Preface

Industrial data handling and processing equipment is being used on an ever increasing scale for monitoring and control of processes.
There are many examples; from simple telemetering of a water level, through automatic logging of results in a test bay, to complex control systems for distribution of electric power over an entire country, and monitoring whole space projects.
One of the major conditions for objective application of these systems is a thorough knowledge of the process which is to be monitored and/or controlled. The manufacturer's familiarity with processes determines the main fields of application. At Brown Boveri these include, at present, generation, transmission and distribution of electrical energy, processing and transport of water and gas, industrial production systems and rail and sea transport.
A broad spectrum of products and services must be available for performing the specific tasks in the selected field of application. The main products include equipment for data acquisition, teleoperation, control and regulating devices, process computers and complete instrumentation for control rooms. The most significant services are system planning, engineering and programming. Combinations of the above form a data system.
Closer inspection of a data system clearly shows three-level task allocation. On the first level individual signals to or from the process are treated independently. On the second they are collected by functional units which permit sequential processing or have specific but restricted logic functions. On the third level, overall data processing is carried out according to the objectives of the process under control.
It can be seen that this three-level concept has another characteristic. A distinction can be made between that part which is not related to specific tasks, and one that is. Viewed through the eyes of the engineer the neutral part performs tasks related to acquisition, transmission, processing and display of purpose-oriented, operational data by means of electronic equipment. The neutral part thus comprises system structures and individual functional units for the various tasks. These determine the basic architecture of the system. Specific objectives can be attained by selection and assembly of the individual components, and applying the necessary software.
Systems are designated small, medium or large, depending on the quantity of data to be processed or on the complexity of the tasks to be performed. Progress in the technology involved, particularly in the case of complex electronic circuitry, has meant that until now, application-oriented products have been used in small and medium systems, and large systems used general-purpose process computers with comprehensive peripherals. However, it is now possible to bridge the gap between these two extremes by using microcomputers and suitable system structures and thus exploit the advantages of programmability and modularity with a favourable cost/efficiency ratio even for small and medium systems and, where necessary, to combine the second and third levels mentioned above.
This step was accomplished at Brown Boveri by the development of the ED 1000 modular family. In general, these modules are programmable central processing units and application-oriented peripherals linked by a common system bus and supported by modular basic and standard software. Various ED 1000 systems can be built-up from these modules, and they

- extend the existing product spectrum in the range of small and medium systems for industrial data applications, and can be expanded to form large systems,
- facilitate uniform system structures for various applications and tasks,
- permit programmable, hierarchical data systems to be built up with distributed intelligence and
- provide for uniform expansion and functional enlargement of existing installations and systems.

A modular concept provides a great deal of freedom for the systems engineer. Nevertheless, it has the inherent hidden danger of too many alternative arrangements. In the case of the ED 1000 family this risk has been reduced by objective policy. Preferred arrangements are defined by standard products. For identification purposes they bear registered trade names such as Indactic® and a two-digit number where they are used in data acquisition and teleoperation applications. The result is a complete integral system using common modules and exploiting the advantages of application-oriented products.
This issue describes the basic idea of the ED 1000 modular family, introduces the main components and illustrates their application in systems by means of examples from the fields of data acquisition and teleoperation.

B. Šakić

Basic Concept of ED 1000 Module Family for Industrial Data Processing Applications

F. Tisi

The fundamentals and basic concept of the computer-supported ED 1000 module family developed by Brown Boveri are discussed. The ED 1000 range of equipment, including the associated software, is designed for tasks in power distribution and industrial data processing applications. Starting with a general review of questions concerning process computer applications, this contribution continues with a survey of demands made of modern system concepts, and concludes with a brief description of the ED 1000 module family.

Introduction

Progress in the field of equipment and systems engineering in power distribution and industrial data processing over the last few years is marked by the breakthrough in process computers. These have become not only an accepted but also an essential tool.

On closer inspection, however, it is immediately apparent that a computer is not simply a computer and also that no problems can be solved by a computer alone. First a distinction must be made between the many and various types of application and tasks to be performed; costs and solutions differ widely. The actual computer is always only a relatively small part of the whole system. It must be augmented by peripherals suitable for the process involved, and the appropriate software.

These factors are reviewed and the basic concept of the ED 1000 module family developed by Brown Boveri for solving these problems is discussed.

Components and Applications of Process Computer Systems

Each process computer system comprises identical main components which are predominant to a greater or lesser degree, depending on application.

A computer system comprises fundamentally equipment (hardware) and programmes (software). Programming makes the equipment suitable for the most diverse applications. Consequently, the appropriate programmes must be compiled for each installation.

As far as the system software is concerned a distinction is made between the operational programmes and the utility programmes, i.e. those necessary for compiling and checking the operational programmes. The operational programmes are divided into organization programmes (executives) and user programmes. The organization system provides the criteria for the user programme sequence which gives the computer system the application-oriented function.

The system hardware is divided into central processing functions, generally in the CPU, and the peripherals. These comprise mainly the process peripherals, providing an interface for the process, and the control peripherals providing a link with the operator.

A computer system is often expanded in stages corresponding to the various types of application of process computers.

Until a few years ago computers were used almost exclusively for internal accounting as off-line computers, i.e. the computer was not connected direct to a process. In this case it is not actually a process computer but an EDP machine. Consequently there were no process peripherals.

The step making it a process computer in real-time operation involves coupling the computer system direct to a process, it is now an on-line computer. In the first phase, process data is collected, processed and presented to the operator in a suitable form. The computer is used primarily for monitoring and evaluation. As far as control is concerned the human being still forms the main link in the chain (open-loop operation). The process peripherals are designed for data input or data collection.

In the next phase the computer finally carries out control functions, either entirely or to a limited extent. Its output is also connected to the process (closed-loop operation). In power system control installations the process peripherals also include traditional telemetering and teleoperation systems.

Control and optimization of complete systems is the most important task alloted to the computer.

Classification of Process Computer Systems

In accordance with their characteristic properties there are four typical sizes of process computer systems (Table 1). This provides a rough estimate of the costs involved for various tasks to be performed.

Miniature systems (type A) are built around a microcomputer which forms the CPU. Microcomputers have introduced the structure of computer-controlled systems into regions where previously fixed-wired, special-purpose equipment was used exclusively. A feature of these miniature systems is that in most cases the programme sequences are stored in ROM's.

Table I: Process computer systems

	Ⓐ Very small	Ⓑ Small	Ⓒ Medium	Ⓓ Large
CPU	Microcomputer	Small process computer	Medium process computer	Large process computer
Programme store	Fixed (ROM)	Core store with 1 to 12 K words	Core store with 4 to 30 K words	Core store with > 30 K words
External data storage	–	Small magnetic tape	Large magnetic tape or disc	Magnetic tape and discs
Process peripherals	For specific purposes	Universal expansion	Universal expansion	Usually coupled to process through interface computer
Operating peripherals	Punched tape reader/punch Teletype	Punched tape reader/punch Teletype Printer CRT	Punched tape reader/punch Teletype Rapid printer CRT	Card reader/punch Tape reader/punch Rapid printer CRT
Preparation programmes	Assembler Configurator Check routines	Assembler Configurator Check routines	Assembler Configurator Check routines Programming aids	Compiler Assembler Configurator Check routines Sophisticated programme aids
System organization	No specific organization system	Small operational system	Medium operational system	Complex operational system
Characteristic properties	Process tasks only Single-purpose unit Suitable for series units	Process tasks only Single purpose unit Suitable for series units	Mainly process tasks Multi-purpose unit Dual computer system possible Programme development possible	Mainly significant background tasks Progressive programme development
Characteristic applications	Teleoperation of substations Data loggers	Teleoperation of substations Data loggers with clear text print-out Simple processing	Teleoperation of large substations Control Processing	Load dispatching Optimization Statistics
Relative costs	1–4	2–10	5–30	20–100

Small systems (type B) are already much more versatile but still largely purpose-oriented. They permit collection, supervision, simple processing and presentation of larger volumes of data.
Medium-sized systems (type C) are the first step towards the universal system. Programming aids are improved accordingly. The system supports more complex programme sequences.
Large systems (type D) are designed for higher-level automation tasks such as optimization, statistics and so on. They have sophisticated programming facilities and operating systems and programmes can be compiled during operation.

Equipment Engineering at Present – Demands Made of Equipment and Programmes

The same tasks are to be carried out in the most varied applications from the sequential recorder on up to the remote-controlled substation, and to load distribution equipment and in process monitoring and control. Parallel or series input and output of analogue and digital signals, data processing, transmission and presentation (logging) and so on. In principle these tasks are to be accomplished by the same hardware in the same system structure and, largely, with the same or similar hardware modules. It is this knowledge which led to the development of process computer techniques.
For financial reasons it was at first only economical to use the process computer for large and medium-sized systems. However, semiconductor engineering has made it possible to apply the same concepts to small and miniature systems. Present-day requirements of data processing systems for industrial applications include the following:

- Modular hardware to enable installations of various sizes to be built up economically using the same modules and also making them easy to expand.
- Programming facilities, i.e. wide-scale replacement of fixed control logics by programmable CPU's.
- Vertical compatible family of CPU's from microcomputers with ROM's up to large process computers with facilities for on-line programme development.
- Modular software with a large proportion of standard software.
- Versatile software for programme preparation and organization programmes adapted to the size of the computer.
- Common interfaces and uniform data traffic between CPU and peripherals.
- High security, reliability and availability.
- Simple checking, servicing and expansion.

Development of the ED 1000 module family was carried out with these requirements in mind. It was based on logical further development and improvement of the well-proved Indactic telecontrol systems [1, 2] and the DP 700 and 1000 process automation systems [3]. The basic concept [4] forms the foundation for more detailed contributions [5 to 11] and is described briefly in the following.

Hardware Structure of the ED 1000 Module Family

The basis of the hardware structure [5] is the *system bus* (Fig. 1) which is identical for all installations. It forms the backbone from both electrical and design aspects. The entire data exchange takes place in uniform fashion over the system bus between the peripherals and the CPU. The interfaces between peripherals and bus are standardized. Each unit can, in principle, occupy any desired space or address. Consequently a modular system is achieved with a family of CPU's.

The modules are mounted in 7E racks of the new Brown Boveri MES modular electronic system. The upper half of the connectors carry the system bus, which is in the form of a printed circuit board, and the lower half connects to the cables which link the module to the processor or to other parts of the equipment (Fig. 2a and b).

A significant feature are the two types of *peripherals*. Type 1 peripherals plug straight into the central processing rack. Larger systems require connection channels which form an extension to the bus providing links to the I/O racks. These contain peripherals of type 2. This concept permits large and small installations to be constructed on an economical basis.

Central processing units [6] of various sizes and performance characteristics are necessary for adaptation to the various tasks. The obvious solution is to use a family of CPU's. In this particular case the PDP 11 family of Digital Equipment Corporation was preferred. All CPU's of this family are compatible with the system bus. In addition, the programmes of each computer also operate on the larger machines of the range. Through a special interface the computers control the ED system bus as a task-oriented extension to their own system bus. The ED 1800 CPU was designed as an extension to this range of computers. It is in the form of a microcomputer based on IC's and is used to advantage where simple standard programmes can be employed, such as in substations of teleoperation systems. The fixed programmes are stored in ROM's. The ED 1800 CPU comprises two printed circuit boards including the memory, and instead of having a computer interface, are plugged direct into the central processing rack. In addition to this, special, optimized control units are available for less complex tasks. They include the transmitter logic for a simple telemetering system and the logic for a programmable control system.

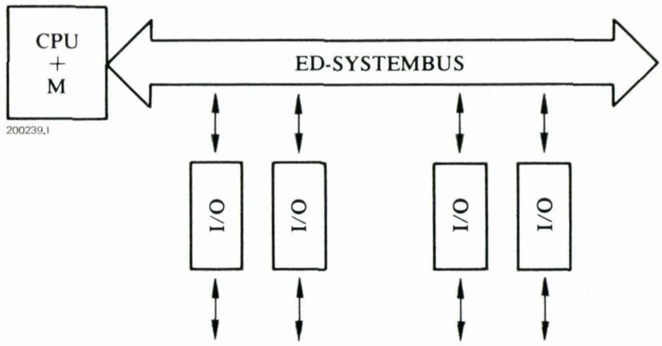


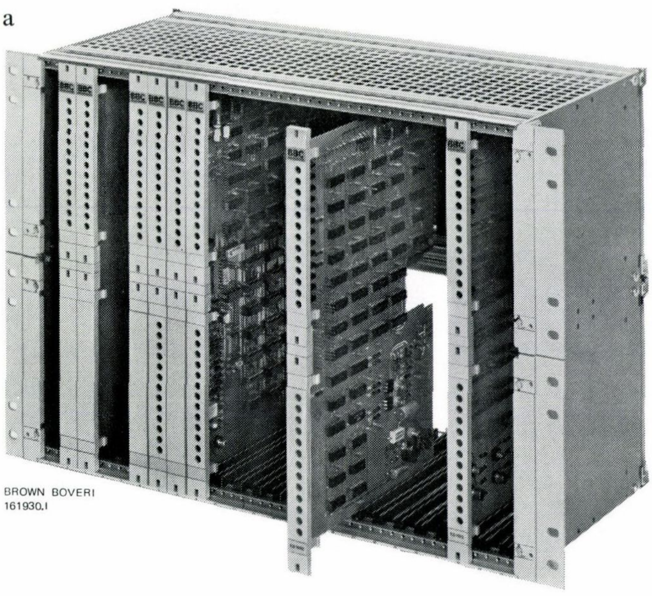
Fig. 1 – Basic structure of ED 1000 module family

CPU = Central processing unit
I/O = Input/output peripherals
M = Memory

Fig. 2 – Rack structure

a: Front view
b: Rear view showing wiring and system bus

a



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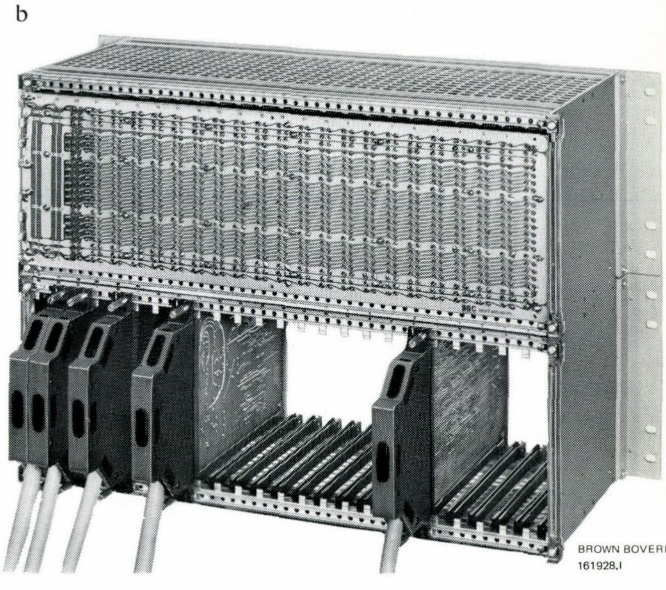

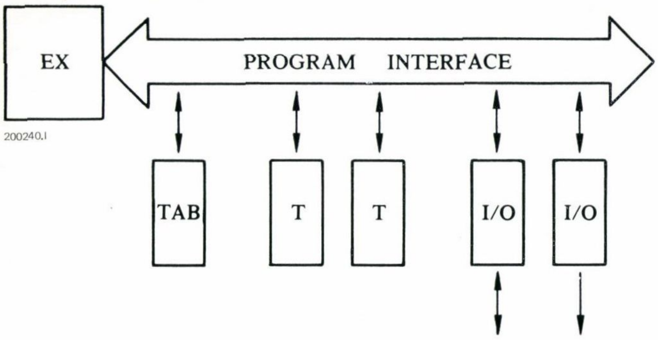

Fig. 3 – Basic software structure

EX = Real-time system
TAB = Tables
I/O = Input/output programmes
T = Operating programmes

Basic Structure of Programmes for the ED 1000 Module Family

A fundamental distinction must be made between *basic*, *standard* and *user* programmes [7]. User programmes vary from one application to another. The aims in software development were firstly, to keep the proportion of user programmes in known, repetitive tasks to a minimum and, secondly, to form the basic and standard programmes in a modular structure. This means that for each application only the programme sections which are necessary for functioning need be implemented (storage capacity requirements) and it is a simple matter to adapt the user programmes to the basic and standard programmes.
The basic software structure is shown in Fig. 3. Within the basic software with its real-time operating system, the calls and the organization of the data tables were standardized for simple combination with the standard and user programmes. These comprise the I/O programmes for controlling the peripherals and the actual processing programmes.

Applications – Standard Systems and Task-Oriented Configurations

The modular compatibility of hardware and software facilitates the most varied configurations for performing a wide range of tasks. Efficient project planning and simple service and maintenance [11] are assured by the defined configuration of *standard systems*.
The system parameters can be selected within certain limits. Examples of these systems include:

– Indactic 13 [8], which is a unidirectional telesignalling and telemetering system for use in point-to-point or communal traffic (linear, radial or radial/linear) using an optimized logic in the transmitting station and an ED 1800 CPU in repeater and receiver stations, i.e. stations of type A according to Table I.
– Indactic 33 [8] which is a bidirectional combined teleoperation system for transmitting all types of data for power supply network control in various operating modes, using an ED 1800 CPU in the substation (type A) and a PDP 11 computer in the control centre (type B or C).
– Indactic 41 [9] an event recorder with an ED 1800 CPU (type A) which can be integrated in a substation of the Indactic 33 system.
– Indactic 42 [9] an event recorder with a PDP 11 CPU (type B) with wide selection of clear text registration as an application-oriented arrangement for integration in a substation or control centre of the Indactic 33 system.

Application-Oriented Configurations

The spectrum of possible configurations for special tasks is virtually unlimited. Examples are quoted in [10]. Here we need mention only that the modular structure and adaptability of this module family makes it particularly useful for extending existing installations, such as introducing an up-to-date control centre with visual display and event recording equipment.

Special Features

Certain particular aspects concerned with the interrelated questions of security of computer systems, multi-computer systems and central or decentral computers are discussed.
The availability of process computer systems at present is of the same order of magnitude as hard-wired systems performing similar tasks, provided that the electro-mechanical service peripherals are maintained regularly.
Although it is theoretically possible to concentrate all tasks in a central large computer system, this procedure is not recommended. As is the case with traditional installations, for example, it is recommended to divide the tasks into various planes according to significance so that, even in the event of a fault, the individual power supply units remain functional. However, the ED 1000 module family has made it technically and economically possible to build up equipment systems in the various planes with different tasks and types of station from modules which are largely identical. The resultant ease of service, maintenance and expandability is obvious.
In systems with a wide range of tasks (type C) it is meaningful to duplicate the CPU and certain other control facilities. Under normal circumstances the computers can share the tasks. If one develops a fault the other can take over the primary tasks. The interface between computer and ED system bus is designed for selective control from one of the two CPU's.
In installations of the order of magnitude of type B it is of advantage to perform only the more important tasks, i.e. those which are application-oriented, in this computer (background computer). The telecontrol tasks or data collection and control is allocated to small or medium-sized systems which can largely be standard systems.

Allocation of Tasks

This brief survey gives rise to the quite justified question of whether computers can and shall control all tasks in the future. First it must again be emphasized that the actual computer is only a small part of the system. Computer systems of size D, C and, in part, also B are allocated tasks which can be performed only by computer. Whether the very small and small systems of types A and B have pur-

Table II: Substation control

Level	Tasks Data acquisition	Data processing	Control	Configuration
1	Data acquisition Conversion Protection	Logic check (interlock)	Control of units	Purpose-oriented unit
2	Data compression Registration Display Logging	Chronological signalling Traffic with regional control centre	Simple switching manoeuvres (e.g. connecting in transformers)	Purpose-oriented unit or microcomputer
3		Collection and display of load flow Build-up and maintenance of station model Correction of measured values	Complex switching manoeuvres (e.g. bus switching) Back-up protection Voltage control	Process computer system

pose-oriented equipment by preference is primarily a question of economics and is to be decided for each application individually.

The example of a local substation control system shows that distribution of tasks between purpose-oriented equipment and process computer systems will remain justified even in the future. In this example also, the tasks can be divided into various levels according to their complexity (Table II). First-level tasks remain allocated to purpose-oriented equipment, while those of the third level can be performed by computers. The middle level is decided from case to case according to the economics involved.

Conclusion

The ED 1000 module family comprises up-to-date equipment based on the latest engineering principles, and can be used for performing a wide variety of teleoperation tasks and also in industrial data handling. Using modular principles throughout has simplified testing, maintenance and expansion. Appropriate basic software and defined standard systems has reduced project planning costs. Configurations for special applications can be built up with a minimum of engineering costs.

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Hardware of the ED 1000 Module Family

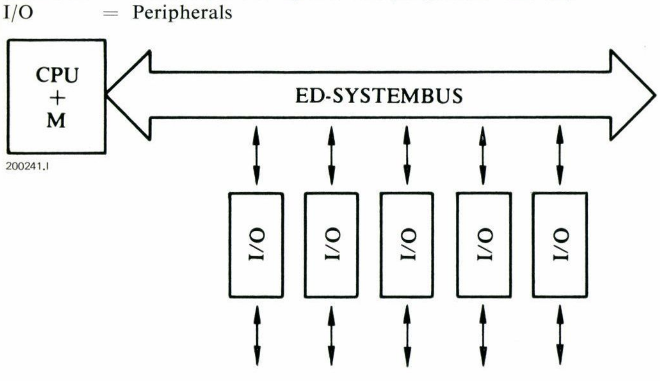
J. Holm

A basically new principle has been employed in developing the hardware of the new ED 1000 module family. In the ED 1000 system the former wired control logic is replaced by a microcomputer embodying all the advantages of this kind of logic. The structure of the hardware can be compared with that of a process computer. The family of modules is based on methods successfully used for years in process computer technology.
The objectives behind this hardware concept are outlined and the features fundamental to all ED 1000 modules are summarized. Internal data traffic and system structure are described and the modules at present available are introduced. The technical data relevant to all ED modules are presented.

Introduction

When acquiring a system one is interested not only in the technical specifications as considered in [1], but also the cost of the system which is another deciding factor. The cost of a system is made up of various items including hardware, planning, design and engineering. Although in recent years hardware costs have remained stable or even fallen, the other cost factors, mainly accounted for by labour, have increased so sharply that total system costs have continued to rise. In consequence, the price of the hardware represents an ever smaller proportion of the total cost, which means that the easily predictable part of the costs of a system is diminishing steadily.

Fig. 1 – Basic structure of ED 1000 module family
CPU + M = Central processing unit and programme memory
I/O = Peripherals



The basic aim of this modular hardware concept is to counteract this tendency by keeping down the engineering costs for a specific project.
The ED 1000 module family has been developed in the light of this objective and the outcome is a high-performance, general-purpose family of process control modules. The following features are basic to the ED 1000 family:

- The central processing unit takes the form of either a computer or programmable logic. These are integral parts of the system. The performance of the system is thus determinded by the stored programme, and not by the hardware used.
- If processing time permits, all decision processes are transferred to the software. The task of the peripheral modules is basically to convert signals coming from, or going to, the process. In this way it is possible to use one and the same circuit board for several, sometimes very different, purposes.
- The system is bus-oriented. Data transfer between all hardware modules, such as digital input/output units and central processors is by a common system bus.
- Each module is both a functional and structural unit.

Internal Data Transfer

The interface between central processor and peripherals are in all cases identical and form the ED system bus (Fig. 1) through which the entire exchange of data takes place. The system bus comprises address lines, data lines, control lines and power supply (Fig. 2).
There are 14 address lines providing 16 K addresses. Of these, 4 K addresses are reserved for modules linked to the process, while the other 12 K addresses are for the programme medium, data store and test routines.
The transfer of data between the modules and the central processor takes place along the eight data lines.
Figures 3 and 4 illustrate data transfer on the ED system bus. To transfer a word from a peripheral module to the central processor (data input) the central processor first applies the address of the peripheral unit and the address of the desired register to the system bus (lines AD), and then emits the master sync signal after about 1 μs. The peripheral unit identifies its address and feeds the required data D to the system bus, and immediately after sends the slave sync signal SS back to the central processing unit. After accepting the information the central processing unit resets the master sync signal MS, whereupon the peripheral unit resets the slave sync signal SS and the data lines. The bus is then free for the next data transfer operation.
In similar fashion the central processor writes data words into the peripheral units.
This so-called asynchronous data transfer has a number of advantages:

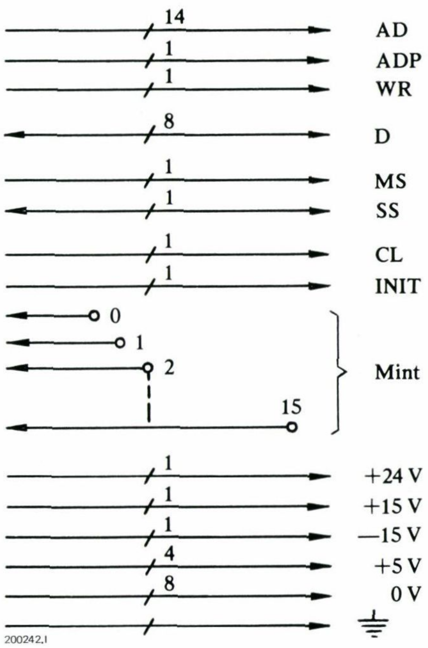


Fig. 2 – ED system bus

AD = Address
ADP = Address parity
WR = Write
D = Data
MS = Master sync signal
SS = Slave sync signal
CL = Clock
INIT = Initialize
Mint = Module interrupt

– Slow and fast devices can be mixed without the need for any special measures.

– The speed of data transfer is always optimum.

– Since there must always be an acknowledge signal SS, it is very easy to check whether the addressed peripheral unit is both present and operational. If no SS signal appears within a specified time, the central processor prints out a fault indication for the operator.

The bus also carries other control signals besides signals MS and SS. The most important of these is a crystal-controlled clock pulse of 1·2 MHz, the chief purpose of which is to provide the modules with an accurate time base.
The system bus is in the form of a printed wiring board with conductors on both sides. One side carries all signal conductors and the other is at zero voltage (ground plane).
The system bus constitutes the wiring in the central tier; this is the tier in which the central processing unit is connected to the system bus. The link to input or output tiers (peripheral tiers) is provided by the 'vertical' bus. This bus consists of a flat cable and is connected to the system bus via an amplifier circuit board. The 'vertical' bus carries the same signals as the system bus, but has no power supply lines.
The transfer of data always takes place between the peripheral unit and the central processing unit which controls it. No provision is made for direct data exchange between two peripheral units. A peripheral module can, however, influence the programme sequence by initiating an interrupt. Each of the maximum of 16 peripheral units in the central tier has its own interrupt vector.
A number of central processing units can be connected to the bus; which of them then controls the bus is determined by an external controller.

Modular Design

A feature of all ED 1000 modules is that each is a functional and structural unit. The peripherals can be divided into two groups: type 1 and type 2. Cost curves for the two types are shown in Fig. 5. A notable characteristic of type 1 is that all devices of this kind can be connected to the system bus. Devices of type 1 are designed for general-purpose application and are not optimized with respect to function. These devices include complete functional units such as A/D convertors, together with their associated multiplexer.
In the case of units of type 2 certain functions are centralized to achieve an optimum performance/price relation-

Fig. 3 – Data transfer through ED system bus

Read sequence
τ = Cycle

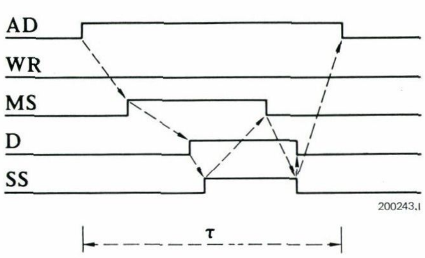
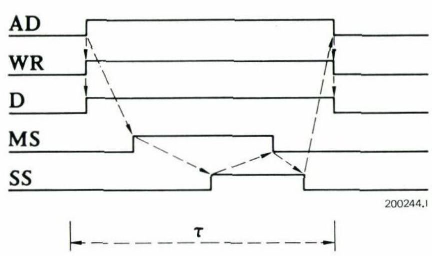


Fig. 4 – Data transfer through system bus

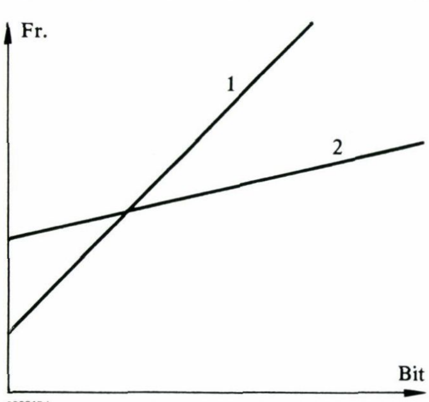
Write sequence
τ = Cycle



The principal ED 1000 modules

Purpose	Module	Type	Remarks
Module tier	ED 100	–	central tier and tier for digital input type 2 tier for digital output type 2 tier for analogue output type 2
Digital inputs	ED 1101	1	with galv. separation, with interrupt
	ED 1102	1	with galv. separation, without interrupt
	ED 1105	1	without galv. separation, with interrupt
	ED 1121	2	with galv. separation, with interrupt
Digital outputs	ED 1201	1	with galv. separation
	ED 1221	2	with galv. separation, acknowledge display
	ED 1223	2	with galv. separation, alarm output
	ED 1225	2	with galv. separation, pulse output
Analogue inputs	ED 1310	1	without galv. separation
Analogue outputs	ED 1401	1	without galv. separation
	ED 1421	2	without galv. separation
Digital inputs and outputs	ED 1505	1	without galv. separation
Special functions	ED 1601	1	channel transmitter
	ED 1602	1	channel receiver
	ED 1611	1	series input/output
	ED 1615	1	data bank
	ED 1617	1	electronic clock
	ED 1620	1	primary coder
	ED 1630	1	increment input
Functions within system	ED 1780	1	system bus amplifier
	ED 1781	1	system bus interface
	ED 1790	1	screening board
Central processing units	ED 1800	1	programmable logic
	ED 1810	1	ROM/RAM
	ED 1841	–	PDP 11 interface
	ED 1842	1	computer interface
	PDP 11	–	process computer family
Power supply units	B5CA	–	+ 5 V/13 A
	B5CC	–	+15 V/1 A and −15 V/1 A
	B5CD	–	+24 V/2 A

Fig. 5 – Relative costs of ED 1000 modules type 1 and type 2



ship. Type 2 peripherals are optimized in terms of function and must all be of the same kind within one tier (Fig. 6).

Under normal circumstances, the central processing unit [2] used is either a computer of the PDP 11 family (Digital Equipment Corp.) or the ED 1800 programmable logic developed by Brown Boveri. Computers of the PDP 11 type control the ED system bus through a special interface adapter (Fig. 7). The ED 1800 logic unit, together with its memory (e.g. ED 1810), consists of two circuit boards located in the central tier. The most important ED 1000 modules available at present are listed in the Table.

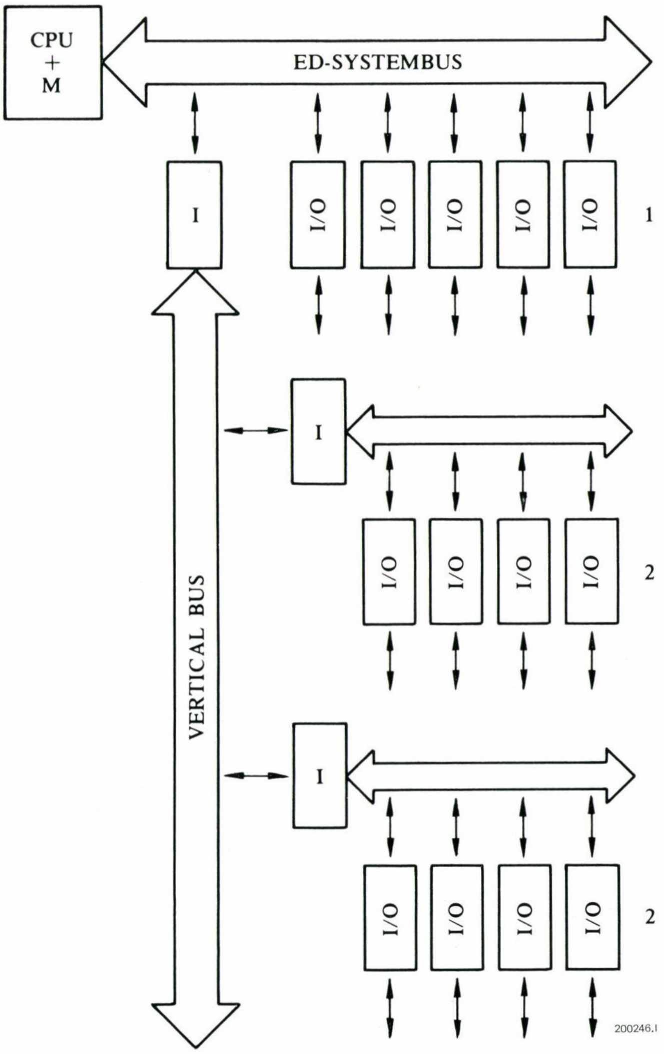
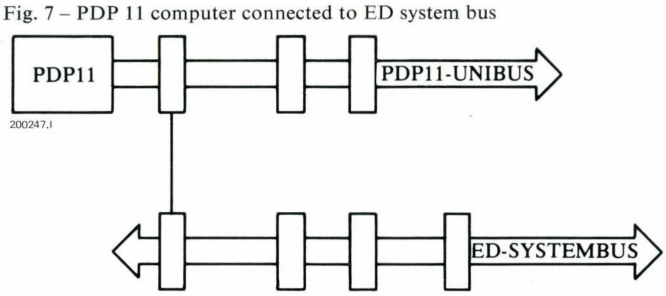


Fig. 6 – System structure for system with modules type 1 and type 2

By employing a uniform modular system structure throughout the ED 1000 range it has been possible to use the same tier design (ED 100) both as a central tier and as a peripheral tier for units of type 2. The tier and its wiring are mechanically identical for all applications, although when used as a peripheral tier the signal conductors carry signals different from those when it is used as a central tier.

Fig. 7 – PDP 11 computer connected to ED system bus



Construction

All tiers and modules of the system are built in accordance with Brown Boveri's new modular electronic system (MES) [3].
The most noteworthy aspects of this form of construction can be summarized as follows (Fig. 8):

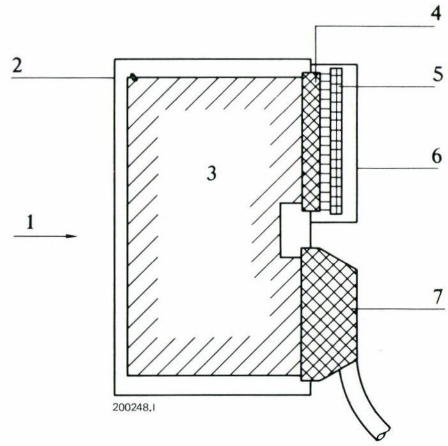
– All circuit boards of the ED 1000 family are 7E boards with two sets of contacts. Internal data traffic passes through the upper set (bus) while the lower set is connected to the process. This results in very good separation between process signals and internal signals. The process I/O cables have plug-in connections to the board and can be wired independently by the user.
– The internal wiring is in the upper half of the tier only. In this way it is possible to use printed wiring for more than 95% of the connections in a tier.
– The wiring area for each tier is protected with a cover held to the back by a simple snap fixing. Perforated plates screen the top and bottom of the tier. The inside of the tier is divided by a screening board into electrically 'clean' and 'dirty' compartments.

General Technical Data of ED 1000 Modules

Certain general data apply to all ED 1000 modules. Deviations from these figures are noted specifically in the appropriate data sheets.
The data relate to the modules, and not to installations built of these modules. Figures for a given installation must be derived from the data of the modules and the particular circumstances.

Fig. 8 – Mechanical arrangement
Side view

1 = Front
2 = Tier
3 = Circuit board
4 = Plug
5 = Wiring board
6 = Protective cover
7 = Periphery cable plug



Operation

Supply Voltage:

External	48 V d.c. +25 %/−15 %; 60 V d.c. +20 %/−15 %
	110/220 V (r.m.s) +25 %/−15 %
	50 Hz ± 2 Hz
	60 Hz ± 2 Hz
Internal	5 V ± 5 %, +15 V ± 2 %
	+24 V ± 10 %, −15 V ± 2 %

Interference and Insulation Voltages; Data Secure:

Sustained voltage	100 V (r.m.s.)
	150 V d.c.
Pulse interference	
High-frequency surge (peak-to-peak)	200 V (pulse frequency < 10 Hz)
Pulse surge (peak)	200 V (pulse frequency < 10 Hz)

Interference and Insulation Voltages; Function Secure:

Test voltage	380 V (r.m.s.) 1 min
	550 V d.c. 1 min
Pulse interference	
High-frequency surge (peak-to-peak)	1 kV (pulse frequency < 10 Hz)
Pulse surge (peak)	1 kV (pulse frequency < 10 Hz)
Insulation:	
Creepage distances	min. 0·5 mm
Air clearance	min. 0.25 mm
	complying with VDE 0110, category A/60

Ambient Conditions

Mechanical Stress:

Location	in stationary equipment
Vibration	< 5 *g* at 10 to 55 Hz
Shock	<15 *g* for max. 11 ms
	complying with DIN 40040, class V

Temperature:	complying with DIN 40040
Data secure	min. 0 °C class K
	max. 60 °C class U
Function secure, in service	min. −10 °C class J
	max. 65 °C class T
Function secure, not operating	min. −25 °C class H
	max. 75 °C class R

Humidity:

Annual mean	75 % without condensation
max. 60 days	85 % without condensation
further 30 days	95 % without condensation
	complying with DIN 40040, class F

Bibliography

[1] *F. Tisi:* Basic concept of ED 1000 module family for industrial data processing applications. Brown Boveri Rev. *61* 1974 (8) 373–377.

[2] *M. Huynen, H. Wahl:* Central processing units of the ED 1000 module family. Brown Boveri Rev. *61* 1974 (8) 383–388.

[3] MES – Modulares Elektronik-Konstruktionssystem. Brown Boveri Mannheim publication D-GJA 3.055.2 D.