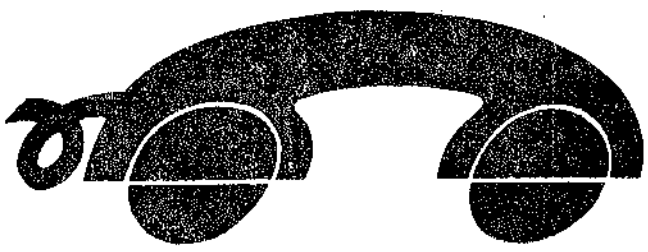
NMT DOC. 1. 1980
Nordic Mobile Telephone group

February 1980

NORDIC MOBILE TELEPHONE

SYSTEM DESCRIPTION



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GLOSSARY OF TERMS

Base station (BS)	The unit which comprises the terminating equipment for the radio path and for the supervisory and control signalling towards the mobile station as well as the mobile telephone exchange.
Base station area (BSA)	The radio coverage area of a base station.
Calling channel (CC)	Normally one of the channels assigned to a base station is a calling channel used for setting up calls to mobile stations. During peak traffic a calling channel may be used as a traffic channel.
Control unit (CU)	Part of the base station, providing start and stop of transmitter, fault indication etc.
Data channel	One of the channels (calling channel, traffic channel or dedicated channel between MTX and base station used for data signalling.
dBmO	The term - x dBmO indicates a power level of x dB below 1 mW at a point of zero relative level.
Fast frequency shift keying (FFSK)	Modulation principle used between the MTX and MS, utilizing the frequencies 1200 Hz for logical one and 1800 Hz for logical zero.
Signal strength receiver (SR)	Part of the base station, providing measurement of radio frequency signal strength on the channel ordered from the supervisory unit of the base station.
Fixed subscriber (SF)	A subscriber in the ordinary telephone network.
Free traffic channel	Traffic channel positively marked as free.
Home mobile telephone exchange (MTXH)	The MTX where the mobile station is registered. Controls the home traffic area.
Home traffic (TAH) area	Traffic area in which the mobile station is registered.
Idle radio channel	Radio channel assigned to a base station and not in use, i.e. not occupied and not free marked.

Local exchange	An exchange in which subscriber lines terminate.
Mobile station (MS)	The equipment used by a mobile subscriber.
Mobile subscriber (SM)	A subscriber with a mobile station in the NMT system.
Mobile telephone exchange (MTX)	The unit which controls the traffic between the mobile stations in its area of operation and the telephone network, as well as supervises the operation of its subordinate base stations.
MTX-area	All the traffic areas controlled by the same MTX.
Multi-frequency code signalling (MFC)	Signalling system used between exchanges in the telephone network according to CCITT Rec R2, utilizing compelled signalling with codes consisting of 2 out of 6 frequencies.
Multi-frequency pulse signalling (MFP)	Signalling system used between exchanges in the telephone network, utilizing 2 out of 6 frequencies in pulses.
Nordic mobile telephone system (NMT)	The public automatic mobile telephone system in the 450 MHz range, common to the four member countries.
Occupied traffic channel	Traffic channel engaged for conversation or call set-up.
Push-button multi-frequency signalling (MFT)	Signalling system used for signalling from subscriber sets in the telephone network according to CCITT Rec Q 23, utilizing 2x1 out of 4 frequencies in pulses, controlled by push-buttons.
Radio frequency (RF)	The frequencies in the 450 MHz range on the radio path.
Roaming mobile subscriber	Mobile subscriber having left his home traffic area.
Supervisory signal (Ø signal)	Out-band pilot signal (approximately 4000 Hz) to supervise the transmission on the traffic channel during conversation.
Supervisory unit (SU)	Part of the base station, providing the interface between the signal strength receiver on the one side, and the MTX or CU on the other side.
Switching call in progress	Method of securing the continuity of an established call when the mobile subscriber moves out of one base station area into another.

Switching logic unit (SLU)	Functional part of the MTX, deciding to which base station a call should be transferred, in the "Switching call in progress"-procedure.
Traffic area (TA)	A group of base station areas, where calls to mobile stations are sent out simultaneously.
Traffic channel (TC)	Channel assigned to a base station and primarily intended for conversation. Traffic channel is also used for call set-up from ordinary mobile subscribers.
Trunk exchange	An exchange, the principal function of which is to control the switching of trunk traffic.
Visited mobile telephone exchange (MTXV)	The MTX controlling the visited traffic area.
Visited traffic area (TAV)	Traffic area, other than the home traffic area, serving the mobile subscriber.

A-subscriber	Calling subscriber
B-subscriber	Called subscriber
BS	Base station
BSA	Base station area
CC	Calling channel
CU	Control unit
FFSK	Fast frequency chift keying
MFC	Multi frequency code signalling
MFP	Multi frequency pulsed signalling
MFT	Push-button multi frequency signalling
MS	Mobile station
MTX	Mobile telephone exchange
MTXH	Home mobile telephone exchange
MTXV	Visited mobile telephone exchange
NMT	Nordic mobile telephone system
PMS	Mobile station with priority
RF	Radio frequency
SF	Fixed subscriber
SLU	Switching logic unit
SM	Mobile subscriber
SR	Signal strength receiver
SU	Supervisory unit
TA	Traffic area
TAH	Home traffic area
TAV	Visited traffic area
TC	Traffic channel
TMS	Test mobile station
VF	Voice frequency
Ø signal	Supervisory signal

1. INTRODUCTION

The Nordic Mobile Telephone System (NMT) is developed jointly by the Telecommunications Administrations of Denmark, Finland, Norway and Sweden in order to establish a compatible automatic public mobile telephone system in the Nordic countries. The system is planned to be put into commercial operation in the Nordic countries in the early eighties.

The mobile stations of the system are fully compatible with the landbased part of the system, regardless of which Nordic country the mobile subscriber happens to be in at the moment. All mobile subscribers are given full roaming capability in all the participating countries.

Mobile stations to be used in the system are to be type approved by the Telecommunications Administration. The mobile stations are to be purchased or leased by the subscribers.

Four kinds of subscriber mobile stations can be accomodated in the system:

- ordinary mobile stations
- mobile stations with priority
- portable mobile stations, and
- coin-box mobile stations

The system is primarily intended for land mobile use. To some extent, however, the network may also be utilized for short-distance maritime mobile communications.

Detailed information on different parts of the system is given in the following NMT publications:

Technical specification for the mobile telephone exchange (NMT Doc. 2)

Technical specification for the mobile station (NMT Doc. 3)

Technical specification for the base station (NMT Doc. 4)

Basic requirements:

- Setting up and charging of calls to and from the mobile station shall be automatic.

- It shall be possible to set up calls between the mobile stations and any fixed telephone subscriber or any other mobile telephone subscriber within the system, regardless of country.

- The costs shall be charged to the calling subscriber, regardless of whether it is located in the mobile system or in the fixed telephone network. The charge shall be based upon the dialled numbers, and the duration of the call.

- The system shall provide for automatic roaming capability for the mobile subscribers within the Nordic countries.

- To the subscribers, the system shall appear as similar as possible to the fixed telephone network. This applies both to the use of the mobile station, the reliability of signalling, charging, and secrecy, and to the services offered.

- The introduction of the system shall not necessitate any significant changes in the fixed telephone networks.

2. SYSTEM CONCEPTS

2.1 GENERAL

The system concept is based upon close interworking with the fixed telephone network. For reasons of compatibility, the interface between the mobile stations and the landbased parts of the system is the same in every country.

The interface between the system and the telephone network is contained in the mobile telephone exchange MTX, which thus has to absorb the differences between the various interfaces to the national networks.

The base stations, serving as the interface between the radio path and the landbased 4-wire transmission systems, perform no switching of the speech path. They are grouped into traffic areas, each connected to only one point in the telephone network, in which an MTX controls the traffic to and from the mobile stations. In some cases, however, one MTX will be in control of two or more traffic areas, fig. 2.1. The MTX will be stored program controlled. The system is designed with a number of facilities which are expected to be of value to the subscribers, such as abbreviated dialling, follow-me etc.

On every base station, one channel is used as calling channel and is marked with a special identification signal. One or several of the other channels, when free, are marked with a free traffic channel identification signal. Stand-by mobile stations in an area under a base station are locked to the calling channel. It is, however, possible for the MTX to permit use of the calling channel for conversation in certain circumstances. This possibility is likely to be utilized only in base stations with few channels at times when all traffic channels are busy.

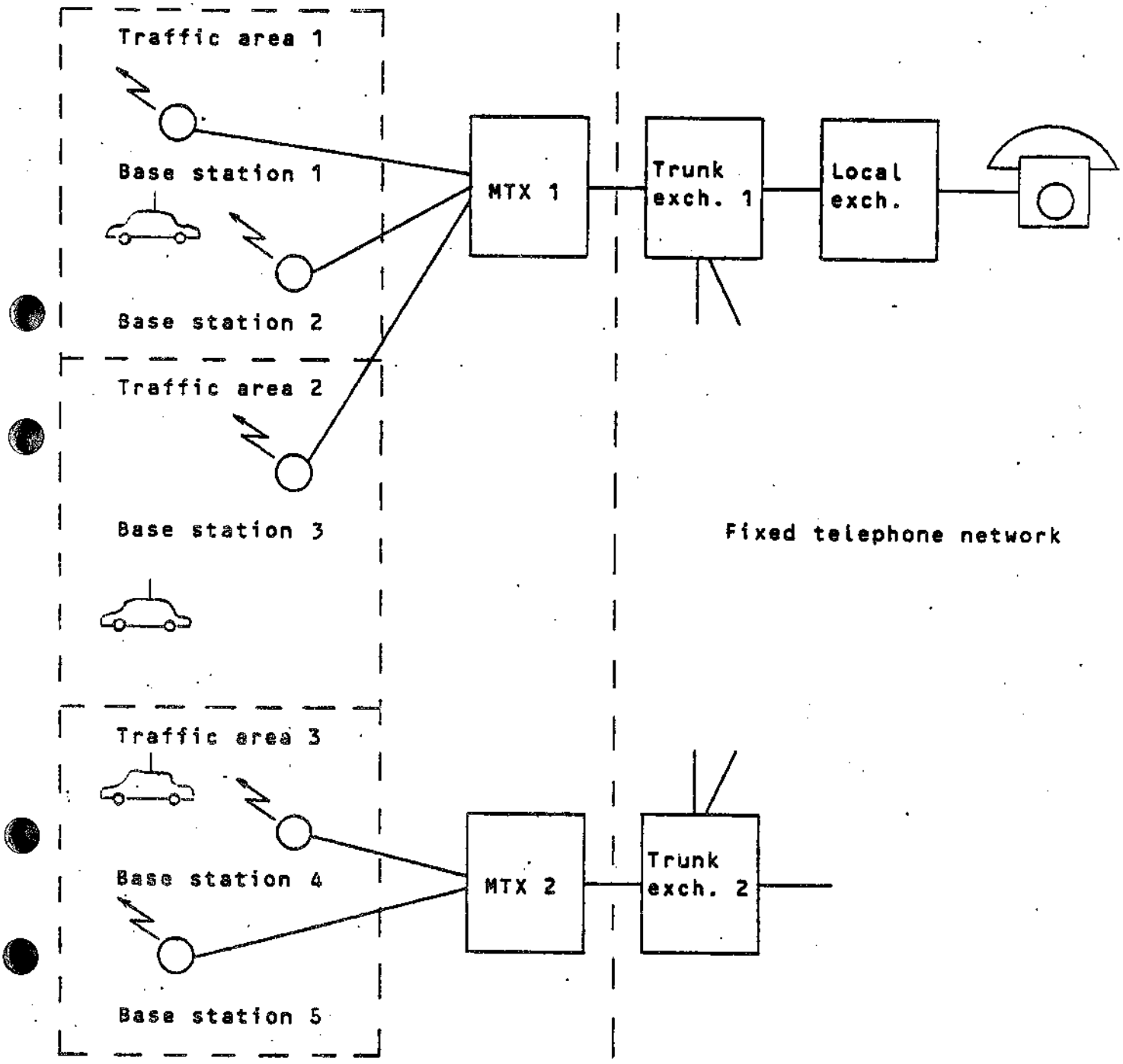


Fig. 2.1 SYSTEM STRUCTURE

In addition to the signals designating the channels as calling or traffic channels, there are signals in order to enable the mobile station to distinguish between traffic areas and between countries, as well as signals indicating the channel number. All signals are transmitted by means of a 1200 Baud FFSK signalling system.

2.2 RADIO FREQUENCIES

2.2.1 Frequency band

The radio frequencies available consist of the bands 453-457.5 MHz and 463-467.5 MHz, which will be used for the paths mobile station to base station and base station to mobile station respectively. With a channel separation of 25 kHz, these bands accommodate 180 channels.

2.2.2 Radio coverage

Because of the limited number of radio frequencies available for the system, the total traffic capacity is expected to become insufficient in densely populated areas over a longer period of time, judging from past experience in mobile telephone systems. In order to increase the traffic capacity, the system is designed for small coverage areas ("small-cells") in those areas. As a consequence, the probability of reaching the coverage limit of a base station during a call increases. In order to reduce the inconvenience of this, the system is designed to switch calls in progress from one base station to another base station, controlled by the same MTX. Furthermore, the transmitter output power of all mobile stations is automatically reduced (ordered by MTX) when entering a small-cell area.

The same power reduction procedure is used in order to reduce interference in cases when mobile stations come close to base stations with conventional coverage areas.

2.3 CALL SET-UP PROCEDURES

2.3.1 Call to mobile station

Calls to all kinds of mobile stations are sent out in parallell over all base stations in the traffic area in which the mobile station is believed to operate. When a mobile station has received a calling signal containing its identification, it returns a call acknowledgement on the return frequency of the outgoing calling channel, whereupon MTX allocates a traffic channel in the base station area where the mobile station has answered the call. The channel number is received by the mobile station, which then switches to the allocated channel.

Thereafter, all exchange of signals between MTX and the mobile station takes place on the traffic channel. The calling channel, on which all other mobile stations remain, is immediately available for the next call.

2.3.2 Call from mobile stations

When an ordinary mobile subscriber initiates a call, the mobile station automatically hunts for and locks to a free marked traffic channel, on which all signals are exchanged and the conversation takes place.

2.4 NUMBERING AND ROUTING

The numbering scheme is designed to meet the following objectives:

a. to enable a calling subscriber to inform the telephone network about the identity of the called mobile station.

b. to serve as routing information for the telephone network.

c. to enable the mobile station to respond to a call from the MTX.

d. to identify a calling mobile subscriber to the MTX.

The existing equipment in the telephone networks in some countries limits the number of digits, preceded by the trunk prefix P_N(0 or 9), to be dialled by a calling subscriber in the landbased network, to a maximum of 7. With an access code consisting of trunk prefix plus 2 digits, i.e. $P_N M_1 M_2$, the available capacity for the subscriber number is 5 digits. It has been found, however, that a six-digit subscriber number series $X_1 X_2 X_3 X_4 X_5 X_6$ must be foreseen from the outset, even though such a number structure cannot at the present time be implemented in the telephone networks in Denmark, Finland and Norway. In the parts of the system between MTX and MS, including both units, the full six-digit number is used in all four countries, as described below.

In Sweden the routing in the telephone network is performed by the existing exchange equipment, utilizing the digits $P_N M_1 M_2 X_1 X_2$, the latter two thus designating the MTX to which the subscriber belongs. In Denmark, Finland and Norway, the routing in the telephone network is performed by analysing the digits $P_N M_1 M_2 (M_3) X_2 (X_3)$.

This structure satisfies the requirement b. above.

Identification of mobile subscriber requires more information than the digits $P_N M_1 M_2 (M_3)$ $(X_1) \ldots X_6$ dialled by the calling subscriber, since it must be possible for MTX as well as for the mobile station to distinguish between identical subscriber numbers $(X_1) \ldots X_6$ belonging to different countries. Therefore, a nationality digit Z is added to the subscriber number $(X_1) \ldots X_6$ for communication on the radio path. The digit Z is only used internally in the system and is not dialled by a calling subscriber. For communication towards a mobile subscriber, Z is added to the subscriber number $(X_1) \ldots X_6$ in his home MTX, even when he is visiting another MTX area. For communication from a mobile subscriber, it is automatically sent by the mobile station logic.

Since the digit X_1 is not dialled when calling mobile subscribers belonging to the networks in Denmark, Finland and Norway, it must be added to the subscriber number by the MTX in those countries, in the same way as Z. In all countries, therefore, mobile subscribers are identified by the number Z X_1 X_2 X_3 X_4 X_5 X_6 within the mobile telephone system, that is in all signalling between:

MTX - MTX

MTX - MS

MTX - BS

The combination Z $X_1 \ldots X_6$ satisfies the requirements c. and d. above.

To summarize, in order to set up call to a mobile subscriber the calling subscriber shall dial the following numbers to reach the relevant MTXH:

Calls to Swedish MS:

national	$P_N M_1$ M_2 X_1 X_2 X_3 X_4 X_5 X_6
international	+ I_1 I_2 M_1 M_2 X_1 X_2 X_3 X_4 X_5 X_6

In MTXH the nationality digit Z is added in front of X_1 X_2 X_3 X_4 X_5 X_6.

Calls to a Danish, Finnish or Norwegian MS:

national	$P_N M_1$ $M_2(M_3)$ X_2 X_3 X_4 X_5 X_6
international	+ I_1 $I_2(I_3)$ M_1 $M_2(M_3) X_2 X_3 X_4 X_5 X_6$

In MTXH the nationality digit Z and a digit X_1 is added in front of X_2 X_3 X_4 X_5 X_6. When in future six-digit mobile subscriber numbers are required in Denmark, Finland and Norway the same will apply as for Sweden.

One of the basic requirements is that the system shall allow setting up calls to a roaming subscriber, i.e. a subscriber who is visiting another traffic area than his own. This requirements necessitates introduction of facilities which the telephone network does not possess today, and the solution chosen is to supply each MTX with a subscriber register so that it can keep track of its own subscribers. When a mobile station moves from one traffic area into another, it automatically sets up an updating call to the MTX in control of the new traffic area. From that MTX, information is forwarded through the telephone or data network to the subscriber's home MTX about his change of "adress". The updating communication which takes place between the mobile station and the visited MTX does normally not require any action on the part of the mobile subscriber.

The subscriber register for the mobile station in the MTXH is then updated and all calls to this mobile subscriber are rerouted to the new MTX-area.

The mobile station is equipped with a "country selector" which prevents it from locking to other base stations than those of the selected country.

2.5 SWITCHING CALL IN PROGRESS

During a call a continuous supervisory signal (a tone of approximately 4000 Hz) is generated at the BS (on order from MTX) and sent to the MS, where it is looped back to the BS. The received return signal is detected and evaluated by the BS which decides if the transmission quality (signal to noise ratio integrated over a certain period of time) necessitates switch-over to another BS or disconnection of the call. BS sends information about the evaluation result to the MTX.

In case switching call in progress shall be performed the MTX orders the surrounding base stations to perform signal strength measurements on the radio channel on which the MS is transmitting. For signal strength measuring all BS are equipped with an all-channel monitor receiver. Information about the measurement results enables the MTX to decide to which BS (if any) the call shall be transferred.

The measuring action is also ordered to the BS in use immediately at the start of a call set-up in order to determine whether the used BS is suitable.

The result of the measurement at the beginning of each call is also used to determine whether the received signal from MS is above a given high level in which case the MTX orders the MS to change to the low output power level mode.

2.6 CHARGING PRINCIPLES

Charging of calls from fixed to mobile subscribers is performed by the equipment already existing in the telephone network, and is based upon an analysis of the dialled digits regardless of the actual location of the mobile subscriber.

Conversely, calls from mobile subscribers are charged according to the dialled digits and the location of the calling subscriber. This information is stored for each call by the MTX for further debiting purposes (toll ticketing).

3. TRANSMISSION MEDIA

Besides the fixed telephone network, two transmission media with very different properties will influence the overall transmission quality, namely on the one hand the landbased transmission system connecting the base stations with MTX and on the other hand the radio path between the base station and the mobile station. These two transmission media will be described in the following.

3.1 LAND BASED CIRCUITS

The communication between MTX and the base station is established via leased 4-wire lines, analog or digital. Normally, the lines are through-connected to the radiopath, but for testing purposes, any such line may be looped in the base station so as to enable the MTX to decide whether a fault is located in the line or in the base station equipment. The requirement regarding the parameters of the lines are essentially the same as for other 4-wire circuits used for speech transmission, except that an upper limit is set on the acceptable group delay distorsion in the band 900-2100 Hz because of the data signalling between MTX and base station, respectively MTX and mobile station. The signal-to-noise ratio will normally be satisfactory. Limits must be placed on the overall loss between MTX and base station in accordance with the various national level plans. In carrier frequency systems, a maximum frequency shift of 2 Hz must be taken into account.

3.2 RADIO PATH

The transmission channel between the base station and the mobile station consists of the radio path. The quality of this channel varies with time due to the movements of the mobile station. It decreases rapidly when either the field strength received or the co-channel interference-ratio between wanted and unwanted signal is below a certain threshold.

The communication to and from the mobile station consists of speech as well as signalling information. The reliability of the transmission of the latter kind of information can be increased greatly under adverse condition by redundancy techniques, known from the data transmission field. However, there is no reason to require reliable signalling under conditions on the radiopath which are too bad to be used for speech. The worst case to account for is the condition of co-channel interference in combination with fading. Considering the repetition rate of the fading minima at an average speed of 50 km/h, and the need for a certain length of time during which the S/N ratio is sufficiently great for the data signalling, one can show that a signalling rate of 1200 Baud is reasonable value.

4. SIGNALLING SYSTEMS

This chapter describes the signalling between the MTX, BS and MS.

This signalling can be divided in 3 groups (see fig. 4. 1a,b)

- Signalling between MTX and MS
- " BS " MS
- " MTX " BS

The signalling between the MTX and the fixed telephone network will follow the normal national telephony signalling procedure.

4.1 FUNCTIONAL DESCRIPTION OF SIGNALS

4.1.1 Signalling between MTX and MS

4.1.1.1 Signalling from MTX to all stand-by MS's

- Number of actually used channel. In order to decrease the risk for a mobile to find a false calling or traffic channel (intermodulation product) this information about the actually used channel is needed.
- Channel indication. The MS's must be able to distinguish between a calling channel, a free traffic channel or an occupied traffic channel with data transmission, and therefore a channel indication must be transmitted.
- Traffic area number. In order to discover a change in traffic area, for roaming updating, this information must be transmitted.

4.1.1.2 Signalling from MTX to a specific MS

- Identity. In order to get in touch with one specific mobile there is a need of an identification. This consists of seven digits (nationality digit Z and mobile number X_1 ... X_6). This is also needed for charging purposes.
- Channel order. In order to get an MS to change to a specific channel there is needed a channel order, which contains the mobile subscriber number and the channel number to which the mobile has to go.
- Line signals. In order to set up and clear a call to or from an MS, line signals of the same type as in the ordinary telephone network are needed. They are:
  - Address complete
  - Ringing order

- Roaming updating confirmation (proceed to send)
- Clearing
- Answer to coin-box (only for coin-box category MS's)

4.1.1.3 Signalling from an MS to MTX

- Number of actually used channel
- Mobile subscriber identity
- Call acknowledgement. This signal is a reply from an MS to a call
- Seizure. This signal informs MTX that an MS wants to make a call
- Seizure from coin-box MS
- Roaming updating. This signal is sent from an MS to inform the MTX that the MS is now in a new traffic area
- Clearing, release guard
- Answer acknowledgement (coin-box)
- Answer (when mobile subscriber answers)
- Digit signals
- MFT converter in/out. These two signals are used in order to call in/out an MFT converter in the MTX when the push-button set of the MS is used for transmission of data into the ordinary telephone network.

4.1.2 Signalling between BS and MS

Supervisory signal

Each established connection is supervised by a continuous supervisory signal (Ø signal) transmitted from the BS to the MS, where it is looped back to the BS. If the S/N of the received signal is below a predetermined value, or no signal is received, the result is reported to the MTX (see paragraph 4.5).

4.1.3 Signalling between MTX and BS

The signalling between MTX and BS can be divided into three different types:

- Individual remote control of each calling and traffic channel such as start and stop of transmitters in BS and remote control of supervisory signal between BS and MS.

- Remote control of signal strength measurements and other more detailed management and maintenance actions in BS.

- Alarms from BS.

This signalling is described in para 4.2.3 and 4.2.4.

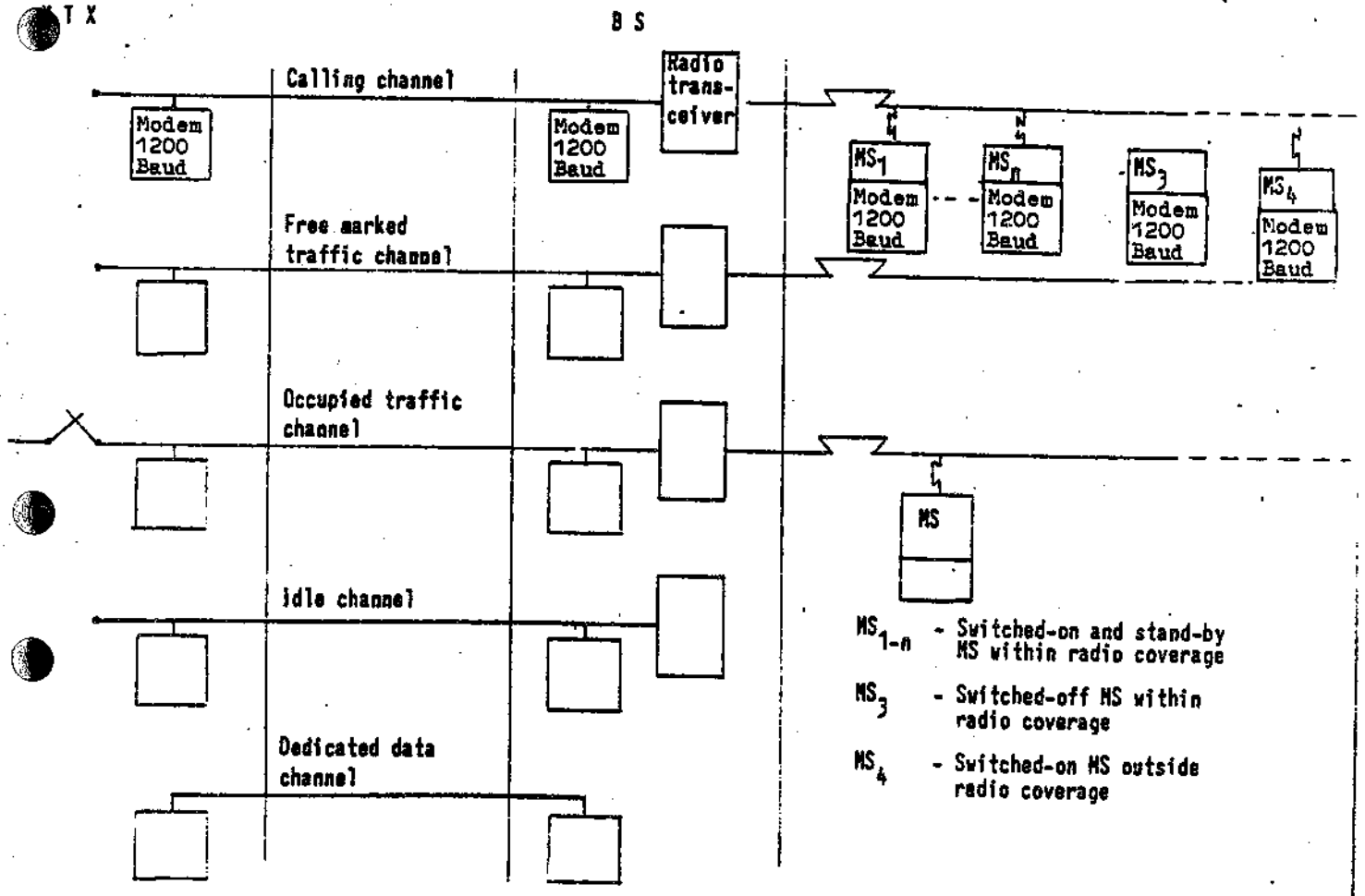
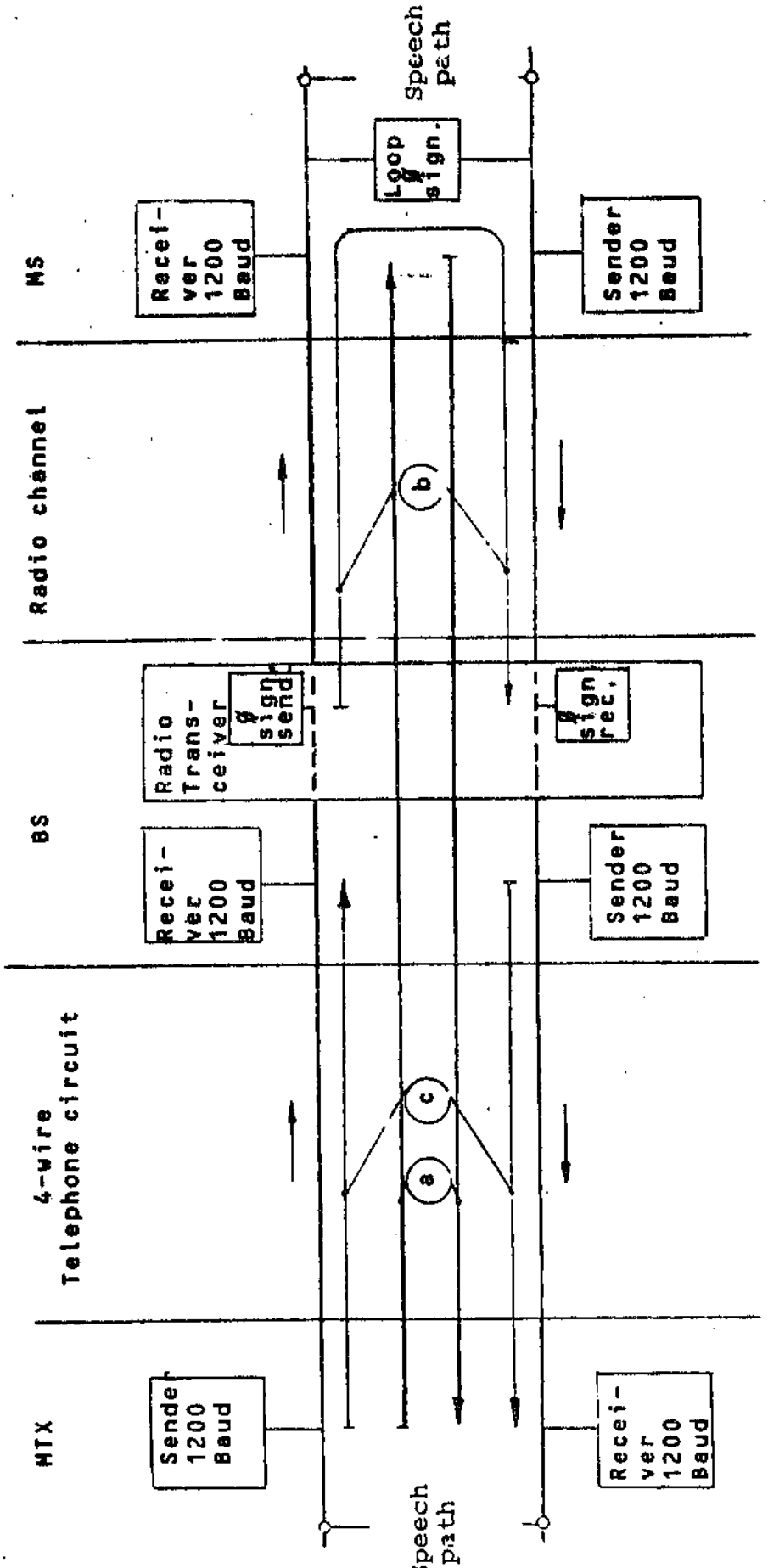


Fig. 4.1a



(a) - Signalling between MTX and MS

(b) - Signalling between BS and MS

(c) - Signalling between MTX and BS

Fig. 4.1b

4.2 DEFINITIONS AND FUNCTIONS OF SIGNALS

The signals between MTX and MS as well as those between MTX and BS are transmitted on a 1200 Bauds signalling link, described in detail in paragraph 4.6. The signals are formated into frames, the format being such that each frame contains 16 hexadecimal digits of information in addition to the synchronization and check bits. The details concerning the frame structures are contained in paragraph 4.3. In paragraphs 4.2.1 through 4.2.5, the frame numbers within brackets refer to the numbering in paragraph 4.3.

For the signalling between BS and MS (i.e. the supervisory signal), the details are brought forward in paragraph 4.5.

All time measurements concerning the signalling procedures are measured from the end of the particular frame, defined as transmission/reception of the last bit in the outgoing/incoming frame in the modem.

4.2.1 Signals in the direction MTX to MS

- Calling channel indication (frame 1a continuously).

  Indicates the calling channel to which mobile stations shall lock when they are not busy. Normally only one channel on the base station has such an indication.

- Combined calling and traffic channel indication (frame 1b)

  Indicates a channel which can be used either as a calling channel or as a traffic channel.

- Call to mobile subscriber on calling channel (frame 2a).

  When a call is generated from MTX to MS, this signal will be used. The mobile subscriber number is included in the signal.

- Traffic channel allocation on calling channel (frame 2b).

  After reception of call acknowledgement MTX sends this signal to inform the MS which channel it shall use for the connection.

- Queueing information to MS with priority on calling channel (frame 2c).

  After reception of seizure from priority MS on CC MTX sends this signal to inform the priority MS that the call is queued in the MTX.

- Traffic channel allocation on traffic channel (frame 3a).

  In the speech condition this signal may be sent to order the MS to switch to another channel (switching call in progress), or to order change of output power in the MS.

- Identity request on traffic channel (frame 3b).

  This is a signal requesting MS about its identity when a connection shall be established.

- Free traffic channel indication (frame 4 continuously).

  This signal marks a free traffic channel, on which mobile stations can make calls. There may be several freemarked traffic channels on one base station.

- Line signal (frames 5a and 5b).

  The meaning of the line signal is indicated by the signal number L (n). (These signals correspond to the normal line signals in the telephone network.)

  Answer to coin-box.

  This signal contains the tariff class information, and informs the coin-box that the charging can start.

  Roaming updating confirmation (proceed to send).

  The signal cuts off the roaming alarm (if set) in the MS. This signal also orders MS to send the dialled number.

  Address complete.

  This signal informs MS that the necessary digits are received.

  Ringing order.

  This signal initiates the generation of a ringing signal in MS.

  Clearing.

  This signal informs MS that the connection shall be released.

- Idle frame (frame 6).

  This signal is used in the signalling sequence e.g. in waiting situations.

4.2.2 Signals in the direction MS to MTX

- Call acknowledgement from MS, and seizure from MS with priority on calling channel (frame 10a).

  This signal is used when an MS answers a call from MTX, and when an MS with priority initiates a call.

- Seizure from ordinary MS, and identity on traffic channel (frame 10b).

  This signal is used when

  - an ordinary MS makes a call (on traffic channel) or
  - the MTX requests MS for identity when establishing a call.

- Roaming updating seizure on traffic channel (frame 11)

  If an MS moves into another traffic area, this signal will be sent to the MTX to indicate that an automatic updating call is made.

- Seizure from coin-box MS on traffic channel (frame 12).

  This signal is used to indicate that a coin-box MS makes a call, and that a special procedure shall be followed during the answer sequency (tariff class information).

- Line signal (frames 13a and 13b)

  These signals are similar to the line signals in paragraph 4.2.1

  Clearing, release-guard

  This signal informs MTX that the connection shall be released.

  Answer acknowledgement from coin-box

  After receiving answer with tariff class information from MTX, the coin-box MS sends this signal containing the received tariff class information, for control purpose.
  MFT converter in

  and

  MFT converter out

  These two signals are intended for use when the mobile subscriber uses his push-button set for data transmission. The translation equipment from 1200 Baud signals to MFT (Multi Frequency Tones) will be activated/ inactivated by these two line signals respectively.

  Answer

  This signal informs MTX that the SM has recognized the ringing signal, and lifted the handset.

- Digit signal (frames 14a and 14b)

  This signal is used to send the pre-dialled digits (including *, # , A, B, C, D) to MTX. One digit is sent in each frame. The first digit is sent in frame 14a, second digit in frame 14b, third digit in frame 14a etc.

- Idle frame (frame 15)

  This signal is used in the signalling sequence e.g. in waiting situations.

4.2.3 Signals in the direction MTX to BS

All these signals have a special Z-value (15) which indicates a message to a BS, and not to an MS.

- Channel activation order (frame 20)

  This signal informs the BS equipment about actions to be taken (e.g. start/stop of BS transmitter, start/stop of sending of Ø signal, control of BS receiver squelch function).

- Signal strength measurement order on data channel or idle or free marked traffic channel (frame 21b)

- Signal strength measurement order on traffic channel actually used (frame 21c)

- Other management/maintenance orders on idle channel or data channel (frame 22)

4.2.4 Signals in the direction BS to MTX

All these signals have a special Z-value (15) which indicates a message from a BS, and not from an MS.

- Channel status information (frame 25)

  Informs the MTX about the BS equipment status, and Ø signal alarms (see paragraph 4.5) on the traffic channel

- Signal strength measurement result (frame 26)

- Response on other management/maintenance orders on idle channel or data channel (frame 27)

- Other maintenance information from BS (frame 28)

  If a message is initiated at the BS, e.g. in connection with alarms, this signal will be used.

4.2.5 Frame for test channel indication (frame 30)

This signal indicates that the channel is reserved for test purposes. A test-marked channel can not be used by any other MS than a test MS.

4.3 FRAME TYPES AND CODING OF SIGNALS

4.3.1 Abbreviations and notations used

The following abbreviations and notations are used in describing frame types and coding of signals whereby all notations represent hexa-decimal digits:

- Number of actually used traffic or calling channel (Channel No.) (see para 4.3.3.1): $N_1N_2N_3$

  $N_1 = N_2 = N_3 = 15$ means separate data line MTX-BS

  $N_1 = N_2 = N_3 = 14$ means empty channel number register in BS

- Number of traffic channel allocated for a call or for measurement (TC No.): $N_aN_bN_c$

- Traffic area number (TA No.): Y_1Y_2

- Mobile subscriber No.: $Z\ X_1X_2X_3X_4X_5X_6$

- The value 15 of Z, Z(15), is used to indicate that the information concerns a base station (BS)

- Tariff class information (for coin-box) Q_1Q_2

- Each type of frame is characterized by a prefix: P(0....15)

- Line signals are indicated: L
- Digit signals are indicated: S
- Idle information is indicated: J
- Channel activation orders and channel status information are indicated: A
- Management and maintenance orders and other information are indicated: $V_1V_2\cdots$
- Signal strength measurement results are indicated: $R(n_1)R(n_2)$
- The notation P (n) indicates value n of prefix P
- Notations $N_1N_2N_3$ and $N_aN_bN_c$ indicate successive N digits
- Supervisory signal frequency $f_\emptyset$

4.3.2 Frame types

The information part of the frames sent from MTX to MS and from MS to MTX contains 64 bits, i.e. 16 hexa-decimal digits. The same frame format is used on calling and traffic channels. However, in the direction MS to MTX on the calling channel, only 12 digits are transmitted (see para 4.7.2).

In the following description each type of frame is given a number, which is used for reference when describing the signalling procedures.

4.3.2.1 Frames used in direction MTX to MS

These frames are divided into four fields containing:

- Number of actually used traffic or calling channel
- Prefix and traffic area number
- Mobile identification field
- Information field

Channel No	Prefix and TA No	Mobile subscriber No	Information
3 digits	3 digits	7 digits	3 digits

1.a Calling channel indication

Channel No.	Prefix	TA No.	Idle
N_1 N_2 N_3	P(12)	Y_1 Y_2	J J J J J J J J J J

1.b Combined calling and traffic channel indication

Channel No.	Prefix	TA No.	Idle
N_1 N_2 N_3	P(4)	Y_1 Y_2	J J J J J J J J J J

2.a Call to mobile subscriber on calling channel

Channel No.	Prefix	TA No.	Mobile subscriber No.	Idle
N_1 N_2 N_3	P(12)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	J J J

2.b Traffic channel allocation on calling channel

Channel No.	Prefix	TA No.	Mobile subscriber No.	TC No.
N_1 N_2 N_3	P(12)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	N_a N_b N_c

2.c Queueing information to MS with priority on calling channel

Channel No.	Prefix	TA No.	Mobile subscriber No.	Fictitious TC No.
N_1 N_2 N_3	P(12)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	N_a N_b N_c

3.a Traffic channel allocation on traffic channel

Channel No.	Prefix	TA No.	Mobile subscriber No.	TC No.
N_1 N_2 N_3	P(5)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	N_a N_b N_c

3.b Identity request on traffic channel

Channel No.	Prefix	TA No.	Mobile subscriber No.	Idle
N_1 N_2 N_3	P(5)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	J J J

4. Free traffic channel indication

Channel No.	Prefix	TA No.	Idle
N_1 N_2 N_3	P(3)	Y_1 Y_2	J J J J J J J J J J

5.a Line signal

Channel No.	Prefix	TA No.	Mobile subscriber No.	Signal No.
N_1 N_2 N_3	P(6)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	L(n)L(n)L(n)

5.b Line signal: Answer to coin-box

Channel No.	Prefix	TA No.	Mobile subscriber No.	Sign. No.	Tariff class info
N_1 N_2 N_3	P(6)	Y_1 Y_2	Z X_1 X_2 X_3 X_4 X_5 X_6	L(0)	Q_1 Q_2

6. Idle frame

Idle	Prefix	Idle
J J J	P(0)	J J J J J J J J J J J

4.3.2.2 Frames used in direction MS to MTX

The frames are divided into four fields containing:

- Number of actually used traffic or calling channel
- Prefix
- Mobile identification field
- Information field

Channel No.	Prefix	Mobile subscriber No.	Information
3 digits	1 digit	7 digits	5 digits

10.a Call acknowledgement from MS and seizure from MS with priority on calling channel (shortened frame).

Channel No.	Prefix	Mobile subscriber No.	Idle
N_1 N_2 N_3	P(1)	Z X_1 X_2 X_3 X_4 X_5 X_6	J(J J J J)

10.b Seizure from ordinary MS and identity on traffic channel

Channel No.	Prefix	Mobile subscriber No.	Idle
N_1 N_2 N_3	P (1)	Z X_1 X_2 X_3 X_4 X_5 X_6	J J J J J

11. Roaming updating seizure on traffic channel

Channel No.			Prefix	Mobile subscriber No.							Idle				
N_1	N_2	N_3	P(14)	Z	X_1	X_2	X_3	X_4	X_5	X_6	J	J	J	J	J

12. Seizure from coin-box on traffic channel

Channel No.			Prefix	Mobile subscriber No.							Idle				
N_1	N_2	N_3	P(11)	Z	X_1	X_2	X_3	X_4	X_5	X_6	J	J	J	J	J

13.a Line signal

Channel No.			Prefix	Mobile subscriber No.							Signal No.				
N_1	N_2	N_3	P(8)	Z	X_1	X_2	X_3	X_4	X_5	X_6	L(n)	L(n)	L(n)	L(n)	L(n)

13.b Line signal: Answer acknowledgement from coin-box

Channel No.			Prefix	Mobile subscriber No.							Signal No.			Tariff class info	
N_1	N_2	N_3	P(8)	Z	X_1	X_2	X_3	X_4	X_5	X_6	L(2)	L(2)	L(2)	Q_1	Q_2

14.a Digit signal (1st, 3rd, 5th ..... digit)

Channel No.			Prefix	Mobile subscriber No.							Pos.ind.		Digit value		
N_1	N_2	N_3	P(7)	Z	X_1	X_2	X_3	X_4	X_5	X_6	S(o)	S(o)	S(n)	S(n)	S(n)

14.b Digit signal (2nd, 4th, 6th ..... digit)

Channel No.			Prefix	Mobile subscriber No.							Pos.ind.		Digit value		
N_1	N_2	N_3	P(7)	Z	X_1	X_2	X_3	X_4	X_5	X_6	S(15)	S(15)	S(n)	S(n)	S(n)

15. Idle Frame

Idle			Prefix		Idle									
J	J	J	P(0)	J	J	J	J	J	J	J	J	J	J	J

4.3.2.3 Frames used between MTX and BS

For communication between MTX and BS the same frame formats are used as between MTX an MS.

20. Channel activation order

Channel No.	Pre-fix	TA No.	BS ind.	Idle	Activ. order	
N_1 N_2 N_3	P(15)	Y_1 Y_2	Z(15)	J J J	A(n)	$f_\emptyset f_\emptyset f_\emptyset f_\emptyset f_\emptyset$

21b Signal strength measurement order on data channel or idle or free marked traffic channel

Channel No.	Pre-fix	TA No.	BS ind.	Idle	Meas. ind.	Idle	TC No.
N_1 N_2 N_3	P(3)	Y_1 Y_2	Z(15)	J J J	V(15)	J J	N_a N_b N_c

21c Signal strength measurement order on traffic channel actually used

Channel No.	Pre-fix	TA No.	BS ind.	Idle	Meas. ind.	Idle	TC No.
N_1 N_2 N_3	P(5)	Y_1 Y_2	Z(15)	J J J	V(15)	J J	N_a N_b N_c

22 Other management/maintenance order on idle channel or data channel.

Channel No.	Pre-fix	TA No.	BS ind.	Idle	Manag./maint. Order				
N_1 N_2 N_3	P(14)	Y_1 Y_2	Z(15)	J J J	V_1	V_2	V_3	V_4 V_5	V_6

In frames 21b and 21c, V(15) is used to indicate signal strength measurement order. Therefore, in frame 22 V_1 must not take the value (15) in order to discriminate from frame 21b and 21c respectively.

15. Idle frame

Idle	Prefix	Idle
J J J	P(0)	J J J J J J J J J J J

25. Channel status information

Channel No.	Pre-fix	BS ind.	Idle	Status info	Idle
$N_1N_2N_3$	P(9)	Z(15)	J J	A(n)	J J J J J J J J

26. Signal strength measurement result

Channel No.	Pre-fix	BS ind.	Idle	Channel No.	Measurement result
$N_1N_2N_3$	P(2)	Z(15)	J J	$N_aN_bN_c$	$R(n_1)R(n_2)R(n_1)R(n_2)$ $R(n_1)R(n_2)$

27. Response on other management/maintenance order on idle channel or data channel

Channel No.	Pre-fix	BS ind.	Idle	Manag./maint. information	Idle
$N_1N_2N_3$	P(4)	Z(15)	J J	V_1 V_2 V_3 V_4	J J J J J

28. Other maintenance information from BS.

Channel No.	Pre-fix	BS ind.	Idle	Maint.-information	Idle
$N_1N_2N_3$	P(13)	Z(15)	J J	V_1 V_2 V_3 V_4	J J J J J

Frame 28 is used for maintenance information, e.g. alarms, initiated by BS. If the channel number register in BS is empty $N_1 = N_2 = N_3 = 14$ is sent from BS.

4.3.2.4 Frame for test channel indication

For use by a test mobile station the following frame is provided in the direction MTX to TMS.

30. Test channel indication.

Channel No.	Pre-fix	TA No.	Idle
$N_1N_2N_3$	P(10)	Y_1 Y_2	J J J J J J J J J J

4.3.3 Coding of signal information

The 16 hexa-decimal digits in a normal frame and the 12 digits in a shortened frame consist each of 4 bits. These 4 bits are coded according to paragraphs 4.3.3.1 - 4.3.3.7.

4.3.3.1 Digits of numerical information

The table below applies to digits of the following numerical information.

- Channel No. $N_1\ N_2\ N_3$ [1)]
- TA No. $Y_1\ Y_2$
- Mobile subscriber No. $Z\ X_1\ X_2\ X_3\ X_4\ X_5\ X_6$ [2)]
- TC No. (Channel order) $N_a\ N_b\ N_c$ [1)]
- Tariff class information $Q_1\ Q_2$
- Measurement results $R(n_1)R(n_2)$

Digits in $N_1N_2N_3$ [1)], $N_aN_bN_c$ [1)] and $R(n_1)R(n_2)$	Digits in $Y_1\ Y_2$, $Z\ X_1X_2X_3X_4X_5X_6$ and $Q_1\ Q_2$	Binary code Bit No. 1234
0	(16)	0000
1	1	0001
2	2	0010
3	3	0011
4	4	0100
5	5	0101
6	6	0110
7	7	0111
8	8	1000
9	9	1001
(10)	0	1010
(11)	(11)	1011
(12)	(12)	1100
(13)	(13)	1101
(14)	(14)	1110
(15)	(15)	1111

(note on next page)

1) In digits N_1 and N_a the least significant bit (bit no. 4) denotes the hundreds digit in the channel number and the bits no. 2 and 3 denote the output power level at which the MS is ordered to transmit (high power 11, low power 10,01 and 00). Only the bit configuration 11 and 10 will be used from the outset. Bit no. 1 shall be reserved for future application but from the outset have the value "0".

In the signalling between MTX and BS the first three bits in N_1 and N_a shall have the value 011 in both directions.

However, between MTX and BS special values and meanings of N_1 may be used (see para 4.3.1).

The power level indication in N_1 corresponds to the actual power level on channel $N_1N_2N_3$, while the power level indication in N_a denotes the ordered power level on channel $N_aN_bN_c$. The same combination $N_1N_2N_3$ is returned from the MS to the MTX.

Example: $N_1N_2N_3$ = 0111 0000 0101

means - high power indication

- channel number 105.

2) The values for digit Z are:

Z(5) indicates Denmark
Z(6) indicates Sweden
Z(7) indicates Norway
Z(8) indicates Finland
Z(15) indicates BS

The other values of Z are spare values.

4.3.3.2 Prefixes

Notation	Coding	Meaning in direction	
		MTX ⟶ MS/BS	MS/BS ⟶ MTX
P(0)	0000	Idle	Idle
P(1)	0001	Spare	Call acknowledgement, seizure and identity
P(2)	0010	Spare	Measurement results
P(3)	0011	Traffic channel	Spare
P(4)	0100	Combined calling and traffic channel	Response on management/ maintenance orders
P(5)	0101	Channel allocation and identity request on traffic channel	Spare
P(6)	0110	Line signal	Spare
P(7)	0111	Spare	Digit signal
P(8)	1000	Spare	Line signal
P(9)	1001	Spare	Channel status information
P(10)	1010	Test channel	Spare
P(11)	1011	Spare	Coin-box seizure
P(12)	1100	Calling channel	Spare
P(13)	1101	Spare	Other maintenance information
P(14)	1110	Measurement/ maintenance orders	Roaming updating
P(15)	1111	Channel activation order	Spare

4.3.3.3 Line signal number L(n) in frames 5 and 13

Notation	Coding	Meaning in direction	
		MTX ⟶ MS	MS ⟶ MTX
L(0)	0000	Answer to coin-box	Spare
L(1)	0001	Spare	Clearing, release-guard
L(2)	0010	Spare	Answer acknowledgement, (coin-box)
L(3)	0011	Roaming updating confirmation (proceed to send)	Spare
L(4)	0100	Spare	Spare
L(5)	0101	Spare	Spare
L(6)	0110	Address complete	Spare
L(7)	0111	Spare	MFT converter out
L(8)	1000	Spare	MFT converter in
L(9)	1001	Ringing order	Spare
L(10)	1010	Spare	Spare
L(11)	1011	Spare	Spare
L(12)	1100	Spare	Spare
L(13)	1101	Spare	Spare
L(14)	1110	Spare	Answer
L(15)	1111	Clearing	Spare

4.3.3.4 Digit value S(n) and position indication S(0/15) in frames 14a and 14b

Notation	Coding	Meaning
S(0)	0000	D or position indication (1st, 3rd .... digit)
S(1)	0001	1
S(2)	0010	2
S(3)	0011	3
S(4)	0100	4
S(5)	0101	5
S(6)	0110	6
S(7)	0111	7
S(8)	1000	8
S(9)	1001	9
S(10)	1010	0
S(11)	1011	*
S(12)	1100	#
S(13)	1101	A
S(14)	1110	B
S(15)	1111	C or position indication (2nd, 4th .... digit)

4.3.3.5 Idle information

Idle information J is coded 0000.

3.3.3.6 Channel activation order in frame 20 and channel status information in frame 25

Notation	Coding	Meaning in direction	
		MTX → BS (frame 20)	BS → MTX (frame 25)
A(0)	0000	Idle radio channel (stop BS transmitter, open line loop, stop sending of Ø signal, switch squelch function in)	Spare
A(1)	0001	Spare	Acknowledge idle radio channel
A(2)	0010	Spare	Acknowledge start Ø signal
A(3)	0011	Send Ø signal ($f_{\emptyset}$ = 1,2,3,4) Switch squelch function out)	Spare
A(4)	0100	Suppress Ø signal alarm A (7)	Spare
A(5)	0101	Loop line in BS	Acknowledge "suppress Ø signal alarm A (7)"
A(6)	0110	Spare	Spare
A(7)	0111	Spare	Received Ø signal below 1:st limit but above 2:nd limit
A(8)	1000	Spare	Received Ø signal below 2nd limit
A(9)	1001	Spare	Reserved for: acknowledge squelch function out
A(10)	1010	Cancel suppression of Ø signal alarm A(7)	Spare
A(11)	1011	Reserved for: Switch squelch function out	Acknowledge "Cancel suppression of Ø signal alarm A(7)"
A(12)	1100	Stop sending Ø signal, switch squelch function in	Spare
A(13)	1101	Spare	Acknowledge stop sending Ø signal
A(14)	1110	Spare	Acknowledge start BS transmitter
A(15)	1111	Start BS transmitter	Spare

Note: Coding and meaning of Ø signal frequency in frame 20 (A=3)

Notation	Coding	Meaning
	0000	Reserved for future use in BS
fø1	0011	Send Ø signal frequency 1
fø2	1100	Send Ø signal frequency 2
fø3	1001	Send Ø signal frequency 3
fø4	0110	Send Ø signal frequency 4

4.3.3.7 Other management/maintenance orders

Notation	Coding	Meaning in direction MTX-BS (frame 22)
V_1 (0)	0000	Idle
V_1 (1)	0001	Alarm reset
V_1 (2)	0010	Reserved for SU/SR alarm reset
V_1 (3)-V_1(5)		Spare
V_1 (6)	0110	RF test loop in
V_1 (7)-V_1(8)		Spare
V_1 (9)	1001	RF test loop out
V_1(10)-V_1(14)		Spare
V_1 (15)		Not used, reserved for frame 21b and 21c.

Note: Alarm reset means that all alarm indicators in BS shall be reset. This makes it possible to see if alarm state has been changed.

4.3.3.8 Response on other management/maintenance orders

Information indicated in V_1 V_2 ..... in frame 27 will be specified later.

4.3.3.9 Other maintenance information from BS

Notation	Coding	Meaning in direction BS-MTX (frame 28)
V_1 (10)	1010	Don't care
V_1 (6)	0110	Block the channel
V_1 (9)	1001	Deblock the channel
V_1 (12)	1100	SU/SR alarm via channel line
V_1 (15)	1111	Shall not be used
V_2 (15)	1111	NMT-alarms
V_2 (1)	0001	House-alarms
V_2 (8)	1000	External alarms

Notation	Coding V_3	Meaning in direction BS-MTX (Frame 28)
V_1 (10) V_2 (15) V_3 (0)	0000	Antenna fault level 1
" " V_3 (1)	0001	Transmitter level 1
V_1 (6) " V_3 (2)	0010	Ø-signal test loop
" V_3 (3)	0011	Spare
" V_3 (4)	0100	Spare
" V_3 (5)	0101	Spare
V_1 (6) " V_3 (6)	0110	Local blocking
V_1 (9) " "	0110	Local deblocking
V_1 (6) " V_3 (7)	0111	Receiver
" V_3 (8)	1000	Spare
V_1 (6) " V_3 (9)	1001	CU
" " V_3 (10)	1010	SU, via data line
V_1 (12) " "	1010	SU, via channel line and CU
V_1 (6) " V_3 (11)	1011	SR, via data line
V_1 (12) " "	1011	SR, via channel line and CU
V_1 (6) " V_3 (12)	1100	Power supply
" " V_3 (13)	1101	Receiver multicoupler
" " V_3 (14)	1110	Transmitter level 2
" " V_3 (15)	1111	Antenna fault level 2
V_1 (10) V_2 (1) V_3 (0)	0000	Fire alarm
V_1 (6) " V_3 (1)	0001	Mains break-down alarm
V_1 (10) " V_3 (2)	0010	Intruder alarm
" " V_3 (3)	0011	Obstruction lighting alarms
V_1 (9) V_2 (1) V_3 (4)	0100	Mains return
V_1 (10) V_2 (1) V_3 (5)	0101	Mains break-down at channel with battery back-up
" " V_3 (6)	0110	Spare
" " V_3 (7)	0111	"

Notation	Coding V_3	Meaning in direction BS-MTX (Frame 28)
V_1 (10) V_2(8) V_3 (8)	1000	Spare
" " V_3 (9)	1001	"
" " V_3 (10)	1010	"
" " V_3 (11)	1011	"
" " V_3 (12)	1100	"
" " V_3 (13)	1101	"
" " V_3 (14)	1110	"
" " V_3 (15)	1111	"

All other combinations of V_1 V_2 V_3 shall be spare.

It shall be possible to increase the number of alarms by using V_4.

Note 1. Character V_4 not specified in the alarm above shall have the value 0000.

Note 2. Level 1 Degradation which not requires an immediate service action

Level 2 Not in function

Note 3. Blocking, deblocking, don't care (see also NMT Doc. 2 Chapter 8 Maintenance of BS).

Three different categories of alarm information shall be sent to the MTX from the base station.

- Blocking, the MTX shall block the channel when it receives this information, i.e. the channel is not longer available for traffic. A blocked channel shall be indicated at the base station. The blocking is initiated by frame 28 from the base station.
- Deblocking, the MTX shall deblock the channel when it receives this information, i.e. the channel is now available for traffic again.
- Don't care, the MTX shall not act on this information.

Note 4. Different classes of alarms

The alarms from the BS are divided in three classes.

- NMT alarms; includes the alarms which are released by the equipment that is included in the NMT system.

- House alarms; includes the alarms which are released from common equipment at the base station such as fire alarm and intruder alarm.

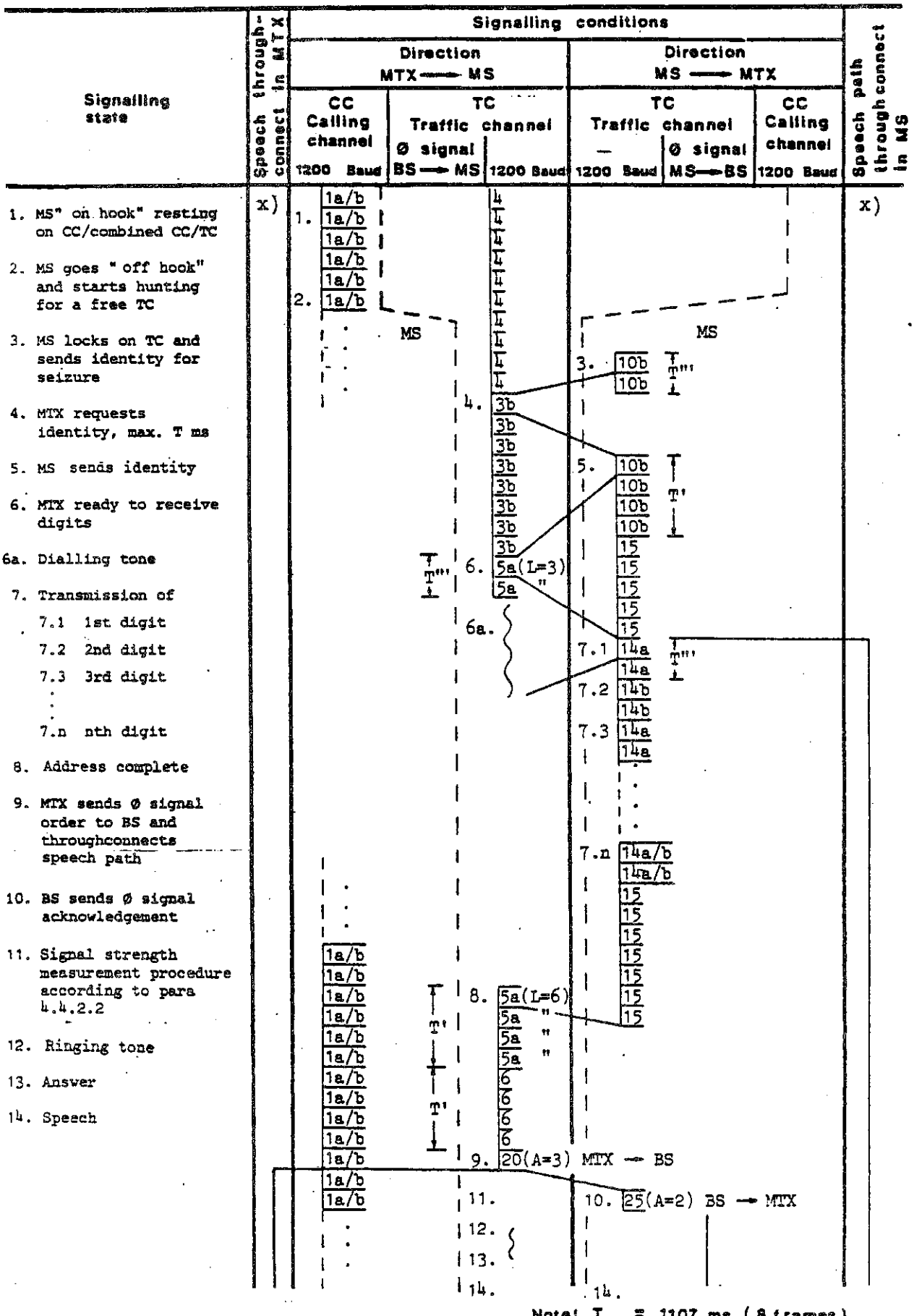
- External alarms; includes the alarms which are released by all other equipment on the station by using the NMT signalling system for alarm information.

It shall be possible to forward information in frame 28 together with circuit identity both to remote and to local I/O-devices.

Note 5. Idling of radio channel at blocking alarm.

After the CU has sent an alarm containing $V_1(6)$, block the channel, the radio channel equipment shall be idled locally. This has the same function as reception of frame 20(A=0) from the MTX.

SCHEME A

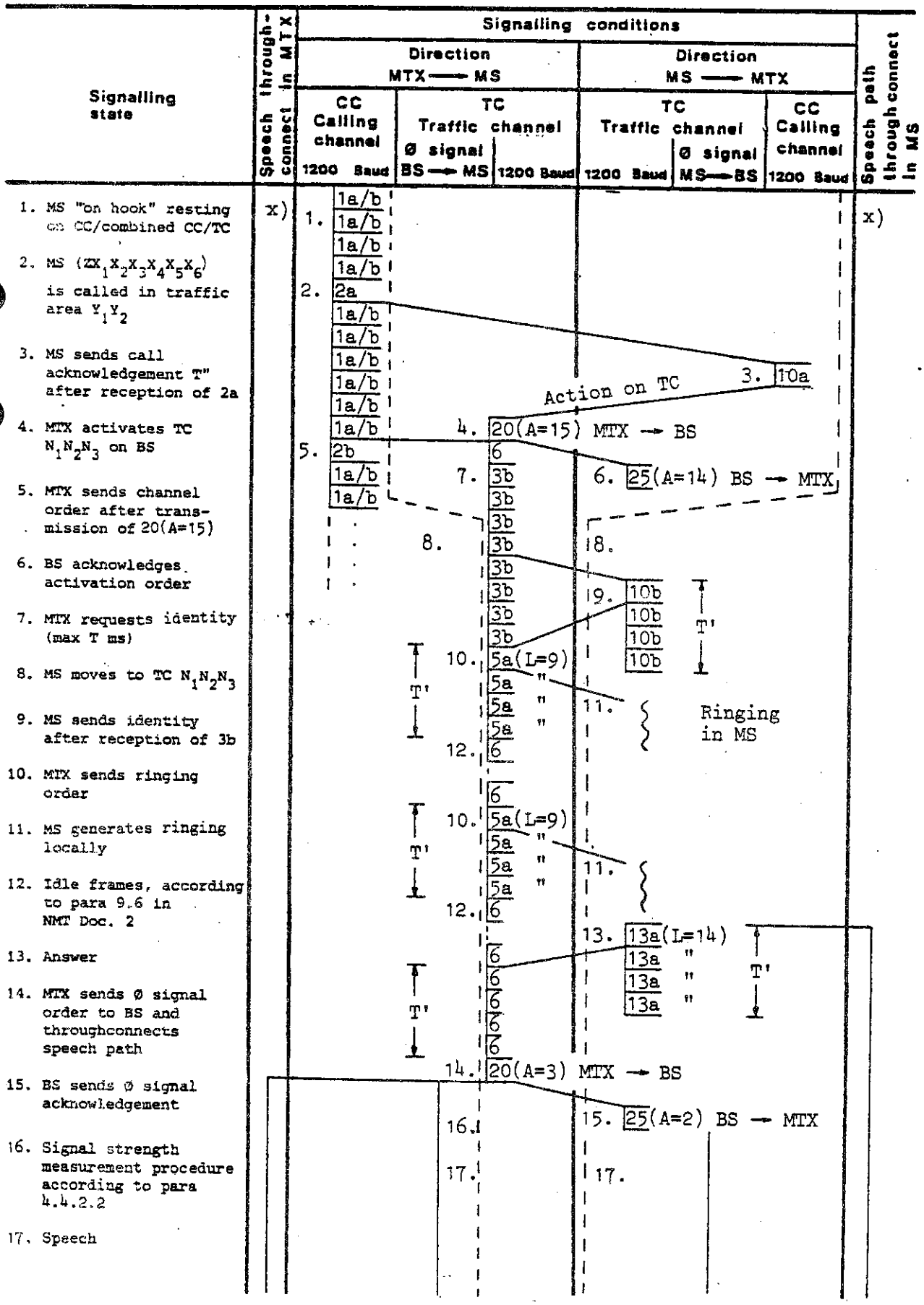


Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2,5 ms
T''' = 277 ms (2 frames)

x) For details, see para 4.6

4.4.1.2 Call mobile telephone exchange ⟶ mobile station

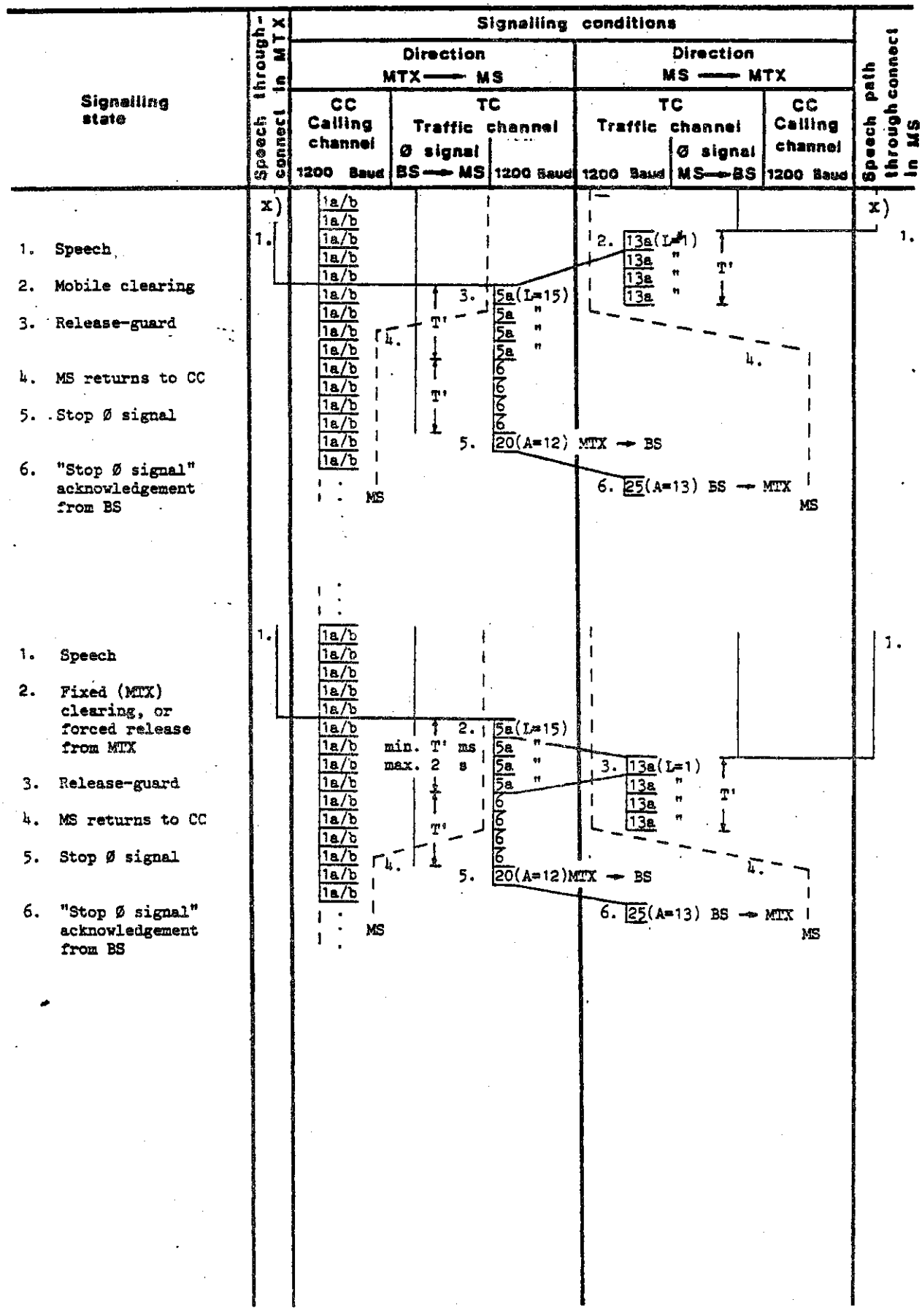
SCHEME B



x) For details, see para 4.6

Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T" = 30±2.5 ms
T''' = 277 ms (2 frames)

4.4.1.3 Clearing sequences



x) For details, see para 4.6

Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30±2.5 ms
T''' = 277 ms (2 frames)

4.4.1.4 Switching call in progress

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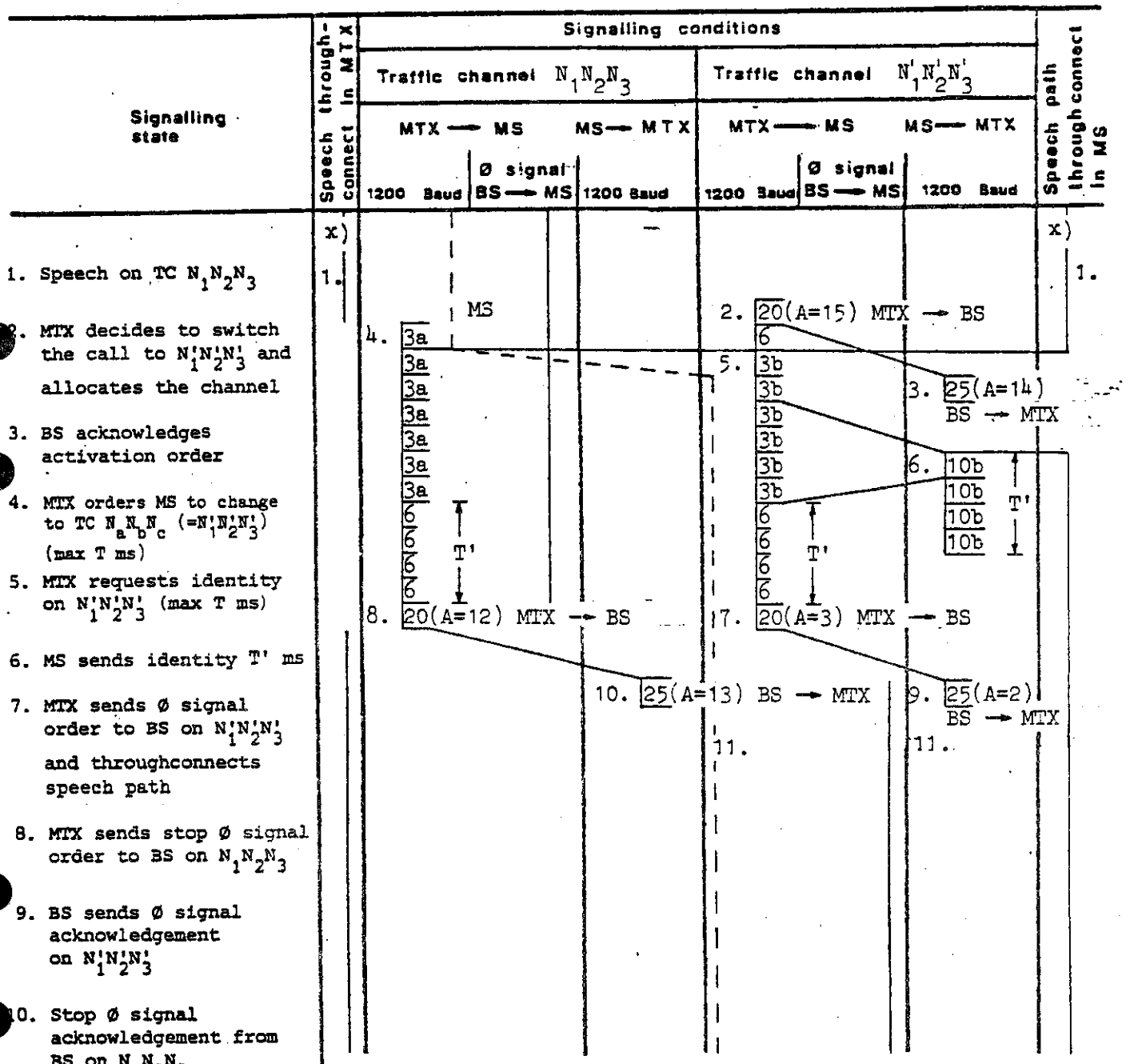
SCHEME C



If MS does not receive request identity on the new TC, it will return to the previous TC and throughconnect speech path.

If MTX does not receive identity on the new TC within T ms, it will throughconnect speech path on the previous TC and send forced release on the new TC.

Note that the supervisory signal will control the previous TC in the last case when the speech path is throughconnected.

x) For details, see para 4.6

Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30±2.5 ms
T''' = 277 ms (2 frames)

4.4.1.5 Roaming information

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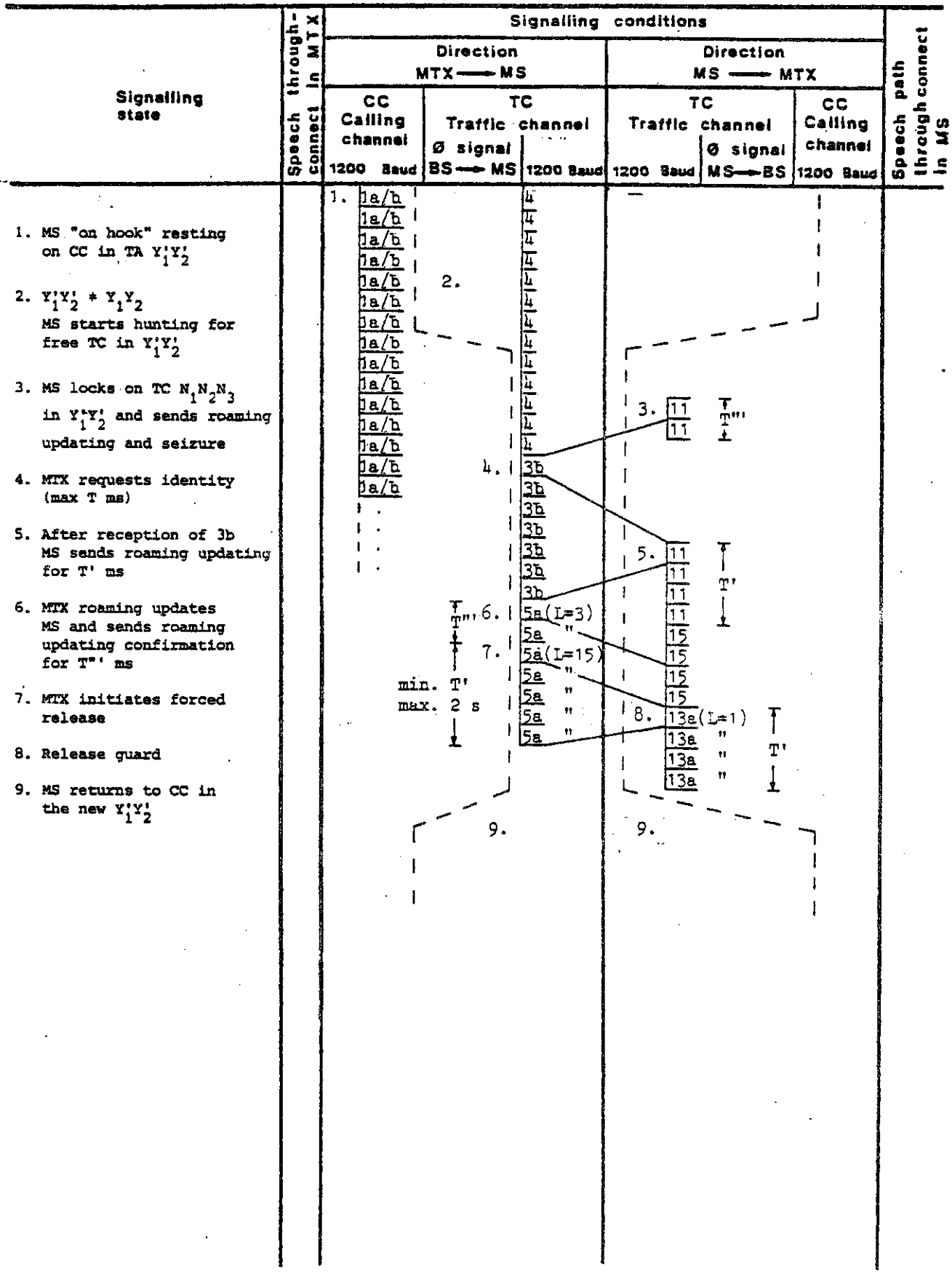
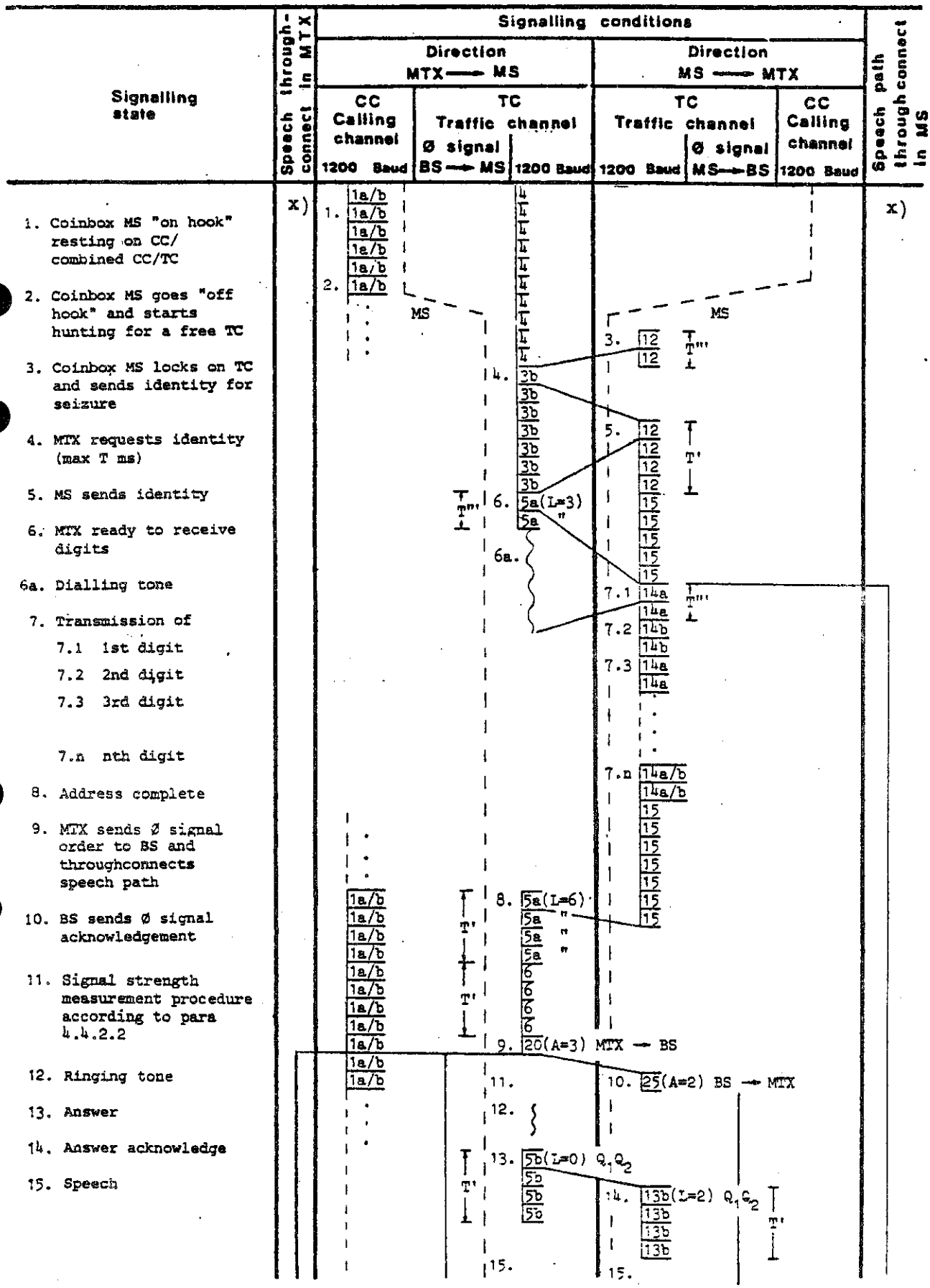
SCHEME D



Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T" = 30 ± 2,5 ms
T"' = 277 ms (2 frames)

4.4.1.6 Call coin-box MS ⟶ mobile telephone exchange



Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2,5 ms
T''' = 277 ms (2 frames)

x) For details, see para 4.6

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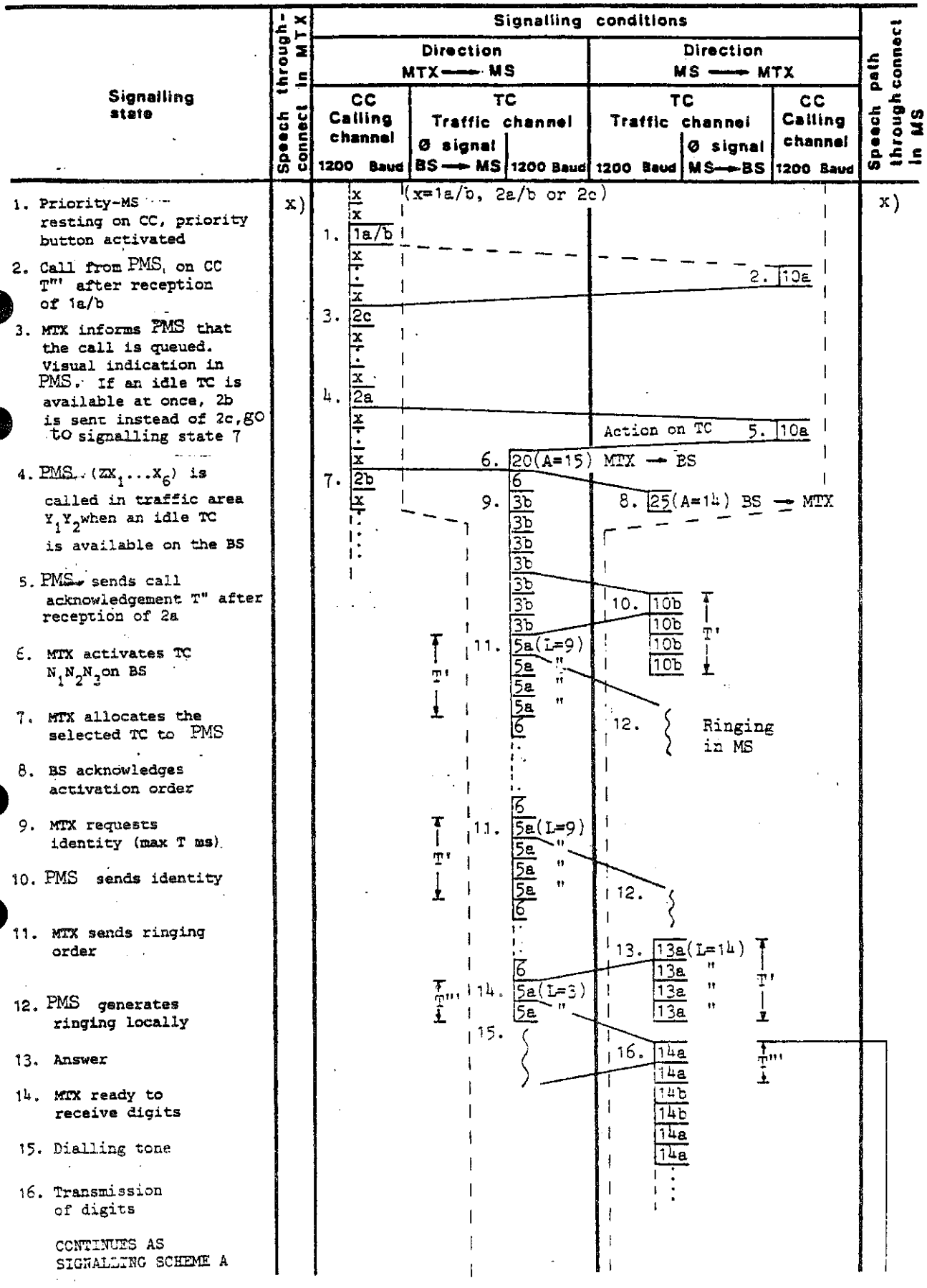
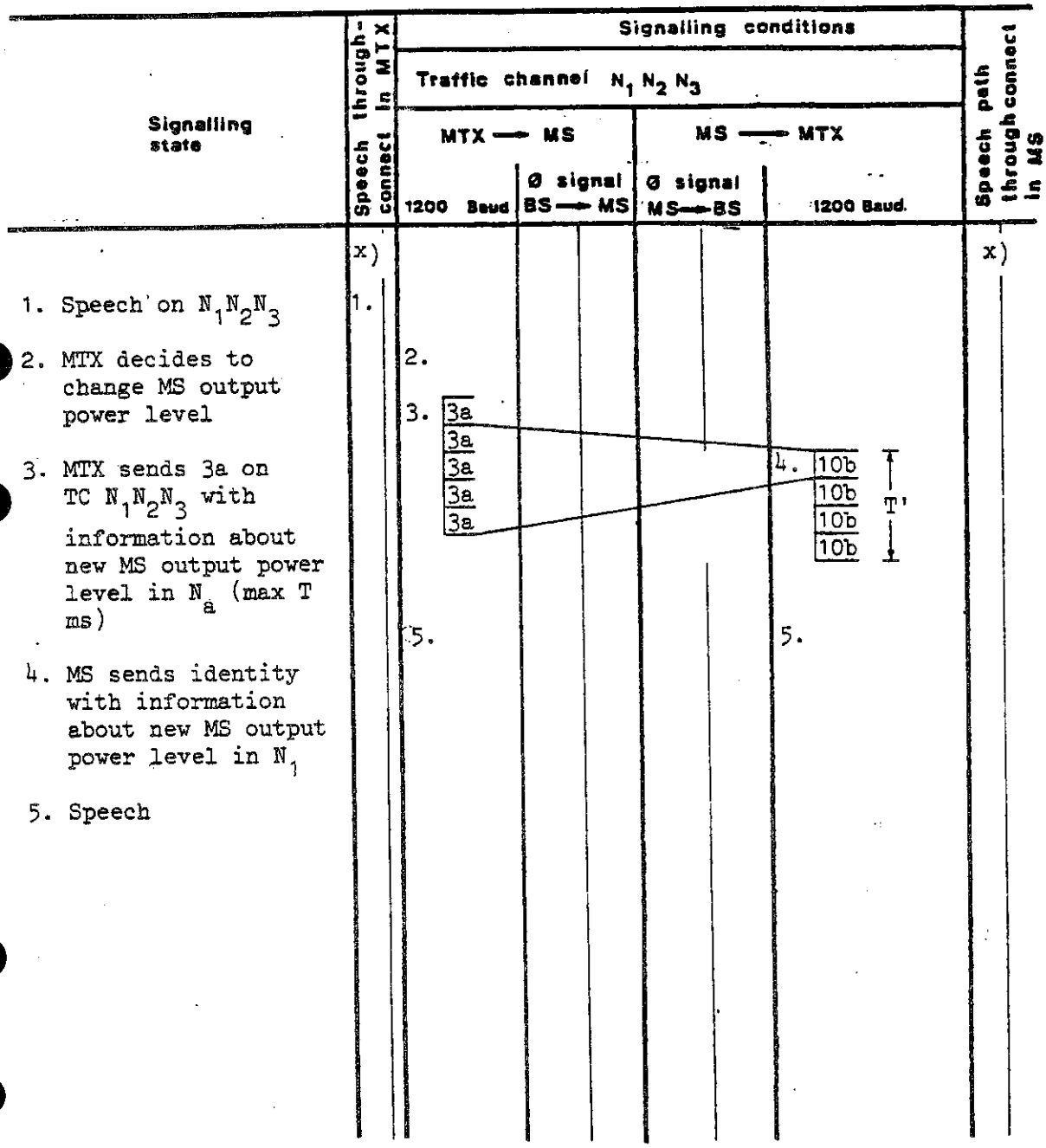
4.4.1.7 Call from mobile station with priority (PMS)



Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2,5 ms
T''' = 277 ms (2 frames)

x) For details, see para 4.6

4.4.1.8 Change of MS output power level on same channel



x) For details, see para 4.6

Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ∓ 2.5 ms
T''' = 277 ms (2 frames)

4.4.2 Signalling procedures between MTX and BS

4.4.2.1 Signalling on each channel

Signalling state	Signalling condition	
	MTX ⟶ BS	BS ⟶ MTX
1. Start BS transmitter	1. 20(A=15)	
2. BS sends "transmitter started" acknowledge		2. 25(A=14) X
3. Send Ø signal	3. 20(A=3)	
4. "Ø signal start" acknowledged from BS		4. 25(A=2) X
5. Suppress Ø signal alarm (frame 25(A=7)) from BS	5. 20(A=4)	
6. "Suppress Ø signal alarm" acknowledged from BS		6. 25(A=5)
7. Cancel suppression of Ø signal alarm in BS		
8. "Cancel suppression of Ø signal alarm" acknowledged from BS	7. 20(A=10)	
		8. 25(A=11)
9. Ø signal alarm from BS		
		9. 25(A=7 or A=8)
10. Stop sending of Ø signal	10. 20(A=12)	
11. "Stop Ø signal" acknowledged from BS		11. 25(A=13)
12. Stop BS transmitter and open "line loop"	12. 20(A=0)	
13. "Stop BS transmitter" acknowledged		13. 25(A=1) X
14. Loop line in BS	14. 20(A=5)	

X No reception of frame 25 within T' ms after frame 20 indicates BS or line fault.

Note: Some of the signalling states described above are normally included in other signalling procedures.

4.4.2.2 Signal strength measurements

(on data channel, idle or free marked TC, or the TC actually in use)

Signalling state	Signalling condition: MTX → BS	Signalling condition: BS → MTX
1. Signal strength measurement order 2. BS starts sending measurement result within T''' after reception of 21 b/c	1. 21b/c 21b/c 21b/c	2. 26 26 26

Note: Several measurement orders may be given in sequence, as indicated above.

Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2,5 ms
T''' = 277 ms (2 frames)

4.4.2.3 BS management, maintenance and alarm

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Signalling state	Signalling condition	
	MTX ⟶ BS	BS ⟶ MTX
1. Management/maintenance order	1. 22	
2. Response on management/maintenance order if so specified		2. 27
3. BS alarm		3. 15 28 x)

x) Frame 15 is sent for synchronization purposes.

4.5 SUPERVISORY SIGNAL BS - MS - BS

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As supervisory signal (Ø signal) on the radio path, a tone is used. The frequency of this tone is selected among four possible frequencies (3955, 3985, 4015 and 4045 Hz) in such a way that it differs for two nearby base stations having the same radio frequencies. The signal is inserted into the speech channel at the base station upon reception of a command from the MTX. In the mobile station, the Ø signal is separated from the speech signal and re-inserted into the speech channel in the direction towards the base station, where it is filtered out and evaluated. The level of the signal is such that a peak deviation of 300 Hz is obtained in both directions.

The evaluation at the base station is performed on the basis of the signal-to-noise ratio (S/N) for the supervisory tone in its frequency band and on the basis of time.

The information forwarded to MTX is one out of the 2 possible messages below.

a) Received Ø signal below 1:st limit but not below 2:nd limit.

b) Received Ø signal below 2:nd limit.

The two messages are also called "Ø signal alarm". Message a) starts signal strength measurement procedure and message b) starts clearing procedure.

4.6 1200 BAUD SIGNALLING EQUIPMENT

For the exchange of messages between MTX, BS and MS binary signalling is used. The necessary equipment at MTX has the following function blocks (fig. 4.6.1): encoder, modulator, equalizer, demodulator and decoder. The BS and MS have the same equipment functionally as the MTX except for the equalizer.

The various blocks are specified below. Concerning such parameters as frequency response and group delay distorsion except for the equalizer, no explicit requirements are given. These parameters are included in the requirements for overall error rate performance when connected to reference counter parts (4.6.3 and 4.6.7).

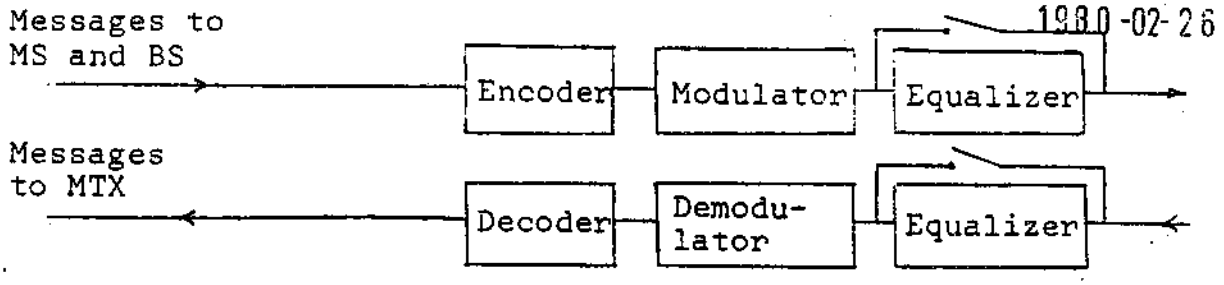

Fig. 4.6.1 Functional block diagram of the 1200 Baud signalling equipment at MTX

4.6.1 Reference data transmitter and receiver

The reference data transmitter and receiver fulfil the error rate performance in para 4.6.7. In the frequency band 600-2400 Hz the group delay distorsion is less than 100 μs and the shape of the spectrum of the transmitted signal deviates from the theoretical by less than 1 dB.

4.6.2 Encoder

In order to combat errors on the radio path due to fading and interference, an error-correcting code is used. The errors appear in bursts and therefore the chosen code is burst error correcting. The type of code is convolutional. The correcting capability of the code is 6 bits when there are at least 19 "errorfree" bits between the bursts. The encoder output bits Y_i are obtained from the encoder input bits X_i according to the following formulas

$$Y_{2i-1} = \begin{cases} \overline{X_i} & \text{for } i = 1 \text{ to } 3 \\ \overline{X_i \oplus X_{i-3}} & \text{for } i = 4 \text{ to } 64 \\ \overline{X_{i-3}} & \text{for } i = 65 \text{ to } 67 \\ 1 & \text{for } i = 68 \text{ to } 70 \end{cases} \quad \left.\begin{array}{l}\\\\\\\\\end{array}\right\} \text{parity check bits}$$

$$Y_{2i} = \begin{cases} 0 & \text{for } i = 1 \text{ to } 6 \\ X_{i-6} & \text{for } i = 7 \text{ to } 70 \end{cases} \quad \left.\begin{array}{l}\\\\\end{array}\right\} \text{information bits}$$

$\oplus$ denotes addition modulo-2. Thus for every information bit two output bits are obtained, one delayed information bit and one parity check bit. The length of the encoded message is 140 bits.

The messages are transmitted in frames which consists of three parts (fig. 4.6.2): bit synchronization (15 bits), frame synchronization (11 bits) and the encoded message (140 bits).

bit sync.	frame sync.	encode message
15 bits	11 bits	140 bits
101010101010101	11100010010	

Fig. 4.6.2 Frame disposition

The bits in a frame are transmitted in the order from left to right.

The bit pattern for the bit synchronization is 101010101010101 and for the frame synchronization 11100010010.

The bit sequences for bit and frame synchronization are intended to facilitate initial synchronization. During a transmission consisting of several frames the encoded messages contain enough information to check whether synchronization is maintained also when the specific frame synchronization sequence has been lost due to transmission errors.

To illustrate the encoding procedure an example is given.

Frame number 1. Free calling channel indication.

N_1 N_2 N_3 P(12) Y_1 Y_2 J J J J J J J J J J

N_1 = 1 representing binary 0001

N_2 = 3 0011

N_3 = 5 0101

P(12) = 12 1100

Y_1 = 6 0110

Y_2 = 4 0100

J = 0000

$X = X_1, X_2, X_3, X_4, X_5, X_6, X_7 \ldots\ldots X_{63}, X_{64}$

= 0001001101011100 00

According to the formulas above the encoded message will be

$Y = Y_1, Y_2, Y_3, \ldots\ldots\ldots Y_{140}$

$Y_1 = 1$; $Y_2 = 0$; $Y_{11} = 1$; $Y_{12} = 0$

$Y_3 = 1$; $Y_4 = 0$; $Y_{13} = 1$; $Y_{14} = 0$

$Y_5 = 1$; $Y_6 = 0$; $Y_{15} = 0$; $Y_{16} = 0$

$Y_7 = 0$; $Y_8 = 0$; $Y_{17} = 1$; $Y_{18} = 0$

$Y_9 = 1$; $Y_{10} = 0$; $Y_{19} = 1$; $Y_{20} = 1$

$Y_{133} = 1$; $Y_{134} = 0$; $Y_{137} = 1$; $Y_{138} = 0$

$Y_{135} = 1$; $Y_{136} = 0$; $Y_{139} = 1$; $Y_{140} = 0$

The bits in the full frame one are thus

10101010101010111100010010101010001010100010 11 10101010

4.6.3 Modulator

The modulation rate is 1200 $\pm$0,1 Baud. The modulation method is FFSK with the tone frequencies 1200 Hz and 1800 Hz for the logical "one" and "zero" respectively. The bit frequency and the modulation tone frequencies shall be derived from the same source. The shift from one frequency to the other shall be continuous in phase. The line diagram for the signal from the modulator shall thus be as shown in the figure 4.6.3 below.

The level from the modulator in the MTX including transmitting filters if so equipped is - 17 $\pm$ 0,25 dBm0. The output level of the modulator in the BS is - 11 $\pm$ 1,5 dBm0. The performance requirement of the modulator including transmitting filter, expressed as maximum increase at required S/N ratio for an error rate of 10^{-4} measured with a reference receiver is 0.5 dB compared with a reference data transmitter.

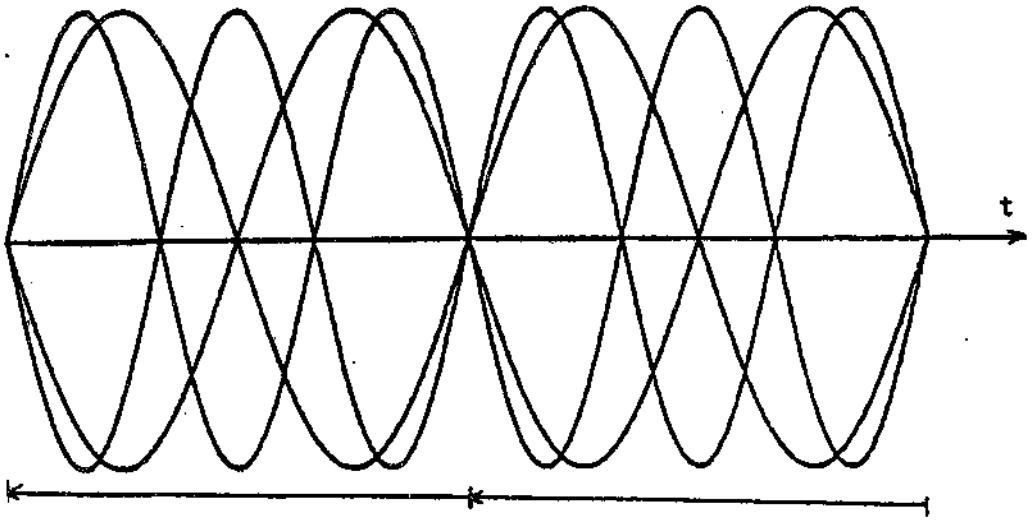

Fig. 4.6.3 Line diagram for the FFSK signal

4.6.4 Transmitting filter

The spectrum S(f) of the signal from the modulator as a function of the frequency is shown in figure 4.6.4 below. Above 3400 Hz the total power shall be below -30 dB relative to the power of the transmitted data signal. A transmitting filter may be used for reduction of spectrum components outside the necessary band (600-2400 Hz).

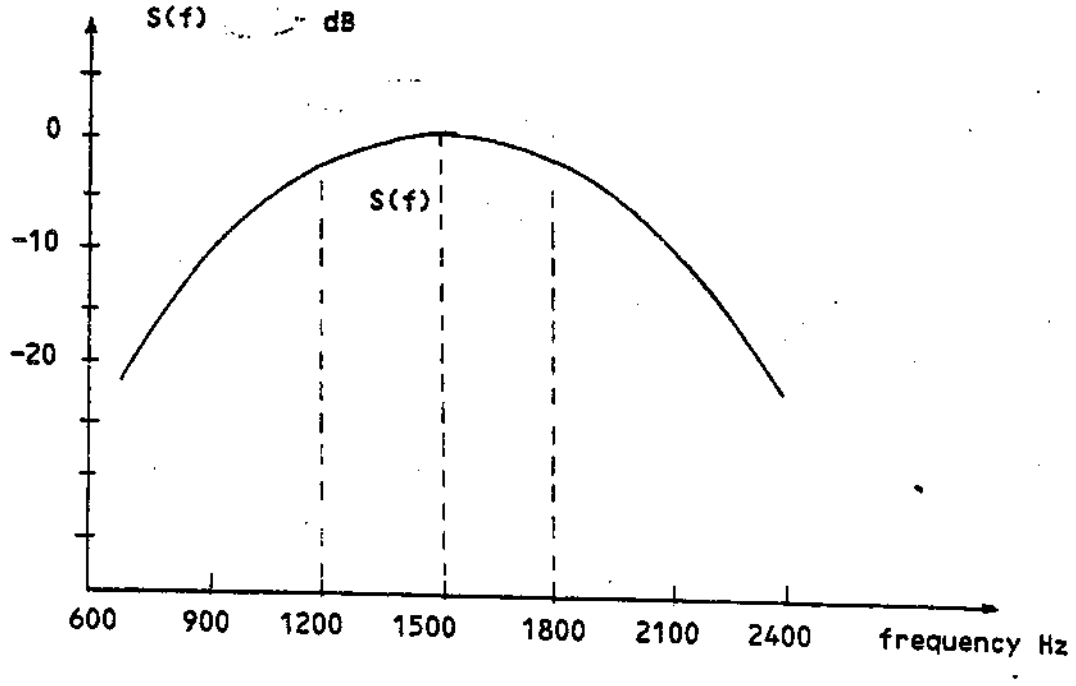

Fig. 4.6.4 Spectrum S(f) of the FFSK signal

4.6.5 Equalizer

The path between the MTX and the BS consists normally of one or more links in carrier systems and/or a physical line. To decrease the problems created by group delay distortion on this path equalizers are necessary. The equipment at the MTX therefore includes a "plug in" standard equalizer with a characteristic as shown in the figure 4.6.5 ±100 µs. Such an equalizer is foreseen in both the transmitting path and receiving path of the MTX.

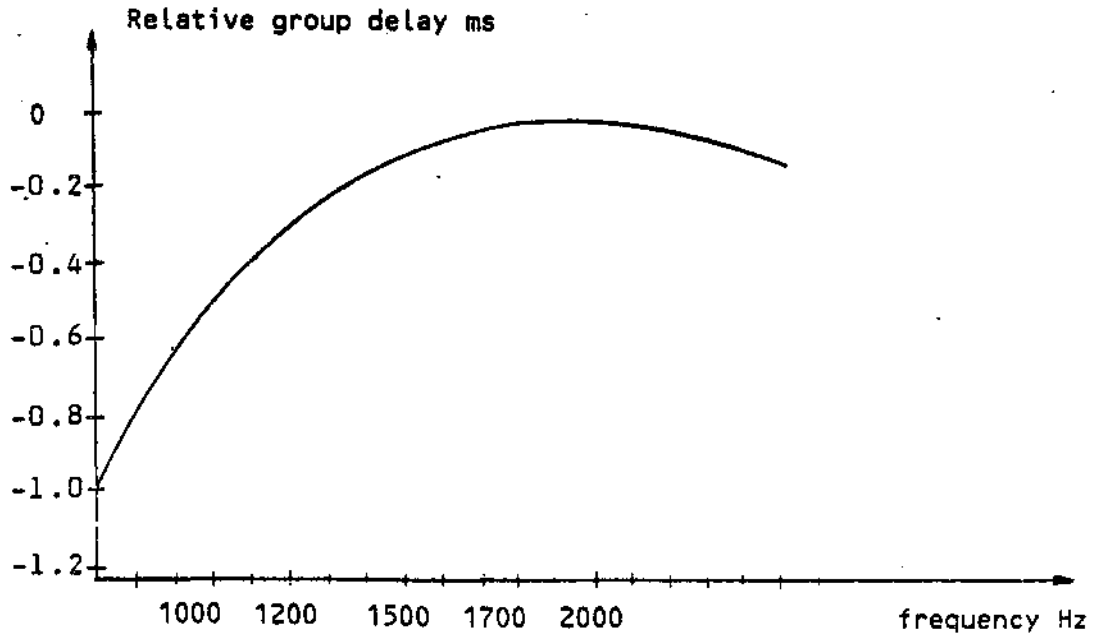

Fig. 4.6.5 Relative group delay of equalizer

4.6.6 Receiving filter

In order to improve the signal to noise ratio before demodulation a receiving filter may be required. This filter shall be designed in such a way that the requirements in para 4.6.7 are met.

4.6.7 Demodulator and signal level detector

The performance requirement of the signal receiving equipment when connected to a reference data transmitter is that the error rate shall be lower or equal to what is indicated by the curve in fig. 4.6.7. This requirement shall also be fulfilled for a shift ± 5 Hz of the frequencies (due to frequency errors in carrier frequency systems) for logical "one" and "zero" for MTX input signal levels in the range $-11\ ^{+3}_{-6}$ dBm0. For BS the input signal level is $-17\ ^{+3}_{-6}$ dBm0.

The modems in BS and MTX shall be equipped with a signal level detector. The function of this detector is to prevent the decoder from reacting upon signals below a level of -35 ± 3 dBm0. The detector shall permit decoding and the modem shall operate if FFSK modulated signals above the threshold level are detected. The error rate may be higher than specified in fig. 4.6.7 if the received level is outside the levels specified in the first paragraph.

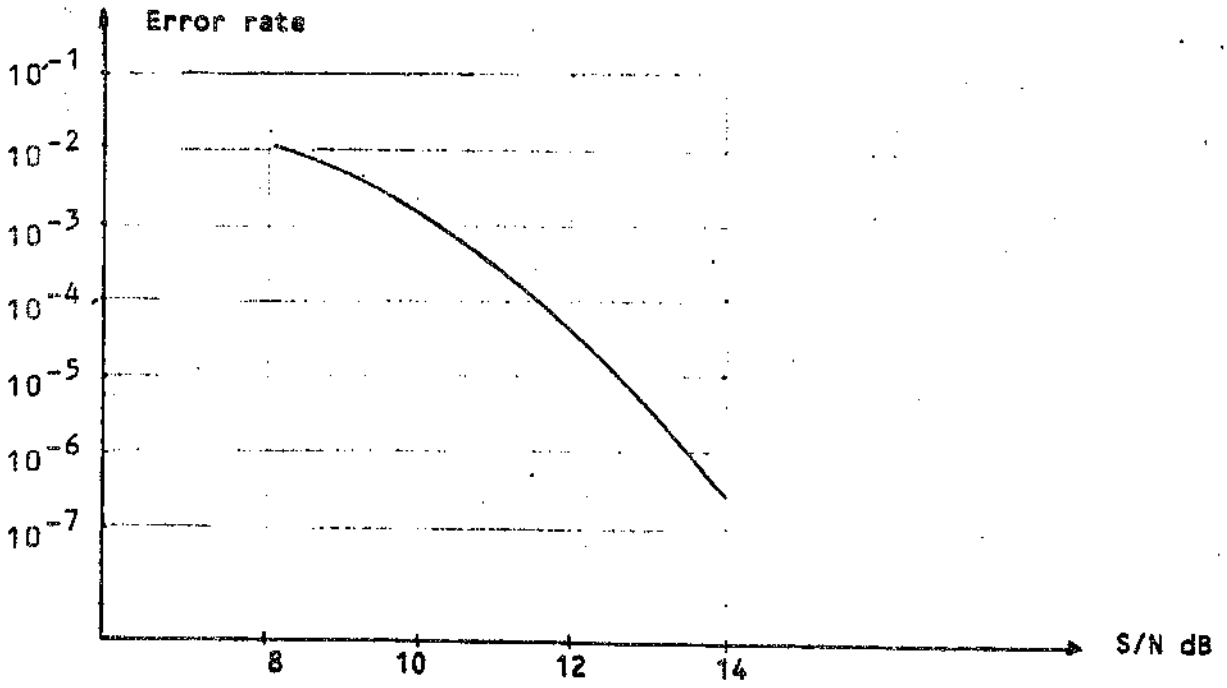

Fig. 4.6.7 Error rate versus signal to noice ratio at input from line (S/N) measured in bit rate bandwidth (1200 Hz) for noise with an even distribution at least from 300 to 3400 Hz.

4.6.8 Decoder and splitting

After reception of frame synchronization the bit stream is functionally divided into one stream containing information bits and another containing parity check bits. "New" parity check bits are calculated from the information bits and compared with the received parity check bits. Errors, if any, are localized and corrected in accordance with the capability of the code.

After reception of frame synchronization it is checked whether the subsequent six information bits all have the value 0.

- If so in the MTX the line to the telephone network is splitted within 10-20 ms. The reconnection time in the MTX shall be 250-300 ms after the last frame sync.
- If so in the MS the audio output is muted. Reconnection of the audio path is delayed T''' (277 ms) after reception of the last framesync.
- In the BS no splitting in the transmitter in the direction MTX ⟵ BS ⟶ MS takes place.

The decoding continues even if the six first information bits differ from the value 0.

4.6.9 Deleted

4.6.10 Muting of speech path

When the 1200 Baud signalling equipment in MTX is sending, the audio signal from the MTX towards the BS is muted.

In the MS the audio path is muted towards the MTX when the MS modem is sending.

In the BS the radio receiver is muted towards the MTX when the BS is signalling to the MTX.

4.7 ACCEPTANCE OF SIGNALS

This paragraph describes how the analysis of frames is to be carried out in the MTX, BS and MS and how they shall behave upon receiving frames containing errors.

The analysis is constructed to draw use of the redundancy in the signalling schemes and the structure of the frames.

4.7.1 Mobile in standby condition

Before locking to a channel the MS checks that N_1 N_2 N_3 P(12) Y_1 Y_2 of the received frame 1 a/b is correctly received. Staying at a channel the MS is primarily looking for an identity match i.e. if there is a call to the MS. The criteria to continue to be locked at the channel is that N_1 N_2 N_3 P(12)Y_1Y_2 is received regularily. However, two complete frames can be lost between two correct frames.

4.7.2 Acceptance of signals after entering a particular signalling scheme

Generally, frames that cannot be interpreted by the logic, shall be ignored. This applies also to frames that have no meaning in an actual signalling sequence.

The frame shall be accepted as a frame by the MTX if it consists of 140 bits in the encoded message. However, on CC from MS/BS to MTX also a shortened frame consisting of at least 106 bits in the encoded message shall be accepted as a frame. In the MS and BS other acceptance criteria are used.

In signalling sequences where identical frames are known to be repeated a number of times, the MTX and MS shall act upon the first of them that can be interpreted by the logic. That is, the MTX and MS shall not confirm the received signal by checking further frames.

4.7.2.1 Signalling scheme A, call MS ⟶ MTX 1980-02-26

- MTX receives seizure from ordinary MS
  (N_1 N_2 N_3 P(1) Z X_1 X_2 X_3 X_4 X_5 X_6 J J J J J)

The call from Z X_1 ... X_6 is accepted if it is a valid mobile number, N_1 N_2 N_3 and prefix are correctly received.

- MS receives identity request
  (N_1 N_2 N_3 P(5) Y_1 Y_2 Z X_1 X_2 X_3 X_4 X_5 X_6 J J J)

The frame is accepted if prefix P(5) and identity Z X_1...X_6 are correctly received.

- MTX receives identity (N_1 N_2 N_3 P (1) Z X_1 ... X_6 J J J J J)

MTX accepts identity if prefix and identity are correctly received.

- Roaming updating confirmation (see 4.7.2.3a)

- The MTX can during the dialling phase receive
  - Digit ($N_1N_2N_3$ P(7) Z $X_1X_2X_3X_4X_5X_6$ S(0/15)S(0/15) S(n) S(n) S(n)
  - Mobile clearing ($N_1N_2N_3$ P(8) Z $X_1X_2X_3X_4X_5X_6$ L(1)L(1)L(1)L(1)L(1)) (see 4.7.2.3b)
  - Idle frame (J J J P(0) J J J J J J J J J J J J)

The digit frame is accepted if the following conditions are satisfied:

a) P(7) is correctly received

b) $N_1N_2N_3$

or

Z X_1 X_2 X_3 X_4 X_5 X_6

or

six out of the ten characters $N_1N_2N_3$ Z $X_1X_2X_3X_4X_5X_6$

are correctly received.

c) S(0)S(0) (or S(15)S(15)) are correctly received

d) S(n) S(n) S(n) are equal.

Further a new digit frame is only accepted when S(0)S(0)/ S(15)S(15) have changed relative to the previous digit.

- The MS can during the dialling phase receive
  - Idle frame (J J J P(0) J J ... J)
  - Forced release ($N_1N_2N_3$ P(6) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$ L(15)L(15)L(15)) (see 4.7.2.3a)
  - Address complete ($N_1N_2N_3$ P(6) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$ L(6)L(6)L(6)) (see 4.7.2.3a)

4.7.2.2 Signalling scheme B, call MTX ⟶ MS

- Call to mobile subscriber on calling channel ($N_1N_2N_3$ P(12) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$ J J J) and
- Call acknowledgement ($N_1N_2N_3$ P(1) Z $X_1X_2X_3X_4X_5X_6$ J(J J J J)

The frames are accepted if identity Z X_1 ... X_6 is correctly received.

- Channel order ($N_1N_2N_3$ P(12) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6N_aN_bN_c$)

The frame is accepted if identity Z X_1 ... X_6 is correctly received and $N_aN_bN_c$ is a valid channel number.

- Identity request ($N_1N_2N_3$ P(5) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$ J J J) (see 4.7.2.1)
- Identity from MS ($N_1N_2N_3$ P(1) Z $X_1X_2X_3X_4X_5X_6$ J J J J J) (see 4.7.2.1)

After the identity check the

- MS can receive
  - Ringing order ($N_1N_2N_3$ P(6) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$L(9)L(9)L(9)
  - Forced release ($N_1N_2N_3$ P(6) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$ L(15)L(15)L(15) (see 4.7.2.3a)
  - Idle frame (J J J P(0) J J ... J)
- MS transmits
  - Answer ($N_1N_2N_3$ P(1) Z $X_1X_2X_3X_4X_5X_6$L(14)L(14)L(14)L(14)L(14))

4.7.2.3a Line signals in the direction MTX ⟶ MS

The line signal is accepted if the prefix P(6) and the identity Z X_1 ... X_6 are correctly received and at least two of the three characters L(n) are equal and meaningful.

4.7.2.3b Line signals in the direction MS ⟶ MTX

The frame is accepted if prefix P(8) and identity Z X_1...X_6 are correctly received and at least three of the characters L(n) are equal and meaningful.

4.7.2.4 Signalling scheme C, switching call in progress

- Traffic channel allocation on traffic channel ($N_1N_2N_3$ P(5) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6N_aN_bN_c$).

(see 4.7.2.2 channel order)

4.7.2.5 Signalling scheme D, roaming information

- Roaming up-dating seizure on traffic channel ($N_1N_2N_3$ P(14) Z $X_1X_2X_3X_4X_5X_6$ J J J J J)

(see 4.7.2.1 seizure)

4.7.2.6 Coin-box

- MTX receives seizure from coin-box MS ($N_1N_2N_3$ P(11) Z $X_1X_2X_3X_4X_5X_6$ J J J J J) (see 4.7.2.1 seizure)

- MS receives answer ($N_1N_2N_3$ P(6) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6$ L(0) Q_1Q_2)

The coin-box accepts answer if P(6), L(0), Z X_1 ...X_6 are correctly received.

- Answer acknowledgement from coin-box ($N_1N_2N_3$ P(8) Z $X_1X_2X_3X_4X_5X_6$ L(2)L(2)L(2) Q_1 Q_2)

The MTX accepts answer acknowledgement if P(8), Q_1 Q_2 and Z X_1 ...X_6 are correctly received and 2 of the 3 L(n) are equal to 2. Q_1 Q_2 must be identical to the values transmitted to the MS.

4.7.2.7 Call from mobile station with priority

- Seizure from MS with priority ($N_1N_2N_3$ P(1) Z $X_1X_2X_3X_4X_5X_6$ J(J J J J)) (see 4.7.2.1 seizure)

- Queueing information to MS with priority on calling channel ($N_1N_2N_3$ P(12) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6N_aN_bN_c$) (see 4.7.2.2 channel order)

4.7.2.8 Change of MS output power level on same channel

- Traffic channel allocation on traffic channel ($N_1N_2N_3$ P(5) Y_1Y_2 Z $X_1X_2X_3X_4X_5X_6N_aN_bN_c$) (see 4.7.2.2 channel order)

- MTX receives identity ($N_1N_2N_3$P(1) Z $X_1X_2X_3X_4X_5X_6$J J J J J) (see 4.7.2.1)

4.7.2.9 Signalling in the direction MTX → BS

- Channel activation order
  ($N_1N_2N_3$ P(15) Y_1Y_2 Z(15) J J J A(n) $f_\phi f_\phi f_\phi f_\phi f_\phi f_\phi$)

  The frame is accepted if P(15) and Z(15) JJJ are correctly received. f_ϕ is valid if two of the last three f_ϕ are equal and meaningful, and A(n) takes the value (3).

- Signal strength measurement order on data channel or idle or free marked traffic channel
  ($N_1N_2N_3$ P(3) Y_1Y_2 Z(15) J J J V(15) J J $N_aN_bN_c$)

  The frame is accepted if P(3) and Z(15) JJJ V(15) are correctly received.

- Signal strength measurement order on traffic channel actually used
  ($N_1N_2N_3$ P(5) Y_1Y_2 Z(15) J J J V(15) J J $N_aN_bN_c$)

  The frame is accepted if P(5) and Z(15) J J J V(15) are correctly received.

- Other management/maintenance order on idle channel or data channel
  ($N_1N_2N_3$ P(14) Y_1Y_2 Z(15) J J J $V_1V_2V_3V_4V_5V_6$)

  The frame is accepted if P(14) and Z(15) J J J are correctly received.

4.7.2.10 Signalling in the direction BS → MTX

- Channel status information
  ($N_1N_2N_3$ P(9) Z(15) J J A(n) J J J J J J J J)

  The frame is accepted if $N_1N_2N_3$, P(9), Z(15) and A(n) are correctly received.

- Signal strength measurement result
  ($N_1N_2N_3$ P(2) Z(15) J J $N_aN_bN_c$ $R(n_1)$ $R(n_2)$ $R(n_1)$ $R(n_2)$ $R(n_1)$ $R(n_2)$

  The frame is accepted if $N_1N_2N_3$, P(2), Z(15) and $N_aN_bN_c$ are correctly received, and two out of the three pairs $R(n_1)$ $R(n_2)$ are identical.

- Response on other management/maintenance order on idle channel or data channel
  ($N_1N_2N_3$ P(4) Z(15) J J $V_1V_2V_3V_4$ J J J J J)

  The frame is accepted if $N_1N_2N_3$, P(4) and Z(15) are correctly received.

- Other maintenance information from BS
  ($N_1N_2N_3$ P(13) Z(15) J J $V_1V_2V_3V_4$ J J J J J)

  The frame is accepted if $N_1N_2N_3$, P(13) and Z(15) are correctly received.

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Nordic Mobile Telephone group

February 1980

NORDIC MOBILE TELEPHONE

SYSTEM DESCRIPTION