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MICROPROCESSOR CONTROL SYSTEM FOR LARGE POWER PLANTS

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ABSTRACT

A general purpose control and monitoring system for power plants has been developed by ERICSSON, Sweden.

Based on distributed microcomputers the system is implementable not only in Power Supply Plants but also in the other systems involved in generation conversion, storage and transportation of energy in conjunction with a telecommunication plant.

The system has been named ERICSSON ENERGY-MASTER and is able to perform the internal control and monitoring functions for the subsystems included in a complete Telecommunication Energy Plant.

The system may be used stand-alone as a Telecommunication Energy Management System with remote operation facilities or as an interfacing subsystem to a Telecommunication Network Operation and Maintenance System.

This paper describes the basic structure of the system and some of its properties and applications.

THE TELECOMMUNICATION ENERGY PLANT CONCEPT

In order to keep a switching centre in operation a number of auxiliary systems are needed, many of which have in common the property that they are dealing with ENERGY.

Such systems are the DC power plant, the AC UPS, the batteries, the standby engine generators, the AC and DC distribution and control systems, and also the air conditioning or cooling equipment, which in fact is nothing other than an energy transportation system.

In the past, many of these systems were treated as entirely separate systems and also in many cases were handled by different authorities in the P&T administrations. Very little thought was given to their optimization!

Two factors have made it urgently necessary to treat all these systems for conversion, storage, generation and transportation of energy in a more coherent way:

1. In modern electronic switching centres they have together a very strong influence on the overall reliability of the centre.

2. They are playing a more and more important economical role both regarding the initial investment costs and, even more important, the operational costs. Energy costs is by no means negligible any more.

Thus the TELECOMMUNICATION ENERGY PLANT should not be regarded as a number of separate subsystems. In fact it is nowadays often the subject of optimization processes when decisions on new installations are taken.

USING MICROPROCESSORS IN THE ENERGY PLANT

The advent of microcomputers as a group of cost-effective and versatile components has given widely extended opportunities for control and supervision of Telecommunication Energy Plants.

Four different hierarchic levels of applications for microprocessors in the Telecommunication Energy Plant can easily be distinguished.

Level 1: As a component for direct control and regulation functions in the individual units such as rectifiers, diesel generator sets, chillers etc.

Level 2: At subsystem level for control coordination of the units in a plant consisting of a number of units e.g. a power supply or standby engine generator plant.

Level 3: Coordination and monitoring of all the subsystems forming the complete Telecommunication Energy Plant.

Level 4: The highest level distinguished is for communication with a remote location, thus enabling control of a large number of Telecommunication Energy Plants from an Operation and Maintenance Centre in the same way as is now commonly accepted for switching networks in general.

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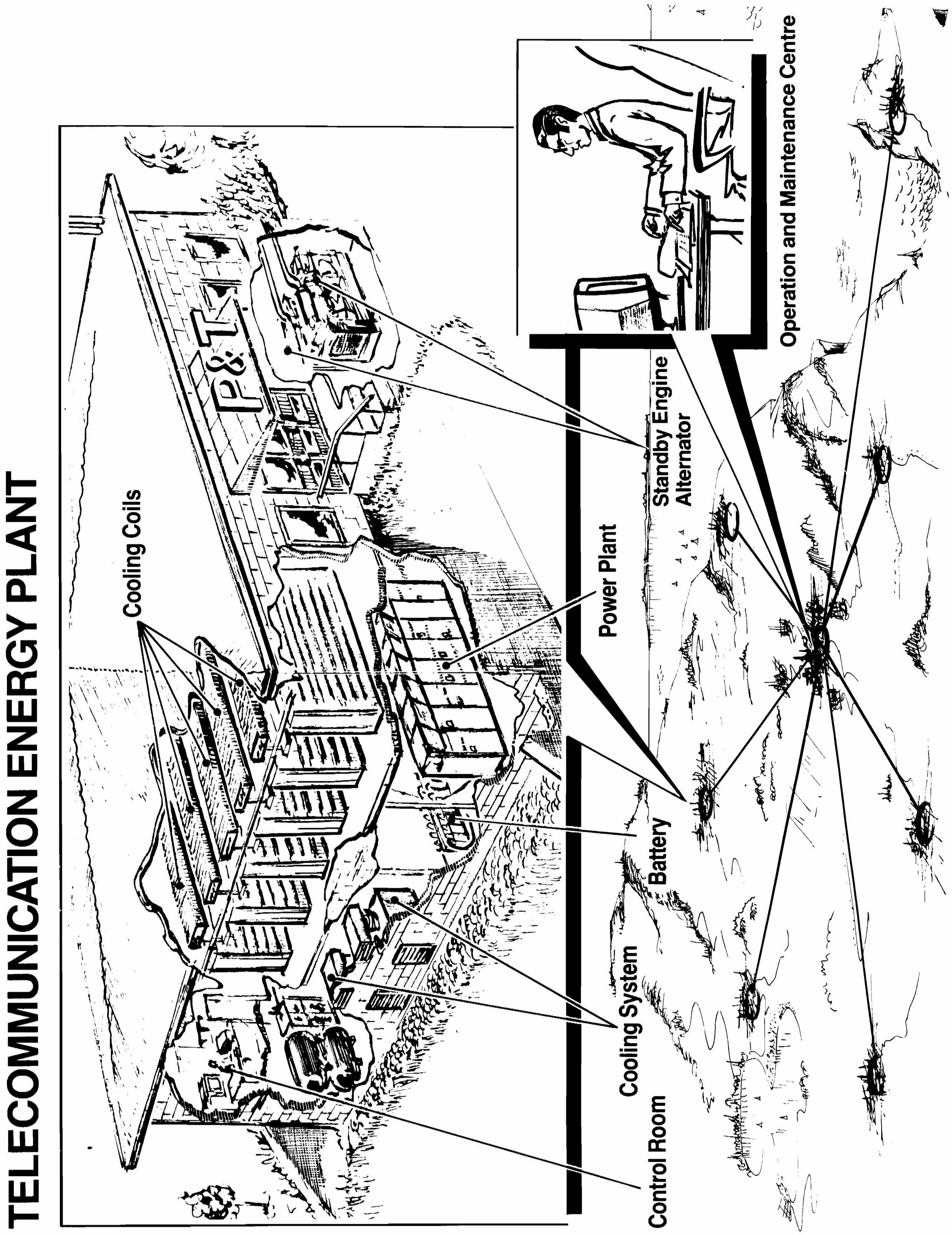


Fig. 1 Remote Operation of a Telecommunication Energy Plant

ERICSSON ENERGYMASTER APPLICATION RANGE

The ERICSSON ENERGYMASTER system is designed to cover all levels of the control hierarchy except the lowest.

Level 1 has been deliberately left outside the system in order to give the units the capability of operating autonomously as a reliability fall-back operation mode in the unlikely case of a major disturbance in the computer system. In this way the same units can also be used for conventional systems where the Energymaster system is not included.

MAIN OBJECTIVES FOR THE ERICSSON ENERGYMASTER

The features and advantages of computer control of power plants have been thoroughly discussed in numerous papers at preceding INTELEC Conferences as may be seen from the extensive list of references concluding this paper.

The main extension of features already described in the referenced articles is the TELECOMMUNICATION ENERGY PLANT concept, which is included to give an overall possibility of optimization for all the auxiliary systems of the switching centres, including cooling equipment, utility switchgear and possibly also lighting systems.

The following is therefore only a summary of some of the possibilities given by the ERICSSON ENERGYMASTER.

Remote operation and control

Probably the most important new facility the computer-based control system gives is the possibility of remote monitoring, control and testing of the Telecommunication Energy Plant.

This means that it is possible to receive information about the operational state (e.g. currents, voltages, alarms, temperature ...) of the energy plants equipped with the ERICSSON ENERGYMASTER system at any time from an Operation and Maintenance Centre (or even via a terminal on top of the desk of the Power Chief!). The connection between the on-site Energymaster equipment and the remote terminal can be a dialled or permanent telephone line or a data communication network.

Intelligent alarm functions with diagnostics

If an alarm is issued from one of the Telecommunication Energy Plants included in the system, diagnostic indications about the type of failure and in many cases even the cause of malfunction can be obtained directly to the Operation and Maintenance Centre by means of the testing routines.

It is needless to point out the economical and practical value of this information when deciding which repair-man should be sent out and with which priority the alarm should be handled.

The new facility of detecting "double alarms", (two or several failing units issuing alarms of the same category) is also extremely useful in this respect.

Remote testing

The remote operation facility can of course be combined with periodic testing according to maintenance routines or manually initiated test of the energy plant equipment.

This feature will have increased importance in the future because the trend is towards a large number of small unattended switching units (concentrators, remote subscriber stages). Frequent maintenance-staff visits on-site only to do routine testing of the equipment will generate very high maintenance costs due to the large number of persons needed and also the costs of travelling.

Energy conservation

That the integrated approach to control of Telecommunication Energy Plants can lead to substantial savings in energy costs has been shown in a number of papers presented at preceding INTELEC conferences.

One of the possibilities that has been widely discussed is to force the rectifier plant to operate at the maximum efficiency point by turning off units not immediately needed for the actual load. This method of rectifier operation was used by Ericsson for more than twenty years. However, the microprocessor system now allows more sophisticated efficiency-algorithms.

It should be possible to apply the same method also to control of the cooling system chillers, probably with even better results since the load there changes within much wider limits than the DC load.

A different method of saving energy costs is what has been called Peak Shaving (8). This method uses the standby engine generators to reduce the peak power demand which, due to the construction of tariffs for electrical energy, may result in lower costs.

All these methods are well within the capability of the ERICSSON ENERGYMASTER.

Statistics

Other new facilities are recording, storage and presentation of statistics regarding operational data such as load drain, voltages, currents, number and duration of mains outages and other parameters that may be of interest for evaluation of the actual energy plant or for dimensioning future plants.

One example where statistics of this kind may give considerable savings is recording and comparison of consecutive results from periodic discharge-tests on batteries. These can serve as a very good basis for decision when a replacement of a battery really is necessary.

Special customer requirements

Due to the fact that many of the functions in the system can be made dependent on software only it is easier to meet special customer requirements regarding the control and alarm functions than it was before when corresponding special functions required hardware changes. The customer can in fact change many of the operational parameters such as voltage limits, alarm categories and others simply by entering certain commands from his terminal. Of course such changes are protected from unauthorized interference by means of a password procedure.

Control functions systematized

The control and monitoring functions now expected of a Telecommunication Energy Plant are so numerous that it can be very difficult to prevent them from mutual interference, and thus to exactly forecast how they will perform in every different mode of operation. This difficulty is accentuated when using analog or random logic control equipment. On the other hand, the problem is almost eliminated by the use of modular programming technique when using computer control system.

STRUCTURE OF ON-SITE EQUIPMENT

ERICSSON ENERGYMASTER consists of a Main Computer (MC) located on-site and a number of Local Computers (LC). Each one of the latter is dedicated to a unit or a group of units in the Telecommunication Energy Plant.

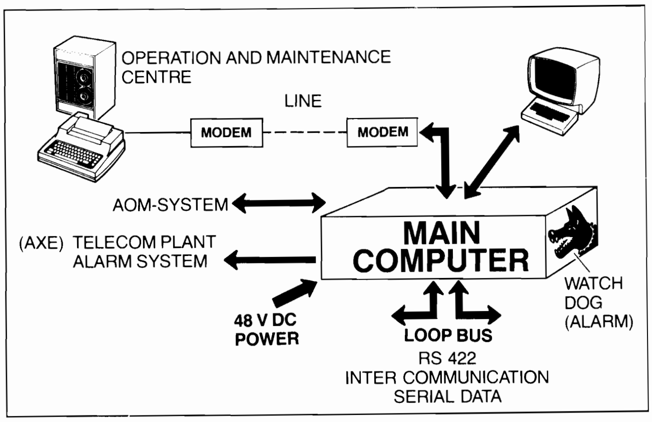
Intercommunication between the Main Computer and the Local Computers is by means of a serial bus designed as a loop, i.e. a LOOP BUS. This means that every Local Computer has access to two separate bus routes for communication with the Main Computer.

In addition to Main Computer and Local Computers the on-site equipment includes one or several terminals for use in connection with installation, testing, fault tracing and monitoring.

Main Computer

The tasks of the Main Computer (MC) are to

- Handle the communication between
  Main Computer - Local Computers
  Main Computer - on-site terminals
  Main Computer - switching system interface
  Main Computer - off-site equipment (via modem)
- Monitor the Local computers
- Handle, interpret and transfer alarms
- Execute commands
- Calculate and transfer control data to the Local Computers
- Store values for statistics and diagnostics.



The Main Computer is built around a microprocessor with storage boards and interface circuits for the communication with the Local Computers.

Depending on the type of external communication used, it also includes modems, interface boards for lineprinters and video terminals, and alarm boards with relay type input/output circuits. The Main Computer also includes a real time clock.

A single Main Computer is capable of handling up to 128 Local Computers.

Local Computer

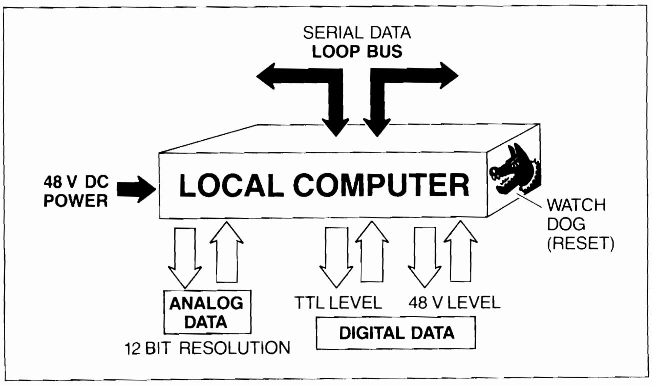
Among the tasks of the Local Computer (LC) are to

- Transfer analog and digital signals and measurement data to and from the equipment to which it is dedicated. Examples of such signals are voltage levels and alarms.
- Convert analog signals to digital data and the reverse.
- Handle the communication with the Main Computer.
- Interstore control data and measured values.
- Work as control and regulation equipment, e.g. for automatic battery charging control.

The Local Computer consists of one single circuit board, complete with 8-bit microcomputer, A/D and D/A converters, measurement amplifiers, interface circuits for digital inputs and outputs, communication circuits for the Loop Bus and a DC/DC converter for direct powering of the unit from the 48 V DC system voltage.

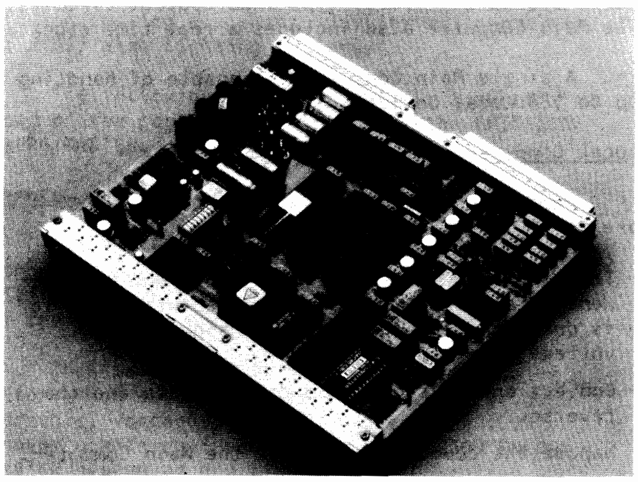
Each one of the Local Computers has 8 inputs and 2 outputs for analog signals with 12 bit resolution and a large number of digital in- and outputs both on TTL-level and system voltage level.

Every Local Computer is given its own identity in the system by means of a programmable on board switch. Apart from this, most of the Local Computers in a system are of identical design both with respect to hardware and software.



This means that it is possible to use the same Local Computer as a spare unit for control of a large number of different types of units.

Another very useful property of the Local Computer is that it can be used as a completely autonomous unit for digital and analog control with its own communication to a terminal or modem.

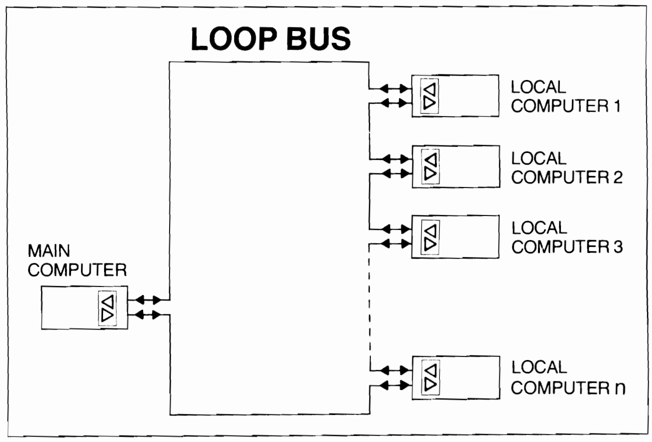


Local Computer Board

The Loop Bus

The internal communication between the Main Computer and the Local Computers is of serial type according to EIA RS 422. This type of balanced serial bus is relatively insensitive to interference combined with long range and high transfer speed. In this system distances between a Main Computer and the Local Computer up to more than 1000 metres are permitted. The transfer speed used is 9600 baud.

The communication bus is configured in the shape of a loop, i.e. a LOOP BUS, passing all the Local Computers with start and end points at the Main Computer. The communication is simultaneously sent in both directions of the Loop Bus. In this way the loop may be broken at any point without disturbing the communication in progress. This means that removal, testing and replacement of a Local Computer can be done during full operation without system breakdown. It is even possible to extend the system with new units during operation.



External communication

All serial ports are of RS 232 type with a transfer speed that can be selected as desired. By means of these ports, on-site terminals can be connected, as well as a remote control centre via modems.

Special I/O-ports give the facility of communication with the switching machine or directly with a superior Telecommunication Management System.

OFF-SITE EQUIPMENT

Communication with the off-site equipment is normally achieved via a modem on a telephone line or a data network, e.g. of packet switching type.

The off-site operation centre can be more or less advanced. In its simplest form it consists of a portable printer terminal and a telephone line modem. When the man on duty for the Telecommunication Energy Plants in the region receives indication that there is a problem, he simply dials the energy plant and gets a status report on the terminal. He can do this from his office, from the Operation and Maintenance Centre, or even from his home.

On the other hand, the off-site equipment can be very sophisticated, controlled by a computer continuously scanning the status of all energy plants, storing data and statistics for future use.

The off-site equipment can also be integrated in a switching network management system.

RELIABILITY AND SECURITY

Because of its central and powerful position in the Telecommunication Energy Plant, it is of great importance that the Energymaster system be designed in such a way that it does not degrade the total system reliability for the Telecommunication Energy Plant and thus the total communication system.

One of the main principles honoured throughout the design of this system is the same as for all other parts of the Telecommunication Energy Plant, namely to avoid central units configured in such a way that in the case of malfunction they cause a telecommunication system break-down.

Some of the measures taken to make the system comply with the most stringent security requirements are described below.

- The Telecommunication Energy Plant is able to perform its basic functions even in case of a malfunctioning Energymaster system.

  The control system is separated from internal regulation functions in the units. If the Energymaster system is down, certain higher level system-functions cease, such as efficiency optimization, equalizing charging of the batteries, the sophisticated diagnostic system, etc. In spite of this the telecommunication system is still provided with supply voltage and cooling as every unit automatically changes to autonomous operation according to hardwired base values.

- WATCH DOG logic gives fast indication in the event of computer failure.

  Watch dog logic means that certain circuits in the computer must be periodically reset by the program. If this fails, an alarm is immediately issued. In this way hardware and software failures are rapidly detected and indicated.

- Separate alarms for computer failure alone and computer failure simultaneous with additional failure in the energy plant.

  It is obvious that the latter type of failure must be treated with much higher priority.

- The LOOP BUS increases the reliability by means of two separate signal routes to the Main Computer from every one of the Local computers.

  The Loop Bus also gives the possibility of allowing service and extension of the Local Computers during full operation of the system.

- Specially designed DC-powered computers with telecommunication grade reliability.

- Password security system with several levels controls access and authorization to change parameters and control values in the system.

  This prevents unauthorized personnel from deliberately or by mistake interfering with the system.

- Plausibility check when control parameters are changed.

PRESENT DEVELOPMENT STATE OF THE SYSTEM

One of the objectives of this system is to give the possibility of fulfilling customer-defined requirements as regards alarm and control functions. Studies of a number of customer requirement specifications show that the potential customers have widely diverging demands in this respect.

The Ericsson Energymaster system is extremely versatile and flexible due to its modular design based on distributed processors. It is technically suitable for the most shifting applications.

The limits of the system is in fact set only by the fantasy of the users and the designers.

This fact makes it virtually impossible ever to claim that the system development is completed and finished.

At present the basic hardware is already in production and a library of basic program modules is available.

The system is fully implemented in the Ericsson ERIPOWER 400 power supply system, and one system is now going to be introduced in regular operation for field testing and evaluation at a major switching centre of one of our customers.

Regarding control of subsystems of the Telecommunication Energy Plant other than the power supply plant, the Ericsson Energymaster at present only uses the alarm and control inputs/outputs of the existing subsystem control units.

The library of functions is rapidly expanding, however.

CONCLUSION

Being a system with very high processing potential, easily expandable and adaptable to varying demands, it is foreseen that the system will prove to be an excellent tool to obtain:

- lower maintenance costs
- optimized operation
- energy conservation
- effective Telecommunication Energy management
- interface to total Switching Network Management systems

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