Multiple Radio Remote Control of Locomotives in Train Sets at Deutsche Bahn AG

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Abstract

One of the goals of freight railways is to improve the economics of their overall system by making greater use of technology, right up to full automation, and by creating flexible production systems.

In a pilot project entitled "Multiple radio remote control of locomotives in train sets" (FFZ), DB AG's Research & Technology Centre in Munich (FTZ) is investigating the working of long and heavy freight trains with several locomotives distributed throughout the train.
Via a radio link, the FFZ system connects up to five groups of tractive units, which are all remote-controlled and monitored by a single driver at the head of the train.

As well as delineating the objectives behind the pilot project, this paper portrays the architecture of the multiple radio remote control system on the Class 232 locomotive, sets out the components and interfaces involved, and describes the course of testing.

1. Introduction

As a key means of remaining competitive in the marketplace, DB Cargo AG is aiming to intensify automation and adopt flexible, economic, demand-responsive and customer-focused modes of production. One interesting mode of production and operation involves multiple radio remote control of locomotives formed in a train, a system whereby several individual trains, each with their own locomotive, are joined to form a larger train remote controlled by radio from the leading locomotive.

In late 1997, DB Cargo AG commissioned Deutsche Bahn AG's Research & Technology Centre in Munich to run a pilot project entitled "Multiple radio remote control of locomotives in train sets". With the participation of the Knorr-Bremse and GE-Harris Harmon companies, a start was made in the summer of 1998 on developing and design-engineering the appropriate radio remote control unit for the Class 232 diesel locomotive. Following the re-engineering and commissioning of two locomotives, testing in homogeneous train formations commenced in the year 2000.

2. Objectives and Requirements

2.1 Objectives

Multiple radio remote control of locomotives in train sets has been practised by American freight railways as a simple and effective means of operating superlong freight trains for some years now. Besides improving the economics of railfreight traffic by

- cutting train-path costs
- saving on traction staff
- reducing the high input associated with forming and splitting up trains
- allowing demand-responsive, flexible production,

multiple radio remote control of locomotives in train sets also enables DB Cargo AG to raise capacity by

- running long freight trains in the brake position "P"
- running heavy trains (coal, iron and steel products, building materials, chemicals)

and constitutes a key contribution towards

- implementation of the "Train Coupling and Sharing" (TCS) concept.

With the distribution of propulsion and braking power within the trainset being optimised, multiple radio remote control of locomotives in train sets also results in a

- reduction of axial forces impacting on the train
- reduction of braking distance
- reduction of diesel and electricity consumption.

2.2 Requirements

The basic requirements for multiple radio remote control are:

- radio remote control of (driverless) slave locomotives from a leading or master locomotive (in which a driver sits) for the purpose of setting tractive effort and brake power (pneumatic and electrodynamic brakes) and of controlling other functions (e.g. sanding, engine ON/OFF, master-switch and pantograph control etc.)
- radio-controlled driving and braking of locomotives in the train giving consideration to the permissible load limits for their draw and buffing gear as well as to dynamic axial loadings
- status data for and faults on the slave locomotives to be reported back by radio to the master locomotive
- operation with regular wagons without any additional devices
- radio remote control of up to five individual trains, each with their own locomotive
- identical components for all locomotives, allowing these all to be deployed as either slave or master tractive units
- operation with through main brake pipe
- safe operation in the event of loss of signal, failure of the main brake pipe or train separation.

3. Principle of multiple radio remote control

The concept underlying "Multiple radio remote control of locomotives in train sets" is as shown in Fig. 1. Each unit entering the marshalling yard has already been configured as a complete train and fitted with multiple radio remote control. Once the incoming loco-hauled trains have been combined to form a larger single train, the radio remote control on the slave locomotives is activated, with radio contact being established between the master and slave locomotives. Drivers on the remote-controlled train sections are able to leave their locomotives, since the multiple radio remote control system operated by the driver on the leading locomotive takes over all the requisite driving and braking functions on the slave locomotives.

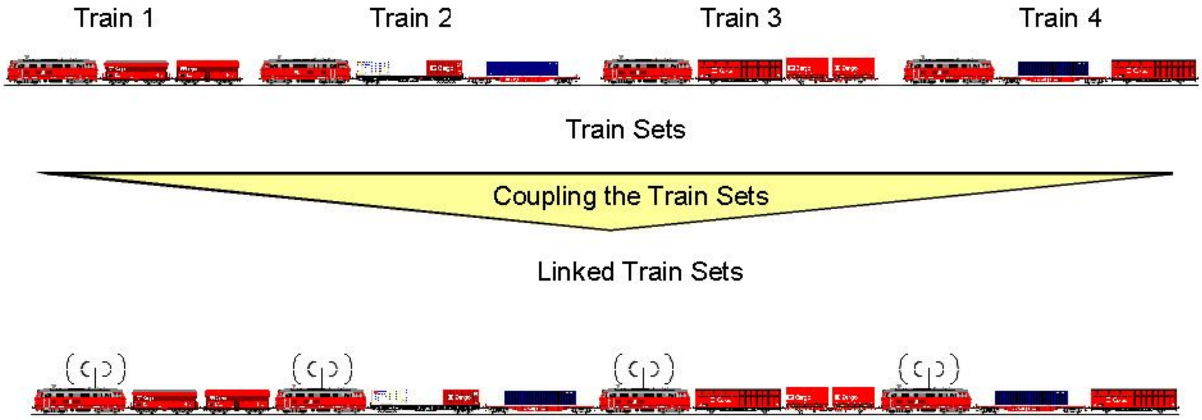


Figure 1: Basic concept of multiple radio remote control

As is the case with the American freight railways and SBB /1/, multiple radio remote control of locomotives in train sets was effected in this pilot project on the basis of a through main brake pipe (TMBP). With the through main brake pipe concept, the main brake pipe (MBP) on the individual trains is connected end-to-end. A pressure drop in the MBP causes the brakes to respond throughout the entire train formation.

4. Architecture and functioning of FFZ on Class 232 locomotives

The FFZ system establishes a radio link between the locomotives formed in a train, allowing driverless slave locomotives to be worked by remote control from a master locomotive. Thus, the driver of Class 232 traction is able to control propulsion, the electrodynamic brake, the indirect-action train brake and the direct-action traction-unit brake on all locomotives in the train (Fig. 2).

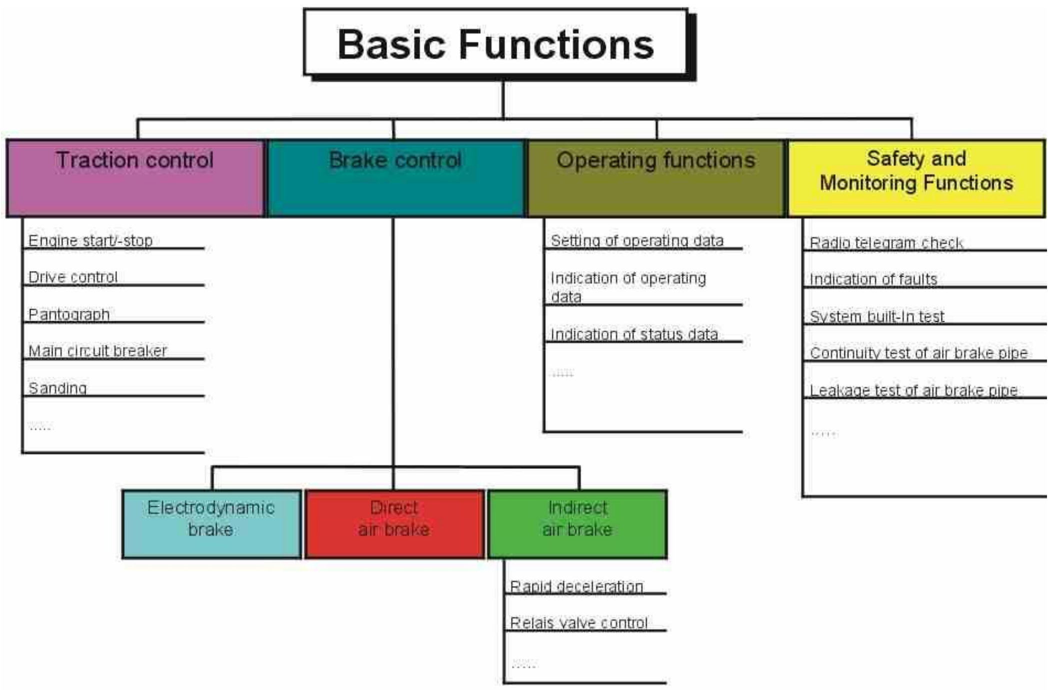
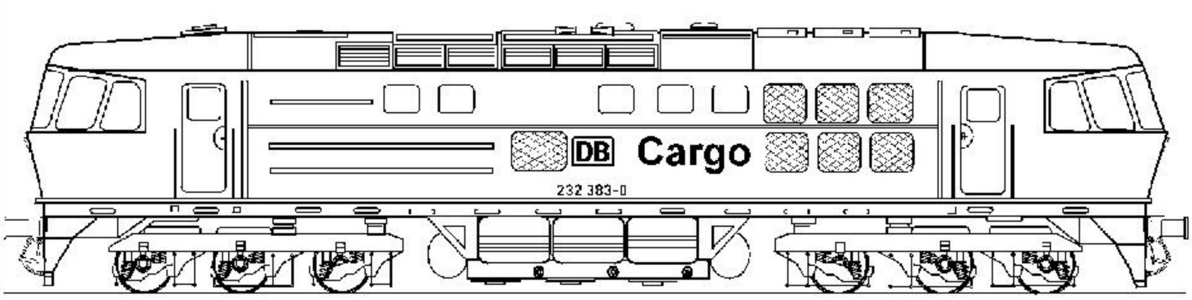


Figure 2: Basic functions of multiple radio remote control

Two Class 232 diesel locomotives were suitably modified for the purposes of the “Multiple radio remote control of locomotives in train sets” pilot project. Between 1973-1982, the former DR company procured more than 500 Class 232 locomotives. The key technical data for Class 232 are summarised in Table 1.



Length above buffer	mm	20.820
Mass	t	120
Wheel set sequence		Co‘ Co‘
Inservice data		1973-1982
Quantity		511
Manufacturer		Lokfabrik „Oktoberrevolution“ Woroschilowgrad
Engine type		5 D 49
Engine manufacturer		Kolomna
Max. power	kW	2200
Nominal speed	U / min	1000
Transmission system		diesel / electric
Max. speed	km / h	120
Max. starting traction	kN	340
Brake type		KE - G P P2 R + E - mZ

Table 1: Principal data for the Class 232 loco

The standard drive and brake control equipment for the Class 232 locomotive is as follows:

- conventional relay-based train control (110 V)
- pneumatic brake operated via driver’s brake valves
- contactor control of the electrodynamic brake
- electromechanical wheel-slip prevention
- mechanical wheel-slide prevention that does not affect the electrodynamic brake.

To safeguard the system functions for multiple radio remote control and harmonise the various component interfaces, it was necessary in addition to the LOCOTROL basic components for Class 232 vehicles to effect modifications and additions to the drive and brake control system:

- zero-potential, interference-proof integration of LOCOTROL III components by means of a relay interface
- fitting of an electrical compressed-air brake control device for exact conversion of electrical variables into pneumatic pressure values
- fitting of an electronic slip/slide control device and the associated electronic engine governor (important in multiple radio remote control especially for self-supporting and reliable functioning of the slave locomotives)

- installation on the driver's desk of a special operating and display device (control panel) required for multiple radio remote control.

Fig 3 illustrates the functional architecture of the overall "multiple radio remote control" system on Class 232 locomotives and the individual components.

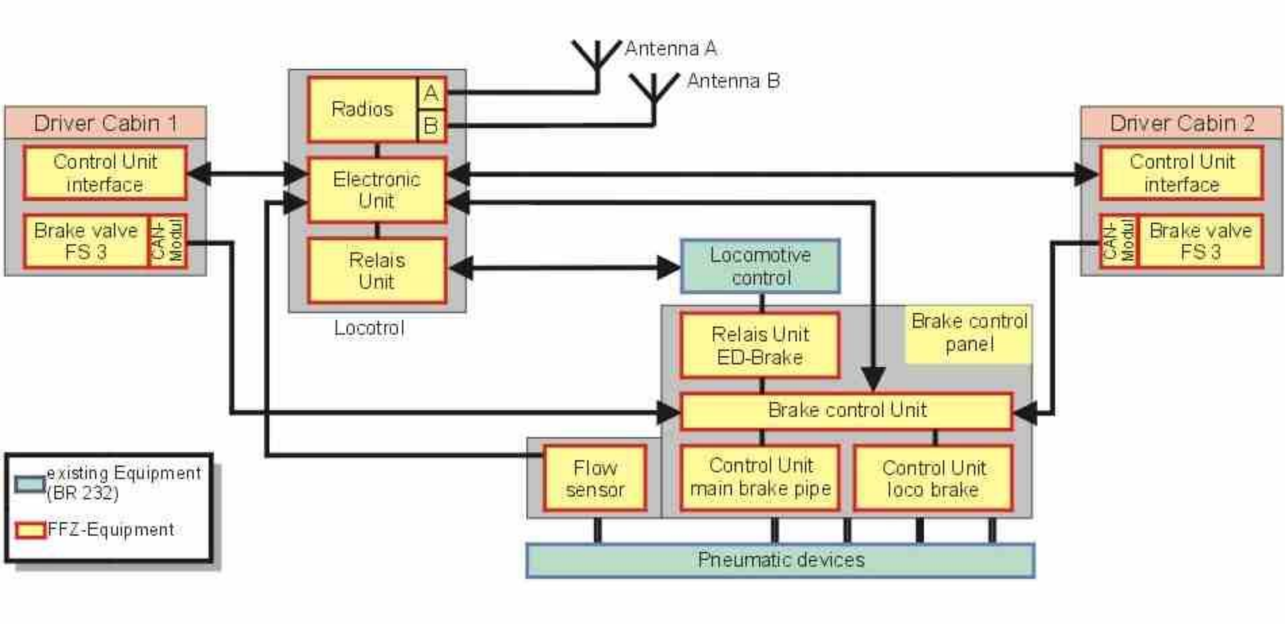


Figure 3: Functional architecture of multiple radio remote control system

4.1 Control panel

At a control panel fitted in every cab that takes the form of a multiline alphanumeric display with operating keys, modes of working can be selected for the train as a whole and for the slave locomotives individually, and system commands and settings can also be entered. The control panel also serves to display status data, operating parameters, alarm messages and system functions as well as to trigger and display system and safety tests.

4.2 Radio remote control system

The "LOCOTROL III Distributed Power" system by GE Harris Harmon, a radio-based communications system for multiple traction in train formations, is being used to deliver the requisite radio-engineering and system-control capabilities.

The transmitter/receiver unit operates with two channels. Thus, it is possible to automatically switch channels in the event of the transmitter/receiver failing. Each slave-locomotive transmission unit additionally serves as a repeater for all radio telegrams from the master locomotive. ARCOR has temporarily assigned 419.73 MHz as a transmission and reception frequency for the testing phase. The maximum transmitting power is 0.5 W. Two antennae are fitted to each locomotive to enhance availability.

The LOCOTROL electronic unit constitutes the central control computer for the multiple radio remote control system.

The interface between the control component of the LOCOTROL electronic unit and the output component of the existing Class 232 loco control system is provided by the LOCOTROL relay unit.

4.3 Brake control system

The D5 driver's brake valve on Class 232 vehicles, used to specify the set point for the indirect-action train brake and the electrodynamic brake, has been replaced by an FS3-1 driver's brake valve so as to simplify the interface (CAN bus) to the brake control device. The microprocessor-based brake control device serves to actuate the indirect-action train brake, the direct-action loco brake and the electrodynamic brake. The relay unit forms the interface between the control component of the brake control device and the output component of the ED brake control system already in place on the Class 232 locomotive and conveys all commands relating to the ED brake to the existing loco control system. The main brake pipe is electropneumatically controlled via a brake device table. The set point for the non-automatic, direct-action compressed-air brake on Class 232 vehicles is transmitted by radio from the auxiliary valve at the driver's desk via the LOCOTROL system. A flowmeter is required to ascertain recharging patterns in the main brake pipe, e.g. continuity testing, on the individual locomotives.

Fig 4 shows how multiple radio remote control equipment is arranged on Class 232 vehicles.

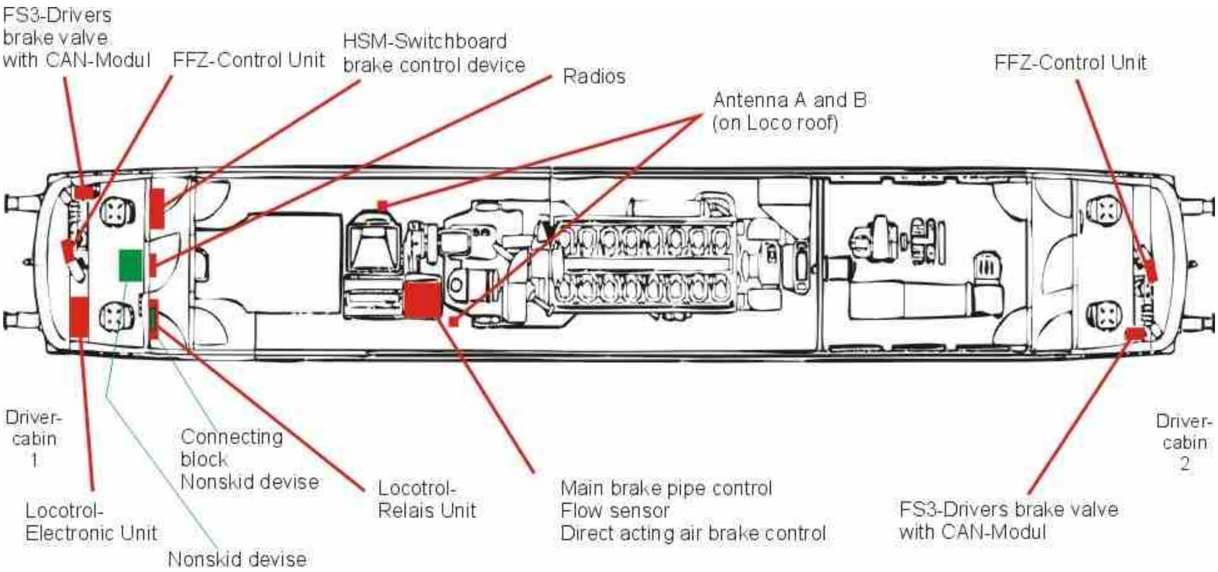


Figure 4: Arrangement of FFZ components on Class 232 vehicles

5. Field trials

The multiple radio remote control system underwent several phases of operational testing in the course of the pilot project.

In Phase I, the system was tested on the large UIC brake test rig operated by Knorr-Bremse. Here, the LOCOTROL components were set up and integrated onto the brake test rig together with the brake equipment as actually configured on the Class 232 locomotive. System integration tests for a simulated train 700 m in length overall combined an examination of the interworking of the individual components, signal transmission, time response, identification of axial dynamics in the train formation, and reactions in the event of a fault.

In Phase II, static locomotive and train-formation tests were carried out on the Class 232 locomotives fitted out for multiple radio remote control, with DB AG wagons being used. These tests were carried out on DB premises and constituted a repetition and continuation of system integration tests on the UIC brake test rig under real conditions. The train, which consisted of two instrumented train sections each 350 m long, was not moved at this stage, however.

Phase III involved dynamic locomotive and train-formation tests. These tests on two instrumented train sections, which were conducted on selected DB AG lines, were designed to assess the system under actual operating conditions.

On the basis of measurement results, it was possible to carry out further simulations required for the production of an external expert's report and for approval by the Federal Railway Office EBA.

Following successful approval by the EBA at the end of 2000, DB Cargo AG initiated commercial trials in heavy gravel traffic on the Eilenburg-Ost/Zella-Mehlis line (Fig 5), the outcome of which will form the basis for full introduction of multiple radio remote control.

Figure 5: Field trials in heavy gravel traffic on the Eilenburg-Ost/Zella-Mehlis line

6. Outlook

Multiple radio remote control of locomotives in train sets constitutes a straightforward, efficient and forward-looking mode of operation for railfreight traffic at DB Cargo AG that, besides improving production economics by cutting outlay on train-paths, also allows savings to be made in terms of human resources whilst increasing capacity through the running of long and heavy freight trains.

Preliminary studies have been carried out on equipping electric locomotives with multiple radio remote control, and the adaptations required. Following a systems decision by DB Cargo, the necessary studies will be continued.

References

/1/ SBB:
Funkferngesteuerte Schiebelokomotiven bei den SBB.
Eisenbahn-Revue 3/1998.

Abbreviations

DB	Deutsche Bahn
DR	Deutsche Reichsbahn
TMBP	Through main brake pipe
FFZ	Multiple radio remote control of locomotives in train sets
MBP	Main brake pipe
LOCOTROL	Multiple radio remote control system supplied by GE-Harris Harmon

Figures and Tables