NMT DOC 450-1
Nordic Mobile Telephone group

August 1997

NORDIC

MOBILE TELEPHONE

SYSTEM DESCRIPTION

NMT DOC 450-1,

INCLUDES ENHANCED FUNCTIONS*)

***)This specification has been developed as a co-operation between the NMT operators in Denmark, Finland, the Netherlands, Norway, Sweden and Switzerland. Whenever this specification is used by a third party, the mentioned operators can not be held responsible for the functionality of the system's ability to work together with mobile stations and/or any other systems.**

CONTENTS

GLOSSARY OF TERMS

Area information	Indicates which base station the signalling comes from. Prevents malfunction due to co-channel interference.
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.
dBm0	The term - x dBm0 indicates a power level of x dB below 1 mW at a point of zero relative level.
DSS	Digital Supervisory signal, out-band digital signal to supervise the transmission on the traffic channel during conversation.
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.
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 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 which codes consisting of 2 out of 6 frequencies.
Nordic mobile telephone system (NMT)	The public automatic mobile telephone system in the 450 MHz range, common to all member countries.
Occupied traffic channel	Traffic channel engaged for conversation or call set-up.
Password	A three digit number added automatically to the end of the subscriber number to prevent unauthorized use of a subscriber number.
Push-button multifrequency 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.
Random challenge (RAND)	A seven digit number, transmitted from MTX to MS during the authentication procedure.
Roaming mobile subscriber	Mobile subscriber having left his home traffic area.

Scrambling	A way to limit the possibility to eavesdrop the dicussion or data traffic on the radio link.
Signed response (SRES)	A four digit number, transmitted from MS to MTX during authentication procedure. SRES is calculated based on the received RAND and the stored SAK.
Subscriber Authentication Key (SAK)	Secret key stored in the MTXH and MS, used for authentication purposes.
SMS	Short message service. Integrated data service, which transmits alphanumeric messages to and from the MS
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
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.

ABBREVIATIONS

A-subscriber	Calling subscriber
B-key	Key for B-number encryption
B-subscriber	Called subscriber
BS	Base station
BSA	Base station area
CC	Calling channel
CU	Control unit
DMS	Data Mobile Station
FFSK	Fast frequency shift keying
MFC	Multi frequency code 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
RAND	Random challenge
RF	Radio frequency
SAK	Subscriber authentication key
SMS	Short message service
SR	Signal strength receiver
SRES	Signed response
SU	Supervisory unit
TA	Traffic area
TC	Traffic channel
TMS	Test mobile station
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.

Several kinds of subscriber mobile stations can be accommodated in the system:

- ordinary mobile stations
- hand-held mobile stations
- mobile stations with priority
- portable mobile stations, and
- coin-box mobile stations
- data mobile stations (DMS)
- mobile stations with enhanced functions like message waiting indicators, calling line identity presentation and/or SMS

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 450-3)

Technical specification for the base station, (NMT Doc 450-4)

Basic requirements set to the NMT system are:

- 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 of setting up a call up to called party's HMTX shall be charged to the calling subscriber, regardless of whether the call is originated 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. See charging principles, para 2.6

- 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.

- The system shall have the capability of switching established calls from one base station to a neighbour base station based on the speech quality, enabling "small cell" -technique to be used.

- Added subscriber identity security is included. In the latest version authentication is allowed practically anytime: When making outgoing calls, answering calls, during conversation (if requested), making roaming updating and making register recalls

- SMS and calling line identity presentation are added to the latest version of specifications.

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.

To minimize the possibility for illicit use of subscriber identity numbers, an authentication procedure will take place on all mobile originated calls. Authentication can also take place when roaming and on mobile terminating calls to secure the case when B-part is charged.

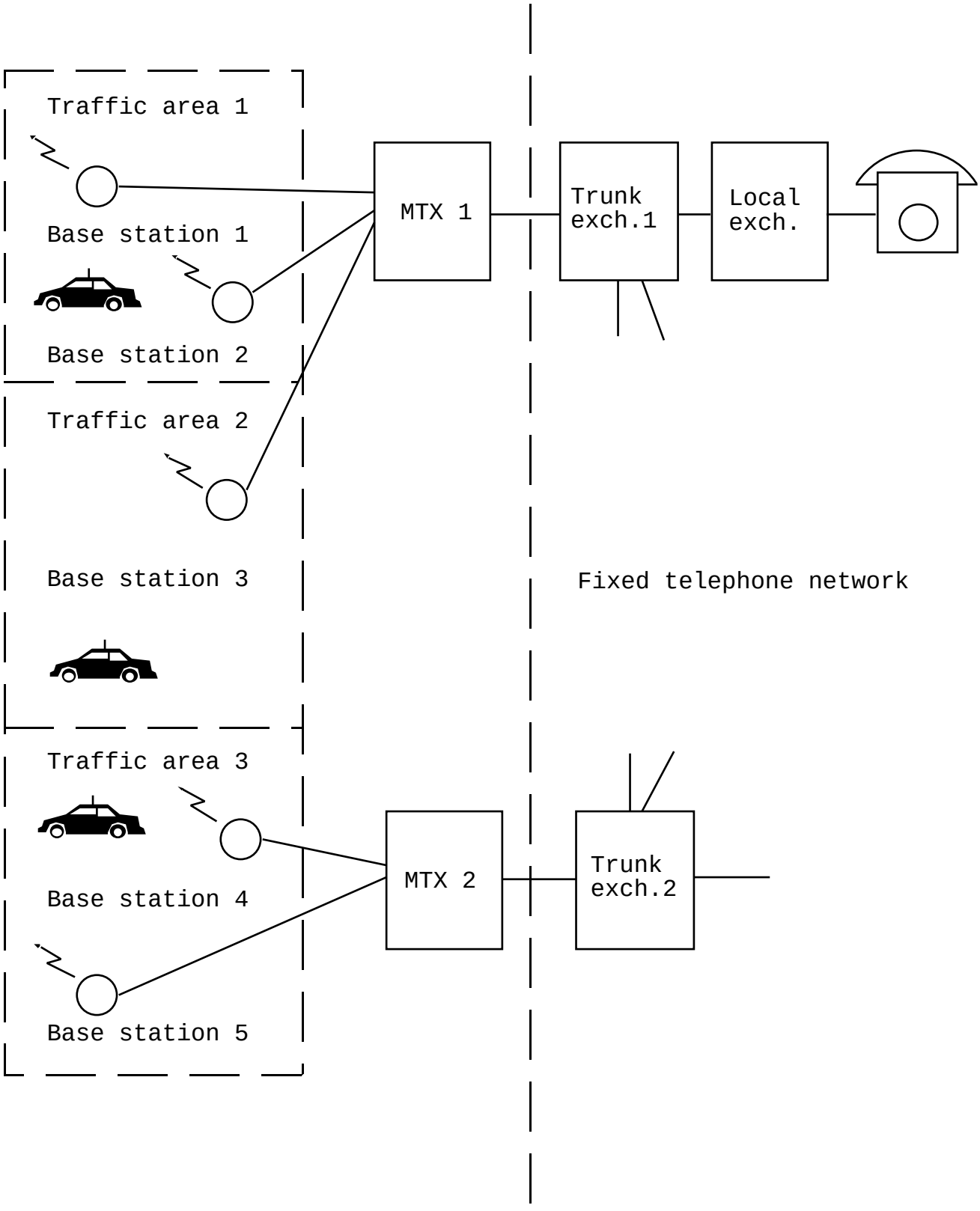


Fig. 2.1 SYSTEM STRUCTURE

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. In the future, however, it is possible that interleaved channels i.e. channels with 12,5 kHz channel separation from the ordinary channels will be used. This, however, will be optional only.

2.2.1.1 Extended band (optional, subject to national regulation)

Futhermore as an option the NMT-450 system is allowed to operate in the following extension band:
452.500-452.975 MHz; MS transmits, BS receives
462.500-462.975 MHz; MS receives, BS transmits
These bands accommodate 20 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. 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 PROCEDURE

2.3.1 Call to mobile station

Calls to all kinds of mobile stations are sent out in parallel 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.

Alternatively the MTX may order the mobile station to search for a free marked traffic channel after having received the acknowledgement on a base station where all traffic channels are occupied.

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.

e. to secure that subscriber numbers are not used unauthorized.

The routing in the telephone network is performed by the following general principles:

In Finland:	$P_N M_1\ M_2\ X_1\ X_2$
In Sweden:	$P_N M_1\ M_2\ M_3\ X_1\ X_2$
In Denmark	$M_1\ M_2\ X_1\ X_2$
In Norway	$M_1\ M_2\ X_1\ X_2$

P_N = trunk prefix
$M_1\ M_2\ (M_3)$ = mobile prefix
$X_1X_2X_3X_4X_5X_6$ = subscriber number series

These structures satisfy the requirement b) above.

Identification of mobile subscriber requires more information than the digits $P_NM_1M_2(M_3)\ X_1 \ldots X_6$ 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.

In all countries mobile subscribers are identified by the number $ZX_1X_2X_3X_4X_5X_6$ within the mobile telephone system, that is in all signalling between:

MTX – MTX

MTX – MS
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 Finnish or Swedish MS:

national $P_NM_1M_2(M_3)X_1X_2X_3X_4X_5X_6$

international $+\ I_1\ I_2\ (I_3)\ M_1M_2(M_3)X_1X_2X_3X_4X_5X_6$

In the MTXH the nationality digit Z is added in front of $X_1X_2X_3X_4X_5X_6$

Calls to a Danish or Norwegian MS:

national $M_1M_2X_1X_2X_3X_4X_5X_6$

international + I_1 I_2 $M_1M_2X_1X_2X_3X_4X_5X_6$

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 "address". 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.

For mobile stations with added subscriber identity security, a special authentication procedure between MTX and MS will take place on all mobile originated calls and also during conversation.

To prevent unauthorized use of a subscriber number a three digit password $K_1K_2K_3$ (given by the operator) is added automatically to the end of the subscriber number Z $X_1X_2X_3X_4X_5X_6$ by the logic in the MS.

This password $K_1K_2K_3$ is not known by the subscriber and is used on the radio path from MS to MTX only in the identification phase. The code is checked in the MTX, where the same password is stored together with other subscriber data.

These structures satisfy the requirement e. above.

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).

The mobile subscriber may be charged with additional costs e.g for incoming or forwarded calls.

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 distortion 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 ±5 Hz must be taken into account.

3.2 RADIO PATH

The transmission channel between the base station and the mobile station consist 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.

3.3 COMPANDER

In order to increase the speech quality on the radio channel, the possibility to use compressor/expander circuits is included. The circuits are placed in the MS's and either in the BS or the MTX, and the compression ratio is 2:1.

3.4 AUDIO SCRAMBLER [OPTIONAL]

In order to increase the speech privacy on the radio channel, the possibility to use audio scrambler circuits will be included. The circuits will be placed in the MS and the MTX.

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

The signalling between the MTX and the fixed telephone network will follow the normal national telephony signalling procedure. The signalling between the different MTX:es is specified in detail in NMT Doc -2.

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 MSs

- 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.
- Power bit information. The MTX informs the MS about the power level to be used when transmitting on this channel towards the MTX.
- 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.
- Additional information e.g real time clock, possibility to use overdecadic b-numbers and message polling. Information about e.g. queuing information are specified in para 4.3.3.10-4.3.3.14.

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.

- Area information. To prevent malfunction due to co-channel interference this information is sent to the MS, and returned back to the MTX.

- 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.

- Queuing information to MS with priority.

- Queuing information to ordinary MS. Informs MS that a call is queued in the MTX.

- Random Challenge. A random number RAND is transmitted to the MS as soon as this MS initiates a call set up. This number is used for authentication purposes by this actual MS. RAND will be selected by the MTX.

- Scanning order, which may be sent instead of the channel order.

- Power bit information. This informs the MS about the actual maximum power level which shall be used from the MS.

- Message(s) indicators (flags)

- 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

  - Request for automatic answer to receive SMS or other DMS data in case of incoming call

  - Identity of calling line

  - Proceed to send (Roaming updating confirmation)

  - Clearing

  - Answer to coin-box (only for coin-box category MS's)

  - Clearing, call transfer activated

  - Switch compander in/out

- Switch audio scrambler in/out

4.1.1.3 Signalling from an MS to MTX

- Number of actually used channel
- Mobile subscriber identity (7 digits supplied with a 3 digit password)
- Area information. This informs the MTX from which BS group the MS received the signalling.
- Call acknowledgement. This signal is a reply from an MS to a call
- Call acknowledgement seizure. This signal is a reply from a called MS, sent on a traffic channel.
- Seizure. This signal informs MTX that an MS wants to make a call. The same signal is used as MS identity on identity request on TC.
- Seizure from coin-box MS. The same signal is used as MS identity on identity request on TC.
- 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)
- Acknowledge request to receive SMS or other DMS data (automatic answer)
- Digit signals. For mobile stations with added subscriber identity security, the digit signals are encrypted, based on the received RAND and the locally stored SAK.
- 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.
- Register recall. This signal is used in order to connect a register to the MS in conversation state, enabling different services, e.g three party conference, to be used.
- Signed response. This signal is sent just before the transmission of digits for mobile originated calls and when MTX asks for authentication. The information is derived from the received RAND from the MTX and the locally stored SAK.

- audio scrambling acknowledged [OPTIONAL]

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), which takes the necessary action.

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 the BS, activation/deactivation of compander 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 action in BS.

- Alarms from BS.

This signalling is described in para 4.2.3 and 4.2.4.

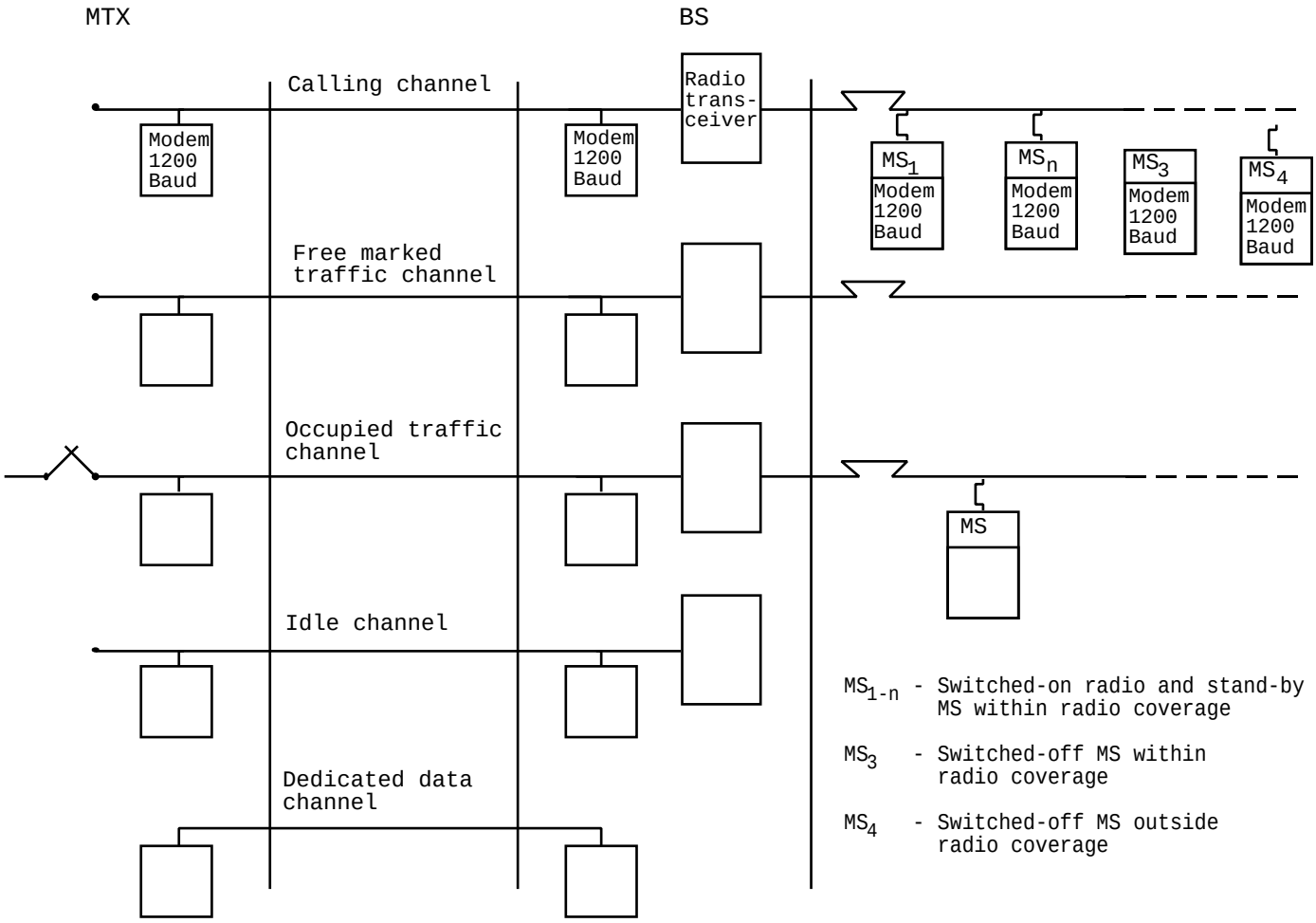

MTX
BS
Calling channel
Free marked traffic channel
Occupied traffic channel
Idle channel
Dedicated data channel
Modem 1200 Baud
Radio trans-ceiver
MS1
MSn
MS3
MS4
MS
MS1-n - Switched-on radio and stand-by MS within radio coverage
MS3 - Switched-off MS within radio coverage
MS4 - Switched-off MS outside radio coverage

Fig. 4.1a

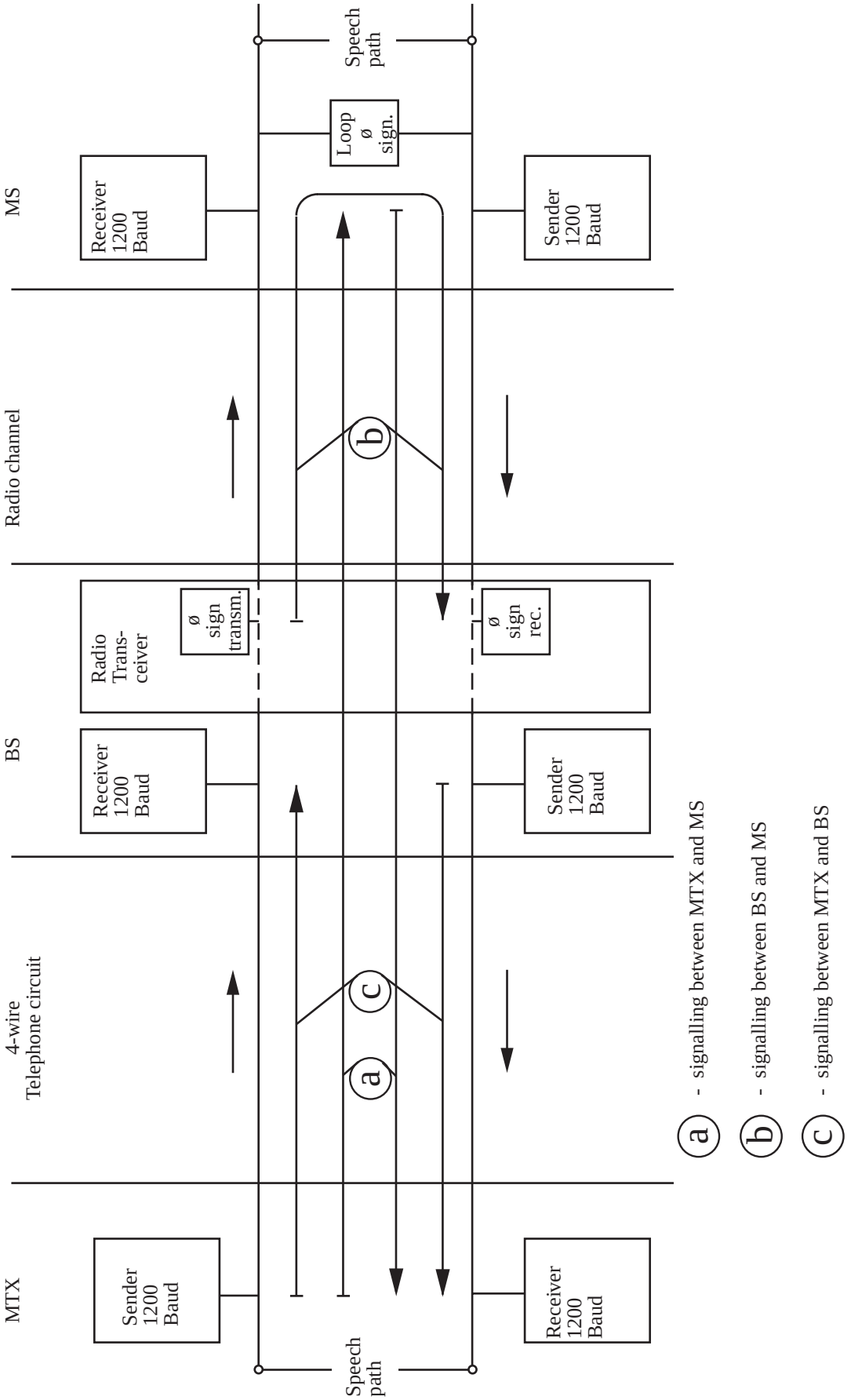

MS
Receiver 1200 Baud
Loop ø sign.
Speech path
Sender 1200 Baud
Radio channel
b
BS
Radio Trans-ceiver
ø sign transm.
ø sign rec.
Receiver 1200 Baud
Sender 1200 Baud
4-wire Telephone circuit
c
a
MTX
Sender 1200 Baud
Speech path
Receiver 1200 Baud
a - signalling between MTX and MS
b - signalling between 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 formatted 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 scanning order on calling channel (frame 2d). MS starts searching for a free traffic channel in order to answer a call from MTX.

- Queuing information to ordinary MS (frame 2f). This signal informs MS that the call to MS is queued in the MTX. The MS shall remain on the channel and wait for further information (e.g. repeated call).

- 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.

- Traffic channel allocation on traffic channel, short procedure (frame 3c). To initiate a shortened switch-over procedure to another channel during speech condition this signal will be used to order the MS to the new channel.

- 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, 5 b and 5c)

  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.

  - Proceed to send the dialled numbers, roaming updating confirmation. In case of MS with added subscriber identity security, a special proceed to send signal will be sent, indicating that the digits must be encrypted using the B-key. 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.

- Switch compander in. This signal informs MS that compander shall be switched in.

- Switch compander out. This signal informs MS that compander shall be switched out.

- Clearing, call transfer activated. This signal informs the MS that the connection shall be released and that the indicator for call transfer must be activated. All other message indicators are set or reset according to information in frame 5c.

- Clearing, call transfer deactivated. This signal informs the MS that the connection shall be released and that call transferred indicator must be deactivated. All other message indicators are set or reset according to information in frame 5c.

- Automatic answer order (data mode) to receive DMS data or SMS messages (frame 5a(L=12)).

- Authentication request indication (frame 7).

  This signal informs the MS about the selected RAND, which shall be used for the calculation of SRES (needed for authentication purposes) and B-key (needed for the encryption of the B-number digits).

- Idle frame (frame 6).

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

- Calling line identity (frame 8).

  This signal carries the A-number which can be in an encrypted form.

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.

- Seizure and identity from called MS on traffic channel (frame 10c). This signal is used when an MS answers a call after received traffic channel scanning order.

- 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 sequence (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 MS has recognized the ringing signal, and lifted the handset.

  - Register recall.

  In conversation state the MS (i.e the mobile subscriber) can connect a register in the MTX to the line. Digits can then be transmitted from MS to MTX.

- 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.. If an authentication procedure has taken place, mobiles with added subscriber identity security will encrypt the digit information.

- Authentication response (frame 16).

  This signal shall be used as a response in the authentication procedure.

- scrambling in/out (frame 7b) [OPTIONAL]

- 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, activate/deactivate compander.)

- 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 signal alarms (see paragraph 4.5) of 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 other MS than a test MS.

4.2.6 Frames related to SSE, DSS and HC [OPTIONAL]

See NMT Doc 900-1 para. 4.3.2.3 to 4.3.2.6

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.: $ZX_1X_2X_3X_4X_5X_6$

- 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...
- 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 information $f_{\emptyset}$
- Password from MS: $K_1K_2K_3$
- Area information from MS T Y_2
  where the two first bits in T is coded according to para 4.3.3.10, while the remaining two bits and Y_2 are the six last bits in Y_1Y_2.
- Additional information: $H_1H_2H_3…H_{10}$
- Random challenge, transmitted from MTX to MS: $C_1C_2C_3C_4C_5C_6C_7$
- Signed response, transmitted from MS to MTX: $R_1R_2R_3R_4$
- Higher limit for signal strength evaluation: l_H
- Lower limit for signal strength evaluation: l_L
- Messages waiting: $F_1F_2F_3$
- Checksum: W_1W_2
- Sequence number M

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 13 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 (May also be used for additional information. See para 4.3.3.10 - 4.3.3.14)
- Information field (See para 4.3.3.10 - 4.3.3.14.

Channel No	Prefix and	TA No	Mobile sub-scriber No	Information
3 digits	3 digits	7 digits		3 digits

1.a Calling channel indication

Channel No.	Prefix	TA No.	Additional info
$N_1N_2N_3$	P(12)	Y_1Y_2	$H_1H_2H_3H_4H_5H_6H_7H_8H_9H_{10}$

1.b Combined calling and traffic channel indication

Channel No.	Prefix	TA No.	Additional info
$N_1N_2N_3$	P(4)	Y_1Y_2	$H_1H_2H_3H_4H_5H_6H_7H_8H_9H_{10}$

2.a Call to mobile subscriber on calling channel

Channel No.	Prefix	TA No.	Mobile subscriber no	Additional info.
$N_1N_2N_3$	P(12)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$H_8H_9H_{10}$

2.b Traffic channel allocation on calling channel

Channel No.	Prefix	TA No	Mobile subscriber No	TC No.
$N_1N_2N_3$	P(12)	Y_1Y_2	Z $X_1X_2X_3X_4X_5X_6$	$N_aN_bN_c$

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

Channel No.	Prefix	TA No.	Mobile subscriber no	Additional info.
$N_1N_2N_3$	P(12)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$H_8H_9H_{10}$

2.d Traffic channel scanning order on calling channel.

Channel No.	Prefix	TA No.	Mobile subscriber no	Additional info.
$N_1N_2N_3$	P(12)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$H_8H_9H_{10}$

2.f Queuing information to ordinary MS

Channel No.	Prefix	TA No.	Mobile subscriber no	Additional info.
$N_1N_2N_3$	P(12)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$H_8H_9H_{10}$

3.a Traffic channel allocation on traffic channel

Channel No.	Prefix	TA No.	Mobile subscriber no	TC No.
$N_1N_2N_3$	P(5)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$N_aN_bN_c$

3.b Identity request on traffic channel

Channel No.	Prefix	TA No.	Mobile subscriber no	Additional info.
$N_1N_2N_3$	P(5)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$H_8H_9H_{10}$

3.c Traffic channel allocation on traffic channel, short procedure.

Ordered Channel No.	Prefix	TA No.	Mobile subscriber no.	TC No.
$N'_1N'_2N'_3$	P(9)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$N_aN_bN_c$

Note: The channel number $N_1'N_2'N_3'$ shall in frame 3c be equal to $N_aN_bN_c$.

4. Free traffic channel indication

Channel No.	Prefix	TA No.	Idle	Additional info.
$N_1N_2N_3$	P(3)	Y_1Y_2	JJJJJJJ	$H_8H_9H_{10}$

5.a Line signal

Channel No.	Prefix	TA No.	Mobile subscriber No.	Signal No.
$N_1N_2N_3$	P(6)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	L(n)L(n)L(n)

5.b Line signal: Answer to coin-box

Channel No.	Prefix	TA No.	Mobile subscriber No.	Signal No.	Tariff class info
$N_1N_2N_3$	P(6)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	L(0)	Q_1Q_2

5.c Line signal: Message(s) waiting [OPTIONAL]

Channel No.	Prefix	TA No.	Mobile subscriber No.	Addit. Info.
$N_1N_2N_3$	P(2)	Y_1Y_2	$ZX_1X_2X_3X_4X_5X_6$	$F_1F_2F_3$

6. Idle frame

Idle	Prefix	Idle		
J J J	P(0)	JJ	JJJJJJJ	JJJ

7 Authentication request

Channel No	Prefix	TA No.	Random challenge	Idle
$N_1N_2N_3$	P(8)	Y_1Y_2	$C_1C_2C_3C_4C_5C_6C_7$	JJJ

8 A-subscriber number

Channel No.	Prefix	TA No.	Seq. No.	Information	Check sum
$N_1N_2N_3$	P(1)	Y_1Y_2	M	$H_1H_2H_3H_4H_5H_6H_7$	W_1W_2

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 (see para 4.3.3.10-4.3.3.11)

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

10.a Call acknowledgement from MS on calling channel (shortened frame).

Channel No.	Prefix	Mobile subscriber No	Area info	Idle
$N_1N_2N_3$	P(1)	$ZX_1X_2X_3X_4X_5X_6$	T	J(JJJ)

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

Channel No.	Prefix	Mobile subscriber No	Area info	Pass-word
$N_1N_2N_3$	P(1)	$ZX_1X_2X_3X_4X_5X_6$	TY_2	$K_1K_2K_3$

10.c Seizure and identity from called MS on traffic channel.

Channel No.	Prefix	Mobile subscriber No	Area info	Pass-word
$N_1N_2N_3$	P(6)	$ZX_1X_2X_3X_4X_5X_6$	TY_2	$K_1K_2K_3$

11.a Roaming updating seizure and identity on traffic channel

Channel No.	Prefix	Mobile subscriber No	Area info	Pass-word
$N_1N_2N_3$	P(14)	$ZX_1X_2X_3X_4X_5X_6$	TY_2	$K_1K_2K_3$

11.b Seizure and call acknowledgement on calling channel from MS with priority (shortened frame)

Channel No.	Prefix	Mobile subscriber No	Area info	Pass-word
$N_1N_2N_3$	P(15)	$ZX_1X_2X_3X_4X_5X_6$	T	J(JJJ)

12. Seizure from coin-box on traffic channel

Channel No.	Prefix	Mobile subscriber No	Area info	Pass-word
$N_1N_2N_3$	P(11)	$ZX_1X_2X_3X_4X_5X_6$	TY_2	$K_1K_2K_3$

13.a Line signal

Channel No.	Prefix	Mobile subscriber No.	Signal No.
$N_1N_2N_3$	P(8)	$Z\ X_1X_2X_3X_4X_5X_6$	L(n)L(n)L(n)L(n)L(n)

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

Channel No.	Prefix	Mobile sub-scriber No.	Signal No.	Tariff class info
$N_1N_2N_3$	P(8)	Z $X_1X_2X_3X_4X_5X_6$	L(2)L(2)L(2)	Q_1Q_2

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

Channel No.	Prefix	Mobile sub-scriber No.	Pos.Ind.	Digit value
$N_1N_2N_3$	P(7)	Z $X_1X_2X_3X_4X_5X_6$	S(0)S(0)	S(n)S(n)S(n)

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

Channel No.	Prefix	Mobile sub-scriber No.	Pos.Ind.	Digit value
$N_1N_2N_3$	P(7)	Z $X_1X_2X_3X_4X_5X_6$	S(15)S(15)	S(n)S(n)S(n)

15. Idle Frame

Idle	Prefix	Idle		
JJJ	P(0)	JJ	JJJJJJJ	JJJ

16. Authentication Response

Channel No.	Prefix	Signed Response
$N_1N_2N_3$	P(12)	$R_1R_2R_3R_4R_1R_2R_3R_4R_1R_2R_3R_4$

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 and MS.

MTX -> BS

20. Channel activation order

Channel No.	Pre-fix	TA No.	BS ind.	Idle	Activ. order
$N_1N_2N_3$	P(15)	Y_1Y_2	Z(15)	JJJ	A(3)$f_øf_øf_øf_øf_ø$
$N_1N_2N_3$	P(15)	Y_1Y_2	Z(15)	JJJ	A(0-2,4-15)JJJJJ and [OPTIONAL]
$N_1N_2N_3$	P(15)	Y_1Y_2	Z(15)	JJJ	A(6,13)$f_øf_øf_øf_øf_ø$
$N_1N_2N_3$	P(15)	Y_1Y_2	Z(15)	JJJ	A(7,14)$l_Ll_Ll_Hf_øf_ø$
$N_1N_2N_3$	P(15)	Y_1Y_2	Z(15)	JJJ	A(15)$l_Ll_Ll_H$JJ

Note: See also para. 4.3.3.6

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

Channel No.	Pre-fix	BS TA No.	Meas. ind.	Idle	Ind.	Idle	Tc No
$N_1N_2N_3$	P(3)	Y_1Y_2	Z(15)	J J J	V(15)	J J	$N_aN_bN_c$

21c Signal strength measurement order on traffic channel actually used

Channel No.	Pre-fix	BS TA No.	Meas. ind.	Idle	Ind.	Idle	Tc No
$N_1N_2N_3$	P(5)	Y_1Y_2	Z(15)	J J J	V(15)	J J	$N_aN_bN_c$

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

Channel No.	Pre-fix	BS TA No.	BS ind.	Idle	Manag/ maint	Order
$N_1N_2N_3$	P(14)	Y_1Y_2	Z(15)	J J J	$V_1V_2V_3$	$V_4V_5V_6$

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.

BS -> MTX

15. Idle frame

Idle	Prefix	Idle		Idle
JJJ	P(0)	JJ	JJJJJJJ	JJJ

25. Channel status information

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

and [OPTIONAL]

Channel No.	Prefix	BS ind.	Idle	Status info	Idle	Info	Idle
$N_1N_2N_3$	P(9)	Z(15)	JJ	A(2,6)	JJJ	$f_{ø}l_Hl_L$	JJ

$N_1N_2N_3$	P(9)	Z(15)	JJ	A(14)	JJJ	Jl_Hl_L JJ
$N_1N_2N_3$	P(9)	Z(15)	JJ	A(7,8)	JJJ	CCC JJ

26. Signal strength measurement result

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

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)	JJ	$V_1V_2V_3V_4$	JJJJJ

28. Other maintenance information from BS

Channel No.	Pre-fix	BS ind.	Idle	Maint information	Idle
$N_1N_2N_3$	P(13)	Z(15)	JJ	$V_1V_2V_3V_4$	JJJJJJ

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	Additional Info
$N_1N_2N_3$	P(10)	Y_1Y_2	JJJJJJJ	$H_8H_9H_{10}$

4.3.3 Coding of signal information

The 16 hexa-decimal digits in a normal frame and the 13 digits in a shortened frame consist each of 4 bits. These 4 bits are coded according to paragraphs 4.3.3.1 - 4.3.3.14.

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 $R(n_1)R(n_2)$
- Password $K_1K_2K_3$
- Additional information $H_1H_2....H_{10}$
- Random challenge $C_1C_2C_3C_4C_5C_6C_7$
- Signed response $R_1R_2R_3R_4$

Digits in $N_1N_2N_3$ 1) $N_aN_bN_c$ 1) R(n1)R(n2) Q_1Q_2 $H_1H_2....H_{10}$ $C_1C_2C_3C_4C_5C_6C_7$ $R_1R_2R_3R_4$	Digits in $ZX_1X_2X_3X_4X_5X_6$ $K_1K_2K_3$ Y_1Y_2	Binary code Bit No 1234
0	10(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
A	0	1010
B	11	1011
C	12	1100
D	13	1101
E	14	1110
F	15	1111

Note 1)

In digits N_1 and N_a, the least significant bit (bit no. 4) denotes the hundreds digit in the channel number. Bits no. 2 and 3 contain information about power level, high power 11, medium power 10 and low power 01, 00. Bit no. 1 which from the outset shall have the value 0, is reserved for future use of interleaved channels.

In case of interleaved channels, the coding of bit no. 4 and bit no. 1 in N_1 and N_a described above shall be replaced by note 3.

In the signalling between MTX and BS, the power bits in N_1 and N_a shall have the value 11 in both directions. However, between MTX and BS special values and meanings of N_1 may be used (see para 4.3.1).

The MS output power shall be controlled in the following way:

- For signalling frames on channel $N_1N_2N_3$ in the direction MTX->MS, not containing a channel order $N_aN_bN_c$, the power bits in N_1 shall control the MS power level. Signalling frames in the direction MS->MTX shall have the same power bits in N_1 as in the received frames from the MTX.

- For signalling frames on channel $N_1N_2N_3$ containing a channel order $N_aN_bN_c$, the MS power shall be controlled by the power bits in N_a. Signalling frames in the direction MS->MTX shall have the same power bits in N_1 as received from the MTX in N_a.

Examples of information in $N_1N_2N_3$:

$N_1N_2N_3$ = 0111 0000 0101
means high power indication, channel number 105.

Examples of MS power change:

1. Call from MTX to MS. High power on CC and TC.

Frame 2b: N_1 = 011x, N_a = 011x
Frame 3b: N_1 = 011x
Frame 10b: N_1 = 011x

2. Call from MTX to MS. High power on CC and TC, bit error in N_a.

   Frame 2b: N_1 =011x, N_a =010x (correct N_a= 011x)
   Frame 3b: N_1 = 011x
   Frame 10b: N_1 = 011x

3. Change of MS power on the same channel.

   a) Reduction of MS power

   Frame 3a: N_1 = 011x, N_a = 010x
   Frame 10b: N_1 = 010x

   b) Increase of MS power

   Frame 3a: N_1 = 010x, N_a = 011x
   Frame 10b: N_1 = 011x

Note 2)

The values for digit Z (for some operators) are:

Z(10)=H_1(0) indicates no additional info
Z(5) indicates Denmark
Z(6) indicates Sweden
Z(7) indicates Norway
Z(8) indicates Finland
for other values, see DOC NMT RD-01.

Z(14) indicates additional info (see para 4.3.3.12)
Z(15) indicates information to/from BS

Note 3)

In case of the optional extended frequency band/ interleaved channels the coding of bit no. 1 and 4 in N_1 and N_a shall have the following meaning.

N_1/N_a	Channel number
0xx0	1 - 99
0xx1	100 - 199
1xx0	200 - 299
1xx1	300 - 400

The channel 200 is in use in some countries and the channel numbers 201-400 are reserved for interleaved channels. The corresponding frequencies are specified in NMT Doc 450-3.
NB! In signalling ($N_1N_2N_3$ and $N_aN_bN_c$) channel 400 is coded as '39A' (1xx1 1001 1010).

Examples:

$N_1N_2N_3$ = 1111 0000 0101
means high power indication, interleaved channel number 305

$N_1N_2N_3$ = 0010 0000 0001
means low power indication, channel number 1 (f_0)

$N_1N_2N_3$ = 1010 0000 0001
means low power indication, interleaved channel number 201 (f_0 + 12,5 kHz)

$N_1N_2N_3$ = 1000 0000 0000
means low power indication, channel number 200.

$N_1N_2N_3$ = 1011 1001 1010
means low power indication, channel number 400.

4.3.3.2 Prefixes

Notation	Coding	Meaning in direction	
		MTX -> MS/BS	MS/BS -> MTX
P(0)	0000	Idle	Idle
P(1)	0001	A-number indentification	Call acknow-ledgement, seizure and identity
P(2)	0010	Message waiting indicators	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	Seizure and identity from called MS on traffic channel
P(7)	0111	Spare	Digit signal
P(8)	1000	Authentication request	Line signal
P(9)	1001	Channel allocation, short procedure	Channel status information
P(10)	1010	Test channel	Spare
P(11)	1011	Spare	Coin-box seizure
P(12)	1100	Calling channel	Authentication response
P(13)	1101	Spare	Other maintenance information
P(14)	1110	Measurement/ maintenance orders	Roaming updating and identity
P(15)	1111	Channel activation order	Seizure and call acknowledgment for MS with priority

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	Proceed to send unencrypted digits (roaming updating confirmation)	Spare
L(4)	0100	Acknowledge MFT converter in	Spare
L(5)	0101	Switch compander in	Register recall
L(6)	0110	Address complete	Spare
L(7)	0111	Switch compander out	MFT converter out acknowledge Forced release MFT converter state
L(8)	1000	Spare	MFT converter in
L(9)	1001	Ringing order	Spare

L(10)	1010	Acknowledge MFT converter out and forced release MFT converted state	Spare
L(11)	1011	Proceed to send encrypted digits (roaming updating confirmation)	Spare
L(12)	1100	Request to receive short message (SMS data)	Acknowledge SMS request [OPTIONAL]
L(13)	1101	Clearing, call transfer activated. Switch compander out if activated.	Spare
L(14)	1110	Spare	Answer
L(15)	1111	Clearing, call transfer not activated. Switch compander out if activated.	Spare

Note Line signals L(5,7,11,12, 13) may only be used towards MSs fulfilling corresponding NMT 450i specification.

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) , see note 2
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, see note 2
S(14)	1110	B, see note 2
S(15)	1111	C or position indication (2nd, 4th .... digit), see note 2

Note 1): For mobile stations with added subscriber identity security, the coding of the digits will be modified (encrypted). See para. 4.3.3.12.5

Note 2): Overdecadic [OPTIONAL] b-number values will be interpreted in MTX the following way:

International prefix information

B-number	meaning
S(13)	international prefix (the + sign)

The bit configuration for S(13) (1101) is the same as used in ‘calling line identification’ for international prefix to allow using the received number directly.

Service information

B-number	meaning
S(14)S(1)	general emergency number
S(14)S(2)	fire alarm
S(14)S(3)	police
S(14)S(4)	ambulance
S(14)S(5)	gas emergency
S(14)S(6)	directory inquiry (national)
S(14)S(7)	directory inquiry (international)
S(14)S(8)	operator assisted service (to make outgoing calls)
S(14) S(9)	local customer care
S(14)S(14)	road service
S(14)S(15)	weather

All other values (starting with S(14), S(15) or S(0)) are spare.

4.3.3.5 Idle information

Idle information J is coded 0000.

4.3.3.6 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, mute receiver, cancel suppression of frame 25 A(7), (deactivate compander, option)	Spare
A(1)	0001	Spare	Acknowledge idle radio channel
A(2)	0010	General channel reset. This frame gives the same result as frames 20 A(0), 22 V_1(1), and 22 V_1(9) together	Acknowledge start ø-signal A(3), A(6), A(13)
A(3)	0011	Send ø-signal, switch squelch function out, (activate compander, option). (Start signal strength evaluation, option)	Acknowledge general channel reset
A(4)	0100	Suppress frame 25 A(7) from BS	Spare
A(5)	0101	Loop line in BS	Acknowledge suppress frame 25 A(7)
A(6)	0110	(Send Ø-signal. Switch squelch function out, activate compander, start signal strength evaluation, all optional)	Acknowledge A(7), A(14) (optional)

A(7)	0111	(Start BS transmitter deactivate muting, send Ø-signal, switch squelch function out, activate compander, set signal strength limits, start signal strength evaluation, all optional)	Received Ø-signal below 1:st limit but above 2:nd limit (or received signal strength below the higher limit, option)
A(8)	1000	Spare	Received ø-signal below 2nd limit (or received signal strength below the lower limit, option)
A(9)	1001	Spare	Reserved for: Acknowledge squelch function out
A(10)	1010	Cancel suppression of frame 25 A(7)	Spare
A(11)	1011	Reserved for: Switch squelch function out	Acknowledge Cancel suppression of frame 25 A(7)
A(12)	1100	Stop sending Ø-signal, switch squelch function in, cancel suppression of frame 25A(7), (deactivate compander, stop signal strenght evaluation, option)	Spare
A(13)	1101	(Send Ø-signal, switch squelch function out, start signal strenght evaluation, option)	Acknowledge stop sending Ø-signal
A(14)	1101	(Start BS transmitter deactivate muting, send Ø-signal, switch squelch function out, activate compander, set signal level limits, start signal streght evaluation,all option)	Acknowledge A(15) Start BS transmitter

A(15)	1111	Start BS transmitter deactivate muting (Set signal strength level limits, option)	Spare

Note 1): Coding and meaning of ø-signal frequency in frame 20 (A=3)

Notation	Coding	Meaning
	0000	Reserved for future use in BS
$f_{ø1}$	0011	Send 0 signal frequency 1
$f_{ø2}$	1100	Send 0 signal frequency 2
$f_{ø3}$	1001	Send 0 signal frequency 3
$f_{ø4}$	0110	Send 0 signal frequency 4

Note 2):

- General channel reset 20 A(2) gives the same result in the BS as the frame 20 A(0), 22 V1(1) and 22 V1(9) together.
- Frame 20 A(3) can, depending on operators implementation, activate the compander in the BS.
- The frames 20 A(7) and 20 A(14) will depending on operators implementation activate/deactivate the compander. Frame 20 A(6) shall activate the compander in BS. When ø-signal is started by 20 A(7 or 14) the activation of the compander shall be delayed 830 ± 30 ms after the end of the received frame 20 A (7 or 14).
- The other frame of 20 A(7)or 20 A(14) and frame 20 A(13) shall not activate the compander in BS.
- Frames 20 A(0), 20 A(2) and 20 A(12) shall deactivate the compander.
- In BS the start of the Ø-signal and squelch function out initiated by 20 A(7 or 14) shall be delayed until the MS opens the squelch.
- The implementation of frames 20 A (7) and 20 A (14) is optional. Implementation of signal strength in the channel unit in the BS is optional.

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	SU/SR alarm reset via channel line and CU
$V_1(3)$	0011	Suppress RF receiver blocking alarm
$V_1(4)$	0100	Selftest
$V_1(5)$	0101	Spare
$V_1(6)$	0110	RF test loop in
$V_1(7)$	0111	Suppress supervision of freemarked CC/TC [OPTIONAL]
$V_1(8)$	1000	Spare
$V_1(9)$	1001	RF test loop out
$V_1(10)$	1010	Cancel suppression of supervision of freemarked CC/TC [OPTIONAL]
$V_1(11)$	1011	Spare
$V_1(12)$	1100	Cancel suppression of RF receiver blocking alarm
$V_1(13)$-$V_1(14)$	1101-1110	Spare
$V_1(15)$	1111	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

Notation	Coding	Meaning in direction BS-MTX (frame 27)
$V_1(0)$	0000	Idle
$V_1(1)$	0001	Spare
$V_1(2)$	0011	Acknowledge alarm reset
$V_1(3)$	0011	Acknowledge SU/SR alarm reset via CU
$V_1(4)$	0100	Acknowledge suppress RF receiver blocking alarm
$V_1(5)$	0101	Acknowledge selftest
$V_1(6)$	0110	Selftest completed
$V_1(7)$	0111	Acknowledge RF test loop in
$V_1(8)$	1000	Acknowledge suppress supervision of freemarked CC/TC [OPTIONAL]
$V_1(9)$	1001	Spare
$V_1(10)$	1010	Acknowledge RF test loop out
$V_1(11)$	1011	Acknowledge cancel suppression of supervision of freemarked CC/TC [OPTIONAL]
$V_1(12)$	1100	Spare
$V_1(13)$	1101	Acknowledge cancel suppression of RF receiver blocking alarm
$V_1(14)$	1110	Spare
$V_1(15)$	1111	Spare

4.3.3.9 Other maintenance information from BS

Notation	Coding (frame 28)	Meaning in direction BS-MTX

$V_1(10)$	1010	Don't care
$V_1(11)$	1011	Don't care [OPTIONAL]
$V_1(3)$	0011	Don't care [OPTIONAL]
$V_1(2)$	0010	Block the channel [OPTIONAL]
$V_1(6)$	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

$V_1(3)$ and $V_1(2)$ are used only in combination with $V_2(15)$

Notation (frame 28)		Meaning in direction BS-MTX
$V_1(10)$	$V_2(15)$ $V_3(0)$	TX antenna fault level 1
$V_1(10)$	$V_2(15)$ $V_3(1)$	Transmitter level 1
$V_1(10)$	$V_2(15)$ $V_3(2)$	Selftest failed
$V_1(10)$	$V_2(15)$ $V_3(3)$	Spare NMT alarm 1
$V_1(10)$	$V_2(15)$ $V_3(4)$	RX antenna fault level 1 [1)]
$V_1(10)$	$V_2(15)$ $V_3(5)$	RF receiver blocking alarm
$V_1(10)$	$V_2(15)$ $V_3(6)$	Combiner alarm level 1 [1)]
$V_1(10)$	$V_2(15)$ $V_3(7)$	High temperature fault [1)]
$V_1(10)$	$V_2(15)$ $V_3(8)$	RF receiver blocking alarm ceasing
$V_1(10)$	$V_2(15)$ $V_3(9)$	Diversity alarm [1)]
$V_1(10)$	$V_2(15)$ $V_3(12)$	Redundant power supply
$V_1(10)$	$V_2(15)$ $V_3(13)$	Redundant master oscillator
$V_1(10)$	$V_2(15)$ $V_3(14)$	Cooling fan fault
$V_1(10)$	$V_2(15)$ $V_3(15)$	Redundant amplifier in receiver multicoupler
$V_1(6)$	$V_2(15)$ $V_3(0)$	RX antenna fault level 2 [1)]
$V_1(6)$	$V_2(15)$ $V_3(1)$	Missing deviation [1)]
$V_1(6)$	$V_2(15)$ $V_3(2)$	Ø-signal test loop
$V_1(6)$	$V_2(15)$ $V_3(3)$	Spare NMT Alarm 2
$V_1(6)$	$V_2(15)$ $V_3(4)$	Channel unit fault level 2 [1)]
$V_1(6)$	$V_2(15)$ $V_3(5)$	Spare NMT Alarm 3
$V_1(6)$	$V_2(15)$ $V_3(6)$	Local blocking
$V_1(9)$	$V_2(15)$ $V_3(6)$	Local deblocking
$V_1(6)$	$V_2(15)$ $V_3(7)$	Receiver
$V_1(6)$	$V_2(15)$ $V_3(8)$	Combiner alarm level 2 [1)]
$V_1(6)$	$V_2(15)$ $V_3(9)$	CU

$V_1(6)$	$V_2(15)$	$V_3(10)$	SU, via data line
$V_1(12)$	$V_2(15)$	$V_3(10)$	SU, via channel line and CU
$V_1(6)$	$V_2(15)$	$V_3(11)$	SR, via data line
$V_1(12)$	$V_2(15)$	$V_3(11)$	SR, via channel line and CU
$V_1(6)$	$V_2(15)$	$V_3(12)$	Power supply
$V_1(6)$	$V_2(15)$	$V_3(13)$	Receiver multicoupler
$V_1(6)$	$V_2(15)$	$V_3(14)$	Transmitter level 2
$V_1(6)$	$V_2(15)$	$V_3(15)$	TX antenna fault level 2
$V_1(2)$	$V_2(15)$	$V_3(0\text{-}15)$	Spare NMT Alarm 4-19 [1]
$V_1(3)$	$V_2(15)$	$V_3(0\text{-}15)$	Spare [1]
$V_1(3)$	$V_2(15)$	$V_3(0)$	Reserved for HC 1 [1]
$V_1(3)$	$V_2(15)$	$V_3(1)$	Reserved for HC 2 [1]
$V_1(3)$	$V_2(15)$	$V_3(2)$	Reserved for SSE 1 [1]
$V_1(3)$	$V_2(15)$	$V_3(3)$	Reserved for SSE 2 [1]
$V_1(3)$	$V_2(15)$	$V_3(4)$	Reserved for SSE 3 [1]
$V_1(3)$	$V_2(15)$	$V_3(5)$	Missing CC indication [1]
$V_1(3)$	$V_2(15)$	$V_3(6)$	Missing CC indication ceasing [1]
$V_1(3)$	$V_2(15)$	$V_3(7)$	Missing TC indication [1]
$V_1(3)$	$V_2(15)$	$V_3(8)$	Missing TC indication ceasing [1]
$V_1(10)$	$V_2(1)$	$V_3(0)$	Fire alarm
$V_1(6)$	$V_2(1)$	$V_3(1)$	Mains break-down alarm
$V_1(10)$	$V_2(1)$	$V_3(2)$	Intruder alarm
$V_1(10)$	$V_2(1)$	$V_3(3)$	Obstruction light alarm
$V_1(9)$	$V_2(1)$	$V_3(4)$	Mains return
$V_1(10)$	$V_2(1)$	$V_3(5)$	Mains break-down alarm at channel with battery back-up
$V_1(10)$	$V_2(1)$	$V_3(6)$	Spare house alarm 1
$V_1(10)$	$V_2(1)$	$V_3(7)$	Spare house alarm 2
$V_1(10)$	$V_2(1)$	$V_3(8)$	Environment temperature alarm [1]
$V_1(10)$	$V_2(8)$	$V_3(8)$	Spare external alarm 1
$V_1(10)$	$V_2(8)$	$V_3(9)$	Spare external alarm 2
$V_1(10)$	$V_2(8)$	$V_3(10)$	Spare external alarm 3
$V_1(10)$	$V_2(8)$	$V_3(11)$	Spare external alarm 4
$V_1(10)$	$V_2(8)$	$V_3(12)$	Alarm unit alarm [1]
$V_1(10)$	$V_2(8)$	$V_3(13)$	MUX alarm [1]
$V_1(10)$	$V_2(8)$	$V_3(14)$	Spare external alarm 5
$V_1(10)$	$V_2(8)$	$V_3(15)$	Spare external alarm 6

All other combinations of V_1 V_2 V_3 shall be spare.

Parameters V_4 can be used in case of manufacturer/ operator defined alarms but shall not be interpreted by the MTX.

Note 1 Optional alarms

Note 2 Character V_4 not specified shall have value 0000.

Note 3 Level 1 Degradation which does not require an immediate service action.

Level 2 Not in function.

Note 4 Blocking, deblocking, don't care (see also NMT Doc.2 (450)/ NMT Doc.900-2 (900) 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 no 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 5 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 at the base 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 6 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.

4.3.3.10 Coding of additional information, area code

4.3.3.10.1 In the direction MTX to MS.

Due to limited space for transmitting area information from MTX to MS, this information is transmitted in frames 1b, 2a, 3b, 4 and 30 as additional information, according to the coding below.

Notation	Coding (hex)	Meaning
$H_8H_9H_{10}$	3F3	Area no. 1
$H_8H_9H_{10}$	3F4	Area no. 2
$H_8H_9H_{10}$	3F5	Area no. 3
$H_8H_9H_{10}$	3F6	Area no. 4
$H_8H_9H_{10}$	000	No area information

4.3.3.10.2 In the direction MS to MTX

The area information and the traffic area information received from the MTX is transmitted back to the MTX by the MS as TY_2 in frames l0b, l0c, lla and 12. In the shortened frame l0a and 11b, only the character T is transmitted as area information. In frame 11b on calling channel, the area information t_1t_2 is set to 00 (binary).

The coding is as follows:

-T = $t_1t_2t_3t_4$

where

t_1t_2= area info (translated from $H_8H_9H_{10}$), coded as

t_1t_2 = 01 (binary)	for Area no. 1
t_1t_2 = 10 -"-	for Area no. 2
t_1t_2 = 11 -"-	for Area no. 3
t_1t_2 = 00 -"-	for Area no. 4 or if no area information is received

t_3t_4 = 2 last bits in Y_1

-Y_2 = Y_2 received from MTX

Note: MS approved according to earlier specifications will send $TY_2 = 00_{hex}$.

4.3.3.11 Coding of additional information, frame 2c, 2d, 2f and 5c

Coding of $H_8H_9H_{10}$ in frames 2c, 2d and 2f.

Notation	Coding (hex)	Meaning
$H_8H_9H_{10}$	3F0	Queuing information to ordinary MS in frame 2f.
$H_8H_9H_{10}$	3F1	Queuing information to PMS in frame 2c.
$H_8H_9H_{10}$	3F2	Traffic channel scanning order in frame 2d.

Coding of $F_1F_2F_3$ in frame 5c

$F_1F_2F_3$= i_1 i_2 i_3 i_4 i_5 i_6 i'_1 i'_2 i'_3 i'_4 i'_5 i'_6

i_1 = 1 indicates SMS message is waiting
i_2 = 1 indicates voice mail is waiting
i_3 = 1 indicates fax is waiting
i_4 = 1 indicates e-mail is waiting
i_5 = 1 indicates data is waiting
i_6 = (spare)

Note that $i_n = 0$ carries no information on the corresponding indicator setting (does not reset the indicator)

4.3.3.12 Coding of additional information, battery saving for mobile stations.

4.3.3.12.1 General

The system makes battery saving function possible in mobile stations. The battery saving period starts at reception of following additional information which is sent on calling channels and combined calling and traffic channels. The mobile station may then close the receiver for the period indicated in the information field. Calls to these mobile stations will be stored in the MTX the necessary time.

4.3.3.12.2 Coding of H_1H_2

$H_1(14)$ and $H_2(11)$ indicates that information for battery saving circuit synchronization is given.

4.3.3.12.3 Groups of mobiles

The mobile stations are divided up into groups according to the last digit X_6 in the mobile station subscriber number. The groups are addressed by the character H_7 in the signalling. The mobile station accepts the battery saving information only if X_6 is included in the groups specified by H_7 in the following table:

H_7	X_6
0	-
1	1, 3, 5, 7, 9
2	2, 4, 6, 8, 0
3	1, 2
4	3, 4
5	5, 6
6	7, 8
7	9, 0
8	1, 2, 3, 4, 5, 6, 7, 8, 9, 0
9-15	Spare

The MTX shall use one of the following combinations:

A) $H_7(1)$ and $H_7(2)$
B) $H_7(3)$, $H_7(4)$, $H_7(5)$, $H_7(6)$ and $H_7(7)$
C) $H_7(8)$

4.3.3.12.4 Battery saving period

The battery saving period starts from the reception of battery saving signal and last the time period given in H_3 according to following table.

Coding of H_3	Battery saving period in frame times (1 frame = 138,33 ms)	
0	0	frames
1	24	"
2	40	"
3	56	"
4	72	"
5	88	"
6	112	frames
7	168	"
8	224	"
9	280	"
10-15	spare	

The time between two battery saving information frames to each group depends on the period given in H_3 and the traffic load on the calling channel. Battery saving information will be sent after other necessary information (calls etc.) has been sent. Also the value of H_3 depends on the traffic situation in the MTX and it will be changed manually or automatically.

4.3.3.12.5 Additional information [OPTIONAL]

Within the battery saving frame some additional information will be sent in the following way:

General Coding of H-values in battery saving frame:

Spare digits in the battery saving frame are taken into use in the following way:

Bit position	meaning
H1: E (1110)	battery saving frame
H_2: B (1011)	battery saving frame
H_3:	battery saving time
H_4:	together with H_5 forms the new operator identifier Y_3
H_5:	together with H_4 forms the new operator identifier Y_3
H_6: 1.bit (ms)	spare
H_6: 2.bit	spare
H_6: 3.bit	overdecadic b-numbers can be used when 1
H_6: 4.bit (ls)	message polling is in use when 1
H_7:	battery saving group
H_8: 1.bit (ms)	real time clock is in use when 1
H_8: 2.bit	part of the real time clock together with H_9 and H_{10}
H_8: 3.bit	part of the real time clock together with H_9 and H_{10}
H_8: 4.bit (ls)	part of the real time clock together with H_9 and H_{10}
H_9:	part of the real time clock together with H_{10}
H_{10}:	part of the real time clock together with H_9

Note
See para. 4.3.3.4 for overdecadic b-numbers
Message polling is part of the new clearing sequence
ms = most significant bit, ls = least significant bit

Real time clock coding, bits in H_8 H_9 and H_{10}

The first bit in H_8 indicates the use of the real time clock (bit is 1). Three last bits in H_8 together with two first bits in H_9 indicate full hours (5 bits). Two last bits in H_9 together with H_{10} indicate minutes. (6 bits).
NB! Real time clock can not be transmitted on a combined channel!

Coding of Y_3

The first five bits (all bits H_4 and the first bit in H_5) are meant to be co-ordinated by the Nordic NMT group which gives 32 different possibilities under one present Y_1. The remaining three bits (8 values) of H_5 can be used by the individual operator to mark different areas together with Y_2 if needed. See NMT doc. NMT-RD.02.

4.3.3.13 Coding of A-subscriber number in frame 8 [OPTIONAL]

Coding of Information

Hexadecimal characters H_X are used to transfer decimal digits of the A-number. This will imply that more than one frame has to be used to transfer the complete A-number. For that reason a sequence number, M, is sent in each frame. The frames sent in a sequence are numbered M(0), M(1) … M(15).

To assure the correctness of the data transferred also a checksum, W_1W_2 is calculated and sent in each frame. The checksum is the modulo 256 sum of the following groups of bits MH_1, H_2H_3, H_4H_5 and H_6H_7. The checksum is calculated for the information inserted in the frame where the A-number may be plaintext or encrypted. Thus the encryption is done before calculating the checksum.

The A-number is transferred in H_1 to H_7. If the SIS for incoming calls is used the number is encrypted.
In the first frame in the sequence (labelled M(0)) H_1 and H_2 have a special meaning and are not encrypted in the frame:
H_1 is used to transfer the length of the sequence. H_1 is coded to the same value as M in the last frame in the sequence. E.g. in a sequence with four frames, H_1 in the first frame is coded as $H_1(3)$.
H_2 is used to indicate the type of information that follows. It is coded as follows:

H_2	Meaning
0	A-number follows, type unknow
1	A-number follows, nationally significant
2	A-number follows, internationally significant
3	Transfer of A-number not possible (for technical reason)
4	Transfer of A-number not allowed
5-15	Spare

The following positions H_X in the first frame and all positions H_X in the following frames are used for transfer of the A-number. The most significant digit is transferred in H_3 in the first frame. $H_X(0)$is used as fillers in the last frame.

The coding for H_X:

Digit in A-number	Hx	binary coding
Filler	0	0000
1	1	0001
…	…	…
9	9	1001
0	10	1010
Spare	11	1011
transferred call ind	12	1100
+ (int. pref.)	13	1101
Spare	14	1110
Spare	15	1111

Transferred call indication H_X (12) is sent after the A-number before possible fillers in the last frame.

Examples

Transfer of nationally significant A-number 060132389

Frame no in seq.	M	H_1	H_2	H_3	H_4	H_5	H_6	H_7	W_1	W_2
1	0	1	1	10	6	10	1	3	9	8
2	1	2	3	8	9	0	0	0	13	10

Capacity

These frames have the following capacity:

1 frame	5 digits
2 frames	12 digits
3 frames	19 digits
4 frames	26 digits
5 frames	33 digits
6 frames	40 digits

4.3.3.14 Coding for BS signalling [OPTIONAL]

4.3.3.14.1 Coding of the alarm levels for received MS signal strength in the BS [OPTIONAL]

Coding	Meaning	
(Binary)	High level, l_H	Low level, l_L
0000	Suppress the function	Suppress the function
0001	30 dB (1µV) E.M.F.	20 dB (1µV) E.M.F
0010	25 " 16	"
0011	20 " 12	"
0100	16 " 8	"
0101	12 " 4	"
0110	8 "	0 "
0111	4 dB (1µV) E.M.F.	-4 dB(1µV)E.M.F.
1000	0 dB (1µV) E.M.F.	Spare

1001	40 dB (1µV) E.M.F.	Spare
1010	35 dB (1µV) E.M.F.	Spare
1111	Spare	Spare

High level and low level, including suppression of the function, can be coded independently of each other. The information is given to the BS in the frame.

4.3.3.14.2 Coding of cause value in frames 25 A(7) and 25 A(8) [OPTIONAL]

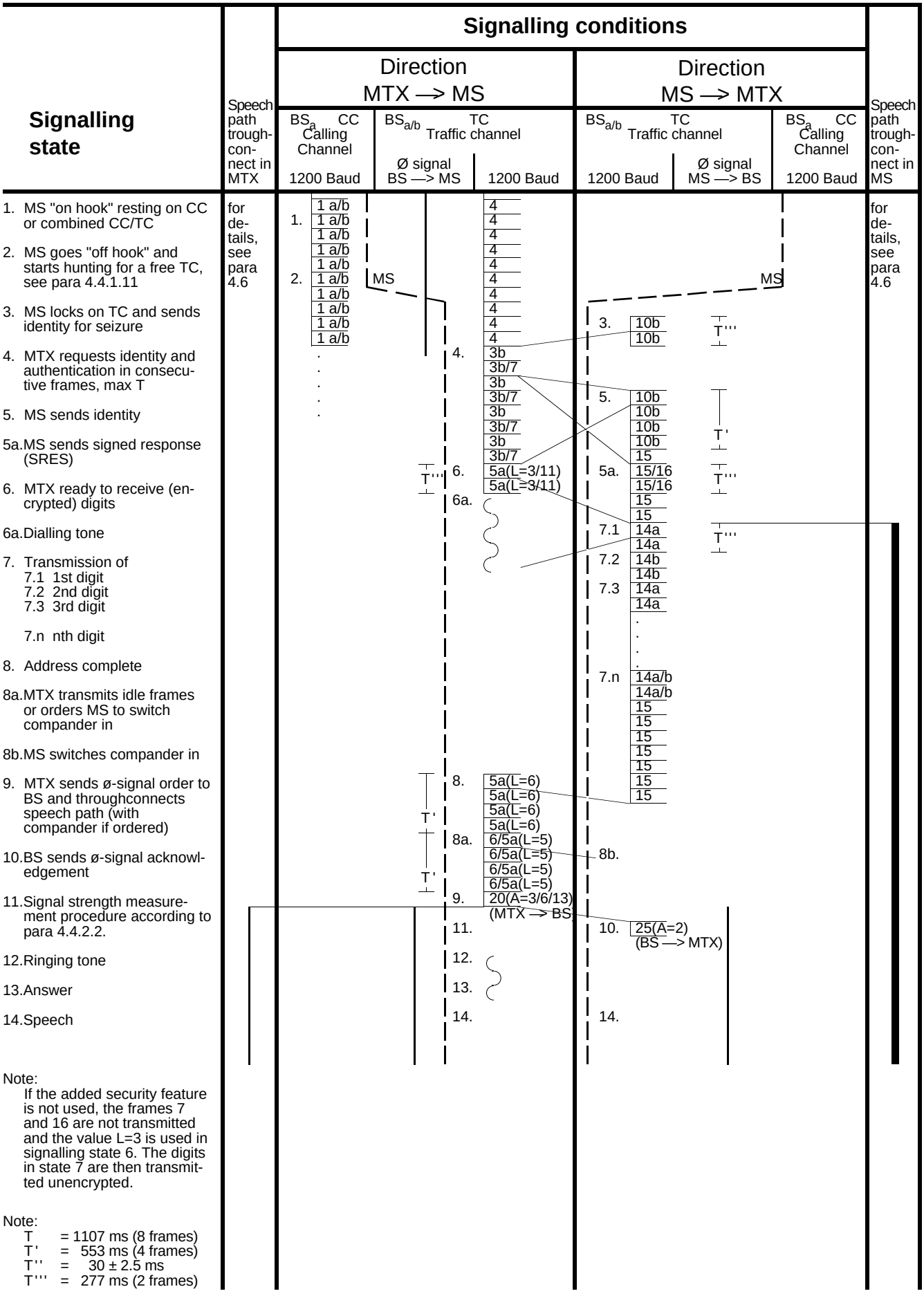
Notation	Coding	Meaning in direction BS to MTX
C(0)	0000	No information given
C(1)	0001	Caused by Ø-signal
C(2)	0010	Caused by RF-signal supervision
C(4)	0100	Caused by co-channel interference
C(8)	1000	Reserved for digital supervisory signal (BER)
C(9)	1001	Caused by the 3 s evaluation period of supervisory signal

Other bit combinations in C are used when several conditions are fulfilled simultaneously by adding the corresponding values of C.

4.4 SIGNALLING PROCEDURES

4.4.1 Signalling between MTX and MS

4.4.1.1 Call mobile station to mobile telephone exchange **SCHEME A**

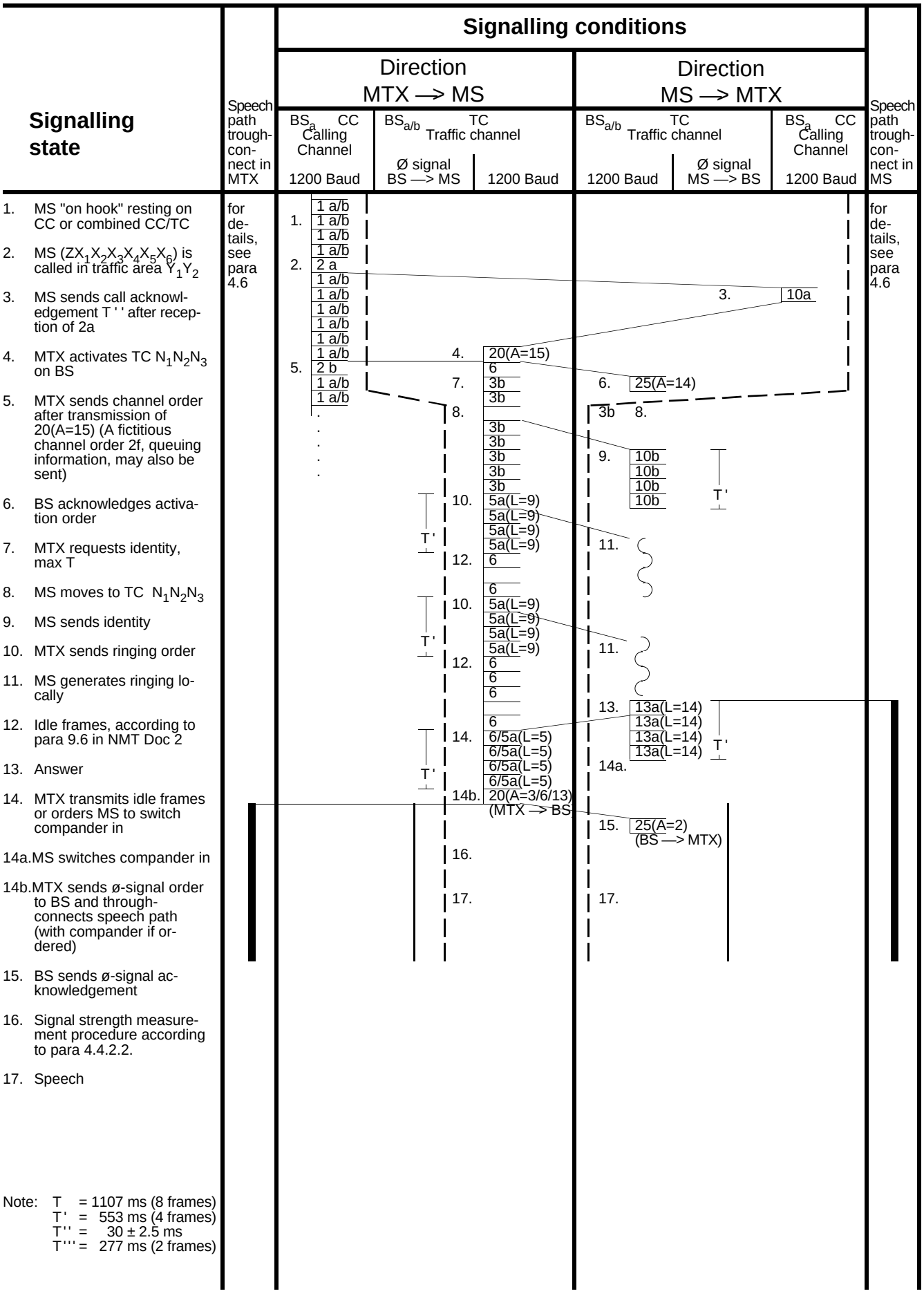


Note:
If the added security feature is not used, the frames 7 and 16 are not transmitted and the value L=3 is used in signalling state 6. The digits in state 7 are then transmit-ted unencrypted.

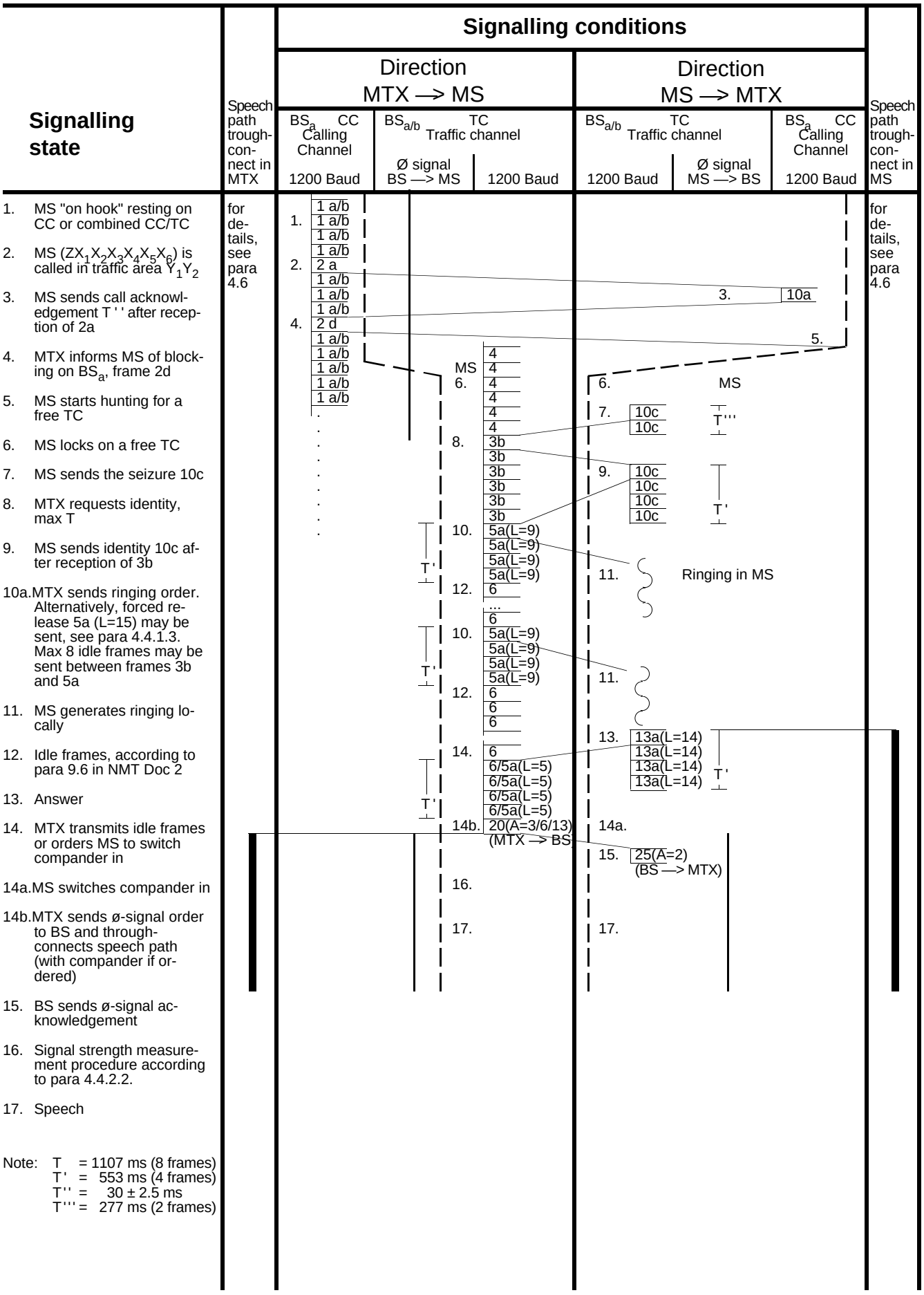
Note:
T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2.5 ms
T''' = 277 ms (2 frames)

4.4.1.2 Call mobile telephone exchange to mobile station

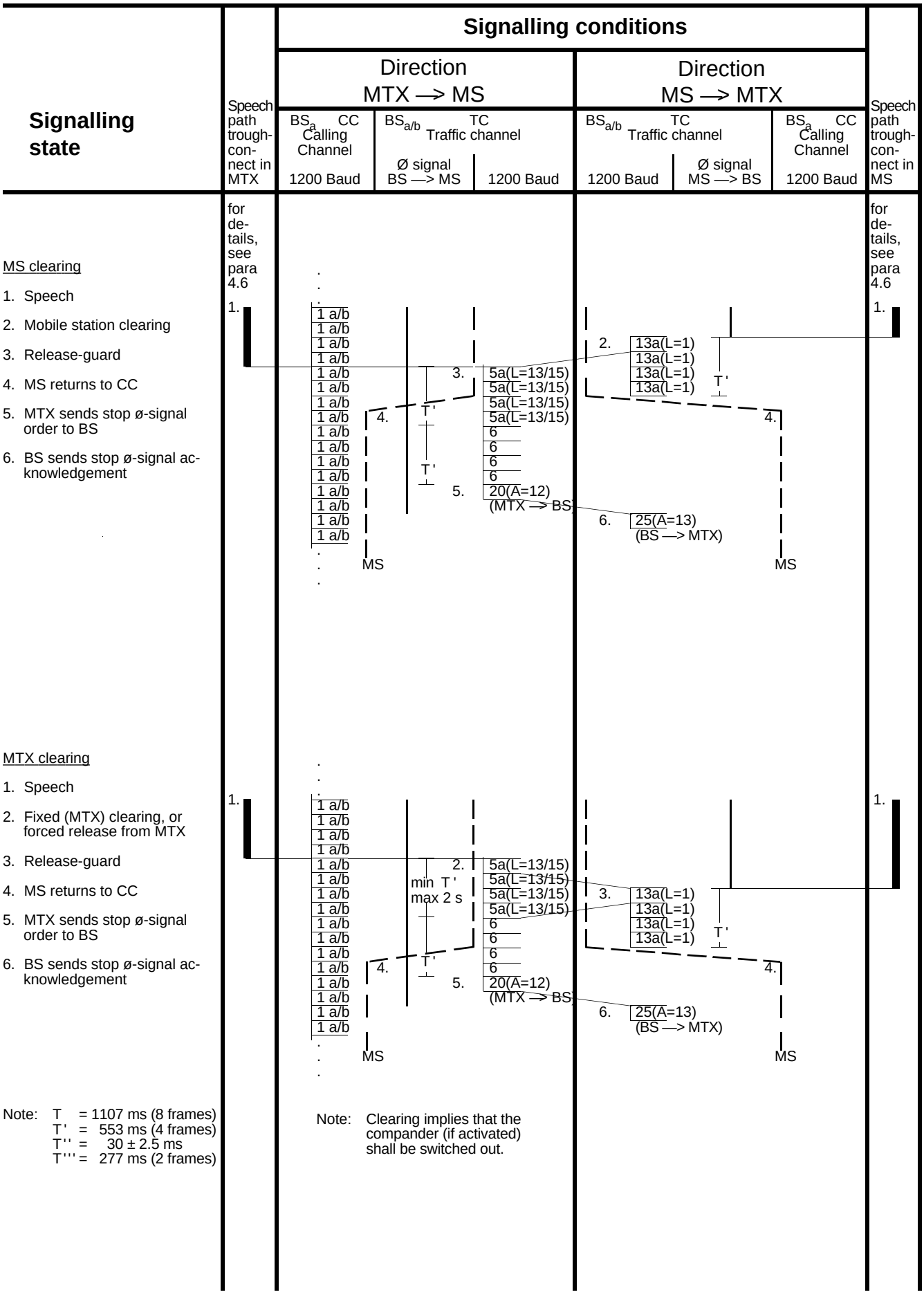
4.4.1.2.1 Call mobile telephone exchange to mobile station, normal case **SCHEME B**



4.4.1.2.2 Call mobile telephone exchange to mobile station, congestion or blocking on BS_a. **SCHEME B.1**



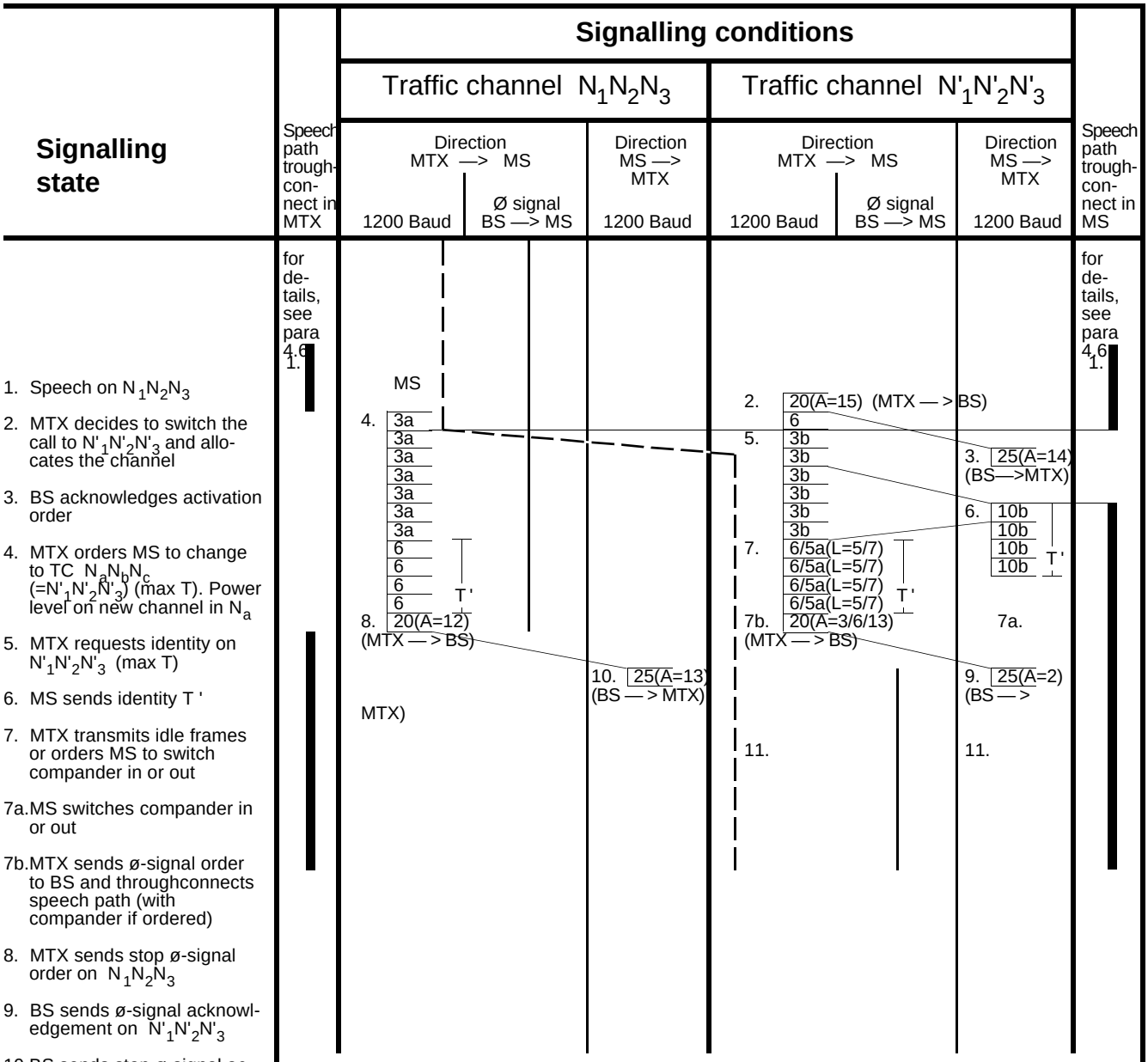
4.4.1.3 Clearing sequences



4.4.1.4 Switching call in progress

4.4.1.4.1 Switching call in progress, ordinary procedure

SCHEME C



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

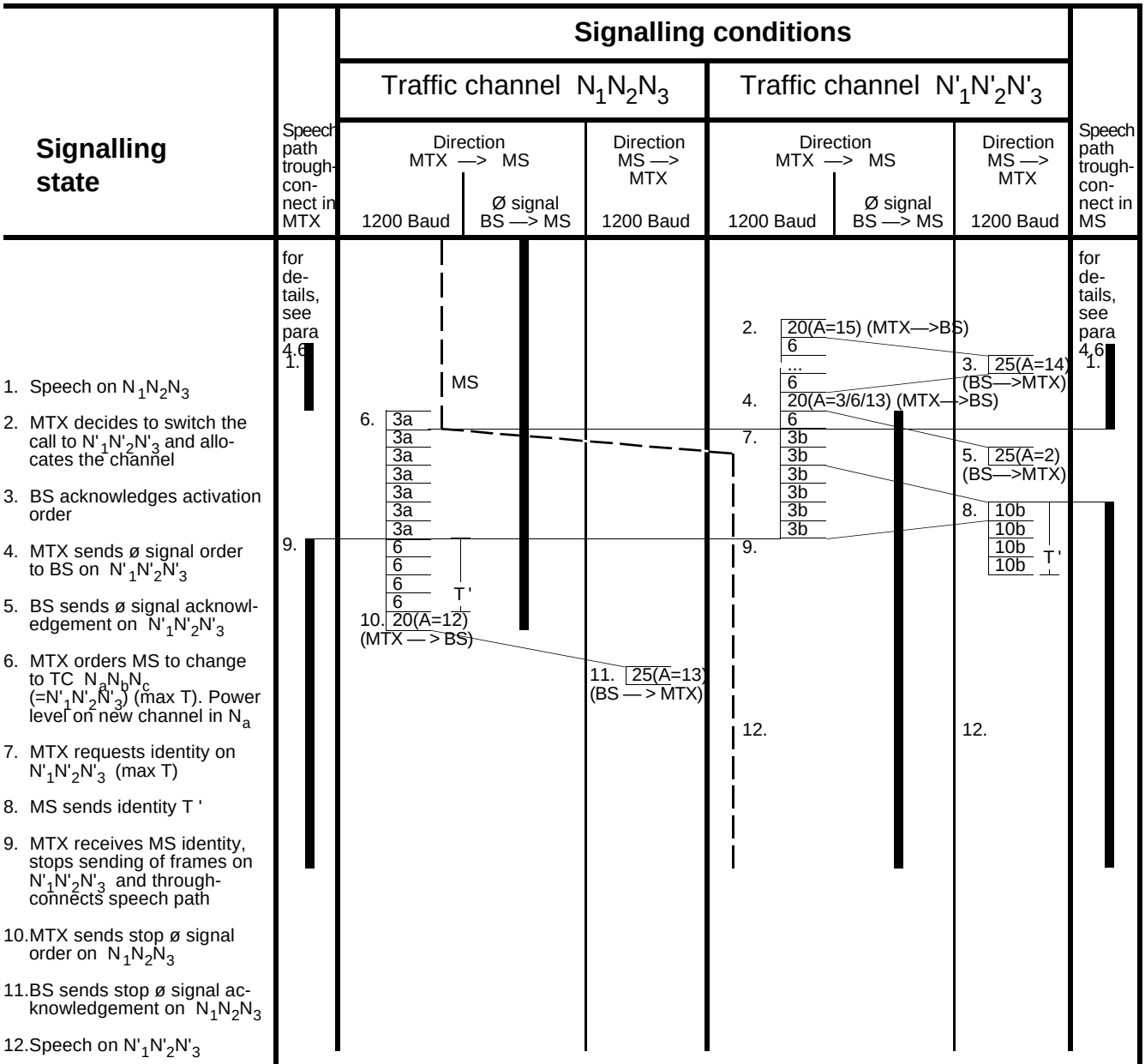
If MS does not receive identity request on the new TC, it will return to the previous TC and throughconnect speech path.

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.

4.4.1.4.2 Switching call in progress, improved procedure

SCHEME C.1'



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

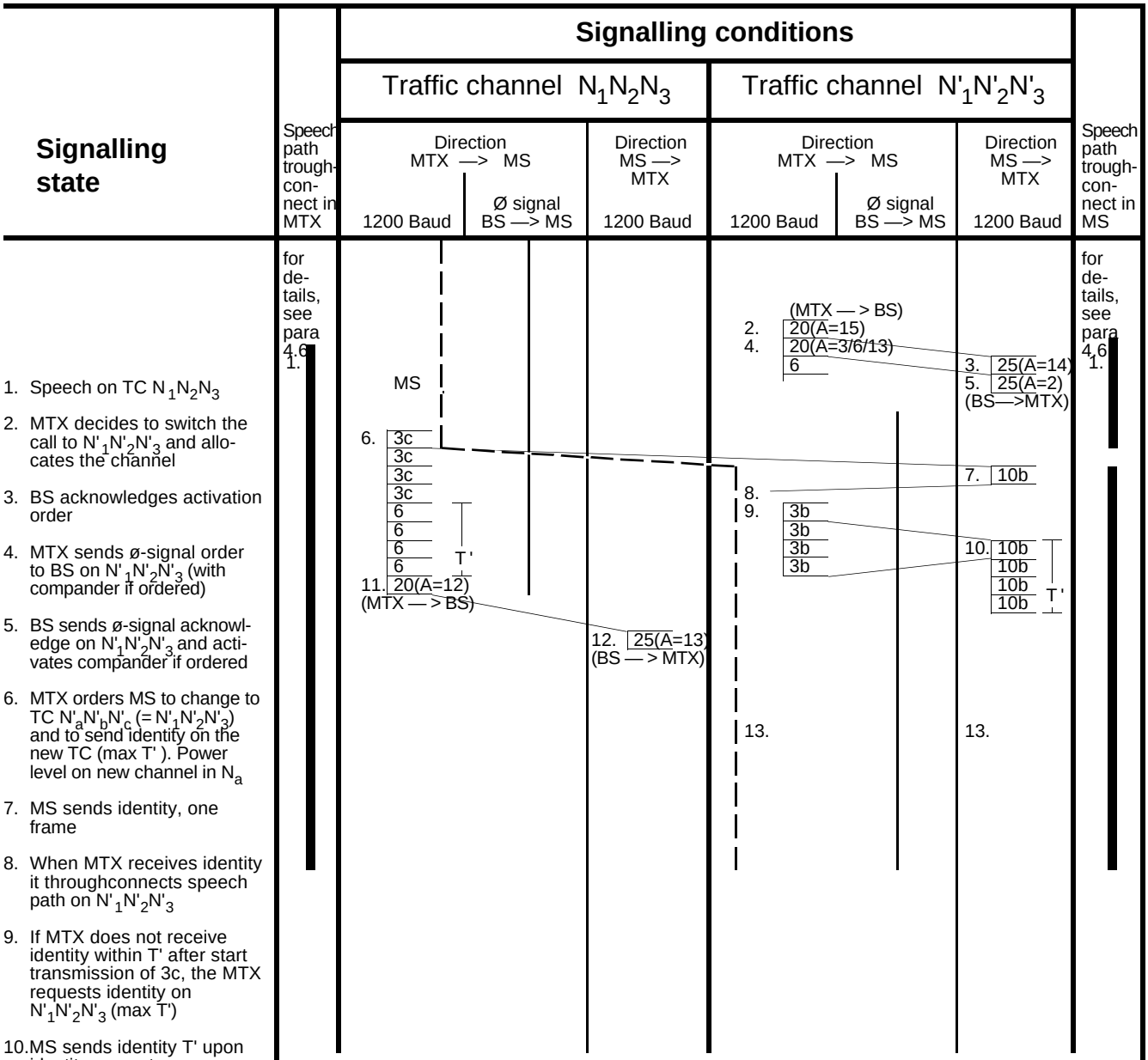
If MS does not receive identity request on the new TC, it will return to the previous TC and throughconnect speech path.

If MTX does not receive identity on the new TC within T, 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.

4.4.1.4.3 Switching call in progress, short procedure.

SCHEME C.2'



1. Speech on TC $N_1N_2N_3$
2. MTX decides to switch the call to $N'_1N'_2N'_3$ and allocates the channel
3. BS acknowledges activation order
4. MTX sends ø-signal order to BS on $N'_1N'_2N'_3$ (with compander if ordered)
5. BS sends ø-signal acknowledge on $N'_1N'_2N'_3$ and activates compander if ordered
6. MTX orders MS to change to TC $N'_aN'_bN'_c$ (= $N'_1N'_2N'_3$) and to send identity on the new TC (max T'). Power level on new channel in N_a
7. MS sends identity, one frame
8. When MTX receives identity it throughconnects speech path on $N'_1N'_2N'_3$
9. If MTX does not receive identity within T' after start transmission of 3c, the MTX requests identity on $N'_1N'_2N'_3$ (max T')
10. MS sends identity T' upon identity request
11. MTX sends stop ø-signal order on $N_1N_2N_3$
10. Stop ø-signal acknowledgement from BS on $N_1N_2N_3$
13. Speech on $N'_1N'_2N'_3$

If the MS receives an RF-signal level above a limit A [A=20±4 dB(1µV)EMF] on the new TC it will transmit frame 10 b and throughconnect speech path. If the RF-signal level received in MS is below the limit A the MS shall not transmit frame 10 unless it receives identity request within T after received channel order. If identity request is not received within T the MS shall return to the previous TC and throughconnect speech path. The received identity request is responded with four identity frames 10b.

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

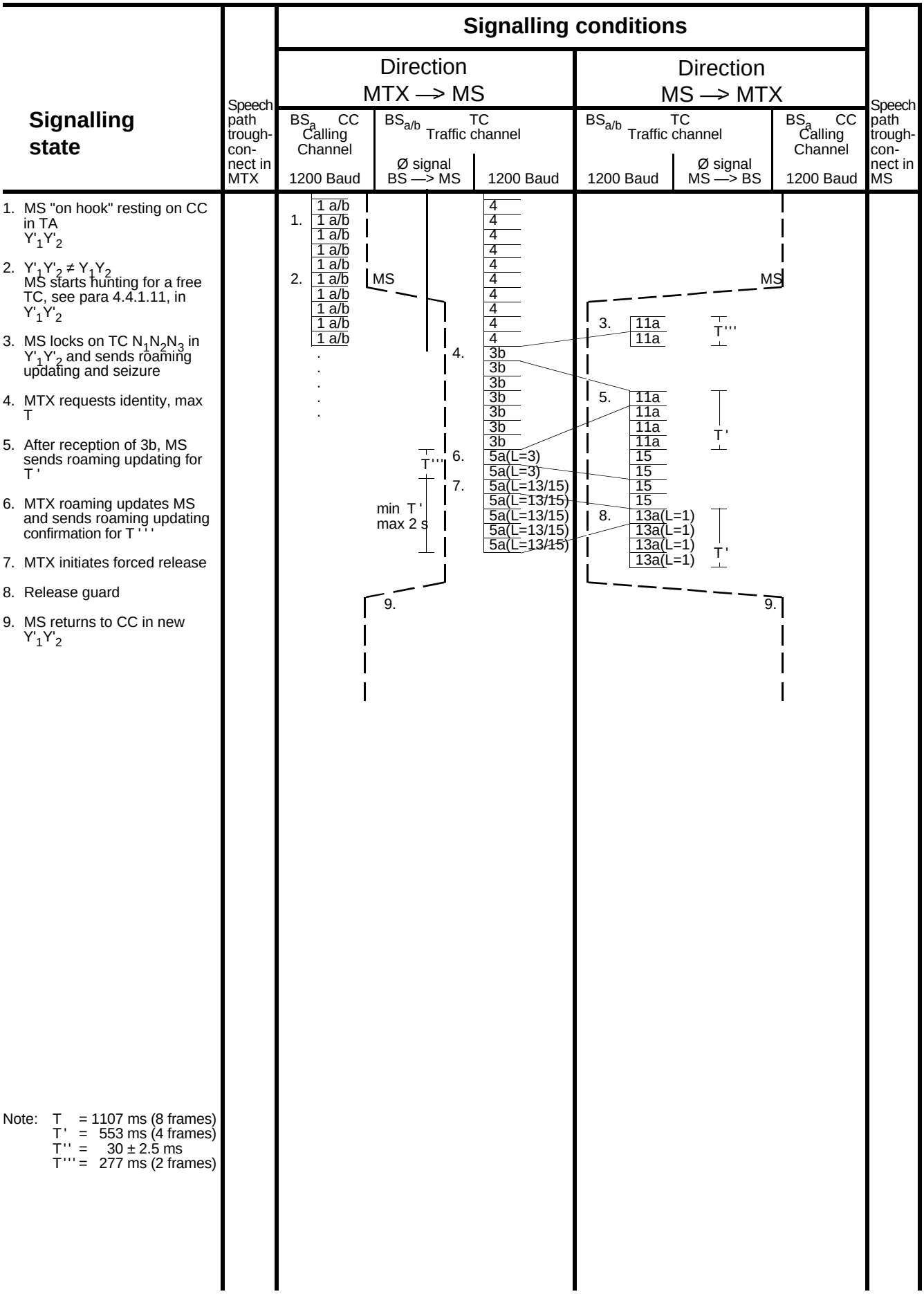
Note that the supervisory signal will control the previous TC in the last case when the speech path is throughconnected.

In state 2 and 4 signals 20(A=15) together with 20(A=3/6/13) can optionally be replaced by the combined signal 20(A=7/14).

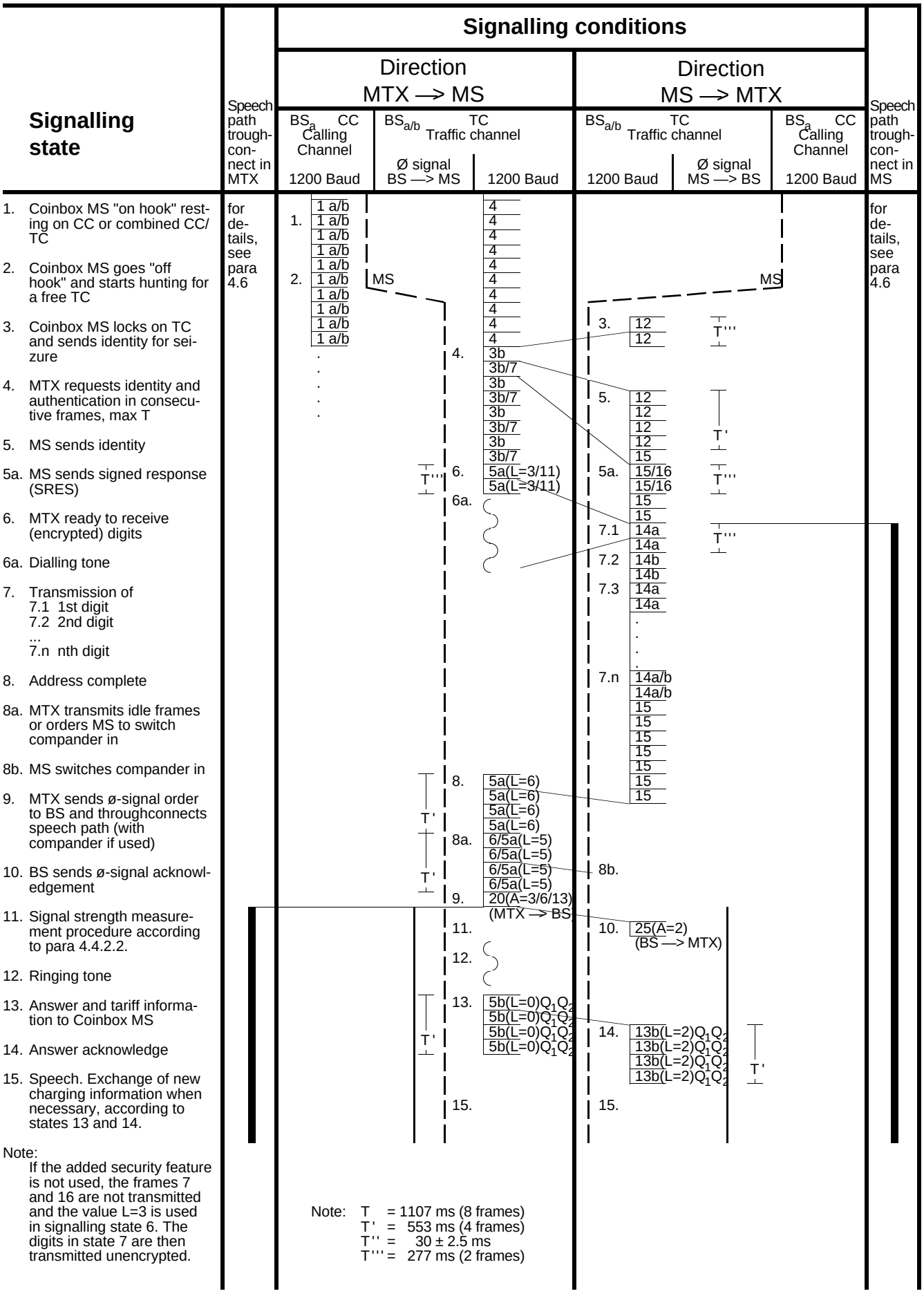
Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2.5 ms
T''' = 277 ms (2 frames)

4.4.1.5 Roaming updating procedure

SCHEME D

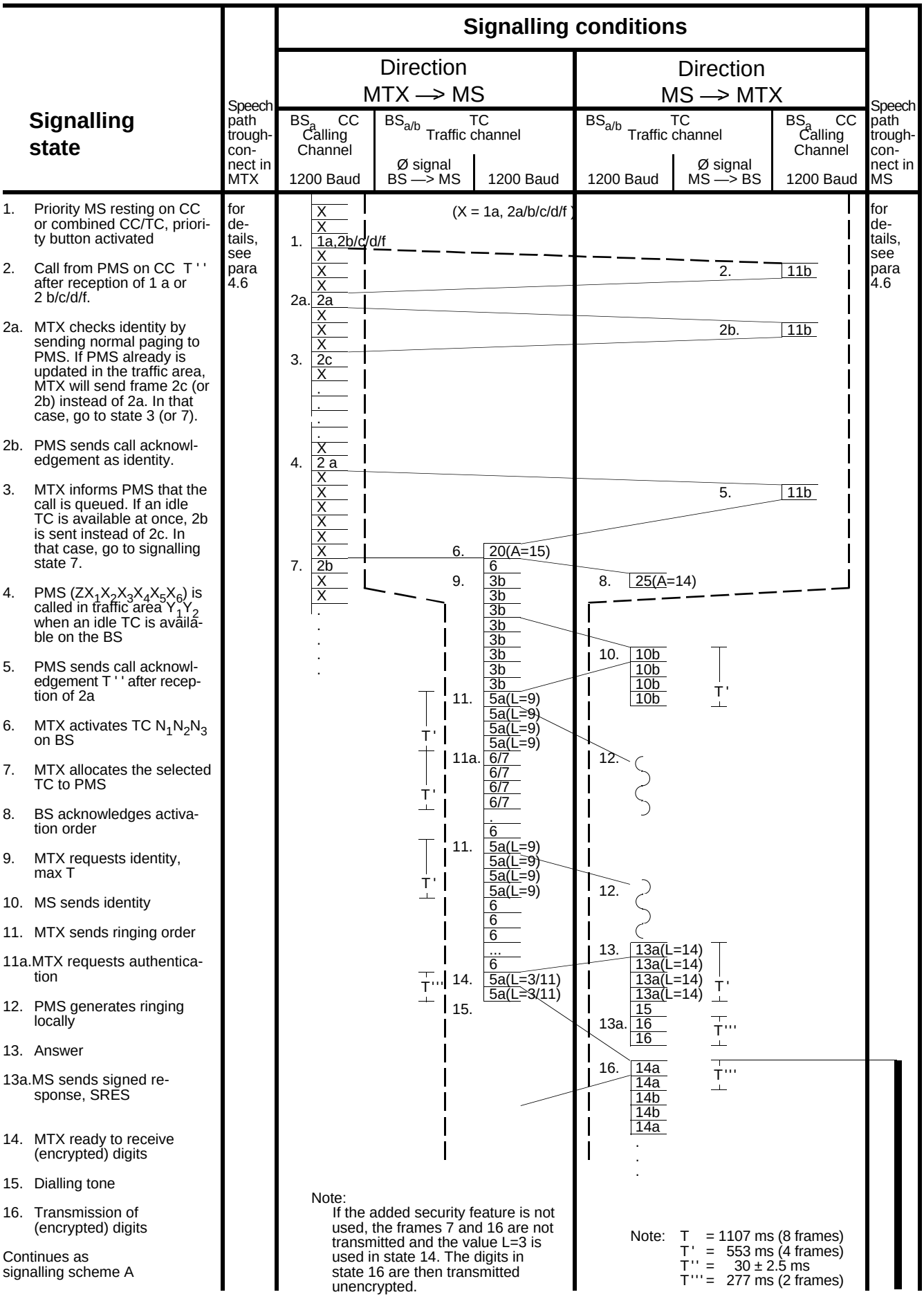


4.4.1.6 Call coinbox MS to mobile telephone exchange

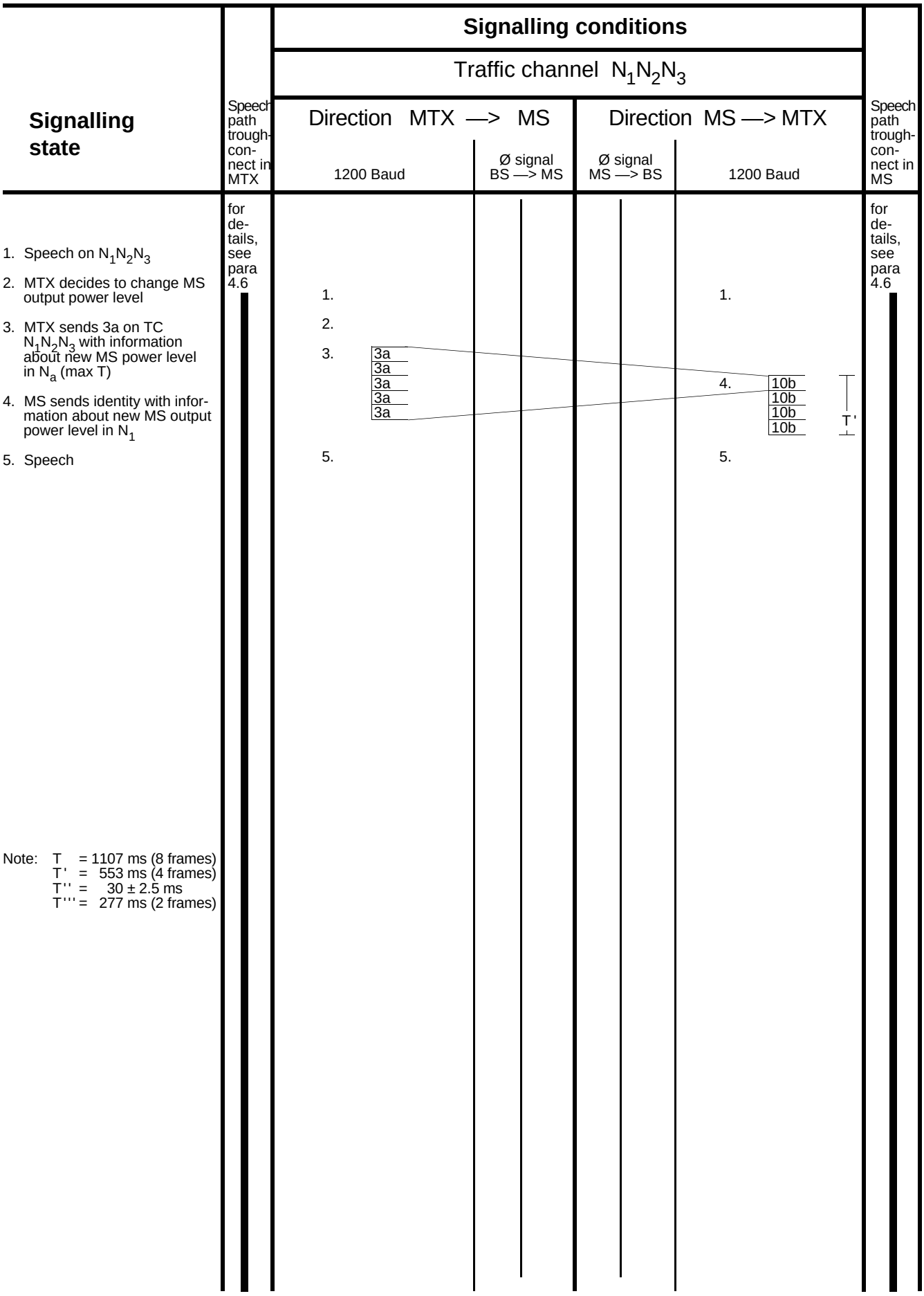


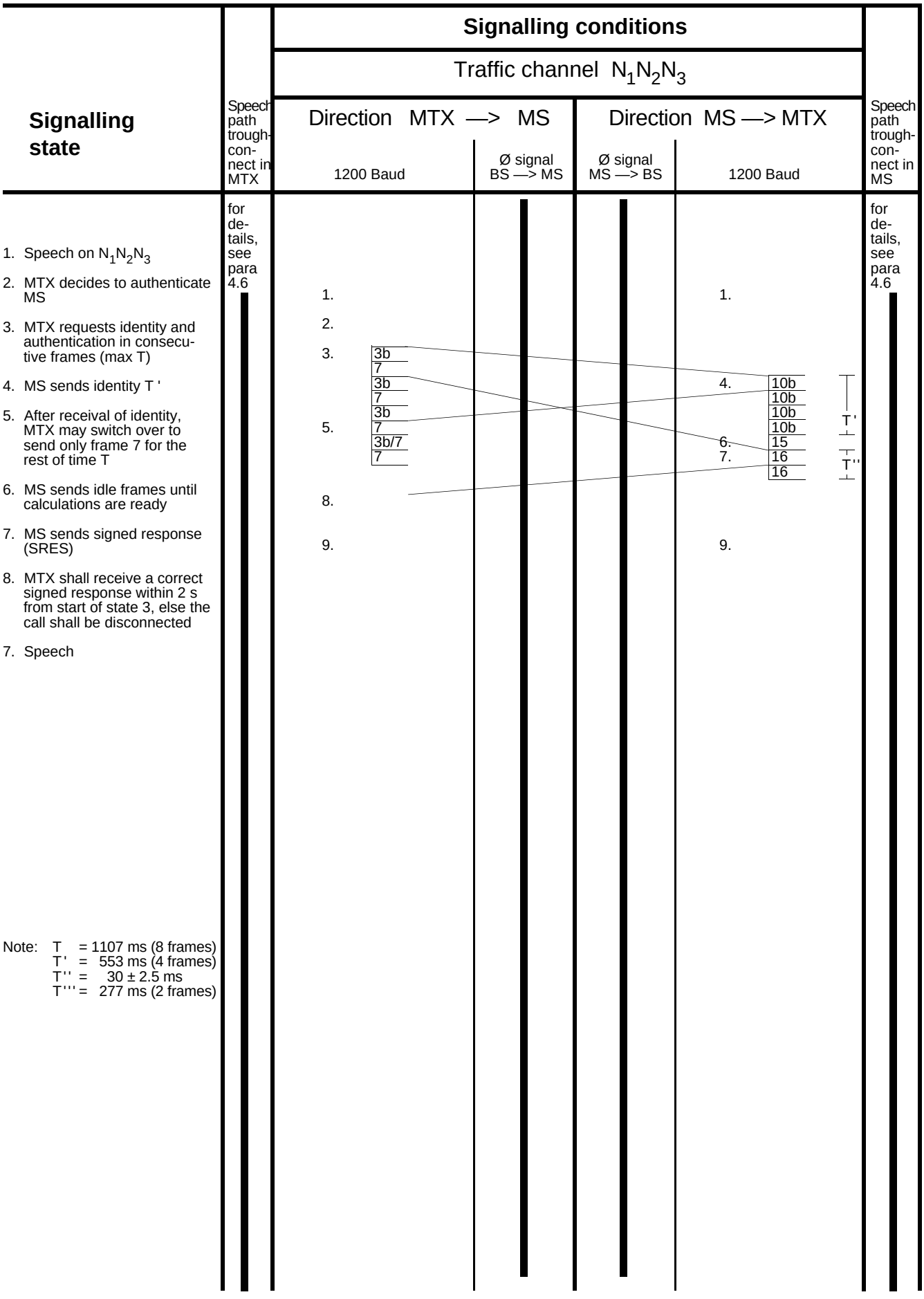
Note:
If the added security feature is not used, the frames 7 and 16 are not transmitted and the value L=3 is used in signalling state 6. The digits in state 7 are then transmitted unencrypted.

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

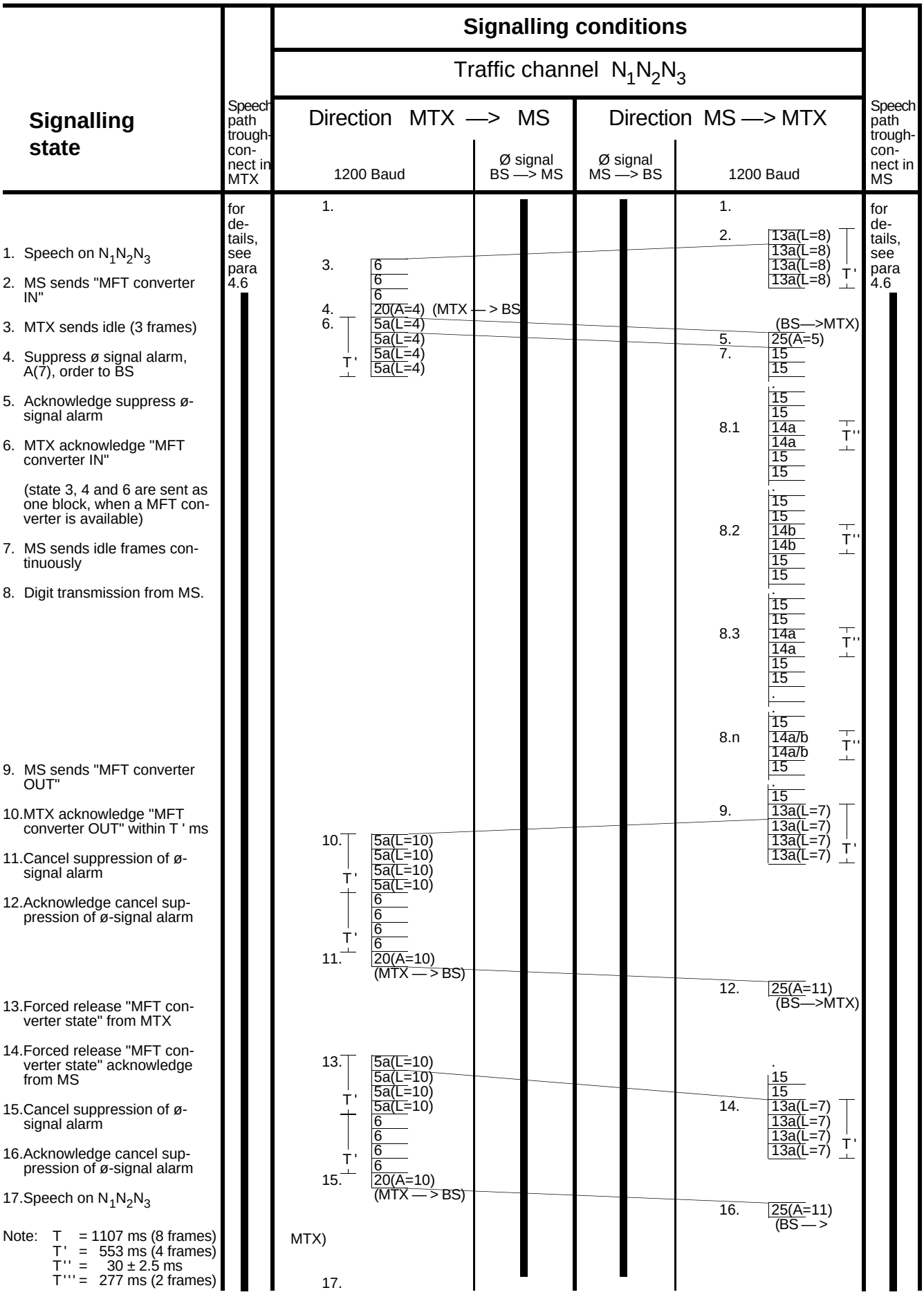

Signalling state
Signalling conditions
Direction MTX —> MS
Direction MS —> MTX
Speech path trough-con-nect in MTX
Speech path trough-con-nect in MS
BSa CC Calling Channel 1200 Baud
BSa/b TC Traffic channel
Ø signal BS —> MS
1200 Baud
BSa/b TC Traffic channel 1200 Baud
Ø signal MS —> BS
BSa CC Calling Channel 1200 Baud
for de-tails, see para 4.6
(X = 1a, 2a/b/c/d/f)
1. Priority MS resting on CC or combined CC/TC, priority button activated
2. Call from PMS on CC T'' after reception of 1 a or 2 b/c/d/f.
2a. MTX checks identity by sending normal paging to PMS. If PMS already is updated in the traffic area, MTX will send frame 2c (or 2b) instead of 2a. In that case, go to state 3 (or 7).
2b. PMS sends call acknowledgement as identity.
3. MTX informs PMS that the call is queued. If an idle TC is available at once, 2b is sent instead of 2c. In that case, go to signalling state 7.
4. PMS ($ZX_1X_2X_3X_4X_5X_6$) is called in traffic area Y_1Y_2 when an idle TC is available on the BS
5. PMS sends call acknowledgement T'' after reception of 2a
6. MTX activates TC $N_1N_2N_3$ on BS
7. MTX allocates the selected TC to PMS
8. BS acknowledges activation order
9. MTX requests identity, max T
10. MS sends identity
11. MTX sends ringing order
11a. MTX requests authentication
12. PMS generates ringing locally
13. Answer
13a. MS sends signed response, SRES
14. MTX ready to receive (encrypted) digits
15. Dialling tone
16. Transmission of (encrypted) digits
Continues as signalling scheme A
1a,2b/c/d/f
11b
2a
2c
2 a
20(A=15)
2b
25(A=14)
3b
10b
5a(L=9)
6/7
6
5a(L=3/11)
13a(L=14)
15
16
14a
14b
T'
T''
T'''
Note: If the added security feature is not used, the frames 7 and 16 are not transmitted and the value L=3 is used in state 14. The digits in state 16 are then transmitted unencrypted.
Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2.5 ms
T''' = 277 ms (2 frames)

4.4.1.8 Change of MS output power level on same channel

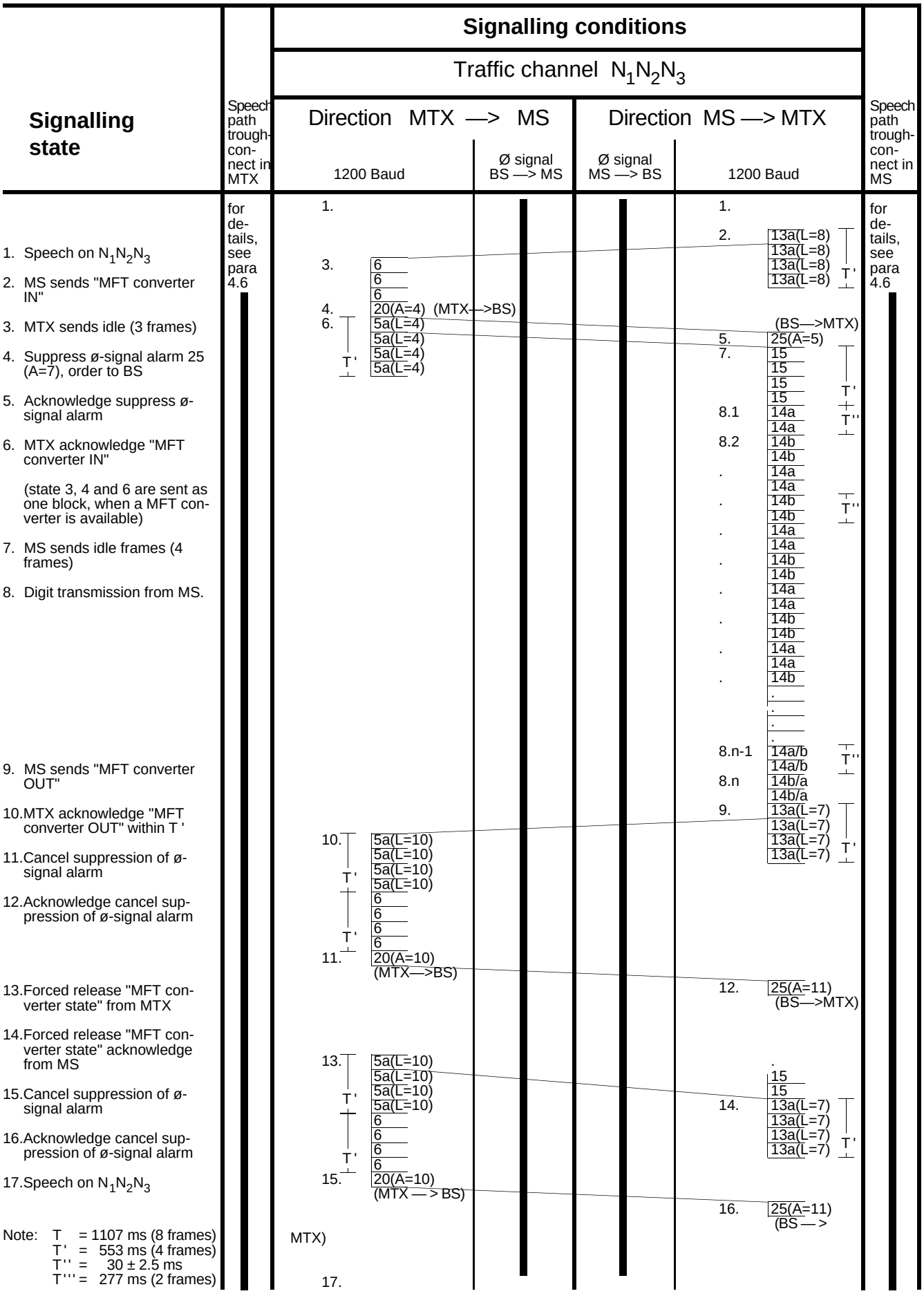



Signalling conditions
Traffic channel $N_1N_2N_3$
Signalling state
Speech path trough-con-nect in MTX
Direction MTX —> MS
Direction MS —> MTX
1200 Baud
Ø signal BS —> MS
Ø signal MS —> BS
1200 Baud
Speech path trough-con-nect in MS
for de-tails, see para 4.6
1. Speech on $N_1N_2N_3$
2. MTX decides to authenticate MS
3. MTX requests identity and authentication in consecu-tive frames (max T)
4. MS sends identity T '
5. After receival of identity, MTX may switch over to send only frame 7 for the rest of time T
6. MS sends idle frames until calculations are ready
7. MS sends signed response (SRES)
8. MTX shall receive a correct signed response within 2 s from start of state 3, else the call shall be disconnected
7. Speech
1.
2.
3.
3b
7
3b
7
3b
7
5.
3b/7
7
8.
9.
1.
4.
10b
10b
10b
10b
6.
15
7.
16
16
9.
T '
T ''
Note: T = 1107 ms (8 frames)
T ' = 553 ms (4 frames)
T '' = 30 ± 2.5 ms
T ''' = 277 ms (2 frames)

4.4.1.9 Push button data transmission from MS

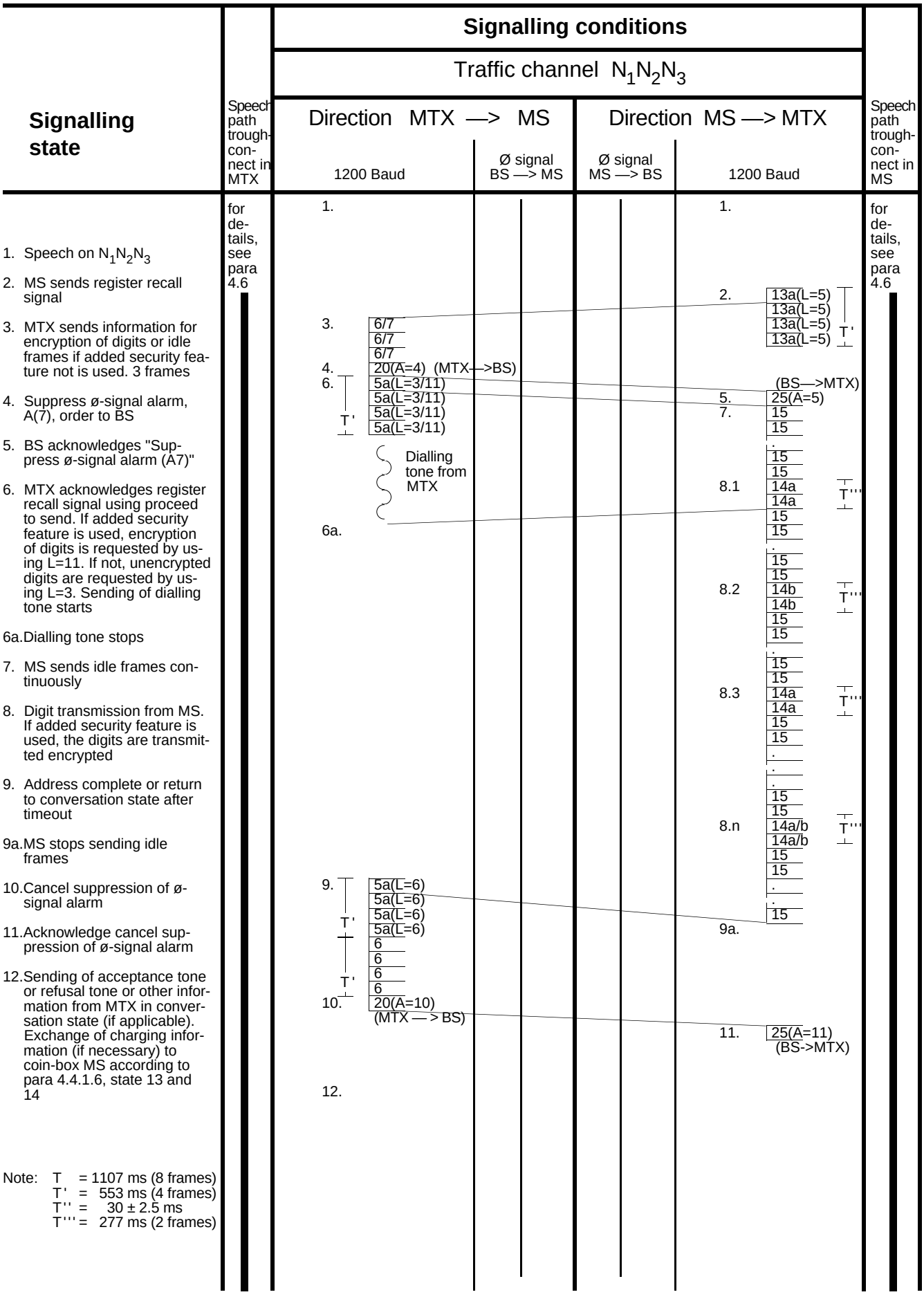


4.4.1.9b Optional use of MFT converter mode, automatic transmission of digits



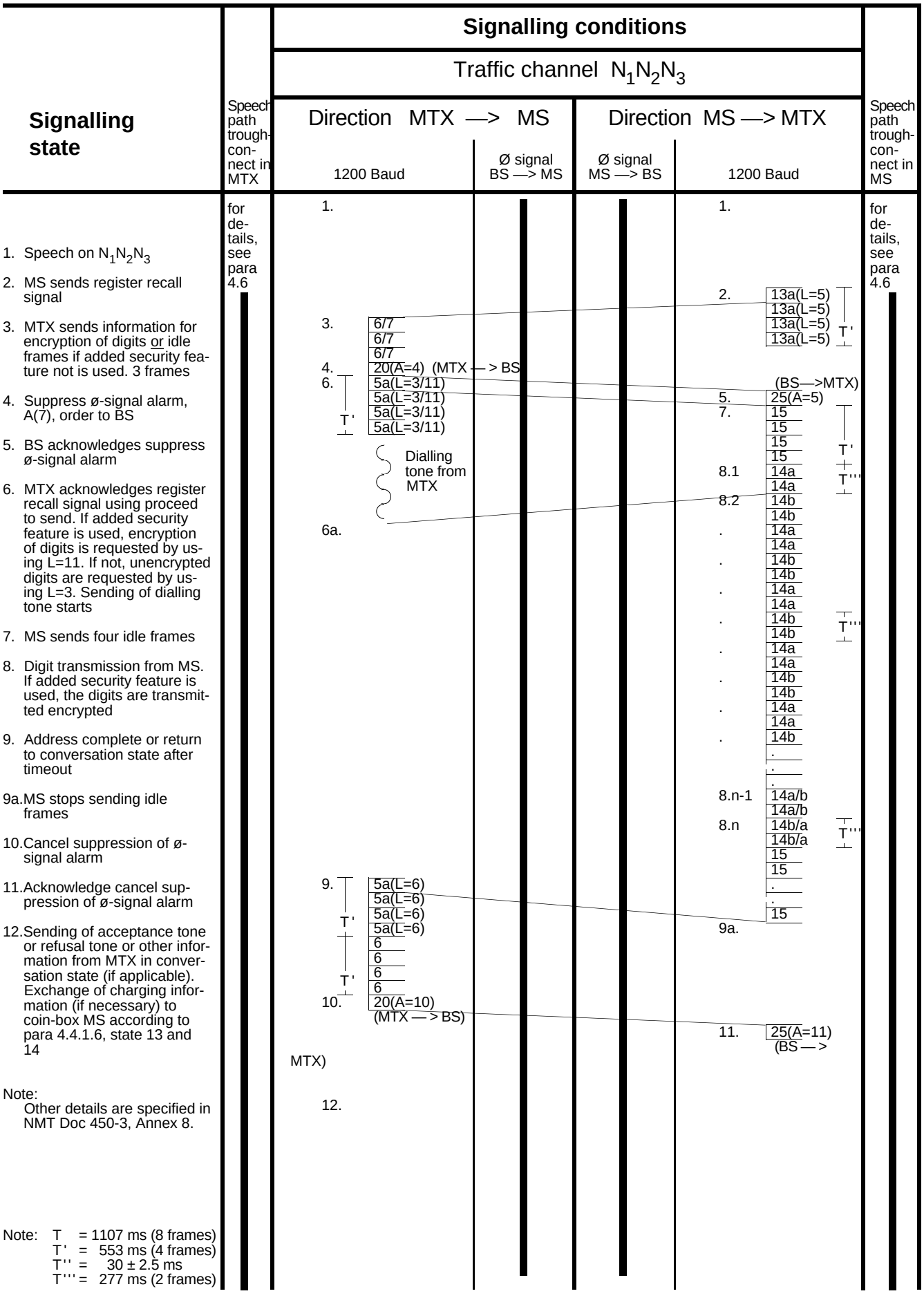
4.4.1.10 Register recall procedures

4.4.1.10.1 Subscriber service by register recall and code sending from MS

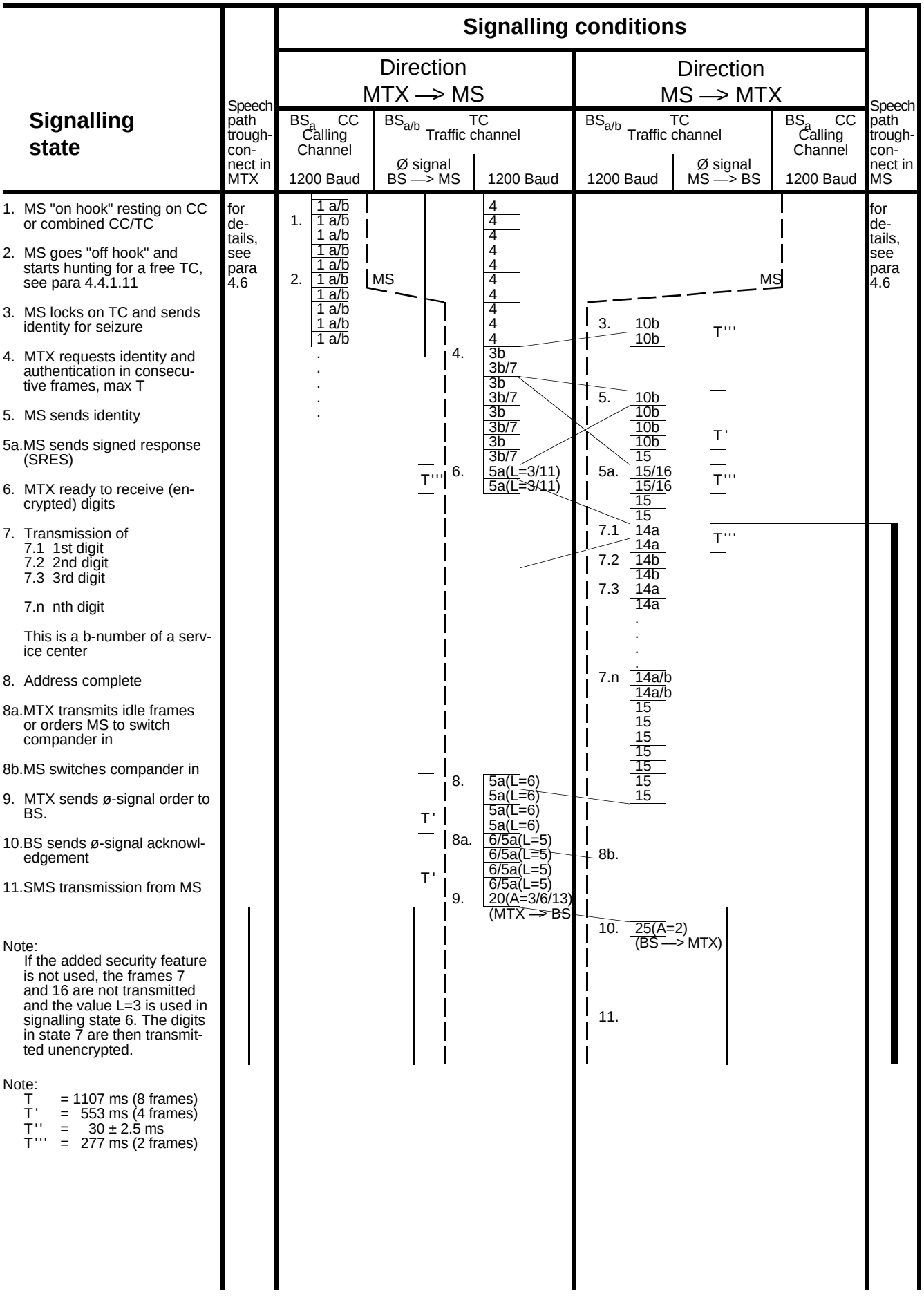


Note: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2.5 ms
T''' = 277 ms (2 frames)

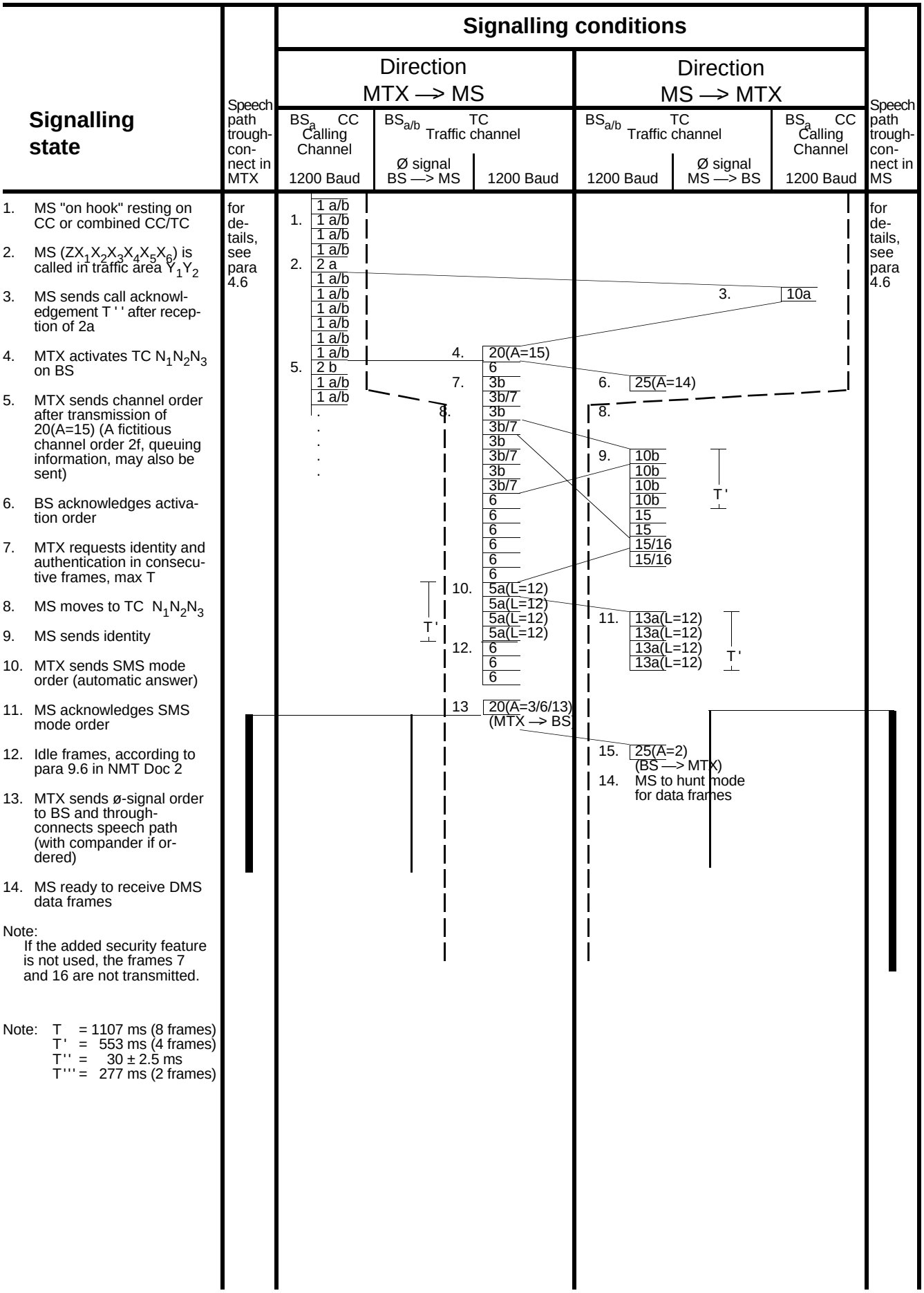
4.4.1.10.1b Optional use of register recall function, automatic transmission of digits



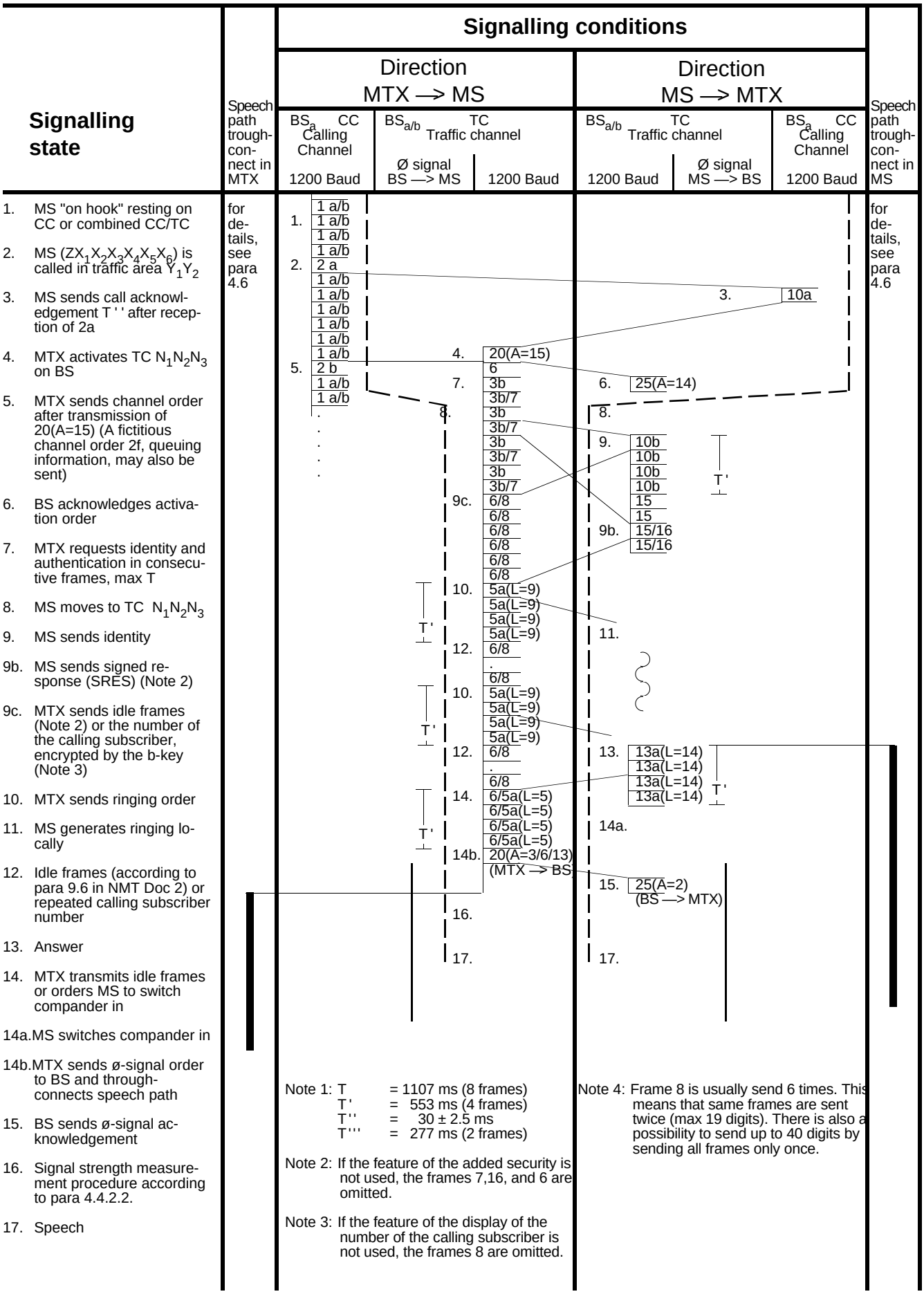
4.4.1.11 SMS call mobile station to mobile telephone exchange **SCHEME A.1 [optional]**



4.4.1.12 SMS call mobile telephone exchange to mobile station, normal case **SCHEME B2 [optional]**



4.4.1.13 Call mobile telephone exchange to mobile station, with A-number and/or authentication **SCHEME B3 [optional]**



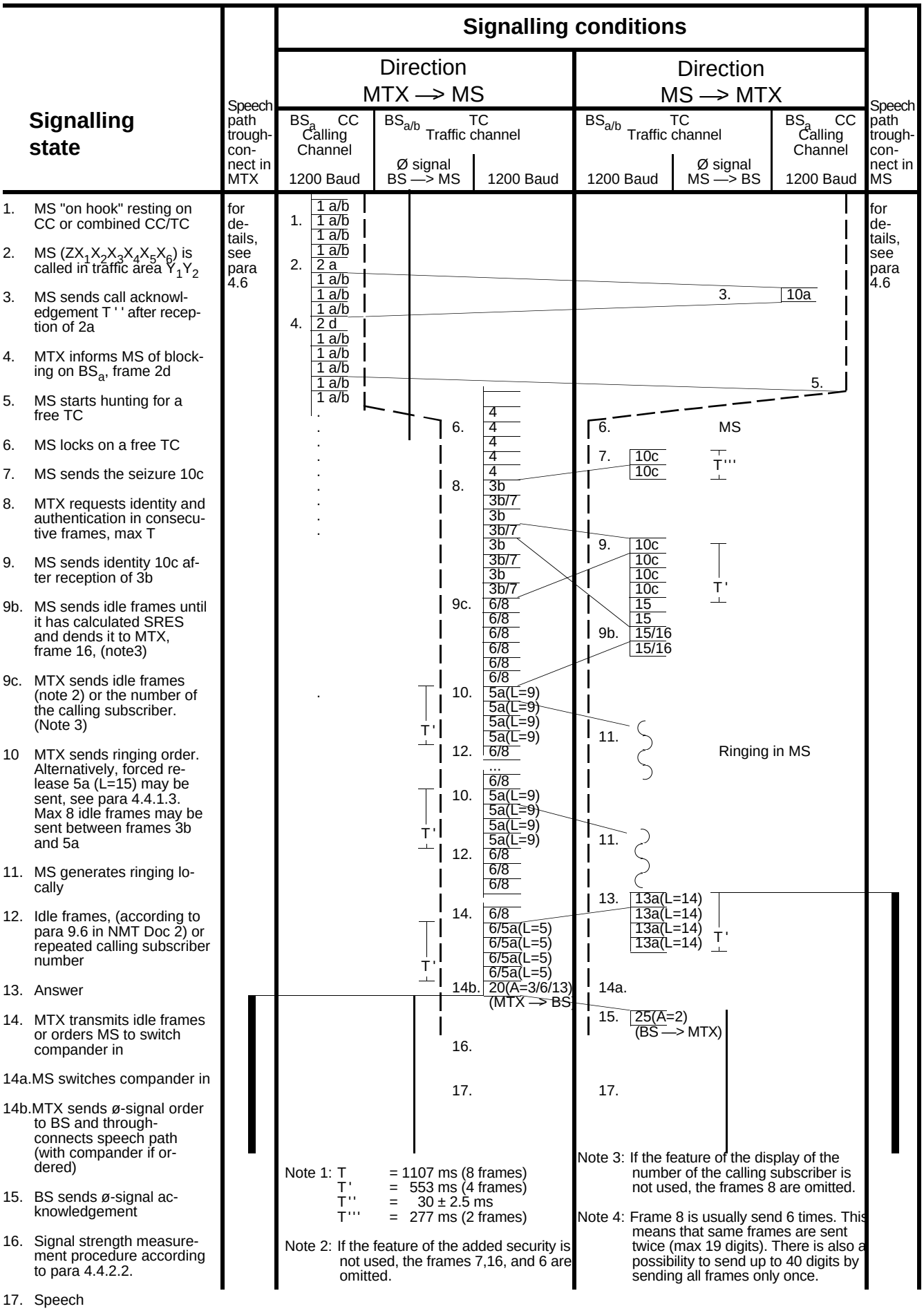
Note 1: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2.5 ms
T''' = 277 ms (2 frames)

Note 2: If the feature of the added security is not used, the frames 7,16, and 6 are omitted.

Note 3: If the feature of the display of the number of the calling subscriber is not used, the frames 8 are omitted.

Note 4: Frame 8 is usually send 6 times. This means that same frames are sent twice (max 19 digits). There is also a possibility to send up to 40 digits by sending all frames only once.

4.4.1.14 Call mobile telephone exchange to mobile station, with A-number and/or authentication ,congestion or blocking on BS_a. **SCHEME B4 [optional]**



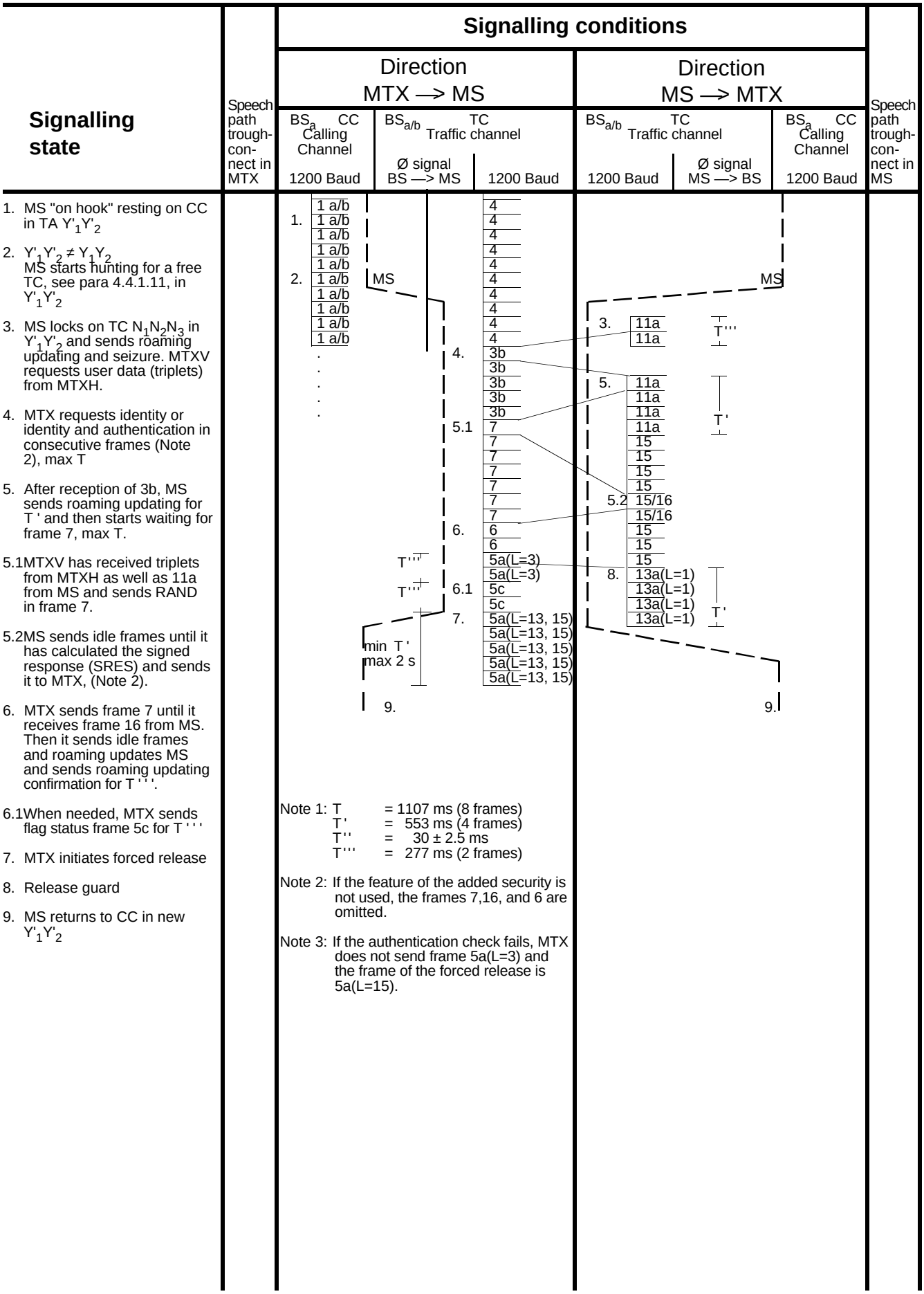
Note 1: T = 1107 ms (8 frames)
T' = 553 ms (4 frames)
T'' = 30 ± 2.5 ms
T''' = 277 ms (2 frames)

Note 2: If the feature of the added security is not used, the frames 7,16, and 6 are omitted.

Note 3: If the feature of the display of the number of the calling subscriber is not used, the frames 8 are omitted.

Note 4: Frame 8 is usually send 6 times. This means that same frames are sent twice (max 19 digits). There is also a possibility to send up to 40 digits by sending all frames only once.

4.4.1.15 Roaming updating procedure with authentication **SCHEME D1 [optional]**

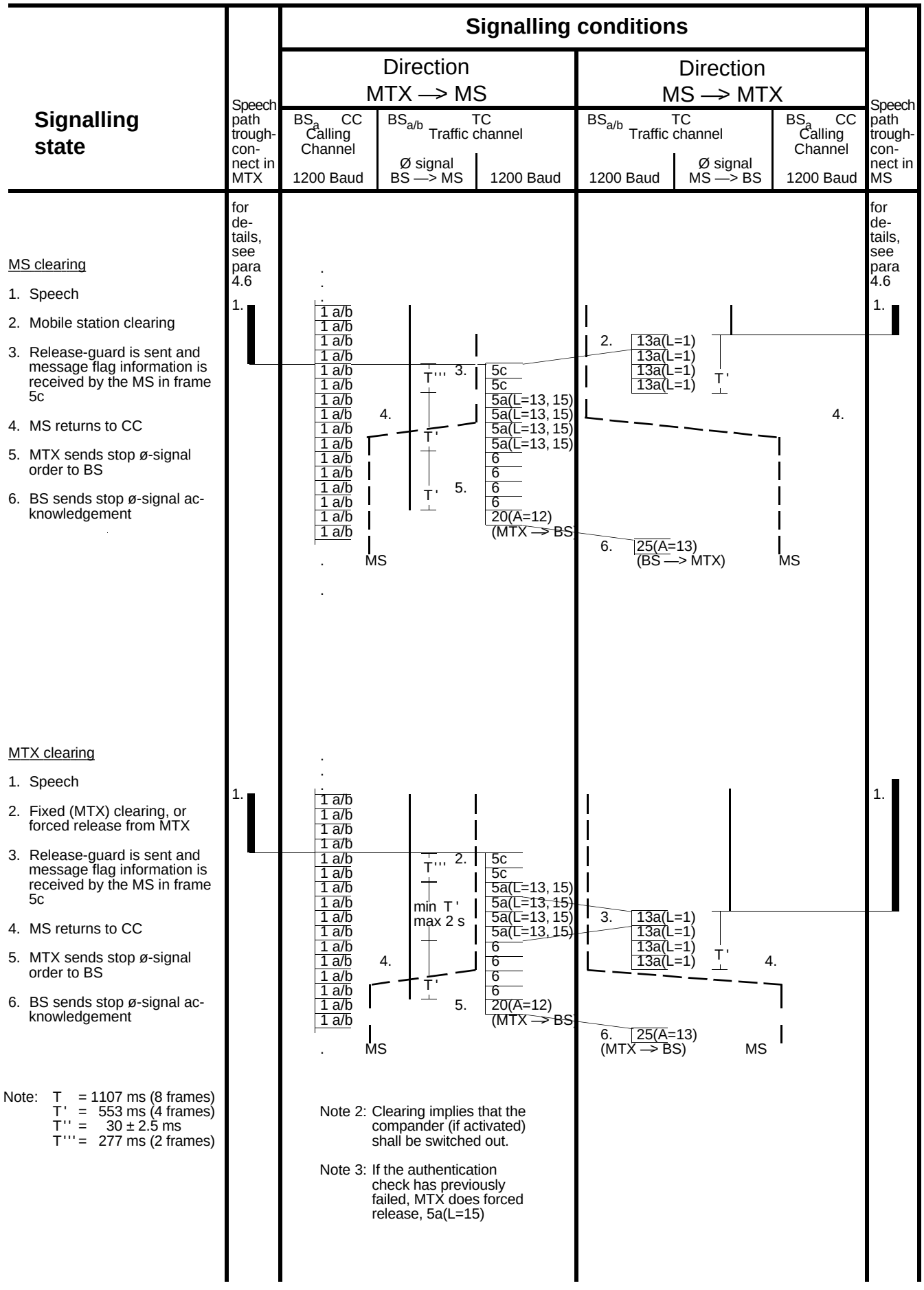


Note 1: T = 1107 ms (8 frames)
T ' = 553 ms (4 frames)
T '' = 30 ± 2.5 ms
T ''' = 277 ms (2 frames)

Note 2: If the feature of the added security is not used, the frames 7,16, and 6 are omitted.

Note 3: If the authentication check fails, MTX does not send frame 5a(L=3) and the frame of the forced release is 5a(L=15).

4.4.1.16 Clearing sequences with message indicators **[optional]**



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

Note 2: Clearing implies that the compander (if activated) shall be switched out.

Note 3: If the authentication check has previously failed, MTX does forced release, 5a(L=15)

4.4.2 Signalling procedures between MTX and BS

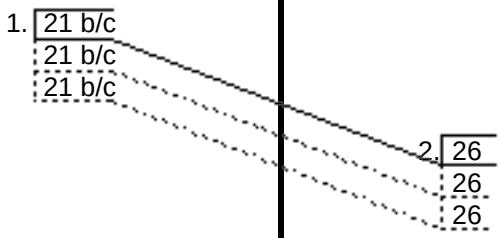
4.4.2.1 Signalling on each channel

	Signalling state	Signalling conditions	
		Direction MTX —> BS	Direction BS —> MTX
1.	Start BS transmitter		
2.	"Start transmitter" acknowledged from BS	1. 20 (A=15)	2. 25 (A=14) x)
3.	Send ø-signal		
4.	"Start ø-signal" acknowledged from BS.	3. 20 (A=3)	4. 25 (A=2) x)
5.	Suppress ø-signal alarm (frame 25(A=7) from BS	5. 20 (A=4)	6. 25 (A=5)
6.	"Suppress ø-signal alarm" acknowledged from BS		
7.	Cancel suppression ø-signal alarm in BS	7. 20 (A=10)	8. 25 (A=11)
8.	"Cancel suppression ø-signal alarm in BS" acknowledged from BS.		9. 25 (A=7 or A=8)
9.	Ø-signal alarm from BS		
10.	Stop sending of ø-signal	10. 20 (A=12)	11. 25 (A=13)
11.	"Stop ø-signal" acknowledged from BS		
12.	Stop BS transmitter and open "line loop"	12. 20 (A=0)	13. 25 (A=1) x)
13.	Stop BS transmitter acknowledged		
14.	Loop line in BS	14. 20 (A=5)	

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

Note: BS starts sending acknowledge within 62 ms after reception of frame 20.
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 channel, free marked TC, or the TC actually in use)

Signalling state	Signalling conditions	
	Direction MTX —> BS	Direction BS —> MTX
1. Signal strength measurement order 2. BS starts sending measurement result within T''' after reception of 21 b/c		

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

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

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

x) Frame 15 is sent for synchronization purposes

4.5 SUPERVISORY SIGNAL BS - MS - BS

As supervisory signal (ø-signal) on the radio path, a tone is used. The frequency of this tone is selected among four possible frequencies (3055, 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 reinserted 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 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.

Optional signal strength measurement alarms, which are performed at each channel at the BS, are transmitted to the MTX in the same way.

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, distortion 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). During conversation state, the 1200 bit/s signalling may be used for end to end user data transfer as specified in Doc 450-3, Annex 21.

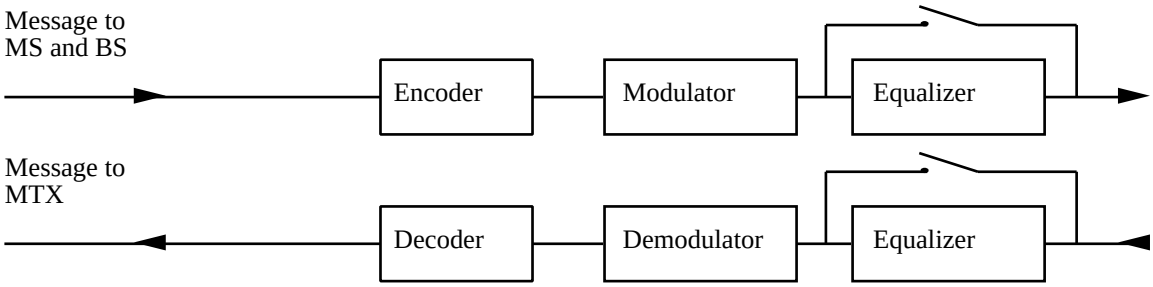


Fig. 4.6.1 Functional block diagram of the 1200 Baud signalling equipment at MTX

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 distortion 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

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

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

$\oplus$ 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.	encoded message
15 bits	11 bits	140 bits
101010101010101	11100010010	

Fig. 4.6.2Frame 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 1a Free calling channel indication.

$N_1N_2N_3$ P(12) Y_1Y_2 JJJJJJJJJJ

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

H_1-H_{10} = 0 0000

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

= 0001001101011100 00

According to the formulas above the encoded message will be

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

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

$Y_7 = 0$; $Y_8 = 0$; $Y_{17} = 1$; $Y_{18} = 0$
$Y_9 = 1$; $Y_{10} = 0$; $Y_{19} = 1$; $Y_{20} = 1$
$Y_{133} = 1$; $Y_{134} = 0$; $Y_{137} = 1$; $Y_{138} = 0$
$Y_{135} = 1$; $Y_{136} = 0$; $Y_{139} = 1$; $Y_{140} = 0$

4.6.3 Modulator

The modulation rate is 1200 ± 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.

The level from the modulator in the MTX including transmitting filters if so equipped is : -17 ± 0.25 dBmO. The output level of the modulator in the BS is -11 ± 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.

These levels are valid in the implementation in the Nordic countries. The levels have to be matched to the line levels in the specific network. See also NMT Doc 450-4 and NMT Doc 900-4 paragraph 2.2.4.2.

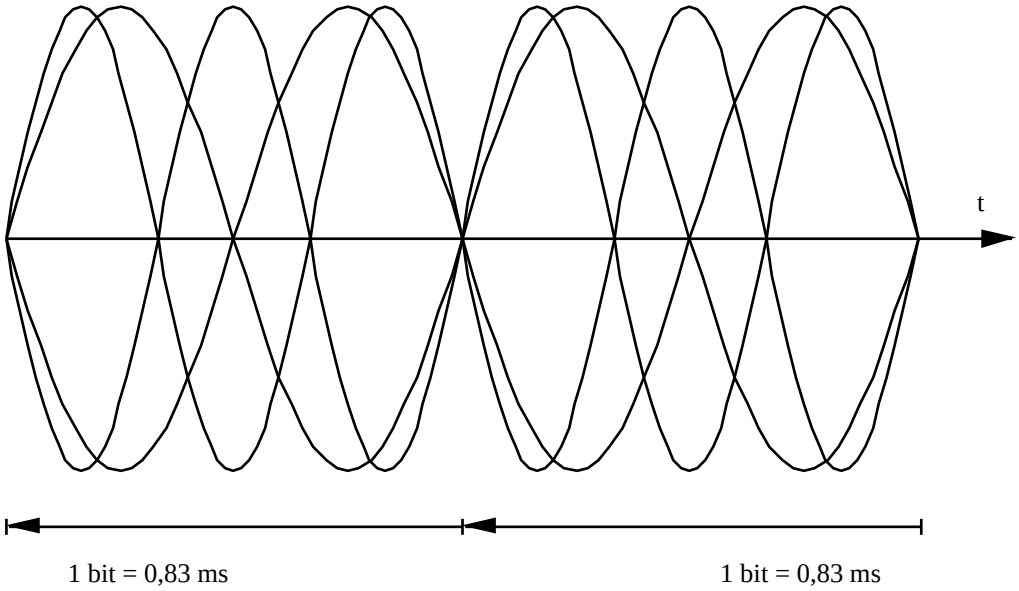


Fig. 4.6.3 Line diagram for the FFSK signal

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 (600-2400Hz).

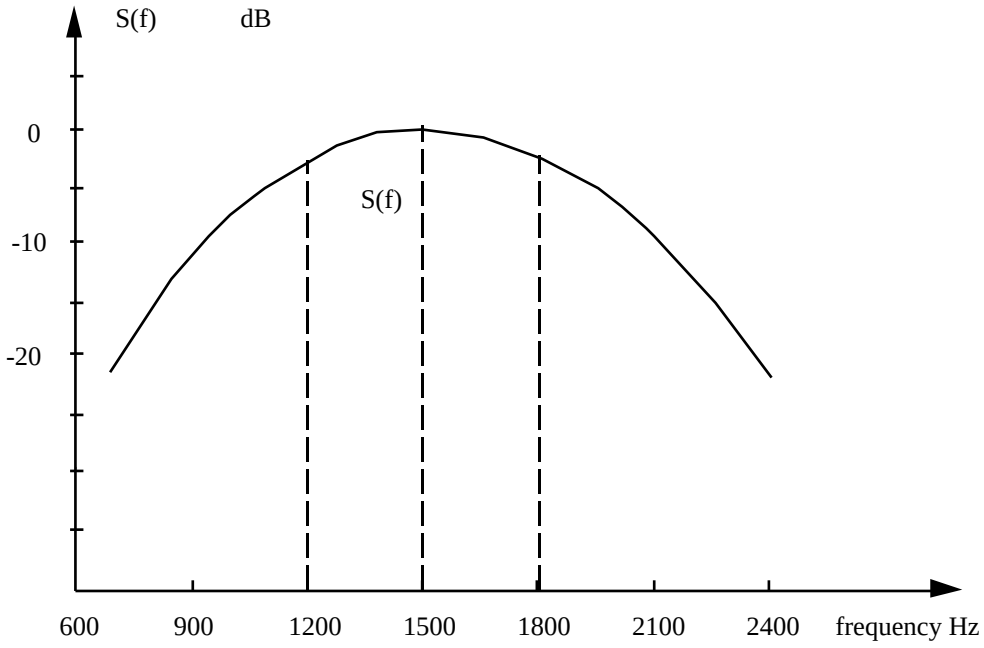


Fig. 4.6.4 Spectrum S(f) of the FFSK signal

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.

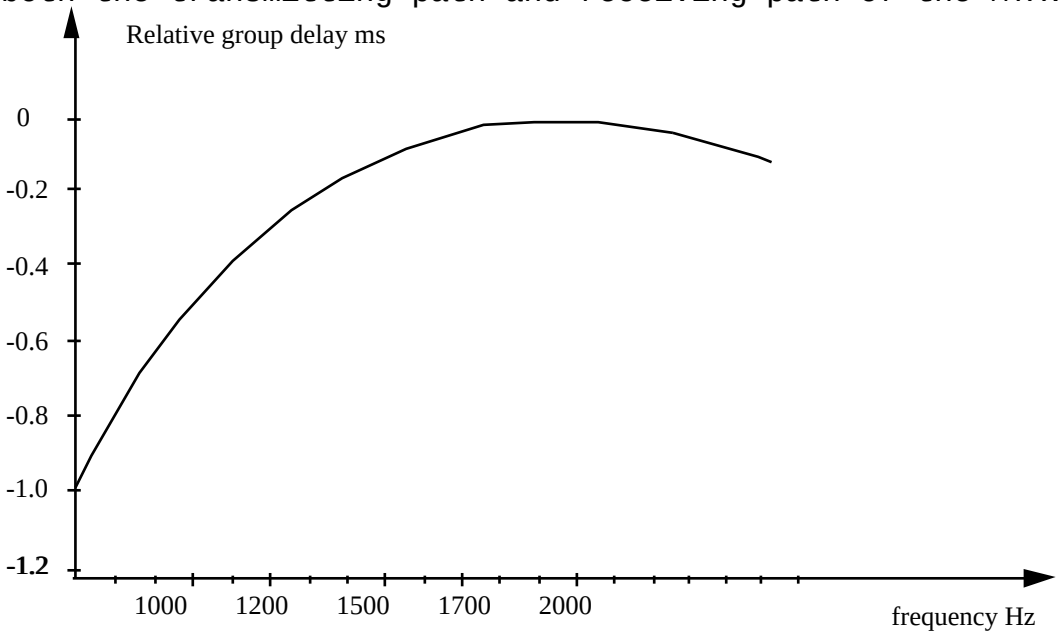


Fig. 4.6.5 Relative group delay of equalizer

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

These levels are valid in the implementation in the Nordic countries. The levels have to be matched to the line

levels in the specific network. See also NMT DOC 450-4 and 900-4 paragraph 2.2.4.2.

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 signal below a level of -35 ±3 dBmO. 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.

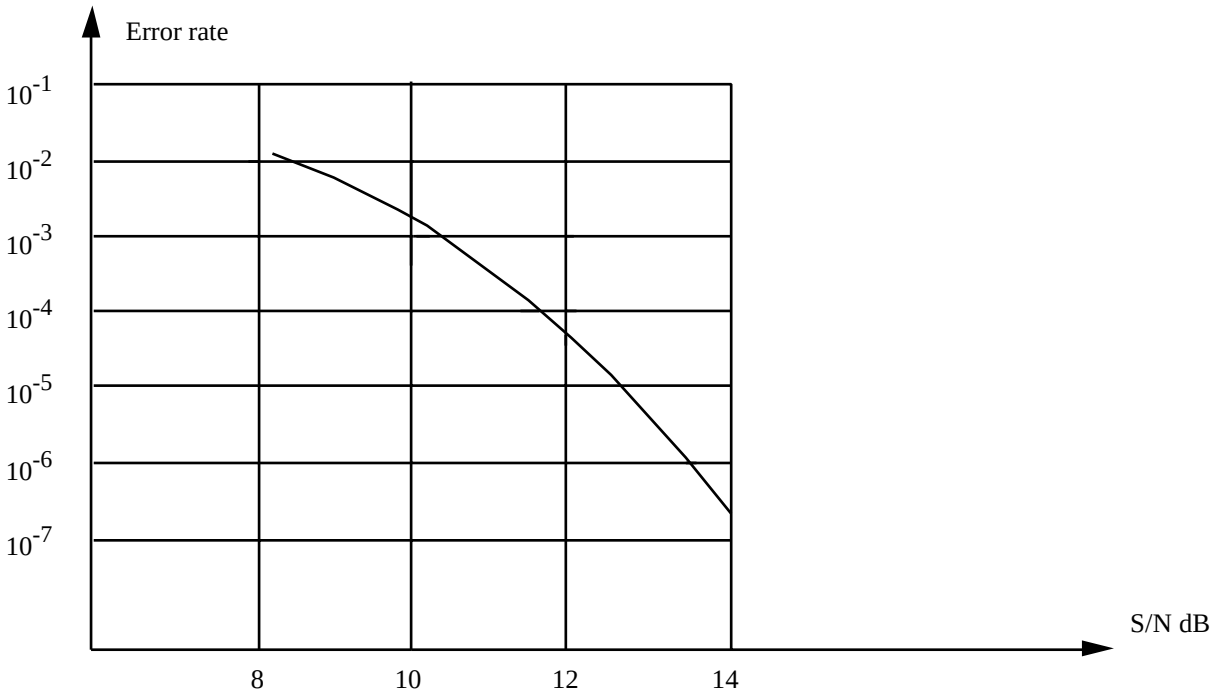


Fig. 4.6.7 Error rate versus signal to noise ratio at input from line (S/N) measured in bit rate bandwidth (1200 Hz) for noise with an even distribution at least from 300 to 3400 Hz.

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 he 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 Muting of speech path

When the 1200 Baud signalling equipment in MTX is sending, the audio signal through 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 $N_1N_2N_3$ P(12) Y_1Y_2 of the received frame 1a/1b 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 $N_1N_2N_3$ P(12) Y_1Y_2 is received regularly. However, two 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 114 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

The frame 1b/4 is accepted as free marked traffic channel, if prefix and Y_1Y_2 are correctly received and $H_8H_9H_{10}$ is one of the following fictitious channel numbers 0, 3F3, 3F4, 3F5 or 3F6.

- MTX receives seizure from ordinary MS

  ($N_1N_2N_3$ P(1) $ZX_1X_2X_3X_4X_5X_6$ TY_2 $K_1K_2K_3$)

  The call from. Z X1 ... X6 is accepted if it is a valid mobile number, $N_1N_2N_3$ and prefix are correctly received and TY_2 are correctly received or equal to zero.

- MS receives identity request
  ($N_1N_2N_3$ P(5) Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ $H_8H_9H_{10}$)

  The frame is accepted if prefix P(5) and identity Z $X_1…X_6$ are correctly received and $H_8H_9H_{10}$ equals 000, 3F3, 3F4, 3F5 or 3F6.

- Authentication request to MS , frame 7
  ($N_1N_2N_3$ P(8) Y_1Y_2 $C_1C_2C_3C_4C_5C_6C_7$ JJJ)

  The frame is accepted if prefix, channel number, Y_1Y_2 and JJJ are correctly received. In register recall procedures, frame 7 shall be accepted independently of the received area code Y_2, but Y_1 has to be correctly received.

- MTX receives identity
  ($N_1N_2N_3$ P(1) $ZX_1…X_6$ TY_2 $K_1K_2K_3$)

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 $N_1\ N_2\ N_3$ P(7) Z $X_1\ X_2\ X_3\ X_4\ X_5\ X_6$ S(0/15) S(0/15)S(n)S(n)S(n)
  - Mobile clearing see (4.7.2.3.b) $N_1\ N_2\ N_3$ P(8) Z $X_1\ X_2\ X_3\ X_4\ X_5\ X_6$ L(1)L(1)L(1)L(1)L(1)
  - Idle frame (J J J P(0) 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) $N_1\ N_2\ N_3$ or Z $X_1\ X_2\ X_3\ X_4\ X_5\ X_6$ or six out of ten characters $N_1\ N_2\ N_3$ Z $X_1\ X_2\ X_3\ X_4\ X_5\ X_6$ 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 (see 4.7.2.3.a) ($N_1\ N_2\ N_3$ P(6) Y_1Y_2 Z $X_1\ X_2\ X_3\ X_4\ X_5\ X_6$) L(15)L(15)L(15)
  - Address complete $N_1\ N_2\ N_3$ P(6) Y_1Y_2 Z $X_1\ X_2\ X_3\ X_4\ X_5\ X_6$ L(6)L(6)L(6)
- Authentication signed response from MS, frame 16 ($N_1N_2N_3$ P(12) $R_1R_2R_3R_4R_1R_2R_3R_4R_1R_2R_3R_4$)

  The frame is accepted if prefix is correct and two of the three $R_1R_2R_3R_4$ -groups are equal and correctly received.

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$X_1X_2X_3X_4X_5X_6$ $H_8H_9H_{10}$)

- Call acknowledgement
  ($N_1N_2N_3$ P(1) $ZX_1X_2X_3X_4X_5X_6$ TJ (JJJ))

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

- channel order
  (N_1 N_2 N_3 P(12) Y_1Y_2 Z X_1 X_2 X_3 X_4 X_5 X_6 N_a N_b N_c)

  The frame is accepted if identity X_1 ... X_6 is correctly received and N_a N_b N_c is a valid channel number.

- Scan order/Queue order, frame 2d/2f
  ($N_1N_2N_3$ P(12)Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ $H_8H_9H_{10}$)

  The frame is accepted if prefix and identity are correctly received, and $H_8H_9H_{10}$ is equal to 3F2 or 3F0 respectively.

- Identity request
  ($N_1N_2N_3$ P(5) Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ $H_8H_9H_{10}$)
  (se 4.7.2.1)

- Identity from MS
  (N_1 N_2 N_3 P(1) $ZX_1X_2X_3X_4X_5X_6$ J J J J J)
  (se 4.7.2.1)

After the identity check the

- MS can receive

  - ringing order
    (N_1 N_2 N_3P(6)Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ L(9)L(9)L(9))

  - Forced release
    (N_1 N_2 N_3P(6)Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ L(15)L(15)L(15))

  - Idle frame (J J J P(0) J J ... J)

- MS transmits

  - Answer ($N_1N_2N_3$ P(8) Z $X_1X_2X_3X_4X_5X_6$ L(14)L(14)
    (see 4.7.2.3b) L(14)L(14)L(14))

- A-number identification:
  ($N_1N_2N_3$ P(1) Y_1Y_2 M $H_1H_2H_3H_4H_5H_6H_7$ W_1W_2)

  Frame 8 is accepted if channel number $N_1N_2N_3$, prefix P(1) and traffic area Y_1Y_2 are correctly received and the checksum W_1W_2 is correct. The A-number is presented to the user if all the frames in the sequence are correctly received. The number of frames in the sequence is stated in H_2 in the first frame.

If all frames are not received correctly at the first transmission, the correctly received frames shall be stored until next similar frame is correctly received. If all frames of the sequence have been correctly received after the second transmission of frames, the A-number information shall be presented to the user.

4.7.2.2b Signalling scheme B1, call MTX –> MS.

- Call to MS on calling channel
  (See 4.7.2.2)
- Call acknowledgement
  (See 4.7.2.2)
- Scan order
  (See 4.7.2.2)
- MTX receives seizure from ordinary MS on traffic channel
  (See 4.7.2.1, except that MS will send prefix P(6) instead of P(1))
- MS receives identity request on traffic channel
  (See 4.7.2.1)
- MTX receives identity on traffic channel (See 4.7.2.1, except that MS will send prefix P(6) instead of P(1))

After the identity check:
(see para 4.7.2.2)

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_2 X_3 X_4 X_5 X_6 are correctly received and at least two of the three characters L(n) are equal and meaningful.

Acceptance criteria for frame 5c:

The frame is accepted if the prefix P(2) and identity $ZX_1X_2X_3X_4X_5X_6$ are correctly received and bit sequence i_1 i_2 i_3 i_4 i_5 i_6 is equal to i'_1 i'_2 i'_3 i'_4 i'_5 i'_6

4.7.2.3b Line signals in the direction MS - > MTX

The line signal is accepted if the prefix P(8) and the identity Z X_1 X_2 X_3 X_4 X_5 X_6 are correctly received and at least three characters L(n) are equal and meaningful.

4.7.2.4 Signalling schemes C and C1', switching call in progress

- Traffic channel allocation on traffic channel
  (N_1 N_2 N_3 P(5) Y_1Y_2 Z X_1 X_2 X_3 X_4 X_5 X_6 N_a N_b N_c)
  (see 4.7.2.2 channel order)

  The frame is accepted if prefix and identity $ZX_1X_2X_3X_4X_5X_6$ are correctly received and $N_aN_bN_c$ is a valid channel number

4.7.2.4b Signalling scheme C2', SCIP.

- Traffic channel allocation on traffic channel, short procedure.
  ($N_1'N_2'N_3'$ P(9) $Y_1Y_2ZX_1X_2X_3X_4X_5X_6$ $N_aN_bN_c$)

  The frame is accepted if prefix and identity $ZX_1X_2X_3X_4X_5X_6$ are correctly received and channel number $N_1'N_2'N_3'$ and $N_aN_bN_c$ are equal and meaningful.

- Identity request
  (see para 4.7.2.1)

- MTX receives identity
  (see para 4.7.2.1)

4.7.2.5 Signalling scheme D, roaming information

- Roaming updating seizure on traffic channel

  ($N_1N_2N_3$ P(14) $ZX_1X_2X_3X_4X_5X_6$ TY_2 $K_1K_2K_3$)
  (see 4.7.2.1 seizure)

4.7.2.6 Coin-box

- MTX receives seizure from coin-box M
  ($N_1N_2N_3$ P(11)$ZX_1X_2X_3X_4X_5X_6$ TY_2 $K_1K_2K_3$)
  (see 4.7.2.1 seizure)

- MS receives answer
  (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

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

- Answer acknowledgement from coin-box
  (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

  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.

- Authentication request to MS , frame 7 (see 4.7.2.1)
- Authentication signed response from MS, frame 16 (see 4.7.2.1)

4.7.2.7 Call from mobile station with priority

- Seizure from MS with priority ($N_1N_2N_3$ P(15)$ZX_1X_2X_3X_4X_5X_6$ T J(JJJ)) (see 4.7.2.1 seizure)
- Queueing information to MS with priority on calling channel (N_1 N_2 N_3 P(12)Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ N_a N_b N_c) (see 4.7.2.2 channel order)
- Authentication request to MS , frame 7 (see 4.7.2.1)
- Authentication signed response from MS, frame 16 (see 4.7.2.1)

4.7.2.8 Change of MS output power level on same channel

- traffic channel allocation on traffic channel (N_1 N_2 N_3 P(5) Y_1Y_2 $ZX_1X_2X_3X_4X_5X_6$ N_a N_b N_c) (see 4.7.2.2 channel order)
- MTX receives identity ($N_1N_2N_3$ P(1) $ZX_1X_2X_3X_4X_5X_6$ TY_2 $K_1K_2K_3$) (see 4.7.2.1 seizure)

4.7.2.8b Authentication during conversation

- MS receives identity request, frame 3b (see 4.7.2.1)
- MTX receives seizure form ordinary MS, frame 10b (see 4.7.2.1)
- Authentication request to MS , frame 7 (see 4.7.2.1)
- Authentication signed response from MS, frame 16 (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) JJJ $A(3)f_øf_øf_øf_øf_ø$

$N_1N_2N_3$ P(15) Y_1Y_2 Z(15) JJJ A(0-2,4-15)JJJJJ
and [OPTIONAL]
$N_1N_2N_3$ P(15) Y_1Y_2 Z(15) JJJ A(6,13)$f_{ø}f_{ø}f_{ø}f_{ø}f_{ø}$
$N_1N_2N_3$ P(15) Y_1Y_2 Z(15) JJJ A(7,14)$l_Ll_Ll_Hf_{ø}f_{ø}$
$N_1N_2N_3$ P(15) Y_1Y_2 Z(15) JJJ A(15)$l_Ll_Ll_H$JJ

The frame is accepted if prefix and Z(15) JJJ are correctly received. $f_{ø}$ is valid if two of the last three $f_{ø}$ are equal and meaningful and A(n) takes the values 3, 6, 7, 13 or 14. Due to implementation other acceptance criteria can be valid for A= 7, 14 or 15 due to setting of alarm levels for received signal strength evaluation [OPTIONAL].

- 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) JJJ V(15) JJ $N_aN_bN_c$

The frame is accepted if P(3), Z(15) JJJ and 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) JJJ V(15) JJ $N_aN_bN_c$

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

- Other management/maintenance order on, idle channel or data channel

N_1 N_2 N_3 P(14) Y_1Y_2 Z(15) JJJ V_1 V_2 V_3 V_4 V_5 V_6

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

4.7.2.10 Signalling in the direction BS -> MTX

- Channel status information

  $N_1N_2N_3$ P(9) Z(15) JJ A(n) JJJJJJJJ

  and [OPTIONAL]

  N1N2N3 P(9) Z(15) JJ A(2,6) JJJ fØlHlL JJ
  $N_1N_2N_3$ P(9) Z(15) JJ A(14) JJJ Jl_Hl_L JJ
  $N_1N_2N_3$ P(9) Z(15) JJ A(7,8) JJJ CCC JJ

  The frame is accepted if N_1 N_2 N_3 , P(9), Z(15) and A(n) are correctly received.
  Due to implementation of cause values and alarm levels for received signal strenght, other acceptance criteria can be valid [OPTIONAL]

- Signal strength measurement result

  (N_1 N_2 N_3 P(2) Z(15) J J N_a N_b N_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_1 N_2 N_3 , P(2), Z(15) and N_a N_b N_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_1 N_2 N_3 P(4) Z(15) J J V_1 V_2 V_3 V_4 JJJJ

  The frame is accepted if N_1 N_2 N_3, P(4) and Z(15) are correctly received.

- Other maintenance information from BS

  N_1 N_2 N_3 P(13) Z(15) JJ V_1 V_2 V_3 V_4 J J J J J

  The frame is accepted if N_1 N_2 N_3 , P(13) and Z(15) and are correctly received.

4.7.2.11 Subscriber service by register recall and code sending.

- Authentication request to MS, frame 7 (see 4.7.2.1)

- Authentication signed response from MS, frame 16 (see 4.7.2.1)

4.7.3 False frame synchronization in BS

Any number of false frame synchronization words within a frame shall be handled. The occurrence of false frame synchronization words shall not cause frames to be lost.

However, there exists a minor possibility that decoding of a frame after synchronizing to a false synchronization word will produce meaningful information. In such situations, the requirement stated above need not be fulfilled.