ERIGEN Data Logger for the Supervision of Solar and Wind Systems and the Collection of Meteorological Data

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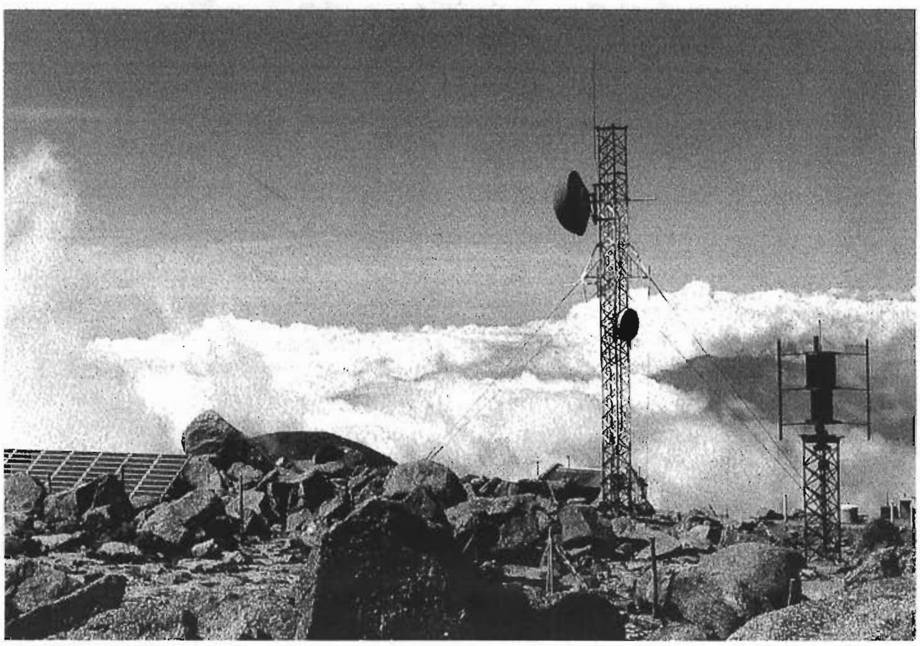
ERIGEN data logger, which is normally combined with an ERIGEN primary power system, assembles, processes and presents data. In addition to data from the primary power system the data logger can handle meteorological data, such as wind direction, wind speed, temperature and air humidity. The data logger can also control various equipment, for example switch power sources, measuring equipment etc. on and off. Different equipments can be used to give commands to and receive data from the logger. A battery-operated alphanumerical terminal is normally used for local applications, but a computer can also be connected via a separate input. Remote control of the data logger is arranged using other types of terminal equipment connected to a telephone network input.
The author describes the design and operation of the data logger.

dataloggers
power supplies to apparatus
telecontrol

Fig. 1
A radio link station on a mountain top in the Andes, Argentina. The station is powered by ERIGEN primary power and supervised by an ERIGEN data logger



Power supply system BZP 101, the ERIGEN primary power plant,[1,2] comprises three separate power sources: wind power, solar power and a diesel generator. The common link between them is the energy store, the battery, fig. 2. If a fault should occur in one energy source the others will still work. The different parts can be supplied separately. The information provided by the system consists of alarm signals of the following types:
- diesel generator does not start
- groups of solar panels out of order
- wind computer not working
- battery voltage too high or too low
- fuse alarm.

When an alarm is obtained a serious fault has already occurred. The subsequent repair work is an emergency action. Moreover, the information received concerning the fault is summary, and hence it is hard to know exactly what spares to bring to the site, which is usually remote and difficult of access. Repair visits are expensive and often also involve hardships.

The data logger BZP 610009 has been designed as a supplement to the primary power system in cases where there is need for more detailed information regarding the working state of the power and when one wishes to control the plant. The logger can transmit data to a central site – via the telecommunications network - which greatly facilitates the planning of repair and maintenance trips before a serious fault occurs.

A hypothetical case, where a fault has occurred in the diesel generator, illustrates the advantages of the data logger. Data from the logger shows that the diesel generator, which normally starts immediately, did not start until the third attempt. It is possible to start and stop the generator by remote control, so it is comparatively easy to come to the conclusion that a fault has occurred in the preheating of the intake air. If this happens during the summer there is plenty of time for repair since the generator starts without preheating as long as the weather is warm.

External signals

The diagram of fig. 2 shows the external connections to the data logger, DL.
- The wind and diesel generators each provides information for and can receive control signals from DL via a parallel interface of its own.
- There are inputs for the connection of 10 analog measuring transducers and for 16 digital indications/alarms. Fig. 2 shows how the transducers are used.
- There are sixteen outputs for the control (ON/OFF) of external units. Two of the outputs are reserved for starting and stopping the diesel generator but the others can be assigned as desired.
- A local terminal with an alphanumerical display can be connected via an RS 232 interface.

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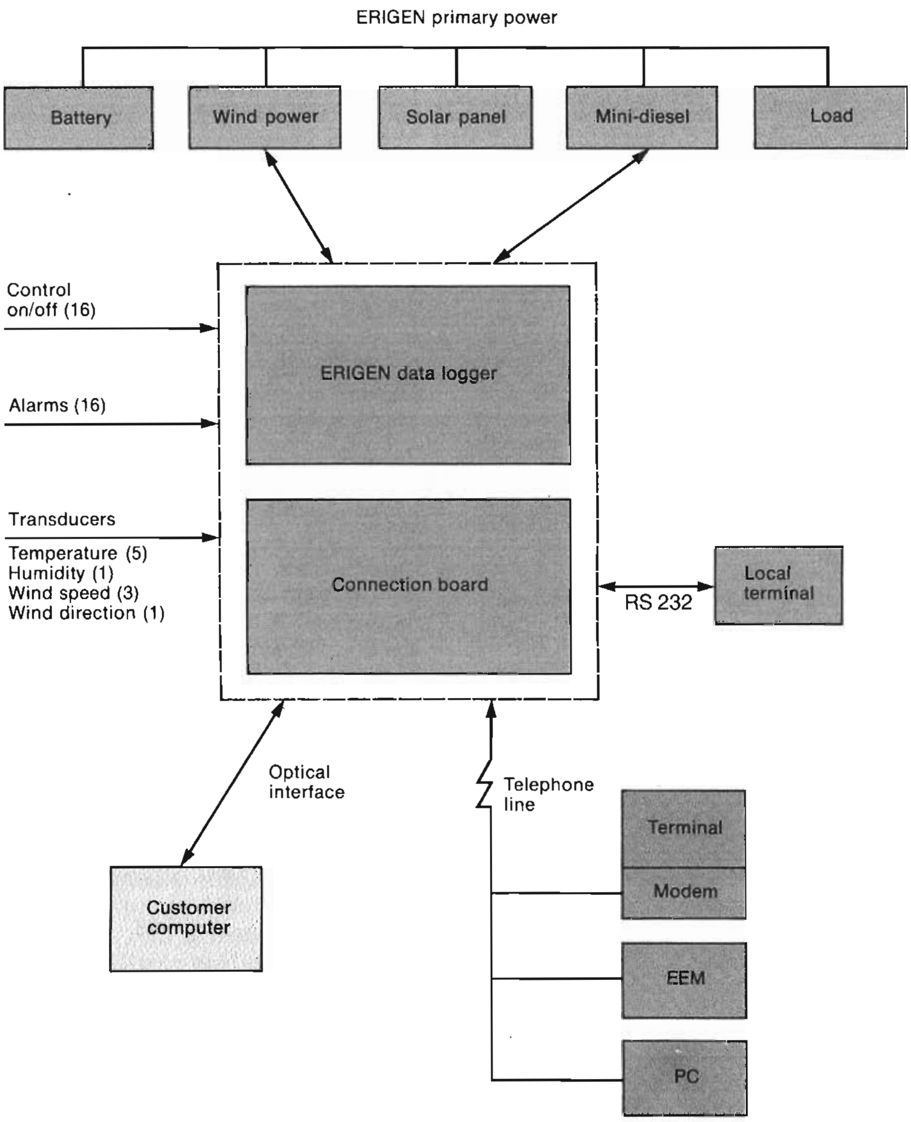
- A local computer can be connected. Optocouplers ensure that the computer is isolated galvanically from the logger. A protocol for computer-computer communication is used.
- DL contains a modem for connection to a telephone line. Various types of equipment can be connected at the far end; the simplest being a combination of modem and terminal.

Variables
The information that can be obtained from the data logger is divided into *variables*. The variables available in the system are shown in fig. 3 and in the box at the end of this article; they include meteorological variables and those describing the operational state of the ERIGEN primary power system. Each meteorological variable comprises the instantaneous value, mean value for one minute, mean value for 24 hours and min./max. values. The other variables consist of the instantaneous value and in certain cases mean values. A request for a variable results in the display of all values forming that variable.

Fig. 2
Connections between the data logger, the power supply system and the telecommunications network
EEM ERICSSON ENERGYMASTER



The data logger gathers variable data continuously. When an update command is given from a terminal the logger transfers all variables to an output file. The points of time at which the values were collected are also stored for presentation together with the data. The data logger can also be programmed to carry out updates automatically at preset times. When presentation of variables is requested they are fetched from the output file.

The 24-hour mean values are calculated for the period midnight-midnight. Displayed mean values all refer to the last full period. Thus when an update is requested the 24-hour mean value given is for the last full 24-hour period prior to the update. The maximum and minimum values are for the period from the previous midnight to the moment of updating. Totals, for example the number of kW-hours of wind energy produced, are measured from the time when the system was started up. The computer therefore stores the starting-up time of the system and displays it on command. Fig. 3 shows a part of a printout from the data logger.

Commands
The operator communicates with the data logger by means of commands. They can be entered via a local terminal or a remote terminal connected over the telecommunications network. All commands are of the following four types:
- @> SHW "TEXT" Cr< displays a variable called "TEXT"
- @> CNG "TEXT" Cr< changes a variable called "TEXT"
- @> START "UNIT" Cr< starts a unit designated "UNIT"
- @> STOP "UNIT" Cr< stops a unit designated "UNIT"

@ is the prompt from the operating system and Cr symbolizes Return. Text within > < is input by the operator. For example, in order to obtain the total wind energy the operator types SHW WTE Cr. The computer responds with WIND TOTAL ENERGY (Wh) = 5326. In this case the total amount of wind energy produced since the system was started is thus 5326 Wh. The command SHW results in the presentation of the data recorded at the latest update. A new update is ordered by means of command CNG OUTBUF.

Fig. 3
A printout from the data logger

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-XP/J00-                            ERIGEN DATA LOGGER-SRV:AXSJOBODA

ACT. TIME  87 05 26 08 51 44
DATA TIME   87 05 26 08 51 33
START TIME  87 05 21 10 50 00
**METEOROLOGICAL DATA**
                                    MINVALUE  MOMVALUE  AVERAGE   AVERAGE   MAXVALUE
                                    24 HRS    SAMPLE    MINUTE    24 HRS    24 HRS

-WIND SPEED-(0-40M/S)
     WS1_______________             0.160     3.52      3.69      4.74      7.84
     WS2_______________             0.00      0.00      0.00      0.00      0.00
     WS3_______________             0.00      0.00      0.00      0.00      0.00

-WIND DIR.-(-N*360-+N*360 DIG.)
     WD1_______________             0.00      0.00      0.00      0.00      0.00

-TEMPERATURE-(-40-+80 C-GRADE)
     TE1_______________             13.1      14.1      14.1      17.9      19.2
     TE2_______________             15.0      15.7      15.7      19.6      21.4
     TE3_______________             15.0      16.0      16.0      18.6      19.5
     TE4_______________             5.76      9.60      9.64      10.8      10.2
     TE5_______________             16.6      17.9      17.7      21.7      23.0

-HUMIDITY-(0-100RH%)
     HU1_______________             28.0      29.6      29.6      27.8      29.6

**POWER SYSTEM DATA**
-WIND POWER PLANT-
     GENERATOR FREQ.-(HZ)____                 49.7      49.0      42.9
     FEED-CURRENT-(A)________                 1.06      0.836     1.68
     -"- -POWER-(W)__________                 54.3      43.0      91.4
     -"- -ENERGY -(WH)_______                                     2190
     -"- -TOT.ENERGY -(WH)___                 9480

-SOLAR POWER PLANT-
     FEED-CURRENT-(A)________                 0.480     0.507     0.302
     -"- -POWER-(W)__________                 24.7      26.1      16.0
     -"- -ENERGY -(WH)_______                                     384
     -"- -TOT.ENERGY -(WH)___                 1260

-DIESEL POWER PLANT
     OPER.TIME-(H)___________                 0.133
     STARTS-(NUMBER)_________                 4.00
     FEED-CURRENT-(A)________                 -         -         -
     -"- -POWER-(W)__________                 -         -         -
     -"- -ENERGY -(WH)_______                                     -

     DIESEL STATUS CODE_______      0 0 0 0 0 0 0 0 0 0 0 0 1 0 1
     (BINARY)

-BATTERY-
     BATTERY VOLTAGE (V)______                51.4      51.4      52.4
     DISCHARGED CAP. -(AH)____                2.31

-POWER CONSUMPTION-
     LOAD-CURRENT-(A)_________                1.14      1.13      1.31
     -"- -POWER- (W)__________                58.4      58.0      69.2
     -"- -ENERGY -(WH)________                                    1660
     -"- -TOT.ENERGY -(WH)____                8210

-ALARMS                             16        12        08        04        01
   (A=ALARM,X=NO ALARM)
     WIND (AL 16-AL 01)                                 -NO ALARMS-
     SYSTEM (AL 16-AL 01)_____                          -NO ALARMS-
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System design

Data logger BZP 610 009 consists of a 19″ BYB magazine equipped with printed board assemblies, which are connected together through the wiring side and by front cabling. The magazine contains the functional units computer, modem and power unit. Front cabling connects the magazine to a separate printed board assembly, transducer connector board TCB, to which external transducers, terminals etc. are connected, fig. 5.

Computer

The computer comprises six printed board assemblies. It is divided into a microcomputer part and an interface part.

Microcomputer part

- The microcomputer board, MCB, contains an eight-bit microprocessor, program store and control logic. Timing circuits and a priority circuit for interrupt handling are also placed on this board. The MCB processor supervises and controls the operation of the logger and ensures that signals from the supervised system and from the operator are received and processed. It is controlled by a real-time program stored in PROMs mounted on MCB and the memory board, MEM.
- The memory board, MEM, can be equipped with a maximum of 64 kbit ROM or RWM.
- The communications board, COB, contains a communications computer, which in real time handles the data transmission between the data logger and the wind system, diesel system and external local computer. Exchange of information between COB and MCB takes place via a dual-port RWM. The COB program is stored in PROMs mounted on COB.

Interface part

- The transducer interface board TIB adapts the level of the analog signals that represent, for example, wind speed, temperatures and humidity and transfers them to CIB.
- The control interface board, CIB, contains circuits which the MCB processor scans in order to read the assembled data. The analog signals obtained from TIB are converted to digital form on CIB.

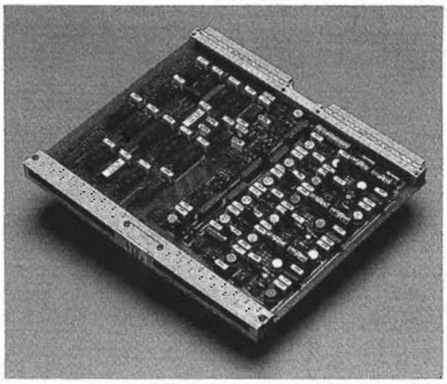


Fig. 4
Transducer interface board, TIB, one of the printed board assemblies in the magazine

- The relay board, REB, contains 16 relays with changeover contacts which are brought out to the front of the board where the relay states are indicated by LEDs. The diodes can be disconnected by means of strapping when minimum power consumption is aimed at.

Modem
The modem unit, MOD, is connected to the data cable from MCB, telephone line and 48 V power supply, all by means of front cabling. In addition to the modem, MOD contains a real-time processor, which handles the setting up of calls and contains a number of operating mode switches, built into DIL packages. The modem is normally set for automatic answering with a transmission rate of 300/300 bauds. The interface is in accordance with CCITT Recommendations V.24 and V.28. The telephone line is protected by a lightning arrester consisting of a gas discharge tube, resistors and protective diodes.

Power unit
The internal power supply unit, IPS, provides ±12 V and 5 V. The power consumption of the data logger is approximately 14 W. The unit can be started by means of an incoming ringing signal and stopped by the computer if minimum power consumption is required. In the idle state the power consumption is 0.2 W. The modem has its own voltage converter and uses approximately 3 W.

Connector board
The transducer connector board, TCB, is normally mounted below the magazine in the rack. The board is used to connect the transducers, terminal and modem to the logger. The board is connected to the magazine via front cabling and is equipped with overvoltage protection circuits.

Local terminal
The terminal is intended for local testing and fault tracing. A Microscribe 802 is normally used. It has an RS 232 interface and is powered by NiCd batteries. The display is an LCD with the format 2x40 characters.

Transducers
- The temperature transducers consist of a transducer element encapsulated in a base. The element is a semiconductor with the designation AD 590. It works as a temperature-dependent current generator; output current changing one μA per °C.
- The humidity transducer is of the polymer thin-film capacitor type. It measures the relative air humidity over the range 0–100%.
- The speed transducer gives a pulse repetition frequency that is proportional to the wind speed. It measures speeds between 0 and 40.8 m/s.
- The wind direction transducer gives an output signal consisting of a seven-bit Gray code. The code is read digitally by the computer and is recorded as a number between 0 and 360°.

There are sixteen alarm inputs, to which potential-free make contacts can be connected, for example fuse alarms, level monitors etc.

Software

The data logger includes a main program, communications program and modem program, all of which are real-time programs. The three programs, which are stored in PROMs, are run in separate processors in MCB, COB and MOD.

In MCB an interrupt occurs once a second. Then the instantaneous values of all analog and digital variables are collected. The clock is updated and all time-controlled functions are checked. Next the processor calculates mean values, max./min. values, power, energy etc. These calculations may be time-consuming and they are therefore divided up so that other interrupts can be handled in between calculation stages. Two-way data transmission via COB to the diesel and wind systems, a process which includes a handshake procedure, can also take place once every second.

The main program, which comprises approximately 20 kbits, is written in macroassembler. Its structure is such that it facilitates changes. New requirements from Ericsson's customers can thus easily be met.

Applications

During the planning work for a power plant consisting of solar and wind generators, it is necessary to estimate the amount of energy available from the sun and wind at the site. In most cases the data available for this purpose is meagre and usually consists of mean values for a large geographical area. The strong influence of the local topography on the wind energy and seasonal variations in the available energy are usually unknown factors.

With ERIGEN data logger the energy supply during a year can be mapped in detail. However, this requires that the site is called at least once a day during the period. If the load on the battery is less than the energy produced, an artificial load must also admit of being switched into circuit by means of a command from a terminal. This can easily be arranged using a load resistor and contactor.

In addition to the evaluation of the station's energy production the operation of the power supply system can be monitored. Basically this is done through analysis of the variables given in the box on next page, but other possibilities are also available.

Supervision of wind power

Supervision of the mechanical system of wind turbine and generator is based on the data for wind speed and generator frequency. The relationship between these two values is described by λ, which is the ratio between the peripheral speed of the turbine and the wind speed. λ should be approximately 4.7 during idling and 3.2 with optimal load on the turbine. If the ratio deviates considerably from these values, damage to the moving parts of the mechanical system might have occurred. For example, damage to bearings and the blade turning mechanism, the protective r.p.m. limiting system, can be detected long before a breakdown occurs and an alarm is initiated. The command-controlled relays make it possible to prevent the automatic switching off of the wind power electronics when the wind is too weak to produce energy. This means that data is recorded even when no energy is being produced.

Other parts of the wind power system can be supervised by studying the variation in power output with the wind force. If the time or opportunity for such a study is not available the supervision can be limited to studying the alarm and status codes from the power plant.

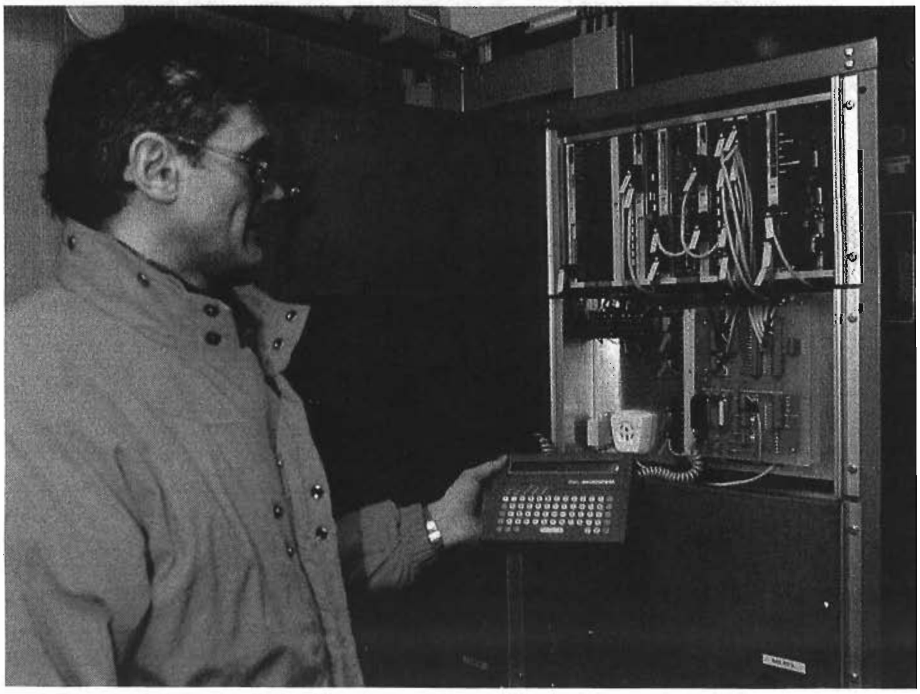
Supervision of solar power

In those cases where the maximum current from the solar panels is small in relation to the battery capacity the panels are usually connected directly to the battery without any regulatory device. The current is then measured by the wind electronics. In larger solar power systems equipped with a regulator, alarms are transmitted to DL via relay contacts. In the former case the function of the solar panels can be checked since they should always provide a small current during daytime, even on cloudy days. In the latter case the regulator issues an alarm when a panel row gives an abnormally low current in relation to the others.

Supervision of diesel generator

The information obtained from the variables, together with the possibility of remote start and stop, provides good facilities for supervising the operation of the generator. Such supervision is very important since the diesel generator is the last and weakest link in the power supply system.

Fig. 5
Rack for a complete ERIGEN system with primary power and data logger. A connected local terminal is also shown



VARIABLES

The following variables are available for printout:

TYPE	SYMBOL	RANGE/UNIT
Meteorological data		
Wind speeds (3)	WS1, WS2, WS3	0 – 40 m/s
Wind direction (1)	Wd1	0 – 360°
Temperatures (5)	TE1 – TE5	–40 to +80°C
Humidity (1)	Hu1	0–100% Rh
Wind power data		
Generator frequency	GFQ	Hz
Current	WCR	A
Power	WPW	W
Energy	WEG	Wh
Total energy	WTE	Wh
Alarm	WIA	16 bit
Solar power data		
Current	SCR	A
Power	SPW	W
Energy	SEG	Wh
Total energy	STE	Wh
Diesel power data		
Operating time	DTM	h
Current	DCR	A
Power	DPW	W
Energy	DEG	Wh
Status code	DST (Alarms etc.)	Binary/16 bits
Battery data		
Voltage	BVT	V
Discharged capacity	DCP	Ah
Load data		
Current	LCR	A
Power	LPW	W
Energy	LEG	Wh
Total energy	LTE	Wh
Other alarms	XAL	16 bits

Supervision and control of external units

The data logger can also be used to control and supervise external units. The analog inputs can be disconnected from the transducers by means of plugs on the circuit board. Transducers for measuring other parameters can then be connected to the system. For example, when there is no need to measure air humidity the channel in question can be connected to another measurement object. The system also contains free digital inputs and outputs for control and supervision.

Centralized supervision of several systems

Manual collection and evaluation of data via a central VDU terminal can be satisfactory if only a few systems have to be supervised. If the number of systems is large it is normally more convenient to let the computer call up and request data automatically. This facility is offered by Ericsson's ENERGYMASTER, EEM, for centralized supervision of exchange power supply systems.[3] When EEM is used, modem MOD in the data logger is connected direct to the communications computer, COB, which always has access to the most recent variable values. COB uses a protocol for inter-computer communication. The high speed of the data transmission keeps costs low. The protocol also minimizes the risk of transmission errors. The presentation is made on the VDU in EEM. Data from all primary power plants can also be compiled and presented with the aid of a menu.

Summary

Recent experience indicates that there is a great need for data communications to telecom equipment installed at remote sites. At such places the power supply equipment is often both more expensive and more complex than the equipment to be powered. It is therefore a natural consequence to include in the power supply system the control equipment for all electronic circuits at the site.

Ericsson has for some years been working on computerized control and supervision equipment for power plants. During this development work the data logger became the natural solution to a problem that affected the whole range of Ericsson's power supply equipment. The first ERIGEN data logger was supplied in 1984, for the supervision of the power equipment of a lighthouse. The load consisted of a radio, radar responser and lighthouse lamps. This initial installation has been followed by many more, often for radio link equipment. Operational experience has been very good.

References

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3. Eriksson, M. and Samsioe, P.: *Supervision System for Energy Equipment.* Ericsson Review *64* (1987):1, pp. 2–8.