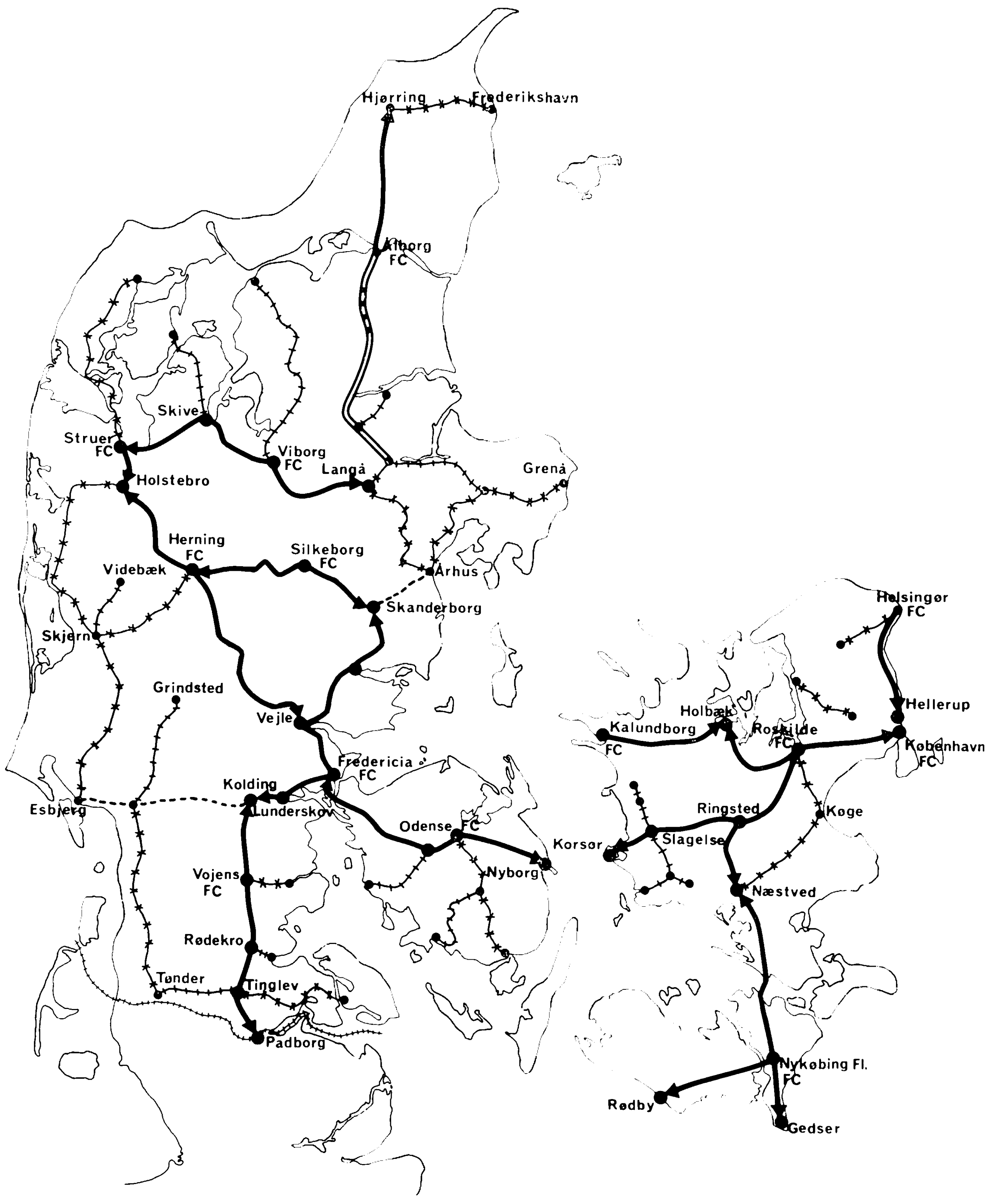
LM ERICSSON
Signalling Systems

INTERNAL TRAIN CONTROL (ITC)

DANISH STATE RAILWAYS

MI/B C 1645Ue



Network of Danish State Railways

The Railways have many advantages over other means of transportation such as higher transport capacity, safety and comfort. One common problem most Railway Administrations are faced with these days is the ever increasing investments required for buildings, rolling stock and personnel.

All over the world, the Railway Administrations try their best to fight the rising expenses with the aid of technical solutions to achieve higher capacity and reduce the personnel without lowering their standard of safety. The introduction of CTC (Centralized Traffic Control) is one phase of this process. Today nobody questions the efficiency and justification for CTC.

The experiences with CTC have been the basis for L M Ericsson´s new system ITC. The ITC (Internal Train Control) system is for remote control of one or two locomotives within a train via a transmission line extending through the train. One locomotive can be remote-controlled from another locomotive or one or two locomotives can be remote-controlled from a non-powered coach with a driving cab.

DSB (Danish State Railways) were the first Railway in the world to adopt this system on a large scale in 1972. DSB operate on the Coast Line between Copenhagen and Elsinore shuttle service on the same tracks as the other passenger traffic and the goods traffic. The schedules of the shuttle service have grown continually and finally the time to shunt the locomotive from one end to the other of the train at the terminal stations made it impossible to increase the capacity.

L M Ericsson has up to now delivered about 75 ITC units and is in the process of delivering another 12 ITC units intended for installation in locomotives and non-powered vehicles with driving cab, hereinafter referred to as driving coaches.

SAVING OF EXPENSES IS POSSIBLE

Most Railways have a need of running certain trains with the driver placed somewhere else than in the locomotive. The nature of this need may vary, as illustrated by the following examples:

Shuttle service

Suburban trains are often operated in shuttle service. In shuttle service the train changes direction at the terminal station without being turned around. Except in multiple unit operation (several motor coaches coupled together to form a train), shuttle service requires one locomotive at each end of the train or, if only one locomotive is used, this locomotive must be shunted from one end of the train to the other at the terminals.

To use two locomotives per train in shuttle service is of course uneconomical because of poor utilization of locomotives, but it saves time. To use only one locomotive requires more time, ties up a larger portion of the yard and requires additional personnel for shunting, which makes this method expensive.


Fig. 1


Fig. 2


Fig. 3


Fig. 4

A more favourable alternative is to use a so called driving coach equipped with control equipment similar to the lococontrols. With this driving coach placed at one end of a train and with remote control of the locomotive from the driving coach, the driver simply moves to the other driving cab when required. This saves time and no extra personnel is needed. (Fig. 1).

Heavy transports

With very heavy transports it may be necessary to distribute the weight of the train, considering the maximum load limit for the tracks, bridges and couplings. This could be done by splitting the transport into two trains, but this of course would decrease the available capacity of the line.

A better alternative would be to use two locomotives, one at the head end and the other located in the position for optimum weight distribution. If necessary, this may be carried a step further by using a driving coach at the head end and the two locomotives located in different positions for optimum weight distribution. These solutions are feasible with remote control of one locomotive from the other and with remote control of locomotives from the driving coach (Figs 2 and 3).

Strain on the couplings

Especially with heavy transports, consideration must be given to the heavy strain on the couplings. This strain may be reduced by suitable distribution of the locomotives in the train, made possible by remote control of the locomotives from a driving cab at the head end of the train (Figs 2, 3 and 4).

Two trains on the same route

When two trains are scheduled to travel over the same route for a considerable distance, it may be advantageous to combine the trains and have one driver operate both from the cab at the head end of the combined train to the junction where the trains are to be split up. From the junction, the trains will then proceed on their separate routes to the final destinations, each with its own driver. The separation of the trains at the junction consumes very little time, since no shunting is necessary. (Figs 2, 3 and 4).

A similar need for a rapid splitting up of trains exists also at the ferry terminals (Figs 2, 3 and 4).

From the above it is readily seen that a great need exists for a system with facilities for controlling locomotives from a different driving position on the train.

THE COMMUNICATION SYSTEM

Direct wire control

A natural way to transmit controls and indications is to use direct wire connections throughout the entire train. However, one obvious disadvantage with this would be that DSB would need about 27 wires just to control the normal operation of the locomotive. This is an expensive solution and requires extremely good electrical couplers between waggons and locomotives. Furthermore, such a system would not be adaptable to the new type of automatic coupling which will be standard in Europe in the near future.

Multiplex system

A better alternative than direct wire connection is a multiplex system which requires only a few common wires for transmission of all information. Other advantages with this are fewer possibilities for contact failures and a low transmission power level on the line wires. Moreover, the regulations issued by the UIC/ORE for the new automatic coupling only allow a few wires for transmitting information between the vehicles in a train. Due to the transmission power level, more consideration must be given to the mechanical strength than to the electrical properties when selecting the wire sizes.

Alternatives to direct wire transmisson

Two types of multiplex systems may be used for wire transmission, frequency or time division multiplex.

Frequency division multiplex

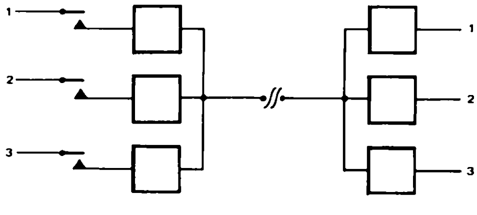


Fig. 5 Frequency division multiplex

Frequency division multiplex is the process of transmitting information in parallel over a common path. A different frequency band is employed for each piece of information. Many frequencies are transmitted simultaneously. Such a system provides rapid communication between the sender and the receiver. A disadvantage with this system is that the amount of information capable of being transmitted simultaneously is relatively limited plus the fact that it is somewhat sensitive to interferences. Furthermore, it requires a transmission line of a rather high electrical quality.

Time division multiplex

With time division multiplex, the sender will, in a certain short time interval, scan the condition to be transmitted on the line, such as one of two possible positions of a relay contact.

In the receiver end a corresponding contact will respond simultaneously by assuming the position of the contact in the sender end. In the subsequent short time interval, the next condition is scanned.

In this manner, the system scans all the conditions to be transmitted in a cyclic pattern and transmits them on the line in separate subsequent short time intervals. This system is less sensitive to interference and does not require a transmission line of such a high electrical quality as the frequency division multiplex system.

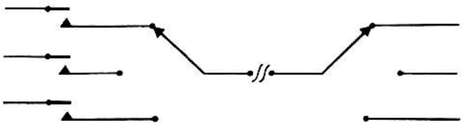


Fig. 6 Time division multiplex

Time division multiplex is used with ITC

A comparison between a frequency and a time division multiplex system shows that the latter is more reliable and can be more readily expanded to handle possible future additions. In order to satisfy their own stringent but justified demands on safety and flexibility, DSB chose L M Ericsson´s time division multiplex ITC-system which can be easily expanded.

LM ERICSSON'S ITC SYSTEM

When designing the new system "Internal Train Control" ITC, L M Ericsson drew upon their vast experience with electronic CTC-systems for railway signalling. ITC is actually CTC applied within a train.

L M Ericsson´s ITC is intended for remote control of one or two locomotives in a train. One or both locomotives may be controlled from one of the locomotives or from a driving coach with control equipment.

ITC does not only permit remote control of the locomotive, it also provides last vehicle detection to assure that the train is intact. Special receivers can be mounted in each car for the remote control of lights and doors etc from the driving cab. Such receivers can be of a much simpler design than the unit in the locomotives or driving coaches. These receivers are controlled over the same pair of line wires as used for the remote control of the locomotives.

To operate the train the driver uses the ordinary controller handles in the locomotive or in the driving coach for speed regulation, driving forwards or reverse, etc.

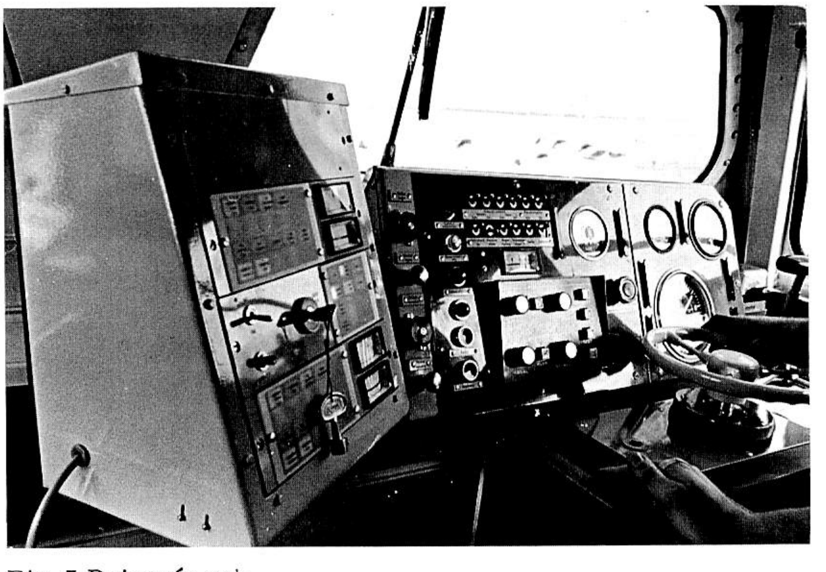


Fig. 7 Driver´s cab

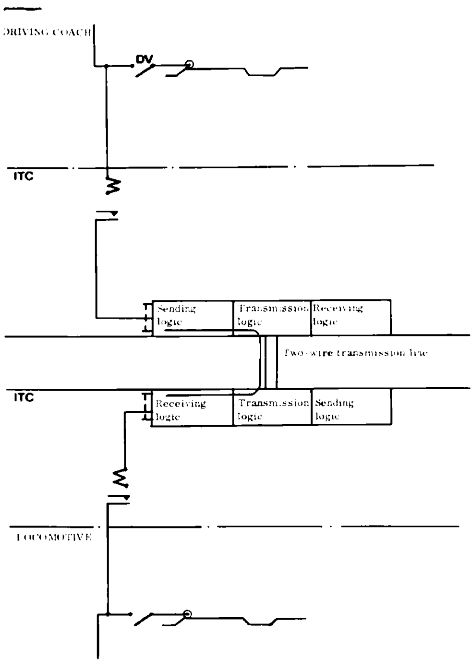


Fig. 8

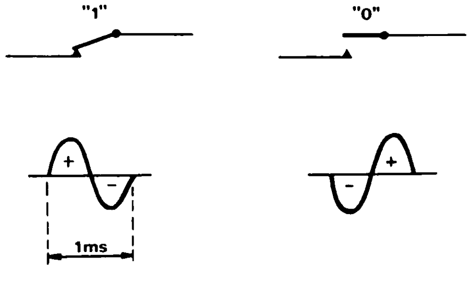


Fig. 9 Ones and zeroes

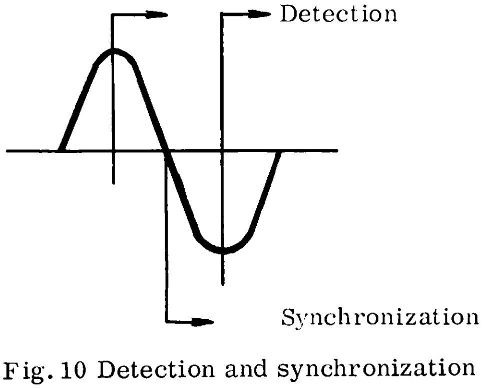


Fig. 10 Detection and synchronization

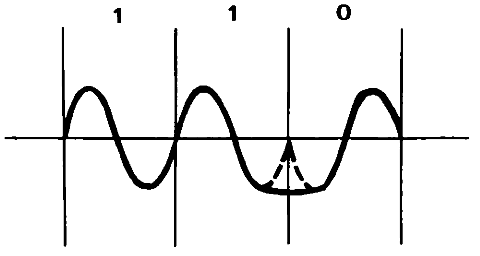


Fig. 11 Pulses on the line

Each driving command is transmitted to both locomotives. The conditions on the locomotives are continuously monitored and are displayed on an indication panel suitably located within the unobstructed view of the driver.

Thus the driver has in front of him at all times the same information from the locomotive remotely controlled by him as he would have if he was onboard the cab of that locomotive. The controls and indications are transmitted so fast that a given command is executed in the manned and unmanned locomotives almost instantaneously.

The purpose of the ITC system

The basic idea is to transmit information in both directions between a driving coach and one or two locomotives.

As it appears from fig. 8, the ITC units in both the driving coach and the locomotives are capable of transmitting as well as receiving. The system thus provides communications in both directions. In order to avoid interferences from the high currents in the locomotives, interface relays are used between the ITC and vehicle equipment on the inputs as well as on the outputs.

The electronic transmitting system

Phase shift keying is used for transmission. The system transmits 1,000 bits per second. One "bit" consists of a positive and a negative pulse which together occupy one millisecond.

All information is transmitted as "1" or as "0". "1" (a closed contact) is represented by a positive followed by a negative pulse, whereas a "0" (an open contact) is represented by a negative followed by a positive pulse.

At the receiver end the two pulses are used for detection of the bit. The zero-passage between the two pulses is used for such things as synchronizing the clock, the operation of which may be compared with the operation of a rotating selector (see above).

On the transmission line, the pulses occur in various combinations so as to form frequencies between 30 to 2,000 Hz. These pulses are combined into words.

Each word consists of 9 bits, 8 out of which carry the actual message while the characteristic of the 9th bit depends upon the number of ones among the 8 preceding bits. The system is designed so that the word will always contain an even number of ones, consequently if the preceding 8 bits contained on odd number of ones, the 9th bit becomes a one. The 9th bit is referred to as the parity bit. To guard against faulty transmission the following two essential checks are carried out at the receiving end.

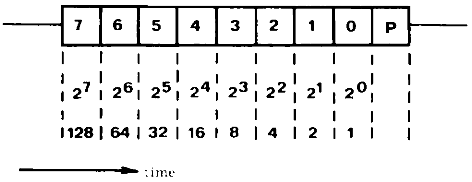


Fig. 12 Transmission word

Each character must consist either of a positive pulse followed by a negative pulse ("1") or a negative pulse followed by a positive pulse ("0"). The word must contain an odd number of ones.

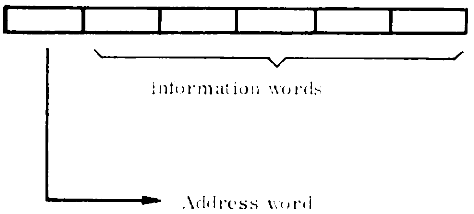


Fig. 13 Message of five message words

The words are combined into a message. The length of a message may vary and in the ITC application 6 or 2 words are used. The first word contains the address and the subsequent ones the actual message. One message may e. g. contain a command to start the train. This message will contain as many bits in one or several words as will be required to start up the train.

The messages are combined into a cyclic transmission sequence referred to as a transmission cycle. A transmission cycle may contain a different number of messages.

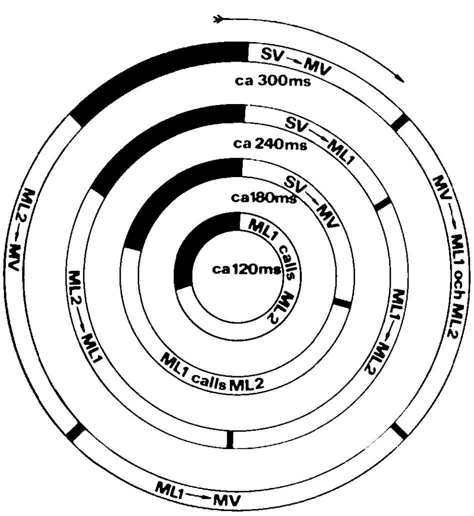


Fig. 14 Examples of transmission cycles with ITC

The longest transmission cycle is 300 milliseconds and is required when two locomotives are controlled from one driving coach. The 300 ms cycle also contains a last vehicle check. The shortest cycle time occurs when the train is driven from the one and only locomotive in the train.

Authorization by key

When the driver turns an Autorization key on the transmission panel, the direction of movement is determined. The ITC unit, where the key was turned, transmits a d. c. current towards the rear of the train via the one or two locomotives to the last vehicles.

The last vehicle responds by transmitting pulses to the driver position. Thus each transmission cycle is initiated by the last vehicle.

Locomotive equipment

The ITC equipment in a locomotive is designated ML. Each end of the locomotive contains a transmission panel and an indication panel for indications from the other locomotive. The regular driving controllers of the locomotive are connected to the ITC transmitter, which transmits controls to the second locomotive, thus a given control is executed almost simultaneously in both the locomotives.

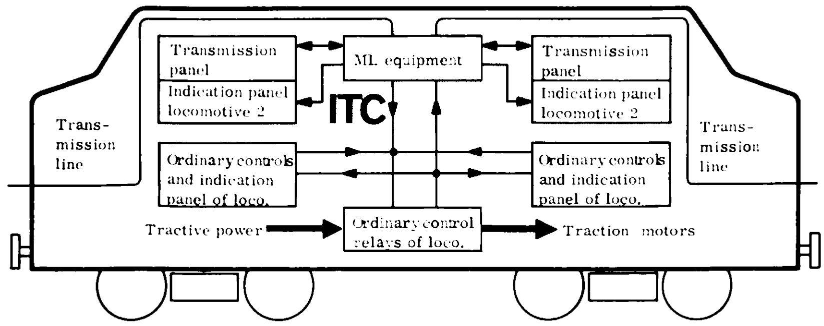


Fig. 15 Locomotive with ITC equipment

Driving coach equipment

The ITC equipment in the driving coach is designated MV. This equipment includes such peripherals as a transmission panel and an indication panel for display of indications from locomotives 1 and 2. The controller handles in the driving coach are connected to the transmitter which sends the controls. The transmission line passes through the driving coach via the MV unit.

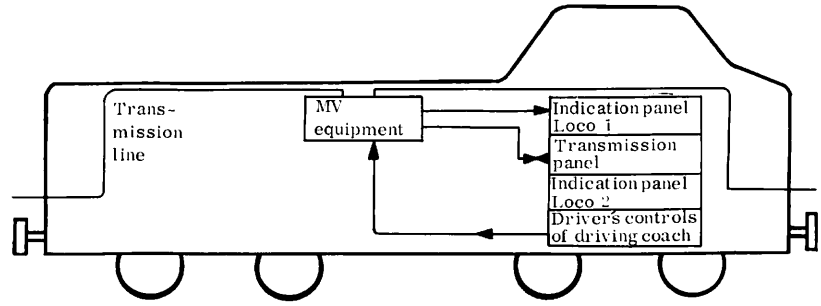


Fig. 16 Driving coach with ITC equipment

The driving coaches used by DSB are designed and manufactured by the Skandia company of Randers (Denmark) in close collaboration with DSB.

An MV unit installed in a driving coach occupies very small amount of space as can be seen from fig. 19.

Electrical design

Integrated circuits of type DTL and TTL are used together with discrete components such as transistors, resistors, diodes and transformers. All semiconductors are of silicon type.

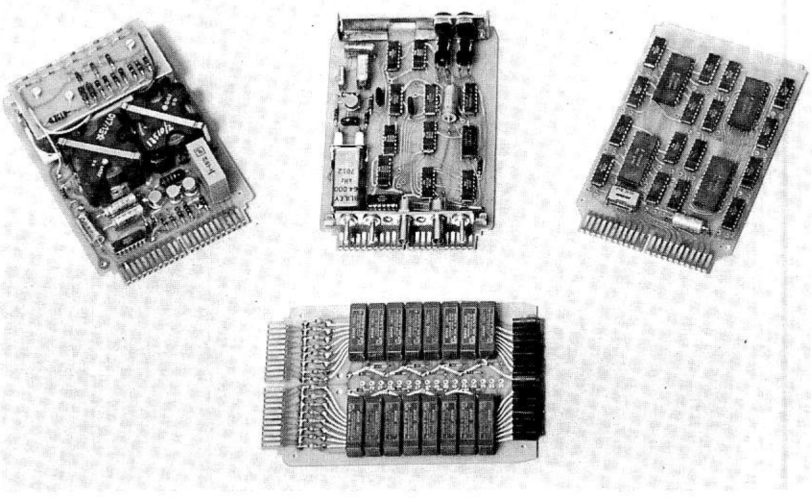


Fig. 17 Different types of printed circuit boards

The electronic components are mounted on a printed circuit board. Long life light emitting diodes and reed relays are mounted on some of the boards. Fork type, gold connector contacts are used on the boards to assure proper functioning with the severe vibrations encountered on the locomotive.

Mechanical build-up

The electronic units are mounted in two shelves on a rack. The rack is suspended on rubber shock absorbers in a case with a weathertight cover. The electronic cards are mounted in cassettes. Each cassette is equipped with a registration device to prevent it from being inserted in the wrong place. The rubber suspension serves as shock-absorbers. The equipment is subject to a shock test of 100 x 2 x 3 impacts of 5 g.

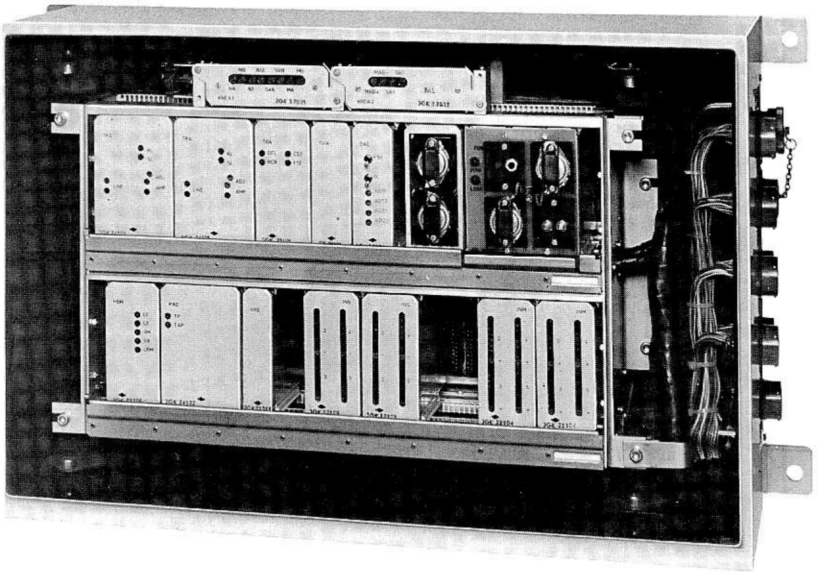


Fig. 18 ML unit for locomotive

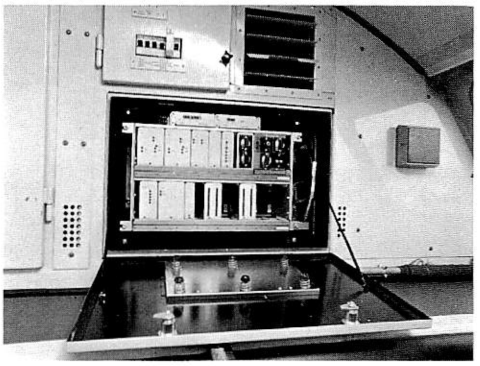


Fig. 19 MV unit in a driving coach

The case is watertight to prevent water and oil from seeping into the case. Captive plug connectors with bayonet locking are used where external cables are connected to the equipment.

The equipment is in no way affected by the temperature and humidity prevailing on the locomotives.

System security

In case of short circuited or broken line wire between the manned driving coach and an unmanned locomotive or between a manned and unmanned locomotive an emergency brake application is initiated in the unmanned locomotive.

A transmission fault which prevents reception of a dead-man´s handle-check activates the emergency brakes when the speed exceeds 20 km/h.

As explained earlier each word of the transmitted message has certain prearranged basic characteristics such as that a bit always consists of a positive followed by a negative pulse or vice versa and each word always contains an odd number of ones (odd parity check). These basic characteristics must be present in the received signal, otherwise the signal is rejected. It can actually be shown that with this precaution, the signal can be subjected to interferences which would alter it in up to four different ways before it is recognized as a valid but faulty signal, i. e. the signal has a hamming distance of four. With a hamming distance of four, the chance of ever getting a wrong side failure is extremely remote.

Voltages

The control units are in DSB´s locomotives fed by 65 V d. c. In the driving coaches the feed voltage is 24 V d. c. from a d. c. /d. c. converter. Voltage variations of ± 15 % can be tolerated. The power to the control units will automatically be switched on when the Authorization key is turned on in any of the driving cabs.

CONCLUSION

In developing the new ITC system DSB and L M Ericsson have in close collaboration utilized L M Ericsson´s experience with railway signalling. The equipment has been installed and service tested in DSB´s locomotives and coaches. It is beyond all doubts that DSB´s decision to introduce ITC will contribute to a better utilization of locomotives, waggons and personnel and a subsequent reduction of operating expenses.

The equipment described in this paper is but one element in a complete line of modern railway signalling systems engineered and produced by L M Ericsson.
This complete line includes relay interlocking, automatic and tokenless block systems, and centralized traffic control with such adjuncts as train describers with or without automatic route setting features based on relay logic or computer technique.
We also specialize in such systems as automatic train control, internal train control and marshalling yard equipment.
Please contact our local representative with your specific questions or write direct to us.

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