ERICSSON REVIEW

Ericsson Quality
Computer-Controlled Electronic Interlocking System, ERILOCK 850
Tone and Ringing Equipment BKL 700
Teletraffic Training, a Profitable Investment
Electronic Fuse for Power Distribution in Systems Sensitive to Transients

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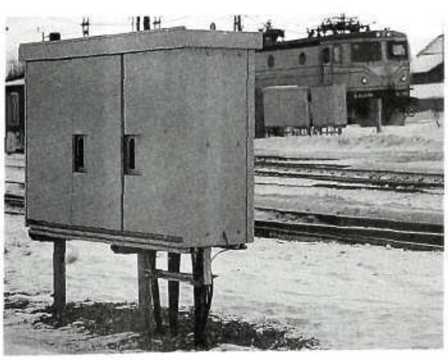

Cover
Ericsson Signal Systems AB, together with the Swedish State Railways, has developed a computer-controlled, fully electronic interlocking system, ERILOCK 850.
The picture shows a part of the Hallsberg railway junction, where the first system is in operation

Computer-Controlled Electronic Interlocking System, ERILOCK 850

Dag Nordenfors and Anders Sjöberg

Ericsson Signal Systems AB, in collaboration with the Swedish State Railways, is continuing the development of computer-controlled interlocking systems for railway yards. The previous system version included some parts that contained safety relays. These have now been redesigned using microcomputer-controlled electronics. The result is a computer-controlled, fully electronic interlocking system, ERILOCK 850. The first system is now in operation at the large Swedish railway junction at Hallsberg.
The authors describe the general design and structure of the system and then exemplify by outlining the scope and installation of the Hallsberg plant. Finally they briefly consider computer aids for planning.

railways
traffic computer control
microcomputers
signalling

The objective of developing a fully electronic interlocking system has been to provide the railway authorities with less expensive and more user-friendly interlocking systems, and also to provide the traffic staff with better facilities for controlling and supervising the train traffic.

The system, fig. 1, comprises the following subsystems:
- control and supervisory system
- interlocking system
- data transmission system, which connects the interlocking system and the object controllers
- object controllers for the signals, points etc.

Control and supervisory system

The basic version of ERILOCK 850 is designed for two operators. They control and supervise the train movements in a railway yard from their own operator's desk, each equipped with a keyset and one or two colour VDUs, fig. 2. They share a typewriter. This equipment enables the operator to set up train and shunting routes, control individual objects (e.g. change points) and supervise the movements of trains.

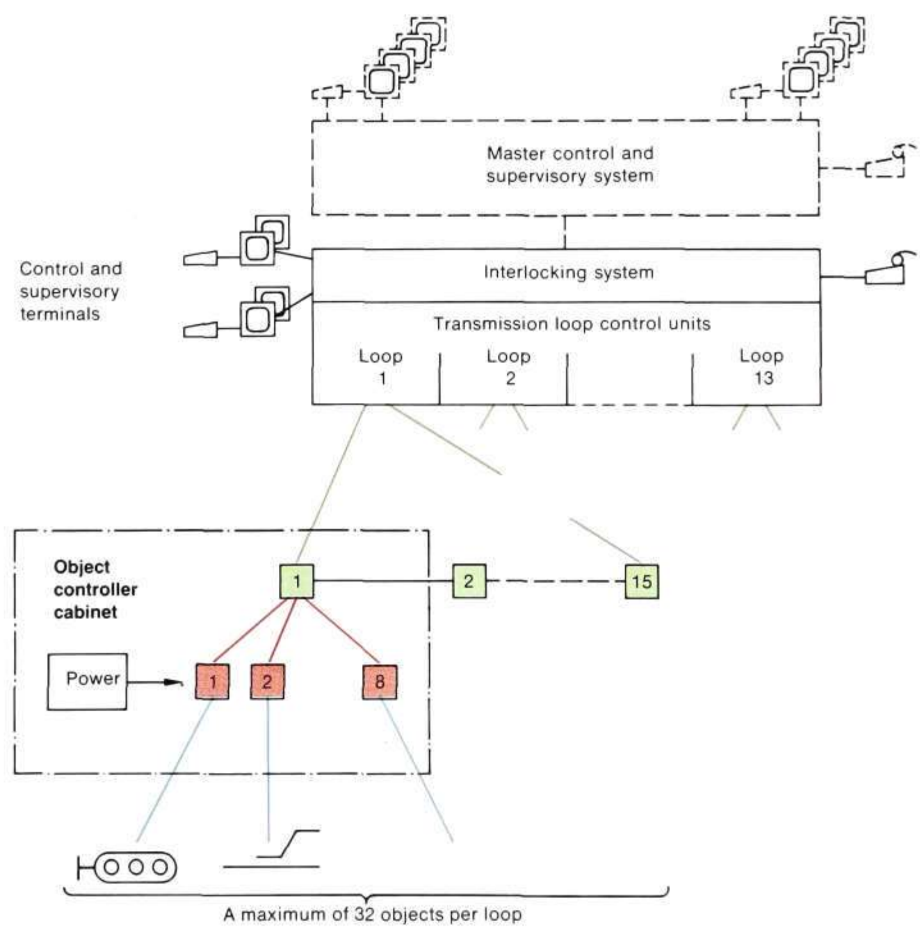

Fig. 1
Block diagram of interlocking system ERILOCK 850. The master control and supervisory system has a wider range of functions, such as train describer system and automatic train routing

Four-wire telecommunications cable or optical fibre
Transmission concentrator
Link to object controllers
Electronic object controller
Multi-wire signalling cable

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ANDERS SJÖBERG
Swedish State Railways

The system contains various alarm functions for the indication of faulty signal lamps, points not detected in end position etc. Alarm information is displayed on the monitors or output on the typewriter. The system can also record certain events for the purpose of checking timetables, investigating accidents and facilitating maintenance.

The program system that handles the basic version of the control and supervisory function is included in the interlocking computer.

In larger plants, the control and supervision is handled by a separate master system, ERICOS 715, which allows the connection of more operators' desks and offers more functions, for example train describer system and more advanced automatic train routing, see section "Systems in operation". The basic system is then only used for maintenance purposes and as a standby for the master system.

Interlocking system

The main purpose of the interlocking system is to ensure the safety of train movements. Once a train route has been established for a certain train it must be protected from other trains. All points in

Fig. 2
Operator's desk at a small station. The interlocking computers can be seen at the rear

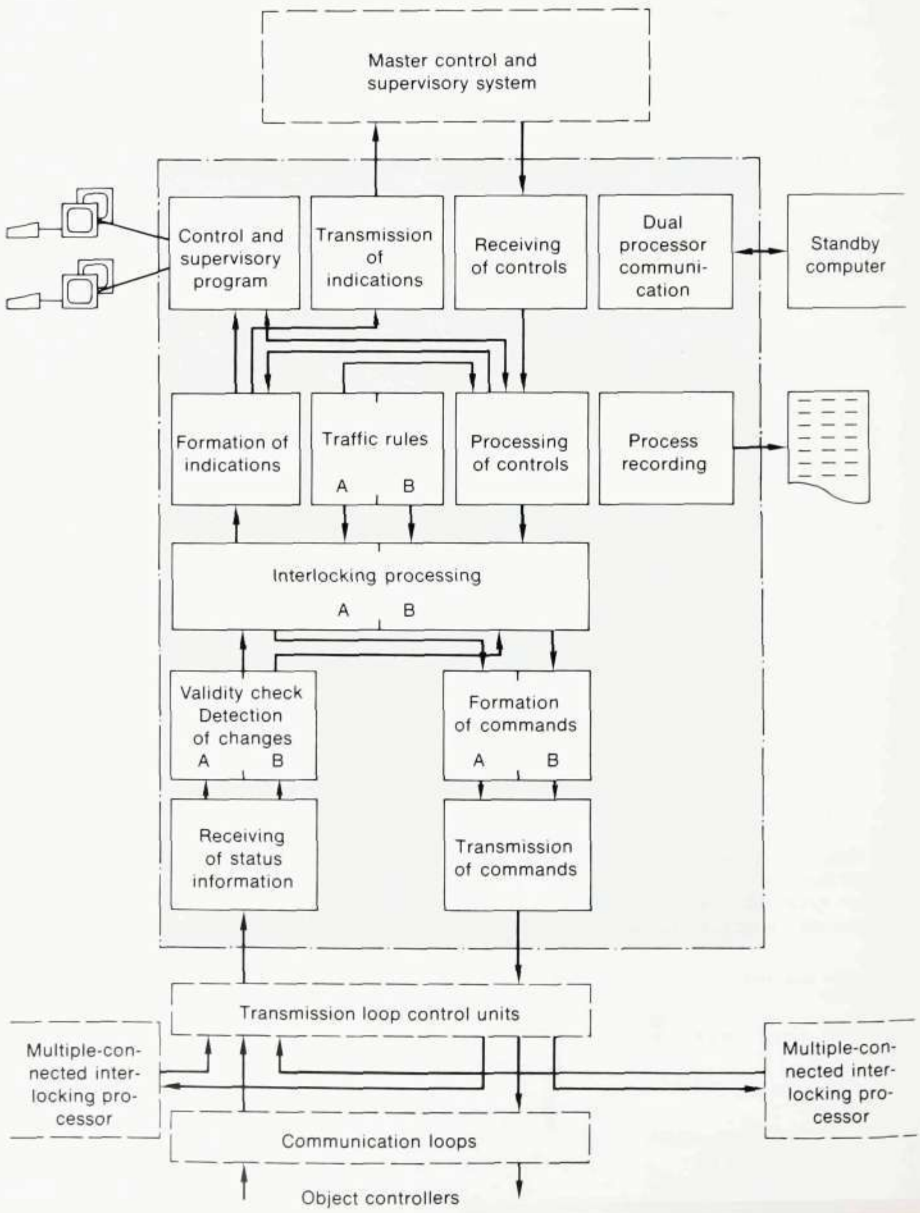


Fig. 3
Block diagram of the interlocking system processing software

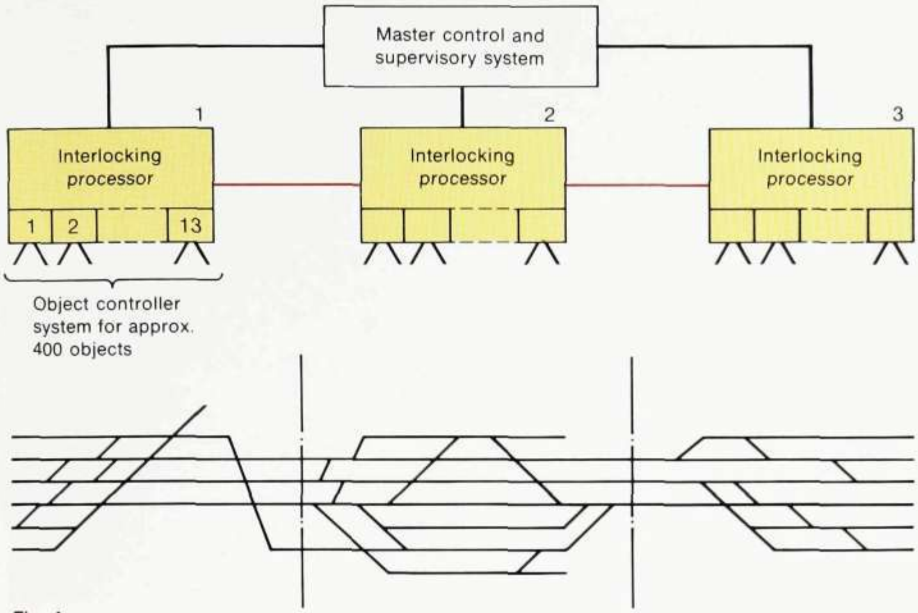


Fig. 4
Multiple connection of several interlocking processors

—— Serial transmission between interlocking processors

that train route must also be locked so that they cannot be changed.

The interlocking system is a program system which utilizes Ericsson's mini-computer UAC 1610 P, fig. 2. In addition to the interlocking program, with the associated conditions for traffic in a railway yard, the computer contains input and output programs as indicated by fig. 3.

An interlocking system has the capacity to control and supervise 400 objects, signals, points etc. Two or more systems can be interconnected, fig. 4, to provide sufficient capacity for larger railway yards.

Object controller

Each object in the railway yard is controlled and supervised by its own microprocessor-controller, fig. 5. The objects include

- signals
- point machines
- level crossing equipment
- point heaters.

The controllers are installed in cabinets, fig. 6, near the objects. Each cabinet holds eight controllers. The cabinets are connected to the interlocking computers via a four-wire telecommunications cable or optical fibre. The objects are connected to the controllers via multi-wire cables. In older systems these multi-wire cables ran from a central relay room, which meant the laying of considerable amounts of multi-wire cable. Some of the gain of the new system lies in the savings made on such cable.

The requirement for fail-safe operation has greatly influenced the design of the object controllers. For example, an electronic safety breaker has been designed which, in case of failure, cuts off the current to "proceed" signal lamps or

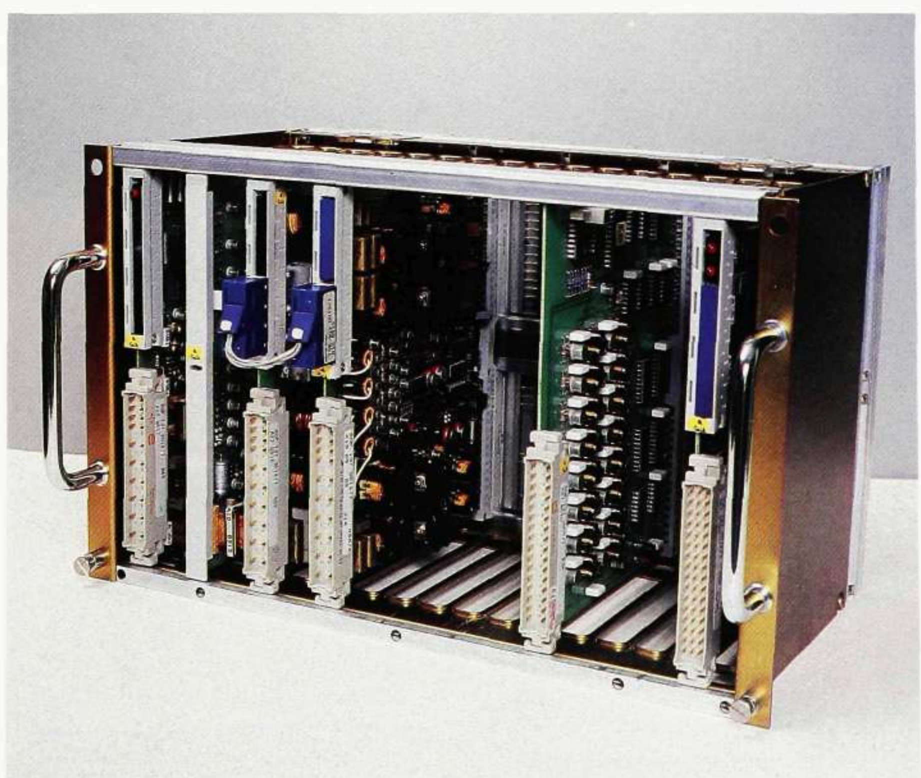


Fig. 5
Signal object controller

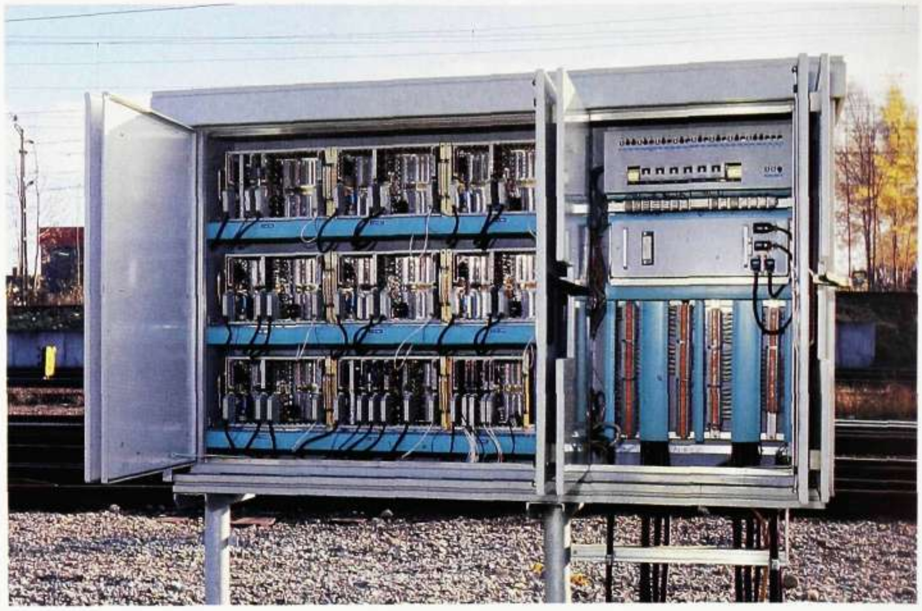


Fig. 6
Object controller cabinet

point machines. Fig. 7 shows the block diagram of an object controller for signals.

Data transmission between the interlocking system and object controllers

Each controller cabinet contains a concentrator, fig. 1, which is connected to a transmission loop starting at the interlocking processing unit. Up to 15 concentrators can be connected to each loop.

HDLC transmission procedure in accordance with ISO 3309 and 4335 is used over the loop. The data rate is 19.2 kbit/s and the transmission mode is duplex.

The type of modems used in the loop is dependent on the transmission medium: four-wire telecommunications cable or optical fibre. The concentrator functions as a regenerative repeater for the signals over the loop.

Fail-safe design apects

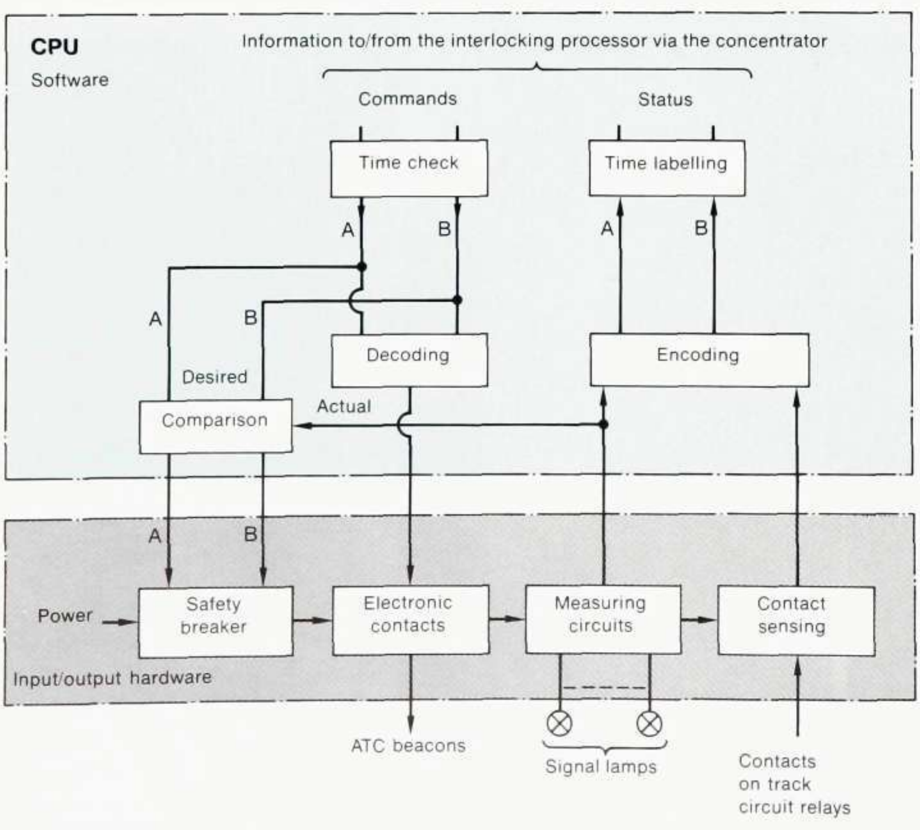
It is essential that certain parts of interlocking systems have fail-safe operation, by which is meant that accidents must be prevented even when a fault occurs in the equipment. This requirement has greatly influenced the design.

When designing the new interlocking system as much use as possible was made of the fail-safe design rules previously devised for relay and electronic systems, but the introduction of computers has made it necessary to prepare new design principles.

The main method, fig. 8, of ensuring fail-safe function of the interlocking system is to have two independent programs in the same computer processing the interlocking data and to ensure that the two programs give the same result before an order can be executed. The two programs, which have been designed by two independent designer teams, perform the same processing function but use the computer hardware in different ways. This technique is used both in the interlocking system and in the object controller systems.

The data transmission between the interlocking system and the object controllers contains so much redundant information that any distortion of information will be detected.

Fig. 7
Block diagram of a signal object controller



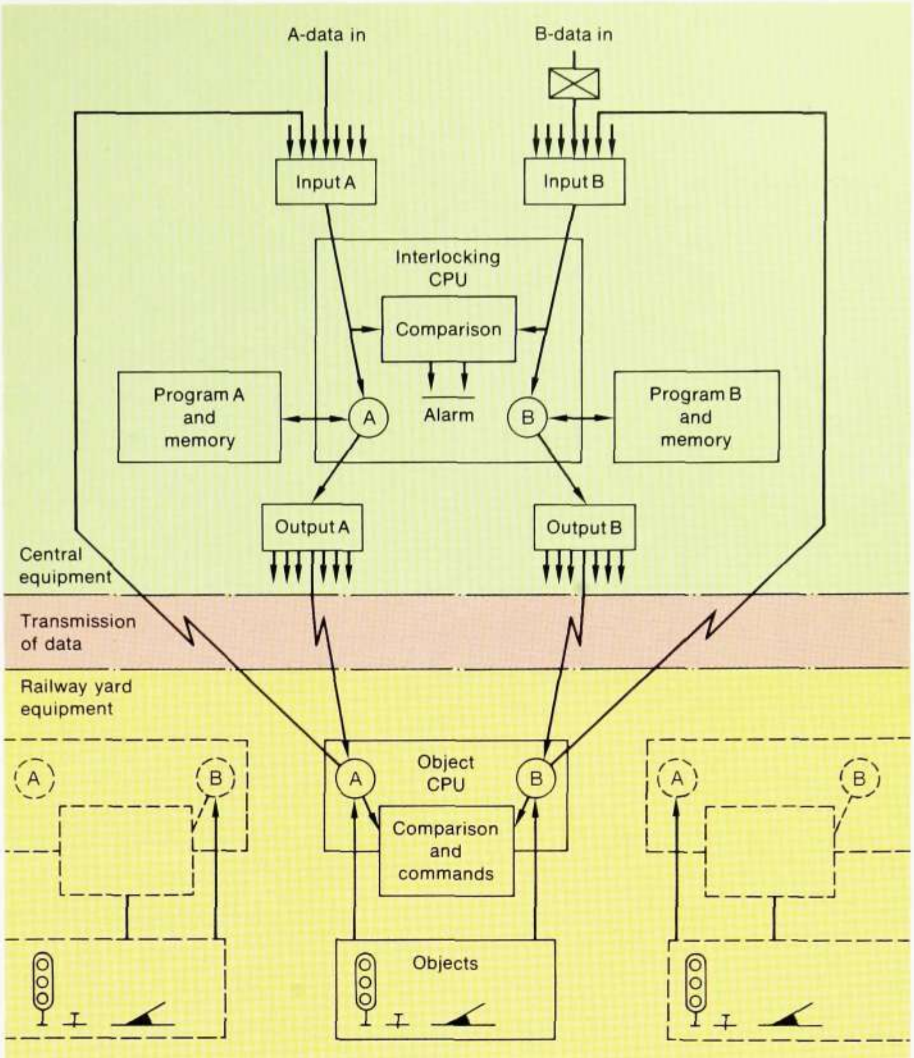


Fig. 8
The main principle of fail-safe function in ERILOCK 850

This method, together with the design rules given below, ensures the fail-safe function as regards random component faults, systematic component faults, the effects of any disturbances and software errors.

Software errors constitute the greatest problem. No way could be found of removing all software errors, and the diversity principle was therefore chosen in order to render remaining errors harmless.

Design rules

- Hardware diversity
  - Two independent calculation channels
  - Different representation and encoding of the data processed in the two channels
- Frequent comparisons of intermediate and final results
- Software diversity
  - Two independent and thereby basically different program systems, which both carry out the processing
- Each program must be so free from errors that the probability of identical independent errors occurring in both programs is negligible
- The input data is updated in each process cycle, i.e. every 0.6 seconds
- Dynamic output of data is necessary in order that the most restrictive state is not to be assumed and maintained
- Important process data is provided with the time of origin in order to ensure that obsolete data is disqualified
- A careful scrutiny ensures that the channels, including the programs, are in fact independent and that a fault cannot influence the channels in an identical way
- Increased availability by means of redundancy, in the form of a simple changeover to another pair of calculation channels.

Measures to increase the availability

The computer equipment of the interlocking system is duplicated in order to increase the availability of the system, with the non-executive computer working in the hot-standby mode. If a separate control and supervisory system is used its computer equipment is also duplicated.

In order to increase the availability of the transmission loop, the equipment has

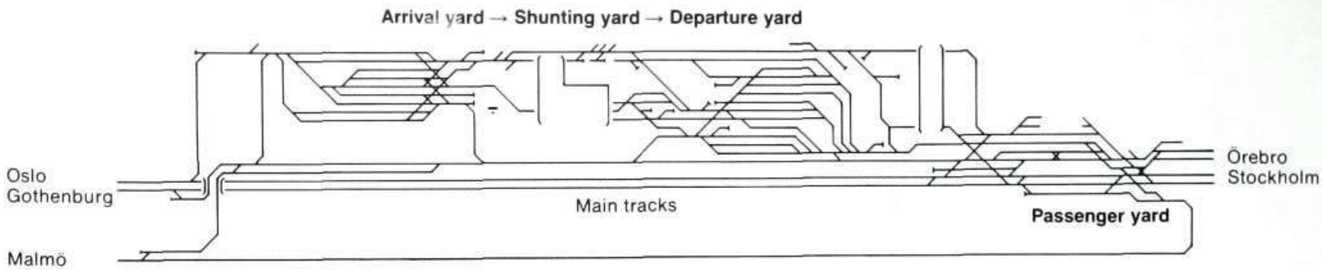


Fig. 9
Layout of the Hallsberg junction

been designed so that the concentrators can communicate with the interlocking computer even if a cable break should occur. If there is a loss of power to the concentrator it is automatically bypassed so as not to disturb the transmission in the rest of the loop.

Systems in operation

The first ERILOCK 850 interlocking system is in operation at Hallsberg, Sweden.

Hallsberg is a railway junction on the main Stockholm-Gothenburg and Stockholm-Oslo lines. It is also a through station for traffic from north to south Sweden, fig. 9.

Traffic at the junction is heavy, with 300 trains and approximately 1500 train movements per day. Up to now the traffic has been handled by means of three interlocking systems, the oldest being from 1932. Fully built out, the new interlocking system will control 200 signals, 190 points, some level crossings and platform equipment.

The station is 8 km long, which makes the new system with its decentralized object controllers particularly suitable.

The traffic is controlled from a centre with desks for a maximum of three operators. Each operator has a keyset and four colour VDUs, figs. 10 and 11. The system also includes a typewriter for the logging of various information, a terminal for technicians, and VDUs installed in the remote control centre and information centre.

The control and supervisory system, type ERICOS 715, comprises the following functions:
- keyset-operated control system
- information system with colour VDUs
- train describer system
- automatic train routing
- timetable comparison
- alarm functions
- recording of events
- transmission of information to and from other information centres.

The recording of events is used to
- facilitate maintenance
- follow up train movements
- facilitate investigations of accidents.

Installation of the Hallsberg plant

The main part of the equipment in an ERILOCK 850 system is manufactured and tested at the factory. It took only a few days to install the computers and the operators' desks.

The cabinets with the object controllers were delivered fully tested. They were placed on concrete bases in the railway yard and then connected to the cable network of the station. The Hallsberg plant will contain approximately 70 cabinets when fully built out.

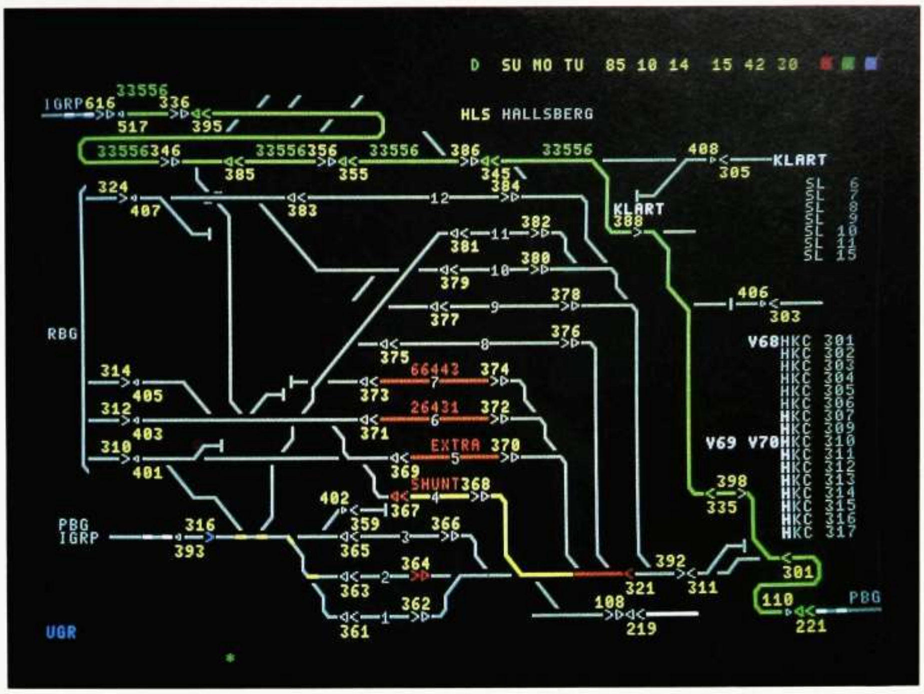
The ERILOCK 850 requires far less installation work than previous systems. Powerful means for testing the installation have contributed to this reduction.

Project planning

The installation data for the Hallsberg plant was produced with the aid of a computerized project planning system that forms part of ERILOCK 850. The project planner's work is reduced to providing installation data for a computer terminal including
- track layout (geography)
- type of railway yard object
- positions for railway yard objects
- permissible speed to or past the object
- positions for cabinets

Fig. 10
Operator's desk at Hallsberg

Fig. 11
VDU picture showing a part of the track network at Hallsberg



The data is input via a computer terminal. On the basis of this information, the project planning system creates
- the data required for the computers
- track diagrams for the VDUs
- documentation for the installation of cabinets and objects
- documentation for the cable network
- equipment lists.

Advantages of system ERILOCK 850

The ERILOCK 850 has many advantages over older technology. The main advantages experienced at Hallsberg are:
- the time required for project planning and installation is considerably shorter
- simple and efficient testing of the installation
- the main part of the installation can be tested without access to the actual railway yard
- easier to make modifications
- more traffic handling facilities for the operators
- automatic recording of events
- lower investment costs.

Fig. 12
Computers for the master control and supervisory system

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