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Translation

ORI

Technical regulations for international analogue ground-train radio systems

Prescriptions techniques pour les systèmes analogues radio sol-train en service international
Technische Vorschriften für Analog-Zugfunksysteme im internationalen Dienst

UNION INTERNATIONALE DES CHEMINS DE FER
INTERNATIONALER EISENBAHNVERBAND
INTERNATIONAL UNION OF RAILWAYS

Leaflet to be classified in Volume :

VII - Way and Works

Application :

With effect from 1 January 1979, with regard to the obligatory provisions for the design and manufacture of installations, except:
- points 5 and 6 (1.7.84)
All members of the International Union of Railways

Record of updates

3rd edition, July 1984

4th edition, July 2005	Retyped in FrameMaker and incorporation of addendum of 1.1.1988. Important: the articles (points) in this leaflet have been renumbered in the new edition. The first digit of each point has been increased by one (i.e. 0 becomes 1, 1 becomes 2, and so on). Please take account of this when using cross-references from other leaflets. For digital ground to train systems: see UIC Leaflet 751-4. Note on the punctuation used in figures: commas are used in English as in all other languages to separate whole numbers from decimals (in accordance with the European Union Interinstitutionnal style guide)

The person responsible for this leaflet is named in the UIC Code

Contents

Summary

This leaflet contains technical regulations for ground-train radio systems in international traffic.

It defines the scope of the leaflet, describes operating modes plus minimal technical specifications.

Detailed provisions ensuring quality of communications are also given, with emphasis on: location of fixed installations, radio coverage, technical transmission/reception characteristics, fixed and mobile aerials, operating modes, quadri-frequency sets, auto-switching of mobile-set frequencies, cable links, loudspeakers and tractive-unit micro-telephone sets.

The leaflet then defines the frequency chart: setting-up and allocation of channels, joint frequency bands, distance between channels, duplex channels, numbering of channels, intermodulation, preferential channels, switchable channels and simplex channels aboard tractive units.

The different radio-control processes are also described: idle mode, connections, operating provisions and warning procedures.

The corresponding command signals are explained in detail.

Links between motive power unit and RIC coaches together with the corresponding communications between drivers, central control and train staff are explained in specific terms.

Finally, the leaflet describes the special features of the ground-to-train radio system with selective call and message transmission by digital code, as well as those of the radio-telephony system with simultaneous transmission of digital messages.

1 - General

1.1 - Scope of leaflet

The railways utilise radio links with numerous different modes of operation.

Operations in frontier zones must comply with the provisions of *UIC Leaflet 471-1* (see Bibliography - page 57).

1.1.1 - This leaflet only concerns installations and equipment for providing permanent analogue radio links between traffic control points and trains running on lines used for international traffic with tractive units crossing frontiers.

For those railways which utilise other systems than radio, bilateral agreements can be concluded between adjacent railways.

1.1.2 - The leaflet does not apply to radio systems:

1.1.2.1 - established along lines where no international traffic runs, and fitted to tractive units which do not leave their own network;

1.1.2.2 - established along frontier lines and on tractive units which run over them without penetrating far onto a foreign network;

1.1.2.3 - established on trains to enable passengers to connect up with the public telecommunications network (service to passengers);

1.1.2.4 - using the resources of public telecommunications networks.

1.1.3 - The leaflet applies to links between the radio installation of tractive units and the loudspeaker equipment of passenger trains (see *UIC Leaflet 568*) (see Bibliography - page 57), enabling announcements to be made to passengers or to train staff.

1.1.4 - In addition, the leaflet applies to links with sound installations in one or more passenger coaches for duty communications concerning train staff.

1.1.5 - The GSM-R system is covered by a separate new leaflet.

The present leaflet contains technical regulations for communications between driver and train staff or between central control and train staff, established through the radio equipment of the tractive unit via the link circuit passing along the train and the various service points installed in the coaches and vans.

1.2 - Modes of operation

1.2.1 - Compatibility between mobile and lineside radio equipment of different Railways.

Radio links with the trains can be utilised in different ways.

However, for practical reasons, the equipment of tractive units crossing frontiers may not be developed for all imaginable and possible modes of utilisation.

Thus, only two different modes of utilisation have been defined, in conformity with the directives of the UIC Operating Committee (see Bibliography - page 57):

- mode 1, with confidentiality of conversation, one of the features of which is that it functions in duplex and will therefore be described as "duplex mode";

- mode 2, without confidentiality of conversation, one of the features of which is that it functions in semi-duplex, and will therefore be described as "semi-duplex mode".

Each Railway may choose the mode of utilisation it intends to adopt by reference to the advantages anticipated in relation to the investments to be undertaken.

Equipment fitted to tractive units worked over inter-running sections must be able to adjust to the duplex mode of operation once one of the Railways concerned in such traffic starts to utilise this mode.

When the semi-duplex mode of operation is used over inter-running sections, bilateral or multilateral agreements govern the conditions under which the tractive units must adjust to the semi-duplex mode of operation.

The provisions for the setting up of lineside installations must be adapted to ensure compatibility with the standard equipment of tractive units.

1.2.2 - The "duplex mode" must allow for:

1.2.2.1 - direct verbal communications between lineside control point (central control) and driver. Calls can be made to trains verbally or selectively (by digital code). Communication must proceed in conditions ensuring confidentiality of conversation.

1.2.2.2 - communications between driver and operating supervisory along the route: these are established through intervention from the central control. The call can also be verbal or selective, and the communication established must observe confidentiality of conversation.

1.2.2.3 - alarm-signal transmission by the driver in order to establish urgent verbal communication with central control or warn other drivers of danger.

1.2.2.4 - message transmission by central control to all drivers (general call) to warn them of danger or for other service information.

1.2.2.5 - permanent supervision of the reception of lineside stations and indication if it is defective, on the tractive units.

1.2.2.6 - message transmission by central control or driver, via the loudspeakers in the coaches, to inform train staff or passengers.

1.2.2.7 - verbal communications between driver and train staff in trains or between central control and train staff.

1.2.2.8 - a radio link independent of the position of the train throughout the zone managed by central control.

Verbal radio communications must not be disrupted by changes in the coverage zone of lineside stations. Central control must not be made responsible for activating a selective system to interlock lineside stations relative to the position of the trains.

1.2.3 - The "semi-duplex mode" must allow for:

1.2.3.1 - open verbal communications between driver and central control without confidentiality, and with verbal calling (for example, through connection of one or more lineside stations to a link circuit with central control).

All users within the zone covered by the connected lineside installations hear the calls and conversations.

1.2.3.2 - direct verbal communications between driver and operating staff of the lines, with verbal calling.

All users within the zone covered by a radio transmitter (lineside points and drivers) hear the calls and conversations inside this zone.

1.2.3.3 - direct verbal communications between drivers situated in the zone covered by the same lineside station, with verbal calling without confidentiality, the lineside stations serving as relays.

All users within the zone covered by a lineside station will hear the calls and conversations inside this zone.

1.2.3.4 - alarm-signal transmission by a driver, either to warn the other drivers running over the line of danger, or to establish urgent communication with central control via the lineside points established along the line.

1.2.3.5 - message transmission by central control to all drivers (general call).

1.2.3.6 - permanent monitoring of the reception of lineside stations and indication of a defect, on the tractive units.

1.2.3.7 - message transmission via the loudspeaker in passenger coaches as in point 1.2.2.6 - page 3.

1.2.3.8 - verbal communications between driver and train staff or between central control and train staff as in point 1.2.2.7 - page 3.

1.3 - Minimal technical regulations

1.3.1 - The minimum technical regulations must guarantee operational compatibility between the radio equipment of tractive units crossing frontiers with the radio equipment of the lines of other Railways.

The following paragraphs define these minimum technical regulations, to guarantee:

- transmission of sound communications of good quality and, where applicable, transmission of digital codes under satisfactory conditions;

- standardisation of radio frequencies used;

- standardisation of tones used as operating signals to regulate the progress of communications and the priority of warning information;

- the possibility for Railways wishing to do so, of making joint use of a selective and data transmission call system in digital code.

R **1.3.2 -** When the radio apparatus of a Railway is not equipped initially for the transmission of digital codes, it is recommended that provision be made for its subsequent development whereby it can be supplemented later by adding an additional housing for this function.

2 - Regulations guaranteeing quality of communications

R 2.1 - Lineside stations

Radio links with trains are established from lineside stations installed along railway lines. They must be close enough together for a satisfactory quality of communications to be obtained down length of the line.

Satisfactory coverage of an entire line with radio waves means that the reception voltage, at the input end of receivers of the tractive units and the lineside stations, must attain or exceed the minimum value prescribed in point 2.4 over 95% of the route and for 95% of the time.

O 2.2 - Sensitivity of lineside and mobile receivers

With a reception voltage of ≥ 1 μV at the input end of receivers, the signal/noise ratio level at their output end must be ≥ 20 dB.

When measuring this characteristic the noise arrester must be made inoperative. The workable signal consists of an oscillation at 1000 Hz with a frequency deviation of 3,0 kHz. Noise is measured by injecting a non-modulated HF signal. The levels of the workable signal and of the noise are measured in actual values.

O 2.3 - Coefficient of distortion in transmitters and receivers

The non-linear coefficient of distortion of a transmitter or receiver, measured by applying a signal of 1 mV to the nominal frequency (frequency of the radio channel) modulated by a frequency of 1000 Hz, must be:

≤ 7% with a frequency deviation of 3,5 kHz,

≤ 10% with a frequency deviation of 4,0 kHz.

2.4 - Minimum reception voltage

Satisfactory transmission of the spoken word means that the vocal frequency signal captured by the receiver in the 300-3000 Hz band must be at least 20 dB above the interference signals.

2.4.1 - Given the interference which exists in the VHF band, within the railway environment, and bearing in mind also the reduction in frequency deviation (see point 2.9.3 - page 8), this requirement is achieved when a minimum reception voltage of 2 μV exists at the input end of receivers of the tractive units.

It is also assumed that an λ/4 omnidirectional aerial with a characteristic impedance of 50 ohms is installed on the roof of tractive units (namely about 4 m above rail level).

2.4.2 - Because the properties of reciprocity of the links in both directions and in the light of experience gained with systems already in operation, it has been established that the quality of transmission from tractive units to lineside stations is just as good and even better than from lineside stations to tractive units. Accordingly, the lineside transmitters and those on the tractive units are

assumed to have the same power. (The directional effect of the lineside aerials does not enter into this consideration since it operates in both directions).

Thus, the minimum reception signal at the input end of the lineside receivers should be 2 μV, for a typical impedance of 50 ohms.

2.5 - Radiating power

O **2.5.1 -** The nominal radiating power of the equipment on tractive units must be 6 watts.

In several countries, higher ratings are prohibited, while lower ratings would reduce the ranges and would require installing a larger number of lineside stations.

R **2.5.2 -** The radiating power of lineside stations should also be 6 watts (see point 2.4.2 - page 6).

O 2.6 - Polarisation of radio waves

In the open air, vertical polarisation must be adopted.

In tunnels, any polarisation can be used (see point 2.8).

O 2.7 - Aerials of tractive units

2.7.1 - In the open air, the aerials for tractive units must have omnidirectional radiation characteristics and show a gain of 0 dB or more in relation to an λ/4 aerial.

They must be fitted on the locomotive roof to obtain a vertical polarisation, and to avoid, as far as possible, reflections and refraction due to the roof superstructure. The loss of gain can attain 9 dB with unsatisfactory fitting conditions.

2.7.2 - To protect staff against dangerous over-voltages in the event of accidental contact with parts under high voltage or with the contact wire, aerials must be connected by galvanising to the frame of the tractive units (in other words brought to the potential of the rail).

They can also be protected by an insulating screening of synthetic material.

2.7.3 - Aerials must be installed to comply with the rolling-stock gauge.

R 2.8 - Aerials of lineside stations

In the open air, all types of aerial with vertical polarisation can be used. The best characteristics to be adopted for the aerials (for example, omnidirectional, slightly or very directional) depend on the topography of the zone to be served.

Radio coverage in tunnels can be obtained by means of radiating circuits (for example, coaxial cables with split screening) or very directive aerials placed at the entrance to or inside the tunnel. In addition, so-called coiled aerials, very directional and with circular polarisation, have proved very favourable in terms of obtaining considerable ranges in tunnels.

O 2.9 - Type of modulation. Frequency deviation

2.9.1 - For radio transmission, frequency modulation (16 F3 type of modulation) should be adopted.

2.9.2 - With a margin of 25 kHz between radio channels, the maximum frequency deviation is 5 kHz.

However, since the coefficient of distortion mentioned in point 2.3 - page 6 is only low enough below 4 kHz, the maximum frequency deviation for simultaneous transmission of the spoken word and of an operating tone is fixed at the nominal value of 4 kHz.

2.9.3 - This maximum frequency deviation should be divided as follows:

- For an operating tone (see point 5 - page 19) : 1,75 kHz in nominal value
- For the spoken word : 2,25 kHz in nominal value

2.9.4 - For each transmission direction of the radio channel, it is prescribed that:

- the peak values of the signal corresponding to a normal sound level shall be transmitted, in accordance with point 2.9.3, subject to a frequency deviation of 2,25 kHz (nominal value),
- the average values of the signal corresponding to this normal sound level shall be transmitted subject to an average value of 1,1 kHz of the frequency deviation.
- the signals corresponding to very high sound levels must be concentrated before modulation in the transmitters, to limit the frequency deviation to the peak value of about 2,25 kHz.

O 2.10 - Duplex and semi-duplex operation

2.10.1 - Compliant with point 1.2.1 - page 2, mode 1 utilisation involves duplex operation. This mode of operation is usual on public radiotelephony networks, and in applications specific to railway operation. It facilitates conversation in service radio communications.

It does not require any switching or timing device for digital-code information bilateral exchanges, and therefore facilitates message transmission.

2.10.2 - For mode 2 utilisation, the semi-duplex system of operation should be adopted (alternate transmission and reception, utilising two different frequencies) in accordance with the provisions described in point 1.2.3 - page 4.

2.10.3 - The radio equipment of tractive units must be able to function in accordance with the directives given in point 1.2.1.

R 2.11 - Radio-wave coverage of line

The requirement of permanent monitoring of the radio link in accordance with points 1.2.2.5 - page 3 and 1.2.2.6 - page 3 implies continuous transmission of a carrier frequency by the lineside stations.

Transmission from each lineside station is a workable signal in the zone of coverage which it is required to serve, but becomes an interference signal in the zones outside. The distances, for which this interference can occur, depend on the topography of the terrain. They vary between 2 and 5 times the extent of the workable range, and in extreme cases can even be still greater.

To avoid interference which can be produced by two adjacent lineside transmitters interfering with mobile receivers, various arrangements can be adopted.

2.11.1 - When the zones to be served are extensive and comprise at least three lineside stations, it is generally necessary to utilise alternately three transmission frequencies along the line. Generally speaking, the workable ranges of the lineside transmitters with the same frequency are then outside the zones where they interfere with each other.

2.11.2 - In cases where the workable ranges of lineside transmitters with the same frequency nevertheless coincide with zones of interference without the level of the interference signal in the workable range of a transmitter exceeding a certain value (2 μV for the average reception voltage, 5 μV peak value), the interference can be reduced satisfactorily by stabilising the two transmission frequencies so that they deviate by a maximum of ± 25 Hz from the nominal frequency, and by equalising the frequency deviations.

2.11.3 - When the interference between transmitters in a zone of coverage corresponds to values exceeding those mentioned in 2.11.2, stabilisation of frequencies is no longer sufficient. It is then necessary to increase the distance between these transmitters. This situation can be achieved by making the transmissions from two or three adjacent intermediate transmitters identical. This consists of:

1. stabilising the transmission frequencies of the transmitters so that they differ by no more than 50 Hz (recommendation for adjustment: ± 5 Hz),

2. equalising their frequency deviations,

3. equalising the phases of the modulation signals in the zones of coverage of adjacent transmitters. This means equalising the propagation times of the modulation signals to the two transmitters and the propagation times of the radio signals along the line.

2.11.4 - When the zones to be served are short and have no more than 3 to 5 lineside stations, it is possible to utilise the system with synchronised transmissions. A duplex channel is then sufficient to serve the entire line (see point 2.11.3).

o 2.12 - Quadrifrequency groups

2.12.1 - To serve a line in the general case defined in point 2.11.1, it is necessary to have three frequencies for the lineside transmitters and a fourth frequency for the mobile transmitters. The switching of the reception frequencies in the mobile receivers must be carried out by means of an automatic device. To arrange this using the simplest possible technique, the four frequencies have been combined in a standard chart to form a "quadrifrequency group".

A duplex channel with a margin of 10 MHz between transmission and reception frequencies constitutes its nucleus. Two additional frequencies for the lineside transmitters are situated with a double channel margin (50 kHz), one above and the other below the transmission frequency of the lineside transmitters of the duplex channel.

2.12.2 - To serve, independently of each other, certain lines whose alignments are close together, particularly near communications centres, several of these quadrifrequency groups are used. The manner in which they must be arranged will be addressed in point 3 - page 11 (Frequency chart).

2.13 - Automatic frequency switching of mobile receivers

O **2.13.1 -** On entering the radio service zone of a central control, drivers must connect to the corresponding channel (namely the one identified by the number of the quadrifrequency group). Within the range of the service zone, an automatic device must ensure switching of the reception frequencies belonging to this quadrifrequency group.

However, it must be borne in mind that switching operations when too frequent and also too late, create undesirable interference particularly during message transmissions envisaged for the future.

R **2.13.2 -** Switching can take place, for example:

1. either when the signal/noise ratio becomes continually or frequently insufficient in the receiver. This corresponds to the following data: when the reception voltage falls during a continuous period of about 1 s or several times during periods of 1 ms below the minimum of 2 μV (see point 2.4 - page 6).

2. or when reception is better on another frequency than the one in use (namely when the signal/noise ratio is best), which must be detected by a comparator device.

One or other of these criteria can be utilised to effect the switching operation.

R 2.14 - Sound-link circuit between central control and lineside stations

Lineside stations must be connected to central control by two pairs of wires, one for the transmission direction and the other for the reception direction.

To ensure that the quality of transmission is as good as for the path of the radio waves, the circuits used should have characteristics which satisfy ITU standards for the 300 to 3400 Hz filter band (loaded or non-loaded circuits).

With these characteristics, the input amplifiers in lineside stations can still suitably compensate for variable attenuation in relation to the frequencies, even for the control signal with the highest frequency (2800 Hz, see point 5.4 - page 20).

O 2.15 - Calls via loudspeakers. Conversations using the micro telephonic handset

The ambient noise level is generally high on tractive units, and interferes with the comprehension of loudspeaker announcements. Use of the micro-telephonic handset improves comprehension of the spoken word in both directions. On the one hand, the ambient noise is muted by the telephone receiver, and on the other the microphone is maintained at a certain distance, which guarantees a constant level for the spoken word.

In addition, use of the micro-handset is essential in duplex operation to avoid acoustic coupling between microphone and loudspeaker.

Micro-telephonic handset equipment must therefore be provided for conversation. Loudspeakers on tractive units must only be used for calls or for listening to other communications (see point 4.2 - page 15).

3 - Frequency chart

(see Appendix A - page 47).

3.1 - Compilation of frequency chart

The frequency chart to be used for ground-train radio links is defined in Appendix A.

This chart has been compiled in accordance with the CEPT Recommendation T/R 22-01 which formalised the recommendations issued at the October 1971 Conference in Paris, attended by the UIC European Railways, with the participation of representatives and specialists from European GPO or Radio Administrations.

However, for the national bodies responsible for allocating frequencies, this recommendation does not have the obligatory status which would enable the Railways to rely on allocation of these bands. On the contrary, the allocation of frequencies must be requested and duly substantiated. Because of the use of frequencies by other radio users in the bands mentioned, it will generally only be possible to obtain allocation of a limited number of continuous frequencies in these bands. Allocation of complete bands to a Railway would be an ideal solution, but must be regarded as exceptional.

In certain countries too, these allocations are subject to certain restrictions, which differ from one country to another.

One restriction extending to international level must be mentioned here: frequencies 457,525; 457,550 and 457,575 MHz are allocated to shipping on the high seas and to inland waterways for ship-to-ship communications.

3.2 - Allocation of channels along international traffic lines

O **3.2.1 -** Channels relating to lines crossing frontiers must be allocated after bilateral or multilateral agreement between administrations responsible for allocating frequencies on the proposal of the Railways of the countries concerned, and preferably from the frequency groups mentioned in point 3.8.1 - page 13. If this is not possible, one of the groups mentioned in point 3.8.2 - page 13 will be used.

It must be remembered here that at frontiers or at frontier stations, traffic control transfers from one Railway to the other, which means that the quadrifrequency group must be changed at these points.

Change of coverage by the lineside stations and therefore also by the quadrifrequency groups shall be arranged as follows:

1. on lines with two frontier stations, it shall take place where the Railways terminate (national frontiers),

2. on lines with a common frontier station, it shall take place at that station.

Lineside installations located between the frontier and the common frontier station must be set up and operated in accordance with bilateral agreements specific to the common frontier station.

O **3.2.2 -** On frontier sections used by international traffic, the channels mentioned in points 3.8.1 - page 13 or 3.8.2 - page 13 shall be used, depending on the availabilities of the internal national charts for frequency allocation.

R **3.2.3 -** Generally speaking, frequencies are only allocated if the request is based on a concrete plan for use. It is recommended that a chart for ground-train radio links should be compiled as soon as possible, and a request made for the allocation of frequencies.

If such a chart cannot be compiled at present, talks should at least be initiated with the administrations responsible for the allocation of frequencies, with a view to reserving frequencies, given that there may no longer be any frequencies available in the near future.

O 3.3 - Common frequency bands

For the requirements of ground-train radio links, the administrations responsible for allocating frequencies can only allocate them in the following bands:

-	mobile transmitters:		457,400 MHz to 458,450 MHz
-	lineside transmitters:	band A	467,400 MHz to 468,450 MHz
		band B	447,400 MHz to 448,450 MHz

Band B is only to be used when it is not possible to use band A. In this case, special agreements must be entered into between Railways which exchange tractive units, concerning the additional equipment which the mobile apparatus must incorporate.

O 3.4 - Margin between adjacent channels

The margin between nominal frequencies in these bands is 25 kHz.

O 3.5 - Duplex channels

As indicated in point 2.12.1 - page 9, the duplex channels are constituted by frequency pairs spaced 10 MHz apart. The frequencies of the lineside transmitters are 10 MHz above (band A) or below (band B) those of the mobile transmitters.

O 3.6 - Numbering of channels

A standard numbering is prescribed to designate the duplex channels and the quadrifrequency groups. See frequency chart in Appendix A - page 47.

3.6.1 - The numbering extends to 59 duplex channels, in which those with the lowest frequencies (No 1 to 8), and those with the highest frequencies (No 52 to 59) fall outside the bands mentioned in point 3.3. They serve to extend the possibilities of allocating frequencies, particularly for lines not used by international traffic.

The numbering of duplex channels is also valid for simplex channels which are used for local radio links and are formed from duplex channels.

3.6.2 - The quadrifrequency groups to be taken into consideration are designated by the numbers 60 to 67 and 70 to 79 (see Appendix A).

3.6.3 - This numbering should be used in talks, exchanges of correspondence or agreements between Railways. It should also be used for indicating channels on the switching equipment of the apparatus on tractive units, and in working instructions intended for staff.

The purpose of this standard numbering is to avoid confusion during talks between Railways, and when using apparatus on tractive units in frontier zones between adjacent Railways.

R

3.7 - Intermodulation

3.7.1 - The groups numbered 60 to 67 have been set so that the corresponding frequencies of these 8 groups possess between them practically no intermodulation effect of the first or second order.

They are therefore particularly suited for use at rail centres where lineside stations serving several lines have to be installed at short distances from each other, a configuration which tends to produce intermodulation between channels.

3.7.2 - The groups numbered 70 to 79 are not devoid of intermodulation effects.

When using these channels, it must be ensured, by careful selection of frequencies and distancing transmitters from each other, that the danger of intermodulation is adequately avoided (as user of the system).

O

3.8 - Preferential channels for international traffic lines

3.8.1 - Groups No 62, 63, 64 and 65 should preferably be used for serving international lines worked used by tractive units of adjacent Railways.

3.8.2 - If this is not possible, groups No 73, 74, 75, 76 or 77 should be used.

3.8.3 - If allocation of frequencies for groups designated in points 3.8.1 and 3.8.2 cannot be obtained, channels can be constituted from groups No 60, 61, 66, 67 or No 70 71, 72, 78 and 79, but this will require the agreement of all the Railways whose tractive units run over the line concerned. This agreement must guarantee the existence of the channel chosen on the switches of the apparatus on tractive units, in accordance with point 3.9.2.

3.9 - Switching channels in apparatus on tractive units

O

3.9.1 - It must be possible for the frequencies designated below to be selected by the apparatus on tractive units. The selection of a channel, identified by its number, must activate simultaneous selection of the four constituent frequencies:

1. the quadrifrequency groups No 62, 63, 64 and 65 mentioned in point 3.8.1,

2. the quadrifrequency groups No 73, 74, 75, 76 and 77 mentioned in point 3.8.2.

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3.9.2 - It is recommended that the frequency groups No 60, 61, 66 and 67, as well as groups No 70, 71, 72, 78 and 79 should also be interposed in the channel switches.

In principle, these groups are intended to serve lines used solely for domestic traffic.

If these groups are used on lines with international traffic under cover of an agreement between the Railways concerned, their incorporation into the switches of the apparatus on tractive units is obligatory, in accordance with point 3.8.3 - page 13.

R **3.9.3 -** It is recommended that the channel switches should be equipped so that they can select the largest possible number of duplex channels numbered 17 to 37 (see Appendix A - page 47).

The automatic switching device of the reception frequencies of the apparatus on tractive units must remain inoperative when these duplex channels are selected.

R **3.9.4 -** Bearing in mind obligatory or recommendatory possibilities of selection for those channel switches utilised in international traffic, and additional frequency-allocation possibilities for lines used solely for domestic traffic, it is recommended that the apparatus should be suitable for selecting all the channels contained in a bandwidth of 1 MHz, quartz only being installed if necessary.

R 3.10 - Simplex channels in apparatus on tractive units

It is technically possible to install, in the apparatus on tractive units, an extra constituent block, so that the apparatus for simplex operations can be used by switching the reception frequency instead of the transmission frequency of each duplex channel fitted to the apparatus.

The radio equipment of tractive units can then be utilised for numerous other railway-specific radio applications, generally local ones.

4 - Operations governing radio links

4.1 - Standby

The radio link is on standby when no verbal communication or any digital message is being transmitted. To ensure proper monitoring of the state of the radio link and manage establishment of communications, the standby state must be characterised by transmission of a "free channel" signal (see point 5.2 - page 19). This is transmitted by the lineside stations and maintains all the mobile equipment on standby.

The "channel free" signal is the same in both operating modes, but is used differently in mobile equipment for each of the two operating modes.

4.2 - Connecting of loudspeakers, connection of listening and speaking circuits

Given the difference in the measures necessary to obtain confidentiality of communications in the duplex operating mode on the one hand, and free communications in the semi-duplex operating mode on the other, the listening and speaking circuits of the mobile equipment which do not participate in the communications must be subject to special switching conditions.

The possibility of obtaining, now or in the future, selective calling of mobile equipment, implies in particular the necessary immobilisation of the listening and speaking circuits in equipment not being used for communication purposes.

The following provisions must be observed:

4.2.1 - The connection of loudspeakers in the mobile equipment must be subsidiary to that of the microtelephonic handset: the loudspeaker is disconnected when the handset is lifted, and reconnected when it is replaced. The listening circuit is connected either to the loudspeakers or the microtelephonic handset.

4.2.2 - Provisions for the duplex mode of operation:

4.2.2.1 - When on standby, the listening circuit is immobilised in order to eliminate parasitic noise. The speaking and listening circuits are nevertheless available for establishing communication.

4.2.2.2 - During a communication, the listening and speaking circuits of the equipment not concerned are immobilised and not available because of the absence of the "channel free" signal.

4.2.2.3 - In the case of equipment which is in communication, the listening and speaking circuits remain in the working state. The absence of the "channel free" signal does not immobilise these circuits in this equipment, unlike the others, in accordance with point 4.2.2.2. The switching criterion which determines this function consists of the simultaneous presence of the "channel free" signal and operation of the push-button of the transmitter releasing issuance of the "pilot" signal when a communication is established. This simultaneity does not exist for equipment which is not involved in the communication, since its transmitters do not transmit when on standby.

4.2.2.4 - The listening circuit is released each time the "listening circuit" signal (see "listening" tone in point 5.3 - page 20) is being continuously received. This signal is attenuated by a narrow band filter in the listening circuit.

O **4.2.2.5 -** To ensure immobilisation, mentioned in point 4.2.2.2 - page 15, of the listening and speaking circuits in all mobile equipment which is not involved in communication, the "channel free" signal must be interrupted immediately at the beginning of transmission or on receipt of the "pilot" signal transmitted by mobile equipment.

4.2.2.6 - The "free" state of the radio channel is only indicated, by an acoustic signal, to the driver when the latter wishes to enter into communication with central control, the radio channel being occupied.

O **4.2.3 -** Regulations for the semi-duplex mode of operation

4.2.3.1 - When on standby, the listening circuit is immobilised in order to eliminate parasitic noise. The speaking and listening circuits are nevertheless available to establish a communication.

4.2.3.2 - During communications (the "channel free" signal being absent), the listening circuits of all mobile equipment are released to allow for simultaneous listening. The speaking circuits remain available.

4.3 - Connection of lineside receivers to the reception circuit linking them to central control

4.3.1 - During radio communication with central control, in both modes of operation, a lineside receiver receiving a signal of sufficient level must be connected.

Since the propagation times of the signals received are different between each lineside station and central control, the signal must only be injected into the circuit by a single receiver, to avoid interference which would occur at central control through phase differences between several signals. If no selection system for the lineside receivers is adopted, their frequencies being the same, it would often happen, because of the zone covered by their ranges, that two lineside receivers simultaneously introduce the signal into the link circuit, and sometimes, in the case of exceptional interference ranges, this could involve three or more lineside receivers.

In the case of systems which transmit messages, it is particularly important to avoid multiple signals with phase differences since these differences, even when small, give rise to errors of detection in the receipt of telegrams. Equalisation of phases from numerous lineside transmitters would be too costly and difficult to achieve.

4.3.2 - In mode 2 (semi-duplex), central control can select the desired lineside receiver manually, if it knows the position of the trains. However, the switching to the next lineside receiver must be carried out in time to coincide with the passage of the train from the zone of coverage of a lineside station to another.

R **4.3.3 -** It is preferable to provide automatic connection of the lineside station receiving a signal, by means of a switching device installed on the actual receivers, without intervention by central control. As a switching criterion, such a device implies reception of a "pilot" signal (see "pilot" tone in point 5.4 - page 20) from the mobile transmitters. This signal must be attenuated by a filter at central control.

O **4.3.4 -** In duplex mode of operation, the mobile equipment in communication with central control must continuously transmit the "pilot" signal, which is superimposed on the modulation by the spoken word during periods of transmission. This arrangement is generally applied in this mode of operation, since all communications take place via central control.

O **4.3.5 -** In semi-duplex mode, the mobile equipment transmits the "pilot" signal at the beginning of each transmission phase only, for links with central control and for at least 1,5 s. The tone can be continuous.

O 4.4 - Communications from one train to other trains or with local stations in semi-duplex mode of operation

Central control is not generally involved in these conversations, and should not therefore hear them (except in cases where it is itself connected).

Situations where lineside receivers are connected to the link circuit must be avoided. The "pilot" signal must not therefore be transmitted for a local communication taking place in the same zone of coverage of a lineside station.

4.5 - Warning signal

R **4.5.1 -** In both modes of operation, there must be a signal which can be activated by the drivers in cases of danger or emergency. This is the "warning" signal (see "warning" tone in point 5.5 - page 21).

Emission of the "warning" tone is effected in various ways by Railways to warn drivers of danger:

1. in duplex mode of operation, the "warning" tone can be utilised as in semi-duplex mode. In this case, greater security of transmission is obtained if the tone or combination of "warning" tones is injected automatically by the transmission telephone circuit so that it is emitted by all the lineside stations.

   Finally, the "warning" tone can be utilised to establish a priority verbal communication with central control. In the event of danger, central control then intervenes to warn the drivers (for example, through general information to all drivers, by releasing the listening circuits as mentioned in point 4.2.2.4 - page 15);

2. in semi-duplex mode of operation, lineside stations receiving the "warning" tone re-emit it or a combination of tones which they generate on its reception; this process is maintained until it can be considered as certain that the warning has been received by the drivers in the vicinity, or until the danger has been averted.

O **4.5.2 -** Transmission of the "warning" signal is initiated by the driver.

In both modes of operation, this transmission must be possible whether the channel is free or whether it is occupied by a communication.

Operation of the warning push-button must cancel immobilisation of the transmitter which may occur at certain times, in duplex mode, while the system is in use.

O **4.5.3 -** Emission of the "warning" tone by the mobile equipment is stopped as follows:

4.5.3.1 - In duplex mode of operation:

1. automatically after 20 s by means of a timing device;

2. and within 20 s by reception of a "channel free" tone impulse.

In order for a priority verbal communication to be established, this impulse has the effect, in mobile equipment, of switching emission of the "warning" tone to emission of the "pilot" tone.

Additional indication concerning item 2 above

The "channel free" tone impulse, the duration of which is 150 to 300 ms, must only be issued 2 s after reception of the "warning" tone at central control; this timelag is motivated by reasons linked to the security of working of the sequences.

In mobile equipment, switching of emission of the "warning" tone to the "pilot" tone must only occur 2 s after reception of the "channel free" tone impulse; this ensures that this impulse is definitely terminated and that the "channel free" tone has not halted emission of the "pilot" tone by operating as a criterion for stopping this emission as specified in point 5.4.6 - page 21.

If another item of mobile equipment were in communication at the time of emission of the "warning" signal, the "channel free" tone impulse would react at the same time on it, causing it to stop and to establish the corresponding immobilisation.

4.5.3.2 - In semi-duplex mode of operation:

1. manually by the driver;

2. or automatically after 20 s by means of a timing device.

R **4.5.4 -** The most effective precaution against the capture effect (stifling of weak warning signals in lineside receivers by a stronger signal emanating from another mobile transmitter) is to bring the lineside stations closer together so that their zones of coverage overlap. In this way, the probability of the warning signal being received at the same time at two lineside stations is increased. The capture effect should only normally occur at one of the receivers.

In semi-duplex mode, alternation of transmission and reception ensures partial protection against the capture effect.

5 - Operating signals

5.1 - General considerations

The technical characteristics of the control signals, also those of the detecting equipment installed in the mobile equipment and lineside installations, must be sufficiently comprehensive to guarantee at all times the working of the mobile equipment with the various items of equipment of the lines.

To obtain reliable detection of these control signals with simultaneous transmission of the spoken word, various solutions can be envisaged, and this leaflet simply elicits recommendations on this subject.

5.2 - "Channel free" signal ("channel free" tone)

O **5.2.1 -** This signal consists of a tone transmitted continuously by the lineside stations when the radio channel is free. Transmission of the signal is interrupted when the channel is occupied (see point 4.1 - page 15).

O **5.2.2 -** Frequency: 2280 Hz ± 1,5%.

O **5.2.3 -** The band occupation width corresponds to a frequency deviation of 1,75 kHz (see point 2.9.3 - page 8).

R **5.2.4 -** Criteria for reestablishing emission of "channel free" tone

5.2.4.1 - In duplex mode of operation:

1. the microtelephonic handset is replaced at central control, or,
2. about 5 s after cessation of emission of the "pilot" tone, or,
3. emission of the "warning" tone ceases.

5.2.4.2 - In semi-duplex mode of operation:

1. end of transmission by mobile equipment participating in a communication (this is a criterion intended to eliminate noise in loudspeakers);
2. disconnection of a lineside station from the telephone line by central control.

R **5.2.5 -** Criteria for halting emission of the "channel free" tone.

5.2.5.1 - In duplex mode of operation:

1. reception of "pilot" tone or
2. reception of "warning" tone or
3. beginning of emission of "listening" tone;

5.2.5.2 - In semi-duplex mode of operation:

1. start of transmission by a mobile item of equipment (criteria for elimination of noise);

2. connection of a lineside station to the telephone circuit.

5.3 - "Listening circuit" signal ("listening" tone)

O **5.3.1 -** In duplex mode of operation, this signal consists of a tone emitted continuously when the listening circuits (loudspeakers or microtelephone handsets) of all the mobile equipment have to be placed in service (see point 4.2.2.4 - page 15).

R **5.3.2 -** In semi-duplex mode of operation, this "listening" tone can be utilised at will for controlling connections to lineside installations. In principle, it produces no effect with mobile equipment.

O **5.3.3 -** Frequency: 1960 Hz ± 1,5%.

O **5.3.4 -** The band occupation width corresponds to a frequency deviation of 1,75 kHz (see point 2.9.3 - page 8).

O **5.3.5 -** In both modes of operation, the "listening circuit " tone must be attenuated by a filter in the listening circuits of the mobile equipment.

Attenuation of filter ≥ 40 dB at 1960 Hz.

R **5.3.6 -** Emission of the "listening" tone is initiatied or halted as necessary.

5.4 - "Pilot" signal ("pilot" tone)

O **5.4.1 -** In both modes of operation, the signal is emitted by the mobile equipment while it is in communication with central control in accordance with the conditions set out in point 5.4.5 (see point 4.3 - page 16).

O **5.4.2 -** Frequency: 2800 Hz ± 1,5%.

O **5.4.3 -** The band occupation width corresponds to a frequency deviation of 1,75 kHz (see point 2.9.3).

R **5.4.4 -** The "pilot" tone must be attenuated by a filter in the listening circuit of central control.

Attenuation of filter ≥ 40 dB at 2800 Hz.

O **5.4.5 -** Criteria for emission of the "pilot" tone

5.4.5.1 - In duplex mode of operation:

1. beginning of transmission by the mobile equipment for radio communications or for message transmission;

2. end of emission of the "warning" tone before 20 s have elapsed, for warning communications (see point 4.5.3.1 - page 17).

5.4.5.2 - In semi-duplex mode of operation:

- operation by the driver of the button for connecting the lineside station or stations to the telephone circuit (see point 4.3.5 - page 17).

o **5.4.6 -** Criteria for halting emission of the "pilot" tone

5.4.6.1 - In duplex mode of operation:

1. end of transmission by the mobile transmitter (when the driver replaces the microtelephone handset);

2. or re-establishment of the "channel free" tone.

5.4.6.2 - In semi-duplex mode of operation:

- after the action referred to in point 5.4.5.2, at the end of each radio transmission until the driver's handset is replaced.

o 5.5 - "Warning" signal ("warning" tone)

5.5.1 - In both modes of operation, this signal is emitted by the mobile transmitters in cases of emergency (see point 4.5 - page 17).

5.5.2 - Frequency: 1520 Hz ± 1,5%.

5.5.3 - The band occupation width corresponds to a frequency deviation of 1,75 kHz (see point 2.9.3 - page 8).

5.5.4 - Criterion for emission of the "warning" tone

- action by the driver.

5.5.5 - Criteria for halting emission of the "warning" tone

5.5.5.1 - In duplex mode of operation:

1. automatically after 20 s by means of a timing device;

2. before 20 s have elapsed by reception of an impulse of the "channel free" tone lasting 150 to 300 ms. The process then requires switching of emission of the "pilot" tone after a timelag of 2 s ± 20% with effect from reception of the impulse of the "channel free" tone (see point 4.5.3.1 - page 17).

5.5.5.2 - In semi-duplex mode of operation:

1. action by the driver;

2. or automatically after 20 s by means of a timing device.

5.6 - Operating signal detectors

O **5.6.1 -** The operating signal detectors must function reliably in terms of the spoken word, so that modulation by the voice does not accidentally simulate the presence of operating signals.

The operating signal detectors must also function reliably with regard to noise. They must not function accidentally if noise occurs at the output end of the receiver (for example, when there is a defect in the noise regulator), otherwise immobilisation would occur in the working of the system.

Various measures can be adopted to guarantee sufficient security of working of these detectors, for example:

R **5.6.2 -** A timing device ensures a timelag T_{an} in functioning. The value of this delay differs depending on the function to be carried out. The timelag for working the detector of the "pilot" tone has purposedly been made very short (see table in point 5.6.6 - page 23), merely to allow for rapid message transmissions.

R **5.6.3 -** The minimum working band width of detectors is the nominal frequency $\pm$ 4,5%.

R **5.6.4 -** The switching margin of the detector (sensitivity), when there is no inverse voltage (see point 5.6.5) is fixed at half the usual level of the operating signals (corresponding to a frequency deviation of 0,88 kHz in the radio band).

R **5.6.5 -** The detector generates at its output end a rectified switching voltage, and a rectified inverse voltage which acts in the opposite direction on the switching stage. The switching voltage is proportional to the operating signal contained in the minimum working band width of the detector; the inverse voltage is proportional to the overall signal received at the input end of the detector and contained in the speech channel outside the working band width of the detector (inverse signal).

Depending on their functions, the working thresholds at the output end of the detectors are regulated for the values of the ratio of the levels of the operating signal and the inverse signal mentioned in the following table (see point 5.6.6). Adjustment must be effected with a frequency deviation of the operating signal equal to a nominal value of about 1,75 kHz.

For larger or smaller values of the operating signal, the ratio of the levels of this operating signal to the inverse signal should vary as little as possible.

R **5.6.6. -** Characteristic values for operating signal detectors:

Operating signal	"Channel free"	"Listening circuit"	"Pilot"	"Warning"
Frequency	2280 Hz	1960 Hz	2800 Hz	1520 Hz
T_{an}	120 ms	200 ms	12 ms	110 ms
Minimum working band width	± 1,5%	± 1,5%	± 1,5%	± 1,5%
Band width outside which the detector does not function	± 4,5%	± 4,5%	± 4,5%	± 4,5%
Frequency deviation corresponding to the sensitivity margin	0,88 kHz	0,88 kHz	0,88 kHz	0,88 kHz
Operating signal - inverse signal ratio corresponding to the working threshold	1 : 1	1 : 2	1 : 2	1 : 2

6 - Links between tractive unit and RIC coaches

6.1 - General provisions

6.1.1 - *UIC Leaflet 568* (see Bibliography - page 57), entitled "Loudspeaker and telephone systems in RIC coaches", defines a standard arrangement making it possible to broadcast music and messages from one coach in a train to the others in the same train.

6.1.2 - In addition, this leaflet provides for the use of a general wiring system consisting of a three-quad cable, two quads of which are reserved for the loudspeaker installation and the remote link between driver and train staff.

Plate 5 appended to *UIC Leaflet 568* shows the allocation of conductors in the cable.

6.1.3 - *UIC Leaflet 568* also provides for the additional use of points for transmitting announcements in coaches, to permit remote link between train staff and either the driver or central control. It stipulates the technical characteristics of the transmission points in coaches. These characteristics are compatible with the technical characteristics of the telephone point and the radio equipment of the tractive unit covered in the present point.

O **6.1.4 -** In order to adapt to the provisions in force on Railways involved in international traffic, these technical characteristics must stipulate the minimum conditions to be satisfied by the equipment on tractive units and in coaches, so that the following communications can be established under satisfactory conditions:

6.1.4.1 - announcements to passengers and train staff via loudspeakers in the coaches (see point 1.1.3 - page 2),

1. from central control through the radio equipment on the tractive unit;

2. through the driver.

6.1.4.2 - telephone conversations (see point 1.1.4 - page 2),

1. between train staff and driver;

2. between central control and train staff through the radio equipment on the tractive unit.

To establish such links, the equipment on the tractive unit can include one or two handsets.

O **6.1.5 -** These technical characteristics must take into account the particular features of the duplex and semi-duplex modes of operation, insofar as this is necessary in terms of the provisions of point 1.2.1 - page 2.

O 6.2 - Extension of the general wiring to the tractive unit

The 12-conductor general wiring mentioned in *UIC Leaflet 568* must be extended up to the tractive unit in order to be connected to the radio equipment, and where applicable to the separate telephone installation.

For this purpose, the tractive unit must be provided, at each end, with a connection as defined in *UIC Leaflet 568*.

For connecting the link cable between two tractive units, these units must be provided with a section of flexible cable with a connecting plug at each end.

6.3 - Announcements by loudspeakers in RIC coaches

6.3.1 - Signals and levels

6.3.1.1 - In order that announcements can be made from central control or from the tractive unit (communications mentioned in point 6.1.4.1 - page 24), the point installed in the tractive unit must supply the operating signals on lead pairs 5/6 and 7/8 with the same levels as the transmission points in coaches (see *UIC Leaflet 568*).

6.3.1.2 - The levels of the electrical signals on lead pair 1/2 are fixed with a view to obtaining the same sound intensity in the loudspeakers of coaches, whether the announcements emanate from transmission points in coaches, the driver or central control.

The effective value of 2 V, mentioned in *UIC Leaflet 568* as the mean voltage corresponding to a normal intensity of the spoken word, supplies the amplifiers of the coaches with a signal giving a satisfactory sound intensity even despite the rolling noise of trains.

6.3.2 - Announcements by the driver

6.3.2.1 - By pressing a push-button, the driver is able to connect the equipment of the tractive unit to lead pairs 1/2, 5/6 and 7/8 of the general wiring system. The radio transmitter is not used for these announcements. During the announcements, the radio signals emanating from the radio reception must not reach lead pair 1/2.

The link with the loudspeakers in coaches is automatically cut off as soon as the handset is replaced.

6.3.2.2 - To obtain a good-quality announcement, it is recommended that the values prescribed in *UIC Leaflet 568* be observed in respect of the microphone and the preamplifier installed in the tractive unit.

It is nevertheless necessary to have a mean voltage of 2 V at least (effective value) on lead pair 1/2, as a radio signal, when the driver is speaking normally with ambient noise.

6.3.2.3 - It must be impossible to make announcements from the tractive unit when the train staff are already making an announcement.

This lock-out device must be indicated to the driver.

6.3.3 - Announcements by central control

6.3.3.1 - In the case of systems which do not transmit messages by digital code, the driver, at the request of central control, manually establishes the connection between the radio reception and lead pair 1/2, also the control voltage on lead pairs 5/6 and 7/8 of the general wiring system. For this purpose, he/she presses the same "train loudspeaker" push-button as for his/her own announcements. The handle of the handset can be designed to differentiate between announcements made by the driver for connection or disconnection of the radio reception channel to lead pair 1/2.

During announcements by central control, the driver must replace his/her handset. The driver can still listen over the loudspeaker.

At the end of an announcement, the link with the loudspeakers in the coaches is automatically cut. For this purpose, the criterion to be used is the fact that the handset in the tractive unit is replaced and:

- in duplex mode:
  the "channel free" signal is received,

- in semi-duplex mode:
  either the "channel free" signal is received,
  or the "listening circuit" signal disappears.

6.3.3.2 - In the case of systems which transmit messages by digital code in accordance with the directives in point 7 - page 30, central control establishes the connection with the loudspeakers in the coaches by the "train loudspeaker" telegram, mentioned in point 7.6 - page 35 without intervention by the driver.

Disconnection takes place by reappearance of the "channel free" signal.

6.3.3.3 - To adapt the output end of the radio receiver of the tractive unit to the loudspeaker circuit, the following values are adopted in accordance with point 2.9.4 - page 8:

- the average level of the spoken word of normal volume of central control is transmitted with a frequency deviation of 1,1 kHz, and supplies the lead pair 1/2 of the general wiring system with an average voltage of 2 V (effective value);

- the peak levels of the spoken word from central control are limited and transmitted by radio with a frequency deviation of maximum value 2,25 kHz. They supply lead pair 1/2 of the general wiring system with a voltage of approximate maximum value of 4 V.

6.3.3.4 - It must be impossible to make announcements from central control when an announcement made by the driver or by train staff, and therefore of a priority nature, is already being made inside the train. This lock-out system must be indicated to the driver.

6.3.3.5 - If central control wishes to be connected to the public address system via the message mentioned in point 7.6, it must receive an indication as to the immediate impossibility of establishing this link when the public address system is occupied by a priority internal communication. This can be reflected, for example, by the absence of the acknowledgement telegram during internal occupation of the public address system (see point 7.2.1 - page 31).

o 6.4 - Telephonic and radiotelephonic communication with train staff

6.4.1 - General provisions

6.4.1.1 - Certain RIC coaches possess a transmission point used by train staff both for loudspeaker announcements in the coaches and for telephone communications with the tractive unit and radiotelephone communications with central control.

6.4.1.2 - The telephone and radiotelephone links of train staff are provided by lead pair 3/4 of the general wiring system.

6.4.1.3 - The technical characteristics for connecting the transmission points in coaches to lead pair 3/4 are as stipulated in *UIC Leaflet 568*. They are compatible with the technical characteristics indicated below concerning the telephone and radiotelephone installations on the tractive unit.

6.4.1.4 - The levels fixed for lead pair 3/4 are intended to ensure a satisfactory radio link with uniform levels for the average radio signal emitted by the various transmission points with ambient noise.

6.4.2 - Telephone link between train staff and driver

6.4.2.1 - Lead pair 3/4 must be connected permanently via a balancing four-wire terminating set to the speech circuit of the driver.

6.4.2.2 - The listening circuit of the driver must only be connected to lead pair 3/4 by the balancing four-wire terminating set during conversations with train staff. The link is established by control voltage on lead pair 3/4.

Nominal value of the continuous control voltage: 24 V,

Tolerance in accordance with *UIC Leaflet 568*: 18 V.... 33 V,

plus at conductor 4
minus at conductor 3.

With the nominal value of the control voltage, the maximum consumption of the control unit of the equipment on the tractive unit is 20 mA.

6.4.2.3 - Lead pair 3/4 must be closed by means of the balancing four-wire terminating set on the characteristic impedance of 600 ohms.

Decoupling between listening channel and speech channel by means of the balancing four-wire terminating set must be greater than 20 dB.

6.4.2.4 - The link is still established by train staff. When the driver wishes to enter into communication, he/she calls the train staff via loudspeakers in the coaches.

When a call is made by the train staff, the control voltage on lead pair 3/4 connects the listening circuit of the driver.

When the driver hears the call over his/her loudspeaker, he/she converses by means of his/her handset. The link is interrupted when the train staff replace their handset.

During conversation with the train staff, the driver must be able to receive radiotelephone calls.

6.4.2.5 - The mean voltage expressed in effective value of the spoken word on lead pair 3/4 must be:

- 500 mV for speech by the train staff,

- 775 mV for speech by the driver.

6.4.3 - Radiotelephone link between train staff and central control

6.4.3.1 - Lead pair 3/4 can be connected permanently to the radiotelephone reception channel by means of the balancing four-wire terminating set, or only during a radiotelephone conversation by

means of a control voltage on lead pair 3/4. If the balancing four-wire terminating set is not connected permanently, care must be taken to ensure that it also remains connected to the radiotelephone reception channel during breaks in listening when the control voltage is absent.

6.4.3.2 - The radio transmitter and listening circuit of the driver must only be connected to lead pair 3/4 by the balancing four-wire terminating set during conversations of the train staff. The link is established by the control voltage on lead pair 3/4.

Nominal value of the continuous control voltage: 24 V,

Tolerance in accordance with *UIC Leaflet 568*: 18 V.... 33 V,

plus at conductor 3
minus at conductor 4.

With the nominal value of the control voltage, the maximum consumption of the control unit of the equipment of the tractive unit is 20 mA.

6.4.3.3 - The radio link is always established by the train staff. When central control wishes to enter into communication, it calls the train staff through the loudspeakers in the coaches.

When a call is made by the train staff, the control voltage on lead pair 3/4 connects the radio transmitter of the tractive unit to lead pair 3/4 in accordance with the following provisions:

- in duplex operation without message transmission by digital code, the control voltage only brings about transmission of the pilot signal if the channel is free (presence of the "channel free" signal). The train staff do not know straightaway whether the channel is free. (It is therefore recommended that an indication should be given to the train staff that the channel is free, by means of a special tone, which can be emitted by the pilot signal at central control and stopped when the handset of central control is removed). The radio link ends with reappearance of the "channel free" signal;

- with duplex operation, with message transmission by digital code, in accordance with point 7 - page 30, only the request for communication expressed by the train staff is memorised in the radio equipment by means of the control voltage, and is only transmitted by coded telegram (see point 7.6 - page 35) when the channel is free.

  When central control replies to the request for communication expressed, it sends a control telegram (see point 7.6) to the radio equipment of the tractive unit, thus establishing the link between the train staff listening at the transmission point of the coach. Radio link ends with reappearance of the "channel free" signal.

  In the 2 modes of duplex operation, radio transmission from the mobile equipment is terminated when the handsets in the tractive unit and the coach are replaced.

  When a link has been established by central control between the telephone network and the driver or the train staff, the central-control installation transmits the "channel free" signal about 5 s after the end of the radio transmission from the mobile equipment, and severs the link established.

- with semi-duplex operation, the control voltage switches in the radio transmitter and releases the pilot signal, whether the channel is free or not. After the conversation, the radio link ends either with the disappearance of the "listening circuit" signal or with reception of the "channel free" signal.

In all the above cases, the driver hears the entire conversation through the loudspeaker or loudspeakers. If necessary, he/she must be able to intervene with central control.

6.4.3.4 - The mean value (effective value) of the radio signals over lead pair 3/4 is 500 mV. It is transmitted in accordance with point 2.9.4 - page 8 over the radio channel with a frequency deviation of 1,1 kHz. The maximum values of the radio signals are limited and transmitted with a frequency deviation of 2,25 kHz.

The mean value (effective value) of the radio signals from central control is transmitted in accordance with point 2.9.4 over the radio channel with a frequency deviation of 1,1 kHz. The radio signals of this value produce, over lead pair 3/4, an average radio signal of 775 mV (effective value). The maximum frequency deviation of 2,25 kHz, with which the limited speech peaks are transmitted, produces on lead pair 3/4 maximum values of about 1,6 V.

6.5 - Telephonic communication between tractive units via the general wiring system

When two tractive units of a train are equipped with radio and linked together by the general wiring system, it is possible to establish a telephone link between them, without precluding the possibility of a radio link with central control.

However, the radio equipment on the tractive units does not supply the control voltage on lead pair 3/4, since it can only be produced by the transmission points in the coaches. Thus, to establish communications between tractive units, it is necessary to connect the balancing four-wire terminating set of each tractive unit to the "listening circuit" via a manual switch operated by the drivers.

The reduction in the quality of radio communications resulting from this permanent connection of the balancing four-wire terminating sets must be accepted under these exceptional conditions.

NB : Since the general wiring system does not exist on freight trains, this link can only be established via the cable mentioned in point 6.2, between two locomotives working as multiple units.

7 - Selective calling, message transmission by digital code

7.1 - General

7.1.1 - This point describes the bidirectional system for message transmission between trains and central control, as utilised jointly at present by certain Railways which have adopted the duplex mode of operation.

It is used as an addition to telephone links and allows for selective calling of trains, transmission by the trains of their identity indicator, also bilateral message transmission.

7.1.2 - The obligation to install equipment working in accordance with this system in foreign tractive units, required to run on Railways which have adopted it, is covered by bilateral or multilateral agreements.

7.1.3 - For selective calls and message transmission, only the numbers of trains which are calling or being called are utilised to recognise them, without any additional letter characters to characterise them.

7.1.4 - Each message is transmitted by a sequence of impulses forming a telegram; this always contains the number of the train concerned.

7.1.5 - Messages transmitted to trains, by pressing on a push-button at central control, can take the form of optical or acoustic signals, or can be utilised to effect switching operations automatically in other installations in the trains (for example, connection of the loudspeaker circuit in coaches).

7.1.6 - Messages transmitted by trains to central control can be issued either manually by the driver on his control panel, or automatically by other installations in the train (for example, conversation request by the train staff). At central control, these messages can be indicated by optical display or be processed.

7.2 - Transmission mode for telegrams

When transmitting a telegram, a check with accompanying display must give an assurance, at transmitting point, that the telegram has definitely been received.

Each transmission of a telegram, recognised as correct by the receiver of the destination point, is followed by the automatic despatch of a telegram acknowledging receipt. This telegram is not acknowledged.

The acknowledgement telegram despatched automatically by the mobile radio equipment is identical to the telegram transmitted by central control.

Acknowledge receipt from central control points, the Railways can supplement the train code by another suitable code. For this purpose, there are two possibilities:

1. utilise the "test" telegram,

2. utilise the same telegram as the telegram received (acknowledgement identical to that of tractive units).

Notes concerning items 1. et 2.:

In the case of item 2., the digital codes are different in both transmission directions, since in specific cases (for example at railhead stations), two tractive units can temporarily bear the same train number. If the telegrams were identical, the acknowledgement, sent by central control to the driver who had despatched the telegram, could be considered by the second tractive unit as an advice intended for it.

With this procedure, the store of telegrams is reduced by 50% because of the differentiation in orders and advices. In the case of item 1., the store of telegrams is not limited. In the event of a conflicting situation, the second tractive unit, bearing the same train number, would take the acknowledgement as a "test" telegram and would execute it as such. However, this would not have any effect on operating safety. In such a case, the radio system can be immobilised for a maximum of 5 s, if by coincidence the two tractive units interpreted in turn the acknowledgement telegram as such or as a "test" telegram. This characteristic must be accepted.

The codes recommended in point 7.6 - page 35 assume that procedure 1. is used.

A telegram is transmitted as follows:

7.2.1 - Transmission of a telegram to a train

7.2.1.1 - Telegram transmission is set in motion at central control manually or by an automatic process.

7.2.1.2 - Transmission of the "channel free" tone (see points 4.1 - page 15 and 5.2 - page 19) is halted.

7.2.1.3 - After a timelag of 180 ms, transmission of the telegram is effected by central control and repeated at intervals of 350 ms for the next 5 s, unless an acknowledgement telegram received in the meantime interrupts this transmission.

7.2.1.4 - All mobile radio sets receive the telegram. They compare the number of their train with that contained in the telegram. The equipment which possesses this number verifies the validity of the telegram and, as pretransmission before the acknowledgement telegram, emits a "pilot" tone lasting 70 ms, which has the effect of establishing connection of the reception circuit at the lineside stations (see points 4.3.3 - page 16 and 5.4 - page 20).

7.2.1.5 - The mobile equipment then sends back to central control an identical telegram as an acknowledgement, following which it reverts to the idle state.

7.2.1.6 - In the case of a telegram not intended to establish a telephone link, central control re-establishes transmission of the "channel free" signal after receipt of the acknowledgement telegram, or after a period of 5 s has elapsed; the system then reverts to standby.

7.2.1.7 - A completed transmission (acknowledgement received) and one which has not been completed (no acknowledgement received) are indicated to the operational staff by a distinctive sign, for example: the former by extinguishing the light of the information transmitted push-button, and the latter by flashing the light of the confirmation push-button.

7.2.1.8 - The telegram received is indicated in the tractive unit by a visual signal and an acoustic signal, or utilised to activate a switching device in the train (for example, connection of the loudspeaker circuit in the coaches).

7.2.1.9 - Contrary to the provisions of point 7 - page 30, when central control establishes telephone links by means of a telegram, it does not transmit the "channel free" signal after receipt of acknowledgement, but only after the communication. The "channel free" signal re-establishes the standby status.

This ruling applies to requests for communications sent to the driver or train staff, also to connection of the radio circuit to the loudspeaker system.

7.2.1.10 - When mobile equipment receives a telegram used to establish a link, it releases its listening circuit and prepares the speech circuit. If it is a "public address system" telegram, the radio reception channel is also connected to pair 1/2 of the general wiring system of the train. The control voltage is established at the same time on pairs 5/6 and 7/8 of the general wiring system.

Reception of the "channel free" tone again immobilises the listening and speech channels and cancels, where applicable, the connections made to the general wiring system.

7.2.1.11 - In a tractive unit which has received a telegram intended to establish a link with the driver or train staff, the speech circuit is released and the pilot signal is transmitted when the handset is removed in the tractive unit, or a control voltage polarised as a result is present on pair 3/4 of the general signalling system.

This assumes that, in the interval, the equipment on the tractive unit has not received the "channel free" signal which would have restored the standby situation.

The "pilot" tone is not necessary in the case of a unilateral link with the loudspeakers in the train. It can therefore either be emitted or cancelled.

7.2.2 - Transmission of a telegram to central control

7.2.2.1 - Manual control by push-button or automatic control results in the storage of a telegram in the radio equipment of the tractive unit.

7.2.2.2 - If the "channel free" signal is not present, the equipment awaits its restoration by central control.

7.2.2.3 - On receipt of the "channel free" signal, the mobile radio equipment emits the "pilot" tone for a period of 70 ms, as a pretransmission preceding that of the telegram.

On receipt of the "pilot" tone by central control, emission of the "channel free" tone is broken off in order to immobilise all the other mobile radio equipment sets.

7.2.2.4 - The mobile equipment transmits the telegram for the first time. It repeats it every 270 ms with transmission of the pilot signal between the telegrams, until receipt of acknowledgement of the

channel free tone. Transmission stops after 8 s. The equipment reverts automatically to standby, if in the meantime it has not received either an acknowledgement or a "channel free" tone.

7.2.2.5 - After receipt of a telegram recognised as valid, central control automatically sends back, as an acknowledgement, a telegram bearing the code number of the transmitting train and an acknowledgement code in accordance with point 7.2, item 1 - page 31 ("test" code) or item 2 - page 31 (advice code).

Since the equipment on tractive units crossing frontiers must recognise both the acknowledgement mentioned in point 7.2, item 1 and that mentioned in point 7.2, item 2, they must only make use, in receiving the acknowledgement from central control, of the train number and, for identity purposes, utilise it as an acknowledgement, while the following message code must remain unused. It is used only for the redundancy check.

7.2.2.6 - On receipt of the acknowledgement telegram, the mobile equipment ceases transmission and reverts to standby.

7.2.2.7 - 0,8 s after transmission of the acknowledgement, or after 5 s for non-operational telegrams, central control restores emission of the "channel free" tone. The mobile equipment thus reverts to standby, unless it has already done so in accordance with point 7.2.2.6.

7.2.2.8 - A transmission which has been completed (followed by an acknowledgement) and one which has not been completed (acknowledgement not received) are indicated in the tractive unit by a distinctive signal, for example the former by extinguishing the light of the corresponding push-button, and the latter by flashing the light of the confirmation push-button.

7.2.2.9 - The telegram received is displayed at central control with the train number or is processed later.

7.2.3 - Interruption of transmission of telegrams by the "warning" signal

On receipt of the "warning" tone emanating from a train (see points 4.5.1 - page 17 et 5.5 - page 21), the transmission of telegrams by central control is immediately interrupted.

These transmissions are also interrupted by mobile radio equipment when it receives a "channel free" tone impulse in accordance with point 4.5.3.1, item 2 - page 17 in response to receipt of the warning tone from other mobile radio equipment.

Radio equipment which has recorded messages in a "channel occupied" situation transfers to the position of transmitter under the effect of the initial "channel free" tone impulse. To stop this equipment in the event of a warning, central control must transmit a second "channel free" tone impulse in accordance with point 4.5.3.1, item 2.

This impulse must take place after about 150 ms after the first one. Thus, with a maximum of 750 ms, the duration of the double "channel free" tone impulse definitely remains below the time constancy of 2 s indicated in the note to point 4.5.3.1, item 2.

7.3 - Structure of the telegram and synchronisation

Each telegram has the following structure:

- synchronisation achieved by an initial sequence of 8 bits with the value 1 followed by the sequence 0010,
- followed by the 6-position train number in B C D code with 4 bits per position, the order of the bits being: 2^0, 2^1, 2^2, 2^3,
- two-position message with 4 bits per position,
- finally, 7 bit redundancy in accordance with point 7.4,
- and, if necessary, extension of the telegram in accordance with point 7.7 - page 36.

7.4 - Security of transmission guaranteed by redundancy

So that the receiver can verify the integrity of the telegrams transmitted, a 7 bit redundancy is available to the transmitter and inserted in the framework of the telegram.

The composition of the redundancy is governed by the following law:

- the dual polynomial consisting of the train number, the information, and 7 bits of value 0 is divided by the generator polynomial 111 0000 1 in accordance with the principle of the modulo 2 addition;
- the following applies:

  0 + 0 = 0
  0 + 1 = 1
  1 + 0 = 1
  1 + 1 = 0 without carrying;

- the remainder of the division is inverted and carried over in place of the last 7 bits of the telegram structure.

The receiver inverts the order of the last 7 bits of the telegram. He considers a telegram as correct when it is possible to divide it without remainder by the polynomial mentioned above. If the division leaves a remainder, the telegram is rejected.

By using the redundancy indicated, a Hamming distance of $d \geq 4$ is obtained for the telegram.

7.5 - Characteristics of the transmission of telegrams

The modulation procedure applied on the radio channel is that of the FSK (Frequency Shift - Keying) - Representation:

value 0 per 1700 Hz
value 1 per 1300 Hz
Frequency deviation: 3,5 kHz
Transmission speed: 600 bits/s ± 2‰

7.6 - Messages

The messages indicated below, also the corresponding codes, are utilised by certain Railways which have adopted the duplex mode with message transmission by digital code. To ensure compatibility of the lineside installations of the Railways with the mobile installations on foreign tractive units crossing frontiers, the messages and their codes must be identical from the lineside and mobile point of view.

The codes listed below only apply if the acknowledgement telegram is formed using the "test" code in accordance with point 7.2, item 1 - page 31.

If a Railway wishes to make use of other messages on its own territory, it must resort to codes different from those shown in the store.

The exchange of messages with foreign tractive units must be covered by an agreement between the Railways in accordance with point 7.1.2 - page 30, to avoid the same codes having different meanings. The codes agreed must be notified to the UIC for subsequent inclusion in the following list:

7.6.1 - Messages sent to the train by central control

"Speech"	Code	0000 1000
"Emergency stop"	"	0000 1001
"Test"	"	0000 0000
"run faster"	"	0000 0100
"run slower"	"	0000 0010
"announcement by loudspeaker"	"	0000 1100
"await a written order at next stop signal and advise approach to stop signal"	"	0000 0110
"Extension of telegram"	"	0000 0011

7.6.2 - Messages sent to central control by the train

"Communication wanted"	Code	0000 1000
"acknowledgement of order" (manual confirmation)	"	0000 1010
"advice"	"	0000 0110
"test"	"	0000 0000
"Train staff wish to establish a communication"	"	0000 1001
"telephone link wanted"	"	0000 1100
"Extension of telegram"	"	0000 0011

7.7 - Extension of telegrams

If, for certain Railways, the telegram structure of 43 bits is not sufficient with 24 bits for the address and 8 for the message, the telegram can be extended.

This extension must be indicated in the basic structure of the telegram by code 0000.0011. If compatibility of extended telegrams cannot be ensured by bilateral or multilateral agreement, they should only be used on a national basis.

8 - Radiotelephone system with simultaneous digital message transmission

(See outline diagram in appendix E - page 56).

8.1 - General

Railways equipped with a ground-train radio telephone system recognise that it is expensive but under-used. It is therefore worth developing further applications other than voice communications, for use on the system even if this involves some additional investment.

NB : A single transmission channel is divided, irrespective of the demand (speech, short message, long message), into 2 sub-channels:
1/4 systematically for short message,
3/4 systematically as priority for speech, and in the second place for long messages.

The objective of the present point is to meet the following functional requirements:

- duplex exchange of telephone or teleadvice (warning) conversations, between the controller or a station and a driver with selective calling from the train called and identification of the train making the call. A general call is possible;

- duplex exchange of data messages of any length between central control and a motive power unit because of the simplification of the system;

- simplex exchange of telephone conversations between drivers within the same radio section;

- the system is also compatible for speech purposes with the UIC semi-duplex system, as defined in this leaflet;

- it will also be possible usable if the spacing between adjacent channels is reduced to 12,5 kHz.

Operation of the system for voice communications is unrestricted (no lockout) and always takes priority.

Short/teleadvice messages are despatched systematically.

The transmission time available for long messages is governed by the degree of occupation of the regulation sector for speech purposes.

The technical description corresponds to this programme:

- technical procedure for operating the system,

- procedure for speech with selective calling or identification,

- procedure for reception and exchange of telegram.

List of standard terms

ARM	=	Asynchronous Response Mode
CCITT	=	International Telegraph and Telephone Consultative Committee
FCS	=	Frame Check Sequence
FFSK	=	Fast Frequency Shift Keying
FSK	=	Frequency Shift Keying
HDLC	=	High level Data Link Control
ISO	=	International Organisation for Standardisation
SARM	=	Set ARM
SYN	=	SYNchronisation
U.A	=	Unnumbered Acknowledged
U.I	=	Unnnumbered Information

NB : In the text below, standard terms are marked by an asterisk *.

List of non-Standard terms

English abbr.		
SCE	=	Speech Compression Expansion
APCOD	=	Application Code
STAFS	=	Fixed Station State
I/F	=	Intermediate / Final
INFOF	=	Information field
FH	=	Final Header
MWDT	=	Mobile station without Data Transmission
MDT	=	Mobile station with Data Transmission
N	=	Node
LOCNO	=	Locomotive number
SYSNO	=	Node number allocated to an MTD
TRANO	=	Train number
P	=	Priority
CP	=	Control post
SC	=	Sub-channel
FS WDT	=	Fixed station without Data Transmission

English abbr.		
FS DT	=	Fixed station with Data Transmission
FSNN	=	Fixed station node number
WDT	=	Without Data Transmission
T/A	=	Transport / Application
DT	=	Data Transmission

8.2 - Details of facilities available in the system

The system allows for:

- voice communications,
- selective calling of mobile unit with data transmission,
- general calling of all mobile units present on the regulation sector,
- automatic identification of the calling point,
- immobilisation of loudspeaker at points not called,
- forwarding of digital messages irrespective of their length.

8.3 - Organisation of the data transmission system over the radio channel

The message transmission and reception procedures over the radio channel are defined in Appendices A - page 47 and B - page 48.

8.3.1 - Definitions

Nodes:

A node is the point which transmits or receives digital messages.

Sub-channels:

These are sub-assemblies or parts of a node. They may be specific inputs/outputs. The destination sub-channel is the sub-channel of the destination node to which the message is forwarded. The source sub-channel is the sub-channel of the source node from which the message originates. The sub-channels used for the exchanges of messages between nodes are as follows:

15H[a]	:	Input/output intended for the connection of a terminal (generally for maintenance).
50H[a]	:	On the MDT: input/output intended for the connection of external data processing equipment.

a. H = hexadecimal coding

NB : The destination sub-channel of the destination node uses the source sub-channel of the source node in cases where a reply needs to be sent to the latter. In the other cases, the source sub-channel is irrelevant and may have any value.

8.3.2 - Main characteristics

The main characteristics are as follows:

- the radio transmitter/receiver points of the mobile units are duplex; the speech link operates in duplex between central control and the mobile unit or between the mobile unit and a station point; on the other hand, it is operated in simplex for mobile unit/mobile unit links;

- in the ground-train direction, as in the train-ground direction, exchanges of data take place for traffic messages over the full band. The division between the "speech" track and the "data" track utilises time-division multiplexing (see Appendix B - page 48);

- in the ground-train direction, a permanent pilot channel transmits service messages continuously at low speed. These messages are forwarded by multiplexing through frequency distribution without interfering with speech reception at the MWDTs (see Appendix C - page 52);

- lastly, in the train-ground direction, the "speech" track has a sub-audible tone at a frequency of 192,8 Hz ± 0,5% (Δf = ± 0,5 kHz), which enables the FSDTs to distinguish the MDTs from the MWDTs. This arrangement guarantees perfect compatibility between the two systems.

8.3.3 - Principle of message transmission over the radio channel

In the ground-train direction, traffic messages are transmitted as soon as they are generated, interrupting any speech link which may be taking place. They are therefore audible in the loudspeakers of the mobile units which are on at that particular time.

In the train-ground direction, a time-based multiplexing procedure is used known as "speech compression-expansion" (S.C.E.), which is described in point 8.4 - page 41 and protects against any interference.

If there is no digital message to be transmitted, the radio carrier is cancelled out enabling another mobile unit to intervene in data transmission mode.

When no telephone conversation is taking place, the MDT can transmit any digital message over the air without observing the synchronisation supplied by the FSDT (see point 8.3.4).

8.3.4 - Use of the pilot channel - Description of the states of the fixed stations (STAFS) - Synchronisation

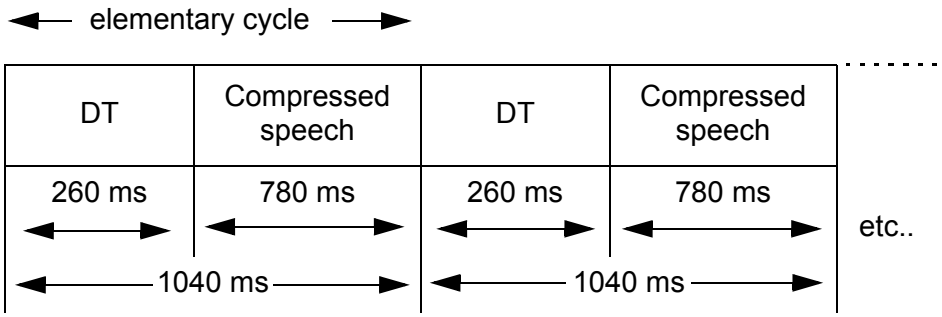
To administer their data transmission (DT) traffic correctly, the mobile units need to know permanently the number and state of the lineside point by which they are covered.

To comply with the functional programme and to allow for possibilities of future applications, 11 states have been adopted. They have been graded so that, for the mobile unit receiver, a higher ranking replaces a lower ranking, as necessary.

The name, ranking, significance and action of the loudspeakers of MDTs of the various states is given in Appendix D - page 55.

8.4 - Speech-data time-division multiplexing for messages in the train-ground direction

The SCE procedure is described below:



Each transmission period

of 1040 ms is divided into two parts of unequal duration:

- the first (260 ms) is reserved for DT,

- the second (780 ms) is allocated to compressed speech.

The latter is obtained as follows: the speech analogue signal is sampled at a frequency of 7,2 kHz. The samples are digitalised and memorised. They are then read at a speed of 9,6 kHz and converted into analogue.

The reverse operation (speech expansion) is obviously carried out by the FSDT before retransmission to central control.

Synchronisation is achieved by means of the pilot channel information transmitted by the FSDT and included in Appendix C - page 52.

8.5 - Selection of type of working, i.e. with or without data transmission (DT or WDT)

The MDT chooses its mode of working, i.e. with or without data transmission, depending on whether or not it decodes the pilot channel data.

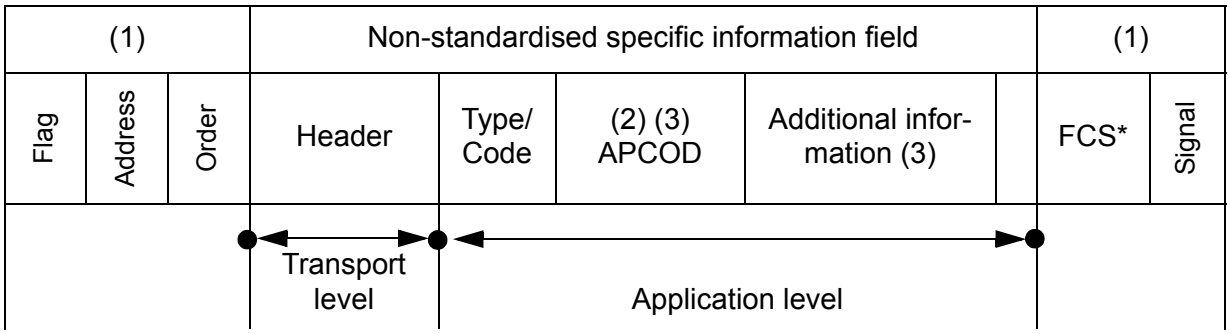
8.6 - Exchanges of traffic messages between FSDT and MDT

8.6.1 - Structure of HDLC frame*

The procedure used for exchanges of traffic messages is of the synchronous type with HDLC* frame structure. It is defined by *ISO* Standards n° 3309 (1979), 4335 (1979) and 6159 (1980)* (see Bibliography - page 57).

The general format of the frames is as follows:

HDLC* frame

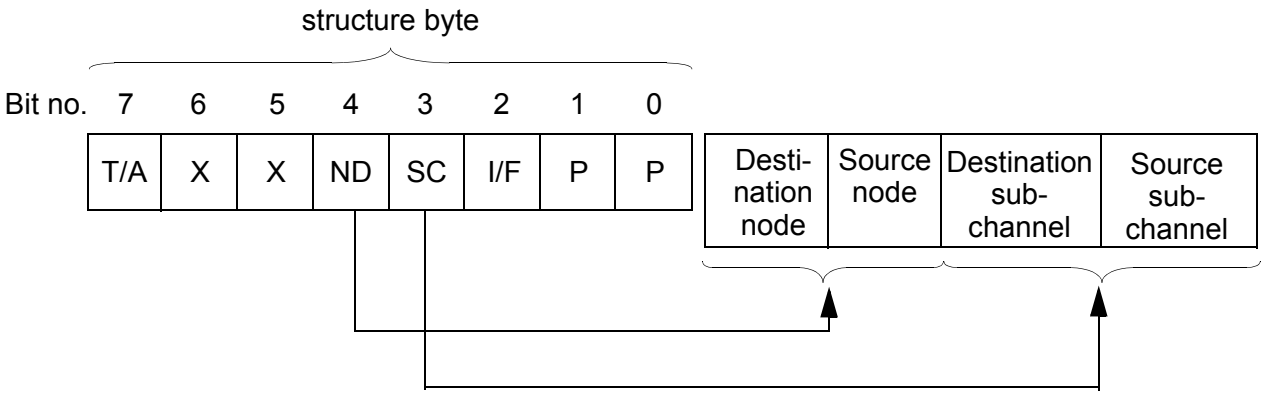


(1) Completely standardised fields
(2) APCOD = Application code
(3) This part may be absent

The composition of the data contained in the various levels of the information field is detailed hereinafter.

8.6.2 - Transport level - Forwarding of messages - Header

The transport level manages the routing of messages from their origin to their final destination. Each transfer from one information processing node to another starts with a group of bytes known as a header, the general composition of which is as follows:



The first structure byte specifies the nature of the information which follows it. This byte has the following composition:

-	bit 7	=	0 :	the information which follows is intended for the transport level (T)
		=	1 :	the information which follows is intended for the application level (A)
-	bit 6	=	0 :	(reserved)
-	bit 5	=	0 :	(reserved)
-	bit4	=	0 :	there is no node (N)
		=	1 :	node numbers (destination and source) follow the first byte
-	bit3	=	0 :	there are no sub-channels (SC)
		=	1 :	numbers of sub-channels (destination and source) follow the numbers of nodes (bit 4 at level 1)
-	bit2	=	0 :	this is an intermediate header[1]
		=	1 :	this is the final header (F)
-	bits 1 et 0	:		these indicate the priority (P) of the message: 00 : max. priority 01 : 10 : 11 : min. priority

The question of priority arises for messages forwarded in the train-ground direction; all these messages have priority 01, except for certain specific cases which have priority 00, and messages arriving on the MDT by sub-channel 50H[1], which have priority 11.

1. H = Hexadecimal coding

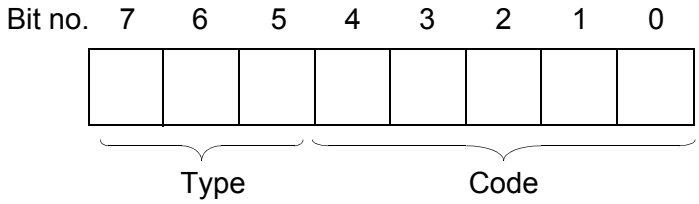
All messages in the ground-train direction have priority 00.

Depending on the value of bits 4 and 3, the header may therefore comprise:

bit 4	bit 3	
0	0	1 byte (the 1st)
1	0	3 bytes (the 1st + nodes)
1	1	5 bytes (the 1st + nodes + sub-channels)

8.6.3 - Application level

The application level consists of one or more messages. Each of them with a TYPE/CODE byte with the following composition:



8.6.3.1 - TYPE bits

The TYPE bits indicate the length of the message.

TYPE bits	000	001	010	011	100	101	110	111
number of additional bytes	0	1	2	3	4	5	6	> 6

A single message of type (111) may be included in the same HDLC* frame. It must then occupy the last position.

8.6.3.2 - CODE bits

1. *Transport level codes (bit T/A = 0)*

   The codes used are specified in Appendix B - page 48.

2. *Application level codes (bit T/A = 1)*

TYPE bits	001	010	...	111
CODE bits	00000	00000	...	00000
TYPE/CODE byte	20 H[a]	40 H[a]	...	E0 H[a]

a. H = hexadecimal coding

The TYPE/CODE byte is immediately followed by a APCOD byte which characterises the message in question.

8.7 - Functional description of the MDT

8.7.1 - Initialisation

When the MDT depends on an FSDT, it must be recognised by the system as soon as it comes into operation in order to be able to operate in digital mode.

Initialisation, namely the allocation of a SYSNO node number, can be achieved in two ways:

- on departure of the train, either manually or automatically at the second change of reception frequency,

- automatically, when changing regulation sector.

In the first case, the mobile unit working in DT mode requests recognition by the system and allocation of a SYSNO.

In the 2nd case, there may be:

- either transfer from a DT regulation sector to another DT sector. The MDT then proceeds automatically with a new initialisation,

- or transfer from a regulation sector not equipped with radio or equipped with WDT radio to a sector equipped with DT radio. In this case, the driver is able to select his TRANO train number in advance while the mobile unit still works in WDT mode. The fact that the initialisation key has been pressed is stored but no other effect is generated. On arrival under the first FSDT, initialisation takes place as above as soon as the mobile unit has switched to DT mode and has established the HDLC* link with the system. If the initialisation key has not been pressed, this takes place at the second change of reception frequency.

8.7.2 - Change of fixed station

At each change of fixed station, the mobile unit exchanges messages prescribed by the HDLC* procedure (see Appendix B - page 48). To avoid overloading the transmission channels (radio in particular), the change of frequency must be clean and irreversible in at least 95% of cases.

Appendix A - UIC frequency chart for the international ground-train radio system

Band B (to be used if it is not possible to make use of Band A						Band A				
Switching band on the tractive units of the network	Groups with 4 frequencies Priority 2 No. of groups	Duplex channel No. 1)	Reception frequency of tractive unit (MHz)	Groups with 4 frequencies Priority 1 No. of groups	Transmission frequency of tractive unit (MHz) 1)	Groups with 4 frequencies Priority 1 No. of groups	Reception frequency of tractive unit (MHz)	Duplex channel No. 1)	Groups with 4 frequencies Priority 2 No. of groups	Switching band on the tractive units of the Railway
		1	447.200		457.200		467.200	1		
		2	225		225		225	2		
		3	250		250		250	3		
		4	275		275		275	4		
		5	300		300		300	5		
		6	325		325		325	6		
		7	350		350		350	7		
		8	375		375		375	8		
		9	400		400		400	9		
		10	425		425		425	10		
		11	450		450		450	11		
	70	12	475		475		475	12	70	
		13	500	60	500	60	500	13		
		14	525		525		525	14		
		15	550	61	550	61	550	15		
	71	16	575		575		575	16	71	
		17	600		600		600	17		
	72	18	625		625		625	18	72	
		19	650		650		650	19		
	73	20	675		675		675	20	73	
		21	700	62	700	62	700	21		
		22	725		725		725	22		
	74	23	750		750		750	23	74	
		24	775		775		775	24		
	75	25	800		800		800	25	75	
		26	825	63	825	63	825	26		
		27	850		850		850	27		
	76	28	875		875		875	28	76	
		29	900		900		900	29		
		30	925	64	925	64	925	30		
	77	31	950		950		950	31	77	
		32	975		975		975	32		
		33	448.000	65	458.000	65	468.000	33		
		34	025		025		025	34		
		35	050		050		050	35		
	78	36	075		075		075	36	78	
		37	100		100		100	37		
	79	38	125		125		125	38	79	
		39	150		150		150	39		
		40	175		175		175	40		
		41	200	66	200	66	200	41		
		42	225		225		225	42		
		43	250	67	250	67	250	43		
		44	275		275		275	44		
		45	300		300		300	45		
		46	325		325		325	46		
		47	350		350		350	47		
		48	375		375		375	48		
		49	400		400		400	49		
		50	425		425		425	50		
		51	450		450		450	51		
		52	475		475		475	52		
		53	500		500		500	53		
		54	525		525		525	54		
		55	550		550		550	55		
		56	575		575		575	56		
		57	600		600		600	57		
		58	625		625		625	58		
		59	650		650		650	59		

Only for national radio services

Frequency bands conforming to the recommendation of the UIC "Radio frequencies" conference (held in the presence of representatives or specialists of the GPO administrations) on 26-27 October 1971, in Paris

Only for national radio services

1) = In the case of use of simplex links on local networks, the frequencies and channel numbers designated by the footnote 1) are also valid.

Appendix B - Procedure for exchange of traffic messages

B.1 - Transmission characteristics

B.1.1 - Modem

- Fast frequency shift keying (FFSK*).
- Modulation speed: 1200 bauds.
- Bit rate: 1200 bit/s.
- Carrier:
  - Fo = 1500 ± 300 Hz
  - Logic states
    0 : 1800 Hz
    1 : 1200 Hz

B.1.2 - Radio

- Deviation: Δf : ± 2,5 kHz.

B.2 - Transmission mode

Synchronous.

B.3 - Transmission procedure

The non-initialised MDTs exchange messages as described in point B.3.1.

The initialisation procedure is given in point B.3.2 - page 49; it enables a node number SYSNO to be allocated to the MDT in question.

Subsequently the messages are exchanged in accordance with an HDLC* procedure, in asynchronous response mode (ARM*), as stated in point B.3.3 - page 50 below. The primary is constituted by the FSDT; the secondaries are MDTs.

B.3.1 - Message exchange between non-initialised MDTs and the FSDT

Non-initialised MDTs have node number (FE)H[1]. Messages exchanged with the FSDT take the form of unnumbered frames (UI* frames). Each MDT recognises the messages addressed to it by means of the LOCNO byte which appears in the information field.

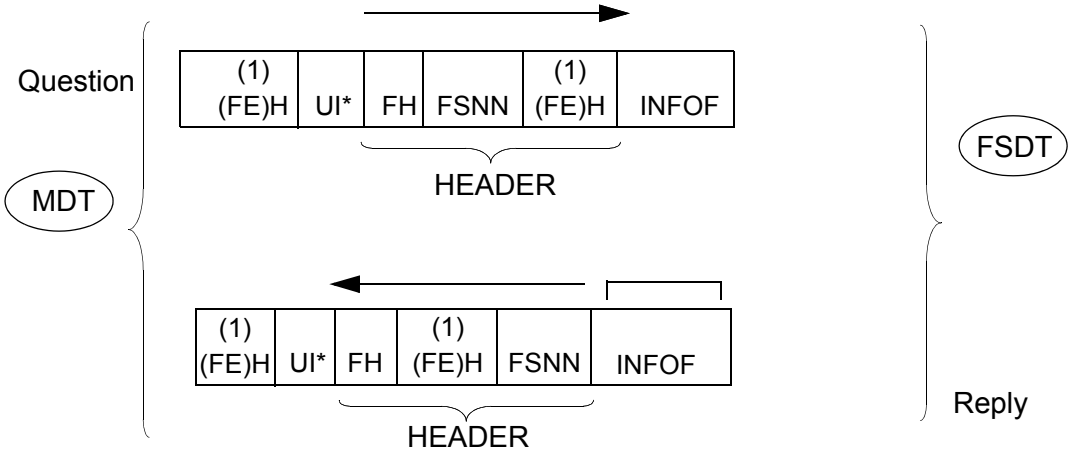
1. H = hexadecimal coding

Form of the messages exchanged

NB : The diagrams represent the HDLC* frames except for signalling sequences and frame control sequences (see *ISO Standards 3309, 4335 and 6159*).

Legend (the bytes not specifically defined are represented in hexadecimal form):

UI*	:	control field of the unnumbered information frame
FH	:	structure of the final header
FSNN	:	fixed station node number
LOCNO	:	tractive unit number
INFOF	:	information field



(1) H = hexadecimal coding

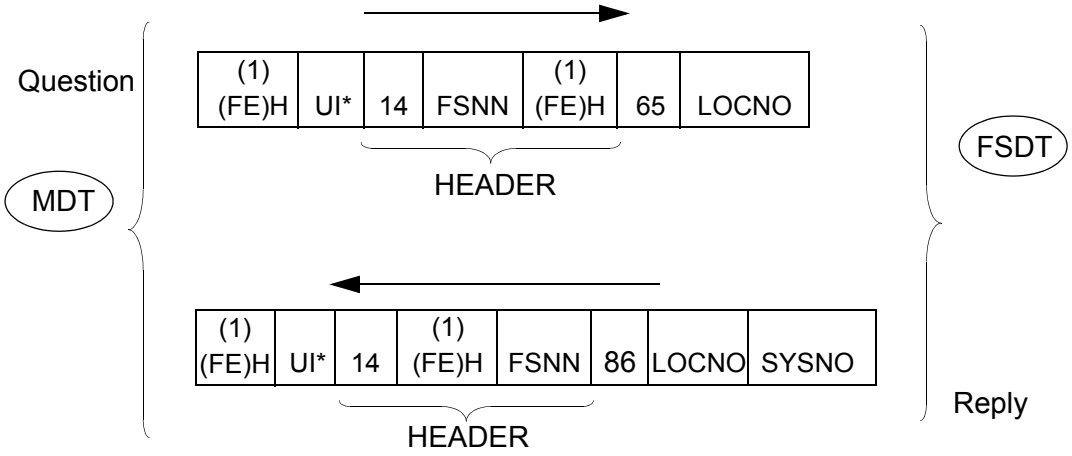
B.3.2 - Initialisation of MTDs

Initialisation takes place when the process is activated:

- either manually by the driver,
- or automatically.

In all cases, in addition to the allocation of a SYSNO node number to the MDT by the procedure described below, initialisation sets off an exchange of specific messages, the purpose of which is to:

- inform the operator at control centre of the presence of the mobile unit in his/her control area,
- inform the station staff that the mobile unit is present, if this possibility exists for stations in the radio block where the MDT happens to be.

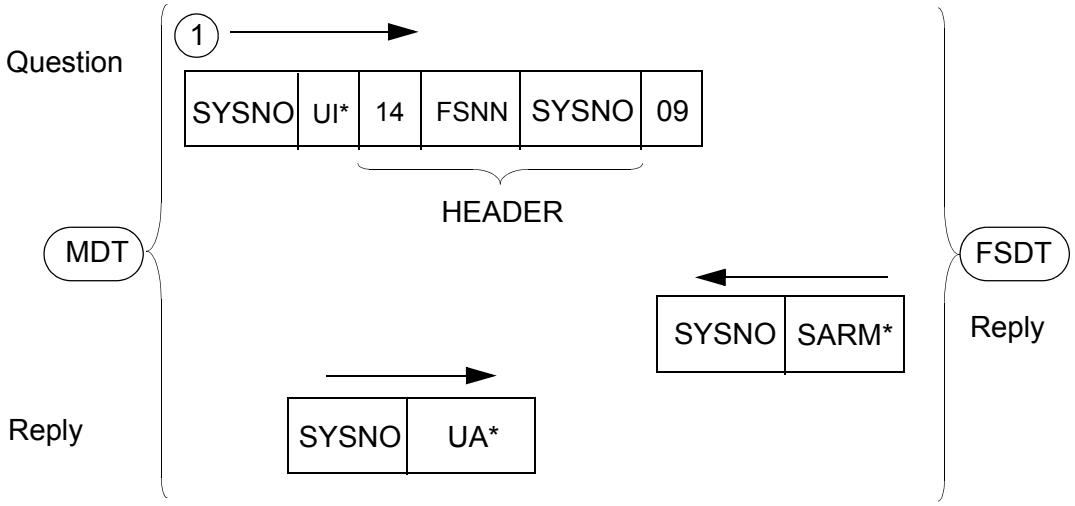


(1) H = hexadecimal coding

B.3.3 - Establishing of the HDLC* link in asynchronous response mode (ARM*)

This procedure is applicable to an MDT which has just been initialised as explained above, or to an MDT which has just passed from the area of one FSW to another (change of reception frequency), or to an initialised mobile unit when resuming reception of the pilot channel after accidental interruption.

Form of the messages exchanged:



- Failing receipt of the SARM* command, the message (1) is repeated 4 times at 3 s intervals. In the case of failure, the MDT continues to send UI* frames to the FSDT.
- Failing receipt of the UA* command, the SARM* command is repeated 4 times at 3 s intervals. In the event of failure, the FSDT continues to send UI* frames to the MDT.

B.3.4 - Exchanges of messages in asynchronous response mode

After the HDLC* link has been successfully established, message exchanges take place in asynchronous response mode (ARM*).

A maximum of 4 attempts may be made to retransmit frames which have been incorrectly transmitted. This applies to both the primary and secondaries.

Appendix C - Procedure for pilot channel transmission

C.1 - Transmission characteristics

C.1.1 - Modem

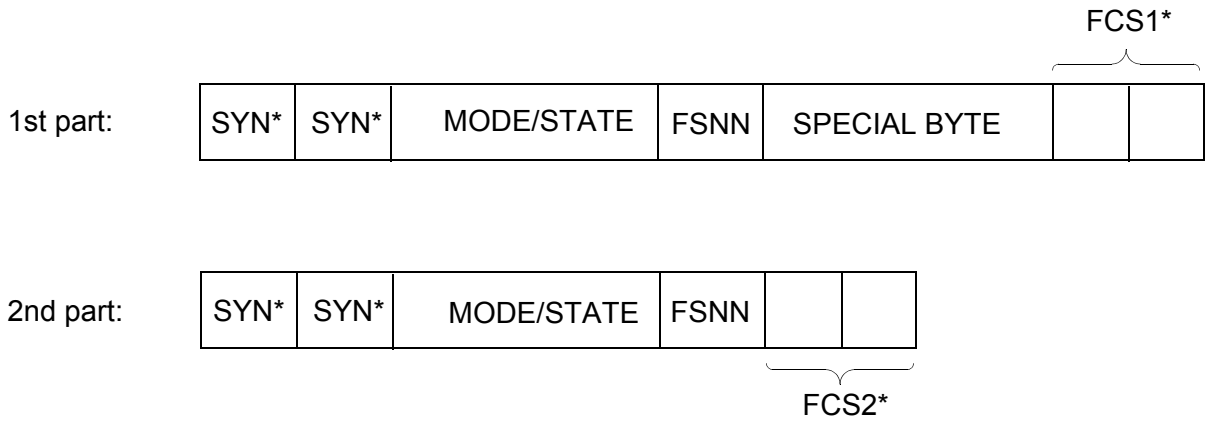
- Frequency shift keying (FSK*).
- Modulation speed: 100 bauds.
- Bit rate: 100 bit/s.
- Carrier:
  - Fo = 155,5 ± 45,5 Hz.
  - Logic states:
    0 : 201 Hz
    1 : 110 Hz
- Operation: bi-synchronous (2 synchronisation bytes).

C.1.2 - Radio

- Deviation: Δf : ± 0,5 kHz.

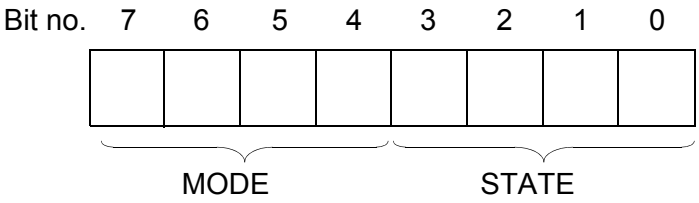
C.2 - Message structure

The message consists of two parts repeated alternately. Their lengths are 7 and 6 bytes respectively. The total duration of the sequence (namely 13 bytes) is therefore 1040 ms



C.3 - Definition

- SYN*: 96H[a]
- MODE/STATE:

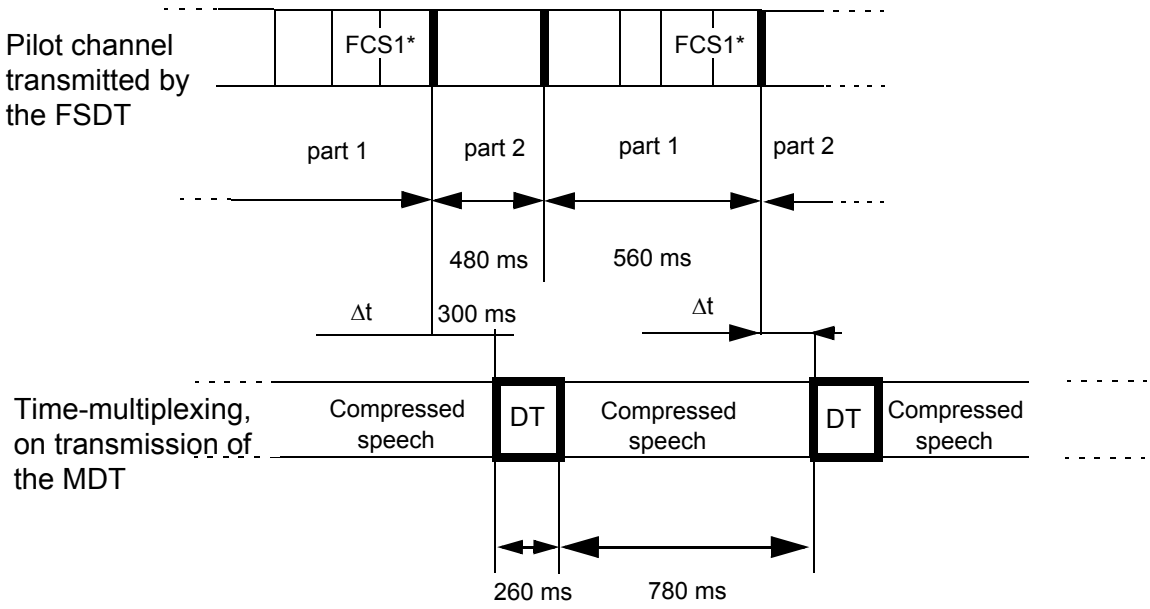


- MODE: the 4 most significant bits define certain characteristics either of the radio link or the radio link or the functioning of the mobile unit.
  - bit 4: 0 : "LS release" button activated[b]
    1 : "LS release" button deactivated[b]
  - bit 5 : this bit takes the values 0 and 1 alternately in relation to the successive radio blocks[c]
  - bit 6 : this bit takes the values 0 and 1 alternately in relation to the successive regulation sectors
  - bit 7 : (reserved)
- STATE: state of the fixed station (see Appendix D - page 55).
- FSNN: fixed station node number.
- SPECIAL BYTE: used for synchronisation of the SCE on the radio link. The mere presence of this byte, independently of its content, ensures synchronisation of the MDTs as per the procedure explained in point C.4 - page 54.
- FCS*: 2 message check bytes as laid down in CCITT*. Recommendation X25 (polynome X16 + X12 + X5 + 1).

a. H = hexadecimal coding
b. Knob inside MDT inaccessible to operator.
c. Radio block = fixed group of one or more slave FSDTs.

C.4 - MDT synchronisation

The messages synchronise the MDTs as per the following diagram:



NB : Δt = time interval between radio reception of the last bit of the FCS1* of an initial part of a message on the pilot channel and beginning of a period allocated to radio transmission of traffic messages. This time must be equal to 300 ± 5 ms to take into account the transmission times within the mobile unit.

Because of the uncertainty of reception timing on the pilot channel, the transmitter of the mobile unit with a traffic message to transmit must:

- not go into operation less than 5 ms after the beginning of a theoretical period allocated to the DT,
- cease operation no later than 5 ms before the end of this period.

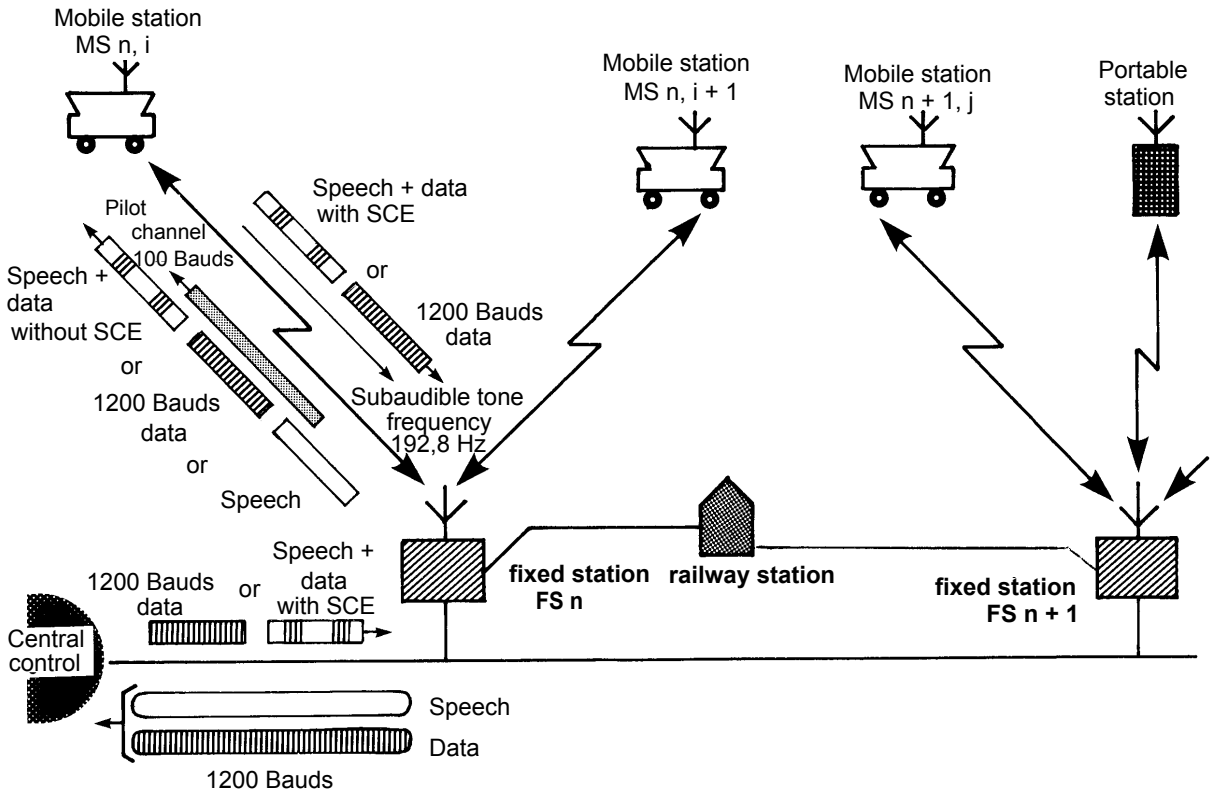
Appendix D - List of SFTD states

Rank	State	Meaning
0	LIBREGU	No conversation taking place between operator and another speaker.
1	LIBRSF	The fixed station is free.
2	DT	Transmission of a long digital message (about 20 000 bits) taking place in the train-ground direction.
3	REGU 1	A speech link exists between an MDT and the operator (general case, except case of REGU 2).
4	MOGA	A speech link exists between a mobile unit and one or more stations of the radio block.
5	REGU 2	The operator is speaking to the WDT mobile units and/or the non-initialised DT mobile units.
6	GAMO	A speech link exists between a station and all the mobile units of the radio block.
7	MOMO	There is a link from a mobile unit to mobile units (all mobile units concerned).
8	REGI	The operator is speaking to all the mobile units (WDT, DT initialised or not) of the radio block.
9	CANT	A mobile unit is calling all the other speakers of the radio block, including the stations and, where applicable, the operator.
A	ALER	The warning is being transmitted by the FSDT.

Correlation between the state of the FSDT and that of the MDT loudspeakers

	State of the FSTD	State of the MDT loudspeakers	
		initialised	non-initialised
Presence of 2280 Hz	LIBREGU	B	B
	LIBRSF	B	B
Absence of 2280 Hz	DT	B	B
	REGU 1	B	B
	MOGA	B	B
	REGU 2	B	D
	GAMO	D	D
	MOMO	D	D
	REGI	D	D
	CANT	D	D
	ALER	D	D
B = locked D = released			

Appendix E - SNCF radiotelephone system with data transmission



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Warning

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