errors.

3.8.1.3 Substitution Error

A substitution error occurs when, in a substitution instruction, the formal operand does not match the specified actual operand. In the case of a substitution error, the error OB 27 is executed and the substituted command is omitted. If error OB 27 was not programmed, the controller goes into STOP mode and the error code is written to the ISTACK.

3.8.1.4 Transfer Error

A transfer error occurs when

- data words are accessed, but no data block was previously called
- during a read/write on a data block, a data word/data byte is addressed which is not part of the block, i.e., block length is exceeded
- an I DB command is being executed, but the free user memory is insufficient to create a data block of the specified length.

In the event of a transfer error, the operation which was the source of the error is not executed, instead error OB 32 is called. If error OB 32 was not programmed, the controller goes into STOP mode and error code is written to the ISTACK.

3.8.1.5 Calling Nonexistent Blocks

This error occurs when a block call command (JU xx, JC xx) specifies a block which was not programmed. In this case error OB 19 is called (if it was programmed) instead of the nonexistent block. The controller does not go into STOP mode, but the error flag is set to indicate an error.

3.8.1.6 Block Stack Overflow

Block nesting depth is restricted to 32. A block stack overflow occurs when the nesting depth of 32 block calls is exceeded (i.e., when the 33rd block is called). When this happens, the controller goes immediately into STOP mode and the ISTACK error code is entered. It is not possible to program any other reaction for this error.

The order in which block calls were issued can be displayed with the PG function "OUTPUT BSTACK".

3.8.1.7 STS Operation (STEP 5 Command)

The STS operation (immediate stop) is actually not an error. In contrast to the STP operation (stop at end of cycle), the STS operation is generally used in OBs in order to stop the PLC in a defined state. The STS operation causes an entry to be made in the ISTACK and the controller to go into STOP mode.

3.8.2 IMC0x-PLC -specific Errors

In addition to runtime errors, there are other errors which are specific to the IMC0x-PLC:

- DB 1 error
- Compiling error
- Memory overflow in runtime area

- LIR/TIR/TNB error (illegal address area)
- Read/write error in retentive data file
- Clock error

When one of these errors occurs, the IMC0x-PLC goes into STOP mode and sets the error display (event flag). In general, unless specifically stated otherwise, the IMC0x-PLC can be started again from the PG, although the error should naturally be corrected first. (The sequence "request overall reset - negative acknowledgement" will switch the controller into RUN mode without using the PG.

3.8.2.1 DB 1 Error

The DB 1 data block contains configuration data for the IMC0x-PLC, e.g., the allocation of logical inputs/outputs to physical addresses in the inputs/outputs (see chapter 9).

When a DB 1 containing an error is loaded, then the appropriate error bit in the error status word SD 104 (see chapter 3.8.3) is set and the IMC0x-PLC goes into STOP mode, or alternatively cannot be switched into RUN mode. Corrective action in this case is to correct and reload the DB 1. Then start the IMC0x-PLC using the PG function PC START. The causes of an incorrect DB1 are described in chapter 5 (DB 1 configuration) of the reference manual.

3.8.2.2 Compiling Error

Each time a new start of the PLC is performed and each time the blocks are loaded via the PG, compiling is performed again. If illegal commands or command sequences are found, bit 15 of error status word SD 104 is set. The illegal code in stored in SD 111.

Illegal command sequences are listed below.

- 0 after 0
- Jump with JO =, JZ =, JM =, JU =, JN =, JP = or JC = in a logical chain with the commands A =, O =, AN =, ON =, AW =, OW =, XOW =, UM, OM, UNM, ONM, UZ, OZ, UNZ, ONZ, A(, O(,), UE, UA, OE, OA, UNE, UNA, ONE, ONA, UT, OT, O, UNT, ONT.

Note:
The PLC cannot be put into RUN status again by deleting the incorrect block. The PLC can only be put into RUN status again by deleting the invalid command in the block or after a new error-free block has been loaded.

3.8.2.3 Memory Overflow in Runtime Area

The compiler run generates processor code from MC5 code. The 80386 code is written to a special memory area, the runtime area. The size of the runtime area is a multiple of the size of the MC5 code.

Normally, program size is restricted in the first instance by the amount of memory needed for MC5 code (`mc5_size`, see chapter 10), i.e., while loading a block the PG reports "Insufficient memory in controller". Only in exceptional cases, where the 80386 code requires more memory area than expected will the error "Memory overflow in runtime area" be reported. This also means that memory for MC5 code is almost completely full. The function "Compress memory" will release unnecessarily occupied memory area, also in the runtime area. If the problem cannot be solved in this way, i.e., there is still insufficient memory, the parameter `mc5_size` must somehow be set larger. If, on the other hand, compressing memory released a sufficiently large memory area, then the controller can be started again from the PG. The controller can be switched back into RUN mode only after compressing memory.

3.8.2.4 LIR/TIR/TNB Error

This error is reported when the commands LIR/TIR/TNB access addresses which are not available under the IMC0x-PLC. This error is also reported when the TNB command attempts to copy data beyond range limits.

3.8.2.5 Clock Error

For the different PLC timer functions the IMC0x-PLC requires a 10 msec clock cycle, which is derived from the RMOS system clock. At the end of every 10 msec timer interval, the internal timer routine is called to update, e.g., the times T 0 to T 127. A clock error is reported if this internal timer routine cannot be processed within a 10 msec time interval, i.e., the timer routine is started again before it has finished processing. The clock error report is initiated by an internal monitoring function when the system load (e.g., from interrupts) is too heavy.

3.8.3 Error Status Word

The error status word SD 104 (address EAD0) is used to report IMC0x-PLC-specific errors. Information on the cause of the error is entered in the system data words SD 105 to SD 111. These system data words can be read out with the PG function "Output addresses".

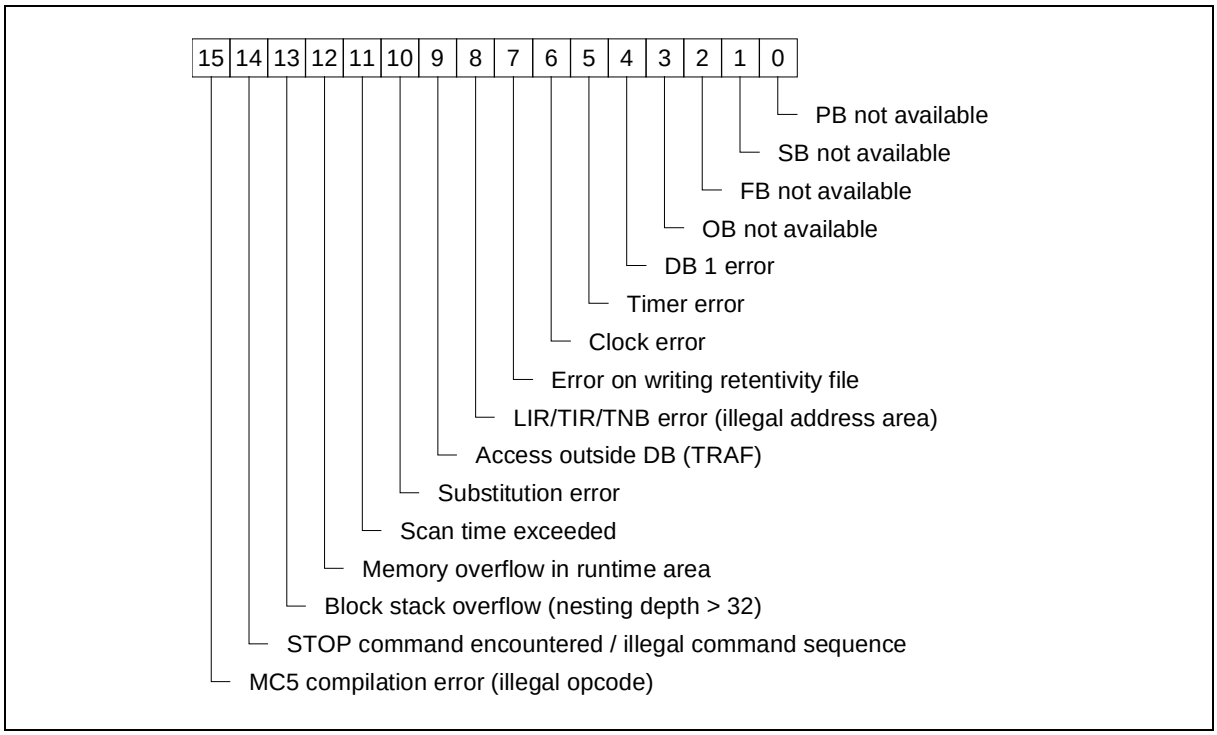


Figure 3. 7 Error status word SD 104 (address EAD0)

Additional information about errors

Table 3. 4 System data words for error localization

System data word	Absolute address	Meaning
SD 104	EAD0	Error status word
SD 105	EAD2	Number of data word in which the error occurred
SD 106	EAD4	Number of data block in which the error occurred (always 0)
SD 107	EAD6	Number of program block in which the error occurred
SD 108	EAD8	Number of sequence block in which the error occurred
SD 109	EADA	Number of function block in which the error occurred
SD 110	EADC	Number of organization block in which the error occurred
SD 111	EADE	Illegal MC5 instruction code

Table 3. 5 System data words for PROFIBUS-DP diagnostics (only with IMC05)

System data word	**Absolute address**	**Meaning**
SD 124	EAF8	Error code (return value of the call `dpn_out_slv_m` or `dpn_in_slv_m`)
SD 125	EAFA	Number of the faulty station
SD 126	EAFC	Slave status of the faulty station (`slv_state`, see Technical Description IMC05-DP)

4 I/O Addressing

Generally, inputs and outputs are addressed via the input process image PII and the output process image PIQ. In addition, it is possible to access inputs/outputs directly via peripheral accesses, without taking the route via the process image. The extended peripheral area forms an additional address area for inputs/outputs which is independent of the process image.

The following I/O operand areas can be used with the IMC0x-PLC:

IB 0 to IB 127 digital inputs, access via the process image

QB 0 to QB 127 digital outputs, access via the process image

PB 0 to PB 127 digital I/O, direct access to digital inputs/outputs

PB 128 to PB 255 and QB 0 to QB 255
extended peripheral areas

Inputs and outputs are allocated to the physical addresses of the appropriate inputs/outputs by means of entries in SWCPLC.C or in the DB 1 data block. DB 1 programming is covered in chapter 9.

4.1 Bitwise Addressing

Individual bits in the process image are represented by specifying the byte plus the bit number, separated by a period:

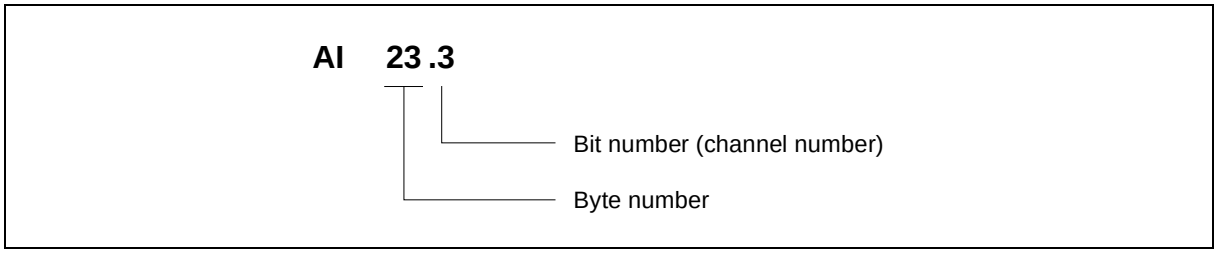


Figure 4. 1 Structure of a bit address

Bitwise addressing is used mainly for addressing digital input/output channels.

Note:
Bitwise addressing with peripheral access is not possible.

4.2 Bytewise and Wordwise Addressing

Bytewise or wordwise accesses are identified by a B or a W following the operand type (I, Q, P).

For wordwise addressing the lower byte number is specified, e.g.:

- QW 34 corresponds to QB 34 and QB 35
- QW 116 corresponds to QB 116 and QB 117

4.3 Access to the PII

At the start of cyclic program execution, the signal states of the digital inputs are read into the PII. This ensures that the signal states remain unchanged during execution of the control program.

The PII can be accessed bit-, byte- and wordwise.

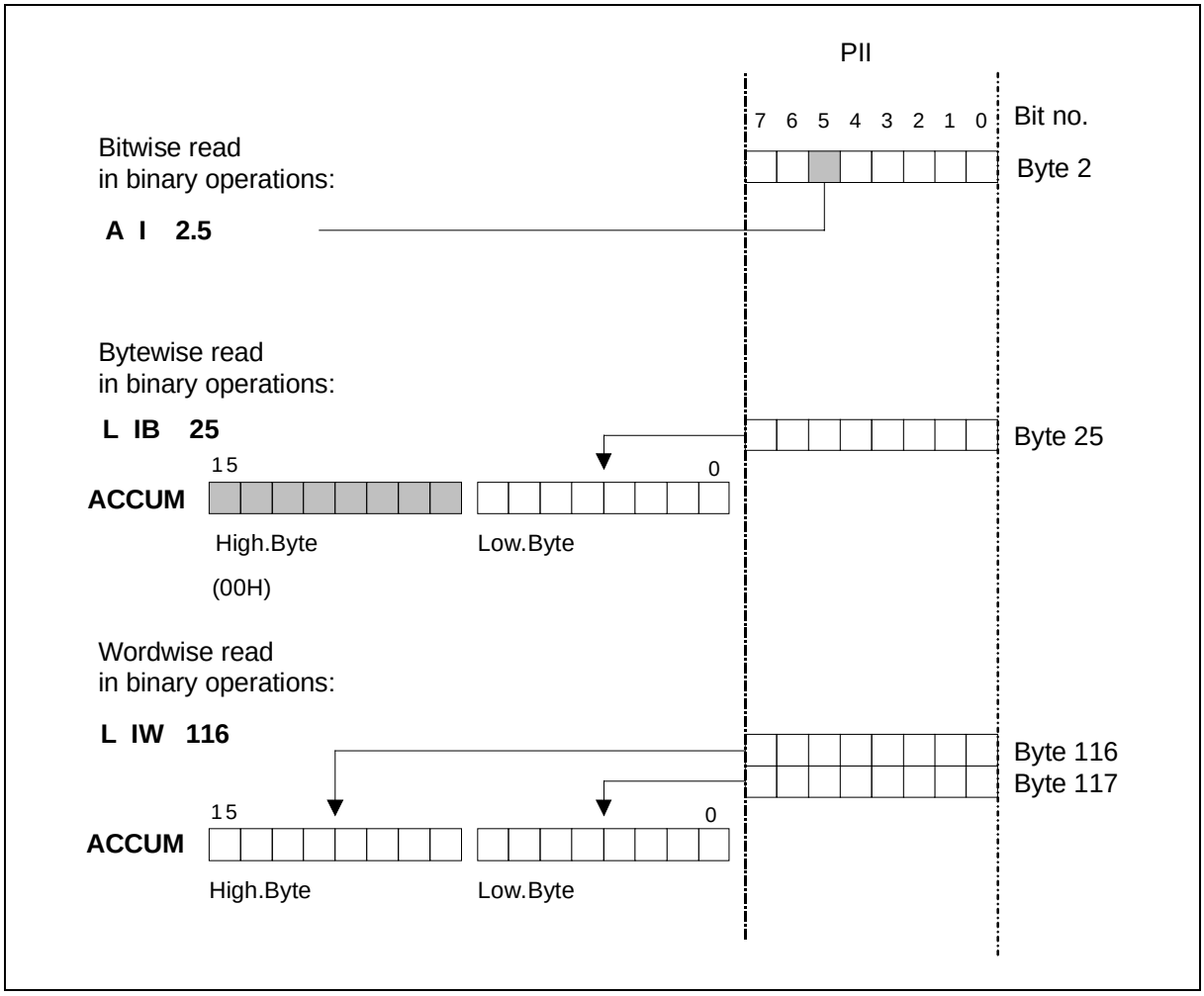


Figure 4. 2 PII access

4.4 Access to the PIQ

At the end of cyclic program execution, the digital outputs are transferred from the PIQ to the peripheral area. This avoids changes to output signal states caused by intermediate results from the control program.

The PIQ can be accessed bit-, byte- and wordwise.

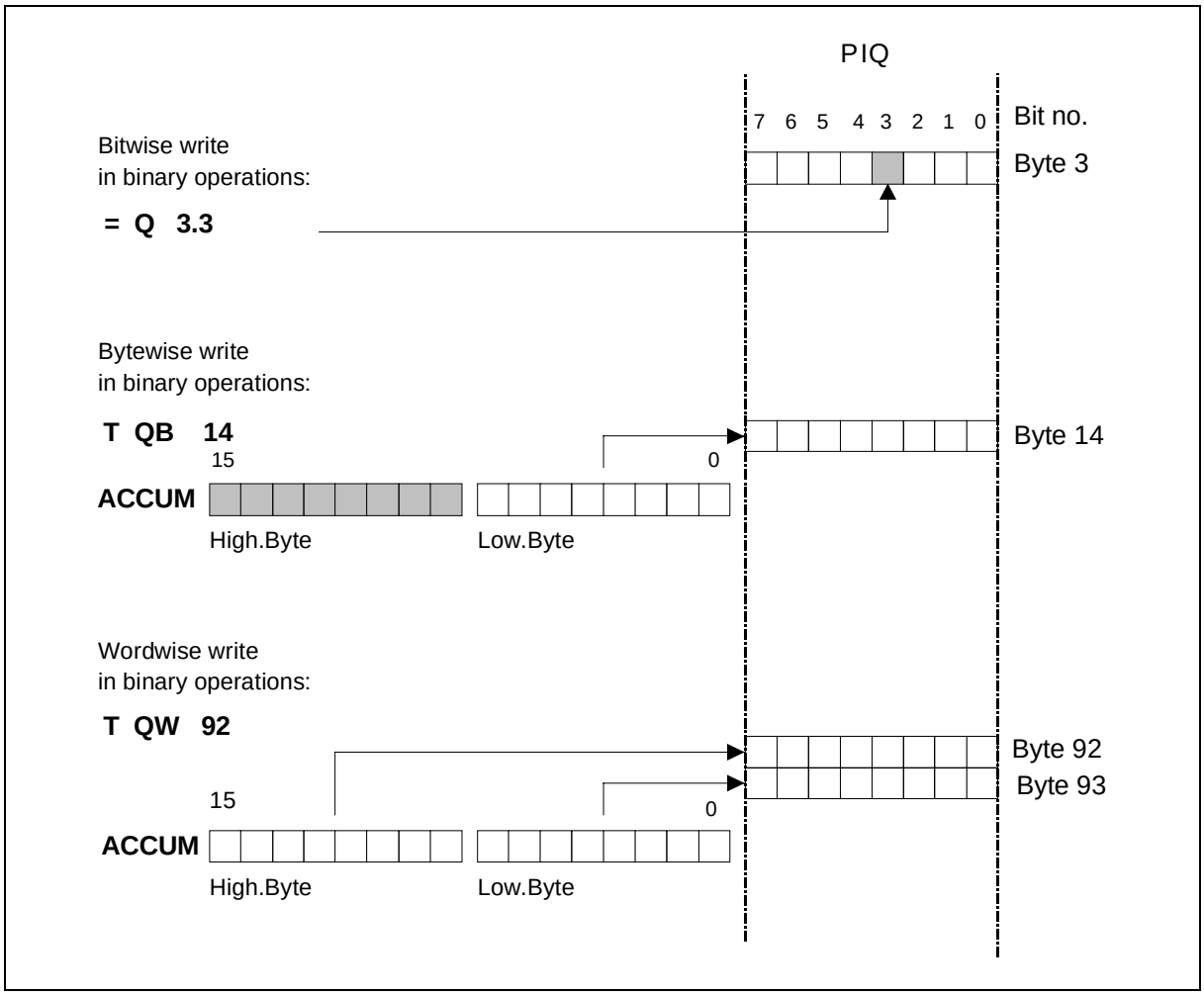


Figure 4. 3 PIQ access

4.5 Direct Access

The IMC0x-PLC also allows direct accesses to inputs and outputs. The load operations L PB 0 to L PB 127 or L PW 0 to L PW 126 access the digital inputs. The transfer operations T PB 0 to T PB 127 or T PW 0 to T PW 126 access the digital outputs. (The physical addresses are the same as for operations with the operands IB 0 to IB 127 or QB 0 to QB 127.)

The operand areas PB 128 to PB 255 and QB 0 to QB 255 (or PW 128 to PW 254 and QW 0 to QW 254) are used to access the extended peripheral area. Again, load operations select inputs and transfer operations select outputs.

Transfer operations to the peripheral bytes PB 0 to PB 127 simultaneously update the output process image (PIQ). This prevents arbitrary resetting of the output when the PIQ is transferred to peripheral devices. The PII is, however, not updated by load operations.

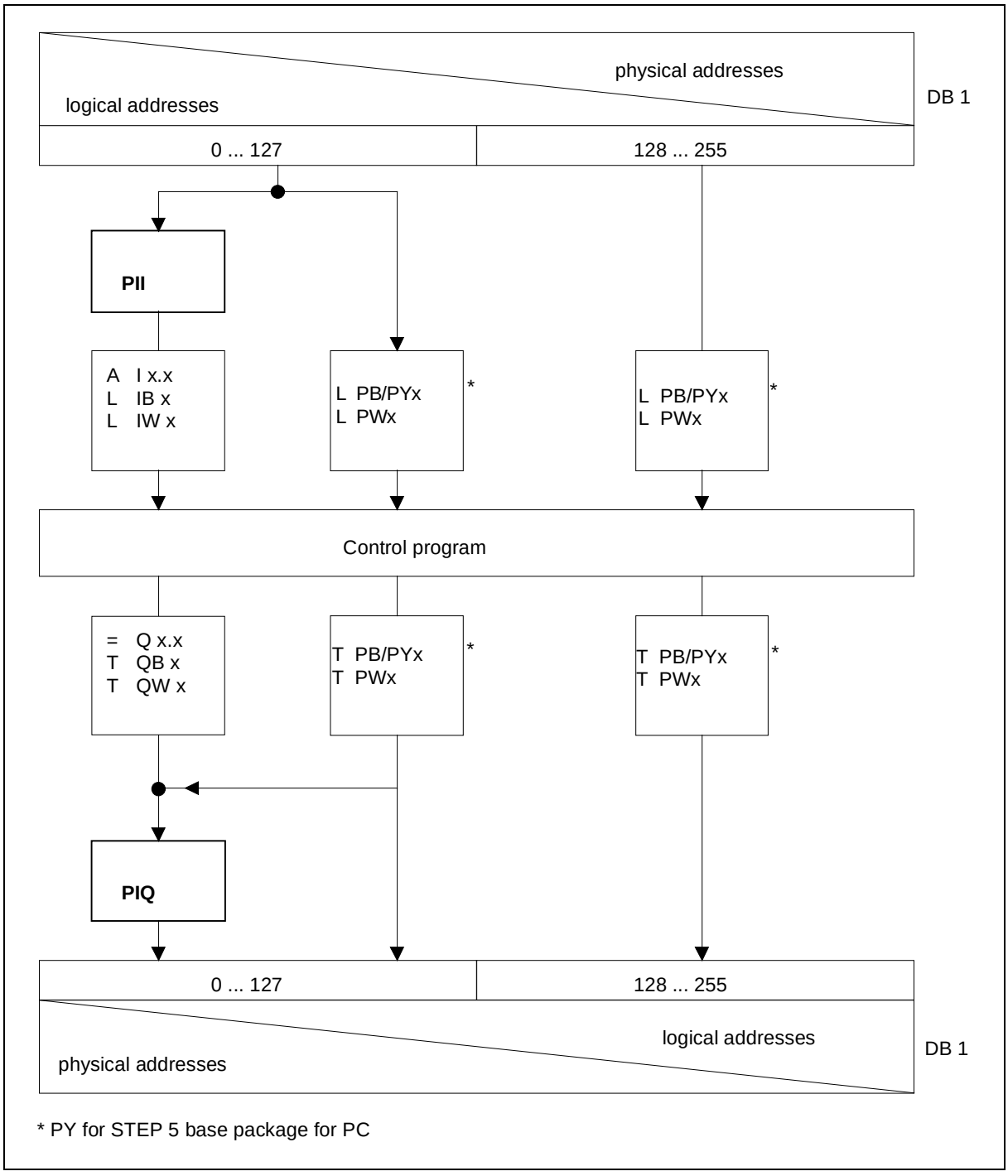


Figure 4. 4 Direct access to inputs/outputs

Address allocation is managed with entries in the data block DB 1.

4.6 Initializing Outputs

The outputs of the IMC05 can be initialized during startup with initial values. There are different ways in which blocks can be initialized:

- initializing by DB 1 data block
- initializing by SWCPLC.C
- initializing in restart OB 22

Initializing by the DB 1 data block is described in chapter 9.

4.7 Access to Decentral Inputs/Outputs

With IMC05

The IMC0x-PLC uses the following calls of the RMOS-DP interface for data communication with the decentral I/O stations. See also the technical description of IMC05-DP.

`Com05DPStart()`	Set up a DP entity
`dpn_init()`	Register a DP application
`dpn_read_cfg()`	Determine the configuration of the DP system
`dpn_in_slv()`	Read the input data of one DP slave
`dpn_in_slv_m()`	Read the input data of several DP slaves
`dpn_out_slv()`	Send output data to one DP slave
`dpn_out_slv_m()`	Send output data to several DP slaves
`dpn_slv_diag()`	Request diagnostic data of a slave

The process image is updated with `dpn_in_slv_m()` and `dpn_out_slv_m()`. The I/O bytes are addressed with `dpn_in_slv()` and `dpn_out_slv()`. These calls require an execution time of 300 to 400 microseconds to access an I/O byte or I/O word.

Since only all inputs or outputs of one station can be read or written simultaneously, a read or write job must be triggered for all I/O bytes of that station when direct I/O accesses (with L PY or T PY) are used.

The I/O bytes written last are stored locally.

IMC0x-PLC supports up to 16 activated PROFIBUS-DP stations. A maximum of 32 bytes are permitted per station.

The PROFIBUS-DP interface is designed as a driver. This ensures that only one job is processed at a time when several requests by various tasks are made.

With IMC01

With the IMC01, decentral I/O cannot be linked directly to the I/O area of the PLC (in contrast to IMC05) since the IMC01 has a DP slave and not a DP master.

However, decentral I/O can be processed with the STEP 5 program. This means that a DP interface must be included in the C program section of the application. See technical description of the IMC01-BSP.
HLL function blocks can then be used to image the DP input and output areas in a PLC data block, for example.

5 Testing and Startup Functions

The IMC0x-PLC supports all the test and startup functions of SIMATIC STEP 5 programmers:

- Status block
- Status variables
- Forcing variables
- Forcing outputs
- Loading of blocks PLC ↔ PG
- Deleting blocks
- PC-START/STOP
- Controller directory
- Memory compression
- Program-dependent signal state reporting
- Process monitoring
- Output of the interrupt stack (ISTACK)
- Output of the block stack (BSTACK)
- System parameter output
- Address output
- Display memory structure

These functions are described below. You will find more detailed information in the corresponding programmer manual.

Communication between the PLC and PG is handled by the AS511 protocol using RS 232-2 of the IMC05 or COM1 of the IMC01. See chapter 5 of the user manual. In the case of different interface formats, you will have to use an interface converter.

Note:
Transfer speed for serial communication is set to 9600 baud.

5.1 Forcing Variables

This test function lets you change any process variables (operand area I, Q, F, D, T, C). The variables are changed at the end of a processing cycle. It is not possible to influence signal states directly during a cycle.

Controlling variables is primarily a way of modifying processing in RUN mode, but it can also be used effectively in STOP mode. Changed variables are accepted at the RUN transition.

5.2 Forcing Outputs

This function lets you address outputs directly so as to test the wiring to peripheral components. You can also check the allocation of logical output bytes to physical addresses (DB 1 configuration). The IMC0x-PLC must be in STOP mode for this test function. All outputs used from the IMC0x-PLC then are reset.

5.3 Compressing Memory

When a block of user memory is deleted, although it then no longer exists logically, it still takes up memory space. The "Compress memory" function releases this space. Memory is also compressed automatically every time the CPU is switched on (power-on reset).

Note:
When a compression is triggered by the PG, for example, this may change the physical address of the data block. Keep this in mind when accessing a data block with a pointer from HLL blocks.

5.4 Direct Signal State Reporting (Status Variables)

While the controller is in RUN mode, this test function reports the state of any specified operand (I, Q, F, D, T, C). The information is taken from the process image of the specified operand at the end of a processing cycle. However, if an operand's signal state changes several times during the course of a processing cycle, this fact cannot be registered by testing in this way.

In STOP mode, the operand area "digital inputs" is not read from the process image, but directly from the inputs.

5.5 Program-dependent Signal State Reporting

This test function reports current signal states and RLO (result of logic operation) of individual operands while program code is being processed.

In addition it lets you make corrections to the program. The controller must be in RUN mode for this test function to operate.

5.6 Process Monitoring

This function lets you execute any code block in step mode. Calling this PG function causes program processing to be halted at a specified point. You specify the halt point - an instruction in the program - by positioning the cursor on it in the chapter of program code displayed on your monitor. Current signal states and RLO, up to the specified instruction, are reported. By repeatedly moving the halt point, you can process any STEP 5 code block step by step.

Process monitoring means that:

- All jump commands are traced
- Block calls are processed without delays. Process monitoring is resumed only after return. At the end of the block (BE) program execution is automatically ended.
- The process image is not updated from/to the inputs and outputs - outputs are set to zero. If the controller is switched from STOP to RUN only after process monitoring has been activated, the input process image is set to zero for the remainder of the program run.

5.7 Output of Interrupt Stack (ISTACK)

Outputting the ISTACK helps to determine the cause of a runtime error. Runtime errors are indicated by setting the error flag. When a runtime error occurs, the controller switches to STOP mode (the mode change includes a ISTACK entry) only if the appropriate error OB is not available, or if a STOP instruction (STS) is programmed.

Note:
ISTACK output by the IMC0x-PLC does not comply completely with S5 conventions. See chapter 15).

5.7.1 Determining the Error Source

The STEP 5 address counter (SAC) in the ISTACK specifies the absolute start address of the block in which the runtime error occurred. However, the erroneous STEP 5 instruction in the block cannot always be identified by means of this address. In this case the SAC indicates the start of the block and the relative command counter (REL-SAC) will always contain the value 0.

The command register BEF-REG, however, contains the MC5 code of the STEP 5 instruction which caused the runtime error. By consulting the table in the Reference Manual, chapter 2.6 you will be able to identify the corresponding STL instruction.

Determining the error source is only relevant, if the error is one of the following:

- substitution error
- transfer error

5.7.2 ISTACK Output to PG

The following tables show the ISTACK of the IMC0x-PLC. In contrast to the PG, only the bits mentioned here are significant. The bold encircled bits have a different meaning.

Table 5. 1 Control bit output

System data word	Absolute address	Control bits 7							0
SD 5	EA0A	–	–	BSTSCH	SCHTAE	ADRBAU	–	–	–
	EA0B	CA-DE	CE-DE	–	REMAN	–	–	–	–
SD 6	EA0C	STOZUS	STOANZ	–	–	–	–	BARB	BARBEND
	EA0D	–	–	MAFEHL	EOVH	–	AF	–	–
SD 7	EA0E	ASPNEP	ASPNRA	–	–	ASPNEEP	–	–	–
	EA0F	KEINAS	–	–	–	–	–	–	URLAD

– = not used

Absolute address	System data word	Interrupt stack							
		Depth: 01							
EB9A ... EBA0	SD205 ... SD208	BEF-REG: 0000 BST-STP: EB07		SAZ: E30A OB-Nr.: 1 REL-SAZ: 0000		DB-ADR: 0000 DB-Nr.:			
EB96 ... EB98	SD203 ... SD204	ACCUM 1: FFF1		ACCUM 2: 00FF					
EBA2 ... EBA8	SD209 ... SD212	Brackets:	KE1: 000	KE2: 000	KE3: 000	KE4: 000	KE5: 000	KE6: 000	
EBAA	SD213	Display of result	CC 1	CC 0	OVFL	CARRY	OR	STATUS	RLO	ERAB
EBAC	SD214	Cause of fault:	STOPS	-	SUF	TRAF	NNN	STS	STUE	FEST
EBA9	(UAW)		NAU	QVZ	-	ZYK	-	PEU	BAU	ASPFA

Figure 5. 1 ISTACK output

5.7.3 Mnemonics of ISTACK Entries

Table 5. 2 Mnemonics of control bits

Abbreviation	Meaning
SD	System data (from address EA00h)
BSTSCH	Block move requested
SCHTAE	Block move active (function KOMP:AG)
ADRBAU	Address list creation
CA-DA	Communication output flags - address list available
CE-DA	Communication input flags - address list available
REMAN	0: no retentivity, 1: retentivity active
STOZUS	STOP state (external request)
STOANZ	STOP display (internal request)
BATPUF	Battery buffering ok (always 1)
BARB	Process monitoring
BARBEND	Process monitoring end request
AF	Alarm enabled
ASPNEP	User memory is EPROM
ASPNRA	User memory is SRAM (buffered)
ASPNEEP	User memory is file
KEINAS	User memory is RAM (unbuffered)

Table 5. 3 Mnemonics of interrupt indications

Abbreviation	Meaning
UAW	Interrupt indicator word
STOPS	Operating mode switch at STOP
SUF	substitution error
TRAF	Transfer error during data block commands: DW number > DB length
STS	Operation interrupted by PG STOP request or STOP instruction
STUEB	Block stack overflow: maximum nesting depth (32) exceeded
QVZ + ZYK	Timer error: processing time for timer OB too long
ZYK	scan time exceeded
ASPFA	Invalid memory module
CC 1 / CC 0	00: ACCUM1 = 0 or 0 moved 01: ACCUM1 > 0 or 1 moved 10: ACCUM1 < 0
OVF	Arithmetic overflow (+ or –)
OR	OR memory (set by command "O")
STATUS	Status of command operand of last executed binary command [1)]
RLO	Logical result of operation
ERAB	Initial request [1)]
KE1 ... KE6	Bracketed stack entry 1 to 6 entered for A(and O(
FKT	0: O(1. A(
BEF-REG	Command register
SAC	Step address counter
DB-ADR	Data block address

Table 5. 3 Mnemonics of interrupt indications

Abbreviation	Meaning
BST-STP	Block stack pointer
OB-NR	Organization block number
DB-NR	Data block number
REL-SAC	Relative step address counter

1) The results in STATUS and ERAB will not be influenced

5.8 Block Stack Output

While a program is executing, the following information on each jump operation is entered in the block stack:

- the data block which was being processed before the jump command,
- the relative return address, i.e., the address at which program processing must start again after the jump command has been executed,
- the absolute return address, i.e., the memory address in program memory at which program processing must start again after the jump command has been executed.

This information can be read out in STOP mode by means of the PG function BSTACK, if the controller stopped because of an error. BSTACK will thus tell you the state of the block stack at the point where processing was interrupted by an error.

Example

Program processing was interrupted at FB 2, the controller reported a TRAF error and switched into STOP mode (the cause was an incorrect DB access, e.g., DB 5 is two words long, DB 3 is ten words long). You can use the BSTACK, to determine how FB 2 was reached and which block is passing incorrect parameters. The BSTACK will contain the three (marked) return addresses.

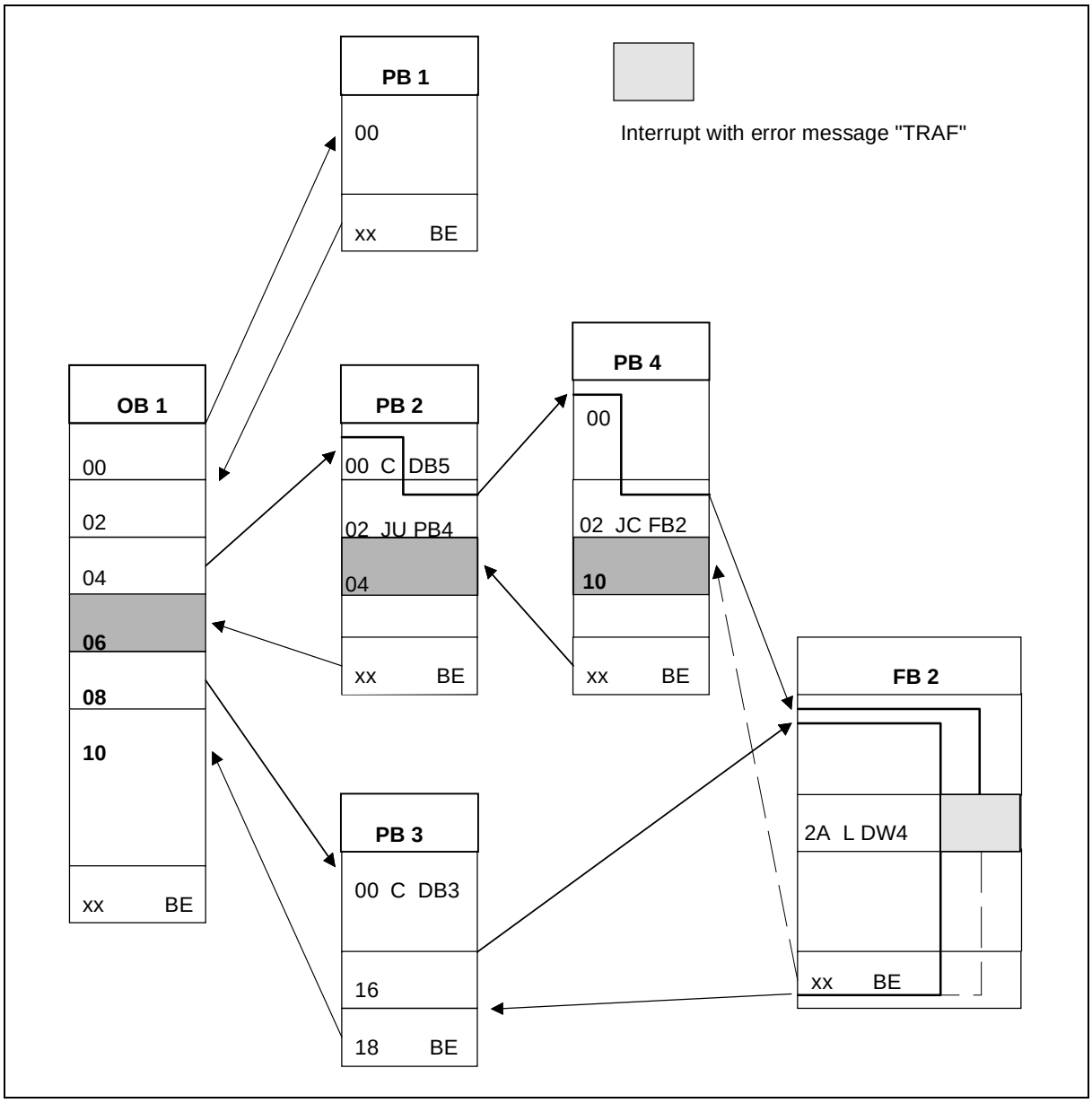


Figure 5. 2 Monitoring program processing via the BSTACK

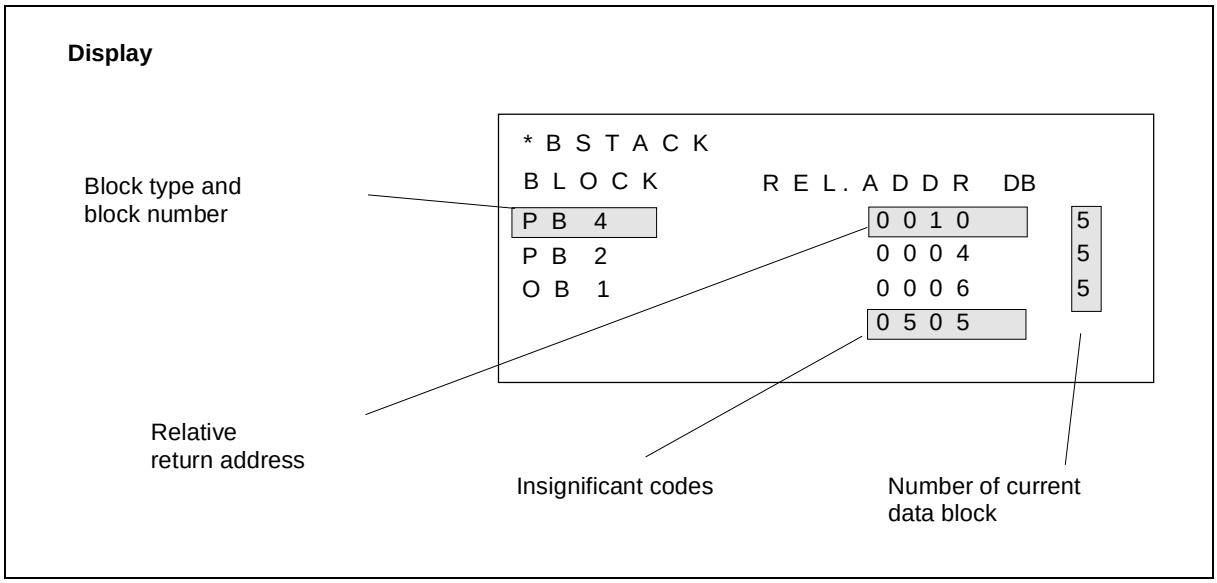


Figure 5. 3 Example of a BSTACK readout

The entry shows that a DB 5 was erroneously accessed via OB 1 → PB 2 → PB 4.

5.9 System Parameter Output

The PG function SYSPAR reports the system parameters as shown below.

Table 5. 4 System parameters

No	System parameters		Content	Explanation
1	Baud rate		9600	Baud
2	Input signal states		F000	Absolute start address in CPU memory
3	Output signal states		F080	
4	Input process image		EF00	
5	Output process image		EF80	
6	Flag area		EE00	
7	Timer area		EC00	
8	Counter area		ED00	
9	SD area		EA00	
10	PLC software release		9F03	
11	Program memory		D800	End address
12	System memory		0000	
13	DB list		0200	Length in bytes
14	Bytes in SB list		0200	
15	PB list		0200	
16	FB list		0200	
17	OB list		0200	
18	FX list		0000	
19	DX list		0000	
20	Length of DB 0		0A00	
21	2nd CPU identification		EF04	
22	Block header length		000A	Length in bytes
23	CPU identification	PG software release	U000	

5.10 Address Output

The PG function "Output addresses" reads out the IMC0x-PLC's STEP 5 memory areas. By checking these memory areas, you can obtain information about, e.g., error sources cycle times. The size of the DB memory is specified during configuration (`db_size`). The PG shows the contents of nonexistent memory addresses as "XXXX".

Table 5. 5 Memory allocation

Absolute address	Content
0000H ... CFFFH	DB memory
DC00H ... E5FFH	Block address list
EA00H ... EBFFH	System data blocks
EC00H ... ECFFH	Timers
ED00H ... EDFFH	Counters
EE00H ... EEFFH	Flags
EF00H ... EFFFH	PII/PIQ, process images
F200H ... F2FFH	Communication flags in shared memory

Table 5. 6 System data allocation

System data word	Absolute address	Meaning
SD 16 ... 31	EA20 ... EA3F	Bitmap for logical inputs and outputs (digital and analog)
SD 64 ... 79	EA80 ... EA9F	Bitmap for communication output flags
SD 80 ... 95	EAA0 ... EABF	Bitmap for communication input flags
SD 96	EAC0	Scan time monitoring
SD 97	EAC2	Time interval for OB 13
SD 98	EAC4	Time interval for OB 12
SD 99	EAC6	Time interval for OB 11
SD 100	EAC8	Time interval for OB 10
SD 104	EAD0	Error status word
SD 105	EAD2	Error DW number
SD 106	EAD4	Error DB number
SD 107	EAD6	Error PB number
SD 108	EAD8	Error SB number
SD 109	EADA	Error FB number
SD 110	EADC	Error OB number
SD 111	EADE	Error opcode
SD 121	EAF2	Current scan time
SD 122	EAF4	Maximum scan time
SD 123	EAF6	Minimum scan time
SD 124 ... 126	EAF8 ... EAFD	PROFIBUS-DP diagnostics
SD 128 ... 201	EB00 ... EB93	Block stack
SD 203 ... 238	EB96 ... EBDD	Interrupt stack
SD 240 ... 243	EBE0 ... EBE7	Reserved
SD 248 ... 255	EBF0 ... EBFF	Reserved for user programs

5.11 Display Memory Structure

This function displays the structure and allocation of STEP 5 program memory (MC5 code). Because the memory is divided into two segments, if you call this function more than once, the display will show MC5 memory and DB memory alternately.

Note:
Different PGs might show differing values in the memory structure display. The IMC0x-PLC gives correct values for the basic package STEP 5 from Version 6.5 or 7.02.

5.12 Error Reporting with the Error Status Word

The error status word SD 104 (address EAD0) is used to report IMC0x-PLC-specific errors. Information on the cause of the error is entered in the system data words SD 105 to SD 111. These system data words can be read out with the PG function "Output addresses". For Details on the error status word see chapter 3.8.3.

6 Introduction to Programming

This chapter is a general introduction to writing controller programs for the IMC0x-PLC. It covers basic programming skills and discusses modular program structures using different types of blocks.

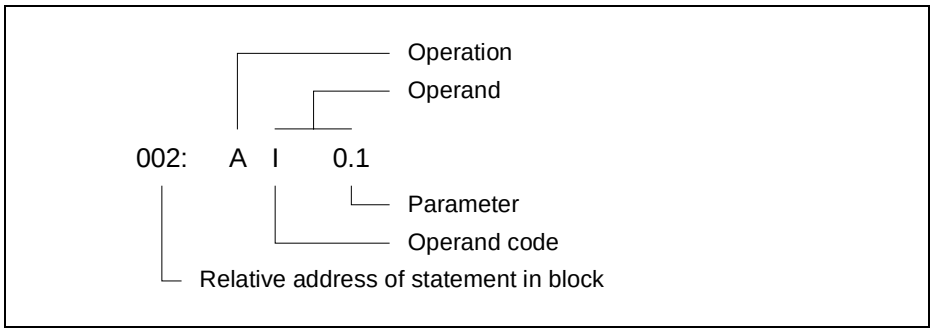
6.1 STEP 5 Programming Language

STEP 5 is a programming language especially developed for writing programs to operate the controllers used in automation technology. STEP 5 is a versatile language allowing you to program operations ranging from simple binary functions to complex digital functions and basic arithmetic operations.

6.1.1 Display Modes

A STEP 5 program for the IMC0x-PLC is written in one of three different ways or "display modes". The mode you chose usually depend on the job you are automating.

Statement list (STL) With a STL, the program to be executed is written as a list of (abbreviated) commands. A command has the following structure:



The operation tells the controller what to do with the operand. The parameter supplies the address of the operand.

Control system flow chart (CSF) In flow chart representation, the program is written as a series of logical operations depicted as boxes.

Ladder diagram (LAD) In a LAD, the program is graphically represented by the symbols used in power supply diagrams.

Programs in CSF and LAD representation can be written only on a programmer with an integrated monitor (e.g., a PG 750 or PC/AT with the necessary software).

The diagram below shows the same logical AND operation, to solve a very simple automation problem, in the three display modes STL, CSF and LAD:

- a signal lamp must light up when the make contact S1 is activated and the break contact S2 is not activated.
- for the controller in the example, the make contact S1 is tested via input I1.1 and the break contact S2 is tested via the input I1.2. The signal lamp is controlled via output Q2.0.

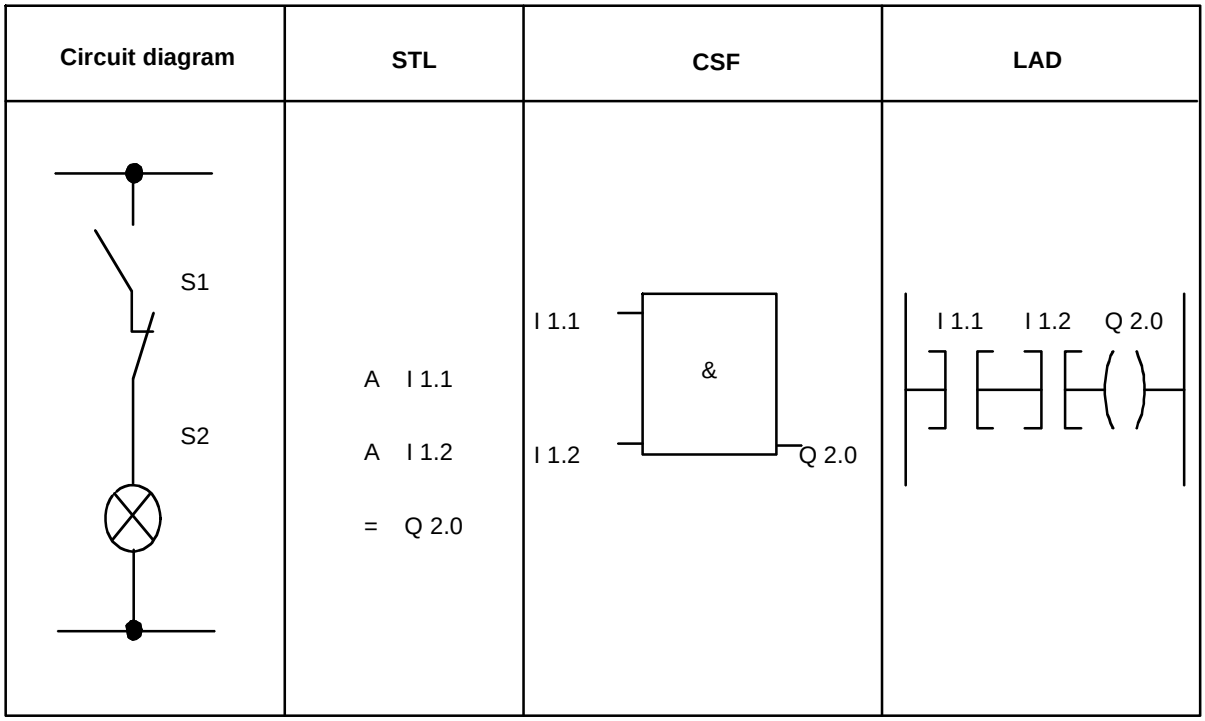


Figure 6. 1 Display modes

You can chose the best display mode for the control task you are programming. It is also possible to write separate program blocks in different representation, i.e., you do not have to write the whole program in a single mode.

Each mode has advantages and disadvantages. STL is the most versatile display mode, but a block programmed in STL cannot always be simply translated into CSF or LAD. On the other hand, blocks programmed in LAD or CSF are easily changed into STL.

In STEP 5 there are three types of operations:

- basic operations
- extended operations
- system operations

Table 6. 1 Features of the operation types

	Basic operations	**Extended operations**	**System operations**
Application scope	All blocks	Function blocks only	Function blocks only
Display modes	STL, CSF, LAD	STL	STL
Criterion			For users with good system knowledge

You will find detailed information on the different operation types in the Reference Manual, chapter 2.

6.1.2 Operand Areas

STEP 5 programming uses the following operand areas:

I (inputs)	Interfaces from the process to the controller via PII
Q (outputs)	Interfaces from the controller to the process via PIQ
F (flags)	Memory for binary intermediate results
D (data)	Memory for digital intermediate results
T (timers)	Register for programming timers
C (counters)	Register for programming counters
P (peripherals)	Direct interface between process and controller (not via the process image)
K (constants)	Fixed number values

The operands in an operand area are identified by specific extensions:

IB 7	denotes, e.g., the 7th input byte of the PII
Q 3.2	denotes, the 2nd bit in the 3rd output byte of the PIQ
KF	denotes, a fixed-point numeric constant (16-bit integer)

A list of all operations and operands can be found in the Reference Manual, chapter 3.

6.2 Program Structure

Control programs can be linear or structured. These two approaches are explained below.

6.2.1 Linear Programming

For simple control tasks, it is often sufficient to write a control program only in the organization block OB 1. During processing the OB 1 is called cyclically by the controller.

Note that OB 1 length is restricted to 4096 words, thus limiting the length of the control program.

6.2.2 Structured Programming

To solve complex automation problems, the program is split up into a number of separate modules or blocks.

There are several advantages:

- long programs can be broken down into simple and easily understandable units
- blocks can be standardized
- blocks which have tested successfully can be used again in other programs. This applies especially to function blocks (FB)
- self-contained blocks are easier to test and debug
- making changes is simplified
- startup is easier
- subprogram techniques can be used (e.g., a block can be called from several different points in the program)

Structured programs can include the following block types:

- Organization block (OB)
  Organization blocks manage the control program. They form an interface between the controller's internal operations and the user's control program. OBs manage, inter alia, cyclic program execution, initialization of the control system or handling of runtime errors (see Table 6. 3).
- Program block (PB)
  Program blocks are the self-contained modules which make up a PLC program. These blocks are called by commands in OBs or FBs. Parameter passing is not possible with PBs. Data can only be transferred to a PB via a data block.
- Sequence blocks (SB)
  Sequence blocks are a special type of program block which contain the program for a sequencer. They are treated like program blocks.
- Function blocks (FB)
  Function blocks are used to program operations which recur frequently. A FB can be called from an OB, PB or another FB. An FB call can be parametrized, i.e., parameters can be passed with the call.
- Data blocks (DB)
  Data blocks contain STEP 5 data needed by the control programs. Typically these data are set values, limiting values or text. Data blocks are also used to pass parameters for PBs.

Block calls are statements which invoke other blocks, causing a jump to the specified block. Organization, program, function and sequence blocks can be nested up to 32 deep.

Note:
When you are calculating nesting depth, remember that some organization blocks are called automatically (e.g., when a runtime error occurs).

Total nesting depth is the sum of the nesting depths of all the blocks in a program. If the nesting depth exceeds 32, the controller reports a "block stack overflow" (STUEB) and goes into STOP mode.

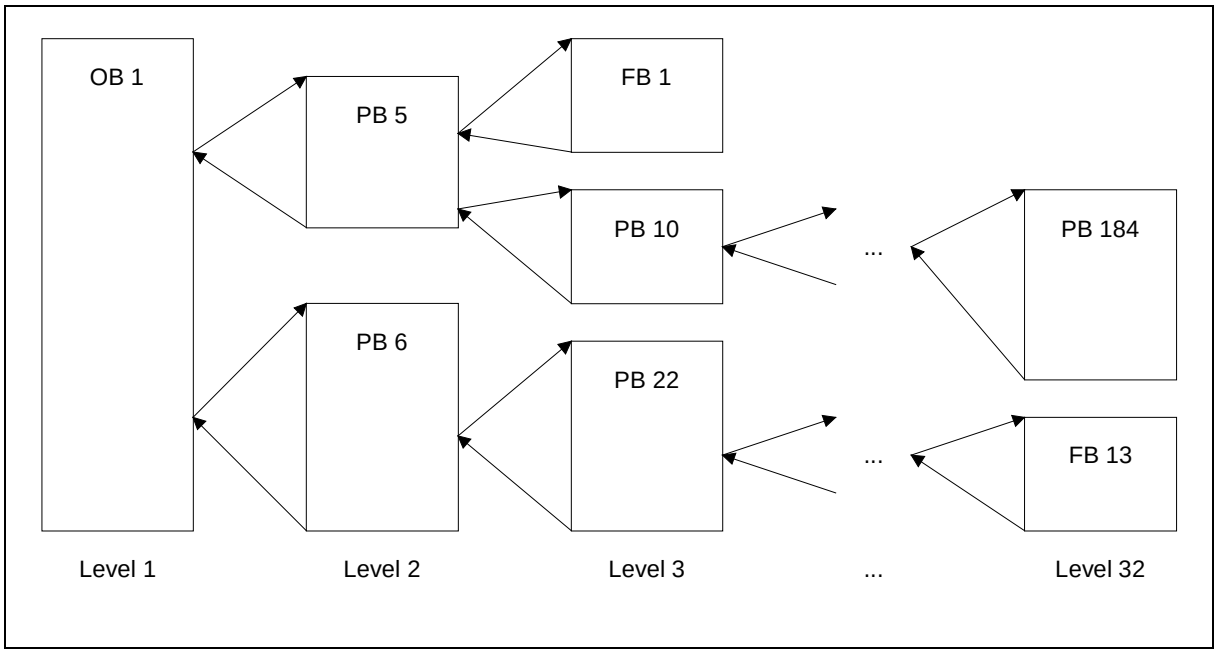


Figure 6. 2 Nesting depth

6.3 Blocks and their Attributes

The table below sets out the most important information you will need about blocks:

Table 6. 2 Block types

	OB	PB	SB	FB	DB
Number	255 [1] OB 1 ... 255	256 PB 0 ... 255	256 SB 0 ... 255	256 FB 0 ... 255	254 [2] DB 2 ... 255
Length (max)	8 Kbytes	8 Kbytes	8 Kbytes	8 K –8 bytes	2 Kwords [3]
Operation set (content)	Basic operations	Basic operations	Basic operations	Basic operations Extended operations System operations	Bit patterns, numbers, texts
Display modes	STL, CSF, LAD [4]	STL, CSF, LAD	STL, CSF, LAD	STL [4]	
Block header length	5 words	5 words	5 words	5 words	
Block calls	JU, JC	JU, JC	JU, JC	JU, JC	Q, I

1) OBs in particular are called by the IMC0x-PLC itself (see Table 6. 3)

2) Data blocks DB 0 and DB 1 are reserved.

3) STEP 5 commands only access the data words DW 0 to DW 255.

4) Blocks OB 208 to OB 223 and FB 208 to FB 223 may also be programmed in high level languages.

The maximum length for each block is 4096 words (8 Kbytes). A block consists of a header and a body. The block header is 5 words long and contains information on the block type, number and length. The PG creates this header when the block is programmed. Depending on the type of block, the block body will contain STEP 5 program code or user data. Function blocks have not only a header, but also additional information for passing parameters.

6.3.1 Organization Blocks (OB)

The organization blocks OB 1 to OB 39 are the interface between the control program and the controller's internal operations.

The controller processes OBs either event- or timer-driven. OBs are grouped according to their function as follows (see also chapter):

- OBs for restart program processing
- OB for cyclic program processing
- OBs for timer-driven program processing
- OBs for handling runtime errors

For details on operating modes, see chapter 3.

Table 6. 3 Overview of organization blocks

Organization block	Function	Meaning
OB 1	Cycle OB	Cyclic program scanning
OB 2	–	Reserved for future applications
OB 3	–	Reserved for future applications
OB 4	–	Reserved for future applications
OB 5	–	Reserved for future applications
OB 10	Timer OB	Timer-driven program scanning
OB 11	Timer OB	Timer-driven program scanning
OB 12	Timer OB	Timer-driven program scanning
OB 13	Timer OB	Timer-driven program scanning
OB 19	Error OB	call of nonexistent block
OB 21	Restart OB	STOP → RUN operating mode switch
OB 22	Restart OB	STOP → RUN operating mode transition after power-on
OB 26	Error OB	scan time exceeded
OB 27	Error OB	substitution error
OB 28	STOP OB	RUN → STOP operating mode switch
OB 31	Trigger OB	Scan time triggering
OB 32	Error OB	Transfer error

OBs not listed here are reserved and may be assigned functions in future program versions. They should not be used for user control programs.

6.3.1.1 Programming Organization Blocks

Organization blocks can be programmed in STL, CSF or LAD. They are programmed in the same way as program blocks. The organization blocks OB 208 to OB 223 can also be programmed in high level language (see chapter 8). Every organization block, including OB 1, must end with the operation BE.

6.3.1.2 Calling Organization Blocks

Organization blocks can be called, like program blocks from any other block. Conditional and unconditional calls are possible. Note that certain OBs are initialized with particular functions.

6.3.2 Program Blocks (PB) and Sequence Blocks (SB)

Program blocks are the separate modules of a PLC program. These blocks are called by commands in OBs or FBs. Parameter passing is not possible with PBs. Data can only be transferred to a PB via a data block.

Sequence blocks are a special type of program block which contain sequencer program code. They are treated like program blocks.

6.3.2.1 Programming PBs and SBs

The following description also applies to programming OBs. PBs, SBs and OBs are all programmed in the same way. Under STEP 5 they can be programmed in STL, LAD and CSF representation. You start writing a program by entering a block number on the PG:

- Program blocks 0 to 255
- Sequence blocks 0 to 255
- Organization blocks 1 to 39

Then you enter your control program. It must end with the instruction BE. You are restricted to the basic STEP 5 operation set. The STEP 5 program code for each block may not take up more than 4091 words in program memory, because the block header which is automatically generated by the PG always takes up 5 words.

Each block should be a self-contained program. Logical operations across block boundaries are not meaningful.

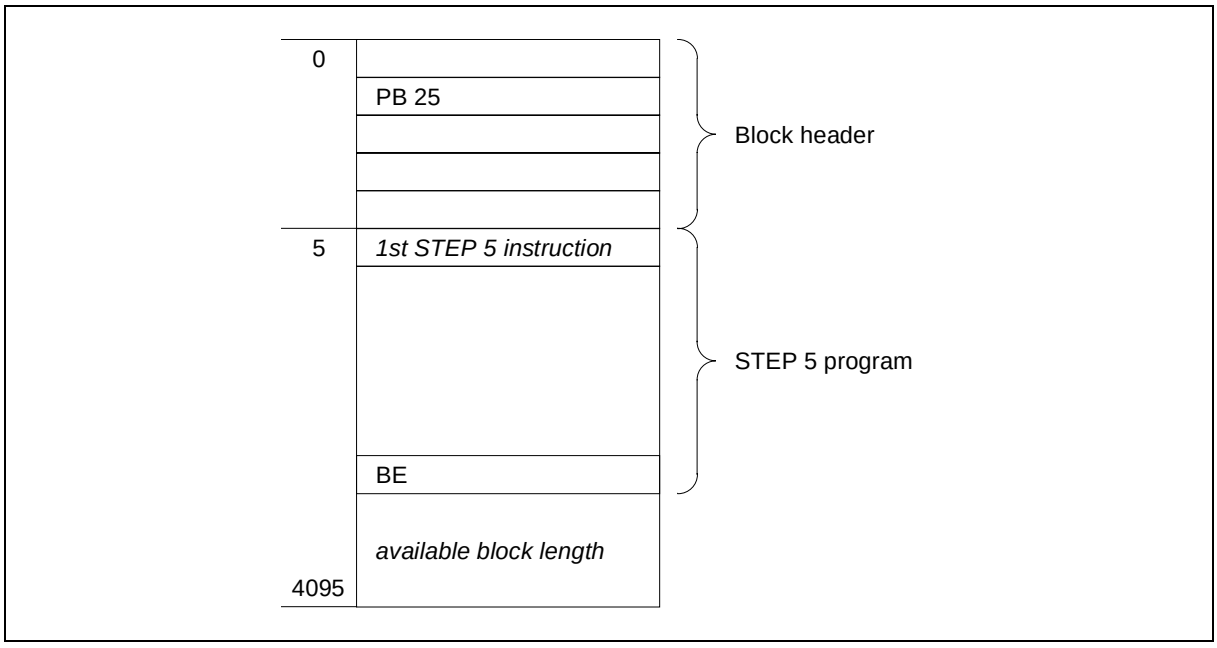


Figure 6. 3 Structure of an organization or program block

6.3.2.2 Calling Program and Sequence Blocks

A block call releases a block for processing. Block calls can be programmed in organization, program, function or sequence blocks. A block call is comparable to a jump to a subprogram and, like jumps, can be conditional or unconditional.

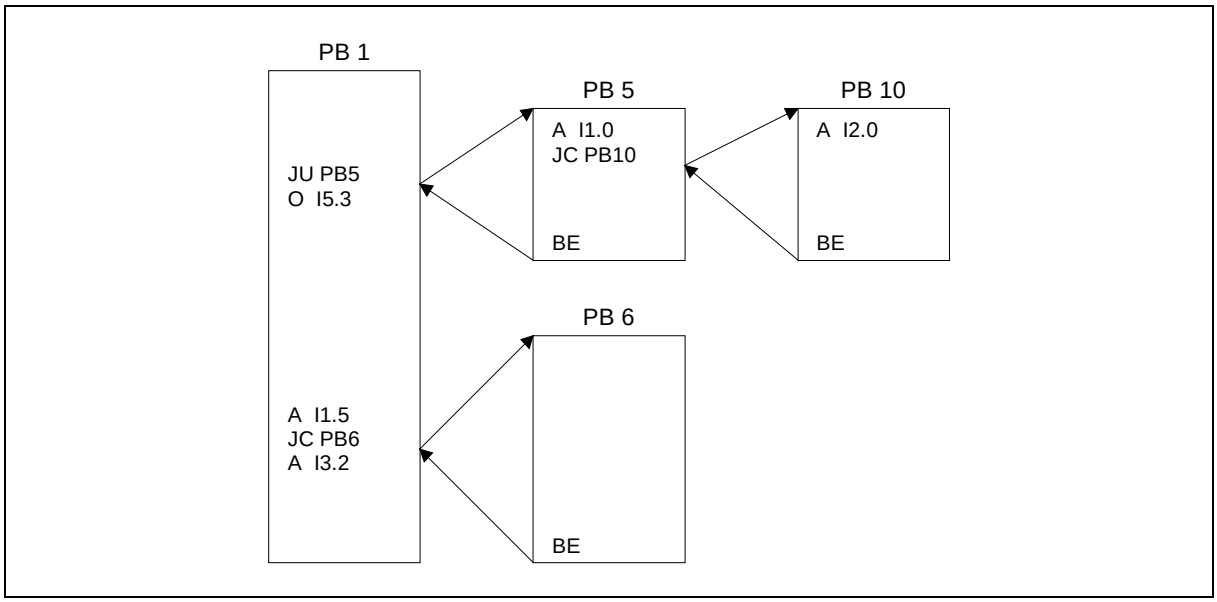


Figure 6. 4 Block calls

When the controller encounters the command BE (block end), it performs a jump back to the block containing the block call, and continues processing with the STEP 5 command immediately following the block call. After a block call and also after a BE command, the result of logic operation (RLO) cannot be combined further, because both these commands are RLO-limiting commands.

- Unconditional call: JU xx
  The specified block is processed, independent of the result of the previous logic operation.
- Conditional call: JC xx
  Whether the specified block is processed or not, depends on the result of the previous logic operation.

If RLO = 1 the jump command is executed, if RLO = 0 it is not. In both cases the jump command causes RLO to be set to 1. This dependence on RLO and change of RLO also applies to the conditional block end command BEC.

6.3.3 Function Blocks (FB)

Function blocks are used to program control functions which either recur frequently or are complex. Function blocks have some special characteristics which distinguish them from organization, program and sequence blocks:

- Function blocks can be parametrized, i.e., the block call can include parameters.
- Function blocks can execute extended operations and system operations.
- Function blocks may be written and documented only as STL (statement list), with the exception of certain FBs which may be written in HLL.

The controller has the following function blocks available:

- FB 0 to FB 207 for programming in STEP 5
- FB 208 to FB 223 for programming in assembler or high level languages (see chapter 8)
- FB 224 to FB 255 are reserved for future use as integrated function blocks.

FB 208 to FB 255 can be programmed in STEP 5, if necessary. However, this option should not be used, so as to avoid conflicts with HLL blocks or integrated function blocks.

In addition to the block header common to all blocks, function blocks contain other organizational information.

Memory requirements for the block header plus the additional information are as follows:

- Block header, as for other block types (5 words)
- Block name (5 words)
- Block parameters if assigned (3 words per parameter).

6.3.3.1 Programming Function Blocks

In contrast to other blocks, a function block can contain additional information such as:

- Library number
  The block can be given a number between 0 and 65535. This number is completely independent of symbolic or absolute FB parameters.
  A library number should be a unique number which identifies a particular function block unambiguously. Standard function blocks already have their own product number.
- Name
  A function block can be identified by a name up to eight characters long.

To assign parameters you must supply the following block parameter data:

- Block parameter name (formal operands)
  Each block parameter is given a name (DECL) which is used as the formal operand in a function block call and is replaced by an actual operand during program execution. The block parameter name may have up to four characters, the first of which must be an alphabetic character. You can program up to 40 parameters per function block.
- Block parameter type
  These are the possible parameter types:
  I Input
  Q Output
  D Date
  B Block
  T Timer
  C Counter
  In graphical representation, output parameters are shown to the right. All other parameters to the left of the function symbol.
- Data type
  These are the possible data types:
  BI for an operand with bit address
  BY for an operand with byte address
  W for an operand with word address
  K for constants
  When assigning parameters all three block parameter specifications must be entered.

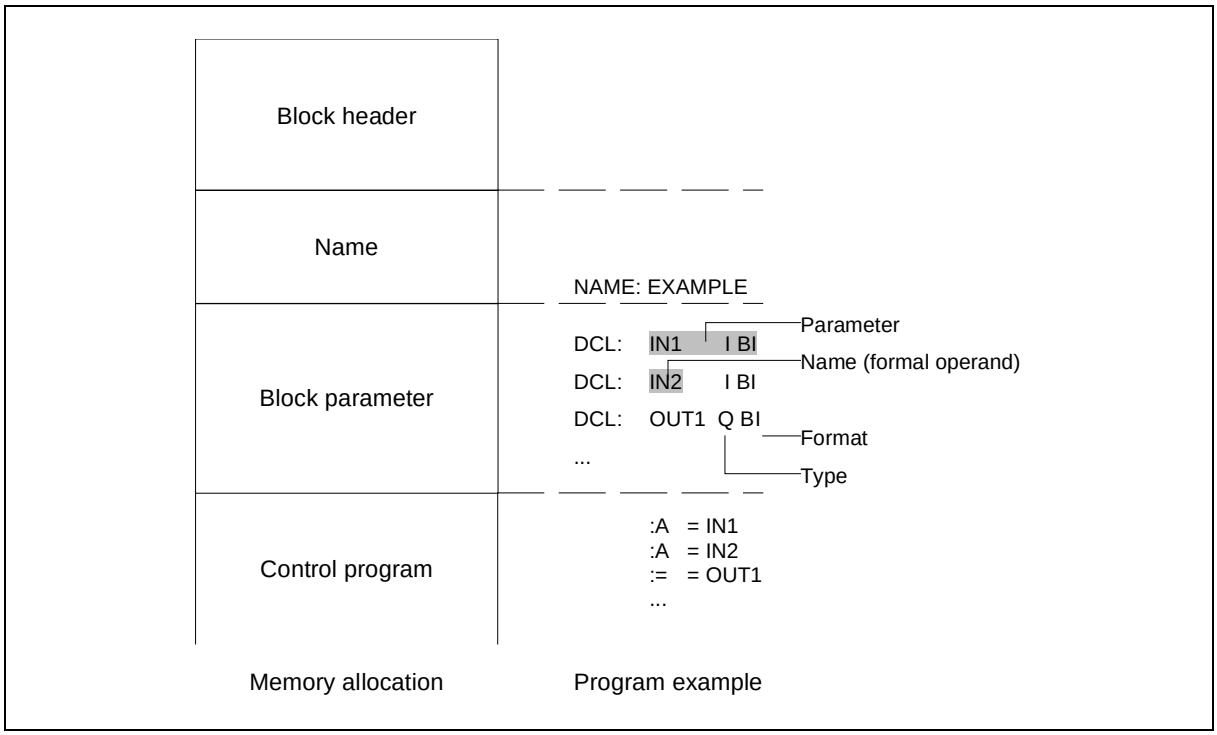


Figure 6. 5 Programming an FB with block parameters

Table 6. 4 Parameter type and data type of block parameters with permitted actual operands

Parameter type	**Parameter format**	**Permitted actual operands**
I, Q	BI Operands with bit address	I x.y Input Q x.y Output F x.y Flag
	BY Operands with byte address	IB x Input byte QB x Output byte FB x Flag byte DL x Left data byte DR x Right data byte PB x Peripheral byte
	W Operands with word address	IW x Input word QW x Output word FW x Flag word DW x Data word PW x Peripheral word
D	KM Binary bit pattern (16 bits) KY Two absolute values (bytes in the range of 0 to 255) KH Hexadecimal value (max. 4 digits) KS max. 2 alphanumeric characters KT BCD-coded time value (1.0 to 999.3) KC BCD-coded counter value (0 o 999) KF Fixed-point value (–32768 o +32767)	Constants

Table 6. 4 Parameter type and data type of block parameters with permitted actual operands

Parameter type	Parameter format	Permitted actual operands
b	No parameter format	DB x Data block, called with command C DBx FB x Function blocks (only valid without parameters), called absolutely (JU FBx) PB x Program blocks, called absolutely (JU PBx) SB x Sequence blocks, called absolutely (JU SBx)
T	No parameter format	T Timer: the value is parametrized as data or programmed as constant in the function block
C	No parameter format	C Counter: the value is parametrized as data or programmed as constant in the function block

Programming FBs in HLL is described in detail in chapter 8.

6.3.3.2 Calling Function Blocks

A function block is stored in program memory under a particular number - as are all other types of block - (e.g., FB 47).

Calls to FBs can be included in any block, with the exception of data blocks.

The call consists of:

- Call instruction
  JU FBx unconditional call
  JC FBx call if RLO = 1
- Parameter list (only if parameters are assigned)

Function blocks programmed in HLL are called in the same way as function blocks programmed in STL.

Function blocks have to be programmed before they can be called. When you are programming an FB call, the PG will automatically ask for the FB parameters.

6.3.3.3 Parametrization

The program in the function block specifies how the operands are processed.

After the jump instruction, the operands which the FB is to use (i.e., parameter list) must be specified in the block in which the FB is called. The valid operands are also called the current operands.

Parameter list

Immediately following the jump instruction, the input and output variables and other data are defined, i.e., each formal operand is supplied with an actual operand. The length of this parameter list will depend on the number of formal operands. Thus a parameter list can contain up to 40 actual operands.

As explained above, when the function block is executed, each formal operand is replaced by an actual operand supplied by the parameter list. The PG automatically keeps track of the order in which variables are substituted.

Figure 6. 6 gives an example of how parameters are assigned to a function block.

Other special characteristics of function blocks

The FB call takes up two words of program memory and each parameter takes up one word of memory.

The identifiers for function block inputs and outputs and their names are stored in the function block itself. For this reason, before you start programming on the PG, all the function blocks you will be using in your program must have been loaded to the program diskette (for offline programming) or into the controller's program memory.

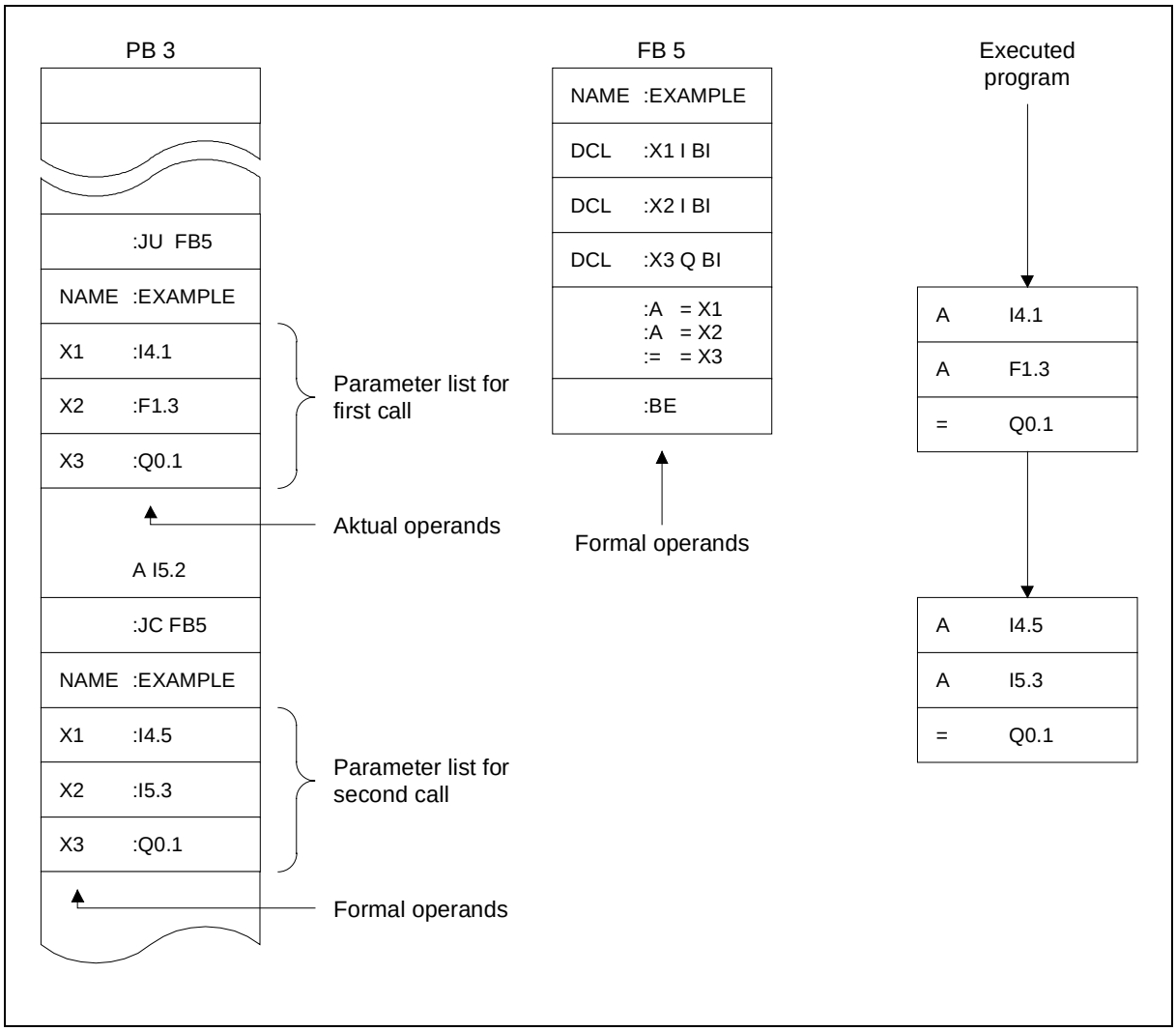


Figure 6. 6 Parameter assignment for a function block

6.3.4 Data Blocks (DB)

Data blocks are used to store the data needed in a user program. No STEP 5 operations are performed in data blocks. The data entered in a data block may be:

- bit patterns of any sort, e.g., for aggregate states
- numbers (hexadecimal, fixed point) for time values, results of arithmetic operations
- alphanumeric characters, e.g., for message texts

6.3.4.1 Data Blocks DB 0 and DB 1

The data block DB 1 is reserved for initialization functions and must therefore be generated before controller startup. You can find more detailed information on the DB 1 in chapter 9. Data block DB 0 is generally not used for the IMC0x-PLC.

6.3.4.2 Generating Data Blocks

To generate a data block you start by entering a data block number (e.g., DB 25). A data block is made up of 16-bit data words, which are entered, beginning with data word 0, in ascending order.

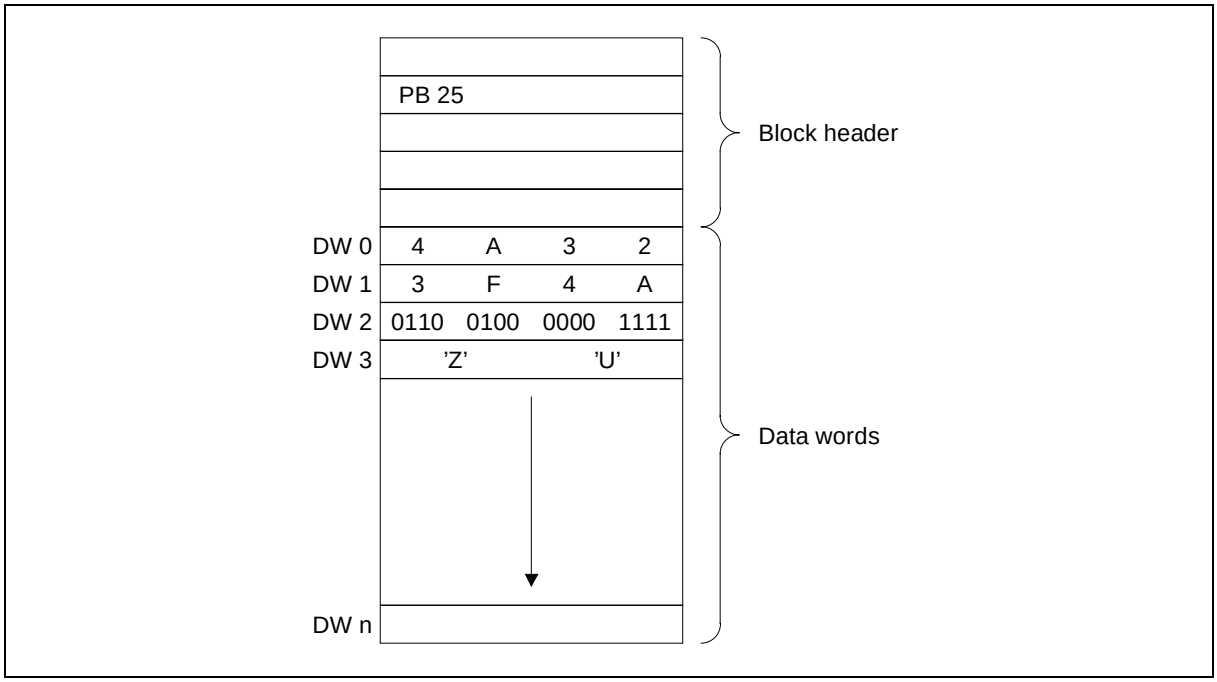


Figure 6. 7 Structure of a data block

Each data word occupies one word of program memory. In addition, the PG generates a block header for each data block , which takes up a further five words of program memory. A data block may occupy a maximum of 4096 words in the controller's program memory. If a PG is being used for input and transfer, the size of the PG's memory must also be considered.

Warning:
Load/transfer commands L/T DW ... can access data up to data word number 255 only. Data blocks DB 0 and DB 1 are reserved and may not be called by user programs.

6.3.4.3 Calling Data Blocks

Data blocks can only be called unconditionally. Once a data block has been called, this block remains valid until a new data block is called. A data block (DB) is called from an OB, PB, SB or FB with the command C DB ... .

Warning:
Before a data word load/transfer can be executed, a data block must have been opened. The data word being addressed by the command must be in the opened data block. If these conditions are not met, a transfer error is reported (see chapter 3.8.1).

Example

Transfer the contents of data word 1 from data block DB 10 to data word 1 of data block DB 20.

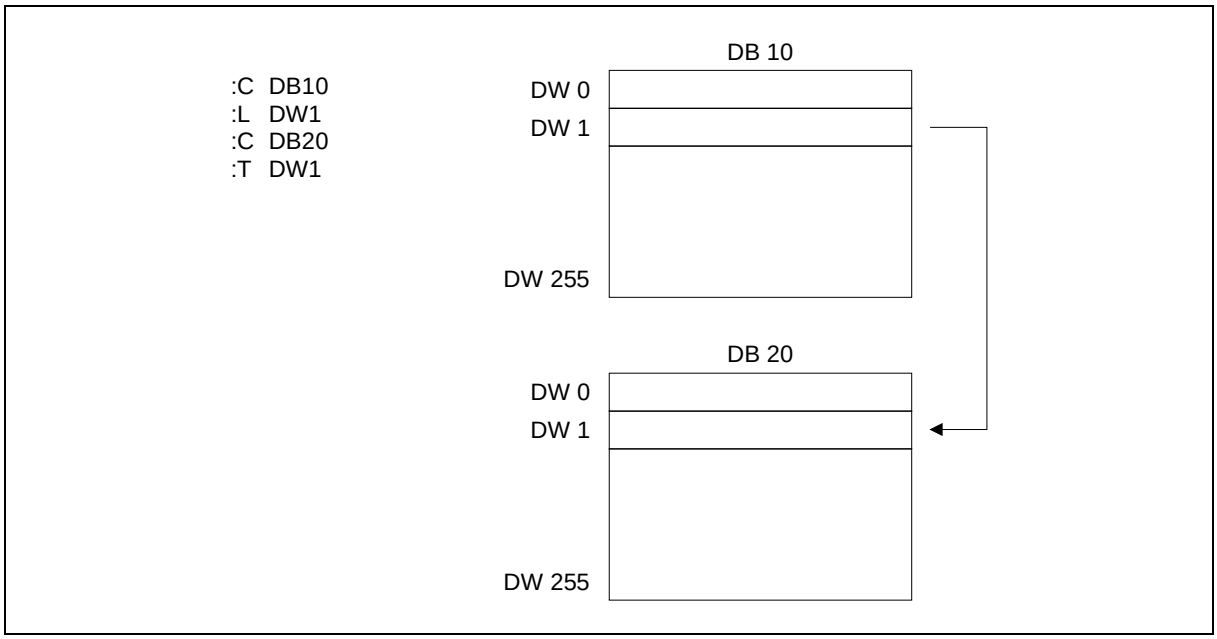


Figure 6. 8 Addressing a data block

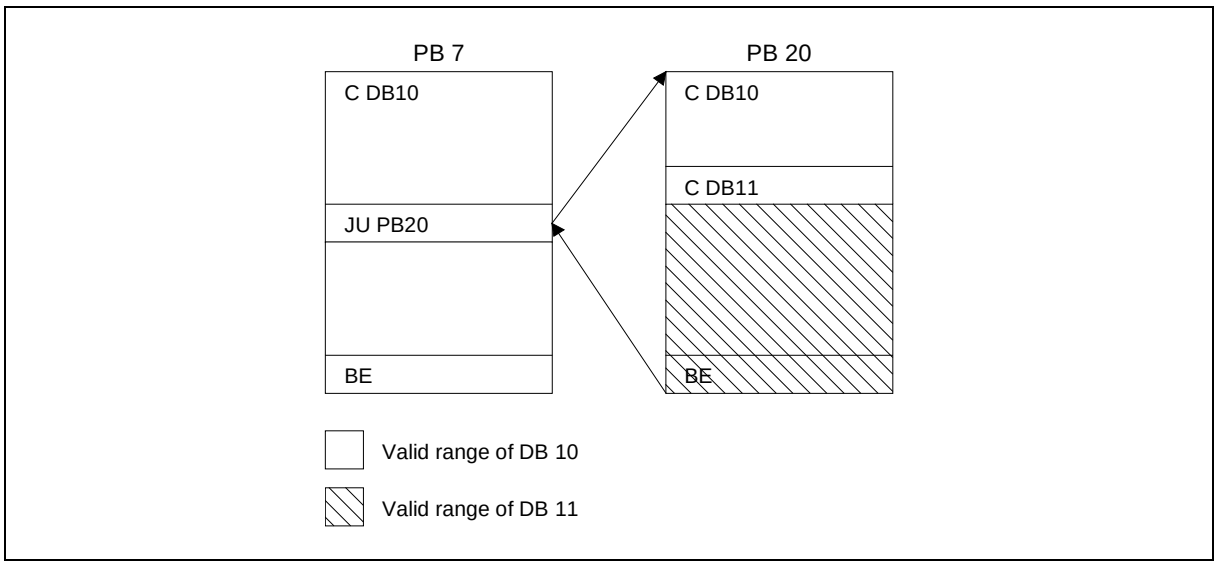


Figure 6. 9 Valid range of a called data block

A command in a program block has addressed a data block. A subsequent command in the program block causes a jump to another program block and from this second program block a second data block is addressed. The second data block is valid only for the second program block. As soon as this second PB is exited with a jump back to the first PB, then the first data block is valid again

Example

In program block PB 7, a command addresses data block DB 10. Subsequent processing uses data from this data block.

A call in PB 7 causes a jump to program block PB 20, which is then executed. Data block DB 10 is still valid. Only when data block DB 11 is called does the data area change and DB 11 become the current data block. From then, until program block PB 20 has finished executing, data block DB 11 is valid.

When execution jumps back to program block PB 7, data block DB 10 is valid again.

6.3.5 HLL Blocks

The IMC0x-PLC lets you program blocks in a high level language (e.g., C) and then link them into a STEP 5 program.

These block types can be programmed in a high level language:

- Organization blocks OB 208 to OB 223
- Function blocks FB 208 to FB 223

Programming, testing and debugging of HLL blocks is described in detail in chapter 8.

6.4 Representing Numbers

STEP 5 lets you represent numbers in the following ways:

- Decimal numbers from -32768 to +32767 (KF)
- Hexadecimal numbers from 0000 to FFFF (KH)
- BCD coded numbers from 0000 to 9999
- Bit patterns (KM)
- Byte constant (KY) from 0,0 to 255,255

Internally, the IMC0x-PLC converts all numbers to 16-bit binary numbers (bit patterns). Negative numbers are represented as two's complement.

Table 6. 5 Organization of a 16-bit fixed-point number

Word number	n															
Byte number	n (high byte)								n +1 (low byte)							
Bit number	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Meaning	2^{15}	2^{14}	2^{13}	2^{12}	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

Table 6. 6 Examples of the controller's representing of numbers

Input value	**Representation in the PLC**
KF –50	1111 1111 1100 1110
KH A03F	1010 0000 0011 1111
KY 3,10	0000 0011 0000 1010

7 STEP 5 User Memory

For the debugging and startup phase, the PG loads a STEP 5 program into the controller's SRAM memory. Completed and debugged programs are copied to EPROM.

User memory is split into two areas:

- MC5 memory for MC5 program code
- DB memory for retentive data and data blocks

Type and size of user memory are configurable and the IMC0x-PLC must include this information for a configured PLC. You can find more information on configuration in chapter 10.

7.1 MC5 memory

This is MC5 memory for SIMATIC S5-115U compatible MC5 code. The maximum size is 32 Kb. The following memory types are supported:

- EPROM:
  The MC5 code is entered in EPROM. Individual blocks can be loaded by the PG into the memory area which is otherwise reserved for data blocks.
- SRAM:
  MC5 code is loaded by the PG.
- Memory area not available:
  MC5 code is loaded by the PG into the memory area which is otherwise reserved for data blocks (only recommended for controllers of limited size).

For details on this memory types see chapter 10.1.

7.2 DB memory

This is the memory area for retentive data and data blocks. The size is configurable between 4 Kbytes and 32 Kbytes. If the MC5 memory is located in EPROM, this memory can also be used to load program blocks. The following memory types are supported:

- SRAM:
  A power failure, or switching off the power supply, will not result in loss of the retentive data and data blocks in this memory. During PG restart after power-up, the integrity of the retentive data is checked. If a data loss has occurred, an overall reset request is issued.
- Dynamically requested RAM, retentivity not available.
  At restart the whole retentive memory area is deleted. Data blocks must be generated new each time by the control program, or loaded by the PG.

7.3 Memory Organization

During a restart, data blocks in MC5 memory are copied into DB memory and may then be modified during subsequent program execution. The changes remain in force until the block is deleted/overwritten. If the block in question is already present in DB memory then no copy operation is performed. Data blocks which are generated during program execution (with I DB), are also located in DB memory.

7.4 Conversion Program CVSTEPV.EXE

Conversion program CVSTEPV.EXE is used to convert a program file generated with STEP 5 into a binary file with the memory image of the MC5 code. This binary file is transferred to a free, sufficiently dimensioned memory segment of the user flash memory of the IMC05.

CVSTEPV.EXE generates a 16-bit format file.

Sign-on message

```
CVSTEPV Vx.y  STEPV FILE CONVERSION
```

Call syntax

```
CVSTEPV <source file> [<destination file>] [/e] [/l] [/s]
```

Option `/e` Generate EPROM block type

When conversion as RAM block type is used, the DBs are loaded from the current MC5 code during the restart after POWER OFF.

Note:
The /e option is mandatory for both the IMC05 and the IMC01.

Option `/s` The file is split into LOW byte and HIGH byte.

Note:
The /s option cannot be used for either the IMC05 or the IMC01.

If no destination file is specified, the source file name is used with the extension BIN or LOW/HIG.

Example

```
CVSTEPV STEPTEST.S5D /e
```

generates the file STEPTEST.BIN

If the program is called without parameters, the sign-on message and the call syntax are displayed:

```
CVSTEPV Vx.y  STEPV FILE CONVERSION

 USAGE: CVSTEPV [options] <source file> [<destination file>]

        e: Generate EPROM block type (Default: RAM block type)
        l: Display the list of sorted blocks
        s: File splitting low byte/high byte
```

Specifying an illegal source file results in a message:

```
    Illegal file <source file>
```

Transferring a STEP 5 file back to the PG

After a program has been loaded, individual blocks are usually changed on the PLC, and then the entire program is transferred again from the PLC to the program file. This means that the STEP 5 file contains more than one block with the same number.

If such a file is to be processed with CVSTEPV.EXE, all invalid blocks must be removed beforehand. Starting with V7.02, the STEP 5 software has the "compress program file" function.

To remove the invalid blocks with an older software version, a new file must be created on the PG. This is done in the following way:

- Perform an overall reset on the PLC.
  If necessary, first save the current status of the STEP 5 program to the PG.
- Load the STEP 5 program into the PLC.
- Select a new program file on the PG, e.g., CVSTEPST.S5D.
- Copy the STEP 5 program from the PLC to the new file.
- Convert this file with CVSTEPV.EXE.
- Delete the file CVSTEPST.S5D!

8 Programming HLL Blocks

Using the HLL (High Level Language) interface, you can program blocks in a high level language (e.g., C) or in assembler and then link them into a STEP 5 program as a function extension. Programming in a high level language or assembler is often more efficient than STEP 5 and also offers an extended address area.

8.1 Block Organization

The following organization and function blocks are available for programming in assembler or a high level language:

- OB 208 to OB 223
- FB 208 to FB 223

If you are programming FB 208 to FB 223 as HLL blocks, you must still enter the proper STEP 5 block headers at the PG, to ensure that block calls can be programmed. Apart from the block headers, STEP 5 should not be used in the blocks OB 208 to OB 223 and FB 208 to FB 223 so as to avoid conflict with HLL blocks.

FB block headers can be transferred to the PLC. If the relevant HLL blocks exist, the HLL code is always executed. If HLL blocks exist, the addresses of STEP 5 function blocks are not entered in the address list.

8.2 Programming

The blocks must be programmed as C functions and linked with a startup code programmed in assembler. The following files are provided for this purpose.

- Sample file: HLLCODE.C (for contents, see below)
- Startup code in Assembler: HSTART.ASM (for CADUL)
- Batch file for generation: GEN_HLLC.BAT (for CADUL)

The HLLCODE.C file contains blocks OB 208, OB 209, FB 208 and FB 209. The functions of these HLL blocks are implemented in C-code sample applications whose scope is described in the function header.
FB 208 is used with the IMC05 for PROFIBUS-DP diagnosis. With the IMC01, it is disabled with Define. FB 209 is a blank function. For testing purposes, the `printf` function can be used to output character strings on the system console, for example.

In HSTART*.ASM, one table each is defined for the OBs and the FBs which must be preset with the addresses of the HLL blocks. 0 is entered for nonexistent blocks.

8.2.1 Programming the Organization Blocks

Organization blocks are assigned as parameter a pointer to the current data block. An HLL program can access this data block, as shown in this example in C:

```
void ob_208 (unsigned short *db_p)
{
  static unsigned short x;
  x = db_p [0];
  .
  .
  .
}
```

For OBs in ASM386 the address of the current data block is passed in registers ES:ESI and the data block length in register EDI.

To clear the STACK the assembler program must end with RET 8 (RETURN FAR).

8.2.2 Programming the Function Blocks

Function blocks are assigned as parameter a pointer to a table of substitution parameters. An HLL program can access this parameter, as shown in this example in C:

```
void fb_208 (unsigned char *subs_p)
{
  static unsigned short x;
  static unsigned short y;
  x = subs_p [0];
  y = subs_p [2];
  .
  .
  .
}
```

For FBs in ASM386 the pointer to the substitution parameters is passed in registers ES:ESI.

To clear the STACK the assembler program must end with RET 8 (RETURN FAR).

Before a function block call can be programmed in a STEP 5 block, the FB in question must exist in the PG, because the PG generates a mask for parameter assignment for the FB call. For each of the function block calls FB 208 to FB 223 a function block (block header only) with the correct substitution parameters must have been generated on the PG.

8.2.2.1 Access to Substitution Parameters

The substitution parameters contain in coded form the reference to the transfer parameters. Each substitution parameter has an identifier and an index.

Bit 15 ... Bit 8	Bit 7 ... Bit 0
Index	Identifier

From this the transfer parameter can be reconstructed in the HLL block in accordance with the following table.

Table 8. 1 Decoding of the substitution parameters

Identifier	**Index**	**Parameter**		**Example**
Cyh (y = 0 ... 7)	x ≤ 7Fh	Input	I x.y	14C4h → I 20.4
Cyh (y = 0 ... 7)	x ≥ 80h	Output	Q (x–80h).y	94C7h → Q 20.7
8yh (y = 0 ... 7)	x	Flag	F x.y	1485h → F 20.5
4Ah	x ≤ 7Fh	Input byte	IB x	1E4Ah → IB 30
4Ah	x ≥ 80h	Output byte	QB (x–80h)	9E4Ah → QB 30
0Ah	x	Flag byte	FB x	280Ah → FB 40
22h	x	Data byte left	DL x	1E22h → DL 30
2Ah	x	Data byte right	DR x	1E2Ah → DR 30
72h	x	Peripheral byte	PB/PY [1)] x	2872h → PB 40
52h	x ≤ 7Fh	Input word	IW x	3252h → IW 50
52h	x ≥ 80h	Output word	QW (x–80h)	8A52h → QW 10
12h	x	Flag word	FW x	1712h → FW 23
32h	x	Data word	DW x	1732h → DW 23
7Ah	x	Peripheral word	PW x	177Ah → PW 23
2Dh	x	Data block	DB x	162Dh → DB 22
3Dh	x	Function block	FB x	163Dh → FB 22
75h	x	Program block	PB x	1675h → PB 22
7Dh	x	Sequence block	SB x	0A7Dh → SD 10
6Dh	x	Organization block	OB x	0A6Dh → OB 10
02h	x	Time	T x	4802h → T 72
42h	x	Counter	C x	2742h → C 39

1) PY at PG with S5-DOS

The thus determined transfer parameters can then be used to access the appropriate PLC data areas.

Note:
If constant values are transferred to an HLL block, these values are not substituted in the call. For this reason, the type of constants must be known to the applicable function since decoding in accordance with this table would produce an incorrect result.

8.2.3 Accessing PLC Data Areas

To enable HLL blocks to access PLC data areas or PLC functions, the IMC0x-PLC initializes the pointer `hll_if_p`, which is defined in the file HLLCODE.C. The associated data types are in the include file HLLTYPES.H. This pointer gives HLL blocks access to the following PLC data areas and PLC functions:

PII, input process image	(IB 0 ... 127 / IW 0 ... 126)
PIQ, output process image	(QB 0 ... 127 / QW 0 ... 126)
Flag	(FB 0 ... 255 / FW 0 ... 254)
Timers	(T 0 ... 127)
Counter	(C 0 ... 127)
shared memory	(see file PLC.H)
Read peripheral byte	(PB 0 ... 255)
Write peripheral byte	(PB 0 ... 255)
Read peripheral byte in Q area	(QB 0 ... 255)
Write peripheral byte in Q area	(QB 0 ... 255)
Read address of a data block	(DB 0 ... 255)

To access a data block, a function must read back a pointer to the data block. The number of the data block is passed as a parameter.

The function returns a NULL pointer if the data block does not exist. The data block length can be read from the block header. Examples of access to PLC data areas can be found in the file HLLCODE.C.

8.2.4 Initialization Function for HLL Blocks

Linking HLL blocks often involves initializing data before an HLL block can be executed.

If HLL blocks have been programmed, then the IMC0x-PLC, during startup, calls the initialization function `hll_init` in the file HLLCODE.C. This function normally contains no commands, however you may insert any commands you wish, e.g., request memory, initialize data structures, synchronize with other tasks, etc.

`hll_init` is called as the last function during IMC0x-PLC startup, and the IMC0x-PLC can only switch into RUN mode once the function has ended.

`hll_init` can return a user-defined error status in the range 0 to 255, the IMC0x-PLC ORs a value not equal to zero with 100H and returns it as the error status of `x_plc_start` or `x_plc_init`. The IMC0x-PLC can only be switched into RUN mode when `hll_init` has completed without an error.

8.3 Linking HLL Blocks

When `x_plc_start` is called from `x_plc_init` (see chapter 10.2 or chapter 10.3) the `memory_mode` and `hll_memory` parameters must be specified appropriately.

8.3.1 Linking HLL Blocks during RMOS Generation

The program code for HLL blocks must be linked during RMOS generation. The IMC0x-PLC is started with the call `x_plc_start` and the following parameters:

```
plc_sw.memory_mode = 0xX3XX; /* PTR_TYPE */
plc_sw.hll_memory.ptr = &hll_block_table;
```

The object block HSTART.OBJ and HLLCODE.OBJ must be linked during RMOS generation. The sample application is automatically compiled by batch files GENSYSC5.BAT or GENDP.BAT (IMC05) or GENSYSC1.BAT (IMC01). If the GEN_HLLC.BAT batch file is started alone, HSTART.OBJ and HLLCODE.OBJ must be linked again to the system.

The files HSTART.ASM and HLLCODE.C must be compiled with the following switches:

```
AS386 HSTART.ASM -VSYMUPPER -DSTART=1
CC386 HLLCODE.C -VCOMPACT -I%RBASE%\INC @CC.CMD
```

8.3.2 Stack Size of HLL Blocks

When you are programming HLL blocks, remember that the available stack is limited. CRUN calls in particular make heavy demands on the stack.

When HLL blocks are called at cycle-driven processing level (OB 1) and at the timer-driven processing level (OB 10 to OB 13) they are processed at task level. RMOS system calls (SVCs) and CRUN calls can be programmed.

Available stack size is

- approx. 400 32-bit words

8.3.3 Floating-point Arithmetic

The IMC0x-PLC command set does not contain floating-point commands. However, floating-point arithmetic can be executed in HLL blocks.

Note:
With the IMC01, floating point arithmetic can only be implemented with an emulation since the IMC01 does not have a coprocessor.

A numeric library must be linked in when the RMOS system is generated (see chapter 14) so that floating point operations can be performed in HLL blocks with the numeric coprocessor (80387). In addition, the IMC0x-PLC must be informed by the flag PLC_NPX in the parameter `memory_mode` that there are floating-point commands in the HLL blocks (see chapter 10).

In the generation batch file GEN-HLLC.BAT (for CADUL) the compiler option -VNDP must be activated, if the numeric coprocessor is used.

8.4 Development and Test Environment

To program HLL blocks you need the same development environment as for generating reloadable tasks at RMOS (CADUL). The programs can be transferred to the user flash memory of the IMC05 or IMC01.

8.4.1 Testing at Assembler Level

At assembler level, HLL blocks are tested with the help of the RMOS debugger. For details on the debugger see RMOS documentation.

8.4.2 Testing High Level Languages

A very convenient tool for testing HLL blocks at high level language level is the source-level debugger from CADUL (separate product). This debugger runs on a host system and is connected to the target system via RS232 connection. The host system is an AT-compatible PC. For details on the source-level debugger see RMOS documentation.

Note:
If you want to connect a debugger with the IMC01, the system console must be moved to COM1. To do this, set variable `imc1_sysconsole = COM1` in the RMCONF.C file. If you do this, no AS511 will be available.

8.4.3 Setting Breakpoints

When testing remember that before entering a GO command, you set one or more breakpoints which will be encountered after the HLL block has been called. Remember also that HLL blocks are only called in RUN mode.

When the controller encounters a breakpoint in an HLL block, the PLC processing cycle is interrupted and then resumed again with the GO command after a set time. To prevent the IMC0x-PLC then going into STOP mode because of an exceeded scan time, scan time monitoring should first be switched off. Before the source-level debugger is exited, all breakpoints must be deleted.

Note:
When a breakpoint is encountered in an HLL block, the communication with the PG is interrupted.

8.5 HLL Blocks for PROFIBUS-DP Diagnosis (Only with IMC05)

In the controller program (i.e., STEP5 program), diagnostic data of a certain station can be fetched by calling an HHL block (i.e., FB 208) which is included. This requires that this HLL block is linked during RMOS generation.

FB 208 calls the `dpn_slv_diag()` function. The following parameters are transferred in consecutive flag words.

- Station number
- Number of diagnostic bytes to be read
- First flag byte for storage of the diagnostic data

The number and layout of the diagnostic bytes depends on the type of station. This is described in the technical description of IMC05-DP.

The diagnostic data are only available on stations for which "provide diagnostic data" has been configured in the PROFIBUS-DP data base.

Block body for the FB 208 (HLL block for diagnostics)

```
FB 208
Network 1
Name   : PLCL2DP
DCL    : STNR I/Q/D/B/T/C: A B/BY/W/D: W
         DIAG I/Q/D/B/T/C: A B/BY/W/D: W
         STS  I/Q/D/B/T/C: A B/BY/W/D: W
       : BE
```

For a sample call for FB 208, see chapter 13.2.

9 DB 1 Configuration

If the application configuration does not use the SWCPLC.C data block DB 1 is required. The DB 1 is divided into data fields, which contain the following application-specific data:

- Allocation of input, output and peripheral bytes to the physical addresses of inputs and outputs
- For initializing outputs
- For defining communication flags
- For defining retentive flags
- For special settings

DB 1 is configured in the SWCPLC.C file. Adaptation of MASK01 to MASK06 in the `x_plc_init` function must be performed in this file.

During a restart the DB 1 is loaded automatically by the controller. The controller then configures itself according to the values specified in DB 1. The data in DB 1 are generally come into effect on a restart and also when the DB 1 is loaded with the PG, but only after a transition from STOP to RUN.

Since DB1 is allocated for the IMC0x-PLC differently from the SIMATIC S5, programming with the aid of a mask (I/O assignment) is not possible as it would be with STEP 5 programmers.

Allocation of the decentral inputs/outputs to the logical I/O operands does not require configuration in DB 1. This allocation is stored with the COM PROFIBUS configuration tool in the DP data base (e.g., NONAME.2BF).

9.1 DB 1 Structure

A data field is identified by a header and an end identifier:

Header ID	Meaning
MASK01	Header for defining communication flags
MASK02	Header for defining local input
MASK03	Header for defining local output
MASK04	Header for defining retentive flags
MASK05	Header ID for initialization of local outputs
MASK06	Header for special settings

In MASK02 and MASK03 the number of input/output bytes is defined and thus the length of the cyclic read/write of the input/output process image.

The initializations in MASK05 and MASK06 are executed on each transition from STOP to RUN.

9.2 Default Values

If no DB 1 is available, or the relevant data field has not been programmed, the following default values are used:

Section	Default Setting
MASK01	Communication flags not defined
MASK02/MASK03	Input/output bytes will not be read/written
MASK04	Retentive flags not defined
MASK05	No initialization values defined
MASK06	• Scan time calculation disabled (see chapter 3.5.1.2) • No initial reset of outputs

The information which is passed to the IMC0x-PLC by loading the DB 1 can be passed directly on program start by SWCPLC.C. DB 1 can still be loaded subsequently. This has the effect of making DB 1 values the default values when the IMC0x-PLC is started.

If DB 1 does not contain individual data fields, the settings from default DB 1 are always used for the SWCPLC.C

9.3 Definition of Communication Flags (MASK01)

The data field for defining of communication flags is structured as follows:

'M' : 'A'	Header for the definition of communication flags
'S' : 'K'	
'0' : '1'	
CE00h	ID for communication input flags
Start index x	Area definition from FB x to FB y (x, y: 0 ... 255; y >= x)
End index y	
CA00h	ID for communication output flags
Start index x	Area definition from FB x to FB y (x, y: 0 ... 255; y >= x)
End index y	
EEEEh	End ID

Figure 9. 1 Data field for communication flags

These entries are made in SWCPLC.C as shown below.

```
/*------------------------[ parameter definitions ]------------------------*/
/*-------------------*/
/*    [ MASK01 ]     */
/*-------------------*/
#define MASK1_SWITCH      1   /* Koppelmerker: 0 = not used                */
                              /*               1 =     used                */
                              /* MB y >= x   : 0-255 input and/or output   */
                              /* if used define input and/or output:       */
#define MASK1_INPUT       1   /* 0= not used, 1: used                      */
#define MASK1_OUTPUT      1   /*    -"-     ,    -"-                       */
...

/*-----------------------------------*/
/* [MASK01] - Link area (MB)         */
/*-----------------------------------*/
#define MASK1_KP_TYP_INPUT  0xce00            /* Koppelmerker-Input     */
#define MASK1_KP_TYP_OUTPUT 0xca00            /* Koppelmerker-Output    */

    if (mask1)
    {
        plc_mask(MASK1);
        plc_link(MASK1_KP_TYP_INPUT,  10, 20, CONT);
        plc_link(MASK1_KP_TYP_OUTPUT, 30, 40, FINISH);
    }
```

9.4 Definition of Digital Inputs and Outputs (MASK02 and MASK03)

9.4.1 Definition of Digital Inputs (MASK02)

In the first half, the operand areas accessed by PB 128 to PB 255 (extended peripheral area) are assigned to physical inputs.

In the second half, the digital inputs are assigned to physical inputs:

- IB 0 to IB 127 (via process image) or
- PB 0 to PB 127 (without process image)

'M' : 'A'	Header for the definition of digital inputs
'S' : 'K'	
'0' : '2'	
Number PB n	Number of addresses for the inputs in the peripheral area (n: 0 ... 128)
I/O mode PB128	I/O mode of the first peripheral byte
Address PB128	Address of the first peripheral byte
. . .	
I/O mode PB(128+n-1)	I/O mode of the nth peripheral byte
Address PB(128+n-1)	Address of the nth peripheral byte
Number IB m	Number of addresses for the inputs in the PII (m: 0 ... 128)
I/O mode IB0	I/O mode of the first input byte
Address IB0	Address of the first input byte
. . .	
I/O mode IB(m-1)	I/O mode of the mth input byte
Address IB(m-1)	Address of the mth input byte
EEEEh	End ID

Figure 9. 2 Data field for inputs

The value for the number of input bytes, IB m, also defines the length of the input process image. The input bytes must be entered without gaps starting at address 0 (i.e., unused input bytes must be entered with dummy definitions).

These entries are made in SWCPLC.C as shown below.

With IMC05

```
/*------------------*/
/*    [ MASK02 ]    */
/*------------------*/
#define MASK2_SWITCH      1   /* Input bytes: 0 = not used                */
                              /*              1 =     used                */
#define MASK2_PB_ANZ      0   /* Number of peripheral bytes for input     */
                              /* in extended peripheral area   PB0 - PB127 */
#define MASK2_EB_ANZ      8   /* Number of digital input bytes EB0 - EB127 */
...

/*----------------------------------*/
/* [MASK02] - INPUT-Bytes (PB,EB)   */
/*----------------------------------*/
#define         DIG_INPUT_01_08        0
#define         DIG_INPUT_09_16        8
#define         DIG_INPUT_17_24        16
#define         DIG_INPUT_25_32        24
#define         DIG_INPUT_33_40        32
#define         DIG_INPUT_41_48        40
#define         DIG_INPUT_49_56        48
#define         DIG_INPUT_57_64        56

    if (mask2)
    {
        plc_par_mask(MASK2);
        plc_par_peab_count(MASK2_PB_ANZ);           /* nr. of PB*/
        if (mask2_pb)
        {
            plc_par_peab(DIG_INPUT_01_08, CONT);        /* PB128 */
            plc_par_peab(DIG_INPUT_09_16, CONT);        /* PB129 */
        }
        plc_par_peab_count(MASK2_EB_ANZ);           /* nr. of EB*/
        if (mask2_eb)
        {
            plc_par_peab(DIG_INPUT_01_08, CONT);        /* EB0   */
            plc_par_peab(DIG_INPUT_09_16, CONT);        /* EB1   */
            plc_par_peab(DIG_INPUT_17_24, CONT);        /* EB2   */
            plc_par_peab(DIG_INPUT_25_32, CONT);        /* EB3   */
            plc_par_peab(DIG_INPUT_33_40, CONT);        /* EB4   */
            plc_par_peab(DIG_INPUT_41_48, CONT);        /* EB5   */
            plc_par_peab(DIG_INPUT_49_56, CONT);        /* EB6   */
            plc_par_peab(DIG_INPUT_57_64, FINISH);      /* EB7   */
        }
    } /* end if ... mask_len > 0 */
```

With IMC01

```
/*------------------*/
/*    [ MASK02 ]    */
/*------------------*/
#define MASK2_SWITCH      1   /* Input bytes: 0 = not used                */
                              /*              1 =     used                */
#define MASK2_PB_ANZ      0   /* Number of peripheral bytes for input     */
                              /* in extended peripheral area   PB0 - PB127 */
#define MASK2_EB_ANZ      8   /* Number of digital input bytes EB0 - EB127 */
...

/*-----------------------------------*/
/* [MASK02] - INPUT-Bytes (PB,EB)   */
/*-----------------------------------*/
#define         DIG_INPUT_01_08        0
#define         DIG_INPUT_09_16        8
#define         DIG_INPUT_17_24        16

    if (mask2)
    {
        plc_par_mask(MASK2);
        plc_par_peab_count(MASK2_PB_ANZ);           /* nr. of PB*/
        if (mask2_pb)
        {
            plc_par_peab(DIG_INPUT_01_08, CONT);        /* PB128 */
            plc_par_peab(DIG_INPUT_09_16, CONT);        /* PB129 */
        }
        plc_par_peab_count(MASK2_EB_ANZ);           /* nr. of EB*/
        if (mask2_eb)
        {
            plc_par_peab(DIG_INPUT_01_08, CONT);        /* EB0   */
            plc_par_peab(DIG_INPUT_09_16, CONT);        /* EB1   */
            plc_par_peab(DIG_INPUT_17_24, FINISH);      /* EB2   */
        }
    } /* end if ... mask_len > 0 */
```

9.4.2 Definition of Digital Outputs (MASK03)

In the first half, the operand areas accessed by PB 128 to PB 255 (extended peripheral area) are assigned to physical outputs.

In the second half, the digital outputs are assigned to the physical outputs:

- QB 0 to QB 127 (via process image) or
- PB 0 to PB 127 (without process image)

'M' : 'A'	Header for the definition of digital outputs
'S' : 'K'	
'0' : '3'	
Number PB n	Number of addresses for the outputs in the peripheral area (n: 0 ... 128)
I/O mode PB128	I/O mode of the first peripheral byte
Address PB128	Address of the first peripheral byte
. . .	
I/O mode PB(128+n-1)	I/O mode of the nth peripheral byte
Address PB(128+n-1)	Address of the nth peripheral byte
Number QB m	Number of addresses for the outputs in the PIQ (m: 0 ... 128)
I/O mode QB0	I/O mode of the first output byte
Address QB0	Address of the first output byte
. . .	
I/O mode QB(m-1)	I/O mode of the mth output byte
Address QB(m-1)	Address of the mth output byte
EEEEh	End ID

Figure 9. 3 Data field for outputs

The value for the number of input bytes, QB m, also defines the length of the input process image. The output bytes must be entered without gaps starting at address 0 (i.e., unused output bytes must be entered with dummy definitions).

Note:
Where initialization values for the outputs are defined (see MASK05), these are written to the extended peripheral area starting at PB 128 to correspond in number and sequence.

These entries are made in SWCPLC.C as shown below.

With IMC05

```
/*------------------*/
/*    [ MASK03 ]    */
/*------------------*/
#define MASK3_SWITCH      1   /* output bytes: 0 = not used                */
                              /*               1 =     used                */
#define MASK3_PB_ANZ      0   /* Number of peripheral bytes for output     */
                              /* in extended peripheral area PB128 - PB255 */
#define MASK3_AB_ANZ      6   /* Number of digital output bytes AB0 - AB127*/
...

/*----------------------------------*/
/* [MASK03] - OUTPUT-Bytes (PB,AB)  */
/*----------------------------------*/
#define         DIG_OUTPUT_01_08        0
#define         DIG_OUTPUT_09_16        8
#define         DIG_OUTPUT_17_24        16
#define         DIG_OUTPUT_25_32        24
#define         DIG_OUTPUT_33_40        32
#define         DIG_OUTPUT_41_48        40

    if (mask3)
    {
        plc_par_mask(MASK3);
        plc_par_peab_count(MASK3_PB_ANZ);           /* nr. of PB*/
        if (mask3_pb)
        {
            plc_par_peab(DIG_OUTPUT_01_08, CONT);        /* PB128 */
            if (mask3_ab)
                plc_par_peab(DIG_OUTPUT_09_16, CONT);    /* PB129 */
            else
                plc_par_peab(DIG_OUTPUT_09_16, FINISH);  /* PB129 */
        }
        plc_par_peab_count(MASK3_AB_ANZ);           /* nr. of AB*/
        if (mask3_ab)
        {
            plc_par_peab(DIG_OUTPUT_01_08, CONT);        /* AB0   */
            plc_par_peab(DIG_OUTPUT_09_16, CONT);        /* AB1   */
            plc_par_peab(DIG_OUTPUT_17_24, CONT);        /* AB2   */
            plc_par_peab(DIG_OUTPUT_25_32, CONT);        /* AB3   */
            plc_par_peab(DIG_OUTPUT_33_40, CONT);        /* AB4   */
            plc_par_peab(DIG_OUTPUT_41_48, FINISH);      /* AB5   */
        }
    } /* end if ... mask_len > 0 */
```

With IMC01

```
/*------------------*/
/*    [ MASK03 ]    */
/*------------------*/
#define MASK3_SWITCH      1   /* output bytes: 0 = not used               */
                              /*               1 =     used               */
#define MASK3_PB_ANZ      0   /* Number of peripheral bytes for output    */
                              /* in extended peripheral area PB128 - PB255 */
#define MASK3_AB_ANZ      6   /* Number of digital output bytes AB0 - AB127*/
...

/*----------------------------------*/
/* [MASK03] - OUTPUT-Bytes (PB,AB)  */
/*----------------------------------*/
#define         DIG_OUTPUT_01_08        0
#define         DIG_OUTPUT_09_16        8

    if (mask3)
    {
        plc_par_mask(MASK3);
        plc_par_peab_count(MASK3_PB_ANZ);           /* nr. of PB*/
        if (mask3_pb)
        {
            plc_par_peab(DIG_OUTPUT_01_08, CONT);        /* PB128 */
            if (mask3_ab)
                plc_par_peab(DIG_OUTPUT_09_16, CONT);    /* PB129 */
            else
                plc_par_peab(DIG_OUTPUT_09_16, FINISH);  /* PB129 */
        }
        plc_par_peab_count(MASK3_AB_ANZ);           /* nr. of AB*/
        if (mask3_ab)
        {
            plc_par_peab(DIG_OUTPUT_01_08, CONT);        /* AB0   */
            plc_par_peab(DIG_OUTPUT_09_16, FINISH);      /* AB1   */
        }
    } /* end if ... mask_len > 0 */
```

9.5 Definition of Retentive Flags (MASK04)

The data field for the definition of retentive flags has the following structure:

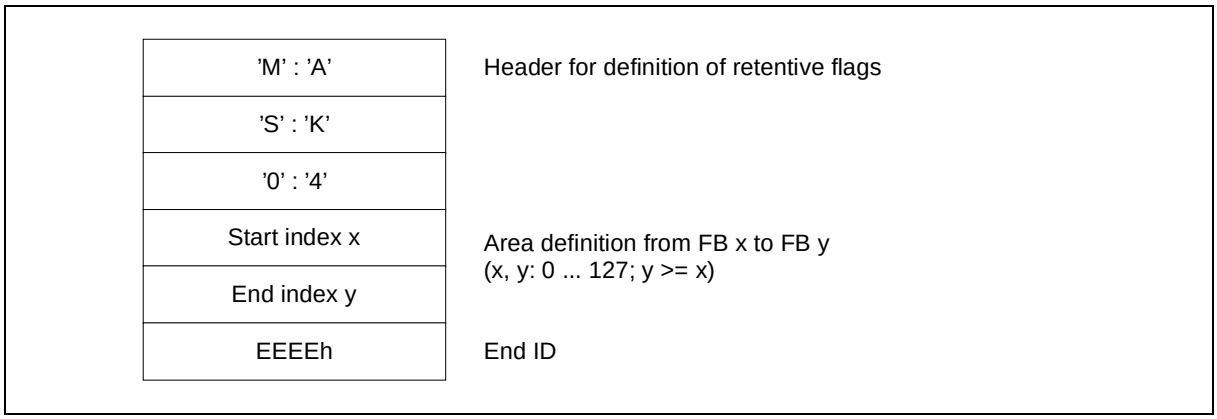


Figure 9. 4 Data field for retentive flags

When retentive flags are entered then the timers T0 to T63 and counters C0 to C63 will automatically be retentive too (see chapter 3.6).

These entries are made in SWCPLC.C as shown below.

```
/*------------------*/
/*    [ MASK04 ]    */
/*------------------*/
#define MASK4_SWITCH      1   /* Remanente Merker: 0 = not used            */
                              /*                   1 =     used            */
                              /* MB y >= x :       MB 0-127                */
...

/*-----------------------------------*/
/* [MASK04] - REMANENT AREA          */
/*-----------------------------------*/

    if (mask4)
    {
        plc_par_mask(MASK4);
        plc_par_rema(0,127);
    } /  end if ... mask_len > 0  /
```

9.6 Definition of Initialization Values (MASK05)

The initialization values for the digital outputs may be entered.

The values are entered in the logical addresses PB 128 to PB 255 (see MASK03) to correspond in number and sequence.

This results in easy initialization; the addresses for the outputs must, however, be entered sequentially in MASK03.

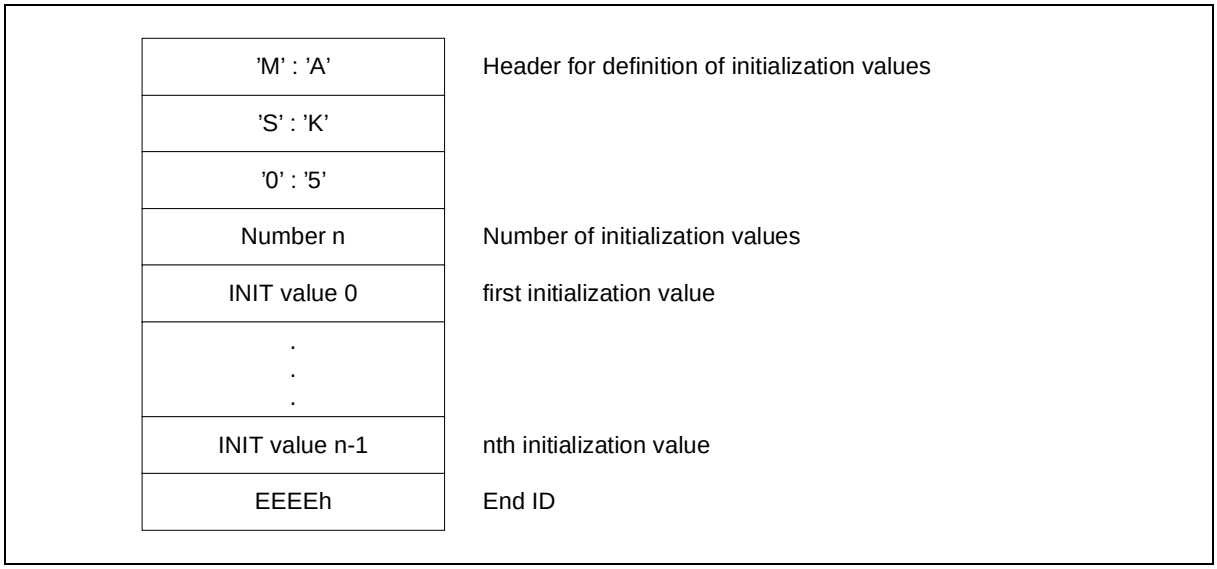


Figure 9. 5 Data field for initialization values

Regardless of its position in DB 1, MASK05 is always processed at the end of the initialization.

These entries are made in SWCPLC.C as shown below.

```
/*------------------*/
/*    [ MASK05 ]    */
/*------------------*/
#define MASK5_SWITCH      1   /* Init values of      : 0 = not used        */
                              /* PB 128 - PB 255       1 =     used        */
...

/*-----------------------------------------------*/
/* [MASK05] - INIT VALUES OF PERIPHERIAL BYTES  */
/* (see nr. of PB defined in MASK3)             */
/*-----------------------------------------------*/

    if (mask5)
    {
        plc_par_mask(MASK5);
        plc_par_pb_init(1, CONT);
        plc_par_pb_init(2, CONT);
        plc_par_pb_init(4, FINISH);
    } /  end if ... mask_len > 0  /
```

9.7 Special Settings (MASK06)

Special settings are made in a configuration data word. The following diagrams show the data field structure for the special settings and the significance of individual bits of the configuration data word:

'M' : 'A'	Header for configuration data word
'S' : 'K'	
'0' : '6'	
Configuration DW	Bit pattern, see below
EEEEh	End ID

Figure 9. 6 Data field for the configuration data word

Structure of the configuration data word

Bit	15 ... 2	1	0	Meaning
				Scan time calculation 0: disabled 1. enabled
				Initial deletion of outputs 0: disabled 1. enabled
				Reserved

Note:
The function "Initial delete" initializes all output boards to zero, corresponding to the configuration in MASK03 (after restart).

These entries are made in SWCPLC.C as shown below.

```
/*------------------*/
/*    [ MASK06 ]    */
/*------------------*/
#define MASK6_SWITCH      1   /* command settings: 0 = not used            */
                              /*                   1 =     used            */
...

/*-----------------------------------------------*/
/* [MASK06] - CONFIGURATION DATA WORD           */
/* cycle flag, enable IO init, PG communication */
/*-----------------------------------------------*/
#define ENABLE_COUNT_CYCLE_TIME       0x0001
#define ENABLE_CLEAR_DIG_OUTPUT       0x0002
#define ENABLE_PG_COMMUNICATION       0x0030

#define DISABLE_COUNT_CYCLE_TIME      0x0000
#define DISABLE_CLEAR_DIG_OUTPUT      0x0000
#define DISABLE_PG_COMMUNICATION      0x0000

    if (mask6)
    {
        plc_par_mask(MASK6);
        plc_par_cdw( DISABLE_COUNT_CYCLE_TIME,
                     DISABLE_CLEAR_DIG_OUTPUT,
                     DISABLE_PG_COMMUNICATION);
    }
```

10 IMC0x-PLC Configuration

The IMC0x-PLC is configured by means of parameters, which are transferred with the nested start calls `x_plc_init` and `x_plc_start`.

10.1 IMC0x-PLC Memory Areas

Configuring memory areas is one of the most important aspects of the IMC0x-PLC configuration. In the simplest case, all memory areas are taken from the HEAP. However, if the MC5 code is in EPROM, or if SRAM is used to store retentive data, memory area addresses must be supplied. The five different memory areas are explained below.

There are five different memory areas:

MC5 memory

Memory area for PLC program / MC5 code (0 ... 32 Kbytes). The following memory types are supported:

Memory type	MC5 code	Reloadable blocks
EPROM:	Must be converted with option /e (see chapter 7.4), is fixed in EPROM.	Blocks are reloaded to the DB memory and are retentive there if the DB memory is retentive.
SRAM	Is loaded from the PG.	Also reload to SRAM
not available	Is loaded from the PG into DB memory.	Also reload to DB memory

DB memory

Memory area for retentive data, data blocks and for reloadable program blocks, (4 ... 32 Kbytes).

The following memory types are supported:

- SRAM:
- Dynamically requested RAM. No retentivity.

HLL memory

Memory area for HLL blocks (0 ... arbitrary size).

The HLL blocks can only be stored in the EPROM.

Shared memory

Memory area for data exchange with another RMOS task (1 kByte).

The following memory types are supported:

- Dynamically requested RAM.
- Reserved memory area in SRAM.

80386 memory Dynamically requested RAM area for generated 80386 code.

The size of this memory area results from the size of the MC5 memory (`mc5_size`) and the size of the DB memory (`db_size`):

Size of the 80386 memory = 8 * `mc5_size` + 6 * `db_size`

10.2 Start Call x_plc_start

`x_plc_start` is called from SWCPLC.C. The referenced structures must also be preset with the required configuration parameters in this file. This function causes the PLC tasks to be dynamically created, cataloged and started.

The return value will tell you whether the call was executed successfully (see chapter 10.4).

Call syntax

```
#include <plc.h>

unsigned int far x_plc_start (SW_DATA *plc_sw,
                              HW_DATA *plc_hw,
                              PLCINIT_FCT init_fct);
```

Call parameters

`plc_sw` This data structure contains the parameters for the software configuration. , e.g., task priorities.

`plc_hw` This data structure contains the parameters for the hardware configuration.

`init_fct` This parameter is for code optimization. This parameter should specify the macro PLC_NO_FILEIO which is defined in PLC.H (in this case no file operation functions are linked).

Return values

See chapter 10.4.

10.2.1 Structure Definition for Software Parameters

```
typedef struct  {
                    WORD16          priority_1;
                    WORD16          priority_2;
                    WORD16          idle_time;
                    WORD16          flag_id;
                    WORD16          memory_mode;
                    WORD32          mc5_size;
                    WORD32          db_size;
                union
                    {
                    BYTE *          ptr;
                    WORD32          addr;
                    }mc5_memory;
                union
                    {
```

```
        BYTE *          ptr;
        WORD32          addr;
        }db_memory;
    union
        {
        BYTE *          ptr;
        WORD32          addr;
        }hll_memory;
        WORD32          shared_memory;
} SW_DATA;
```

Meaning of the structure elements

`priority_1`

Priority of the PLC cycle task, 3 ... 245.

The overall reset task priority is `priority_1` – 1 and the communication task priority is `priority_1` + 1.

`priority_2`

Priority of PLC timer tasks, 5 ... 247.

These tasks must be specified a priority as high as possible (higher than `priority_1` but smaller than 248). For details on priority assignment see chapter 14.1.

`idle_time`

Pause length for the PLC task in msec (=processing time for other tasks with lower priority), 0 ... 255.

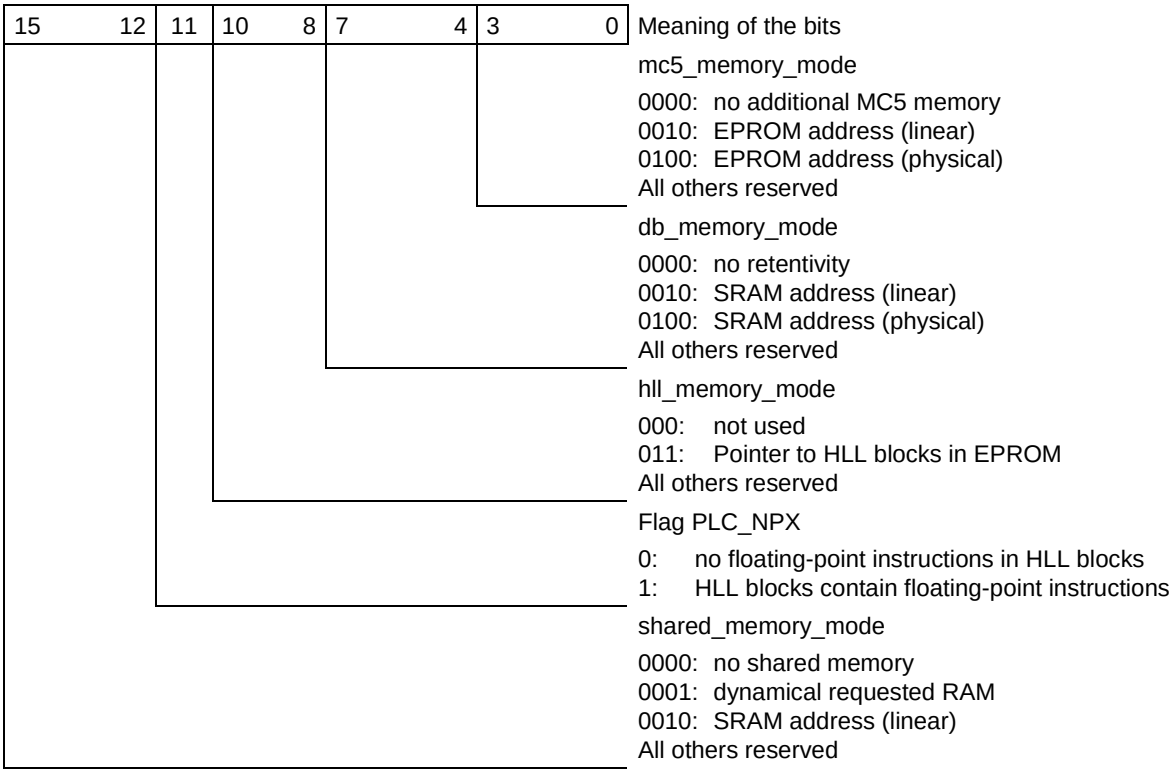
After the `idle_time` has elapsed, the PLC task again becomes active, but the task switch takes place only at the next RMOS timer interrupt. The precise length of `idle_time` in practice, thus also depends on the RMOS system clock. The PLC cycle is extended by the effective `idle_time`. `idle_time` is thus included in the scan time calculation and must not be overlooked in specifying the time interval for scan time monitoring.

`flag_id`

RMOS event flag group ID for PLC operating mode display or operating mode selection, 0 ... 31

0 means that the event flag group is not processed. For bit allocation see chapter 11.2.

memory_mode Bit coded information for memory configuration:



The following definitions in the header file PLC.H are used to set the memory type in the parameter `memory_mode`:

```
#define     NULL_TYPE       0x0000#define     ALOC_TYPE
0x0001
#define     MAP_TYPE        0x0002
#define     PTR_TYPE        0x0003
#define     MAP_TYPE_PHYS   0x0004#define     PLC_NPX
0x0008
```

The definitions can be used to preset the parameter `memory_mode` with symbolic names. This requires that the PLC_NPX flag be set for floating point support in HLL blocks, e.g.:

```
plc_sw.memory_mode =
       (NULL_TYPE<<12)            | /* Type of shared_memory */
       ((PTR_TYPE | PLC_NPX)<<8)  | /* Type of hll_memory    */
       (NULL_TYPE<<4)             | /* Type of db_memory     */
        MAP_TYPE;                   /* Type of mc5_memory    */
```

If `memory_mode` = 0x0000, required memory is assigned for MC5 code and data from the heap administered for RMOS.

If `memory_mode` = 0x0000 and `mc5_size` = 0 and transfer of blocks via the PG interface, these are stored in DB memory (i.e., `db_size` must be initialized with sufficient space).

mc5_size Length of memory area for MC5 code, 0 ... 0xFFFF.

db_size

Length of retentive memory areas (retentive flags, timers, counters and data blocks), 0x0400 ... 0xFFFF.

Remember that the first 512 bytes of DB memory are reserved for retentive flags, counters and timers. The first DB is located in retentive memory starting at base address db_memory + 552 bytes.

MC5 memory

The meaning of this parameter depends on the value of memory_mode:

memory_mode	Meaning
xxx0h	No additional memory area for MC5 code is available, i.e. all blocks are loaded into DB memory.
xxx2h	mc5_memory is the **linear** address of an EPROM or SRAM memory area containing the MC5 code.
xxx4h	mc5_memory is the **physical** address of an EPROM or SRAM memory area containing the MC5 code.

DB memory

The meaning of this parameter depends on the value of memory_mode:

memory_mode	Meaning
xx0xh	No retentivity, the required RAM memory is dynamically requested.
xx2xh	db_memory is the **linear** address of a SRAM memory area.
xx4xh	db_memory is the **physical** address of a SRAM memory area.

HLL memory

The meaning of this parameter depends on the value of memory_mode:

memory_mode	Meaning
x0xxh	No HLL blocks are available, hll_memory is not evaluated.
x3xxh / xBxxh	hll_memory is a pointer (selector:offset) to the table [1] for the HLL blocks in the EPROM (hll_block_table).

1) The table is stored in HSTART.ASM. See chapter 8.

If HLL blocks are used, the flag PLC_NPX must be set:
(memory_mode=XXXX|1XXX|XXXX|XXXXB)

Shared memory

The meaning of this parameter depends on the value of memory_mode:

memory_mode	Meaning
0xxxh	Shared memory is not available, i.e., no data exchange with another task takes place using this memory area.
1xxxh	shared_memory is a dynamically requested memory area, i.e., the parameter shared_memory is not used. The memory required for data exchange with other tasks is dynamically requested by the IMC0x-PLC. The global pointer x_plc_shared_mem_p enables other tasks to access shared memory.
2xxxh	shared_memory is the address of a memory area (e.g., dual-port RAM).

10.2.2 Structure Definitions for Hardware Parameters

Parameters for the hardware configuration are organized in the following structure:

```
typedef struct  {
                    WORD16          in_mode;
                    WORD16          in_addr;
                    WORD16          out_mode;
                    WORD16          out_addr;
                    WORD16          mask_reg;
                    WORD16          int_mask;
                    WORD16          pic_base;
                    WORD16          pit_vector;
                    WORD32          mmio_addr;
                    WORD16          mmio_mode;
                    WORD16          mem161_io;
                    WORD16          db1_len;
                    WORD16 *        db1_p;
                } HW_DATA;
```

Meaning of the structure elements

in_mode Reserved, must always be 0x4000

in_addr Reserved, must always be 0x00

out_mode Reserved, must always be 0x4000

out_addr Reserved, must always be 0x00

mask_reg Reserved, must always be 0xA1

int_mask Reserved, must always be 0x00

pic_base Reserved, must always be 0x70

pit_vector Reserved, must always be 0x00

mmio_addr Reserved, must always be 0x00

mmio_mode Reserved, must always be 0x00

mem161_io Reserved, must always be 0x0320

db1_len Length of the DB 1 data structure in words.

db1_p Pointer to the DB 1 data structure.

10.3 Start Call x_plc_init

This function is defined in SWCPLC.C and is called from RMCONF.C. It enters all required parameters into the appropriate data structures and then calls the `x_plc_start` function.

Call syntax

```
extern unsigned int _FIXED _FAR x_plc_init (char *inifile);
```

The *`inifile` parameter is not evaluated.

10.3.1 Parametrization in the Configuration File SWCPLC.C

With IMC05

```
/*---[plc_sw_data]-------------------------------------------------------*/
  plc_sw.priority_1      = 241;      /* pri of cycle task, pri+1 of com task */
  plc_sw.priority_2      = 243;      /* pri of alarm task and time task      */
  plc_sw.idle_time       = 10;       /* pause of cycle task in ms            */
  plc_sw.flag_id         = 0;        /* eventflag group                      */
  plc_sw.memory_mode     = 0x0322;   /* memory_mode:
                           !!!+-----  mc5_memory_mode(NULL_TYPE,MAP_TYPE)
                           !!+------  db_memory_mode (NULL_TYPE,MAP_TYPE)
                           !+-------  hll_memory_mode(NULL_TYPE,PTR_TYPE)
                           +--------  reserved
                                      0 = NULL_TYPE,2 = MAP_TYPE,3 = PTR_TYPE */
  plc_sw.mc5_size        = 0xC000;   /* length of mc5 code = 48 KByte  */
  plc_sw.db_size         = 0x8000;   /* length of remanent data = 32 KByte   */
  plc_sw.mc5_memory.addr = 0x5e0000; /* lin.  address of mc5 flash memory    */
                                     /* => use address offset > 0x400000     */
                                     /*    with flash-loader                 */
  plc_sw.db_memory.addr  = 0x0f8000; /* lin.  address of remanent memory     */
  plc_sw.hll_memory.ptr  = &hll_block_table; /* phys.  address of hll table  */
  plc_sw.shared_memory   = 0x0000;   /* reserved                             */

/*---[plc_hw_data]-------------------------------------------------------*/
                                     /* Note: direct IO not available !!!    */
  plc_hw.in_mode         = 0x4000;   /* MMIO_MODE and NO_IO                  */
  plc_hw.in_addr         = 0;        /* not used if NO_IO                    */
  plc_hw.out_mode        = 0x4000;   /* MMIO_MODE and NO_IO                  */
  plc_hw.out_addr        = 0;        /* not used if NO_IO                    */
  plc_hw.mask_reg        = 0;        /* io-address maskregister, not used    */
  plc_hw.int_mask        = 0;        /* int mask for alarm-obs               */
                                     /* !!! not used !!! => has to be: 0     */
  plc_hw.pic_base        = 0;        /* pic base for alarm ints, not used    */
  plc_hw.pit_vector      = 0;        /* reserved                             */
  plc_hw.mmio_addr       = 0;        /* reserved                             */
  plc_hw.mmio_mode       = 0;        /* reserved                             */
  plc_hw.mem161_io       = 0;        /* reserved                             */
  plc_hw.db1_len         = DB1_LEN;  /* see definition above                 */
  plc_hw.db1_p           = &plc_db1[0];  /* local db1 struc with   */
                                              /* parameters (see below) */
```

The sections MASK01 to MASK06 and the parameters they contain are entered in the same way as in data block DB 1 (see chapter 9).

With IMC01

```
/*---[plc_sw_data]-------------------------------------------------------*/
  plc_sw.priority_1      = 241;      /* pri of cycle task, pri+1 of com task */
  plc_sw.priority_2      = 243;      /* pri of alarm task and time task      */
  plc_sw.idle_time       = 10;       /* pause of cycle task in ms            */
  plc_sw.flag_id         = 0;        /* eventflag group                      */
  plc_sw.memory_mode     = 0x0322;   /* memory_mode:
                             !!!+-----  mc5_memory_mode(NULL_TYPE,MAP_TYPE)
                             !!+------  db_memory_mode (NULL_TYPE,MAP_TYPE)
                             !+-------  hll_memory_mode(NULL_TYPE,PTR_TYPE)
                             +--------  reserved
                                     0 = NULL_TYPE,2 = MAP_TYPE,3 = PTR_TYPE */
  plc_sw.mc5_size        = 0xC000;   /* length of mc5 code = 48 KByte        */
  plc_sw.db_size         = 0x8000;   /* length of remanent data = 32 KByte   */
  plc_sw.mc5_memory.addr = 0x3FA0000; /* lin.  address of mc5 flash memory   */
                                     /* => use address offset > 0x3E0000     */
                                     /*    with flash-loader                 */
  plc_sw.db_memory.addr  = 0x0f8000; /* lin.  address of remanent memory     */
  plc_sw.hll_memory.ptr  = &hll_block_table; /* phys.  address of hll table  */
  plc_sw.shared_memory   = 0x0000;   /* reserved                             */

/*---[plc_hw_data]-------------------------------------------------------*/
                                     /* Note: direct IO not available !!!    */
  plc_hw.in_mode         = 0x4000;   /* MMIO_MODE and NO_IO                  */
  plc_hw.in_addr         = 0;        /* not used if NO_IO                    */
  plc_hw.out_mode        = 0x4000;   /* MMIO_MODE and NO_IO                  */
  plc_hw.out_addr        = 0;        /* not used if NO_IO                    */
  plc_hw.mask_reg        = 0;        /* io-address maskregister, not used    */
  plc_hw.int_mask        = 0;        /* int mask for alarm-obs               */
                                     /* !!! not used !!! => has to be: 0     */
  plc_hw.pic_base        = 0;        /* pic base for alarm ints, not used    */
  plc_hw.pit_vector      = 0;        /* reserved                             */
  plc_hw.mmio_addr       = 0;        /* reserved                             */
  plc_hw.mmio_mode       = 0;        /* reserved                             */
  plc_hw.mem161_io       = 0;        /* reserved                             */
  plc_hw.db1_len         = DB1_LEN;  /* see definition above                 */
  plc_hw.db1_p           = &plc_db1[0];  /* local db1 struc with   */
                                          /* parameters (see below) */
```

The sections MASK01 to MASK06 and the parameters they contain are entered in the same way as in data block DB 1 (see chapter 9).

10.4 Error Codes for x_plc_start and x_plc_init

The functions `x_plc_start` and `x_plc_init` return an error status as return value. This code is defined in the header file PLC.H.

Table 10. 1 Error codes for `x_plc_start` and `x_plc_init`

Error	Error code hex	Meaning
E_PLC_OK	0x00	The function was executed successfully.
E_PLC_START	0x01	One of the tasks could not be started.
E_PLC_CREATE	0x02	One of the tasks could not be created, because the maximum number of dynamic tasks (see Software Configuration, Number of SMRs) was exceeded or because no GDT slot was free.
E_PLC_ALOC	0x03	There is insufficient free memory in the HEAP.
E_PLC_PARAM	0x04	The value for memory configuration (parameter `memory_mode` in the `x_plc_start` call, or in the file SWCPLC.C) is invalid.
E_PLC_DESC	0x05	No GDT entries free.
E_PLC_DRIV	0x06	The AS511 driver is not configured.
E_PLC_MASK	0x07	Reserved
E_PLC_INTR	0x08	Reserved
E_PLC_CATALOG	0x09	One of the tasks could not be cataloged because the resource directory is full.
E_PLC_CFG_OPEN	0x0A	Nonexistent configuration file SWCPLC.C.
E_PLC_CFG_READ	0x0B	I/O error on reading the configuration file SWCPLC.C.
E_PLC_TIC	0x0C	An illegal value was configured for the RMOS system clock. Legal values are 1 msec, 2 msec, 5 msec, 10 msec.
E_PLC_PRIO	0x0D	One of the parameters `priority_1` or `priority_2` (in the `x_plc_start` call, or in the file SWCPLC.C) is illegal.
E_PLC_STL_READ	0x0E	Error while loading an HLL block (configuration error).
E_PLC_STL_FORMAT	0x0F	Error while loading an HLL block (configuration error).
E_PLC_MC5_SIZE	0x10	The value entered for the parameter `mc5_size` is too large (maximum 0FFFFH).
E_PLC_DB_SIZE	0x11	The value entered for the parameter `db_size` is too large (maximum 0FFFFH).
E_PLC_FILE_SIZE	0x12	Error while reading the MC5 code file. The file length is larger than the available memory area (parameter `mc5_size`).
E_PLC_DB_CPY	0x13	Insufficient memory area for copying data blocks from MC5 memory to DB memory.
E_PLC_MC5_OPEN	0x14	Error while opening the MC5 code file. The specified drive cannot be mounted or a subdirectory does not exist. The error message is not issued, if a valid path was specified but the file to be read is nonexistent.
E_PLC_MC5_READ	0x15	Error while reading the MC5 code file (I/O error).
E_PLC_DB_OPEN	0x16	Error while opening the file for writing retentive data.
E_PLC_DB_READ	0x17	Error while reading the file for writing retentive data (I/O error).
E_PLC_DB1_WRITE	0x18	Error while writing the file for writing retentive data (I/O error).
E_PLC_DB1_DATA	0x19	Error in the DB 1 data structure. The end identifier (0EEEEH) could not be found.
E_PLC_FLG_ID	0x1A	Invalid event flag group ID (`flag_id`).

Error on PROFIBUS-DP connection (only with IMC05)

The exact cause of the error can be determined with the `x_plc_dp_error` (unsigned int) error variables.

Table 10. 2 Error codes on the PROFIBUS-DP link

Error	Error code hex	Meaning
E_PLC_L2_VECTOR	0x1B	Error during installation of the unit or the interrupt handle. `x_plc_dp_error` contains the error status of the `RcCom05DPInitUnit()` call.
E_PLC_L2_INIT	0x1C	Error during installation of the driver. `x_plc_dp_error` contains the error status of the `RcCom05DPInit()` call.
E_PLC_DP_START	0x1D	Error during startup of the DP driver. `x_plc_dp_error` contains the error status of the `Com201Start()` call.
E_PLC_DP_INIT	0x1E	Error during registration of the DP application. `x_plc_dp_error` contains the error status of the `dpn_init()` call.
E_PLC_DP_OPEN	0x1F	Error during opening of the DP data base (CRUN call `fopen`). `x_plc_dp_error` contains the CRUN error number.
E_PLC_DP_READ	0x20	Error during reading of the DP data base. `x_plc_dp_error` contains the CRUN error number.
E_PLC_DUP_IO	0x21	An I/O address is configured as both local and decentral.
E_PLC_DP_CFG	0x22	Error during determination of the slave configuration of the DP system, `x_plc_dp_error` contains the error status of the `dpn_read_cfg()` call.
E_PLC_DP_MAX32	0x23	More than 32 slave stations are configured in the data base.
E_PLC_DP_BASE	0x24	Error during evaluation of the DP data base (e.g., no data base generated with COM PROFIBUS)

Error Variable x_plc_error

The error variable `x_plc_error` (data definition in PLC.H) is used to write additional error codes for the RMOS taskloader or for RMOS-CRUN. The contents of this error variable can be used to supply supplementary error information on the console.

For the return values below, the error variable `x_plc_error` will contain the error code **errno** from the RMOS-CRUN library (see RMOS documentation, CRUN):

- E_PLC_MC5_OPEN (0x14)
- E_PLC_DB_OPEN (0x16)
- E_PLC_MC5_READ (0x15)
- E_PLC_DB_READ (0x17)
- E_PLC_DB_WRITE (0x18)

Error variable x_plc_dp_error (only with IMC05)

The error variable `x_plc_dp_error` (data definition in PLC.H) is used to write additional error codes for the function `x_plc_init`. The contents of this error variable can be used to evaluate the error status of the particular call or output it on the console.

10.5 I/O Interface PLC_IOIF.ASM

Configuring the hardware for the IMC0x-PLC is handled as far as possible with the parameters (`plc_hw`) which are loaded with the call `x_plc_start`/`x_plc_init`. In addition, certain IMC0x-PLC functions which directly access hardware are supplied as source code in the file PLC_IOIF.ASM. This file's object code is normally in the library RM3PLC.LIB. If you have to modify this file, then the file must be recompiled and linked as an independent object code module called PLC_IOIF.OBJ, ahead of the library RM3PLC.LIB (linking in this order is essential).

The file PLC_IOIF.ASM contains the following functions:

x_plc_vector_table Reserved function. Do not call.

x_plc_mask_pic Reserved function. Do not call.

x_plc_free_pic Reserved function. Do not call.

x_plc_save The IMC0x-PLC installs an NMI handler (if this option is configured) to save retentive data in the event of a power failure (power fail signal). At this point the NMI handler can be extended for extra data saving.

10.6 Directory Entries

The call `x_plc_start` or `x_plc_init` generates various tasks and enters them in the RMOS catalog. Each of these tasks is assigned a priority via parameters `priority_1` and `priority_2`. The directory entries are listed in chapter 14.1 .

11 Operator Interface and Display Elements

The IMC0x-PLC has two interfaces to handle operating and display elements for an application (see chapters 10.5). Manipulation/indication can be performed via an RMOS event flag group.

An event flag group can be used for operating mode selection/display by another RMOS task. In this way the RUN/STOP operation of the IMC0x-PLC can be controlled by another RMOS task. The ID of the event flag group is configurable. The ID 0 indicates that the event flag group is not used.

11.1 What is an Event Flag?

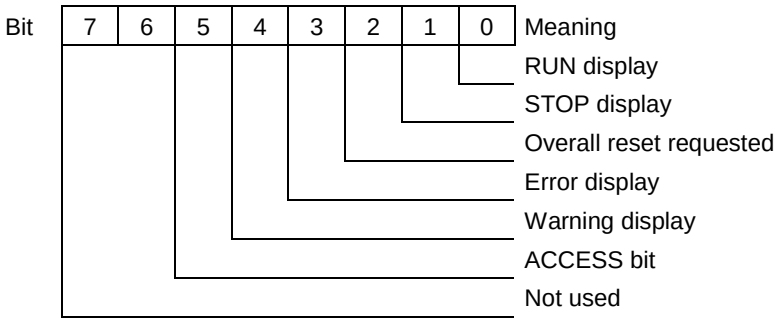
An event flag is a single bit in memory used for communication between different RMOS tasks by virtue of being set or reset. Event flags are grouped to form event flag groups made up of 32 bits. Each individual flag is accessed by specifying the event flag group ID combined with a 32-bit mask. The event flag group ID for the IMC0x-PLC is configurable (0 to 31). ID 0 means that no flag in the event flag group is accessed. The event flag group can be used, e.g., to allow another RMOS task to control IMC0x-PLC RUN/STOP operations. You will find more information, e.g., about the RMOS system calls for event flag operations, in the RMOS documentation.

11.2 Working with Event Flags

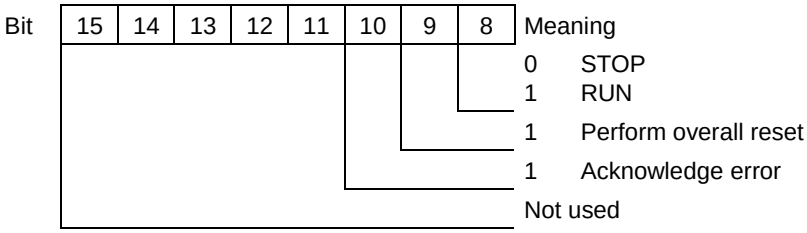
The IMC0x-PLC's event flag group is used to allow some other RMOS task to control operating mode selection and/or display. The lower value byte (Bit 0 to 7) is used for PLC operating mode display for the other task. The higher value byte (Bit 8 to 15) is used for operating mode selection RUN/STOP, or overall reset, or error acknowledgement. (An overall reset is only possible in STOP mode.)

Bit allocation in the IMC0x-PLC event flag group

Display flags (low-order byte)



Control flags (high-order byte)



The ACCESS bit is used to control access to shared memory (see chapter 12). It is interpreted as follows:

ACCESS bit=0	Local access to shared memory by another task is prohibited.
ACCESS bit=1	Local access to shared memory by another task is allowed. (The ACCESS bit always has the opposite state to bit 0 in the acknowledgement byte). After accessing shared memory, the task must reset the ACCESS bit.

12 Working with Shared Memory

The shared memory allows you to monitor internal processing sequences and to display the status of input and output process images (PII and PIQ), counters and timers (process visualization). The shared memory is also the location of the communication flags, used to synchronize other processes with the IMC0x-PLC. On the IMC0x-PLC side, a flag area can be defined as communication flag.

The shared memory is a common local memory area and is used to exchange data, either with another RMOS task. The shared memory address is configurable (see chapter 10). Its size is 1 Kb.

12.1 Base Address

The shared memory base address is identical for both tasks. The memory is dynamically requested by the IMC0x-PLC. Another task can access this memory by using the global pointer `x_plc_shared_mem_p`.

12.2 Structure and Contents

The following table shows the contents of the shared memory. The addresses are relative to the base address.

Address offset	Meaning
3FFH	Acknowledgement byte
3FEH	Status byte
3FAH ... 3FCH	Reserved
3F8H ... 3F9H	Current scan time (in msec)
3F6H ... 3F7H	Version number
280H ... 3F5H	Reserved
180H ... 27FH	256 bytes communication flags defined as input flags or output flags
140H ... 17FH	32 counter words (64 bytes)
100H ... 13FH	32 timer words (64 bytes)
80H ... 0FFH	128 bytes process image of outputs (PIQ)
00H ... 7FH	128 bytes process image of inputs (PII)

The structure of the shared memory is defined in the header file PLC.H.

Note that some time can elapse between system power-up after a reset and the IMC0x-PLC start; during this time the contents of shared memory are undefined. After the IMC0x-PLC start, the shared memory is first deleted and then written to, for the first time, towards the end of the first PLC cycle. shared memory entries are valid only as long as the status byte contains the identification 01.

The shared memory entries are as follows:

Status byte

The status byte shows the operating state of the controller and the IMC0x-PLC. Possible entries and their meaning are set out in the table below:

Status byte	Meaning
00	State immediately after reset, the data in shared memory are deleted.
01	The controller is in the PLC cycle, the data in shared memory are valid.
02	The controller is in STOP mode. The data in shared memory originate from the last PLC cycle and are not updated anymore.

Acknowledgement byte

The contents of the acknowledgement byte regulate access rights to shared memory - and to the communication area in particular - for the IMC0x-PLC and for the task which is communicating with it. This avoids conflicts in shared memory accessing and the data inconsistencies which would result. (For details of the access mechanism see chapter 12.3).

Acknowledgement byte	Meaning
00	Access to shared memory is permitted only for the task communication with the IMC0x-PLC: This code is entered by the IMC0x-PLC after reading/writing the IMC0x-PLC data, enabling access to shared memory for the task. The IMC0x-PLC thereafter does not access shared memory again, until an acknowledgement (01) is entered by another task. Immediately after reset, the data in shared memory are deleted.
01	Access to shared memory is permitted only for the IMC0x-PLC: This code is entered by a task after reading the data in shared memory, or after writing the input communication flag. The IMC0x-PLC accesses shared memory only after acknowledgement by another task.

Current scan time

This is the current scan time in msec units. The current scan time is the time taken by the most recent PLC cycle. The scan time is entered only if scan time calculation was specified in DB 1 configuration. If this was not the case, the value will always be 0.

Version number

This is the IMC0x-PLC version number. On IMC0x-PLC startup the current version number is written to the shared memory as a 16-bit word:

Version number	Meaning (Version)
0104H	V1.4
0200H	V2.0

Communication flag

During DB 1 configuration, a start index/end index is set up to identify an area from FB 0 to FB 255 as communication flag input and output. In the same way, the communication flags are mapped in shared memory (within the communication flag area in shared memory).

The following data areas are copied from the internal data areas to shared memory at the end of a PLC cycle:

- process image of inputs (PII)
- Process image of outputs (PIQ)
- Counter
- Timers

Note:
Although the IMC0x-PLC updates the contents of shared memory, it does so always only at the request of the other task (see "Access Control" below).

12.3 Access Control

There are two mechanisms for regulating access to shared memory:

- Reading/writing the acknowledgement byte
- Setting/resetting the RMOS event flag (ACCESS bit)

12.3.1 Access Control Using the Status and Acknowledgement Bytes

Here access to shared memory is a handshake process synchronized by means of the status byte and acknowledgement byte:

- The IMC0x-PLC copies the RUN/STOP status to the status byte. Following an operating mode transition from STOP to RUN, the communication input flags are read from shared memory and after the first PLC cycle the PLC data are written to shared memory. (If communication input flags are defined, these must already have been set in STOP mode by another task.) The acknowledgement byte is then reset from 1 to 0 thus enabling the other task to access shared memory.
- Another task can now read data from the shared memory and, if necessary write new data to the communication input flags. Afterwards the task must set the acknowledgement byte from 0 to 1. The IMC0x-PLC will not access shared memory until the task has set the acknowledgement byte.
- The IMC0x-PLC updates the data in shared memory after each PLC cycle, but only if the acknowledgement byte was previously set to 1.
- During an operating mode transition from RUN to STOP, the IMC0x-PLC resets the acknowledgement byte, thus enabling the other task to access shared memory.

Another task can access shared memory after each PLC cycle. The task can select any time frame by means of the acknowledgement mechanism. The task must ensure, by cyclically setting the acknowledgement byte, that data in the shared memory are updated by the IMC0x-PLC. A task access is only allowed once the IMC0x-PLC has reset the acknowledgement byte.

12.3.2 Access Control Using the RMOS Event Flag

If the shared memory is being used as local memory for data exchange with another RMOS task, access can be synchronized either via the acknowledgement byte or via the ACCESS bit in the event flag group.

The access mechanism is the same as that using the status and acknowledgement byte, except that the value of the ACCESS bit is reversed.

The ACCESS bit is Bit 4 of the event flag group. The flag group ID is passed at IMC0x-PLC start (Chapter 11.2 explains the contents of the event flag group).

13 PROFIBUS-DP Link (Only with IMC05)

13.1 Access to Decentral Inputs/Outputs

The PROFIBUS-DP connection consists of the PROFIBUS-DP driver (RMOS driver) and the DP interface (procedural interface). The logical assignment of the inputs/outputs (IB, QB and PB) to the decentral I/O stations is performed with the DP data base which is created with the COM PROFIBUS configuration tool. The following calls are used by the DP interface for data communication with the decentral I/O stations.

`Com05DPStart()`	Set up a DP entity
`dpn_init()`	Register a DP application
`dpn_read_cfg()`	Determine the configuration of the DP system
`dpn_in_slv()`	Read the input data of one DP slave
`dpn_in_slv_m()`	Read the input data of several DP slaves
`dpn_out_slv()`	Send output data to one DP slave
`dpn_out_slv_m()`	Send output data to several DP slaves
`dpn_slv_diag()`	Request diagnostic data of a slave

The process image is updated with `dpn_in_slv_m()` and `dpn_out_slv_m()`. The I/O bytes are addressed with `dpn_in_slv()` and `dpn_out_slv()`. The number of stations, the address assignment, and the number of decentral I/O bytes per station are determined with `dpn_read_cfg()` and direct access to the DP data base via CRUN. If the IMC0x-PLC goes into STOP status, DP communication remains activated. The IMC0x-PLC supports up to 16 activated DP stations of the 126 maximum possible DP stations of the DP bus system (calls `dpn_in_slv_m()` and `dpn_out_slv_m()` only permit 16 DP stations). Up to 32 bytes are supported per DP station.

The DP connection can be used to simultaneously read or write-access only all outputs/inputs of one station. When direct I/O accesses are used (T PB / L PB), a read/write job must be triggered for all I/O bytes of the applicable station. The I/O bytes written last are stored locally. The initialization values for the outputs are set to zero in accordance with SINEC L2 (IM 308). When writing an I/O byte, this can be used to write all output channels of a station without reading the station.

Accesses to the decentral I/O bytes are performed by the IMC0x-PLC with `dpn_in_slv()` and `dpn_out_slv()` calls. However, these calls may only be executed at the task level.

The time blocks are always executed at the task level regardless of the PROFIBUS-DP interface. In principle, access to I/O bytes in the time blocks is possible.

The PROFIBUS-DP interface requires that the execution time for an access to an I/O byte/I/O word is approximately 300 to 400 µsec. Since the DP interface is implemented as a driver, it ensures that only one job is processed although several DP requests have been made by different tasks.

13.2 PROFIBUS-DP Diagnostic Functions

13.2.1 Diagnostics while Read/Write Accessing the Process Image

While the process image is being **read** during the PLC cycle, accessibility of all decentral stations configured in the DP data base is checked with the `dpn_in_slv_m()` call. If an error occurs, the error code from `dpn_in_slv_m()` is stored in system data word SD 124 (EAF8H). Since the IMC0x-PLC evaluates the data base and thus only addresses stations which are also configured in the data base, `dpn_in_slv_m` is always concluded with no errors. `slv_state` of all stations can be evaluated to determine whether all configured stations are actually connected. The read/write-access of the process image is only correct when the current operating status of DP slave `slv_state` of all stations indicates that these are in the data transfer phase. Thus all `slv_state` are evaluated when the process image is read.

If a DP slave indicates with `slv_state` that it is not in the data transfer phase, SD 124 is set to "STATION_ERROR" (value 0x01). The incorrect station number can be read from system data word SD 125 (EAFAH). The first incorrect `slv_state` of a station is stored in system data word SD 126 (EAFCH).

Table 13. 1 Information in `slv_state` of `dpn_in_slv_m()`

Literal	Value	Meaning
DPN_SLV_STAT_OFFLINE	0x00	Slave not in the data transfer phase (startup)
DPN_SLV_STAT_NOT_ACTIVE	0x01	Slave not activated in the data base
DPN_SLV_STAT_READY	0x02	Slave in the data transfer phase
DPN_SLV_STAT_READY_DIAG	0x03	Slave in the data transfer phase. Diagnostic data are available.
DPN_SLV_STAT_NOT_READY	0x04	Slave not in the data transfer phase
DPN_SLV_STAT_NOT_READY_DIAG	0x05	Slave not in the data transfer phase. Diagnostic data are available.

When the process image is **written**, a check is only made to determine whether an error code occurred during the `dpn_out_slv_m()` call. If so, the error code is stored in SD 124. SD 125 and SD 126 have no meaning.

The startup phase of the IMC0x-PLC (call `x_plc_init`) is always concluded without errors regardless of whether the stations could be addressed. Whether the IMC0x-PLC switches to the RUN state depends on the QVZ setting in the DP data base. The QVZ setting is set for each station separately in the DP data base. As already mentioned above, the prerequisite for transition to the RUN state is that all configured stations are actually present (i.e., no error has occurred for `dpn_in_slv_m()` or `dpn_out_slv_m()`). If a DP slave has the setting 'QVZ = J' in the DP data base, a switch to RUN status is not made when one of the above described errors occurs. If all DP slaves have the setting 'QVZ = N' a switch to RUN status is made.

An error during DP communication while the IMC0x-PLC is in RUN status is indicated by a value other than 0 in system data word SD 124. With the setting 'QVZ = J' the IMC0x-PLC goes into STOP status when an error occurs. With the setting 'QVZ = N' system data word SD 124 should be evaluated by the user program so that an error can be determined.

Note:
These data words are only deleted when an operating mode change from STOP to RUN occurs.

13.2.2 Diagnosis While Reading/Writing I/O Bytes

The same error evaluation is used for reading/writing the I/O bytes as for reading/writing the process image.

Depending on the QVZ setting, a switch to STOP status is made when an error occurs.

13.2.3 HLL Block for the Diagnostic Function

By calling an HLL block (FB 208) included with the IMC0x-PLC, diagnostic data can be obtained with the controller program (STEP 5 program).

By calling HLL block FB 208, the station diagnosis can be requested in the controller program for a certain station with the call `dpn_slv_diag()`. The station number and the desired number of diagnostic bytes are transferred as parameters in two consecutive flag words and the first flag byte of several consecutive flag bytes (usually 3 to 16 flag words) for the storage of the diagnostic data. The return status, `slv_state` and the number of diagnostic bytes available are stored with the `dpn_slv_diag()` call in three additional consecutive flag words. The layout of the consecutive flag words (usually 3 to 16 flag words) with the diagnostic data depends on the station type and is specified in /DPPROG/. The diagnostic data are only available for a station when "provide diagnostic data" is configured in the DP data base. Diagnostic data for standard slaves and non-standard slaves (ET200U and ET200B) are supported. The IMC05-DP converts diagnostic data from non-standard slaves in accordance with conventions. The length of the diagnostic data is typically in the range of 6 to 32 bytes. The maximum length is 244 bytes.

Note:
The HLL block for diagnostics only stores the diagnostic data in the flag words. The IMC05-DP is responsible for correct provision of the data.

Sample call for FB 208 (HLL block for diagnosis):

```
       L       124         Error for DP connection ?
       L       KH 0000     AKKU1= 0
       !=F                 Equal ?
       JZ =    M1          No error
       L       125         Load station number
       T       FW 10       Load station number in flag word 10
       L       KH 0032     AKKU1= 32
       T       FW 12       Load number of diagnostic bytes in FW 12
Name   :       PLCL2DP
       JU      FB 208
STNR   :       FW 10       Station number in flag word 10
DIAG   :       FB 20       Diagnostic data in FY 20 to FY 51
STS    :       FW 52       Status of diagnostic block in FW 52, 54
                           Number of valid diag. bytes in FW 56
       L       FW 52       Load return status
       L       KH 0000     AKKU1= 0
       ><F                 Unequal ?
       JZ =    M2          Error: Wrong station address
       L       FW 54       Load slv_state
       L       KH 003      AKKU1= "data and diagnostic data valid"
       !=F                 Equal ?
       JZ =    M33         Diagnostic data available
```

```
       L       KH 005     AKKU1= "only diagnostic data valid"
       ><F                Unequal ?
       JZ =    M3         No diagnostic data available

M33:                       Diagnostic data available
       L       FW 20      Load diagnostic data
       ...
M3:                        No diagnostic data available
       ...
M2:                        Wrong station address
       ...
M1:                        No error for SINEC DP connection
       ...
```

FB 208 is contained in the included example (HLLCODE.C) for the HLL blocks. The diagnostic data of a station are requested by the HLL block with `dpn_slv_diag()`.

On the PG, the 'Status Variable' and 'Force Outputs' functions can be used to access the decentral input/output stations. If an error occurs during these accesses, the error information is stored in the system data starting at SD 124 (starting at EAF8) where they can be read with the PG.

13.3 DP Configuration for IMC0x-PLC

13.3.1 Allocation of the Digital Inputs/Outputs (DB 1 Configuration)

Allocation of the decentral inputs/outputs to the logical I/O operands is not stored in the DB 1, but in the DP data base (e.g., NONAME.2BF). This data base is created with the COM PROFIBUS configuration tool. It describes the configuration of the DP bus system. The decentral I/O must be addressed linearly (i.e., no page frame addressing). In the following, the name NONAME.2BF is used as the file name for the DP data base. The name is specified with the configuration tool. During the startup phase of the IMC0x-PLC (call `x_plc_init`), the address allocation of the local I/O is set up first and then the decentral I/O. If an I/O byte is configured as both local and decentral, configuration is aborted with the error E_PLC_DUP_IO for `x_pic_init`.

The local I/O bytes must start at address 0, and the decentral I/O bytes must be located after the local I/O bytes. Similarly, the local input/output bytes should start at address 0, and the decentral input/output bytes should be located after the local input/output bytes. Blank entries between the local and decentral I/O bytes are ignored.

13.3.2 Constants for Error Identifiers

Literal	Value	Meaning
DPN_NO_ERROR	0x00	No error
DPN_ACCESS_ERROR	0x80	An attempt was made to transfer more than one signaling job for a handle.
DPN_APPL_LIMIT_ERROR	0x81	The maximum permissible number of DP applications was exceeded. Up to 32 DP applications are permitted per unit of the DP driver.

DPN_LENGTH_ERROR	0x84	Structure element `.length` of the structure `dpn_interface` is outside the permissible value range. The data length does not match the configured values.
DPN_MODE_ERROR	0x87	The function call cannot be processed in the current operating mode, or a state was skipped while changing the operating mode.
DPN_NO_DBASE_ERROR	0x88	No entries or incorrect entries in the DP data base
DPN_REFERENCE_ERROR	0x8B	The structure element `.reference` of the structure `dpn_interface` is invalid.
DPN_SLV_STATE_ERROR	0x8E	The structure element `.slv_state` of the structure `dpn_interface` is invalid.
DPN_STAT_NR_ERROR	0x8F	The structure element `.stat_nr` of the structure `dpn_interface` is invalid (e.g., DP slave not configured in the DP data base).
DPN_WRONG_BOARD_ERROR	0x91	The structure element `.reference.board` of the structure `dpn_interface` is invalid.
DPN_SYS_STATE_ERROR	0x92	The structure element `.sys_state` of the structure `dpn_interface` is invalid.
DPN_GLB_CTRL_ERROR	0x93	Invalid value range for control command for call of the `dpn_global_crtl()` function.
DPN_BOARD_ERROR	0x94	Hardware error

The following constants have only been defined to ensure source code compatibility with the DP programming interface of the CP5412(A2) product. These error identifiers do not occur with the DP driver.

DPN_CENTRAL_ERROR
DPN_CLOSE_ERROR
DPN_MEM_BOARD_ERROR
DPN_MEM_HOST_ERROR
DPN_OPEN_ERROR
DPN_RECEIVE_ERROR
DPN_REFERENCE_DIFF_ERROR
DPN_SEND_ERROR
DPN_USER_DATA_ERROR
DPN_WD_EXPIRED_ERROR

14 RMOS and PLC Configuration

The distribution package contains the standard RMOS configuration files for generating the IMC0x-PLC. The IMC0x-PLC makes no special demands on the RMOS configuration. All the required system resources, except the AS511 driver for communication with the PG, are dynamically requested during the IMC0x-PLC start. The IMC0x-PLC parameters are passed with the IMC0x-PLC start call, independent of the RMOS configuration. The IMC0x-PLC memory areas are either requested dynamically from the HEAP as required, or they are allocated directly via physical addresses. The IMC0x-PLC returns an error status, if there is not enough free memory in the HEAP. RMOS clock time must be set to either 1, 2, 5, or 10 msec, so that the IMC0x-PLC's 10 msec clock time can be derived from it.

If you are adapting an existing RMOS configuration to include the IMC0x-PLC, you should pay special attention to the following:

- Start call `x_plc_start`/`x_plc_init` in the initialization task
- AS511 driver for PG communication
- Adequate HEAP size for dynamically requested memory areas
- RMOS clock time (1, 2, 5 or 10 msec)
- RMOS SVCs
- File management system (FISY, optional)

Notes:
The interrupt for RMOS clock time must have a higher hardware-based priority than `priority_2` + 8.

14.1 Directory Entries

The call `x_plc_start`/`x_plc_init` generates and catalogs a number of tasks. Each of these tasks is assigned a priority via parameters `priority_1` and `priority_2`. The memory area required for a stack size per task of approx. 2 kbytes is taken from the HEAP.

Task type	Name	Priority
PLC cycle task	PLC_EXE_CYCL	`priority_1`
Communication task	PLC_COM_PG	`priority_1` + 1
Overall reset task	PLC_CLEARALL	`priority_1` – 1
PLC timer task OB 10	PLC_TIM_OB10	`priority_2`
PLC timer task OB 11	PLC_TIM_OB11	`priority_2` + 1
PLC timer task OB 12	PLC_TIM_OB12	`priority_2` + 2
PLC timer task OB 13	PLC_TIM_OB13	`priority_2` + 3
PLC ERROR_OB task	PLC_ERROR_OB	`priority_2` + 4
Reserved	PLC_INT_OB2	`priority_2` + 8
Reserved	PLC_INT_OB3	`priority_2` + 7
Reserved	PLC_INT_OB4	`priority_2` + 6
Reserved	PLC_INT_OB5	`priority_2` + 5
PG driver	PLC_AS511	-
Loader Result Segment	PLC_LRS_XXXX	-

Note:
The driver (AS511) for communication with the PG catalogs itself during RMOS startup.

The loader result segment of HLL blocks is not cataloged.

14.2 IMC0x-PLC Configuration and Generation Files

The following subdirectories contain the configuration files for generating the IMC0x-PLC.

- SYSIMC5\PLCIMC5 and SYSIMC5\PLCIMC5\SRC for IMC05
- SYSIMC1\PLCIMC1 and SYSIMC1\PLCIMC1\SRC for IMC01

Table 14. 1 Configuration files for generating IMC0x-PLC

File name	Meaning
RMCONF.C	RMOS configuration file (contains the initialization task)
GENSYSC5.BAT or GENDP.BAT	Batch files for system generation with CADUL for IMC05 (with or without PROFIBUS-DP connection)
GENSYSC1.BAT	Batch file for system generation with CADUL for IMC01
RM3PC15.BLD	Builder file
SWCPLC.C	IMC0x-PLC - configuration file (see chapter 10.3.1)

14.3 Configuring and Generating IMC0x-PLC

The IMC0x-PLC is configured in the SWCPLC.C file. Blocks `[plc_sw]` and `[plc_hw]` must be configured there in function `x_plc_init` as described in chapter 10.

Assignment of the serial interfaces for IMC05

Interface	Allocation
RS232-1	RMOS-BYTE driver with 19200 baud
RS232-2	AS511 communication driver of the IMC0x-PLC with 9600 baud

Assignment of the serial interfaces for IMC01

Interface	Allocation
COM1 (RS 232)	AS511 communication driver of the IMC0x-PLC with 9600 baud
COM2 (RS 485)	RMOS-BYTE driver with 19200 baud Since the interface only provides semi-duplex mode on the hardware side, only `printf` outputs can be made here.

The following batch files are available for generating an RMOS system with IMC0x-PLC.

For IMC05 in directory SYSIMC5\PLCIMC5

- GENSYSC5.BAT: Generates a system **without** DP connection
- GENDP.BAT: Generates a system **with** PROFIBUS-DP connection

For IMC01 in directory SYSIMC1\PLCIMC1

- GENSYSC1.BAT: Generates a system

These batch files are called as follows without parameters. They generate the RM3_PC15.SYS system file in the same directory.

The system file is transferred to the IMC05 or IMC01 with batch file FLASHPLC.BAT or FLASHDP.BAT (only IMC05), or with the IMC05/IMC01 service programs.

The batch file FLASHPLC.BAT is called without parameters. FLASHDP.BAT can be called with the following parameters.

Parameter	Transferred Components
ALL	All components (RMOS3, any existing HLL blocks, user program, MC5 program and DP data base). If no parameter is specified, this setting is used.
MC5	Only MC5 program
DB	Only DP data base

15 Compatibility to SIMATIC S5-115U

This is an overview of the functions which differ from the SIMATIC S5-115U controller.

15.1 Commands

The following commands are implemented in the IMC0x-PLC additionally.

- xF (multiplication)
- :F (division)

The following commands are not, or not fully, S5-compatible:

- The command BI (process block parameters indirectly) is not implemented.
  (An actual operand is interpreted as MC5 code in a BI command.)
- For the commands LIR, TIR, TNB (data transfer with indirect addressing), the address area is restricted and an access to the peripheral boards is not possible.
- The commands LDI, TDI (access to the second memory bank, MC5 memory) is not implemented.
- The processing operations (DO FW, DO DW) may not be immediately followed by any of the following operations.
  TNB, JU =, JC =, JZ =, JN =, JP =, JO =
- SU command - set bit
  (With the SIMATIC S5-115U, the timer can be started by SU T7.15. With the IMC0x-PLC, although this command will cause the relevant bit to be set, it will not start the timer.)
- Jumps into sequences of logical instructions are not permitted.

15.2 Execution Times

Execution times for the different commands are specified in the operation list (see Reference Manual).

15.3 Program Memory

Under the IMC0x-PLC, the following memory areas are available for user programs:

- 4 Kbytes to 32 Kbytes for data blocks (DB memory)
- 0 Kbytes to 48 Kbytes for program blocks (MC5 memory)

15.4 Data Blocks DB 0/DB 1

The data block DB 0 (address list) is not supported by the IMC0x-PLC. The data block DB 1 is reserved for initialization functions and has a special format compared with SIMATIC S5-115U (see chapter 9).

15.5 Special Organization Blocks

An operating mode transition from RUN to STOP executes STOP OB (OB 28), if this has been programmed.

15.6 Display of Results

The result displays do not conform completely to S5:

Display byte

CC 1	CC 0	OV	Free	OR	STATUS	RLO	ERAB/

ERAB/ Initial request is not displayed.

STATUS the value of the last binary operand is not supported by the IMC0x-PLC. It can, however, usually be deduced from other values (RLO).

OR Internal display for "AND before OR operation" is not displayed.

15.7 ISTACK Display

The following control bits or interrupt displays have no significance under the IMC0x-PLC:

Control bits:

NEUSTA, BATPUF, LADFNI, SYNFEH, NINEU, PROEND, MAFEHL, UAFEHL, NAUAS, QUITT, SPABBR, PBSSCH, PADRFE, ASPLUE, RAMAFE, SUMF

Interrupt displays:

NNN, FEST, NAU, QVZ, KOLIF, SYSFE PEU, BAU, ASPFA, STATUS, ERAB, URLAD

(see chapter 5.7.3).

15.8 BASP

The signal BASP ("Block command output") is not supported by the IMC0x-PLC. The output bytes in the extended peripheral area become inactive at an operating mode transition from RUN to STOP, during process control or as a result of a runtime error.

15.9 STATUS Block

The IMC0x-PLC does not support status processing with specification of a block list (nesting); on the PG status processing may only be called without nesting. Status processing with nesting means that the program status is displayed only if the block was called in a prescribed sequence (e.g., OB 1 → FB 11 → FB 20).

15.10 Alarm Blocks

If processing of an alarm block takes longer than the set time interval, an alarm error is reported in the error status word EAD0 and the IMC0x-PLC switches to STOP mode. Processing of an alarm block can be interrupted by an alarm with higher priority.

15.11 Integrated Function Blocks

The integrated function blocks of the SIMATIC S5-115U CPU 944 are not included in the IMC0x-PLC.

15.12 Standard Function Blocks

The standard function blocks for the SIMATIC S5-115U have not been tested for the IMC0x-PLC, to some extent they are not executable. (The GRAPH 5 function blocks are not executable.)

15.13 Clock Functions

The CPU 943/CPU 944 clock functions are not supported.

15.14 Time Behavior on Loading Blocks in RUN Mode

When program blocks (OBs, PB, SBs, FBs) are loaded with the PG, the blocks must be compiled. When the IMC0x-PLC is in RUN mode, the compiler run is fitted in between two PLC cycles, i.e., the start of the next PLC cycle is delayed by the time taken for the compiler run. There is thus no guarantee of loading blocks without stalling.

It takes approximately 75 msec to compile a block 1024 words long.

15.15 Step/Transition Programming with GRAPH 5

Step/transition programming with GRAPH 5 is not supported because GRAPH 5 function blocks are not executable under the IMC0x-PLC.

15.16 Alarm Blocks

Alarm blocks are not available with IMC0x-PLC.

A List of Abbreviations

Abbreviation	Meaning
ACCUM 1	Accumulator 1
ACCUM 2	Accumulator 2
ASCII	American Standard Code for Information Interchange
BARB	Program check (PG function ISTACK)
BARBEND	Request for end (PG function ISTACK)
BEF-REG	Instruction register (ISTACK)
BF	Byte constant (fixed-point number –128 ... +127)
BSTACK	Block stack
BST-STP	Block stack pointer (ISTACK)
C	Counter (0 ... 127, for bit test and set operations 0.0 ... 127.15)
CC 0	Condition code 0
CC 1	Condition code 1
CPU	Central processing unit
CSF	Control system flowchart display mode
D	Data bit (0.0 ... 255.15)
DB	Data block (1 ... 255)
DB-ADR	Data block address (ISTACK)
DL	Left byte of data word (0 ... 255)
DR	Right byte of data word (0 ... 255)
DW	Data word (0 ... 255)
F	Flag
FB	Function block (0 ... 255)
FW	Flag word (0 ... 254)
FY	Flag byte
HLL	High level language
I	Input (0.0 ... 127.7)
IB	Input byte (0 ... 127)
IMC	Industrial Micro Computers
ISTACK	STEP 5 interrupt stack
IW	Input word (0 ... 126)
KB	Constant (1 byte 0 ... 255)
KC	Constant (counter 0 ... 999)
KE1 ... KE6	Nesting stack entry 1 ... 6 (ISTACK)

KF	Constant (fixed-point number -32768 ... +32767)
KH	Constant (hexadecimal 0 ... FFFF)
KM	Constant (arbitrary 16-bit pattern)
KS	Constant (2 arbitrary alphanumeric characters)
KT	Constant (time value 0.0 ... 999.3)
KY	Constant (2 bytes 0 ... 255 per byte)
LAD	Ladder display mode
MC5 code	S5 machine code, control code
MC5	S5 machine code
MMIO	Memory Mapped Input / Output
NAU	Power failure (ISTACK)
NEUSTA	Restart (ISTACK)
NR	Block number (OB, PB, SB, FB, DB ISTACK)
OB	Organization block (1 ... 255)
OP-Code	Operation code
OV	Overflow (set, for example, after number range overrun in arithmetic operations
PB	Program block (0 ... 255)
PG	Programmer
PII	Process image of inputs
PIQ	Process image of outputs
PLC	Programmable Logic Controller
PLC cycle	PLC operating mode, read in - process - read out
PW	Peripheral word (0 ... 254)
PY or PB	Peripheral byte (PG-dependent name 0 ... 255)
Q	Output (0.0 ... 127.7)
QB	Output byte (0 ... 127)
QB	Peripheral byte in the Q-area (0 ... 255)
QVZ	Acknowledgment delay
QW	Output word (0 ... 126)
QW	Peripheral word in the Q-area (0 ... 254)
REL-SAC	Relative STEP 5 address counter
RLO	Result of logic operation
SAC	STEP 5 address counter
SB	Sequence block (0 ... 255)
SD	System data area (for load and transfer operations 0 ... 255, for bit test and set operations 0.0 ... 255.15)
STL	Statement list display mode

STOANZ	Stop display (ISTACK)
STOZUS	Stop display (ISTACK)
STUEB	Stack overflow (runtime error)
SUF	Substitution error (runtime error)
SVC	Supervisor call - RMOS system call
T	Timer (0 ... 127, for bit test and set operations 0.0 ... 127.15)
TRAF	Transfer error (runtime error)
ZYK	Scan time overrun (ISTACK)

B Software Notations

In this documentation the following notational conventions are used:

Commands

Commands are used to control the program execution in interactive or batch mode. In this text, commands are printed in `Courier` [1] font. A command consists of at least one element.		
Elements are constants or variables. They are composed of letters, digits and special characters (e.g., * ? .).		
`UPPER CASE`	Constant	Upper case elements are constants. They must be entered as shown, but upper or lower case letters can be used.
`1847`	Constants	Numbers are always constants.
`X`	Variables	Lower case elements are variables which must be replaced by actual values.
`( ) \ : ; >`	Special characters	Special characters and blanks are used as delimiters to separate one element from the next and must be entered.
Meta characters specify the use of elements characters within commands. Meta characters are not entered.		
Representation	Function	Explanation
`< >`	Delimiters	Variables are enclosed by pointed brackets.
`[ ]`	Optional	Elements in square brackets are optional.
⌈a⌉ a|b|c {b} ⌊c⌋	Selection	One element must be selected from elements which are enclosed by braces or separated by vertical lines.
`...`	Repetition	Ellipses indicate an optional repetition of the previous element.

1) Program listings are also printed in Courier font. Listings are case sensitive and do not follow the general notational rules for commands. The programming language, C for instance, differentiates between upper case and lower case letters.

Data Types

Data type	Length at RMOS3
char	8 bits
BYTE, char	8 bits
short	16 bits
WORD, short	16 bits
int	32 bits
WORD, int	32 bits
long	32 bits
DWORD, long	32 bits
word32	32 bits
pointer far	48 bits
pointer near	32 bits
enum	32 bits
float	32 bits
double	64 bits

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