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BRITISH RAILWAYS BOARD



RADIO ELECTRONIC TOKEN BLOCK SYSTEM

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SPECIFICATION NO. BR 1654

VHF BAND III REPEATER BASED RADIO

ELECTRONIC TOKEN BLOCK SYSTEM

FOREWORD

This specification is issued by the Director of S & T Engineering, British Rail, Materials Management Group, Room 1103 Rail House, Gresty Road, Crewe, CW2 6EA; from whom further copies may be obtained.

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Where the Tenderer is unable to comply with sections of this Specification, full details must be given, quoting the relevant paragraph number(s).

A unit price for all items requested in the Schedule must be provided.

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1. REFERENCES

British Railways Specification	967 -	Railway Signalling apparatus - environmental conditions.
British Railways Specification	1609 -	National Radio Network - Band III. Overlay System.
British Railways Specification	1851 -	Band III RETB equipment.
British Railways Specification	1894 -	Radio Aerial System - including Towers and Masts
Railway Industries Association Specification BRB/RIA 13		General Specification for Electronic Equipment
Dept of Trade & Industry (D.T.I) Specification MPT 1317		The code of practice for transmission of data over 1 and PMR.
	MPT 1323	Angle modulated radio equipment for use at base and mobile stations in the PMR service operating in the band 174-225 Mhz
	MPT 1327	Common Signalling protocol for land PMR operators in the band 174-225 Mhz
	MPT 1401	Radio Regulatory Specification for analogue and digital private fixed radio relay equipment operating in the band 12750 13250 Mhz.
British Standards	4200 -	Guide on the reliability of electronic equipment and part used therein.
	6301 -	Safety requirements for apparatus for connection to the British Telecom network.
	6305 -	General requirements for apparatus for connection to the British Telecom public switched network.
	9000 -	General requirements for electronic components or assessed quality.
Post Office Technical Guide No. 25	-	Transmission design requirements for the connection of privately owned and maintained equipment to British Telecom circuits.
Post Office Technical Guide No. 26	-	Requirements for the electrical protection of British Telecom maintained plant from privately supplied and maintained apparatus.

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Where this specification requires reference to British Standards, BR & RIA specifications, EIA recommendations and D.T.I. specifications the latest issue and amendments shall apply, unless specially stated. Where confliction exists between any of the above specifications or standards the more stringent condition is deemed to apply.

2. SCOPE

This specification describes the general requirements of the radio and associated equipment to be employed on British Rail Repeater Based Band III Radio Electronic Token Block Systems.

- 2.1 The specification details the operating principles, the equipment requirements and quantities for the scheme, and such other information so as to enable the manufacturer to supply equipment which will satisfactorily fulfil the operational requirements of the Radio Electronic Token Block System.
- 2.2 This Specification defines which parts of the equipment are to be supplied by the Manufacturer and which are to be provided by BR. It defines the information to be provided between BR and the Manufacturer.
- 2.3 This Specification defines how the equipment is to be divided up into modules, how they are to be connected and the interfacing between them.
- 2.4 This Specification defines which parameters have been given definite values and which ones are to be defined by Agreement between BR and the Manufacturer.
- 2.5 This Specification lays down the procedures to be carried out during fulfilment of the Contract and the Testing for Type Approval and Inspection.

3. GENERAL SYSTEM DESCRIPTION

In order for a railway train or engineers' rail mounted equipment to proceed safely along a section of track without the risk of collision, various 'signalling' methods are employed. One of them being the 'Single Line Key Token' system, where possession of the only Token for a section of track enables the holder sole access to that track.

This requires 'token instruments' at each end of the section and links between them in order to form an 'interlock' which prevents false issuing of tokens.

A modern development of this principle is Radio Electronic Token Block (RETB).

An RETB scheme has a Solid State Interlocking (SSI), which is processor based, centrally located in a Signalbox and operated by a signaller. This controls the issue of tokens, in the form of secure data telegrams, to trains via a chain of fixed radio stations, these being linked to each other by cross-channel repeaters. The link between the Signaller/SSI and fixed stations will be by either:-

- (i) A fixed mobile located at the Signalbox, or
- (ii) A 4 wire landline to one of the fixed stations, or
- (iii) A 4 wire landline to a remote mobile and
- (iv) Dial-up landline to a fixed mobile linking into the chain of fixed stations.

The system shall carry not only R.E.T.B. data telegrams but also speech between all users, (i.e., Signaller to/from mobile, mobile to mobile) and data for other purposes, e.g., Fringe Signalboxes, Level Crossings, point control, fixed station testing and alarms.

The mobiles (to B.R. Specification 1609) will be mounted in various types of locomotive, multiple unit, rail and road engineers' vehicles.

The mobile will be coupled to an RETB Token Cab Display Unit (CDU).

4. System Operation and Facilities

- 4.1 This section describes how calls will be progressed through the fixed system the layout of which is shown in Drawing T4524. Details of control telegrams are given in BR Specification 1609. It should be noted that all calls will operate in the simplex mode.

4.2 Channel Selection

The mobile user will select the appropriate B.R. channel number (between 100-199) which will cause RQR telegrams to be sent to the relevant fixed station. On receipt of the RQR telegram the fixed station shall check the incoming SYS No. and if valid respond with the ACK telegram, this will open the mobile loudspeaker and enable the transmission of speech and data.

The mobile user will then be able to hear all the traffic on the system.

This facility is available on all fixed stations.

4.3 Mobile to Signalman Call Sequence for Speech

When the mobile user keys his microphone a 'PTT'* telegram will be sent to the fixed station network. Upon successful receipt of the 'PTT' telegram, the fixed station concerned will go into talkthrough and a 'refresher timer' will start. At the same time a 'Super Audio Tone (SAT)' burst, in the range 3.5kHz to 3.9kHz will be generated at the fixed station.

This transmission from the fixed station will be received at adjacent repeater stations. The repeater stations will detect this SAT and on doing so, shall immediately key the co-sited transmitter which again will broadcast an SAT burst.

The SAT will be filtered off and regenerated in each repeater.

The next fixed station will detect the Super Audio Tone and repeat the sequence by going into talkthrough and sending an SAT burst.

This sequence of operation will be repeated throughout the chain. Thus the whole scheme will be transmitting the audio from the mobile.

The signal then reaches the local fixed station which works to the Signalman's mobile, or to a fixed station or fixed mobile connected by landline to the Signalman's panel.

*A PTT telegram is a MPT1327 Call Maintenance 000 telegram.

In the case of a landline connected fixed station, or mobile, the opening of the squelch will cause a continuous out of speech band tone (i.e. within the range 2.7kHz - 3.0kHz) to indicate this condition at the Signal box. As long as the first fixed station (i.e. that keyed by the PTT telegram) squelch is open it will remain

in talkthrough generating bursts of Super Audio Tone at intervals

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governed by the refresher timer. Following repeaters and fixed stations will regenerate their SAT on detection of the incoming SAT. Failure to receive the SAT in the expected time will cause the transmitter to be dekeyed.

On drop out of the squelch in the first fixed station the transmitter will stay keyed for a specified time, to allow for mobile flutter. Subsequent repeaters and fixed stations will dekey immediately their squelch closes; and will not rekey until the next burst of SAT is received.

4.4 Signalman to Mobile Call Sequence for Speech

The Signalman can call any train on the system directly by speech.

The calls will be made by one of the following methods:-

4.4.1 Via a fixed mobile at the Signal Box into the fixed station chain. This fixed mobile will send an PTT telegram and access its appropriate fixed station, as described for the mobile previously (see part 4.3).

4.4.2 If the signal box is remote to the area it controls then a 4 wire landline to a fixed station or mobile will be used. Keying of the fixed station or mobile will be by an out of band (within the range 2.7kHz - 3.0kHz) tone. In some circumstances the fixed station may be adjacent to the signal box, however the same landline facilities shall apply, for spares compatability reasons, d.c. control shall not be permitted.

4.5 In the event of the Signalman's mobile or 4 wire circuit to the fixed station failing, alternative access will be gained by the use of B.T. (or B.R. E.T.D.) dial up circuits (2 wire). These will connect to a fixed mobile radio, which will use an PTT message to access the appropriate fixed station when keyed. Both squelch and keying signals will be conveyed over the 2 wire circuit using out of speech band tones (within the range 2.7kHz - 3.0kHz). This mobile will operate in simplex.

4.6 Mobile to Mobile Speech

4.6.1 ← This will operate in exactly the same way as the Mobile-to Signalman circuit.

→ 4.6.2 The complete radio system is in talkthrough and therefore all calls will be heard by all units.

4.7 Exchange of Tokens

Exchange of tokens is commenced by verbal messages, followed by actual exchange of data telegrams.

Data messages are 1200 Bits per Second F.F.S.K., in accordance with MPT 1317.

The initial data message is sent from the Solid State Interlocking (SSI). It requires a squelch signal (from the Signaller's radio interface) to ensure the system is free, then initiates a key instruction to the radio interface. This key instruction will cause an PTT telegram (if radio fitted) or key signal to line (if a 4 wire connection) to be sent, after which the transmit clock (TX CLK) will be sent to the SSI interface. The SSI will now output data to all mobiles. On receipt of this telegram the appropriate mobile will respond with a data handshake and following the handshake the SSI will transmit the token.

The timing diagrams are given in Appendix A & B. The SSI interface is to drawing No. ELS-A1-3311 issue D dated 15/8/84.

The recovery of the token from the train consists of a data handshake only, again originated by the SSI.

If no response is received from the train the SSI will make 5 attempts to transmit a token.

4.8 Fringe Signal Boxes, Level Crossing Monitoring, Point Control, etc. (Ancillary data, see part 5.4.2.).

4.8.1 Data exchange for control of fringe signalling information, monitoring of level crossing alarms and point control is not necessarily preceded by speech, the first message may be initiated by either end. Data is 600 bits per second (FSK) with tone frequencies of 1060Hz and 1260Hz.

4.8.2 The radio interface is at audio with squelch and key conditions on separate lines.

5. SYSTEM DETAIL

This section contains the following detailed Specifications:-

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System Timing.
Fixed Stations, Fixed Mobiles, Cross Channel Repeaters.
Interfaces.
Signalman's Control Panel.
Telephone.
Alarms.
Data and Tones present on system and filtering requirements.
Levels of Signals present on system.

All mobile and portable radios requested within the schedule must conform to BR Specification 1609.

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5.2. Timing

All timings quoted shall be to an accuracy of $\pm 5\%$. The limits indicated below are to be technician adjustable in the field.

5.2.1. Refresher Timer

All fixed stations shall be fitted with this timer.

When an PTT telegram is decoded by the receiver, the Refresher Timer is reset, and a burst of SAT is transmitted by the fixed station. The Refresher Timer shall be set at 5 seconds, but capable of variation between 2 and 10 seconds, and will key the SAT generator at 5 seconds intervals until the receiver squelch is closed (see part 5.2.3.).

5.2.2. SAT Timer

The Super Audio Tone Burst Timer shall be fitted to all fixed stations and repeaters. The SAT timer shall be set to give 100ms Bursts of SAT (see part 5.7) but shall be capable of variation between 30ms & 300ms.

The SAT shall be detected within a minimum of 20ms and a maximum of 30ms at all fixed stations and repeaters.

5.2.3 Anti-Flutter Timer

Should the Mobile which sent the PTT telegram drop out due to signal flutter, the fixed station that acknowledged it shall be capable of holding it's transmitter key line up for 20ms, the

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receiver squelch shutting as normal, to prevent rebroadcast of white noise. The timer is to be variable between 5ms and 50ms. This timer shall not delay the rise time of the transmitter. Non receipt of an PTT telegram will inhibit the Anti-Flutter Timer.

5.2.4 Self Test Timer

A Self Test Timer shall be included in the Signal Box Control Equipment which will initiate individual testing of all fixed stations. This sequence shall happen every 60 minutes, if the system is free, or at first available free period thereafter. The timer shall be variable between 15 to 150 minutes.

5.2.5 All 5 types of fixed equipment detailed in 5.3.1 shall adhere to the following timing specifications:-

Receiver Squelch opening 10ms maximum.
Transmitter rise time of 10ms maximum
Receiver Squelch close time of 10ms maximum
Transmitter fall time of 10ms maximum (after removal of key condition).

5.2.6. Repeater Turn Round Time

The time taken for a repeater to reverse its direction of working shall not exceed 70ms. i.e., the time for the receiver squelch to close, the transmitter to dekey, the second receiver squelch to open and its associated transmitter to key.

5.2.7. Aerial Change Over Relays

These where fitted shall operate within 10ms.

5.3 Fixed Radio Equipment

5.3.1 The fixed radio network will be made up of radio equipment having the following facilities:-

5	Fixed Station without landline interface. Talkthrough	
.	operation keyed by receipt of Super Audible Tone or PTT	
3	telegram. The fixed station will respond to an ~~PTT~~ RQR	
.	telegram with an ACK telegram including the originating	
1	mobile identity (BR Specification 1609). 25W R.F.	
.	transmitter output, internal duplexer fitted, but capable	
1	of two aerial working	
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5	Fixed Station with 4 wire landline interface. Talkthrough	
.	operation keyed by receipt of Super Audible Tone or PTT	
3	telegram. Transmitter keyed by out of band tone on	
	landline. Receiver squelch operation signalled on landline	

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1 by out of band tone. The fixed station will respond to an
. RQR telegram with an ACK telegram including the
2 originating mobile identity (BR Specification 1609).25W
. R.F. output, internal duplexer fitted, but capable of two
aerial working.

5 Cross Channel Repeater. Made up of two identical fixed
. stations operating on mobile frequencies. No landline
3 interface.

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On detection of SAT each receiver shall key the co-sited transmitter and inhibit keying of its own transmitter. To be fitted with aerial changeover relays, One aerial socket on each fixed station. 25W R.F. outputs.

5 Fixed mobile with 2 wire dial up landline. Simplex working
 . Transmitter keyed by out of speech band tone(i.e. within
 3 the range 2.7kHz - 3.0kHz) on landline. Receiver squelch
 . operation signalled on landline by out of band tone. 25W
 1 R.F. output.

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5 Fixed Mobile for signal box use, up to 15m of local
 . cabling. Simplex working. Transmitter keyed by various
 3 signalbox functions. Receiver squelch operation output to
 . the Signalbox radio interface. 25W R.F. output.

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5.3.2 On fixed stations type 1 & 2, only the fixed station receiving the PTT telegram from the mobile will enable its Refresher Timer. All other fixed stations will detect and regenerate the SAT. The same fixed station will output a burst of SAT as previously described and shall enable its own Anti-Flutter Timer.

Absence of an PTT telegram on an incoming signal will inhibit the Refresher and Anti-Flutter Timers.

5.3.3 Each fixed station shall be fitted with channel selection switches to select the 255 channels defined in Appendix C.

5.3.4 Fixed station equipment must operate in an environment as specified in British Rail Specification No. 967 Category D, unless a relaxation to Category B is given in the Schedule.

5.3.5 The equipment shall incorporate a float charged battery unit as detailed in 5.3.13 and be capable of operation from one of the power supplies as specified in Part 5.10 and detailed in the Schedule.

5.3.6 The equipment shall operate in the VHF Band **III** and conform to Department of Trade and Industry Specification MPT 1323.

5.3.7 Solid state circuitry techniques shall be used throughout, with the exception of certain switching functions, which may be relay controlled.

5.3.8. All fixed stations shall be of one type, including line terminating units, and be identical in operation so that they

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may be readily interchanged for maintenance purposes.
DC control will not be permitted.

5.3.9 Transmitters

- 5.3.9.1 The long term frequency drift of the transmitter shall not exceed two parts in 10^6 per year.
- 5.3.9.2 The RF power output to the aerial feeder shall be not less than 25 watts.
- 5.3.9.3 The transmitter output to the aerial shall be 50 ohms unbalanced via an 'N' type female socket.
- 5.3.9.4 A Reflectometer shall be incorporated as standard test equipment with the transmitter. Where a duplexer is fitted the reflectometer shall be connected in the feed to the aerial not the transmitter connection to the duplexer.
- 5.3.9.5 The transmitter shall be capable of withstanding an open or short circuit on the RF output continuously.
- 5.3.9.6 The transmitter shall be capable of continuous operation.

5.3.10 Receiver

- 5.3.10.1 The long term ageing rate of the first local oscillator crystal shall be not less than 2 parts in 10^6 per year.
- 5.3.10.2 Sensitivity shall be at least 12 dB SINAD for $0.3\mu\text{V}$ p.d. input.
- 5.3.10.3 The aerial input shall be 50 ohms unbalanced via an 'N' type female socket.
- 5.3.10.4 A method of muting the receiver output in the absence of a carrier input (squellch) shall be provided. The muting threshold shall be adjustable with the control contained internally within the receiver. It shall not be possible to adjust the muting to be less sensitive than $3\mu\text{V}$ (p.d.).
- 5.3.10.5 A local loudspeaker, with adjustable volume control, shall be provided to monitor the audio output of the receiver.

5.3.11 Duplex Filters

- 5.3.11.1 A duplex filter will be required at fixed stations unless otherwise specified. (See schedule).
- 5.3.11.2 The duplex filter should normally be contained within the fixed station equipment housing.
- 5.3.11.3 The duplex filter shall comply with the following:-
- 5.3.11.4 Tuning Range: 195-207Mhz.
- 5.3.11.5 Continuous Power Rating: 25W

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- 5.3.11.5 Impedance: 50 ohms.
- 5.3.11.6 Minimum isolation between the transmitter and receiver ports shall be 55dB at 5MHz spacing or greater.
- 5.3.11.7 Maximum Insertion Loss in the Transmitter & Receiver Path: 1.0dB.
- 5.3.11.8 Connectors: The aerial connector shall be N type female socket.

5.4.11. Line Termination Unit

- 5.3.12.1 The line terminating unit shall be the interface between the 4-wire control line or microwave link and the fixed station.
- 5.3.12.2 This unit may be integrated with the fixed station equipment.
- 5.3.12.3 The unit shall be designed to accept signals from line between the levels of 0dBm and -25dBm measured at 800 Hz and provision shall be made for the adjustment of the input signal from line to the correct level for the equipment. Output to line shall be adjustable between the levels 0dBm and -25dBm measured at 800 Hz.
- 5.3.12.4 The input and output impedances of the unit to line shall be 600 ohms balanced.
- 5.3.12.5 The 4-wire terminating unit shall provide audio paths in the frequency band 300Hz to 2.5kHz for speech. The band 2.6 to 3.0 kHz is available for signalling functions (see Part 6).
- 5.3.12.6 The landline terminations shall include protection to BS 6301.
- 5.3.12.7 The landline termination shall be approved by the PTO for connection and must conform to BS 6305.

5.3.13 Engineers' Facilities

The Maintenance Engineer must be able to:-

- 5.3.13.1 Speak via the link with the fixed station disconnected.
- 5.3.13.2 Speak via the fixed station, with the link disconnected.
- 5.3.13.3 Monitor the fixed station and link simultaneously, without affecting any signal levels
- 5.3.13.4 Override the muting control.
- 5.3.13.5 Select continuous transmit.
- 5.3.13.6 Select continuous transmit with SAT.

5.3.13.7 Select talk-through by means of a locking key.