

S I M A D Y N D

User's Guide

Diagnose

System software

Interface operation system

version: 900601.300

date: 15.10.90

SIEMENS AG ASI SWE

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## 1 Overview

This document has four main objectives:

- to classify and define terms of the SIMADYN D operating system,
- to outline its basic functions,
- to summarize its performance data and
- to describe the operating system interfaces.

The tasks of an operating system are generally defined as follows:

"The operating system is the sum of those programs which form part of the computer system and which are required to operate the system and execute the user programs" /1/.

It enables the user programs to employ hardware functions in user-friendly form as shown in the layer model of Fig.1.

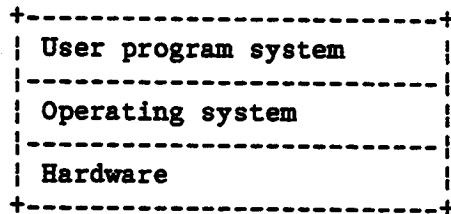


Fig.1 Layer architecture

Operating systems are available which run in the following modes:

- Batch
- Interactive
- Real-time.

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| V 900601.300<br>751040.txt<br>15.10.90 | 1 Overview |
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A real-time operating system is "a system in which the computer must respond to an operator communication in the shortest possible time" /1/.

An operating system of this type permits real-time processing. This is an "operating system in which the programs must be in a permanent state of readiness to process incoming data to the extent that results of processing are available within the specified time. Depending on application, the data may be accumulated randomly or at predefined times" /1/.

SIMADYN D is used for digital control applications and these require a real-time operating system capable of responding at very high speed. The response time is derived from the basic sampling time, which is determined by the cyclic interrupts of a timer.

The basic sampling time can be set on the timer and may not be less than 1 ms.

|                                        |         |
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| V 900601.300<br>751040.txt<br>15.10.90 | 2 Tasks |
|----------------------------------------|---------|

## 2 Tasks

The components of an operating system can be divided into two basic categories:

Open-loop control programs    Used to run the user program system on the hardware

Working programs                For generating and maintaining the user program system.

The tasks for both categories are listed below.

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|              |                |
|--------------|----------------|
| V 900601.300 | 2 Tasks        |
| 751040.txt   | 2.1 Components |
| 15.10.90     |                |

## 2.1 Components

### Open-loop control programs

SIMADYN D

|                       |                                           |                                  |
|-----------------------|-------------------------------------------|----------------------------------|
| Process coordination: | Task management                           |                                  |
|                       | Cyclic interrupts                         | *Task manager for T1..T5         |
|                       | Acyclic interrupts                        | *Task manager for I1..I5         |
| Memory management:    | In segments and with permanent assignment | *Initialisation/memory division  |
| I/O control:          | Transfer from and to user programs        | Communications                   |
|                       | Drivers                                   |                                  |
| Data management:      | Internal                                  | *Task manager/<br>*Buffer system |

The tasks marked with '\*' form a component of the operating system nucleus of SIMADYN D.

### Working programs

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|            |                             |             |
|------------|-----------------------------|-------------|
| Utilities: | Console routine             | Monitor     |
|            | Test and exception handling | Diagnostics |
|            | Basic system functions      |             |

Standard functions: Standard function blocks

Further utilities (editors, compilers, linkers) are required to generate the user program, e.g. using the STRUC language or for generating user function blocks.

|                                        |                         |
|----------------------------------------|-------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 2 Tasks<br>2.2 Hardware |
|----------------------------------------|-------------------------|

## 2.2 Hardware

The tasks listed in section 2.1 are implemented on different hardware units:

1. Open-loop control programs      Target hardware: Processor module  
   Monitor and utilities            Operating system: SIMADYN D
2. User program                      Target hardware: Processor module  
   with function blocks            Operating system: SIMADYN D  
                                      For development, see sec. 2.3
3. Utilities for making              Target hardware: Programmer, PC  
   the user program                Operating system: CP/M, MS-DOS

The development environment for the components of the system software itself is according to object:

- Objects acc.to 1.                    Host:                    Intel SME Series III/IV  
                                      Operating system: ISIS NDX
- Objects acc.to 3.                    Host:                    Programmer  
                                      Operating system: CP/M

## 2.3 Development of user program

After the user has generated his user program on the programmer using STRUC, he links and locates it together with the system software and produces the EPROMS required for the target hardware. For this purpose, the entire system software of the target hardware is available on the programmer.

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| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system |
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### 3 SIMADYN D operating system

The operating system includes the following components:

- Task manager for  
cyclic and interrupt-driven processing
- Hardware and software initialisation
- Memory management (buffer management)
- Operating system data and lists
- Interface to the central AMC lists
- Link to other components (system interfaces)

The operating system is capable of both multiprocessing and multitasking modes.

|                                        |                              |
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| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system |
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The basic functions of the operating system are embedded in the total system which at the same time illustrates the main interfaces to the environment.

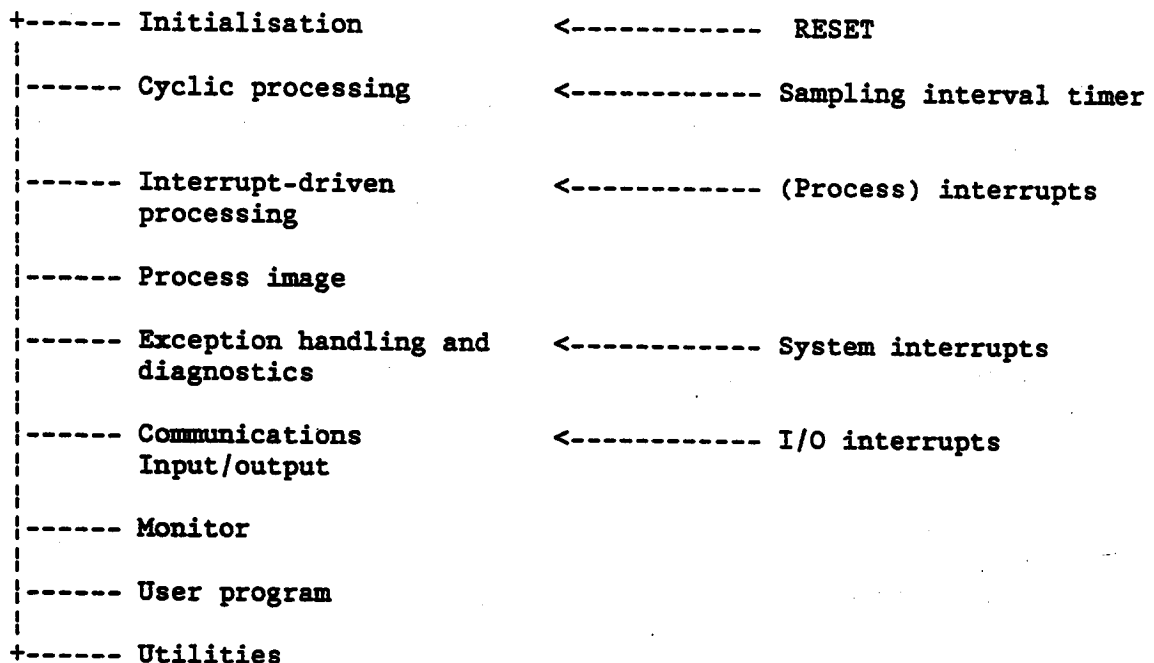


Fig. 2

### 3.1 Multiprocessing mode

The SIMADYN D hardware features the option of using several processors for one application system (multiprocessing mode). Each processor module features, in this case, both system and user software.

The operating system software is largely identical on each processor module. During normal operation, the processor modules communicate with each other only using the data areas of the C and L bus communication memory. During initialisation and exception handling, the C or L bus interrupts are also used for coordination.

The processor modules do not behave symmetrically; in addition to having different hardware characteristics, the first processor module of a bus section is assigned the bus master function during initialisation and is responsible for coordinated execution.

|                                        |                                                                        |
|----------------------------------------|------------------------------------------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.2 Multitasking mode and task manager |
|----------------------------------------|------------------------------------------------------------------------|

### 3.2 Multitasking mode and task manager

The task manager coordinates execution of tasks by the processor in accordance with their priority. Several tasks are managed, which have different priorities due to the existence of different sampling times as the result of cyclic processing or following interrupts during interrupt processing.

### 3.3 Initialisation

Initialisation begins by switching on the power supply or activating the RESET button and the associated Reset pulse. It is the job of initialisation to prepare the hardware and software for normal operation. It consists of the following main functions:

- Delete memory areas (RAM, C and L bus communication memory)
- Initialise interrupt vectors
- Initialisation of the hardware and peripherals using initialisation blocks (IBs)
- Program timer
- Divide RAM for Stack
  - Components of the user program (function packages)
  - Buffer system
- Divide C and L bus communication memory for
  - System data and lists
  - Buffer system
- Copy data from EPROM to RAM
- Transfer corrections from EEPROM to RAM
- Initialise memory areas (RAM, C and L bus communication memory), the same for counters, addresses, lists, control data
- Check configured sampling times
- Perform validity check of the planned data from the EPROM
- Start initialisation of the user program using initialisation mode of the function blocks for cyclic and interrupt-driven tasks
- Call initialisation for communication mode
- Check result of initialisation
  - if error occurs: output message
  - if no error occurs:
    - set enable identifiers for the total system
    - enable interrupts
- Call background tasks for selfmonitoring and diagnostics

|                                        |                                                       |
|----------------------------------------|-------------------------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.4 Cyclic processing |
|----------------------------------------|-------------------------------------------------------|

### 3.4 Cyclic processing

The task manager performs cyclic processing of the tasks. The sampling times for the tasks are based on a power of 2 ratio according to

$$T(i) = T(0) * (2^{**} j)$$

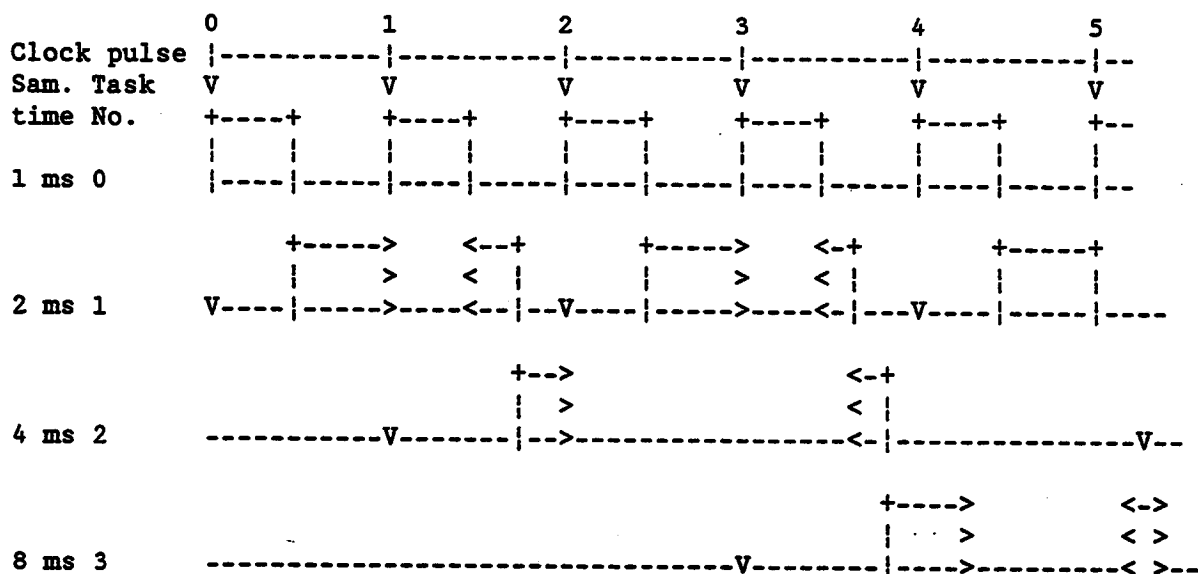
with  $T(0)$  as basic sampling time,  
 $j$  defines the value of the sampling time  
 with  
 $0 \leq j < 16$   
 $i$  numbers the sampling times with  
 $0 \leq i < 5$ .

With a basic sampling time of 1 ms, for example, the sampling times may be 1 ms, 2 ms, 8 ms, 32 ms, and 128 ms. The basic sampling time is defined for each processor on configuring the master program using STRUC. Similarly, the sampling times for the tasks in the master program executing on each individual processor are configured in the mask for the processor module. In order to avoid accumulative points, the tasks are started out of phase with the basic clock, i.e. the basic clock is always used to mark the start of a second lower-priority task. As a result of the discrete division of the sampling times based on the power of 2 ratio, full allowance is made for lower-priority tasks so that never more than one low-priority sampling time coincides with the basic clock.

Task priority decreases with increasing sampling time.

The task manager is started with the basic sampling time clock pulse of the sampling timer. The sampling time is calculated and thus at the same time the second lower-priority task assigned to the basic clock. If the task to be started has a lower priority than the interrupted task, its start is buffered and the interrupted task is continued. Otherwise, the calculated task is started. The status of the interrupted task is defined in a task-specific data area, which permits processing to continue almost without problems provided no task of higher priority is pending.

|                                        |                                                       |
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| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.4 Cyclic processing |
|----------------------------------------|-------------------------------------------------------|



The priority of a task increases as the sampling time and/or rising task number decreases. The arrowhead "V" marks the start of a task with respect to the basic clock.

Interruption of a task is marked by ">" and its continuation by "<".

The time actually required by the operating system (according to section 4.4) is not shown in the diagram. If this were shown exactly, the actual start time of the task would be delayed by the respective time proportion.

Fig. 3 Interrupt structure

|                                        |                                                                 |
|----------------------------------------|-----------------------------------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.5 Interrupt-driven processing |
|----------------------------------------|-----------------------------------------------------------------|

### 3.5 Interrupt-driven processing

In addition to cyclic processing, the operating system also manages tasks which are started by acyclic interrupts, in particular process interrupts. The following interrupts are possible:

- Software interrupts
- CPU timer interrupts
- CIO port interrupts.
- L-\C-Bus interrupts

The priorities of the interrupts and of all the other remaining interrupts are set by the hardware structure. Using STRUC, the applications programmer configures the interrupts required for this application and their processing in interrupt-driven function packages.

### 3.6 Process image (system mode)

A check is made before task processing begins to determine whether an associated process image should be updated or not. If so, updating takes place before the start by calling the system mode of the function blocks. Updating concerns

- Binary inputs/outputs such as the status images for controller enables and the position of limit switches.
- Serial inputs/outputs, i.e. data which has been sent or received via a serial interface using the communications software and sent to the function blocks to coincide with updating of the process image, e.g. the setpoint transferred by a controller.
- Analog inputs/outputs such as values for temperature, speed, etc.

The system mode for both starting tasks is started before the normal mode adaption.

|                                        |                                                   |
|----------------------------------------|---------------------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.7 Data exchange |
|----------------------------------------|---------------------------------------------------|

### 3.7 Data exchange

Intertask communication is implemented by data areas using a buffer system in the

- Local RAM for exchange of data between tasks running on one processor
- C bus communication memory and
- L bus communication memory for data interchange between tasks running on different processors.

The buffer system is designed for cyclic processing involving one data source and N data sinks with N+2 buffers so that one free buffer is always available. The buffer system is managed by the operating system. This basically consists in keeping a free buffer available as write buffer and updating the read buffer for data sinks.

Interrupt processing is supported as follows:

A local buffer area is reserved on the local RAM and is used to exchange data between processor-local interrupt-driven tasks or with cyclic tasks.

Each coupling memory features a "fast" area, which is used for the direct interchange of data between interrupt-driven tasks running on different processors.

Data transport is carried out by special function blocks for data import and export.

A semaphore mechanism ensures data consistency, except in the case of the "Fast" connections.

|              |                              |
|--------------|------------------------------|
| V 900601.300 | 3 SIMADYN D operating system |
| 751040.txt   | 3.8 Monitor                  |
| 15.10.90     |                              |

### 3.8 Monitor

The monitor is the central console routine of the processor module. It is an instrument used for start-up, diagnostics and troubleshooting.

The monitor must be linked to a task with medium sampling time in order to ensure satisfactory response time. This sampling time is configurable and must be at least 32 ms.

Since the processing time of the monitor is not fixed, the task linked to it and the tasks of lower priority can be blocked. A time slice system has therefore been implemented which assigns a maximum of 5 % of the monitor sampling time to the monitor for processing.

The user interface is formed by the service device which are driven via the communications software.

Using the monitor, the user is able to access all of the processor modules of the system from an operator panel.

The intended use of a monitor on a processor module must be configured in the user program using STRUC.

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|--------------|------------------------------|
| V 900601.300 | 3 SIMADYN D operating system |
| 751040.txt   | 3.9 Communication            |
| 15.10.90     |                              |

### 3.9 Communication

The communication system performs all input/output transfers between the hardware and the associated software components and the user interfaces.

The interfaces and their assignments must be configured in the user program using STRUC.

The communication system forms its own independent processes which are controlled by input/output interrupts independently of the operating system.

The enforcement of configuration for the transfer canal has to be taken from the description of communication configuration.

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| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.10 Exception handling |
|----------------------------------------|---------------------------------------------------------|

### 3.10 Exception handling

SIMADYN D discerns between errors during initialisation respectively during normal operation.

Errors during initialisation normally mean that no start enable is issued for the system.

Errors during normal operation are of two types: one type enables operation to continue and the other requires that processing is aborted.

The system informs the user about its status, particularly of course about error statuses, using an LED display on the processor module.

In the event of an error, detailed information which is deposited in error data fields of the operating system enable an accurate analysis to be made of the error.

This data can be read and modified using the monitor, provided it is available, or using the hexamonitor.

The meanings of the error signals and information can be found in the manuals 'Error Handling PM general' /2/ and 'Error Handling PM Communication' /3/. The usage of the hexamonitor is explained in /2/.

|              |                              |
|--------------|------------------------------|
| V 900601.300 | 3 SIMADYN D operating system |
| 751040.txt   | 3.11 User program            |
| 15.10.90     |                              |

### 3.11 User program

The user program implements the technological tasks on the target hardware. It is generated on the programmer in the STRUC programming language with the support of the available utilities such as editor, STRUC compiler, linker/locator and EPROM driver.

As the user program is generated on the programmer, the link and locate procedure combines the user and system software for a processor to form a system which is then programmed in EPROMs for use on the target hardware.

The user program can be distributed amongst several processor modules, provided these are interlinked. An MS2 or an MS3 module must be loaded accordingly for each processor module. The distribution of the user program amongst the processor modules and the processor module links must be configured in the STRUC master program.

The STRUC source code of the user program is converted by the STRUC compiler to data structures for processing by the operating system on the target hardware.

### 3.12 Utilities

These are basic system functions for the operating system such as timer functions, functions for controlling the display on the processor module, special test routines and interrupt routines for handling system errors.

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|                                        |                                                            |
|----------------------------------------|------------------------------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 3 SIMADYN D operating system<br>3.13 Background processing |
|----------------------------------------|------------------------------------------------------------|

### 3.13 Background processing

If there are no tasks to be processed by the processor, the processor operates the background task.

Background tasks are:

- the hexamonitor used as a debugging aid
- the on-line test mode in which memory test routines are run.

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|              |                                 |
|--------------|---------------------------------|
| V 900601.300 | 4 Characteristics               |
| 751040.txt   | 4.1 Number of processor modules |
| 15.10.90     |                                 |

#### 4 Characteristics

Important characteristics and technical data of the operating system are listed below for the total system.

##### 4.1 Number of processor modules

Maximum number of processor modules  
in a subrack 8

A processor module requires two slots. The slots not occupied by processor modules can be occupied by I/O modules and communication memory modules.

##### 4.2 Sampling times

|                                           |    |
|-------------------------------------------|----|
| Number of function packages               | 11 |
| of which for permanent processing         | 8  |
| for system diagnostics (@SIMD)            | 1  |
| for communications                        | 2  |
| Number of configurable sampling intervals | 5  |
| Number of available sampling intervals    | 16 |

from basic sampling time  
T(0)  
to T(0) \* (2 \*\* 15)

Configurable from T(0) to 32768 \* T(0)

For example from 1 [MS] to 32.768 [s]

Basic sampling time T(0) configurable from 1 [MS] to 16 [MS]  
in increments of 0.1 ms

|                                        |                                     |
|----------------------------------------|-------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 4 Characteristics<br>4.3 Interrupts |
|----------------------------------------|-------------------------------------|

#### 4.3 Interrupts

|                                       |    |
|---------------------------------------|----|
| Number of function packages           | 1  |
| Number of configurable interrupts     | 5  |
| Number of available interrupts, total | 14 |
| of which software interrupts          | 8  |
| CPU timer interrupts                  | 2  |
| CIO port interrupts                   | 2  |
| Bus interrupts                        | 2  |

|              |                                             |
|--------------|---------------------------------------------|
| V 900601.300 | 4 Characteristics                           |
| 751040.txt   | 4.4 Execution times of the operating system |
| 15.10.90     |                                             |

#### 4.4 Execution times of the operating system

The execution time of the operating system is declared on following on the base 8 MHz processor with submodul.

For 16 Mhz processors the computing time is about the half shorter.  
By using MS31-, MS4- or MS45-submodules you can achieve a farther speeding up at about 10 - 20 per cent.

The Signals which are leaded over L- and/or C-Bus represent an almost constant load, as the bus always is timed by 8 MHz.

Task of the basic sampling time (calculation basis you can find above!)

|                    |        |
|--------------------|--------|
| time for start     | 188 us |
| time for terminate | 70 us  |
| -----              |        |
| total              | 258 us |
|                    | =====  |

#### Low-priority task

|                     |        |
|---------------------|--------|
| Start and terminate | 113 us |
|---------------------|--------|

Low-priority task, if the task of the basic sampling time is not configured

|                     |        |
|---------------------|--------|
| Start and terminate | 332 us |
|---------------------|--------|

#### Additional proportion for

|                     |       |
|---------------------|-------|
| Local buffer system | 20 us |
| C bus buffer system | 20 us |
| L bus buffer system | 20 us |

In buffer systems, the buffer load and number of data transfer paths in a multiprocessor system determine the execution time required by the operating system. This means, above all, that the search times for free buffers decrease with a lower load and smaller number of transfers.

The time required by the operating system decreases with increasing sampling time.

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|                                        |                                                                  |
|----------------------------------------|------------------------------------------------------------------|
| V 900601.300<br>751040.txt<br>15.10.90 | 4 Characteristics<br>4.4 Execution times of the operating system |
|----------------------------------------|------------------------------------------------------------------|

With reference to these points, the relative time required for execution of a task by the operating system is shown in the table below for the 5 sampling times from 1 ms to 16 ms:

| Sampling time | Without buffer load | Average buffer load | Full buffer load |
|---------------|---------------------|---------------------|------------------|
| 1 ms          | 26%                 | 43%                 | 53%              |
| 2 ms          | 5%                  | 14%                 | 19%              |
| 4 ms          | 2.5%                | 7%                  | 10%              |
| 8 ms          | 1.2%                | 3.5%                | 5%               |
| 16ms          | 0.6%                | 1.7%                | 2.5%             |

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|              |                   |
|--------------|-------------------|
| V 900601.300 | 4 Characteristics |
| 751040.txt   | 4.5 Memory data   |
| 15.10.90     |                   |

#### 4.5 Memory data

Processor modules:      RAM                    max. 128 kByte  
Memory sub modules:    EPROM/RAM        max. 512 kByte  
                          EEPROM            max. 8 kByte  
Coupling memory:       L-/C-Bus each max. 64 kByte

|              |                   |
|--------------|-------------------|
| V 900601.300 | 4 Characteristics |
| 751040.txt   | 4.5 Memory data   |
| 15.10.90     |                   |

#### 4.6 Memory requirement of the operating system

On the processor module, the operating system stores its code in the EPROM area and the data in the RAM area.

|             |             |                                   |
|-------------|-------------|-----------------------------------|
| It requires | RAM area:   | 5K bytes                          |
|             | EPROM area: | 13K bytes for initialisation      |
|             |             | 2K bytes for cyclic operation     |
|             |             | 6K bytes for the hexamonitor      |
|             |             | 1K bytes for version number, etc. |
|             |             | -----                             |
|             | total       | 22K bytes                         |

The operating system uses

ca. 1K byte

at the beginning of both the C bus and L bus coupling memory on the coupling memory module for management of operating system lists.

In addition to this memory area, memory space is also required for the buffer system and other components, e.g. the communication system.

|              |                                     |
|--------------|-------------------------------------|
| V 900601.300 | 4 Characteristics                   |
| 751040.txt   | 4.7 Version of the operating system |
| 15.10.90     |                                     |

#### 4.7 Version of the operating system

The operating system is identified by its version number.

On the absolute address segment=OFFE0h and Offset=0  
(in the memory sub modul) a text is deposited in this form.

yy\_mm\_dd\_Vxzy            where yy: year, mm: month, dd: day  
                              "V": version  
                              xzy: version number

for instance for the version 3.0 as "900601V300"

#### 5 Bibliography

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R. Oldenbourg Verlag, 2. Auflage 1986
- /2/ User's Guide  
Service Part A  
Error Handling PM general
- /3/ User's Guide  
Service Part A  
Error Handling PM Communication
- /4/ User's Guide  
STRUC L Part B  
Communication Configuration